NEWS

208/13

ROHDE&SCHWARZ

USB power sensors for all applications

Rohde&Schwarz power sensors offer maximum precision in a handheld design. Measurement results can now even be displayed on a smartphone.
Also in this issue: the first sensor to cover the frequency range from DC to 110 GHz.

WIRELESS TECHNOLOGIES

World's first regulatory test system for 2.4 GHz and 5 GHz band radio systems

GENERAL PURPOSE

Bench oscilloscopes: time domain, frequency domain, logic and protocol analysis functions in a single instrument

BROADCASTING

Medium-power and low-power transmitters with small footprint added to new transmitter generation

NEWS

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Cover feature

As a pioneer in integrated USB power sensors, Rohde&Schwarz has continually enhanced its portfolio over the years. The new R&S®NRP-Z58 power sensor is another market innovation: As the first power sensor to cover the frequency range from DC to 110 GHz without interruption, it bridges the gap for applications in the millimeter-wave range (page 22).

USB power sensors from Rohde&Schwarz offer everything needed to perform measurements quickly and precisely, without a base unit. A background article on page 26 explains why they are always the better choice.

Previously, a PC was needed to display measurement results. Today, a tablet or mobile phone can be used – thanks to the "Power Viewer Mobile" Android app, available free of charge on Google Play.

Overview NEWS 208/13

WIRELESS TECHNOLOGIES

GENERAL PURPOSE

Radio systems operating in the 2.4 GHz and 5 GHz bands have to meet new requirements. The R&S®TS8997 regulatory test system is the first solution worldwide to support the required tests (page 6).

Using the R&S®ZNB network analyzer with switch matrices from Rohde&Schwarz, the number of test ports can be increased to 32 (page 48).

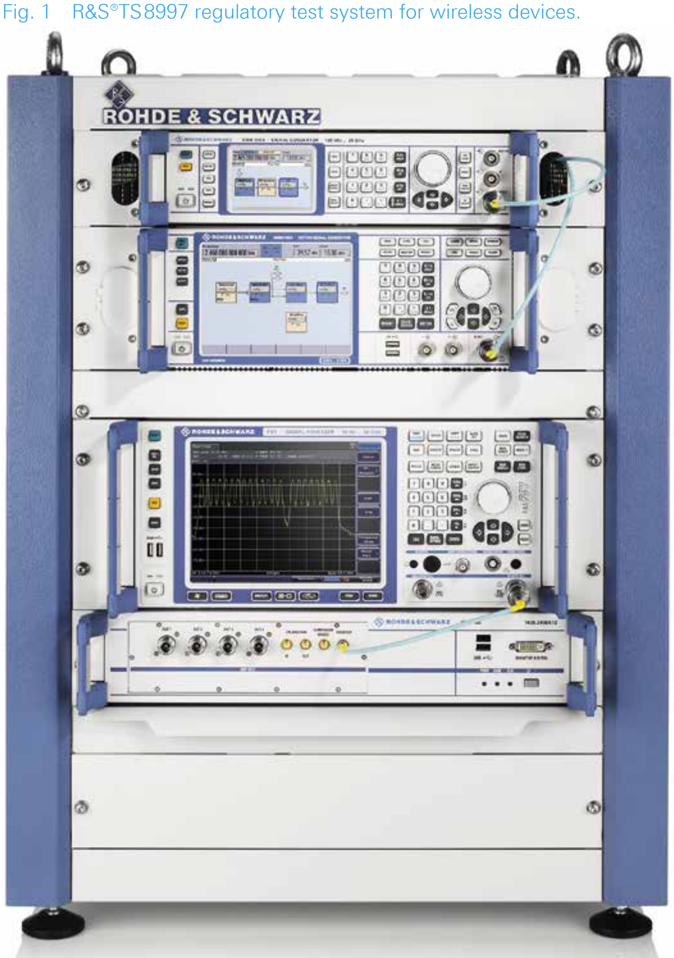
World's first regulatory test system for 2.4 GHz and 5 GHz band radio systems

Starting January 2015, radio systems operating in the 2.4 GHz and 5 GHz frequency bands will have to meet new, enhanced requirements under the European R&TTE Directive. The R&S®TS 8997 regulatory test system for wireless devices is the first solution worldwide to support the required tests. It contains power measurement functionality specifically developed for this purpose as well as automated test sequence control.

Large number of radio services and transmission technologies

The density and diversity of radio services in the license-free 2.4 GHz and 5 GHz bands is steadily growing. Systems using WLAN 802.11a/b/g/n and Bluetooth®, as well as other applications such as wireless video transmission and radio remote control operate in these bands. In the future, car-to-car communications in line with the 802.11p standard will also take place in the 5 GHz band. Many users share these frequency bands, using diverse bandwidths and transmission technologies such as wideband OFDM, MIMO, frequency hopping and direct sequence spread spectrum (DSSS). Keeping this variety in mind, it is important to minimize mutual interference as far as possible.

Fig. 1 R&S®TS 8997 regulatory test system for wireless devices.



New, extended requirements

In order to minimize interference between radio systems in a densely occupied spectrum, wireless devices will in the future have to pass specific tests in order to be certified. The test cases are defined in the current, revised versions of the ETSI EN 300 328 and ETSI EN 301 893 standards; both standards are also included as harmonized standards under the European R&TTE Directive.

The revision and extension of the ETSI EN 300 328 standard became necessary in order to introduce methods that allow different applications to coexist in the 2.4 GHz band. For example, the new version (V1.8.1) of the standard defines adaptivity mechanisms to help ensure that all users will still have access to available frequency resources as band occupancy increases. Alternatively, systems can function without adaptivity if they fulfill certain requirements with respect to power and timing behavior. All these requirements call for new, and in part complex, test methods. In the previous version (V1.7.1) of the standard, the requirements existed only at a rudimentary level, and test methods were not yet defined.

A new power measurement procedure has been introduced in order to measure a wide range of signal parameters such as burst power, duty cycle, TX sequence, TX gap and medium utilization (MU) factor. The revised standards also cover transmission using multiple antennas, e.g. MIMO, and call for special test equipment. Additionally, they include tests to verify a radio system's ability to adapt to ambient conditions, i.e. to detect other services and avoid collisions. ETSI EN 300 328 covers DUTs with and without frequency hopping and listen before talk (LBT) functionality.

Block diagram of the R&S®TS8997

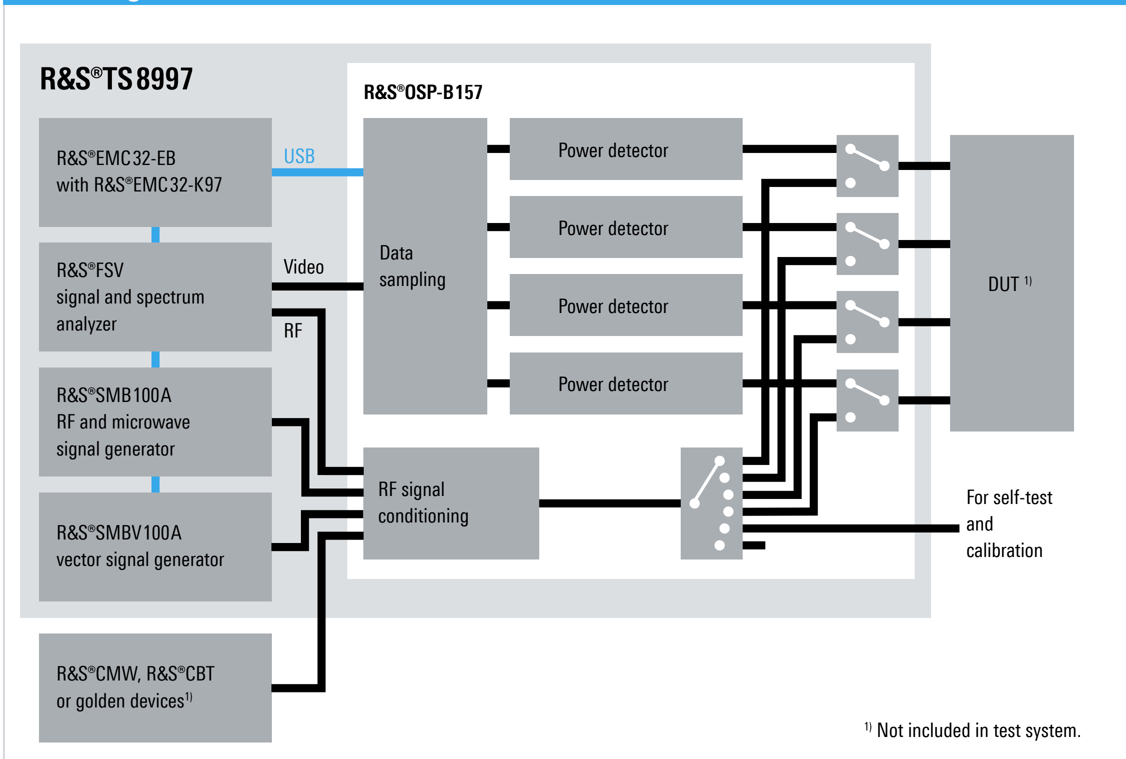


Fig. 2 Block diagram of the R&S®TS8997 regulatory test system. All power measurement functionality is integrated in a specially developed module, the R&S®OSP-B157 for the R&S®OSP120 open switch and control platform. This module also handles path switching and RF signal conditioning for the power measurements and, as far as possible, other measurements.

In addition, the standards require automated test procedures. While the previous version (V1.7.1) of ETSI EN 300328 still allowed users to conduct tests manually using a spectrum analyzer, the current version (V1.8.1) stipulates that the relevant parameter values have to be determined from millions of individual measured values. Some of the tests are multi-staged, and in some cases the results of a measurement are needed for the next measurement. This calls for software-based test procedures.

R&S®TS8997 test system covering all certification requirements

The R&S®TS8997 test system (Figs. 1 and 2) covers all tests mandatory for the 2.4 GHz and 5 GHz bands (Fig. 3). It contains the following components:

- R&S®FSL or R&S®FSV signal and spectrum analyzer
- R&S®OSP120 open switch and control platform with special measurement module
- R&S®SMB100A RF and microwave signal generator
- R&S®SMBV100A vector signal generator
- R&S®EMC32 measurement software with the R&S®EMC32-K97 and -K10 measurement options

IMST GmbH, a German radio competence center, supported Rohde&Schwarz during the specification of the individual test sequences and verification of the test cases for

Test case	2.4 GHz band (ETSI EN 300328)	5 GHz band (ETSI EN 301893)
Carrier frequency accuracy	–	●
RF output power	●	●
Transmit power control (TPC)	–	●
Spectral power density	●	●
Duty cycle, TX sequence, TX gap	●	–
Dwell time, minimum frequency occupation, hopping sequence (only for frequency-hopping DUTs)	●	–
Hopping frequency separation	●	–
Medium utilization (MU) factor	●	–
Adaptivity	●	●
Occupied channel bandwidth	●	●
Transmitter unwanted emissions in the out-of-band domain	●	●1)
Transmitter unwanted emissions, in-band domain	–	●
Transmitter unwanted emissions in the spurious domain	●	–
Receiver spurious emissions (RSE)	●	●1)
Receiver blocking	●	–
Dynamic frequency selection (DFS) / radar detection	●	–

1) For spurious emission measurements above 18 GHz, the RF cable needs to be manually replugged.

Fig. 3 Test cases covered by the R&S®TS8997 regulatory test system.

compliance with ETSI EN 300328 using the R&S®TS8997. IMST GmbH has extensive experience with the relevant tests and operates a test lab which is accredited according to the R&TTE Directive. It also actively participates in the ETSI standardization processes.

Special standard-compliant power measurements

The standard calls for a special procedure for fast, wideband power measurements with a high sampling rate of ≥ 1 Msample/s, sufficiently high resolution and an uninterrupted measurement time of several seconds. This could be done using special analog detectors and a suitable oscilloscope. However, this would require data acquisition and analysis software specially tailored to the oscilloscope and capable of efficiently processing several million measured values.

With the R&S®TS8997, all power measurement functionality is integrated into a specially developed module (R&S®OSP-B157) for the R&S®OSP120 open switch and control platform. This module also handles path switching and RF signal conditioning for the power measurements and, as far as possible, other tests. Featuring large memory depth and a high sampling rate, the module delivers accurate measurements for any type of signal, e.g. for complex signals with slow repetition rates. The R&S®EMC32 measurement software handles test sequence control as well as result analysis and display.

Support of multiple antenna systems

An increasing number of wireless devices use multiple antennas for MIMO or beamforming. For these devices, it is essential that power measurements be perfectly time-synchronized and uninterrupted. The R&S®TS8997 regulatory test system is designed to handle four-channel power measurements and therefore supports measurements on all commonly used devices, e.g. WLAN routers with 4×4 MIMO. The parallel A/D converters are clocked synchronously.

High-resolution measurements

The ETSI EN 300328 standard requires up to 30000 analyzer sweep points. The R&S®FSL or R&S®FSV analyzer used in the test system meets this requirement. Tests performed on real DUTs, however, have shown that the number of points required by the standard is not sufficient for some radio technologies, resulting in higher measurement uncertainty. The R&S®TS8997 is therefore ready to provide an additional, alternative test mode with typically one million points. This mode can be enabled as a software option as soon as a revised version of the standard is adopted.

Automated test sequences

The test sequences and analysis routines required by the standards are implemented in the R&S®EMC32-K97 / -K971 / -K972 / -K973 options for the R&S®EMC32 measurement software. The software is used in many test houses to carry out EMC, radiated spurious emission (RSE) and equivalent isotropic radiated power (EIRP) measurements, and can now be used for these measurements as well. This results in consistent, integrated test procedures that are useful, for example, when conducted values have to be calculated from measured radiated EIRP values, or the other way round.

The software options also handle the automated execution of all test sequences, including querying of the relevant parameters for the devices and radio standards (Fig. 5). This is helpful for the user, since specific tests are only required for specific standards, and in some cases the results of a measurement are used in the next one. To set up a radio link to the DUT, either a Rohde&Schwarz wideband radio communication tester, e.g. the R&S®CMW500, or a golden device is used.

Upgrading existing systems to the R&S®TS8997 regulatory test system

The R&S®EMC32 measurement software comes with a large number of device drivers, making it possible to use other, equivalent Rohde&Schwarz instruments that the user may already have in service as an alternative to a turnkey test system. Other systems, for example those used by development labs for other tests, can also be used. Existing EMC systems can be easily expanded with the R&S®TS8997 specific R&S®OSP module and, if necessary, additional instruments.

Spectrum of a frequency-hopping DUT

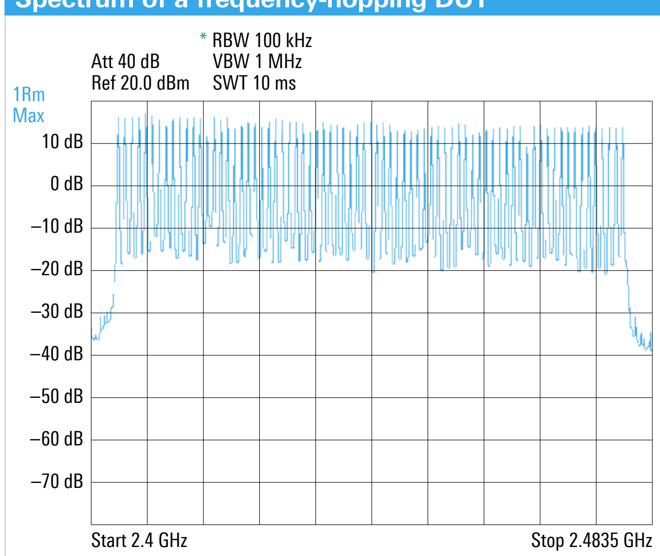


Fig. 4 Typical spectrum of a frequency-hopping DUT in the 2.4 GHz band.

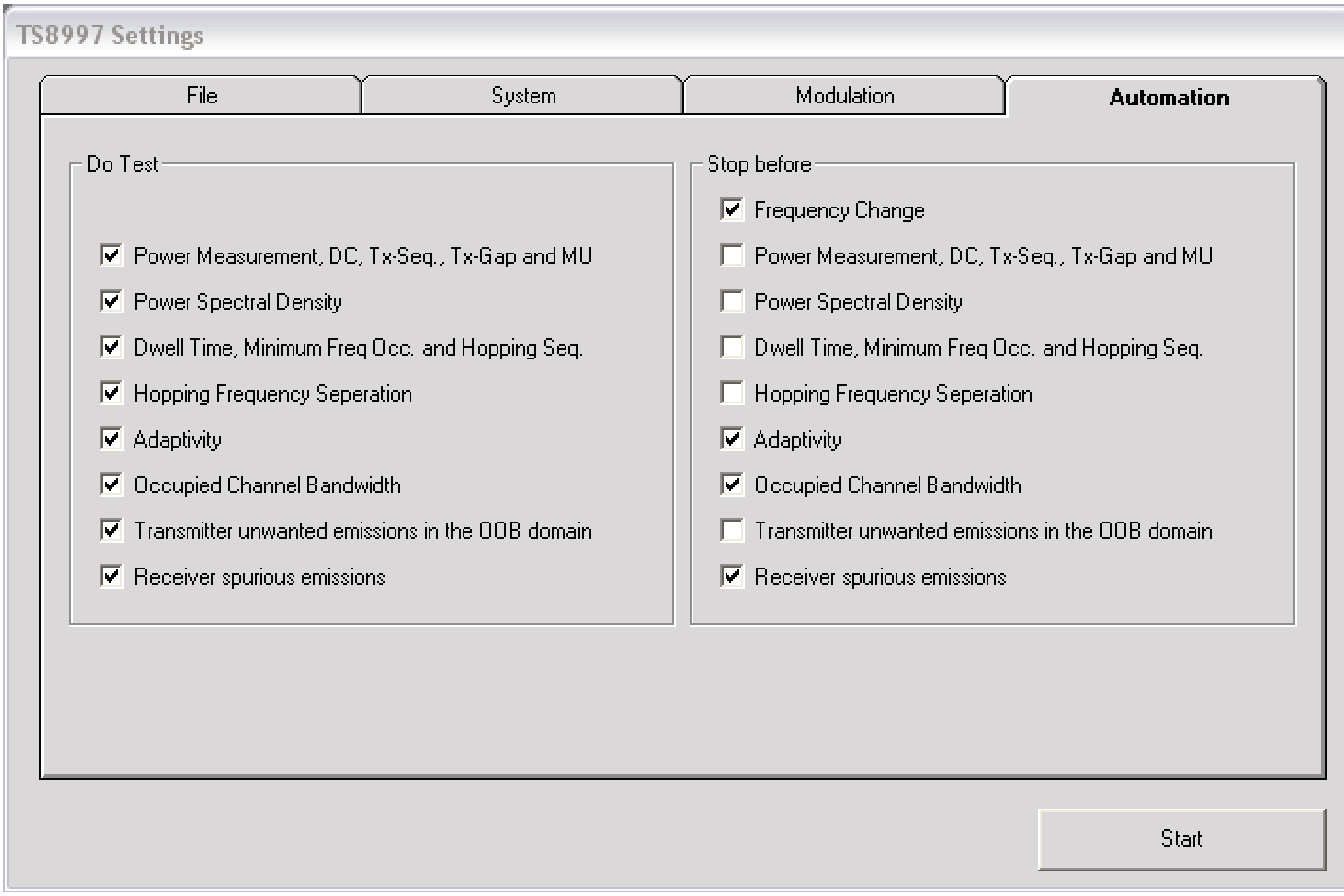


Fig. 5 R&S®TS8997 GUI for the automated execution of the test cases implemented in the R&S®EMC32 measurement software.

Summary

The R&S®TS8997 regulatory test system for wireless devices is the world's first full-featured solution to support the measurements and test automation for the test cases stipulated by ETSI EN 300328 V1.8.1 and ETSI EN 301893 V1.7.1 under the R&TTE Directive. Test automation, handled by the widely used R&S®EMC32 measurement software, helps users carry out the tests efficiently. Existing EMC test systems can be upgraded to the R&S®TS8997 regulatory test system.

Edgard Vangeel, Chairman of ETSI TG11, appreciates that "the R&S®TS8997 from Rohde&Schwarz implements the new standard, making it a success for test houses and the industry as a whole".

Michael Steinmüller; Frank Tofahrn (IMST GmbH)

Location based services with GPS, GLONASS, Galileo and OTDOA

Checking the weather forecast during breakfast or finding your way in rush hour traffic – just two examples of apps that allow smartphone users to benefit from location based services (LBS). How do these useful helpers manage to find the phone's exact position so quickly? This article gives you a behind the scenes look at positioning for location based services. It also outlines the comprehensive range of Rohde & Schwarz test systems which ensure that all components used in positioning work together seamlessly.

Positioning using terrestrial methods: cell ID, enhanced cell ID, OTDOA

There are different methods for determining the position of a mobile phone. The simplest way is to detect the cell ID; however, this method delivers relatively inaccurate information. Better results are achieved with the enhanced cell ID method. In addition, it takes signal parameters into account, for example the reference signal received power and quality (RSRP and RSRQ), which makes it accurate within approximately one hundred meters. In the future, observed time difference of arrival (OTDOA) will provide even more accurate results. This method is used by the LTE wireless communications standard and is based on the delay differences between signals emitted by several LTE base stations.

The conventional satellite-based method: A-GPS

Significantly better results are obtained by using GPS signals, increasing accuracy to within a few meters. However, there is one serious disadvantage to using GPS alone: If a GPS module is not used for a longer period of time, it will typically take up to 50 seconds before the position is displayed. This is due to the GPS signal's low data rate of 50 bit/s that is used to transmit navigation information (satellite paths and correction data). The waiting time can be reduced by using assisted GPS (A-GPS). With this method, the GPS receiver uses additional information delivered by the wireless communications network. This information is referred to as assistance data and includes navigation and other information. The information is delivered quickly, as the location server transmits it through the network in a matter of seconds.

An overview in the labyrinth of protocols

Communications between the mobile phone and the location server can take place in two ways: either via control message (C-plane, similar to SMS) or through IP packets together with other user data (U-plane), see Fig. 1. To date, a new location protocol has been defined for each major wireless communications standard: RRLP, RRC, TIA-801 and LPP. In spite of the variety: All protocols transmit basically similar assistance data. Fig. 2 shows the possible combinations of protocols and wireless communications standards for the C-plane and U-plane. If communications take place via the U-plane, the location protocols are additionally packaged into the secure user plane protocol (SUPL), which takes care of encrypting and authenticating sensitive position data.

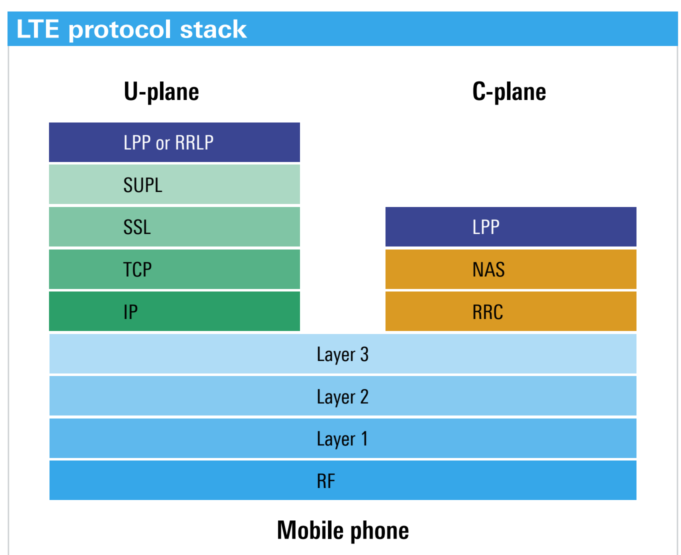


Fig. 1 Communications between mobile phone and location server: LTE protocol stack for U-plane and C-plane.

	GSM	WCDMA	LTE	CDMA2000®
C-plane	RRLP	RRC	LPP	TIA-801
U-plane	RRLP	RRLP	RRLP / LPP	TIA-801

Fig. 2 Possible combinations of wireless communications standards and location protocols. With U-plane transmission, theoretically every location protocol can be sent using every wireless communications standard. The table shows only combinations that are actually used.

System combination for higher accuracy – hybrid positioning

In the meantime, GPS has competition: The Russian GLONASS system is completely functional worldwide since October 2011, and the European Galileo system has four satellites in orbit since October 2012. China has also entered the race with its Beidou system. The assistance data used in the global navigation satellite systems (GNSS) – the generic term for all satellite navigation systems – differ significantly from each other (Fig. 3). This made expansions for all location protocols and for the SUPL protocol necessary.

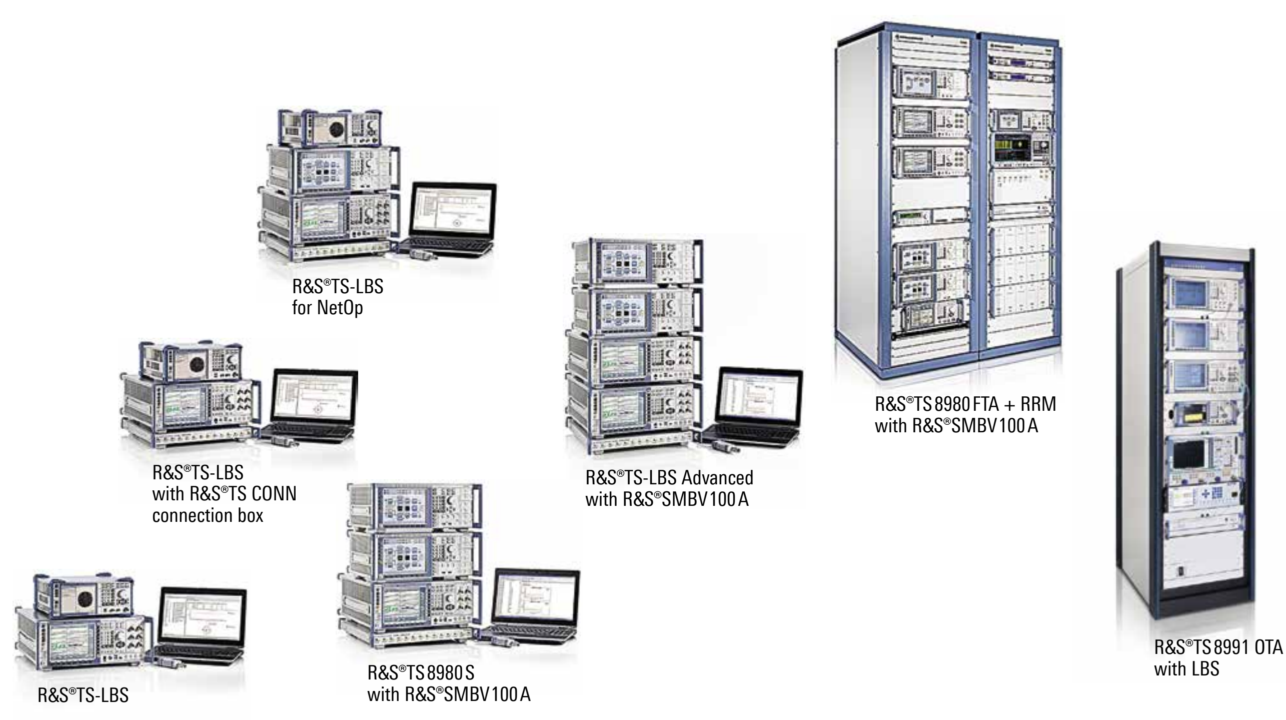
By combining data from different satellite systems and OTDOA it is possible to more accurately calculate a position than with one system alone. Especially in street canyons, where receivers made for only one system have failed,

A comprehensive program: Rohde&Schwarz test systems

Numerous tests examine the performance of terminals with respect to A-GNSS and network based methods (OTDOA / enhanced cell ID), also while simulating extreme conditions. Over-the-air (OTA) measurements verify if a terminal offers adequate sensitivity in any spatial orientation. The minimum performance measurement checks the accuracy and duration of the positioning operation. The complex message flow can be checked using protocol conformance tests. Rohde&Schwarz offers the appropriate test systems for all of these applications. They support C-plane as well as U-plane communications and cover all important wireless communications standards (GSM, WCDMA, LTE and, in the near future, CDMA2000®) with the R&S®CMW500 wideband radio communication tester as a network simulator. All A-GNSS tests can be performed using an R&S®SMBV100A vector signal generator with the appropriate options.

The test hardware can be configured on a modular basis to meet particular requirements: from a compact minimal setup (consisting of an R&S®CMW500, an R&S®SMBV100A and a controller) and OTA performance test systems to the R&S®TS8980FTA test system with integrated radio resource management (RRM) testing and simulation of multiple OTDOA cells as well as fading simulation. The test system can be integrated into the user-friendly R&S®CONTEST software platform to perform automated test sequences.

LBS test systems



Equipment for every type of requirement: test systems for terminals which use A-GNSS and network based methods.

Assistance data: GPS versus GLONASS

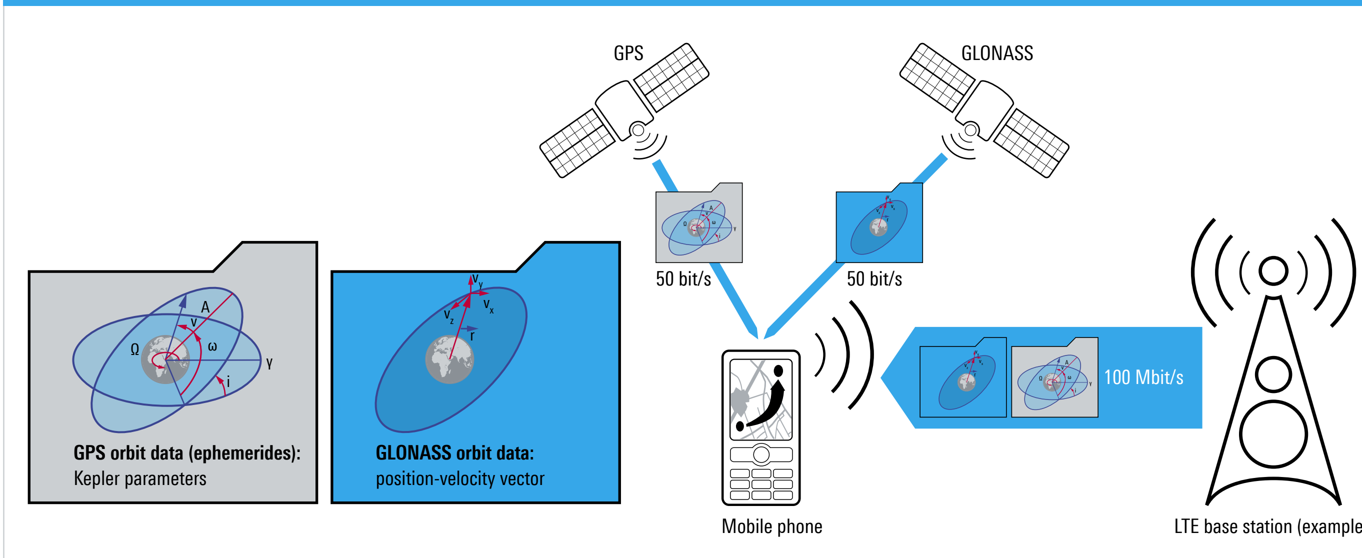


Fig. 3 GPS and GLONASS have very different assistance data. For A-GPS and A-GLONASS, assistance data is transmitted via the wireless communications network within seconds instead of using a slow satellite connection.

it is still possible to determine the position by using several systems. If necessary, the complex hybrid position calculation can be transferred from the mobile phone to the network since the phone is connected to the network provider's location server.

To the rescue: emergency procedures in SUPL 2.0

Not only does the expansion to SUPL 2.0 support the new GNSS as well as LTE; completely new functions for U-plane communications were also added. For example, emergency procedures make it possible to automatically and reliably transmit a caller's position to rescue teams in case of an emergency (Fig. 4). Also, the new geofencing function can transmit a message from the mobile phone to an authorized partner station when someone enters or leaves a defined area (Fig. 5).

Map source: © OpenStreetMap contributors
www.openstreetmap.org

Fig. 4 In case of an emergency, the caller's position is transmitted to rescue teams within seconds.

Summary

The development and use of location based services is still in its early stage. This field is certain to produce new ideas and applications in the coming years. Rohde&Schwarz can provide the required test and measurement solutions and will continue to be a front-runner as new developments evolve.

Stefan Maier; Ewald Zelmer

Map source: © OpenStreetMap contributors
www.openstreetmap.org

Fig. 5 The geofencing function informs the user about another person's arrival at a specific train station.

R&S®FSW signal and spectrum analyzer: measuring E band microwave connections

The growing volume of data traffic due to the use of wireless devices calls for high bandwidths for connecting base stations to the network. Two 5 GHz frequency bands between 71 GHz and 86 GHz are available in the E band for point-to-point connections. The high frequencies are a challenge for T&M equipment; not only when developing transmit and receive modules, but also when measuring transmission systems.

E band: extra bandwidth for more data

Over 30 years ago at the World Radiocommunication Conference WARC-79 in Geneva [1], the International Telecommunication Union (ITU) passed the decision to dedicate the E band frequencies from 71 GHz to 76 GHz and from 81 GHz to 86 GHz for transmission applications. It took more than 20 years before commercial interest in these applications emerged and led the US Federal Communications Commission (FCC) and European authorities to issue licenses for these bands and to specify the technical requirements for their use. The reason why interest finally evolved was that, by now, it had become possible to commercially manufacture components for this frequency range. At the same time the demand for increasing transmission rates made it necessary to use new frequency bands. Transmission links with data rates of several Gbit/s are no problem in the E band. The two frequency bands, each with a continuous range of 5 GHz, make transmission bandwidths of several 100 MHz possible. Combined with a simple modulation method such as BPSK, high data rates can be achieved. Consequently, it is possible to implement simple and reliable transmit and receive modules for these millimeter-wave connections. It goes without saying that more complex types of modulation may be used as this technology evolves. The achievable range in these frequency bands is only insignificantly shorter than for example in the 38 GHz band. This was proven with open field tests done in normal weather conditions with an attenuation of 0.5 dB/km [2].

The high frequencies pose new T&M challenges. Although licensing protects against interference from other microwave sources, the power and spectrum of the transmitters must be measured to ensure disturbance-free coexistence of licensed communications. The requirements for transmitters in this frequency range, especially for the radiated power (EIRP) spectrum density mask, are described in [3].

Additional articles about the R&S®FSW signal and spectrum analyzer in this issue:
The new R&S®FSW43 and R&S®FSW50 models are introduced on page 38. Read how a new option enables precise, quick and wideband measurement of group delay on page 43.

Spectrum measurements in the E band – harmonic mixers are essential

Spectrum analyzers are the most suitable instruments for these sophisticated measurements. However, commercially available spectrum analyzers have a continuous frequency range of up to 67 GHz only. To carry out spectrum measurements in the E band, they must be used together with external harmonic mixers [4]. The mixers multiply the spectrum analyzer's local oscillator output signal and use a suitable harmonic to downconvert the millimeter-wave signal to be measured to the analyzer's intermediate frequency. However, the large number of harmonics created in the mixer and the input signal's harmonics produce a multitude of signals in the spectrum. The image frequency is not suppressed because there is no preselection.

This will not create any problems as long as only CW signals are present at the mixer's input. With this type of signal, the spectrum analyzer can tell the difference between real signals and unwanted mixing products and their image-frequency signals that are present at the mixer output. To enable this distinction, the analyzer conducts a reference measurement prior to the actual measurement. During the reference measurement, the local oscillator frequency is increased to a value that is twice the intermediate frequency. Only signals that are detected in the reference measurement and in the actual measurement are real signals and are displayed in the spectrum.

If modulated signals are present at the mixer input, the task is more complicated. The real signal and the signal received on the analyzer's image frequency may overlap each other, especially in the case of very wideband signals, so that it is no longer possible to tell them apart.

Spectrum measurement

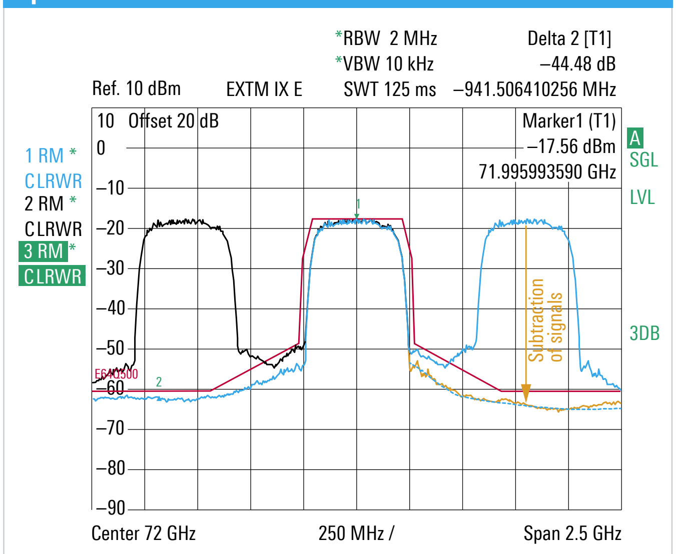


Fig. 1 Measuring a 500 MHz bandwidth E band input signal with the R&S®FSQ signal and spectrum analyzer. The blue curve shows the results of the actual measurement, the black curve represents the reference measurement. It is apparent that the image signal, which has a frequency positioned above that of the input signal, can still be subtracted (orange curve). This would not be possible with 1 GHz bandwidth input signals.

Fig. 1 shows a spectrum measurement performed with the R&S®FSQ, a high-end signal and spectrum analyzer. This instrument no longer belongs to the newest generation and has an intermediate frequency of 404 MHz. The frequency difference between the input signal and the image-frequency signal is 808 MHz. With this 500 MHz bandwidth input signal, it is just still possible to test if it complies with the EIRP spectrum density mask according to [3], by subtracting the reference measurement spectrum from that of the actual measurement. If the input signal had a bandwidth of 1 GHz, that would no longer be possible because the input signal and image-frequency signal would superimpose on each other. The influence of the image-frequency signal would strongly distort time domain analysis of the signal (I/Q data), where correction using a reference measurement is not possible.

