NEWS

213/15

ROHDE&SCHWARZ

Invasion of radars

Until recently, radar systems were a niche technology for the military, meteorology and air and sea navigation. Now they have conquered the wide-base market as indispensable components of automotive engineering.

Wireless technologies

Easy characterization of complex smartphone frontends

Broadcast and media

DOCSIS 3.1 standard speeds up cable networks

Radiomonitoring / radiolocation

Virtual control centers revolutionize air traffic control

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

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NEWS

Published by
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Chief editor: Volker Bach, Rohde&Schwarz
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English translation: Dept. GF-MC7
Photos: Rohde&Schwarz
Printed in Germany
Volume 55
Circulation (German, English, French, Spanish and Japanese) 75000
approx. three times a year
ISSN 0028-9108
Supply free of charge through your nearest
Rohde&Schwarz representative

PD 3606.9627.72

Cover feature

For an innovation to become a widely marketable product, all of its key components must reach a certain degree of maturity and be available in sufficient volume at a reasonable cost. Without the fortunate convergence of the development of flat panel displays, electronic memories, batteries as well as sensor and communications technologies, the smartphone could not have taken shape or begun its unprecedented victory march. There are parallels in the electronization of automobiles. Initially, only individual subsystems were electronically upgraded, starting with the drivetrain. Now all components are networked via electronic control units and on-board computers thanks to miniaturization, digitization and more affordable high-performance electronics. New components are continuously being added to this complex meshwork as engineers seek to implement additional features for convenience and safety. As a result, formerly exotic technologies such as radar are now being used on a massive scale – and even for security-critical tasks, which is why these technologies must meet the highest reliability requirements. But as is nearly always the case when it comes to high frequencies, the Rohde&Schwarz portfolio features the problem-solving T&M equipment – products such as the ARTS9510 automotive radar target simulator, which can eliminate the need for a large number of costly drive tests. Even the "full-fledged" radars that normally come to mind when this term is used are not left out. Special software analyzes their signals for all key criteria, making it possible to continue optimizing these systems in a focused manner. All articles on this topic can be found starting on page 30.

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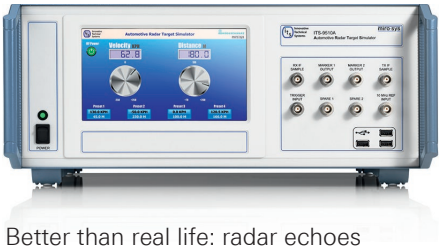
ARTS9510 automotive radar target simulator



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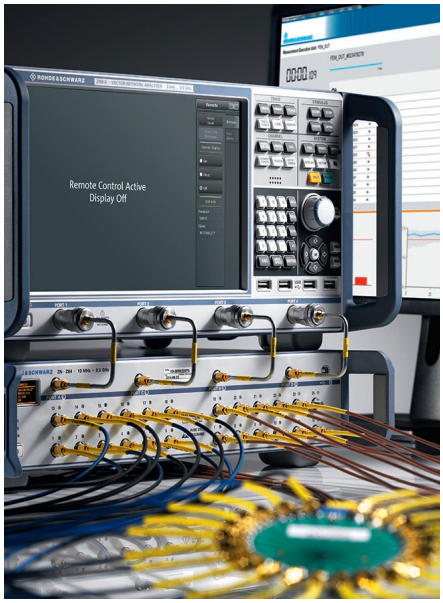
With its MIPI® RFFE interface, the R&S®ZNB network analyzer can address frontend modules directly from the firmware (page 22).



For the third consecutive year, Rohde & Schwarz DVS GmbH supported the Berlinale with technical equipment (page 46).

Photo: Jan Windszus / Berlinale

A unique cloud solution is helping ATC authorities tackle the current structural changes (page 54).

Targeted primarily at regulatory authorities: the compact R&S®AU600 active omnidirectional receiving antenna system with a frequency range from 20 MHz to 8 GHz (page 60).

About as small as it gets: new network scanner for walk and drive tests

Most data traffic in mobile networks is generated indoors. Which is why network operators, infrastructure manufacturers and network service providers need ultracompact test solutions that can be conveniently employed by technicians walking around critical indoor areas, such as airports, train stations and trains. The test and measurement equipment must also be capable of handling the multistandard / multiband scenarios that are rapidly developing in the wireless world. The R&S®TSMA network scanner fits the bill exactly. It is the first scanner to feature an integrated Windows PC and it only has to be connected to a QualiPoc test smartphone from SwissQual and / or to a tablet to create a complete walk and drive test system. The connection is made over Bluetooth®. QualiPoc permits comprehensive voice and data analyses in all standards and bands, supplemented with RF information supplied by the scanner. Even more detailed coverage measurements, especially those for optimizing LTE networks, are possible with the R&S®ROMES4 drive test software that can be installed on the R&S®TSMA and remotely controlled from an Android, Apple or Windows tablet.

Carrier aggregation tests in LTE bands for different duplex modes

The only good substitution for bandwidth is even more bandwidth. This is why 3GPP Rel. 10 (LTE-Advanced) includes the possibility of aggregating up to five frequency bands (component carriers) – not necessarily even adjacent to one another – into a single channel with a maximum bandwidth of 100 MHz. Even though there are not yet any real networks utilizing this option, the mobile communications industry must be proactive in running standard-compliant tests on network components and UEs currently in development. At this year's Mobile World Congress, Rohde&Schwarz was not only the first to offer a MIMO test solution for four aggregated component carriers, but also the first to permit operation of the aggregated cells in different duplex modes using the TDD/FDD joint operation test functionality (3GPP Rel. 12). Network operators often have spectra in various frequency bands, which they exploit in TDD or FDD mode depending on conditions. TDD/FDD joint operation enables them to combine FDD and TDD cells for more flexible spectrum management. The carrier aggregation test functionality is available for both the R&S®CMW500 RF tester and the R&S®CMW500 protocol tester.

2 GHz analysis bandwidth with an eye to 5G

The fifth generation of wireless communications is still in the initial phases of development and far from being ready for standardization of any kind. However, in the foreseeable future, current technologies will no longer be sufficient to handle the scenarios of the next decade. The Internet of Things will multiply the number of objects with network access. At the same time, technical requirements will extend to extreme data rates and ultrafast response times on the one hand and very slow, power-saving communications on the other. Discussions about possible 5G solutions meticulously cover every possible technical aspect, but generally speaking they propose much more bandwidth than current systems – up to 2 GHz. This is possible only in the higher microwave regions, such as the 28 GHz, 60 GHz and 73 GHz bands that are currently being investigated for suitability. The R&S®FSW signal and spectrum analyzer with 2 GHz analysis bandwidth and input frequencies up to 85 GHz is the right tool for these investigations. An R&S®RTO1044 oscilloscope serves as the A/D converter that digitizes the analyzer's high initial IF. The signal transmitted back via LAN is processed by the analyzer and mixed into the digital baseband, where it can be extensively analyzed.

Testing the eCall and ERA-Glonass in-vehicle emergency call systems for compliance with the latest specifications

The launch date for eCall, the European Union's in-vehicle emergency call system, has finally been set. Starting in April 2018, eCall will be required in all new car models. Russia is even further along. Since January of this year, all new import models must be equipped with the local ERA-Glonass system, which operates in a similar manner. Because automobile manufacturers and suppliers usually have to test both systems, it makes sense to use the same setup to perform all tests. An ideal setup is the R&S®CMW500 (for mobile network simulation), the R&S®SMBV100A (for GNSS simulation) and the R&S®CMW-KA09x system software. The current version of the software includes the latest requirements in line with EN 15722 (eCall) and GOST (ERA-Glonass), i.e. a revised version of the minimum set of data (MSD) for eCall, plus tests for external audio components, WCDMA support, security settings for SIM cards and handling of SMS text messages for ERA-Glonass. Electronic devices that need to be certified for the Russian market in line with this standard must be submitted for testing to the Certification Center Svyaz-Certificate in Moscow – which uses the Rohde&Schwarz solution to perform the tests.

When slower is better: signal generation for testing chip designs

Each new generation of T&M equipment performs better than the equipment it replaces. But being too fast can also cause problems. For example, when testing RF chip designs in an early stage – before the chip hardware is even available – i.e. when testing must be performed on a software model in a design and verification system. To test the design in a realistic environment, authentic I/Q data of a complex mobile communications signal should be used, such as can be generated by an advanced signal generator like the R&S®SMW200A. However, the simulator does not even come close to the speed of chip hardware and is therefore overwhelmed by the high data rate at the generator's digital I/Q output. This is where the new R&S®SMW-K551 option can help: its purpose is to slow down the R&S®SMW200A. The simulator sets the desired speed – synchronous, asynchronous or even down to a complete stop. The setting applies to all generator functions, including MIMO, fading and the addition of noise. Chip manufacturers can use the same instruments and data to perform all tests, from the software model to prototype to mass production.

IP probe assists network operators when analyzing data traffic

Data networks are intended to transport user data without distinguishing between types so as to ensure a consistently high quality of service, regardless of whether dealing with email, a voice over IP call or a video stream. However, because the performance requirements differ widely for these services, network operators want to know exactly who is using their network and for what purpose so that they can precisely tailor their capacities and other business decisions to match. Typical questions are: What percentage of the network traffic is taken up by video data? What was the traffic profile at a specific time when a large number of users complained about a poor data rate? Will it be enough to expand the network capacity, or are additional investments needed in traffic management? Or perhaps: Are the owners of a certain type of UE especially big social media users? Or even: How do specific consumer groups react to marketing campaigns? These types of questions cannot be answered just using the information from the IP headers, but rather require reliable data classification. This is possible with the new R&S®Net Sensor. It recognizes the 2000 most used protocols and applications in the world, across all network layers. Analysis and clear data presentation – offline or in real time – is provided by the R&S®Net Reporter. The R&S®Net Sensor is suitable for all IP-based fixed and mobile networks.

Vector-modulated signals for applications up to 40 GHz

Telecommunications and radar are encroaching in ever higher frequency ranges, where they require the same advanced signal generation options as are typically associated with lower frequencies. The microwave models of the R&S®SMW200A vector signal generator up to 12.75 GHz, 20 GHz, 31.8 GHz or 40 GHz meet these needs. Whereas in the past, microwave users often had to accept compromises in terms of RF performance and operability as well as deal with error-prone, multi-instrument setups, the R&S®SMW200A now provides most complex signals of the highest quality out of the box. The applications are diverse. Radio relay link and satellite technology use high-quality modulation modes such as 1024QAM that require a modulation quality on par with that offered by the R&S®SMW200A. Radars work with modulated pulses or CW signals as well as phase-controlled antenna arrays – a productive environment for the R&S®SMW200A, especially when combined with the new R&S®SMx-K3x pulse sequencer software and upgraded to the maximum of four phase-coherent paths using external R&S®SGS100A / SGU100A generators (figure). Last but not least, the R&S®SMW200A now also covers frequency ranges that are the focus of 5G mobile radio development, facilitating the identification of suitable technologies.

Now frequencies under 1 GHz for the R&S®BBA150 broadband amplifier family

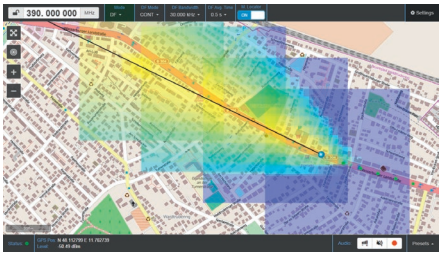
The power amplifiers in the R&S®BBA family have in recent years made the amplifier know-how of Rohde&Schwarz – gained through many years of experience in building broadcast transmitters – available for other applications, in particular EMS measurements, but also for product validation tests and quality assurance tests. New amplifier modules from 9 kHz to 250 MHz and from 80 MHz to 1 GHz for the R&S®BBA150 platform round out the offering, providing a finely scaled program up to 6 GHz. In both new frequency ranges, the amplifiers are available with output power levels from 70 W to 2.5 kW. One of the strengths of the R&S®BBA system is its flexibility. For example, different frequency and power ranges can be accommodated in the same housing and / or rack. Additional system components are not needed because the controller, switch matrix, sample ports and interlocks are built in.
The R&S®EMC32 EMC measurement software can be used to integrate the R&S®BBA systems transparently and easily into an EMC test center.

Preconfigured all-in-one system simplifies the setup of EMS/EMI test systems

Setting up an EMI/EMS test system – regardless of scope – is associated with high costs and effort, starting with initial planning and design and extending to installation, configuration and calibration of the instruments and other components. The standardized R&S®CEMS100 test platform simplifies and reduces the time required for this process. Composed of proven system components that are harmonized to work together, e.g. signal generators, switching units, broadband amplifiers and EMC software, the R&S®CEMS100 is a cost-effective, off-the-shelf solution for precompliance tests and certification up to 3 GHz (radiated EMS measurements) in line with IEC/EN 61000-4-3. Adding a test receiver permits automated EMI measurements up to 6 GHz without even changing antennas. This is due to the high-performance EMS/EMI hybrid antenna that covers the complete frequency range.
The system is supplied fully tested, calibrated and preconfigured to the extent possible without a test chamber. Supplemental upgrades, e.g. for testing conducted disturbance, are easily accomplished.

Measuring up to ten DME ground stations simultaneously from the air

Ground-based distance measuring equipment (DME) remains a cornerstone of flight navigation, even in this era of satellite navigation. DME ground stations function as transponders for pulses transmitted by airplanes. The delay of the reply pulse is used to determine the (slant) distance of the airplane to the ground station. To ensure the reliability of the system, the International Civil Aviation Organisation (ICAO) mandates regular monitoring, including measurements from the air. Because flight hours are expensive, it makes sense to perform this task as efficiently as possible. This is where the R&S®EDS300 DME / pulse analyzer shows its strength. With the new R&S®EDS-K5 option, it is capable of characterizing ten DME ground stations simultaneously, with a high degree of precision and at a distance of up to 310 nautical miles (50 ms overall measurement time). In real-world terms, this means that only one test flight is needed for a reliable evaluation of all stations in range. Additional advantages of the R&S®EDS300: all-in-one instrument with built-in pulsed power transmitter (interrogator), fully suitable for measurements on TACAN stations (the military version of DME) and for DME measurements on the ground.



Automatic EMI location from motor vehicles

Manual signal location in urban areas is very time-consuming and error-prone due to the multipath propagation of signals resulting from reflection and diffraction on buildings, and requires experienced personnel. The R&S®MobileLocator software overcomes these difficulties through statistical analysis and evaluation of a series of individual bearings, obtained during the drive from a standard, easily modified automobile. The system consists of a roof antenna with magnetic mount, an R&S®DDF007 portable direction finder and a software package installed on a laptop or a powerful Windows tablet. Remote operation from any tablet with a web GUI (system software on the laptop) is also possible. The radiolocation results, which become more accurate as the drive time increases and with proximity to the target, are converted into a heat map that displays a corridor to the target along with color-coded probability zones for the target location. The final radiolocation result is then marked with a circle. To exactly locate the source of interference, a handheld antenna is connected to the portable direction finder and the source of the interference is sought out on foot, e.g. inside a building.

Cost-efficient compact receiver for outdoor radiomonitoring

With the R&S®EM100 digital compact receiver, the Rohde&Schwarz portfolio already included a versatile and economical radiomonitoring solution. After being encased in a weatherproof housing in line with IP67 and equipped with everything required for operation on a mast or in an automobile, the proven technology is now also available for rough outdoor use under model designation R&S®EM100XT. The instrument functions either as a receiver (9 kHz to 7.5 GHz) or as a direction finder (20 MHz to 6 GHz, TDOA or AOA). A remote control and analysis software application is included and can be extended as needed to manage a network of R&S®EM100XT sites or to automate tasks. Integration into an R&S®ARGUS or R&S®RAMON software environment is also seamless. The extremely compact and robust R&S®HE600 active omnidirectional receiving antenna is the ideal partner antenna for radiomonitoring tasks, while a wide range of stationary and mobile models are available for direction finding.

eMBMS application tests with the R&S®CMW500 and R&S®CMWcards

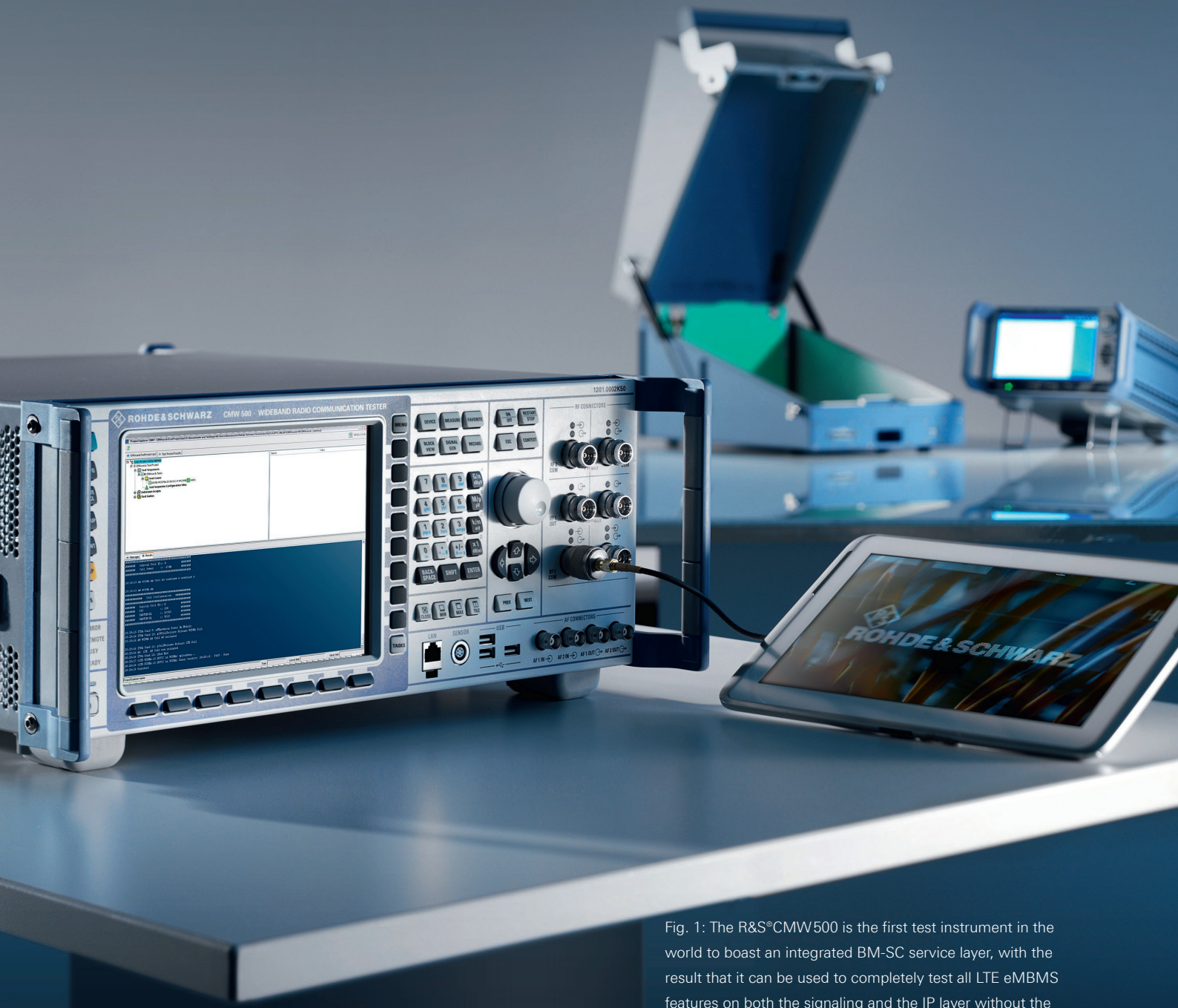


Fig. 1: The R&S®CMW500 is the first test instrument in the world to boast an integrated BM-SC service layer, with the result that it can be used to completely test all LTE eMBMS features on both the signaling and the IP layer without the need for additional test instruments.

New technical approaches are needed to address the heavy load placed on mobile networks by video on demand, video streaming and file sharing services. One solution specifically designed to broadcast video services to a large number of subscribers in LTE networks is the evolved multimedia broadcast multicast service (eMBMS).

Mobile network operators must also continually optimize their networks' air interface in order to handle the increasing data volumes resulting from services such as video broadcasting and file sharing in a spectrum-efficient and cost-effective manner and still provide good quality of service. One way to get the data glut under control is to supplement WLAN traffic offload [1] with the new eMBMS service for LTE networks (see box) standardized by 3GPP in Release 9 of the LTE specifications.

Rohde&Schwarz offers a UE test solution based on the proven R&S®CMW500 wideband radio communication tester (Fig. 1), a solution that includes all of the LTE network elements needed for comprehensive testing of the protocol layer (control plane) and eMBMS data services (IP user plane) (Fig. 2). Chipset and UE manufacturers as well as mobile communications providers can now quickly and efficiently test eMBMS devices in the lab – including eMBMS middleware and video apps.

An overview: evolved multimedia broadcast multicast service (eMBMS)

eMBMS allows mobile communications providers to broadcast the same content, such as sporting events, TV programs or films, to many users simultaneously – in the same or in different cells. This was achieved by adding new transport and logical channels to the LTE protocol stack (PMCH in the physical layer; MCH, MTCH and MCCH in layer 2), which reduces the load on conventional shared channels. At the higher protocol layers, the IP unicast protocol is replaced by the IP multicast protocol.

The LTE network architecture was also enhanced to include a broadcast multicast server (BM-SC), an MBMS gateway and a multicell coordination entity (MCE) for the cell parameters used on the logical and physical layers. To synchronously transmit the contents to all subscribers in one or more cells, MBSFN areas must be defined in which the affected cells are combined.

Many mobile communications providers are already working on implementing eMBMS in their networks. Initial field trials have been successfully completed and commercial eMBMS-based video offerings will be started in many countries this year.

eMBMS test case with R&S®CMWcards

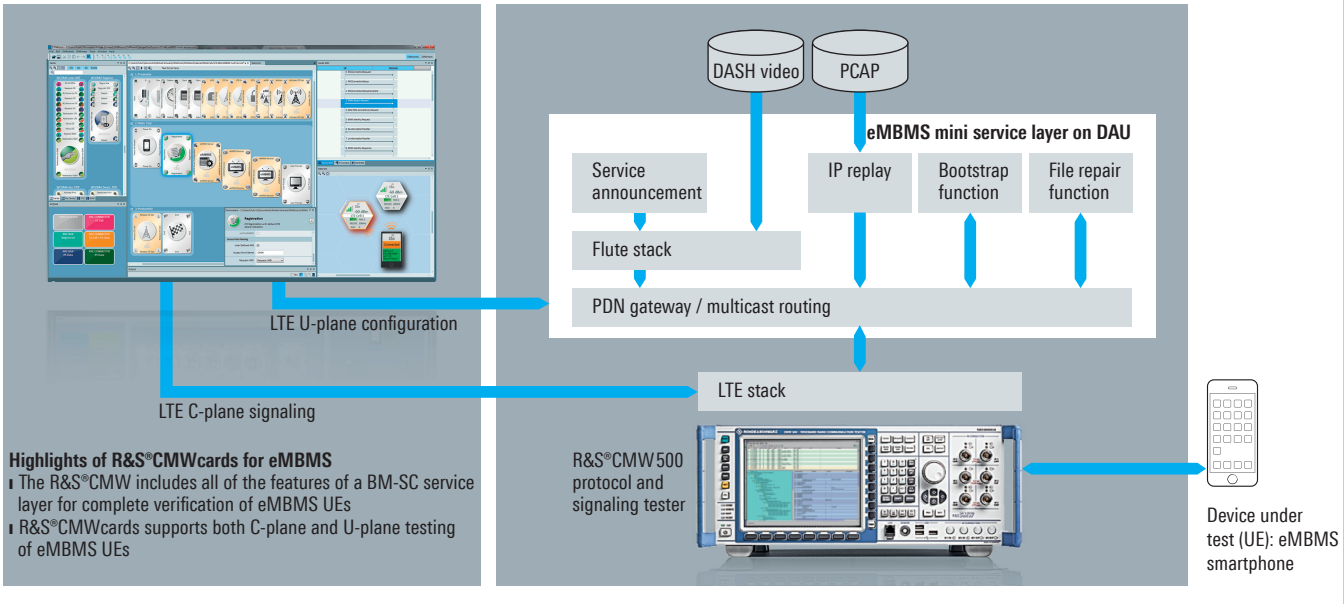


Fig. 2: The R&S®CMW500 with the R&S®CMWcards option – all you need for comprehensive eMBMS application tests.

