NEWS

203/11

ROHDE&SCHWARZ

Network analysis at your fingertips

Measurement results in just three operating steps with a touchscreen – this unrivaled operating concept combined with excellent technical characteristics makes the new network analyzers the top choice for development and production of sophisticated products.

WIRELESS TECHNOLOGIES

Where efficiency counts: handheld analyzer for installing cables and antennas

SECURE COMMUNICATIONS

Portfolio completed: IP-based voice communications system for air traffic control

RADIOMONITORING / RADIOLOCATION

Compact monitoring receiver with excellent price/performance ratio

NEWS

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Cover feature

More efficiency, less stress – the new R&S®ZNB and R&S®ZNC network analyzers deliver what users want. High measurement speed combined with excellent measurement accuracy – characteristics that set them apart from conventional network analyzers – ensure the highest possible efficiency in development and production for customers in the communications and electronic goods industry. The many measurements are no longer a source of stress

thanks to the analyzers' sophisticated operating concept. In just a few steps, results are clearly displayed on the large touchscreen (page 30).

Another innovation is the R&S®ZVA110 network analyzer. With a continuous sweep from 10 MHz to 110 GHz, it is ideal for on-wafer component characterization. The R&S®ZVA110 is ready for the future – its frequency range can be expanded to 500 GHz for band-specific measurements (see page 36).

Overview
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WIRELESS TECHNOLOGIES

The R&S®ZVH cable and antenna analyzer.

GENERAL PURPOSE

R&S®TS8980 test system analyzes LTE quality indicators: CQI, PMI and RI

LTE stands for fast and reliable data transmission. Accurately measuring the channel quality with the user equipment plays a major role. The R&S®TS8980 RF conformance test system can analyze this measurement with new test cases while scrutinizing the CQI, PMI and RI quality indicators of the LTE standard.

Three LTE quality indicators in detail

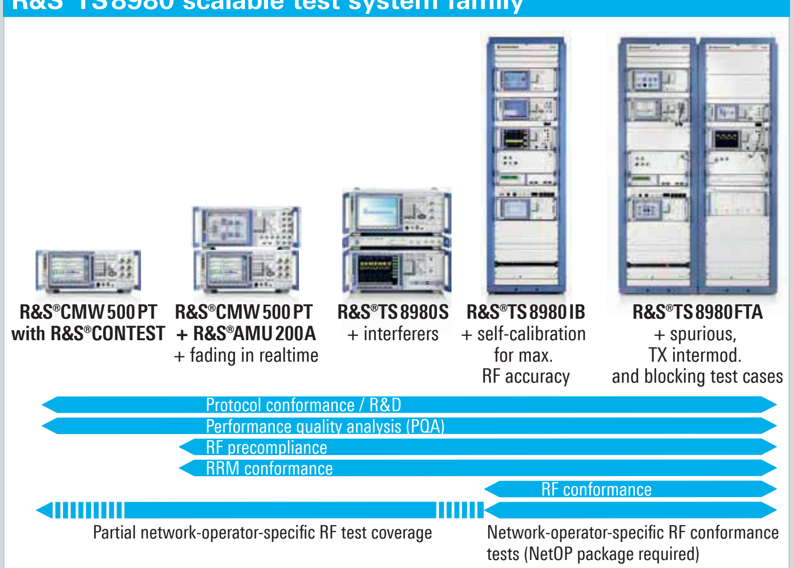
The LTE standard [1] defines three quality indicators that serve as a benchmark for the transmission quality in the downlink: CQI, PMI and RI (channel state information – CSI). The user equipment (UE) can measure all three and transmit the information in the uplink to the base station (BS), which then adapts the signal transmission in the downlink accordingly, although this is not mandatory. To actually improve transmission quality through a modification in the downlink, the statistical properties of the channel must remain constant between the time a quality indicator is reported to the BS and the time the transmission is modified (coherence time).

Channel quality indicator (CQI)

The CQI indicates the highest modulation and the code rate at which the block error rate (BLER) of the channel being analyzed does not exceed 10 %. The CQI accepts discrete values between 0 and 15 (FIG 1). Index 0 indicates that the UE has not received any usable LTE signals and that the channel is inoperable. The CQI report for the UE has a wide variety of settings. As an example, the UE can use one of two methods to send the CQI value to the BS via the uplink:

- periodically via the PUCCH or PUSCH channels,
- aperiodically via the PUSCH channel. In this case, the BS explicitly requests the UE to send a CQI report.

R&S®TS8980 scalable test system family



With the new R&S®TS8980 scalable RF conformance test systems for LTE and WCDMA/HSPA+, Rohde&Schwarz is paving the way for its customers to develop broadband wireless user equipment, from design to the fastest possible market introduction. The extremely high level of flexibility to configure and scale the systems means that they are easily and quickly adapted to individual requirements. The R&S®TS8980 test system family offers room for individual expansion, from the R&S®CMW500PT protocol tester combined with the R&S®CONTEST software for development tasks in the lab to the R&S®TS8980FTA test system for full-scale RF user equipment certification. A detailed article (R&S®TS8980 test system family for LTE and WCDMA/HSPA+) can be found on the Internet ("News&Events", "R&S News Magazine", No. 202).

CQI index	Modulation	Target code rate	Imcs	Information bit payload (subframes 1, 2, 3, 4, 6, 7, 8, 9)	Binary channel bits per subframe (subframes 1, 2, 3, 4, 6, 7, 8, 9)	Actual code rate
0	out of range	out of range	DTX	–	12600	–
1	QPSK	0.0762	0	1384	12600	0.1117
2	QPSK	0.1172	0	1384	12600	0.1117
3	QPSK	0.1885	2	2216	12600	0.1778
4	QPSK	0.3008	4	3624	12600	0.2895
5	QPSK	0.4385	6	5160	12600	0.4114
6	QPSK	0.5879	8	6968	12600	0.5549
7	16QAM	0.3691	11	8760	25200	0.3486
8	16QAM	0.4785	13	11448	25200	0.4552
9	16QAM	0.6016	16	15264	25200	0.6067
10	64QAM	0.4551	18	16416	37800	0.4349
11	64QAM	0.5537	21	21384	37800	0.5663
12	64QAM	0.6504	23	25456	37800	0.6741
13	64QAM	0.7539	25	28336	37800	0.7503
14	64QAM	0.8525	27	31704	37800	0.8394
15	64QAM	0.9258	28	31704	37800	0.8394

FIG 1 CQI indexes with the associated transport formats (source: [4], conditions: 50 resource blocks allocated, SIMO, Imcs = modulation and coding scheme index).

In addition, the frequency domain resolution in the CQI report can be varied. Apart from the wideband CQI for the entire channel bandwidth, there are different subband CQIs, each of which indicates the transmission quality for a specific frequency subrange. All previously mentioned setting alternatives are verified using tests specified in [1].

The CQI index reported to the BS by the UE is derived from the quality of the downlink signal. In contrast to other mobile radio systems such as HSDPA, the LTE CQI index is not directly associated with the measured signal-to-noise ratio. Instead, it is also influenced by the signal processing in the UE. With the same channel, a UE featuring a powerful signal processing algorithm is able to forward a higher CQI index to the BS than a UE that has a weak algorithm.

Precoding matrix indicator (PMI)

The precoding matrix determines how the individual data streams (called layers in LTE) are mapped to the antennas. Skillfully selecting this matrix yields a maximum number of data bits, which the UE can receive together across all layers. However, this requires knowledge of the channel quality for each antenna in the downlink, which the UE can determine through measurements. If the UE knows what the allowed precoding matrices are, it can send a PMI report to the BS and suggest a suitable matrix.

Rank indicator (RI)

The channel rank indicates the number of layers and the number of different signal streams transmitted in the downlink. When using a single input multiple output (SIMO) or a transmit diversity configuration, only one layer is utilized. In contrast, 2 × 2 MIMO (multiple input multiple output) with spatial multiplexing (see [2] and [3]) uses two layers. The goal of an optimized RI is to maximize the channel capacity across the entire available downlink bandwidth by taking advantage of each full channel rank.

RI is not the sole benchmark for the state of the channel when using LTE. CQI and PMI are taken into account as well, since the value of the RI also influences the allowed precoding matrices and CQI values. In contrast, the BS can only utilize the CQI reporting to adapt the downlink channel (assuming the RI does not change such as in pure SIMO mode).

The BS is not forced to react to the feedback from the UE and modify the signal in the downlink accordingly. In most cases, it nevertheless makes sense to do this in order to reduce the error rate and increase the data throughput. However, inaccurate feedback from the UE regarding the state of the channel can lead to exactly the opposite situation. For this reason, it is vital to ensure that the UE accurately indicates the state of the channel by means of the CQI, PMI and RI parameters. To address this requirement, the test specification [1] defines several test cases that are used to verify if a UE accurately determines the CQI, PMI or RI values (CSI values) even under difficult conditions such as additive white Gaussian noise (AWGN) and fading. These test cases can be carried out with the R&S®TS8980 RF test system family. The R&S®CMW500 wideband radio communication tester assumes the role of the base station while the R&S®AMU200A fading simulator simulates the channel.

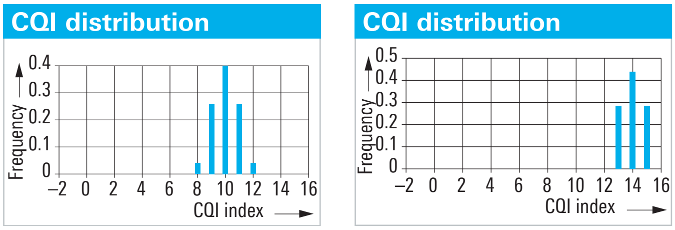


FIG 2 Example of a CQI distribution across 2000 samples sent to the BS by the UE (left: test 1, SNR = 10 dB, right: test 2, SNR = 16 dB). The distributions show that based on the analysis of the channel state by the UE, the BS should utilize the CQI index 10 and 14 respectively.

For median CQI +1, the error rate **must be equal to or greater than 10 %** (FIG 4), since in this case a lower code rate and – depending on the CQI value – a higher order modulation that is more susceptible to errors is selected. If the error rate is less than 10 %, the channel state tends to correspond to the median CQI +1 value. In this case, the UE would not have passed the test, since:

- a higher data rate can be achieved by utilizing the median CQI +1, where the error rate is less than 10 %,
- this also means that the median CQI produced from the CQI distribution, which was sent to the BS by the UE, did not reflect the real state of the channel. This error reduces the data rate that is possible with the current channel quality.

R&S®TS8980 combined with R&S®CONTEST

Using the current LTE software for the R&S®TS8980, all test cases are carried out with the easy-to-use graphical interface of the R&S®CONTEST software. The software displays the CQI distributions in the report in the form of bargraphs at runtime (FIG 2). A wide selection of test parameter settings allows users to analyze the CQI, PMI and RI measurements of the UE across different channels, even outside of the official RF test specification. The individual parameters can be configured in a window in R&S®CONTEST (FIG 3). Individual test sequences (test plans) can then be easily put together with a mouse click. The reports from R&S®CONTEST are sorted according to various criteria and analyzed. Additional features of R&S®CONTEST are described in [5].

A brief explanation of the individual test cases for CSI reporting for FDD based on the test specification [1] is provided in the following sections. In the future, the R&S®TS8980 will feature the capability to use similar test cases for TDD as well.

Test cases 9.2.x: CQI under AWGN conditions

For this group of test cases, the R&S®TS8980 test system, functioning as a BS, first sets a modulation and a code rate that correspond to a CQI index of 8. The UE then determines the state of the channel and sends a corresponding CQI for the entire bandwidth (wideband CQI) back to the BS. The software produces a CQI distribution from 2000 received CQI indexes, which the BS uses to calculate a median CQI (FIG 2).

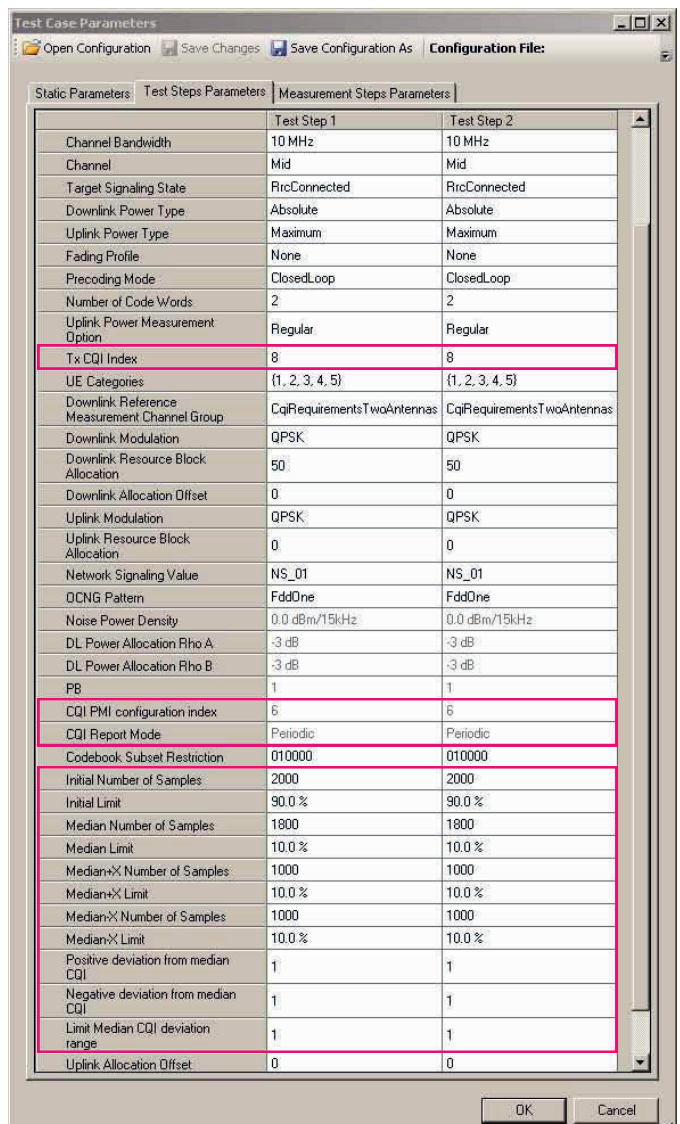
In the next step, the downlink is configured with three different CQI indexes: with the median CQI and the ±1 deviations from the median CQI. In all three cases, the block error rate

$$\text{BLER} = \text{NACK}/(\text{ACK} + \text{NACK}) \qquad \text{(formula 1)}$$

is measured and compared to a predefined upper and lower threshold of 10 %:

$$\text{BLER}_{\text{Median CQI}-1} \leq 0.1 \leq \text{BLER}_{\text{Median CQI}+1} \qquad \text{(formula 2)}$$

FIG 3 R&S®CONTEST provides a clear and concise list of all test parameters. The specific parameters for the channel state information tests are framed by a red border.



	Test Step 1	Test Step 2
Channel Bandwidth	10 MHz	10 MHz
Channel	Mid	Mid
Target Signaling State	RrcConnected	RrcConnected
Downlink Power Type	Absolute	Absolute
Uplink Power Type	Maximum	Maximum
Fading Profile	None	None
Precoding Mode	ClosedLoop	ClosedLoop
Number of Code Words	2	2
Uplink Power Measurement Option	Regular	Regular
Tx CQI Index	8	8
UE Categories	{1, 2, 3, 4, 5}	{1, 2, 3, 4, 5}
Downlink Reference Measurement Channel Group	CqiRequirementsTwoAntennas	CqiRequirementsTwoAntennas
Downlink Modulation	QPSK	QPSK
Downlink Resource Block Allocation	50	50
Downlink Allocation Offset	0	0
Uplink Modulation	QPSK	QPSK
Uplink Resource Block Allocation	0	0
Network Signaling Value	NS_01	NS_01
OCNG Pattern	FddOne	FddOne
Noise Power Density	0.0 dBm/15kHz	0.0 dBm/15kHz
DL Power Allocation Rho A	-3 dB	-3 dB
DL Power Allocation Rho B	-3 dB	-3 dB
PB	1	1
CQI PMI configuration index	6	6
CQI Report Mode	Periodic	Periodic
Codebook Subset Restriction	010000	010000
Initial Number of Samples	2000	2000
Initial Limit	90.0 %	90.0 %
Median Number of Samples	1800	1800
Median Limit	10.0 %	10.0 %
Median+X Number of Samples	1000	1000
Median+X Limit	10.0 %	10.0 %
Median-X Number of Samples	1000	1000
Median-X Limit	10.0 %	10.0 %
Positive deviation from median CQI	1	1
Negative deviation from median CQI	1	1
Limit Median CQI deviation range	1	1
Uplink Allocation Offset	0	0

TX CQI #0 Used	11
Requested Samples	1000
Measured Samples	2000
Measured ACK (CQI #0)	1780
Measured NACK (CQI #0)	220
Measured StatDTX (CQI #0)	0
Measured NACK/(ACK+NACK) (CQI #0)	0.110
Lower Limit NACK/(ACK+NACK)	0.100
Result	Inside

TX CQI #0 Used	9
Requested Samples	1000
Measured Samples	2000
Measured ACK (CQI #0)	1820
Measured NACK (CQI #0)	180
Measured StatDTX (CQI #0)	0
Measured NACK/(ACK+NACK) (CQI #0)	0.090
Upper Limit NACK/(ACK+NACK)	0.100
Result	Inside

FIG 4 Excerpt from the R&S®CONTEST report, which is displayed on the R&S®TS8980 during a test run. The table on the left contains the measurement results for median CQI +1; the table on the right shows median CQI –1.

The CQI feedback of the UE under 2 × 2 MIMO is also tested. The test concept is similar to the one described above, with the exception that 2 × 2 MIMO operates with two data streams. The BS records a CQI distribution for each individual stream. The CQI indexes for both code words must adhere to the BLER conditions (formula 2) in order for the UE to pass the test.

Test cases 9.3.x: CQI under fading conditions

This series of tests utilizes various, and for the most part frequency-selective interference to analyze the CQI indexes of the entire frequency range, as well as those of the individual subbands. The various transmission conditions in the subbands also lead to different CQI distributions.

When there is a single CQI index for all subbands, the data throughput must be less than when there are multiple CQI indexes, each of which the UE recommends for a specific subband. Only then will the UE pass the test. The ratio of the data throughputs measured by the R&S®TS8980 is a benchmark for what is gained by utilizing the individual CQI values for each subband.

Test case 9.3.3.1.1 has another special feature. In addition to fading, the average power of the AWGN noise is frequency-selective and varies depending on the subband. In this way, the UE is tested to determine how it deals with interference signals that have power levels similar to the signal from the BS in the downlink.

Test cases 9.4.x: precoding matrix indicator (PMI)

The UE can use the PMI reporting to recommend a downlink precoding matrix to the BS that will achieve the highest data throughput for the given channel state. Test cases 9.4.x calculate the ratio γ between the throughput under randomly selected but equally distributed PMIs, and the throughput when utilizing PMIs that have been configured in accordance with the feedback of the UE. If the PMIs have been adapted, the throughput must increase by 10 % and 20 % respectively in order for the UE to pass the test.

One unique feature of the tests from the 9.4.x series involves the UE-dependent configuration of the signal-to-noise ratio (SNR). The SNR is individually configured for each UE, such that the throughput is between 58 % and 62 % when randomly selected PMIs are utilized. This levels out the throughput for all UEs. Whether the UE has passed the test depends solely on the ratio γ, and not on its performance at a specific SNR.

Test case 9.5.1.1: rank indicator (RI)

Test case 9.5.1.1 checks all quality indicators (CQI, PMI, RI) in the report of the UE at the same time. The extent to which the three indicators are interdependent can also be tested. If the UE changes the RI value, then the CQI and PMI must be changed accordingly.

Summary

In addition to TX, RX, performance and MIMO test cases under LTE, the R&S®TS8980 test system family can now also be used to test the CQI, PMI and RI quality indicators. Manufacturers and test houses can now ensure that the prerequisites are in place for high data rates and reliable transmission with the LTE standard. The versatile capabilities of the test systems are far from being exhausted however. The systems can also execute LTE radio resource management tests and throughput measurements under real conditions for LTE / HSPA+ / WCDMA. Moreover, the NetOP package for the R&S®TS8980IB and R&S®TS8980FTA test systems provides applications tailored specifically to network operators.

Dr. Thomas Brüggen

References

[1] 3GPP 36.521-1 V9.3.0 test specification, "User equipment (UE) conformance specification, radio transmission and reception, part 1: conformance testing".
[2] From SISO to MIMO – taking advantage of everything the air interface offers (2). News from Rohde&Schwarz (2007) No. 194, pp. 4–7.
[3] Radio conformance test systems ready for MIMO. NEWS (2010) No. 200, pp. 6–8.
[4] 3GPP 36.521-1 V9.3.0 test specification, "User equipment (UE) conformance specification, radio transmission and reception, part 1: conformance testing", table A. 4–3, p. 382.
[5] R&S®TS8980 RF conformance test system family for LTE and WCDMA / HSPA+. Article available on the Internet ("News&Events", "R&S News Magazine", No. 202).

Modular drive test system for coverage and QoS measurements

The quality and availability of radio networks are critical to their acceptance by users. Operators must therefore work continually to maintain their networks to a high standard. This task is made significantly easier by powerful mobile test systems – such as the sophisticated and versatile R&S®ROMESCUBE modular system.

Mobile, reliable, for all standards

As a result of the steady increase in data volumes, conventional test systems with multiple test mobile phones, data cards or data sticks that are based exclusively on a standard PC quickly reach their limits with respect to processing power and speed. In addition, when testing at the application level, their monolithic system architecture typically allows only one network connection (to a specific application) via the operating system.

None of these limitations apply to the R&S®ROMESCUBE modular system with its multiprocessor architecture. Built using one to five R&S®R4C-CPU base modules and one R&S®R4C-SYS system module, it is an ultracompact drive test system (FIGs 1 and 2). The individual base modules use integrated test mobile phones and the R&S®ROMES4 test software, and can independently perform specialized mobile radio network tests in parallel. They are connected via LAN to a host PC, which can be a laptop. The tests can be configured and controlled from the PC. The measurements and calculation algorithms run on the base modules. The results are forwarded to the host PC, where they are displayed, analyzed and stored. This ensures reliable measurements for the latest broadband mobile radio standards.

The R&S®R4C-SYS system module provides the DC power supply and network infrastructure for up to five base modules. An integrated, high-sensitivity GPS receiver provides the necessary geographic coordinates.

FIG 1 The R&S®ROMESCUBE modular system is very easy and quick to set up. It consists of just a few universal modules and the software is fully preinstalled – simply plug in the system and start testing.

FIG 2 The R&S®R4C-CPU base module.

A quick-lock assembly on the individual modules allows them to be combined quickly into a compact test system. This minimizes cabling – an important aspect for mobile systems with respect to the reliability of test sequences.

Always up to date with plug-ins

The base modules can be individually configured for each specific task using test plug-ins (R&S®R4C-B2, R&S®R4C-B3). Corresponding USB data sticks can also be used as needed.

The plug-ins offer a number of advantages over mobile phones that are connected conventionally via USB:

- Little or no cabling, compact size, mechanical and electrical reliability, since they are plugged into the base module and secured with screws
- Comparable, standardized test results, since the same module type can always be used
- No noise, mismatch or external influences when analyzing voice quality, since the calculation is carried out digitally

The R&S®R4C-CPU base modules provide numerous interfaces:

- 2 × Gbit LAN for the host PC and the R&S®TSMW radio network analyzer
- IEEE 1394 FireWire for connecting the R&S®TSML, R&S®TSMU or R&S®TSMQ radio network analyzers
- 2 × USB 2.0 (high power, software-controlled) for connecting conventional test mobile phones
- 4 × USB 2.0 for connecting USB data sticks, PC mouse, keyboard, etc.
- DVI for connecting a monitor (for testing a base module without a host PC, for service configuration, etc.)
- 2 × SMA for external antennas
- 10 V to 28 V DC power supply input

R&S®ROMES4 test software

The R&S®ROMES test software was enhanced to ensure transparent implementation of the distributed software architecture for exceptional ease of use. The internal R&S®ROMESCUBE network configures itself fully automatically. Hardware detection allows test sensors to be set up with virtually no action on the part of the user. The host PC downloads updates for system and test software components centrally. The result is a semi-autonomous test system that can be operated without specialized knowledge of the R&S®ROMES4 test software. Cost of ownership is reduced and the modular architecture allows the user to determine the initial acquisition costs.

Summary

R&S®ROMESCUBE is extremely versatile: from a small, portable system with one radio network analyzer and only a few test mobile phones for use within buildings, to drive test systems with up to five test modules using the R&S®TSMW and R&S®TSMU families of radio network analyzers, to comprehensive, fully integrated vehicular systems for benchmark and QoS testing with simultaneous operation of more than five test mobile phones. The systems remain portable and can be used in any vehicle. Costly, specialized vehicles are needed only in very few special situations.

Wilfried Kalthoff; Martin Gaßlbauer

Key facts

- Scalable, compact, robust, light-weight
- Numerous standard interfaces – flexible use for all measurement tasks
- Usable for all modern mobile radio standards
  - GSM (GPRS, EGPRS, EDGE)
  - UMTS (HSDPA, HSUPA, HSPA, HSPA+, DC-HSPA+, LTE ready)
- Simple and robust assembly using snap-in technology with quick-lock module connections

Comprehensive transmitter and receiver tests on WLAN user equipment

The R&S®CMW270 and R&S®CMW500 testers offer an extensive range of tests in line with the IEEE 802.11 WLAN standard for testing transmitters and receivers in development and production. A single instrument covers all required tests: from conventional SISO with only one transmit and one receive antenna to modern 4×4 MIMO with four transmitters and four receivers.