R&S®FSW: able to handle wideband-modulated signals

The R&S®FSW [5] signal and spectrum analyzers with the R&S®FSW-B21 option (LO/IF connectors for external mixers) have a major advantage compared to conventional instruments. With an intermediate frequency of 1.3 GHz, the R&S®FSW analyzers have an image-free frequency range of 2.6 GHz. This makes it easy to measure the EIRP spectrum density mask of wideband-modulated signals, even if their bandwidth reaches into the GHz range. Together with the latest generation of Rohde&Schwarz harmonic mixers, e.g. the R&S®FS-Z90 (60 GHz to 90 GHz), the achievable dynamic range is truly unique. The mixer has a typical conversion loss of 23 dB at 80 GHz, resulting in a displayed average noise level (DANL) of approximately –150 dBm/Hz for the complete test setup, including the R&S®FSW. A 1 dB compression point

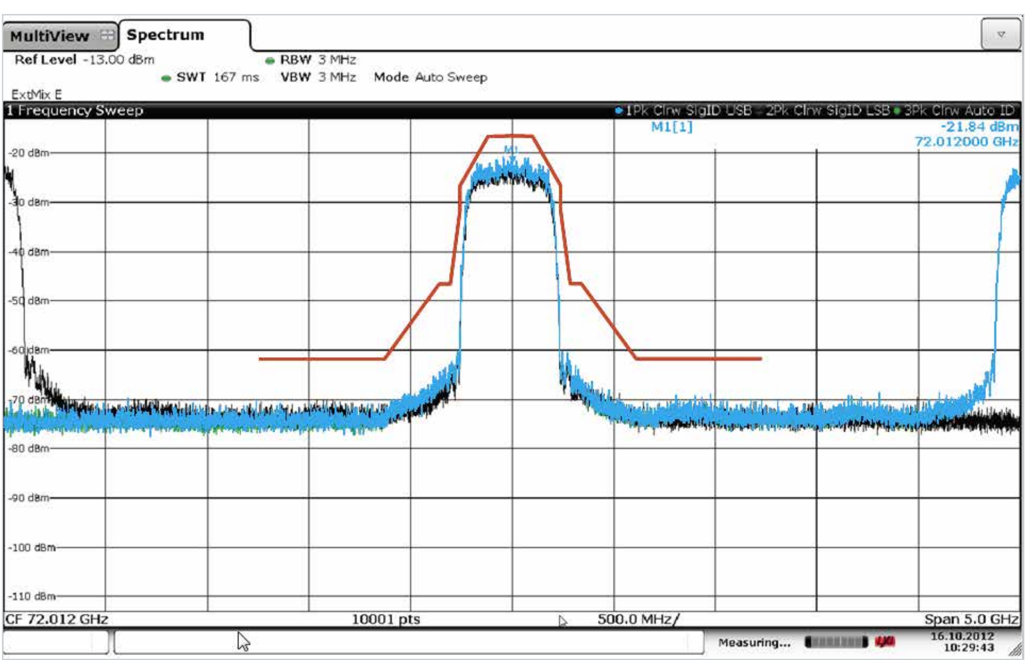


Fig. 2 Measurement of the same signal as in Fig. 1 with the R&S®FSW signal and spectrum analyzer. The input and image-frequency signal are 2.6 GHz apart. Measuring the spectrum mask or analyzing the modulation quality of significantly wider signals is possible without any difficulty.

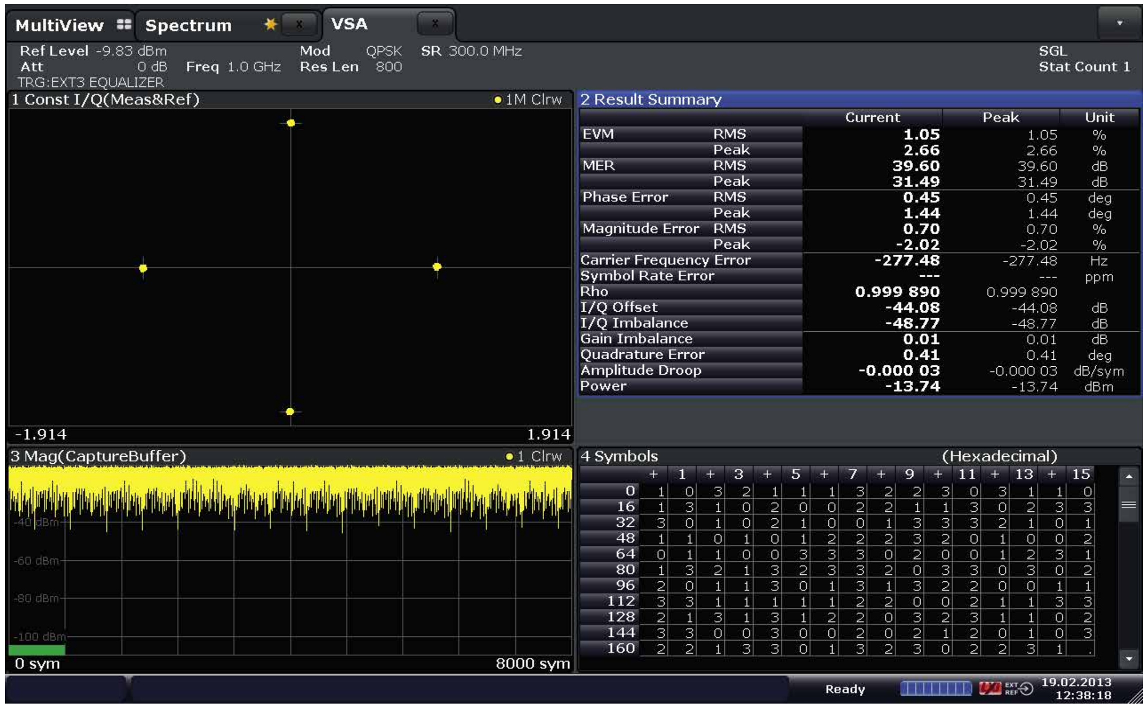


Fig. 3 Modulation analysis of a 300 MHz bandwidth QPSK signal. Besides graphic displays, e.g. the constellation diagram or input signal versus time, values displayed in tabular form offer information about the modulation quality at a glance.

of nominally –3 dBm results in a dynamic range sufficient for measuring the spectrum mask. The ETSI technical specification [3] defines a value of 50 dB. The R&S®FS-Z90 harmonic mixer is also equipped with an isolator at the input, which makes a VSWR of typically 1.4:1 possible. Power measurement errors due to reflections at the input resulting from mismatch are typically reduced by a factor of 5 compared to mixers without isolators.

Fig. 2 shows the measurement of the same signal of an E band microwave connection as Fig. 1. The 500 MHz bandwidth input signal and the image signal are 2.6 GHz apart, and it is possible to measure if the spectrum is within the prescribed mask (red line). The required dynamic range of at least 50 dB is also easily achieved with this setup.

The R&S®FSW can measure the spectrum as well as the modulation quality. Its high analysis bandwidth of up to 320 MHz (R&S®FSW-B320 option) makes it possible to capture wideband signals, demodulate them with the R&S®FSW-K70 vector signal analysis option and to analyze the modulation quality.

Fig. 3 shows the analysis of a 300 MHz bandwidth QPSK signal. The error vector magnitude (EVM) as a measure of the modulation quality, as well as the frequency error, the symbol rate error and many more parameters can be measured. The R&S®FSW signal and spectrum analyzer displays the results in tables or graphs. For example, the phase and amplitude are displayed in a constellation diagram, which delivers a visual impression of the modulation quality.

Summary

E band microwave connections are becoming more and more popular due to the constantly growing demand for higher data volumes to be transmitted. This range offers the highest achievable data rates of all available wireless transmission technologies. A spectrum analyzer with an external harmonic mixer is required to measure the spectrum. The R&S®FSW signal and spectrum analyzer's high intermediate frequency offers a wide image-free range. The low conversion loss of the Rohde&Schwarz harmonic mixers provides a high dynamic range, and the good matching results in high power measurement accuracy. This makes the R&S®FSW together with the R&S®FS-Z90 harmonic mixer a peerless solution for spectrum measurements in the E band.

Dr. Wolfgang Wendler

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[4] Dr. Florian Ramian: Using Harmonic External Mixers to Extend the Frequency Range. Rohde&Schwarz, Application Note 1EF75.
[5] The new benchmark: the R&S®FSW signal and spectrum analyzer. NEWS (2011) No. 204 (extra section following page 32).

WLAN IEEE 802.11ac measurements now possible with midrange instruments

The new WLAN IEEE 802.11ac standard increases the data transmission rate many times over. Although users benefit from this increase, it poses a challenge to manufacturers. The new technology places extremely high demands on the components used. Now all required measurements can be performed using midrange instruments from Rohde & Schwarz – and cost-optimized test systems for production can be implemented quickly.

WLAN IEEE 802.11ac – new standard for higher data rates

Using a smartphone or tablet PC to access the Internet over WLAN has become commonplace. More and more devices such as set-top boxes and TV sets support WLAN, and new applications are placing greater demands on data rate. The required signal bandwidths are available only in higher frequency ranges.

For this reason, the WLAN IEEE 802.11ac standard is taking a new direction. It also uses bandwidths of 80 MHz and 160 MHz in the 5 GHz band, making it possible to achieve data rates of several Gbit/s. It employs a higher-order modulation and offers extended support of multi-antenna technology (MIMO) using up to eight antennas and of multi-user MIMO.

Fig. 1 The R&S®SMBV100A (top) is the world's first vector signal generator that can generate WLAN signals with 160 MHz RF bandwidth without an additional instrument. The R&S®FSV signal and spectrum analyzer (bottom) also supports the new WLAN standard.

256QAM requires good signal quality

IEEE 802.11ac not only supports the modulation modes used up to now (BPSK, QPSK, 16QAM and 64QAM) but also 256QAM. The wireless device determines, on the basis of the measured signal quality, which modulation mode is used.

In the case of multi-user MIMO, a WLAN switch serves several users on the same frequency at the same time thanks to multipath propagation and beamforming through multi-antenna technology. Each user is assigned a spatially separate data stream. Although multi-user MIMO improves the capacity of the entire system, the individual data streams lead to a higher noise level. An especially high signal-to-noise ratio, with an EVM below –32 dB, is required for demodulating 256QAM signals.

The frequency response requirements are also higher. At both the transmitter and the receiver end, constant signal power is required across a bandwidth that is four times higher than that with IEEE 802.11n. Deviations would lead to a higher EVM – an obstacle for transmission with higher-order modulation, such as in the case of 256QAM.

Digital predistortion to counteract nonlinear effects

In order to fulfill these requirements, components such as amplifiers and mixers must have low inherent noise and linear behavior across a wide frequency range. Although noise components cannot be removed from the signal, digital predistortion makes it possible to compensate for nonlinear effects. The signal is digitally predistorted before the amplifier opposite to the amplifier's distortion. Predistortion and distortion cancel each other out in the amplifier, and a linearly amplified signal is the result.

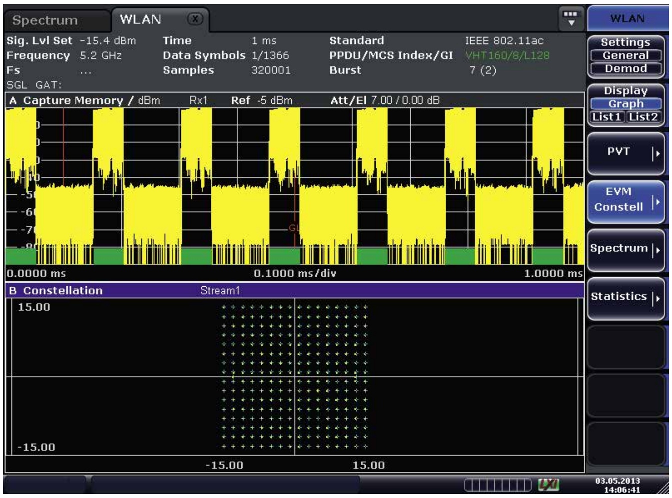


Fig. 2 The upper diagram shows seven demodulated WLAN bursts. The constellation diagram of a 256QAM is shown at the bottom. The clear constellation point matrix indicates high signal quality. Any deviations from this pattern provide useful information about the error source.

Fig. 3 Alternatively, the most important measurement results are displayed in tabular form.

Extended tests required

The tests required by IEEE 802.11ac are an extension of the previous standard. Transmitter tests cover spectral mask, spectral flatness, center frequency and modulation quality. At the receiver end, the tests focus on sensitivity, adjacent channel suppression, nonadjacent channel rejection, maximum input power and clear channel assessment (CCA) sensitivity. Developers and manufacturers of components for WLAN IEEE 802.11ac need signal sources and analyzers that offer at least an I/Q modulation and analysis bandwidth of 160 MHz in the 5 GHz band.

Rohde & Schwarz test solution

The newest generation of the R&S®SMBV100A vector signal generator and of the R&S®FSV signal and spectrum analyzer is ready to handle this task (Fig. 1). All required transmitter and receiver measurements are easy to perform with these two instruments. The required signal generation and analysis functions are included and can be executed manually or using test sequence control.

The R&S®SMBV100A offers a variety of functions: Different bursts for different WLAN signals can be mixed using the frame block configuration. An 80 MHz burst in line with IEEE 802.11ac, 11n or 11a can follow a 160 MHz burst in order to simulate the signal traffic that may occur at an access point. For MIMO tests, signals for up to eight antennas are supported; for static tests in the generator with different levels and phases, these signals can be added in order to generate the suitable sum signal for the receive antenna. White Gaussian noise can be superimposed on the signal to emulate the noise in a receiver's RF frontend.

These functions are complemented by the generator's high signal quality. The error vector magnitude for a 160 MHz bandwidth signal measured at 256QAM is –47 dB at 5.7 GHz. The R&S®SMBV100A also excels with a frequency response of 0.2 dB (meas.) across a bandwidth of 160 MHz.

To analyze signals in line with IEEE 802.11ac, the R&S®FSV performs spectral measurements of e.g. nonharmonic and out-of-band emissions as well as the adjacent channel leakage ratio. Comprehensive modulation parameter measurements are available in the time domain. Users can conveniently switch between the different measurements, and the most important results can be displayed in graphical or tabular form (Figs. 2 and 3). The touchscreen makes operation especially easy.

The R&S®FSV and R&S®SMBV100A are universal instruments used for developing and producing base stations, mobile phones and amplifiers. Other applications that also require high bandwidths are LTE-Advanced with bandwidth requirements of up to 100 MHz for measuring carrier aggregation, predistortion of broadband amplifiers for multistandard base stations, and broadband pulses.

Markus Lörner; Martin Schmähling

Standard-compliant NFC signals defined in detail at the press of a button

Near field communications (NFC) has everyday applications. It has become a standard feature for high-end mobile phones, in particular. The standard-compliant NFC signals required for the development and production of these devices are generated by the Rohde&Schwarz family of signal generators equipped with the R&S®SMx-K89 option.

NFC – just another short-range transmission standard?

Unlike the technologies typically used for data transmission over short ranges, such as Bluetooth®, transmission via NFC is limited to significantly shorter distances (see box on page 19). Although this initially appears to be a limitation, it is in fact the basis for using NFC to open up new and different areas of applications than those available with Bluetooth®, for example. Whereas connections with ranges of more than several meters need to be explicitly activated or authorized on mobile devices in order to save energy and protect data, NFC connections are established using a more intuitive process: The devices are simply held next to one another or placed onto a terminal. This ease of use makes NFC ideal for a number of new applications. Some examples:

- Cashless payments using a mobile phone or a payment card
- Easy activation of a WLAN connection in a restaurant. On entering the restaurant, guests simply hold their mobile device briefly up to a terminal, and the rest is taken care of automatically. There is no more need for cumbersome codes, and the restaurant still ensures that only guests use its free access
- More exotic applications are also already available, such as an app for smartphones that replaces the old-fashioned hiking pass (Fig. 1)

Example of an NFC application

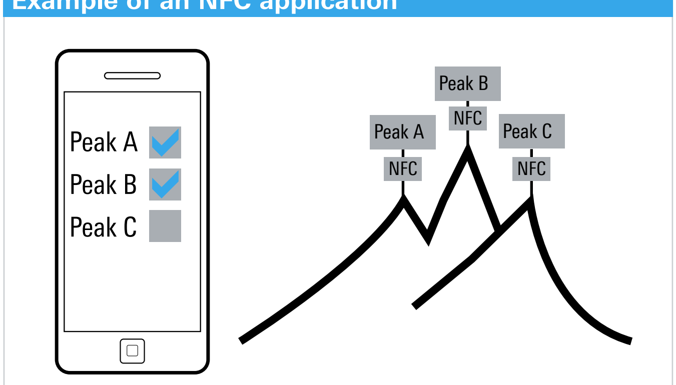


Fig. 1 In High Tatras National Park in Poland, NFC tags are placed at the mountain peaks. Using an NFC-capable smartphone and an app, hikers can fill out their electronic hiker pass by briefly holding the phone next to the NFC tag each time they reach a mountain peak.

NFC testing during development and production

In many of these applications, devices from different manufacturers must communicate with one another. To ensure interoperability, the NFC Forum has defined standardized test procedures. These tests, which are described in the "Test Specifications / Cases for the NFC RF Analog Specification", can be used by manufacturers of NFC-capable devices during development and production to verify that their devices meet the NFC standard requirements.

A device plays one of two roles in NFC communications. The device that provides the energy required for the transmission is the polling device, or simply the poller. If it uses the energy from another NFC-capable device to respond to that device, it is the listening device (the listener). A short overview of NFC transmission technology is provided in the box on page 19. The NFC Forum test specification mentioned above includes tests for both types of NFC devices.

Tests on listening devices

In this group of tests, the device under test (DUT) is a listener (Fig. 2). A generator, such as the R&S®SMBV100A from Rohde&Schwarz, generates the poller signals and also provides the energy required for the transmission during the entire test sequence by generating a carrier signal at 13.56 MHz. An additional NFC reference antenna (the reference polling device) is needed in order to apply this RF signal along with the carrier and the modulated poller signal to the DUT. The structure of this antenna – and associated electronics – has been specified in detail by the NFC Forum.

If the listening DUT functions correctly, it responds by modulating the electromagnetic field of the poller (load modulation). The reference antenna registers this response and makes it available at its connector as an electrical signal. An NFC signal analysis system – such as the R&S®RTO oscilloscope in combination with the R&S®FS-K112 PC software – analyzes the signal and helps to determine whether the listening device has passed the test.

Tests on listening devices

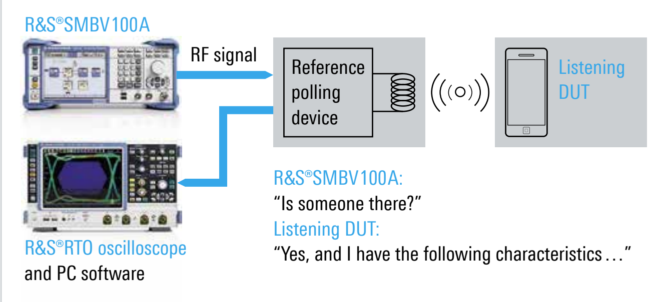


Fig. 2 Typical setup for listening device tests.

The principle behind near field communications

With NFC, transmission takes place over distances of only a few millimeters; for example, by laying a payment card onto a terminal or holding two mobile telephones next to each other. One of the devices generates an electromagnetic field with a frequency of 13.56 MHz (Fig. 3). Unlike mobile radio transmission, however, this signal is not broadcast into open space (into the far field), but is inductively coupled with the other device in the near field, much like in a transformer.

The device that generates the field is called polling device or poller, and the second device is the listening device or listener (in this context, a payment card is also a "device"). Data transmission from poller to listener involves the poller modulating the amplitude of its field, which is registered by the listener.

NFC principle

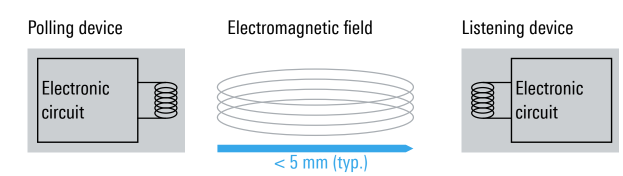


Fig. 3 Two devices communicate via NFC using an electromagnetic field with a frequency of 13.56 MHz.

The transmission from listener to poller takes place by means of load modulation: The listener does not draw a constant amount of energy from the field; instead, it can change the amount of drawn energy over time (by changing the impedance). Feedback changes the amplitude of the alternating electromagnetic field, which the poller can register.

NFC-A, NFC-B and NFC-F

For this type of transmission in the near field, various transmission standards – driven by various companies – have gained acceptance over time. The NFC Forum has incorporated the most important of these standards into the common NFC standard. The fact that the new standard from the NFC Forum is based on different existing standards is reflected in the division of the new standard into substandards NFC-A, NFC-B and NFC-F. All three of these substandards use a 13.56 MHz field. They differ only in how this field is amplitude-modulated, how the transmitted symbols are coded and in the bit rate.

NFC-B load modulation is sometimes also referred to as BPSK. However, it is not the field that undergoes phase modulation, but a subcarrier, which in turn modulates the amplitude of the 13.56 MHz field.

Polling test

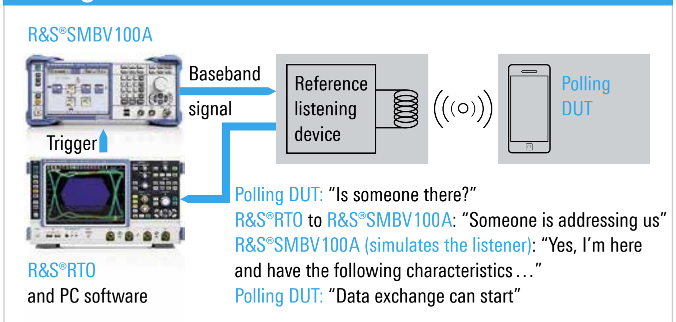


Fig. 4 Typical setup for polling device tests.

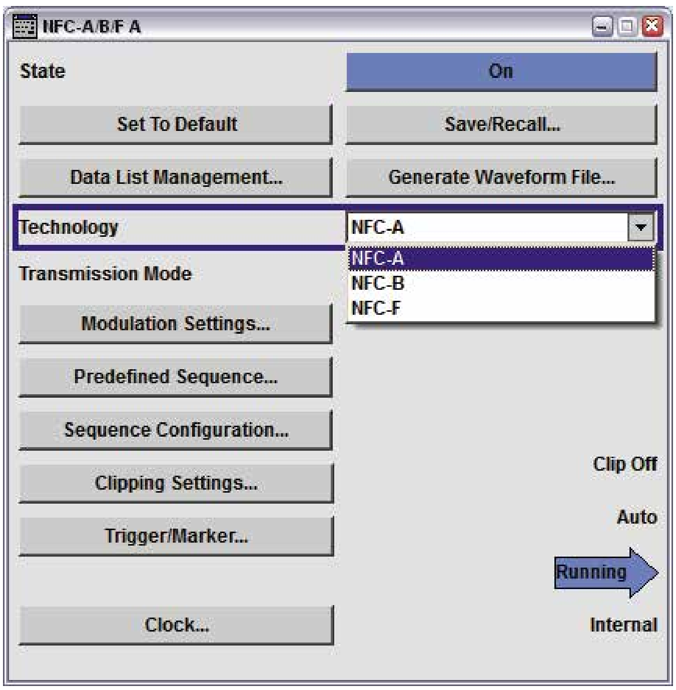


Fig. 5 The main menu for the R&S®SMx-K89 option. All three NFC Forum substandards are supported: NFC-A, NFC-B and NFC-F.

Setting the modulation parameters

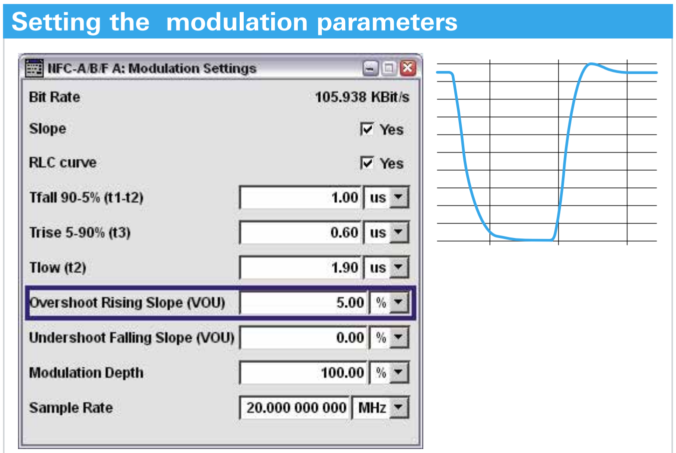


Fig. 6 Modulation parameters are used to modify the signal edges as needed. The artificial overshoot of 5 % after the rising edge is clearly visible.

Tests on polling devices

In the case of polling tests, the DUT generates the 13.56 MHz field for NFC transmission and modulates it with a poller signal. This test setup also requires an NFC reference antenna that is positioned in the poller field. The envelope for the received poller signal is output at a connector and checked by the NFC analysis system. For some poller tests, this is sufficient to determine whether the device passes or fails.

For other polling device tests, a signal generator must generate a listener response that prompts the poller to send additional signals (Fig. 4). The generator is triggered by the analysis system and then sends a suitable response to the reference antenna in the form of a baseband signal. The electronics in the reference antenna then perform the load modulation of the electromagnetic poller field. If the polling DUT behaves in line with the standard, it will output an additional poller signal that can then be analyzed.

The Rohde & Schwarz family of signal generators generates all NFC signals

When retrofitted with the new R&S®SMx-K89 option, the Rohde & Schwarz family of signal generators can conveniently generate the described poller and listener signals. This option is available for the R&S®SMU200A and R&S®SMBV100A vector signal generators, as well as for the R&S®AMU200A, R&S®SMJ100A and R&S®SMATE200A. The signals generated by this option are compliant with the NFC standard and support the three substandards NFC-A, NFC-B and NFC-F (Fig. 5).

The signals can be precisely parameterized. As a result, the edge shape can be changed, or the signals can be artificially degraded with overshoot in order to test whether the DUT still functions under adverse conditions (Fig. 6). All parameters can be defined manually via the graphical user interface, or when automated test sequences are available, the generator can also be remotely controlled in realtime by using SCPI commands via a GPIB or Ethernet connection.

If the standard-compliant base tests are to be supplemented with more in-depth, user-defined tests, the R&S®SMx-K89 option can be used to flexibly combine individual NFC commands into extensive sequences (Fig. 7). This option provides the basic commands for device search and conflict prevention as well as the NFC-A / -B / -F protocol commands used for data transmission (type 1 to 4 tag platform, ISO DEP, NFC-DEP).

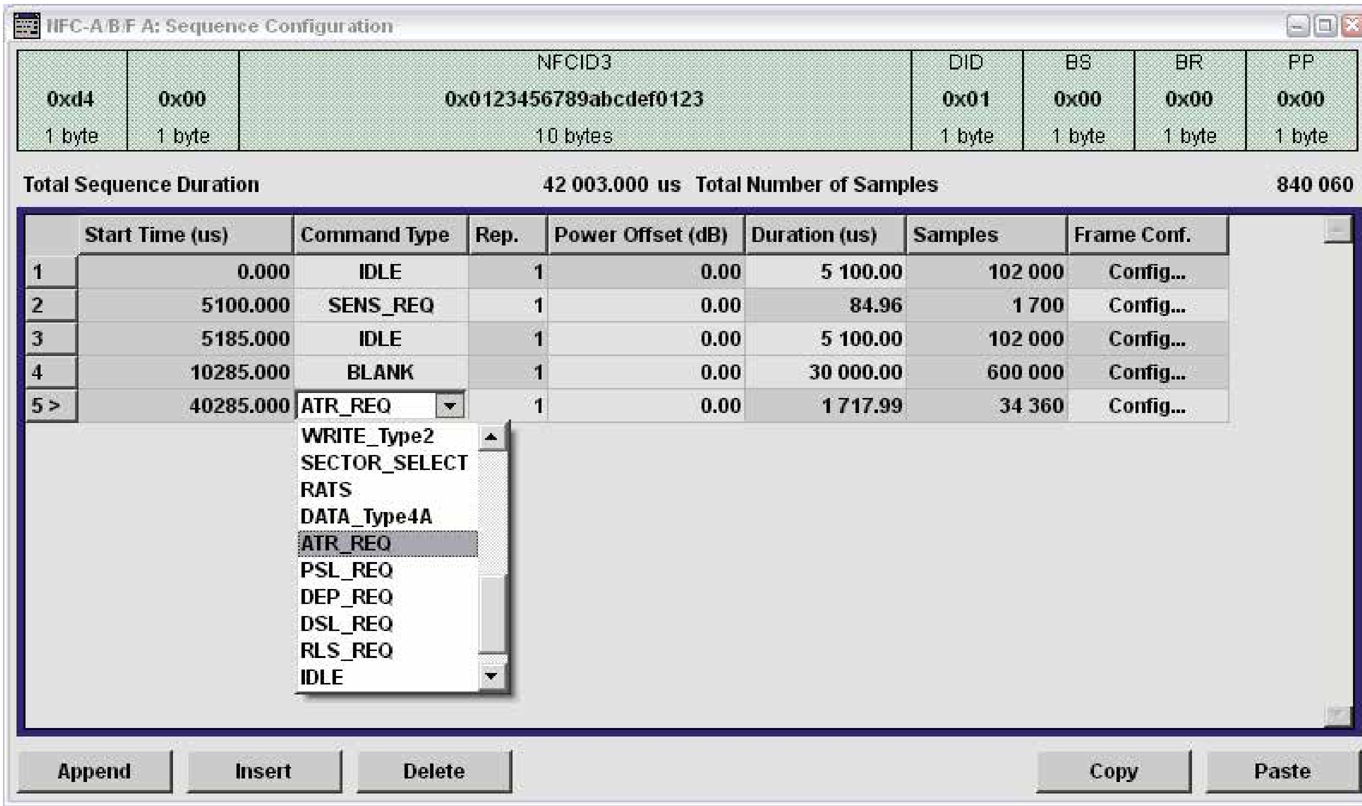


Fig. 7 NFC commands can be flexibly combined into longer sequences. The commands for the protocols based on NFC-A / -B / -F are supported (type 1 to 4 tag platform, ISO DEP and NFC-DEP).

NFC tests – one source

The Rohde&Schwarz NFC test portfolio includes everything needed to perform the tests described above. A complete set of reference antennas is available as an interface to the NFC field (R&S®CSNFC-B8 NFC Forum reference equipment) [1].

Existing Rohde&Schwarz equipment for mobile radio measurements can be expanded to include NFC functionality; additional instruments are not necessary. The R&S®FS-K112PC NFC measurement software, for example, can be used to test NFC signals captured using the R&S®RTO oscilloscope or the R&S®FSV signal and spectrum analyzer.

The new R&S®SMx-K89 option is available for all current Rohde&Schwarz vector signal generators and rounds out the offering of NFC test and measurement equipment [2].

Bertram Fesl

More information

[1] Rohde&Schwarz NFC / RFID technology page: http://www.rohde-schwarz.com/technology/nfc

[2] R&S®SMBV-K89 NFC A / B / F product page: http://www.rohde-schwarz.com/product/smbvk89

Fig. 1 R&S®NRP-Z58 USB power sensor with adapter for the WR-10 waveguide band (R900, WG-27) from 75 GHz to 110 GHz.

Power sensor with 1 mm coaxial connector covers the frequency range from DC to 110 GHz without interruption

Until recently, there was no worthy solution available on the market for power measurements on wideband sources up to 110 GHz, or for level calibration of network analyzers that have 1 mm test ports. The available V-band and W-band power sensors are based on obsolete technology, and they cover only the signal components within their respective frequency band. This means that users need multiple, harmonized sensors to perform broadband measurements. Not so with the new R&S®NRP-Z58 thermal power sensor: It covers the entire frequency range from DC to 110 GHz without interruption.

We recognized a need …

When looking for power sensors that can be used for applications in the millimeter-wave range, the selection on the market is very small. Many of the available sensors use extremely outdated technology. This applies to the frequency range from 67 GHz to 75 GHz and for the W-band (75 GHz to 110 GHz). In fact, only one rather old, diode-based sensor type and one calorimetric-based power sensor are available for the W-band. These sensors cannot be used to detect signals below the cutoff frequency for the type of waveguide used by the sensors, for example. This makes it difficult to perform power measurements on wideband sources such as photodetectors and photoreceivers for the 100G Ethernet. Similar problems exist for level calibration of network analyzers having 1 mm test ports. Previously, the only calibration option was to measure individual frequency ranges sequentially using the appropriate power sensor for that range. In addition, an adapter was needed between a waveguide power sensor and the coaxial connector at the source. Aside from the effort involved and the lack of automation, this method is also associated with greater wear and tear on the sensitive 1 mm connector. This wear and tear is caused not only by the repeated connections that are required when changing the sensor, but also by the mechanical stress resulting from the greater weight and larger dimensions of conventional waveguide power sensors.

Thermoelectric transducer

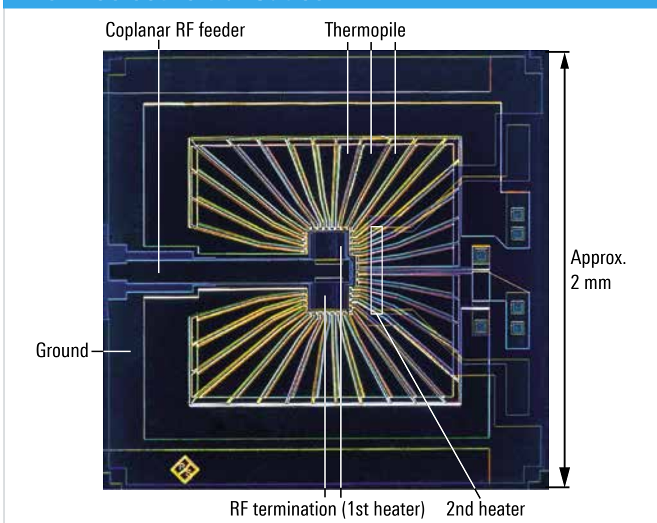


Fig. 2 Structure of the thermoelectric transducer – a Rohde&Schwarz development.

… and brought an innovative product to the marketplace

With the new R&S®NRP-Z58 thermal power sensor (Fig. 1), these problems are a thing of the past. A single 1 mm coaxial connector (male) makes it possible to cover the entire frequency range from DC to 110 GHz without interruption. The power measurement range extends from 0.3 µW (–35 dBm) to 100 mW (+20 dBm), covering the range of greatest interest. The new power sensor is also lightweight and easy to use, and can be operated directly from a PC via a USB interface. Other exceptional features include rapid measurements, excellent linearity, an internal verification option and full traceability to the primary standards from renowned national metrology institutes. Not only is the R&S®NRP-Z58 the first choice for power measurements on 1 mm coaxial ports, it can also replace waveguide power sensors in many other applications (see box on page 25).

The R&S®NRP-Z58 110 GHz power sensor is part of the R&S®NRP family of products from Rohde&Schwarz, and it incorporates all the main features of this family of products. At the core of the new power sensor is the indirectly heated thermoelectric transducer – a Rohde&Schwarz development that combines very good impedance matching values with a high dynamic range and a response time of only a few milliseconds (Fig. 2). The connection to the RF frontend is via a patent-pending wideband transition that converts the radially symmetric field of the incident wave to the field distribution of the coplanar transducer input, while at the same time providing excellent thermal isolation (Fig. 3). These and other thermal design measures ensure that the zero drift remains negligible, even with ambient temperature changes or when screwing on the sensor. Virtually no drift is expected under constant ambient conditions, because the architecture of the signal processing chain ensures that the 1/f noise is suppressed completely. This is why the zeroing performed at the plant is sufficient in many cases. In addition, the R&S®NRP-Z58 does without an internal zeroing function; it would cause long, asynchronous interruptions in the measurement without providing improvements.

Internal DC reference voltage

To verify the thermoelectric transducer and the connected analog signal processing chain, the R&S®NRP-Z58 power sensor has a DC reference (Fig. 4) that makes calibration to an external 50 MHz reference source unnecessary. During calibration, the power sensor can remain connected to the DUT for as long as the DUT supplies a sufficiently stable signal. With a reproducibility in the range of 10^{-4}, verification via the integrated DC reference far exceeds an external calibration with an RF signal.

The factory calibration for more than 200 frequencies is fully traceable to the primary standards of the national metrology institutes in either Germany (Physikalisch-Technische Bundesanstalt, PTB) or the United States (National Institute of Standards and Technology, NIST). In addition, Rohde&Schwarz benefits from a microcalorimeter very recently put into use by the PTB that covers the entire W-band. In this range, the calibration uncertainties of the new power sensor are 6.0 % to 7.0 % (calculated using GUM with a coverage factor of two).

Highly linear power display

A high degree of linearity for the power display was a top priority during development, because this attribute is important for relative measurements. These include scalar attenuation, amplification and reflection measurements, as well as indirect power measurements using directional couplers and so on. The absolute reference for indirect power measurements is normally obtained by means of a system calibration at a single level. With a linearity uncertainty of maximally 0.23 % (0.01 dB), the R&S®NRP-Z58 is comparable to conventional, thermistor-based power sensors that use a DC substitution to ensure high linearity. In the R&S®NRP-Z58, the DC substitution was omitted in favor of measurement speed. Instead, a numeric linearity correction is used. This linearity correction is based on a calibration of the thermoelectric transducer with DC voltages performed at the plant, and it can remain unchanged for the life of the sensor.

Measurement speed

Although the attainable measurement speed is comparable to that of any other state-of-the-art thermoelectric power sensor, it can vary significantly depending on the application. If the only goal is to record as many readings as possible within a given time span, the mode that includes buffering can be used to record more than 500 readings per second. The

R&S®NRP-Z58 frontend

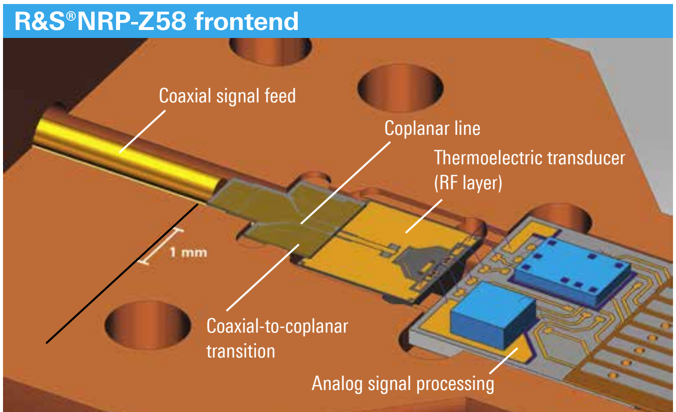


Fig. 3 RF frontend with coaxial-to-coplanar transition.

Calibration with DC reference

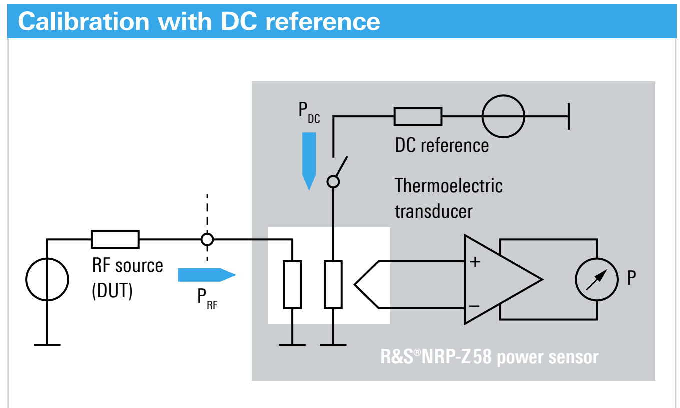


Fig. 4 Circuitry for internal calibration with DC voltage.

Power measurements on any interface in the frequency range up to 110 GHz

Although the R&S®NRP-Z58 power sensor was developed for broadband applications with a 1 mm connector, it can also be used on waveguide interfaces by using a suitable adapter (Fig. 5). This opens up entire new possibilities for these applications. In principle, only one R&S®NRP-Z58 is needed to perform power measurements on any interface in the frequency range up to 110 GHz. This makes it easy to measure in those frequency bands for which a waveguide power sensor is not commercially available, such as the WR-12 band (R740, WG-26) from 60 GHz to 90 GHz. In this case, it is possible, of course, to equip a waveguide power sensor for the WR-10 band with an adapter for WR-12, but this is not a very viable option. The long waveguide sensor would be extended even more, and the already small frequency range would shrink to the overlap with the waveguide band on the DUT, i.e. to the band from 75 GHz to 90 GHz.