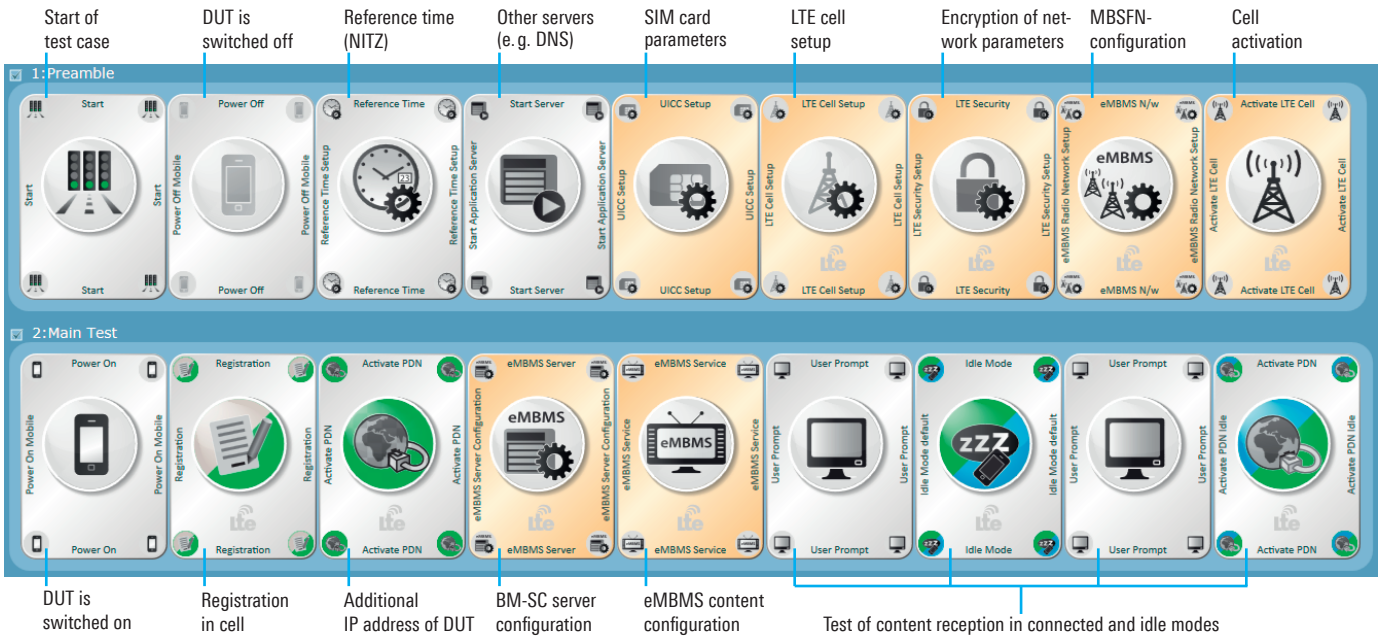


Fig. 3: R&S®CMWcards test case for eMBMS with one LTE cell.

eMBMS protocol and application tests with R&S®CMWcards

The R&S®CMWcards graphical test case development tool for the R&S®CMW500 combines the LTE, WCDMA, GSM and WLAN tests into a single application. Now it can also be used for eMBMS protocol stack and application tests. The R&S®CMW500 is the only test platform in the world to offer a specifically designed eMBMS mini service layer on the data application unit (DAU, an integrated server in the R&S®CMW500), which provides all required eMBMS services.

Based on a playing cards metaphor, R&S®CMWcards abstracts the logical flow of a test case, from configuration of the LTE cells, definition of the reference time and configuration of the eMBMS services within the BM-SC to the signaling flow for UE cell registration and subsequent data transmission.

Fig. 4: R&S®CMWmars GUI: Protocol measurement charts graphically display the downlink / uplink data rates and BLER measurements for all protocol layers over time.

Fig. 3 shows an R&S®CMWcards test case with one LTE cell. After registering on the network, the mobile device receives one or more video streams in this cell, first in connected mode and then in idle mode. The user can configure up to two MBSFN area IDs, each with up to two LTE cells. This extends the test coverage to accommodate a wide variety of eMBMS use cases, including reception during cell reselections, handover and carrier aggregation as well as fading scenarios with many different fading profiles. The MBMS interest indication and MBMS counting procedures that were added by the 3GPP LTE RRC TS 36.331 specification are offered as separate cards and can be included in any eMBMS test case.

R&S®CMWcards comes with a wide variety of LTE eMBMS signaling and application tests, allowing users to immediately put a UE into operation and use it to quickly generate additional test cases.

Visualizing eMBMS measurements in R&S®CMWmars

The R&S®CMWmars graphical message analyzer aids in troubleshooting complex message protocols. Its powerful tools graphically display signaling procedures or signaling message flows between the UE and the R&S®CMW500 wideband radio communication tester, making them easy to follow [2].

For detailed analysis of LTE and WCDMA protocol layers 1 through 3, R&S®CMWmars was enhanced to include six additional graphical tools. These new analysis views and features such as CMWmars scripting are part of the R&S®CMW-KT023 CMWmars advanced extension software option, which combines the previous R&S®CMW-KT016 and R&S®CMW-KT017 protocol test monitor options. Key features include:

- Protocol measurement charts that graphically display the downlink / uplink data rates and block error rate (BLER) measurements for all protocol layers over time (Fig. 4)
- Monitor views that show configuration data and values measured on the PHY, MAC, RLC, PDCP protocol layers for every LTE and WCDMA cell simulated by the R&S®CMW500 wideband radio communication tester (Fig. 5)
- The RRC monitor view that displays layer 3 system information and radio bearer settings

In online mode, the protocol measurement charts and monitor views are updated in realtime during a test sequence, while in offline mode they are updated after the test is completed and a message log file is loaded.

For testing signaling scenarios and IP data streams, the R&S®CMWmars advanced extension graphically displays the eMBMS-specific measured values and data rates of each eMBMS flow /radio bearer separately for every MBSFN area (Fig. 6).

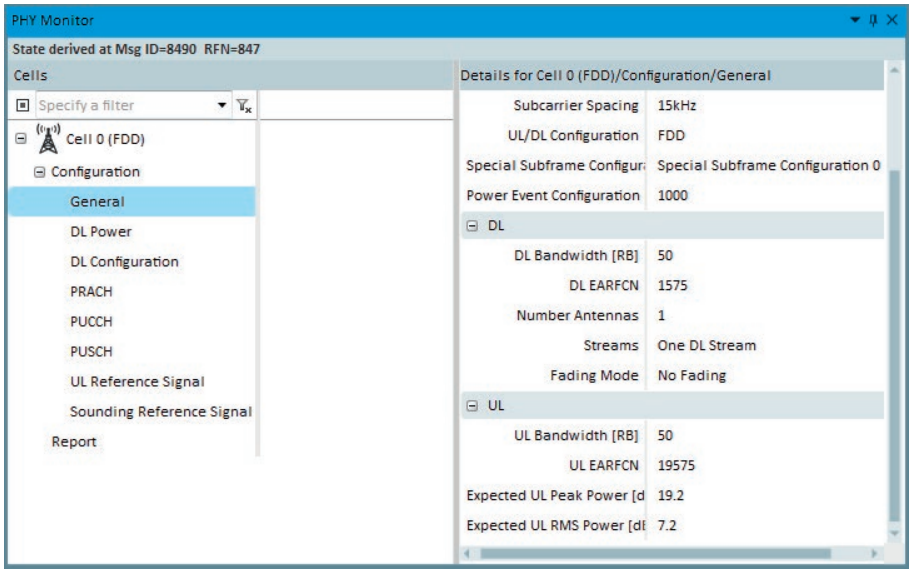


Fig. 5: Monitor views show configuration data and values measured on the PHY, MAC, RLC, PDCP protocol layers for every LTE and WCDMA cell simulated by the R&S®CMW500.

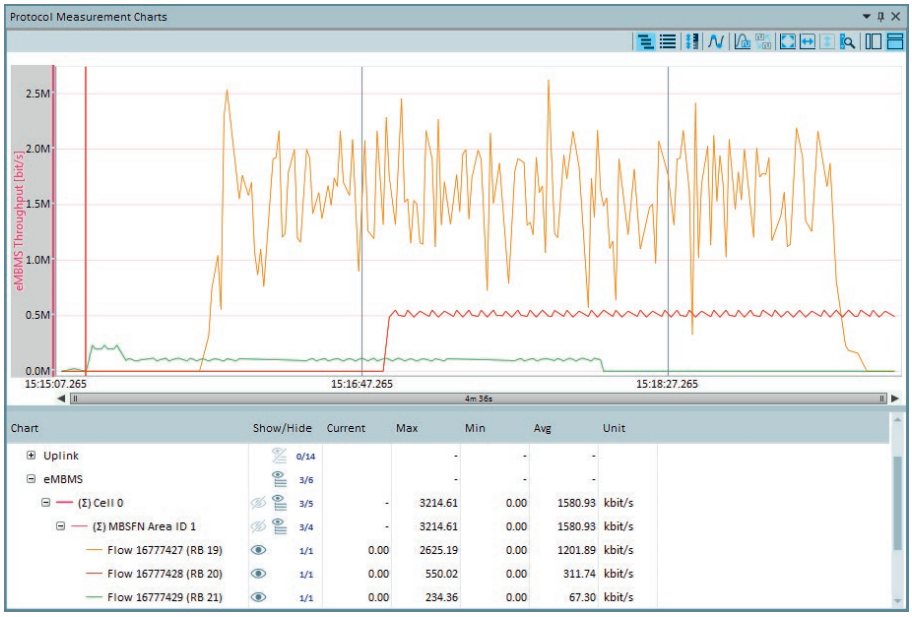


Fig. 6: For testing signaling scenarios and IP data streams, the R&S®CMWmars advanced extension graphically displays the eMBMS-specific measured values and data rates of each eMBMS flow / radio bearer separately for every MBSFN area.

Summary

The R&S®CMW500 wideband radio communication tester is the first test instrument in the world to boast an integrated BM-SC service layer, with the result that it can be used to completely test all LTE eMBMS features on both the signaling and the IP layer without the need for additional test instruments.

Easy generation of LTE eMBMS test cases in R&S®CMWcards and the new R&S®CMWmars advanced extension graphical analysis tool greatly facilitate verification of eMBMS-ready smartphones, significantly reducing the time required for troubleshooting.

Manuel Galozy; Thomas Moosburger

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[1] WLAN traffic offload – bypass for crowded mobile networks. NEWS (2015) No. 212, pp. 10–15.
[2] Now easier than ever: analysis of complex wireless protocols. NEWS (2014) No. 210, pp.10–13.

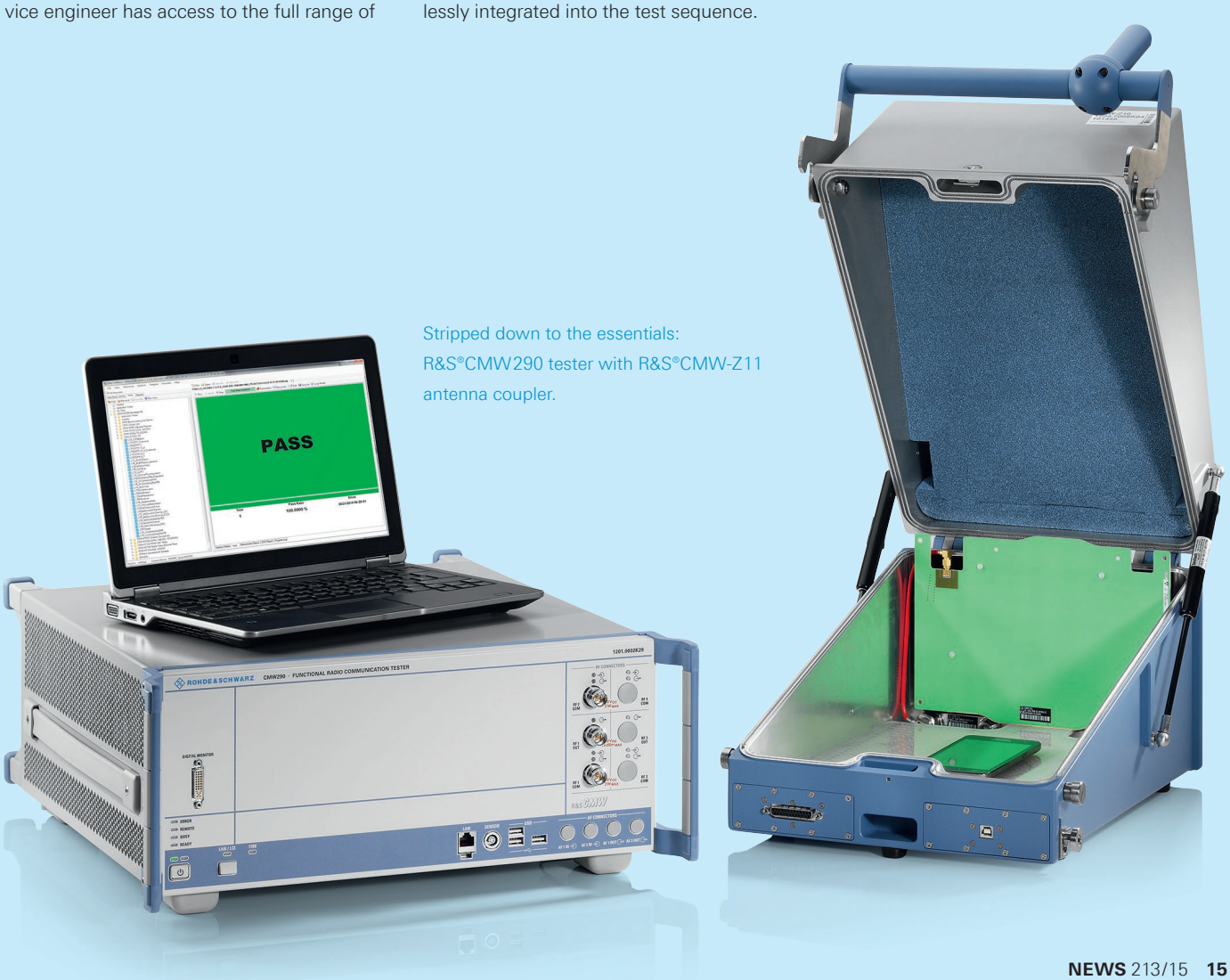
In brief

R&S®CMW290 mobile radio service tester

A constant barrage of new mobile phone models, deadline pressure, quality standards – everyday life in service centers demands an efficient and streamlined workflow. The new R&S®CMW290 functional radio communication tester meets these demands when it comes to diagnostic testing of wireless user equipment.

For the R&S®CMW290, Rohde&Schwarz took the powerful functionality of the R&S®CMW500 mobile radio communication tester – the global leader in testers for the development and production of wireless equipment – and stripped it down to only those functions that are needed for service. To allow the service engineer to focus on the task at hand, operation is exclusively via a PC using the R&S®CMWrun sequencer software tool, which includes test cases for all conventional mobile radio and wireless standards as well as a database of the T&M specifications for the mobile phone models under test. An expert view, in which the service engineer has access to the full range of features, makes it possible to change the test sequence and to add new models. In test mode, the GUI is free of distractions and is primarily used to start the test, which then runs fully automatically and concludes with the (printable) test report. All GUIs can be replaced with customer-specific versions. The R&S®CMW290 is therefore also suitable for making quick diagnoses at the point of sale, e.g. in flagship stores. At the other end of the complexity scale for mobile phone servicing lies device calibration and adjustment, both of which require test software from the mobile phone manufacturer on the R&S®CMW platform. If such software exists, it can be seamlessly integrated into the test sequence.

The DUTs are connected via cable or – more typically – wirelessly via a shielded antenna coupler. The R&S®CMW-Z11, specifically adapted to the R&S®CMW290, is the preferred tool, not only for the wireless communications industry but wherever high-quality radio modules require maximum reliability, such as in the automotive, medical or A&D sector. The Internet of Things with its innumerable radio interfaces also generates test requirements; the industry is ready for this development with the R&S®CMW290.



Stripped down to the essentials: R&S®CMW290 tester with R&S®CMW-Z11 antenna coupler.

R&S®CMA180 radio test set: greater versatility with new add-ons

Just over a year on the market, the R&S®CMA180 now comes with a range of new features and add-ons giving this radio test set even greater versatility.

Fig. 1: A large, user-friendly touchscreen combined with sophisticated test and measurement features make the R&S®CMA180 radio test set a compact general-purpose instrument for maintenance and repair of professional radios.

Numerous professional users of classic analog and noncellular digital radio are using the R&S®CMA180 radio test set (Fig. 1), which was released one year* ago, for repair and maintenance of their radios. They appreciate this complete and versatile test set because it can perform all relevant measurements without additional tools.

As the number of users increased, there was a strong demand for additional features. Rohde&Schwarz developed numerous add-ons that are now available to ensure even greater versatility. Active or passive IF components can now be measured and the adjacent channel power (ACP) tested. For field use far away from any power supply, batteries are now available for interruption-free measurements, and a transit case protects the instrument against damage. The following provides an overview.

Tracking generator

Measuring a filter in the full frequency range of the R&S®CMA180 from 0.1 MHz to 3000 MHz? Nothing could be easier – with the tracking generator. Coupled with the sweeping spectrum analyzer and connected to the RF COM – RF IN or RF OUT – RF IN / RF COM female connectors (depending on the desired level range), the R&S®CMA180 can now passively or actively test RF / IF components.

ACP / harmonics measurement

Radios must not under any circumstances interfere with the radio traffic in adjacent bands. The ACP measurement determines the power a transmitter emits into adjacent channels and helps to minimize this interference. The channel and the measurement bandwidth settings can be set as needed (Fig. 2). Results are represented in graphical and tabular form. Even the occupied bandwidth can be measured selectively by allowing the test set to determine the bandwidth occupied by a specified percentage of the transmit power.

GPS, Glonass and Galileo receiver testing

With the R&S®CMA-KV140 option, users can test GPS receivers integrated into the radio. For this purpose, the ARB generator in the R&S®CMA180 simulates specific positions in large cities with a signal mix from ten satellites. A properly functioning GPS receiver in the radio will display the number of satellites, signal strength and GPS coordinates of the selected position in the city. The R&S®CMA-KW620, -KW21 and -KW22 options simulate the signals of individual GPS, Glonass and Galileo satellites specially for production testing.

NATO approval for the R&S®CMA180

For servicing all radios that are used in NATO, the R&S®CMA180 radio test set received the required NATO stock number (NSN: 6625-12-397-3866). This gives it approval for all NATO military forces.

Fig. 2: Measuring the adjacent channel power. Channel and measurement bandwidth settings can be adjusted as needed.

Fig. 3: The R&S®CMA-Z600A AF impedance matching unit is a valuable add-on for audio functions.

Fig. 4: Replaceable batteries enable interruption-free operation over long periods of time.

Fig. 5: Well-protected while on the go with the R&S®CMA-Z030A display protection cover.

Fig. 6: The R&S®CMA-Z025A soft case has an opening on the back for connecting to a power supply so that the measuring instrument does not need to be removed.

AF impedance matching

The R&S®CMA-Z600A AF impedance matching unit enhances the versatile audio functions of the R&S®CMA180. It provides various input and output impedances between high/low impedance and 600 Ω, balanced/unbalanced as well as XLR connections (Fig. 3).

Well-protected while on the go

As a portable instrument, the R&S®CMA180 is ideal for field work. In conjunction with a solid state disk (SSD), its mechanical stability, operating temperature range from 0 °C to +50 °C and maximum permissible humidity of up to 95 % make it perfect for use in the field. This test set complies with the specifications of MIL-PRF-28800, class 3.

The battery set (Fig. 4) allows the R&S®CMA180 to operate for approx. 90 minutes independent of a current source. The batteries can be replaced during operation and recharged in an external charger. This ensures long, interruption-free operation.

A display protection cover (Fig. 5) and connector protection caps protect the instrument during transport. The soft case (Fig. 6) or transit case also protect the instrument against damage.

Gottfried Holzmann

* NEWS (2014) No. 211, pp. 18–20.

R&S®SMW200A vector signal generator with up to eight independent baseband sources

The multiple entities option turns the R&S®SMW200A into the world's first individually scalable eight-channel vector signal generator for complex multisignal scenarios. The R&S®SMW200A can be equipped with two internal RF paths and can supply additionally connected R&S®SGT100A external RF generators to provide eight full-featured RF paths in the smallest of spaces.

One test signal is not enough

With data volumes steadily growing, it is no easy task to ensure reliable and efficient mobile communications also in the future. The frequency spectrum below 6 GHz primarily used today is limited and in part highly fragmented. As a result, it is not possible to achieve a higher data throughput

Fig. 1: An R&S®SMW200A vector signal generator combined with six R&S®SGT100A RF generators yields a configuration with eight complete paths that can be used to generate multiple signals.

simply by broadening the signal spectrum, plus the signals in the available frequency spectrum interfere with one another to a growing extent. Higher transmission rates are instead achieved by bundling multiple carriers from various frequency bands (carrier aggregation). In addition, technologies are used that improve spectral efficiency (e.g. MIMO), and methods employed that permit various signals to coexist in the same frequency band largely without interference (e.g. beamforming, interference cancellation, interference coordination). However, a single test signal, a single carrier or a single simulated antenna is no longer sufficient for testing systems employing such methods and technologies. Instead, significantly more complex test signals are needed. This is where the R&S®SMW200A multichannel vector signal generator comes in (Fig. 1).

Eight baseband sources in one instrument

The baseband architecture of the R&S®SMW200A is as flexible as it is powerful. Enhanced with the R&S®SMW-K76 multiple entities option, the instrument generates up to eight independent test signals simultaneously. A laborious time synchronization of multiple separate signal generators is no longer needed. In multichannel configuration, the R&S®SMW200A performs multistandard radio (MSR) tests just as easily as it generates complex multicarrier scenarios (e.g. for LTE carrier aggregation) or simulates interferers (e.g. for LTE feICIC tests[1)], as described in 3GPP Release 11).

In the past, these tests required the calculation of all test signals involved into a single waveform. This quickly reaches its limits, however, when it comes to bandwidth and ARB memory depth. In addition, only small level differences are possible between the signals. Using dedicated baseband sources in the R&S®SMW200A and adding the signals in real time is a significantly better approach in terms of test times and flexibility than the conventional multicarrier waveform approach.

Real-time signal processing saves test time

Fig. 2 shows an example of a complex multicarrier scenario along with the block diagram displayed on the R&S®SMW200A. The baseband block on the left is used to configure and generate up to eight signals. The optional fading simulator can be used to add SISO fading to each of the signals. AWGN can also be superimposed on each channel. The I/Q stream mapper block handles real-time addition of the signals and the assignment of each signal stream to one of the generator's two RF outputs, or to one of its analog or digital I/Q outputs. The frequency, phase and level can be individually defined for each signal. Even complex multicarrier scenarios are easily generated in this manner. In the example, signals A to D are output on an 80 MHz wide frequency band (RF A) and signals E to H to a second frequency band (RF B). Real-time signal addition makes it easy to modify individual signals or channel conditions without having to recalculate the other signals. In contrast to tests using a single

1) feICIC = further enhanced inter-cell interference coordination.

Complex multicarrier scenario

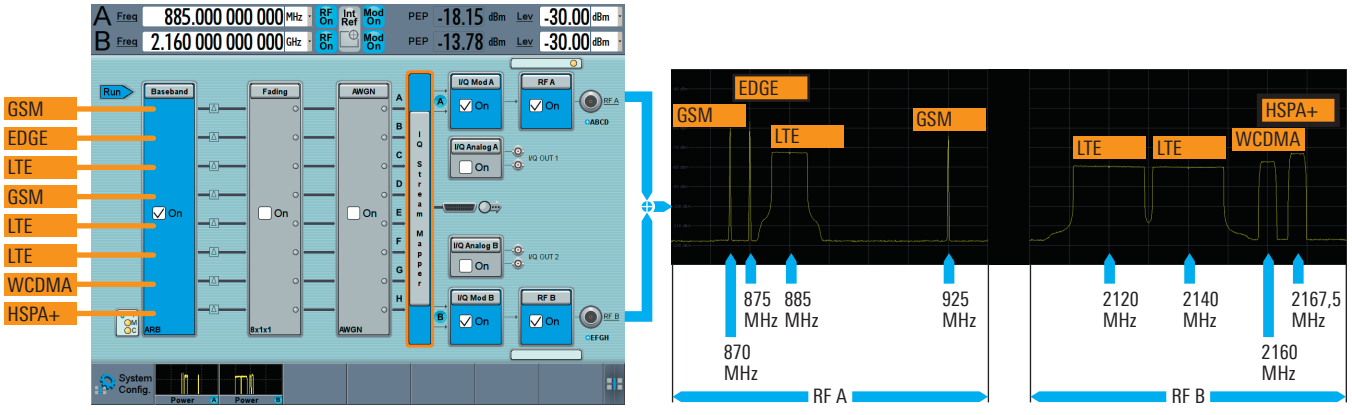


Fig. 2: Generating multiple carriers in two frequency bands.

Multichannel MIMO simulator

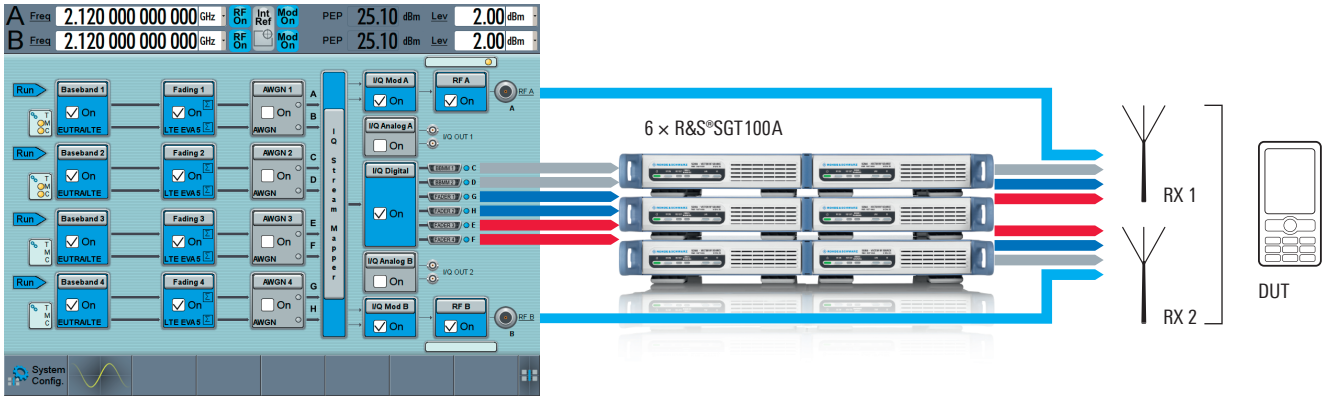


Fig. 3: Generating four LTE-A cells or carriers, each with 2 × 2 MIMO.

multicarrier waveform, work is completed quickly and easily, saving valuable test time. The R&S®SMW200A can also generate long duration signals that are not possible with a multicarrier waveform because of the usually limited ARB memory. Separate SISO fading channels ensure that the precise Doppler frequency shifts are used for each carrier.

Flexible RF extension

For applications requiring more than two frequency bands or antenna signals, the R&S®SMW200A can be expanded with external R&S®SGT100A RF generators to a total of eight RF paths (Fig. 1). This permits all eight signals to be output separately in the frequency range up to 6 GHz in order to test multi-antenna receivers or to implement phase-coherent beamforming applications, for example. The R&S®SGT100A generators are conveniently controlled from the R&S®SMW200A – the entire test setup fitting into a maximum of seven HUs.

