NEWS

211/14

ROHDE&SCHWARZ

Precise antenna characterization

Test and DF antennas are only as good as the T&M equipment used to characterize them. The new Rohde&Schwarz antenna test chamber makes it possible to characterize antennas under test (AUT) with utmost precision – the prerequisite for creating highly accurate antennas.

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NEWS

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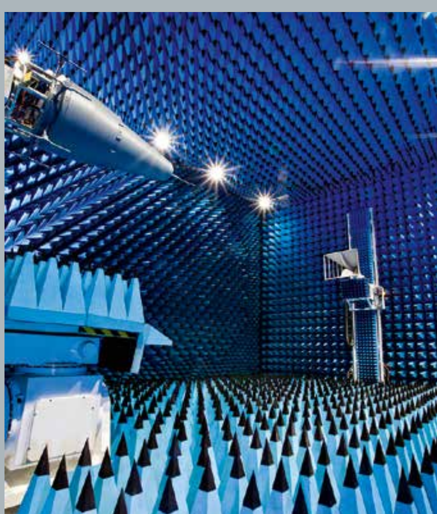
Cover feature

Advanced, high-precision communications equipment calls for highly accurate T&M equipment in development and production. Rohde & Schwarz can draw on long-standing experience both in RF engineering and the associated T&M technology. The company was therefore able to design its own new antenna test chamber at its Memmingen plant and equip it with its own T&M products. For an antenna to handle highly demanding and sophisticated tasks, e.g. for T&M or DF applications, its three-dimensional radiation



pattern must be exactly known. Due to the complexity of this task and the limitations inherent in antenna design modeling, simulation programs can deliver only approximate predictions. This is why anechoic chambers are still indispensable when it comes to developing antennas of utmost precision. The Rohde & Schwarz antenna test chamber was designed with ambitious requirements in mind, making it a state-of-the-art facility unique in Europe. For example, the test chamber needed to offer a continuous measurement range from 200 MHz to 40 GHz and an outstanding angular accuracy of 0.02° for positioning the antenna under test (AUT), which can weigh up to 200 kg. All of the imposed requirements were fully met, and the test chamber is now in operation. For details, refer to the article on page 52.

Overview
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Wireless technologies

Test systems

Testers

Signal generation and analysis

General purpose

Signal generation and analysis

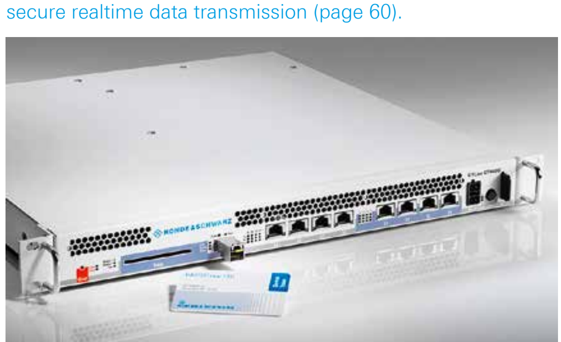
Power measurement

Oscilloscopes

The next-generation R&S®TS8980 conformance test system meets all current, relevant requirements for RF and RRM tests on wireless user equipment and is the only system to cover all standards from GSM to LTE-Advanced (page 6).

EMS measurements require very high field strengths when testing large EUTs. The R&S®BBL200 broadband amplifiers generate the required field strengths for these applications (page 41).

The R&S®SITLine ETH40G, the world's first Ethernet encryptor to achieve 40 Gbit/s data throughput, provides secure realtime data transmission (page 60).



Conformance test system with unique test coverage

With its combination of test coverage and usability, the next-generation R&S®TS 8980 conformance test system outperforms any other solution on the market. For RF and RRM* tests on wireless user equipment, it meets all current, relevant requirements established by the GCF and PTCRB certification authorities and the most prominent network operators. And it is the only system to cover all standards from GSM to LTE-Advanced.

* Radio resource management

Fig. 1: The R&S®TS8980 (shown here in various configurations) is optimized for 24/7 operation and offers full remote control combined with exceptional measurement accuracy. More than 20 reference test systems operate around the clock at Rohde&Schwarz for the development, test and support of 140 customer systems.

New wireless communications standards set the pace

The growth of the wireless communications market continues unabated. To ensure that the required resources are available, network operators are equipping their base stations with an economical mix of established wireless communications standards (e.g. GSM) and new developments (e.g. LTE). The various demands placed on user equipment (UE) have grown in parallel, because these devices must ensure the best possible access to services provided by the network operator, both within the home network and while roaming. And they must accomplish all this via whatever wireless communications standards are currently in place. As a result, user equipment in most countries now handles GSM, WCDMA, LTE and lately also LTE-Advanced.

While GSM utilizes a very manageable four frequency bands, LTE has increased to more than 25 and is trending higher. LTE-Advanced adds numerous band combinations that must be tested. This alone is enough to increase the number of conformance tests needed for UE. But the sheer number of devices that must undergo these tests is also growing, as UE expands to encompass not only mobile phones, but also notebooks, tablets and integrated modules, such as those found in motor vehicles.

Moreover, special requirements are continually introduced by network operators, who request additional tests for their specific network situations. To improve the quality of their services even further, operators require, for example, adjacent channel immunity tests for two bands located in very close proximity to one another.

All of these requirements call for easy-to-use conformance test systems that can perform needed tests quickly and fully automatically. Ideally, the conformance test systems support all required tests so that the device under test (DUT) needs to be configured and connected only once.

Development teams additionally need access to the entire range up to the limits so that they can find ways to implement highest performance at lowest cost. This requires functions such as margin search, sweep mode and simultaneous control of a connected climatic chamber with a temperature range from –50 °C to > +50 °C.

Unique test scope and usability

The R&S®TS8980 conformance test system (Figs. 1 and 2) is the only system in the world that already meets these extensive requirements today. It covers not only the established wireless communications standards with its GSM and WCDMA support, but also their leading edge successors LTE and LTE-Advanced. Moreover, these standards can all be tested on the same test system and in a single test sequence. The system is designed for fully automated, round-the-clock operation, with full remote control and continual transmission of test results to any selected database server. It independently sends configurable e-mail notifications to the operator when user intervention is required, and it automatically repeats tests as needed based on defined criteria.

This extensive scope of functions brings distinct advantages to the operations of the three largest user groups of the R&S®TS8980:

- Test houses can already begin processing of results during the test run, inform their customers about any necessary rework and compile the information needed for certification
- Chipset or UE manufacturers can already set their global development teams to work on future developments during the test run, then update the DUT firmware from any site and immediately test changes
- Network operators can fully concentrate on their bottom line by running acceptance tests on new devices efficiently, with the most automation and the least effort possible

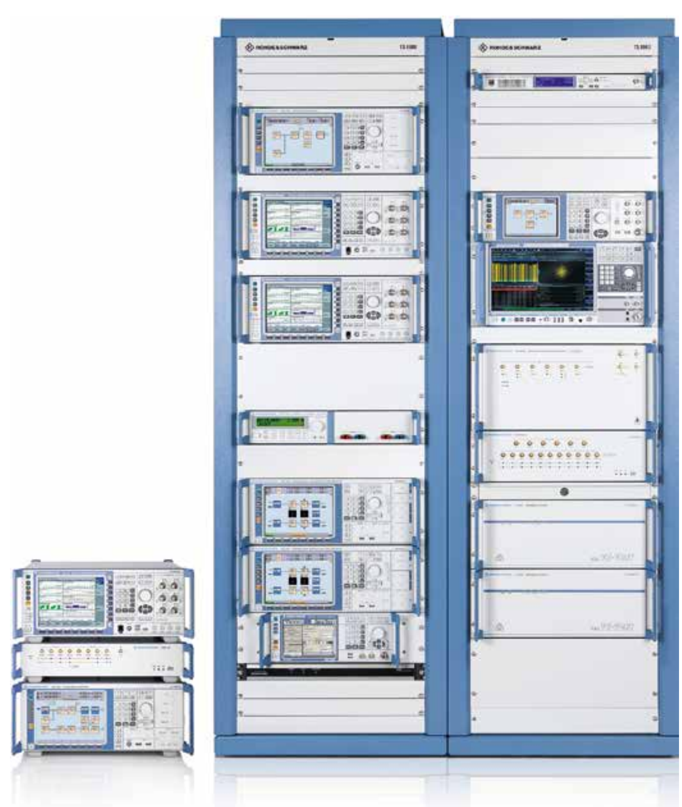
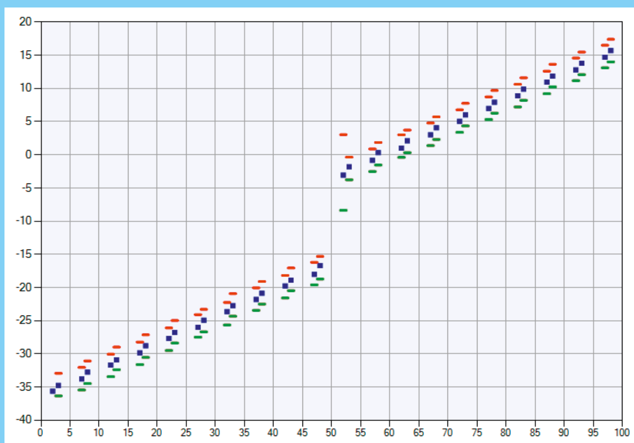
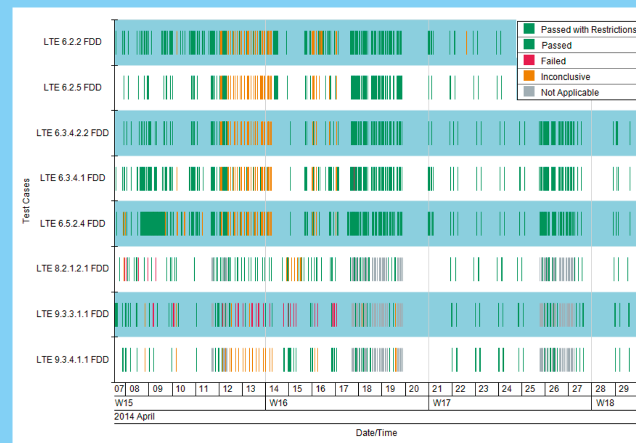


Fig. 2: Depending on customer requirements, the R&S®TS8980 test system can be delivered in a space-saving configuration (on the left) or in a configuration with wider test coverage – both configurations support LTE-Advanced. See Fig. 1 for additional configurations.

Examples of new measurement functions provided by the R&S®TS8980



Power vs. subframe measurement. During the test sequence, the test results are displayed on the screen in realtime together with the limits defined by the 3GPP standard. (Blue: power in dBm, with upper and lower limit in red and green).



The R&S®CONTEST sequencer software offers a wide variety of analysis functions. For example, the verdict vs. time function shows the effect of new DUT firmware version versus time.

RF and RRM on one system

In addition to RF tests on the physical layer, a single test plan can also include handover and cell reselection tests as part of radio resource management (RRM). In particular, test sequences for smartphones with their advanced functions benefit from this expanded test coverage. The supplemental CDMA2000® and TD-SCDMA standards available for RRM additionally facilitate acceptance testing for divergent target markets without requiring separate test systems. Even speech and data quality tests (SVLTE and SGLTE) are available when simultaneously using CDMA2000® and LTE, for example.

Support for LTE TDD and LTE FDD

A special characteristic of LTE and LTE-Advanced is the availability of two modes: LTE FDD and LTE TDD. Frequency bands for both modes have meanwhile been put into service in all large markets, and leading manufacturers have already announced that all future wireless devices will include both modes.

Rohde&Schwarz is the only manufacturer that has placed great emphasis on developing both modes from the outset, so that today the R&S®TS8980 is the system with the most comprehensive test coverage for these two LTE modes. The strong commitment of Rohde&Schwarz to LTE TDD was recognized by the largest network operator in the world, China Mobile, which honored the R&S®TS8980 with the distinguished GTI Award this year.

Thanks to its modular design the test system can be precisely customized to any application. For example, customers who initially only need test capacity for GSM and LTE can later easily add WCMDA and LTE-Advanced – with minimal impact on the hardware (Fig. 2).

The most compact system in its class

Although the R&S®TS8980 has already been the most compact test system in its class, the introduction of tunable filters made it possible to further reduce the space requirements. A single rack now provides complete RF test coverage for GSM, WCDMA, LTE and LTE-Advanced, including two downlink component carriers. As a result, valuable space is made available in shielded chambers for additional test equipment.

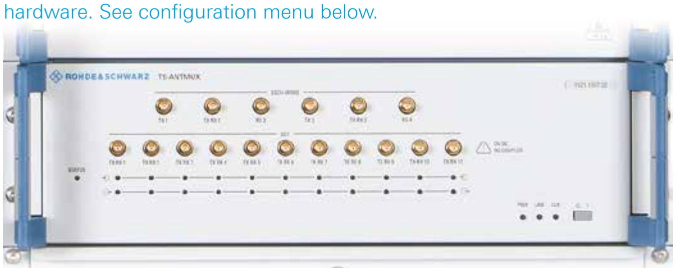
The new tunable filters (Fig. 3) can be combined with the existing band filters to increase the available frequency range to values between 450 MHz and over 3500 MHz, providing a wider bandwidth than any other conformance test system of this type.

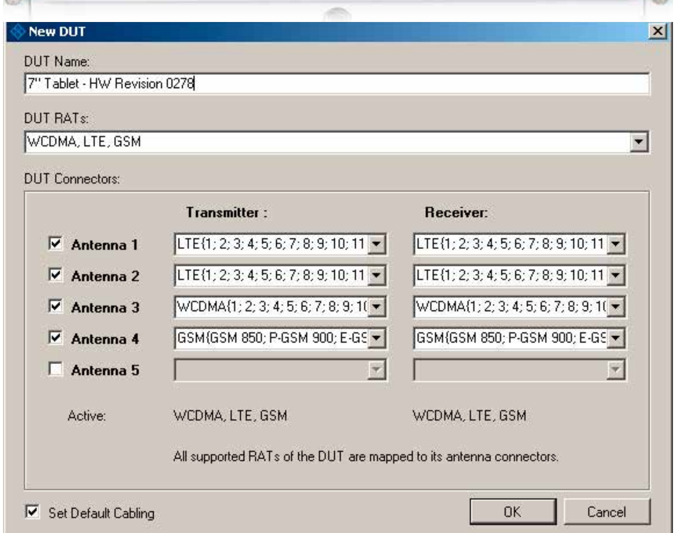
Full automation for more complex designs

With the introduction of carrier aggregation in LTE-Advanced, wireless communications modules have become more complex than ever before, making it necessary to redesign the RF path between the amplifier and the antenna. One way that manufacturers are dealing with this new complexity is to assign the frequency bands or standards to the various antennas in the wireless devices. Until recently, this required a manual reconfiguration of the RF cabling during the test sequence – bringing with it an additional source of errors as well as requiring manual intervention, for which the time cost cannot be estimated.

Fig. 3 (detail from Fig. 1): A single, tunable filter replaces more than 25 individual filter modules from the previous design – and still fulfills the higher UE output power requirements for GSM or LTE HPUE (high-power user equipment).

Fig. 4 (detail from Fig. 1): The new antenna multiplexer makes it possible to test even complex antenna configurations without additional external hardware. See configuration menu below.





These problems are avoided with the new antenna multiplexer (Fig. 4), which can be used to assign the frequency bands and wireless communications standards to the available antennas in just about any configuration. This permits manufacturers more flexibility with design and allows full and unrestricted automation during conformance testing.

The leader in new wireless communications standards

As early as 2013, the R&S®TS8980 took the next big step in public wireless communications with the introduction of initial tests for LTE-Advanced. As a result, the scope of tests has been expanded to cover three major topics from 3GPP Release 10:

- Carrier aggregation for two downlink carriers (CA 2DL)
  Permits data rates of up to 300 Mbit/s – on a single UE
- Enhanced inter-cell interference coordination (eICIC)
  In today's advanced, heterogeneous networks consisting of large and small cells, this is a key feature for achieving higher data rates by optimized interference management
- Enhanced downlink multi-antenna transmission (eDL-MIMO)
  The newly defined transmission mode 9 permits for the first time up to eight MIMO layers in the downlink, plus multi-user MIMO

The next developments are already being prepared, so that customers can verify and certify the latest technologies on their wireless UE:

- Carrier aggregation for two uplink carriers (CA 2UL)
- Carrier aggregation for three downlink carriers (CA 3DL)
- Coordinated multipoint transmission (CoMP)

Summary

Through the use of the latest Rohde&Schwarz T&M instruments, including the R&S®FSW signal and spectrum analyzer and the R&S®SMW200A vector signal generator, plus continually updated switching and filter technologies, the R&S®TS8980 conformance test system has become the gold standard for testing next-generation wireless devices. The wide range of upgrade options allows customers to use and expand their investment flexibly over many years. Just as its predecessor, the R&S®TS8950, set the pace for GSM and WCDMA, the R&S®TS8980 has taken on the same role for LTE and LTE-Advanced while remaining a high-quality replacement for the previous generation of test systems.

Martin Luley

Fig. 1: Help is summoned automatically: When eCall is on board, the public safety answering point is notified within seconds after a crash.

Standard-compliant testing of eCall in-vehicle systems

The EU is aiming for the automatic emergency call (eCall) system to be mandatory in all new cars by the end of 2015. The eCall conformance test system from Rohde & Schwarz enables manufacturers to quickly and reliably verify their eCall solutions.

Uniform pan-European eCall service

In May 2010, the UN General Assembly proclaimed the period of 2011 to 2020 as the decade of action for road safety. During this period, international measures are to be taken to effectively reduce the high number of fatalities and serious injuries due to road traffic. The European Union's contribution to this effort was to design eCall, an automatic emergency call system. The Commission as well as the European Parliament and Council have approved the initiative. It stipulates that all new car and delivery vehicle models that come on the market in the EU after the cut-off date (not yet negotiated at the time of going to press) must support eCall operation.

What is eCall?

eCall automatically contacts the emergency services in the event of a serious accident. The in-vehicle electronics determine whether or not a serious accident has taken place. Typically, eCall activation is linked to airbag deployment. However, it is up to the manufacturer to determine which sensors are integrated and according to which criteria. In addition, the system can also be activated manually to report an emergency that cannot be detected automatically – for example, when a passenger has an urgent health problem – or an emergency involving another vehicle.

Since eCall requires both a wireless communications connection and satellite positioning, even low-cost small cars will have to be delivered with this functionality ex works. Car manufacturers have the option of either integrating a pure eCall modem or equipping vehicles with eCall-compatible telematics units, which of course can also be used for infotainment purposes.

How eCall works

The eCall system consists basically of three components: the in-vehicle system (IVS, normally an integral part of the telematics system), the telephone network that is used for communications (wireless and fixed network) and the public safety answering point (PSAP). When activated, the system dials the standardized pan-European emergency number 112. A special flag that must be implemented by the network operator is transmitted with the signal to alert the called station that it is dealing with an eCall. Control is passed on to the PSAP, which asks the IVS to transmit the standardized 140-byte eCall minimum set of data (MSD). The MSD contains all essential information that rescue services require in order to respond appropriately: vehicle position and heading (important on highways), time of accident, vehicle type, engine and/or fuel type (important for the fire department), number of occupants (closed safety belts). Additional information is optional. The well-established in-band modem technology was chosen to transmit the MSD due to its extensive availability (GSM) and the prioritization of voice telephony. It sends the data as beeps over the voice channel like in the days of acoustic couplers for telephones. The data is decoded at the PSAP and displayed on the operator's console. Then a voice connection is established between the operator and the vehicle so that the parties can interact directly.

Test solution

Developers of telematics systems as well as automobile manufacturers are faced with the task of testing eCall products from different perspectives:

- Module tests (some at the chipset level) are performed during the development phase, during production and when servicing the IVS to analyze design aspects and test module functions
- The complete, functioning IVS must pass the functional checks and type approval tests laid down in the relevant conformance test specifications. For eCall, this is the European CEN/TS 16454 standard for the required end-to-end conformance tests
- The automobile manufacturer has to perform the most expensive tests – verifying that the IVS functions when installed in the vehicle. This includes crash tests to confirm that the system works in a specific vehicle model

The Rohde & Schwarz test solution

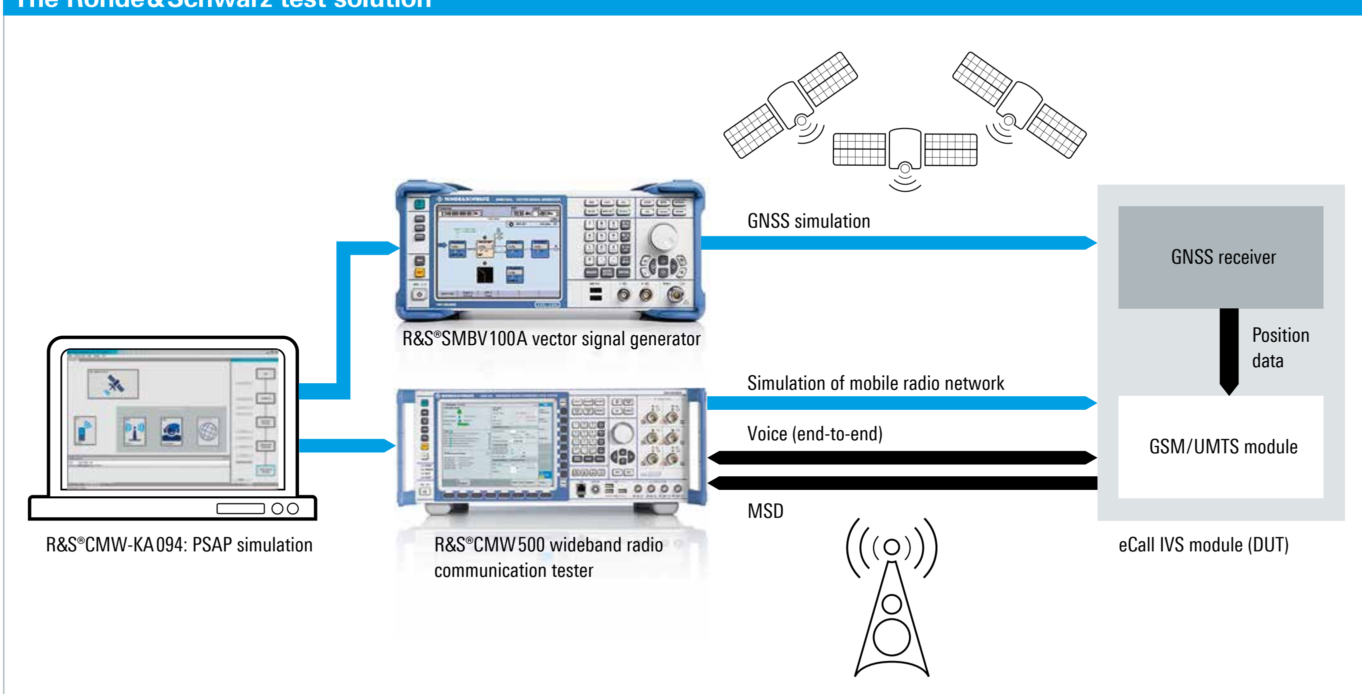


Fig. 2: The test system consists of an R&S®CMW500 wideband radio communication tester for the network simulation, an R&S®SMBV100A vector signal generator for the GNSS simulation and PC application software.

The Rohde & Schwarz test solution covers the second scope of tasks – standard-compliant functional testing of the complete eCall IVS. Fig. 2 shows the setup. The test system provides the IVS with two interfaces: a mobile radio interface in the form of the R&S®CMW500 wideband radio communication tester that simulates the network, and a GNSS interface in the form of the R&S®SMBV100A generator that functions as a GNSS simulator and provides the required position information. Both devices are controlled by a connected PC using the R&S®CMW-KA094 application software, which simulates the functions of the public safety answering point, controls the test sequence and provides the graphical user interface (Fig. 3).

The test programs check whether the IVS quickly and correctly contacts the public safety answering point, whether the MSD is transmitted in line with the standards and whether the final voice connection is correctly established. The system naturally provides more than just a simple Go/NoGo test. All relevant parameters are measured and logged. The three system components PSAP, mobile radio network (simulation) and GNSS (simulation) can be influenced in many ways in order to test special circumstances and simulate any imaginable operating state. This provides the user with a comprehensive test solution that ranges from a fast, automatic IVS functional check to a detailed test of the interaction of all system components.

Volker Bach

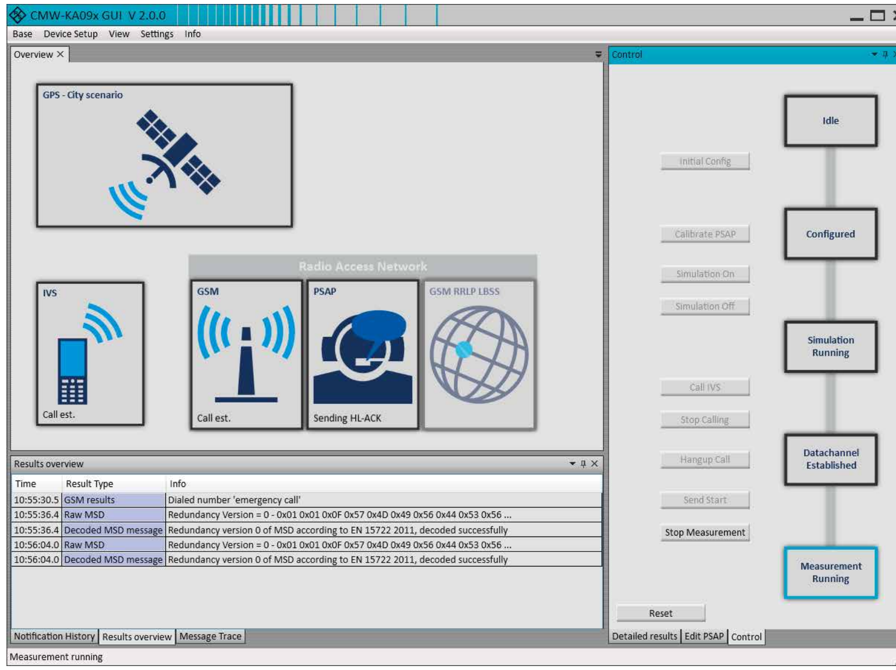


Fig. 3: The R&S®CMW-KA094 application software simulates the functions of the public safety answering point and controls the test sequence.

Webinar on topic

The webinar outlines the technology of the eCall system, provides an overview of the standardization and demonstrates the operating principle of the test system described in the article.
Link:
www.rohde-schwarz.com/news211/01

LTE-A tests: easy, dynamic and flexible using the R&S®CMW500 callbox

LTE-Advanced places new requirements on T&M equipment. The widely used, versatile R&S®CMW500 callbox is keeping pace with this development, and the latest version is the ideal test solution for use in development, production and service.

The challenge: LTE-Advanced

The continually rising demand for higher data rates made it necessary to extend the tried and tested LTE standard. LTE already offers a maximum bandwidth of 20 MHz, which together with the use of 64QAM MIMO and full resource allocation permits a maximum data rate of 150 Mbit/s in the downlink (DL). LTE-Advanced, also known as Release 10 of the 3GPP specification, increases the bandwidth and the data rate by using carrier aggregation (CA). Carrier aggregation refers to the allocation of multiple single channels (component carriers, CC) in one or more frequency bands based on the frequency spectrum available to a network operator (Fig. 2).

In the case of DL carrier aggregation, one carrier functions as a primary cell (PCell or PCC) with access to both the DL and UL. Signaling takes place over this carrier. Additionally allocated DL carriers are known as secondary cells (SCell or SCC). Previously, secondary cells only used the DL.

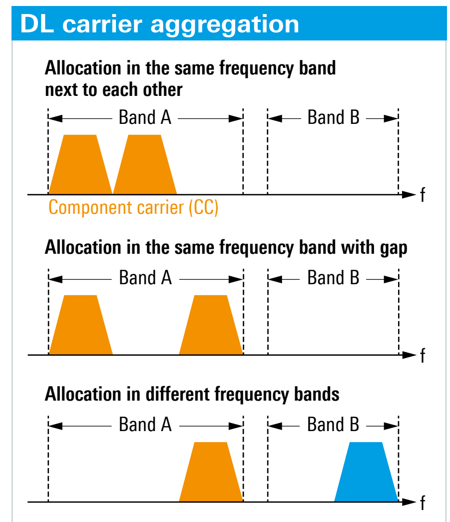


Fig. 2: Possible carrier positions.

Fig. 1: The R&S®CMW500 wideband radio communication tester with the new callbox is ideally suited to meet LTE-A T&M challenges.

In real networks, each LTE cell can assume the function of a PCell or SCell. DL carrier aggregation with two component carriers doubles the bandwidth to a maximum of 40 MHz and the data rate up to 300 Mbit/s.

Always in the lead with the R&S®CMW500

Carrier aggregation increases the complexity of RF and application tests, placing new requirements on T&M equipment. The R&S®CMW500 wideband radio communication tester (Fig. 1) has kept pace with the developments and is already well-equipped to handle these new requirements. As an excellent tool for testing two downlink carriers and one uplink carrier, the popular R&S®CMW500 callbox is now also available for LTE-Advanced. It handles all complex test requirements easily, quickly and clearly.