In addition to its universal usability, there are other solid arguments for using the R&S®NRP-Z58 in waveguide applications; arguments that more than outweigh the disadvantages associated with adapters. These include significantly faster measurement speed, elimination of the cumbersome alignment to a 50 MHz reference source, higher temperature stability, full traceability of the calibration, the thermal measurement principle and last, but not least, operation without a special base instrument.

Attenuation of the upstream adapter and its interaction with the input of the power sensor can be elegantly compensated by means of embedding. To make this possible, the R&S®NRP-Z58, like all power sensors in the R&S®NRP series, includes S-parameter correction functionality. It allows the four S-parameters of the adapter to be stored in the sensor for many frequencies, and then be automatically included in the measurement result. The effect of the reflection on the waveguide input of the power sensor, which on average is slightly increased by the adapter, can only be compensated by gamma correction. Although this method is also implemented in the R&S®NRP-Z58, the user must know the complex reflection coefficient at the output of the DUT. If this value is known, the remaining mismatch uncertainties are negligible. Otherwise – at least with high accuracy requirements and a poorly matched DUT – the possible effect of the mismatch on the measurement result should be estimated.

Fig. 5 R&S®NRP-Z58 power sensor with adapter for the WR-10 waveguide band (R900, WG-27) from 75 GHz to 110 GHz.

aperture for a measurement point can be set very precisely to a half-millisecond, and the measurement can be either triggered or run continuously. Even if every reading is output separately instead of being buffered, about 350 triggered test results per second are still possible. Of course, the rate of measurement will be slower during low power measurements when it becomes necessary to average multiple test results in order to obtain a stable reading. However, the R&S®NRP-Z58 can use averaging factors that are lower than those required by other W-band products because its inherent noise is significantly lower. As a result, the settling times are more than ten times shorter than before, which means that even levels up to –10 dBm can be measured virtually without delay, while maintaining a satisfactory degree of stability.

Mechanically ruggedized and extremely precise

The 1 mm connector on the R&S®NRP-Z58 is essential for the impedance matching, reproducibility and load capacity of the new product. This is why Rohde & Schwarz manufactures the connector at its own plant, where it is also subjected to a rigorous quality control. The coupling nut on the connector is fitted with ball bearings. These make it possible to hand-tighten the power sensor so precisely that there is no need for a torque wrench. The reduced friction also prevents the outer conductor from rotating when the coupling nut is tightened, thereby reducing wear and tear on the connector.

Thomas Reichel

The better choice: USB power sensors from Rohde & Schwarz

Within just a few years, power sensors with a USB interface have largely replaced the traditional combination of analog power sensor and analog/digital base unit in RF and microwave T&M applications. The driving forces behind this trend are lower costs and universal applicability thanks to the popularity of the USB interface. However, most people are unaware that the concept of a power meter fully integrated into a sensor is an important factor motivating the advancement of RF power measurement technology both in functional and qualitative terms.

Why sensors?

Power meters take a unique position among T&M equipment in the field of RF engineering. They are the only devices that are connected directly to the device under test (DUT), i.e. without using an RF cable. This is due to the need to measure the DUT's power on a load that should be perfectly matched. Even an RF cable firmly connected to the power meter would deteriorate matching and reproducibility, with a negative impact on results.

Since it is typically not possible to connect a complete measuring instrument weighing several kilograms directly to the DUT's RF connector, the RF transducer was separated from the instrument early on and accommodated in a small power sensor. The sensor was connected directly, and only a relatively uncritical, low-frequency output signal from the transducer had to be transmitted to the base unit.

Fig. 1 Selection of power sensors from the R&S®NRP product family.

Although this instrument concept held its own in the market for many years, it was ultimately unable to satisfy new requirements that arose most notably in the world of digital wireless communications. Despite ongoing advances in electronics, production costs and sales price could not be reduced further. Functionality was limited, and even measurement speed and accuracy were constrained by the distributed instrument concept. The only way to overcome these barriers was by integrating the base unit functionality into the sensor.

Fig. 2 Interfaces for power sensors compared by size (to scale): peak power analyzer (left), standardized interface for R&S®NRP (center) and micro USB.

Rohde&Schwarz: the integration pioneer

By the mid-1990s, advances in the miniaturization and performance of electronic components had reached a point where such integration was technically feasible. Rohde&Schwarz was the first company to implement this concept when it developed the R&S®NRT-Z directional power sensors, which could be controlled via the RS-422 interface. These sensors supported operation with a dedicated R&S®NRT digital base unit as well as with a PC via an RS-232 or PC Card interface. The concept set new standards and was widely imitated by competitors.

Integrated power meters became truly popular in the early 2000s with the commercial launch of the R&S®NRP-Z series of power sensors with a USB interface (Fig. 1). As accessories for a wide range of instruments as well as devices now capable of transforming even a tablet or a mobile phone into a power meter (see title photo*), these sensors benefited greatly from the popularity of the USB interface. However, the huge popularity of the USB interface is only the most obvious reason for their success.

Smaller, lighter and more economical

In a classic power meter, about two-thirds of the costs are attributable to the base unit. By integrating all of the base unit's measurement functionality into the sensor, costs can be cut in half compared to classic systems (assuming, of course, that a computer or a measuring instrument is available to handle the output of results).

Savings are even higher when comparing integrated wideband power sensors with the functionally equivalent peak power analyzers. For a long time, these devices were unique among power meters due to their ability to analyze pulsed or modulated signals and display them in the time domain. This makes their design substantially more complex than that of conventional power meters, so that peak power analyzers remain more expensive to this day. An example of this is seen in their costly sensor interface (Fig. 2) that, however, does not prevent the length of the connecting cable from impacting results.

Integrated wideband power sensors such as those from the R&S®NRP-Z8x series can be manufactured at a fraction of the cost while delivering almost all of the performance of peak power analyzers: 30 Hz video bandwidth, 13 ns rise time, 80 Msample/s realtime sampling rate, internal and external trigger, automatic determination of pulse parameters. The length of the connecting cable does not impact results. Other benefits in the Rohde&Schwarz wideband power sensors include unrivaled dynamic range along with an extremely fast statistical analysis function.

Besides cost savings, the reduction in weight and volume is just as beneficial. Savings even exceeding 90 % can be achieved when using an integrated power meter.

Better and more accurate without a base unit

The standardized single-channel interface used in conventional power sensors is both their greatest strength and weakness. On the one hand, this interface enables the use of different sensors on a base unit. On the other hand, it considerably limits signal processing capabilities. This is most apparent with multipath sensors, which are so important today. Since the only way to operate them involves sequential transmission of detector signals to a classic base unit, their potential has only been barely exploited. Switching delays and hysteresis effects occur during test path switching, plus the standardized measurement channel has other substantial drawbacks. It is not suitable for gated measurements, nor for measurements of the envelope power.

By contrast, multipath sensors with integrated signal processing support a concept that is perfectly matched to the characteristics of the detector used. Here, signals are processed in parallel for up to three test paths, meaning that a valid measured value is always available. This concept does away with repeated measurements due to the selected test path being

* The free Power Viewer Mobile app for Android devices is available from Google Play. This associated application note "Using R&S®NRP-Z Power Sensors with Power Viewer Mobile for Android Handheld Devices" can be downloaded (search term: 1MA215).

underdriven or overdriven. Moreover, the entire measurement channel can be configured so that gated power measurements can be performed, e.g. on communications signals with a TDMA structure.

One might speculate that the classic concept at least offers the benefit of higher accuracy. But in the case of the otherwise very precise thermoelectric power sensors, it turns out that integrated solutions can deliver even better performance. This is because analog base units have their own intrinsic error contributions that do not occur with integrated concepts (Fig. 3).

Elimination of the base unit has other benefits too. Since results are dependent on the power sensor only, relative power measurements can be performed with lower uncertainty and better reproducibility, and manufacturers can compensate zero offsets on a sensor-specific basis. Accuracy in relative power measurements is increased significantly: Instead of a type B uncertainty of at least 1 % for the combined sensor and base unit in a classic power meter, the integrated thermal power sensors of the R&S®NRP-Z5x series offer a figure not higher than 0.23 % across the entire power measurement range.

50 MHz reference source no longer state of the art

The reference source known from classic power meters was not there from the start. It was introduced during the changeover from (now obsolete) thermistor power sensors to thermoelectric designs. Whereas the thermistor power sensors exhibited inherent long-term stability due to DC substitution, this is not generally true for thermoelectric and diode-based detectors. Consequently, competitors to this day do not calibrate these sensor types in absolute terms, but instead only use relative calibration with a reference to 50 MHz. An absolute reference is provided with the 50 MHz source installed in the base unit.

Although Rohde&Schwarz pursued a different approach from the start with its power sensors from the R&S®NRV and R&S®NRP families using absolute calibration, here too, the 50 MHz source was an important accessory used to verify power sensors which, despite their verified long-term stability, might still suffer damage.

From the current perspective, an external reference source is no longer state of the art. On the one hand, using it requires disconnecting the power sensor from the DUT and connecting it to the source – a tedious and time-consuming step and even impracticable in many cases. On the other hand, the source's inherent uncertainty casts doubt on its relevance. Ranging from 0.4 % to 1.2 %, this uncertainty is well above the observable drift, meaning its only remaining use is in detecting significant damage.

USB power sensors have again provided the critical push toward a change in the prevailing concept. Since a 50 MHz reference source for these sensors is typically not available on site, the only choice is to perform verification in the actual sensors. This approach has been implemented for the very first time – and with a high level of accuracy – in the R&S®NRP-Z5x thermal power sensors (see page 22). These sensors contain a reference circuit based on a highly stable DC source. The signal delivered by the reference circuit can

Factors contributing to total measurement uncertainty

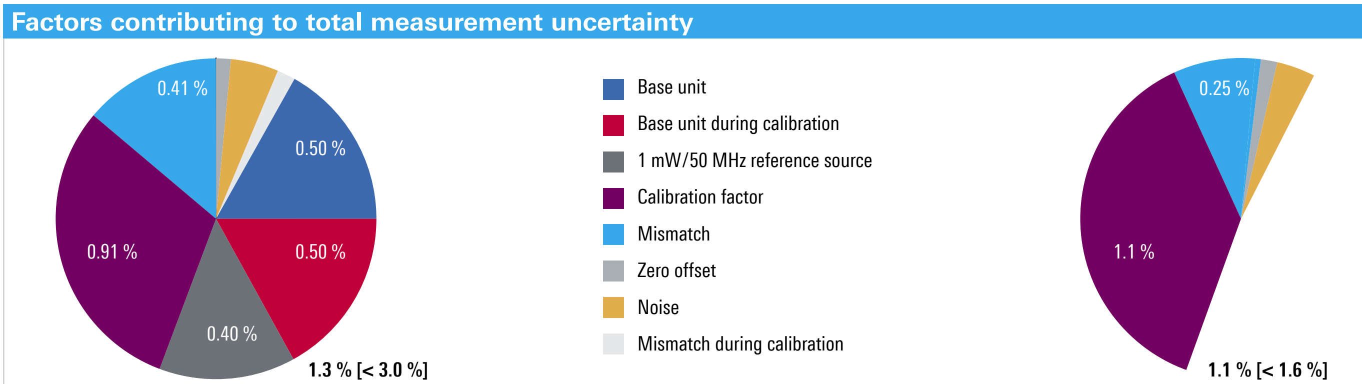


Fig. 3 Factors contributing to total measurement uncertainty in absolute power measurements using a thermoelectric power sensor in a standard application: signal frequency 2 GHz, power level –3 dBm, source SWR 1.10. Left: classic power measuring instrument of current design; right: R&S®NRP-Z51 (model .03). The numerical values represent expanded measurement uncertainties (k = 2) calculated according to the ISO/IEC Guide to the Expression of Uncertainty in Measurement (GUM). In bold: total expanded measurement uncertainty after addition of the squares of the partial uncertainties. In parentheses: sum of partial uncertainties after linear addition.

Three-path concept

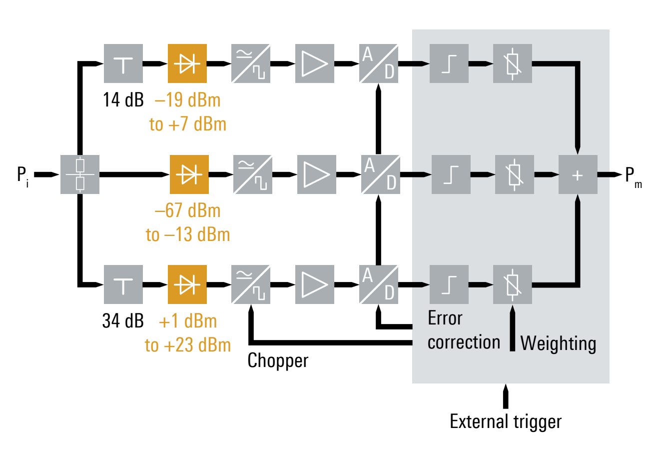


Fig. 4 Architecture of the three-path sensors from the R&S®NRP series.

Comparison of measurement times

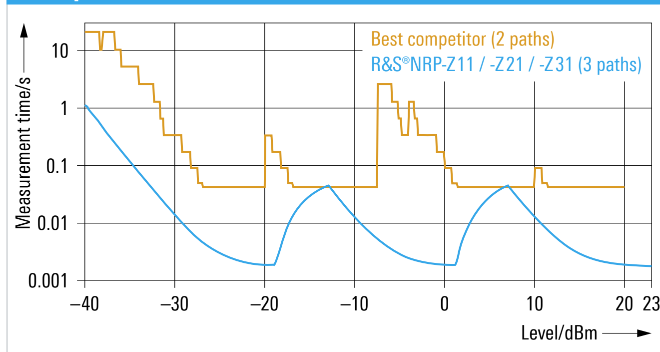


Fig. 5 Shortest possible measurement time for settled measurements using a multipath sensor, for a 2 sigma noise component of max. 0.01 dB in the measurement result.

be superimposed on the signal under test, making it possible to verify the entire sensor from the thermoelectric converter to the A/D converter in just a few seconds – without having to disconnect the power sensor. With reproducibility in the order of 10^{-4}, a level of confidence is achieved previously attained only by thermistor power meters. It can be assumed that this concept will be applied with other sensor types, too.

Not all sensors are the same

Few products manage to exploit the potential of integrated sensor concepts as fully as the power sensors of the R&S®NRP series. Many of the products that have recently pushed their way into the market were conceived solely as low-cost alternatives to classic power meters and therefore do not deliver the same accuracy and speed. Detectors are also used that involve the risk of users inadvertently committing serious measurement errors.

CW sensors and sensors with logarithmic detectors (referred to in this context) are suitable by definition only for spectrally pure sinusoidal signals, and fail when confronted with superimposed interfering signals (noise, harmonics) and modulation. While in the past it still made sense to use CW sensors due to the short measurement times they delivered with their large signal-to-noise ratio, they are clearly obsolete today. Integrated multipath sensors represent by far the best choice in such applications. They exhibit none of the described restrictions – and they are faster.

Of course, integrated multipath sensors can also widely differ in quality, especially in terms of measurement speed. Three characteristics must come together in order to achieve top performance. The first involves multiple detector diodes, i.e. integrated arrays of diodes connected in series. They improve the RF properties and increase the dynamic range for each measurement path. The second characteristic is a weighting method patented by Rohde&Schwarz that circumvents hard switching between the paths in favor of a smooth transition (Fig. 4). Here, the results from the adjacent measurement path are used in each case to compute the final result in a wide overlap range of 6 dB (power ratio 4:1). These two characteristics alone help to reduce the averaging time in the transition regions by a factor of 100.

The third characteristic is a third measurement path – a feature implemented so far by Rohde&Schwarz only. Using multipath sensors from Rohde&Schwarz, measurement times can be reduced by a factor of 20 compared to the best competitor (Fig. 5). At the same time, these sensors offer 10 dB better dynamic range.

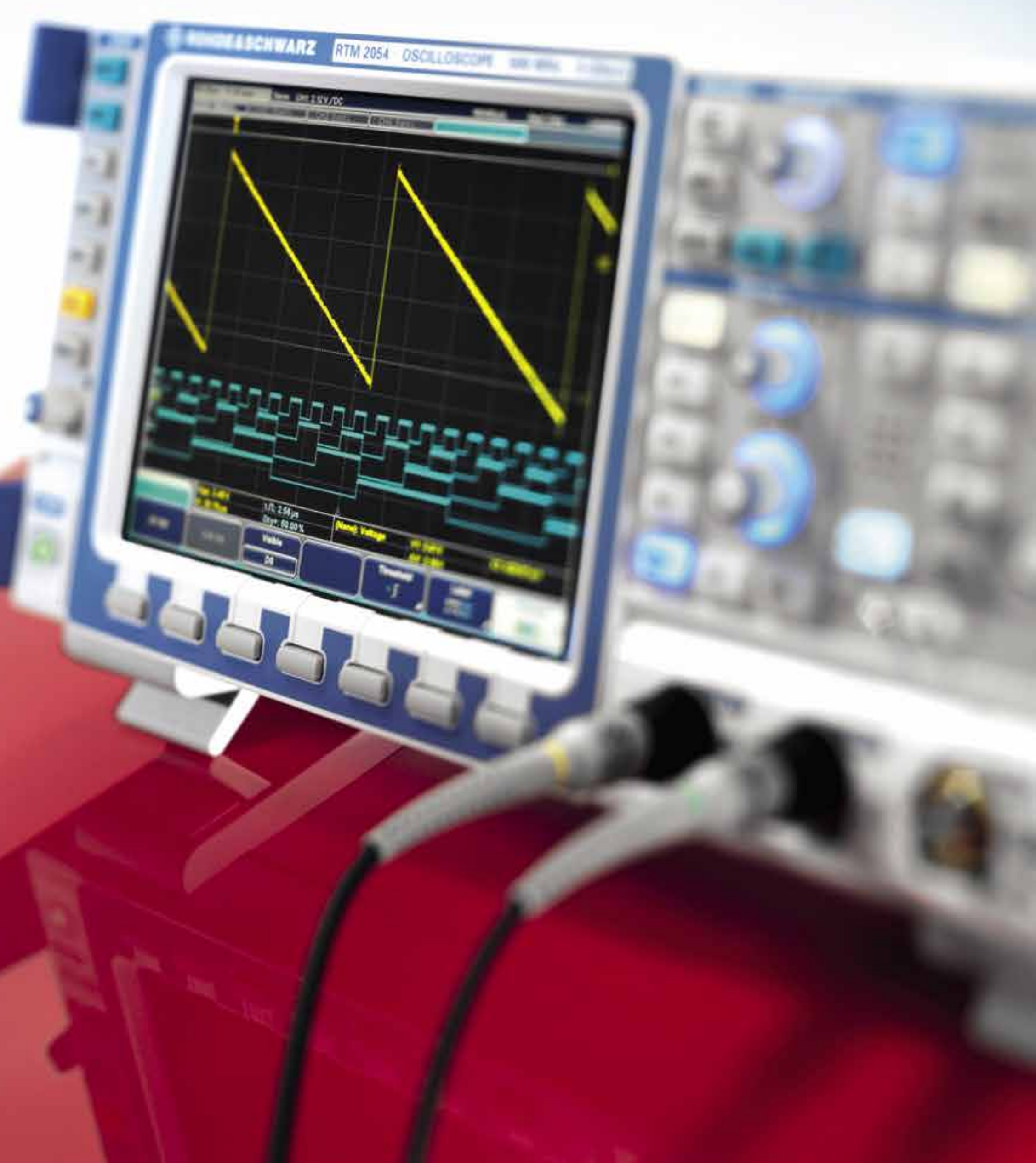
Outlook

The preceding description could easily create the impression that the development potential for USB power sensors is exhausted. However, this is in fact only just the beginning, since these sensors are not subject to any of the constraints related to the classic concept. Consequently, ongoing miniaturization in the component sector should lead to even more powerful concepts such as establishing a common timebase for multichannel measurements with distributed sensors.

Thomas Reichel

The new R&S®RTM 2000: switch on, measure, done

Ease of use, quick access to functions, fast and reliable results – this is precisely what oscilloscope users want in their everyday measurement tasks and the new R&S®RTM 2000 bench oscilloscopes deliver. R&S®RTM users are already evaluating results while other oscilloscopes are still booting up, and they can see signals that otherwise would be lost in noise.



The R&S®RTM are bench oscilloscopes for everyday use. With a bandwidth of 350 MHz or 500 MHz, they are ideal for a large number of applications. By combining time domain, frequency domain, logic and protocol analysis functions in a single instrument, they can be used for comprehensive testing of most embedded systems in development, production and service.

Bench oscilloscopes: What characteristics are important?

Bench oscilloscopes like the R&S®RTM are used for general measurement tasks in development, production, service and education. They boast lightweight, compact design, low noise and most especially simple and intuitive operation. The instrument design is flexible and extensible, allowing it to grow with user requirements. Customers can add software and hardware options as well as upgrade their oscilloscope's bandwidth.

What did Rohde&Schwarz improve on the R&S®RTM?

R&S®RTM oscilloscopes in overview

Bandwidth	
R&S®RTM 2032 / 2034	350 MHz (2 / 4 analog channels)
R&S®RTM 2052 / 2054	500 MHz (2 / 4 analog channels)
Sampling rate	2.5 Gsample/s; 5 Gsample/s, interleaved
Memory depth	10 Msample; 20 Msample, interleaved
Logic analysis	
(R&S®RTM-B1 option)	
Max. sampling rate	5 Gsample/s
Max. memory depth	20 Msample

Logic analysis: more details with the R&S®RTM

The R&S®RTM-B1 option adds 16 logic channels to the R&S®RTM oscilloscopes. The R&S®RTM oscilloscopes' sampling rate of up to 5 Gsample/s makes it possible to accurately measure the timing of logic signals. Since the signals can be precisely time-referenced to one another, timing and clock errors on serial or parallel bus signals can be detected with greater ease. The high sampling rate is used over the entire acquisition time, ensuring high time resolution even for long acquisition times.

The R&S®RTM stores logic signals with a memory depth of up to 20 Msample. This makes it possible to acquire and analyze complete complex control sequences, such as those needed during the development of a CAN bus control device in the automotive industry. Difficult-to-find faults are quickly detected by the R&S®RTM logic analysis function.

The VirtualScreen integrated in the R&S®RTM oscilloscopes doubles the usable screen area to display all channels with no overlapping. Math, reference and logic signals as well as protocol data can be displayed above or below the analog channels, allowing a complete overview of all measurement data. The R&S®RTM activity display also shows the current status of all logic signals (high, low, toggle) regardless of the trigger parameter settings (Fig. 1).

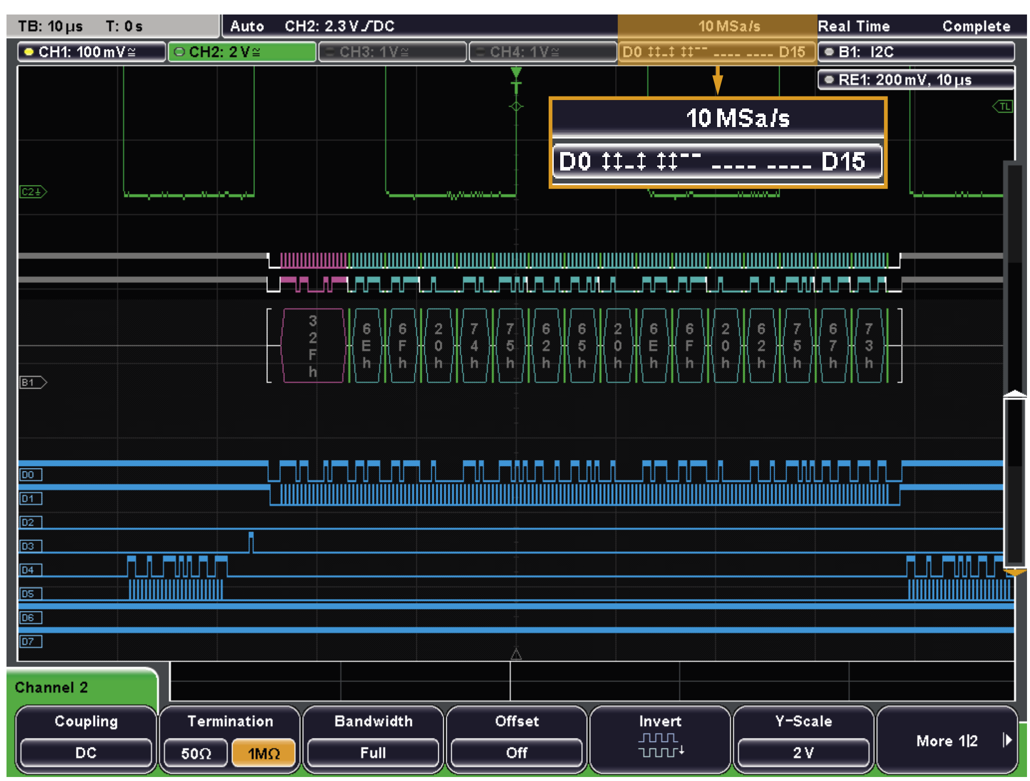


Fig. 1 Status information for the digital signals independent of acquisition and instrument settings.

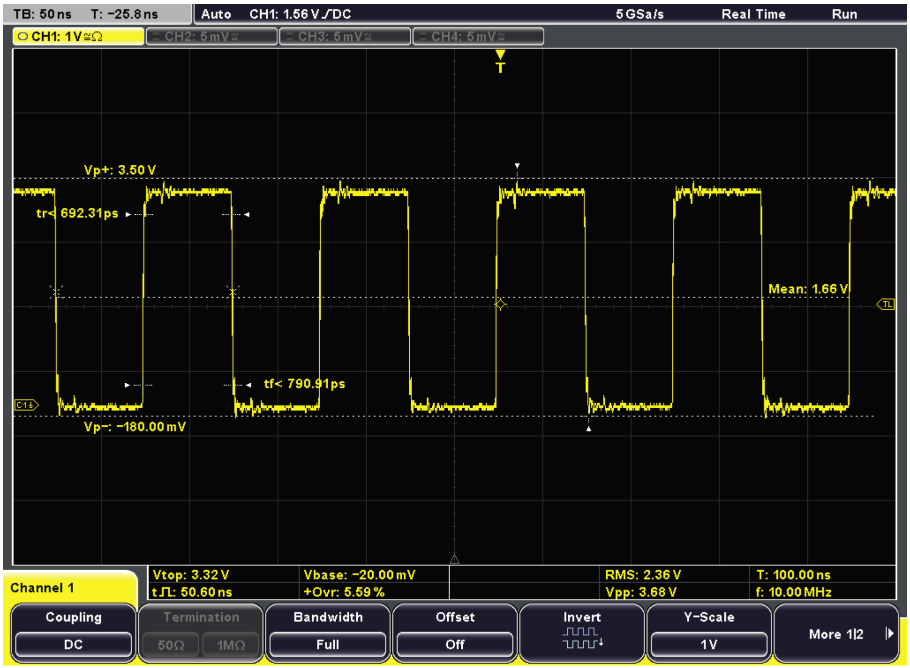


Fig. 2 QuickMeas: automatic measurement and graphical display at the push of a button.

QuickMeas function

Measurement value		Display
Vp_+	positive peak voltage	graphical display directly on the waveform
Vp_-	negative peak voltage	
tr	rise time	
tf	fall time	
Mean	mean voltage	
V_{pp}	peak-to-peak voltage	tabular display on the bottom right of the screen
RMS	RMS value	
T	time	
f	frequency	

Fig. 3 The QuickMeas function displays key measurement values automatically.

Signal analysis: faster to the finish line with the R&S®RTM

Especially during development, signals need to be analyzed in detail, and their properties (e.g. frequency or rise and fall times) have to be determined. The R&S®RTM oscilloscopes offer powerful tools that facilitate signal analysis and deliver precise results. At the push of a button, the unique QuickMeas function displays the key measurement values for a currently active signal using auxiliary lines and markers (Figs. 2 and 3). A variety of automatic measurement functions for rapid signal analysis are also available, such as measurement of peak-to-peak voltage or signal frequency. The results are presented in tabular form, with statistical evaluation if desired.

Another highlight of the R&S®RTM oscilloscopes is cursor-based measurements. Besides the standard ΔT and ΔV measurements, the oscilloscope cursor menu provides additional functions such as measurement of the mean voltage or RMS value, as well as a pulse counter over a user-defined signal range.

Debugging: everything at a glance with the R&S®RTM

Discovering signal faults can be very time-consuming. The R&S®RTM oscilloscopes shorten debugging time through the use of powerful tools such as the integrated mask test and FFT analysis. Mask tests quickly reveal whether a specific signal lies within defined tolerance limits and use statistical pass/fail evaluation to assess the quality and stability of a device under test. Any violation of an active mask can result in the automatic stopping of acquisition or the output of an acoustic signal. This makes it easy to identify signal anomalies and unexpected results. The mask test function is easy to use. Just a few keystrokes are needed to define a new mask from a reference signal (Fig. 5). The mask tests can also be remotely controlled, which is useful for automating quality tests in production applications.

The FFT function has a dedicated button and enables users to detect and analyze faults within a signal's spectrum. With the FFT activated, the R&S®RTM oscilloscopes simultaneously provide a spectral display of the signal and a small time domain window for checking the sampling interval. The autoset button is extremely convenient: The instrument selects the amplitude and frequency scaling that optimally matches the measured signal. The FFT function allows a rapid analysis of DC/DC converter designs to identify interference frequencies, for example.

Accuracy: a Rohde&Schwarz strength

Rohde&Schwarz has many years of experience developing professional test and measurement equipment. In the R&S®RTM oscilloscopes, this expertise has been translated into the very low-noise, high-precision analog frontend. With an input sensitivity of up to 1 mV/div, the frontend achieves a high vertical resolution over the entire bandwidth. Since no software-based zoom functions are used, the R&S®RTM oscilloscopes show a signal's real sampling points even at

Acquisition time		
	5 Gsample/s	**2.5 Gsample/s**
10 ksample	2 µs	4 µs
1 Msample	200 µs	400 µs
10 Msample	2000 µs	4000 µs
20 Msample	4000 µs	8000 µs

Fig. 4 Acquisition time with the R&S®RTM as a function of memory depth and sampling rate.

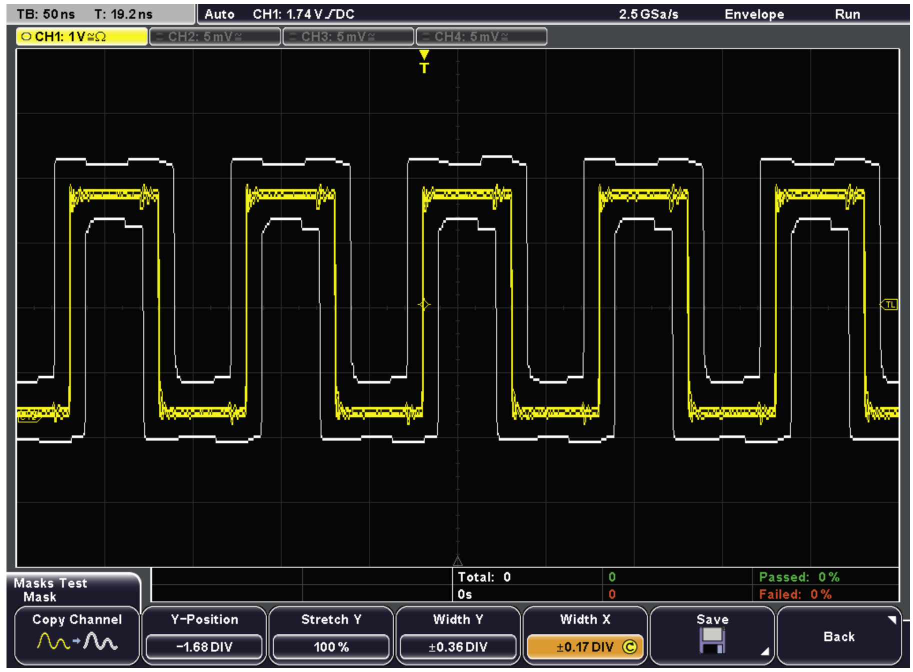


Fig. 5 Mask test function: Just a few keystrokes are needed to define a mask from a reference signal.

1 mV/div. The combination of precise analog frontend and powerful trigger system makes it possible to analyze low-level and high-frequency signals.

The accuracy with which a measurement signal is displayed depends heavily on the oscilloscope's inherent noise. For this reason, the R&S®RTM oscilloscopes have low-noise frontends and A/D converters. As a result, they are able to measure precisely, even at the smallest vertical resolutions. This precision is retained even when additional channels are used. The R&S®RTM oscilloscopes have an excellent channel-to-channel isolation of > 50 dB up to 500 MHz, which ensures that the signal from one channel has the lowest possible influence on signals in other channels.

Deep memory: long sequences at high resolutions

The more details an oscilloscope can show, the higher the probability of detecting signal faults or important events. As a prerequisite, the oscilloscope must have a high time resolution, i.e. a high sampling rate. Many applications require long acquisition times, for instance for analyzing transients or serial protocols. This is where the R&S®RTM oscilloscopes excel, with a memory depth of 20 Msample at a time resolution of up to 200 ps (5 Gsample/s sampling rate). This memory depth makes it possible to acquire up to 4 ms at the maximum sampling rate, so that even rare signal faults can be found (Fig. 4). The acquisition time can be extended by reducing the sampling rate.

Usability: clear benefits for the user

R&S®RTM oscilloscopes make user wishes come true: Just unpack the instrument, switch it on and start measuring. Color-coded controls for vertical settings and the trigger visualize the channel that is currently in focus. This color coding corresponds to the signal display on the screen. As a result, users can easily navigate and work smoothly, even during complex tests and measurements. The logically grouped menus with flat structures add to the usability. Dedicated keys are provided for the most frequently used functions.

Another facet of usability is allowing operators to correct errors easily. Restoring previous settings is no problem with the undo/redo function. Corrections are easy to make if the wrong key is pressed. The R&S®RTM oscilloscopes are fluent in different languages. In addition to English and German, seven other languages are available.

Summary

A bench oscilloscope should be fast and easy to use and deliver reliable results. It should handle time domain, frequency domain, logic and protocol analysis in a single instrument. As a true scope of the art, the R&S®RTM has these strengths.

Ernst Flemming

R&S®RTO oscilloscopes verify compliance of USB 2.0 interfaces

The USB interface is by far the most dominant interface in mobile devices, electronic consumer goods and industrial products. There is a correspondingly high demand for reliable, fast test solutions in development and integration. This demand has now been met: The high-performance R&S®RTO oscilloscopes and new software enable automated USB 2.0 compliance tests.

In demand: automated USB 2.0 test solutions for the lab

In high-speed (HS) mode, the USB 2.0 interface achieves a data transfer rate of 480 Mbit/s. In the PC world where this interface originated, the 5 Gbit/s USB 3.0 standard has become established (super-speed mode). For many mobile applications, PC peripheral devices, equipment and systems used in industry, medicine and A&D environments, the data rate provided by the USB 2.0 interface is fully adequate, which explains its growing popularity in these sectors.

The USB 2.0 standard was published in 2000, and commercially available components based on this standard have now reached technical maturity. Nevertheless, developers are still faced with challenges related to the integration of these components on printed boards and in devices. For example, insufficient isolation with respect to other boards can result in ground loops or crosstalk, which can have a negative impact on the operation of the USB interface. For debugging and stability tests, developers must rely on test solutions that conform to the relevant standards. Accordingly, the organization responsible for USB standardization – the USB Implementers Forum (USB-IF) – has defined a test process with appropriate compliance measurements whose purpose is to ensure the error-free interoperability of a wide variety of devices with USB interfaces. Products bearing the USB logo must pass this compliance test.

Labs need automated USB test solutions in order to prepare for compliance testing performed by certified test labs.

Automated compliance test solution from Rohde & Schwarz

The high measurement accuracy of the R&S®RTO oscilloscopes provides a solid foundation for reliable compliance test results. For testing USB 2.0 interfaces in HS mode, either the R&S®RTO1024 oscilloscope (2 GHz bandwidth) or the R&S®RTO1044 (4 GHz) can be used. R&S®ScopeSuite from Rohde & Schwarz is a powerful software tool that guides the user step-by-step through compliance tests, configures the oscilloscope, automatically executes the measurements and compiles the results in a clear measurement report. The R&S®RTO-K21 software option includes USB 2.0 compliance tests for USB devices, hubs and hosts (Fig. 1). To connect the device under test (DUT) to the oscilloscope, Rohde & Schwarz offers the R&S®RT-ZF1 test fixture set that can be used for USB 2.0 signal quality tests and for legacy tests on USB 1.1 and USB 1.0 interfaces.

Test setup

The test setup varies based on whether the DUT is a USB device, host or hub and on the speed mode selected for compliance testing. The test fixture boards (signal quality board and load board) contain different sections for the individual tests. Fig. 2 shows the test setup for HS device signal quality (SQ) tests. R&S®ScopeSuite runs on a PC that controls the R&S®RTO. The oscilloscope is connected to the DUT via a differential probe and the test fixture board. The USB-IF software (HS electrical test tool) sets the DUT to the necessary test state. This software should be run on a separate PC since it modifies the USB stack during operation.

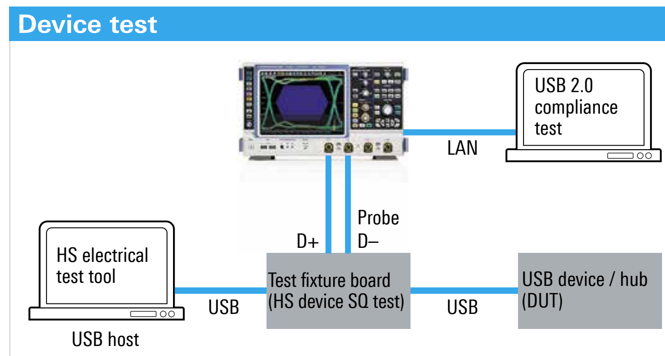


Fig. 2 Test setup for HS device signal quality (SQ) test.

	USB test			Probes	
	Device	Host	Hub	Differential	Single-ended
High-speed tests					
Signal quality (SQ)	•	•	•	1	
Packet parameter	•	•	•	1	
Chirp timing	•	•	•		2 active or passive
Suspend/resume/reset	•	•	•		2 active
J / K, SEO_NAK levels	•	•	•		2 active
Receiver sensitivity (requires 2 generator channels)	•		•	1	
Hub jitter			•	1	
HS repeater			•	1	2 active
Full-speed test					
Full-speed SQ	•	•	•		3 active or passive
Low-speed test					
Low-speed SQ	•	•	•		2 active or passive
Legacy tests					
Inrush current (with current probe)	•		•		
Back voltage	•		•		3 active
Host drop		•			2 active
Host droop		•			2 active or passive

Fig. 1 Compliance tests and required extensions supported by the R&S®RTO-K21 software option.