Generating multiple MIMO systems

By pairing the R&S®SMW-K76 multiple entities option with the R&S®SMW-K74 MIMO fading option, the R&S®SMW200A is expanded into a powerful multichannel MIMO simulator.

The available hardware resources can be assigned to several quasi-separate subsystems to generate multiple MIMO scenarios, including 4 × 2 × 2. Fig. 3 shows the block diagram displayed on an R&S®SMW200A that generates four separate LTE-A systems simultaneously, each with 2 × 2 MIMO. Whether generating, for example, four aggregated MIMO LTE-A carriers using cross-carrier scheduling or creating multiple LTE-A base station cells for testing interference signal suppression or handover scenarios: the R&S®SMW200A masters these tasks brilliantly.

Summary

The R&S®SMW200A is an individually scalable vector signal generator that delivers up to eight signals in parallel. From a simple generator without channel simulation to a multiple MIMO simulator with additional RF extensions, it does it all. Internal real-time signal addition permits new approaches to testing that are far superior to the conventional multicarrier waveform approach. Even complex test scenarios can be implemented with minimal hardware. Simple upgrade options ensure that functionality not needed today can be easily added tomorrow. The R&S®SMW200A is a versatile, future-ready platform for all types of multichannel tests.

Simon Ache

Effectively characterizing frontend modules during production

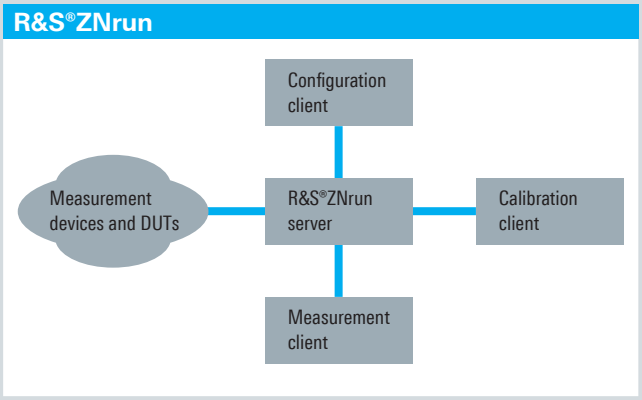
Production tests on multiport DUTs, e. g. frontend modules for smartphones, are increasing in complexity. In addition to the traditional RF measurements, T&M equipment must also handle new features and developments, such as DUT configuration via GPIO and handler I/O interfaces and via the MIPI® RFFE interface. Rohde & Schwarz provides unique solutions for these applications with the R&S®ZNrun automated test software and the optional R&S®ZN-B15 MIPI® RFFE interface card.

Fig. 1: The R&S®ZNB vector network analyzer with the R&S®ZN-Z84 switch matrix during a measurement of a frontend module. With the R&S®ZN-B15 interface card inserted into the analyzer, the module's MIPI® RFFE interface can be addressed directly via the analyzer firmware.

MIPI® Alliance
The MIPI® Alliance is a global, non-profit organization comprised of a number of companies working together with the objective of defining interface standards for the components used in mobile phones. The MIPI® Alliance views its role as supplemental to existing organizations, such as 3GPP.

The MIPI® Alliance is organized into several working groups that specify the individual interfaces on a mobile phone. One of these is the RFFE working group.

Rohde&Schwarz is one of more than 200 companies who are members of the MIPI® Alliance.



Functional blocks of the R&S®ZNrun software.

R&S®ZNrun server: controls the individual software clients; configures the T&M equipment and the DUTs
Configuration client: creates measurement execution units (MEUs) generates the connection and measurement plan
Calibration client: performs system error correction
Measurement client: performs the measurements and displays the measurement throughput

Increasing complexity for frontend modules

Today's mobile radio standards are becoming more and more complex and cover an increasingly growing range of functions. This is also reflected by the frontend modules (FEMs) used in smartphones, where the number of integrated components, such as low-noise amplifiers and filters, is on the rise. This diversity also has an impact on T&M equipment, leading to an increase in the number and types of RF measurements required and in the number of ports to be analyzed. FEMs with 16, 20, 23 or more ports are now typical.

Vector network analyzers such as the R&S®ZNB with the R&S®ZN-Z84 switch matrix (Fig. 1), or the R&S®ZNBT multiport vector network analyzer are ideal for these complex RF measurements.

The R&S®ZNB supports the MIPI® RFFE interface

A standardized interface is a key requirement for FEMs in order to ensure interoperability with other components in a mobile phone. For example, other mobile phone components must be able to address the frequency selection filters in a frontend module in order to utilize the more than 12 mobile radio bands plus supplemental services such as WLAN and GPS. A working group within the MIPI® Alliance (see blue box) developed the MIPI® RF frontend (RFFE) interface for this purpose. The new optional R&S®ZN-B15 interface card for the R&S®ZNB supports this interface.

R&S®ZNrun for fast and easy measurements

The large number of test ports and the different characteristics of the components used in FEMs make it difficult to keep an overview of the required measurements. The parameters to be measured at each port must be precisely defined, as well as the appropriate configurations for the T&M equipment.

Rohde&Schwarz developed the R&S®ZNrun software for PCs (see gray box) to make it easier for users to keep track of the large number of measurements to be made – often more than 200 – and to optimize measurement speed. After launching the software, the user selects the type of Rohde&Schwarz network analyzer being used plus any connected switch matrix. The user can then focus on the DUT and enter the number and type of ports. In addition, the individual measurements must be defined. Based on this information, R&S®ZNrun generates a connection plan. As a final step, the user connects the DUT to the T&M equipment as shown in the connection plan, then the software takes over and performs all configurations.

R&S®ZNrun takes into account the characteristic features of the T&M equipment being used, for example the fact that the R&S®ZN-Z84 switch matrix uses switches and therefore cannot measure all ports simultaneously. Ports also have different characteristics as a result of the different switching levels being used. The software optimizes measurement speed by selecting the appropriate sequence of measurements in order to minimize the number of required switching operations. A pass/fail display simplifies sorting of measured FEMs. The software indicates the duration of measurements performed on each DUT and whether all measurements were passed, and it summarizes

the results in a long-term view. This makes early problem detection and elimination possible – essential for production environments.

Fast and flexible reconfiguration of test stations

The R&S®ZNrun software was designed with a view to high flexibility in production. For example, exchanging a network analyzer at a fully configured test station, e.g. replacing a four-port analyzer with a two-port instrument, takes just a few mouse clicks. All the user has to do is load the test plan, enter the new analyzer type and save it. The software automatically updates the connection plan, and measurements with the new analyzer can be started. Time-consuming configurations of the individual test steps and of the analyzer are no longer necessary. If additional T&M equipment is needed, such as a power supply unit, it can be integrated in the test sequence by using a plug-in.

Often, settings on the DUT, e.g. the position of an internal switch, must be changed. To handle these tasks, the R&S®ZN-B15 interface card is equipped with two types of interfaces: ten independent general purpose input output (GPIO) interfaces and two MIPI® RFFE interfaces. The GPIOs – which are controlled via the R&S®ZNrun GUI – can be used for powering as well as for addressing FEMs via GPIO pins. The MIPI® RFFE interface can be integrated into the R&S®ZNrun test sequences via a plug-in.

Integrated interface card in place of external modules

The new R&S®ZN-B15 MIPI® RFFE interface card for integration into the R&S®ZNB network analyzer makes it possible to program MIPI® RFFE interfaces on FEMs directly from the analyzer firmware (Fig. 2). This significantly reduces the complexity of test setups compared with solutions using external modules. If an external MIPI® RFFE

Test setup

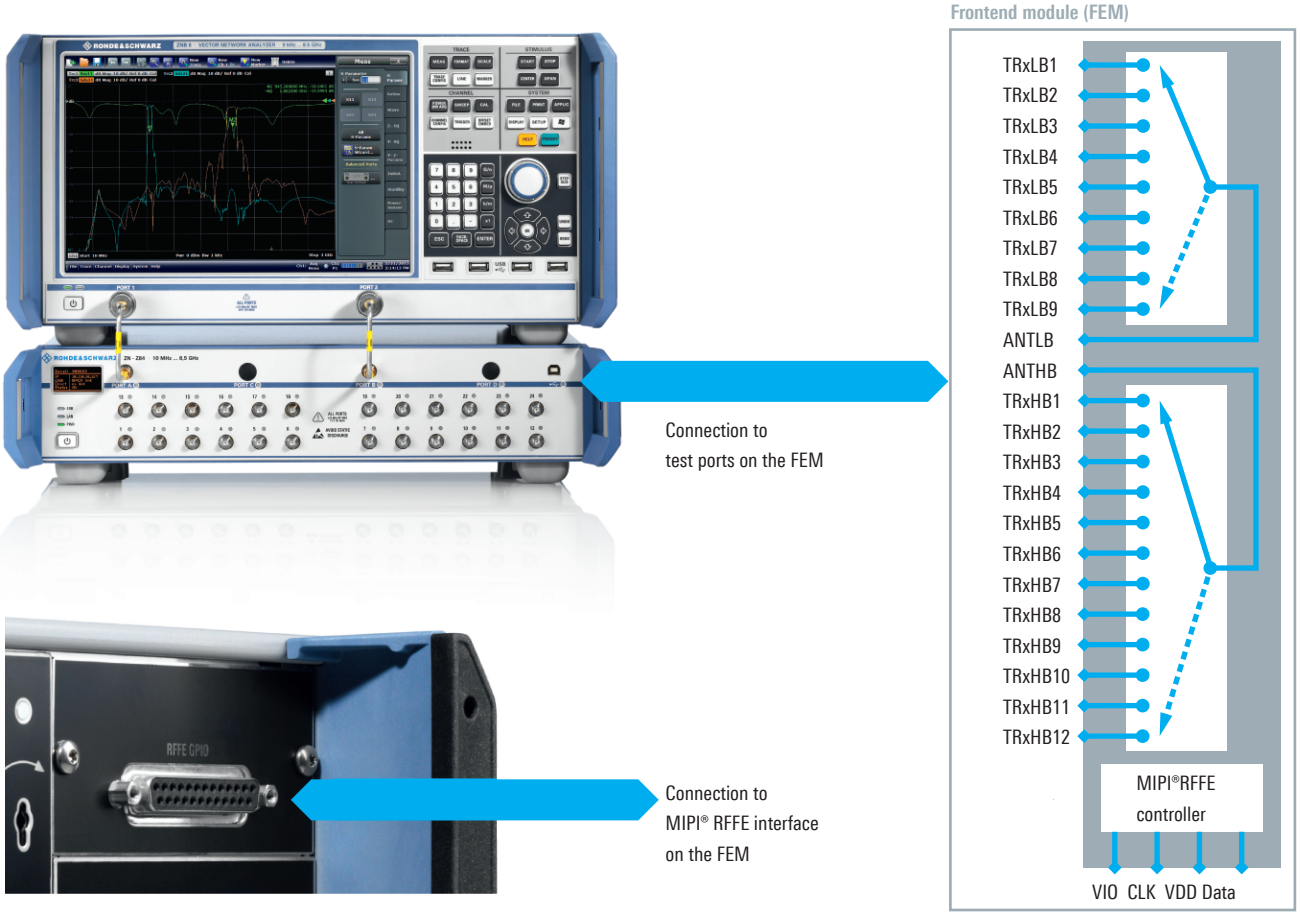


Fig. 2: With the R&S®ZN-B15 MIPI® RFFE interface card inserted into the R&S®ZNB network analyzer, it is easy to address FEMs with a MIPI® RFFE interface.

control board were used, possibly connected to a controller via USB, it would take considerable effort both to address the control board and to synchronize it with the test system and the DUT.

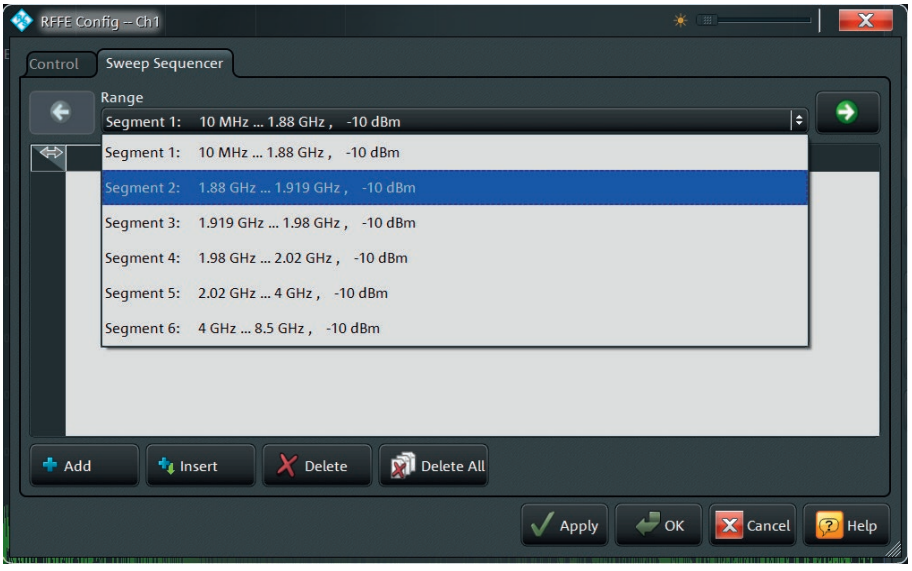
The R&S®ZN-B15 interface card can be configured via the analyzer GUI (Fig. 3), although all necessary functions are also available as SCPI commands. The card permits programming of the MIPI® RFFE and the GPIO interfaces both for a channel and for a frequency segment. The voltages of the GPIOs can be set independently of one another and also set automatically via a sequencer at the start of the sweep.

With the sequencer, the FEM programming can be incorporated into the sweep sequence and adapted as required for the individual frequency segments (Fig. 4). The segmented sweep function makes it possible to measure a variety of parameters, including insertion loss, isolation or reflection, in a single sweep for various configurations of the FEM. This results in efficient FEM characterization.

The R&S®ZN-B15 interface card can also be used to read the contents of the registers of a frontend module. This information can be used to improve testing, particularly in production applications. For example, a frontend module ID can be read and subsequently made available during the production process. By reading the registers, the FEM programming can also be verified by checking if the registers were set correctly.

Fig. 3: Menu for configuring the R&S®ZN-B15 MIPI® RFFE interface card to match the DUT characteristics.

Fig. 4: Menu for defining the test sequence.



Summary

The R&S®ZNrun software and the optional R&S®ZN-B15 MIPI® RFFE interface card for the R&S®ZNB simplify the characterization of FEMs. R&S®ZNrun optimizes test sequences within production environments and offers a high degree of flexibility, while the R&S®ZNB-B15 interface card greatly facilitates DUT control.

Volker Herrmann; Tanja Menzel

R&S®RTM2000: multitalented oscilloscope with spectrum analysis capabilities

Thermostats and electric blinds can be remotely controlled, sensors transmit health data to smartphones, and tires automatically report the tire pressure – wireless interfaces are everywhere. Consequently, more tests are necessary in the frequency spectrum.

Trend toward versatile test instruments

The integration of radiocommunications components in advanced embedded systems increases the amount of testing that has to be done during development. In addition to characterizing and debugging analog and digital signals in the time domain, frequency spectrum analysis is becoming increasingly important. It is not enough to simply test the wanted signals; EMI and the resulting errors also have to be detected.

For efficient development, a workbench full of instruments – including an oscilloscope, spectrum analyzer, logic analyzer, protocol analyzer and multimeter – is required. T&M equipment manufacturers are addressing this trend by increasingly integrating individual specialized instruments into a single universal test instrument. This reduces space requirements and investment costs. The instruments are also easier to use thanks to a uniform GUI tailored to the specific requirements of each measurement discipline.

Fig. 1: The R&S®RTM2000 oscilloscope, now with spectrum analysis function.

Two-path architecture of the R&S®RTM2000

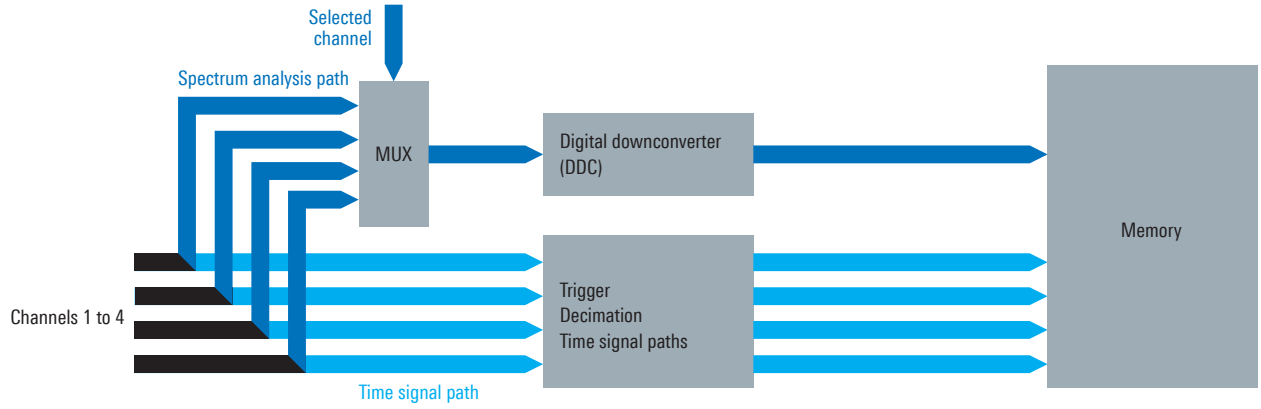


Fig. 2: Two-path architecture for simultaneous measurements and independent setting of time and spectrum analysis parameters.

The first functions to be integrated were digital signal analysis and protocol analysis. In 2010, the R&S®RTO high-performance digital oscilloscope already offered spectrum analysis functions, implemented with intelligent, hardware-assisted fast Fourier transformation (FFT). This functionality is now also available in the R&S®RTM2000 oscilloscope (Fig. 1). The new range of functions includes an integrated digital voltmeter – either in the probes or in the base unit.

Integrated instruments offer the greatest benefit when their individual functions can be independently configured yet used in parallel. For example, if a very long acquisition cycle is required for protocol analysis in the time domain in order to acquire all needed communications signals, then the sampling rate must be decreased (depending on the available memory). If at the same time high-frequency signal components in the spectrum need to be analyzed in detail, then the full sampling rate is needed for this signal path. Only through parallel and time-correlated analysis is it possible to detect and eliminate interactions. Allowing functions to be used in parallel provides high flexibility and eliminates the need to compromise on test coverage.

Spectrum analysis with oscilloscopes

While logic and protocol analyses are now also available in the lower price classes, only a few oscilloscopes offer true spectrum analysis functionality. Insights into the frequency spectrum are usually only possible by using the rigid conventional FFT, which can require several seconds for individual calculations. Typical FFT implementations calculate the spectrum over the entire acquired waveform. Because the resulting frequency resolution and range seldom match the problem under analysis, it is necessary to zoom in on the relevant section. Several convenient software applications use gating to allow preselection – albeit in the time domain, not the frequency domain. This is important when analyzing switching processes, for example. However, these methods do not change the fact that the sampling rate must be reduced due to a lack of memory.

Additional measurement tools and display options are also important during analysis. Spectrum analysis includes displays for min. hold, max. hold and average that allow borderline cases and average values to be quickly detected. Markers for automatic peak searches facilitate spectrum analysis. Changes in the spectrum over time or sporadic interfering signals are visible in the spectrogram display, with color coding of amplitudes versus frequency and time.

All of these features are available in the R&S®RTM-K18 spectrum analysis and spectrogram option for the R&S®RTM2000 oscilloscope. Its specialized architecture – with a separate spectrum analysis signal path directly after the A/D converter – makes it possible to directly analyze the spectrum of analog input signals, from DC to the instrument bandwidth (Fig. 2). Thanks to this two-path architecture, correlations between data errors on digital interfaces and spectral interference can be detected. A hardware-implemented digital downconverter (DDC) in the R&S®RTM2000 reduces the spectrum to the relevant parts, ensuring high-speed analysis. The measurement parameter settings can be separately optimized in the time domain (duration and resolution) and in the frequency domain (center frequency, span and resolution bandwidth).

Example:
EMI debugging on a switched-mode power supply

The R&S®RTM-K18 option's measurement tools allow efficient analysis of one of the primary sources of electromagnetic interference: the ubiquitous switched-mode power supply (SMPS) and its lines. Typically, interference signals from these components fall significantly below 20 MHz, while most EMC standards specify conducted emission limits of up to 30 MHz and radiated emission limits of up to 1 GHz. While these measurements are usually performed by specialized labs, especially in the far field, it is possible to analyze specific lines or components during development by using the R&S®RTM-K18 option and appropriate near-field probes (Fig. 3). Design problems can be quickly identified and eliminated.

Fig. 3: The R&S®RT-HZ15 near-field probe set allows the oscilloscope to analyze specific lines and components.

Spectrum analysis is started with the press of a button; the display can be adjusted as needed. In Fig. 4, the time domain view is disabled to focus on the frequency spectra. The current spectrum is shown at the bottom, and the individual spectra are displayed over time line by line in the top half of the screen. The various operating states of the SMPS are clearly identifiable. In the example, it can be seen that several interferers occur independently of the SMPS load. Markers and the max. hold trace (blue) in the bottom half of the screen make it possible to quickly determine the frequencies. Because analysis using near-field probes also identifies the location of the emission, the problem is resolved satisfactorily by adding targeted shielding or by replacing components.

Example: VCO analysis

Analyzing the switching behavior of a voltage-controlled oscillator (VCO) that can be controlled via serial protocols is more complex. In the example (Fig. 5), the VCO is cyclically

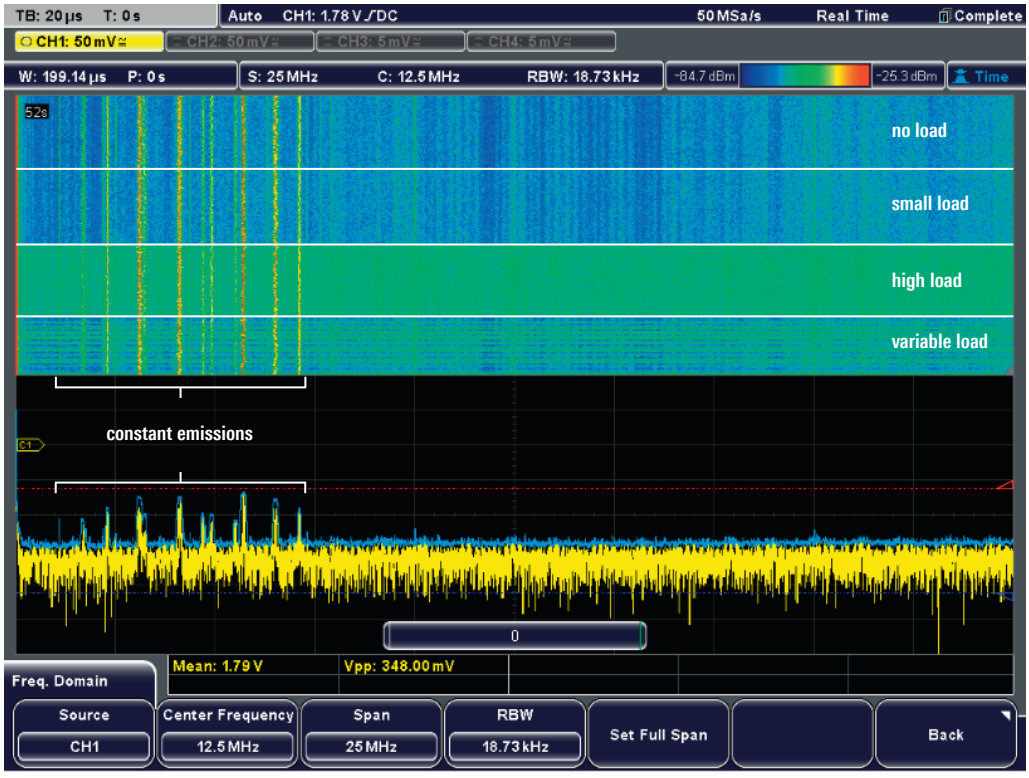


Fig. 4: Emission profile of an SMPS analyzed using the R&S®RTM-K18 spectrum analysis and spectrogram option. The various load states are clearly seen in the spectrogram (top). The spectrum window (bottom) shows the max. hold trace for all load conditions.

switched between three states. To select the events to be analyzed, the protocol trigger is set to the command that sets the frequency (data: 01 h, upper part of screen). By limiting spectrum analysis to specific segments of the time signal, the states before, during and after switching can be easily analyzed. In the example, the analyzed time slice is set to shortly after each switching operation, which is indicated by the two vertical lines in the top part of the screen. Switching between states is best seen in the spectrogram (middle of screen). In the example, the analyzed oscillator is incorrectly set to the same frequency multiple times, and so the same lines appear multiple times in the spectrogram. The determined time interval between the frequency switchovers indicates that the underlying problem is in the control. Any outliers would be clearly visible in the spectrogram and easily isolated and analyzed. If the R&S®RTM-K15 history and segmented memory option is enabled, the faulty waveform and its associated spectrum (bottom of screen) can be loaded from the up to 460 Msample memory and analyzed using the oscilloscope's analysis tools.

Summary

The time-correlated spectrum analysis function integrated in the R&S®RTM2000 oscilloscope is another important analysis tool for developers and is a consistent step forward in the trend toward integration of T&M equipment. Specifically, the R&S®RTM2000 is now an oscilloscope, spectrum analyzer, logic analyzer, protocol analyzer and digital multimeter in one. Developers of complex embedded systems with RF interfaces, in particular, will now often be able to do without specialized equipment and still achieve their goals more quickly and systematically. Development time is also reduced if preliminary EMI studies are performed using near-field probes that permit precise localization of problematic components.

Dr. Philipp Weigell

Spectrum analysis and spectrogram option		
Spectrum	Sources	each analog channel, reference waveforms, mathematic waveforms
	Span	1 kHz to 1.25 GHz
	Resolution bandwidth	span/10 ≥ RBW ≥ span/1000
	Windows	flat top, Hanning, Hamming, Blackman, rectangle
	Display formats	normal, max. hold, min. hold, average
Spectrogram	Size	up to 600 lines
	Color schemes	rainbow, temperature, monochrome
Markers	Automatic peak markers	up to 100
	Reference markers	via index or frequency

Fig. 6: Key characteristics of the R&S®RTM-K18 option.