Flexible dynamic parameterization of each carrier in FDD or TDD

The same flexible, dynamic parameterization widely associated with the R&S®CMW500 for LTE is now also available for each individual component carrier. All bandwidth, band and frequency combinations can be regrouped without restriction. The parameterization is performed dynamically for each separate carrier. This also applies to the scheduling and power settings. A straightforward display shows the PCell and SCell settings at any time, as well as the current call state and important signaling processes (event log). The expanded capability report provides a clear overview of the Release 10 capabilities as well as the band and bandwidth combinations supported by the DUT (Fig. 3).

Call setup and signaling

Once the DUT is attached to the PCell, the user can dynamically aggregate the SCell. Using the R&S®CMW500, this can be done either fully automatically or manually in individual steps. In the latter case, the user triggers the individual signaling steps for the RRC and MAC layers manually. This useful function, along with the associated debugging options, has already proven its effectiveness in R&D, for example during the initial commissioning of DUTs for LTE-Advanced. Test reports for the PCell and SCell are also optionally available (Fig. 3).

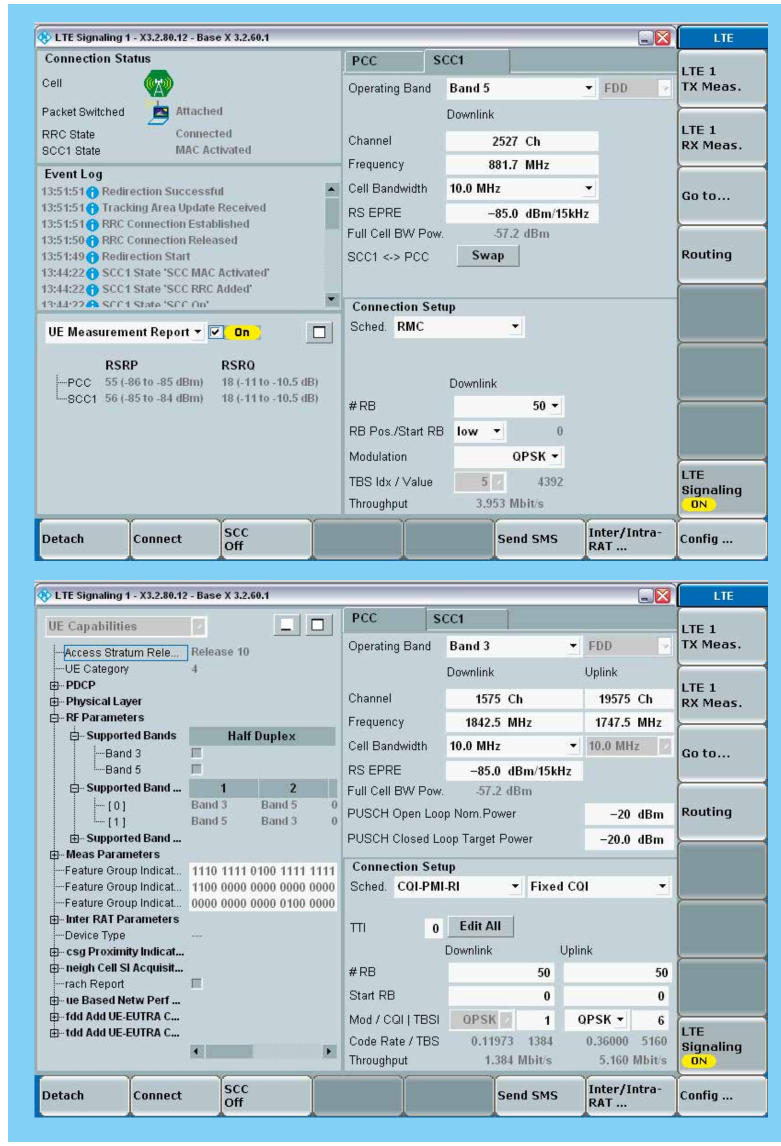


Fig. 3: PCell / SCell measurement reports and Release 10 capabilities.

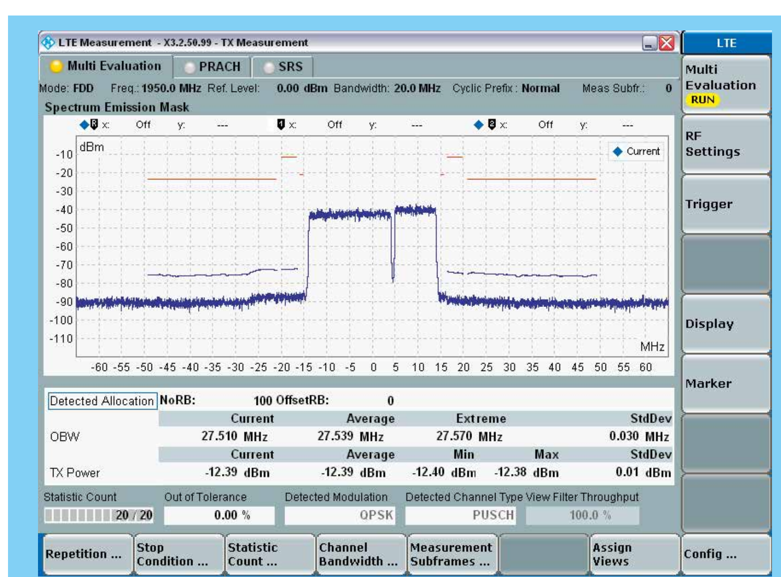


Fig. 4: UL carrier aggregation measurement.

Transmitter tests

The transmitter tests do not differ from Release 8 with respect to DL carrier aggregation with one UL CC. The existing tests can be used unmodified. Most tests for UL carrier aggregation with two UL CC are also performed on individual carriers. Only for intraband contiguous UL CA, new algorithms that measure both carriers simultaneously are only needed for spectrum, in-band emission and several power measurements (Fig. 4).

Receiver tests – Cat6 UE is child's play

Receiver tests are especially critical when using DL carrier aggregation. It is important to be able to appropriately verify the continually increasing data throughputs. The R&S®CMW500 offers a variety of options for detailed analysis of the total throughput or the throughput per carrier on various layers (MAC / RLC / IP). Dummy data can be added in the form of MAC padding or IP data (UDP, TCP). This is especially helpful when verifying the peak data rates, e.g. 300 Mbit/s in the DL and 50 Mbit/s in the UL for Category 6 UE (Fig. 5).

All of these challenging tests are almost child's play with the R&S®CMW500 and its integrated client/server architecture. The R&S®CMW500 is one of the few compact one-box testers in the callbox segment that offers these test options.

A number of IP-based setting options (RLC AM / UM) along with the optional use of HARQ profiles for triggering retransmissions provide additional flexibility for application testing in R&D. A quick and easy precompliance test of the receiver in the DUT is also possible by using the integrated error insertion per carrier and corresponding error analysis.

The CA test solution in the R&S®CMW500 also includes a time-optimized early-pass/early-fail analysis with a variety of user-defined decision criteria per carrier. Together with the R&S®CMWRun sequencer software tool, the tester covers a wide range of transmitter and receiver tests in line with 3GPP 36.521 as well as performance tests.

Another T&M challenge: harmonics

When using carrier aggregation with its different band combinations, harmonic interference can occur. For example, a PCell in band 17 and SCell in band 4 means that the third harmonic of the UL in band 17 will be located in the DL of band 4, thereby reducing the SCell sensitivity in the

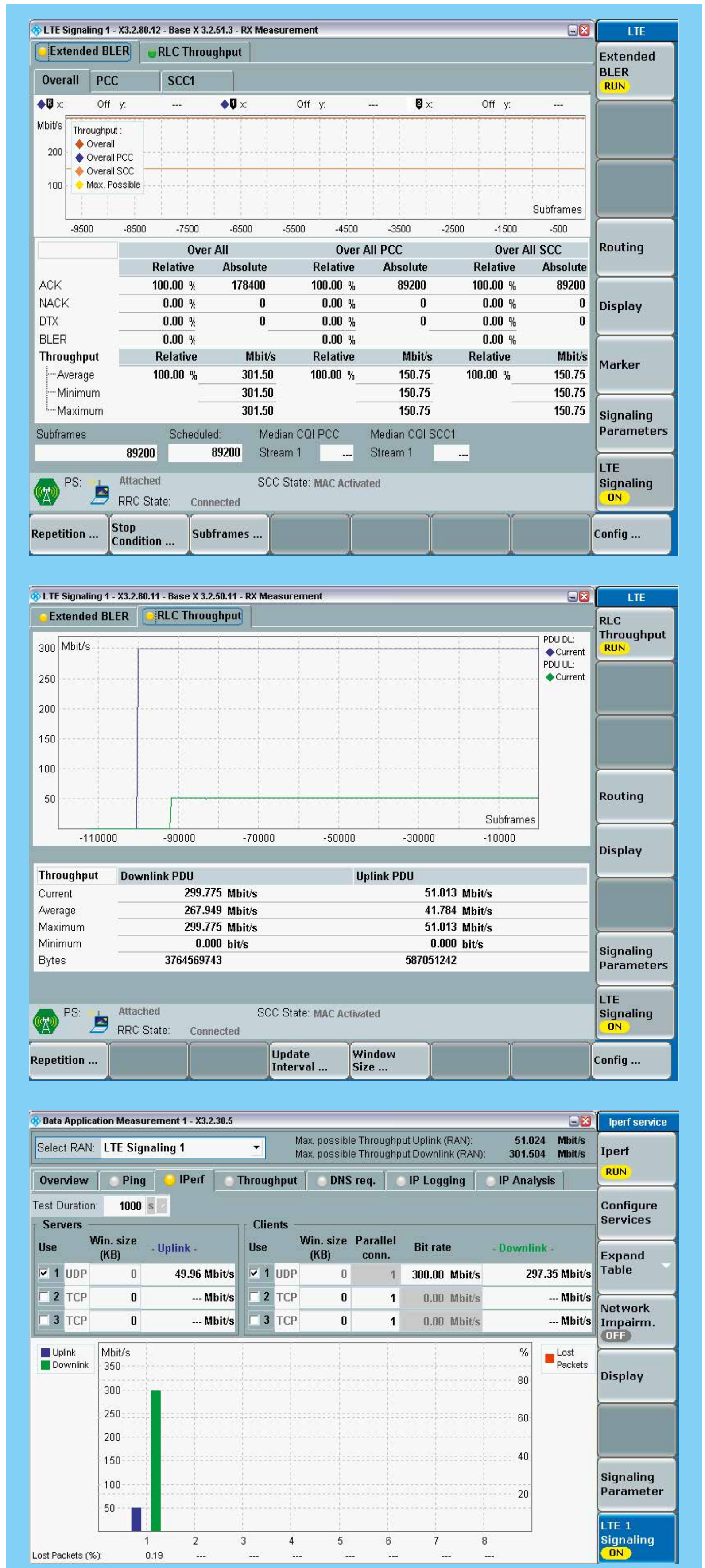


Fig. 5: Peak data rate measurements on Category 6 UE using the R&S®CMW500.

susceptible level limit range. In the opposite situation, with the PCell in band 4 and SCell in band 17, this would not be the case.

These tests are completed quickly and easily by pressing the cell swap button on the R&S®CMW500 to swap the PCell and SCell in the established call. A user can quickly check the sensitivity using the receiver BLER measurement for one band combination, and then immediately afterwards press the cell swap button to determine the sensitivity for the same combination with swapped cells.

Interference from fading

To simulate fading scenarios, 3GPP has defined various fading profiles (pedestrian, vehicular, typical urban, high-speed train, etc.). The fading simulator integrated into the R&S®CMW500 permits these profiles to be applied dynamically to each individual carrier (Fig. 6).

The dynamic scheduling feature is especially beneficial when testing these fading applications. The R&S®CMW500 responds to the channel quality feedback sent by the DUT (CQI / PMI / RI) and adapts the scheduling dynamically. This typically improves data transmission, decreasing the number of failed transmissions per unit of time and increasing the transmission data rate. A histogram with the relevant reports per carrier permits straightforward evaluation of the UE feedback (Fig. 6).

The R&S®CMW500 with its integrated fading simulator and receiver measurement options is an easy-to-use, one-box solution for testing complex scenarios. The R&S®CMW500 works perfectly with the R&S®AMU200A fading simulator and the R&S®SMW200A vector signal generator for performing tests with complex, user-defined fading profiles.

Summary

With its broad range of test options, the R&S®CMW500 callbox is the ideal and cost-effective answer to the complex challenges posed by LTE-A tests. The R&S®CMW500 callbox turns the R&S®CMW500 into a compact one-box solution for LTE-A with proven automation and easy, user-friendly operation. Its dynamic range and flexibility make the callbox the perfect solution for meeting the challenges faced in everyday testing. As a result, the R&S®CMW500 is the number one solution for use in production, service and R&D testing.

Anne Stephan

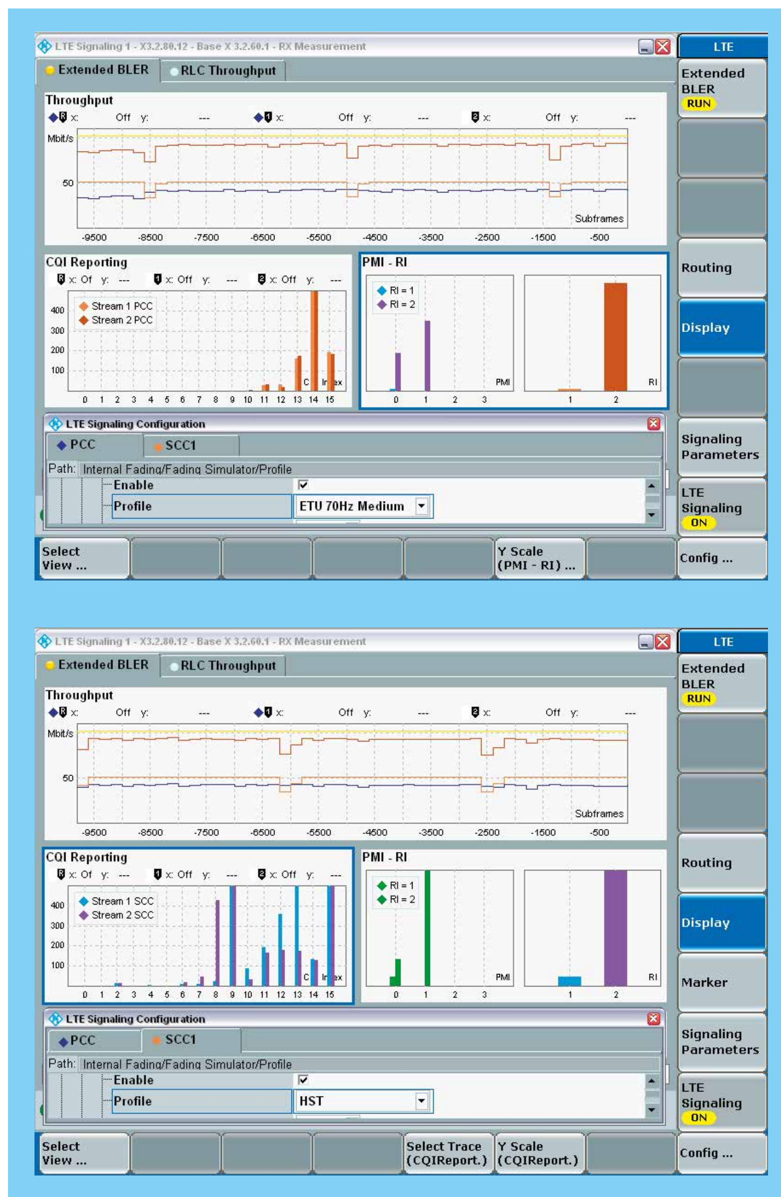


Fig. 6: Fading profiles and CQI / PMI / RI reporting for each carrier.

State-of-the-art testing for all types of radios

Alongside the billions of mobile radio users, there still exists a large community of users of classic radio applications. The new R&S®CMA180 radio test set is specially designed to meet the requirements of these (typically professional) users.

Analog radio and proprietary digital radio – a broad field for professionals

According to an ITU forecast, the number of mobile phones across the world will equal the global population sometime in 2014. However, such dominance on the part of mobile radio is not so apparent from a typical frequency allocation table. Here it becomes obvious that many other radio applications exist besides mobile radio. This includes aeronautical radio, military radiocommunications services, public safety and security (PSS) applications and a wide range of activities in the unlicensed ISM frequency bands. In the case of ordinary voice communications services, analog techniques are typically still used, i.e. the audio signal is directly modulated onto the RF carrier based on amplitude, frequency or phase modulation. Data transmitting systems use proprietary transmission formats, such

Clear, ergonomic touch menus instead of a collection of buttons: With the R&S®CMA180, Rohde & Schwarz has once again set a new standard in state-of-the-art T&M design.

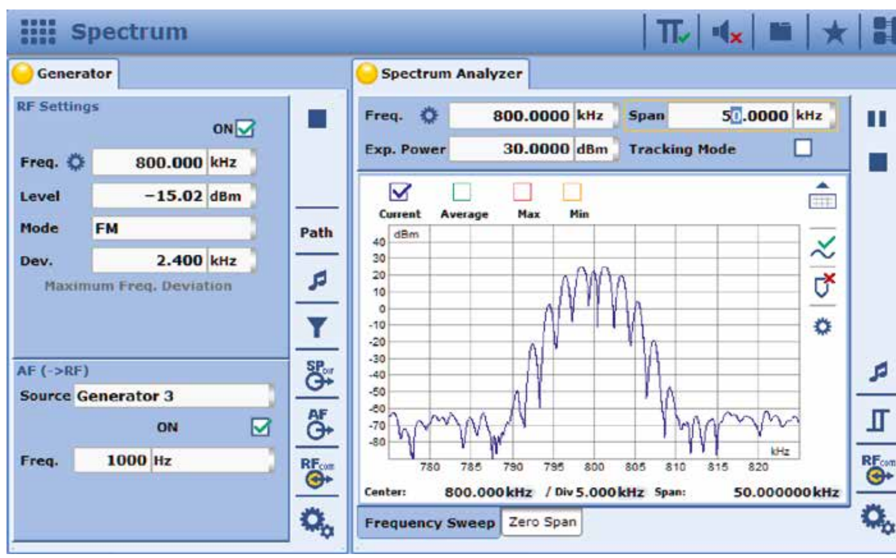
as automotive remote control keys in civil applications and military software defined radio systems. All of these applications require T&M instruments that are able to perform in-depth testing and analysis of these radio components during development, production and servicing. The new R&S®CMA180 from Rohde&Schwarz was specially designed for such applications.

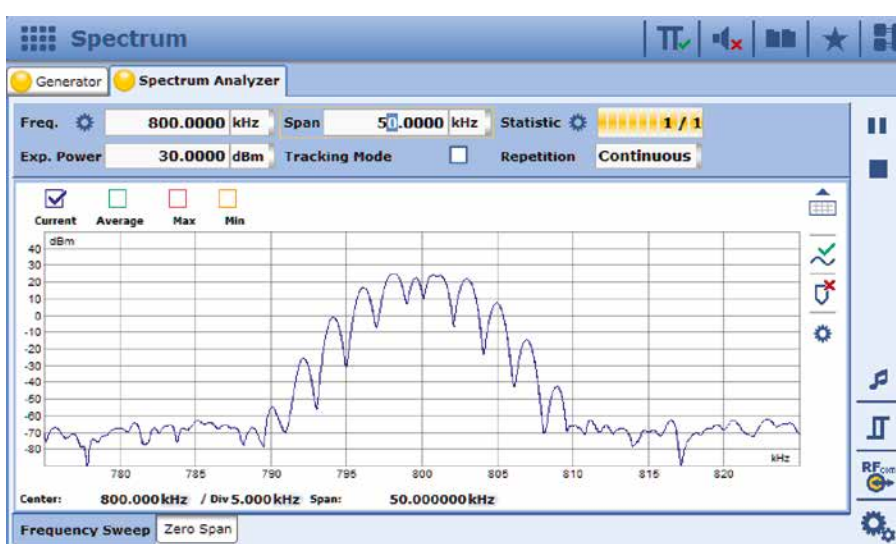
A digital tester looks deep into the analog world

The R&S®CMA180 makes extensive use of digital signal processing and advanced computer technology. The instrument is very easy to use with its large touchscreen while also supporting sophisticated test and measurement. The high level of digitization reduces the number of hardware components, making the instrument more compact and boosting its MTBF.

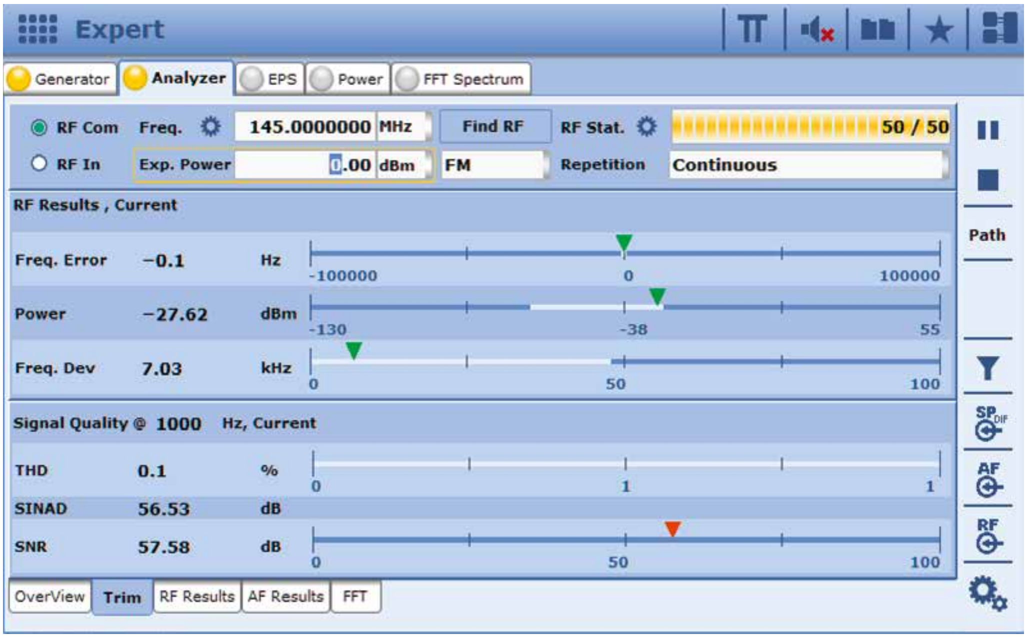
The R&S®CMA180 is a standalone instrument that can perform all relevant measurements without any additional equipment. It demodulates and modulates analog RF signals, making it ideal for testing transmitters and receivers.

For receiver tests, audio signals from the internal generators or from external sources can be modulated onto the RF carrier. The signal demodulated by the device under test (DUT) is fed into the R&S®CMA180 via analog or digital inputs and then analyzed. For transmitter tests, the R&S®CMA180 demodulates the received signal and accurately measures the audio signal and the RF signal. The R&S®CMA180 exactly suits the requirement profile for instruments of this type. However, a closer look immediately reveals some very impressive features. Audio analysis example: The R&S®CMA180 analyzes demodulated signals from radios based on SINAD, THD and SNR as well as signals from any other source that is connected via an analog or digital interface. Internally generated audio signals can be user-configured and output for external applications. Special capabilities of this type also exist at the RF end. For example, two independent RF signals can be generated for receiver measurements and parameterized to introduce intermodulation products into the receive channel. This makes it possible to analyze the receiver's response to interference signals – without requiring an additional generator. For evaluation, the R&S®CMA180 features two spectrum analyzers (FFT and swept), which can also be used in zero span mode to display transients or pulsed signals in the time domain, for example. Just like the audio analyzer, these two spectrum analyzers are also available for general lab applications.





Two alternate views of the same measurement: In split screen mode (top), the generator and analyzer values are displayed simultaneously so the DUT's response to changes in the settings can be tracked without delay. In tab mode, the entire screen is devoted to a single presentation.



The trim view provides an overview of important measurement values and their position within the tolerance windows.

With analog radios, high transmit power is typically required to cover large distances when no repeater network is available to rebroadcast the signals. The R&S®CMA180 handles up to 150 W peak input power and is capable of working with "heavy artillery" if necessary.

Custom signals – with built-in ARB

The built-in ARB generator is ideal for generating complex analog or digital RF signals (including customer-specific RF signals). With a bandwidth of up to 20 MHz and a memory depth of 256 Msample, the R&S®CMA180 can even generate broadband and frequency hopping signals. Signals are saved in I/Q waveform format while tools such as R&S®WinIQSIM2™, MATLAB® and Mathcad® can be used for signal calculations.

Test automation ensures reproducible results and high throughput

The R&S®CMA180 is also ideal for carrying out maintenance work. One challenge for large service centers or organizations involves performing identical test sequences on distributed radio stations using different personnel. R&S®CMArun allows easy implementation of test sequence control. Users can apply predefined test sequences for certain radio types or create custom test sequences. The R&S®CMArun graphical user interface makes it easy to program these test sequences. For each test run, a test report is automatically generated to display the measurement results in tabular or graphical format including limit evaluation (pass / fail). Reports can be stored and statistically evaluated as required. Besides the R&S®CMA180, R&S®CMArun allows integration of the DUT and additional equipment into the test sequence via relays and TTL inputs / outputs. R&S®CMArun is therefore an ideal tool for final testing in radio production.

Ready for the future with optional software for special requirements

Users who have to frequently perform tests on custom-built radio systems typically want good software support that eliminates the need to set up the test instrument for each specific task. The R&S®CMA180 can be easily extended with appropriate software modules. The first options are in preparation and will allow GPS receiver tests and measurements on VOR/ILS radio navigation equipment. The instrument's digital signal processing and impressive specifications provide a solid foundation for additional software solutions – such as testing of SDR radios and digital PSS standards. With the R&S®CMA180, Rohde & Schwarz offers its customers a future-ready instrument that is revolutionizing the testing of radios of every generation, configuration and size.

Gottfried Holzmann; Markus Hendeli; Rainer Winkler

The app version of this article contains a video about the R&S®CMA180.

R&S®SMW200A: two paths up to 20 GHz, fading and AWGN – with just one instrument

Two new options extend the frequency range of the high-end R&S®SMW200A vector signal generator to 12.75 GHz resp. 20 GHz. A single generator can now generate two different modulated signals up to 20 GHz, including fading and AWGN. This opens up a wide range of applications in the areas of A&D, telecommunications, research and education.

The R&S®SMW200A for vector-modulated microwave applications

The R&S®SMW200A vector signal generator (Fig. 1) with two 6 GHz RF paths has been on the market since April 2013. With its characteristics, the R&S®SMW200A easily meets the high measurement requirements associated with modern telecommunications standards. Measurements must take into account real interference in addition to the wanted signals and the interferers specified in the standards. For example, if an "ideal" wanted signal is to be disrupted, the generator can simulate this using fading and additive white Gaussian noise (AWGN). Even complex signals from multiple antenna systems on the transmitter and receiver ends (MIMO modes 2 × 2, 4 × 4, 8 × 2, etc.) can be easily configured and generated in a reproducible manner.

Two new options are now available for applications in even higher frequency ranges. These options extend the upper frequency limits of the generator to 12.75 GHz resp. 20 GHz while maintaining the characteristics and functions listed above. The extended frequency range makes it very easy to perform blocking tests up to 12.75 GHz as specified in many telecommunications standards. Using the 20 GHz frequency option, A&D applications can be run in the X or Ku band. Additional applications become possible when an R&S®SMW200A is equipped with two of the new 20 GHz frequency options. Both RF signals can be phase-coupled for tests on phased array antenna systems. When more than two phase-coherent signals are required, additional R&S®SMW200A generators can be cascaded.

Fig. 1: Two new options extend the upper frequency limits of the R&S®SMW200A to 12.75 GHz resp. 20 GHz, opening up new areas of application.

More often than not, just one R&S®SMW200A suffices

Depending on requirements and the complexity of the application, baseband sources, RF or microwave generators, fading simulators and noise sources are needed for the measurements. Other solutions require several instruments to be connected and synchronized, but thanks to its broad range of functions, a single R&S®SMW200A (Fig. 2) is often all that is needed:

- Extendable to 20 GHz (one or two paths)
- Baseband bandwidth up to 160 MHz (RF)
- External I/Q bandwidth up to 2 GHz (RF)
- Electronic attenuator up to 12.75 GHz
- Fading simulators
- Simulation of higher MIMO modes (2 × 2, 4 × 4, 8 × 2, etc.)
- Touchscreen with block diagram
- Context-sensitive help
- SCPI-based macro recorder*

* The SCPI-based macro recorder and code generator creates executable remote control code based on manual operating steps (for MATLAB®, LabWindows/CVI, etc.).

R&S®SMW200A: feature-rich

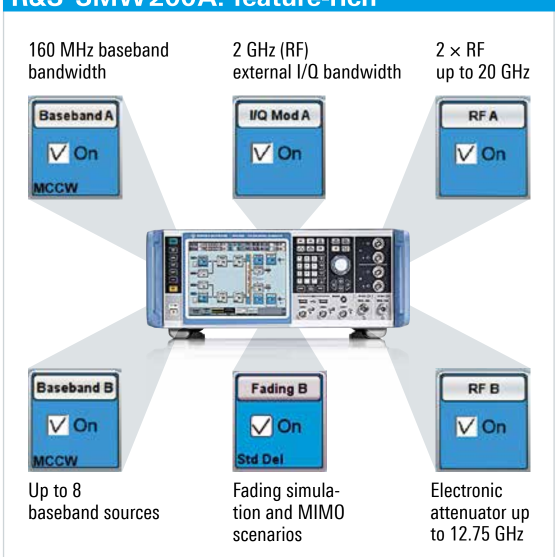


Fig. 2: The most important features of the R&S®SMW200A microwave vector signal generator.