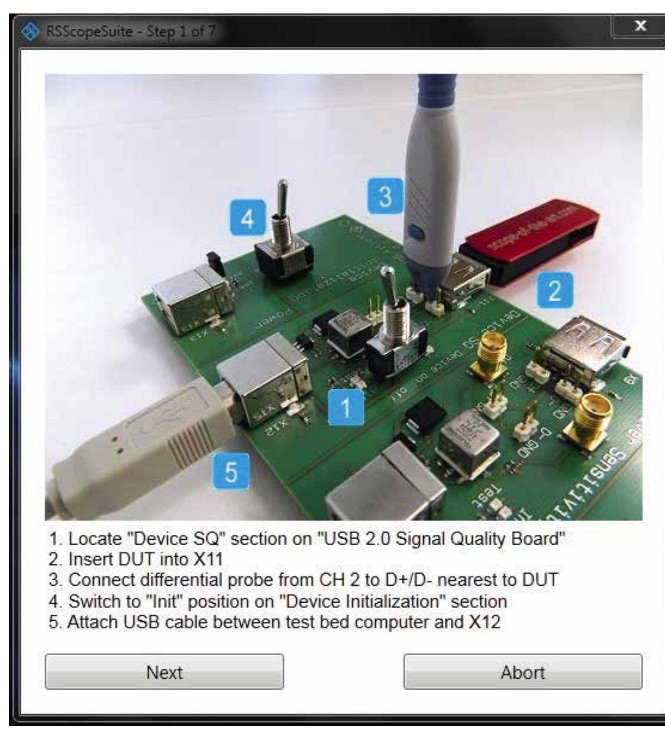


Fig. 3 Picture-based instructions for the test sequence: device HS mode, signal quality test with the R&S®RT-ZF1 test fixture set.

Fast and reliable testing with R&S®ScopeSuite

R&S®ScopeSuite controls the measurement settings and test sequence on the R&S®RTO oscilloscope via the LAN interface. Prior to starting the test, the user can define user data, all settings for the test setup and measurement reports. The limit editor allows the user to individually adjust the standard-specific test limits. Taking the test setup into account, R&S®ScopeSuite guides the user through all of the selected compliance tests. Detailed instructions with pictures make it easy to correctly connect the probes to the test fixture and DUT (Fig. 3).

At the beginning of a typical test, the HS electrical test tool configures the test mode for the DUT. The DUT then transmits specific test signals that are captured by the oscilloscope (Fig. 4) and passed on to the R&S®ScopeSuite software for analysis. R&S®ScopeSuite uses the USB-IF electrical test tool to analyze the results.

Test sequences are very flexible with R&S®ScopeSuite. For example, the user can use the Repeat – Keep Previous function (Fig. 5) to repeat test cases as required for debugging or stability tests. All results are documented in the measurement report. If the user makes an error during the test, such as an improperly connected probe or a test mode that was incorrectly configured with the HS electrical test tool, the result can simply be discarded and the test case repeated using the Repeat – Discard Previous function.

Detailed reports document the test sequences

Detailed documentation of measurement results is not only an essential component of compliance testing, it is also very important for debugging and exchanging data with colleagues and customers. R&S®ScopeSuite offers an extensive range of documentation functions. The user can, for example, add measurement details and screenshots to the pass/fail results. R&S®ScopeSuite also allows new tests to be added to an interrupted test sequence so that all results will be available in a single report (Fig. 6). Reports can also be generated at a later point in time. The available output formats are PDF, RTF and HTML.

Guido Schulze

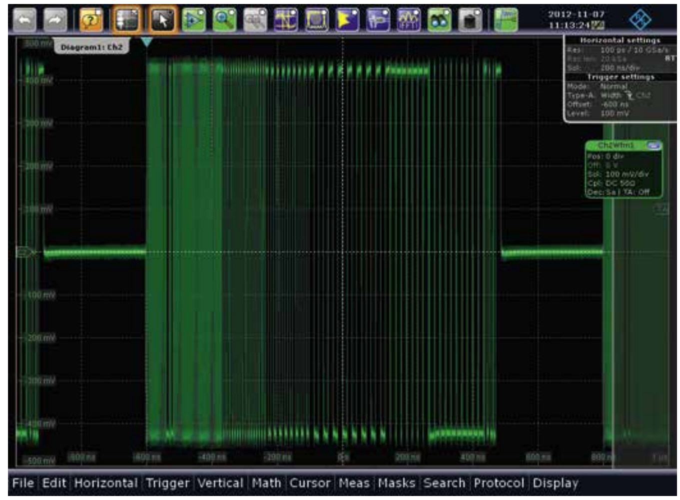


Fig. 4 Waveform during HS signal quality test.

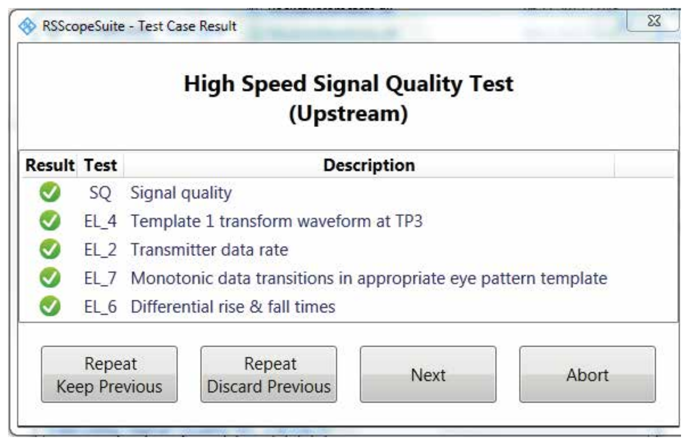
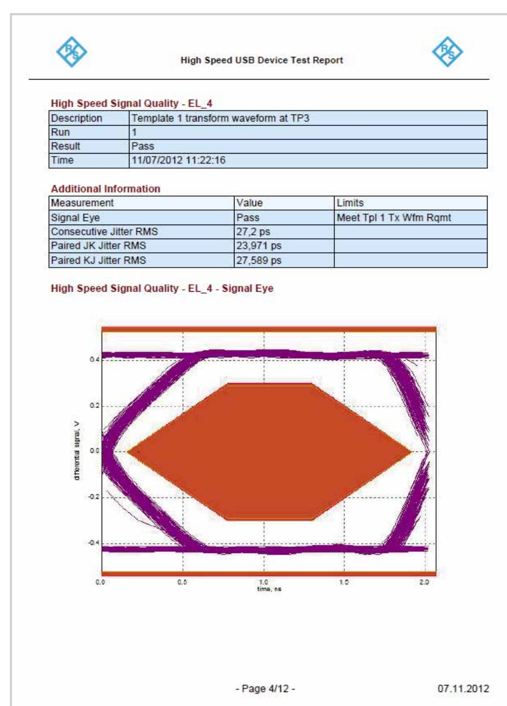


Fig. 5 Flexible control of test sequence.



High Speed USB Device Test Report

High Speed Signal Quality - EL_4

Description	Template 1 transform waveform at TP3
Run	1
Result	Pass
Time	11/07/2012 11:22:16

Additional Information

Measurement	Value	Limits
Signal Eye	Pass	Meet Tpl 1 Tx Wfm Rqmt
Consecutive Jitter RMS	27,2 ps	
Paired JK Jitter RMS	23,971 ps	
Paired KJ Jitter RMS	27,589 ps	

High Speed Signal Quality - EL_4 - Signal Eye

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Fig. 6 Reports can be individually configured: numerical results and diagram of the eye pattern test.

Precision analysis of satellite-based landing system signals

On the ground or in the air, the R&S®EVS300 analyzer is capable of performing VHF data link measurements on ground based augmentation systems (GBAS) as well as measurements on conventional ILS ground systems and VOR systems. The battery-powered R&S®EVS300 ILS/VOR analyzer is an all-round tester for terrestrial navigation and ground based satellite navigation applications.

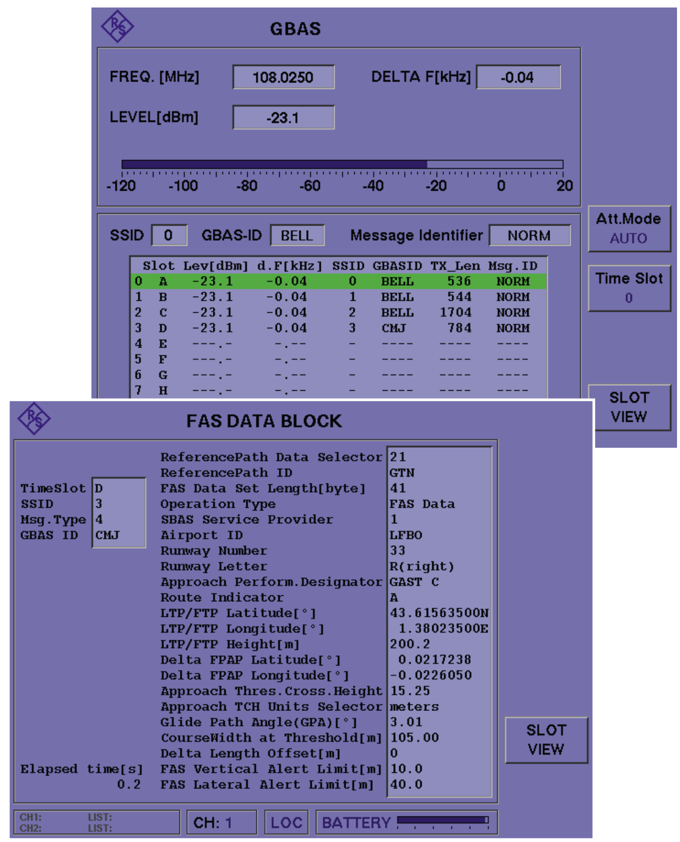
GBAS – the new landing system

For decades, precision approach systems have been based on analog instrument landing systems (ILS). Since the beginning of 2012, DFS, the German air navigation service provider has been operating a ground based augmentation system in Bremen. This is a pilot system approved by the German Aviation Safety Agency and the first system for which category (CAT) I satellite-based precision approach has been permitted. Two to four high-precision GPS reference receivers input correction data into a multimode receiver on board the aircraft via a VHF data link (D8PSK, 108.025 MHz to 117.95 MHz).

Systems must be able to function reliably under all conditions within the limits established by the International Civil Aviation Organization (ICAO). Service providers around the world will be facing new challenges over the next few years as they support and qualify a combination of conventional and new technologies, both on the ground and in the air. Equipped with the R&S®EVS-K9 option, the R&S®EVS300 is ideal for analyzing both analog systems and GBAS systems.

Precision measurements with high reproducibility

The R&S®EVS-K9 option accurately measures the level and frequency of GBAS signals in the VHF range. Ground and flight inspections are crucial for system analysis. The R&S®EVS300 supplies precise data for both of these



Overview of the GBAS timeslots (top) and decoded GBAS data for a landing approach.

R&S®EVS300 ILS/VOR analyzer.

applications. In addition to measuring analog signal parameters, the analyzer determines the data content used to correct GPS-based approaches. This enables the user to verify, for instance, the GBAS ID, the message block identifier and the final approach segment data block (FAS DB), either on the display or via remote control on a PC.

The R&S®EVS300 efficiently verifies the correct functioning of advanced precision approach systems, helping to ensure the highest possible level of aviation safety.

Klaus Theißen

R&S®FSW signal and spectrum analyzer: best in class now up to 50 GHz

The new R&S®FSW 43 and R&S®FSW 50 signal and spectrum analyzers make the outstanding features of the R&S®FSW family available now also in the microwave range up to 50 GHz: excellent RF performance with unmatched phase noise and exceptionally low inherent noise, wide analysis bandwidths and convenient operation via touchscreen. Harmonic mixers extend the frequency range up to 110 GHz and beyond.

Best performance in the microwave range for sophisticated users

Measurements on microwave components and systems used in radar or microwave transmission systems are typical applications for the new R&S®FSW 43 and R&S®FSW 50 signal and spectrum analyzer models (Fig. 1). High demands on the analyzer phase noise are standard, e.g. when developing local oscillators for radar transmitters or communications systems, or when measuring densely occupied spectra with widely differing signal levels or unwanted emissions in neighboring channels in microwave transmission systems. Like the R&S®FSW models available to date, which are among the world's top performers, the new models exhibit values that even many signal generators cannot achieve: –117 dBc (1 Hz) at 40 GHz at 10 kHz offset from the carrier. At 1 GHz they typically achieve –137 dBc (1 Hz), same as the other R&S®FSW models.

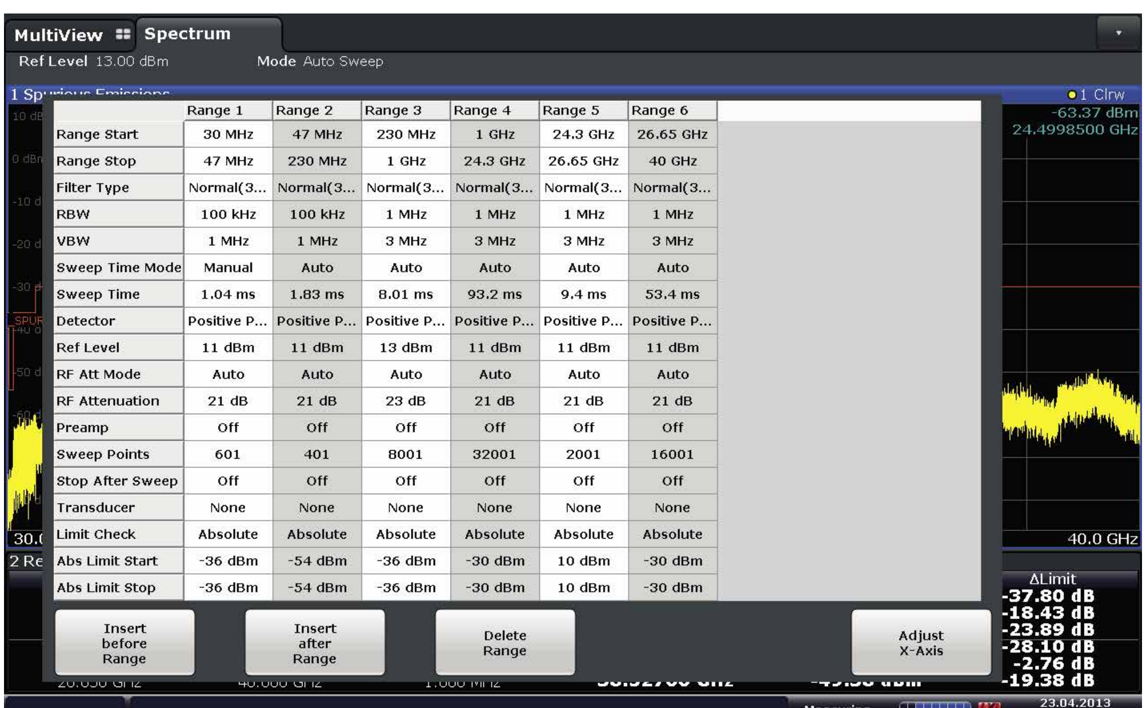
Low inherent noise and high dynamic range are essential for measuring spurious emissions. The new analyzers offer exceptional values. For example, the R&S®FSW 43 measures low signal levels with a good signal-to-noise ratio, i.e. with low measurement uncertainty, with a displayed average noise level (DANL) of typically –144 dBm (1 Hz) at 40 GHz or –164 dBm with activated preamplifier (Fig. 2). Nonetheless, it is usually necessary to perform the measurements with a

Fig. 1 The high-performance R&S®FSW signal and spectrum analyzer was developed to meet demanding customer requirements. Offering low phase noise, wide analysis bandwidth and straightforward and intuitive operation, the analyzer makes measurements fast and easy.

very narrow resolution bandwidth to minimize inherent noise to an extent that leaves sufficient margin relative to the stipulated limit. If conventional analyzers are used, this considerably prolongs the measurement time, especially when a wide frequency range is to be analyzed. With this scenario, the R&S®FSW in FFT sweep mode delivers high measurement repetition rates, even with narrow resolution bandwidths and a wide span. The previously time-consuming spurious emissions measurements are quickly completed [1].

In the spurious emissions measurement window, users enter the settings for the various frequency ranges in a table (Fig. 3).

Fig. 2 Displayed average noise level (DANL) of the R&S®FSW43 signal and spectrum analyzer up to 43 GHz with preamplifier off (yellow) and on (blue).



	Range 1	Range 2	Range 3	Range 4	Range 5	Range 6
Range Start	30 MHz	47 MHz	230 MHz	1 GHz	24.3 GHz	26.65 GHz
Range Stop	47 MHz	230 MHz	1 GHz	24.3 GHz	26.65 GHz	40 GHz
Filter Type	Normal(3...	Normal(3...	Normal(3...	Normal(3...	Normal(3...	Normal(3...
RBW	100 kHz	100 kHz	1 MHz	1 MHz	1 MHz	1 MHz
VBW	1 MHz	1 MHz	3 MHz	3 MHz	3 MHz	3 MHz
Sweep Time Mode	Manual	Auto	Auto	Auto	Auto	Auto
Sweep Time	1.04 ms	1.83 ms	8.01 ms	93.2 ms	9.4 ms	53.4 ms
Detector	Positive P...	Positive P...	Positive P...	Positive P...	Positive P...	Positive P...
Ref Level	11 dBm	11 dBm	13 dBm	11 dBm	11 dBm	11 dBm
RF Att Mode	Auto	Auto	Auto	Auto	Auto	Auto
RF Attenuation	21 dB	21 dB	23 dB	21 dB	21 dB	21 dB
Preamp	Off	Off	Off	Off	Off	Off
Sweep Points	601	401	8001	32001	2001	16001
Stop After Sweep	Off	Off	Off	Off	Off	Off
Transducer	None	None	None	None	None	None
Limit Check	Absolute	Absolute	Absolute	Absolute	Absolute	Absolute
Abs Limit Start	-36 dBm	-54 dBm	-36 dBm	-30 dBm	10 dBm	-30 dBm
Abs Limit Stop	-36 dBm	-54 dBm	-36 dBm	-30 dBm	10 dBm	-30 dBm

Fig. 3 The spurious emissions measurement function carries out measurements using different settings for the various frequency ranges. The desired settings are entered in a clearly structured table

The R&S®FSW processes this table in a single sweep and lists measured spurious signals and their margins relative to the limit. Spurious measurements can be performed easily using different bandwidths and optimized level settings for the various frequency ranges (Fig. 4).

Reliable analysis of signals up to 110 GHz and beyond

The frequency ranges above 50 GHz, respectively 67 GHz, have become increasingly important over the past few years. The number of commercial applications, e.g. at 77 GHz (automotive radar) and 85 GHz (microwave links), is on the rise. Plus, an increasing number of standards require spurious emissions measurements up to 110 GHz and beyond.

Signals that are beyond the upper frequency limit of the R&S®FSW26, R&S®FSW43 and R&S®FSW50 models are usually analyzed with external harmonic mixers. The mixers can be operated on these models using the R&S®FSW-B21 option, which provides the ports for the LO and IF signals for the external mixer. Rohde&Schwarz also supplies matching harmonic mixers, i.e. the R&S®FS-Z60, R&S®FS-Z75, R&S®FS-Z90 and R&S®FS-Z110, which seamlessly cover frequencies from 40 GHz to 110 GHz. The frequency response, respectively conversion loss, for the individual mixers are loaded into the R&S®FSW from a USB stick with just a few keystrokes. In addition to Rohde&Schwarz mixers, the R&S®FSW can also be used with other types of mixers. It supports three-port mixers (LO input and IF output on separate ports) as well as two-port mixers (LO input and IF output on the same port). The diplexer required for operation is integrated in the R&S®FSW-B21 option. The analyzer supports harmonic numbers higher than 100, making it possible to analyze signals up to 1.1 THz.

A few points must be observed when employing harmonic mixers. They downconvert the signal to be analyzed to the IF by mixing it with harmonics from the LO signal. The harmonics are generated in the mixer itself, meaning that there are always several LO frequencies and that the signal of interest is mixed not only with the desired harmonic, but with all others as well. By displaying a large frequency range (large span), the mixing products, which are at the wrong frequencies, become visible (Fig. 5). If the frequency of the signal to be analyzed is unknown, it must be determined which of the possibly numerous signals is the signal of interest and which are multiple response signals, i.e. signals produced through mixing with an unwanted harmonic. This task is handled using the signal identification (signal ID) function, which marks multiple response signals and suppresses them if desired (Fig. 6). For details, refer to [2].

Fig. 4 Result of a measurement using the spurious emissions function.

A particularly important requirement is that the LO frequency be as high as possible. This reduces the number of multiple response signals displayed as well as the phase noise. The R&S®FSW has a very high LO frequency range at 7.65 GHz to 17.45 GHz. This means that a lower harmonic will suffice to analyze a given frequency range (75 GHz to 110 GHz: e.g. n = 8 instead of n = 16).

Harmonic mixers have no input filter, so that reception of the image frequency at a distance of twice the intermediate frequency is not suppressed. This means that mostly pairs of signals are displayed. The signal ID function is helpful for stationary and not very wideband signals. Nonstationary, e.g. pulsed or wideband modulated, signals, such as those

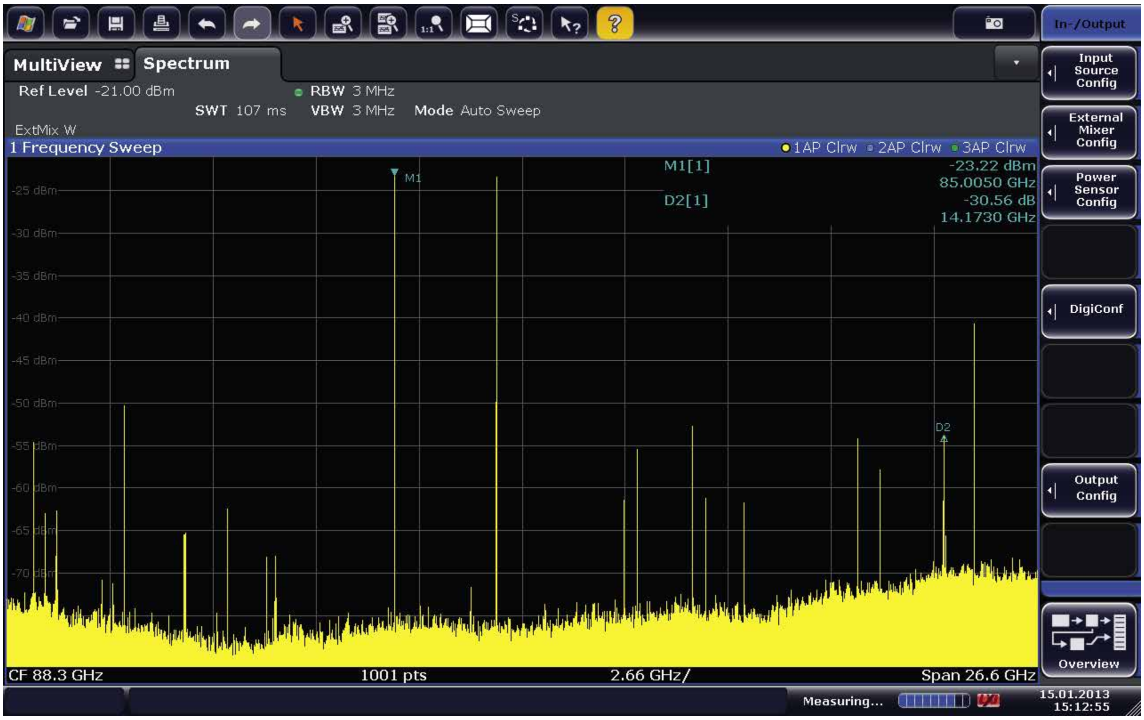


Fig. 5 Result of a measurement using a harmonic mixer to upconvert a 14 GHz signal to an 85 GHz signal. The display shows numerous multiple response signals in addition to the signal of interest.

Fig. 6 The built-in signal identification function detects and suppresses multiple response signals so that only the signal of interest is displayed.

frequently used in the millimeter-wave range are more difficult to handle because of the large available frequency range, for example in FMWC radar systems for automotive applications or in microwave systems in the 80 GHz band. For these and other types of signals for which signal identification fails, high intermediate frequency is especially important. Without applying signal ID routines, a large unambiguous frequency range can be achieved in which neither multiple response nor image frequency signals are displayed. With an IF of 1.3 GHz, the R&S®FSW outperforms most of the conventional analyzers (which have significantly lower IF, often in the order of just a few hundred megahertz). The R&S®FSW therefore provides unambiguous spectral analysis of signals with bandwidths of up to 2.6 GHz.

R&S®FSW-B10 external generator control

The R&S®FSW-B10 external generator control transforms the R&S®FSW signal and spectrum analyzer into a scalar network analyzer. It controls signal generators such as the R&S®SMB, R&S®SMF or instruments from other manufacturers in such a way that they work as tracking generators. Transmission measurements can be conducted without any extra equipment or accessories. An SWR bridge or a directional coupler is required for reflection measurements (scalar). To compensate for the frequency response of feeder lines, the R&S®FSW offers normalization functions for transmission and reflection measurements. Using external generators makes it easy to carry out measurements also on frequency-converting DUTs. The R&S®FSW can be configured to measure even multipliers or dividers.

Group delay measurements using signal analyzer functionality

The R&S®FSW uses a multicarrier signal with equally spaced carriers to perform group delay measurements, traditionally a task for network analyzers. The R&S®FSW measures the carrier phases before and after the DUT. Based on the differences, it calculates the gain or insertion loss and the group delay. This function is especially beneficial if a network analyzer would have to be included in a test system for the sole purpose of measuring group delay. With the R&S®FSW signal and spectrum analyzer providing this functionality, test systems become less complex and require fewer cables (see article on page 43).

Summary

The R&S®FSW43 and R&S®FSW50 with the R&S®FSW-B21 option now make the outstanding RF characteristics, large analysis bandwidths and innovative analysis functions of the R&S®FSW signal and spectrum analyzer family available also for applications in the microwave range.

Herbert Schmitt

References

[1] Rohde&Schwarz Application Note 1EF80 ("Speed Considerations for Spurious Level Measurements with Spectrum Analyzers").
[2] Rohde&Schwarz Application Notes 1EF43 ("Frequency Range Extension of Spectrum Analyzers with Harmonic Mixers") and 1EF75 ("Using Harmonic External Mixers To Extend the Frequency Range").

All application notes can be downloaded from the Internet.

Group delay measurements: precise, fast, wideband

Phase distortions in a transmission system are determined using group delay measurements. These distortions must be as low as possible. A comprehensive measuring tool for performing this important task in the development and testing of complex communications systems, e.g. in satellite systems, is now available: the R&S®FSW signal and spectrum analyzer with the R&S®FSW-K17 option.

Multicarrier method and its impressive characteristics

Detecting amplitude and phase distortions is crucial to characterizing the quality of a transmission path. The reason: Signal deformations resulting from these distortions are directly linked to a deterioration of the signal-to-noise ratio (SNR) and an increased bit error rate at the receiver end.

Vector network analyzers are normally used to determine the group delay as a measure of phase distortion. The R&S®FSW-K17 multicarrier group delay measurement option now makes it possible, for the first time, to carry out this important measurement with the R&S®FSW signal and spectrum analyzer (Fig. 1). The new option uses a multicarrier method and offers the following benefits:

- High-precision group delay measurements with measurement uncertainty of just ±300 ps
- Extremely fast test runs
- Relative and absolute group delay measurements
- Very wideband measurements (up to 160 MHz)
- Simple measuring procedure (also remote controlled) and intuitive use

Besides evaluating the group delay, the option can also display the amplitude distortion. R&S®FSW-K17 allows the complete analysis of the existing linear signal distortions.

Quick and easy results

Fig. 2 shows the test setup for determining the group delay: A signal generator, e.g. from the R&S®SMx family, generates a multicarrier signal in the frequency range that is being examined. The use of wideband multicarrier signals makes it possible to quickly determine the group delay over the entire frequency range. The multicarrier signal is defined by the center frequency, the carrier spacing and the span. These parameters are entered in the R&S®FSW-K17 configuration dialog. This information is all the option needs to be able to automatically determine and set all other parameters, such as a favorable measuring time that is a meaningful compromise between high precision and fast measurement.

Calibration without the device under test (DUT) is carried out first, in order to determine the reference phases and amplitudes of the individual carriers. The calibration data can be easily and conveniently saved in a file and retrieved again at any time. This saves time during subsequent measurements, and makes it possible to quickly switch between different measurement scenarios.

In order to determine the group delay, the multicarrier signal is measured at the output of the DUT. The R&S®FSW-K17 option can determine the group delay over the frequency range of the carriers from the phase difference between

Fig. 1 The R&S®FSW26 signal and spectrum analyzer with the R&S®FSW-K17 multicarrier group delay measurement option. The combination of low phase noise, large analysis bandwidth and state-of-the-art user interface makes the R&S®FSW a unique measuring instrument in its class. Equipped with the R&S®FSW-B160 analysis bandwidth extension, group delay measurements up to a bandwidth of 160 MHz can be performed.

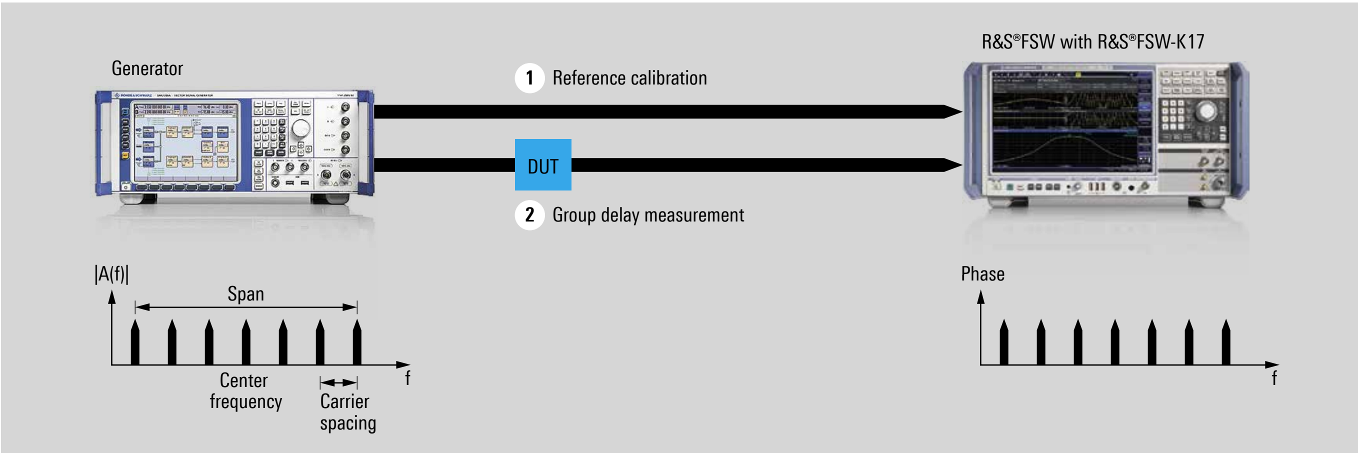


Fig. 2 Test setup for determining the group delay: A signal generator generates a multicarrier signal, which is defined by the center frequency, the carrier spacing and the span. During calibration (❶), the signal is fed directly to R&S®FSW-K17 without a DUT. The option measures the reference phase of the carriers. Then the group delay of the DUT can be measured (❷).

the reference measurement and the current measurement. And it does this with high precision: For example, at a center frequency between 100 MHz and 6 GHz, the measurement uncertainty for the group delay for a signal with a carrier spacing of 100 kHz and 601 carriers (60 MHz bandwidth) is just ±300 ps.

Relative group delay measurements ignore the constant delay caused by the DUT. This delay affects all frequency components in the same way and does not lead to a change in the signal shape. However, the absolute group delay is significant in certain cases, e.g. if the signal delays of two transmission channels are to be adjusted. R&S®FSW-K17 can also be used for such measurements. To create an absolute phase reference, the external trigger input is activated on the R&S®FSW and connected to the generator. By averaging the group delay over consecutive measurements, a measurement uncertainty of just ±300 ps can be achieved here as well.

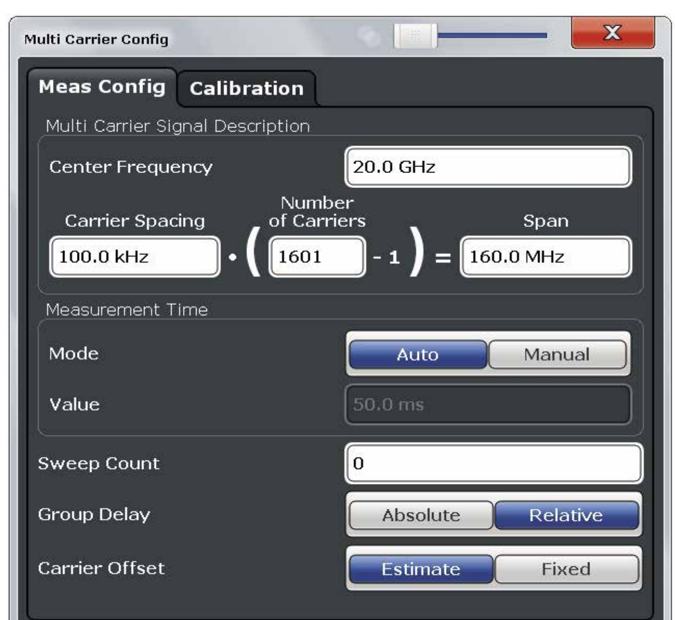
Intuitive operation via touchscreen

All of the main parameters to be set are quickly accessible in a single configuration dialog provided by the new option (Fig. 3). Furthermore, users can conveniently configure the screen layout to meet their needs. The various diagrams for the group delay measurement option on the large touchscreen of the R&S®FSW allow an intuitive workflow and clearly display the results (Fig. 4).

Versatile use in satellite measurement systems

The complex transmission equipment, the wideband design and efficient channel utilization in satellite systems require a large number of quality-determining measurements. Measuring the group delay for analyzing phase distortions is especially important in this case. Due to its versatility, the R&S®FSW-K17 option can be used for a wide range of applications in this environment, e.g. in the manufacture of satellite transponders or entire ground stations. Distortion-free signal transmission is only possible with a flat amplitude characteristic and a linear phase characteristic. In order for the systems to fulfill these conditions as best as possible, measurements are performed using R&S®FSW-K17 and the compensation circuits are dimensioned accordingly on the basis

Fig. 3 The R&S®FSW-K17 configuration dialog provides a complete overview of all key parameters for group delay measurements. After configuring the center frequency, carrier spacing and span, the user can immediately start the measurement.



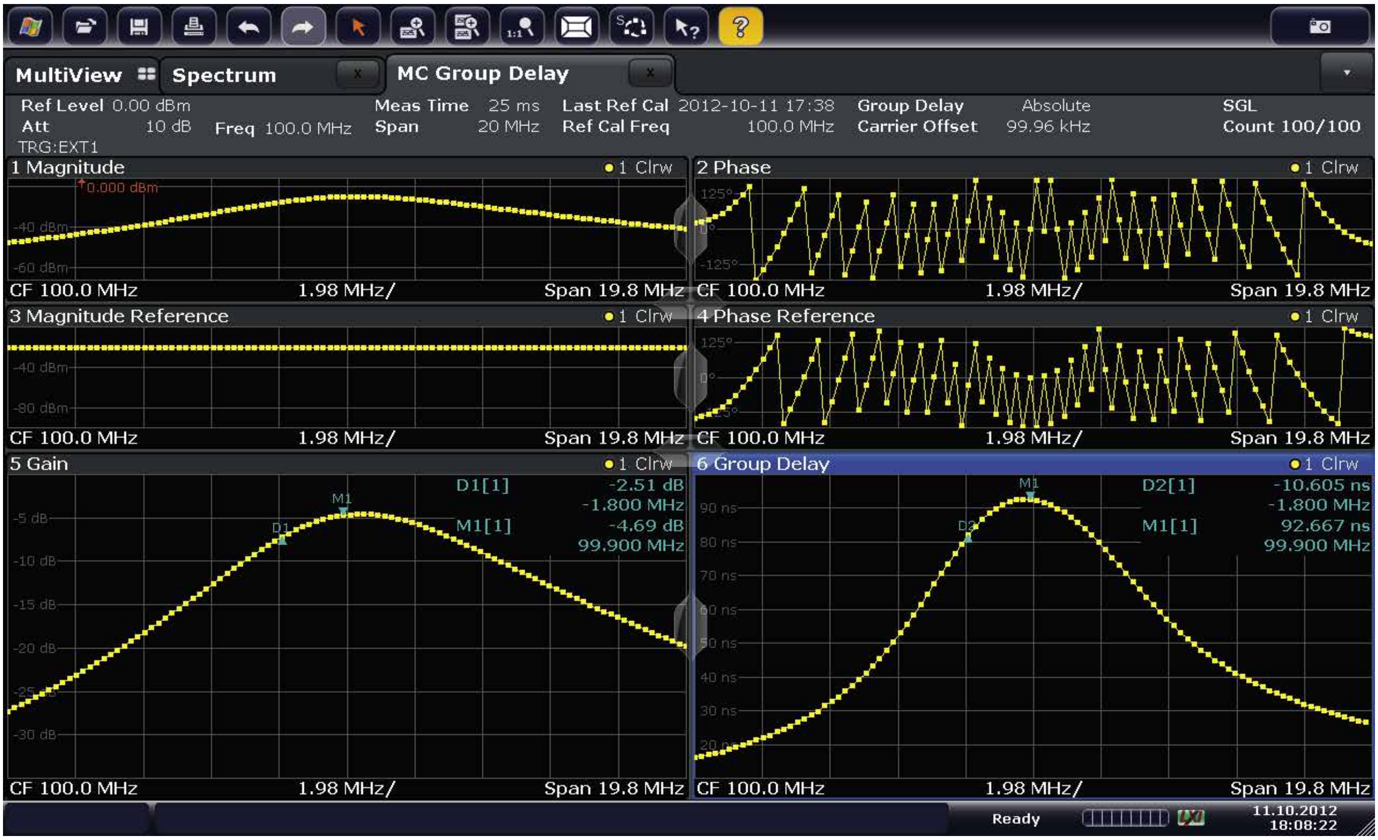


Fig. 4 Nice and clear: Example of DUT measurement with bandpass characteristic. The user can see the amplitude and the phase of the applied multi-carrier signal (windows 1 and 2). Apart from this signal, which is present at the DUT output, the reference signals from the calibration measurement can be displayed at any time (windows 3 and 4). By comparing the reference signal and the measured signal, R&S®FSW-K17 determines the transfer function as a measure of the amplitude distortions (window 5) and the group delay as a measure of the phase distortions (window 6).

of the results. The same method is used in numerous other applications, such as in the measurement of modules for radar applications.

To ensure that the transmission equipment of a satellite can be used without decreased performance, payload tests must be carried out before the satellite is put into operation. In many cases, the original signal has to be measured in a different frequency band because of the frequency-converting transmission elements. R&S®FSW-K17 can also be used for such measurements. The option is exceptionally easy to configure: After calibrating at the original frequency, only one parameter has to be changed for the measurement – the center frequency. The R&S®FSW-K17 option automatically creates the relationship between the reference carriers of the multicarrier signal and the frequency-converted measurement signal.

The measuring speed plays an important part in payload tests. Here too, the R&S®FSW-K17 option is extremely useful: For a wideband, relative group delay analysis over a span of 160 MHz with a carrier spacing of 200 kHz (800 carriers), the option only needs 350 ms, and a mere 80 ms with a carrier spacing of 1 MHz (160 carriers). Because the phase relation between the reference calibration and the measurement is the only thing that is important for analysis, it is possible to work with crest factor optimization on the generator. A multicarrier signal with a low crest factor improves the SNR for the group delay analysis and protects the DUT.

Summary

The R&S®FSW-K17 multicarrier group delay measurement option provides a comprehensive range of measurements of the distortion characteristics of transmission systems. The group delay as a measure of phase distortion can be measured both relatively and absolutely. Because of the extremely easy operation, the fast measuring procedure and the high degree of accuracy, the option can make its mark in practice. And it expands the wide-ranging measurement capabilities of the R&S®FSW high-end signal and spectrum analyzer. Together with signal generators such as the R&S®SMU and the R&S®SMBV, Rohde&Schwarz offers a complete measuring package for analyzing group delays.