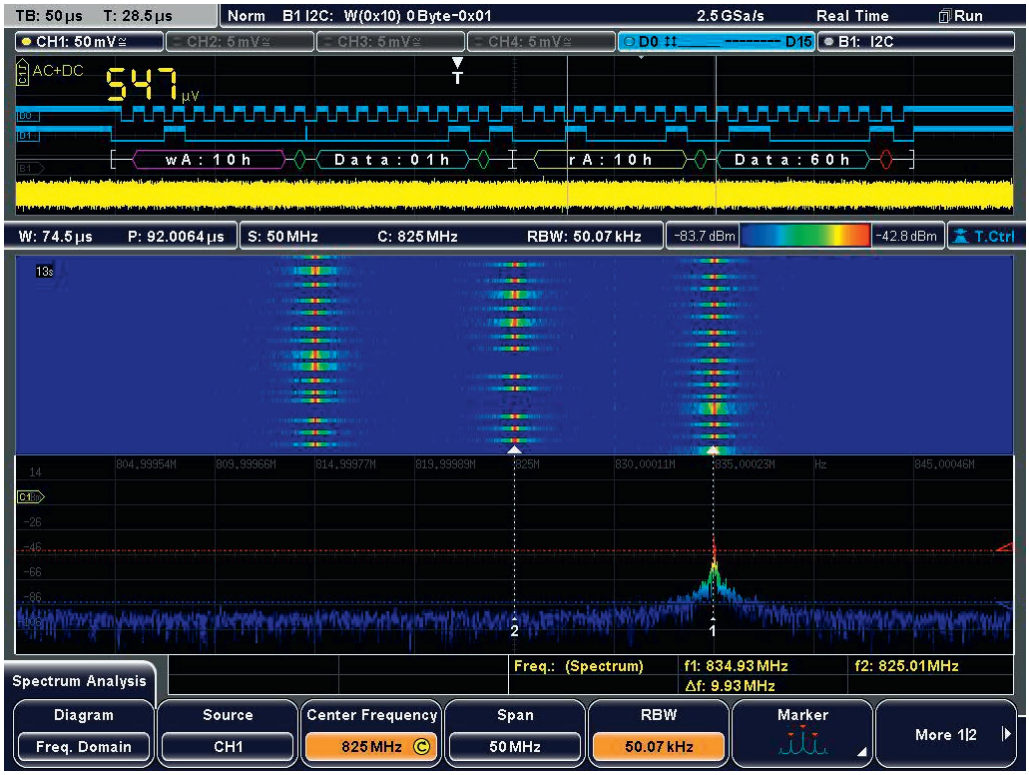


Fig. 5: Analysis of a VCO showing errors in the frequency switching behavior. The top part of the screen shows the analog, digital and decoded serial bus signals as well as the results of the voltage measurement using the digital voltmeter. The bottom part of the screen shows the current spectrum with color-coded amplitude. Lines appearing multiple times in the spectrogram (middle of screen) indicate faulty frequency switching.

Simplicity now available: measurements on automotive radars in all bands

Fig. 1: The R&S®FSW85 signal and spectrum analyzer is the world's first instrument that can cover the frequency range from 2 Hz to 85 GHz in one sweep.

The high resolutions of automotive radar sensors require signal bandwidths up to the gigahertz range. For this reason, frequency bands around 24 GHz and 79 GHz are provided for these applications. Up until now, harmonic mixers had to be used for test and measurement because no analyzer was available that covered up to over 79 GHz in a single sweep. Rohde&Schwarz has now launched a signal and spectrum analyzer that outperforms all others: the R&S®FSW85.

Test and measurement for automotive radars: at the frontier of what is currently possible

Radar sensors measure the range, radial velocity and location of targets in the vicinity under any weather conditions. Thanks to good performance data and low costs, they lay the foundations for more and more assistance and safety functions in vehicles (Fig. 2), nowadays even reaching the compact class. Sensors for the automotive sector operate in the frequency bands around 24 GHz, 77 GHz and 79 GHz (see box on page 32 for details).

In order to detect and resolve two adjacent objects, the range resolution of the sensor must be higher than the separation of the objects from each other. However, wide signal bandwidths are required for a high range resolution. This is not just a challenge for signal generation and evaluation in the sensor, but also requires high-end T&M equipment for development, verification and standard-compliant analyses. The measuring instruments must cover the frequency range up to 81 GHz and offer analysis bandwidths up to 2 GHz. Signal and spectrum analyzers are the instruments mainly worth considering for this task, but up to now they only reached bandwidths up to 500 MHz and did not even come near the maximum input frequency of 81 GHz.

Now there is one that can: R&S®FSW85 signal and spectrum analyzer

Up until now, the frequency range of analyzers had to be expanded with the help of external harmonic mixers for measurements in the 79 GHz band. This setup, however, has no preselection, i. e. when the signal is downconverted to an intermediate frequency, the user sees both the signal and its image. This disadvantage can be avoided with an additional measurement for which the frequency of the local oscillator is shifted by double the intermediate frequency. This enables the analyzer to detect and then remove unwanted mixing products. However, this only works when the intermediate frequency is higher than half of the signal bandwidth so that the image and signal do not overlap. This is not the case for a majority of the available spectrum analyzers. Another factor to take into account is that it is cumbersome to reduce the input level in a suitable manner when measuring with harmonic mixers, for attenuators must be attached to the waveguides and then readjusted for each changing level.

With its frequency range from 2 Hz to 85 GHz in one sweep, the R&S®FSW85 (Fig. 1) is the first choice for radar applications in the 79 GHz band. Thanks to its integrated preselection, it displays the signal without unwanted mixing products when measuring the spectrum even if this is significantly wider than double the intermediate frequency. In addition, signals with different levels can be easily analyzed without having to adjust the input level using cumbersome external attenuators. The attenuator in the R&S®FSW85 takes over this task.

Radar-supported vehicle functions (selection)

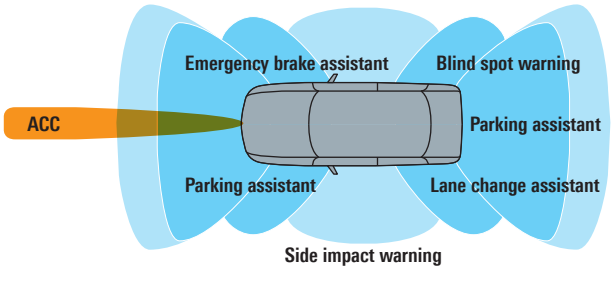


Fig. 2: Today radar sensors are used for numerous assistance and safety functions. Almost all of them require a high spatial resolution that can only be achieved with high bandwidths like the bands around 79 GHz.

Its internal analysis bandwidth of up to 500 MHz suffices for many automotive radar measurements. In the 79 GHz band, however, signals have a considerably larger bandwidth. For these applications, the R&S®FSW85 can be equipped with the R&S®FSW-B2000 bandwidth option. In combination with the R&S®RTO1044 oscilloscope, it can perform measurements up to a signal bandwidth of 2 GHz. The R&S®FSW85 downconverts the signal to an intermediate frequency of 2 GHz. The signal is then digitized by the oscilloscope, which acts as an A/D converter. This data is transmitted to the analyzer via LAN, where it is equalized and mixed into a digital baseband. The measurement applications in the R&S®FSW85 receive equalized I/Q samples as a basis for the analysis. The R&S®FSW85 fully controls the oscilloscope and transfers, processes, equalizes and analyzes the digital data. The signal path from the analyzer's RF input to the oscilloscope's A/D converter is characterized with respect to amplitude and phase response. The connection of the R&S®RTO1044 oscilloscope to the R&S®FSW85 is completely transparent for the user and measurement option operation is identical in all cases regardless of whether or not the A/D converter in the oscilloscope or the one in the analyzer is used.

For wideband, linearly frequency-modulated continuous wave signals like those used in automotive radars, the customized R&S®FSW-K60C measurement application is available. It records a signal up to 2 GHz bandwidth and analyzes it automatically. Important parameters such as chirp rate or deviations from ideal linear behavior are measured and displayed graphically or in tabular form. Fig. 5 shows a typical example.

Frequency bands for automotive radars

The frequency bands (Fig. 3), the emitted power level and the test requirements for automotive radars are defined in various standards such as EN 301091 V1.4.0. In Europe, automotive radars are temporarily using the 24 GHz band; however this must be discontinued by 2022. The European Commission has proposed the internationally available 79 GHz band as a replacement in its "79 GHz Project" [1]. The use of this band is currently being discussed and has already been accepted in many countries due to the significant advantages that it offers. Along with minimal limitations regarding the emitted power level and a smaller form factor for the sensors, it offers a wide signal bandwidth up to 4 GHz and a higher range resolution, as the following example shows: While a modulated signal bandwidth of 150 MHz allows a range resolution of one meter to be achieved, ten centimeters can be achieved at 1.5 GHz. The wider bandwidth also allows the integration of technical measures into the sensors to minimize interference between several radars, for example, frequency hopping.

Higher frequencies are not only helpful for the development of smaller sensors, they also help to improve the radial velocity resolution. The radial velocity resolution depends on the wavelength and the coherent processing interval of the radar waveform. If the coherent processing interval is kept equal, the radial velocity resolution improves by about a factor of 3 when the signal is emitted at 79 GHz instead of 24 GHz.

Chirp sequences are often used in automotive radars (Fig. 4), i. e. several linearly frequency-modulated signals with a duration of approx. 100 µs and a bandwidth of several hundred megahertz up to several gigahertz [2].

Frequency band	Bandwidth
24 GHz to 24.25 GHz	250 MHz
21 GHz to 26 GHz	5 GHz
76 GHz to 77 GHz	1 GHz
77 GHz to 81 GHz	4 GHz

Fig. 3: Frequency bands for automotive radar in Europe.

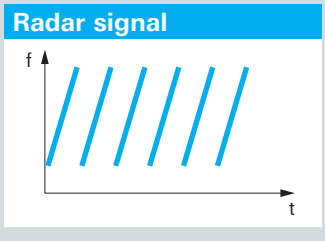


Fig. 4: Typical profile of a radar signal (FMCW radar).

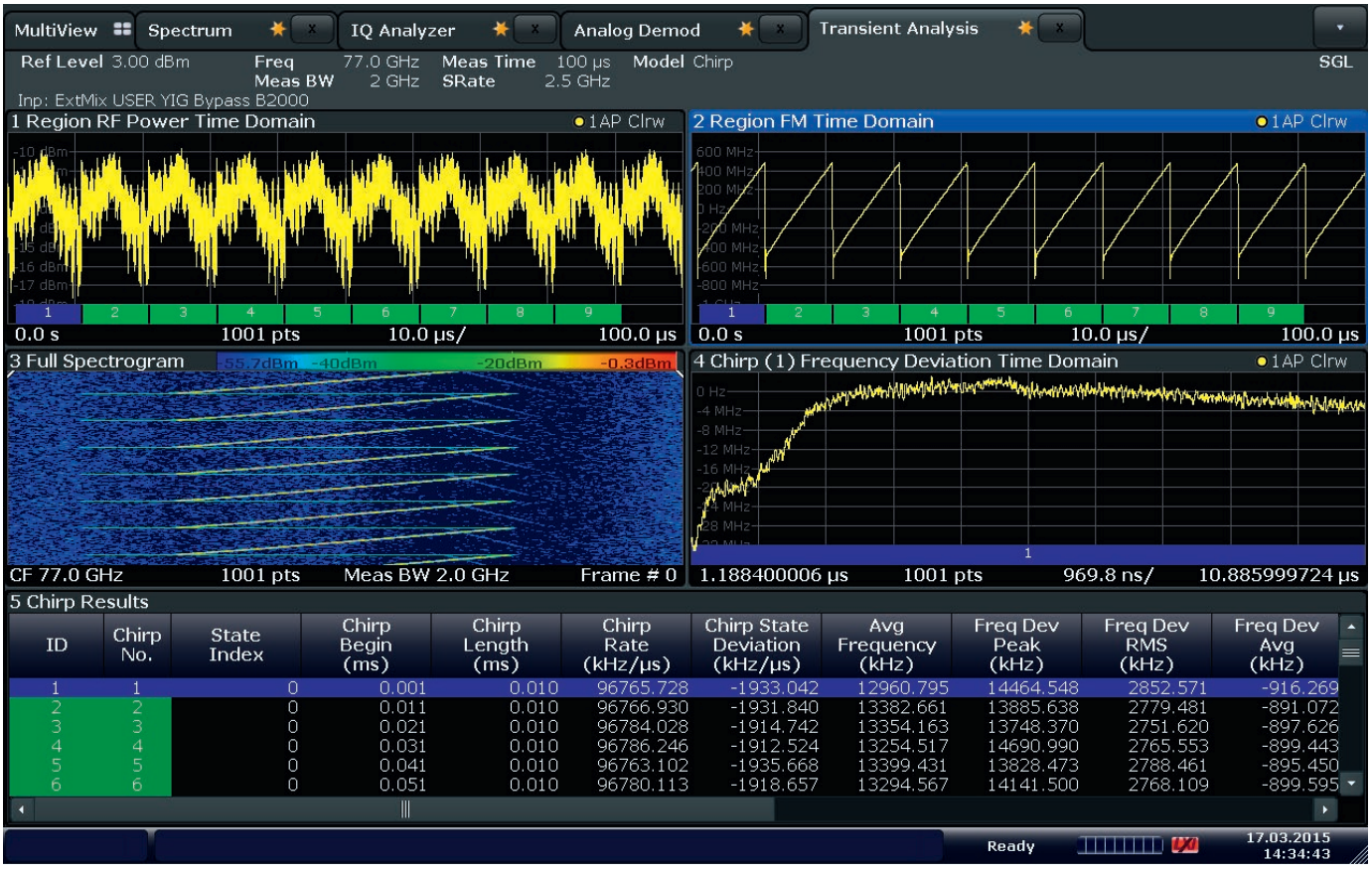


Fig. 5: Measurement of a 1 GHz FM chirp signal using the R&S®FSW-K60C option. Graphical depictions showing the frequency versus time or the power in the time domain. A table lists the most important measurement parameters.

Summary

Due to the considerable technical hurdles, until now there has never been a genuinely effective signal analyzer for measurements in the upper frequency bands (e.g. W band) for automotive radars. The R&S®FSW85 is not only the first instrument that provides sufficiently wide coverage of the input frequency range, it also provides analysis bandwidths that are indispensable for radar with high range resolutions. In addition, all important parameters can also be measured and displayed at the push of a button using the software option customized for automotive radars. The R&S®FSW85 is also well-suited for other applications in the frequency range above 50 GHz, such as the analysis of WLAN 802.11ad or 5G signals (see information under NEWS compact on page 6).

Dr. Steffen Heuel; Dr. Wolfgang Wendler

Condensed data of the R&S®FSW85

Frequency range	2 Hz to 85 GHz
Phase noise	–137 dBc (1 Hz), 10 kHz offset at 1 GHz
Signal analysis bandwidth	up to 2 GHz
Total measurement uncertainty	< 0.4 dB to 8 GHz
Real-time analysis	up to 160 MHz bandwidth
Inherent noise 75 GHz < f ≤ 85 GHz	typ. –128 dBm/Hz

References
[1] See "79 GHz Project" at www.79ghz.eu.
[2] Rohde&Schwarz White Paper; Heuel, Steffen; "Radar Waveforms for A&D and Automotive Radar" (search term: 1MA239).

Better than real life: radar echoes from a target simulator

Until recently, radar sensor development was one of the automotive industry's last remaining electronics fields without realistic lab and production testing. It was simply not feasible to simulate reproducible scenarios with multiple moving and static targets at greatly varying distances in the confines of a building. With the ARTS 9510 automotive radar target simulator, these tests are simplicity itself.

Radar sensors are key components in advanced driver assistance systems (ADAS) and have made possible an entirely new class of in-vehicle comfort and safety functions within just a few years. ADAS applications such as brake and lane change assistants and adaptive cruise control take an active role in vehicle guidance and therefore play a major role in safety. The reliability requirements for these systems are correspondingly strict, and thorough field testing is required before they are launched on the market. Lab testing, however, should be conducted prior to field testing in order to anticipate all critical situations using realistic test scenarios. There is an economic reason behind this approach: test drives are costly and time-consuming, while lab tests are relatively cost-efficient, can be quickly executed and – always desirable

Fig. 1: Radar sensors are currently used in all types of vehicles. The ARTS 9510 radar target simulator is the first instrument to enable flexible test setups to verify these sensors under lab conditions.

in T&M applications – can be repeated and varied under defined conditions (field-to-lab testing, FTL). The ARTS9510 radar target simulator now opens up these advantages for testing in-vehicle systems equipped with radar sensors.

For all application and radar scenarios

The ARTS9510 family was developed specifically for the automotive industry, i. e. for radars operating in the 24 GHz and 77 GHz frequency bands. Their flexible, future-ready architecture enables these instruments to do more than just handle FMCW signals. They can deal with the entire spectrum of radar technologies. Versatility is a key advantage in every respect. The instrument platform can be custom configured to match the specific use case and the radar characteristics to be covered. Variations of the simulator include both design (desktop instrument with integrated computer and graphical user interface or remotely controlled system instrument) and module configuration (frequency ranges, bandwidths, optional extensions) options. The ARTS meets all current and future requirements for simulated distances, variable target sizes (radar cross section, RCS), resolutions and object speeds. It delivers the same precision for near-range radars such as those used for parking assistants as it does for long-range systems, for which it can simulate an object at up to 2.4 km traveling at radial velocities of up to 700 km/h. Optionally it can even display the angle of arrival of moving objects.

The ARTS is right for the lab and the production line. The horn antenna (optionally, bistatic operation is possible with two antennas for greater dynamic range) can be placed on the rear, side or bottom panel of the instrument, making it possible to configure convenient desktop test setups as well as horizontal and vertical assemblies in test chambers (Fig. 2). Installing a microwave transceiver for either horizontal or vertical signal polarization creates an additional degree of freedom. And if these options are not enough, the highly compact (approx. the size of a matchbox) transceiver module can be detached from the simulator for remote operation. This dramatically expands its range of applications, for example, in EMC chambers.

Holistic approach: the ARTS as a component of HIL systems

The trend toward autonomous vehicles will continue to generate increasingly more and demanding test cases to cover the complexity of real-life situations in the most comprehensive way possible. It is no longer enough to generate and analyze signal traffic via wired bus systems (CAN, FlexRay, LIN, etc.). On the contrary, realistic system simulation requires all control loops to be closed via the RF connections involved (GPS, radar, C2C, eCall, etc.). Hardware-in-the-loop (HIL) systems for these simulations must also be outfitted with various

Fig. 2: ARTS9510 designs and operating modes: desktop model with touchscreen user interface and rear-mounted antenna; system instrument with side or floor-mounted antenna.

Sample automotive radar test setup

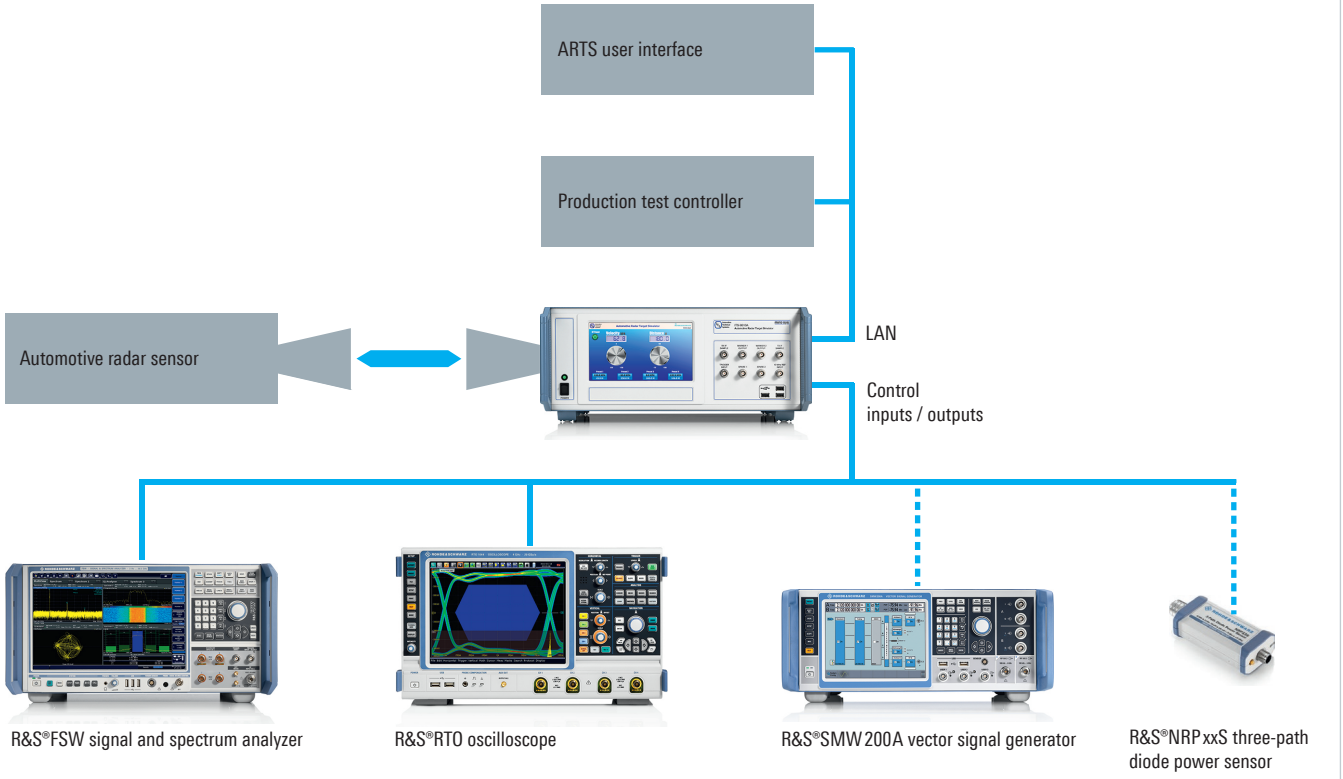


Fig. 3: The ARTS9510 target simulator in a sample setup with additional test instruments: signal and spectrum analyzer with radar analysis software, oscilloscope for signal visualization, signal generator for signal effects, power sensor for precise measurement of transmit power.

air (wireless) interfaces, and the ARTS offers such a realtime-capable interface. All other interfaces are available from the Rohde&Schwarz T&M instrument portfolio. The radar target simulator itself is a compact, modular and flexible toolbox enabling test engineers to use the included DLL/API libraries to develop their own signal and control routines and generate, for example, nonlinear velocity profiles. As an additional feature, test engineers may use the simulator's large memory depth to program long-time (20 to 30 minutes, depending on the number of target parameters and their rate of change), multitarget scenarios and assign individual dynamic ranges to each target.

An IF control output allows users to analyze the received signal with external test instruments. Fig. 3 shows possible extensions for examining radar signals more thoroughly. The combination with the R&S®FSW signal and spectrum analyzer provides an especially comprehensive image. While the ARTS is used primarily to assess the functionality of radar sensors and to close signal paths in HIL scenarios, the R&S®FSW enables exact, automatic measurements of the signals themselves. This makes it possible to quickly identify possible trouble spots and optimization potential in sensors (see article on page 30).

Summary

The ARTS9510 represents another important developmental step in the effort to use sophisticated T&M equipment to control functionalities and comply with safety standards for increasingly complex automotive systems. Automobile manufacturers, tier 1 suppliers as well as sensor and chipset manufacturers can now use this instrument to create reproducible, reliable test conditions in every phase of the development and production process, while drastically reducing test drive costs and development times. The ARTS9510 can be upgraded to a fully configured radar technology test environment by adding other RF T&M equipment from the Rohde & Schwarz portfolio.

Udo Reil; Lutz Fischer; Volker Bach

Pulse compression analysis in radar systems

A new option for the R&S®FSW signal and spectrum analyzer analyzes how radar system components influence the performance of pulse compression.

Today's pulse radar systems frequently use pulse compression techniques. These techniques improve the range resolution and range using the same output power. For this purpose, the transmission pulse is initially extended and modulated over time. Known transmission signal types include linear frequency modulation (also called a chirp) and binary phase shift keying (BPSK) with Barker codes. In the radar receiver, the receive signal is compressed using a matched filter or correlation. This improves the time resolution and the range resolution by a factor of the compression.

Measuring the pulse length is not enough for a measurement-based evaluation of the range resolution. Instead, a signal analyzer, similarly to a radar receiver, must analyze the transmission signal via a suitable matched filter. This is where the R&S®FSW signal and spectrum analyzer with the R&S®FSW-K6S time sidelobe measurement option comes into play. R&S®FSW-K6S is an upgrade to the R&S®FSW-K6 pulse measurements option (page 38) and requires this option.

The R&S®FSW displays the compressed pulse in the time domain as a result (see figure). An expansion of the impulse response (the mainlobe), which leads to a poorer range resolution, is easy to detect. Any additionally occurring time sidelobes or range sidelobes, as well as other influences from filters, amplifiers or other components of the radar transmitter, are also easy to identify. An important measurement parameter is, in particular, the spacing of the sidelobes with respect to level and time because the sidelobes appear as ghost targets. In addition to the compressed pulse, the R&S®FSW outputs a table showing the width of the mainlobe, as well as the level and time spacing of the time sidelobes (sidelobe suppression, sidelobe delay) along with the power contained in the mainlobes and sidelobes. The frequency- and phase-error displays for the original pulse also help to identify possible causes of error.

Because numerous signal types much more complex than chirp or Barker codes are also used today – many of them have a proprietary format – the R&S®FSW can load user-specific filters as I/Q data, making it an all-purpose measuring instrument.

Herbert Schmitt

Window 3 (Correlated Magnitude) shows the mainlobe and time sidelobes for a radar pulse spread by means of a Barker code. In addition, we can see that the sidelobe suppression limited by the code being used is approx. 21 dB.