The R&S®SMW200A allows the user to concentrate on the measurement task at hand without wasting time on cabling and calibrating discrete test setups. The following applications illustrate this advantage.

Blocking tests up to 12.75 GHz

Telecommunications standards specify comprehensive conformance tests. One of these is the blocking test which requires a vector-modulated wanted signal as well as a vector-modulated interfering signal or a CW interferer. For LTE tests (Release 11, 3GPP TS 36.141), for example, the wanted signal is around 2 GHz, however the interfering signal can be up to 12.75 GHz (Fig. 3). In discrete test setups, two generators are required for this test. However, only one R&S®SMW200A is necessary because it can be equipped with up to two RF paths.

For these tests, the signal quality is just as important as the multitude of functions. An excellent adjacent channel leakage ratio (ACLR) is vital for a vector-modulated interfering signal whose frequency is close to the wanted signal. Extremely low wideband noise (❶) is required for a CW interferer at 12.75 GHz as shown in the example in Fig. 3. At the same time, the quality of the wanted and interfering signals must also be high (e.g. level accuracy; ❷) and the signal content must be precisely specified. These are signal scenarios where the correct configuration and signal quality will have a decisive impact on the accuracy and reproducibility of measurement results.

Manual configuration of these kinds of signals is time-consuming and prone to errors. The R&S®SMW200A test case wizard makes it easy to

Example: blocking test

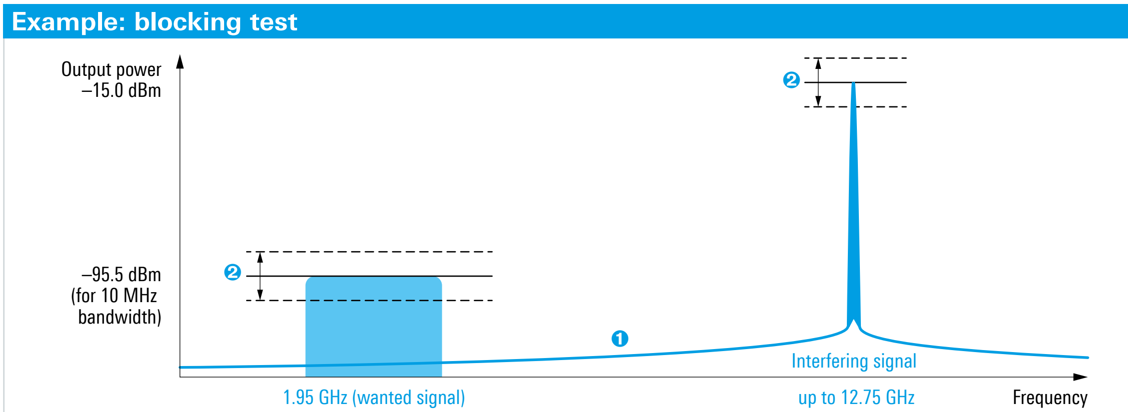


Fig. 3: The low wideband noise (❶) and the high level accuracy (❷) of the R&S®SMW200A yield accurate and reproducible measurement results.

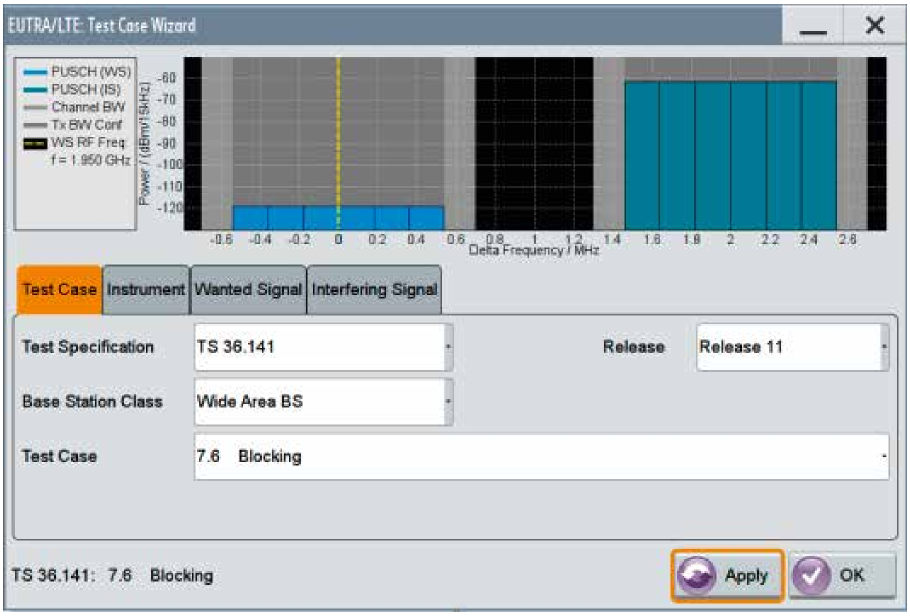


Fig. 4: Complex LTE test scenarios can be configured in seconds using the test case wizard.

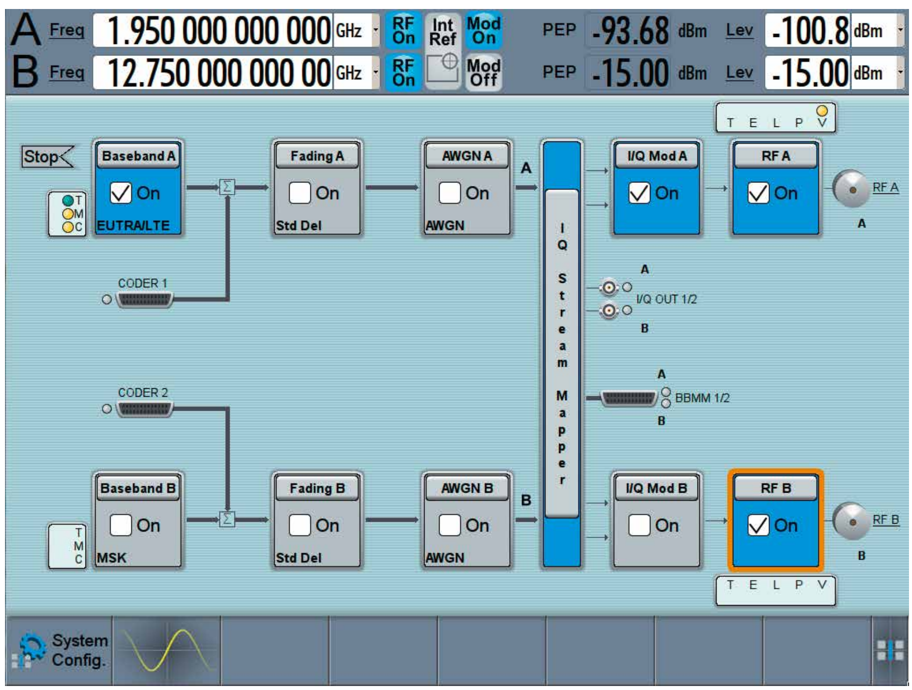


Fig. 5: LTE blocking test in the R&S®SMW200A blocking diagram. In the upper signal path, the LTE wanted signal is generated at 1.95 GHz with a level of –100.8 dBm; in the lower signal path, the CW interferer is generated at 12.75 GHz with a level of –15 dBm.

set up complex test scenarios – practically at the push of a button (Figs. 4 and 5): Simply select the appropriate Release version, press "Apply" and start measuring.

Phase-coherent signals up to 20 GHz

Beamforming applications, i.e. measurements on active antenna systems, require high-quality, phase-coherent test signals. One common reference is usually not sufficient to ensure that the relative phases remain stable over a long period of time. LO coupling, such as offered by the R&S®SMW200A, is required. LO coupling enables extremely precise and long-term stable phase synchronization of both generator paths – internally in a single instrument, without additional cabling. If additional phase-coherent signals are required, the LO signal of the master R&S®SMW200A can be forwarded to slave R&S®SMW200A generators (Fig. 6).

Coupling of local oscillators

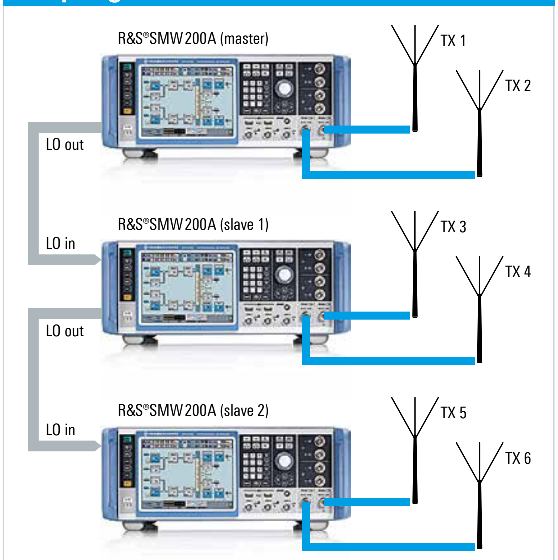


Fig. 6: Phase-coherent coupling of several R&S®SMW200A (six phase-coherent carriers in this example).

Testing direct microwave links up to 20 GHz

One of many applications for direct microwave links (point-to-point communications) is the networking of base stations via the air interface instead of wired connections. One of the frequency bands used for this is the Ku band up to 18 GHz. These connections require high data rates, which are achieved via an appropriately high order of modulation (128QAM and higher) and via wide bandwidths (50 MHz and more).

This obviously places high demands on the signal quality. After all, it is the error vector magnitude (EVM) of the DUT, and not of the signal source, that is to be measured. Due to its outstanding EVM, the R&S®SMW200A is ideal for these types of measurements, even for high orders of modulation and wide bandwidths. For a 10 GHz carrier frequency, the measured EVM is 0.36 % with 128QAM and 0.37 % with 1024QAM (each at 20 MHz bandwidth). This is an outstanding 49 dB for both orders of modulation. The measurements in Fig. 7 show the EVM vs. frequency for a 1024QAM signal.

Summary

2 × 20 GHz, baseband, fading simulation and AWGN: convincing arguments for the R&S®SMW200A, which combines all of these features in a single instrument. The R&S®SMW200A considerably simplifies complex measurements, minimizing the time effort involved and eliminating sources of error. Thanks to its scalability, the R&S®SMW200A can be tailored to the required applications and upgraded when new challenges arise. All this makes the R&S®SMW200A a secure investment and the ideal tool for developing and testing high-end products quickly and efficiently.

Frank-Werner Thümmler

Error vector magnitude (1024QAM)

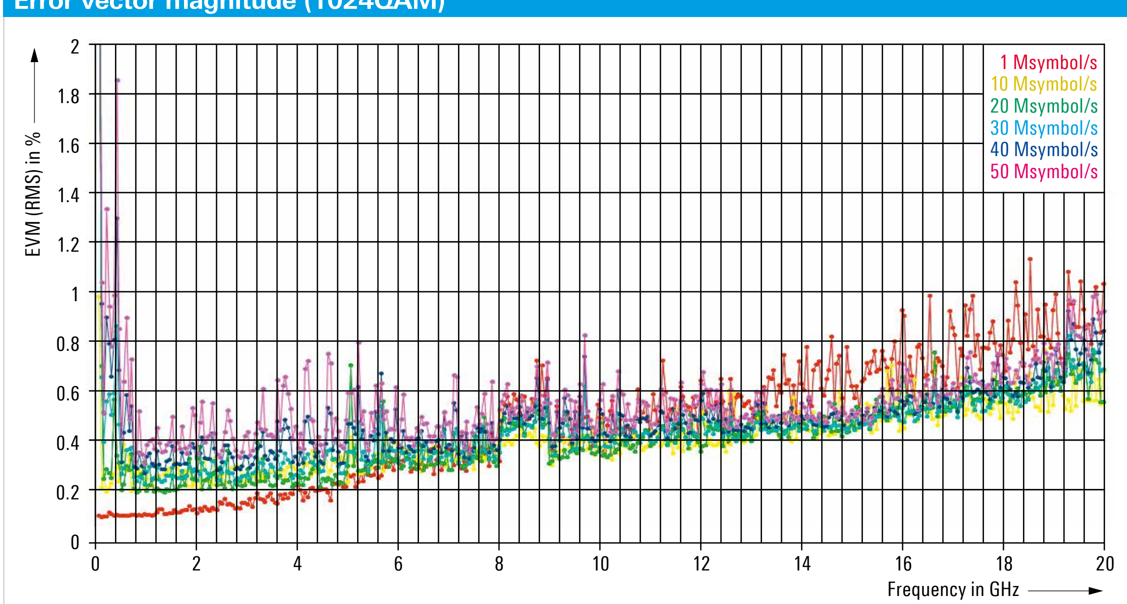


Fig. 7: EVM vs. frequency for various bandwidths, measured on a 1024QAM signal generated by the R&S®SMW200A.

Digital signal analysis at bandwidths up to 500 MHz

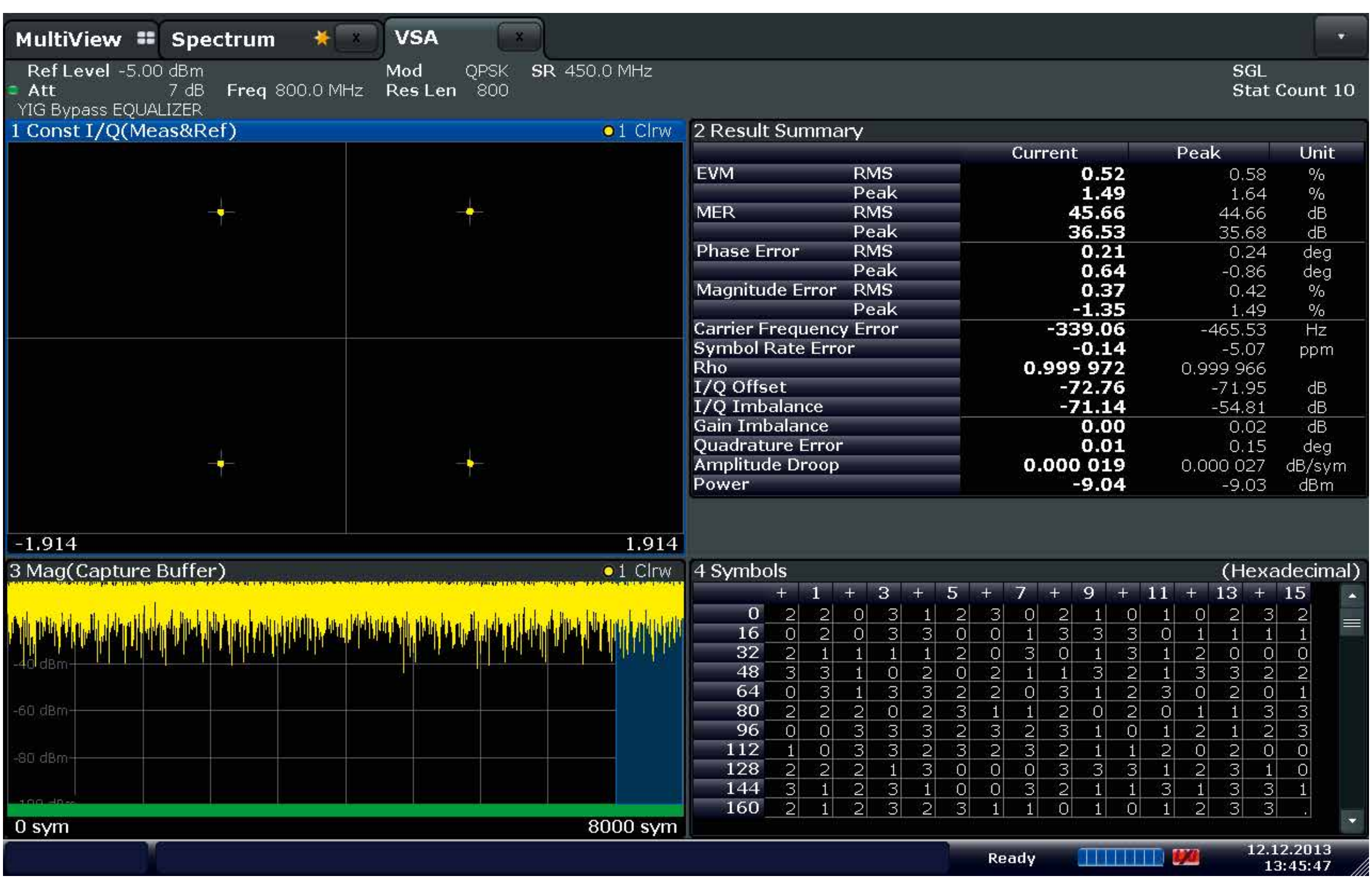
The R&S®FSW signal and spectrum analyzer, equipped with the new R&S®FSW-B500 hardware option, offers analysis bandwidths up to 500 MHz. This innovation benefits users in research and development, for example. It can help them perform challenging measurement tasks associated with radar and satellite applications as well as on the components used for fast, wireless connections, including WLAN or Beyond 4G (5G).

High bandwidths – challenging measurements

The trend in digital wireless communications is toward ever higher data rates. This makes ever larger frequency bandwidths necessary for transmission. In wireless communications, the channel spacing for GSM was 200 kHz, whereas for UMTS it was already 5 MHz. The current LTE standard uses signals up to 20 MHz wide, which can also be bundled. The WLAN standards likewise require ever increasing signal bandwidths – IEEE 802.11ac currently requires up to 160 MHz. The DVB-S bandwidth for communications signals via satellite is around 30 MHz. Signals with a bandwidth of up to 500 MHz are planned in the Ka band for its successor, DVB-S2, under the name “DVB-S2 wideband”. Even wider signals are used in the microwave links that interconnect wireless communications base stations, for example. These signals are modulated in the E band at 71 GHz to 76 GHz with a bandwidth of up to 2 GHz.

The quality of these digitally modulated signals is characterized by parameters such as the error vector magnitude (EVM) and the total power dynamic range. These parameters can only be acquired by demodulating the signals. This requires signal analyzers with an analysis bandwidth that is at least as wide as the signal bandwidth.

Fig. 1: Demodulation of a QPSK-modulated signal with a bandwidth of just under 500 MHz using an R&S®FSW.



Analysis using signal and spectrum analyzers

Analysis of communications signals

Fig. 1 shows an example of the demodulation of a QPSK-modulated signal with an R&S®FSW signal and spectrum analyzer equipped with the R&S®FSW-K70 vector signal analysis option and the R&S®FSW-B500 option. In the table next to the constellation diagram, the analyzer displays the most significant parameters for characterizing the signal quality, including EVM as well as phase and symbol rate errors. The vector signal analysis option makes it possible to demodulate any modulated single carrier up to a bandwidth of 500 MHz and provides numerous other analysis functions, including channel compensation. In this example, the signal is analyzed at a sampling rate of 450 MHz. As a result of the RRC filter with a rolloff factor of 0.1, it has a bandwidth of just under 500 MHz.

The principle behind communications signal analysis using a signal and spectrum analyzer

In order to digitally demodulate signals, the amplitude and phase of the signal must be known. Spectrum analyzers are the instrument of choice for this task. Fig. 2 shows a simplified block diagram of a signal and spectrum analyzer. It receives the broadband signal and converts it to the first intermediate frequency (IF). The signal is then downconverted to a frequency of less than half the sampling rate of the analog-to-digital converter (ADC) and digitized. An FPGA or ASIC digitally processes the signals from the ADC for further analysis.

The first local oscillator sets the center frequency of the frequency range to be acquired. The bandwidth is determined by the sampling rate of the ADC, since according to the Nyquist-Shannon theorem the sampling rate must be at least twice the analysis bandwidth. Therefore an ADC with a sampling rate of more than 1 GHz is required for a 500 MHz analysis bandwidth. The entire signal path must be designed with filter bandwidths of more than 500 MHz.

During subsequent digital signal processing, the signal is first equalized in order to balance out frequency-dependent amplitude or phase changes in the signal path. Equalization takes place on the basis of calibration values that were acquired using a known, wideband reference signal. The analyzer then digitally downconverts the real sample values to the complex baseband. These I/Q samples are now filtered, and the sampling rate is adjusted depending on subsequent analysis tasks. All information within the acquisition cycle and the analysis bandwidth is contained in the I/Q samples. Finally, T&M applications can be used for further investigation and demodulation of the signal.

Basic design of a signal and spectrum analyzer

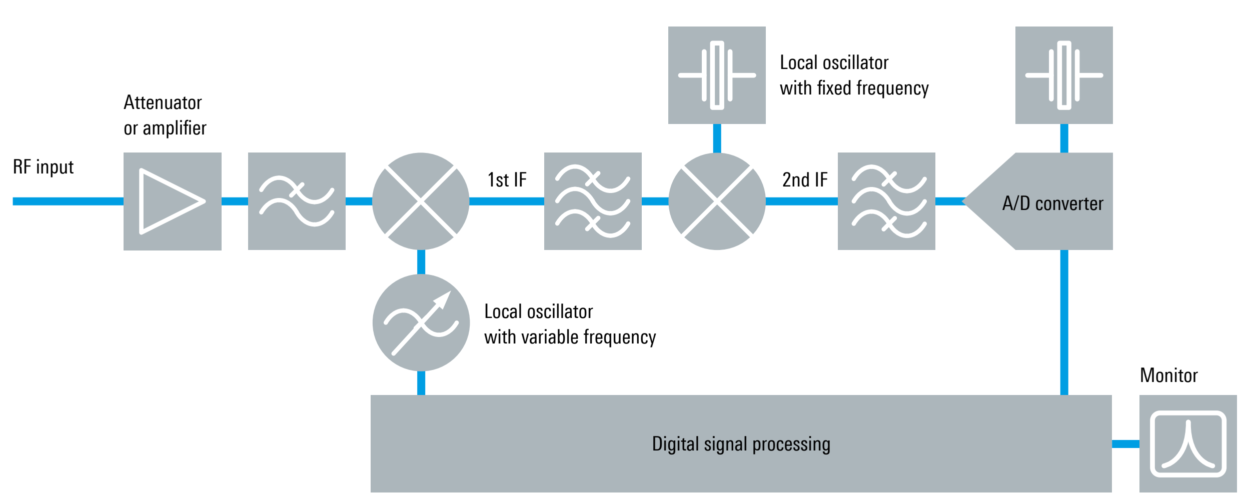


Fig. 2: Simplified block diagram of a signal and spectrum analyzer. Not shown: differing signal paths for the various frequency ranges.

Short pulses require high bandwidth

Ever increasing analysis bandwidths are also needed for analyzing continuous or pulsed signals, such as those used for radar systems. In the case of radar equipment, the signal bandwidth that is used determines the range resolution. This important system parameter specifies what the minimum distance between two objects must be in order for them to be detected as individual objects. The higher the bandwidth of a radar transmission signal, the higher the range resolution.

Pulsed radar equipment often uses different pulse lengths. Pulse compression is frequently used for medium to long distances. Long modulated pulses are transmitted and compressed by matched filters in the receiver. For high range resolution when objects are very close to the radar device, extremely short pulses are required. Pulses of less than 8 ns are required to accurately resolve 1 m.

The time resolution that a signal analyzer needs for determining the pulse rise and fall times of radar equipment or for acquiring extremely short pulses is inversely proportional to the analysis bandwidth. The higher the analysis bandwidth, the more accurately time changes can be determined. Pulses with a pulse width starting at about 8 ns can be measured with an analysis bandwidth of 500 MHz.

Frequency-modulated radar signals

Portable monitoring radars and radar equipment used for driver assistance systems in motor vehicles often use frequency-modulated continuous wave radar. Signal sections in which the frequency changes uniformly are known as chirps. The distance from detected objects and their speed are calculated from the frequency difference between the transmitted and received signals. The range resolution is determined by the bandwidth of the chirps. A range resolution of 30 cm is achieved with a bandwidth of 500 MHz. Fig. 3 shows an example of a linear frequency-modulated continuous wave radar with an up-chirp (section with increasing frequency) and a down-chirp (section with decreasing frequency).

The usable bandwidth depends on which frequency bands the regulatory authorities have assigned to the specific applications. The 24 GHz band that is frequently used by automotive radar allows a bandwidth of 200 MHz. In the 77 GHz band, bandwidths of up to 2 GHz are used. A quality feature of this type of radar system is a constant chirp rate, i.e. the constant frequency change rate within a chirp. In order to measure the chirp rate, the analysis bandwidth of the signal analyzer must be at least the bandwidth of the signal.

Frequency-modulated continuous wave radar

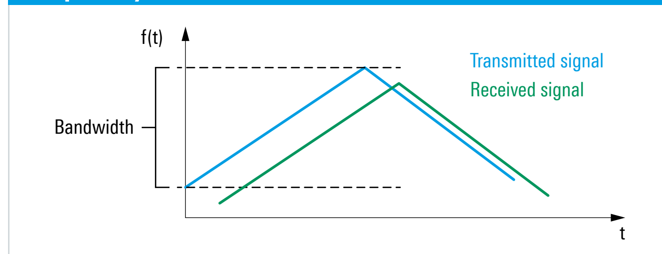


Fig. 3: Linear frequency-modulated continuous wave radar with an up-chirp (section with rising frequency) and a down-chirp (section with falling frequency). The bandwidth determines the range resolution.

Exceptional challenges for communications equipment components as well

RF components in mobile phones, base stations or WLAN equipment must exhibit linear behavior over a very wide frequency range in order to maintain good transmit and receive characteristics. Unwanted nonlinear effects, however, always occur in the upper power range of amplifiers. These degrade the signal quality and cause a higher EVM value along with interference in adjacent channels. The possible consequences are lower modulation depths and therefore slower data rates.

However, if these effects have been characterized, they can be digitally compensated. The signal is digitally predistorted upstream of the amplifier to counteract the distortion of the amplifier. Predistortion and distortion cancel each other out in the amplifier, and a linearly amplified signal is the result. To also detect and correct distortion products of the fifth order, the analysis bandwidth of the spectrum analyzers should ideally be five times as wide as the signal bandwidth.

Summary

The high-end R&S®FSW signal and spectrum analyzer can be used together with the R&S®FSW-B500 500 MHz analysis bandwidth option for all analyzer models up to 67 GHz across the entire spectrum. This opens up new R&D applications for measurements on digital communications equipment components. Even extremely wideband modulated signals up to 500 MHz such as those used in microwave links can be demodulated and comprehensively characterized. Amplifiers with a bandwidth of 160 MHz, which are required for WLAN IEEE 802.11ac, can be digitally predistorted. Radar developers who want to investigate short pulses or wideband chirps will likewise benefit from the high analysis bandwidth.

Martin Schmähling

Fig. 1: The R&S®NRP-Z41 and R&S®NRP-Z61 multipath power sensors.

The world's first multipath power sensors up to 40 GHz and 50 GHz

The new R&S®NRP-Z41 and R&S®NRP-Z61 power sensors are unique in the field of RF power measurement. They are the world's first multipath power sensors that offer upper frequency limits of 40 GHz and 50 GHz. These values are almost twice that of comparable sensors from the competition, which currently reach 26.5 GHz.

Comprehensive portfolio of multipath power sensors

Multipath power sensors from Rohde & Schwarz feature a dynamic range of up to 90 dB, short measurement times and low measurement uncertainty [*]. They can perform precise average value measurements on CW or any wideband modulated signals. Even modulated signals' envelope versus time can be displayed, either directly or by means of average power measurements in defined gates.

As part of the R&S®NRP product family, the R&S®NRP-Z41 and R&S®NRP-Z61 sensors (Fig. 1) share all of the characteristics of this portfolio. They are complete measuring instruments that include a USB port, making it possible to operate them in conjunction with the R&S®NRP base unit, a PC, spectrum and network analyzers or signal generators. Even a smartphone with an appropriate app can be used as a display device. Like all sensors in the R&S®NRP family, the new sensors permit auto-averaging, embedding of upstream components and gamma correction for compensating measurements errors caused by mismatch.

State-of-the-art technology makes it possible

At the heart of the new sensors lies the detector chip (Fig. 2). The integration of the entire detector on a single chip made it possible to increase the upper frequency limit from 33 GHz to

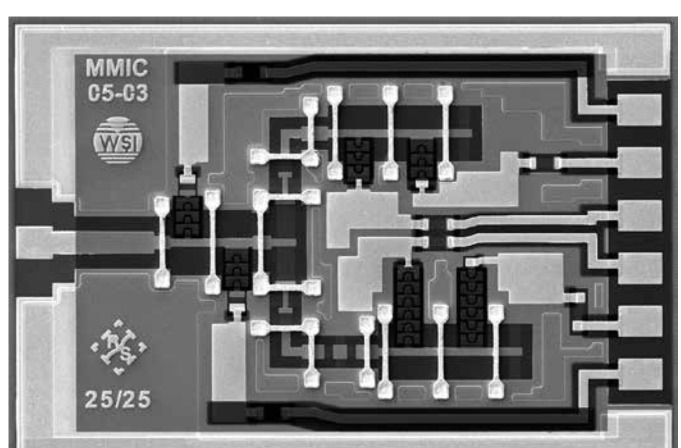


Fig. 2: Scanning electron microscope image of the integrated detector chip (dimensions: 1.5 mm × 1.0 mm).