Complete transmitter analysis

Most mobile user equipment supports data transfer via WLAN. The IEEE 802.11 standard, also known as WLAN or Wi-Fi*, has been continuously enhanced in accordance with the constantly growing demand for ever higher data rates. Higher-order modulation techniques (from BPSK to 64QAM) and larger bandwidths (5 / 10 / 20 / 40 MHz) provided ways to improve transmission rates. The R&S®CMW270 / R&S®CMW500 testers are able to comprehensively analyze RF signals of all specified WLAN signals (FIGs 1 and 2).

* Wi-Fi is the name of a consortium of companies that certifies devices with air interfaces based on the IEEE 802.11 standard. In some countries, Wi-Fi is also used as a synonym for WLAN.

Statistical analysis of measurement results is an essential tool when developing transmitter components. In the search for a suitable amplifier, for example, knowing the power distribution is a decisive factor in the cost/benefit analysis. Since, due to system reasons, the transmit power of an OFDM burst is not constant, its peak values are important for preselection. What is even more interesting, however, is how often these peaks occur. The complementary cumulative distribution function (CCDF) provides an informative statistical analysis of this characteristic (FIG 3). The CCDF displays the probability of the signal transmit power being higher than the calculated average value. Such an analysis can be helpful in estimating how often a cheaper but less powerful amplifier reaches the limits of its output power and how often it does not reach peak level or clips signals. This information is useful in determining the suitability of an amplifier.

FIG 1 The power vs. time measurement graphically displays the measured transmit power over the duration of a burst. The transmit power-up and power-down ramps are of particular interest. For DSSS signals in line with IEEE 802.11b, section 18.4.7.6 specifies the time for the burst to transit from 10 % to 90 % or 90 % to 10 % of linear power.

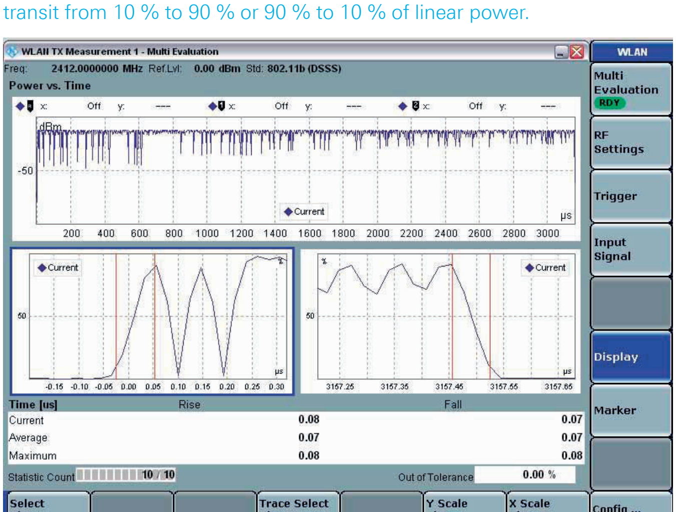
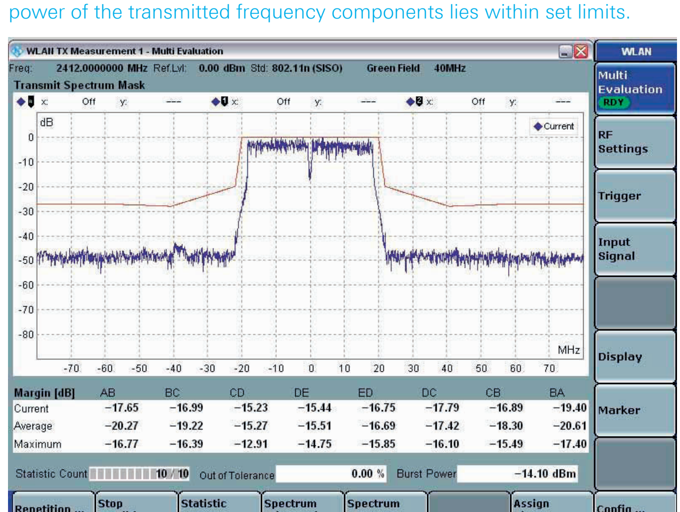


FIG 2 A fundamental prerequisite for interference-free radiocommunications is adherence to specified frequency ranges, especially by preventing unnecessary transmit power outside the assigned transmission channel. The transmit spectrum mask measurement allows users to verify if the power of the transmitted frequency components lies within set limits.



Interference tests / regression tests

Modern mobile phones support a variety of radio links, which may even use the same frequency band. To ensure smooth operation, any mutual parasitic coupling is analyzed and eliminated as far as possible in the development phase. The R&S®CMW500 is ideally suited for the simulation of different test scenarios because it can generate a large number of standardized signals in addition to WLAN and Bluetooth®, GSM and LTE. The R&S®CMW500 can also generate such RF signals independently of each other, combine them and transmit them together over the same output. The R&S®CMW-B590D advanced frontend option makes this possible, eliminating the need for external combiners.

MIMO: multiple transmitter measurements*

The IEEE 802.11n standard specifies the use of multiple transmit and receive antennas as another way to increase data throughput. The R&S®CMW-KM652 option enables multiple transmitter measurements on WLAN MIMO devices. The latest version of this software option can determine the error vector magnitude (EVM) of up to four simultaneously active transmit antennas on the basis of their sum signal, taking into consideration both the pilot signals and the data subcarriers (FIG 4). The level of testing offered by this option fulfills the highest production quality requirements.

Receiver tests for 4×4 MIMO

In addition to comprehensive transmitter tests, the R&S®CMW270 / R&S®CMW500 testers also support receiver tests on WLAN devices equipped with up to four receivers. To generate suitable test signals, every receive antenna needs its own signal generator. The R&S®CMW-B571B option can be used to add signal generators to a dual-channel R&S®CMW270 / R&S®CMW500 tester. Receiver tests can then be carried out using only one tester, even in the maximum configuration.

Summary

The R&S®CMW500 tester, with comprehensive tests for WLAN devices, is the first choice for measurements in line with cellular standards.

Thomas A. Kneidel

* See also: Time-optimized WLAN MIMO transmitter measurements in production. NEWS (2010) No. 202, pp. 9–10. Detailed version available on the Internet at "News&Events" – "R&S News Magazine".

FIG 3 Following a statistical analysis of the measured output power, the CCDF displays the probability of the signal transmit power being higher than the calculated average value. The output power is indicated in dB relative to the average value.

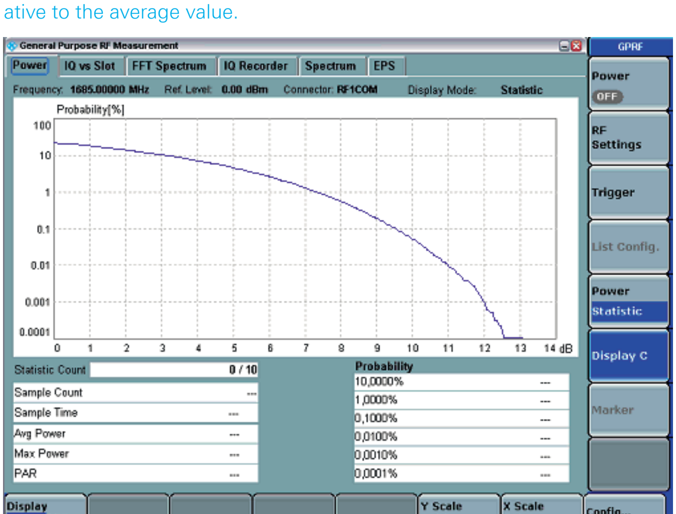
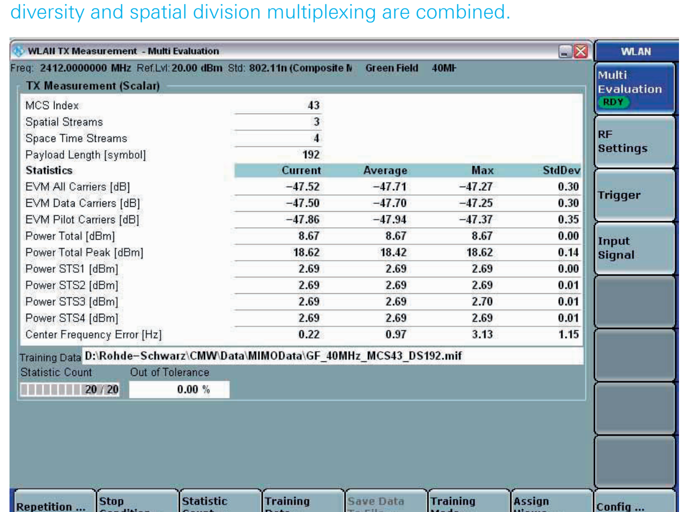


FIG 4 Analysis of three independent data streams which are sent simultaneously over four antennas using Alamouti's space-time block coding scheme. The R&S®CMW-KM652 option can use the sum signal to provide statistics such as the EVM value of the data carrier – even when transmit diversity and spatial division multiplexing are combined.



Cost-effective OTA performance testing of MIMO-enabled LTE devices

High-quality wireless devices require an omnidirectional and uniform antenna radiation pattern. This pattern can be verified by measuring the over-the-air (OTA) performance. These measurements, which are an essential part of the certification test, need to be extended to include MIMO operating modes. The Rohde & Schwarz two-channel test method makes these measurements both cost-effective and reproducible.

MIMO OTA measurements require new test methods

Currently, OTA performance tests for single input single output (SISO) are standardized for 2G, 3G and WLAN devices. These tests provide important information about the behavior of wireless devices within the network. Within an anechoic environment, the radiated 3D pattern of both output power and receiver sensitivity are measured and used to derive the total radiated power (TRP) and the total isotropic sensitivity (TIS) as specified by CTIA [1], and similarly by 3GPP [2].

Multiple input multiple output (MIMO) techniques were established to increase network performance for data applications in particular. The channel capacity of the allocated frequency spectrum is increased by the use of spatial multiplexing. However, with new transmission technologies come new test requirements.

For 2×2 MIMO mode with two downlink data streams, the user equipment (UE) has two receive antennas. The correlation of the RX antennas has to be as low as possible to achieve a good separation of the simultaneously received data streams. To understand the performance of the antennas, it is not sufficient to evaluate the pattern of each receiving antenna separately. OTA performance tests for MIMO-enabled devices need to verify the following transmission schemes:

- Transmit diversity with redundant data streams for a wider signal range
- Spatial multiplexing with multiple data streams for higher data throughput

LTE modems are mostly operated inside buildings. Full 3D evaluation is required to assess the modem's multipath reception from all angles of arrival (AoA). A spherical (3D) test approach provides realistic test conditions similar to operation in the field.

Cost-effective MIMO OTA measurements using the two-channel test method

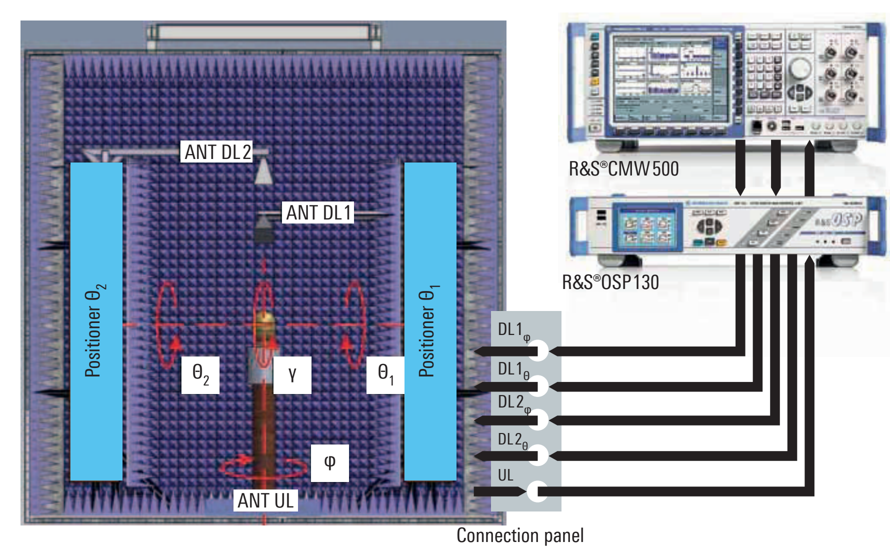
The two-channel test method from Rohde & Schwarz [3] presents a straightforward, cost-effective approach for verifying OTA performance on MIMO devices. The UE is positioned close to two rotating, cross-polarized test antennas, each radiating different signals for the MIMO downlink. Repeating the measurement for several other constellations and polarizations provides a comprehensive overview of the UE's antenna characteristics.

SISO OTA measurements for 2G and 3G are still mandatory. Ideally, the anechoic chamber can be used for both SISO and MIMO tests without any modification. Existing SISO OTA test systems should be easy and inexpensive to upgrade for MIMO operation.

The R&S®TS8991 OTA performance test system fully supports the two-channel test method for MIMO OTA (FIG 1). An OTA test chamber contains a communications antenna for the uplink (ANT UL) and two angular positioners to set an arbitrary geometrical constellation of the two test antennas ANT DL1 and ANT DL2. The 3D evaluation is performed with a constant angular separation of the test antennas during the movement. An offset of 10° simulates rural conditions, 90° in contrast urban conditions. The UE is placed on an azimuth positioner. External instrumentation includes the R&S®CMW500 wideband radio communication tester as a base station emulator (BSE) and the R&S®OSP130 open switch and control platform as a switch matrix.

The two-channel method also verifies the performance of smart UE antennas with adaptive receiving characteristics and load impedances. True load impedance of UE antennas is assured, since the method does not require connecting any auxiliary RF cabling to the antenna ports during the test.

MIMO OTA measurements



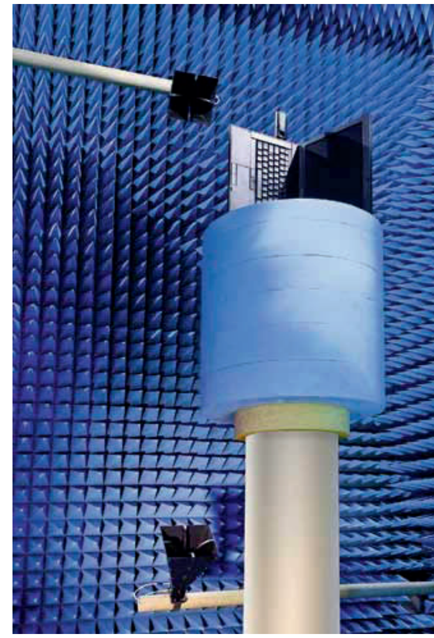


FIG 1 Main components of the R&S®TS8991 OTA performance test system for MIMO measurements.

Conclusive test results through conducted and radiated measurements

OTA tests characterize MIMO performance of the UE under simulated real-world conditions. MIMO antenna performance can be determined by additionally carrying out optional conducted measurements and comparing them against the results of the radiated measurements. Tests in conducted and radiated mode are performed with the same BSE signaling settings.

The following example shows a series of tests performed on four different LTE modems. The tests use 2 × 2 open-loop spatial multiplexing as a DL MIMO transmission scheme with 16QAM modulation. In conducted mode, data throughput is measured as a function of absolute DL power. Two RF cables connect the BSE ports to the corresponding UE antenna ports. The obtained results provide the reference sensitivity performance for the selected transmission scheme and BSE settings. Maximum spatial diversity is achieved, since there is no coupling between the two RF channels. Accordingly, MIMO throughput in conducted mode represents the best possible MIMO sensitivity of the UE under test. The throughput is limited only by UE receiver performance.

See FIG 2 for the results of the test example. In conducted mode, UE 2 and UE 4 provide the best receiver sensitivity. UE 1 has an up to 4 dB poorer sensitivity. UE 1, UE 2 and UE 3 were tested in band 7 (2.6 GHz); UE 4 was tested in band 20 (800 MHz).

In radiated mode, the UEs were tested in different geometrical constellations of test antennas, with four polarization combinations for each constellation. The average throughput TP_{av} (RS EPRE) is the linear average of the throughputs in all measurement cases for the given RS EPRE power level (FIG 3). UE 2 utilizes its original built-in antennas. UE 2 ExtAnt utilizes two cross-polarized dipoles separated by half a wavelength connected to the UE 2 antenna ports. This arrangement

Results of conducted measurements

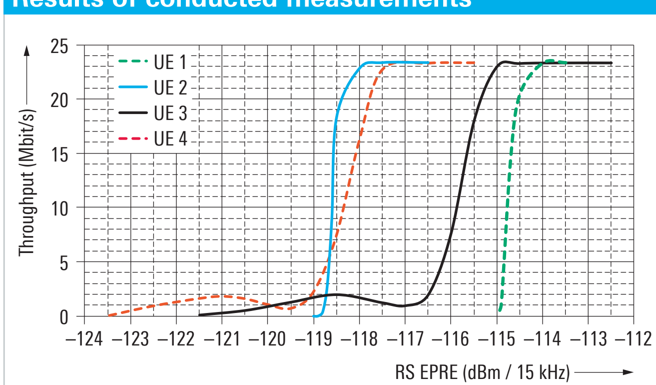


FIG 2 Data throughput as a function of downlink power (RS EPRE) at the UE antenna ports.

provides the best MIMO antenna performance because the external antennas are arranged to maximize spatial and polarization diversity.

Significant deterioration of MIMO antenna performance is noticeable for UE 4. Even though it achieved the best MIMO sensitivity in conducted mode, it has the worst average throughput TP_{av} in radiated mode. To obtain a TP_{av} of 50 %, UE 4 requires 5 dB higher DL power than UE 2. This result agrees with expectations because UE 4 operates in band 20, where wavelengths are more than three times longer. Since the geometrical dimensions are similar to UE 2, it is much more difficult to obtain an antenna design with similar spatial and polarization diversity.

An example of 3D spherical distribution of MIMO effective isotropic sensitivity (EIS), which was generated by the R&S®AMS32 system software, is presented in FIG 4. The received power correlates to a block error rate (BLER) of 50 %.

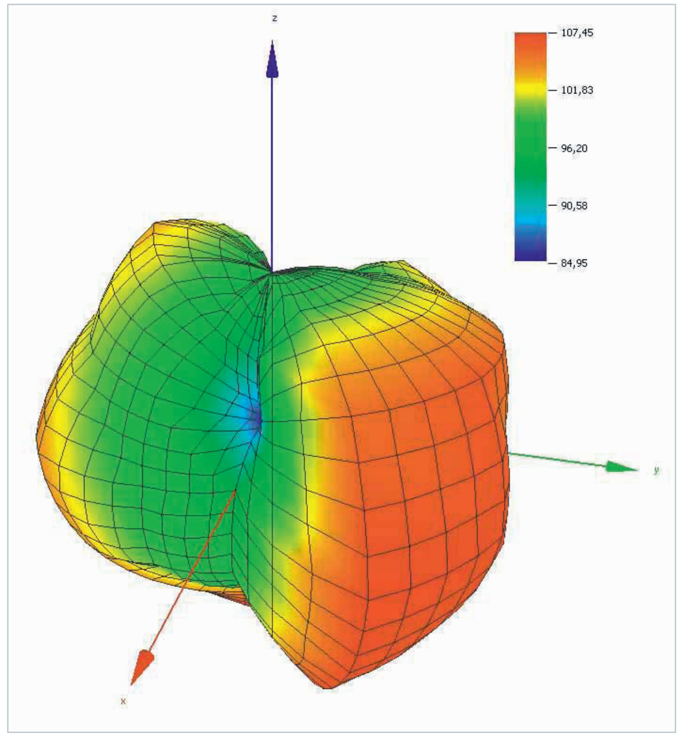


FIG 4 MIMO EIS 3D distribution of UE 4.

Standardization for MIMO OTA tests

Candidate test methods for MIMO OTA performance were proposed and discussed. The standardization bodies involved in getting an OTA standard ready are mainly CTIA in the USA and RAN4 at 3GPP. At the moment, it is not clear which body will be faster in having an agreed test proposal ready for publication.

The decision for a test method needs to be based on more than just the quality of results (in other words, how well the method can judge performance and discriminate between good and not-so-good designs). It must also take the complexity of the solution into account, since this is closely related to the investment costs for that solution. Test times are another important consideration.

The European COST Action 2100 has worked out the fundamentals of MIMO OTA testing. The new COST Action IC1004, slated to start in summer 2011, will support standardization.

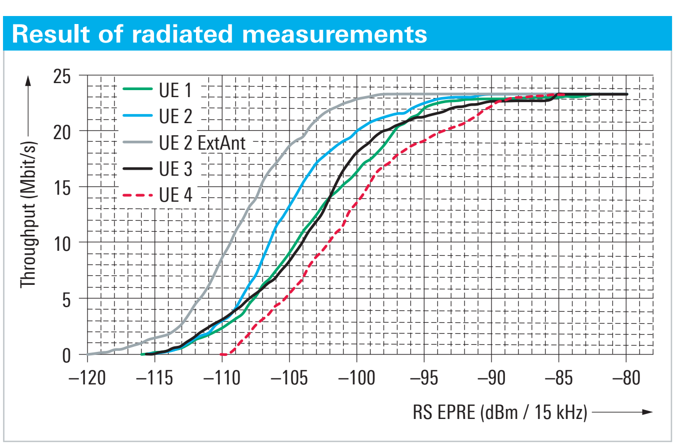


FIG 3 Average throughput TP_{av} (RS EPRE) in radiated mode; all four polarization combinations.

Summary

To obtain a complete picture of MIMO OTA performance, UE antennas need to be tested under varying geometrical conditions in a 3D environment. Tests performed in two dimensions are no longer sufficient; a wide range of AoAs and polarizations is necessary. Additional measurements in conducted and radiated mode help to distinguish antenna and receiver performances of a wireless device and to identify design errors.

The two-channel test method can also be used to verify the effects of multipath propagation (fading). This is accomplished by adding the R&S®AMU200A baseband signal generator and fading simulator to the R&S®TS8991 MIMO OTA test system and by including the appropriate fading profiles in the DL data streams generated by the R&S®CMW500.

The Rohde&Schwarz two-channel test method can be easily implemented in existing SISO test systems by simply adding an angular positioner with a second test antenna to the system. The presented test approach facilitates systematic OTA verification of MIMO-enabled devices. Good designs can be distinguished from those that are not so good, and ranked on the basis of quantitative and reproducible measurements.

Erwin Böhler; Adam Tankielun

References

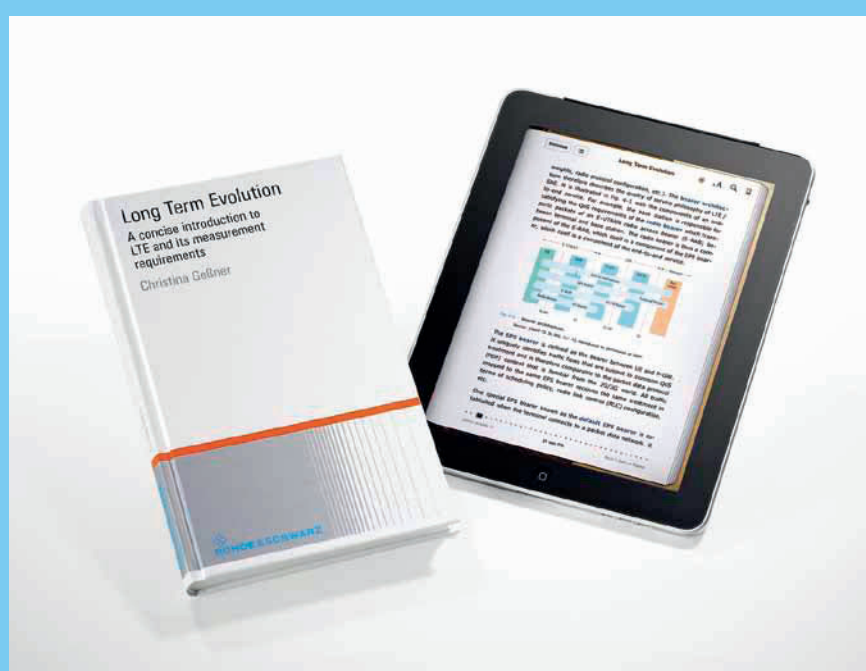
[1] CTIA Test Plan for Mobile Station Over the Air Performance; Rev. 3.1; 2011-01.
[2] 3GPP TS 34.114; User Equipment (UE) / Mobile Station (MS) Over The Air (OTA) antenna performance; V8.4.0 (2010-06).
[3] Rohde&Schwarz White Paper 1SP12; Two-Channel Method for OTA Performance Measurements of MIMO-Enabled Devices; www.rohde-schwarz.com (search term: 1SP12).

Abbreviations

3GPP	3rd Generation Partnership Project
BLER	Block error rate
COST	European Cooperation in Science and Technology
CTIA	Cellular Telecommunications Industry Association
DL	Downlink
EIS	Effective isotropic sensitivity (single geometrical point)
MCS	Modulation and coding scheme
MIMO	Multiple input multiple output
OTA	Over the air
RS EPRE	Energy per resource element (EPRE) of the reference signal (RS)
SISO	Single input single output
TIS	Total isotropic sensitivity
TP	Throughput
TRP	Total radiated power
UE	User equipment
UL	Uplink

LTE basics, compact and concise

A new book from Rohde&Schwarz introduces the LTE standard and provides an overview of the air interface measurements required for the base station and the UE. "Long Term Evolution", written by Rohde&Schwarz author Christina Geßner, is priced at EUR 58. It can be purchased in bookstores and from the Rohde&Schwarz web shop, where an extract can be read. Plus, it is available as an eBook for iPad and Amazon Kindle.