Analysis of very long radar pulse sequences

The R&S®FSW signal and spectrum analyzer now has a free upgrade to its R&S®FSW-K6 pulse measurements option that efficiently segments signals before they are analyzed. This saves memory space and increases the analysis period so that trends become visible for pulse parameters.

Pulsed radar systems transmit high-power pulses. Each pulse is followed by a pause in which echoes can be received. In many pulsed radar systems, the carrier frequency of the pulses remains constant. Only the pulse repetition interval (PRI) and the pulse width (PW) vary. The PRI determines the maximum unambiguous measurement range. The longer the PRI, the greater this range is. The pulse width of an unmodulated pulse determines the range resolution. Longer pulses have more power per pulse and therefore achieve a longer range. Shorter pulses allow detection of objects even at a lesser range. In addition, they improve the range resolution, i. e. the capability to resolve objects as separate items. However, they require a higher spectral bandwidth.

Marine and air surveillance radars regularly change their operating modes. They use different PRIs and PWs in search mode, acquisition mode or tracking mode because these require various compromises between minimum and maximum range and range resolution. Other techniques include modulation of phase or frequency during a pulse, which encompasses pulse compression (see page 37).

For development, optimization and troubleshooting of radar transmitters, pulse trains must be characterized over a long period. To capture sporadic events or small but continuous effects such as temperature drifts, it is desirable to record and measure all emitted pulses over a period of several minutes.

Pulse analysis using a spectrum analyzer

Spectrum analyzers are excellent tools for analyzing radar signals. They have a wider frequency range than oscilloscopes and allow detailed measurements of phase and frequency within a pulse. This is not possible with simple pulse analyzers. Spectrum analyzers have made great strides over the last few years with regard to analysis bandwidth. The R&S®FSW signal and spectrum analyzer (shown on page 30), for example, now offers an analysis bandwidth up to 2 GHz and a frequency range up to 85 GHz. This makes it possible to analyze even very short pulses, with the result that spectrum analyzers have replaced oscilloscopes. In addition, features such as rapid identification of spurious emissions, low phase noise and extensive pulse analysis functions running as software directly on the analyzer make the R&S®FSW an indispensable tool for the production and development of radar equipment.

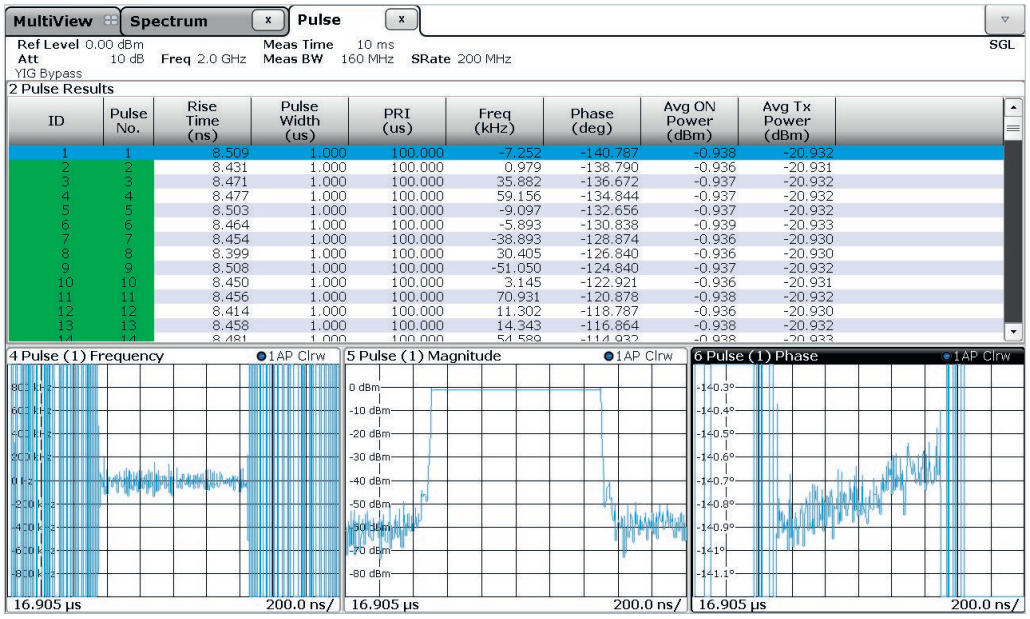
Fig. 1 shows the result of the analysis of radar pulses using the R&S®FSW equipped with the R&S®FSW-K6 pulse measurements option. Pulses with a length of 1 µs and a pulse repetition interval of 100 µs were recorded at a 200 MHz sample rate. The table shows the most important parameters such as rise time, pulse width, PRI and frequency. The graphs below the table display frequency, magnitude and phase vs. time for an individually selected pulse (highlighted in blue in the table). The software allows further detailed analyses of pulse parameters such as rise and fall times, dwell time, settling time, overshoot and undershoot.

Segmented capture saves memory space and increases the analysis period

The high sample rates required and the limited memory space restrict the continuous recording and analysis period. The pulse analyzer software has been equipped with efficient signal segmentation and memory management so that pulse parameter trends can be analyzed by the R&S®FSW over a long period. The principle: superfluous data is omitted. The nature of pulsed signals is that only noise is recorded during the pauses. Omitting the noise while recording saves memory space and makes a longer recording time available.

This has been achieved with a simple yet effective algorithm. It ensures that the I/Q samples together with the time at which they were recorded are not saved to memory unless the power level has exceeded a specific threshold. Samples can also be saved before the trigger event. All additional samples up to the next trigger event are rejected. With typical duty cycles of 1 %, the maximum observation period can be increased by a factor of 100. If you take into account 50 % pre- and post-trigger values, i. e. a recording time of double the pulse length per pulse, then this still results in a factor of 50. Accordingly, a higher duty cycle increases the maximum recording time. The segmented recording of I/Q signals can be initiated by an external trigger and the internal power trigger.

Fig. 1: Result table of the R&S®FSW-K6 pulse measurements option. It shows the most important parameters of each pulse, such as rise time, pulse width and repetition interval, as well as frequency.



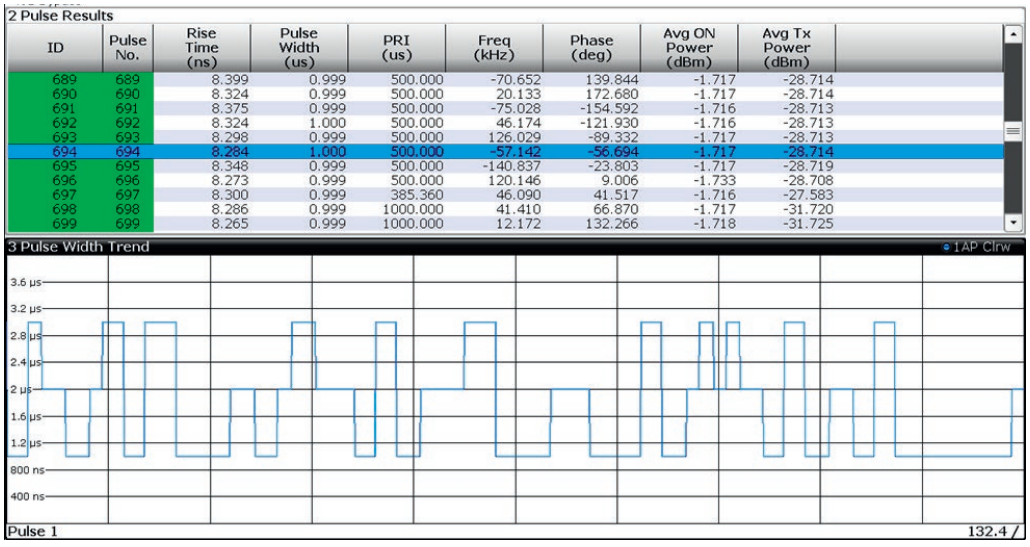


Fig. 2: Display of a 20 s recording time, showing that the radar system being analyzed operates in three different modes.

Evaluation of trends

Fig. 2 shows the pulse width vs. the pulse number over a recording time of 20 s. You can see that the radar device operates in three different modes (1 µs, 2 µs and 3 µs pulse width) which appear in random order. Without segmented recording, the maximum recording time would only be 2.3 s at a 200 MHz sample rate, which is not enough to see the pattern of the different modes.

Segmented recording expands the analysis period, allowing a series of many consecutive pulses to be recorded. This makes it possible to detect and analyze parameter trends and to track changes from pulse to pulse. Effects such as changing modes, for example, do not remain hidden.

Martin Schmähling

DOCSIS 3.1 – the game changer for cable TV and Internet

The new DOCSIS 3.1 standard offers significant benefits to cable network operators. Its numerous technological advances serve to increase the data rates drastically in both the upstream and downstream without costly modifications to the network structure.

For cable networks, the "last mile" to the connection at the user's home is the bottleneck that prevents higher data rates. This last segment is made up of optical fiber and coaxial cables, amplifiers and electrical/optical converters. This mix of optical fiber and coaxial cables is known as a hybrid fiber-coaxial (HFC) network. Fig. 1 illustrates a typical cable network.

The Data Over Cable Service Interface Specification (DOCSIS) 3.1 published in October 2013 acts as a game changer for cable networks. Its technical innovations allow cable network operators to maximize both the downstream (DS) and upstream (US) throughput in their networks without making expensive changes to the HFC network infrastructure.

The DOCSIS standard was developed by the nonprofit consortium CableLabs and ratified in mid-1997 (Version 1.0). DOCSIS specifications cover the complete communications infrastructure for IP connections, various layers, and bidirectional data transmission over the cable TV network. Since previous versions remain as part of the DOCSIS 3.1 specification, network components must be downward compatible. An application note from Rohde & Schwarz discusses the fundamental technological advances of DOCSIS 3.1 and provides a first look at measurements [1].

Current cable networks use different versions of the standard. Fig. 2 shows the differences between DOCSIS 3.0 and DOCSIS 3.1 for the upstream and the downstream.

DOCSIS 3.0 is still being used in many countries around the globe. Europe uses a modified version (EuroDOCSIS) that reflects the standard 8 MHz channel bandwidth found there. EuroDOCSIS provides higher downstream rates than in the USA or Asia, where 6 MHz channels are typical. DOCSIS 3.0 defines a two-path communications system, where the downstream employs a 64QAM or 256QAM single-carrier method in line with the ITU-T J.83/B and DVB-C standards [2].

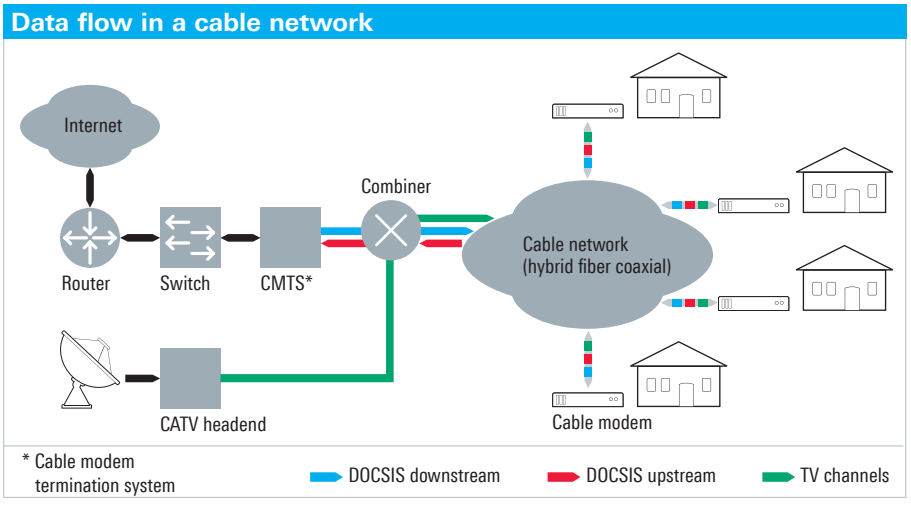


Fig. 1: A typical cable network that provides television and Internet services to homes via cable modems.

Downstream		
Parameter	**DOCSIS 3.1**	**DOCSIS 3.0**
Modulation	OFDM, 4k and 8k FFT, similar to DVB-C2	single carrier with J.83/B or DVB-C
Frequency range	108 MHz to 1218 MHz (1794 MHz)	45 MHz to 1002 MHz
Channel bandwidth	up to 192 MHz	6 MHz or 8 MHz
QAM order	up to 4096 (optionally 8k, 16k)	up to 256
Error protection	LDPC, BCH	Reed-Solomon
Downstream data rate	10 Gbit/s (20 Gbit/s)	300 Mbit/s (1 Gbit/s)

Upstream		
Parameter	**DOCSIS 3.1**	**DOCSIS 3.0**
Modulation	OFDM, 2k and 4k FFT, similar to DVB-C2	single carrier with TDMA or CDMA
Frequency range	5 MHz to 204 MHz	5 MHz to 50 MHz
Channel bandwidth	up to 96 MHz	up to 6.4 MHz
QAM order	up to 4096	up to 64
Error protection	LDPC, BCH	Reed-Solomon, Trellis
Upstream data rate	1 Gbit/s (2.5 Gbit/s)	100 Mbit/s (300 Mbit/s)

Fig. 2: Comparison of key features of DOCSIS 3.1 and DOCSIS 3.0. Values in parentheses are future extensions.

DOCSIS 3.1 incorporates portions of the PHY layer specification from the DVB-C2 standard with OFDM and very high orders of QAM (up to 16kQAM for future applications). The downstream bandwidth can extend to a maximum of 192 MHz, making data rates of up to 10 Gbit/s possible.

DOCSIS 3.1 – the network operator's recipe for success

The demand for greater bandwidths and better quality of service (QoS) is steadily growing. Against this background, DOCSIS 3.1 is a clarion call to network operators, who also face stiff competition from wireless / LTE and DSL Internet providers.

Many developments and forces drive the market. These include the demand for faster Internet access, new business services, over-the-top (OTT) content, 3D TV as well as 4K and 8K TV transmission, to name only a few. A number of network operators are pushing Wi-Fi over cable. This makes the WLAN available not only at users' homes but also at access points outside the home. Subscribers benefit from the convenience of having WLAN access when moving about outdoors in the vicinity of their home. Providing a significant boost in data throughput, DOCSIS 3.1 fulfills the requirements for all of these new services and is essential for network operators to be competitive on the market.

DOCSIS 3.1 also offers financial benefits. The enhanced standard makes more efficient use of the spectrum. Higher order constellations make it possible to transmit more bits over the same bandwidth – lowering the cost per bit. But above all, network operators can leave their copper cable infrastructure in place for the last mile and still achieve data rates not possible with DOCSIS legacy versions.

The DOCSIS 3.1 standard supports the different bandwidths in Europe, America and Asia. As it is downward compatible, it permits a smooth transition to the latest standard, minimizing cost and risk for operators.

Major leap forward in technology

A primary difference from the previous versions is the use of orthogonal frequency division multiplexing (OFDM) in DOCSIS 3.1. This multicarrier technique offers many advantages:

- Longer symbol times improve immunity to impulsive noise
- Suppression of individual subcarriers prevents bit errors caused by ingress noise
- Multiple modulation profiles accommodate for different reception conditions
- Time and frequency interleaving improve immunity against impulsive noise and narrowband interference (GSM phones)
- A guard band (cyclic prefix) prevents intersymbol interference (ISI)
- Symbol shaping prevents interchannel interference through steeper channel spectral edges

DOCSIS 3.1 also uses a powerful error protection (low density parity check; LDPC). This permits significantly higher order constellations (at present

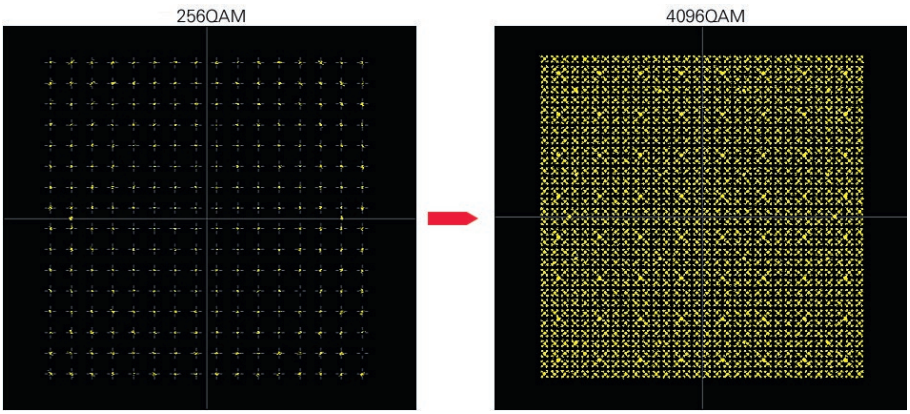


Fig. 3: A key improvement in DOCSIS 3.1 is the use of higher order constellations that allow higher data rates. The screenshots were taken using the R&S®CLGD DOCSIS 3.1 cable load generator and the R&S®FSW signal and spectrum analyzer.

4096QAM; in future up to 16kQAM) and thus drastically higher data rates (Fig. 3).

DOCSIS 3.1 also reduces or even eliminates the need for RF guard bands as it defines channels with up to 192 MHz bandwidth (Fig. 4). This technology was employed by Japan Cable Television Engineering Association (JCTEA) to increase the downstream data rate for HEVC encoded high frame rate 8K transmissions.

Higher order constellations require a better signal quality (modulation error ratio; MER). The headend must therefore generate downstream signals with the highest possible MER. The upstream path must also exhibit high modulation quality as it is susceptible to noise. This is why testing and maintenance are vital for DOCSIS 3.1 compliant cable networks. High-quality T&M equipment is essential to carry out the required types of analyses.

Large channel bandwidths in DOCSIS 3.1

Fig. 4: Large channel bandwidths eliminate the need for RF guard bands, resulting in more efficient transmission.

Customized profiles for different network areas

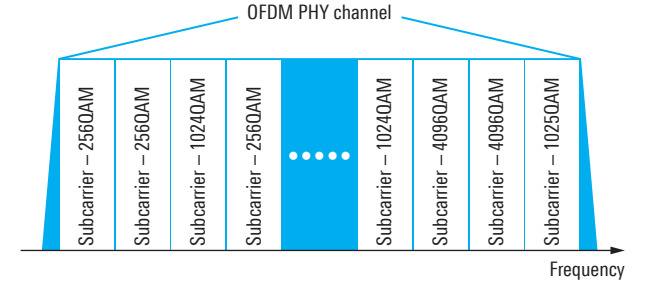


Fig. 5: Each subcarrier in an OFDM cable channel can be assigned an individual constellation order.

Key feature: profiles

One outstanding feature offered by DOCSIS 3.1 are profiles that can be used to apply the appropriate signal configuration to individual areas in a network topology. Not all cable modems receive the same level of signal quality. The signal quality at the modem is dependent on the distance to the cable modem termination system (CMTS), the type and number of upstream components (Fig. 6), and various types of interference on the transmission path. Profiles take advantage of the ability to assign an individual constellation order (QAM) to each subcarrier in an OFDM cable channel. By assigning suitable profiles to groups of modems having similar signal quality, it is possible to provide a maximum number of modems in the network with the best possible channel capacity at a given carrier-to-noise ratio (CNR) (Fig. 5).

Different reception conditions in a cable network

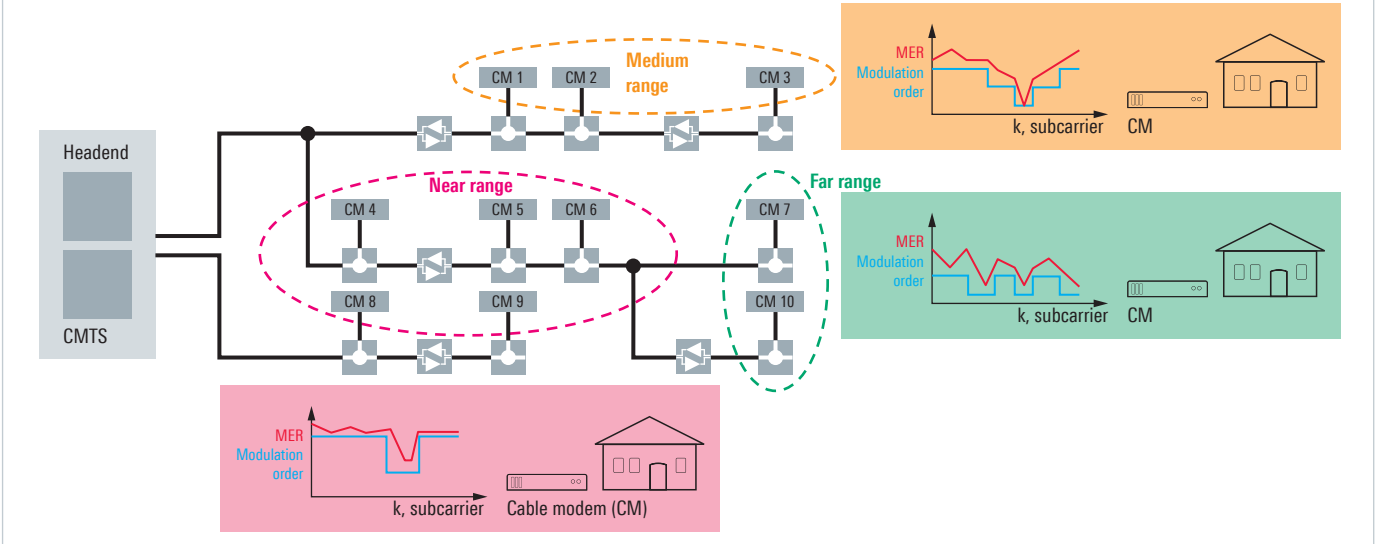


Fig. 6: The signal quality (MER) is dependent on the cable network infrastructure and the distance between the cable modem and the cable modem termination system (CMTS).

Without the option to assign different profiles, the CMTS would have to generate signals with a sufficiently low-order constellation to ensure that they can still be decoded reliably by the modem with the worst CNR. This would unnecessarily reduce the data rate for all of the remaining cable modems. The process is similar to that for the physical layer pipes (PLPs) in the DVB-T2 standard, where broadcast services can be adapted to a variety of situations, e. g. reception on a roof antenna, indoor reception or mobile reception.

The future

Since its publication, DOCSIS 3.1 has generated a lot of activity in the USA CableLabs has hosted two events in Louisville, Colorado, giving CMTS and cable modem manufacturers, T&M equipment providers and network operators the opportunity to meet and test their systems for interoperability. Rohde&Schwarz participated in the tests and also made signal generators and analyzers available.

As part of the preparations for the 2020 Olympic Games in Tokyo, JCTEA recently modified the DVB-C2 standard to launch UHD-2 8K broadcasting (at 120 frames/s) starting in 2016. The associated services will use HEVC encoding and primarily require a data transmission rate of 100 Mbit/s. With support from Sony, JCTEA proposed some enhancements to the DVB-C2 working group that permit the standard to be used in accordance with Japanese government broadcasting regulations:

- Notifications from early warning systems (earthquakes, etc.). These signals must be included in the layer 1 signaling to ensure sufficiently robust transmission
- More precise specifications for PLP bundling.
  This is currently specified only in general terms (Annex F to EN 302 769 V1.2.1). Japan is expected to be the first country to utilize PLP bundling commercially
- New modulation and coding schemes for greater flexibility. The schemes currently defined in the DVB-C2 standard deliver a data rate of 49 Mbit/s (1024QAM with code rate 5/6) at an acceptable signal-to-noise ratio. 56 Mbit/s (4096QAM with code rate 5/6) is also available at a 6 MHz channel bandwidth; this however requires a higher MER

These requirements were submitted by the DVB-C2 Commercial Module Group and approved in February 2015 by the DVB Steering Board [3].

Japanese network operator J:COM plans DOCSIS 3.1 test phases through the end of 2015, at which time all analog TV services in cable networks will be switched off throughout the country. It can therefore be expected that QAM (J.83/C) and DOCSIS 3.1 signals will coexist in the network during test phase 1.

In some European countries, including Germany, it is possible that PAL (analog), QAM (DVB-C) and DOCSIS 3.1 signals will coexist in the cable networks during test phase 1 (Fig. 7). A similar situation is expected in the USA with NTSC (analog) and J.83/B.

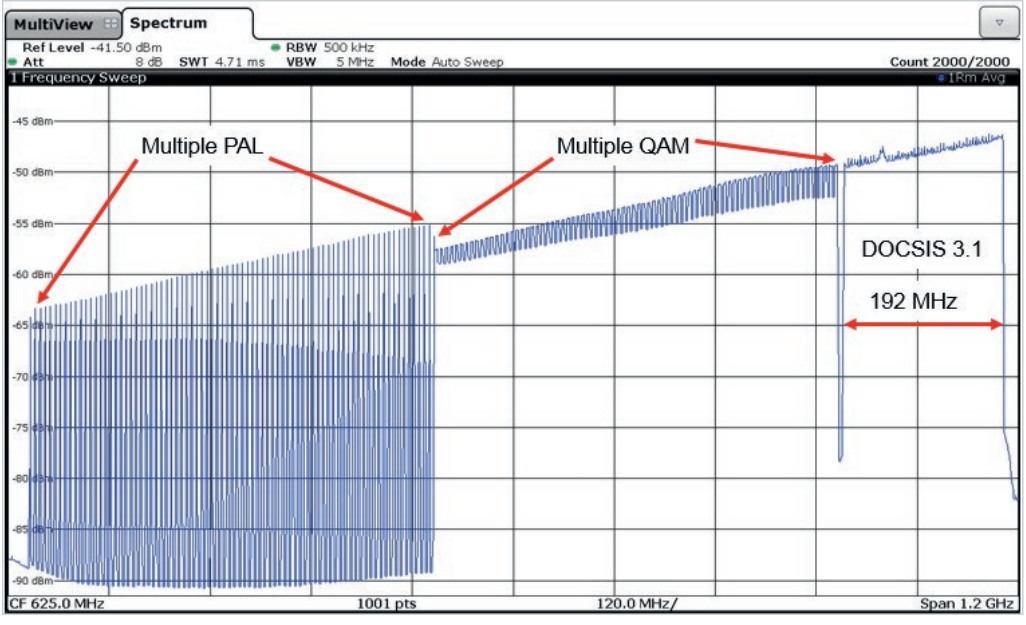


Fig. 7: During the roll-out phase, analog and QAM signals will coexist with DOCSIS 3.1 signals. The screenshot shows the output signal from an amplifier, measured with an R&S®FSW signal and spectrum analyzer. The uptilt compensates for the frequency response of the cable and the amplifiers.