50 GHz. The detector consists of three measurement paths. The RF or microwave signal from the input end is applied directly to the most sensitive path. The other two measurement paths receive the input signal with varying degrees of attenuation. Each path includes a full-wave rectifier, consisting of a diode stack with a load capacitor. The path attenuations are adjusted so that over the entire level range of –67 dBm to +20 dBm, at least one path is always available for detection of the signal within the square law region of the detector. This ensures that measurement errors resulting from nonlinearities or modulated signals are so small that their effect on the overall measurement uncertainty is negligible.

The detector chip connection with its coplanar structure at the input end is made via a patented, extremely low-reflection microwave transition. A metalized film is used to continuously convert the coaxial field pattern into a coplanar field. A highly advanced coaxial system – also used in other Rohde & Schwarz products up to 110 GHz – is located at the detector input.

In keeping with the thermal power sensors of the R&S®NRP family, the coupling nut on the connector for both new sensors is fitted with ball bearings. This special feature provides several advantages over conventional solutions. For example, it allows very sensitive handling and provides excellent reproducibility of both reflection and power measurements. It establishes a reliable connection without unnecessarily rotating the sensor, thereby reducing wear and tear on the coaxial connector. In addition, a securely tightened connection will not loosen if the sensor is rotated.

Applications

The R&S®NRP-Z41 and -Z61 sensors have characteristics comparable to the R&S®NRP-Z11 / -Z21 and -Z31 sensors, except that they extend the frequency range to 50 GHz. They are ideal for all research, development and production applications that depend on fast measurement speeds, high measurement accuracy and a wide dynamic range. For example, they are ideal for level measurements in microwave systems (carrier frequencies of e.g. 38 GHz or 42 GHz), for radar pulse power measurements or for characterizing broadband amplifiers.

Dr. Werner Perndl

A comparison of sensor technologies

Rohde & Schwarz is the only manufacturer offering three state-of-the-art sensor technologies for the frequency range above 26.5 GHz:

- Thermal power sensors
- Multipath power sensors and
- Wideband power sensors

Average sensors with only one path and the associated limited level range, as well as CW diode sensors, are old technologies and therefore not part of the R&S®NRP family.

Thermal power sensors

- Measurement of average power for any signal
- Reference measurements with very low measurement uncertainty
- Linearity standard for RF and microwave signals
- No errors for any wideband modulated signal
- Harmonics measured according to their power
- No measurement of envelope power (rise time approx. 1 ms)

Multipath power sensors

- Measurement of average power for any wideband modulated signal
- Measurement of envelope power with video bandwidths of less than 100 kHz (rise time approx. 4 µs)
- Fast measurement for even the widest possible dynamic range

Wideband power sensors

- Time-based or statistical analysis, including pulse analysis of wideband signals with video bandwidths of up to 30 MHz (rise time approx. 13 ns)
- Average power measurement for
  - Any wideband signals at levels less than –15 dBm
  - Signals with bandwidths smaller than the video bandwidth for any level

References

* The following article provides a detailed description of the advantages and characteristics of multipath power sensors:
The better choice: USB power sensors from Rohde & Schwarz. NEWS (2013) No. 208, pp. 26 – 29.

R&S®RTE oscilloscopes: ease of use combined with powerful analysis tools

The new R&S®RTE digital oscilloscopes offer fast and reliable solutions for everyday T&M tasks such as general debugging, embedded design development and power electronics analysis. Users benefit from features unusual in this price class, such as 5 Gsample/s per channel and an acquisition rate of one million waveforms per second.

More confidence in measurement results

Digital oscilloscopes can be used for a wide range of applications from simple measurements such as frequency and rise and fall times to complex analyses such as determining the switching loss of a switched-mode power supply. The most important factor for users is that they can rely on the quality of measurement results. That goes without saying for R&S®RTE oscilloscopes (Figs. 1 and 2), which benefit from the company's many years of experience in the development of precision test and measurement equipment. The new oscilloscope series is positioned under the R&S®RTO family in the Rohde & Schwarz oscilloscope portfolio (see box on page 32).

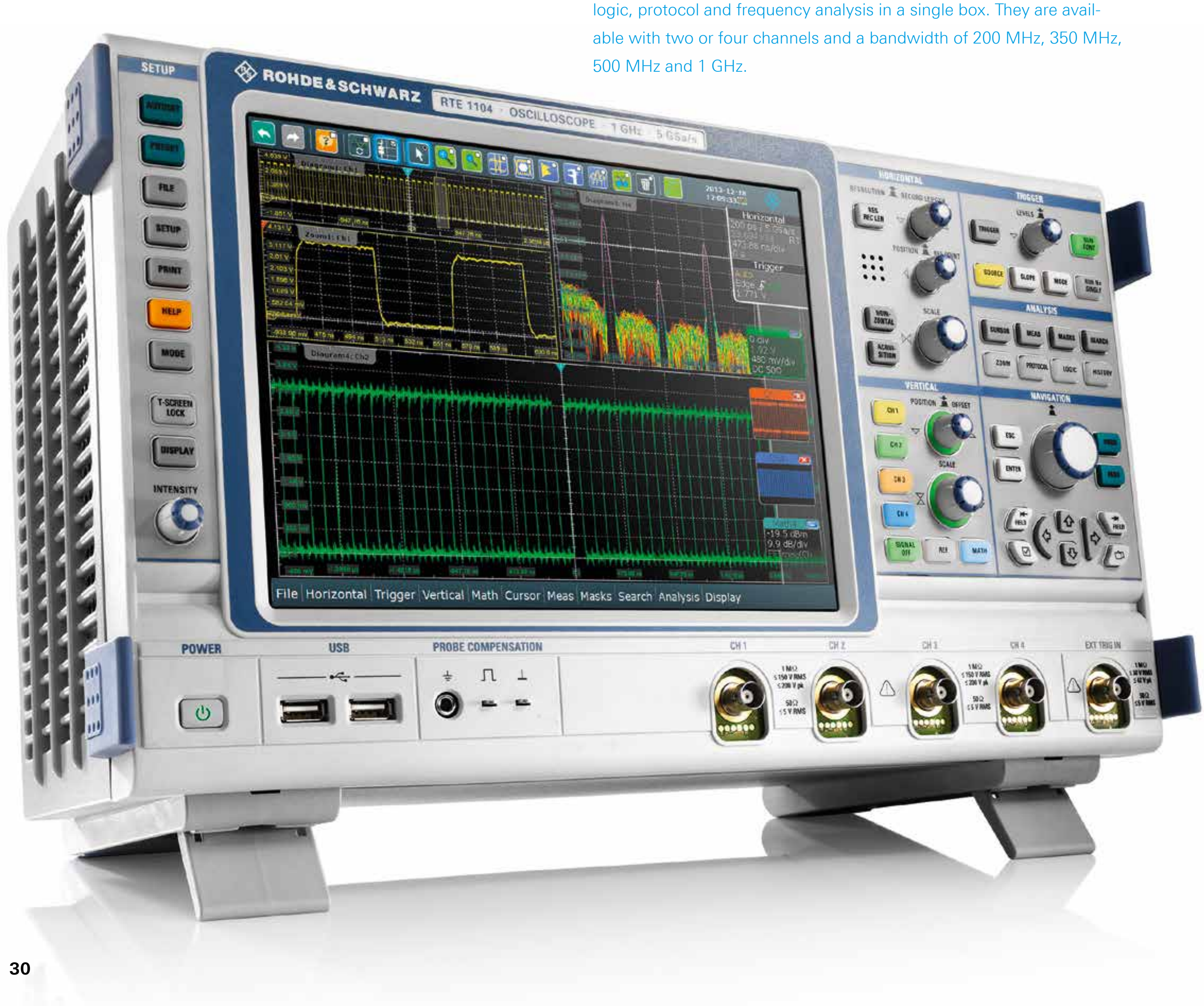


Fig. 1: The multifunctional R&S®RTE oscilloscopes provide time domain, logic, protocol and frequency analysis in a single box. They are available with two or four channels and a bandwidth of 200 MHz, 350 MHz, 500 MHz and 1 GHz.

The R&S®RTE at a glance	
Bandwidth	200 MHz, 350 MHz, 500 MHz, 1 GHz (upgradeable)
Analog channels	2 / 4 channels
Sample rate	5 Gsample/s per channel
Memory depth	10 Msample per channel (optionally 50 Msample)
Acquisition rate	> 1 000 000 waveforms/s
ENOB (ADC)	> 7
R&S®RTE-B1 mixed signal option	16 digital channels, 5 Gsample/s and 100 Msample per channel
Color display (touchscreen)	10.4", 1024 × 768 pixel

Fig. 2: Key features of the R&S®RTE oscilloscopes.

The more details an oscilloscope can show, the higher the probability that the user will be able to analyze signal faults or important events. As a prerequisite, the oscilloscope must have a high time resolution that is based on the sampling rate. In addition, many applications also require long record lengths, for instance for analyzing the data content of serial protocols. In order to maintain a high sampling rate even for long signal sequences, the oscilloscope requires a deep memory. The R&S®RTE offers a powerful combination of sampling rate and memory depth. A sampling rate of 5 Gsample/s at a memory depth of 10 Msample is available per channel (can be optionally expanded to 50 Msample per channel).

The less often signal faults occur, the longer it can take to detect them. This makes a high acquisition rate critical. The core of the R&S®RTE is an ASIC that was especially designed for parallel processing. As a result, the R&S®RTE can acquire, analyze and display more than one million waveforms per second without a special acquisition mode (Fig. 3). The high acquisition rate makes it possible to find signal faults faster and more reliably, effectively shortening debugging time.

The highly accurate digital trigger system is another factor ensuring precise results. This unique system determines when a trigger condition is met by directly analyzing the digitized signal with 500 fs resolution independently of the current sampling rate. The result is very low trigger jitter (< 1 ps RMS) and high measurement accuracy. Thanks to the digital trigger system, the trigger hysteresis can be adjusted to the signal quality. This ensures, for example, stable triggering even on extremely noisy signals.

The single-core A/D converter with more than seven effective bits (ENOB) almost completely eliminates signal distortion. The input sensitivity of 1 mV/div without any bandwidth limitations ensures that low-amplitude signals can also be measured with a high degree of accuracy.

More functions and faster results

The R&S®RTE oscilloscopes include many integrated measurement tools for detailed signal analysis. They range from simple cursor functions to mask tests to complex mathematical operations. Many measurement functions such as histograms, spectrum display and mask tests are hardware-implemented. This makes the oscilloscope very responsive and ensures high acquisition rates, so that statistically conclusive measurement results are available fast.

The app version of this article contains a video about the R&S®RTE.

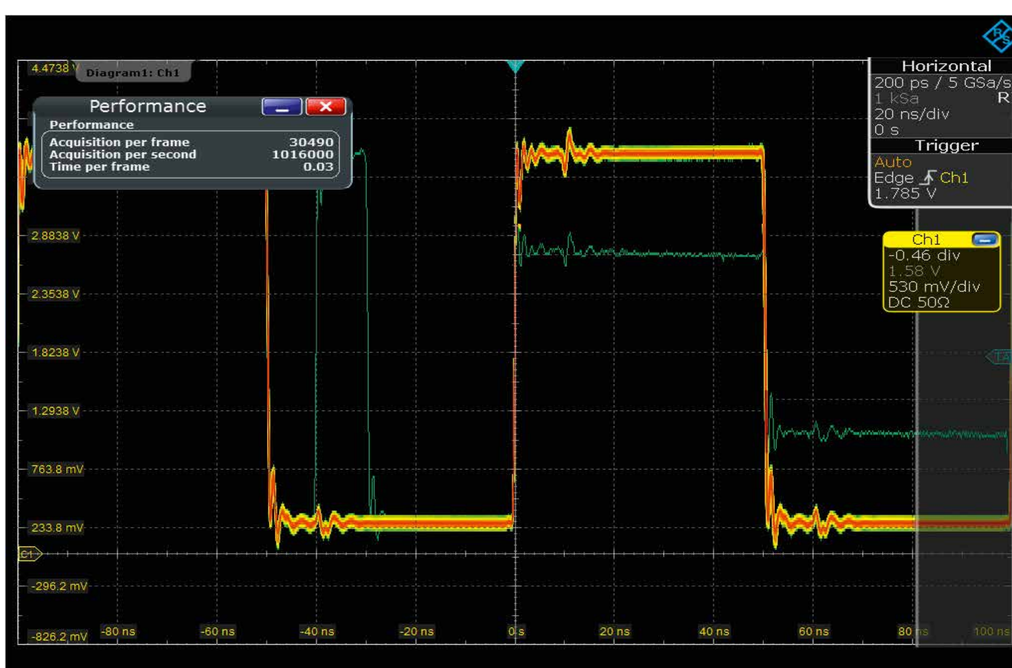


Fig. 3: The R&S®RTE oscilloscopes find rare signal faults very quickly thanks to their high acquisition rate of one million waveforms per second.

In addition to the automatic measurements that are customary for digital oscilloscopes, the R&S®RTE offers the QuickMeas function, which is unique for an instrument in this class. QuickMeas simultaneously displays the results of several measurement functions (Fig. 4), which users select according to their needs. A toolbar at the upper edge of the screen provides fast access to all R&S®RTE tools.

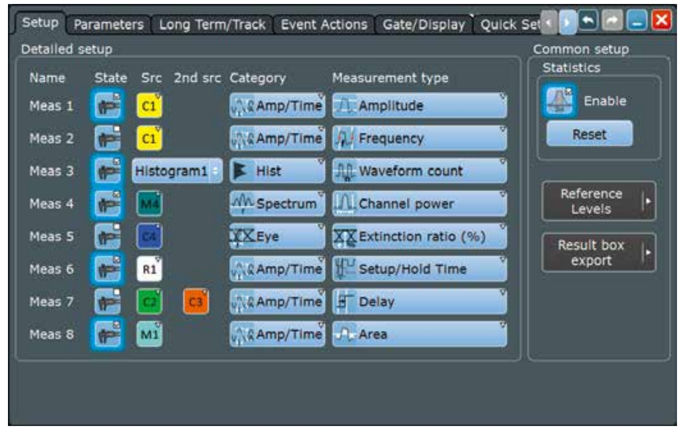


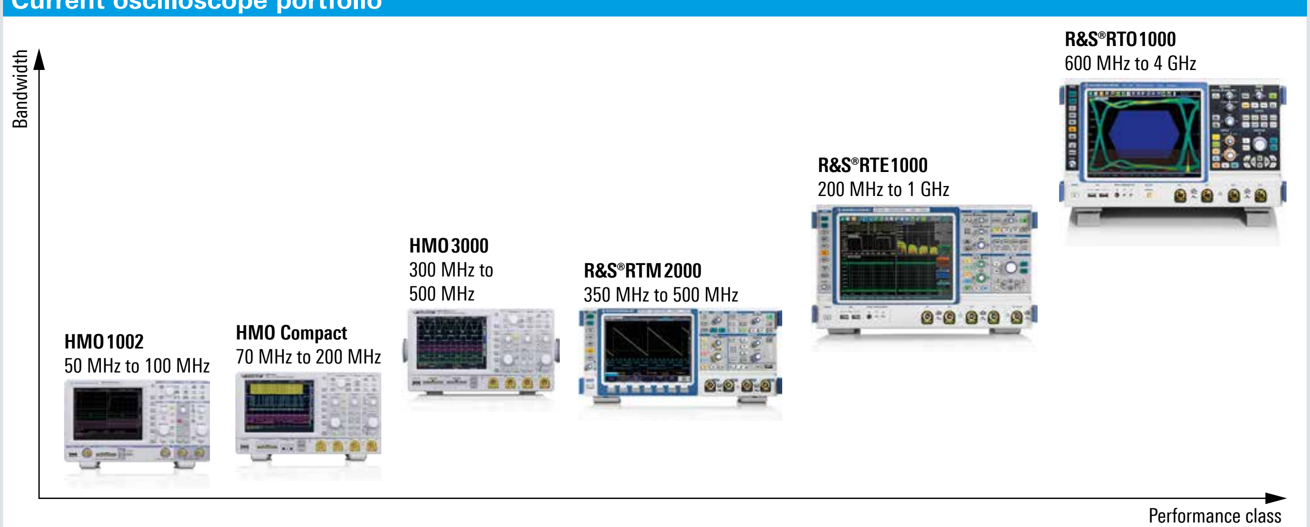
Fig. 4: In the R&S®RTE oscilloscopes, up to eight automatic measurements can be configured and activated simultaneously.

Mask tests reveal whether a specific signal lies within defined tolerance limits and use statistical pass/fail evaluation to assess the quality and stability of a device under test. Mask creation in the R&S®RTE is simply a matter of pressing a few buttons. The high acquisition rate ensures that mask violations are detected rapidly and reliably. Signal anomalies and unexpected results are easy to identify by stopping the measurement if the mask is violated.

Where does the interference pulse in the signal come from? What caused the loss of a data bit? The real cause of a problem can often only be found by looking at the history of a signal sequence. The R&S®RTE history function always provides access to previously acquired waveforms. This enables users to later analyze in detail the measurement data stored in memory.

The FFT function of the R&S®RTE makes spectral analysis easy (Fig. 5). The high acquisition and postprocessing rate conveys the impression of a live spectrum, and operation is as simple as entering the center frequency, span and resolution bandwidth. Using the persistence mode, rapid signal changes, sporadic signal interference and weak superimposed signals can easily be made visible. The ability to overlap FFT frames enables the R&S®RTE to also detect intermittent signals such as pulsed interferers. This powerful FFT function plus the high dynamic range and input sensitivity of up to 1 mV/div make the oscilloscopes ideal for tasks such as EMI debugging of electronic circuits during product development (see page 38).

Current oscilloscope portfolio



The Rohde & Schwarz oscilloscope portfolio ranges from cost-effective models for training, service and simple lab applications to high-end measuring instruments for development applications with high demand on bandwidth and performance.

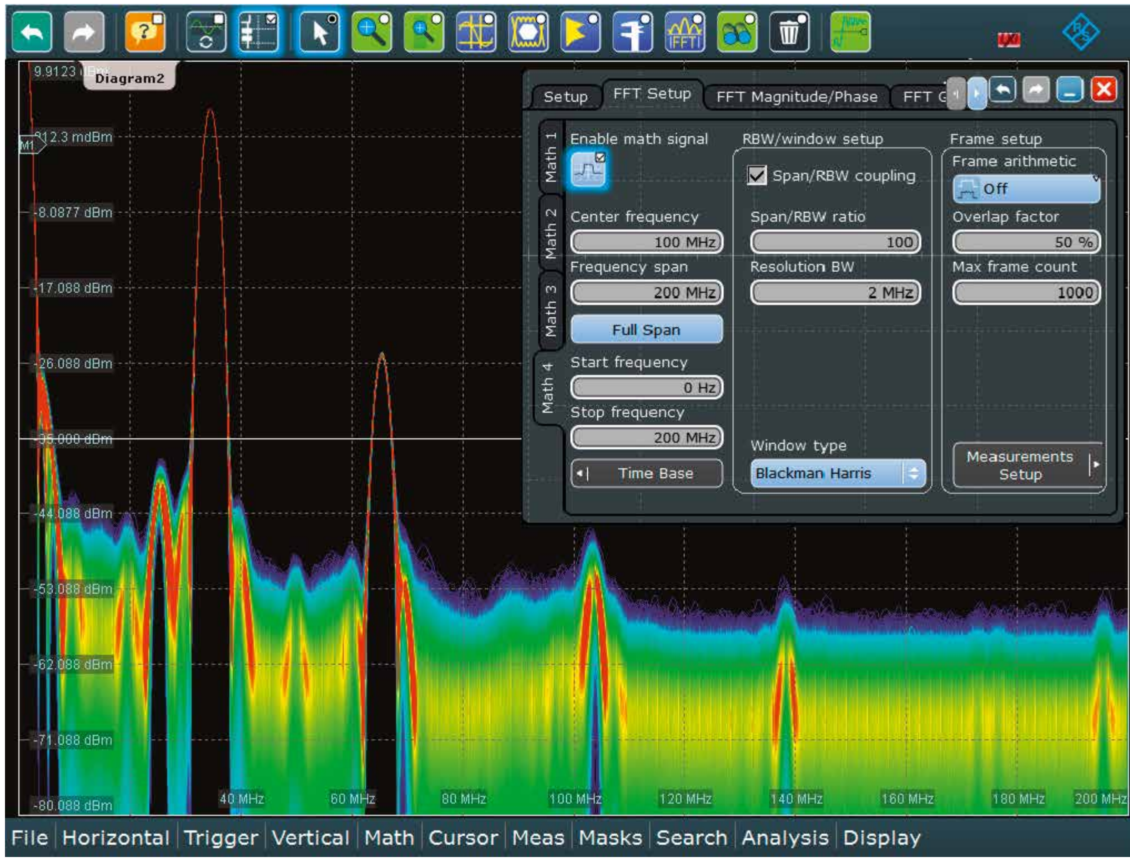


Fig. 5: The R&S®RTE FFT function offers accuracy, speed, functionality and ease of use.

More fun to use

Thanks to the high-resolution 10.4" XGA touchscreen, users can intuitively perform their daily T&M tasks. For example, users can simply drag & drop waveforms to arrange them on the screen, and they can flexibly organize the screen according to their requirements by dividing it into several diagrams. Realtime miniature views of the signals on the edge of the screen allow users to always see what is happening. The R&S®RTE controls are color-coded and indicate which channel is currently active. The color coding corresponds to the signal display on the screen. Dialog boxes are opened as semi-transparent overlays over the active waveforms, which maintain their full size. Users can adjust the transparency of dialog boxes as required. Signal flow diagrams and forward and back buttons in the dialog boxes simplify navigation. The configurable toolbar provides fast access to frequently used functions. Users simply select a tool and apply it to their waveform. Tools with related functions are grouped together. In addition to the standard tool suite, the R&S®RTE features many highlights such as fingertip zoom, which allows users to quickly view signal details by moving their finger or mouse along the signal. Another example is the SaveSet tool, which enables users to quickly load different configurations. To select the right configuration, the user simply swipes a screenshot.

Broad range of dedicated application solutions

In addition to the standard functionality, the R&S®RTE oscilloscopes offer various optional application solutions, including trigger and decoding options for serial buses (such as I²C, SPI and CAN) and a power analysis option. The logic analysis capability offered by the R&S®RTE is essential for analyzing digital components of embedded designs. The R&S®RTE-B1 mixed signal option can be added to any base unit and offers 16 additional digital channels with a sampling rate of 5 Gsample/s and a memory depth of 100 Msample per channel. It is possible to decode up to four serial or parallel buses simultaneously.

A comprehensive portfolio of high-quality active and passive probes is available for the R&S®RTE to perform measurements in common voltage and current ranges. One of the highlights of the active probes from Rohde&Schwarz is a micro button on the probe tip. This button can be used to perform a variety of functions such as run / stop, autoset and adjust offset on the oscilloscope. The highly precise R&S®ProbeMeter DC voltmeter (measurement error: ±0.1 %) is integrated into the active probe and provides a convenient means of answering questions such as “Is the supply voltage correct?” and “Is DC voltage superimposed?”

Sylvia Reitz

Ethernet compliance testing with the R&S®RTO oscilloscope

In industry, IT and the private sector, it is difficult to imagine a world without Ethernet data exchange. An automated test solution that supports compliance tests on Ethernet interfaces is now available for the R&S®RTO digital oscilloscopes. A test wizard guides the user through the measurements to deliver precise measurement results.

Ethernet originated in the world of computer networking but is now well-established as the communications interface for countless electronic devices and systems. For example, this standard is used in the automotive industry to control robots in production systems. Developers must ensure the interoperability of Ethernet interfaces. The necessary tests must be determined along with acceptance criteria and how to quickly detect any possible design flaws. Ethernet compliance tests allow comprehensive verification of interfaces based on standardized test sequences, thereby providing support to hardware developers as they work to debug and release their designs.

Fig. 1: Ethernet compliance testing with the R&S®RTO: Just load the test software, connect the test fixture set and follow the test wizard through the configuration process for the tests.

	10BaseT	100BaseTX	1000BaseT	10GBaseT
Standard	IEEE 802.3 clause 14	IEEE 802.3 clause 25	IEEE 802.3 clause 40	IEEE 802.3an
Coding	Manchester coding, unidirectional, 2 twisted pairs	4B5B, MLT-3, unidirectional, 2 twisted pairs	8B10B, PAM-5, bidirectional, 4 twisted pairs	128-DSQ, PAM-16, bidirectional, 4 twisted pairs
Signal levels	Manchester level change	3 levels	5 levels	16 levels
Transmission bandwidth	10 MHz	32.5 MHz	62.5 MHz	500 MHz

Fig. 2: Protocol characteristics of various Ethernet standards.

Standardized Ethernet compliance tests

Ethernet was developed in the 1970s by Robert Metcalfe for use as a communications protocol. Beginning in 1980, Ethernet was standardized by the IEEE 802 working group and then continually developed. 10BaseT, 100BaseTX and 1000BaseT are the most popular electrical Ethernet standards (Fig. 2). For switches and servers, interfaces with 10GBaseT Ethernet are also being developed to allow higher data throughput. All of these interfaces use two or four twisted pairs typically with RJ-45 connectors.

The Ethernet standard with the lowest data rate (10BaseT) is based on a signal with Manchester coding. The other standards considered here with higher data rates use more complex coding schemes for data transmission along with up to 16 electrical signal levels.

IEEE has specified compliance tests for the electrical characteristics of Ethernet interfaces. The documentation describes comprehensive tests of transmitter signal quality and some tests of receiver signal quality. The specification defines test setups, test sequences and special test modes. The user is expected to manually activate the test modes when performing the compliance tests, e.g. by setting the appropriate register entries. Details can be found in the documentation for the Ethernet chip that is used. Fig. 3 shows an example of test mode 1 for the 100BaseT transmitter test used to measure the quality of the 1000BaseT signal (peak voltage, maximum droop, differential output template).

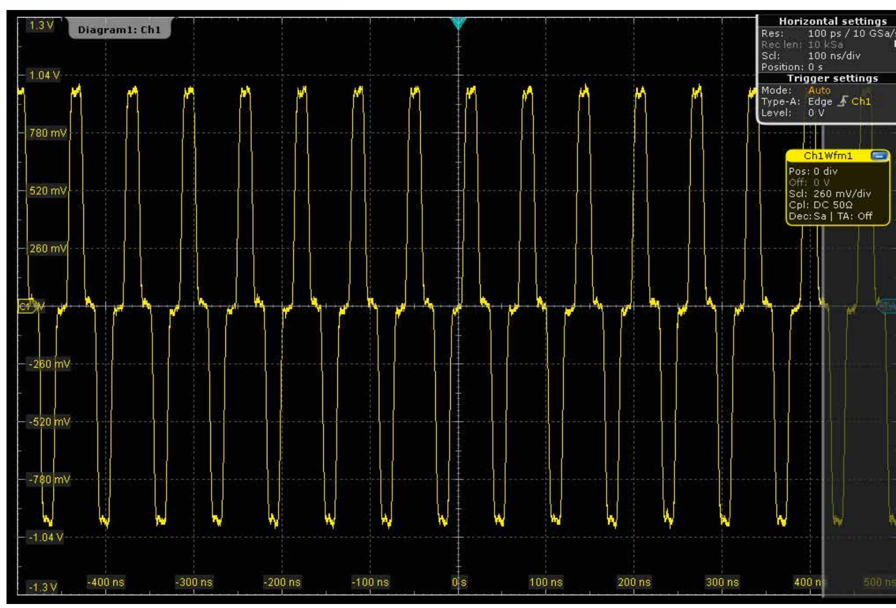
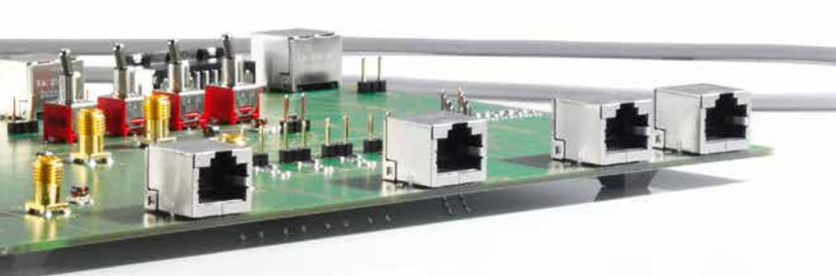


Fig. 3: Signal acquired by oscilloscope from Ethernet chip in mode for 100BaseTX tests for peak-to-peak jitter measurements.

The University of New Hampshire InterOperability Laboratory (UNH-IOL) is industry-recognized worldwide for Ethernet compliance testing. For this reason, Rohde & Schwarz requested the UNH-IOL to validate the R&S®RTO oscilloscope and R&S®ScopeSuite software for compliance testing in line with the 10BaseT, 100BaseTX and 1000BaseT Ethernet standards. The UNH-IOL confirmed that "the R&S®RTO oscilloscope and R&S®ScopeSuite correlate with the UNH-IOL's time tested techniques and methodologies."



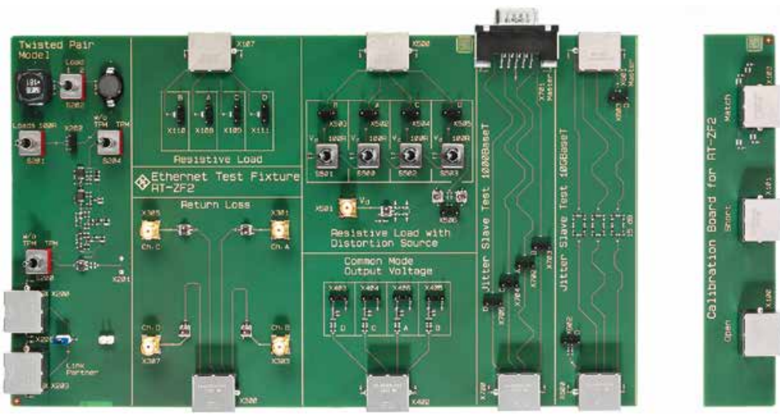


Fig. 4: R&S®RT-ZF2 Ethernet test fixture set for 10BaseT, 100BaseTX, 1000BaseT and 10GBaseT Ethernet compliance tests.