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www.books.rohde-schwarz.com

Where efficiency counts: handheld analyzer for installing cables and antennas

The R&S®ZVH is a handheld cable and antenna analyzer that is specially tailored for use in the installation of antenna systems. The analyzer greatly simplifies acceptance measurements in the field. Highly practical wizards make it easy to test antenna cables, filters and amplifiers. Convenient tools for preparing test reports simplify the documentation process. Featuring excellent RF specifications, the R&S®ZVH is among the best portable instruments of its kind.

Automated test sequences for higher efficiency

Every minute spent at an antenna tower counts, because the next site is waiting. Therefore, each movement must be just right, and the tool that is used should simplify and speed up work. This especially applies to the RF test equipment used, because the installers are usually not T&M specialists. The R&S®ZVH (FIG 1) was developed to help them do their job. The analyzer doesn't waste any time preparing for measurements, and the operating steps are very straightforward. An automatic software wizard ensures that all measurements are fast and error-free. A complete sequence for testing an antenna system can be predefined on a PC using the R&S®ZVHView software and then loaded on all of the R&S®ZVH analyzers in use. The operator on site only has to launch the wizard and run through the procedure by following the prepared instructions (FIG 2). Nothing is left out, no mistakes are made, and all teams perform the same measurements everywhere. The rest is just as easy: The keystroke that closes the wizard sequence saves all the test results to

FIG 1 The R&S®ZVH cable and antenna analyzer.

FIG 2 Each individual measurement in a test sequence can be assigned a comment with helpful information for the user.

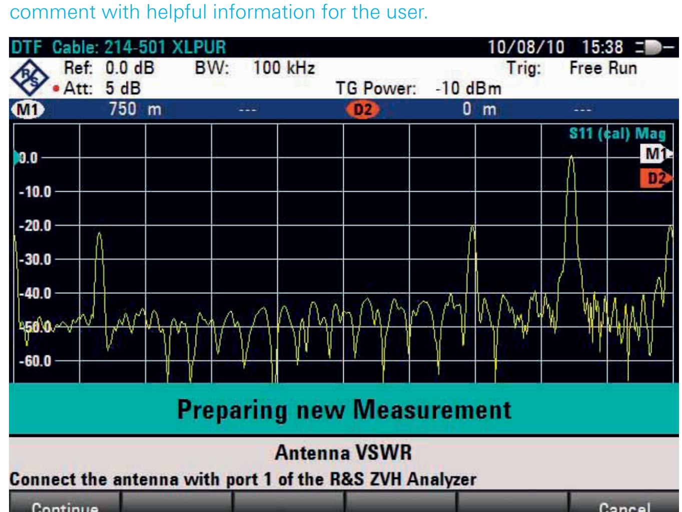
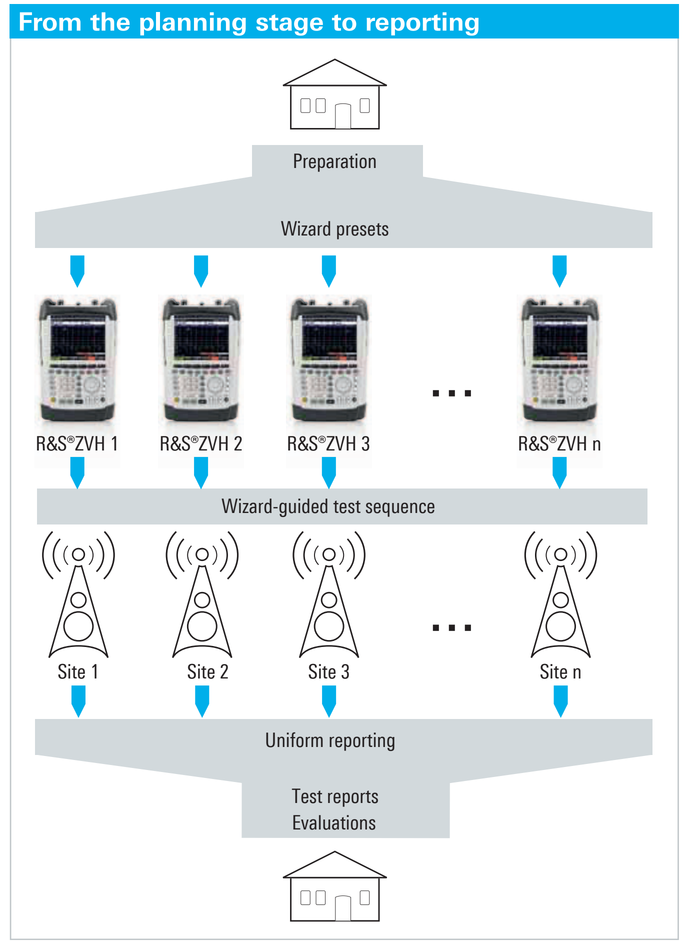


FIG 3 Test sequences can be predefined on a central PC and transferred to all R&S®ZVH analyzers that will be used on a project. On site, the software wizard guides the user step-by-step through the predefined test sequence. All measurement results are stored in a single file which can easily and centrally be converted to a uniform, well-structured test report using the report generator in the R&S®ZVHView software.



a file. This file can then be sent via LAN, USB, memory card, USB memory stick or e-mail to a central computer where a standardized, well-structured and therefore easy-to-compare test report can be generated in just a few simple steps (FIGs 3 and 4).

Optimized for field applications

Weighing only 3 kg, the R&S®ZVH is a handy instrument. Frequently used functions have their own function keys and are within fingertip reach. The brilliant color display is easy to read even under poor lighting conditions. Its backlighting can be adjusted to suit the current conditions. For use in extremely strong sunlight, a special monochrome mode provides optimal contrast. The R&S®ZVH is equipped with a rugged, splash-proof enclosure to protect it against the challenges it can encounter in the field. The battery has sufficient capacity for up to 4.5 hours of operation. It can be exchanged within seconds if more operating time is required.

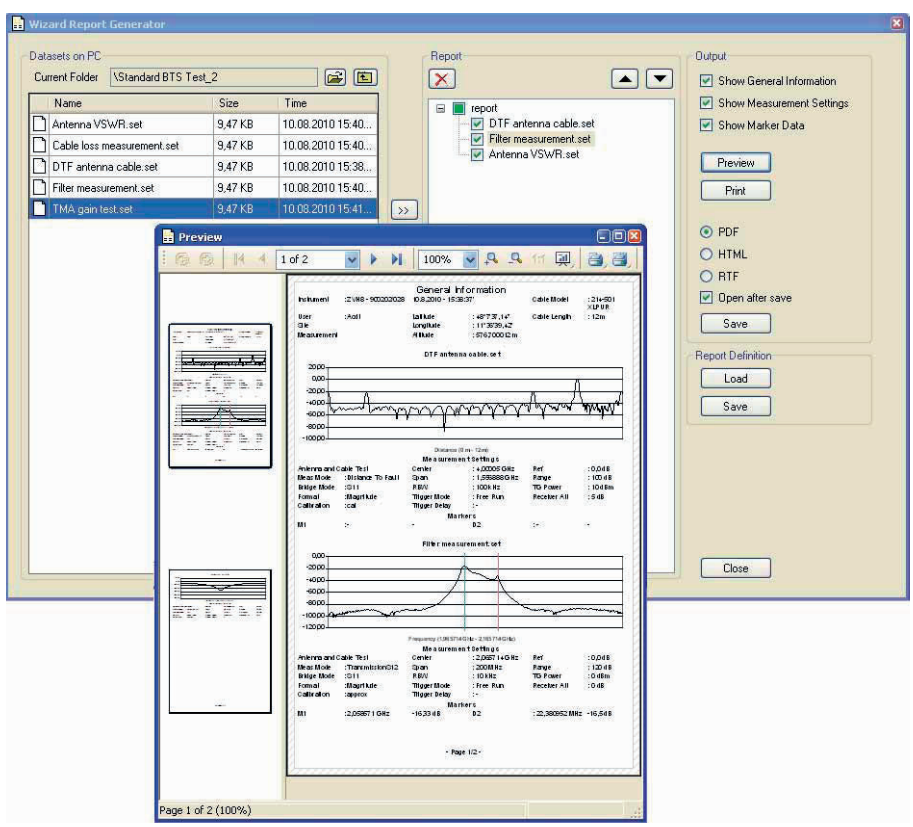


FIG 4 With just a few mouse clicks, the individual results of a test sequence are combined into a conclusive test report.

All important measurement functions included

After an antenna system has been installed, the next step is to ensure it provides the coverage specified by the network planner. Accordingly, the installer must perform an acceptance test to verify that the antenna cable and the antenna are functioning properly. For this type of work, the R&S®ZVH provides all of the necessary test functions in its basic version. Using the distance-to-fault (DTF) measurement, the analyzer computes the distance to cable faults that can be caused by pinched cables or by loose or corroded cable connections (FIG 5). The built-in threshold function makes sure that only true cable faults are listed, i.e. faults that violate a specified tolerance. This considerably simplifies the evaluation of the measurement. A reflection measurement detects antenna mismatches quickly and dependably. The vector measurement is highly accurate as a result of the associated system error correction. The function used in the one-port cable loss measurement can determine the loss of previously installed cables with little effort. For this application, it is sufficient to connect one end of the cable to the analyzer's measurement port. The other end is terminated with a short circuit or simply left open. The built-in DC voltage supply (bias) supplies power to active DUTs such as amplifiers via the RF cable. This capability is especially useful when working with tower-mounted amplifiers (TMA) found in mobile radio base stations.

FIG 5 Distance-to-fault (DTF) measurements can be used to quickly locate damage.

Modular system with future-ready design

In its basic version, the R&S®ZVH is precisely tailored to the requirements encountered in the installation of antenna systems. Options can be retrofitted at any time to meet further requirements such as transmission measurements, spectrum analysis or power measurements.

The transmission measurement option is used to measure the transmission characteristics of components such as filters and amplifiers. For example, this option makes it possible to determine whether a harmonics filter is working properly and the base station is transmitting within the intended band. The R&S®ZVH can display filter characteristics in just a few operating steps. The analyzer can also be used to quickly verify that a TMA is functioning correctly. The high dynamic range of typically up to 100 dB makes it possible to measure the isolation between antennas.

If more in-depth measurements are required, the R&S®ZVH can be expanded into a spectrum analyzer. The activation process is simple, requiring only a license key to be entered. The spectrum analysis option includes a number of measurement functions such as the following:

- Channel power
- Occupied bandwidth
- Power of pulsed signals (TDMA power)
- Adjacent-channel leakage ratio (ACLR)
- Spurious emissions (spectrum emission mask)
- Spectrum due to modulation of pulsed signals

For use in analyzing intermittent interference or fluctuations in the wanted signal, an optional application for spectrogram measurements is available.

The R&S®ZVH-K9 option transforms the R&S®ZVH into a high-precision power meter. Determining the transmitted power is an essential step upon completion of a new installation, after a repair or when it is suspected that the transmitter station's output stages are no longer operating at the expected output power. For transmitter systems with integrated power couplers, the coupling power can be determined using the terminating power sensors available as an option. For tests on the transmitter system without power couplers, directional power sensors are available. These sensors allow simultaneous measurement of the output power and impedance matching of an antenna during live operation.

R&S®ZVHView software: an efficient operations center

The R&S®ZVHView PC software (FIG 6) makes it easy to define test sequences (wizard), administer instrument settings and document measurement results. In only a few mouse clicks, the report function summarizes the individual results from a test sequence in a test report that can be saved in PDF, HTML or RTF format.

Summary

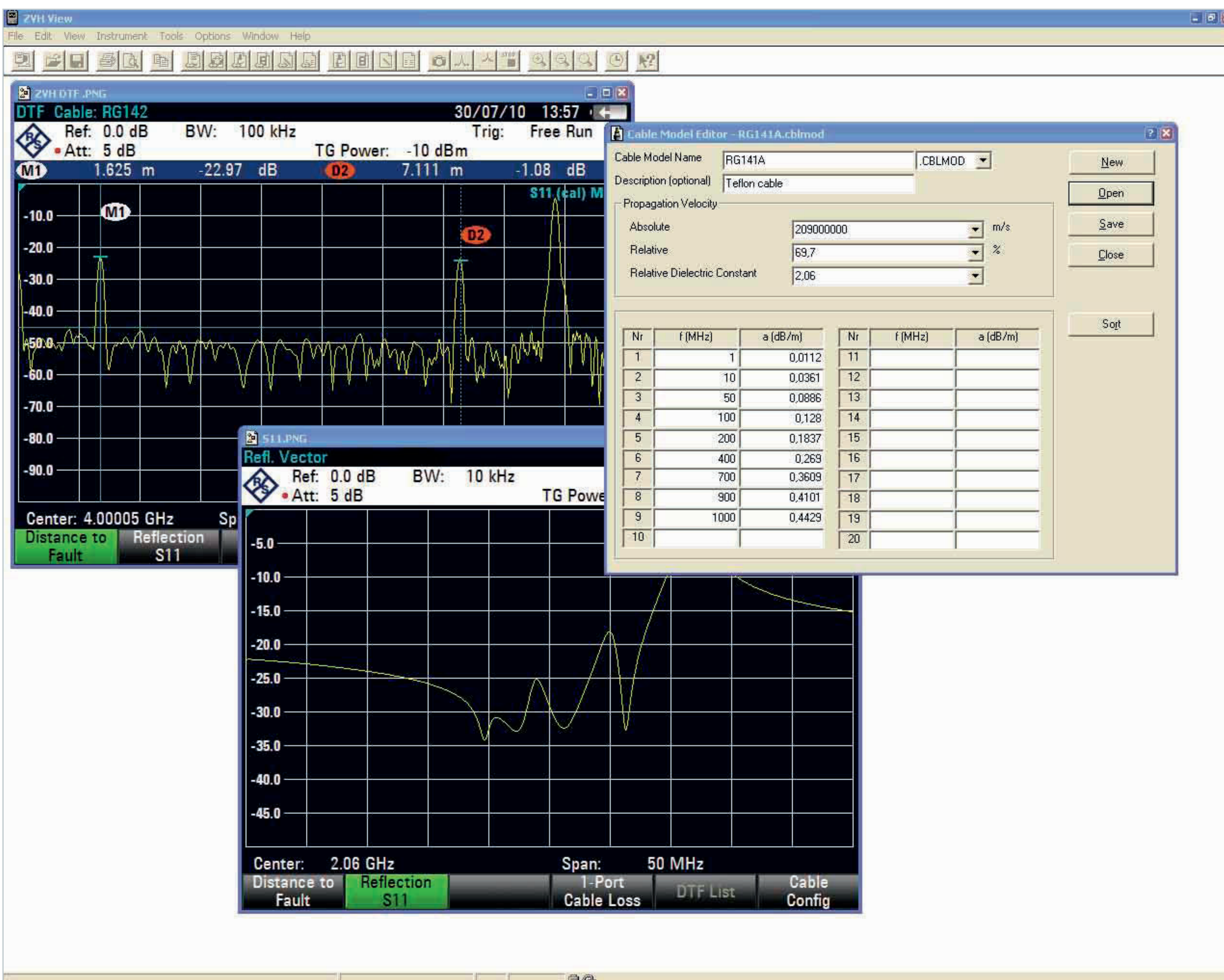
Antenna installers will appreciate the operating ease of the automated test sequences provided by this analyzer. Unusable measurement results due to improper operation as well as complicated handling of printed test instructions are all a thing of the past with the R&S®ZVH. After the work has been completed, preparing the test reports is faster than ever. The R&S®ZVH makes it possible to set up significantly more antenna systems in the same amount of time compared with other commercially available test equipment. Isn't that a reason to celebrate?

Rainer Wagner

Key features at a glance

- Frequency range from 100 kHz to 3.6 GHz or 8 GHz
- Easy operation with user-configurable test sequences (wizard)
- Simple generation of test reports
- 100 dB (typ.) dynamic range for filter and antenna isolation measurements
- Built-in DC voltage supply (bias) for active components
- Spectrum analysis option
- Power meter option
- Li-ion battery for up to 4.5 hours of operation
- Rugged, splash-proof housing for field work
- Easy handling due to low weight (3 kg with battery)

FIG 6 The R&S®ZVHView software comes with the analyzer.



Analysis made easy: wizard for describing OFDM signals

The PC-based R&S®FS-K96 OFDM vector signal analysis software now includes a wizard that makes it significantly easier to describe an OFDM signal. The graphical user interface and step-by-step instructions enable quick description of even complex OFDM signals.

The OFDM transmission scheme – …

Many modern wireless communications systems such as WiMAX™ and WLAN 802.11n use orthogonal frequency division multiplex (OFDM) multicarrier modulation to distribute information to multiple carriers. As a result, signals are less sensitive to interference and echoes than with single-carrier modulation methods. Specialized measuring equipment is required to analyze the modulation quality of OFDM signals.

Since 2008, Rohde&Schwarz has offered the R&S®FS-K96 OFDM vector signal analysis software (formerly R&S®FSQ-K96) which can be used with its various analyzers (FIG 1) to demodulate both standard-compliant and proprietary OFDM signals. The software's new configuration file wizard makes it much easier for the user to describe an OFDM signal and generate the configuration file that is needed for demodulation.

… a measurement challenge

In order to demodulate OFDM signals correctly, the software must know the signal characteristics in detail or, to be more precise, the relevant parts of the physical layer. Most relevant is the description of the time/frequency structure of a transmitted frame. A schematic example of such a frame is shown in FIG 2. The structure of a frame consists of multiple cells.

The description of the physical layer is extremely complex for many OFDM-based standards, be it proprietary standards or standards that have already established themselves on the market. The specification for the DVB-T2 standard, for example, is 164 pages long.

General parameters such as frequency, symbol rate, FFT length and guard interval length can be directly entered in the R&S®FS-K96 software. Other OFDM parameters, e.g. for

FIG 1 The R&S®FS-K96 software can be used with various Rohde&Schwarz spectrum analyzers (here the R&S®FSVR) which it controls via LAN or GPIB.

the modulation formats used, are provided in a user-defined configuration file that describes the OFDM signal down to each individual cell. Until now, configuration file generation required the use of MATLAB® so that users had to be familiar with this software and the standard.

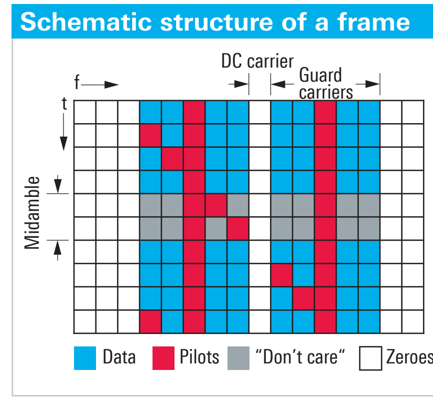


FIG 2 A cell can be a data, pilot, zero or "don't care" cell. In addition, each pilot cell must be assigned a specific constellation point and each data cell the modulation used.

Step-by-step to a finished configuration file with the wizard

Complicated programming using MATLAB® is no longer necessary. The configuration file wizard included in the R&S®FS-K96 software installation package is a convenient user tool for generating the configuration file for any OFDM standard. The step-by-step instructions and graphical display speed up and simplify the procedure.

The starting point for the signal description is I/Q data for the signal being measured. This data already exists in the majority of cases; but if not, MATLAB® can still be used as the description language. After completing the step-by-step instructions, the user receives a map of the physical layer – solely using graphical analysis of the I/Q data. The configuration file that is generated serves as a basis for analyses with the R&S®FS-K96 software.

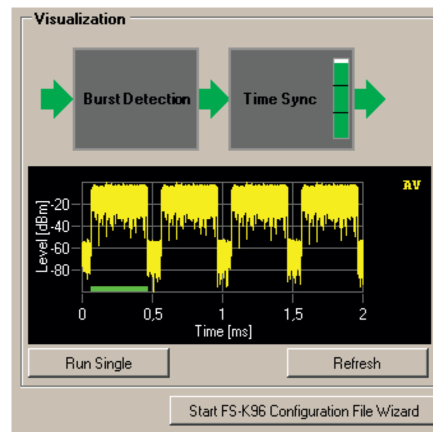


FIG 3 The signal flow diagram shows whether the settings made are suitable for the signal that is being measured.

Preparing the I/Q data

The user can record the I/Q data with the R&S®FS-K96 software. In the demodulation dialog field, the user selects whether the wizard will be later used to generate the configuration file. A dialog box opens which guides the user through setting the necessary parameters such as frequency and FFT length. In the displayed signal flow diagram (FIG 3), the user can easily check whether the settings made are suitable for the signal before starting the wizard.

Signal description with the wizard

The wizard guides the user step-by-step to a finished configuration file (FIG 4). The user loads the I/Q data and then selects the data range. In the third step, the user synchronizes the data (FIG 5), which serves as the basis for the remaining work steps.

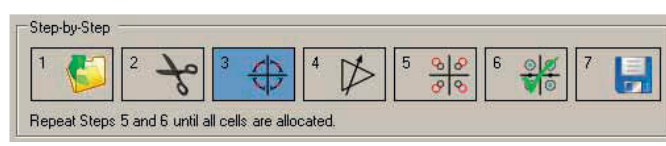
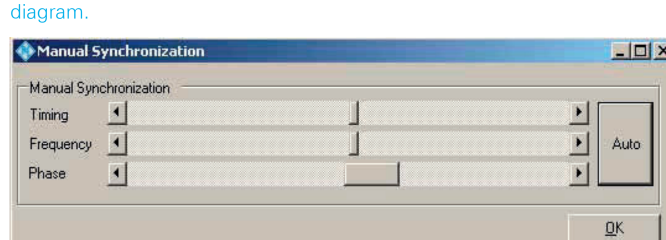


FIG 4 The wizard guides the user step-by-step to the finished configuration file.

After correcting the gain, the user starts dividing the frame into pilot, data, zero and "don't care" cells. The wizard simultaneously displays the I/Q constellation and the frame (FIG 6). In the frame display, the cells are placed over the carriers, i.e. the frame display has a time axis and a frequency axis. The frame display and the I/Q constellation are linked; if the user selects individual points in the I/Q constellation by clicking them, the wizard automatically marks the corresponding location in the transmitted frame. After selecting the points, the user allocates the function to the individual cells. For example, the signal structure in FIG 6 shows that the circled BPSK cells are probably training symbols (pilots). The user simply

FIG 5 In step 3, the user only has to adjust the timing, frequency and phase by simply sliding the graphical bars to obtain a clear constellation diagram.



clicks to allocate this function. These cells are then hidden and no longer shown in the constellation, making it immediately evident which cells still require allocation. In the example, the BPSK-modulated pilots, the data cells with 64QAM modulation, the zero cells and the boosted cells at the beginning of the frame still need to be allocated. If the function of individual cells is unknown, these can be specified as "don't care" cells. The R&S®FS-K96 software ignores them in the subsequent measurement. When all cells have been allocated, the configuration file is finished. After the file is saved, it can be loaded into the R&S®FS-K96 software, and measurement (including demodulation of the signal) can start.

Numerous results for the analysis of OFDM signals

In addition to a numeric table that lists, for example, EVM results or the I/Q offset, R&S®FS-K96 offers a large number of graphics that simplify fault analysis. Additional configurable windows make it easy to display the most important results side-by-side for direct comparison (FIG 7).

Flexible license keys, also for measurements without an analyzer

The PC-based OFDM vector signal analysis software makes it possible to perform modulation measurements on generic OFDM signals using the R&S®FSQ / R&S®FSG / R&S®FSV / R&S®FSVR signal and spectrum analyzers and the R&S®FSUP signal source analyzer (FIG 8). The license key for the software is not installed on the analyzer, as was previously the case. It is installed on a Smart Card which can be connected to the PC via a USB dongle, for example. In order to meet different user requirements, two different options with flexible license types are available:

R&S®FS-K96: This option requires a connection to one of the above-mentioned analyzers via LAN or the IEC/IEEE bus, and a Smart Card with a valid license key. This option is recommended for test setups where new data needs to be taken on a continuous basis.

R&S®FS-K96 PC: This option can be used with or without a connection to one of the above-mentioned analyzers. It is suitable for analyzing I/Q data that has been previously recorded with the aid of an analyzer.