Summary

It can be assumed that DOCSIS 3.1 will provide a strong impetus for the cable market over the next few years as it drastically improves upstream and downstream performance in terms of capacity, robustness and flexibility. It increases data rates to a maximum of 10 Gbit/s in the downstream and 2.5 Gbit/s in the upstream without requiring significant changes to the HFC network infrastructure. This potential should also satisfy the high expectations from cable customers, and it will ensure that the standard remains viable for future 4K and 8K TV broadcasts.

Dr. Nik Dimitrakopoulos; Peter Lampel; Greg Kregoski

References
[1] "DOCSIS 3.1". Application Note from Rohde&Schwarz (search term for download: 7MH89).
[2] "Recommendation J.83 (1997) Amendment 1 (11/06)". November 2006. Retrieved 2013-06-20.
[3] https://www.dvb.org/resources/.

Measuring equipment for DOCSIS 3.1

Now that the DOCSIS 3.1 standard has been defined, the industry players need to get to work. A completely new generation of broadband modulators and tuners will be needed for cable modems and their counterparts in the headend (CMTS). Even if the network infrastructure is left untouched, it will still be necessary to test the amplifiers and converters with the new signals. The large number of signals present on the broadband cable is especially critical since distortion can easily occur due to intermodulation. With OFDM, signal peaks can also occur, which lead to laser clipping in electrical/optical converters, resulting in interference and loss of data. In addition, during a transition period, DOCSIS 3.1 must share the cable with the older 3.0 version, as well as with existing digital television and even with analog TV and VHF radio. T&M equipment must be capable of handling this complex scenario.

Broadband cable with customized loading for the lab bench: R&S®CLGD DOCSIS cable load generator

The R&S®CLGD signal generator simulates a (fully) loaded broadband cable and is especially suited for investigating the mutual influence from DOCSIS 3.1, J.83/A/B/C and analog TV signals in order to ensure that the new broadband data services can coexist with conventional TV broadcasting. In a downstream frequency range from 47 MHz to 1218 MHz (1794 MHz optional), it simultaneously generates either up to eight DOCSIS 3.1 channels or, in the case of mixed-mode operation, two DOCSIS 3.1 channels and up to 158 digital TV channels. In the upstream, the range from 5 MHz to 204 MHz is supported, and this range can be supplied with DOCSIS 3.1 signals up to a 96 MHz bandwidth, or with DOCSIS 3.0 TDMA or CDMA signals.

Each downstream channel is continuously modulated in real time either with an internally generated MPEG-2 transport stream or PRBS content or with data fed over IP. This permits direct BER measurements over the entire frequency range without requiring changes to the configuration. The R&S®CLGD makes such simulations realistic by adding different types of interference such as additive white Gaussian noise (AWGN), impulsive noise, microreflections (in line with SCTE 40), narrowband ingress, and AC hum. The instrument is operated from a PC or via a convenient web GUI.

The only thing missing is the DUT: the R&S®CLGD and R&S®FSW offer all the functions needed to analyze DOCSIS 3.1-ready network components.

Comprehensive DOCSIS 3.1 analysis with the R&S®FSW signal and spectrum analyzer

The R&S®FSW-K192 option is available on the R&S®FSW signal and spectrum analyzer for analyzing DOCSIS 3.1 downstream signals. This software application offers a wide range of graphical displays with detailed results as well as tables listing measurement parameters, greatly facilitating precise characterization and troubleshooting on the DUT. Time-saving automated functions are also available to make measurements more convenient. For example, the software can automatically identify a number of different signal parameters, making initial measurements possible without detailed knowledge of the signal. However, demodulation and decoding of all code words requires an in-depth understanding of the DOCSIS 3.1 profile being used. This information can likewise be obtained automatically by reading the data from the physical layer link channel (PLC), or the data can be entered manually.

The software captures a number of key signal quality parameters, including modulation error ratio (MER), which can be determined with a high degree of accuracy even in an extremely densely populated I/Q diagram (16kQAM). R&S®FSW-K192 is additionally capable of decoding the detected symbols and of measuring the bit error rate, even down to extremely low values (10^{-10}).

Photo: Jan Windszus / Berlinale

Rohde & Schwarz once again Official Digital Cinema Partner to the Berlinale

For the third consecutive year, Rohde & Schwarz DVS GmbH supported the Berlinale with technical equipment. Rohde & Schwarz systems formed the centerpiece of the digital workflow, ensuring it ran efficiently and reliably behind the scenes.

The 65th Berlin International Film Festival (Berlinale) ran from February 5 to 15, 2015. It is one of the film industry's most important events worldwide. The growing digitization in the film industry, however, presented technical challenges to the festival team. This is because 95 % of the roughly 2500 screenings were based on digital film material that needed to be available in the standardized Digital Cinema Package (DCP) format. Production companies, however, do not usually provide their films as DCPs, but in other formats or on tape. This meant the entire festival archive first had to be converted. This is where the studio equipment from Rohde & Schwarz came to the rescue – for the third time in a row.

DCPs from any input format

The Rohde & Schwarz systems were installed in Colt Technology Services' (also an Official Digital Cinema Partner to the Berlinale) data processing center, where they formed the centerpiece of the digital workflow. The R&S®VENICE ingest and production server (shown on next page) digitized the analog material, making it available for further processing. The R&S®VENICE can record and convert signals on up to four channels simultaneously.

The R&S®CLIPSTER mastering station then took over the task of processing the immense amount of data. With its market-leading performance and ability to process all the latest video formats, the R&S®CLIPSTER converted the submitted films into the DCP format in a very short time and stored them on the central R&S®SpycerBox video storage solutions. Last-minute adjustments such as subtitle changes were also easy to make.

The R&S®SpycerBox, the video storage family from Rohde & Schwarz, formed the on-site backbone of the festival's digital cinema solution, boasting a storage capacity of 1 petabyte. Both the film material of the Berlinale itself and that of the European Film Market (EFM) were stored on these highly failsafe storage solutions.

Ove Sander, Technical Manager – Digital Cinema, Berlin International Film Festival, was absolutely delighted at how the Berlinale went:

The Berlinale

The Berlinale is one of the international film industry's most important events. With ticket sales exceeding 335,000 and over 20,000 industry visitors from 128 countries attending, including some 4000 journalists, the Berlinale is an appealing mixture of art, glamor, celebrations and business. The Berlin International Film Festival's public program shows around 400 films each year, most of which are world and international premieres. Films of all genres, lengths and formats are presented in the various sections of the festival.

The European Film Market (EFM) is the business epicenter of the Berlinale and one of the world's most important international film markets. Running parallel to the festival, the EFM provides a platform for over 480 film-industry companies and welcomes over 8000 participants – including producers, buyers, sellers, distributors, cinema operators and film financiers. They all use the EFM to build and foster networks, strengthen their position in the industry or negotiate film rights. In addition to the films from the Berlinale program, over 500 more films were presented at the EFM.

The R&S®VENICE ingest and production server (top of left rack) digitized the analog material thanks to its huge range of supported file formats, codecs and interfaces. The R&S®CLIPSTER mastering station (bottom of left rack) processed the immense amount of data. The R&S®SpycerBox video storage solutions in redundant configuration can be seen in the right-hand rack.

"We are pleased that we could once again count on the systems from Rohde & Schwarz DVS this year. With its incredible speed, the R&S®CLIPSTER mastering station let us generate all DCPs in good time prior to the start of the festival. The DCPs were backed up by the reliable R&S®SpycerBox solutions, so we could depend on everything to run smoothly even when things got hectic during the festival."

Katrin Brussa

Technology & Innovation Day

Rohde & Schwarz holds the "Technology and Innovation Day" every year as part of the Berlinale. In 2015, high-profile speakers from the media industry gave insights into how 4K UHD material can be processed from production to distribution. Planning is underway to continue this exclusive event series in Berlin in February 2016.

vdek opts for encryption from Rohde & Schwarz SIT

The laws provide special protection for health insurance information. After a nationwide call for bids, the Verband der Ersatzkassen e. V. (vdek) decided in favor of the encryption solutions from Rohde & Schwarz SIT and the German integration partner Pan Dacom Direkt to help ensure appropriate security of information flowing between its data centers.

Health insurance information contains extremely private data such as diagnoses, prescriptions for medicine and descriptions of disease progression. If such data falls into the wrong hands, information on health conditions can be used against insured individuals directly or sold on the black market. In the digital age, doctor-patient confidentiality is no longer sufficient to ensure that this does not happen. Data protection must be ensured for electronic transmissions as well.

As a representative and service provider for health insurance funds in Germany, vdek is a strong believer in data protection. "We feel obliged to use the most current and secure encryption techniques at all times to ensure reliable protection for the data entrusted to us," explains Peter Neuhausen, who heads vdek's IT department. vdek is responsible for the data of 26 million insured persons from a total of six health insurance providers. "As an umbrella organization, we have to set a good example," says Neuhausen.

vdek has established a remote backup at an external data center to meet its ever growing data processing requirements. This center is located several kilometers from vdek headquarters and connected in a cost-effective manner using available public fiber-optic links. This is why special data protection is needed. "Sensitive data must never be transmitted via public links without encryption," says the vdek expert. "The risk of unauthorized access is simply too high."

Requirements met: fast, efficient and secure

Along with the strongest possible protection for their data, vdek member funds expect quick access to their data to ensure, for example, expeditious invoicing and quick response times for information requests. As an umbrella association, vdek is set up to be organizationally flexible and quickly implement the requirements of its member funds. "That is exactly why it is so important to us to have an encryption solution that is fast and efficient enough to meet our needs. This also enables us to set an example and demonstrate new IT security practices for our member funds," says Neuhausen.

Key criteria when choosing among the different bidders in the nationwide call for bids included approval from the German Federal Office for Information Security (BSI) and excellent service. Although the data center is only a backup for the time being, the solution also needed to support synchronous mirroring to avoid time-consuming and costly retrofitting at a later time. Important factors in this context are high bandwidth and low latency.

vdek headquarters building.

Photo: Georg Lopata

Since the R&S®SITLine ETH product family from Rohde&Schwarz SIT GmbH was the only solution to meet these technical requirements, the company won the call for bids together with its established integration partner Pan Dacom Direkt GmbH and will provide protection for insurance information transmitted between data centers. Pan Dacom Direkt is a full service product integrator in the field of network technology and will be the customer's direct point of contact for hardware installation, connections to existing fiber-optic lines and on-site support. "Especially for large data centers, the solution from Rohde&Schwarz SIT is just perfect", explains Yurda Oktay, head of business development at Pan Dacom Direkt. "It delivers top technical performance and is also easy to integrate."

Preventing data tapping

vdek will use an R&S®SITLine ETH40G Ethernet encryptor to safeguard its data lines as well as the R&S®SITScope central security management system that makes it easy to configure and administer the encryptors. The R&S®SITLine ETH40G was specially designed for exchanging huge quantities of encrypted data in real time, which is exactly what occurs in data centers. With its high throughput rate of 40 Gbit/s at only 3 µs encryption latency, the new flagship of the R&S®SITLine ETH product family (Fig. below) meets the demanding requirements of data centers, while taking up only 1 HU.

Encryption takes place on the data link layer (OSI layer 2). This provides the additional advantage of reducing security overhead by up to 40 percent compared with IP encryption (OSI layer 3), thereby saving bandwidth. That makes this encryptor ideal for vdek, as it protects the association's data lines without compromising performance.

Security made in Germany

"As an IT security partner for the German federal government, Rohde&Schwarz SIT meets more than just our technical requirements," adds Peter Neuhausen. "We appreciate the trustworthiness of German IT security products." Both Pan Dacom Direkt and Rohde&Schwarz SIT place great emphasis on developing and manufacturing their products in Germany. This means vdek can rely on the high German data protection standards – an important advantage, especially when it comes to encryption.

Christian Reschke

The products of the R&S®SITLine ETH family offer encryption solutions for every need and take up only 1 HU of rack space.

Big data security: Rohde&Schwarz SIT wins German Data Center Award

The German Data Center Awards were presented for the fifth time this April. Rohde&Schwarz SIT prevailed over renowned international competitors to take first place in the "Data Center IT and Network Infrastructure" category with its R&S®SITLine ETH40G Ethernet encryptor.

The German Data Center Award is one of the IT industry's leading performance indicators. Organizer "de-ce Beratung" registered a record number of entries this year. An independent jury of business and scientific experts evaluated the submitted products in a total of eight categories.

The R&S®SITLine ETH40G is the first high-speed encryptor to have a data throughput of 40 Gbit/s. It protects the real-time connections of data centers against manipulation and espionage without impairing network performance. The solution offers made-in-Germany security for the big data infrastructures, private clouds and backbone networks of companies and government authorities.

The jury was also impressed by the energy-efficient, scalable design of the R&S®SITLine ETH40G as well as a multitude of practical features that minimize encryption operating costs and maximize availability. The jury honored this achievement by selecting the high-speed encryptor for cloud backbones and big data as the winner from among 18 submissions.

IP encryption solution from Rohde&Schwarz SIT and Cisco for unthrottled network traffic

Cisco is the world's largest network equipment provider. To use the company's state-of-the-art routing technology in German government networks, an innovative national encryption solution that meets government IT security standards will be required. Rohde&Schwarz SIT develops such a solution: R&S®SITLine IP.

High network efficiency and secure encryption in a single device

Failsafe performance and availability were central issues for data networks for a long time. Today, efficiency, quality of service and data protection play an important role.

IPSec is a common, well-known data stream encryption technology. It is used for designing virtual private networks (VPN) and, for example, when mobile user equipment dials in to a corporate network via the Internet. To do this, IPSec defines a securely encrypted point-to-point connection (VPN tunnel) through the network.

IPSec-based solutions, however, can be an obstacle for advanced wide area network architectures. Their encrypted tunnels hide information required for intelligent routing, putting major constraints on network traffic optimization. The result is a rigid overlay network of VPN tunnels, requiring considerable administrative effort if there is an increasing number of locations.

Advanced networks are only efficient if their traffic is optimized. Optimization allows intelligent routing methods, for instance, to deliver high availability and quality of service in large, heavily meshed networks with numerous terminals and hubs. When connections fail, the mechanisms integrated into the network routers search for alternative paths to target terminals. The quality of service can also be set. For example, IP-based phone conversations (e.g. VoIP) can be prioritized higher than email data packets. This optimization is required for technical reasons and complies with the concept of net neutrality. However, it is severely hampered when encrypted tunnels cause critical information to become unavailable.

R&S®SITLine IP: intelligent routing based on encryption

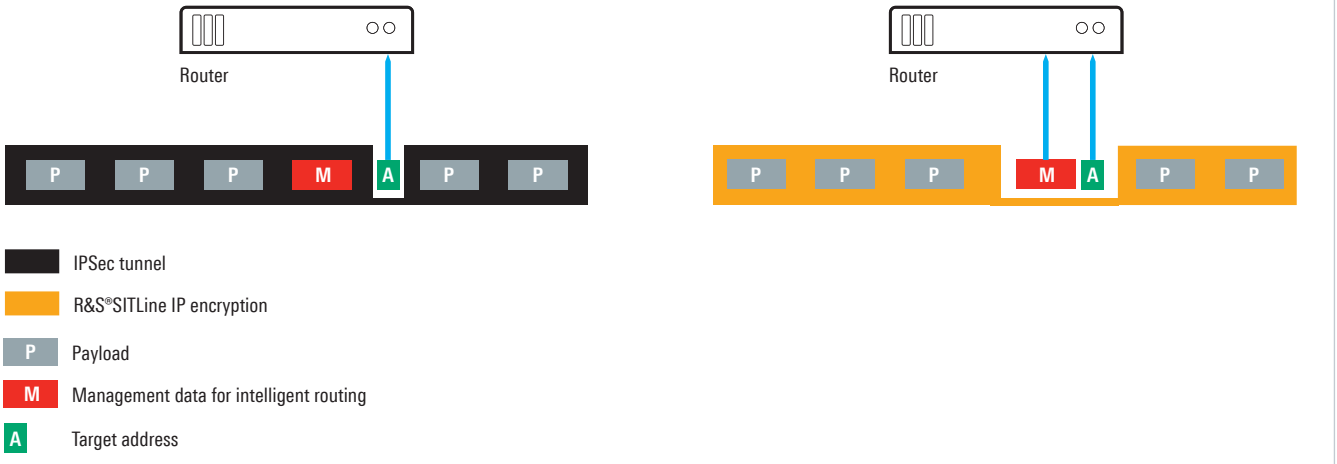


Fig. 1: Unlike conventional IPSec tunnels (left), the R&S®SITLine IP solution encrypts payload only; service and routing information remains available for network traffic optimization.

Group-oriented IP security solutions offer a way out by encrypting only the sensitive payload and leaving service and routing information available (Fig. 1). The group key concept greatly simplifies customer network administration (Fig. 2) and considerably increases overall resilience.

IP security solution for government networks

Cisco International and Rohde&Schwarz SIT are implementing these advanced types of solutions for high-security German government networks using encryption technology made in Germany. As part of this exclusive cooperation, Rohde&Schwarz SIT is developing encryption devices that can be seamlessly integrated into Cisco networks.

The new R&S®SITLine IP devices encrypt data traffic in real time for all transmission paths in a manner that is transparent for network components, which makes them ideal for government networks. They also feature independent, made-in-Germany hardware to ensure additional security without degrading the performance of advanced meshed networks. The R&S®SITLine IP encryptors operate together with Cisco's latest integrated services routers, but there is strict separation between the security and network components. That means proven high security and total interoperability thanks to the cooperative effort with Cisco.

Cisco International
Headquartered in San Jose, California, Cisco is the world's leading supplier for Internet-based network solutions. Its approximate 74,000 employees delivered around USD 47 billion in global revenue in fiscal year 2014. The company focuses on six fields: core networking, Cisco video and collaboration, access (wired and mobile), security, unified data centers and services. Cisco's security field brought in approximately USD 1.5 billion in 2014.

The development of R&S®SITLine IP is based on the innovative platform architecture already in use in the R&S®SITLine ETH Ethernet encryptors (Fig. on page 50) and approved by the German Federal Office for Information Security (BSI). The company plans several R&S®SITLine IP models with throughput rates between 100 Mbit/s and 10 Gbit/s and intends to obtain BSI approval for these encryptors up to the German restricted (VS-NfD) classification level.

A trustworthy value added chain for the applied solutions is especially important for government networks. Rohde&Schwarz SIT develops and manufactures its products at its own secure locations in Germany. This also ensures the long-term availability of the platform components as well as the products based on them.

The partners complement each other perfectly – German security technology for the highest standards from Rohde&Schwarz SIT and state-of-the-art network technology from Cisco. Together they can equip the world's leading IT infrastructure with German crypto equipment and meet the additional needs of government IT networks in Germany. It is a model that can set an international precedent when high performance and national security are required.

Christian Reschke

R&S®SITLine IP for reduced configuration effort

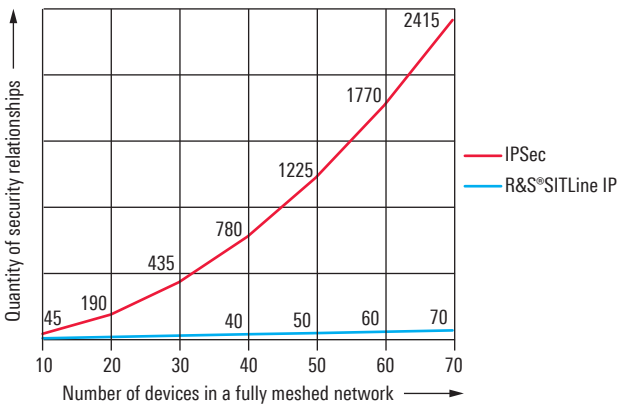
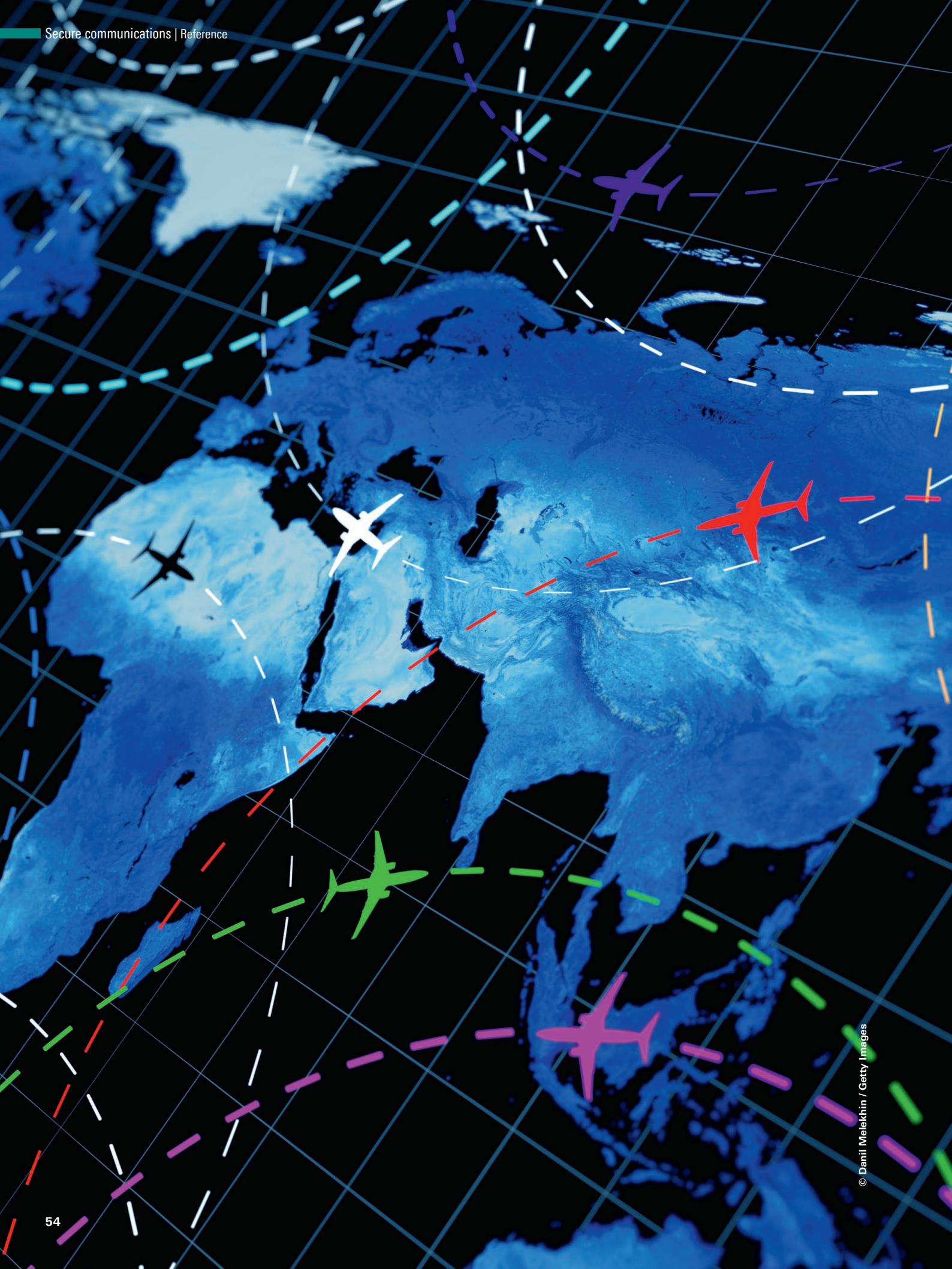


Fig. 2: Configuring a fully meshed network is significantly less complex with R&S®SITLine IP group encryption than with comparable IPSec-based protection.



Innovative cloud architecture for air traffic control

A unique solution from Rohde&Schwarz can help national and international air traffic control (ATC) authorities rise to the approaching challenge of drastic structural changes. The latest example comes from Ireland and Iceland where a joint air traffic control modernization project is underway for the North Atlantic flight corridor.

In focus: flight density and costs

Rising air traffic density and pressures to reduce costs create challenges for ATC authorities. The piecemeal air space over Europe complicates matters as well. Fig. 1 shows the current national ATC areas of responsibility in the air space over Central Europe. The red lines indicate two hypothetical flight routes – one from France to Germany and another from Italy to Germany. Even short flights like these entail frequent switching between air traffic control authorities: France – Belgium – Netherlands – Germany, and Italy – Switzerland – Austria – Germany.

Geographic conditions can also dictate frequent ATC responsibility transfers (see Fig. 2). The radio shadowing in this example means that additional communications resources are needed to ensure seamless flight monitoring and control. The widespread time division multiplexing (TDM – originally developed for public phone networks) technology used here makes it impossible to network these resources. TDM allows users to exploit only those radio resources that are connected to their local control centers. The connections are circuit-switched and there are no through-connections for radio resources between individual control centers (or they are not feasible due to interface incompatibility).

All of these constraints have a negative impact on air traffic. On the one hand, frequent ATC responsibility transfers require large numbers of personnel at numerous control centers. This ultimately affects ticket prices, as airlines have to pay an air traffic control fee for each flight – a fee that includes personnel expenses and operating costs. On the other hand, ATC personnel have a higher workload, as each ATC responsibility transfer requires an official handover of the aircraft being controlled. Handovers take a certain amount of time. As a result, frequent transfers increase the loads on pilots and controllers and ultimately limit the capacity of the controlled airspace. High operating costs and limited air space capacity reduce opportunities for additional growth with the current configuration of Central European airspace. The same problem occurs in more or less identical fashion in the global air space.