Josef Zwack

Easy and accurate: analyzing measurement uncertainty using verification kits

How accurate are measurement results after a network analyzer has been calibrated? This question is not easy to answer because many factors contribute to measurement uncertainty. Rohde & Schwarz software and verification kits provide fast and reliable answers.

How good is the calibration?

Measurement uncertainty after calibration essentially depends on the measurement accuracy of the network analyzer itself. However, the calibration kit and test cables used also have considerable influence. Users might be tempted to reconnect the same calibration standards that were just used to get information about the quality of the calibration and, consequently, the measurement accuracy. But that is not a viable approach. Not even the standards from another calibration kit can provide information about the actual measurement uncertainty. At most, they indicate if the calibration is useful. The only way to get precise information about the absolute measurement uncertainty after calibration is to analyze the measurement results obtained with verification standards, which are DUTs precisely characterized by the manufacturer.

Fig. 1 The Rohde & Schwarz T-checker makes it easy to verify the quality of a calibration.

Verifying the effective system data with a symmetrical T-piece

The simplest method of verifying the quality of a calibration is to perform the measurement with a symmetrical T-piece, for example the Rohde & Schwarz T-checker (Fig. 1). Its S-parameters have a defined relationship to each other and are measured after the calibration using the T-checker. The evaluation shows the deviation from theoretical results and supplies information about the quality of the calibration. The T-checker is recommended for use in production or in laboratory applications with average precision requirements, because only this one standard needs to be connected. That means information about the quality of the calibration will be delivered quickly.

When maximum accuracy is required: Rohde & Schwarz verification kits

Verification kits, which include multiple standards, deliver the most accurate results for the measurement uncertainty. Verification kits from Rohde & Schwarz contain a male and a female offset short, a male and a female mismatch, an attenuator and a stepped through. The air line, which is difficult to handle, was purposely left out. All of these calibration standards differ substantially from the conventional standards – open, short and match – because they have a different impedance, meaning they can be used as verification standards. They are measured in steps of 250 MHz and specified together with their measurement uncertainty data at the Rohde & Schwarz calibration lab, which is certified by the DAkks (Germany's national accreditation body).

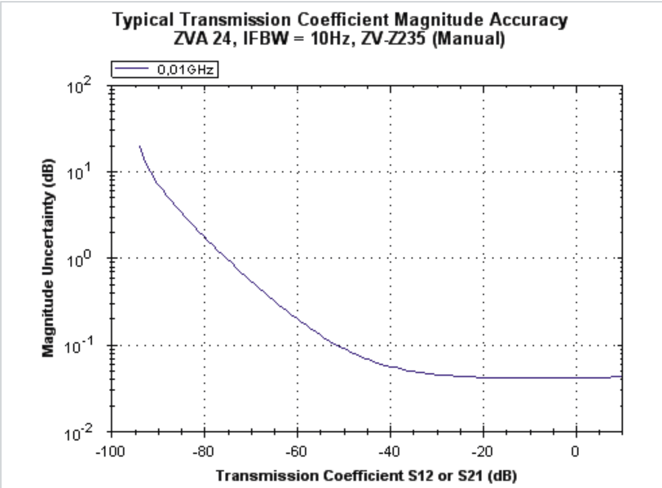


Fig. 2 The VNAMUC software calculates the theoretical measurement uncertainty.

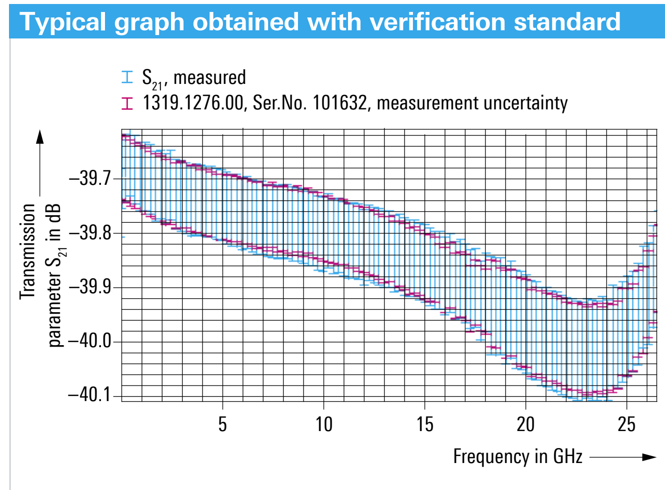


Fig. 3 Graphic display of results obtained with verification standards for a 40 dB attenuator.

Determining the measurement uncertainty

The Rohde & Schwarz vector network analyzer measurement uncertainty calculator software (VNAMUC, Fig. 2) calculates the theoretical measurement uncertainty (without cables). The user needs to enter the type, options and settings of the Rohde & Schwarz analyzer and the calibration kit used; the software will then deliver the results and display them graphically.

In order to get precise information about the actual measurement uncertainty, the measurements must be carried out using verification standards. The results are compared with the results measured and documented at the Rohde & Schwarz calibration lab and graphically analyzed. As shown in Fig. 3, results should be within the tolerance band for the specific standard.

Presently, the Rohde & Schwarz product range includes two verification kits: the R&S®ZV-Z435 with 3.5 mm connectors for frequencies up to 26.5 GHz (Fig. 4) and the R&S®ZV-Z470 for N connectors and frequencies up to 18 GHz. Additional kits for 2.92 mm, 2.4 mm and 1.85 mm connectors will be available soon. Used together with the VNAMUC measurement uncertainty software, they are indispensable for precisely determining the measurement uncertainty and provide clear information about the accuracy of measurement results after calibration.

Andreas Henkel

Fig. 4 Standards included in the R&S®ZV-Z435 verification kit (from left): 2 × offset short, 2 × mismatch, one attenuator and one stepped through.

R&S®ZNB: convenient network analysis with up to 32 ports

Today's smartphones and tablet PCs support multiple frequency bands along with functionality such as WLAN, Bluetooth® and GPS. The frontend modules delivering this functionality have numerous RF ports, and the parameters of these modules need to be fully characterized. Modules with up to eight RF ports can be characterized using the eight-port R&S®ZVT network analyzer. Scenarios involving more ports call for other solutions (the latest generation of components can have more than 20 ports). Rohde&Schwarz offers appropriate solutions in conjunction with the R&S®ZNB network analyzer.

More ports using a switch matrix

What is needed is an easy-to-use system that is able to characterize many test ports: In conjunction with a switch matrix, the R&S®ZNB network analyzer fulfills both of these requirements (Fig. 1). Using switch matrices to increase the number of test ports is not a new thing. What is new here is that the network analyzer's firmware is able to directly control the switch matrix and allows direct selection of the test parameters. Using the R&S®ZNB with the switch matrices currently offered by Rohde&Schwarz, the number of test ports can be increased to 32 (Fig. 2). Nevertheless, the instrument is just as quick and easy to operate as a base unit with two or four test ports. For example, a two-port R&S®ZNB used with an R&S®ZV-Z81 model .09 switch matrix with two inputs and nine outputs (Fig. 3) turns into a nine-port network analyzer. A four-port R&S®ZNB combined with two switch matrices, each with two inputs and 16 outputs, transforms into a 32-port analyzer. Using the 32-port configuration, it is theoretically

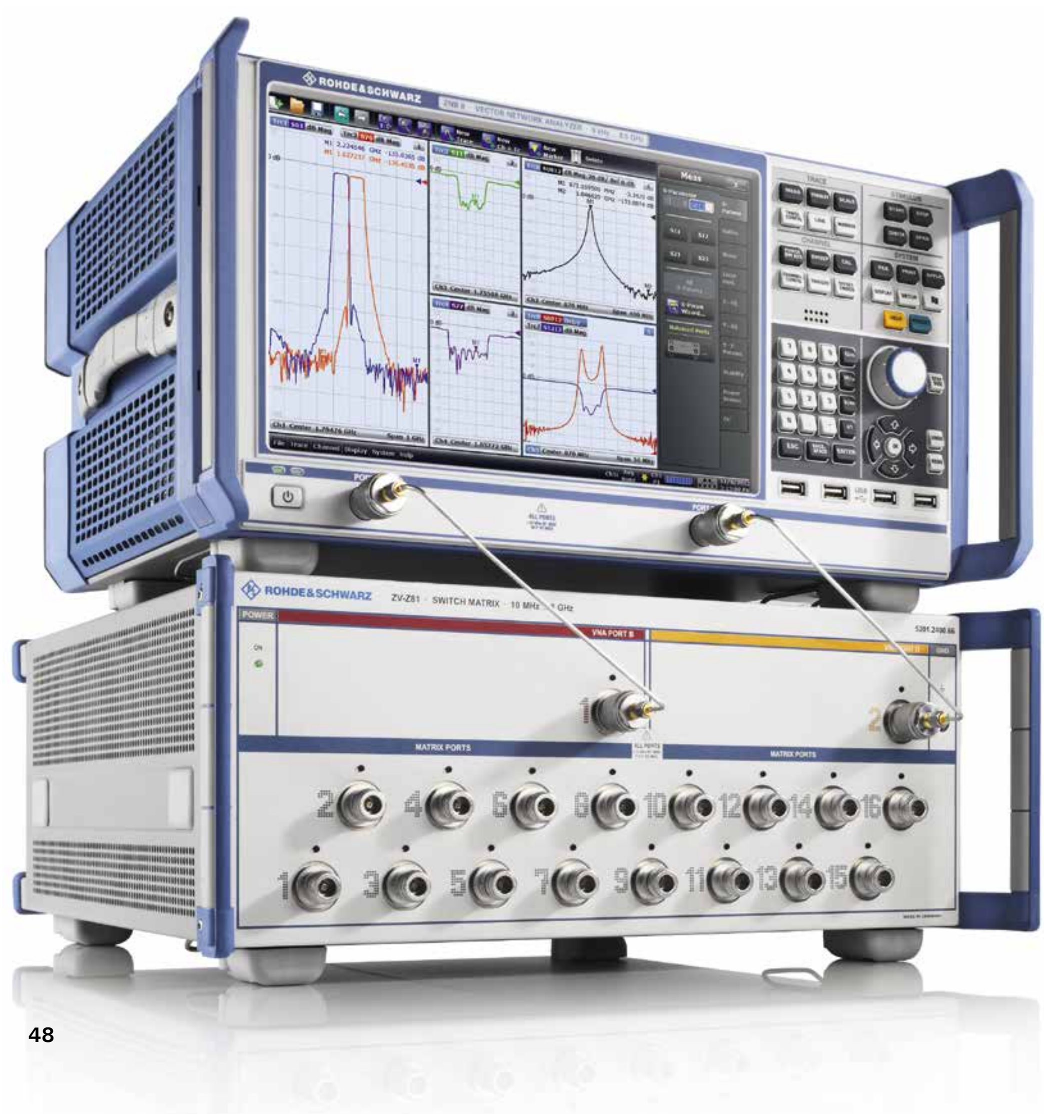


Fig. 1 Multiport network analysis with the R&S®ZNB. Using an R&S®ZV-Z81 model .66 switch matrix provides a total of 16 test ports.

Switching matrix	Inputs	Outputs	Switch type
R&S®ZV-Z81 model .05	2	5	full crossbar / electronic
R&S®ZV-Z81 model .09	2	9	full crossbar / electronic
R&S®ZV-Z81 model .66	2	16	full crossbar / electromechanical
R&S®ZV-Z82 model .10	4	10	full crossbar */ electronic

Fig. 2 Currently available switch matrices from Rohde&Schwarz.
* Requires a four-port R&S®ZNB.

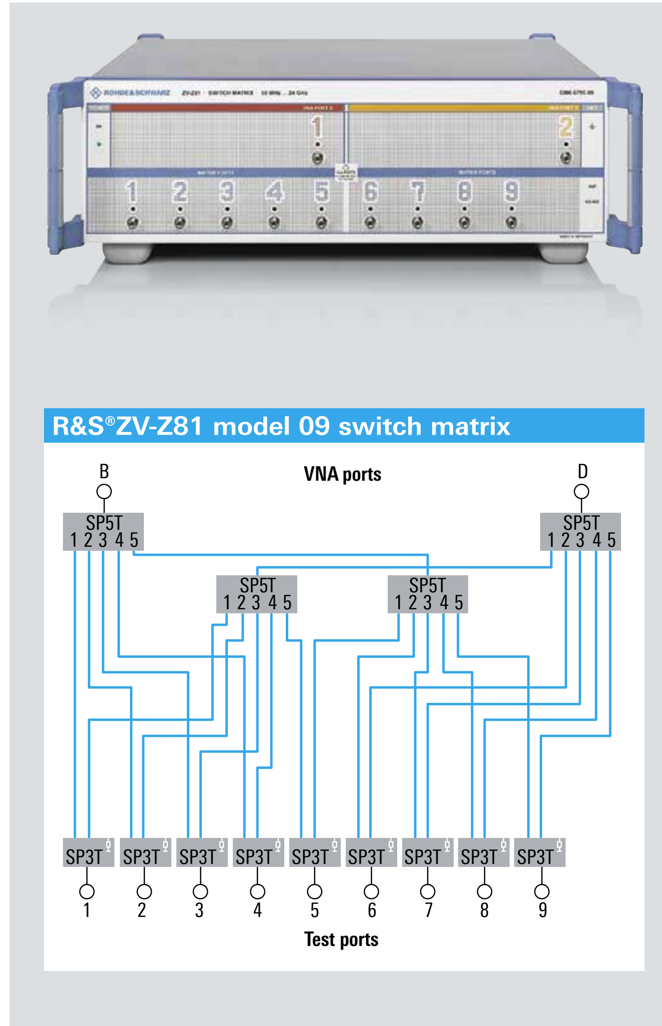


Fig. 3 R&S®ZV-Z81 model .09 switch matrix with two inputs and nine outputs.

possible to characterize all 1024 (32 × 32) S-parameters of a 32-port DUT.

Due to the relatively limited power handling capacity of the electronic switches in the matrices, measurements involving high signal levels (e.g. on amplifiers) were previously subject to significant restrictions. Now there is a solution to this problem: If a switch matrix with two inputs is connected to a four-port R&S®ZNB, the analyzer's remaining two ports with their high output power of +15 dBm and high power handling capacity of up to +27 dBm are available to characterize the active components of a DUT, e.g. for measuring compression (Fig. 4). This configuration avoids the conventional approach involving slow mechanical switches and provides a way of increasing production throughput because the high measurement speed of the R&S®ZNB and the short switching times of the electronic switches in the matrices combine to reduce overall test time.

Effortless configuration like never before – results in only three steps

In contrast to commercial solutions available until now, no additional software or macros are required to configure and control the test setup and measurements. The R&S®ZNB controls the switch matrix via a LAN or USB connection. Once connected to the R&S®ZNB, the switch matrix type and the assignment of the port numbers are detected automatically, and measurements can be started immediately. The large 30 cm (12.1") touchscreen combines with the analyzer's intuitive graphical user interface (GUI) to provide straightforward display and easy evaluation of results – even with a large number of traces.

With the two-port and four-port R&S®ZNB network analyzers, users can easily select and display S-parameters (balanced and unbalanced) as well as wave quantities and their ratios directly on the GUI. Here, the analyzers' operating concept

Fig. 4 11-port network analysis system, with two ports on the R&S®ZNB as additional ports.

– designed with a consistent focus on multiport applications – proves effective once more. Users can enter the indices for the S-parameters and power levels on the numerical keypad, allowing each parameter to be selected with a maximum of three steps, even when testing DUTs with many ports (Fig. 5).

Fig. 5 S-parameter selection by direct index entry.

Calibration – simple and fast

When using switch matrices, it is imperative to calibrate the test setup prior to carrying out measurements in order to compensate for effects such as insertion loss introduced by the matrix switches. The R&S®ZNB supports manual multiport calibration techniques that require a minimal number of through connections. Nevertheless, it is advisable to use automatic calibration units in order to minimize the number of screw connections and avoid long calibration times as well as premature wear of the ports and calibration standards.

Rohde&Schwarz offers calibration units with two, four, six or eight ports (Fig. 7). By reconnecting the calibration unit sequentially to the test ports, all ports of the multiport system can be calibrated. An electronic wizard guides the user step by step through the calibration process (Fig. 6).

Fig. 6 12-port calibration using a four-port calibration unit.

Summary

The R&S®ZNB, in conjunction with a switch matrix, delivers a dependable network analysis system for characterizing balanced and unbalanced modules and components with up to 32 ports. Operation and result evaluation are simple and intuitive even with a large number of ports and are handled directly on the analyzer's GUI. Using automatic calibration units with up to eight ports, even systems with many ports are quick and easy to calibrate.

Thilo Bednorz

Fig. 7 Calibration units from Rohde&Schwarz. Right: R&S®ZV-Z51, bottom: R&S®ZV-Z58.

Broadband amplifiers open up applications in the microwave range

The new R&S®BBA150 broadband amplifier starts with a base frequency range of 800 MHz to 3 GHz. In combination with the well-established R&S®BBA100 broadband amplifier family, the R&S®BBA150 permits the implementation of amplifier systems with multiple frequency ranges from 9 kHz to 3 GHz and numerous power classes.

New applications up to 3 GHz

The development focus of the new R&S®BBA150 was to design a broadband amplifier that is optimized for high frequencies, compact and lightweight (Fig. 1). The R&S®BBA150 opens up new applications, such as EMS measurements up to 3 GHz in line with different standards. The amplifier is also suitable for industrial applications, such as component production and quality assurance, as well as for research, physical engineering and communications engineering. The R&S®BBA150 is currently available with an instantaneous frequency range from 800 MHz to 3 GHz and output powers of 30 W, 60 W, 110 W and 200 W.

Most advanced RF design on the market

The R&S®BBA150 features the most advanced RF design currently available on the market thanks to decades of experience in developing amplifiers, the use of state-of-the-art design and simulation programs as well as of advanced power semiconductors. The compact, 4 HU R&S®BBA150 achieves output powers of up to 200 W and weighs only 24 kg (200 W version) thanks to its lightweight construction.

Efficient, rugged, series-produced

The ruggedness of the R&S®BBA150 ensures uninterrupted operation, an important economic factor. The R&S®BBA150 is series-produced in line with high quality standards at the Teisnach plant, one of Europe's most advanced plants. The amplifier's lean firmware with effective monitoring and protection mechanisms provides operational safety. Generous dimensioning of the RF amplifier stages ensures sufficient margin and compliance with warranted data sheet parameters without pushing the amplifiers to their limits. The R&S®BBA150 broadband amplifiers' high tolerance to mismatch (e.g. short-circuiting at the RF end or an open RF output) helps ensure high reliability.

Fig. 1 The R&S®BBA150 power amplifier is available with output powers of 30 W, 60 W, 110 W and 200 W.

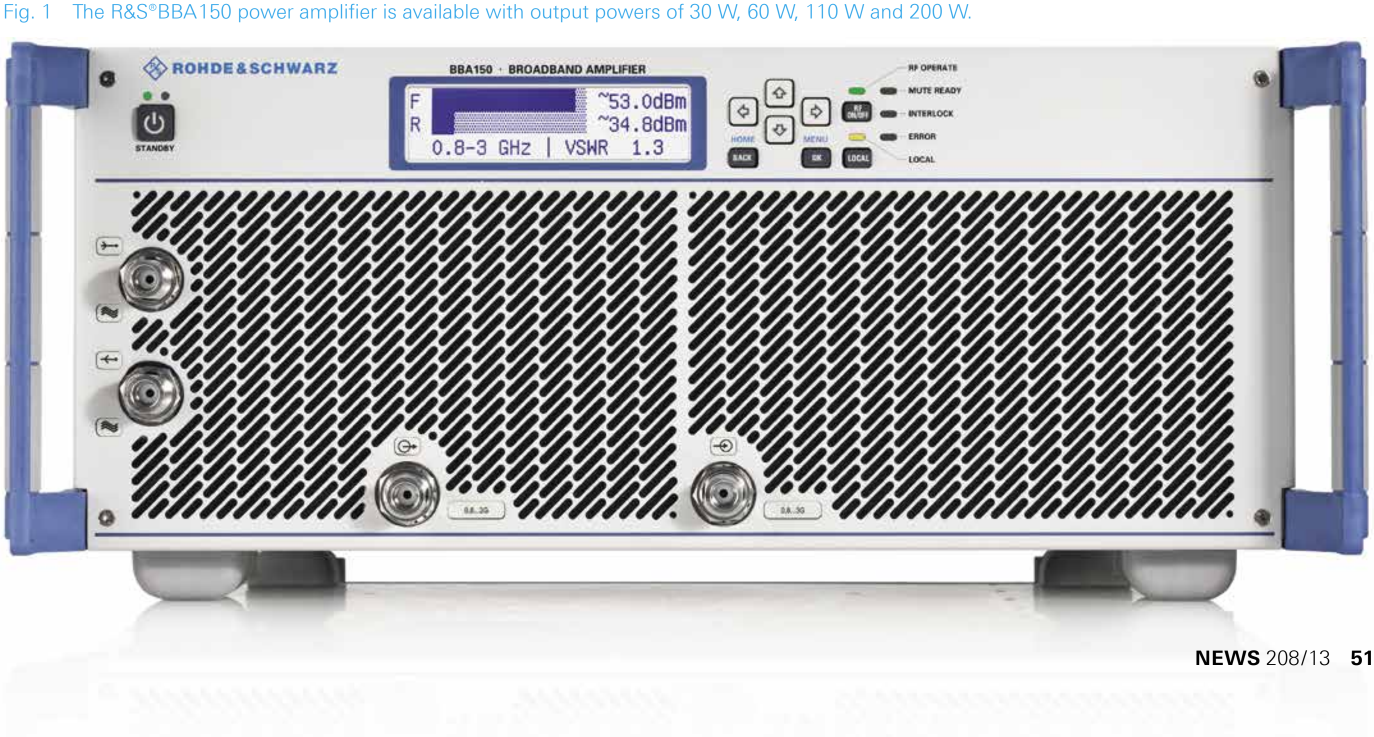


Fig. 2 R&S®BBA150 operating panel on a web browser.

Fig. 3 Overall amplifier system consisting of the R&S®BBA150 and R&S®BBA100.

Versatile operation

The amplifier can be operated either using the display and pushbuttons on the front panel or via a common web browser user interface (Fig. 2). The R&S®EMC32 EMC measurement software, which fully supports the R&S®BBA150, is ideal for automated test sequences. Remote control via Ethernet is also possible; a large number of remote control commands in line with the SCPI nomenclature are available.

Two families – one amplifier system

The R&S®BBA150 can, of course, be used as a standalone product. However, its strengths are also brought to bear in combination with the R&S®BBA100 broadband amplifiers: Both amplifier families can be seamlessly integrated into a combined amplifier system for the frequency range from 9 kHz to 3 GHz (Fig. 3). In such systems, the R&S®BBA150 benefits from the R&S®BBA100 RF switching options, such as the RF input switch, RF output switches and RF sample port switches (Fig. 4).

When so desired, the R&S®BBA100 as the master controls the R&S®BBA150 and integrates it like an additional RF path. The overall system functions as a multiband amplifier that optionally has a common RF input, common sample ports and RF switches. It is remotely controlled via a single interface.

Excellent service and quick maintenance

The modular structure of the R&S®BBA150 allows problems to be remedied quickly and keeps downtime to a minimum. All modules can usually be replaced at the local Rohde&Schwarz office or the nearest service center. Spare parts are available worldwide. If the problem cannot be eliminated by replacing modules, the instrument will be repaired at the plant within a maximum of ten working days (plus shipping time).

And that is not all: The extended warranty offers high availability of the R&S®BBA150 broadband amplifier at low, calculable operating costs. The terms of one to four years – over and above the three-year warranty – provide long-term investment protection.

Amplifier system combining the R&S®BBA100 and the R&S®BBA150

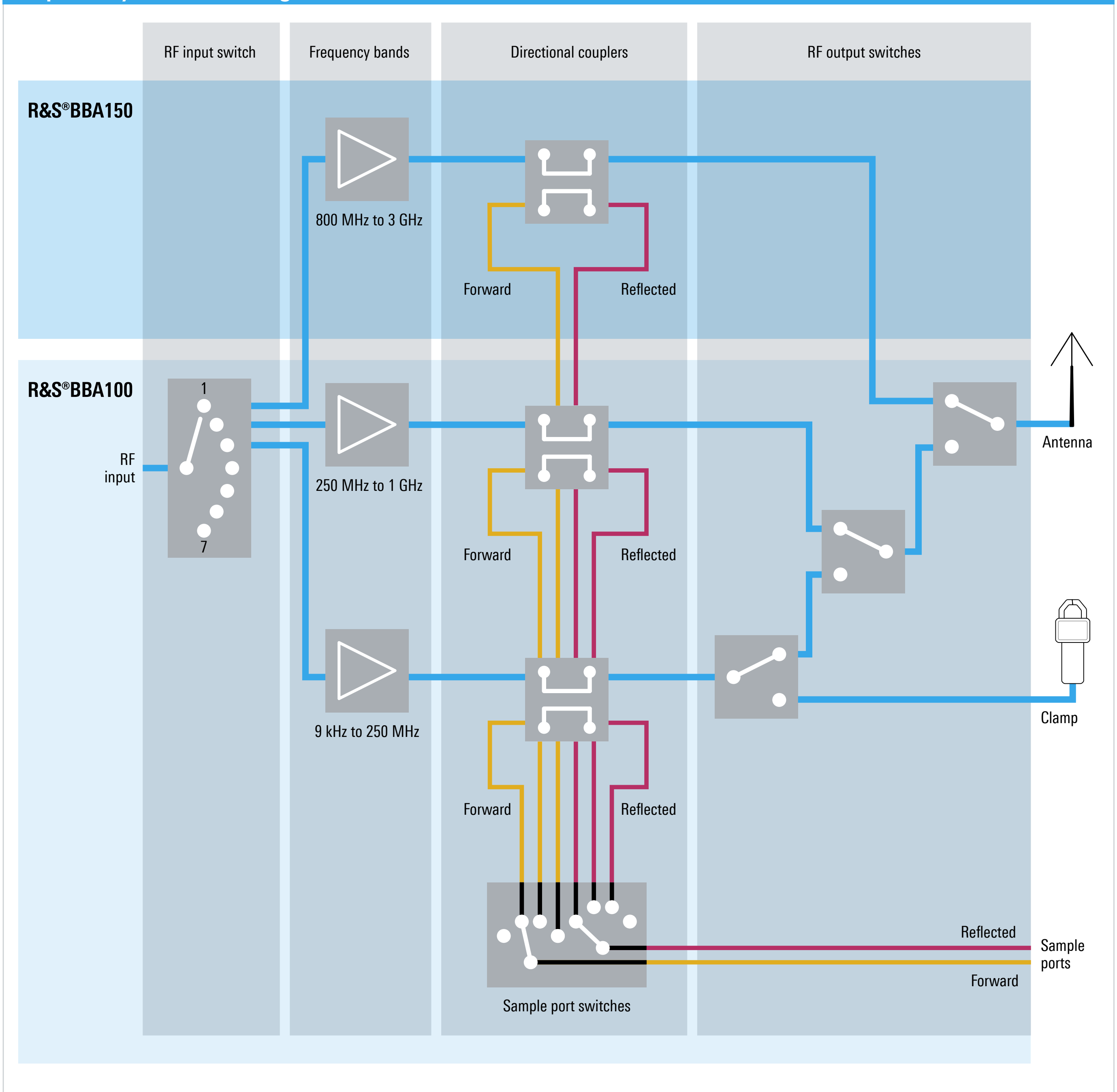
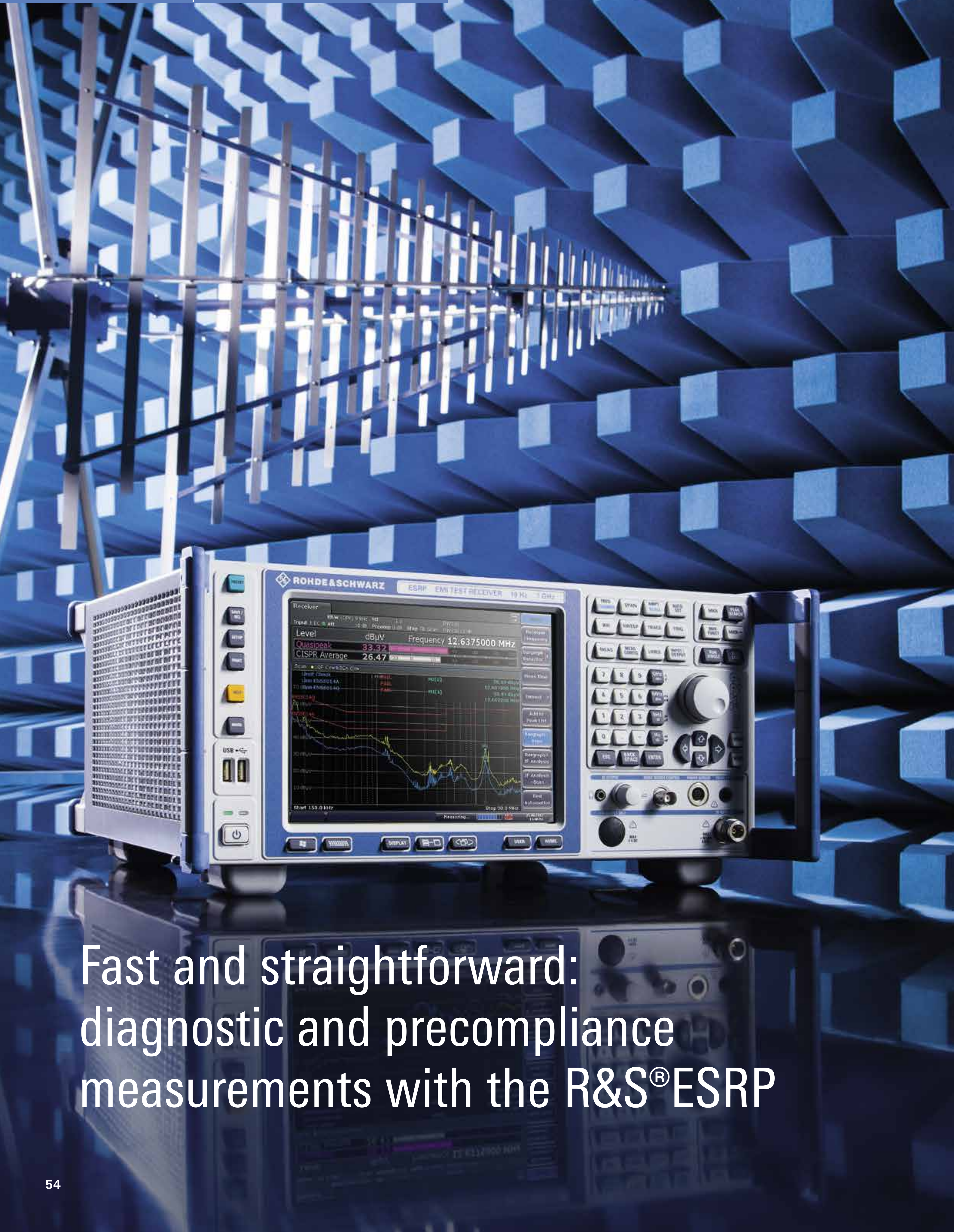


Fig. 4 The amplifier system shown above consists of an R&S®BBA150 and an R&S®BBA100 with frequency ranges from 9 kHz to 250 MHz (band A), 250 MHz to 1 GHz (band C) and 800 MHz to 3.0 GHz (band D).

Summary

The new R&S®BBA150 power amplifier is an important addition to the Rohde&Schwarz EMC portfolio. The amplifier's advanced design, seamless integration into the well-established R&S®BBA100 broadband amplifier family and worldwide service make the R&S®BBA150 ideal for EMC applications and other tasks. The modular concept enables later upgrading of the power and frequency range and protects investments.

Sandro Wenzel



Fast and straightforward: diagnostic and precompliance measurements with the R&S®ESRP

Many of the requirements – such as speed, functionality and ease of use – imposed on EMI test receivers for certification measurements also play a major role in everyday laboratory applications as well as in the runup to final certification. The new R&S®ESRP EMI test receiver for the precompliance class has been optimized to meet these requirements. This instrument vastly accelerates EMI measurements that could otherwise take hours to execute.

High speed now also in precompliance

Following last year's launch of the world's fastest EMI test receiver – the R&S®ESR* – for compliance measurements, Rohde & Schwarz has now spared users a long wait for a comparable instrument for diagnostic measurements during development and in laboratories. Like the R&S®ESR, the R&S®ESRP (Fig. 1 on left) also performs an FFT-based time domain scan, speeding up precompliance measurements by orders of magnitude. The R&S®ESRP is intended primarily for EMI diagnostic measurements during development as well as all measurements in the runup to product certification, and covers commercial EMI standards as well as military test specifications up to 7 GHz.

The receiver is available in two models for the frequency range from 9 kHz to 3.6 GHz / 7 GHz. The lower frequency limit can be extended down to 10 Hz in each model using the R&S®ESRP-B29 option (Fig. 2). The instrument is operated using a convenient touchscreen.

Basic EMC publication supports FFT-based receiver technology

The publication of Amendment 1:2010-06 to the 3rd edition of the CISPR 16-1-1 basic standard for radio disturbance measuring apparatus has generated significant activity. The next editions and revisions of commercial product family standards such as EN 55011 to EN 55032 will reference – if not already the case – the latest edition of this important basic EMC publication. Accordingly, measurement results generated using FFT-based receiver technology are now admitted. These measurements can be implemented through baseband conversion (Fig. 3) or using broadband intermediate frequency (IF) stages. In this way, the required measurements can be completed much faster while maintaining the same accuracy and, very importantly, the same reproducibility.

Time domain scan speeds up measurements

The R&S®ESRP-K53 time domain scan option affords an impressive acceleration of measurements thanks to its powerful FFT algorithms. In time domain scan mode, the R&S®ESRP completes measurements many times faster than in conventional stepped frequency scan. The time domain signal is recorded with a 128 MHz sampling rate and digitized with a 16-bit A/D converter for further processing. Fig. 4 shows just how much faster measurement results are generated (difference between stepped frequency scan and time domain scan in CISPR bands B and C/D).

The overall measurement times marked red in Fig. 4 are example values for typical measurements in CISPR band C/D that automotive suppliers and manufacturers must perform in line with the CISPR 25 product family standard up to 1 GHz at a measurement bandwidth of 9 kHz (–6 dB). In stepped frequency scan mode, 4 kHz steps are used to provide seamless measurements, and for a measurement time of 10 ms, even pulses with a repetition rate of approx. 100 Hz are recorded.

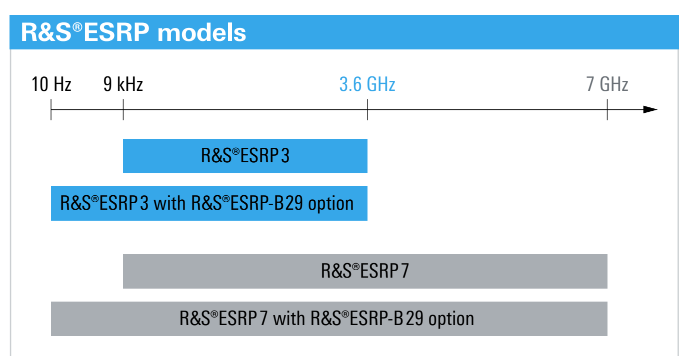


Fig. 2 R&S®ESRP EMI test receiver models and frequency ranges.

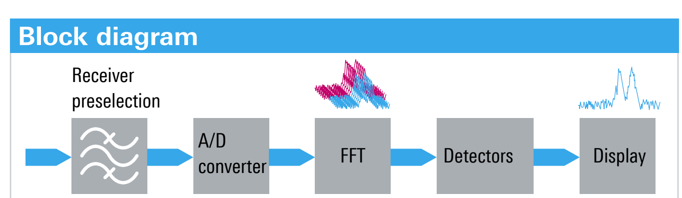


Fig. 3 Block diagram of the R&S®ESRP with baseband conversion up to 30 MHz.

* The world's fastest EMI test receiver drastically reduces testing times. NEWS (2012) No. 207, pp. 22–27.

The time domain scan delivers results about 500 times faster, even though this mode – with a step size of 2.25 kHz – nearly doubles the number of test points. As seen in Fig. 4, considerable time can also be saved with measurements in other bands, thereby substantially reducing the expenditures involved in readying a product for industrial production.

Seamless recording of electromagnetic disturbances

Using the time domain scan, performing EMI measurements in the CISPR bands is now a matter of seconds. The R&S®ESRP records the spectral signal components without any time gaps using a bandwidth of up to 30 MHz. With a virtual step size of ¼ of the resolution bandwidth and Gaussian FFT windows overlapping by more than 90 %, the receiver achieves very good level measurement accuracy for pulsed disturbances (Fig. 5). The total measurement uncertainty therefore meets the CISPR 16-1-1 requirements also for pre-compliance measurements.

Speed is also crucial when testing devices that can be operated, or measured, only during a short period of time – either because they change their behavior (fluctuating or drifting disturbances), or because extended operation might be destructive, or because their operating cycle calls for high speed (as in the case of electric window lifters in motor vehicles). The time domain scan function in the R&S®ESRP makes it easy to handle such scenarios.

Users can also increase the measurement time in order to reliably detect narrowband intermittent interferers or isolated pulses.

Frequency range	Detector, measurement time, IF bandwidth	R&S®ESRP overall measurement time	
		Stepped frequency scan	Time domain scan (optional)
CISPR band B 150 kHz to 30 MHz	peak, 100 ms, 9 kHz	7462 test points: 755 s	13 267 test points: 2 s
CISPR band B 150 kHz to 30 MHz	quasi-peak, 1 s, 9 kHz	7462 test points: 12 960 s	13 267 test points: 60 s
CISPR band C / D 30 MHz to 1000 MHz	peak, 10 ms, 120 kHz	24 250 test points: 254 s	32 334 test points: 6 s
CISPR band C / D 30 MHz to 1000 MHz	peak, 10 ms, 9 kHz	242 500 test points: 4310 s	431 112 test points: 8 s
CISPR band C / D 30 MHz to 1000 MHz	quasi-peak, 1 s, 120 kHz	24 250 test points: approx. 600 min	32 334 test points: approx. 33 min

Fig. 4 Comparison of overall measurement times obtained with stepped frequency scan and with time domain scan using typical measurement settings. Marked red: examples of overall times for typical measurements that automotive suppliers and manufacturers must perform in line with the CISPR 25 product family standard up to 1 GHz at a measurement bandwidth of 9 kHz (–6 dB).