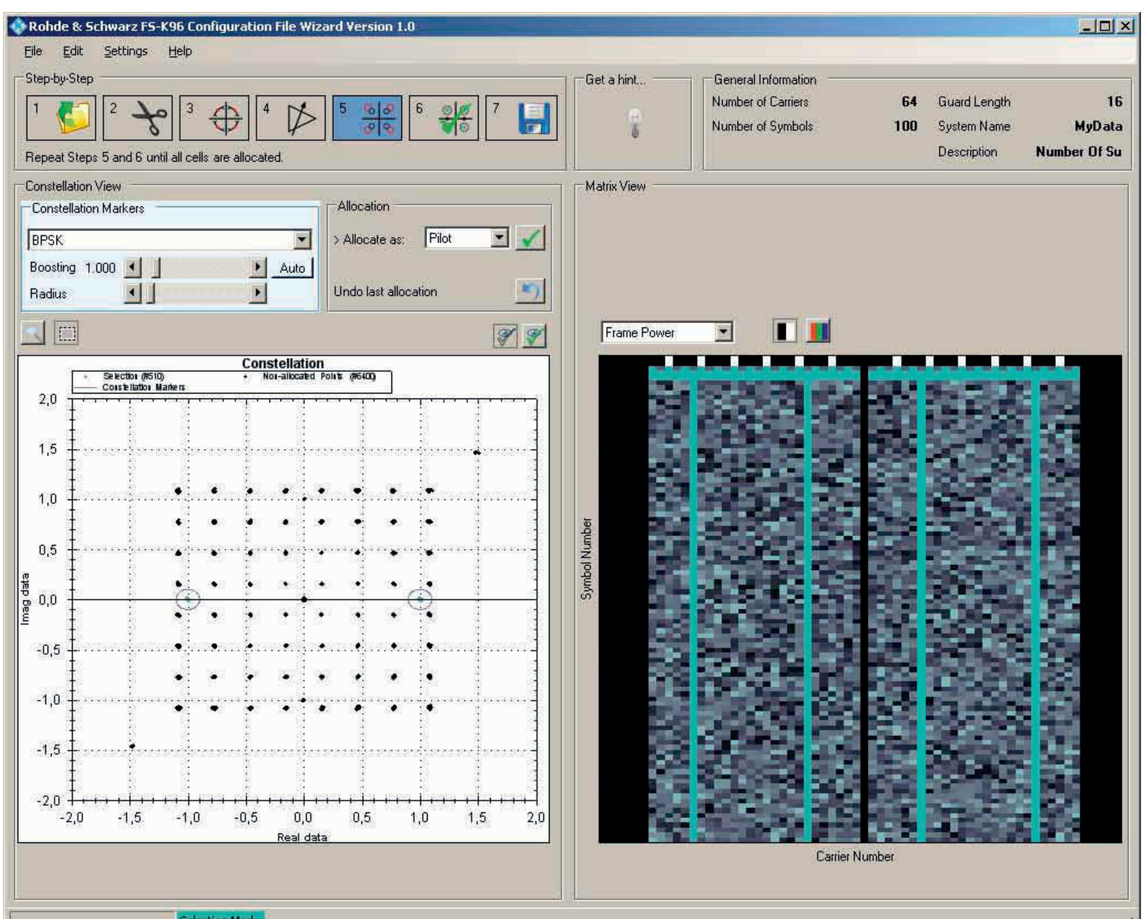


FIG 6 I/Q constellation and frame display at a glance.

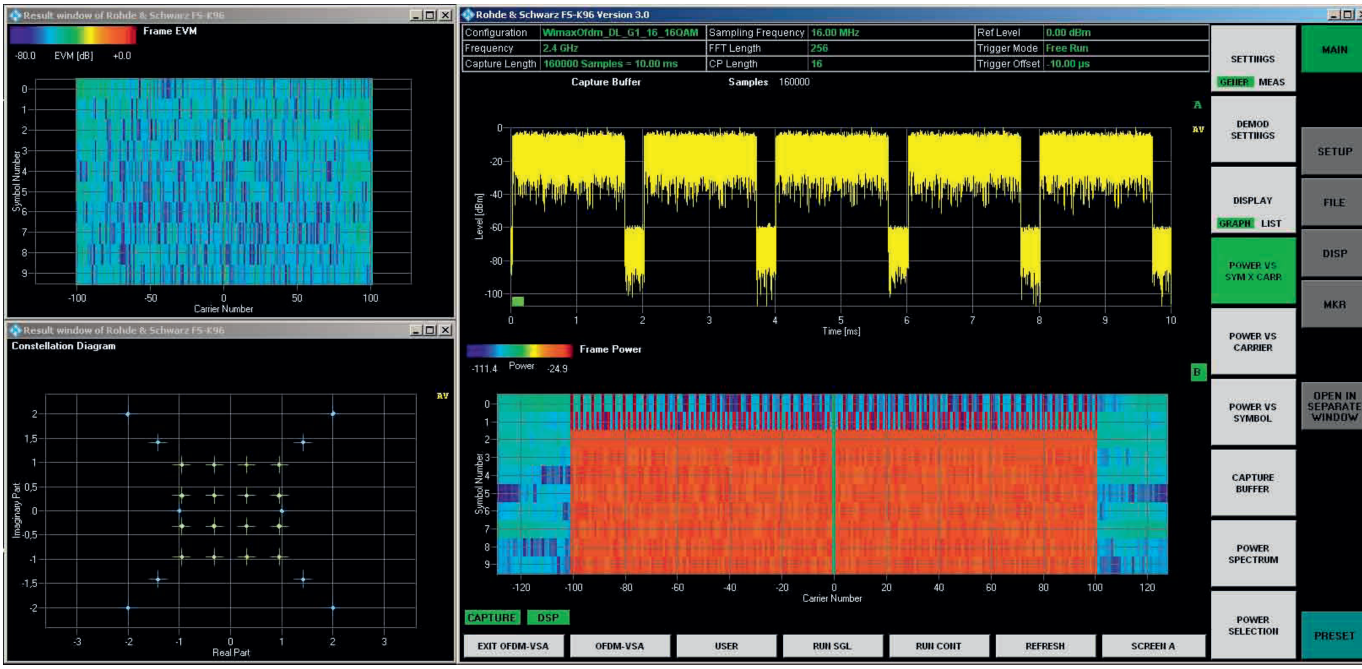


FIG 7 Numerous result windows make analysis easier.

R&S®FS-K96U: For upgrading from R&S®FS-K96 to R&S®FS-K96 PC at a later date.

License model: Both permanent license keys and time-limited license keys are available for the R&S®FS-K96 software. Time-limited license keys are ideal for project-related work that only lasts for a limited period of time.

Supplied configuration files

For standard-compliant measurements, the software includes preconfigured configuration files for DVB-T, WiMAX™ 802.16 OFDM, WLAN 802.11a and WLAN 802.11n Mixed Mode. Templates in the form of MATLAB® scripts are provided for other standards such as DVB-T2, ISDB-T, MOCA or CMMB.

Summary

R&S®FS-K96 from Rohde & Schwarz is a powerful software package for generic OFDM signals. Numerous measurement results make fault analysis easier. The new wizard supports individual configuration – even without programming knowledge. In order to give interested parties an insight into the software and the configuration file wizard, four different I/Q files can be analyzed free of charge without a Smart Card. The files are example signals of common OFDM standards (e.g. WLAN). Download the software from the Internet and try it out.

Dorothea von Droste; Susanne Godtmann

FIG 8 The key characteristics of the signal and spectrum analyzers with which the R&S®FS-K96 software can be used.

	R&S®FSQ	R&S®FSG	R&S®FSV	R&S®FSVR	R&S®FSUP
Frequency range	20 Hz to 40 GHz	9 kHz to 13.6 GHz	9 kHz to 40 GHz	10 Hz to 40 GHz	20 Hz to 50 GHz
Signal analysis bandwidth	120 MHz	28 MHz	40 MHz	40 MHz	28 MHz
EVM (WLAN)	< –45 dB	< –44 dB	< –44 dB	< –44 dB	< –44 dB
Analog baseband inputs	yes	no	no	no	no
Digital I/Q interface	yes	yes	yes	yes	no

Analyzing WiMAX™, LTE and WLAN MIMO signals

More and more radio standards are using MIMO technology to address the constantly rising demand for transmission capacity. The current application firmware for the R&S®FSQ, R&S®FSG and R&S®FSV signal analyzers is following this trend. The firmware is used to measure transmitted WiMAX™, 3GPP HSPA, 3GPP LTE and WLAN MIMO signals.

MIMO measurements with signal analyzers from Rohde&Schwarz

The box below provides an overview of the various MIMO technologies. Performing measurements on MIMO systems requires adapting the algorithms in the analysis software. The primary purpose of many test applications for verifying design parameters, or for use in production, is to determine if the transmitted signals adhere to the relevant standards and whether the physical characteristics fall within the specified limits. In such cases there is no need to simultaneously measure the various transmit paths. Instead, they can be tested sequentially. Only one signal analyzer is needed to measure parameters such as error vector magnitude (EVM), power and I/Q imbalance.

Measurements that have to be carried out for development or certification testing are significantly more extensive. In order to fully reproduce the data in transmit signals or analyze the crosstalk between the antennas for example, measurements must be performed simultaneously on both antennas. One signal analyzer is still sufficient if the system is using transmit diversity (multiple input single output – MISO). However, space-division multiplexing requires two or more signal analyzers to calculate the channel matrix and demodulate the signals. The solution from Rohde&Schwarz uses one of the analyzers as the master, which triggers the other analyzers (slaves). The only function of the slaves is to record the data that is centrally accumulated.

MIMO technologies at a glance

The use of multiple input multiple output (MIMO) technology – i.e. using multiple transmit and receive antennas in parallel – increases transmission rates and improves transmission quality. This technology takes advantage of multipath propagation in radio channels, which is perceived as interference in conventional radio standards. In MIMO systems, each additional path between transmitter and receiver increases the signal-to-noise ratio. Mobile applications in particular benefit substantially from multipath reception, because the required minimum receive level can be lower. Most communications standards define MIMO operating modes for two, three or four antennas.

MIMO systems use transmit diversity or space-division multiplexing. With transmit diversity, a bit stream is transmitted simultaneously via two antennas, but with different coding in each case. The coding is based on the Alamouti scheme. This improves the signal-to-noise ratio and the cell edge capacity. The improved transmission rate is an indirect result of the improved signal quality. With space-division multiplexing, different bit streams are simultaneously transmitted to two receive antennas, which increases the data throughput and improves bandwidth utilization. Article [1] provides more information on this subject using WLAN as an example.

In modern wireless communications systems, the base station continuously adjusts the signal coding in order to take full advantage of multipath propagation. To reduce the correlation between the propagation paths, the transmitter can delay all of the transmission signals except one. This method is referred to as cyclic delay diversity or cyclic delay shift.

In order for a base station to serve multiple subscribers or multiple wireless devices, it usually implements collaborative MIMO for transmission to the wireless communications network. This is similar to space-division multiplexing. Instead of utilizing two transmit antennas however, two subscribers transmit over the same frequency. The throughput of the overall system is increased, but not the throughput for each subscriber.

The basis of the majority of the applications for broadband transmission is the OFDM method. In contrast to single-carrier methods, an OFDM signal is a combination of many orthogonal, separately modulated carriers. Since the data is transmitted in parallel, the symbol length is significantly greater than in single-carrier methods with identical transmission rates. OFDMA combines multiple physical carriers and each subscriber is allocated a specific number of carriers based on the bandwidth required. OFDMA is ideal for MIMO since the required precoding can be individually adapted to each subscriber.

MIMO in WiMAX™ systems

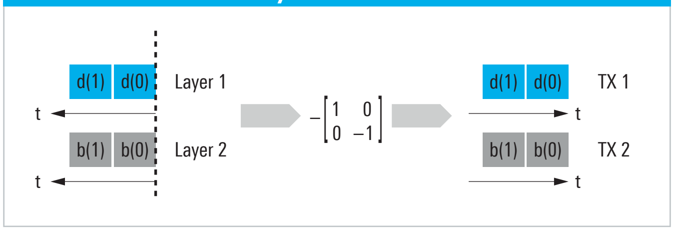


FIG 1 Due to the diagonal transmission matrix, the individual data stream symbols are not distributed to the antennas.

MIMO in UMTS-LTE systems

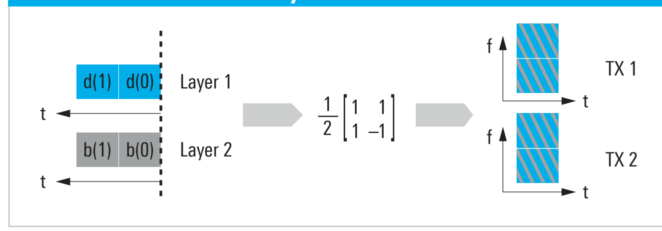


FIG 2 The non-diagonal elements cause a symbol to be distributed to multiple antennas.

MIMO measurements on WiMAX™ systems

Although the IEEE 802.16e-2005 standard defines MIMO with two or four antennas, current installations are limited to two antennas. WiMAX™ utilizes transmit diversity (Matrix A) and space-division multiplexing (Matrix B). Antenna 0 and antenna 1 have different burst structures. The first zone is a partially utilized subchannelization (DL-PUSC) zone with preamble that is always transmitted via antenna 0. No signal is transmitted via antenna 1. Both antennas transmit MIMO signals during the subsequent zone. Diagonal matrices are used for MIMO precoding, which is why the transmitted symbols are not distributed between the antennas. One symbol is transmitted via antenna 0 and the next via antenna 1, etc. (FIG 1). For this reason, it is not necessary to simultaneously acquire the signals from both antennas if users do not want to fully demodulate the signal and want to analyze only the physical transmit characteristics. The transmitted MIMO signals can be analyzed separately. Only one signal analyzer is required, which reduces the costs for measurement equipment. However, a different synchronization algorithm is required for measurements on antenna 1 since there is no preamble. FIG 3 illustrates wired measurements of a WiMAX™ Matrix A signal. The different burst structures of the two antenna paths can be clearly seen in the time display (upper section). The transmission channels are displayed in the section underneath. For Matrix A, both antenna paths can be measured simultaneously using one analyzer.

MIMO in UMTS long term evolution

To ensure that UMTS remains competitive for ten or more years, the UMTS long term evolution (LTE), which is based on OFDMA technology and also known as Evolved UTRA or Evolved UTRAN, was specified in 3GPP, release 8. LTE utilizes transmit diversity and space-division multiplexing (which can be combined with cyclic delay diversity).

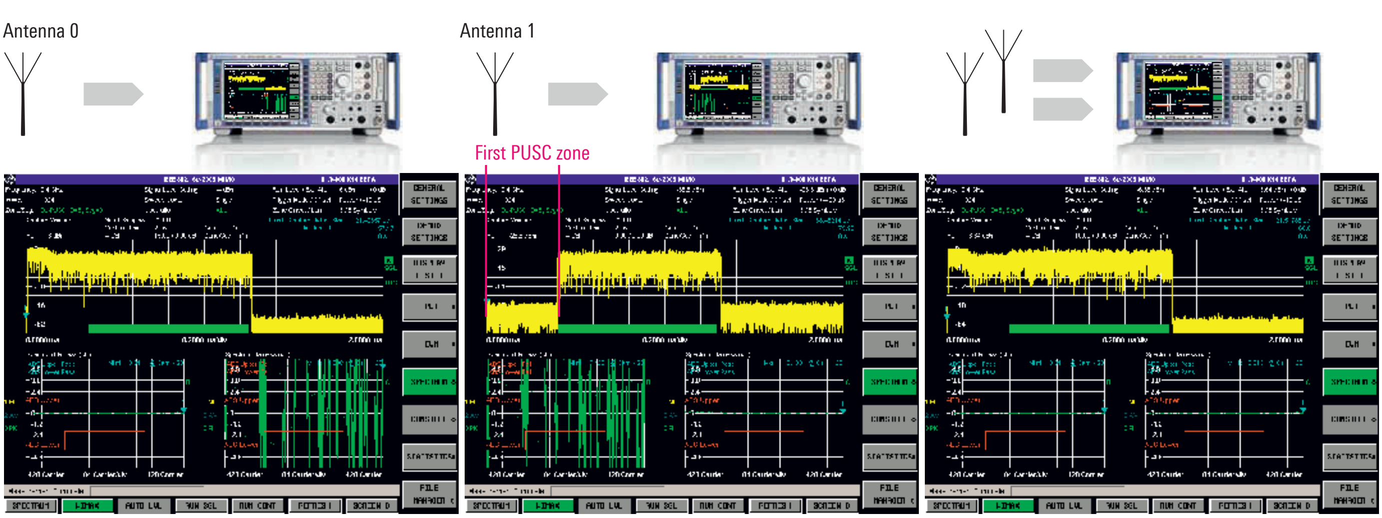


FIG 3 Wired measurement of the channel properties of a WiMAX™ Matrix A signal.

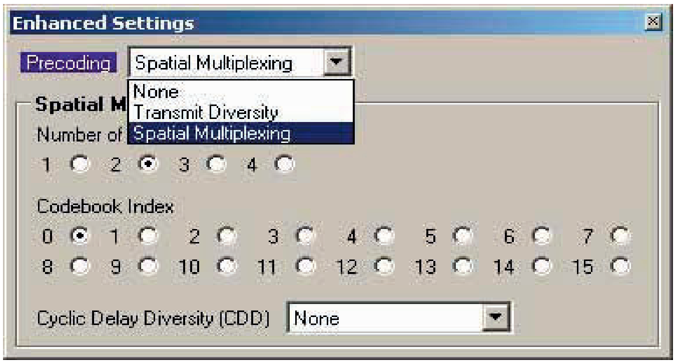


FIG 4 The R&S®FSQ-K102 firmware supports all MIMO operating modes.

The payload (code words) is scrambled and modulated with the appropriate format (QPSK, 16QAM or 64QAM). The information is then mapped to layers, where the number of layers is less than or equal to the number of antennas in the system. For precoding, the information is multiplied using a matrix (FIG 2).

Depending on the conditions in the transmission channel, the matrix is filled with various content. There is a large number of possible predefined matrices, which the standard refers to as codebook entries. If the non-diagonal elements in the matrix do not equal zero, the payload is distributed between the antennas. In order to analyze such signals, the signal analyzer must simultaneously capture the RF signals from all transmitters before the content can be reconstructed. In contrast to WiMAX™, two or more signal analyzers are required to calculate the channel matrix and demodulate the signals. For this measurement configuration, the Rohde&Schwarz solution also uses one of the analyzers as the master and the others as slaves. The option supports all MIMO operating modes with up to four antennas (FIG 4). After the signal from different analyzers has been combined, the result can be displayed in a constellation diagram for example (FIG 5).

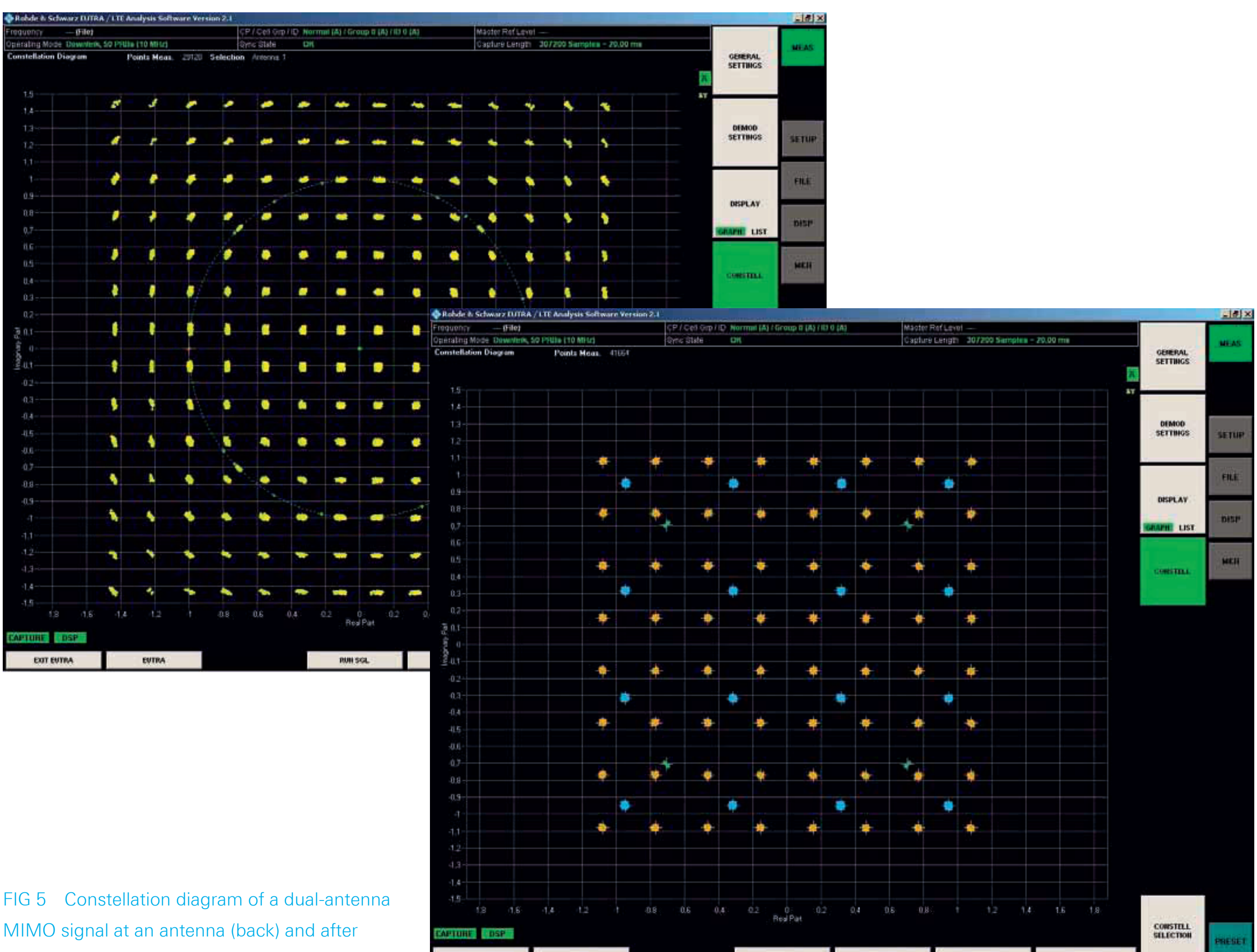


FIG 5 Constellation diagram of a dual-antenna MIMO signal at an antenna (back) and after MIMO decoding (front).

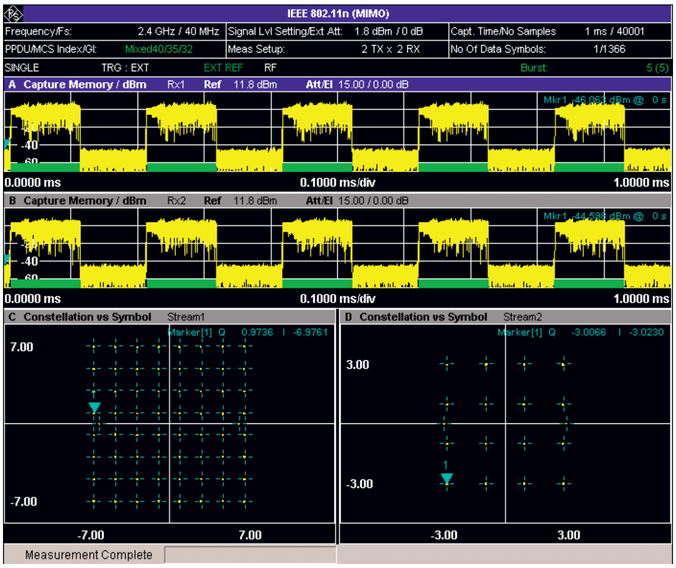


FIG 6 Constellation diagram of a WLAN MIMO signal with differently modulated data streams (16QAM and 64QAM).

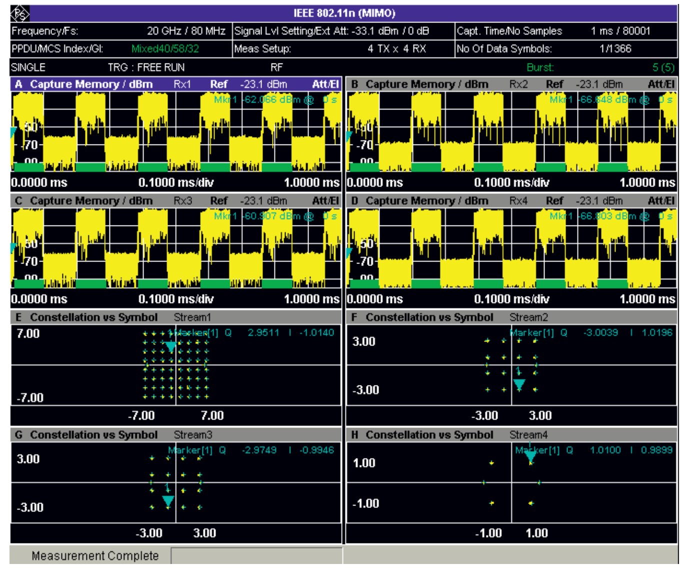


FIG 7 Constellation diagram of a 4×4 WLAN MIMO signal with differently modulated data streams (64QAM, 16QAM, QPSK). Only **one** R&S®FSQ signal analyzer was used to sequentially acquire and then measure the four antenna signals.

MIMO and WLAN IEEE 802.11n

WLAN-n (IEEE 802.11n) is an extension of the IEEE 802.11a/g Wi-Fi communications standards and is designed to enable a net data throughput of up to 600 Mbit/s in wireless LANs. To achieve this high rate, the standard specifies the use of 20 MHz and 40 MHz channel bandwidths and MIMO applications with up to four data streams (see [2]). Since the spatial mapping of the data streams to the various antennas is similar to LTE and because diagonal matrices may not necessarily be used for the coding, the analysis generally requires multiple signal analyzers.

The R&S®FSQ-K91n option for the R&S®FSQ signal and spectrum analyzer allows users to carry out MIMO measurements on WLAN 802.11n signals with a bandwidth of 20 MHz or 40 MHz and, for the time being, with two transmit and two receive antennas (2×2). Due to the generally non-diagonal and to some extent even user-definable matrices, WLAN MIMO measurements typically require two analyzers. When measuring recurring test signals, the individual antennas can also be measured sequentially. The transmit signals are recorded sequentially and stored as I/Q data. An R&S®OSP switch and control platform can also be used to switch between the analyzer inputs. The measurement parameters are then calculated. This operating mode can also be used to measure 4×4 systems. To simplify the measurement settings for the user, the R&S®FSQ automatically finds nearly all key parameters (FIG 6) such as the bandwidth used or the operating mode (mixed, Greenfield).

After recording, the R&S®FSQ demodulates the signal and displays all the results in multiple, easy-to-read windows that can of course be zoomed and viewed individually. FIG 7 is an example of a constellation diagram displaying two differently modulated data streams of a WLAN MIMO signal.