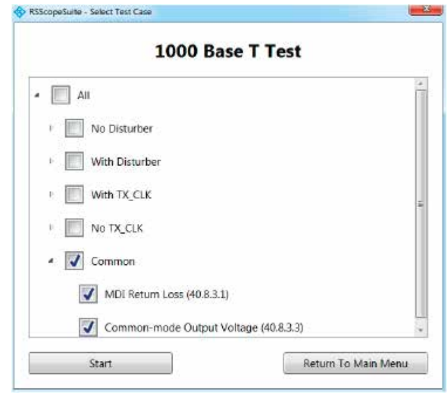


Fig. 6: Test selection for 1000BaseT Ethernet compliance testing.

Complete test equipment for Ethernet compliance tests

Developers need to perform Ethernet compliance tests on components or devices as part of basic R&D or when debugging their designs during integration. For analysis and verification applications, Rohde & Schwarz offers a complete solution based on the R&S®RTO oscilloscopes (Fig. 1) as well as appropriate software options and test accessories:

- R&S®RTO-K22: Ethernet compliance test software for 10BaseT, 100BaseTX and 1000BaseT
- R&S®RTO-K23: Ethernet compliance test software for 10GBaseT
- R&S®RT-ZF2: Ethernet test fixture set for 10 / 100 / 1000BaseT and 10GBaseT
- R&S®RT-ZF2C: 1000BaseT jitter test cable

Ethernet compliance tests are very demanding on the oscilloscope. During transmitter distortion tests, for example, the transmitter signal distortion must not exceed a value of 10 mV even with an unwanted signal of 5.4 V (V_{pp}) and 20.833 MHz The outstanding dynamic range provided by the R&S®RTO oscilloscopes ensures exact results in this critical test.

The R&S®RT-ZF2 test fixture set (Fig. 4) is equipped with all interfaces from 10BaseT to 10GBaseT, making it simple to connect the oscilloscope probes to the DUT signal lines. Fig. 5 shows the test equipment required for compliance tests in line with the applicable Ethernet standards.

Fast results with the R&S®ScopeSuite test software

When putting new hardware designs into operation, developers tend to be under significant time pressure, making it important to perform the relevant tests as quickly as possible. Easy-to-operate test software such as R&S®ScopeSuite with its high level of automation can make a huge difference. The integrated test wizard guides the user through the test setup, automatically configuring the oscilloscope as well as the connected signal generator and spectrum or network analyzer. Depending on the user's preference, R&S®ScopeSuite can be installed on a separate PC or on the oscilloscope itself. For operation on the

Test equipment	10 / 100 / 1000BaseT	10GBaseT
Oscilloscope	10 / 100BaseT: at least R&S®RTO1002, 1000BaseT: at least R&S®RTO1012	at least R&S®RTO1022
R&S®ScopeSuite software	R&S®RTO-K22 Ethernet compliance test	R&S®RTO-K23 10G Ethernet compliance test
Test fixture	R&S®RT-ZF2 Ethernet test fixture set	R&S®RT-ZF2 Ethernet test fixture set
Probes	10 / 100BaseT: 1 differential probe, at least R&S®RT-ZD10 1000BaseT: 2 differential probes, at least R&S®RT-ZD10	1 differential probe, at least R&S®RT-ZD30
Recommended extras	1000BaseT: – R&S®RT-ZF2C jitter test cable – HAMEG HMF2550 or Tabor WX2182B function generator for 1000BaseT signal distortion tests – R&S®ZVL vector network analyzer for return loss measurements	– spectrum analyzer for transmitter linearity measurements with start frequency < 1 MHz (e.g. R&S®FSL3) – vector network analyzer for return loss measurements with start frequency < 1 MHz (e.g. R&S®ZVL3)

Fig. 5: Test equipment required for Ethernet compliance tests.

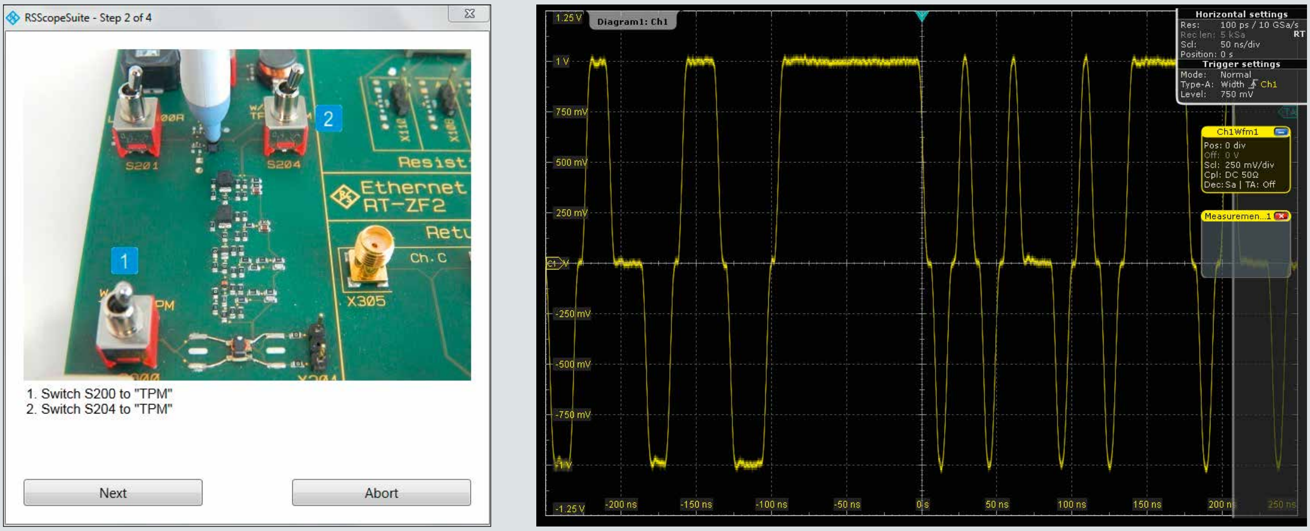


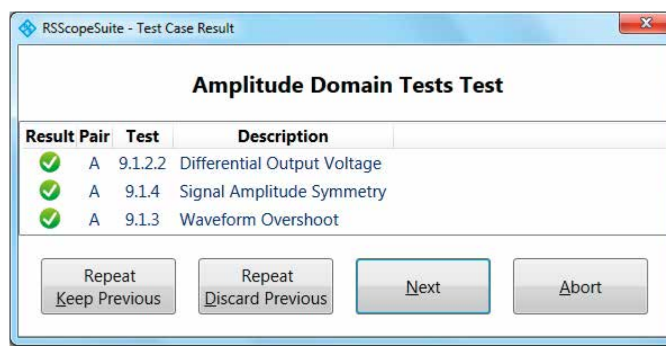
Fig. 7: Instructions for an Ethernet compliance test case. The configuration on the test fixture is explained on the left while the signal acquired by the oscilloscope from the Ethernet chip in the configured test mode is visible on the right.

R&S®RTO oscilloscope, it is convenient to use an additional monitor where R&S®ScopeSuite can be controlled with a mouse while the oscilloscope screen simultaneously displays waveforms and results.

R&S®ScopeSuite includes all of the established test cases for the different Ethernet standards. Individual tests or complete test groups can be selected (Fig. 6). After the software has been launched, it automatically configures the R&S®RTO. Then, the test wizard conveniently guides the user through the configuration steps using graphics (Fig. 7).

Once all the steps are complete, the measurements are executed automatically. R&S®ScopeSuite shows the test results with a traffic light display to provide a fast overview (Fig. 8). Here too, the flexibility of the R&S®ScopeSuite software is apparent: For example, a test can be repeated at the push of a button if signal errors occur. Upon completion of the measurements, the user can compile the relevant results into a test report to obtain clear, complete documentation with figures and tables (Fig. 9).

Fig. 8: Test result with traffic light display and option to repeat test.

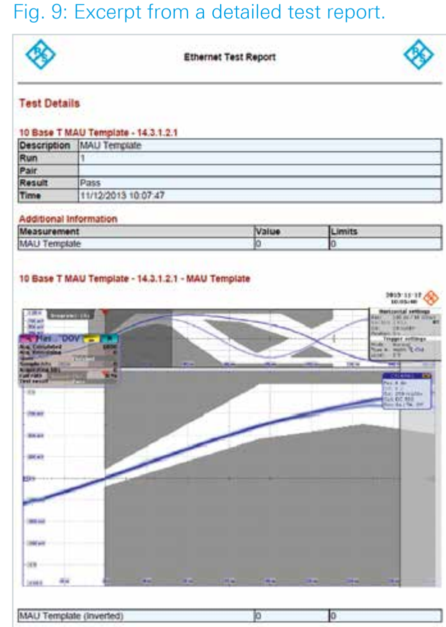


Summary

Based on the R&S®RTO oscilloscope, the R&S®RT-ZF2 test fixture set and the options R&S®RTO-K22 for 10 / 100 / 1000BaseT and R&S®RTO-K23 for 10GBaseT, Rohde & Schwarz is now offering a complete solution for compliance testing of the most popular Ethernet protocols. The outstanding dynamic range and the low-noise frontends of the R&S®RTO ensure accurate results even in the critical transmitter distortion tests. The complete solution works quickly to deliver precise results that can be fully documented to meet the user's requirements.

Ernst Flemming

Fig. 9: Excerpt from a detailed test report.



Fast and efficient EMI debugging with oscilloscopes

Due to their high sensitivity and dynamic range combined with powerful FFT capabilities, the R&S®RTO and R&S®RTE oscilloscopes are ideal for EMI debugging. Electromagnetic interference from electronic circuits and boards can be detected and analyzed with high speed and accuracy.

Fig. 1: The R&S®RTO and the new R&S®RTE (see photo) digital oscilloscopes are powerful tools for EMI debugging due to their low-noise frontend and easy-to-use FFT functionality.

FFT analysis with intuitive control like in a spectrum analyzer

The FFT function is the key feature to EMI debugging with oscilloscopes. Conventional FFT implementations in oscilloscopes are inconvenient to use because the displayed frequency span and the resolution bandwidth are controlled by the time domain settings. This makes it difficult to navigate in the frequency domain and slows down signal analysis in the spectrum.

In the R&S®RTO and R&S®RTE, Rohde & Schwarz has developed an intuitive approach in which the FFT function is controlled in a similar way as in a spectrum analyzer. Typical parameters such as the start and stop frequency and the resolution bandwidth can be set directly (Fig. 2). The oscilloscope automatically makes the relevant time domain settings using its powerful signal processing capabilities and deep acquisition memory. This allows users to easily analyze EMI in the time and in the frequency domain, which greatly speeds up the process of identifying EMI sources.

EMI debugging using advanced oscilloscopes

In the past, oscilloscopes were hardly the right choice for EMI debugging. They lacked adequate sensitivity for proper detection of electromagnetic interference. In addition, their fast Fourier transform (FFT) functions were not powerful enough to handle spectrum analysis, besides being complicated to use. However, all of this has changed with the introduction of the R&S®RTO digital oscilloscope from Rohde & Schwarz. Featuring sensitivity of 1 mV/div, bandwidth of up to 4 GHz and very low inherent noise, this oscilloscope is an ideal choice for EMI detection and analysis using near-field probes. Based on the results of EMI compliance tests, the oscilloscope can be used in development labs to investigate electromagnetic emissions produced by electronic designs and identify their root causes. As a lower-cost alternative in such applications, there is the new R&S®RTE oscilloscope with a bandwidth of up to 1 GHz (Fig. 1 and article on page 30).

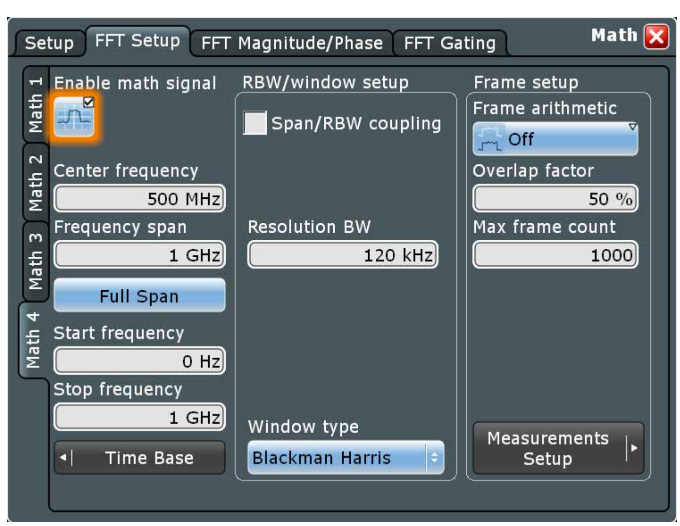


Fig. 2: Almost like a spectrum analyzer: user interface for the FFT function in the R&S®RTO and R&S®RTE digital oscilloscopes.

Color-coded spectra for visualization of sporadic emissions

The overlapping FFT function is a special feature of the FFT implementation in the R&S®RTO and R&S®RTE (Fig. 3). It provides high sensitivity for EMI detection while simultaneously allowing visualization of the spectral emissions over time. The oscilloscope divides the detected signal into many segments prior to FFT processing and computes a separate spectrum for each segment. This technique helps to reveal sporadically occurring, low-level signals in individual spectra. In the next step, the individual spectra are combined into an overall spectrum where the signals are color-coded by frequency of occurrence, i. e. sporadic signals have a different color compared to constant emissions. The color-coded overall spectrum provides an excellent overview of the nature and frequency of occurrence of the electromagnetic emissions that are present.

Correlation of sporadic emissions with events in the time domain

The gated FFT function allows the FFT to be restricted to a specific interval in the acquired time domain signal (Fig. 4). This time window (gate) can be moved across the entire acquisition period. This is useful for determining what segments of the time domain signal correlate with what events in the spectrum. For example, EMI from switched-mode power supplies can be correlated with overshoots in the switching

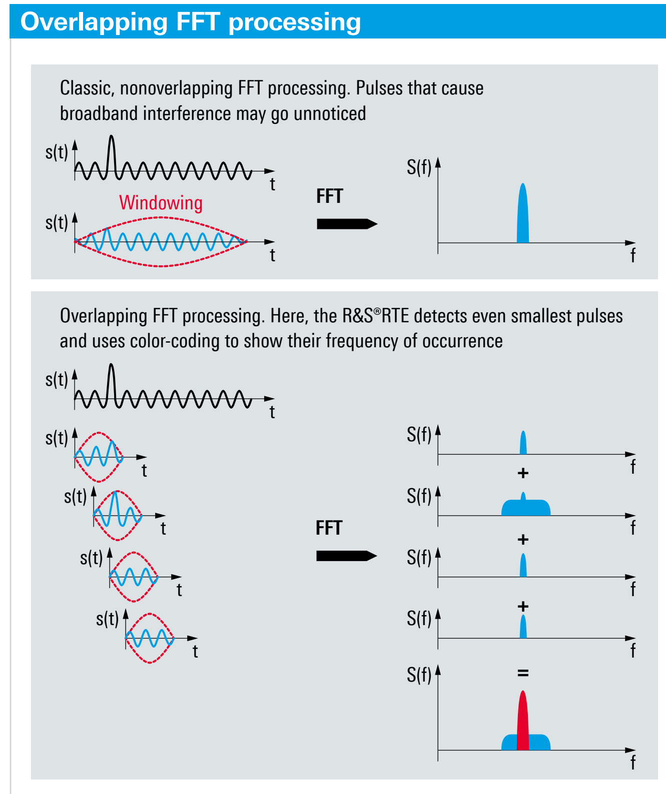


Fig. 3: The overlapping FFT function splits the acquired time domain signal into multiple segments before FFT processing begins. This ensures high sensitivity for detecting sporadic EMI. The individual spectra are color-coded to show their frequency of occurrence.

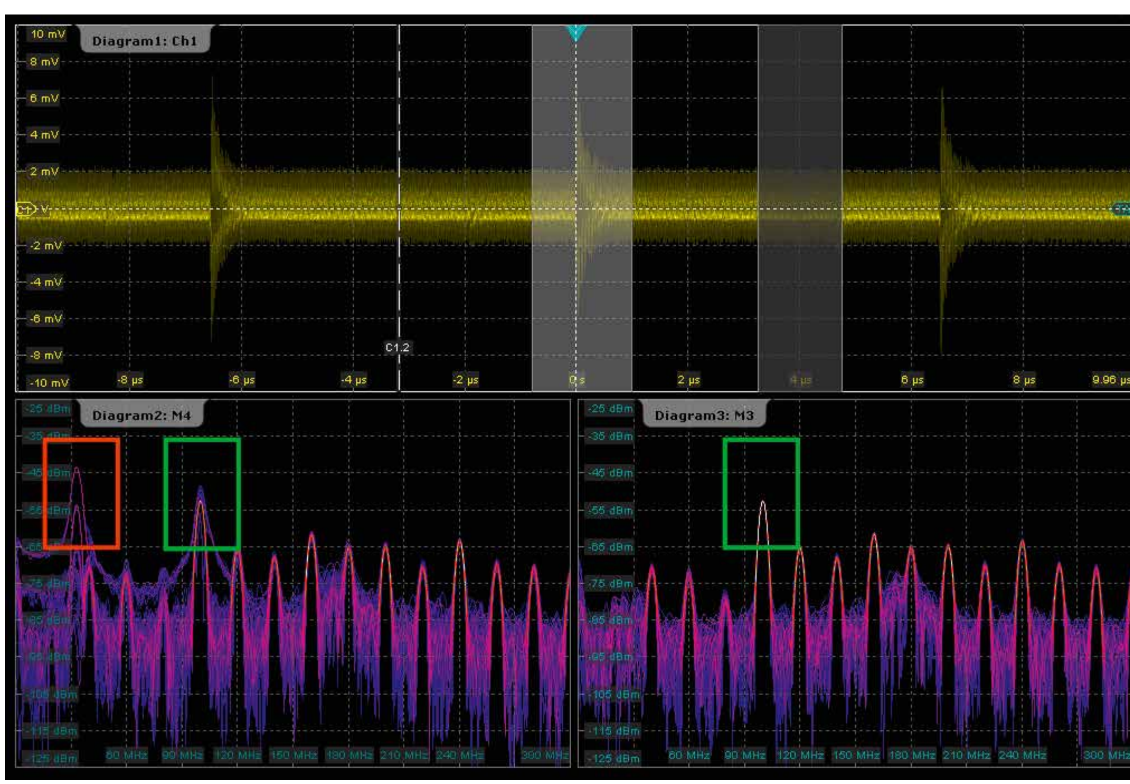


Fig. 4: The gated FFT function displays the spectrum for defined time intervals (gates) of the acquired signal. The two time intervals that underwent FFT processing are highlighted in gray while the resulting spectra are displayed on the left and right below. Gated FFT makes it possible to correlate sporadic EMI with the time domain signal. Highlighted red: spectral component produced by an EMI pulse. Highlighted green: constant spectral component that is present in both spectra.

transistor. Intermittent emissions produced by high-speed data buses with improperly routed lines can also be clearly correlated with the relevant signal sequences using the gated FFT. After a problem is identified, the oscilloscope can be used to quickly assess the effectiveness of countermeasures such as blocking capacitors, additional shielding or changes to the routing of the bus signals.

Detection of sporadic emissions

Sporadic emissions rank among the most challenging EMI problems. First of all, such emissions are difficult to detect. Moreover, conventional measuring equipment is limited in its ability to analyze detected signals. Here, the mask function of the R&S®RTO and R&S®RTE offers a convenient solution (Fig. 5). It allows simple and flexible definition of frequency masks. If a signal violates a mask, it can be frozen with the "Stop On Violation" function. The ability to modify FFT parameters such as the frequency span being examined and the resolution bandwidth – even for previously acquired signals – makes this function very powerful. Even hard to detect electromagnetic emissions can be analyzed in detail.

The history function is also very useful for investigating EMI. It automatically saves the most recent signal acquisitions up to the maximum memory depth. In this manner, current and prior acquisitions can be compared and analyzed without limitations.

Summary: Oscilloscopes are useful tools in EMI debugging

Featuring powerful FFT signal processing, high input sensitivity and extensive acquisition and analysis capabilities, the R&S®RTO and R&S®RTE oscilloscopes are valuable tools for developers who need to perform EMI debugging on electronic circuits. Using overlapping FFT processing and color-coded spectral display, the oscilloscopes provide an overview of the frequency of occurrence of spectral components in the acquired signals, allowing fast identification of EMI sources. Since the FFT function is controlled similarly as in spectrum analyzers, users can easily navigate in the frequency domain without having to worry about the time domain settings.

Various add-ons such as the R&S®HZ-15 compact, broadband near-field probe set round out the EMI T&M product portfolio. A new application note entitled "EMI debugging with the R&S®RTO and R&S®RTE oscilloscopes" provides useful tips and includes a practical example showing how to identify EMI trouble spots in electronic designs (search term: 1TD05).

Dr. Markus Herdin

Visit www.scope-of-the-art.com/en for more information.

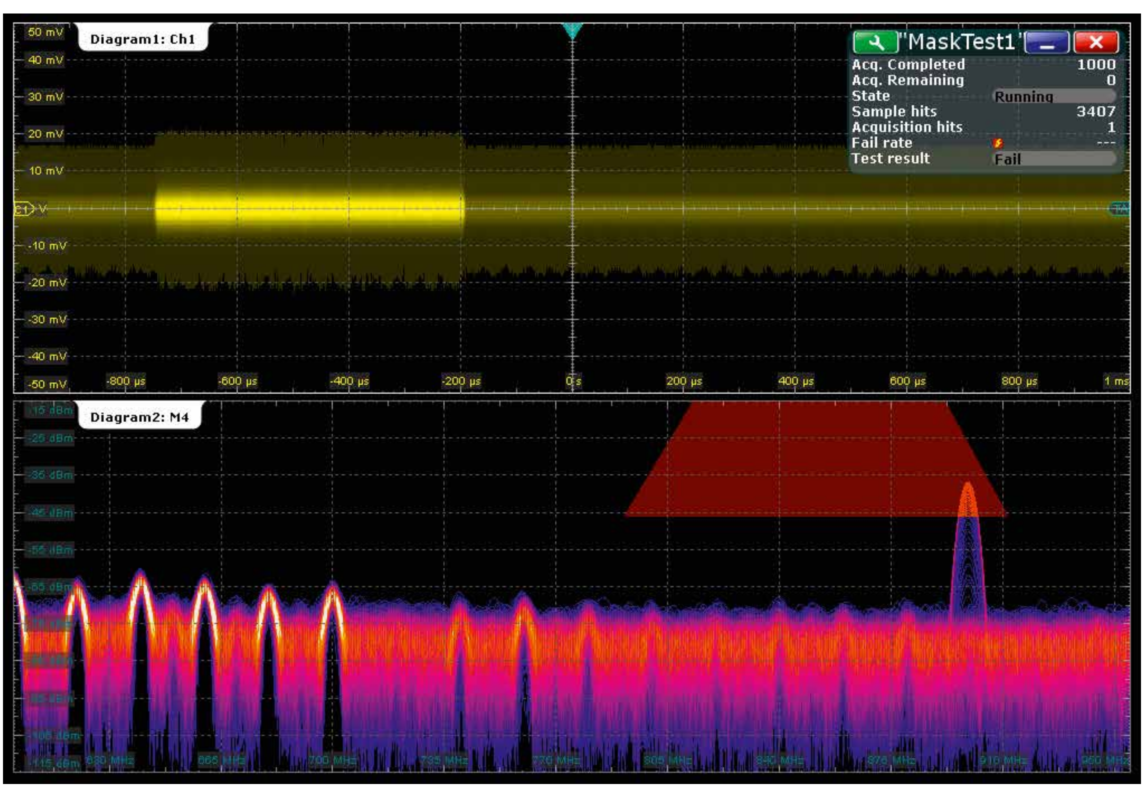


Fig. 5: The mask function of the R&S®RTO allows detection and detailed analysis of sporadic emissions.

Fig. 1: High field strengths are required for EMS measurements on trucks, for example. The new R&S®BBL200 broadband amplifiers offer up to 10 kW RF power and generate the required field strengths in the frequency range from 9 kHz to 225 MHz.

When high field strength matters: broadband amplifiers up to 10 kW

Sometimes EMS measurements require very high field strengths, e.g. when testing large EUTs in EMC chambers. For these applications, the new R&S®BBL200 broadband amplifiers offer up to 10 kW of nominal power and generate the required field strengths in a frequency range from 9 kHz to 225 MHz.

High field strengths for EMS measurements

Especially customers from the automotive and aerospace & defense sectors use their EMC chambers to subject large EUTs to EMS measurements where high field strengths are required (Fig. 1). Offering 3 kW, 5 kW and 10 kW of nominal power in a frequency range from 9 kHz to 225 MHz (Fig. 2), the new models of the R&S®BBL200 broadband amplifier family (Fig. 3) are ideal to meet this need for high field strengths and high amplifier power. They also fulfill typical requirements as specified by relevant standards. The outstanding performance at 1 dB compression and high mismatch tolerance make EMC measurements possible even under challenging conditions.

Rohde & Schwarz has recently added the R&S®BBL200 to its portfolio. The tried and tested broadband amplifiers of the R&S®BBA100 and R&S®BBA150 families offer up to 1.7 kW output power in a frequency range from 9 kHz to 6 GHz.

Sophisticated RF design and state-of-the-art liquid cooling

The R&S®BBL200 broadband amplifiers raise the bar in every respect for high-power amplifiers. Their fully solid-state RF design offers many benefits and efficiently eliminates the drawbacks of tube technology, such as aging or poor efficiency. They have been optimized for smooth operation at high RF powers. High-power couplers are used to generate up to 10 kW of RF output power. In conjunction with numerous measuring points, the efficient firmware monitors all amplifier runtime parameters and ensures smooth operation.

Broadband amplifier models	Frequency range	Nominal power
R&S®BBL200-A3000	9 kHz to 225 MHz	3000 W
R&S®BBL200-A5000	9 kHz to 225 MHz	5000 W
R&S®BBL200-A10000	9 kHz to 225 MHz	10 000 W

Fig. 2: Power classes and frequency range for the new R&S®BBL200 broadband amplifier family.

Fig. 3: R&S®BBL200-A3000 broadband amplifier model. Left: front view; right: rear view. Pump units and compression tanks are located in the rack.

The mechanical concept, including the liquid cooling system, also sets new standards. This is where the Rohde & Schwarz know-how – gained from manufacturing thousands of high-power TV transmitters in operation worldwide – came into play. As a result, the amplifiers feature a compact design and low noise level. All of the liquid cooling components, which were taken unmodified from the sound and TV broadcast transmitters, are known for their high degree of operational safety. Thanks to the closed cooling circuit, the liquid cooling is exceptionally easy to handle and requires very little maintenance. The coolant, available anywhere in the world and of course RoHS compliant, is based on glycol, water and anti-corrosion additives.

The broadband amplifier rack (Fig. 3) accomodates all pump units and compression tanks. Only a compact heat exchanger needs to be located separately and can typically be placed anywhere up to 20 m from the broadband amplifier. This has the advantage that the bulk of waste heat from the amplifier system can be dissipated outside of the amplifier room (usually limited in size), considerably reducing air conditioning requirements.

The indoor heat exchanger, coolant hoses and a filling pump are part of the equipment supplied. Of course, an appropriate solution can also be defined for special installations (e.g. separate cooling circuit or outside wall mounting of heat exchanger) – as the cooling concept is extremely flexible.

Series production in Germany

The R&S®BBL200 broadband amplifiers are series-produced in one of Europe's most advanced plants. The multiple award-winning* Rohde&Schwarz plant in Teisnach, Germany, offers superior manufacturing depth. From precision mechanical engineering and machining to printed board production, final assembly and automated final testing, all manufacturing steps are united under the same roof.

Fig. 4: The R&S®BBL200 can also be operated directly from the front panel.

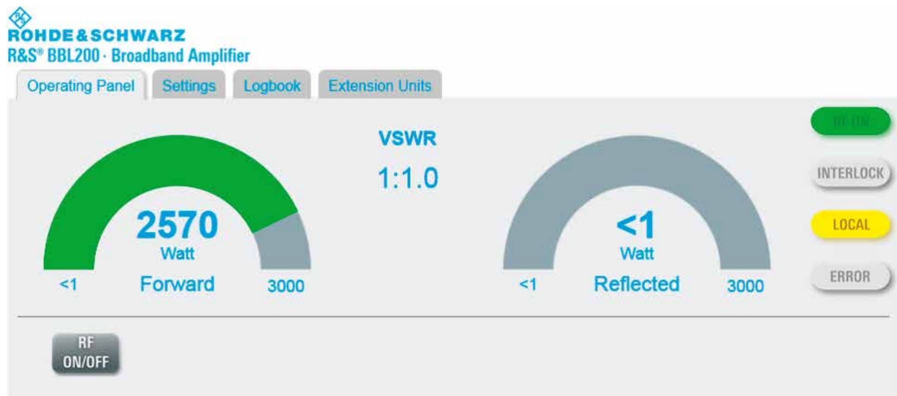


Fig. 5: Operation via the web browser interface.