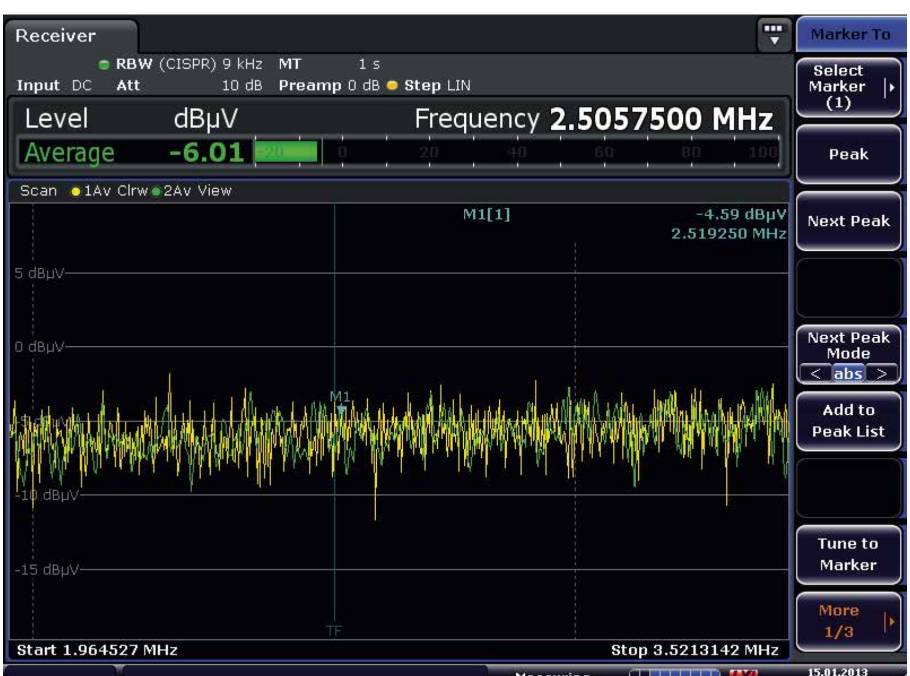


Fig. 5 Level error: stepped frequency scan (yellow) vs. time domain scan (green).

The optional R&S®ESRP-B2 preselection and RF preamplifier module contains 16 filters and a 20 dB preamplifier for a maximum frequency of 7 GHz. Equipped with this module, the R&S®ESRP performs measurements of intermittent disturbance signals with pulse repetition rates of 10 Hz or higher in line with the CISPR 16-1-1 basic standard. Featuring a preselection filter bandwidth from 150 kHz to 30 MHz, the test receiver measures conducted disturbances in a single step simultaneously on 13 267 frequencies using the time domain scan (Fig. 6).

IF analysis function for higher-resolution spectral display

Critical signal amplitudes in the spectrum can be analyzed in greater detail using the IF analysis function of the R&S®ESRP. This function provides a spectral display of the RF input signal in a selectable range (up to 10 MHz) around the EMI receiver frequency. The IF spectrum display can be coupled to the bargraph display for the current receive frequency. Alternatively, the IF spectrum display can be coupled to the marker position,

Fig. 6 In a single step: conducted disturbance measurement in CISPR band B.

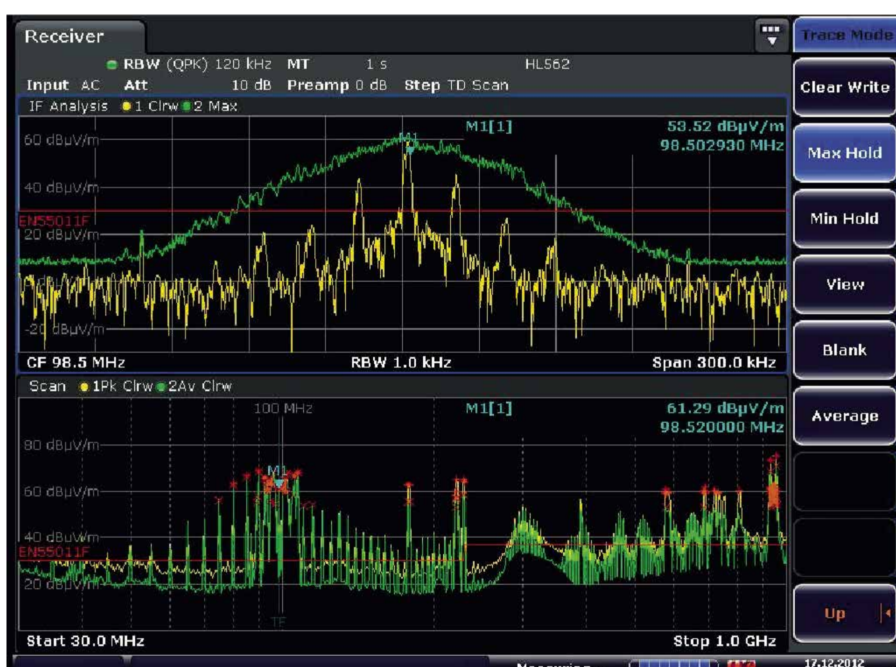


Fig. 7 IF spectrum with IF center frequency coupled to position of marker in preview measurement spectrum (marker track function).

e.g. in a preview measurement using the marker track function (Fig. 7); in this way, the center frequency of the IF spectrum is always equal to the instrument's current receive frequency. This enables very accurate and fast tuning to the signal of interest. In addition, the IF spectrum display provides a detailed overview of the spectrum occupancy around the signal of interest and – with sufficiently wide IF bandwidth – information about the spectral distribution of a modulated signal in the measurement channel. Any signals received can be quickly classified as disturbance signals or wanted signals. AM or FM audio demodulation can be activated in parallel, making it easier to identify detected signals, for example in order to find and exclude ambient signals in open area measurements.

Spectrum analyzer functions and EMI measurements in spectrum analyzer mode

The frequency range from 9 kHz to 3.6 GHz / 7 GHz can be extended down to 10 Hz using the R&S®ESRP-B29 option. If preselection is deactivated in spectrum analyzer mode, the separate R&S®FSV-B22 RF preamplifier option can be used to increase the sensitivity of the R&S®ESRP. Featuring low displayed average noise level (–168 dBm (typ.) at 1 Hz bandwidth with preamplifier switched on), the R&S®ESRP measures even low-level signals precisely. Due to its very wide dynamic range, the instrument meets the special requirements of CISPR 16-1-1 Ed. 3 (use of spectrum analyzers without preselection for standard-compliant disturbance measurements), relating to disturbance signals with a pulse repetition rate of 20 Hz or higher.

RF disturbance measurements can be performed in spectrum analyzer mode either with or without preselection activated. The number of test points is selectable. For a conclusive evaluation, up to 200 001 points can be specified. By contrast, up to 4 million points per trace are available in test receiver mode. Diagnostic measurements during development also require high accuracy and reproducibility. "Normal" resolutions of 8000 or 32 000 points, as typically used in conventional spectrum analyzers, quickly hit critical limits and are not adequate for EMI measurements.

Up to 16 configurable markers can be placed on the frequencies of disturbance signals to carry out targeted analysis. Markers can be coupled with a CISPR weighting detector to enable direct comparison with limit values. The spectrum can also be displayed along a logarithmic frequency axis, which simplifies result analysis across a wide frequency range and displays limit lines in compliance with relevant standards. Critical frequencies are presented in a peak list, enabling fast comparison of disturbance signals with limit lines.

Tracking generator for scalar network analysis

An internal tracking generator (R&S®FSV-B9 option) enhances the R&S®ESRP to operate as a scalar network analyzer in the frequency range from 9 kHz to 7 GHz. With this option, users can quickly and easily determine the frequency-dependent insertion loss of test cables or filters, for example, and store the results as correction tables (transducers) in the R&S®ESRP.

Fig. 8 The R&S®ESRP in a ruggedized housing with corner guards and carrying handle for field use.

Ready for field use

For field applications in a vehicle or an open area, the R&S®ESRP can be extended with the R&S®FSV-B30 DC power supply (12 V to 15 V) and supplied in a ruggedized housing with corner guards and carrying handle (Fig. 8). During open area measurements, the test receiver will reliably operate for several hours when equipped with the R&S®FSV-B32 lithium-ion battery pack, e.g. for recording series of measurements.

In the standard version, the R&S®ESRP comes equipped with a hard disk drive for data storage. The hard disk drive can be replaced with a solid state drive to handle scenarios with above-average fluctuations of the operating temperature, or when the instrument is exposed to strong shock and vibration loads, for example in vehicles.

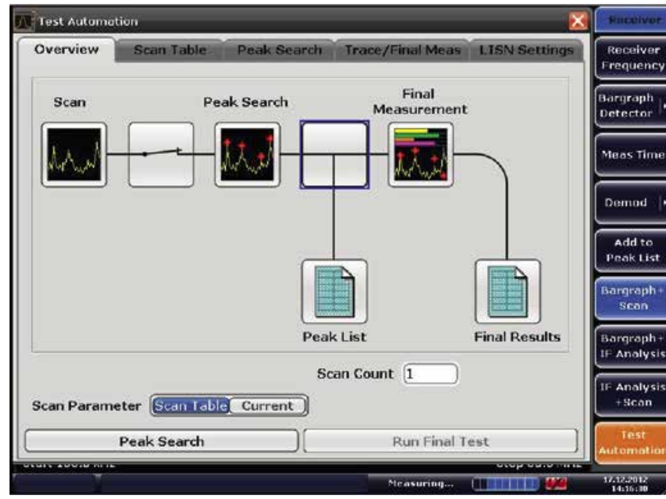


Fig. 9 Test automation menu for configuring automated test sequences.

Automated measurements and software support

The R&S®ESRP has an integrated test automation function to support configurable, automated test sequences including preview measurement, data reduction and final measurement (Fig. 9). The number of frequencies for final measurement and the margin relative to one or more limit lines are specified here. The test sequence is launched with a keypress and then runs fully automatically. It is also possible to carry out the final measurement interactively. Touching the peak list icon opens a list of previously detected frequencies. The number of final measurement frequencies can be adjusted, to be followed by final evaluation with quasi-peak, CISPR-average or CISPR RMS-average weighting. The trace wizard is used to assign the appropriate detectors.

Moreover, the R&S®ES-SCAN and R&S®EMC32 EMC application software packages are available for automated and semi-automated EMI test execution under external computer control. The R&S®ES-SCAN EMI software is cost-effective, user-friendly Windows software created especially for disturbance measurements during development. It ideally complements the R&S®ESRP.

The R&S®EMC32 EMC measurement software can also be used with the R&S®ESRP. The software has a modular design and supports manual, semi-automated and fully automated electromagnetic interference and immunity measurements in line with commercial and military standards. The software provides reliable recording, analysis, documentation and traceability of measurement results and offers remote control capability for a wide variety of accessory components such as mast and turntable systems.

The R&S®ESRP can be remotely controlled via GPIB or LAN with user-created programs via standard IEC 625-2 (IEEE 488.2) interfaces or LAN interfaces (10/100/1000BaseT). For integration of the R&S®ESRP, drivers for LabVIEW, LabWindows/CVI and VXI Plug & Play are available free of charge on the Rohde&Schwarz website.

Summary

The R&S®ESRP EMI test receiver for the frequency range from 10 Hz to 7 GHz has been designed for diagnostic measurements during development and for precompliance measurements in the runup to final certification testing. Due to its outstanding RF specifications, high speed and wealth of measurement functions, the instrument is ideal for applications during development as well as in laboratories. It has been optimized to execute EMI measurements as fast as possible and with the required level of accuracy. Using an FFT-based time domain scan, the instrument measures electromagnetic disturbances at high speed. At the same time, the R&S®ESRP is a full-featured, powerful signal and spectrum analyzer for lab applications. The instrument comes with a clearly structured, intuitive touchscreen interface and is very easy to use – a tremendous advantage considering its wide range of applications. This multipurpose instrument helps users to obtain the desired results faster and ready their products for final certification and industrial production.

Volker Janssen

References
Amendment 1:2010-06 to CISPR 16-1-1:2010-01 (Edition 3): Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus
For more information about the R&S®ESRP, visit:
http://www.rohde-schwarz.com/en/product/esrp-productstartpage_63493-35077.html

Efficient transmitter systems for all power classes

The R&S®THU9 UHF high-power transmitters were launched in 2011. Since then, Rohde & Schwarz has been busy expanding this completely new generation of transmitters. And now the R&S®TMU9 UHF medium-power transmitters and the R&S®MLx low-power transmitters are taking over the market. All models boast small footprint and high efficiency (see also the article on page 63).

Fig. 1 The MultiTX design of the new R&S®TMU9 transmitter makes it possible: Up to six transmitters can be housed in one rack – a space saving of up to 80 % compared to the previously required space. In this example, three transmitters are built in, each delivering an output power of 1.14 kW.

R&S®TMU 9 family of TV transmitters: minimum operating costs – maximum flexibility

Small footprint, short delivery times, low operating costs and maximum availability – these are the qualities most valued by network operators for transmitters used in terrestrial broadcast networks. And all of these qualities are offered by the R&S®Tx9 generation of transmitters, which has now been expanded to include the R&S®TMU 9 air-cooled transmitters with power classes between 300 W and 2.85 kW.

MultiTX – winning strategy against insufficient space and high rent costs

Lack of space and rising rent costs – problems every network operator knows. Additional multiplexers are frequently needed at transmitter sites that are already short on space. Not to mention the additional rent costs to open up space for more transmitter racks. These serious problems for operators were the focus behind the development of the new R&S®TMU 9 family of UHF transmitters for power levels between 300 W and 2.85 kW. The MultiTX concept makes it possible to integrate up to six transmitters into one rack and achieve space savings of up to 80 % compared to the previous space requirements (Fig. 1). Complete backup systems can be housed in a single transmitter rack, e.g. a 2+1 system with an output power of 1.14 kW, which allows users to save space and commissioning time. The R&S®TMU 9 with output power levels of 1.14 kW is also available without a rack, allowing empty spots in existing racks to be filled.

Fig. 2 The R&S®TMU 9 can take on many different configurations: This picture shows R&S®TCE 900 base units pulled from the rack. They can be configured either as exciters or as transmitter control units by changing the plug-in board.

Modular and series produced – ready for any project and any timeline

Fixed schedules for commissioning transmitters are a daily fact of life for network operators. Series-produced transmitters help because they can be delivered fast. Yet it should be possible to configure them so flexibly, as if each were custom-made. A good example is the series-produced, completely modular R&S®TMU 9. Its modularity allows more than 50 different configurations. This is easily seen in the cooling system: Many countries use ducted exhaust air systems, while in other countries the warm exhaust air is blown directly into the room and must be cooled there. The cooling system of the R&S®TMU 9 can be adapted to meet local requirements. Its modularity makes it quick and easy to retrofit the transmitter to meet any new requirements in the future.

The R&S®TCE 900 base unit is also modular: Depending on the plug-in board, it can function as either an exciter or as a transmitter control unit (Fig. 2). Boards can be added or swapped out at any time. If multiple transmitters from the new R&S®Tx9 generation are being used in a network, spare parts are easily and inexpensively procured thanks to the seamless compatibility of the R&S®TCE 900.

Doherty method – reduces operating costs by more than 40 % over the entire lifecycle

The current generations of transmitters from many manufacturers typically consume four to five times more energy than they output. The R&S®TMU 9 improves on this statistic: With an efficiency of up to 38 %, it is the first air-cooled transmitter that can reduce energy costs by more than 40 %.

Transmitter based on Doherty technology

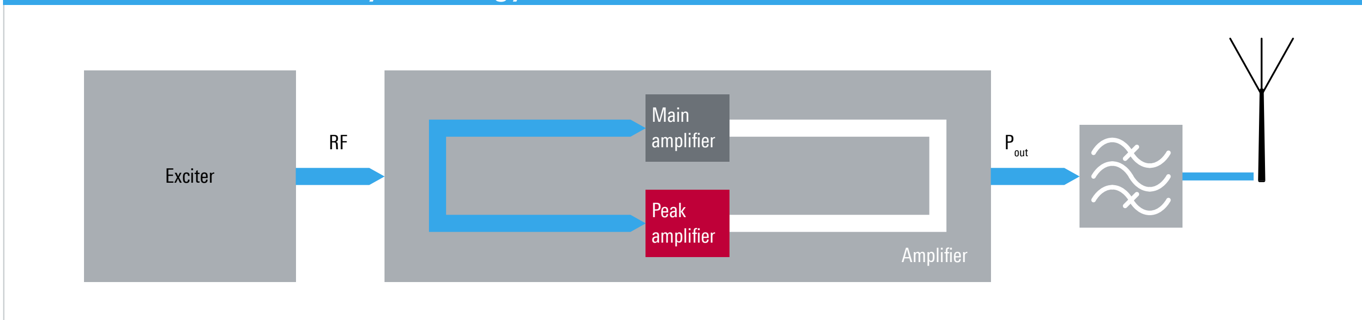


Fig. 3 The R&S®TMU9 uses Doherty technology, which allows it to achieve an efficiency of up to 38 %.

Doherty power amplifiers are the trick behind the efficiency. This Doherty technology is based on the findings of William H. Doherty in the 1930s. It has been used successfully in wireless communications for many years and helps to reduce energy costs. The basic principle involves splitting the signal amplification into two paths. One path amplifies the peak signals and the other – the main amplifier – amplifies the average signals (Fig. 3). This has the advantage that the main amplifier does not have to hold power in reserve for the peak signals. The peak amplifier is used only when power peaks actually occur. The result is energy savings in both amplifiers. Rohde&Schwarz has revolutionized Doherty technology with its R&S®TMU9. For the first time, the formerly narrowband Doherty architecture has been implemented in broadband amplifiers. This simplifies spare part provisioning in large transmitter networks with many different frequencies by reducing the number of different amplifiers that need to be kept on hand.

Innovative redundancy concept for maximum availability

Contracts between network operators and broadcasting corporations regulate the costs incurred due to an interruption in the transmission or when the transmitter is not commissioned on schedule. The R&S®TMU9 provides relief with respect to the commissioning schedule. The transmitters are delivered prewired and just need to be slid into place – making on-time commissioning considerably easier. Their versatile operability is also an advantage: The transmitters can be operated locally via a laptop or using an optional touchscreen, or remotely via a web browser or SNMP.

Unstable power networks, air conditioning system failures or problems with signal feeds – the R&S®TMU9 provides a variety of options to meet these challenges. Redundant power supplies in the amplifiers protect against the failure of individual phases and of a complete power supply unit. Special solutions for exhaust air ducting allow the transmitter to be operated regardless of whether air conditioning is available. This increases availability and also reduces energy consumption. For more stringent availability requirements, sophisticated redundancy concepts are offered, e.g. dual drive, backup drive or N+1 systems.

R&S®TMU9: presented in September – on air and winning awards by December

In September 2012, the R&S®TMU9 was presented to the technical audience at the IBC, which is held every year in Amsterdam. Only two months later, the first two transmitters went on air. Their high efficiency and compact design was enough to convince Onecast (a Bouygues company), one of the network operators belonging to the largest broadcaster in France, TF1. Onecast ordered the two transmitters in a MultiTX configuration with Doherty technology and ducted exhaust air. The project also included ten transmitters from the new R&S®THU9* generation of high-power transmitters, also in MultiTX configuration and with Doherty technology. This project earned Onecast an award in the competition for responsible purchasing in the category "most economical and eco-friendly projects" within the Bouygues group of companies, awarded for the first time in December 2012.

Christian Wachter

* Efficiency redefined: the R&S®THU9 UHF high-power transmitters. NEWS (2011) No. 204, pp. 46–52.

Antennas and mains supply are all the R&S®MLx low-power TV transmitter needs

TV transmitter networks are supposed to provide gap-free coverage, even in areas such as valleys or shadow zones between high-rise buildings. Gaps in coverage are usually filled by a large number of low-power transmitters, requiring a rather complex infrastructure and an investment that is difficult to calculate. The new R&S®MLx low-power transmitter avoids these potential cost traps because it can make do with only minimal infrastructure.

Complex transmitter infrastructures drive hidden costs up

Terrestrial broadcasting networks are normally set up for large area coverage with a combination of high-power and medium-power transmitters (> 600 W). The network operators then use low-power transmitters (< 10 W) to close coverage gaps, for instance in valleys, urban canyons or tunnels. A suitable infrastructure for operating low-power transmitters includes protective housing (a building or an outdoor cabinet), cooling system, power supply, transport stream feed, network infrastructure for monitoring, GPS signals, as well as transmit antennas and, if necessary, receive antennas (Fig. 1). These infrastructure requirements should not be underestimated, for complete coverage usually calls for a large number of transmitter sites and a level of investment that is hard to calculate.

Required infrastructure

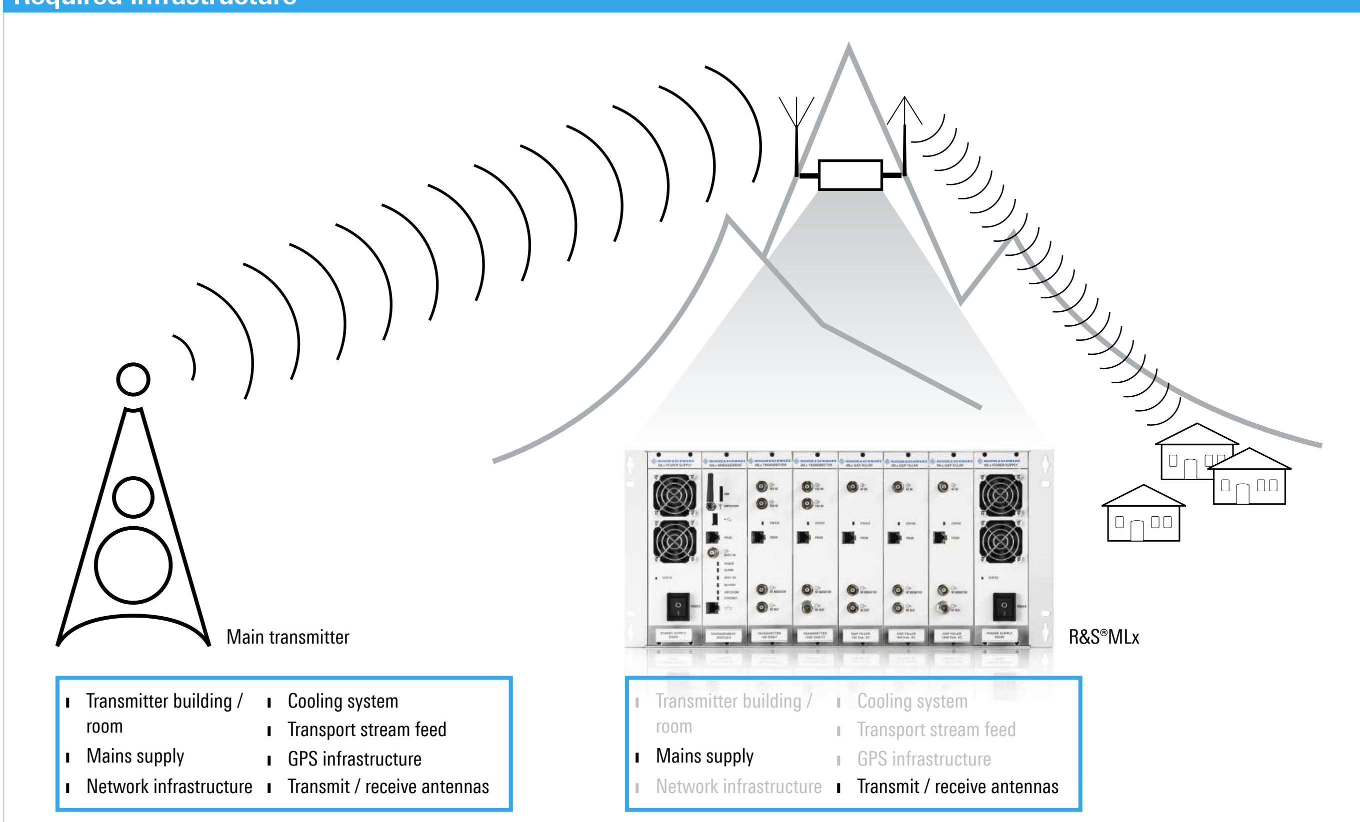


Fig. 1 The required budget for filling gaps in TV network coverage is kept within reasonable limits by using low-power transmitters that make minimal demands on infrastructure.

R&S®MLx: robust low-power transmitter with minimal requirements

The new R&S®MLx multichannel low-power transmitter (Fig. 2) was developed with special focus on modest infrastructure requirements. Its modular system design combines versatility with failsafe performance and a small footprint. The compact 5 HU, 19" subrack has a depth of only 250 mm, allowing parallel operation of any combination of up to six transmitters, gap fillers or retransmitters for DVB-T, DVB-H and DVB-T2 with output power of 1 W, 5 W and 10 W.

The compact design and easily accessible interfaces mean the R&S®MLx can be installed in a minimum of space, e.g. in outdoor cabinets where the rear panel is inaccessible. Neither a transmitter room nor a building is necessary. The system dissipates very little heat, and a combined fan and convection cooling allows operation in many regions without an air conditioning system. The integrated satellite receiver enables wireless transport stream feeding, and the built-in UMTS/3G modem makes a wired infrastructure for transmitter monitoring unnecessary (Fig. 3). The system also features a GPS receiver and advanced echo cancellation for up to +24 dB echo gain. The only on-site essentials are transmit and receive antennas and mains supply.

A key feature of the new transmitter is its high availability. The redundancy concept ensures fine-tuned backup of 1+1 to 6+1 systems. A redundant power supply unit can also be integrated to enhance availability.

Flexibility in choosing a site

Competitor products in the 10 W power class often require a lot of space because they have a mounting depth of 450 mm or more as well as interfaces on the front and rear panels. The actual footprint of such transmitters significantly exceeds their mounting depth since the interfaces have to be accessible for maintenance work. If a product that has these disadvantages also necessitates a wired infrastructure, the number of suitable installation sites decreases significantly.

With the R&S®MLx, there is no need to make compromises of this type. Thanks to its compact design and high degree of independence from air conditioning and wired infrastructures, the R&S®MLx can be installed in outdoor cabinets, allowing virtually unlimited positioning of the transmitter system.

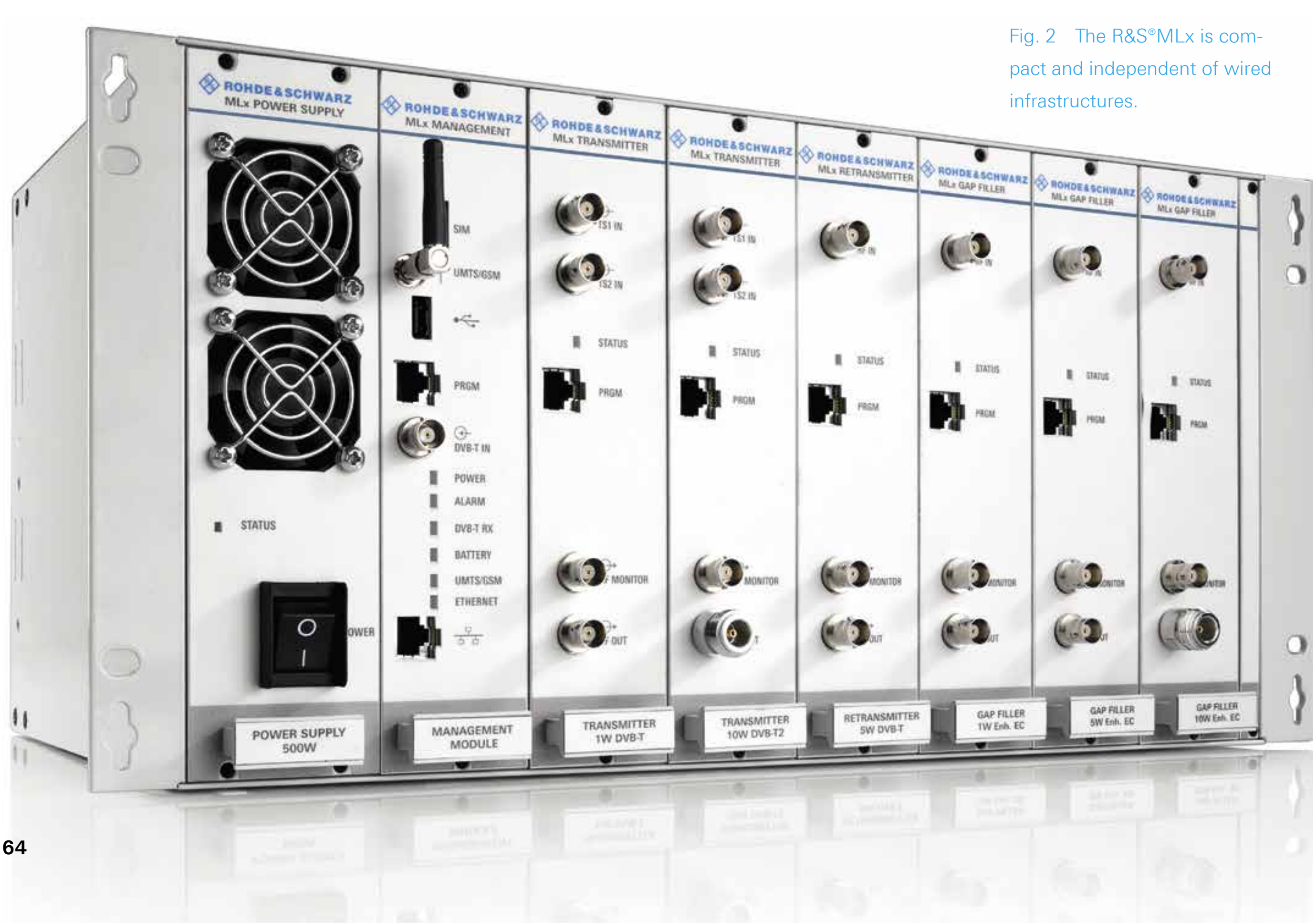


Fig. 2 The R&S®MLx is compact and independent of wired infrastructures.

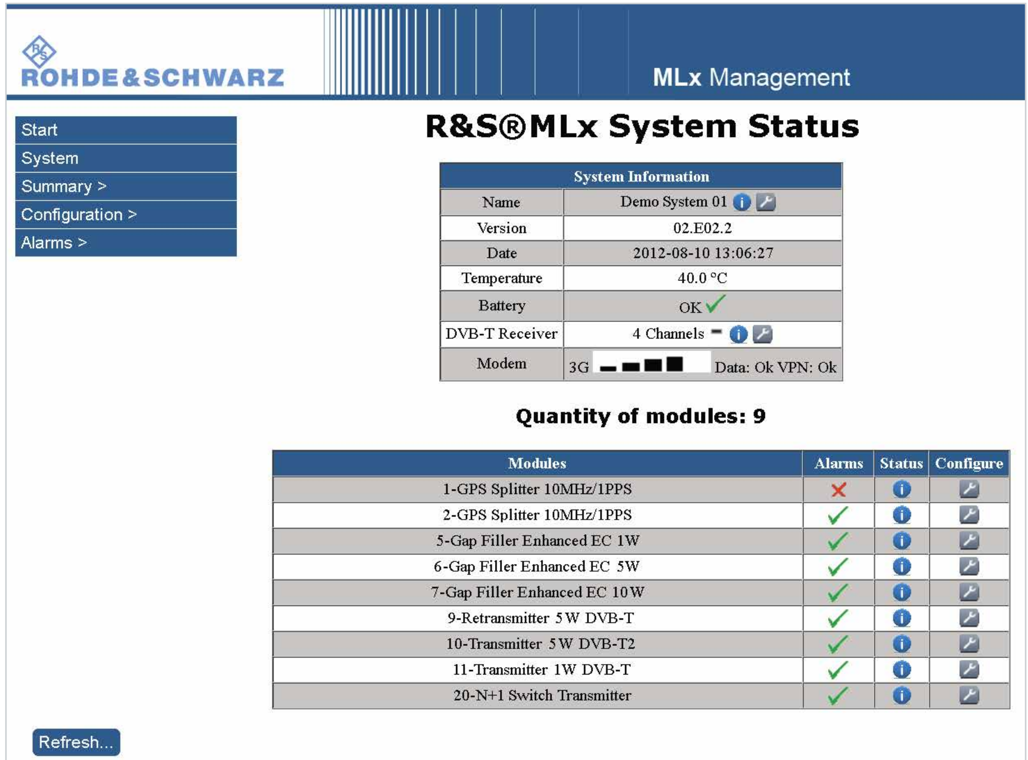


Fig. 3 The R&S®MLx can be easily controlled remotely via a web browser user interface.

Summary: a multi-application transmitter

Compact and modular, the R&S®MLx is perfect for a broad range of application scenarios in transmitter sites or outdoor cabinets, in urban environments and remote regions. The R&S®MLx is excellent for areas with urban canyons and their many shadow zones, where signal propagation conditions are complex and space is limited. A site for the transmitter can be selected with a high degree of freedom, since a wired infrastructure is not needed and unmatched echo cancellation is integrated in the system.

In remote areas, even a basic infrastructure can be absent – e.g. on a small island, where there is frequently no main transmitter, no wired signal feed and no means of monitoring. In such a scenario, the integrated satellite receiver, UMTS/3G modem and transmitter modules of the R&S®MLx provide a superior solution, which can be up and running quickly and does not require extensive additional investment.

Unlike competitor broadcast transmitters in the same power class, the R&S®MLx is optimized for minimum infrastructure requirements. It is highly flexible when it comes to site selection and can be used universally in a wide range of application scenarios.

Maurice Uhlmann

R&S®MLx modules

- Power supply unit
- Redundant power supply unit (optional)
- Management module
- GPRS/UMTS/3G modem (optional)
- Channel modules with 1 W, 5 W or 10 W output power (up to six for each system)
- Transmitter modules for DVB-T or DVB-T2
- Retransmitter modules for DVB-T
- Gap filler modules for DVB-T / DVB-T2 / ISDB-T
- GPS receiver module
- Redundant GPS receiver module (optional)
- Satellite receiver module
- N+1 switching unit for transmitter and gap filler modules

Bavarian Broadcasting Corporation performs DVB-T2 field tests in Munich

Comprehensive testing is required before a network can begin regular operation using new broadcasting standards. This was also true for the transition from the DVB-T to the DVB-T2 TV standard. In 2010, the Bavarian Broadcasting Corporation started field testing in Munich. Rohde & Schwarz provided the necessary transmitters and T&M equipment.

A long journey – from the standard to a comprehensively tested network

In the spring of 2007, the first technical details for the new DVB-T2 terrestrial broadcasting standard were made public. In late 2009, Rohde & Schwarz finished implementing the new standard in the R&S®SFU broadcast test system to enable testing of consumer receivers. The first test networks in 2010 were pure multifrequency networks (MFN). At that time there was no experience regarding DVB-T2 single-frequency networks (SFN) since these networks required T2 gateways that had yet to be developed.

In early 2010, the Bavarian Broadcasting Corporation (BR) launched an initiative for additional field testing with the goal of testing the operability of DVB-T2 SFNs and setting up an IP-based distribution network to supply transmitter sites with the DVB-T2 MI transport stream. The focus of testing was also on the distributed MISO method, which was to be compared with SISO, the traditional configuration for DVB-T. Experts selected three of the Bavarian Broadcasting Corporation's transmitter sites that were well-suited for MISO tests, located about 10 km apart from each other and essentially covering the Munich metropolitan area (Fig. 1).

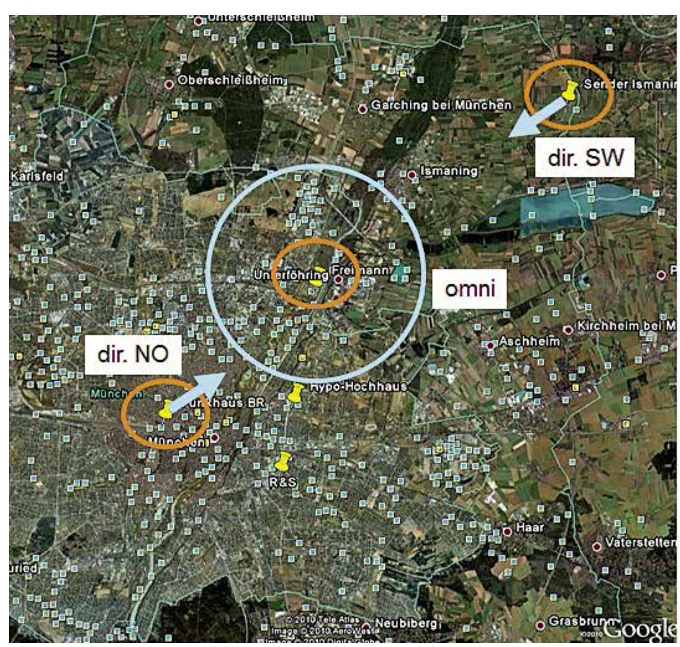
MFN with three transmitters

In September 2010, the Freimann site, with its 110 m high antenna and an ERP of approximately 5 kW as a pure omnidirectional antenna, was the first to go into operation. At first, the installed air-cooled 800 W R&S®NV8302V medium-power transmitter worked with the following operating parameters: 16K normal, code rate = $^2/_3$, g = $^1/_{16}$, SISO, single PLP; later it was switched to 32K extended carrier. Initially, an MFN with a TS-ASI feed was planned, with the transport stream already embedded in an IP distribution network. In the fall of 2010, the test team mounted antenna arrays on the BR radio mast at a height of 210 m in Ismaning pointing toward Freimann, again with an ERP of approximately 5 kW. An air-cooled R&S®SCV8302R compact transmitter with an output power of 600 W was connected to the antennas. In March 2011, the same type of transmitter was installed for the BR broadcasting center located at Munich central station. Now all three sites were on air as MFNs in SISO mode. Drive tests in this DVB-T2 network revealed a net data rate of about 26 Mbit/s – twice that of a DVB-T network – and with the same robustness. Just as with DVB-T, there were destructive notches in the spectrum at approximately the same levels and delay differences of a few microseconds between two transmitter sites (Fig. 2).

Single-frequency network in MISO mode

The R&S®TSE800 transmitter system extension was installed at each site in order to successively upgrade the network to MISO and full DVB-T2 functionality as well as to multi-PLP mode with a single PLP being used. This was followed by the configuration of the SFN. Tests for MISO mode began in the spring of 2012.

Fig. 1 DVB-T2 network test area in Munich.



Additive overlay in the SFN

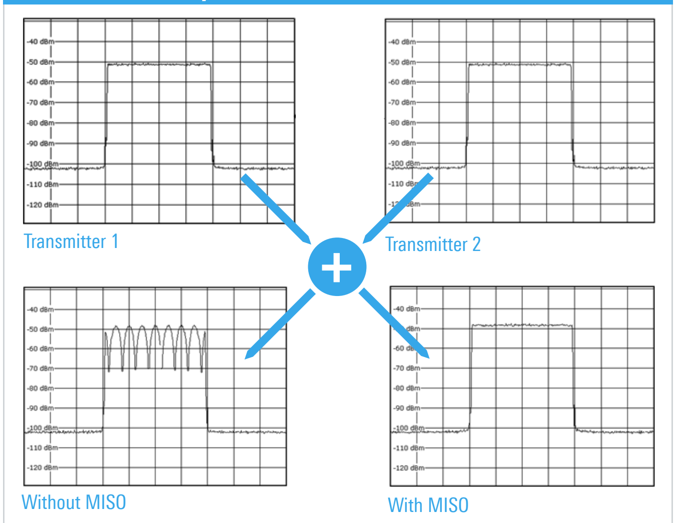


Fig. 2 Impact of additive overlay in the SFN for MISO and with SISO. There is no correlation between the signals from transmitter 1 and transmitter 2.