Summary

The R&S®FSQ, R&S®FSG and R&S®FSV signal analyzers from Rohde&Schwarz offer versatile, scalable solutions for testing WiMAX™, LTE and WLAN MIMO transmitter systems. A range of signal generators is also available for carrying out receiver tests [2], [3].

Johan Nilsson; Dr. Wolfgang Wendler

References

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[2] R&S®Axx / R&S®SMx Signal Generators – IEEE 802.11n: all signals for development, production, service. News from Rohde&Schwarz (2008) No. 195, pp. 24–25.
[3] R&S®SMU200A / R&S®AMU200A Generators: MIMO receiver tests using only one signal generator. News from Rohde&Schwarz (2007) No. 193, pp. 9–10.
– From SISO to MIMO – taking advantage of everything the air interface offers (2). News from Rohde&Schwarz (2007) No. 194, pp. 4–7.
– Application Note 1MA179, “WLAN 802.1n: From SISO to MIMO”.

Network analysis at your fingertips – for demanding applications in development and production

More than 60 years of experience in vector network analysis and the constant effort to develop innovative, easy-to-operate T&M equipment – these are the cornerstones on which the development of the new R&S®ZNC and R&S®ZNB vector network analyzers is based. The new instruments feature excellent performance characteristics, high long-term stability and exceptional ease of operation.

Analyzers that match challenging tasks

Rohde&Schwarz developed its new R&S®ZNC and R&S®ZNB vector network analyzers to meet the growing requirements encountered in the development, production and servicing of products of the mobile radio and electronic goods industries. The implementation of more and more sophisticated RF technologies in products addressing the wide-base market also places more stringent demands on the network analyzers

FIG 1 The R&S®ZNB8 (top) and the R&S®ZVL vector network analyzers (bottom) in a production environment.

FIG 2 The R&S®ZNB and R&S®ZNC provide truly intuitive measurement and analysis. Basic functions are operated via hardkeys; all other functions are controlled via the 30 cm (12.1") touchscreen. Submenus and multilevel, nested menu structures are not needed.

used to characterize the RF components and modules of such products. Therefore, a new approach was taken when the R&S®ZNC and R&S®ZNB were developed. The new analyzers easily handle the requirements encountered in series production of state-of-the-art RF components and also offer versatile functionality for use in laboratory applications. In both T&M and production, the analyzers set new standards in their product class.

The R&S®ZNC is a very cost-effective network analyzer suitable mainly for S-parameter measurements in the development and production of passive components such as filters, antennas and cables. The two-port analyzer has a frequency range from 9 kHz to 3 GHz. It offers a dynamic range of 130 dB, low trace noise of 0.004 dB RMS (at 10 kHz IF bandwidth), IF bandwidths of up to 300 kHz and output power of up to 10 dBm (13 dBm with extended power range option).

The R&S®ZNB (FIGs 1 and 2) features higher dynamic range (up to 140 dB at 10 Hz IF bandwidth), IF bandwidths of up to 10 MHz and output power of up to +13 dBm that can be adjusted electronically in a range of more than 95 dB. The R&S®ZNB has electronic step attenuators in the receive paths, allowing it to handle input powers of up to +27 dBm. The analyzer can generate more than 100 traces covering up to 100 000 points, which makes it ideal even for complex measurement tasks. It offers short sweep times of 4 ms for 401 points while maintaining high accuracy. The analyzer is available as a two-port or four-port model with a frequency range from 9 kHz to 4.5 GHz or 8.5 GHz. It is the right choice for T&M applications in the development and production of sophisticated two-port and multiport RF components, such as testing high-blocking base station duplex filters or mobile phone components, e.g. balanced SAW filters, or characterizing amplifiers.

Both R&S®ZNB models feature excellent temperature and long-term stability, which ensures reliable measurements over several days without having to recalibrate the instruments. The analyzers come with an innovative user interface. They have identical remote control command sets, and can therefore easily be interchanged as required for a specific DUT, for example in production applications.

The short-depth, compact analyzers leave plenty of space for the measurement application. They feature low operating noise thanks to low power consumption and a sophisticated cooling concept. Low noise operation is beneficial in noisy production environments and T&M environments as well. The low power consumption also reduces operating costs and protects the environment.

Easier than ever before – measurement results in just three operating steps

Particular highlights offered by the R&S®ZNB and the R&S®ZNC are the 30 cm (12.1") touchscreen and the carefully thought-out operating concept, which make configuring, measuring and analyzing truly intuitive. Many input functions can be accessed via pop-up menus on the touchscreen (FIG 2). Arranging diagrams, moving traces between diagrams, setting up markers for analysis and zooming in on details – all it takes is a simple movement with your finger or the mouse on the high-resolution touchscreen.

Submenus and multilevel, nested menu structures are not needed. In addition to hardkeys and softkeys, the R&S®ZNB and R&S®ZNC include a soft panel as a new control feature. The soft panel immediately shows the control elements that may be needed for a measurement and allows users to access all instrument functions in a maximum of three operating steps. It can optionally be arranged on the right or left to accommodate both right- and left-handed users. The innovative instruments provide network analysis literally at the touch of a finger: Users can shift traces between diagrams, position markers on traces, move scaling reference lines and activate pop-up menus in order to edit test parameters right where they are displayed.

Measurement tasks such as characterizing amplifiers and RF modules, which involve a large number of test parameters, can be split up and assigned to multiple, clearly arranged instrument setups containing just a few traces. All setups are available at your fingertips. This straightforward operating concept not only benefits beginners and infrequent users; it also makes operation easier for experienced users and increases measurement efficiency.

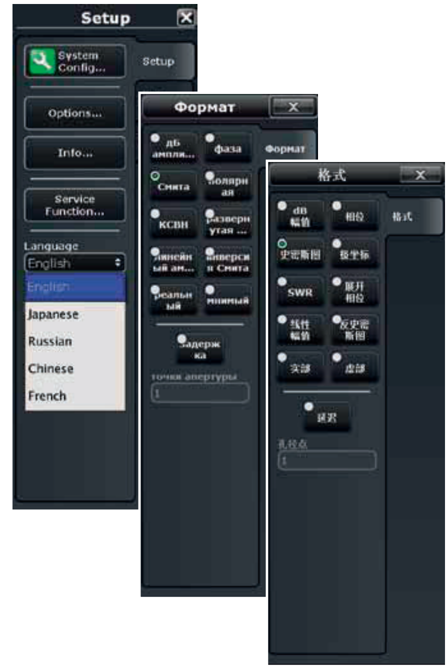
The R&S®ZNB and the R&S®ZNC offer users a wide choice of options when it comes to displaying results. Traces can be freely assigned to diagrams and channels, and assignments can be changed at any time during the measurement. To maximize the display area, which may be a useful option during manual adjustments, the soft panel can be hidden to make the entire screen area available for displaying results (FIG 3).

A wide variety of analysis functions help the user evaluate important parameters at a glance:

FIG 3 The soft panel can be hidden, leaving the full screen area for the display of results.

FIG 4 Equation editor for trace mathematics.

FIG 5 Complex measurement tasks are easiest to solve in one's native language. The new network analyzers therefore speak the user's language. The figure shows the R&S®ZNB and R&S®ZNC soft panel menu for language selection (left) and menus in Russian and Chinese (middle and right).



- Ten markers per trace
- Automatic bandwidth measurements
- Limit line and ripple check with pass / fail indication
- Statistical trace analysis including maximum, minimum, RMS and peak-to-peak detection as well as compression point measurement
- Equation editor for complex, realtime trace mathematics (FIG 4)

Same as the network analyzers of the R&S®ZVB and R&S®ZVA families, the R&S®ZNB and R&S®ZNC have an undo / redo function for canceling or restoring entries.

Complex tasks are easiest to solve in one's native language. The new network analyzers therefore speak the user's language. Currently available languages include English, French, Russian, Chinese and Japanese (FIG 5).

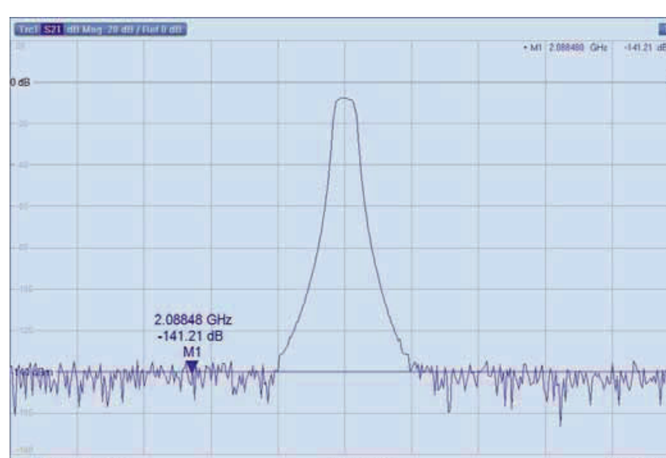
High speed, high precision and excellent long-term stability – ideal for development and production

Fast or accurate? This is the question users are often faced with in production. Either, they can carry out measurements using narrow IF bandwidths to avoid errors caused by noise, which is the more time-consuming approach. Or, they can use wide IF bandwidths to exploit the instrument's maximum sweep speed, which is at the price of larger measurement errors. The R&S®ZNB eliminates this problem, as it combines a fast synthesizer with high sensitivity and a wide dynamic range.

Wide dynamic range yields short measurement times for high attenuation

When measuring high attenuation, for example in the stopband of a base station duplex filter, the measurement speed is determined by the required dynamic range and the corresponding IF bandwidth. Reducing the IF bandwidth by a factor of 10 will increase the dynamic range by 10 dB. In the case of narrow IF bandwidths, the measurement time per point is approximately 1/IF bandwidth. The larger the IF bandwidth, the shorter the measurement time. A 10 dB increase in dynamic range will boost measurement speed by a factor of 10. The R&S®ZNB offers a dynamic range of up to 140 dB at 10 Hz IF bandwidth (R&S®ZNC: 130 dB). At a dynamic range of 120 dB, the measurement time per point is therefore

FIG 6 Filter measurement at 10 Hz IF bandwidth.



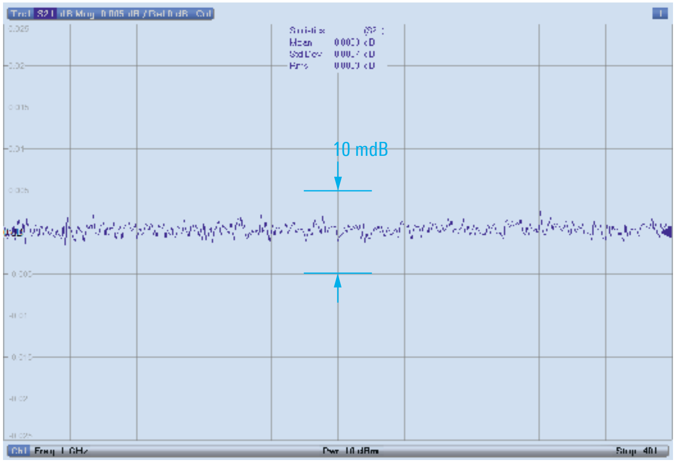


FIG 7 Trace noise at 10 kHz IF bandwidth.

FIG 8 R&S®ZNB calibration wizard.

only 1 ms (R&S®ZNC: 1 ms at 110 dB). In addition to high measurement speed, the analyzers offer a signal-to-noise ratio (SNR) sufficient to provide high measurement accuracy (FIG 6).

Fast synthesizers yield short measurement times for low attenuation

Measurements of low attenuation, for example in the passband of a base station duplex filter, can be carried out at maximum IF bandwidth. Measurement time is not determined by the IF bandwidth, but by the speed of the synthesizer. At an IF bandwidth of 1 MHz, the R&S®ZNB requires only 4 ms for a sweep covering 401 points (R&S®ZNC: 11 ms for 401 points at 300 kHz IF bandwidth). The measurement error is virtually negligible due to the low trace noise (FIG 7).

Fast data transfer via IEC/IEEE bus and LAN

The hardware concept of the R&S®ZNB and R&S®ZNC makes it possible to transfer the data measured during a sweep to a controller via the IEC/IEEE bus or LAN while data is being captured during the next sweep. This means that data transfer time is practically insignificant, which substantially cuts down on measurement time. In automatic operation, measurements can be speeded up even further by outputting control signals (referred to as channel bits) via a digital interface on the R&S®ZNB rear panel. The control signals synchronize the device under test (DUT) with the internal measurement sequences of the R&S®ZNB.

Fast switching between instrument setups

To carry out complex measurements with different instrument setups, users of the R&S®ZNB and R&S®ZNC do not need to load the setups from the hard disk each time. Once called, the setups for the required measurements, including calculated data such as calibration values, remain available in RAM. This reduces switching time, especially for measurements involving a large number of points. Switching between setups in remote operation is virtually instantaneous. Manually, all the user has to do is touch the screen to activate the setup needed for a specific DUT or measurement.

The right calibration method for every application

High accuracy not only calls for low trace noise and a wide dynamic range, but also for appropriate calibration methods. The R&S®ZNB and R&S®ZNC support calibration methods for various applications, for example for measuring DUTs with coaxial and waveguide connectors as well as DUTs held in test fixtures and on wafers. Graphical wizards guide the user step by step through the calibration (FIG 8).

TSM: new manual calibration method requiring only three calibration standards

A network analyzer's accuracy after calibration essentially depends on the quality of the calibration standards used. The quality of the standards, in turn, depends mainly on how accurately they can be described by models. Describing the open standard by a model may be problematic. Rohde&Schwarz therefore created the new TSM calibration method for its R&S®ZNB. The new method requires only a through, a short and a match standard; an open standard is not needed. TSM provides accuracy equivalent to that of TOSM, and reduces the number of calibration steps from seven to five.

Precise measurements even with inexpensive calibration kits

The R&S®ZNB and R&S®ZNC support a large number of calibration methods. The UOSM (unknown through, open, short, match) calibration method deserves special mention, as it supports economy calibration kits that do not contain a through standard. Instead of using a high-quality through standard, a simple adapter not known to the network analyzer is used when calibration is carried out with such a kit. While such adapters are inexpensive, they lead to measurement uncertainties of up to a few tenths of a dB with calibration methods requiring a through, an open, a short and a match standard. When using the UOSM method, the adapter's characteristics are irrelevant, and accuracy after calibration is comparable to that achieved with a high-quality through standard.

Automatic calibration in 30 seconds

For applications calling for speedy calibration, for example in production, the R&S®ZNB and R&S®ZNC support automatic calibration units. Controlled via USB, these units carry out full calibration within 30 seconds at the press of a key (FIG 9). This affords an enormous speed advantage and minimizes the risk of operator errors over manual calibration especially when full four-port calibration is performed, for example on balanced two-port components. FIG 10 shows the R&S®ZNB's effective system data after a full two-port calibration using mechanical calibration standards.

High temperature stability for long calibration intervals

Careful calibration increases measurement accuracy but interrupts the development or production process. Temperature and long-term stability are the key characteristics determining the calibration interval; the R&S®ZNB hardware was consequently developed bearing these characteristics in mind. Another important factor crucial to high stability is good raw data. The R&S®ZNB offers directivity of more than 30 dB and a test port match of up to 25 dB even without calibration. A calibrated R&S®ZNB enables precise measurements over several days without recalibration, i.e. without interruption. This increases productivity in development and production.

FIG 9 R&S®ZV-Z51 calibration unit (automatic).

	9 kHz to 100 kHz	100 kHz to 4.5 GHz	4.5 GHz to 8.5 GHz
Directivity	46 dB	45 dB	40 dB
Source match	41 dB	40 dB	36 dB
Load match	44 dB	45 dB	40 dB
Reflection tracking	0.02 dB	0.02 dB	0.05 dB
Transmission tracking	0.028 dB	0.018 dB	0.09 dB

FIG 10 Effective system data of the R&S®ZNB after full two-port calibration using mechanical calibration standards.

Amplifier measurements with up to 27 dBm output power

The R&S®ZNB offers a wealth of functions for measuring amplifiers. It measures S-parameters as well as output power, stability factors, power consumption, impedances and Z-parameters as a function of frequency or power. The analyzer's high output power of up to +13 dBm and wide electronic power sweep range of more than 95 dB enable fast and wear-free measurements on amplifiers of nearly all power classes under different stimulus conditions. The electronic receiver step attenuators are designed to handle input powers of up to +27 dBm, enabling the R&S®ZNB to perform compression-free measurements even on amplifiers with high output powers. Amplifier characterization also includes determining the RF-to-DC transfer characteristics of power-monitoring level detectors, and measuring power consumption to determine efficiency. For this purpose, the R&S®ZNB offers four DC inputs with a voltage range of up to ±10 V and sensitivity of 10 µV.

Rohde&Schwarz network analyzers upgrade your test system

Network analyzers are the core of many test systems, for example in RF component production. Replacing an obsolete network analyzer with a latest generation Rohde&Schwarz network analyzer will significantly increase system performance. The R&S®ZNB and R&S®ZNC support the remote control command sets of practically all other Rohde&Schwarz network analyzers as well as those of other manufacturers' instruments. Replacing old instruments with a state-of-the-art analyzer from Rohde&Schwarz is therefore easily possible. In most cases it is sufficient to verify the R&S®ZNB's or R&S®ZNC's response during a measurement sequence; there is no need for costly modifications in the system software.

Thilo Bednorz

Network analysis from 10 MHz to 110 GHz in a single sweep

The R&S®ZVA110 vector network analyzer covers the entire frequency range from 10 MHz to 110 GHz, making it ideal for on-wafer measurements as well as other applications. Millimeter-wave converters can be used to expand the frequency range of the R&S®ZVA110 to 500 GHz for band-specific measurements. In addition, the R&S®ZVA110 is able to perform frequency-converting and pulsed measurements.

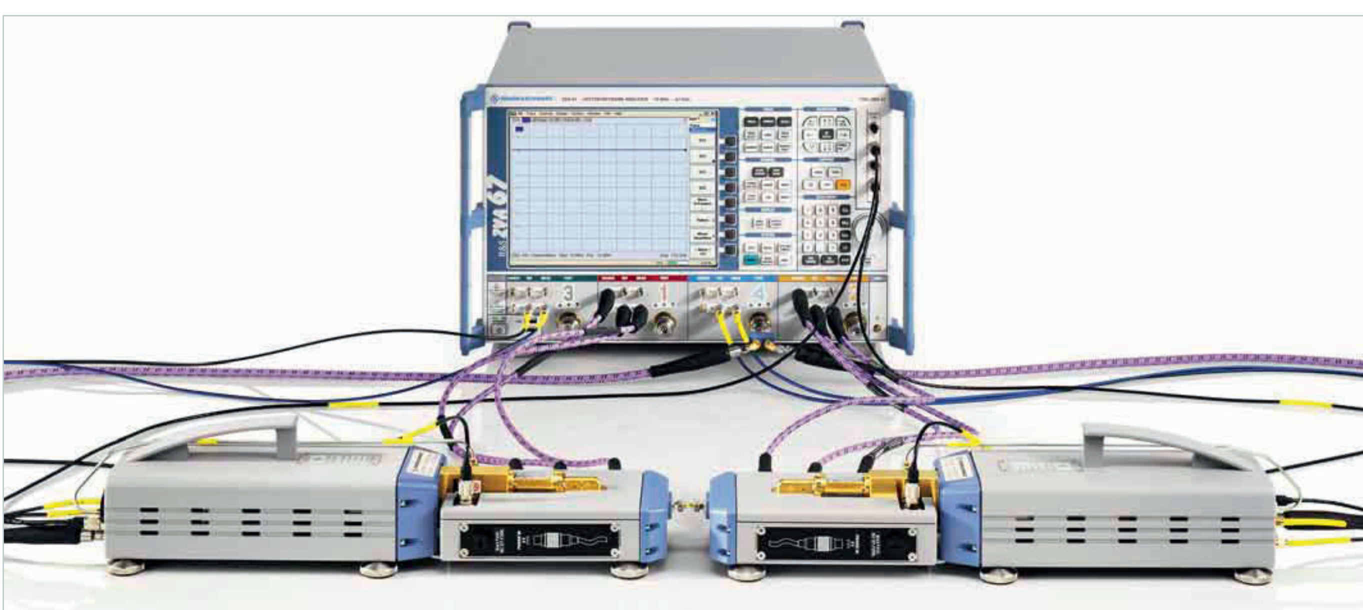
The most compact 110 GHz system on the market

The high-end R&S®ZVA110 vector network analyzer (FIG 1) consists of an R&S®ZVA67 four-port vector network analyzer that is enhanced by two R&S®ZVA-Z110E millimeter-wave converters and two diplexers with 1 mm ports. In the analyzer's basic frequency range between 10 MHz and 70 GHz, the test signal is routed to the 1 mm test ports via the diplexers. In the range between 70 GHz and 110 GHz, the test signal from the analyzer is upconverted in the millimeter wave converters and routed via the diplexers to the 1 mm test ports. Controlled by the network analyzer, the diplexers automatically switch between the two paths, enabling continuous sweeps from 10 MHz to 110 GHz. No additional control hardware or external signal source is required, making the R&S®ZVA110 the most compact 110 GHz system on the market.

The modular system can be easily expanded to cover band-specific measurements up to 500 GHz. It is a simple matter to connect other Rohde&Schwarz millimeter-wave converters instead of the existing converters and diplexers; no additional hardware or software is needed. This flexibility means real investment protection since the system can be expanded to handle future test requirements.

The R&S®ZVA67 is the only network analyzer that offers four coherent signal sources up to 67 (70) GHz whose amplitude and phase offset can be adjusted relative to each other. This unique functionality is useful in applications such as antenna beamforming, modulator characterization and for true differential measurements.

FIG 1 The R&S®ZVA110 does not require additional control hardware or external signal sources, making it the most compact 110 GHz network analyzer system on the market.



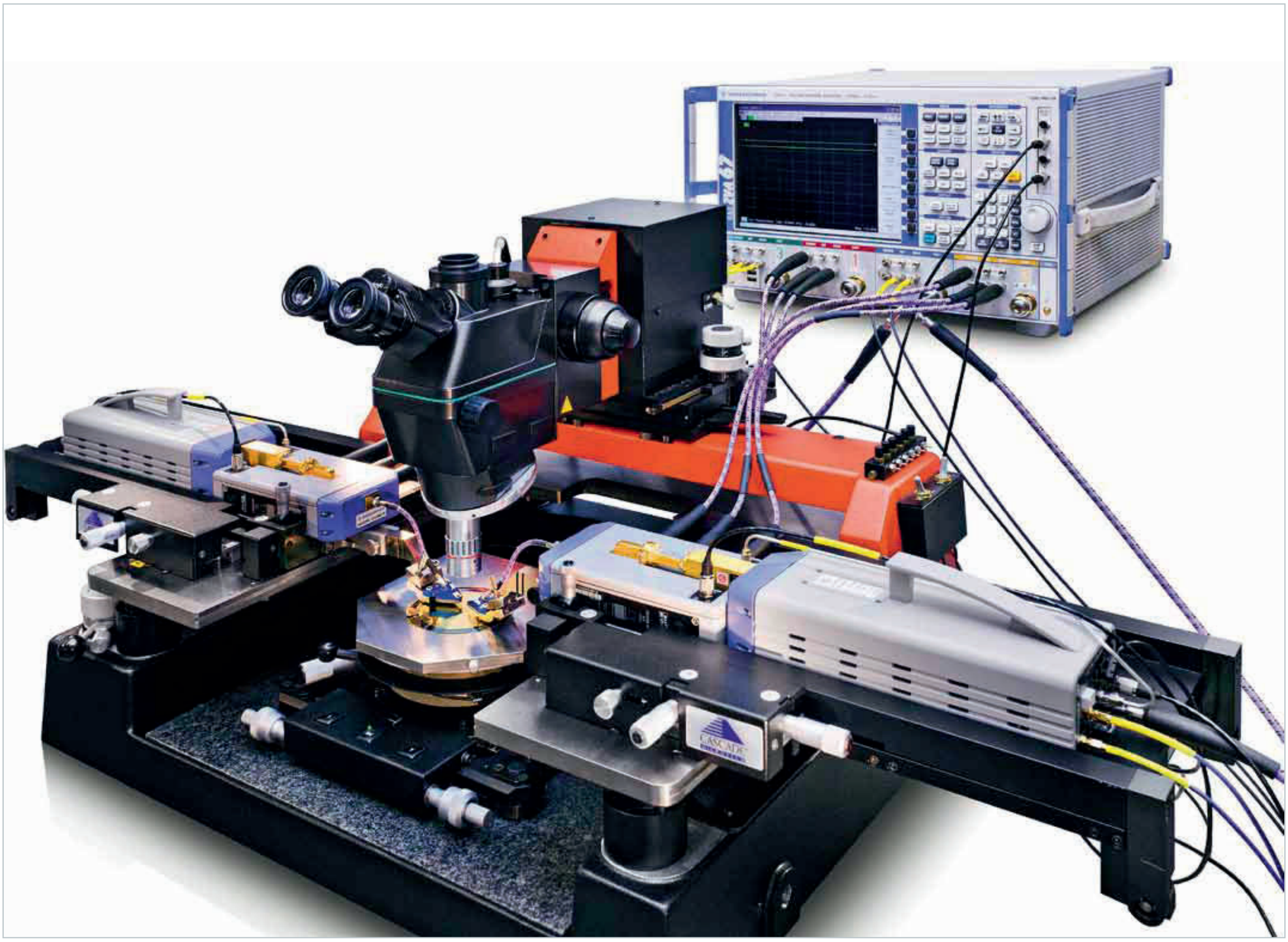


FIG 2 On-wafer measurement with the R&S®ZVA110.