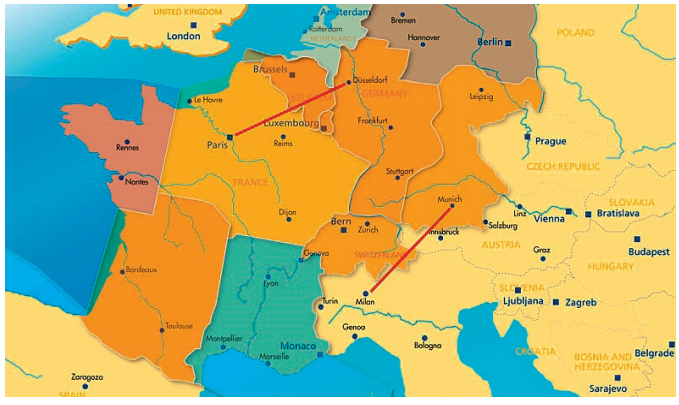


Photo: FABEC

Fig. 1: Sample flight routes (red) with frequent ATC responsibility transfers in the small-scale airspace over Central Europe.

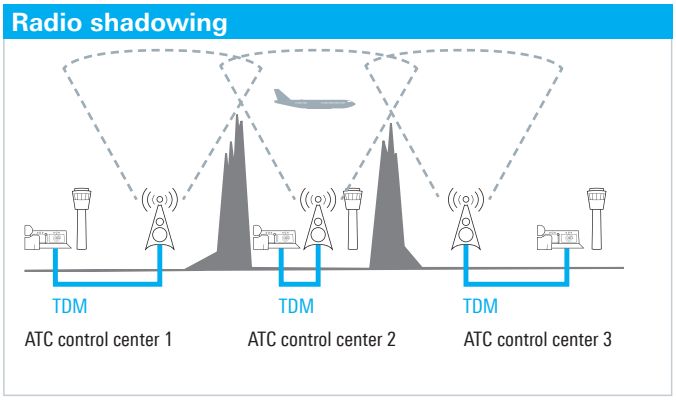


Fig. 2: Radio shadowing induced by geographic constraints necessitates frequent transfers of responsibility between various ATC control centers.

The solution: IP technology and standardization

The above problems can be solved by taking two engineering measures. The first is to ensure universal accessibility of communications resources across national and geographic borders. The second is to use standardized, manufacturer-independent interfaces to access radios for voice communications between air traffic controllers and pilots as well as for special telephone connections for controller-controller voice communications between ATC centers.

Use of the Internet protocol (IP) makes it possible to achieve universal accessibility. Industry stakeholders and ATC authorities in Europe joined together to establish the EUROCAE ED-137 standard for interfaces several years ago. Rohde&Schwarz was and is involved in developing its specifications. The original European ED-137 standard has been adopted by more and more ATC authorities around the world including the United States, Australia, Brazil, China, etc. – a trend that was confirmed when the International Civil Aviation Organization (ICAO) added the standard to its global regulations.

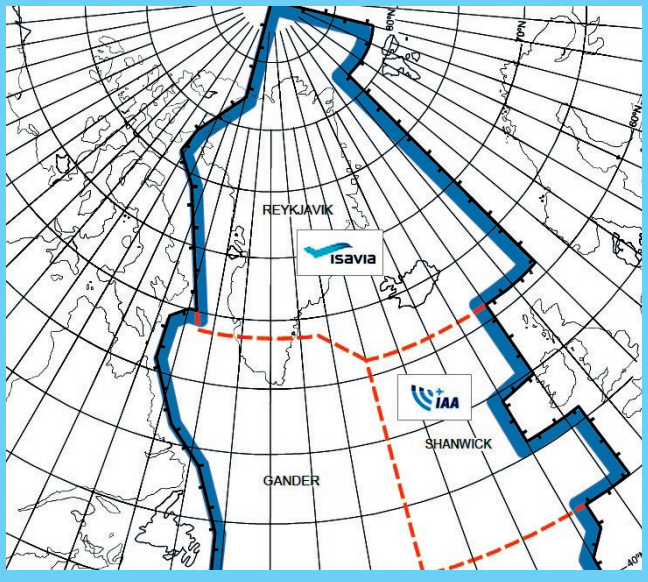
That is how voice over IP (VoIP) technology, known as Internet telephony, is finding its way into air traffic control. To meet the demanding safety requirements existing for ATC, several adaptations and expansions such as enhanced failsafe performance, simplex method, etc. have been added to the standard. The R&S®VCS-4G voice communications solution and R&S®M3SR Series4100 / 4400 and R&S®Series4200 radios come equipped with interfaces that adhere to EUROCAE ED-137.

Global innovation from Rohde&Schwarz: cloud architecture for ATC

The consistent use of VoIP technology in control center voice communications systems and radios has enabled Rohde&Schwarz to become the world's first manufacturer to implement the "cloud" principle in ATC communications (Fig. 3 and box below).

The solution features IP-based technology throughout, doing away with TDM. All communications resources are equipped with ED-137 VoIP interfaces and connected via a common, high-availability, secure IP backbone. This makes it possible to virtually pool physically and geographically distributed control centers into unified logical units. Entire control centers can be eliminated as VoIP works through the IP backbone to provide access to radios that would otherwise be unreachable. In addition to a reduction in costs, this virtual coupling of control centers also offers advantages such as higher availability and increased overall system failsafety. This is why, for example, "virtual control center part 2" in Fig. 3 can fully assume the duties of "virtual control center part 1" in case of failure by remotely accessing the radios previously assigned to that location. This transition is transparent to air traffic. The same applies if a virtual control center is taken out of operation for maintenance or becomes uneconomical to operate for a period of time.

The world's first ever cloud-based virtual center technology implemented in the R&S®VCS-4G system solution from Rohde&Schwarz supports ATC authorities as they make necessary structural changes in national and international



Areas of responsibility of the ATC centers in Ireland and Iceland across the North Atlantic flight corridor.

R&S®VCS-4G in action with IAA and ISAVIA

The Irish (IAA) and Icelandic (ISAVIA) air traffic control authorities are jointly responsible for the flight corridor over the North Atlantic (Fig.). The modernization program for both the IAA and ISAVIA ATC communications systems involved the previously impracticable requirement of making it possible for the Icelandic authority to take on full control of Ireland's duties and vice versa. This requirement stemmed from economic considerations and the demand for efficient, dynamic resource distribution between both ATC authorities. There

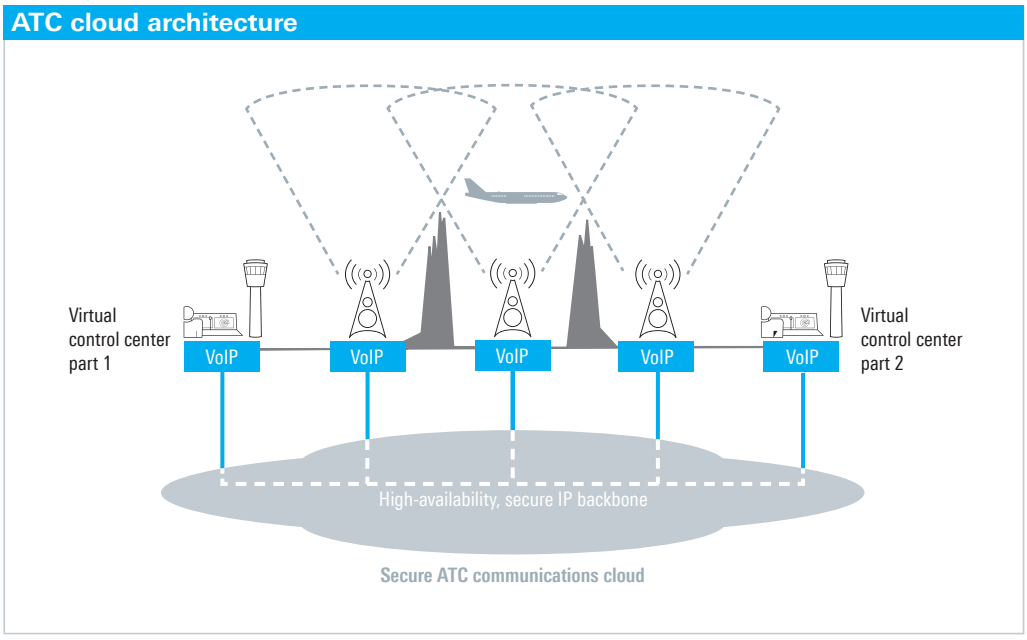


Fig. 3: All communications resources are equipped with ED-137 VoIP interfaces and are connected via a common, highly available and secure IP backbone.

airspace. The system prevents the above-mentioned negative effects of national and geographic constraints on air traffic. Consolidating required control centers and providing cloud-based access to communications resources reduces the number of complex, time-consuming ATC handovers between control centers and lowers operating costs.

Fig. 4 outlines the essential components of the R&S®VCS-4G. All of the voice communications systems and radios together form a communications resource cloud. Each air traffic controller at each control center can transparently access any ground-to-air (radio) or ground-to-ground (phone line) channel in the entire network.

was also a demand for enhanced operational safety in case of major system malfunctions or even total failure of one of the two systems.

R&S®VCS-4G virtual center technology enabled Rohde&Schwarz to prevail over the global market leader during the tender process. The ATC centers in Ballygireen (Ireland) and Gufunes (Iceland) are now both being equipped with an R&S®VCS-4G system. The systems are interconnected in a cloud architecture so as to allow air traffic controllers at either control center to fully or partially take over the duties of the other center for ground-to-air and ground-to-ground communications. The high-performance IP connection required to link the two ATC centers runs through leased, redundant IP backbones installed in submarine cables. Rohde&Schwarz integrated existing competitor VHF and HF radios into its solution to cover ground-to-air communications. The company installed R&S®M3SR Series4100 HF receivers as well. Unlike competitor devices, these receivers connect via VoIP in line with EUROCAE ED-137. An automatically controlled antenna switch matrix modified to customer specifications was also part of this substantial order.

The customers state that it was more than technology leadership that made the difference in awarding the tender to Rohde&Schwarz. It was the company's customer-oriented approach summed up in the phrase "everything from a single source." The system solutions were delivered in mid-2014. They will replace the old systems and enter regular operation in the second half of 2015 after integration and testing have been completed.

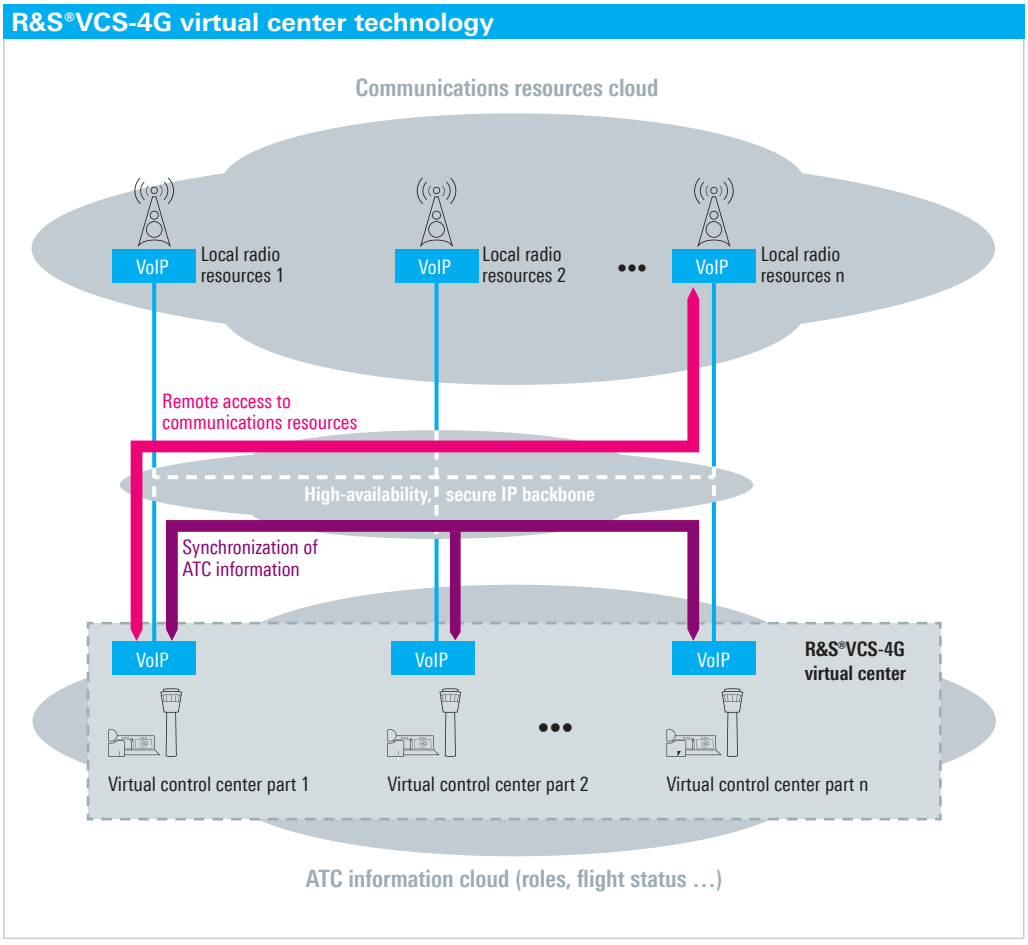


Fig. 4: Key components of R&S®VCS-4G virtual center technology.

The workflows required for the diverse ATC tasks are stored at every control center in what is known as a VCS configuration and management system (VCMS) server. The ATC information stored and managed there defines items such as air traffic controller roles, i. e. who is responsible for what part of the air space and what communications resources (radios, phone lines) are reserved for that individual controller. In the R&S®VCS-4G system solution, the various local VCMS servers are implemented as a Linux-based, highly advanced, distributed PostgreSQL database system with automatic data synchronization and replication between local database instances. All of the VCMS servers together form a cloud for ATC information.

Summary

International air traffic control is facing major challenges from rising air traffic densities and demands to reduce costs. Technology can play a significant role in mitigating the severity of the situation by virtualizing ATC control centers. To achieve this, all communications resources belonging to an extended control area are exported to a cloud. The recources in the cloud can be jointly used by the participating control centers via standardized IP access. Rohde&Schwarz proved the advantages of this approach for the first time ever when it equipped the ATC centers (Ireland and Iceland) responsible for air traffic over the North Atlantic. This was made possible by creating an all-IP-based, currently unique communications system that includes everything from the air traffic controller's microphone to the antenna.

Dr. Markus Lautenbacher

From the microphone to the antenna – end-to-end system solutions from Rohde&Schwarz

Rohde&Schwarz is the only manufacturer on the market that can offer ATC customers a complete, end-to-end system solution covering everything from the air traffic controller's communications system through a broad selection of radios to a variety of amplifier, filter and antenna options. Here are a few examples:

R&S®GB5400 controller working position

- Functions: fully VoIP-based ground-to-air and ground-to-ground communications for controller working positions
- Device options:
  - 12" and 15" touchscreen options
  - Up to four loudspeakers and four headsets
  - Redundant power supplies and IP network connections
  - New: compact version that requires minimal space
- Audio interfaces: VoIP (EUROCAE ED-137)
- Hardware: custom Intel-based PC board
- Operating system: custom CentOS Linux

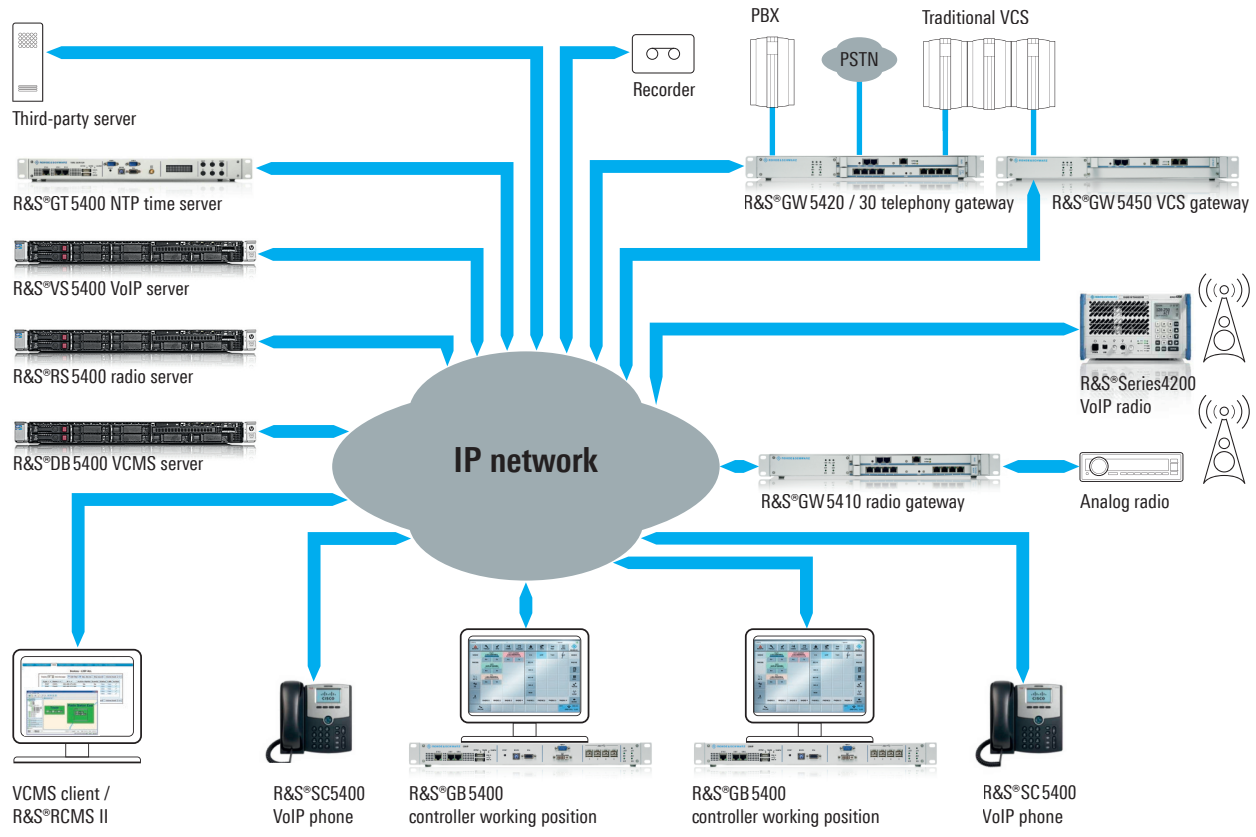
R&S®Series4200 software defined radios

- VHF / UHF frequency range: 112 MHz to 156 MHz / 225 MHz to 400 MHz
- Power: 50 W for VHF and UHF
- Automatic main / standby operation
- Best signal selection (BSS) in the receiver
- Data transfer via VDL mode 2
- Detection of simultaneous transmissions (DSiT) in the receiver
- Audio interfaces:
  - Analog
  - E1
  - VoIP (EUROCAE ED-137)

R&S®M3SR Series4100 software defined radios

- HF frequency range: 1.5 MHz to 30 MHz
- Power: 150 W, 500 W, 1000 W, 4 kW
- HF broadband / HF split site systems
- Embedded secure voice and data capable
- IP over air (IPoA)
- SIP-based remote voice operation
- Audio interfaces:
  - Analog
  - VoIP (EUROCAE ED-137)

End-to-end ATC system solution from Rohde&Schwarz



One for all: compact antenna system for broadband radiomonitoring

The new R&S®AU600 active omnidirectional receiving antenna system is unique in the market. It is targeted primarily at regulatory authorities that perform spectrum monitoring in line with ITU recommendations. However, other users involved in broadband radiomonitoring in the VHF, UHF and lower SHF ranges can also benefit from this system. The R&S®AU600 is the first single system to cover the frequency range from 20 MHz to 8 GHz and to provide simultaneous interception of vertically and horizontally polarized signals.

Fig. 1: The R&S®AU600 active omnidirectional receiving antenna system is built to handle horizontally as well as vertically polarized signals. It covers an unrivaled range for such antennas from 20 MHz to 8 GHz. The system can be controlled by the R&S®OSP120 open switch and control platform (top device in figure) or the R&S®OSP130 (bottom).

Compact and rugged

The antenna system with its four antennas has a total height of only 102 cm. It weighs approx. 17 kg (Fig. 1). The protective radome is built from acrylonitrile styrene acrylate (ASA) to ensure high impact resistance and resistance to atmospheric conditions but without degrading the RF characteristics of the antennas. The system is designed to withstand wind speeds up to 275 km/h.

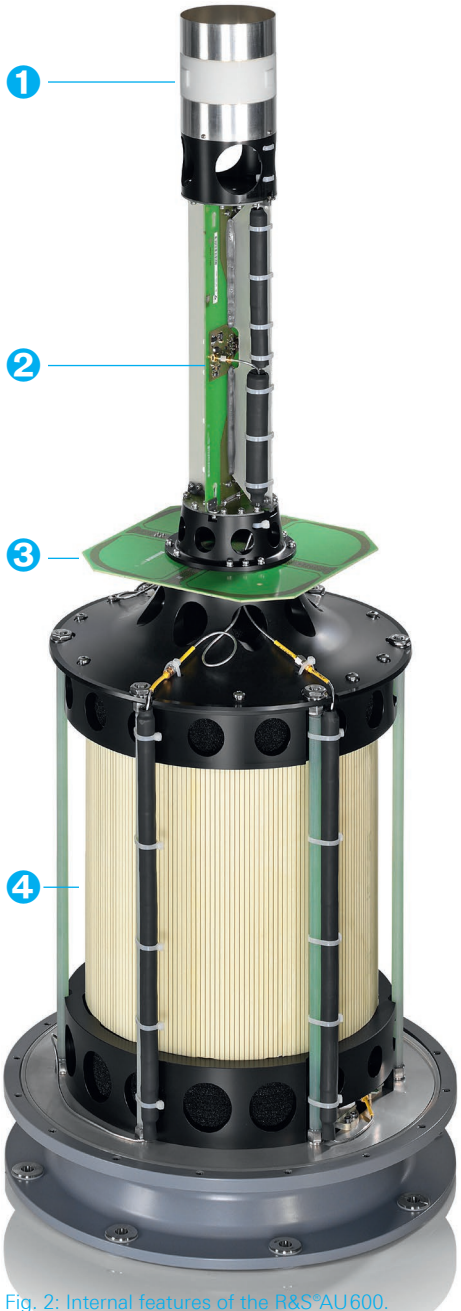


Fig. 2: Internal features of the R&S®AU600.

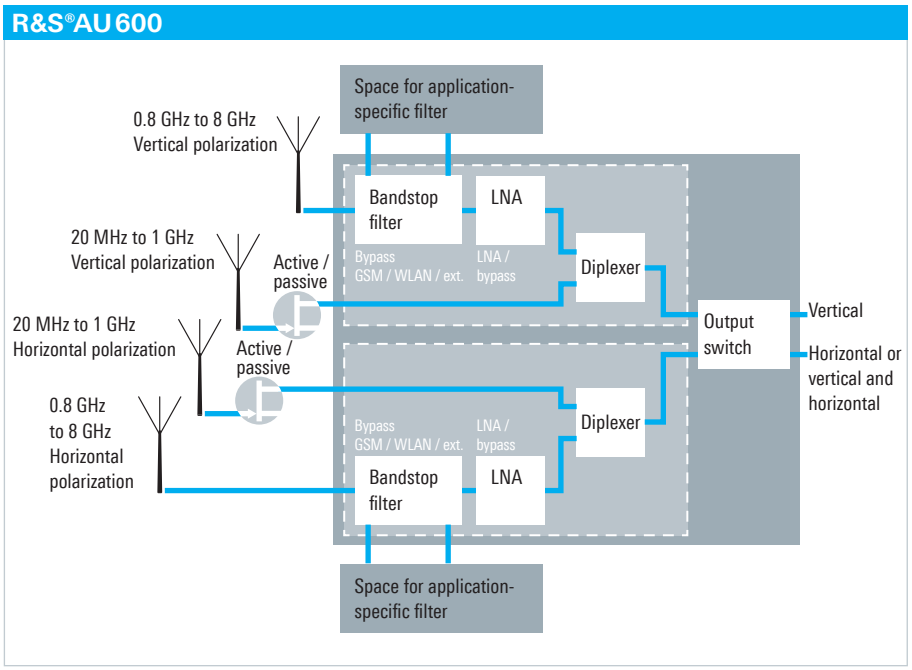


Fig. 3: Block diagram of the antenna system.

Fig. 2 shows the system with the radome removed. A broadband biconical antenna ❶ at the tip handles vertically polarized signals from about 800 MHz. Underneath is a vertically polarized active dipole ❷ for the frequency range from 20 MHz to 1 GHz which can be switched to passive mode. Horizontally polarized signals below 1 GHz are received by the active quadruple loop antenna ❸. It can also be switched to passive mode. For horizontally polarized signals from about 800 MHz, another biconical antenna is used. While it has a vertical physical orientation, the specially designed polarization filter ❹ allows broadband rotation to the desired polarization.

The signals from all four antennas are fed to a switch module in the flange. Along with the necessary solid-state switches, the switch module contains bandstop filters, low-noise amplifiers (LNA) and diplexers for connecting the received signals to either two RF sockets or just a single RF socket (Fig. 3).

Key features

- Outstanding field strength sensitivity ranging to –45 dBµV/m (referred to 1 Hz bandwidth and 0 dB S/N)
- Excellent circularity of azimuthal radiation pattern
- Very good polarization decoupling of 17 dB (typ.) broadband
- Amplifiers with large-signal immunity and outstanding second-order and third-order intercept points

System with two receivers

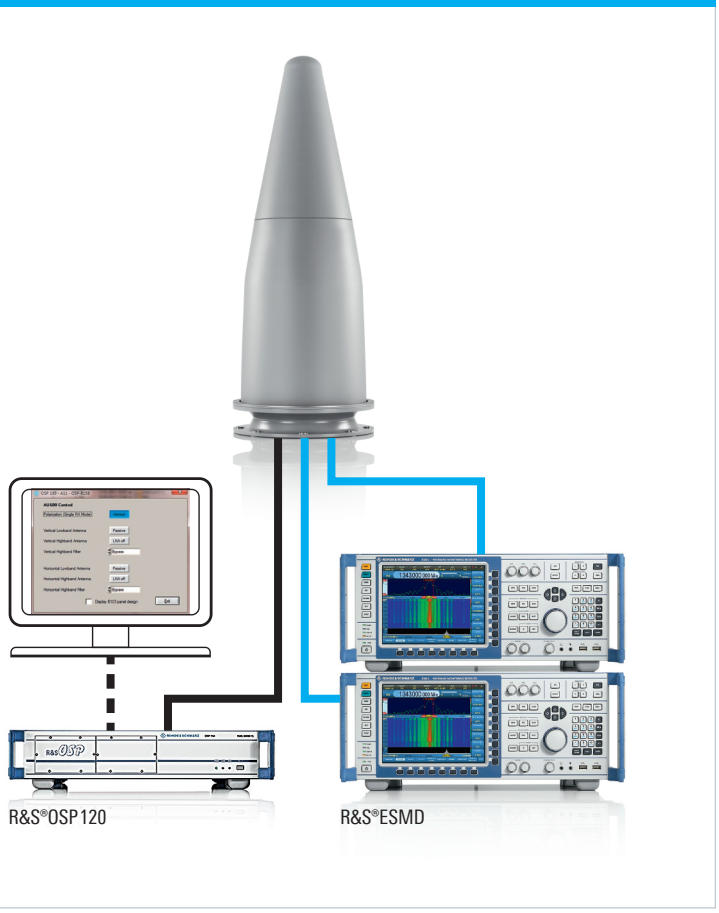


Fig. 4: Typical application with two monitoring receivers.