Technical parameters of the field test

- **Frequency:** 706 MHz, channel 50
- **Transmitter sites** in the SFN
  Freimann: 5 kW ERP, 800 W transmitter output power, 110 m omnidirectional antenna
  Ismaning: 5 kW ERP, 600 W transmitter output power, 210 m directional antenna SW
  BR broadcasting center: 5 kW ERP, 600 W transmitter output power, 90 m directional antenna NO
- **Ismaning playout center:** with live content adjusted to the data rate (SD and HD programs from ARD (German Public Broadcaster) and the Bavarian Broadcasting Corporation), first with T&M components, then with standard headend components and finally with the new R&S®AVHE100 headend from Rohde&Schwarz
- **Transmitter operating parameters** usually 32 K ext., code rate = $^2/_3$, g = $^1/_{16}$, MPLP with one PLP (T2 network parameters were varied)

Using network planning software, the team determined which test locations would be most relevant for the planned drive tests. The software simplified the selection thanks to its comprehensive maps and diagrams that clearly show the calculated field strengths, impulse responses and locations with the same delay differences, etc.

Equipped with T&M equipment from Rohde&Schwarz, vehicles belonging to BR and the Munich Broadcast Technology Institute (Institut für Rundfunktechnik, IRT) completed numerous drive tests in the SFN. A pivotable, directional test antenna located on Rohde&Schwarz grounds provided supplemental field strength values. GPS time and frequency standards synchronized the SFN with the transmitter sites. The Rohde&Schwarz gateway was synchronized via an NTP server with GPS connection.

Using the R&S®ETL test receiver, the test team evaluated the receive situation with respect to level, constellation, MER, spectrum and impulse response at all measurement locations. The Bavarian Broadcasting Corporation test vehicle was equipped with a horizontally polarized omnidirectional antenna with a known antenna gain or k factor. A precision attenuator was attached to attenuate the input signal in precise increments. The R&S®ETL and other consumer receivers were connected alternatingly to the attenuator. On each receiver, the test team measured the maximum possible attenuation of the signal or fall-off-the-cliff point with a resolution of one tenth of a decibel – at each measurement location and with various network configurations (SISO, MISO, etc.). This attenuation value was determined based on manual visual and acoustic evaluation of the receiver's video and audio signals. The higher this value, the better the particular receiver was able to handle the receive situation or the set network parameters.

Summary

The field tests delivered useful, practical information about numerous design parameters in DVB-T2 SFNs. This information can be used to optimize network coverage.

Roland Janik (Bavarian Broadcasting Corporation);
Walter Fischer; Peter Knidlberger (Rohde&Schwarz)

Abbreviations

ERP	effective radiated power
g	guard interval
MER	modulation error ratio
MFN	multifrequency network
MIMO	multiple input multiple output
MISO	multiple input single output
NTP	network time protocol
PLP	physical layer pipe
SFN	single-frequency network
SISO	single input single output

Customized test receivers for detecting leaks in cable TV networks

Leaks are unacceptable. What plumbers and secret agents have known for many years has now become a critical issue for cable TV network operators as well. Due to the digitization of terrestrial television, the former UHF TV band is now available as digital dividend for wireless communications services. These services can be subject to interference caused by unwanted emissions from cable TV networks, and this interference must be detected as fast as possible.

Potential for conflict: LTE networks and cable TV in the UHF range

Since the digitization of terrestrial TV, many countries have discontinued TV broadcasting in the UHF range. The freed-up frequency band – available as digital dividend – was auctioned off to private operators. These operators plan to set up LTE networks in the UHF range in order to provide fast, mobile Internet and to improve Internet access in rural areas. To ensure the quality of services and prevent damage to their business, the new license owners take great care to ensure that no interference occurs in their part of the spectrum. Unlike terrestrial television, cable TV continues to use the UHF band and overlaps with the new LTE networks. If leaks occur in cable TV networks, interference in LTE networks is inevitable.

Fig. 1 R&S®EFL110 with R&S®EFL-Z100 VHF/UHF directional antenna.

US leadership position

The US FCC regulatory authority long ago defined strict limits for radiated emissions in the aeronautical radio band from 108 MHz to 139 MHz. Limits* for the range between 700 MHz and 800 MHz in which the new LTE networks operate have recently been introduced (Fig. 2). The objective of the FCC limits is to protect LTE networks from unwanted radiated emissions from cable TV networks. As owners of the spectrum, LTE network operators can force cable TV network operators to comply with these limits.

Cable TV network operators accountable

Many cable TV network operators still do not have measuring equipment capable of detecting radiated emissions in the UHF band. Measuring equipment for the VHF aeronautical radio band has been around for some time now, but it is narrowband and cannot detect UHF signals. However, this is necessary since leaks at higher frequencies generate for more emissions than leaks at lower frequencies. Sometimes the field strength of radiated emissions from a poorly tightened screw connector can barely be measured in the VHF band, whereas in the UHF band it is significantly above the permissible limit.

Measuring instruments for detecting leaks in cable TV networks must be sensitive and designed for broadband operation in order to reliably detect limit violations in both the VHF and UHF band. They must be fast enough to detect even sporadic interference and also be able to make interference visible long enough for users to see it.

* FCC Electronic Code of Federal Regulations, Title 47, Part 76 "Multichannel video and cable television service", §76.605.

Frequency range	Limits for radiated emissions
f ≤ 54 MHz	15 μV/m at a distance of 30 m
54 MHz < f ≤ 216 MHz (includes the aeronautical radio band from 108 MHz to 139 MHz)	20 μV/m at a distance of 3 m
f > 216 MHz (includes the LTE band from 700 MHz to 800 MHz)	15 μV/m at a distance of 30 m

Fig. 2 FCC limits for radiated emissions in the VHF/UHF band.

Interference detection using FFT analysis and a directional antenna

A combination of FFT analysis and spectrogram display is the right method for this task. FFT analysis covers the entire frequency band of interest or individual subbands and calculates the signal spectrum. The spectrogram display is used to make sporadic interference visible for a while. The current FFT spectrum is color-coded and displayed in the top line of the spectrogram. Previous measurement values slowly move downwards. This type of display is also referred to as waterfall diagram.

Simply detecting radiated emissions is not enough; the source of interference also has to be located. This requires a directional antenna. When the directional antenna points at an interference source, the test receiver immediately registers an increase in level. The measured value is visible for a while in the spectrogram display, allowing users to see radiated emissions on the display that were only briefly indicated by the antenna (Fig. 3). The spectrogram helps users to identify interference sources. Measuring instruments that generate an acoustic signal where the pitch of the tone is proportional to the measured field strength are particularly helpful.

Customized test receivers from Rohde & Schwarz

The R&S®EFL110 cable TV leakage detector and the R&S®EFL210 cable TV analyzer and leakage detector are two new test receivers specially designed for detecting leaks in cable TV networks (Fig. 1). Both instruments include an FFT analyzer with spectrogram display and a sweep spectrum analyzer and are able to measure the frequency range from 5 MHz to 2500 MHz. To verify compliance with the FCC limits, their sensitivity is optimized for the bands from 108 MHz to 139 MHz and 700 MHz to 800 MHz. A VHF/UHF directional antenna is available as an accessory. The R&S®EFL210 has been additionally equipped with a TV test receiver that supports the US J.83/B cable TV standard and the NTSC, PAL and SECAM standards for analog television. Once the source of interference has been eliminated, users can test the TV signal quality. The R&S®EFL110 and R&S®EFL210 are small, lightweight, robust and battery-operated and have been optimized for outdoor use. The 5.7" display adapts itself to the ambient brightness and is always clearly visible. A special daylight mode makes it possible to read the display even in bright sunlight.

The R&S®EFL110 and R&S®EFL210 test receivers are ideal tools for cable TV network operators, helping them to economically and quickly find leaks in their networks – before authorities have to act.

Peter Lampel

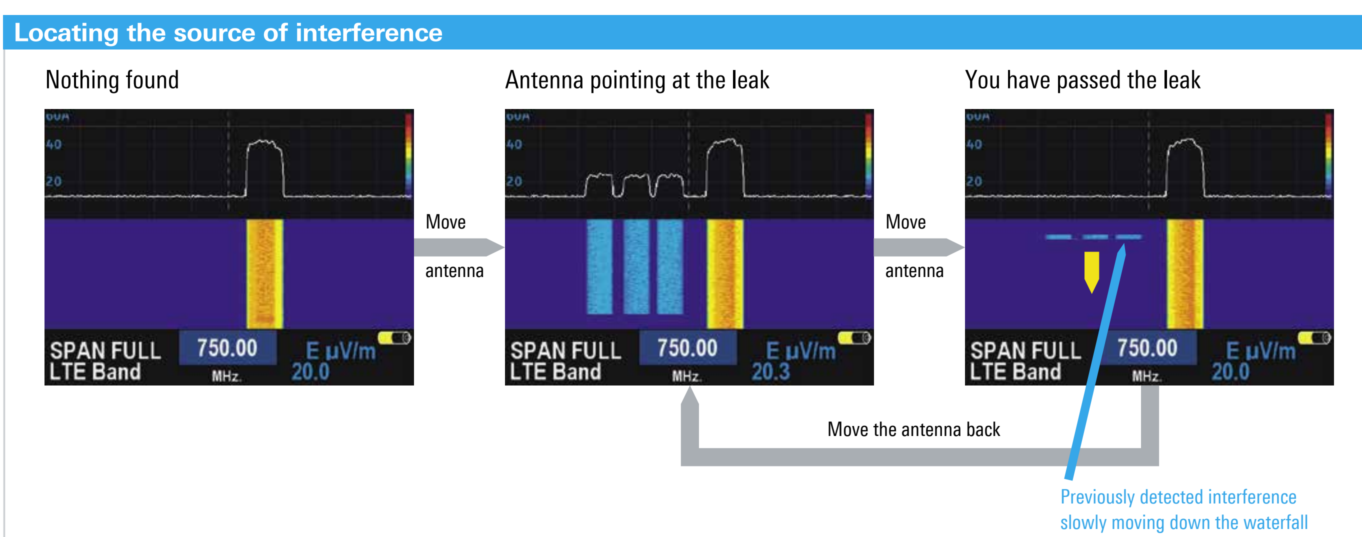


Fig. 3 Interference sources can be easily located using the directional antenna and spectrogram display.

New concept for communications and intercept antennas on ships

Even on large floating military platforms there is limited space for all the antennas that are required for communications, navigation and intelligence as well as for weapons and radar warning systems. Antenna systems must be individually optimized in terms of frequency range and radiation pattern since the critical applications they support cannot tolerate performance trade-offs. Extensive studies by Rohde&Schwarz on behalf of the German navy targeted at solving such challenging problems delivered results that have now been transformed into innovative products.

Antenna systems — where less can be more

The demand for communications lines as well as additional antenna-based applications on board ships is growing, and this trend is expected to continue in the future. Mechanical designers are faced with difficult challenges as they have to arrange all the antennas at optimum positions and avoid performance trade-offs despite space constraints. The level of expertise required for mechanical design and placement is very high since the antennas must not be negatively impacted by the ship's structures or adjacent antennas and they must avoid interfering with one another. The consequences could be fatal, and the affected communications systems would experience a loss of efficiency. For example, the circularity in the pattern of antennas that are otherwise omnidirectional could be degraded or their vertical radiation pattern could exhibit an unfavorable change. This would shift the main lobe, decrease the antenna gain in the relevant direction and possibly even cause nulls to appear at certain azimuth and elevation angles. As a result, it would practically be impossible to meet special military requirements (STANAG), e.g. for omnidirectional coverage for communications links.

Rohde&Schwarz has long worked to overcome this challenging problem and has developed solutions as part of its extensive studies on behalf of the German navy. The theoretical results generated by these research activities have now been transformed into products including innovative communications antennas and a highly integrated DF and monitoring antenna system. All the new systems require significantly less individual antennas and perfectly meet the complex and growing technical requirements for equipment used on board ships.

New concept eliminates antenna overcrowding on ships

In addition to the requirement for absolute circularity in the pattern, the product design description also wanted Rohde&Schwarz to optimize the elevation radiation pattern. Frequently, the radiation patterns of conventional antennas deteriorate by developing side lobes except in the case of narrowband antenna models. The gain in the direction of the horizon exhibits a sizable drop. As a result, the main lobe does not cover the horizon. Nulls can interrupt communications – a problem that must be strictly avoided during communications with approaching aircraft.

The impressive radiation patterns of the new R&S®AD066FW broadband VHF/UHF communications antenna (Fig. 1) demonstrate what advanced antenna design can achieve. The antenna operates across an extremely wide frequency range from 118 MHz to 453 MHz. Highlight: The antenna is made up of circularly arranged individual radiators that are interconnected into a beam forming network (BFN). This clever design delivers outstanding circularity in the radiation pattern of typically ±0.6 dB and enables usage as a multiple link antenna. Multiple VHF and UHF radio lines (or even all radio lines as a function of the radio concept) on board the ship are connected to an antenna and operated simultaneously (Fig. 2). This significantly reduces the number of antennas required on ships and also reduces the variety of problems associated with antenna interactions.

In order to achieve the decoupling between the transmit and receive paths that is necessary for proper reception, it is recommended to use a second (identical) antenna arranged above the first antenna. Due to the design-driven optimization of the mast decoupling achieved with the R&S®AD066FW, impressive isolation figures of 40 dB or more are possible even when the antennas are stacked directly. The antenna's modular design allows adaptation to a wide variety of mast diameters with comparable electrical

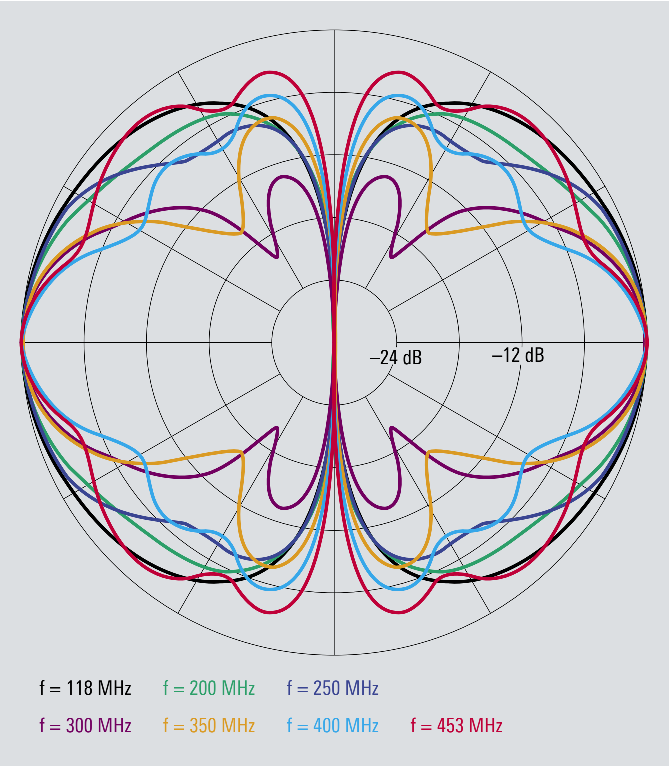


Fig. 1 New R&S®AD066FW broadband VHF/UHF communications antenna with vertical patterns (relative electric field strength).

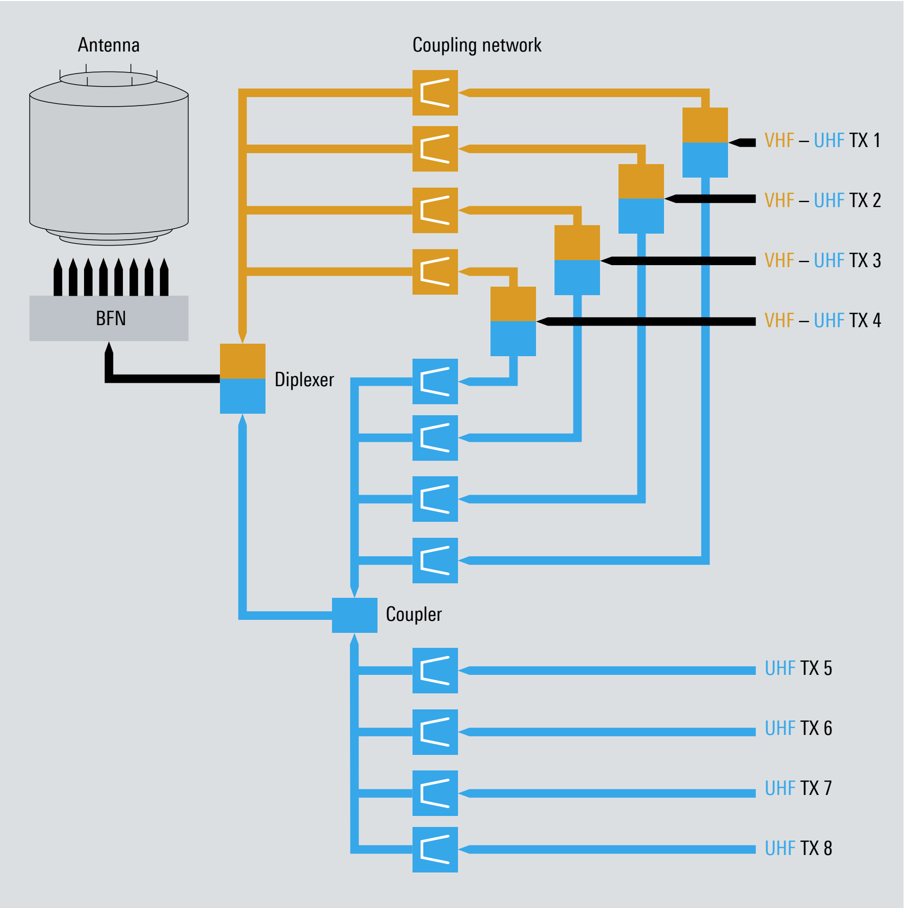


Fig. 2 Basic principle of a multiple link antenna with beam forming network on eight radio lines.

Fig. 3 The R&S®AD016M broadband communications antenna operates in the frequency range from 960 MHz to 1220 MHz and is ideal for applications involving the LINK 16 data radio standard. Due to its stackability, the top of the mast is free for other sensors.

specifications. The detached, exchangeable BFN improves stackability and simplifies maintenance.

Another advantage of this antenna design is that mounting is possible even in an exposed position using a suitably dimensioned mast. An appropriate mast, which can ideally be extended up to the highest point of the ship, can accommodate additional transmit antennas or sensors both below and above the R&S®AD066FW so their performance can benefit from the "panoramic view" available there. For example, this might be tactical data link (TDL) antennas and especially the R&S®AD016M broadband communications antenna (Fig. 3). This antenna is also new and has a design similar to the R&S®AD066FW.

The R&S®AD016M operates in the frequency range from 960 MHz to 1220 MHz and is ideal for applications involving the LINK 16 data radio standard. Due to the stackability, this application does not require a separate mast or mounting on a cross-arm that would invariably impact the circularity of the radiation pattern. Moreover, the top of the mast is left free for other additions — a basic requirement for innovative new antenna concepts. Why? The top of the mast is reserved for antennas that by necessity must be placed at the highest point on the ship such as sensors for sensitive intelligence systems.

Space-saving: a highly integrated antenna system

Rohde&Schwarz has developed equipment and antennas for intelligence systems for decades now. Since these systems are expected to cover constantly expanding frequency ranges, optimized antenna systems with sensors for widely diverse frequency bands are growing in importance. Rohde&Schwarz has taken this requirement into account with a new, highly integrated DF and monitoring antenna system: The R&S®ACD001 integrated C/R-ESM antenna system (Fig. 4) covers the frequency range from 1 MHz to 18 GHz and can be extended up to 40 GHz with an option that can be integrated into the system. Ideally, the antenna system should be positioned at the top of a mast. In systems with digital direction finders, receivers and signal analyzers from Rohde&Schwarz, outstanding overall performance can be achieved.

The key facts of the R&S®ACD001 are as follows:

- Reception of signals with vertical, horizontal and circular polarization
- Omnidirectional and directional radiation patterns simultaneously over entire frequency range
- Usable as DF and monitoring antenna
- Effective lightning protection (mandatory due to positioning at top of mast)
- Outstanding EMC shielding (e.g. in case of exposure to radar signals)

Fig. 4 R&S®ACD001 integrated C/R-ESM antenna system for the frequency range from 1 MHz to 18 (40) GHz.

The R&S®ACD001 antenna system can be used independently or in combination with the stackable antennas presented here. By choosing the appropriate antennas and placing them carefully on the ship, it is possible to meet many requirements despite inherent space constraints. Fig. 5 gives an example of the design of a compact mast structure and how to place such high-performance antenna arrays on ships.

All antennas from Rohde&Schwarz are built to withstand extreme ambient conditions since the exposed position due to RF-related reasons demands a high level of shock resistance and high immunity to electric discharge. Their radar cross-section has been minimized in order to best limit the exposure to enemy reconnaissance.

Overview of other innovative products

In order to satisfy increased environmental requirements, Rohde&Schwarz has improved its existing portfolio of conventional ship antennas in parallel with the development of new "integrated antennas". The antennas listed below were specially designed for ship applications and are optimized for top RF performance, low weight and small dimensions.

A good example is the slender R&S®AD066ST UHF omnidirectional antenna with its very rugged mechanical design (Fig. 6). It is ideal for frequency-agile communications systems in the frequency range from 225 MHz to 400 MHz that demand a high level of decoupling between the transmit and receive paths.

Fig. 5 Sample design of a mast structure with possible arrangement on board ships.

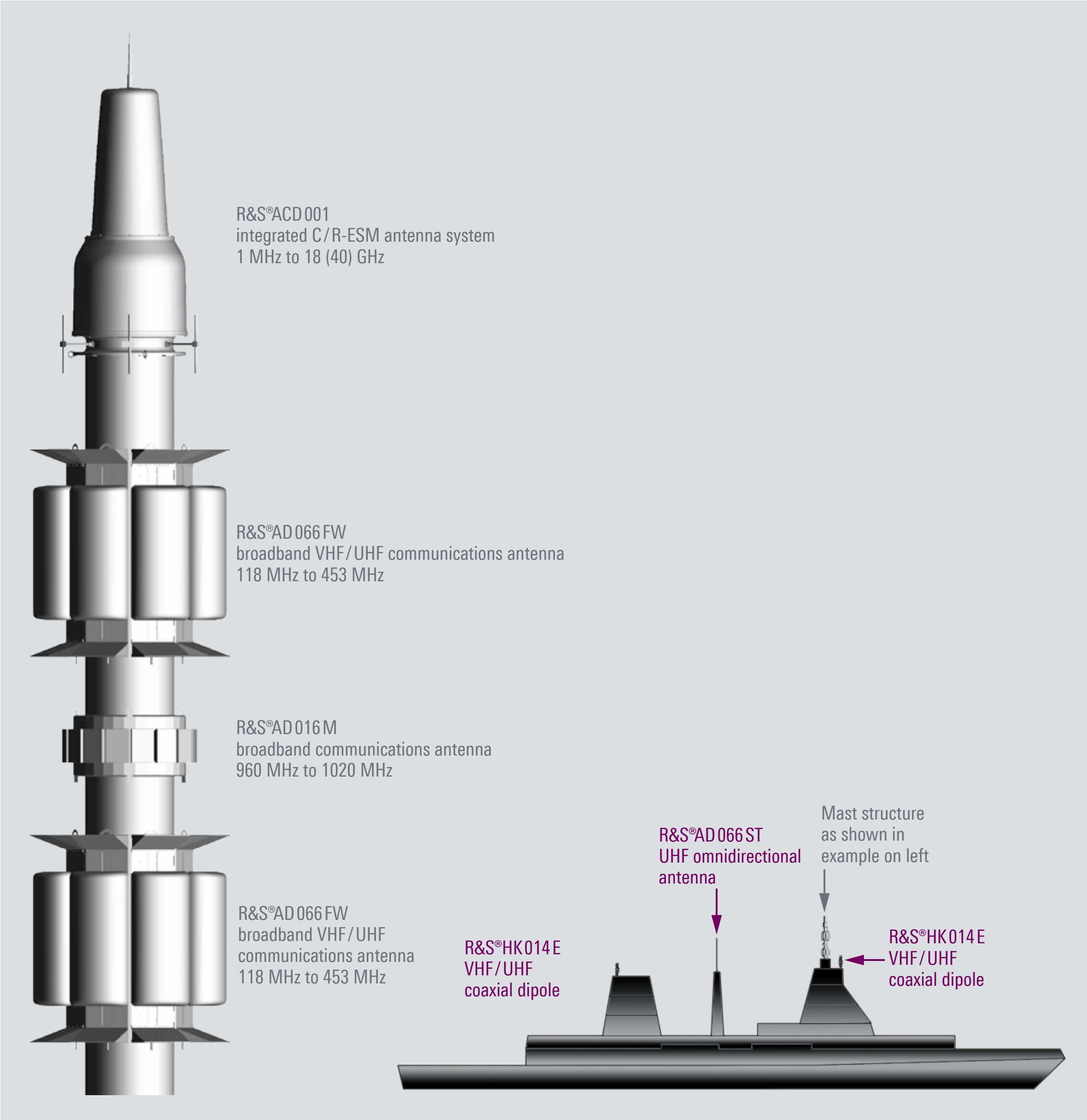


Fig. 6 R&S®AD066ST UHF omnidirectional antenna.

The new R&S®AD033V3 UHF omnidirectional antenna (Fig. 7) uses a similar approach as the R&S®AD066FW broadband VHF/UHF communications antenna (Fig. 1). Except for the frequency range (UHF only; 225 MHz to 450 MHz), it has comparable properties but is smaller and lighter.

Even the R&S®HK014 omnidirectional VHF/UHF coaxial dipole, which is very broadband with respect to its size and has been successfully used for decades in various civil and military applications, has undergone reworking to meet increased environmental requirements. The result is the R&S®HK014E VHF/UHF coaxial dipole (Fig. 8), which also features improved RF figures and a more favorable radiation pattern.

The new R&S®AD016MC compact broadband transmit antenna (Fig. 9) can be used as an alternative to the R&S®AD016M broadband communications antenna in cases where no stacking is required. Despite the same power handling capacity, it is significantly more compact and lightweight than the R&S®AD016M. Its wide frequency range from 800 MHz to 8000 MHz also allows it to be used with other services besides LINK 16.

Fig. 8 The R&S®HK014E VHF/UHF coaxial dipole features improved RF figures and a more favorable radiation pattern.

Summary

The Rohde & Schwarz portfolio of individual antennas and antenna systems for use on board ships has been significantly expanded and reworked. This allows antenna implementations to satisfy extremely demanding electrical and mechanical requirements while taking individual customer requirements into account.

Klaus Fischer; Andreas Knüttel

Fig. 7 R&S®AD033V3 UHF omnidirectional antenna for 225 MHz to 450 MHz.

Fig. 9 The R&S®AD016MC compact broadband transmit antenna with its wide frequency range from 800 MHz to 8000 MHz can also be used with other services besides LINK 16.

R&S®EB510 HF monitoring receiver for gapless shortwave radiomonitoring

Even in the age of Internet and worldwide satellite communications, employing communications links in the shortwave range remains attractive because of the great advantages offered. As a result, there is still a high demand for radiomonitoring tasks in the shortwave range. This article provides several examples that illustrate how the R&S®EB510 HF monitoring receiver can be used universally for these applications.

R&S®EB510 HF monitoring receiver

Today, shortwave communications is still attractive because long distances can be bridged without requiring costly infrastructure (see box on page 77). As a result, there is still a high demand for radiomonitoring in the shortwave range. The compact, highly sensitive R&S®EB510 HF monitoring receiver (Fig. 1) is ideal for shortwave radiomonitoring because it covers the frequency range from 9 kHz to 32 MHz. It offers realtime bandwidths up to 32 MHz and digital I/Q data up to 5 MHz. With its excellent HF characteristics (including direct sampling with low phase noise), powerful digital signal processing and a variety of useful functions (such as different scan modes and multichannel demodulation), it covers virtually all radiomonitoring tasks. It can be used as a sensor node, as a handoff receiver, as a standalone radiomonitoring receiver, in frequency management and for many other applications.

Fast, high-resolution frequency scan

Due to its realtime bandwidth of 32 MHz, the receiver makes active transmitters visible in the HF spectrum at a glance. For higher resolutions (step sizes < 10 kHz) the panorama scan option (R&S®EB510-PS) is available. It allows users to refine the resolution to 0.1 kHz, regardless of the frequency range of interest. Finer resolutions boost sensitivity, extend the dynamic range and ensure greater immunity to signals in adjacent channels. This makes it possible to capture more signals in the spectrum (Fig. 2).

Fig. 1 R&S®EB510 HF monitoring receiver with front panel.

Fig. 2 Top: Fixed frequency mode (FFM) within the realtime bandwidth of 32 MHz at a resolution of 10 kHz. Bottom: Panorama scan (PS) mode with resolution refined to just 1 kHz captures more emissions (highlighted in red).

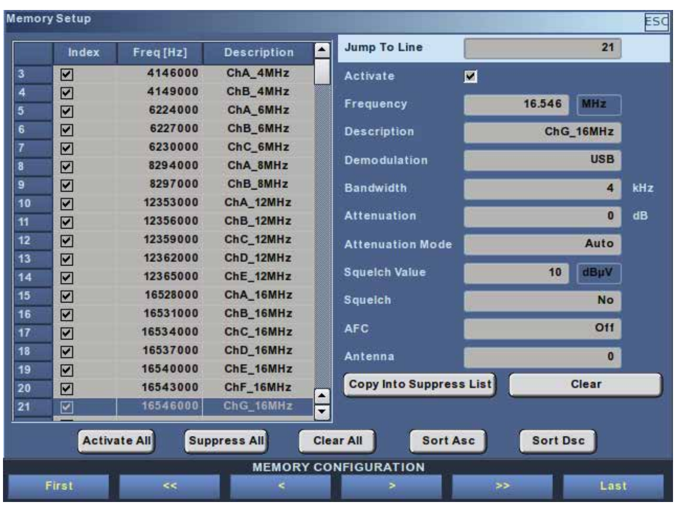


Fig. 3 Frequency storage settings menu.

Versatile R&S®EB510: example applications

Radiocommunications monitoring using memory scan

Shortwave communications is subjected to a variety of influences, including fluctuations in the altitude and intensity of ionized layers, periods of heavy solar activity or seasonal effects. This is why users must select the appropriate frequencies when establishing a radio link depending on the time of day, season of the year and the distance to be bridged. To facilitate this task under such extremely diverse conditions, the R&S®EB510 provides up to 10 000 programmable memory locations for storing the frequencies of interest. These frequencies can then be recalled at a scan speed of 1600 channels/s. Every memory location is defined with the frequency, an individual description, the demodulation mode and bandwidth, the attenuation and the squelch values (Fig. 3). Stored frequencies can be copied into a suppression list so that they are excluded from the scan.

Multichannel monitoring

When equipped with the R&S®EB510-DDC option, the receiver has three digital downconverters (DDC). In combination with the main demodulator, it can monitor up to four signals at the same time (Fig. 4). For demodulation, users can apply master settings to all channels or assign different settings to individual channels – e.g. bandwidth and demodulation mode – to make it possible to demodulate the audio content. All the channels (or just some of them) can be output via LAN and recorded for subsequent classification (using the R&S®GX430 PC-based signal analysis and signal processing software, for example).

Fig. 4 Simultaneous monitoring of up to four signals.

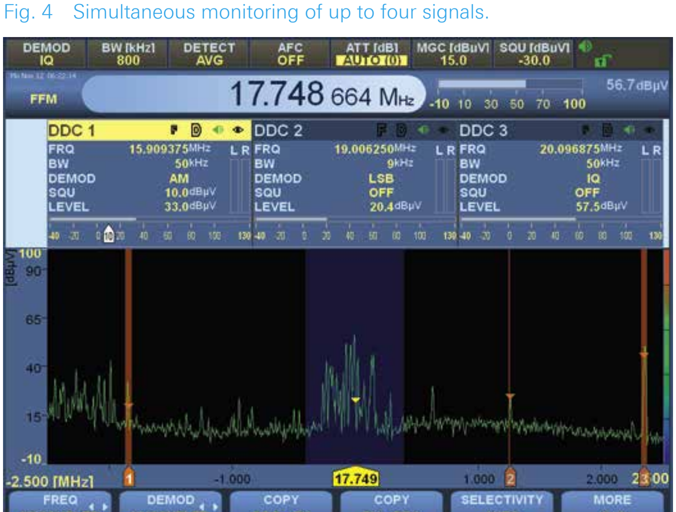
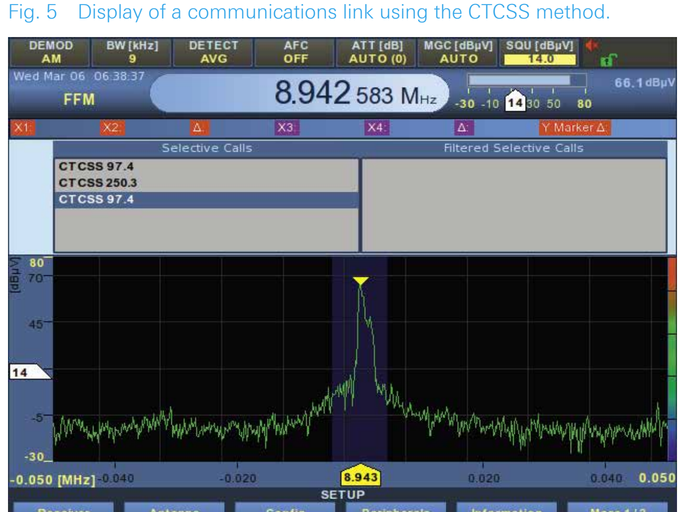


Fig. 5 Display of a communications link using the CTCSS method.



Selective call identification

Selective calling is typically used in mobile land-based or ship-based radiocommunications. This feature makes it possible to address a subset of receivers or to establish a link directly to a specific radio. This prevents interference from other radio traffic on the same channels. The receiver automatically displays received selective call standards and permits the results to be filtered based on specific selective call types.

The R&S®EB510-SL selective call option allows the R&S®EB510 to decode and display numerous selective calling methods: CCIR1, CCIR7, CCITT, EEA, EIA, EURO, DCS, DTMF, CTCSS, NATEL, VDEW, ZVEI1 and ZVEI2. The example in Fig. 5 shows a recorded signal that is coded using the continuous tone-coded squelch system (CTCSS). The frequencies of the two applied tones are 97.6 Hz and 250.3 Hz (numbers 13 and 51).

Summary

With its large realtime bandwidth and innovative gapless signal processing with no blind time, the R&S®EB510 HF monitoring receiver detects low probability of intercept (LPI) signals or frequency hopping and radar signals, and it can demodulate numerous analog transmissions (AM, FM, USB and LSB). Its interface compatibility allows the R&S®EB510 to be integrated easily and efficiently into existing systems and to replace older receivers, such as the R&S®ESMB and the R&S®EB200.

Nellie Pang; Peter Kronseder

Advantages of shortwave communications

In the shortwave range (3 MHz to 30 MHz), communications links can be established over short distances and also over very long distances. In addition to direct line of sight (LOS), there are two other propagation methods: via ground wave and via sky wave.

Within the HF range with its comparably low frequencies and consequently long wavelengths, ground waves can pass through liquids such as sea water as well as solid obstacles.

Multiple reflections between the ground and the ionosphere permit sky waves to cover large distances, even reaching the other side of the globe under favorable conditions. When establishing radiocommunications links under sky wave propagation conditions, users must understand the influences that result from the ionosphere and solar activity and must know what frequencies are suitable based on the season, the time of day and the distance to be bridged.

Shortwave communications systems are easy to deploy and do not require complicated network infrastructures. Typically employed in long-range communications, frequencies in the HF range are used for air-to-ground voice communications as well as for air traffic management, marine communications and the dissemination of meteorological information.

Key features of the R&S®EB510

- Frequency range from 9 kHz to 32 MHz
- Realtime bandwidth (IF spectrum) of up to 32 MHz and parallel demodulation with bandwidths from 100 Hz to 5 MHz
- Fast panorama scan with up to 60 GHz/s across entire frequency range
- High-speed frequency and memory scan with up to 1600 channels/s
- Polychrome IF spectrum for reliable detection of overlain pulsed signals

R&S®EB510 HF monitoring receiver without front panel for remote control via LAN.

The R&S®GX430 signal analysis software now processes up to four channels

The well-established R&S®GX430 PC-based signal analysis and processing software detects, classifies, demodulates and decodes analog and digital signals. The new release, version 4, adds an array of powerful features, including the ability to process signals on up to four channels in parallel as well as fully automatic operation according to user-defined rules.

R&S®GX430 version 4 at a glance

R&S®GX430 is a standalone software solution that analyzes, classifies, demodulates and decodes analog and digital signals. The software runs on a standard Windows® PC, is quick to set up and easy to operate. This PC communicates with Rohde&Schwarz monitoring receivers or direction finders via Ethernet LAN. Besides the software's already existing benefits, the capabilities of R&S®GX430 have been enhanced in the new release to include new key features and multiple improvements:

- Multichannel monitoring, on up to four channels in parallel (formerly, just one) if connected to monitoring receivers or direction finders with internal digital downconverters (DDC), such as the R&S®ESMD wideband monitoring receiver
- Fully automatic signal processing, by applying user-defined rules
- Integration of third-party receivers, by developing customized receiver drivers
- Signal recording on R&S®AMREC digital wideband storage devices; signal replaying with overview spectrogram

Multichannel monitoring

In dense signal scenarios, the ability to process multiple channels concurrently is essential. To handle such situations, the R&S®ESMD is the ideal instrument to combine with the R&S®GX430 software. The R&S®ESMD features a wide frequency range, outstanding receive characteristics, 20 MHz realtime bandwidth (optionally expandable to 80 MHz) and a wealth of functionalities. When equipped with the R&S®ESMD-DDC digital downconverter option, the receiver has four additional DDCs that operate entirely in parallel within the realtime bandwidth and can be parameterized independently of each other. This means that, besides the wideband demodulation path, R&S®GX430 receives up to four downconverted signals from the receiver via the Ethernet LAN interface and processes them. The following DDCs are available, depending on the system configuration:

- R&S®ESMD / R&S®DDF255 direction finder: four internal DDCs (**4 × 1 MHz** bandwidth) for user-defined placement within the receiver's realtime bandwidth of up to **80 MHz** (Figs. 1 to 3)
- R&S®EB500 monitoring receiver / R&S®DDF205 direction finder: three internal DDCs (**3 × 1 MHz** bandwidth) for user-defined placement within the receiver's realtime bandwidth of up to **20 MHz**
- R&S®EB510 monitoring receiver: three internal DDCs (**3 × 150 kHz**) for user-defined placement within the receiver's realtime bandwidth of up to **32 MHz**

R&S®GX430 key facts

- **NEW:** Multichannel monitoring of up to four channels in parallel (4 × 1 MHz bandwidth)
- **NEW:** Fully automatic signal processing, by applying user-defined rules
- **NEW:** Integration of third-party receivers
- **NEW:** Signal recording on R&S®AMREC; signal replaying with overview spectrogram
- Detection, classification, demodulation and decoding of analog and digital signals
- Online and offline signal processing
- Automatic and manual signal measurement
- Modulation type and transmission system classification
- Powerful classifier and extensive library of demodulators and decoders
- Automatic signal search and classification of signals in a user-defined frequency range
- Precise measurement of all technical signal parameters (bandwidth, level, modulation type, symbol rate, shift, etc.)
- Measurements in line with ITU-R SM.1600

Fig. 1 Example of a system configuration with the R&S®ESMD wideband monitoring receiver. The R&S®ESMD can provide the R&S®GX430 software with up to four DDC channels (each with a bandwidth of 1 MHz) in the frequency range from 9 kHz to 26.5 GHz. The DDC channels can be located anywhere in the receiver's 80 MHz realtime bandwidth.