Amplifier characterization

A power meter makes it easy to calibrate the test setup for a constant power at the input of the amplifier under test. The electronic attenuator in the R&S®ZVA-Z110E millimeter-wave converter regulates the R&S®ZVA110 output power, which also allows compression point measurements to be performed on the amplifiers. The coherent signal sources enable true differential measurements up to 110 GHz.

On-wafer measurements

Continuous sweeps up to 110 GHz are especially interesting for on-wafer measurements (FIG 2) since, in order to obtain comparable results, measurements in the entire frequency range up to 110 GHz should be carried out using a single test setup – which is no problem with the R&S®ZVA110. The R&S®ZVA110 is also compatible with commercially available probers and the SuessCal and WinCal™ software packages.

Optimal test setup for on-wafer measurements

The losses that occur between the converters and the probe tips are uncritical at low frequencies, but become more important as frequencies increase. Common 1 mm coaxial cables have relatively high loss. A 16 cm long cable, for example, has a total loss of about 3 dB. These figures make it clear why it would not make sense to integrate the converters and diplexers into the R&S®ZVA base unit. The cable loss between the test port and the DUT would be too high. For this reason, the diplexers are designed and set up so that the signals in the basic frequency range up to 70 GHz are not combined with the signals from the converter path (up to 110 GHz) until just before the 1 mm test port. The signal path from the test port to the probe tip needs to be as short as possible. Short 1 mm coaxial cables are commonly used, with a length of 16 cm, for example (FIG 3). Semi-rigid cables are used for a stable test setup. The wafer prober manipulators on which the converters, diplexers and probe tips are mounted, are designed so that the entire setup moves as a single unit.

FIG 3 Test setup with diplexers, 1 mm coaxial cables and probe tip.

Probe tip contact on the wafer or a substrate

Probe tip contact can be made manually or automatically via a wafer prober using appropriate control software. In order to achieve comparable results, it is important that one and the same test setup be used for measurements. The R&S®ZVA110's continuous sweep from 10 MHz to 110 GHz and the sophisticated trace / channel concept make this possible. Nothing stands in the way of performing frequency and power sweeps to measure amplifier compression characteristics using a single test setup.

On-wafer amplifier characterization

In addition to S-parameters such as gain and matching, the compression of amplifiers is of interest. Traditional compression point measurements on amplifiers using coaxial connectors require power calibration at the amplifier input in order to maintain a defined input level that is constant over frequency. However, it is not possible to perform power calibration on the wafer plane. How can a constant, defined absolute power over frequency be obtained with the reference plane shifted to the wafer (i.e. the probe tips)?

One possibility is to perform power calibration at the 1 mm diplexer output. By determining the frequency-dependent loss between the diplexer output and the probe tip, the output power of the R&S®ZVA can be corrected such that the power calibration plane is shifted to the wafer. In other words, the losses in the path from the diplexer to the probe tip are compensated by the R&S®ZVA's higher output power. These losses can be determined using transmission measurement on two contacting probe tips or using reflection measurement on one probe tip.

An alternative method is to use UOSM calibration using the diplexer to wafer path as an unknown through standard. The losses are measured and automatically taken into account when setting the R&S®ZVA generator power level. Coaxial 1 mm calibration standards are used at the diplexer end, and on-wafer calibration standards are used at the wafer end.

Summary

The R&S®ZVA110, with its continuous sweep from 10 MHz to 110 GHz, is an outstanding instrument for on-wafer characterization of components. It can be expanded to cover band-specific measurements up to 500 GHz. The flexibility and the versatility of this analyzer provide true investment protection.

Andreas Henkel

Condensed data of the R&S®ZVA110

Frequency range	10 MHz to 110 GHz
Dynamic range at 110 GHz	> 80 dB, typ. 89 dB
Output power at 110 GHz	–28 dBm to –11 dBm, electronically adjustable
Output power accuracy at 110 GHz	< 3 dB, typ. 2 dB
Max. permissible input power	+27 dBm
Trace stability	10 MHz to 110 GHz: typ. < 0.4 dB and typ. < 4°
Effective source match	10 MHz to 110 GHz: typ. < 32 dB
Effective directivity	10 MHz to 110 GHz: typ. < 32 dB
Effective load match	10 MHz to 110 GHz: typ. < 32 dB

Signals for GPS, Galileo and digital communications standards in a single instrument

With its new software options, the R&S®SMBV100A vector signal generator can now generate signals for GPS and Galileo receiver testing as well as perform realtime simulation of open-ended, real-world scenarios with up to 12 satellites. It also handles multipath propagation and satellite shadowing.

Advance of location-based services

Many mobile network operators offer their customers added value with location-based services (LBS), providing selective information and data based on the user's current location. Of course, operators have to find the user's location first, which they typically do using a global navigation satellite system (GNSS) receiver that is integrated into mobile phones. This receiver must be tested, both in development and production. There are numerous commonly used tests, such as determining how quickly a receiver can fix its position after being powered on, defining the sensitivity level, or determining how accurately the calculated position matches the user's actual location. Since today's mobile phones support wireless standards such as WLAN and Bluetooth® in addition to mobile radio standards, it's a definite bonus to have a generator that can generate all of the necessary test signals.

R&S®SMBV100A: GNSS simulator and all-round vector signal generator in one

That's exactly what the R&S®SMBV100A can do with its excellent RF characteristics and its new, versatile GNSS options. It can simulate GPS and Galileo signals separately or simultaneously (in hybrid mode), just as they are "seen" by today's GNSS receivers in the real world. Hybrid mode improves accuracy and availability, especially in cities where shadowing occurs.

The GNSS simulator for the R&S®SMBV100A consists of several options, allowing users to adapt it to their specific needs and to define the most suitable scope of functions for development or production.

The R&S®SMBV100A can directly generate signals for a number of different standards, making it unique in its class. It supports both the GSM/EDGE, 3GPP with HSPA, and LTE mobile radio standards and the Bluetooth® and Wi-Fi wireless standards, which are frequently used in both cellular and satellite navigation devices. Signals for the various sound broadcasting standards, such as FM stereo (with RDS), HD Radio™, Sirius and XM Satellite Radio, and DAB round out its portfolio.

An important criterion when using smartphones for location-based services is the time required to fix the device position. This time is kept to a minimum because the mobile radio network transmits GPS data (known as assistance data) to allow

The R&S®SMBV100A vector signal generator offers characteristics often found only in significantly more expensive instruments, and at an attractive price. It provides an output level of typ. +24 dBm up to 6 GHz and a maximum RF bandwidth of 528 MHz. Digital standards such as WiMAX™, 3GPP FDD, HSPA and LTE can be set directly on the instrument via its intuitive user interface. An integrated modulation generator internally generates the baseband signals, eliminating the need for an additional PC.

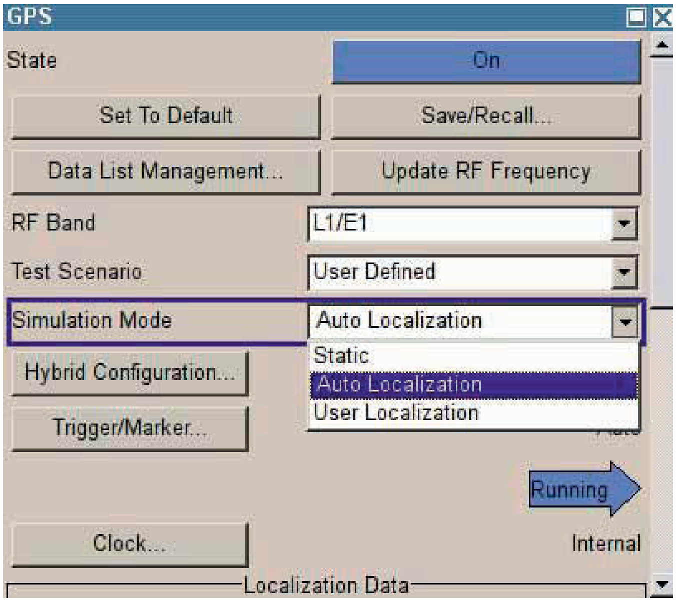


FIG 1 GNSS main menu for setting the various simulation modes.

the receiver to track the satellites faster. The GNSS simulator in the R&S®SMBV100A generates this assistance data, which a radiocommunications tester then transmits to the phone via an active mobile radio connection at the same time as the R&S®SMBV100A generates the corresponding satellite signal.

For development or production – the right signals are always available

Only a few keystrokes are needed to generate complex, open-ended scenarios with up to 12 satellites. To handle the wide range of application requirements, the GNSS simulator in the R&S®SMBV100A offers a number of modes tailored to the specific needs of each application, thereby simplifying the required measurements (FIG 1).

Receiver tests in development

RF receiver tests, cross-correlation tests and jamming tests performed during development require signals from one or more satellites. The number and level of the satellites can vary, but – to ensure a constant level for sensitivity tests – the signals should typically not move on the horizon like real satellites. These tests are performed in the Static simulation mode. In this mode, the simulated satellites do not move, though their number and characteristics can be changed as needed.

Functional tests on chipsets

When performing functional tests during the development of chipsets or when implementing the GNSS application in a variety of instruments, Auto Localization is the best simulation mode, for example, to quickly fix a device's position. For this mode, the GNSS simulator comes with a number of predefined cities on various continents. The simulator automatically selects up to 12 satellites that offer the best constellation for the selected position at the current moment in time. The GNSS simulator in the R&S®SMBV100A comes preloaded with an almanac file containing the information needed to calculate the satellite paths so the user can start testing immediately. From the Internet, users can also download GPS almanac files that are updated weekly with the latest satellite paths.

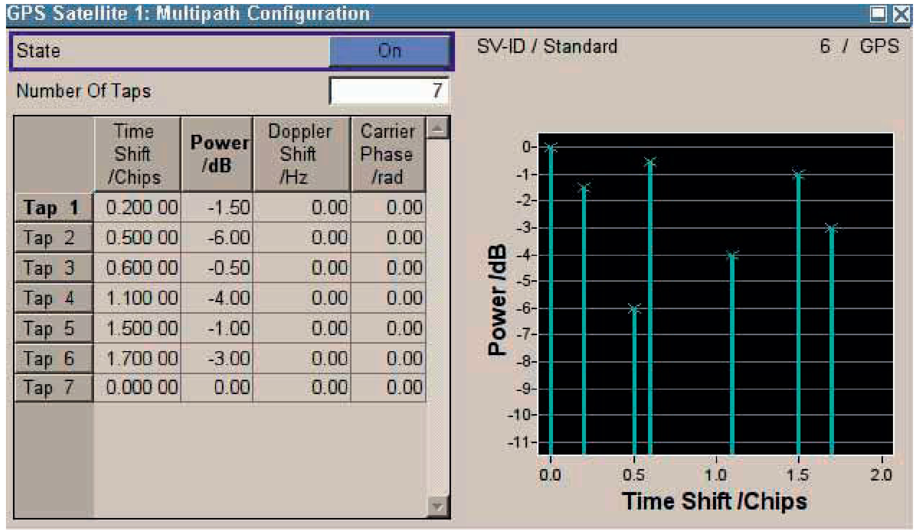
The Auto Localization mode isn't just good for carrying out tests with a static position, such as time to first fix (TTFF). It can also simulate a moving receiver, making it easy to perform a virtual drive through downtown Manhattan, followed by a quick tour around the Colosseum in Rome. Automatic, realtime exchange of satellite signals in the R&S®SMBV100A make it possible to generate scenarios that are unlimited in time.

Comprehensive functional tests under real-world conditions

The User Localization simulation mode is used to perform comprehensive functional tests, such as short-term shadowing and multipath propagation of satellite signals, simulating real-world conditions. As in Auto Localization mode, a moving receiver can be simulated in this mode. The user has full control over the number and selection of simulated satellites as well as their signal level (FIG 2). Users can change the signal level or activate / deactivate satellites in realtime without interrupting the GNSS signal, so that the receiver remains synchronized. It is therefore possible to simulate a drive through a city in which some satellites are blocked by high-rise buildings and others are only sometimes visible. It is even easy to simulate a drive through a tunnel: The user first turns off all satellites, then after a few seconds activates the same or different satellites and checks how the receiver responds to total shadowing and how it behaves during resynchronization.

In cities, satellite signals are sometimes reflected, causing multipath reception. Since the reflections typically differ for each satellite, the R&S®SMBV100A can define the multipath propagation for various satellites separately. It is capable of supporting up to a total of 16 paths. Settings such as signal level and delay can be made separately for each path (FIG 2). For the best real-world simulation for GNSS receivers, the propagation characteristics for the troposphere and the ionosphere can be modeled and included in the signal generation process.

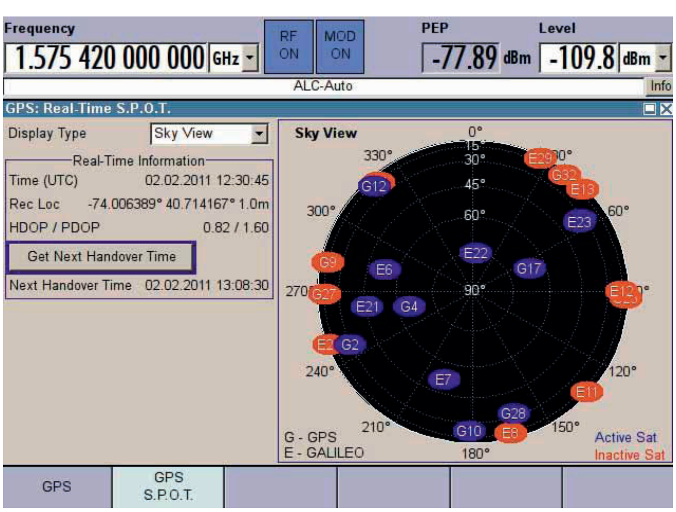
FIG 2 Definition of multipath propagation for a satellite.



GNSS receiver test in production

Full position fixes are rarely performed during GNSS receiver tests in production because they take quite long. Usually it suffices to ensure that the receiver is functioning correctly and the antenna connection is good. The fastest way to do this is with the receiver in a special test mode using only one static satellite. The user first sets the mode to Static and then uses a low test level to test the sensitivity, the antenna connection and the functioning of the receiver.

Visualization of the satellites at the simulated time. The picture shows a hybrid setup with color coding of the active and passive satellites; G stands for GPS satellites and E for Galileo satellites.



Summary

With its GNSS simulator, the R&S®SMBV100A offers versatile, comprehensive tests for GPS and Galileo applications and is also a full-featured vector signal generator with excellent RF characteristics for all other wireless standards commonly used in navigation devices and mobile phones. This unique combination makes it possible to perform many tests both simply and cost effectively.

Markus Lörner

Key features

- Support of GPS L1 / L2 and Galileo E1, including hybrid constellations
- Simulation of realistic constellations with up to 12 satellites in realtime (no precalculated waveforms)
- Flexible scenario generation, including moving scenarios (e.g. through the import of NMEA[1] waypoints), multipath propagation, dynamic level control and atmospheric modeling of propagation characteristics – without the need for additional software tools
- Unlimited simulation time with automatic, on-the-fly exchange of satellites
- User mode for full flexibility to select satellites and define navigation data (import of RINEX[2] files)
- Support of predefined and user-defined A-GPS test scenarios, including generation of assistance data

1) National Marine Electronics Association.
2) Receiver independent exchange format.

R&S®SMB100A generator: now with electronic step attenuator and expanded range up to 12.75 GHz

The new R&S®SMB-B112 frequency option extends the frequency range of the R&S®SMB100A signal generator to cover the 100 kHz to 12.75 GHz range, opening up new fields of application. The option also equips the generator with a fast, wear-free electronic step attenuator – a feature not found in any other signal generator in the frequency range up to 12.75 GHz.

Now up to 12.75 GHz – and fit for additional applications

The current R&S®SMB100A analog signal generator family covers the frequency ranges of 9 kHz to 1.1 / 2.2 / 3.2 / 6 GHz. Some of its most important characteristics are an electronic attenuator, a fast VCO-based synthesizer and high output power. The new R&S®SMB-B112 option covers the frequency range from 100 kHz to 12.75 GHz. All other characteristics of this compact ¾ 19", 2 HU generator remain identical (FIG 1). The upper frequency limit of 12.75 GHz opens up new applications, such as the blocking tests specified in digital standards (CW interferers) or tests on radar systems and communications satellites in the X band.

Unique up to 12.75 GHz: rapid level changing thanks to electronic attenuator

Irrespective of whether it is an analog or vector signal generator, users must be able to quickly set the required level – over as wide a range as possible. Therefore, the instruments are equipped with attenuators consisting of several attenuator pads with different attenuation. Together with appropriate amplifier stages, these components provide an excellent signal/noise ratio and outstanding linearity. The individual attenuator pads are switched on and off either mechanically (with relays) or electronically (with electronic switches). The level is usually attenuated electronically in the range up to 6 GHz, and until now it has always been attenuated mechanically in the range above approx. 10 GHz.

The new R&S®SMB-B112 frequency option provides the R&S®SMB100A generator with a feature that is unique on the market: The option's electronic attenuator sets levels up to 12.75 GHz electronically – with fast setting speed and outstanding resistance to wear. The generator is the ideal choice when a large number of level settings need to be made within a short time period, such as during level sweep, in automatic test systems and on production lines. Its level setting times of just a few hundred microseconds reduce measuring costs relative to the overall test setup. The CMOS switches in the electronic attenuator have been specially developed for strict requirements. They are superior to conventional methods, since there is no level drift after switching – a crucial advantage when it comes to high level accuracy and reproducibility.

FIG 1 The new R&S®SMB-B112 frequency option extends the frequency range of the R&S®SMB100A signal generator to cover the 100 kHz to 12.75 GHz range – all other characteristics remain unchanged.

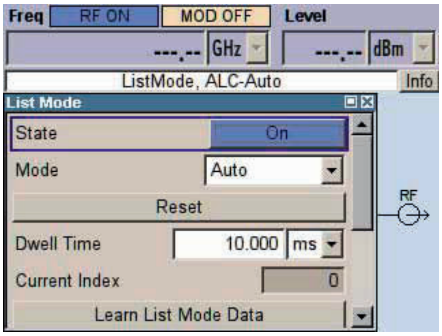
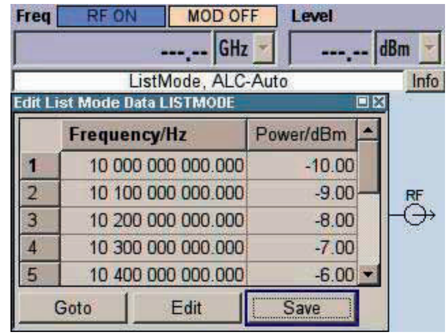


FIG 2 The List mode menu.

FIG 3 Frequency and level pairs in the List mode editor.



VCO for fast frequency change

Short frequency setting times and low phase noise are essential criteria for generators that are used in the development of electronic components. Yttrium iron garnet (YIG) oscillators, which feature broadband capabilities and low noise, have been used for quite some time in the high-frequency area.

When extremely short frequency setting times are required, VCOs are the first choice, since their frequency setting times of several microseconds are clearly superior to those of YIG oscillators (several hundred microseconds). This is particularly noticeable during a frequency sweep or in List mode (FIGs 2 and 3), where the R&S®SMB100A processes a large number of stored frequency and level pairs, making parameter changes even faster. The advantages of the new R&S®SMB-B112 frequency option with its VCO-based concept are reflected in decisive cost benefits in automatic test systems and on production lines.

Comparison of frequency and level setting times

The new option has two outstanding advantages: fast frequency change using a VCO and fast level change using the electronic attenuator. A comparison of instruments based on the above concepts versus instruments based on YIG technology and mechanical attenuation clearly shows the time savings that can be achieved (FIG 4). If, for example, an automatic test system requires 1000 different frequency settings per DUT, it is possible to save up to 13 s per DUT.

However, switching times are just one side of the coin. The other side is the number of possible switching operations. Mechanical attenuators reach the end of their life after several million switching operations and must be replaced, with the associated service effort and cost. Electronic attenuators are practically wear-free.

Summary

The R&S®SMB-B112 option extends the frequency range of the R&S®SMB100A signal generator to 12.75 GHz and includes an electronic step attenuator. The generator's many unique characteristics are unrestrictedly available in the extended frequency range. Overvoltage protection up to 12.75 GHz is optionally available.

No compromises have been made in terms of operation and service, either. The modular design of the generator family allows users to keep calibrated spare components on hand and replace them themselves if necessary; the instrument does not have to leave the premises. The instrument's appearance and handling, the remote control commands and the front panel (including the display for block diagrams) have all been retained.

Frank-Werner Thümmler

Setting times	R&S®SMB100A signal generator	Typical microwave signal generator
	100 kHz to 12.75 GHz, with electronic attenuator and VCO	**10 MHz to 20 GHz, with mechanical attenuator and YIG**
Frequency change (10 GHz to 12 GHz)	< 3 ms (< 1 ms in List mode)	< 14 ms
Level change (–20 dBm to 0 dBm)	< 2.5 ms (< 1 ms in List mode)	< 25 ms

FIG 4 Comparison of time required for frequency and level changes with the R&S®SMB100A signal generator and a typical microwave generator.

DME signal analyzer: compact, fast, versatile and precise

Precise and reliable navigation and flight approach systems are vital to ensuring international aviation safety. The associated DME and TACAN systems must be continuously tested and maintained. Tailor-made for carrying out such tasks are "specialists" such as the compact R&S®EDS300 DME/pulse analyzer, which features extremely high sensitivity and measurement accuracy.

Robust, compact and modular – for mobile and stationary applications

The R&S®EDS300 DME/pulse analyzer (FIG 1) is a digital test receiver featuring a robust and compact design. It was developed for stationary applications, but is especially suited for mobile measurements and installation into test vehicles and flight inspection systems. The modular structure provides a high degree of flexibility when adapting the analyzer to the task at hand. For instance, it can be enhanced with up to three additional receiver modules for flight inspection applications. Additional applications, such as TACAN analysis, are available after installation of a software option.

The R&S®EDS300 is a standalone, remote-controlled monitoring system that can be deployed for the continuous monitoring and recording of navigation signals. It features an external hard disk port for recording large volumes of data. Together with the R&S®EVS300 ILS/VOR analyzer, the R&S®EDS300 can analyze virtually the entire signal spectrum encountered in terrestrial flight navigation (FIG 2).

Speed and accuracy are not mutually exclusive

Analyzing pulse amplitude, shape and position with maximum input sensitivity in multiple channels at the same time demands tremendous processing power. The R&S®EDS-K2 software option for DME pulse shape analysis provides intelligent algorithms that accelerate the processing of the measurement results, enabling the R&S®EDS300 to identify and accurately measure the levels of up to ten different DME stations within one second in multichannel operation (FIG 3).

Complete TACAN signal measurements

The R&S®EDS-K1 software option for TACAN analysis expands the analyzer to include measurement functions for completely analyzing signals from TACAN stations, making it ideal for commissioning and service tasks. The analyzer measures the modulation depth and modulation frequency of the 15 Hz and 135 Hz signal components and derives the azimuth by detecting main and auxiliary reference bursts.

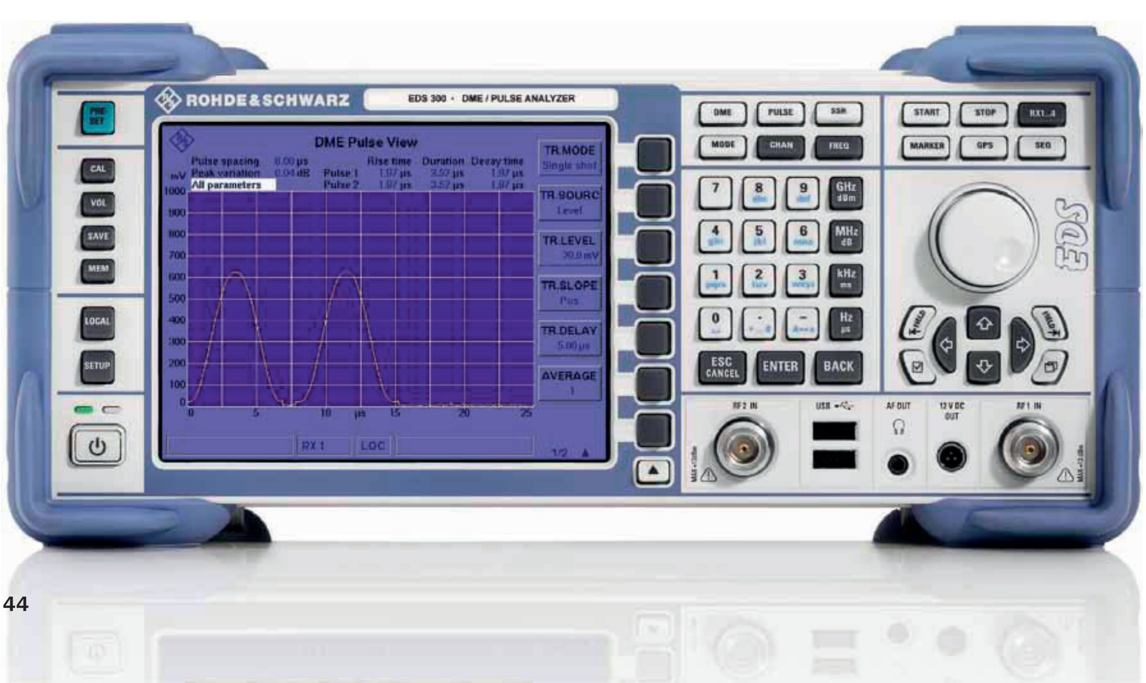


FIG 1 The compact R&S®EDS300 is also ideal for mobile measurements and for installation into test vehicles and flight inspection systems.