Flexible control and operation

The R&S®BBL200 is manually operated via the display and the buttons directly on the instrument (Fig. 4). This is ideal for use in an amplifier room, for example, to easily change settings. A clever menu structure provides straightforward access to all essential information and settings. During operation, RF output power, reflected power and VSWR are displayed.

The web interface integrated into the R&S®BBL200 is called up via LAN and web browser (Fig. 5). The R&S®BBL200 can be conveniently operated via a standard web browser using a notebook near the amplifier or a control workstation PC.

The Ethernet interface makes it possible to automate test sequences with remote control commands in line with the SCPI nomenclature. TCP/IP networks are now standard for equipment networking and control; a separate infrastructure is no longer needed. To make integration especially easy, the R&S®BBL200 allows an IP network address to be set manually or assigned automatically via the dynamic host configuration protocol (DHCP). The tried and tested GPIB interface is another available option. This interface makes it easier to integrate the amplifier into existing GPIB laboratory networks. The remote control commands for all Rohde&Schwarz broadband amplifiers are identical, which simplifies control and integration.

Excellent service and quick maintenance

Like other amplifier families from Rohde&Schwarz, the R&S®BBL200 broadband amplifier family features modular design. This makes it easy, for example, to remove amplifier plug-ins. The liquid cooling system does not pose any problems when amplifier modules are exchanged. Self-connecting and self-shutting valves reliably ensure perfect sealing, even during maintenance and service. Downtime is minimized and costs reduced when problems arise because components can be replaced faster and systematically. Spare parts are available worldwide.

A three-year warranty makes the system particularly trustworthy, and the extended warranty options allow additional coverage for up to four years. This permits long-term planning of the cost of ownership, which remains low and calculable.

Sandro Wenzel

* The Rohde&Schwarz plant in Teisnach has received the following awards:
2010 "Factory of the Year"
2013 "Best Factory"
2014 "Bavarian Quality Award"

R&S®THU9 high-power TV transmitter commissioned for use by Chinese network operator

When digital television coverage is required for large regions, the R&S®THU9 liquid-cooled TV transmitters are the answer. Their advantages with respect to power efficiency, space requirements and operability were enough to convince Hunan TV, the second-largest TV network operator in China.

In China, if you were to ask anyone on the street about Hunan TV – Hunan Wei Shi in Chinese – you would very likely get an immediate, positive response. "Yes, of course I know it! I watch programs like 'Happy Camp', 'Super Girl', … every week …". In fact, many of the programs and TV series produced by Hunan TV have garnered top ratings and are even known outside China.

This success – making Hunan TV one of the most-loved TV broadcasters and the second-largest TV network operator in China after the national broadcaster CCTV – is based on the operator's determination, passion and drive for innovation. It was these qualities, as well as a spirit of pioneering, that Hunan TV also exhibited in 2012 with the decision to announce the first large-scale DTV project. Digitization of the terrestrial TV network is still in its infancy in China, with the State Administration of Radio, Film and Television (SARFT) shifting out the analog switchoff (ASO) date from 2015 to 2020.

Because cable and IPTV dominate the markets in Chinese cities, the focus for terrestrial TV broadcasting lies on coverage for rural and fragmented regions where inhabitants cannot afford high

Two of the R&S®THU9 liquid-cooled high-power TV transmitters that provide the southern Chinese province of Hunan with digital television.

Hunan province in China

The world's first terrestrial UHD TV network in Korea uses Rohde & Schwarz transmitters

Televisions with UltraHD resolution (also known as UHD or 4K) are quickly becoming a favorite among consumers, who are impressed by the picture quality. However, true 4K programming is thin on the ground. Korean Broadcasting System (KBS), Korea's largest public broadcaster, filled this gap earlier this year and was the first broadcaster in the world to start regular, terrestrial transmission of 4K programs – initially limited to the capital city Seoul and environs. The transmitters, which are operated in DVB-T2 mode, were supplied by Rohde & Schwarz (models R&S®THU9 and R&S®SVC8302). To be able to deliver the high data rates required by a UHD program, all of the resources provided for by the DVB-T2 standard must be put into play. The 4K transmission channel carries only a single program in place of the usual four multiplexed programs. The powerful 256QAM option (rotated) is used as the modulation mode, and the HEVC coder (H.265) was selected for video encoding, allowing double the compression of the typical H.264 coder at the same quality. This permits a bandwidth of only 6 MHz to carry a data rate of more than 25 Mbit/s, which together with data reduction measures is sufficient to transmit a 4K program with impressive quality.

The KBS antenna tower (left) is used to broadcast the world's first terrestrial 4K programs.

cable fees. The Hunan province in the south of China (one of China's most densely populated regions; see map) was therefore selected. More than 638 million people, representing 41 ethnic groups, live on approximately 200 000 square kilometers. The province is home to numerous mountain ranges, and transmitter stations are positioned on mountains with peaks at least 1000 meters above sea level to facilitate broadcast coverage. Some of these peaks now sport transmitters from Rohde & Schwarz. Rohde & Schwarz terrestrial TV transmitters have long had an excellent reputation with network operators in China as a result of their technical characteristics, quality and the dedicated service provided by the local Rohde & Schwarz subsidiary. This is why Rohde & Schwarz remains the market leader, in particular for liquid-cooled high-power TV transmitters, in spite of stiff competition.

Thanks to its R&S®THU9 liquid-cooled TV transmitters (see figure), Rohde & Schwarz has now also added Hunan TV as a customer. The efficiency advantages offered by the transmitters with respect to power efficiency, space requirements and operability were key selling points.

The first project involved four transmitters at 5.2 kW output power and two at 2.6 kW at a total of three stations, broadcasting 20 TV programs over two multiplexers. The pump and the bandpass filters for the 5.2 kW transmitters were integrated into the transmitter rack. This all-in-one concept saves space and reduces the installation effort. As a result, Rohde & Schwarz China was able to install and commission the systems, including combiners, antennas, etc. at all stations within only a few weeks. Even a delay caused by a continual downpour lasting six days did not put the completion date in jeopardy.

Since 2013, the transmitters have been broadcasting signals in compliance with the DTMB standard, to the complete satisfaction of the customer. In the meantime, all station engineers have been trained on the new transmitters during multi-day sessions conducted by Rohde & Schwarz China.

The first DTMB project with the R&S®THU9 transmitter family is a significant milestone for both parties and a good basis for many more success stories.

Fang Yang; Owen Zhang

Automatic precompliance testing of D-Book-conformant TV receivers

The D-Book, a technical specification from the UK's Digital TV Group (DTG), provides a detailed description of the technical hurdles that a DVB-T/DVB-T2 receiver must overcome in order to be sold in the United Kingdom. However, manufacturers are known to use the same test specifications for equipment destined for other regional markets. A new, fully automated solution from Rohde & Schwarz provides an elegant way to perform these tests using a single measuring instrument.

"Logo tests" for verifying product quality

Since manufacturers are allowed to self-certify the compatibility of their products with the DVB-T/DVB-T2 standard, it is clearly in their interest to ensure that their receivers will work properly in real-world TV networks. However, the DVB-T/DVB-T2 standard does not contain any T&M specifications for receivers that could serve as a foundation for satisfactory product quality testing. In certain countries, this gap has been filled by standardization organizations that are typically initiated by local network operators who come together to issue detailed technical recommendations for equipment manufacturers in their region of influence. Examples of these requirement catalogs include the Scandinavian NorDig standard and the Digital TV Group's D-Book for the United Kingdom. Manufacturers wishing to market their TV sets or set-top

DTG Testing

DTG Testing, the test house of the Digital TV Group (DTG), has approved the R&S®BTC broadcast test center together with the R&S®AVBrun D-Book test suite for precompliance testing to D-Book 7.3.

boxes with the UK's familiar Freeview logo must have their products certified by an accredited test house such as DTG Testing. Due to time and cost constraints, manufacturers are unlikely to accept such a procedure unless they are relatively certain to pass the test – especially since products generally require further approvals such as for the HDMI™ and MHL™ interfaces. In the past, achieving such certainty required manufacturers to perform their own tests using custom test systems with numerous components. The disadvantages of such systems are obvious and include the high cost of purchasing, calibrating and servicing the system and the need for control software. In contrast, the turnkey D-Book test solution from Rohde & Schwarz, which has been tested and approved by DTG, offers a very compact approach with an all-in-one measuring instrument – the R&S®BTC broadcast test center and the D-Book test suite based on the R&S®AVBrun test sequence software.

Fig. 1: The setup for D-Book-conformant precompliance tests is limited to an R&S®BTC broadcast test center, a remote control device, a remotely switchable power supply, and a Windows PC for configuring and controlling the tests.

Automated picture quality analysis beats conventional test and measurement

In order to ensure that TV receivers can handle a wide range of receiving conditions, chapters 9 and 10 of the D-Book define a number of RF tests for different signal scenarios (channel allocations, interferers). Remarkably, however, the D-Book does not specify whether the quality verification is done using objective T&M procedures (BER measurements, transport stream analysis) or just by visual picture inspection. The ideal solution, of course, would be a mixture of both – an automated picture quality analysis by a measuring instrument using assessment methods adequate to a human viewer. That's exactly what the R&S®BTC offers (see box) and what the Rohde & Schwarz test solution is based on. Automated picture quality analysis has also the major benefit that no contact with internal interfaces (typically hard to reach) is required in order to tap the signals. Instead, consumer electronics equipment can be tested in what is basically its delivery state. Access is required only to the RF (or antenna) input and a standard device output, preferably an HDMI™ interface. With receivers that do not have a digital output, measurements can be made on an analog interface such as Scart or RGB.

Picture quality analysis with the R&S®BTC

The picture quality is automatically assessed by the R&S®BTC A/V distortion analysis function. The deviation from an assumed ideal reference, and not the absolute A/V quality, is assessed. Consequently, the reference recording must originate from the same video processing chain and the same A/V material. Suitable transport streams with short A/V sequences (e.g. 20 s) are an integral part of the R&S®AVBrun test suite software.

The D-Book recommends that picture assessment should have three observation periods of 10 s each (this applies to each defined signal scenario). The criterion for good signal quality is that no visible errors occur during two out of three observation periods. When an instrument such as the R&S®BTC is used to perform this assessment, the challenge is to translate the concept of a "visible error" into a measurable quantity. Various methods are commonly used. One method involves the peak signal-to-noise ratio (PSNR) – a quality parameter that takes into account the mean square deviation of the color intensity and brightness for each pixel in the test picture with respect to the corresponding reference pixel. Although the PSNR method is well established, it ignores certain idiosyncrasies of human image perception which mean that a poor PSNR value does not necessarily imply that a human viewer would also find the picture to have low quality. The structural similarity (SSIM) measurement method provides a better model of human visual perception. Based on the insight that people perceive images in terms of structures, the method analyzes the extent to which these structures are retained in comparison to the reference picture. The result is an index value between 0 and 1, where 1 implies full agreement with the reference picture. The R&S®BTC determines the PSNR and the SSIM value (along with other quality indicators; see Fig. 2). The tolerance limits for pass/fail decisions in line with the D-Book are stored as a parameter set, but they can also be user-specified for other measurements.

Fig. 2: The distortion analyzer of the R&S®BTC combines various picture quality parameters in a clear analysis screen.

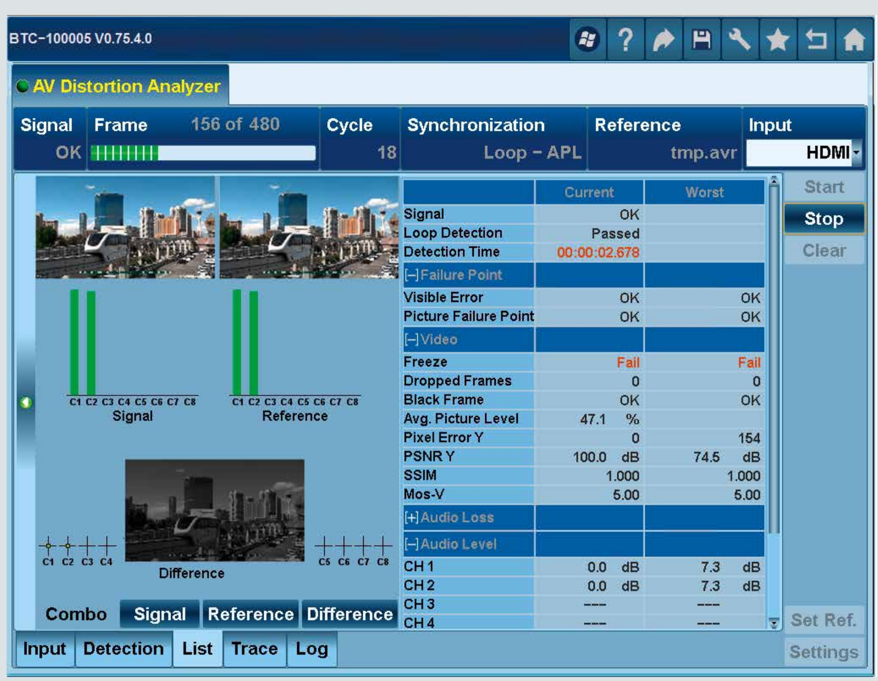
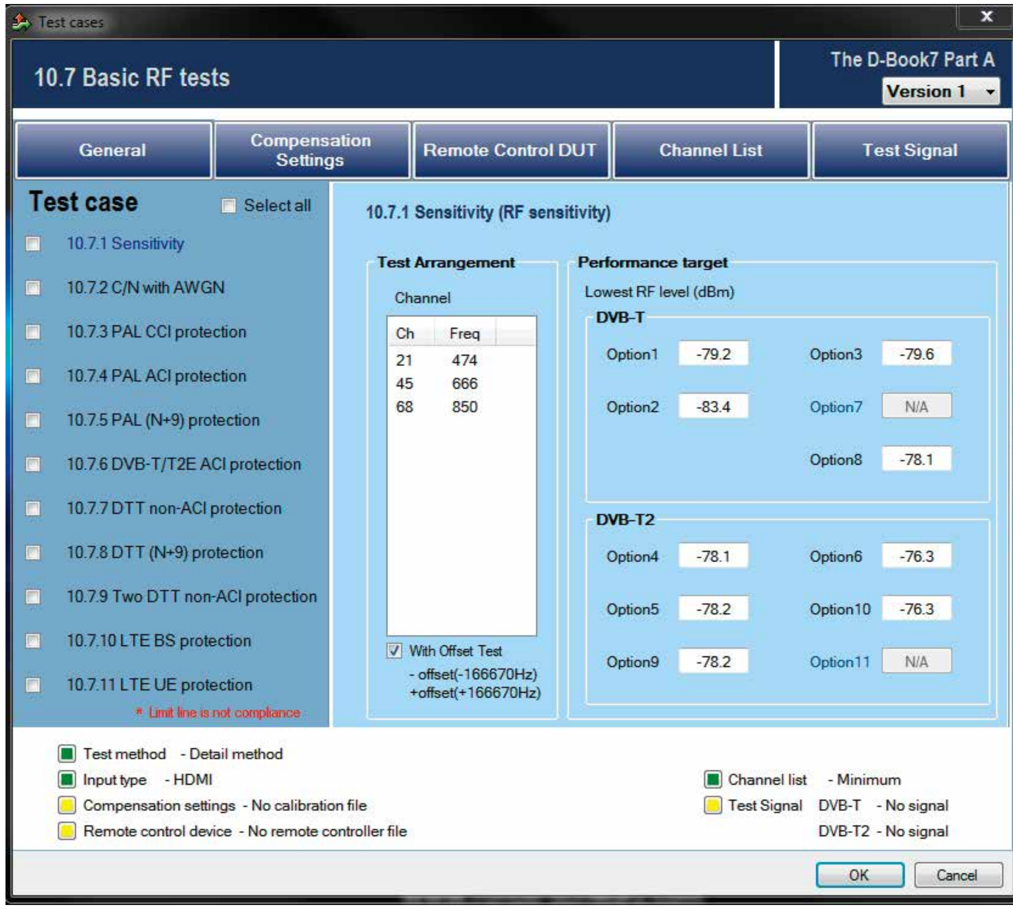


Fig. 3: The user interface for the R&S®AVBrun test sequence control software with the R&S®BTC-KT3310 D-Book test suite closely parallels the structure of the D-Book specifications and is largely self-explanatory.



A compact all-in-one solution to replace expensive rack systems

Fig. 1 shows the simplicity of the test setup. The R&S®BTC handles all of the functions needed to generate the necessary signal scenarios and analyze the output signal. Only the following components are needed to perform fully automated tests (even unattended): an adaptive remote control device (RedRat3-II), a remotely switchable power supply (NET8212), and a PC for configuring and controlling the tests. The remote control device is used to control the channel switching as required by the test software; the switchable power supply allows a DUT to be restarted in case it crashes or fails to respond (which is detected by the system) so the test can resume from the point of interruption. R&S®AVBrun is the Windows software used for test automation with the R&S®BTC. It is extended with the R&S®BTC-KT3310 test suite for D-Book-conformant tests. The terminology and chapter numbers used in the menus correspond to the D-Book layout to make the configuration process fast and easy (Fig. 3). The default settings can be used to perform all of the tests exactly as described in the D-Book. However, users can deviate from the recommendations if necessary in order to analyze errors or perform more in-depth studies that go beyond the specified parameters. Test passed or failed (and if it failed): Where are improvements necessary? Hints on that can be found in the clear test report generated by the software according to the test plan each time it runs. The report can be saved in PDF or XML format. The entire test procedure involves only a bare minimum of manual intervention, thereby boosting the efficiency while eliminating possible error sources.

Another benefit is that the single calibration procedure required for the test setup (including the RF cable and adapter / attenuator) can be performed very quickly from the menus with an R&S®NRP power sensor connected to the R&S®BTC.

Test modules for additional standards in preparation

The R&S®AVBrun software is suitable for automating all types of tests with the R&S®BTC. The D-Book test suite will be followed by additional test suites for the latest NorDig standard (version 2.4) as well as the E-Book standard (IEC 62216). The R&S®BTC is advancing in the direction of a universal tester for automatic precompliance measurements on broadcast receivers in all markets.

Vandy Eng

Full channel loading: simulation of cable networks with TV and DOCSIS 3.1

Once upon a time, cable television was a service used to deliver TV programs. Nowadays, however, the same cable can be used to provide telephone and Internet service to homes. The Internet in particular is demanding increasing amounts of bandwidth. More efficient transmission methods are needed since the frequency range cannot be extended without limitations. The new DOCSIS 3.1 standard supports unprecedented data rates in the downstream and upstream, placing new requirements on T&M equipment.

The last mile – meaning the cable run that connects to the user's home – is the most complex part of any network infrastructure. Changes here are complex and expensive, which is why network operators want to postpone them as long as possible. For cable TV, the last mile – which consists of optical fiber and coaxial cables, amplifiers and electrical/optical converters – is the bottleneck that prevents higher data rates.

Maximizing data throughput with existing HFC network infrastructure

This is where the new DOCSIS 3.1 standard comes in. It was created in order to maximize data throughput in the downstream and upstream without requiring any changes to the existing hybrid fiber coaxial (HFC) network infrastructure. To achieve this objective, DOCSIS 3.1 introduces fundamental innovations. The most significant advance involves usage of low density parity check (LDPC) forward error correction (already tried and tested with second-generation TV standards) in combination with robust OFDM modulation. LDPC error protection is so effective that even constellations such as 4096QAM can be used with DOCSIS 3.1 – something that was hardly conceivable in the past. DOCSIS 3.1 uses channel bandwidths of 192 MHz in the downstream and 96 MHz in the upstream; however, scaling is possible if necessary. This, in fact, is the benefit of OFDM modulation: It provides the flexibility to adapt the signal bandwidth to a given network's specific characteristics. However, since OFDM and LDPC together do not yet achieve the desired increase in data throughput, the frequency ranges have also been redefined in DOCSIS 3.1 (Fig. 1). The upper limit will be raised in two stages: first to 1218 MHz and then to 1794 MHz. In this case too, the error protection is expected to compensate for the cable's poor transmission characteristics at higher frequencies. The upstream will be extended to 5 MHz to 204 MHz. As a result of these measures, DOCSIS 3.1 is expected to support

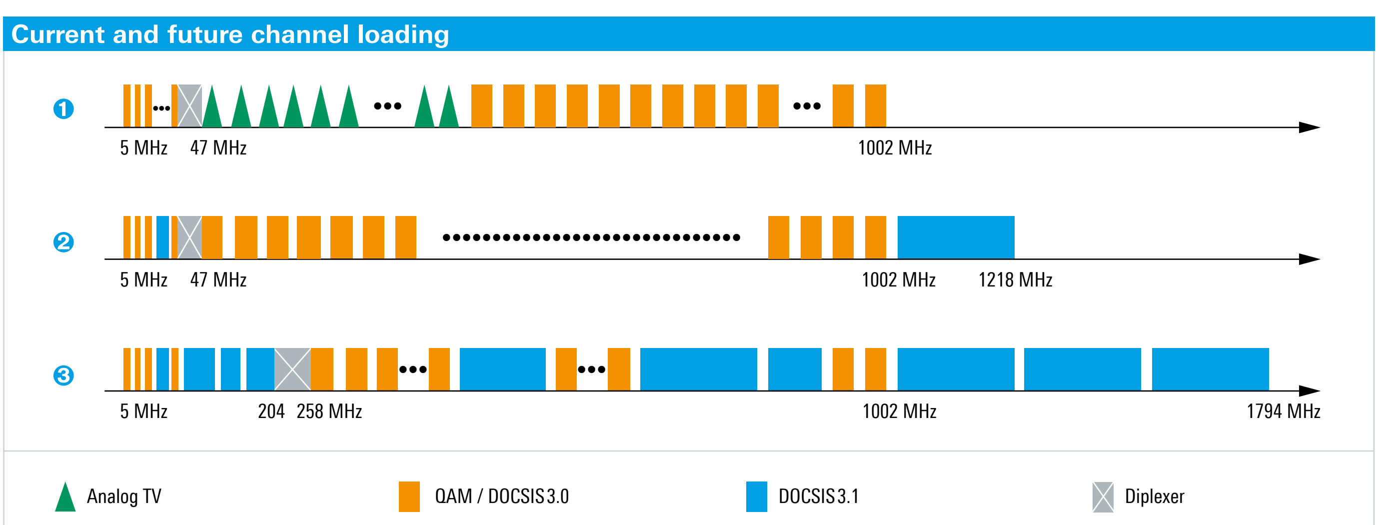


Fig. 1: ❶ Typical loading of cable TV networks with analog and digital channels up to 1002 MHz. ❷ Extension up to 1218 MHz with DOCSIS 3.1. ❸ Final expansion with upstream up to 204 MHz and downstream up to 1794 MHz.

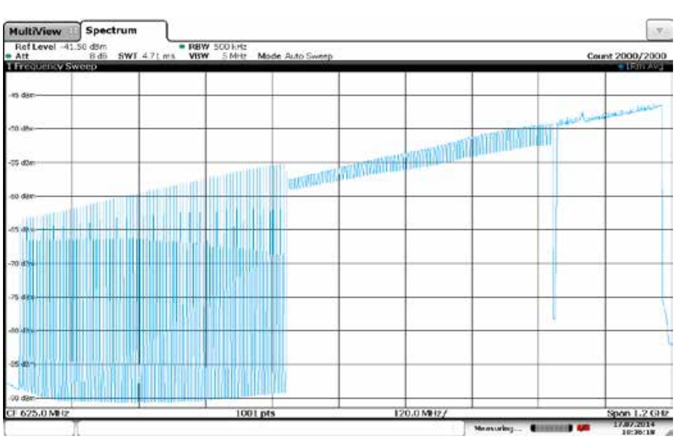
Fig. 2: The R&S®CLGD DOCSIS cable load generator provides DOCSIS 3.1 signals as well as digital and analog TV signals in the downstream along with DOCSIS 3.1 and DOCSIS 3.0 signals in the upstream.

data rates of more than 10 Gbit/s in the downstream and 1 Gbit/s in the upstream. Initial field trials are scheduled for 2014. Commercial deployment of DOCSIS 3.1 is planned starting in 2016.

New tests for cable tuners, modulators and amplifiers

Once the standard has been defined, the industry players need to get to work. A new generation of broadband modulators and tuners for cable modems and cable modem termination systems (CMTS) is required. Even if the network infrastructure is left untouched, it will still be necessary to test the amplifiers and converters with the new signals (Fig. 3). The large number of signals present on the cable is especially critical since distortion can easily occur due to intermodulation. Signal peaks can also occur which lead to laser clipping in electrical/optical converters, resulting in interference and loss of data. During a transition period, DOCSIS 3.1 will have to coexist in the cable with existing digital TV as well as analog TV and FM sound broadcasting to some extent. In the upstream, DOCSIS 3.1 and DOCSIS 3.0 will be used in parallel during the transition period. Here, it is important to determine whether the different systems interfere with one another and if so, how much.

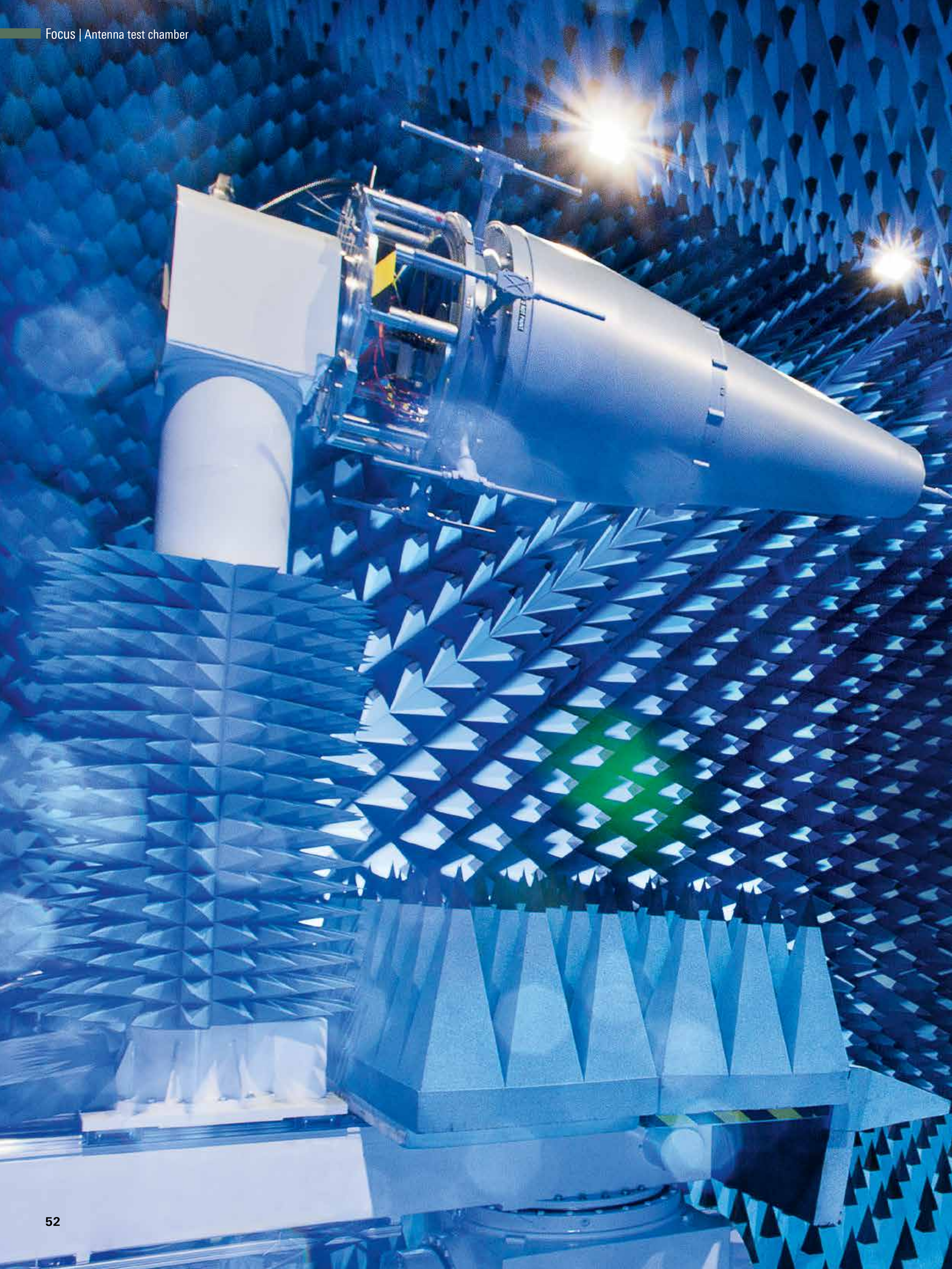
Fig. 3: Test signal for a cable TV amplifier with analog TV, QAM and a 192 MHz DOCSIS 3.1 signal with a total of 15 dB uptilt. The DOCSIS 3.1 signal contains the bulk of the power.