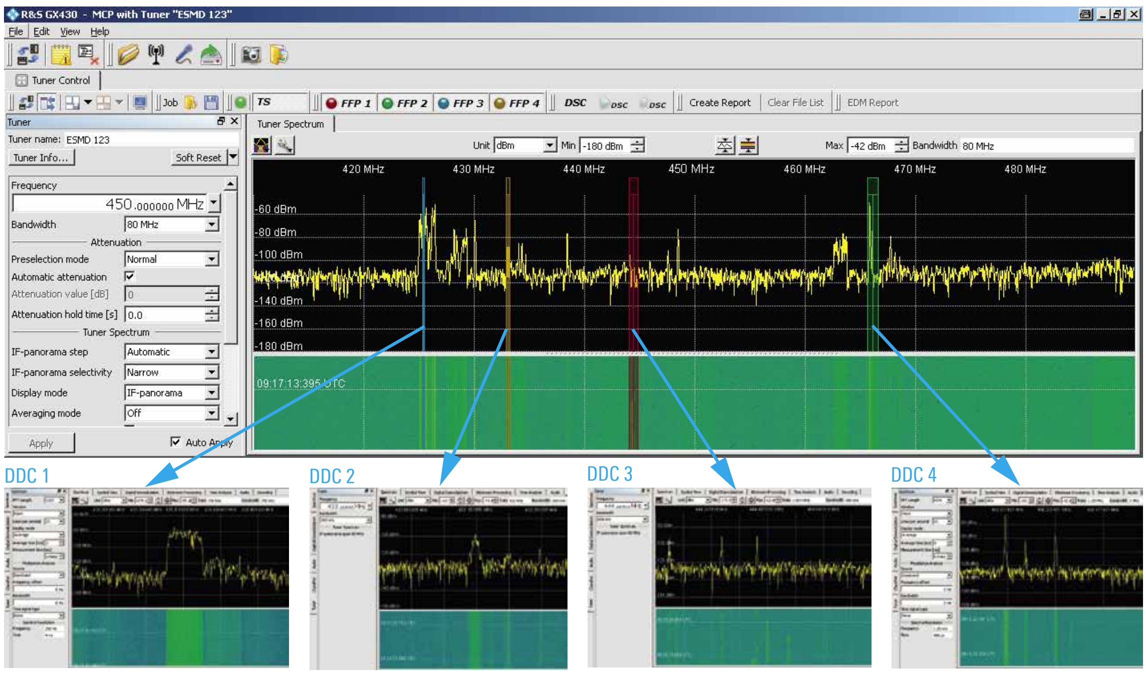


Fig. 2 The R&S®GX430 signal analysis software can process up to four channels within the receiver's realtime bandwidth by using the DDCs from the receiver.

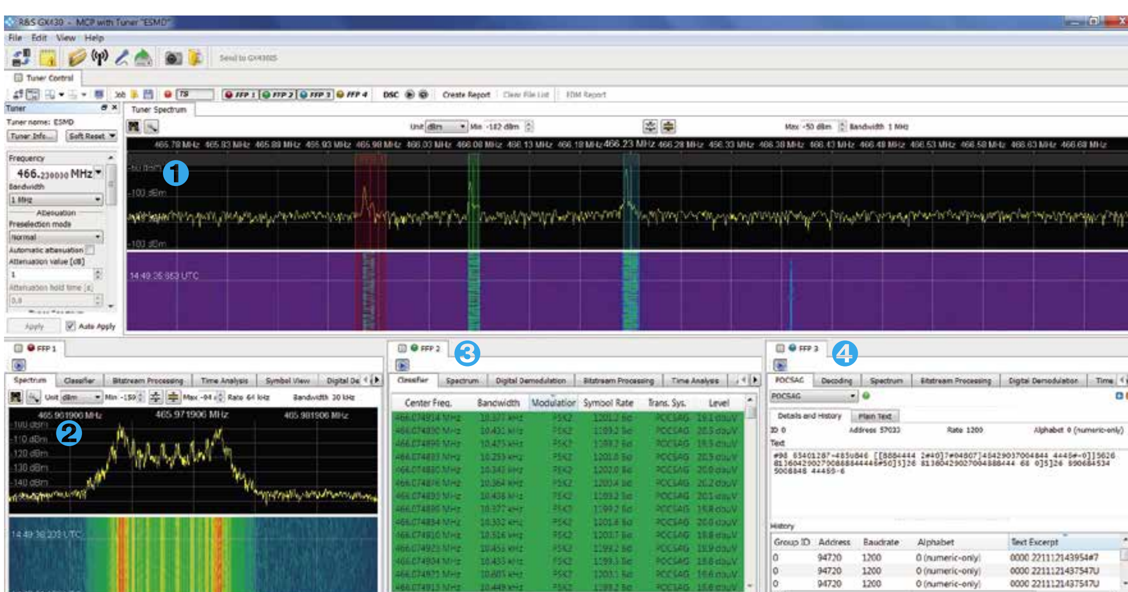


Fig. 3 Example of processing of three signals:
❶ wideband spectrum of R&S®ESMD receiver with position of three avtivated DDCs;
❷ spectrum of first signal;
❸ result of classification of second signal;
❹ decoded text of third signal.

Fully automatic signal processing

An important new feature in R&S®GX430 is its ability to combine signal detection and classification with fully automatic signal processing (demodulation, decoding and recording). This enables the system to independently monitor a wide frequency range, eliminating routine user tasks. The monitoring receiver can operate in fixed frequency or scanning mode. An automatic signal detector is used to detect and monitor

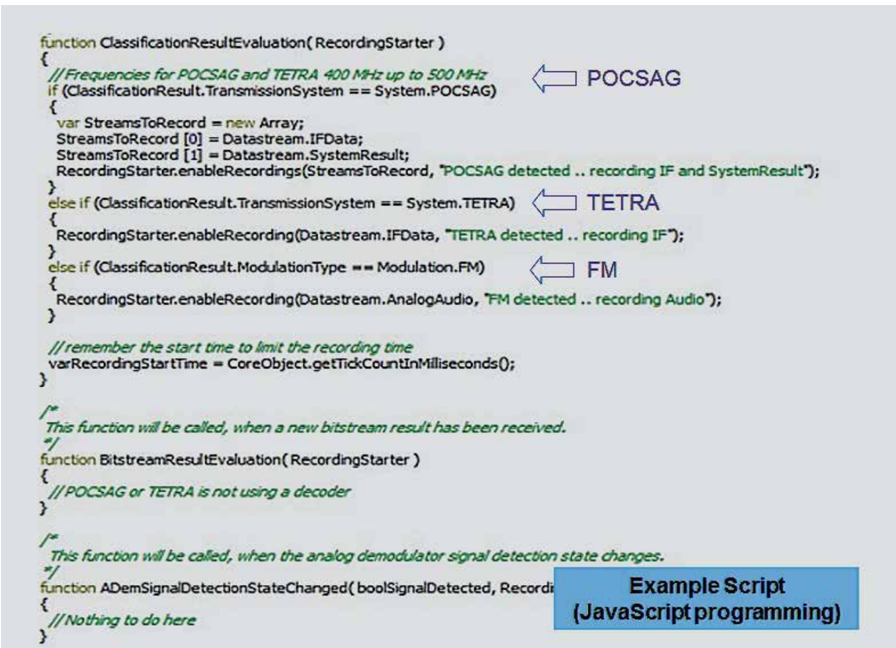


Fig. 4 Example of a script containing user-defined rules (here, automatic handling of POCSAG, TETRA and analog FM signals). Each action is triggered fully automatically, which reduces user workload by automatically processing detected signals.

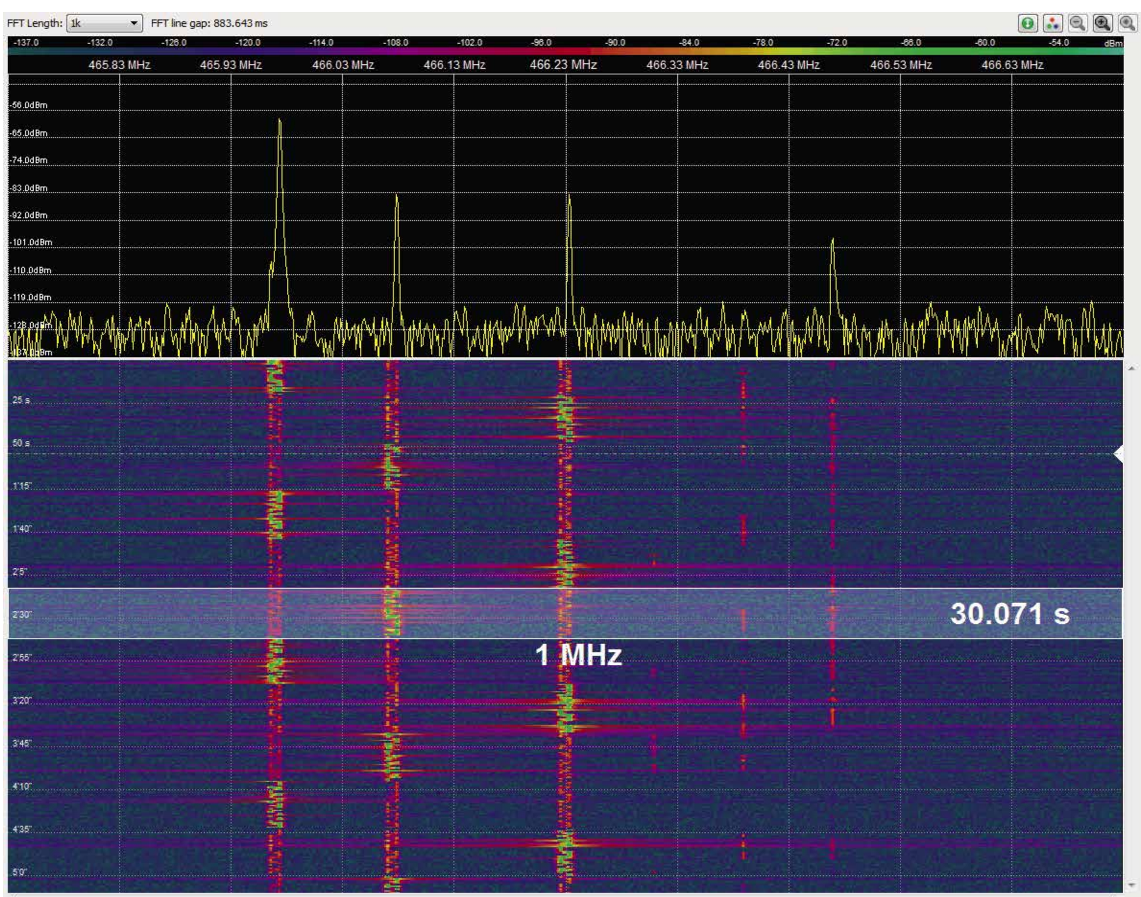


Fig. 5 A spectrogram provides an overview of a signal recording over a period of five minutes. A 30 s segment has been selected for replay.

active signals based on their spectral energy. The available DDC channels are automatically assigned to detected signals, and the signal types are classified. Depending on the signal type, the software automatically initiates and executes actions according to rules that the user has defined through an easy-to-operate script interface. Such actions include triggering an alarm/notification, starting a recording, or demodulating/decoding signals of interest (Fig. 4).

Integration of third-party receivers

R&S®GX430 works best with direction finders and receivers from Rohde&Schwarz, such as the R&S®ESMD, R&S®EB500 or R&S®EB510. However, to enhance the software's flexibility and extensibility, users can now incorporate customized drivers to support third-party receivers. Users can develop and install their own drivers; they are implemented as a Windows® dynamic link library (DLL) and run in R&S®GX430. The drivers are needed to convert third-party receivers' commands and data formats into the dedicated commands and data stream formats used by Rohde&Schwarz receivers. The required C++ source code framework will be provided by Rohde&Schwarz. The company also has expert trainers who can assist customers' programmers with the development process.

Signal recording and replaying

The R&S®GX430 software can now directly access R&S®AMREC digital wideband storage devices such as R&S®GX425, R&S®GX460 and R&S®GX465. For complex signal scenarios, the recommended approach is to record the signals for subsequent analysis. R&S®GX430 can also record signals to and replay them from the local hard disk.

Moreover, the software offers an additional function for managing the recorded signals. The signal recordings can be represented in an overview spectrogram, and the sections for replay can be defined (Fig. 5). As the user moves the cursor over the spectrogram, the spectrum line is calculated accordingly. This enables the user to define the start/end point and the looping portion for quick and easy replay. The overview spectrogram offers numerous benefits:

- Convenient navigation even in long signal recordings (several hours)
- Clear overview of the entire recording's signal scenario
- Reliable detection of relevant signal activity
- Reduction in replay time by focusing only on a selected replay section of the signal

R&S®GX430 and R&S®GX435 compared

R&S®GX430 and the R&S®GX435 multichannel signal analysis system (see article on page 82) have similar features but are intended for different applications (Fig. 6). R&S®GX430 is specially designed for easy setup and for installation on a Windows® PC; it is tailored for direct user operation, and therefore remote control is not provided. It can only control one receiver and handle up to four channels at once. In replay mode, it can process only a single channel because it cannot utilize the receiver's DDCs. It provides the following interfaces for working with R&S®RAMON systems: ReportEdit, master-slave handover, reporting to RAMON signal database, AllAudio.

Criteria	R&S®GX430	R&S®GX435
Maximum number of monitoring receivers supported in parallel	1	multiple
Maximum number of channels processed per monitoring receiver	4	126
Maximum number of channels processed during replay of recorded signal scenarios	1	32
Remote control over LAN or WAN	no	yes

Fig. 6 Key differences between R&S®GX430 and R&S®GX435.

By contrast, the R&S®GX435 multichannel signal analysis system is designed for configurations with multiple monitoring receivers and can process up to 126 channels per receiver. In replay mode, it can process up to 32 channels by using its own DDCs. The R&S®GX435 system integrates optimally with other sensor subsystems in R&S®RAMON systems. As a result, it can be controlled remotely over a LAN or WAN.

New dongles

Users can purchase version 4 as an upgrade from the prior software version (V02.8x). When they upgrade, their old USB copy protection and licensing dongle will be replaced with a new copy protection device. Users can choose between a USB dongle, a USB mini dongle or an SD card.

Summary

R&S®GX430 is a software solution that runs on standard Windows® PCs and is designed to monitor signal scenarios, either manually or fully automatically according to user-defined rules. The latest release, version 4, can process up to four channels in parallel. It also allows users to write and integrate their own driver software for third-party receivers, and can record and replay signals on R&S®AMREC systems.

YingSin Phuan

Automatic radiomonitoring with the R&S®GX435 signal analysis system

R&S®GX435 is a powerful, flexible, fully automatic solution for detecting, classifying and processing radiocommunications signals. It is used in multichannel monitoring systems in combination with Rohde&Schwarz monitoring receivers to process signals from the HF to the SHF range.

R&S®GX435 at a glance

The R&S®GX435* multichannel signal analysis system supports a wide spectrum of applications ranging from manual signal processing and analysis of an individual signal to automatic recognition of all the signals in a wideband signal scenario. The software runs on modular, easy-to-maintain hardware components (Fig. 1), connected to Rohde&Schwarz monitoring receivers. R&S®GX435 is scalable, from a few channels up to systems with 126 channels per receiver. It also provides open interfaces for integrating customized signal processing modules.

R&S®GX435 combines powerful signal classifiers and an extensive library of demodulators/decoders with automatic signal processing workflows. Users can adapt these extensive resources flexibly to suit their own specifications and requirements. To achieve the most effective signal search and detection workflow, the system supports three different operating modes.

Detection of fixed frequency and burst signals

Basics

R&S®GX435 has been specially tailored for fully automatic signal searching, monitoring and processing. The system supports a combination of automatic signal detection and classification with automated signal processing (demodulation, decoding and recording).

In automatic signal detection, the system monitors user-selected frequency ranges for fixed frequency and burst signals. The detector detects signal events in the receiver's FFT spectrum based on spectral energy levels above a defined threshold. This threshold is adapted to reflect the current noise floor. The software generates a detection result for every detected signal that matches the predefined criteria (bandwidth, level, etc.) and compares the results cyclically with the results from prior processing cycles. The detected signals can be classified and measured automatically. The system reports the following emission events:

* The system was presented in NEWS (2011) No. 204, pp. 58–61. It is now marketed as the R&S®GX435 multichannel signal analysis system, with enhanced features and new hardware modules.

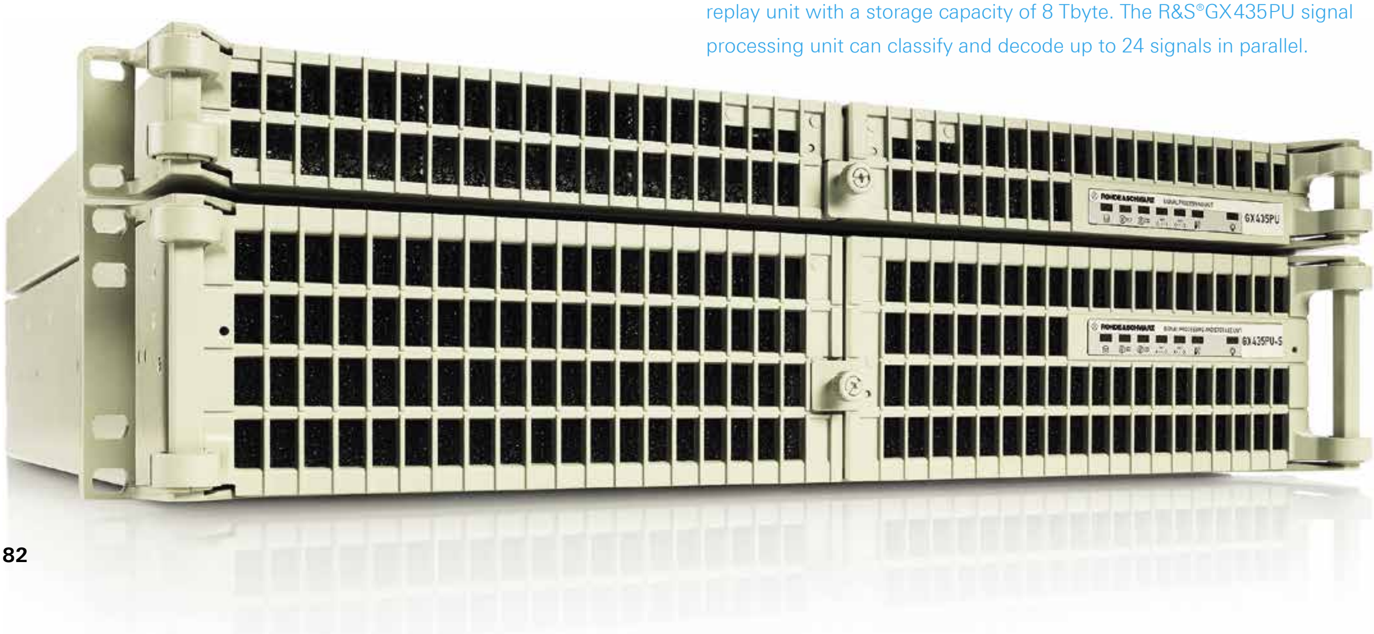


Fig. 1 R&S®GX435 comprises two main hardware components based on multicore PC server technology. The R&S®GX435PU-S signal processing and storage unit (lower component) controls the system, detects the signals, computes the digital downconverters and serves as a recording / replay unit with a storage capacity of 8 Tbyte. The R&S®GX435PU signal processing unit can classify and decode up to 24 signals in parallel.

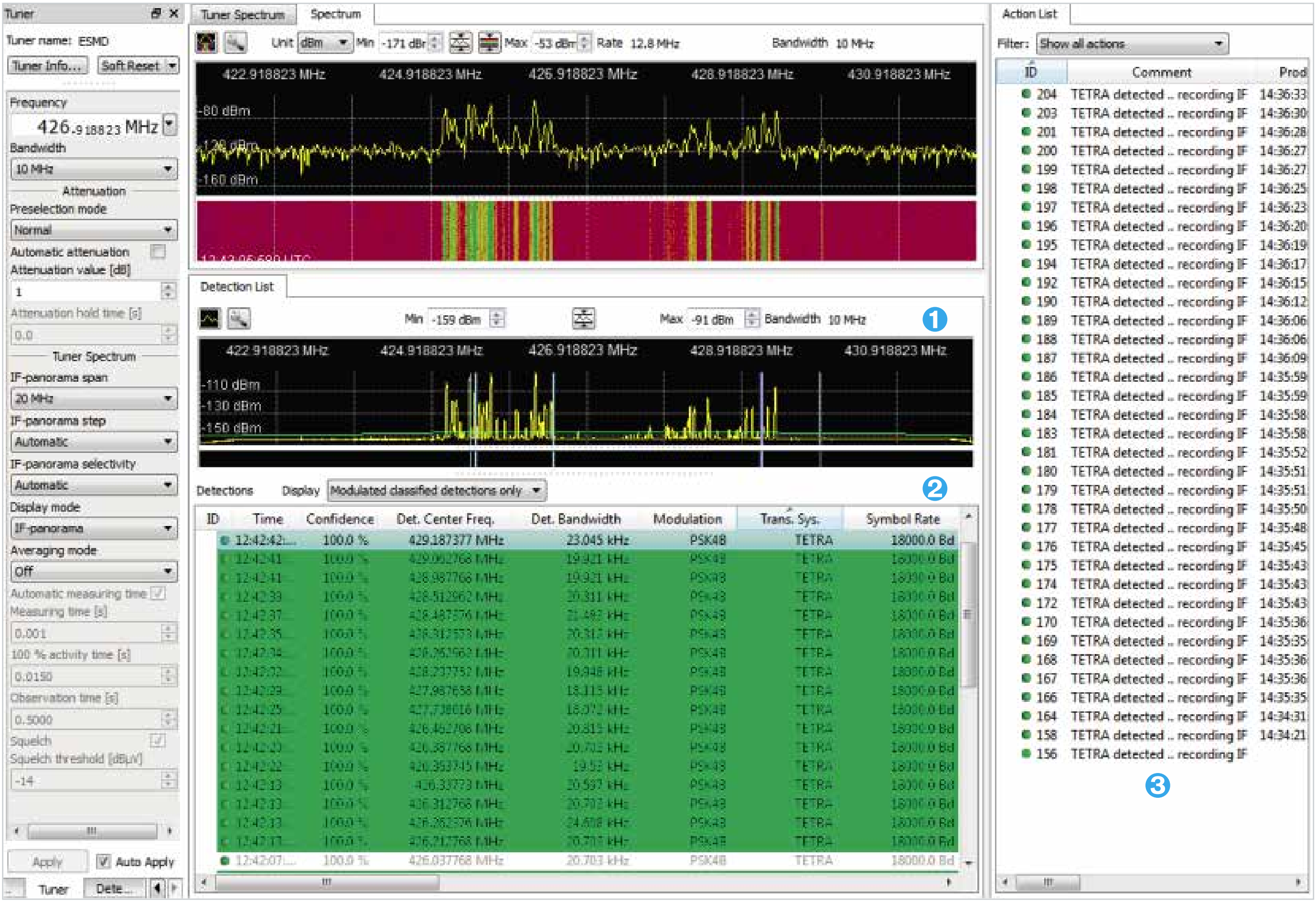


Fig. 2 The fixed frequency mode (FFM) automatically searches for and detects all signals based on their spectral energy (❶) in a defined frequency range within the receiver's realtime bandwidth. The classifiers are then automatically assigned in sequence to the detected signals and the results are compiled in a list (❷). A user-defined rule is applied to each detected signal. The automatic actions that are triggered are logged in a result list (❸).

- New signals (signals exceeding the set threshold for the first time)
- Changes in the characteristics of known signals (changes in the level, bandwidth or center frequency)
- Inactive signals (signals whose level falls below the set detection threshold)
- End of signal

The detector monitors the emission event, determines the emission parameters and tracks the signals based on their assigned emission IDs.

For automatic searching and classification, users can configure the number of classifiers to be used, the desired classification depth and the rules for automatic processing of the detected signals. The classifiers automatically determine the modulation parameters and codes of the emissions found. When more classifiers are allocated, signal scenario reconnaissance is faster and the number of emissions that can be classified in parallel increases. For fully automatic signal processing, users can configure a rule-based automated workflow.

R&S®GX435 has three signal detection modes:

1. Fixed frequency mode (FFM)
2. Scanning mode (with several handoff receivers)
3. Stepping mode (with a single wideband monitoring receiver)

1. Fixed frequency mode (FFM)

Application: automatic signal scenario monitoring and signal detection up to 80 MHz realtime bandwidth, with subsequent automatic signal processing and content recovery.

The monitoring receivers are connected to R&S®GX435 via an Ethernet LAN interface. In the basic version, each receiver delivers an I/Q data stream with a realtime bandwidth of up to 10 MHz. Signal content is extracted with the aid of digital downconverters (DDC) and then processed in parallel, i.e.

classified, demodulated, decoded and the I/Q data recorded (Fig. 2). Each DDC can set its center frequency and bandwidth within the limits of the monitoring receiver's realtime bandwidth. R&S®GX435 works best with Rohde&Schwarz monitoring receivers such as the R&S®ESMD, R&S®EB500 and R&S®EB510. With user-developed drivers, third-party receivers can also be integrated.

The R&S®DDF225 digital direction finder and wideband monitoring receivers such as the R&S®ESMD can be optionally equipped with a board for hardware-accelerated signal processing. The board has four field-programmable gate arrays (FPGA) that support powerful signal processing functions. The most important of these functions are for increasing the detection bandwidth up to 80 MHz and extract a large number of signals via DDCs, enabling the R&S®GX435 multichannel signal analysis system to access wideband signal scenarios up to 80 MHz (HF: 20 MHz) per receiver in realtime for concurrent processing of up to 32 channels (HF: 126).

2. Scanning mode
(with several handoff receivers)

Application: continuous searching for new emissions in a wide frequency range while processing detected signals in parallel.

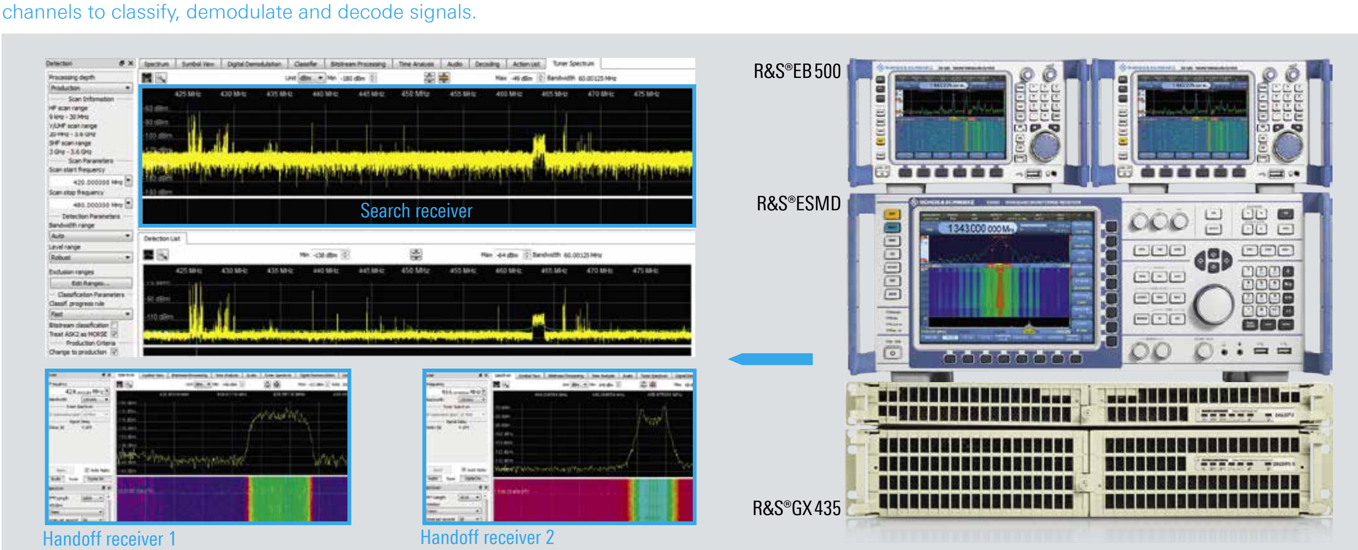
A search receiver is essential when it comes to detecting signals across a wide frequency range. The receiver operates in scanning mode and works with several handoff receivers. The search receiver continuously monitors the spectrum within the set frequency range using panorama scan, and the automatic detector in R&S®GX435 detects all the signals in the range. The handoff receivers act as parallel processing channels to classify, demodulate and decode the detected signals (Fig. 3).

3. Stepping mode
(with a single wideband monitoring receiver)

Application: automatic detection and monitoring of a wide frequency range using a single wideband monitoring receiver; this mode is intended for systems with limited resources.

Compared with the scanning mode described above, the stepping mode only requires a single wideband monitoring receiver with scanning capabilities. First, the receiver operates in scanning mode and searches for emissions in the set frequency range. Next, the scanning mode is halted and the automatic detector searches the spectrum for emissions in the same way as in the fixed frequency mode (see above). The entire scan range is then processed in steps of 10 MHz using DDCs to extract the signals. Steps of 80 MHz are possible using an R&S®ESMD receiver or an R&S®DDF255 direction finder fitted with the hardware-accelerated signal processing board.

Fig. 3 In the scanning mode, the R&S®ESMD wideband monitoring receiver operates as a search receiver, continuously monitoring the spectrum for emissions. Two R&S®EB500 handoff receivers act as processing channels to classify, demodulate and decode signals.



Detecting frequency-agile short-time signals

Application: monitoring frequency-agile radiocommunications.

Besides detecting fixed frequency or burst signals, R&S®GX435 can also automatically detect frequency-agile short-time signals (hoppers). These are intercepted by a detector optimized specifically for this signal type. The detector analyzes each individual hop to determine the relevant technical parameters. This makes it possible to classify each hop and assign it to the relevant transmission system. The software evaluates the parameters statistically and displays the results as a histogram (Fig. 4). It also presents the detection results as a list of short-time emissions along with various parameters, such as frequency, bandwidth, power, start/stop intervals, duration as well as modulation type and modulation parameters. This information enables users to determine the active hopper transmitters and the types of hopper radios.

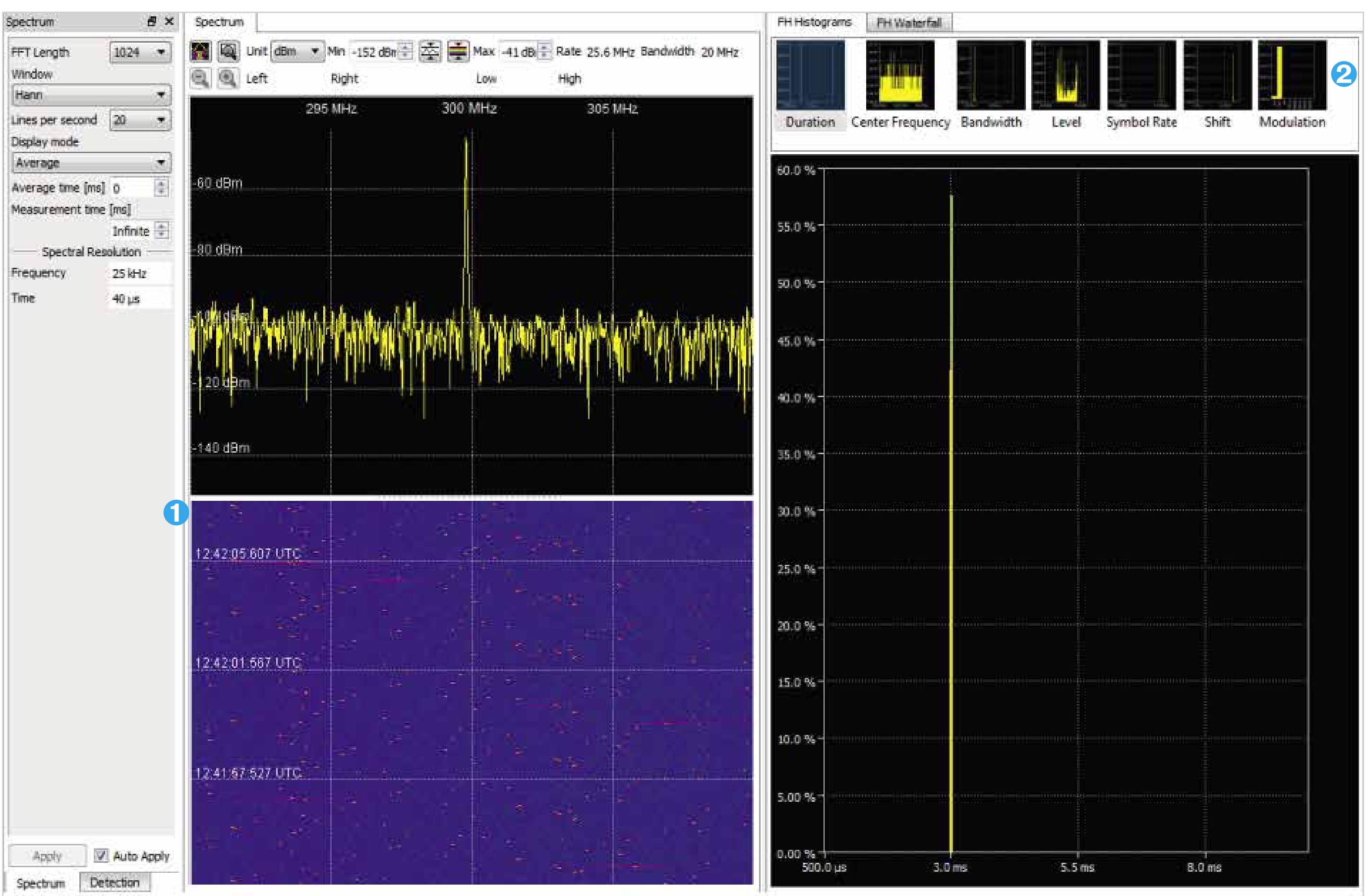
Summary

R&S®GX435 is a modular, automatic radiomonitoring system for multichannel analysis and processing of analog and digital signals. Thanks to its various signal detection modes and sophisticated signal detectors, it offers fast, reliable and precise signal detection as well as subsequent classification, demodulation, decoding and recording of the signals.

An additional detector, referred to as spectral shape detector, is due to be available in the second half of 2013. It is capable of matching signals based on their spectral shape. Users can then define the spectral shapes of signals of interest, based on either live or recorded signals.

YingSin Phuan

Fig. 4 The spectrum and the waterfall diagram show a frequency hopping signal in the defined frequency range (❶). The histograms (❷) display various emission characteristics (hop duration and bandwidth, modulation type, symbol rate, etc.).



New production plant in Malaysia

At the beginning of December 2012, Rohde & Schwarz opened its new production plant in Malaysia. Johann Kraus, Plant Manager of Rohde & Schwarz Teisnach, will also be the new Managing Director of Rohde & Schwarz Technologies Malaysia Sdn Bhd. The new production site in Johor Bahru and its 25 employees will be responsible for assembly and final testing of T&M instruments for the world market.

Symbolic ribbon cutting (left to right): Patrick Pötschke (Supervisory Board), Peter Riedel (Supervisory Board), Dr. Günter Gruber (German Ambassador in Malaysia), Manfred Fleischmann (President and CEO of Rohde & Schwarz), Dr. Dirk-Eric Loebermann (Executive Vice President, Production and Materials) and Johann Kraus (Managing Director of RSTMY).

Rohde & Schwarz supplies Federal Network Agency with direction finding systems

Rohde & Schwarz prevailed against the competition in a European call for bids from the German Federal Network Agency (BNetzA). The Federal Network Agency will deploy the R&S®DDF550 digital wideband direction finder, a state-of-the-art direction finding system for the VHF/UHF range, and the required antennas. For six generations, Rohde & Schwarz has been supplying the regulatory authority with direction finding systems. The order is for 20 units with an option for five additional direction finders. Rohde & Schwarz is also responsible for setting up and commissioning the systems. The direction finders will be integrated into the Federal Network Agency's existing radio measurement and location system (FuMOS).

Rohde & Schwarz presents top topics and applications at MWC 2013

In 2013, the Mobile World Congress in Barcelona, the world's most important wireless communications trade fair, was held at its new venue. On 132 m^2 of space, Rohde & Schwarz showcased products from the fields of wireless communications T&M and secure communications. As in previous years, the focus was on the R&S®CMW500 wideband radio communication tester with solutions for WLAN offloading, IP analysis, eCall (LBS LTE emergency call) and more. The trade fair's key topic was LTE-Advanced carrier aggregation. More than a dozen T&M applications were showcased at the Rohde & Schwarz booth. A broad range of Rohde & Schwarz T&M instruments could also be seen at the booths of customers and partner companies. Subsidiaries SwissQual and ipoque, who both had their own booths at the fair, offered additional products for network operators.

The theme of the Rohde & Schwarz booth was "R&S 4Genius – your companion for new technologies".

Technology Week: 10th anniversary set new records

In mid-November 2012, Rohde&Schwarz Taiwan hosted the Technology Week for the 10th time and set a new record in the number of visitors. Around 850 participants made their way to the event held at venues in Taipei und Hsinchu. Product managers from Rohde&Schwarz and guest speakers from ST-Ericsson, SGS, Wistron NeWeb Corp and GCT Semiconductors spoke on topics such as 4G mobile solutions, the challenges of compliance testing, and development trends for network operators. Rohde&Schwarz also showcased products and applications from the fields of test and measurement, broadcasting, as well as radiomonitoring and radiolocation.

Tsai Chi-Wen, Managing Director of Rohde&Schwarz Taiwan (center), and guest speakers from ST-Ericsson, SGS, GCT and WNC.

R&S®VTC: honored twice

The R&S®VTC video test center from Rohde&Schwarz was awarded two prizes in the past six months. At the DesignCon 2013 in Santa Clara, California, the R&S®VTC received the annual Best in Test award that is voted for by the readers of the Test & Measurement World, an internationally renowned technical journal.

Readers of Funkschau, a German trade journal, also chose the R&S®VTC as an "information and telecommunications product of the year". The R&S®VTC was awarded first prize in the "T&M equipment" category in mid-October 2012. A major factor for the decision in favor of the R&S®VTC was that the R&S®VTC offers almost all required tests and analyses in a single instrument.

Markus Kien (far right), Deputy Chief Editor of Funkschau, congratulated the R&S®VTC development team on its victory in the "T&M equipment" category.

R&S®RTO oscilloscope named product of the year for the second time

As in 2011, readers of the German trade journal Elektronik rated the new series of laboratory oscilloscopes from Rohde&Schwarz number one in the "Test and measurement" category. This year, the 4 GHz model took first place. The trade journal's readers voted for their favorites in ten categories from among the 111 most innovative products of the year.

Wolfgang Hascher (right), editor of the Elektronik trade journal, presents the first place trophy to Guido Schulze, Head of Product Management, Oscilloscopes.

Cooperation with Dolby

Since February 2013, Rohde&Schwarz has collaborated with Dolby Laboratories, Inc. to provide the digital audio format specialist with audio analyzers. The R&S®UPP and R&S®UPV platforms have been upgraded with new software that enables Dolby licensees to perform Dolby compliance tests quickly and efficiently.

Final negotiations in mid-November: Wolfgang Kernchen, Director of the Signal Generators, Audio Analyzers and Power Meters Subdivision (fourth from right), and Mathias Bendull, Senior Director, Broadcast Consumer Audio, Dolby Laboratories (second from right).