Application examples

Fig. 4 shows a typical application. In a system with two monitoring receivers (e.g. R&S®ESMD), horizontally and vertically polarized signals can be received simultaneously in the frequency range from 20 MHz to 8 GHz. The power supply and antenna switching functionality are provided by the R&S®OSP120 open switch and control platform, which is equipped with the R&S®OSP-B158 plug-in module. The control signals are transmitted via a differential interface to minimize susceptibility to external interference. Cable sets are available in lengths up to 50 m with rugged MIL-STD connectors at the antenna end.

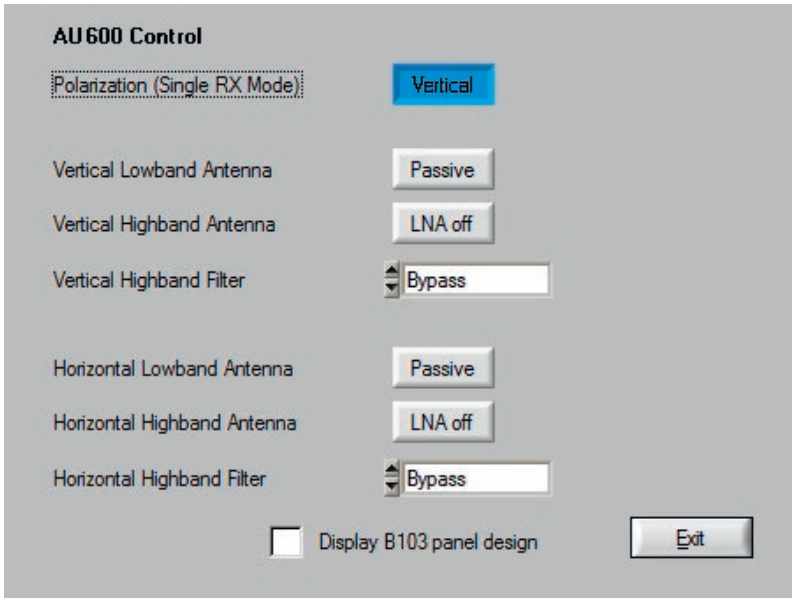
If only a single receiver is available, the user can of course switch between horizontal and vertical polarization within the antenna system.

Control functions

The antenna system allows individual settings for optimal adaptation to the current receiving situation. Fig. 5 shows some possible settings. For example, the low-noise amplifiers (LNA) can be activated or deactivated independently for each polarization in the frequency range above 800 MHz. The active antennas for the lower frequency range can also be individually set for each polarization plane. Plus, the R&S®AU600 allows selection of bandstop filters for the GSM / UMTS, WLAN / LTE band 7 frequency ranges as well as of additionally installed customer-specific bandstop filters. For control purposes, either the R&S®OSP120 base unit with monitor interface or the R&S®OSP130 base unit with display and control panel can be used. Switching is performed as follows:

- With a PC connected via LAN using software supplied with the R&S®OSP base units
- Via SCPI commands generated by control software (e.g. MATLAB®, LabVIEW or a TCP/IP client)
- With the control panel on the R&S®OSP130 base unit

Fig. 5: The antenna system can be optimally adapted to current receiving conditions.



Bandstop filters simplify location selection

Selection of an appropriate location for a radiomonitoring system can be complicated when conflicting factors must be reconciled. For example, the height of the antenna above ground plays an important role in determining the antenna´s range or geographic coverage. In densely built-up areas, the roofs of the highest buildings are ideal while in rural areas, any accessible peaks or hills are favored.

However, this can generate conflicts with spectrum users who also need to install their transmitting antennas at such prominent locations. In order to reduce potential interference to the receiving system right at the antenna, the R&S®AU600 has two integrated, switchable bandstop filters for the most common competing bands (GSM / UMTS and WLAN / LTE band 7). Fig. 6 illustrates the typical stopband suppression of over 25 dB with the integrated GSM / UMTS filter. For frequencies produced by other potential interferers, application-specific bandstop filters can be integrated into the R&S®AU600 (Fig. 7).

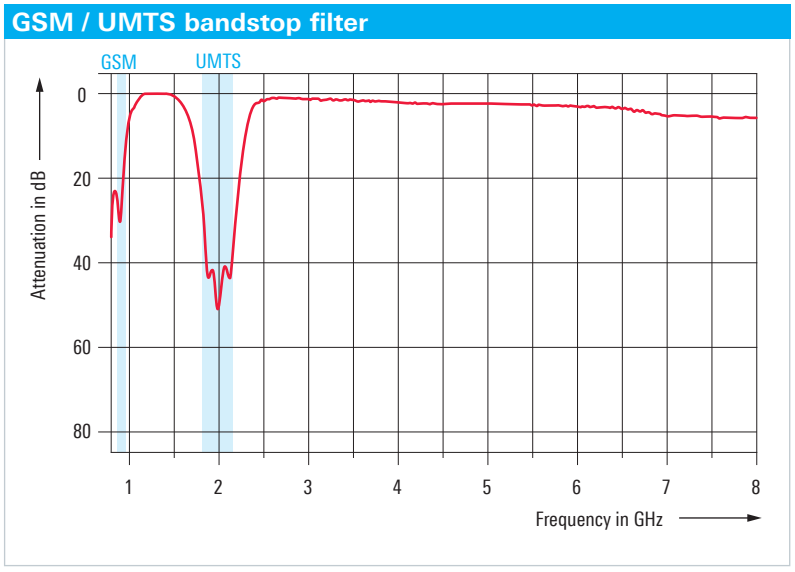


Fig. 6: The bandstop filter for GSM / UMTS has stopband attenuation of over 25 dB.

Fig. 7: Bottom of antenna flange (cover plate removed) with room for two application-specific filters.

Summary

The R&S®AU600 from Rohde&Schwarz is an all-in-one solution for frequency monitoring from 20 MHz to 8 GHz. This currently unrivaled product offers excellent control flexibility combined with outstanding bandwidth and ease of use, even in interference-prone environments, to satisfy almost any requirement.

Maik Reckeweg

Strong interest in cybersecurity solutions at CeBIT 2015

At this year's CeBIT, Rohde&Schwarz SIT and gateprotect were pleased to see a high level of interest in the IT security solutions presented for networks and critical infrastructures. Numerous visitors were interested in learning how industrial companies and energy suppliers can protect themselves against cyberattacks. German Minister for Economic Affairs Sigmar Gabriel, German Minister of the Interior Thomas de Maizière, Chinese Vice Premier Ma Kai and Bavarian State Minister Ilse Aigner informed themselves about the latest technical developments. They gained insight into how intelligent energy networks can be protected against tampering and operating errors, for example. The new R&S®SITLine ETH4G Ethernet encryptor celebrated its debut as the perfect mid-range instrument for getting started with secure link encryption. When bandwidth requirements increase, it is the only device in the world that can boost its data throughput to 40 Gbit/s by a mere firmware upgrade and without having to replace the device. With more than 200,000 visitors and 3300 exhibitors, CeBIT is the largest IT trade fair in the world.

German Minister of the Interior Thomas de Maizière (right) talking with SIT Managing Director Frank Lüdeking.

Rohde&Schwarz acquires Sirrix AG

Through the acquisition of Sirrix, the Rohde&Schwarz group of companies is gaining additional expertise in the growing IT security market. The cutting-edge solutions from Sirrix include user-friendly products for endpoint security and trusted infrastructure. The company's core expertise lies in creating trustworthy IT security products based on the latest scientific research. Sirrix will enhance the Rohde&Schwarz cybersecurity portfolio. Conversely, Rohde&Schwarz is the right partner to help Sirrix bolster the market image of its technically leading solutions. The company was founded in 2005 as a spin-off of the German Research Center for Artificial Intelligence (DFKI) at Saarland University in Saarbrücken. Today, the successful company has additional locations in Bochum and Darmstadt.

5G test solution in cooperation with Fraunhofer Institut

At the Next Generation Mobile Networks (NGMN) conference in Frankfurt, Rohde&Schwarz and the Fraunhofer Heinrich-Hertz Institute (HHI) presented a new 5G channel sounding solution. It consists of the R&S®SMW200A vector signal generator and the R&S®FSW signal and spectrum analyzer. The instruments are combined with a synchronization unit and application software from Fraunhofer HHII. The system can be used to examine propagation conditions in the microwave and millimeter-wave spectrum. This knowledge is crucial for developing new channel models for making this spectrum usable for 5G. As a result, both partners are making an essential contribution to developing a standardized link and system design in the race for 5G.

Rohde&Schwarz solution to test in-vehicle emergency call systems in Russia

The Certification Center Svyaz-Certificate in Russia is now using the R&S®CMW500 to certify ERA-Glonass systems in line with the TR CU 018/2011 technical guideline. The well-established radiocommunications tester from Rohde&Schwarz is the first choice for the independent Russian test lab. Effective January 1, 2015, all new car models introduced to the Russian market must be equipped with an automatic ERA-Glonass emergency call system. The independent Certification Center Svyaz-Certificate is the first and currently only test lab in Russia accredited to certify these systems.

R&S®VTC video test center in use in Taiwan

Telecom Technology Center (TTC) is the national testing laboratory for digital TV in Taiwan and offers comprehensive tests for equipment such as set-top boxes. With the addition of the R&S®VTC video test center from Rohde&Schwarz, TTC has extended its testing capabilities for A/V products. As a result, the laboratory can now perform tests on digital broadcasting equipment with respect to the very latest requirements. TTC will use the video test center primarily to test composite video and component video signals and to perform audio analysis. The instrument can also be used to measure all key parameters of the HDMI 2.0 standard. Since 2005, TTC has played a crucial role in the development of DTV test and measurement equipment and corresponding test platforms.

All over the world: transmitters from Rohde&Schwarz

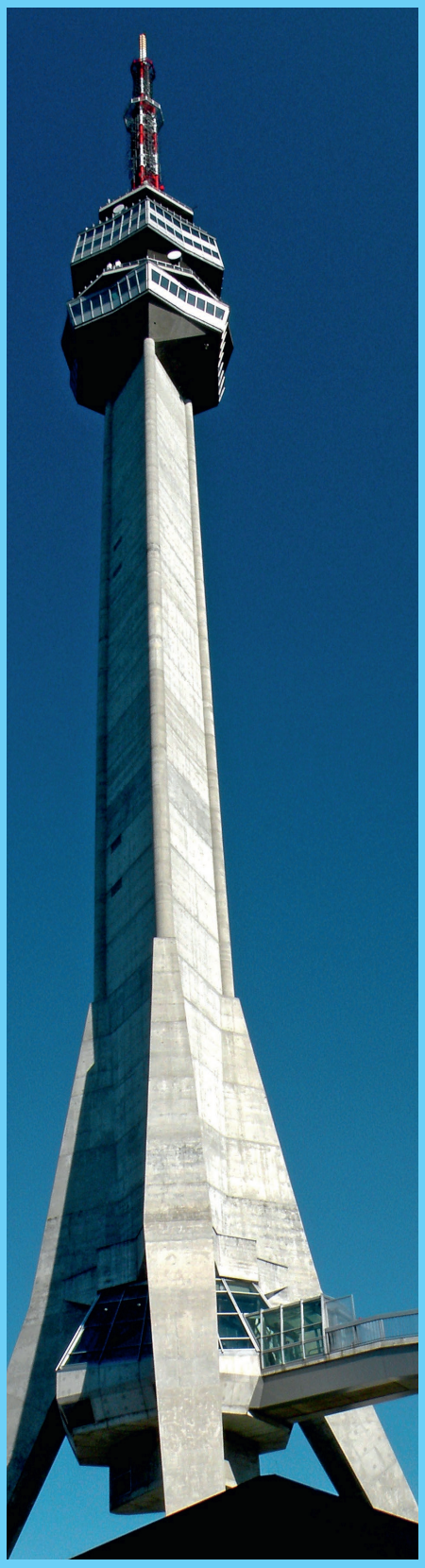
Digital broadcasting in Greece

In February 2015, the last analog TV transmitters were switched off on Greece's southeastern Aegean islands and Crete. In less than a year, the private network operator Digea set up a nationwide DVB-T transmitter network featuring Rohde&Schwarz equipment. More than 900 TV transmitters in different power classes up to 5.4 kW were installed at 156 sites during this period. Multiple sites are equipped with N+1 transmission systems, which ensures high operational reliability. Signals from the studio to the transmitters are distributed via satellite and received by the R&S®AVG050 ISDB-T BTS gateway. The operating status of all 900 transmitters is continuously monitored at the broadcasting center in Athens using R&S®BC-NETSTATE network management software and T&M equipment from Rohde&Schwarz.

Final phase of DVB-T2 rollout in Serbia

The state-owned broadcaster Emisiona Tehnika Veze (ETV) in Serbia is entering the third and final phase of the switchover to DVB-T2. For this to happen, the broadcaster opted for a consortium made up of Rohde&Schwarz Austria, Kathrein and Comutel doo. The consortium has been commissioned to set up three new multiplexers. Rohde&Schwarz will deliver 40 R&S®THU9 high-power transmitters for ten sites and 24 R&S®TMU9 medium-power transmitters for six sites, each with 3+1 standby configuration, as well as more than 240 R&S®MLx and R&S®XLx low-power transmitters. ETV provides sound and TV broadcasting services throughout the country and operates more than 250 transmitter sites. The changeover to DVB-T2 in Serbia with 98 percent coverage of households was to be completed by June 2015.

The Avala transmitter sites provides coverage to Belgrade.



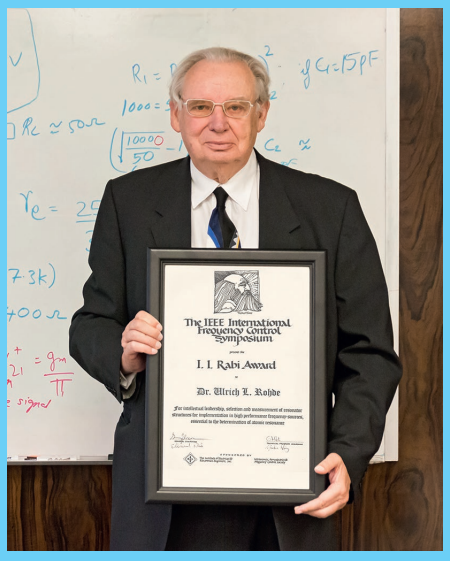
Digital high-power transmitters for Mexico's public service TV

The transmitter building in the design of the RTV logo was set up in the middle of the rainforest in Potroltepec.

Radiotelevisión de Veracruz (RTV), the public service broadcaster for the Mexican state of Veracruz, has been operating four digital R&S®THU9 high-power transmitters from Rohde&Schwarz since the end of 2014. Like all broadcasters in Mexico, RTV must ensure that its programs are broadcast in the digital ATSC standard by the end of 2015. Rohde&Schwarz has equipped the transmitter sites Coatzacoalcos, Ocozotepec, Las Lajas and Potroltepec accordingly. The solution integrates not only the R&S®ETL TV analyzer, but also the portable R&S®FSH3-TV TV spectrum analyzer, the R&S®DVSG digital video signal generator and the R&S®NRP2 power meter. In the case of the Potroltepec transmitter sites, Rohde&Schwarz managed the construction project because the entire sites had to move.

Awards from all over the world

Professor Rohde receives IEEE award



Professor Rohde with the prestigious IFCS I. I. Rabi Award.

The International Frequency Control Symposium of the IEEE global professional association honored Prof. Dr.-Ing. habil. Dr. h.c. mult. Ulrich L. Rohde with the prestigious IFCS I. I. Rabi Award 2015. The award was presented to Professor Rohde at a joint conference with the European Frequency and Time Forum in Denver, Colorado, USA, in mid-April 2015. The I. I. Rabi Award honors outstanding contributions related to the fields of atomic and molecular frequency standards, as well as time transfer and dissemination. Professor Rohde received the award for intellectual leadership, selection and measurement of resonator structures for implementation in high performance frequency sources, essential to the determination of atomic resonance. In 2014, this international symposium had presented Professor Rohde with the C. B. Sawyer Memorial Award for developing software allowing nonlinear noise analysis on RF circuits and for creating highly stable frequency sources.

Frost & Sullivan award for oscilloscopes

Frost & Sullivan honored Rohde & Schwarz with the 2015 Competitive Strategy Innovation and Leadership award. The award was presented based on an analysis of the oscilloscope market performed in spring 2015. Despite intense competition, Rohde & Schwarz succeeded in establishing itself among the leading suppliers within a short period of time. In the span of just five years, the company has developed an impressive product portfolio with numerous innovations in addition to further improving its existing solutions. Each year, Frost & Sullivan gives out the award to a company that has developed a competitive strategy able of capturing a greater market share, increasing customer satisfaction and attaining a stronger brand position. The nomination is made on the basis of an analysis of all market participants.

The hard work has paid off: Rohde & Schwarz receives the Frost & Sullivan award for its activities in the oscilloscope market.

GTI award – yet again

At the Mobile World Congress 2015, the broad T&M portfolio from Rohde & Schwarz specifically for the TD-LTE standard was officially honored: The Global TD-LTE Initiative (GTI – the industry association) presented Rohde & Schwarz with the distinguished GTI Innovation Award 2015 for its accomplishments in this area. Thanks to its ongoing efforts, the company was honored for supporting GTI and the entire TD-LTE industry. This was the second time since 2014 that Rohde & Schwarz received the award in Barcelona.

Post Pick award for R&S®CLIPSTER at NAB

The US technical journal Post Magazine recognized the R&S®CLIPSTER mastering station in its New Technologies category at NAB 2015. The mastering station earned honorable mention thanks to the latest technological advancements in interoperable mastering format (IMF). The R&S®CLIPSTER now features enhanced key IMF mastering functions for creating more efficient workflows – an innovation that impressed the jury of Post Magazine editors and industry specialists. The jury votes to determine the most innovative products and technologies every year.

Headends for Hungarian satellite operator HDT

Hungarian satellite operator Hungaro DigiTel (HDT) has been using encoders, multiplexers and monitoring equipment from Rohde&Schwarz. Formerly a data communications service provider, the satellite operator has expanded its portfolio to include broadcasting of TV programs. To encode and multiplex these programs, Rohde&Schwarz integrated its R&S®AVHE100 headend into the broadcaster's direct to home (DTH) platform. In the first stage, a total of five HD and six SD channels will be broadcast via Amos or Eutelsat. HDT also employs solutions from Rohde&Schwarz subsidiary GMIT to automatically monitor signals. The BMM-810 multiviewer and the compact Prismon system detect content errors. A video wall enables HDT to visually monitor the programs.

Tennis in 4K with Rohde&Schwarz

In December 2014, satellite operator Eutelsat broadcast the Italian Serie A1 tennis finals in Genoa in 4K via HOT BIRD. The high-resolution video content was broadcast on the Italian television channel SuperTennis. Rohde&Schwarz Italy was responsible for coding the signals with the R&S®AVHE100 headend. A key challenge during the broadcast was making the tennis ball visible at high speed. This turned out well even at ball speeds of 200 km/hour. Other companies involved in the broadcast were Grass Valley, Broadcast Solutions, Telecine Service and M-Three Satcom.

Tennis balls remained visible at top speeds of 200 km/hour.

Modern air traffic control system for Colombia

The Colombian Special Administrative Unit of Civil Aeronautics (UAEAC) has awarded Rohde&Schwarz a contract to modernize the country's civil air traffic control (ATC) system. This modernization project will put Colombia in the top rank in Latin America with regard to civil aviation safety and future-oriented technology. Rohde&Schwarz will also provide products and services for this turnkey project. This includes R&S®Series4200 radios for towers, area control centers and remote radio sites. Rohde&Schwarz will also handle the system integration of its own equipment as well as subsystems supplied by third-party companies. In total, 984 radios along with the necessary antennas and filters will be installed at 106 locations by February 2016.

Successful acceptance test for R&S®VCS-4G in Romania

The volume of civil and military air traffic in the airspace of Constanta, Romania has increased significantly in recent years, requiring a new voice communications system (VCS). The system specification prepared by the Romanian air traffic services administration (ROMATSA) was successfully implemented by Rohde&Schwarz Topex. This includes an entirely IP-based voice communications system in line with the ED-137B EUROCAE standard and capabilities for flexible role (tasks of air traffic controllers) and airspace sector management. The R&S®VCS-4G for the tower in Constanta delivered by Rohde&Schwarz now provides more than 90 controller working positions at ROMATSA. In turn, ROMATSA has further reinforced its longstanding, strategic partnership with Rohde&Schwarz Topex. The VCS from Rohde&Schwarz has not only provided ROMATSA with a customized solution that meets all technical and operational needs but the system is also capable of handling the close integration with other air traffic control systems in the future.

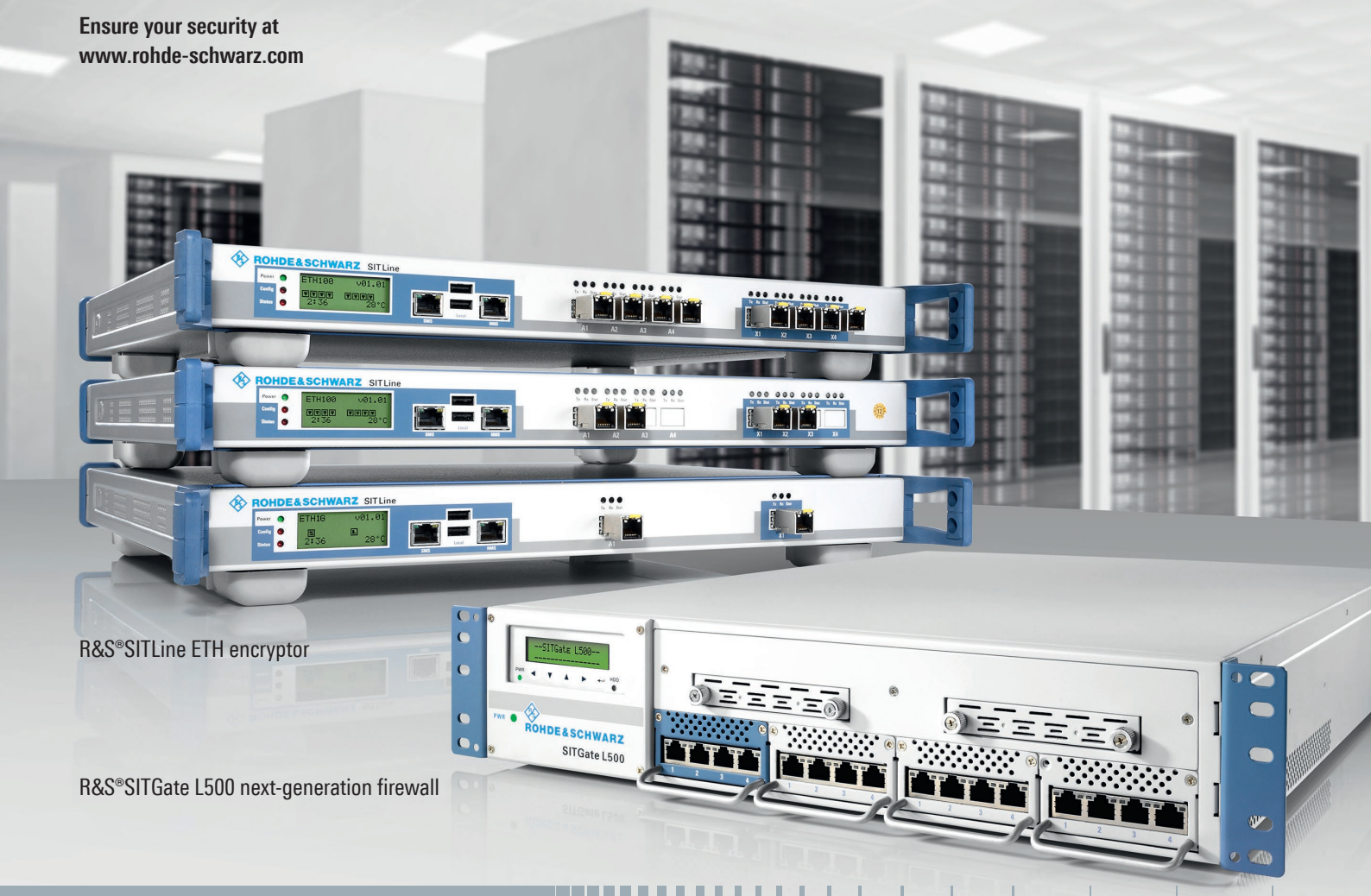
See the article on page 54 for more in-depth information about the R&S®VCS-4G.

Innovative solutions for the highest IT security requirements.

Attacks on computers and networks are on the rise. Cyber crime and data theft have dramatic consequences ranging from enormous economic damage to loss of image and customers. Years of work can be destroyed in minutes.

Rohde&Schwarz supports government, society and business with IT solutions and encryption technology made in Germany.

Ensure your security at www.rohde-schwarz.com



R&S®SITLine ETH encryptor

R&S®SITGate L500 next-generation firewall

ROHDE&SCHWARZ