Simulating cable TV networks with full channel loading

For analyzing this type of loading and coexistence scenarios, Rohde & Schwarz has launched a new signal generator: the R&S®CLGD DOCSIS cable load generator (Fig. 2), which has evolved from the R&S®CLG. The R&S®CLGD generates DOCSIS 3.1 signals as well as digital and analog TV signals in the downstream along with DOCSIS 3.1 and DOCSIS 3.0 signals in the upstream, allowing users to simulate any conceivable channel loading scenario. The R&S®CLGD makes such simulations realistic by adding different types of interference such as white noise, impulsive noise, microreflections, narrowband ingress and 50 Hz / 60 Hz AC hum. The new generator is an ideal tool for developing broadband tuners for the new generation of cable modems and CMTS. It is also well-suited to qualifying amplifiers and electrical/optical converters with DOCSIS 3.1 signals.

Peter Lampel



Europe's most advanced antenna test chamber goes into operation

Rohde & Schwarz has created and installed a new anechoic test chamber at its Memmingen plant. The state-of-the-art facility is used for carrying out precision antenna measurements and offers performance characteristics unique in Europe. The test chamber supports all types of measurements for the comprehensive Rohde & Schwarz antenna portfolio. In particular, it is used to perform three-dimensional radiation pattern measurements on direction finding (DF) antennas (see figure). It features an exceptionally wide frequency range from 200 MHz to 40 GHz and an outstanding ±0.02° angular accuracy for positioning the antenna under test (AUT). The chamber's eight-axis positioning system moves the AUT into the desired position. The system can handle AUTs with a weight up to 200 kg.

Constraints of PC antenna simulation

Rohde & Schwarz ranks among the most renowned antenna manufacturers in the world. The company's product portfolio includes broadband antennas for a wide range of applications, including EMC testing, spectrum monitoring, and radiomonitoring and radiolocation. These high-tech, performance-optimized antenna systems require advanced, high-precision T&M technology and equipment in development and production. Numerical simulation tools used during the design phase, in combination with ever more powerful computers, can simulate antennas efficiently and accurately by way of approximation. However, with antennas becoming more and more complex, simulation times also increase and are in part extremely long. More often than not, it is hardly possible to fully model the antenna structure or its details. This is aggravated by the fact that the electrical properties of the materials used are often not sufficiently known, plus they vary with frequency.

Notwithstanding the above constraints, it is imperative that antenna tests and measurements be conducted with the utmost accuracy in development and production. This applies, for example, to DF antenna systems. Their three-dimensional radiation patterns need to be measured with high accuracy for the systems to deliver precise bearings. The calibration values determined during these measurements are used, together with suitable algorithms, to correct even the smallest individual RX values measured for a specific radio signal for different angles of incidence and different signal types. The calibration values are the prerequisite for obtaining accurate bearings and, ultimately, for locating unknown radio transmissions with high precision.

Precise characterization is also required for test antennas, which in part need to comply with accredited and international standards. For each antenna, a calibration data set is created that comprehensively characterizes the antenna. Calibration is mandatory to ensure that the measurement data obtained for an antenna under test (AUT) measured with a specific test antenna are correct, verifyable and reproducible in order to allow the data to be compared, for instance, with legally stipulated limits.

Positioning system

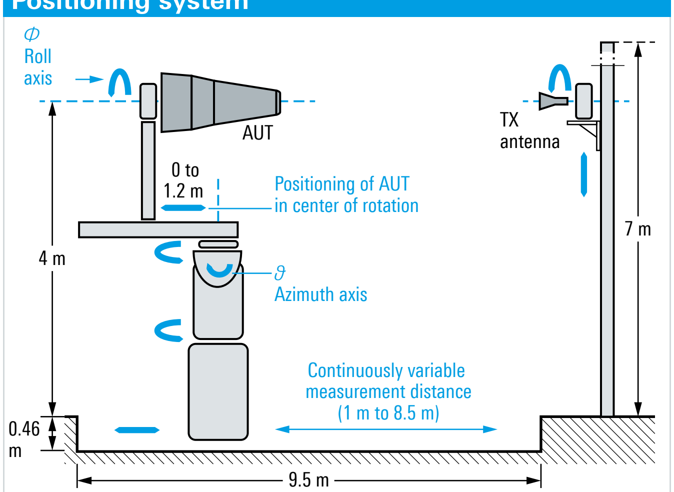


Fig. 1: Eight-axis positioning system in new antenna test chamber at Rohde & Schwarz Memmingen plant.

Key specifications for antenna test chamber

- Frequency range: 200 MHz to 40 GHz
- 3D near-field and far-field measurements
- Chamber dimensions (L × W × H): 14 m × 10 m × 8 m
- Antenna weight: up to 200 kg; antenna length: up to 2 m
- Flexible eight-axis positioning system
- Measurement distance: < 8.5 m
- Positioning accuracy: ±0.02°
- Shielding effectiveness: > 80 dB
- T&M instrument for antenna characterization: R&S®ZVA 40 vector network analyzer

Test chambers ensure high-precision measurements

Test chambers are the best choice when highly accurate and reproducible measurements are required. The shielded chambers prevent unwanted external interference from affecting measurement results and offer constant conditions, ensuring long-term stability and reproducibility, which are essential requirements for high measurement accuracy and reliability. Test chambers are not subject to influences that distort measurement results, such as electromagnetic fields caused by weather conditions during far-field measurements. Measurements can be carried out at any time of the day and at frequencies not permitted at open area test sites. Plus, new product developments are kept confidential.

The broad Rohde & Schwarz antenna portfolio includes products of all sizes and weights for applications from the AF to the GHz range. This calls for a correspondingly versatile test system. A universal test system is required to cover antennas with both low and high directivity. This is best achieved with a system that performs spherical measurements, i.e. that collects measurement data over the surface of a sphere. The challenge is the measurement distance required in each case. For example, a parabolic antenna with a diameter of 3 m requires a far-field measurement distance of 2 km at an 18 GHz measurement frequency. Applying the rule of thumb of $4D^2/\lambda$, this distance may produce a phase error of up to 11.25°. This contrasts with the Rohde & Schwarz antenna performance specifications, which require a DF accuracy of 1° to 2°. The approach to solving this problem is to transform near-field measurement data into far-field data. To be able to measure both under near-field and far-field conditions, Rohde & Schwarz decided in favor of a flexible eight-axis positioning system from ACC (Fig. 1) that allows continuous adjustment of the measurement distance between 1 m and 8.5 m. For further key data for the test chamber, refer to the box on page 54.

Near-field measurements are performed in the radiative near-field region, which contains practically no reactive components. The antenna radiation pattern is already fully formed in this region, and there is distinct polarization. Near-field-to-far-field transformation of measurement data can help to determine whether the far-field condition was met during a measurement. If this is the case, the pattern shown below (Fig. 2) should not change any more. As the measurement distance increases, there is less and less interaction between the AUT and the probe. A short measurement distance is beneficial for the signal-to-noise (S/N) ratio. However, amplitude and phase inaccuracies have a more dramatic impact in the near field than in the far field. Since the far field is calculated from the near-field measurement data, near-field measurements require a high positioning accuracy. The positioning system from ACC offers an accuracy of 0.02°, which makes it ideal for this application. Near-field measurements are usually carried out as sphere measurements using grid sampling. In addition, two linearly independent polarizations need to be measured. These measurements can take a long time, depending on the AUT size and the measurement frequency. Far-field measurements are therefore the preferred choice, provided the antenna's electrical dimensions allow this method.

Rohde & Schwarz uses the ARCS software from March Microwave Systems in which a near-field-to-far-field transformation software from TICRA is implemented. The TICRA software models an electromagnetic near field using multipoles as equivalent sources based on the following formulas:

$$\vec{E}(\rho,\vartheta,\Phi) = \beta_0\sqrt{Z_{F0}}\sum_{c=3}^{4}\sum_{s=1}^{2}\sum_{n=1}^{\infty}\sum_{m=-n}^{n} Q^{(c)}_{smn}\vec{F}^{(c)}_{smn}(\rho,\vartheta,\Phi)$$

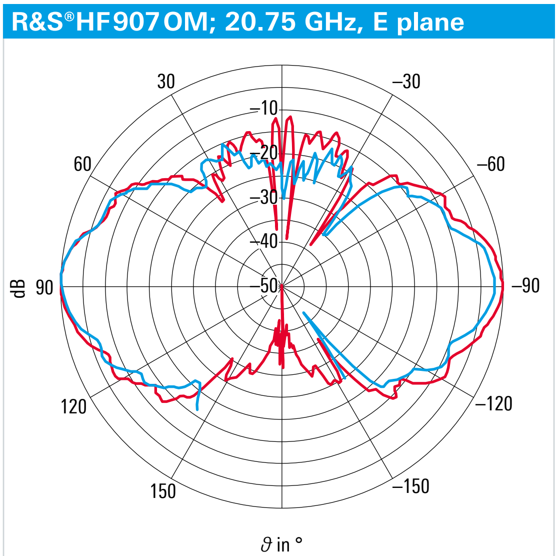
$$\vec{H}(\rho,\vartheta,\Phi) = \mathrm{j}\frac{\beta_0}{\sqrt{Z_{F0}}}\sum_{c=3}^{4}\sum_{s=1}^{2}\sum_{n=1}^{\infty}\sum_{m=-n}^{n} Q^{(c)}_{smn}\vec{F}^{(c)}_{(3-s)mn}(\rho,\vartheta,\Phi)$$

$\vec{E}(\rho,\vartheta,\Phi)$ designates the electrical field in a spherical coordinate system, $\vec{H}(\rho,\vartheta,\Phi)$ describes the magnetic field, β_0 is the wave number of free space, Z_{F0} is the impedance of free space, Q stands for the AUT's spherical mode coefficients, and $\vec{F}$ represents the spherical vector modes. For more information, refer to [*]. In reality, however, the number of spherical modes does not approach infinity but is truncated after n = N. The second translation axis of the positioning system can be used to position the AUT's phase center as precisely as possible in the center of rotation, minimizing the number of modes required for electromagnetic near-field modeling and keeping AUT phase variation to a minimum. If the AUT's phase center is outside the center of rotation, the number of required modes increases and the AUT phase varies strongly (see Fig. 3). Depending on the number of required modes, the sampling grid must be selected so that the antenna radiation pattern can be exactly and unambiguously reproduced.

To take into account the impact of the probe, the AUT's spherical-mode field representation is transformed into the probe's coordinate system, and the following transmission formula can be derived:

$$b'_0 = \underbrace{\frac{a_0}{2}\sum_{\substack{smn\\ \sigma\mu\nu}} T_{smn}\, e^{\mathrm{j}(m\varphi_0+\mu\chi)}\, d^{n}_{\mu m}(\vartheta_0)\, C^{sn(3)}_{\sigma\mu\nu}(\beta_0 r)\, R^{\text{probe}}_{\sigma\mu\nu}}_{a_{\sigma\mu\nu}}$$

R&S®HF907OM; 20.75 GHz, E plane



R&S®HL050; 8.5 GHz, E plane

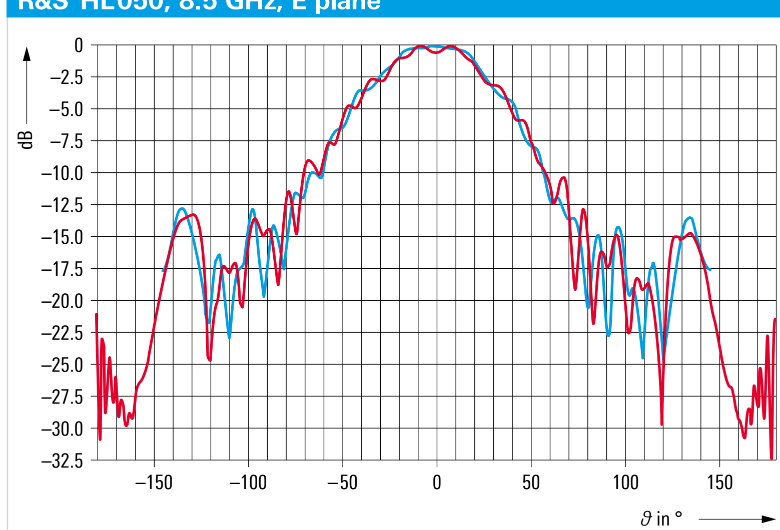
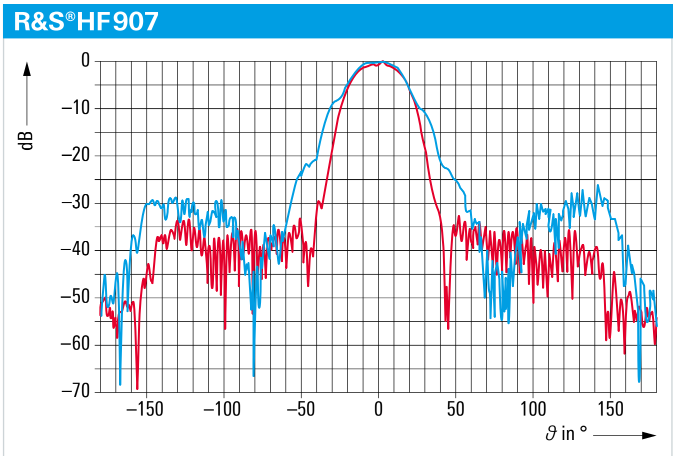


Fig. 2: Does the antenna pattern change at a distance of →∞? In the above example, the far-field condition is fulfilled to a high degree, so that there is hardly any change in the antenna pattern after near-field-to-far-field measurement data transformation. Blue: near-field measurement data; red: measurement data transformed from the near field into the far field.



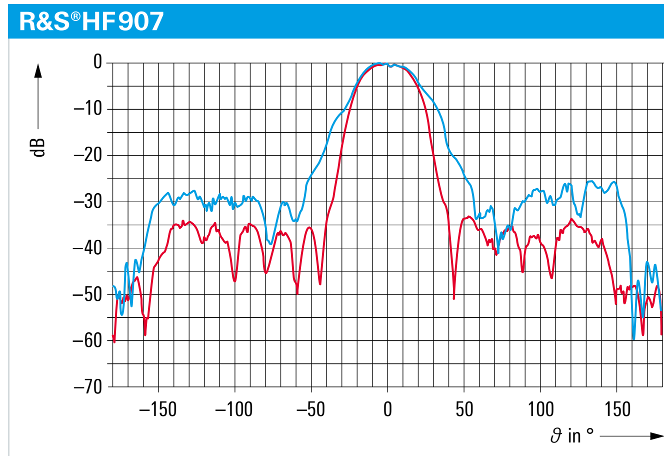


Fig. 3: Measurement results with the AUT phase center outside (left) and inside (right) the center of rotation. Blue: near-field measurement data; red: measurement data transformed from the near field into the far field.

The translation and rotation coefficients are represented by $a_{\sigma\mu\nu}$. R is the probe's receiving coefficient; a and b designate the forward and the reflected power waves. The transmission matrix can be easily resolved for first-order probes by applying a twofold fast Fourier transform (FFT). The drawback is that real-world first-order probes are narrowband. At the Rohde & Schwarz Memmingen plant, double-ridged waveguide horn antennas are used to perform broadband measurements. One of these antennas covers the frequency range from 1 GHz to 18 GHz, for example. In cooperation with the Institute for High-Frequency Engineering at the Technische Universität München (TUM), Rohde & Schwarz is investigating the impact of the probe on the measurements. The institute developed a new transformation algorithm based on equivalent current sources. The new algorithm includes full probe correction. Commercial software (such as TICRA) only supports first-order probe correction. Another advantage of using equivalent current sources is that the current distribution close to the AUT's aperture can be visualized. This diagnostic approach (Fig. 4) is useful during antenna development. The current distribution in the antenna aperture reveals design errors and provides information about the radiation pattern.

During the evaluation phase for the antenna test chamber, measurements on antennas with known characteristics were performed, for example on the R&S®HL223 log-periodic antenna (200 MHz to 1.3 GHz). Fig. 5 shows the antenna gain measured in the new antenna test chamber using the three-antenna method. The measured gain is compared against the gain of a calibrated antenna. The data of the calibrated antenna is given with a measurement uncertainty of ±1 dB. The gain values measured in the antenna test chamber already follow the calibrated antenna curve very closely. Below 0.5 GHz, the measured values and the values of the calibrated antenna deviate slightly from one another, since in this frequency range the positioning system contributes to the radiation characteristic, for example.

To further enhance measurement accuracy, the gating function implemented in the ARCS software is used. Data acquired in the frequency domain are transformed into the

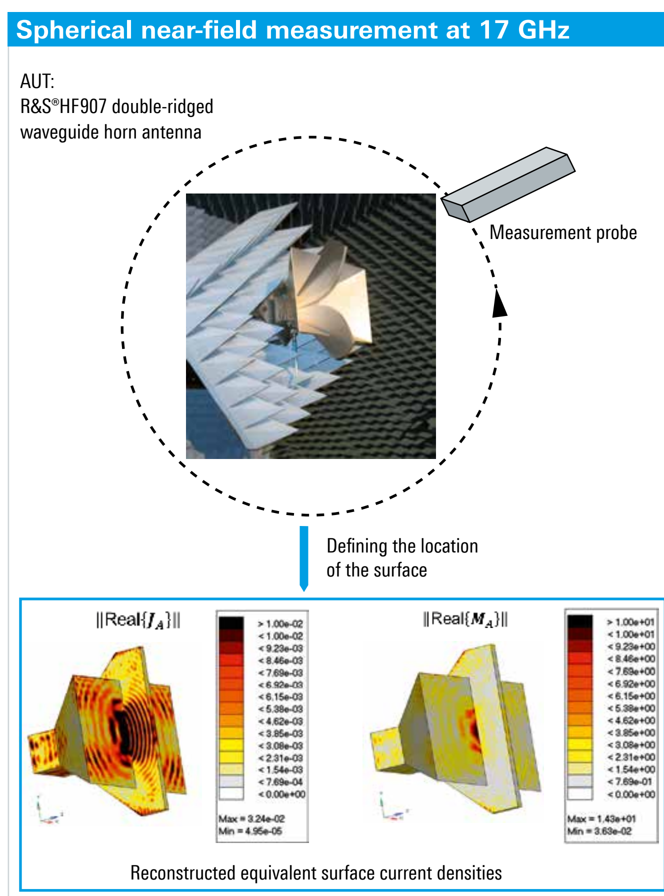


Fig. 4: Representation of currents on antenna aperture.

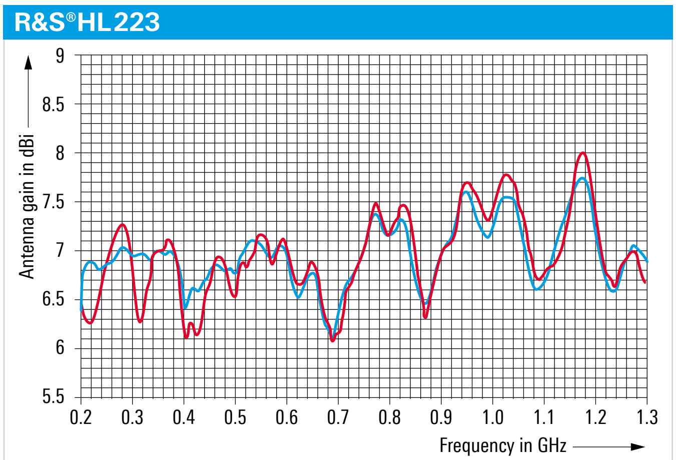


Fig. 5: Comparison of R&S®HL223 antenna gain measured in the Memmingen antenna test chamber (blue) with the gain of a calibrated antenna (red).

time domain using an inverse FFT (IFFT). Depending on the frequency resolution Δf and the bandwidth B, the following alias-free range (AFR) is obtained:

$$AFR = \frac{c}{B/(N_f - 1)} = \frac{c}{\Delta f},$$

In the AFR, only the true time domain responses are shown. c represents the speed of light. Reflections in the measurement path caused by components with different impedances or by nonideal absorbers can be filtered out in the time domain by selecting the appropriate ACRS TimeGate function and length (Fig. 6). It is helpful to know the measurement path when determining the extent to which the signal amplitude can be attributed to the antenna and what peaks are undesirable. If the antenna response in the time domain extends over a longer period of time and is superimposed with reflections, it is virtually impossible to tell the antenna signal from undesired responses. Further correction mechanisms are therefore required. The TUM Institute for High-Frequency Engineering in cooperation with Rohde & Schwarz is currently developing echo suppression methods. One approach is to carry out near-field measurements on different radii. The results are transformed into far-field data, and a set of far-field radiation patterns is created. Using singular value decomposition, these patterns are split into major and minor components. The minor components lead to errors; only the major component is assumed to represent the true far field. Further methods aimed at enhancing measurement accuracy are under way.

Summary

The new antenna test chamber enables high-precision 3D measurements from 200 MHz to 40 GHz. As a result, Rohde & Schwarz is ideally equipped to meet the T&M challenges for its comprehensive antenna portfolio.

Dr. Yvonne Weitsch

Reference
* Hansen, Jesper E.: Spherical near-field antenna measurements. IEE Electromagnetic Waves Series 26, Peter Peregrinus Ltd., London U.K., 1988

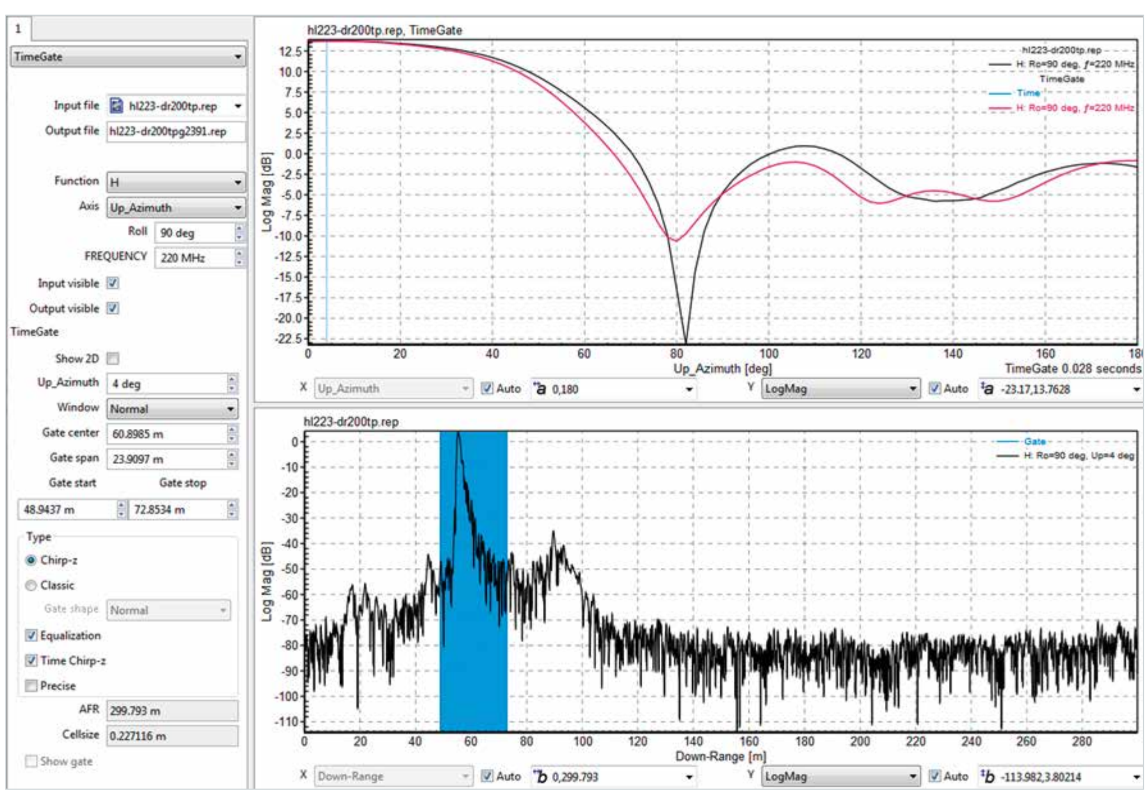


Fig. 6: The ARCS software TimeGate function can be used to filter out reflections that occur in the measurement path.

Universal platform architecture for fast, secure encryption

Nowadays, it is an undisputed fact that companies and government institutions need to protect their data and communications against unauthorized access. But what exactly is the best way to achieve this objective? The platform architecture developed by Rohde & Schwarz SIT sets a benchmark for future encryption technology. It combines the benefits of commercial network products and dedicated security solutions.

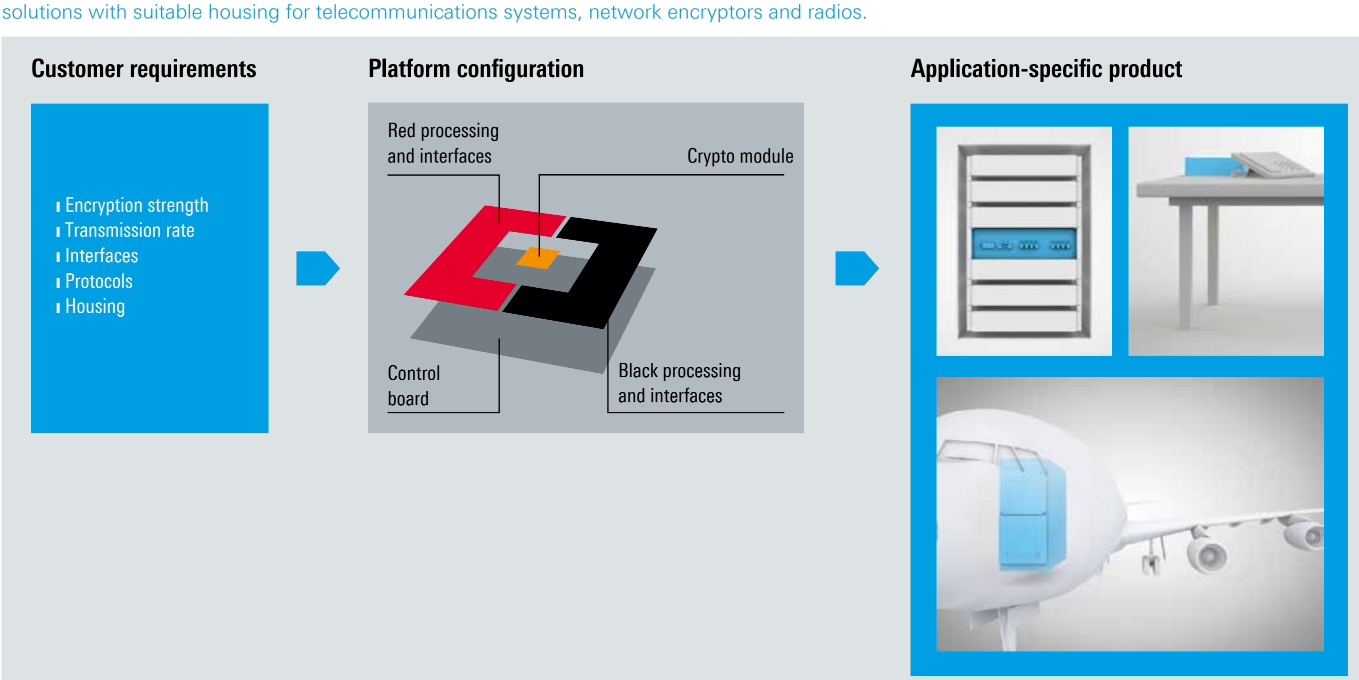
Standard products or custom solutions?

Until now, companies and government institutions had to choose between two alternatives for protecting their data. Today's standard voice and network communications products generally include security and encryption functions. However, in many cases the functionality is not sufficient to protect against professional attacks. The alternative is specially developed high-security solutions. These solutions provide a high level of security, but they can be difficult to use and tend to be expensive due to the low volumes. Therefore, the private sector often relies on the security functions found in standard products. Government agencies and armed forces, however, are obligated to deploy specially approved solutions.

Standard products have a different focus

For network encryption, many companies use the security functions provided by network components such as routers and switches. However, it usually does not pay off for the manufacturers of these products to invest in comprehensive security measures. They are under intense pressure to create innovative products with increasingly short product life cycles. Complex security features tie up additional product development resources, increase costs and run the risk of slowing down the pace of functional innovation. The procurement process also rarely focuses on security features due to the greater emphasis on other technical capabilities.

Flexibility and security: The new platform architecture from Rohde & Schwarz SIT GmbH is used to derive dedicated, application-specific encryption solutions with suitable housing for telecommunications systems, network encryptors and radios.



Custom development is time-consuming and expensive

Due to their sovereign responsibilities, government agencies and armed forces must satisfy extremely demanding security requirements. Such institutions are obligated to use approved high-security products to protect classified information according to the classification level. Suppliers of these solutions custom-develop the equipment to conform to the required security level. Such products have a very extensive list of integral requirements that encompasses the development processes as well as functionality and long-term availability (see box).

Another problem is that attack methods are continually evolving. Equipment considered secure today can potentially become a security risk in the future. In the worst case, the equipment could lose its approval, necessitating costly updating or replacement.

Network technology is also rapidly evolving, and embedded security solutions are not always able to keep pace. In a high-security environment, it can be very time-consuming and expensive to update operating systems, deploy faster Internet connections and integrate additional sites into networks.

An innovative, scalable platform architecture made in Germany

Highest reliability and future viability were top priorities for Rohde & Schwarz SIT GmbH when the company began developing its new encryption platform. A new approach was needed to be able to offer reliable and secure encryption solutions in the future. The idea was not to weigh the advantages and disadvantages of known standard and custom solutions, but to combine the benefits of both.

This approach led to an entirely new solution that allows encryption products to be derived from a scalable hardware and software architecture by combining individual modules (see figure). The actual application determines what encryption strengths, network protocols and transmission rates are required. Despite their different applications and housing, new military crypto devices, network solutions for data centers and compact desktop devices for everyday office use are all supported by the platform's underlying technology.