Teamwork: R&S®EVS300 and R&S®EDS300

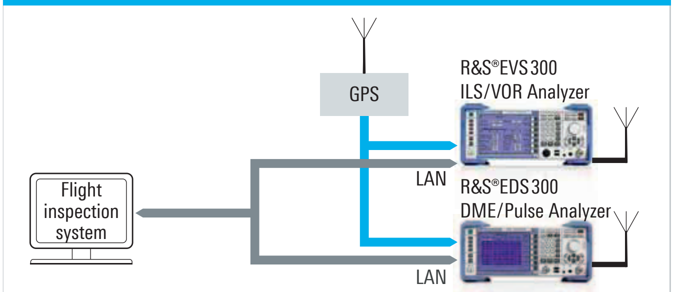


FIG 2 Integration of the R&S®EDS300 and the R&S®EVS300 into a flight inspection system.

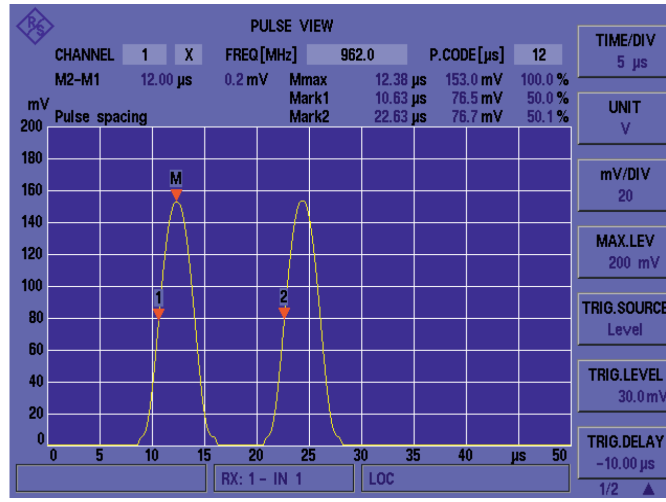


FIG 3 The R&S®EDS-K2 software option for DME pulse shape analysis.

Integration into existing flight inspection systems

The R&S®EDS300 features trigger inputs for integration into existing flight inspection systems. Plus, it can synchronize to a time server connected to a flight inspection system. Use of the GPS time stamp (R&S®EDS-K3 option) ensures the precise linking of the measurement value and the recording position. The analyzer can be completely remote-controlled via the TCP/IP protocol. This allows the R&S®EDS300 to be individually adapted to any existing architecture and a variety of operating systems.

Customer-specific requirements and enhancements

The R&S®EDS300 can be adapted to existing systems or expanded to meet individual customer requirements at any time, such as the integration of an interrogator for carrying out distance measurements. The Rohde&Schwarz Service Center in Cologne has a team of specialists available to help in these situations.

Gabriele Hanke

Condensed data of the R&S®EDS300

Frequency range	960 MHz to 1215 MHz
Dynamic range	–90 dBm to –10 dBm
DME	
Pulse shape (rise time, pulse duration, decay time)	
Resolution	0.01 µs
Deviation	< 0.1 µs
Pulse spacing	
Resolution	0.01 µs
Deviation	< 0.05 µs
TACAN (optional)	
Bearing	
Resolution	0.01°
Deviation	< 0.2°
Modulation depth (0 % to 50 %)	
Resolution	0.01 %
Deviation	< 0.5 %

Highlights of the R&S®EDS300

- Compliance with ICAO Doc. 8071, ICAO Annex 10
- High input sensitivity of –90 dBm
- Excellent immunity to interference (within and outside of the useful band)
- High-precision level measurements (up to ten DME channels per second)
- Measurement of DME/N and DME/P systems
- Analysis of stationary and mobile TACAN stations
- Diverse synchronization capabilities (GPS, trigger and remote control)
- LAN interface for remote control of all functions and for measurement data output
- Wide operating temperature range from +5 °C to +40 °C
- Low weight (< 7 kg); high degree of mechanical durability
- Analog output for additional analysis of received signals in the baseband
- Analysis of external baseband signals
- Built-in test (BITE)
- RS-232-C and USB ports for GPS receivers (NMEA)
- USB port for simple data export and software updates

Abbreviations

DME	Distance measurement equipment
DME/N	DME narrow spectrum characteristic standard (DME method used almost exclusively in civil aviation for distance measurement)
DME/P	DME precise (more precise DME method that is seldom used at present)
ICAO	International Civil Aviation Organization
TACAN	Tactical air navigation (military DME variant that also allows to the azimuth direction to be determined)
VOR	VHF omnidirectional radio range (navigation aid for determining the azimuth direction)

High-reproducibility ILS ground measurements directly on runways

One challenge facing airports today is that they need to be able to automate and conduct ILS ground measurements at regular intervals, as specified in ICAO Annex 10 and Doc. 8071 using as little personnel as possible. The R&S®TS6300 test system is the answer: It supports all localizer and glide path measurements as required by ICAO and delivers reproducible results.

Mobile system for ILS measurements

The R&S®TS6300 is a modular test system that can perform ILS ground measurements at airports (FIG 1). It not only meets all the requirements of the ICAO standards, it is also exceptionally easy to operate and offers very high reproducibility of measurement data. The core of the system is the R&S®EVS300, a portable level and modulation analyzer designed specifically for starting up, checking and maintaining ILS and VOR systems (FIG 2). It is a compact instrument, capable of acquiring all key parameters at a rate of 100 measurements per second, synchronizing these with the GPS position, and digitally separating course and clearance signals using only one signal processing channel. This makes it ideal for performing mobile measurements. The ILS/VOR analyzer also meets the full range of demands of ground measurements and flight inspection systems. This permits the direct correlation of ground-based and airborne measurements, as recommended in ICAO Doc. 8071.

FIG 1 Vehicle with built-in telescopic mast for localizer measurements.

Photo: Rohde&Schwarz Service Center in Cologne.

The other important component of the system is the R&S®ILSChecker software that was developed in cooperation with the Swiss Skyguide air navigation services organization. This sophisticated and exceptional piece of software engineering reflects Skyguide's in-depth expertise and many years of experience in the field of ATC.

R&S®ILSChecker: data acquisition, visualization and evaluation

R&S®ILSChecker runs on Windows®. It acquires data, displays it graphically and offers users a range of specialized evaluation options. Since the measurement results it delivers are highly reproducible, changes in the ILS signal are easy to identify and can be mapped precisely to their causes. Large reflective surfaces such as the tail units of big aircraft on taxiways or construction cranes at an airport, for example, can impair an ILS signal — hence the importance of regularly checking whether the signal is still within the permitted tolerances.

The software can load a reference trace to enable results to be compared with previous measurements: It shows the raw data, filtered data and the reference trace as a graphic during the actual measurement process. The information displayed includes key parameters such as the minimum, maximum and average DDM, SDM and RF level, as well as the course/clearance ratio along the length of the runway. The system can also check the course alarms at 90 Hz and 150 Hz in the same way as in airborne measurements.

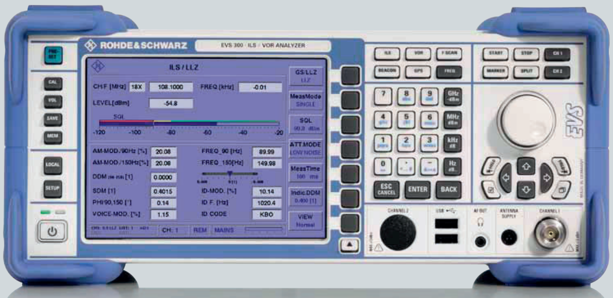


FIG 2 The R&S®EVS300 ILS/VOR analyzer.

The R&S®EVS300 ILS/VOR analyzer with its extensive scope of functions is an ideal instrument for conducting ground-based and airborne ILS / VOR / marker beacon measurements. Its extremely fast measurement data processing, remote control capability, and large internal data memory round out its well-thought-out design.

For details, see News from Rohde&Schwarz (2007) No. 194, p. 30–32.

FIG 3 Course structure measurement with reference traces.

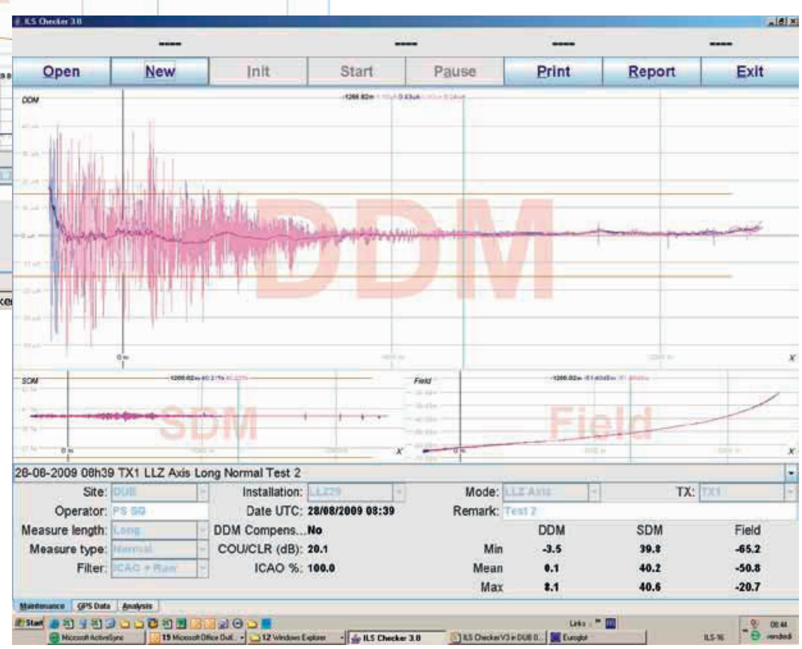


FIG 4 Course structure measurement, raw data, and data filtered in accordance with ICAO standards.

Localizer course structure

Signal measurements carried out along the runway centerline are essential for assessing the quality of an ILS system. The results are used to verify the runway's designated ILS category. The parameters needed to filter the DDM values in accordance with ICAO regulations are adjusted automatically at runtime using GPS data to reflect the speed at which the test vehicle is moving. Along with the data measured at a rate of 100 Hz, the software also displays the filtered data needed to assess the signal's limits (FIGs 3 and 4). The exceptional reproducibility and accuracy of the data ensure close correlation between the measurements on the ground and in the air and help minimize the effort involved in flight inspections.

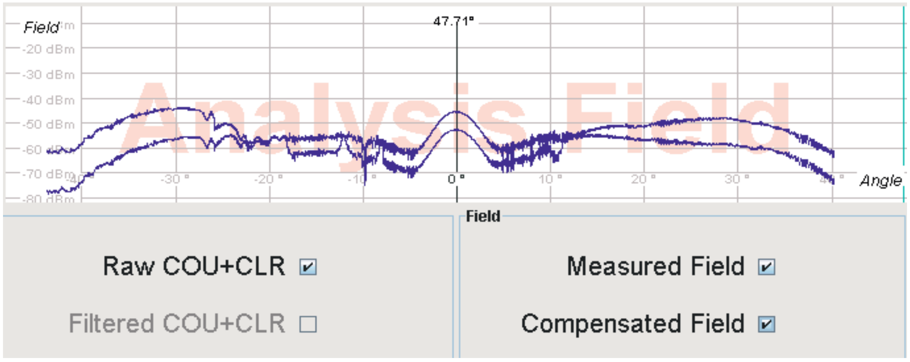


FIG 5 Measured and compensated field strength of LLZ coverage.

> **Outstanding features**
> - Complies with ICAO Doc. 8071, ICAO Annex 10, Volume 1
> - Records 100 data sets per second, including GPS time and location information
> - Fully supports all stipulated localizer and glide path measurements
> - Automatically adjusts lowpass filter time constants to vehicle speed
> - Offers highly reproducible measurements that clearly identify changes in the ILS signal and map them to their causes
> - Reduces costs since only one operator is required

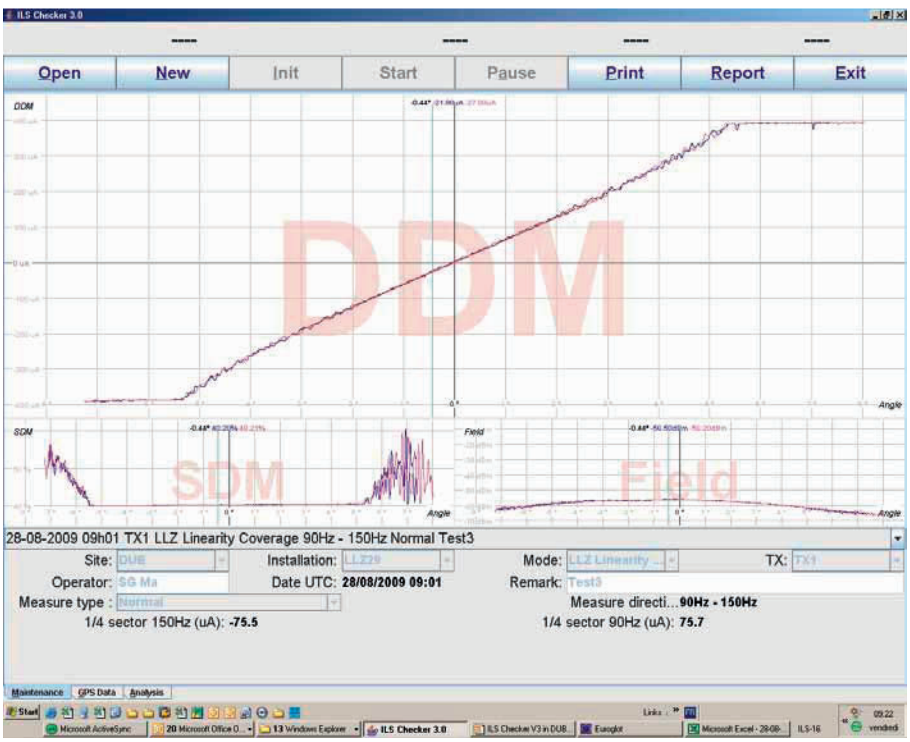


FIG 6 Measurement of LLZ linearity coverage with reference trace.

LLZ coverage and LLZ linearity coverage

It is not always possible to perform orbit measurements covering the ideal arc of ±35° around the localizer antenna (LLZ). R&S®ILSChecker takes the pattern of the test vehicle's receive antenna into account as well as changes in distances between the localizer antenna and the vehicle. This means that the software can compute and compensate for variance in the LLZ antenna pattern it displays (FIG 5). The linearity of the DDM values in the course sector is a key quality criterion of the localizer's radio transmission system (FIG 6).

Glide path coverage

The vertical glide path is measured using a mobile telescopic mast set up at a defined point (usually, the runway threshold) at a specific distance from the transmit antenna. Measurements are carried out while the mast is gradually extended from an initial height of 5 m up to 22 m (FIGs 7 and 8).

Data evaluation using R&S®ILSChecker Reader

The time window available for performing measurements is often very small, but owing to the high measurement rate, the test system can check the results while it records the values, Photo: Rohde&Schwarz Service Center in Cologne.

FIG 7 Telescopic mast for glide path measurements.

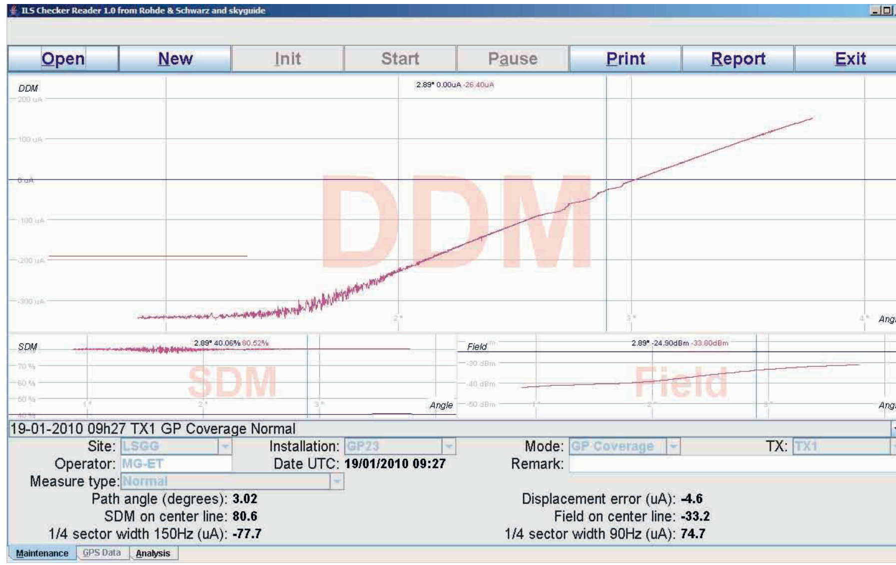


FIG 8 Glide path coverage measurement.

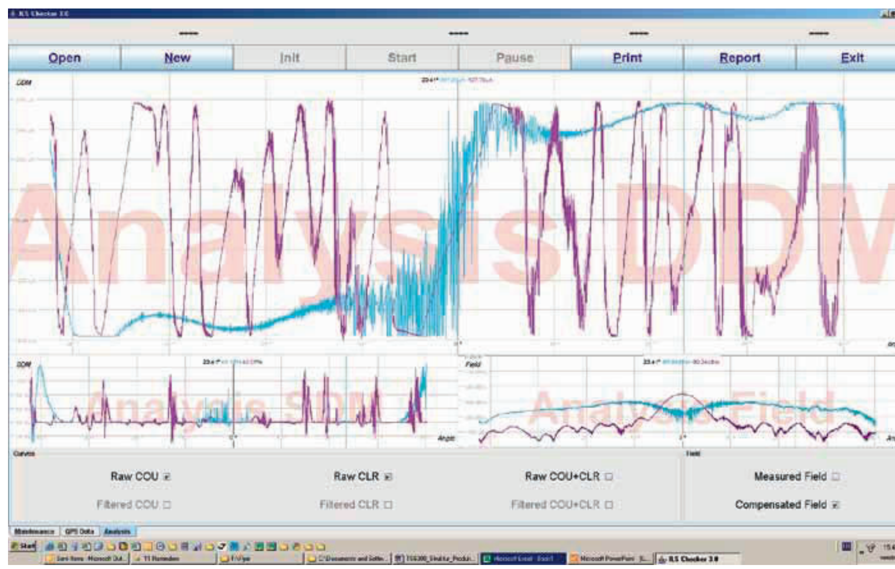


FIG 9 Detailed analysis of course and clearance.

enabling errors to be corrected instantly. A detailed evaluation can be performed later in the lab using the R&S®ILSChecker Reader software, which can be installed on any number of PCs without the need to purchase additional licenses (FIG 9). The GPS data recorded concurrently enables users to determine the position and speed at which each value was measured. The local reference system is coordinated with the flight inspection data, making it easy to compare the filtered values for course and clearance DDM, SDM and level, as well as the course only, clearance only and course and clearance signals.

Mix-and-match modularity

The R&S®TS6300 is a highly modular solution that can encompass everything from installation kits to fully equipped vehicles and can be tailored individually to customers' requirements. It is even possible to integrate existing customer equipment. For details, contact the Rohde&Schwarz specialists at the company's service center in Cologne.

Gabriele Hanke

The R&S®FSVR real-time spectrum analyzer boasts expanded functionality

The R&S®FSVR, a unique combination of realtime spectrum analyzer and full-featured signal and spectrum analyzer, was introduced to the market around a year ago. Many users have been persuaded by its speed, ease of operation and the range of new display alternatives. The only missing features were measurement results in the time domain and more ways to postprocess recorded data. The R&S®FSVR has now been enhanced to include a wealth of additional functions, leaving hardly any wish unfulfilled.

Power versus time

This function displays the power in the time domain in realtime, so that users can measure the duration of signals or sporadic interference. In order to detect interference, the frequency mask trigger (FMT) can also be used in this display mode. Plus, a time domain trigger can be used, for example, to trigger pulse edges. A pre- and post-trigger domain determines how much I/Q data will be stored before and after the trigger event for subsequent in-depth analysis. If, for example, the user wants to check the stability of the repetition rate of pulse sequences (often referred to as pulse-to-pulse jitter), it helps to monitor how the power or spacing of the pulses changes over time. The waterfall diagram in the power versus time function is an indispensable tool for this purpose (FIG 1).

New trigger functions

The R&S®FSVR stops signal processing as soon as the FMT detects an event. This allows the user to analyze the current spectrum and its generation, and then rearm the trigger. The new automatic rearming feature simplifies the analysis as the user only sees the spectra that are of interest. Pre- and post-triggers can be used to define the I/Q data that is captured with each event. The spectrogram is postprocessed in this mode, which makes it possible to increase the time resolution to 4 µs (instead of 52 µs in the realtime spectrogram mode).

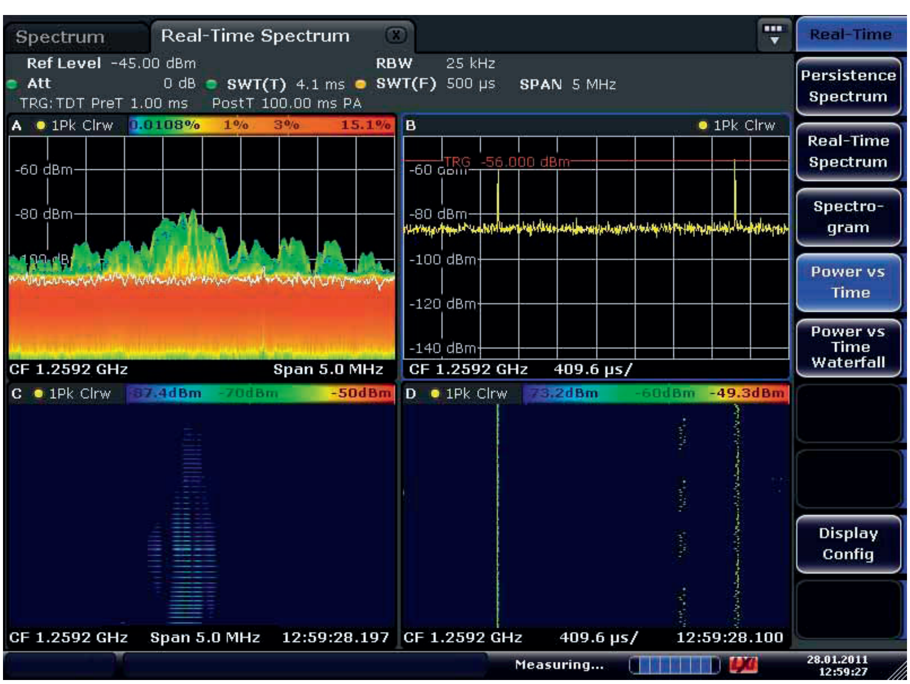


FIG 1 The many display functions in the frequency and time domain, here for a radar signal. The signal spectrum (in persistence mode) and the spectrogram in the frequency domain can be seen on the left. Power versus time is displayed in the upper right part of the screen. The new time domain trigger triggers the display on the first pulse. The window below shows a power versus time waterfall diagram. The solid line represents the pulse that activates the trigger. The line on the far right is no longer linear and clearly shows variations in the pulse spacing. Additional reflections can be seen from time to time (line in the middle).

Transfer of I/Q data in realtime operation

The 1.56 firmware version allows the I/Q data that was captured in the R&S®FSVR in realtime mode to be transferred to an external computer via GPIB or LAN, making it available for postprocessing in MATLAB®, for example. The FMT can be used to detect exactly the data that needs to be analyzed in more detail using external programs. This is useful when performing troubleshooting in development labs.

R&S®FSV-B17 digital baseband interface

For the seamless recording of up to 40 MHz RF signals over a time frame of minutes or even hours, Rohde&Schwarz offers the R&S®FSV-B17 digital baseband interface. When combined with the R&S®IQR I/Q data recorder, users can record signals from sources such as radar, radio or DVB over an extended time period under real field conditions and replay them in the lab using a Rohde&Schwarz vector signal generator. Users can test components in the lab under real conditions and analyze signals in detail.

In addition, a direct connection between the digital interfaces of the R&S®FSVR and a Rohde&Schwarz vector signal generator allows users to modify or distort the captured RF signal and then retransmit it. This is useful for simulating fading during the development of wireless communications components.

Frequency mask trigger for analyzing digital and analog modulation or in the I/Q analyzer

The R&S®FSV-K70 vector signal analysis option now includes the FMT (FIG 2) and can be used to analyze the modulation characteristics of digitally modulated signals in the presence of sporadic interference. This is a typical application for base station manufacturers who need to analyze how interference impacts data throughput.

The FMT can also be used to analyze analog modulated signals in the AM / FM / φM measurement demodulator or to display the frequency or phase versus time. Settling effects can now be studied in more detail, which is very helpful for developers of synthesizers. The FMT in the I/Q analyzer allows users to start the R&S®IQR I/Q data recorder with the trigger output while the data is being output over the digital baseband interface in realtime.