Another innovation is the software defined encryption. Devices are provided with the necessary cryptographic applications and interfaces as a function of the application and network protocols (e. g. Ethernet, IPsec, SCIP, VoIP).

This approach – unique among commercial encryption solutions – has many advantages. Development cycles are shorter and production is more efficient thanks to synergistic effects.

Requirements for high-security solutions

- A product's security functions must be based on a comprehensive analysis of the relevant threats and weaknesses. Implementation requires a combination of software components and reliable hardware.
- Red / black separation is another essential characteristic of high-security products. The secret plain-text data (red) must not come in contact with the encrypted data (black). The only physical link is the crypto module used for encryption and decryption. Both the hardware and the software must strictly adhere to this concept.
- Additional physical security mechanisms include methods of preventing compromising RF leakage and also protection against unauthorized opening of the devices – for example, by automatically erasing the data memory.
- It is critical to ensure that cryptographic processes use true random numbers and do not generate only quasi-random keys.
- Devices for military applications must additionally be able to withstand challenging combat conditions on land, on water and in the air.
- Suppliers of high-security products must ensure that development and production take place exclusively in secure facilities and that all personnel have the relevant security clearances.

Users benefit from faster access to technological advances without any security compromises.

Rohde & Schwarz is clearly on the right track with this solution. At CeBIT 2014, the first network encryption device based on this platform concept was presented to the public: the R&S®SITLine ETH40G, which is optimized for data center applications. This encryptor achieves a data throughput that is currently unrivaled worldwide (see page 60).

Christian Reschke

World's fastest Ethernet encryptor ensures security without data bottlenecks

The R&S®SITLine ETH40G, the world's first Ethernet encryptor to achieve 40 Gbit/s data throughput, provides secure realtime data transmission. With only 3 µs encryption latency, the encryptor is ideal for use in data centers and for video conferences, reliably protecting the transmitted data against espionage and manipulation.

The Big Data challenge

For companies and government authorities alike, the efficient use of huge data volumes (big data) is an issue that impacts competitiveness and entails major challenges. When transmitting big data, it is especially important that proper security is ensured without causing performance bottlenecks. A unique solution to this problem is now available from Rohde & Schwarz SIT GmbH: the R&S®SITLine ETH40G (Fig. 1). This Ethernet encryptor combines data security with top speed. It is the first in the world to support 40 Gbit/s data throughput.

Extremely high-speed encryption

The R&S®SITLine ETH40G was developed specifically to support realtime, encrypted data transmission. The encryptor extends the R&S®SITLine ETH product line (see box on page 62) and is based on the new, universal platform architecture developed by Rohde & Schwarz SIT GmbH (page 58). It is the first encryptor to optimize the performance-critical characteristics of bandwidth, latency, quality of service, port density and energy consumption in a single box. Encryption is implemented on the data link layer (layer 2), which offers additional benefits. Security overhead is reduced by up to 40 percent compared to IP encryption (layer 3), saving bandwidth (Fig. 2). The IP configuration of the network to be protected is not impacted, which can significantly reduce the workload for IT departments.

Ethernet encryption vs. IPsec encryption

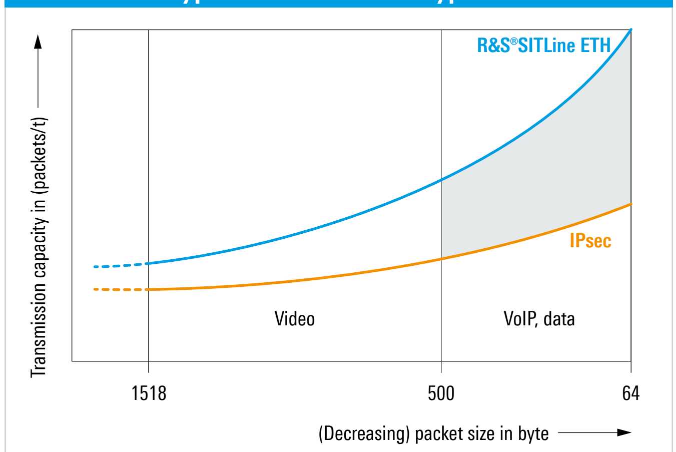


Fig. 2: Transmission performance of Ethernet encryption (layer 2) vs. IPsec encryption (layer 3). Using the R&S®SITLine ETH for encryption has clear benefits, especially for applications with small packet sizes.

This new encryptor class is especially ideal for data center operators and users, for use in backbone networks and for interconnecting sites within organizations. It offers protection in public and private networks without performance compromises for users (Fig. 3).

Fig. 1: Taking up just one height unit in a rack, the R&S®SITLine ETH40G performs low-latency encryption of up to four 10 Gigabit Ethernet lines.

Automatic setup and operation of secure links

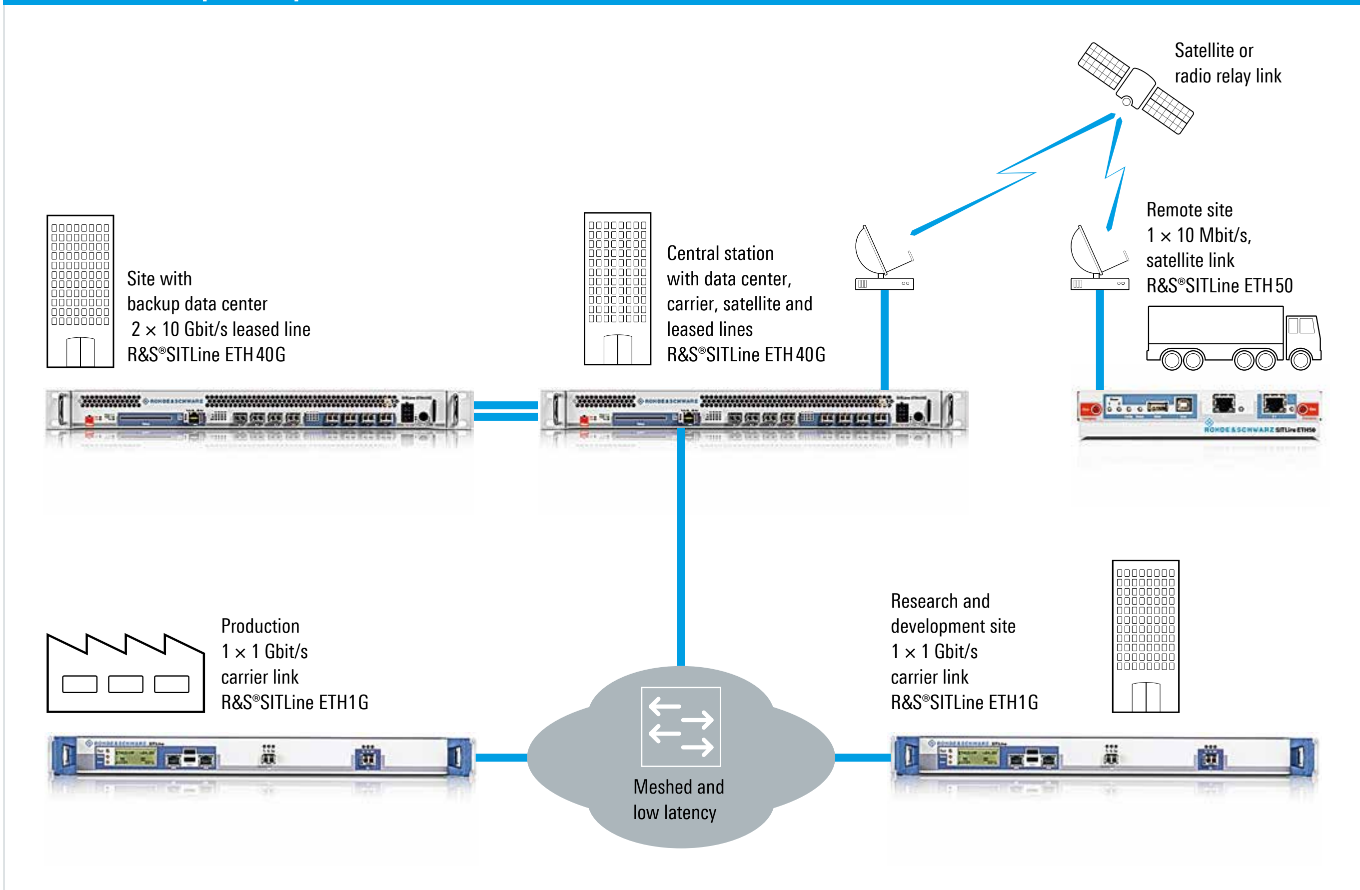


Fig. 3: The R&S®SITLine ETH is preconfigured before it is sent to the operating site. On startup, it automatically sets up encrypted layer 2 links via Fast Ethernet, 1 Gigabit Ethernet and 10 Gigabit Ethernet. The same applies to backup devices.

Hitachi Data Systems relies on encryption solutions from Rohde & Schwarz SIT GmbH

Hitachi Data Systems Deutschland GmbH, a subsidiary of the international electrical and mechanical engineering group Hitachi Ltd. (TSE: 6501), offers its network attached storage (NAS) systems together with R&S®SITLine ETH Ethernet encryptors (Fig. 4). As a result, data can be stored in encrypted format and also transmitted securely. The NAS system provides central storage capacity for unstructured data such as media files, Office files and e-mails. The Ethernet encryption that is used also saves resources. It generates up to 40 percent less additional data volume compared to other IP-based encryption solutions. In critical applications such as georedundant data center mirroring, the storage area network protocols benefit especially from the remarkable realtime characteristics of Rohde & Schwarz encryptors. Each data packet spends only 3 microseconds in the R&S®SITLine ETH 40G for secure encryption or decryption – in practice a barely measurable latency.

Fig. 4: Network attached storage from Hitachi with the R&S®SITLine ETH 40G.

R&S®SITLine ETH Ethernet encryptors – a comprehensive product range

Besides the flagship, the R&S®SITLine ETH40G, the product range includes a number of other devices with bandwidths starting at 25 Mbit/s. These encryption devices make it easy to safeguard data communications. Except for the security parameters, no network-specific configuration steps are required. The devices can be easily integrated into existing IT systems because security management and network management are separate and discrete. There is no need to adapt the network infrastructure, which can be a time-consuming process. The R&S®SITLine ETH encryptors are ideal for more than just point-to-point connections, however. Their innovative group encryption can also be used to safeguard transmissions in fully meshed switched networks. As a result, companies can safely distribute storage solutions to multiple geographically remote sites. It makes no difference whether the networks are implemented using private or public lines nor which data protection jurisdictions the lines pass through. Another benefit is that the encryptors operate fully autonomously since they perform mutual authentication without a central key server. These self-configuring crypto connections ensure maximum availability of the security network.

In addition to protecting internal data against attacks, companies also need to worry about theft of personal customer data and payment information due to the significant legal risks involved. The R&S®SITLine ETH encryptors provide effective protection in this area as well. Companies and governmental organizations have to be able to rely on the devices they use, especially when handling sensitive data. The network encryptors from Rohde&Schwarz SIT GmbH have been approved by the German Federal Office for Information Security (BSI) for handling data classified as RESTRICTED and NATO RESTRICTED. Rohde&Schwarz SIT GmbH, a 100 % subsidiary of the family-run Rohde&Schwarz electronics group, develops and produces its products in Germany. Customers can rely on the high German data protection standards – a significant advantage, especially when using encryption equipment.

For details on these products, visit **www.sit.rohde-schwarz.com**

Powerful encryption combined with conservative energy use

Strong algorithms are needed to reliably protect data transmission. For each data connection to be secured, a unique set of keys is generated and replaced at frequent intervals. The security keys are based on true random numbers generated by a hardware-based random number generator certified in line with the Common Criteria evaluation assurance level 5 (EAL5).

Advanced elliptic curve cryptography (Diffie-Hellman key exchange method) is used for mutual authentication between devices. Symmetric algorithms with a high key length in line with the Advanced Encryption Standard 256 are used to encrypt the transmitted data.

The advanced electronic components used in Rohde&Schwarz T&M products ensure top efficiency, and purchasing synergies keep production costs low. The efficiency positively impacts power consumption. Despite the high processing power required for broadband encryption, the R&S®SITLine ETH40G consumes only 100 W, making its power dissipation negligible when planning data centers.

Another important consideration for applications in data centers is extremely high availability. The R&S®SITLine ETH40G is optimized in this aspect as well. Parallel encryption lines and hot-swappable wear-and-tear parts (e.g. fans and power supply) ensure 99.9941 % availability – or theoretically a maximum of 31 minutes of downtime and maintenance time per year. In practice, even better values can be achieved. R&S®SITLine products with bandwidths up to 1 Gbit/s have been in continuous operation at Rohde&Schwarz since 2011 – with 100 % availability.

Christian Reschke

Recording, analyzing and documenting signals using a single receiver

A new option for the R&S®ESMD wideband monitoring receiver offers a wide range of opportunities for detecting, analyzing and documenting signals – without requiring the functions of a full radiomonitoring system.

The R&S®ESMD as an efficient small system

The R&S®ESMD wideband monitoring receiver (Fig. 1) is used as one of the main components in many large radiomonitoring systems where it functions as a fast search receiver or an I/Q data source. In networked systems, the receiver has a passive role and is controlled by system software. The new R&S®ESMD-RR record and replay option for I/Q data makes it possible to record and replay I/Q data directly in the R&S®ESMD, eliminating the need for a full radiomonitoring system. The R&S®ESMD is transformed into a small signal interception and analysis system with excellent mobility and flexibility.

Fig. 1: The R&S®ESMD wideband monitoring receiver operates in the frequency range from 8 kHz to 26.5 GHz and features a realtime bandwidth of 80 MHz. It is one of the most versatile and powerful instruments currently available on the market. For more information on the receiver, visit the Rohde & Schwarz website (search term: ESMD), where you can also find four videos:
www.rohde-schwarz.com/news211/02
www.rohde-schwarz.com/news211/03
www.rohde-schwarz.com/news211/04
www.rohde-schwarz.com/news211/05.

Bandwidth	Maximum record length
2 MHz	approx. 2.5 min
10 MHz	approx. 42 s
40 MHz	approx. 10 s
80 MHz	approx. 5 s

Fig. 2: Maximum recording capacity of the R&S®ESMD internal memory.

Recording I/Q data in the receiver's memory

In combination with the new R&S®ESMD-RR option, the R&S®ESMD records I/Q data up to the full 80 MHz bandwidth and stores it in the internal memory. The maximum record length with the largest bandwidth is approx. five seconds (Fig. 2).

The memory functions as a ring buffer with a record length that can be defined by the user prior to recording. When the recording is started, the receiver begins to write the I/Q data into the ring buffer. One of three stop conditions must be selected in order to end recording. The receiver continuously overwrites the ring buffer until the chosen condition occurs. The following conditions are available:

- MANUAL: The user waits during recording until the relevant event occurs and presses the stop key to end recording and save the event in the memory.
- BUFFER FULL: The receiver fills the previously defined ring buffer only a single time. It stops recording as soon as the buffer is full.
- TRIGGER: Recording stops when the realtime event capture (REC) defined by the user is triggered.

If the MANUAL condition is selected, the success of the recording depends on the user's alertness. The user must monitor the signals in the spectrum and stop recording at the right moment (Fig. 3). While the TRIGGER condition requires advance knowledge of the signal form or frequency, the user can capture any signal if recording is terminated manually. BUFFER FULL is the ideal choice for recording a section of a continuous signal where the actual time of the recording is not relevant.

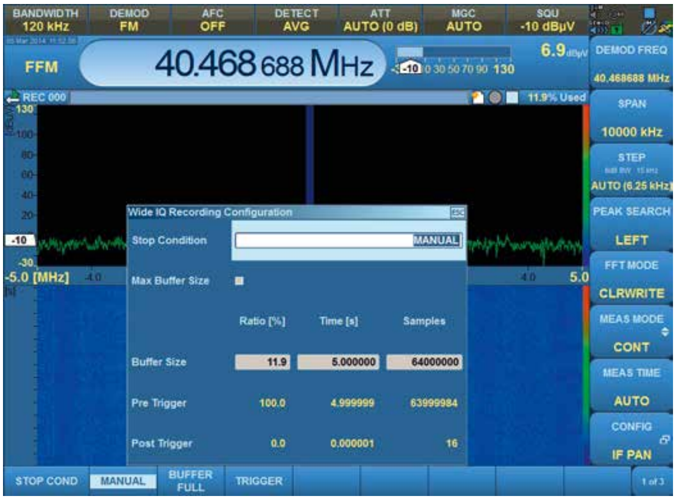


Fig. 3: In MANUAL mode, the user monitors the signals in the spectrum and stops recording at the right moment.

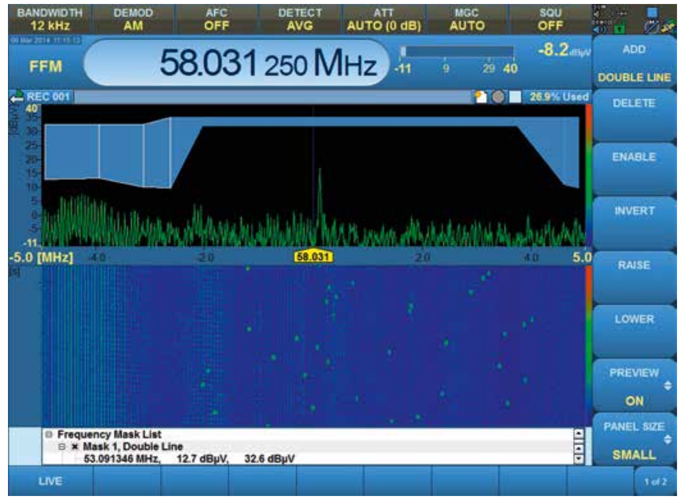


Fig. 4: Mask for triggering realtime event capture (REC) to respond to anomalies in a known signal.

Never miss an event with flexible realtime event capture

Based on the center frequency and signal form in the spectrum, the user decides whether a signal is relevant. The signal's I/Q data is necessary for further analysis. In large radiomonitoring systems, the R&S®ESMD provides the I/Q data of signals of interest for online analysis using signal analysis software. If only one R&S®ESMD is used, the I/Q data can be stored in the internal memory for manual analysis directly on the instrument or exported for subsequent automated analysis using separate software.

Rare, short-time signals are difficult to record. In order to record the I/Q data of these signals, the configurable REC function included in the R&S®ESMD-RR option can be used to stop recording in the ring buffer. Once recording is stopped, the ring buffer contains the events defined as relevant by the user. For this purpose, a mask must be edited in the live spectrum and used as a trigger to stop recording (Fig. 4).

The mask behavior is controlled by three different trigger conditions:

- Positive edge: Recording in the ring buffer is stopped if a signal enters the defined mask. This condition is ideal for rare, short-time events.
- Negative edge: The receiver stops recording in the ring buffer if a signal leaves the defined mask. This condition can be used to trigger on the disappearance of a signal, e.g. if a signal is hidden behind a pulsed signal. The signal becomes visible in the gaps between the pulses.
- Gate: This condition is recommended for recording I/Q data from voice communications. As long as a signal is in the predefined mask, the memory is filled up to a predefined length. The receiver stops recording when the data volume in the ring buffer reaches a predefined value or the signal leaves the mask. It then starts a new recording. If a signal touches the mask again, the process is repeated. The user specifies the number of individual recordings. This process is repeated until the defined number of recordings is reached or the entire memory is full. It is also possible to specify whether to bridge over speech pauses during voice communications without interrupting recording.

The pre-trigger and post-trigger time can be used to control when recording is stopped relative to the trigger event. If the pre-trigger time is set to 100 % (always specified as a percentage), the receiver immediately stops recording when the trigger event occurs, and all I/Q data captured prior to the occurrence of the event is stored in the internal memory. If the pre-trigger time is set to 50 %, the trigger event is located in the middle of the recording. As a result, recording continues after the trigger event for half of the record length. The user defines which I/Q data is important relative to the trigger event.

In-memory processing of I/Q data

In mobile applications without access to large radiomonitoring systems, the R&S®ESMD can be used to replay stored I/Q data for manual analysis. The I/Q data can also be

Fig. 5: Use of digital downconverters for replaying I/Q data.

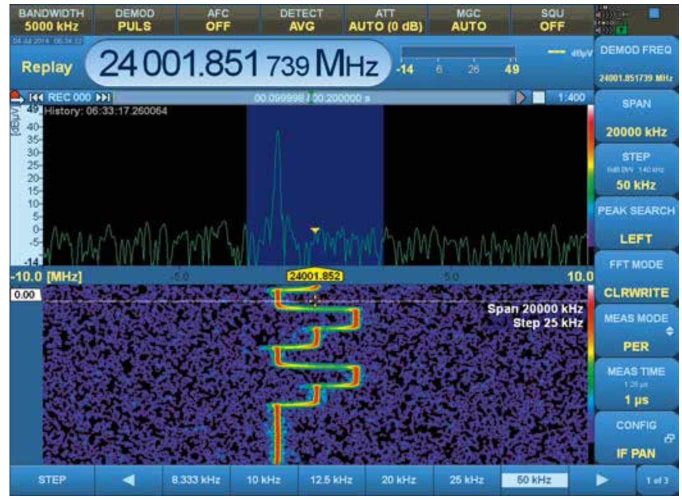


Fig. 6: View of an FSK radar signal with high time resolution.

exported to external storage media for subsequent analysis (e.g. using signal analysis software or another R&S®ESMD).

Realtime replay – signals as received from an antenna

All of the signal information the receiver provides during live operation is saved in the I/Q data, including GPS data, frontend gain and attenuation settings, and a high-accuracy timestamp. As a result, signal scenarios can be reconstructed with the correct level, time and location information.

Recorded I/Q data is forwarded for replay to the R&S®ESMD internal signal processing stage just like live signals present at the antenna input. All receiver functions are available, including demodulation of analog modulated signals and setting of digital downconverters (Fig. 5). The user sets all parameters as if the receiver were in live mode. All changes are immediately adopted without additional calculation time and the updated data is displayed in realtime. I/Q data replay is limited only by the recording bandwidth and time limits.

Detailed display

The advantage of replaying I/Q data from the receiver's internal memory compared to signal processing in live mode is especially apparent when analyzing digital signals, radar pulses and short-time emissions. When analyzing these signals, users are interested in the time behavior of the signal. The receiver calculates a large number of spectra that must be combined in live mode prior to display. Combining the spectra in the MAXIMUM FFT mode makes it possible to detect even extremely short pulses but details about the signal time behavior might be lost.

When replaying I/Q data, the time resolution in the waterfall diagram can be increased as far as the nanosecond range per line. The R&S®ESMD is therefore able to display even very short events with high resolution and provide a detailed overview of the spectral signal characteristics not possible in live mode (Fig. 6). Using time and frequency markers, the signal characteristics of known and unknown signals can be analyzed, leaving no details undetected.

Summary

The R&S®ESMD-RR record and replay option for I/Q data makes it easy to search within known signals and detect and analyze unknown signals. Equipped with this option, the R&S®ESMD provides a wide range of opportunities for detecting, analyzing and documenting signals – without requiring the functions of a large radiomonitoring system.

Benjamin Bulach

Professor Dr. Ulrich L. Rohde

Professor Rohde receives C.B. Sawyer Memorial Award

The IEEE IFCS nomination committee has conferred the 2014 C.B. Sawyer Memorial Award on Prof. Dr.-Ing. habil. Dr. h. c. mult. Ulrich L. Rohde. Professor Rohde accepted the prize at the IEEE International Frequency Control Symposium in Taipei in May 2014. The Award recognizes entrepreneurship in the field of RF engineering and individuals who have made an outstanding contribution to the development, production or characterization of resonator materials or structures. Professor Rohde received the prize primarily for PC software that makes it possible to analyze the nonlinear noise characteristics of RF circuits. It was also granted in recognition of his founding of Synergy Microwave Corp, USA, a company that develops and produces highly powerful, extremely low-noise oscillators, RF components and subsystems.

World's fastest Ethernet encryption device premiers at CeBIT

Trade fair visitors and journalists were not the only ones interested in SIT. Pictured here is German Federal Interior Minister Thomas de Maizière (right) speaking with Winfried Wirth, President of Rohde & Schwarz SIT.

Rohde & Schwarz SIT GmbH presented its new flagship of the R&S®SITLine product family at CeBIT 2014. The R&S®ETH 40G was especially designed for realtime encrypted exchange of massive amounts of data (see page 60). German Federal Interior Minister Dr. Thomas de Maizière joined those showing interest in big data encryption when he visited the Rohde & Schwarz booth. Also on display was the R&S®TopSec office gateway – a technology that provides tap-proof fixed-network phone connections for internal company communications.

First crypto day debuts at Rohde & Schwarz France

Rohde & Schwarz France held an in-house cryptology trade fair for the defense sector in March 2014. Around 40 guests from the French Defense Ministry and Army traveled to Meudon-la-Forêt to learn about the development of SIT encryption devices for government purposes. The presentation of the scalable encryption platform, a Rohde & Schwarz SIT GmbH development (see page 58), generated great interest as well. Future military crypto equipment is expected to benefit from this new modular platform concept that adapts crypto applications to requirements using software defined encryption and highly secure update mechanisms. The platform will make it possible to more quickly fill capability gaps in highly secure and interoperable encryption. Following the successful premiere in France, similar in-house trade fairs will be held in other countries in the near future.

Radio communication tester gifted to university in Hong Kong

Rohde & Schwarz Hong Kong has donated an R&S®CMU 200 universal radio communication tester to the Hong Kong University of Science and Technology (HKUST). The instrument will be used for teaching and research activities in the university's wireless communications and integrated circuits lab. One of the region's renowned universities in the wireless R&D field, HKUST focuses on MIMO antennas, advanced wireless communications, millimeter-wave technology and IC design. Rohde & Schwarz Hong Kong and HKUST have cooperated closely for several years. The company has provided the university with test equipment on multiple occasions and sponsored its wireless lab since 2007. HKUST graduates work at Rohde & Schwarz as well as major local customers such as ASTRI and Innofidei.

The official transfer ceremony (left to right): Rohde & Schwarz Hong Kong Managing Director Frank Wong; HKUST Prof. Amine Bermak; Heino Gregorek, Head of Rohde & Schwarz Regional Development for Asia Middle; HKUST Prof. Danny Tsang; HKUST Prof. Patrick Yue.

Audio broadcasting technology trends

The Rohde & Schwarz transmitter subdivision conducted the fourth workshop of the Technology Trends in Terrestrial Broadcasting series in February 2014. The event was held at the Teisnach plant and focused on audio broadcasting. In addition to transmitters, the subdivision presented other products including test and measurement equipment and a network management system. Network operators made up the bulk of the workshop's 20 attendees from eight countries. They learned about Rohde & Schwarz audio broadcasting products and had an opportunity to personally test them. Guest lectures included a presentation by the Fraunhofer Institute on the value-added services of the DAB standard. Network operator Media Broadcast reported on the installation of the DAB network in Germany. The workshop is held once a year and has become well established with Rohde & Schwarz customers.

Teisnach plant receives Bavarian Quality Award

The Rohde & Schwarz plant in Teisnach received the 2014 Bavarian Quality Award – an honor established by the Bavarian State Ministry of Economic Affairs, Infrastructure, Transport and Technology in 1993. This year, 37 Bavarian companies took part in the competition. The Teisnach plant's consistent focusing on of quality, flexibility and efficiency was crucial to its selection as the winner. The jury was also persuaded by the plant's continual technological development and extensive manufacturing depth.

Award ceremony at the Munich Residenz (left to right): Prof. Dr. Horst Wildemann, Jury Chairman; Johann Kraus, Teisnach Plant Manager; Gerhard Kokott, Head of Decentralized Quality Management in Teisnach; Hartmut Penning, Director of Corporate Quality and Environmental Management; Emilia Müller, State Minister; Dr. Dirk-Eric Loebermann, Executive Vice President of Production and Materials.

Awards at NAB

The technical journals Radio Magazine and Radio World have given NewBay Media's Best of Show Award to the R&S®THR9 FM transmitter family. These high-power transmitters feature energy efficiency values as high as 75 %. The winner of the award is selected by a group of specialized engineers at NAB. Their primary determination criteria are innovative value, functional details, price / performance ratio and applicability for the industry.

The Post Magazine jury at NAB 2014 found the SpycerBox Cell from Rohde & Schwarz DVS GmbH worthy of recognition and honored the product with a special mention. The SpycerBox Cell was developed to store immense amounts of data in 4K production environments and can process data in HD, 4K or higher resolutions depending on how they are used in TV and post production workflows.

First location successes with Rohde & Schwarz radiomonitoring system in Paraguay

Rohde & Schwarz implemented the third phase of a nationwide radiomonitoring project for Paraguayan regulatory authority Conatel in February 2014. The authority carries out national regulatory activities in the field of frequency management and monitoring. Even during the startup and training phase, it managed to locate three pirate transmitters. Rohde & Schwarz partner Promec installed the system on site. The contract included a central office with five workstations. There are also four vehicle-based mobile units and three transportable units. The integrated R&S®ARGUS monitoring software uses the units to locate transmitters via triangulation. The units communicate with each other via UMTS / LTE and a mesh network. The system consists of digital radio direction finders, monitoring receivers, direction finding antennas and monitoring antennas from Rohde & Schwarz.

Representatives of Conatel, Promec and Rohde & Schwarz during final acceptance of the radiomonitoring system in Paraguay.