Dr. Wolfgang Wendler

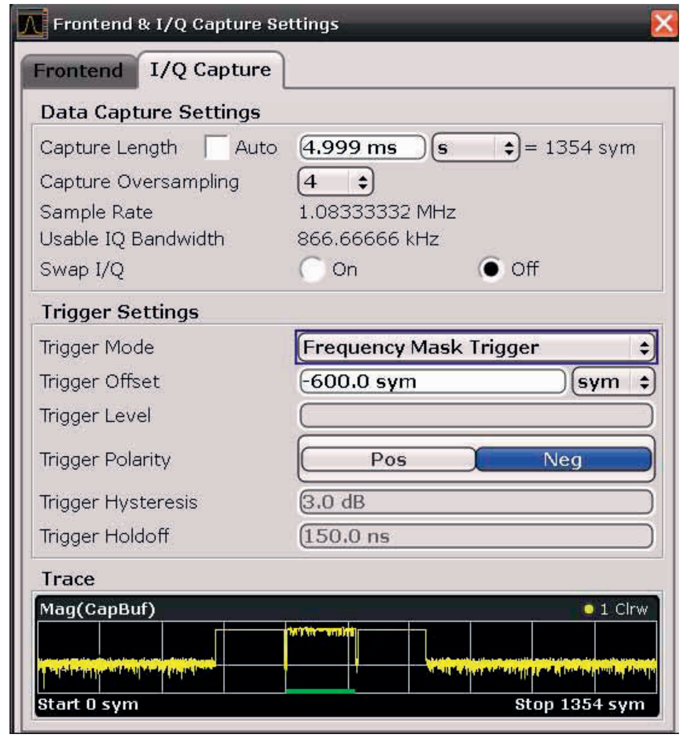
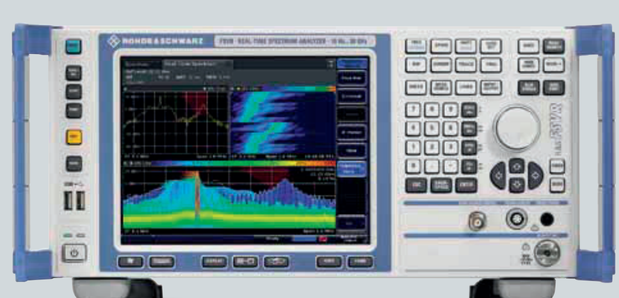


FIG 2 Typical input window for defining measurement parameters in the R&S®FSV-K70 vector signal analysis option. This option adds the “frequency mask trigger” as a trigger mode in the R&S®FSVR trigger settings.

The R&S®FSVR real-time spectrum analyzer and signal and spectrum analyzer was introduced in the previous edition of NEWS (No. 202, pp. 14–17).



All-in-one system: new features for the R&S®BBA100 broadband amplifiers

Broadband amplifiers from Rohde & Schwarz offer more than just RF output power. They allow the setup of complex yet compact amplifier systems. New internal switching functions make it possible to conveniently switch the amplifier output power to different loads without the need for external switching matrices. Existing amplifiers from other manufacturers can now easily be integrated into an R&S®BBA100 system.

New RF switching functions

The R&S®BBA100 broadband amplifiers were launched one year ago under the motto "all-in-one system". Their many features and unique modular concept made them unrivaled on the market. The amplifiers can be tailored to meet specific requirements, offer a sophisticated yet simple service concept and are easy to operate. Their many remote control interfaces make them easy to integrate into various applications.

The new RF switching functions allow the setup of amplifier systems of unparalleled compactness without requiring external add-on devices such as switching matrices or separate system controllers (FIG 1). In addition to an RF input switch, the R&S®BBA100 now also offers RF output switches and an RF sample port switch. The RF output switches apply the RF output power of the different amplifiers to various loads, such as antennas or clamps. The switches can be configured in 2:1 or 1:2 versions and cascaded as required. When an RF path is selected, the switches are automatically selected and correctly set.

The RF sample port switch is used to apply the various sample signals from the different amplifiers to two separate sample ports for forward and reflected power. When the desired RF path is selected, switching is performed automatically. This makes it much easier to connect other T&M instruments since they do not have to be disconnected and reconnected.

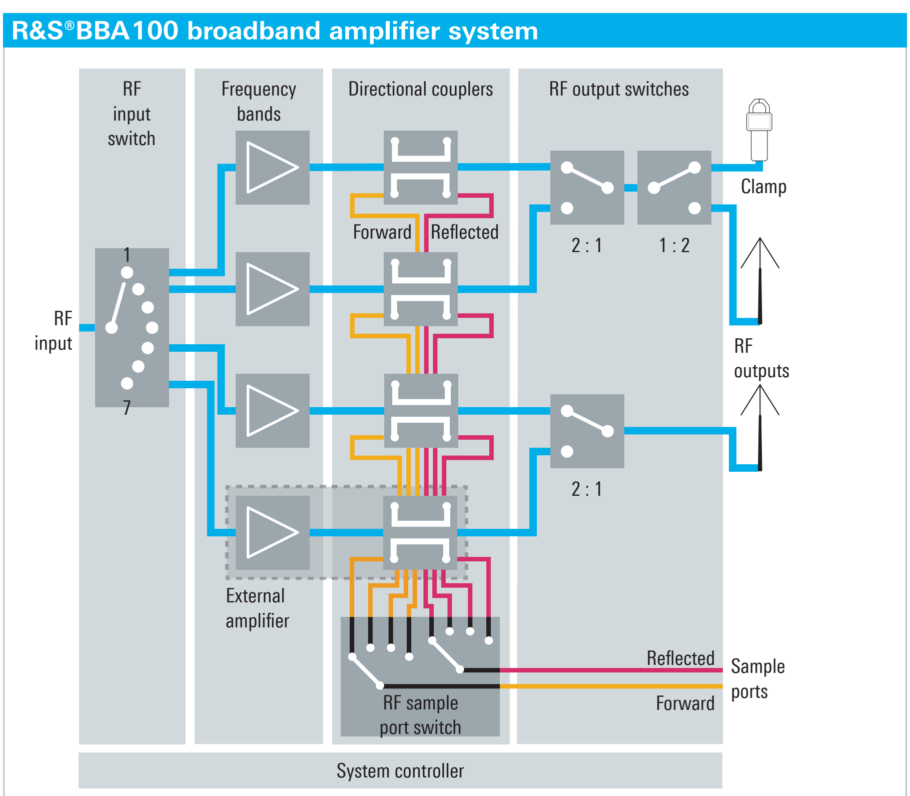


FIG 1 Block diagram of a fully equipped R&S®BBA100 system with multiple frequency bands, an external amplifier from another manufacturer and diverse switching options.

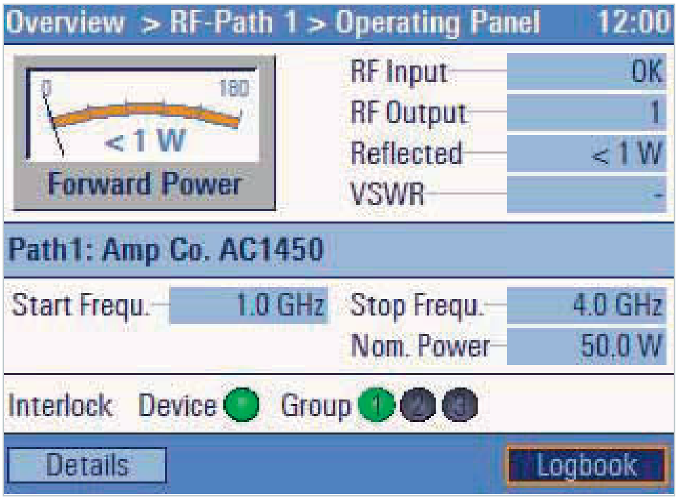


FIG 2 Amplifiers from other manufacturers can now be easily integrated into an R&S®BBA100 system. They are shown with their user-specific names on the display or web browser (example here: “Amp Co. AC1450”).

The amplifiers were described in detail in NEWS (2010) No. 201, pp. 28 – 31

Quick integration of existing amplifiers

Users can integrate existing amplifiers from other manufacturers into an R&S®BBA100 system and maintain consistent overall operation. Up to two external amplifiers can be integrated as two additional RF paths. These signal paths are routed through the R&S®BBA100 where they can be switched as needed. The R&S®BBA100 system controller acts as a switching center, ensuring consistent operation throughout the system. The additional RF paths are available as usual on the graphical user interface. These paths can be given suitable names and conveniently selected (FIG 2). They can also be activated using R&S®BBA100 remote control commands.

The R&S®EMC32 EMC measurement software can handle the commands of many other amplifiers on the market. It is recommended when amplifiers from other manufacturers need to be directly controlled.

USB remote control

For remote control, the R&S®BBA100 now comes with a USB port in addition to GPIB, Ethernet and optical Ethernet. Since USB is widespread among PCs and laptops, it is ideal for obtaining quick results without any configuration effort. The large number of remote control commands provide the same functionality as other remote control interfaces and are oriented on the SCPI nomenclature. For example, the

RF:BAND:PATH n

command can be used to select an RF path, which can then be put into the “RF Operate” mode (output of RF power) using the

RF:OUTP:STAT ON command.

The USB remote control option can also be added to existing systems using a software update (subject to a charge).

There’s more in the pipeline ...

Since the introduction of the new Rohde&Schwarz broadband amplifier family about a year ago, a lot has happened. Today, many customers all over the world are using the R&S®BBA100 in a wide variety of applications. The new options for the all-in-one system offer added value for many applications. The R&S®BBA100 broadband amplifiers are ideal for the varied tasks required today and tomorrow in EMC environments, labs and research. People who know Rohde&Schwarz also know that there is more to come.

Sandro Wenzel

Analyze ISDB-T / ISDB-T$_B$ transport streams in detail and detect errors quickly

The R&S®DVMS DTV monitoring system and the R&S®ETL TV analyzer receive, analyze, and monitor digital TV signals (RF) and MPEG-2 transport streams (baseband). The new firmware now offered for the two instruments supports ISDB-T and ISDB-T$_B$ in addition to the previously integrated standards DVB and ATSC and provides useful new characteristics for network operators and developers.

ISDB-T / ISDB-T$_B$ signals quickly reviewed …

In Brazil and many other Latin American countries, the transport stream structure for digital terrestrial television complies with the ISDB-T$_B$ standard, also referred to as SBTVD. ISDB-T$_B$ is derived from the Japanese ISDB-T standard. The R&S®DVMS DTV monitoring system and the R&S®ETL TV analyzer (see box below for details) display the elements of an incoming transport stream – including all ISDB-T- / ISDB-T$_B$ specific elements, such as the H-EIT, M-EIT and L-EIT tables – structured in tree format (FIG 1). The structure of the ISDB-T / ISDB-T$_B$ broadcast transport streams (BTS) sent to the transmitter as well as their specific additional information differ significantly from the transport streams received via antenna. The BTS-specific structure is reflected in the output: The tree structure shows how every element relates to the respective transmission layer (A, B, C). Transmitter control elements that are not sent to the receiver are identified as "not transmitted". This type of display provides a quick overview of the transport stream structure, and also allows the user to quickly detect any inconsistencies and deviations from the desired structure.

… and monitored in detail

The transport stream structure defined in the ISDB-T / ISDB-T$_B$ standards is reflected in the transport stream monitoring functions. The monitoring parameters as defined by ETSI TR 101 290 for DVB were included and expanded in ISDB-T / ISDB-T$_B$. This affects the CRC and SI repetition parameters, as well as all table parameters. The limit values for the repetition rates to be monitored are defined in ARIB STD-B10 / Part 2 for ISDB-T and in ABNT NBR 15603-2 for ISDB-T$_B$. These values are used as default settings and – similar to all other limit values – can be modified as required. This ensures that the measurements are always made in compliance with valid standards unless the user explicitly selects different specifications. Both the R&S®DVMS and the R&S®ETL exceed the recommendations in ETSI TR 101 290 and support data rate monitoring, including all ISDB-T- / ISDB-T$_B$ specific elements. This allows users to easily detect irregularities, dropouts or peak values. For BTS, the summary data rates for the individual layers are measured in addition to simple screening.

Functionality and typical applications for the R&S®DVMS and R&S®ETL with respect to ISDB-T / ISDB-T$_B$

R&S®DVMS1
DTV monitoring system

Functionality
Monitoring of a transport stream (only one height unit and ½ rack width); detailed analysis functions

Typical application
Monitoring of signal generation, multiplexing and signal distribution by network operators and broadcasters; error analysis during the development of encoders, multiplexers, etc.

R&S®DVMS4
DTV monitoring system

Functionality
Monitoring of up to four transport streams (only one height unit); detailed analysis functions

Typical application
Monitoring of signal generation, multiplexing and signal distribution by network operators and broadcasters

R&S®ETL
TV analyzer

Functionality
Detailed analysis of the RF and / or transport stream characteristics

Typical application
Transmitter installation, acceptance and maintenance

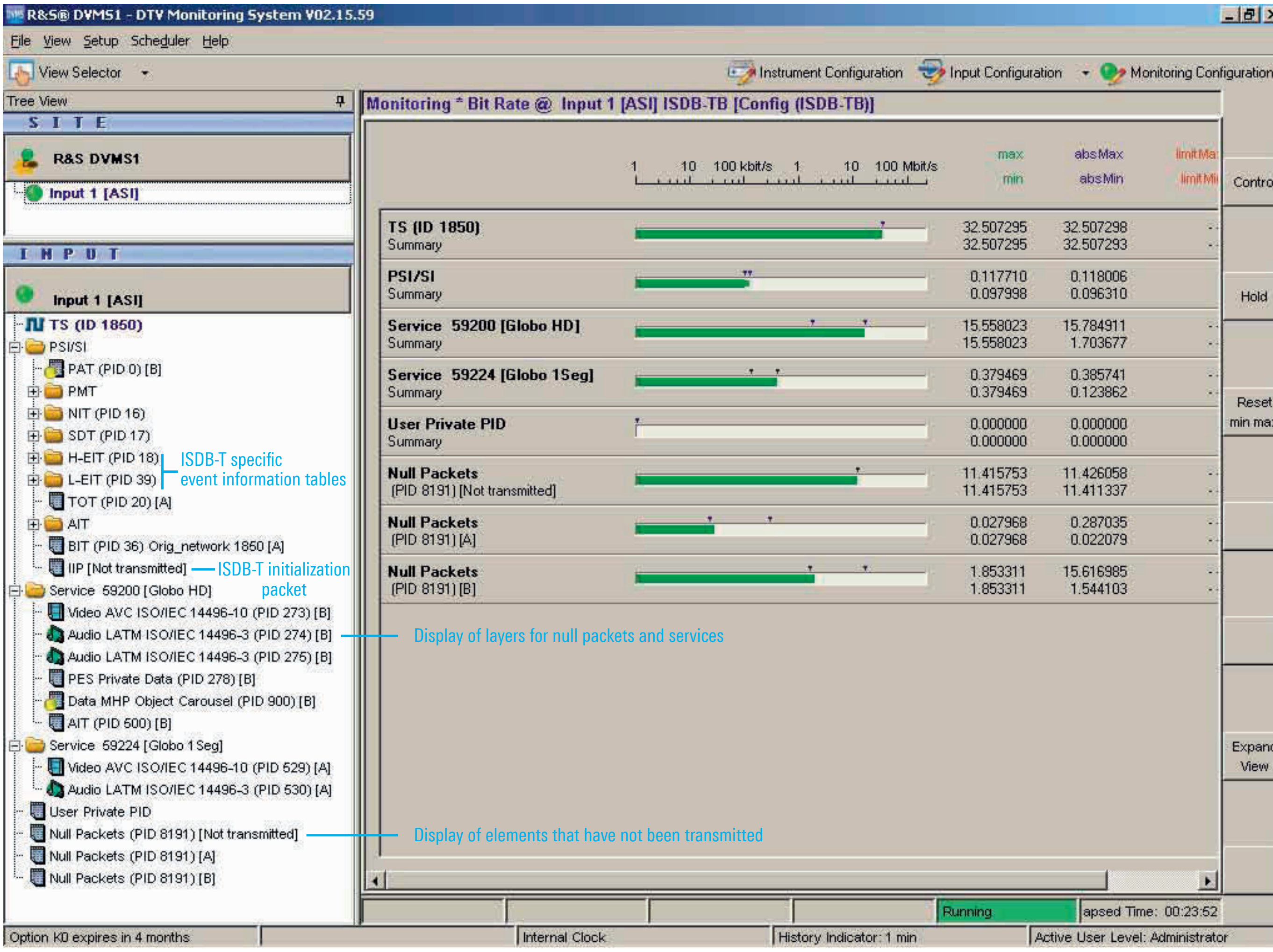
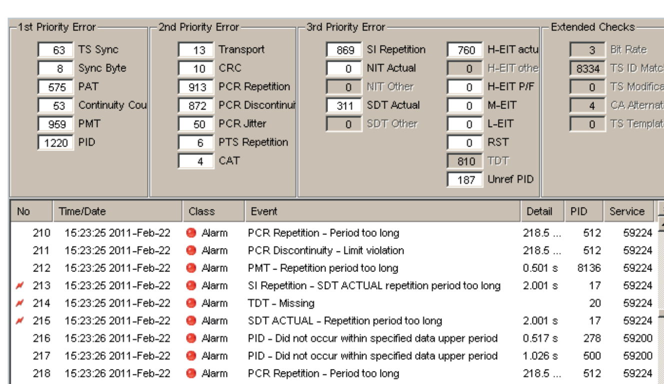


FIG 1 Detailed display of all ISDB-T / ISDB-T_B specific elements in a tree structure as well as of the bit rates on the R&S®DVMS user interface.

The TS template monitoring functions have also been expanded. This means that with ISDB-T / ISDB-T_B, the required repetition rates for the H-EIT, M-EIT and L-EIT tables are additionally monitored for every service.

The extensive monitoring functions reliably detect all relevant nonconformities, allowing a quick response to errors and making it possible to prevent network failures (FIG 2).

FIG 2 Detailed report entries and error counters.



Significantly expanded interpretation functions

The interpretation functions provide a detailed presentation of all structures, tables and descriptors for the ISDB-T / ISDB-T_B standards (FIG 3) and output the elements of the standardized syntax in coded and interpreted format. The ISDB-T initialization packet (IIP) is also supported for the BTS. The packet interpreter displays the TMCC data appended to every transport stream packet (8 additional bytes). This makes it easy to check the contents and to find syntax errors quickly. The PID list was expanded to include a "layer" column, where the allocation of each element in the transport stream to a layer can be entered, allowing users to sort by this criterion. In this way, entries are easily found and analyses can be improved.

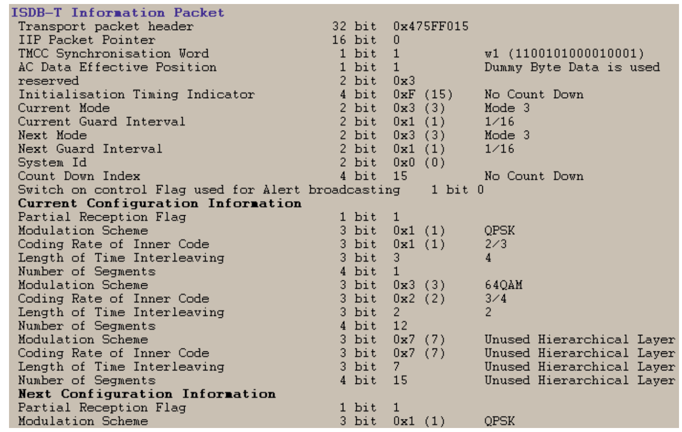
Numerous other functions

Many additional functions can be used without restrictions for analyzing ISDB-T / ISDB-T_B transport streams. They allow a detailed analysis of the transport stream and make investments in additional analysis equipment unnecessary. Other functions include analysis of the program clock reference (PCR, FIG 4) and the presentation time stamp (PTS). The "TS Capture" option provides a wide range of recording functions for transport stream segments and offers the appropriate settings for trigger events and data filters. Since the individual service contents are displayed as thumbnails (only on the R&S®DVMS), the user has a good overview of all services available in the transport stream. The R&S®ETL contains a hardware decoder that supports the common interface for decoding restricted-access content.

And all via firmware update, without additional fees …

Support of the ISDB-T / ISDB-T_B standards does not require an additional option, but is enabled automatically with a firmware update. The corresponding firmware versions for the R&S®DVMS (version 2.10 and later) and the R&S®ETL (version 2.11 and later) are already available. Detailed information on the contents of this article, as well as other functionality provided by the R&S®DVMS and the R&S®ETL families of instruments, is available on the Internet.

Michael Fischbacher; Thomas Tobergte



ISDB-T Information Packet			
Transport packet header	32 bit	0x475FF015	
IIP Packet Pointer	16 bit	0	
TMCC Synchronisation Word	1 bit	1	w1 (1100101000010001)
AC Data Effective Position	1 bit	1	Dummy Byte Data is used
reserved	2 bit	0x3	
Initialisation Timing Indicator	4 bit	0xF (15)	No Count Down
Current Mode	2 bit	0x3 (3)	Mode 3
Current Guard Interval	2 bit	0x1 (1)	1/16
Next Mode	2 bit	0x3 (3)	Mode 3
Next Guard Interval	2 bit	0x1 (1)	1/16
System Id	2 bit	0x0 (0)	
Count Down Index	4 bit	15	No Count Down
Switch on control Flag used for Alert broadcasting	1 bit	0	
Current Configuration Information			
Partial Reception Flag	1 bit	1	
Modulation Scheme	3 bit	0x1 (1)	QPSK
Coding Rate of Inner Code	3 bit	0x1 (1)	2/3
Length of Time Interleaving	3 bit	3	4
Number of Segments	4 bit	1	
Modulation Scheme	3 bit	0x3 (3)	64QAM
Coding Rate of Inner Code	3 bit	0x2 (2)	3/4
Length of Time Interleaving	3 bit	2	2
Number of Segments	4 bit	12	
Modulation Scheme	3 bit	0x7 (7)	Unused Hierarchical Layer
Coding Rate of Inner Code	3 bit	0x7 (7)	Unused Hierarchical Layer
Length of Time Interleaving	3 bit	7	Unused Hierarchical Layer
Number of Segments	4 bit	15	Unused Hierarchical Layer
Next Configuration Information			
Partial Reception Flag	1 bit	1	
Modulation Scheme	3 bit	0x1 (1)	QPSK

FIG 3 The interpreter function output has been expanded significantly.

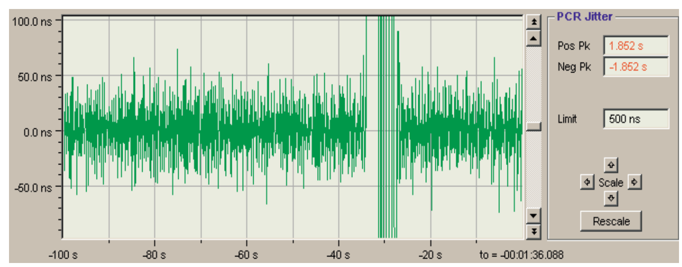


FIG 4 Program clock reference (PCR) analysis.

Abbreviations

BTS	Broadcasting transport stream
CRC	Cyclic redundancy check
EIT	Event information tables
ISDB-T	Integrated services digital broadcasting – terrestrial
ISDB-T_B	Integrated services digital broadcasting – terrestrial Brazil
SBTVD	Sistema Brasileiro de Televisão Digital
SI	Service information
TS	Transport stream

R&S®TSE800: DVB-T2 for the 8000 transmitter family

Digital television with the DVB-T2 standard is currently available in the United Kingdom, Italy, and recently also in Sweden. Existing transmitter systems from the 8000 family can be easily retrofitted for the new standard with the R&S®TSE800 transmitter system extension.

DVB-T2 – a variant of DVB-T?

Even if the name makes it sound as if DVB-T2 is a variant of DVB-T, so many new features were added over the course of the ETSI 2009 standardization that one has to refer to it as a new standard. Compared with DVB-T, the DVB-T2 technology offers features such as:

- Program-specific coding and error protection by means of multiple physical layer pipes (PLP) in the transport stream
- Efficiency optimization by avoiding signal peaks, through tone reservation for instance (suitable modulation of unused carriers)
- Multiple input single output (MISO) applications with multiple input paths using the Alamouti algorithm
- Further options for configuring FFT and FEC parameters, and much more

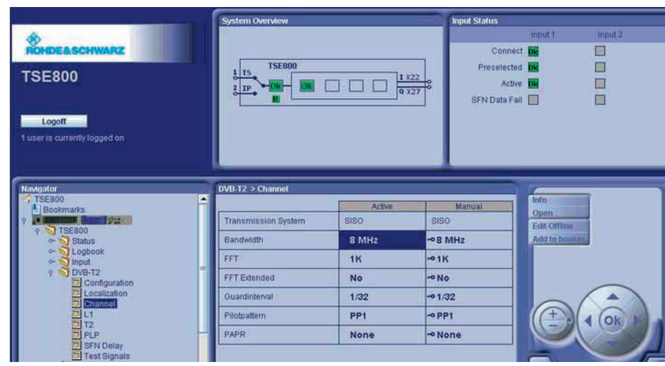


FIG 2 The R&S®TSE800 can be operated over a web browser.

Transmitter system retrofitting

The R&S®TSE800 transmitter system extension (FIG 1) is compatible with all 8000 family transmitters: rackmounted transmitters from the R&S®NV8000 family, compact transmitters from the R&S®SCx8000 family and low-power transmitters from the R&S®SLx8000 family. The transmitters are made DVB-T2-capable by installing the R&S®TSE800 before an R&S®Sx800 or R&S®Sx801 exciter or directly before an R&S®SLx8000 low-power transmitter and then feeding the required I/Q-modulated data stream over an ASI interface. Integration into a rack transmitter is completed by installing the R&S®NetCCU800 transmitter control unit, which has a user interface for easy operation of all devices connected to the system. In this way, previously delivered transmitter systems are easy to retrofit with DVB-T2 capability. No changes are required to the existing hardware, ensuring that investments are protected. Many customers have already taken advantage of this straightforward opportunity to retrofit their systems. The capability to feed the signal using the Internet protocol (IP), which is increasingly in demand, can also be implemented with the R&S®TSE800.

The R&S®TSE800 boasts a 19", one height unit design. As well as over the integrated display, it can also be operated over a web browser (FIG 2) or via SNMP. The modular design enables simple retrofitting with option cards, such as a receiver board that transforms the R&S®TSE800 into a retransmitter.

Stefan Dzieminski

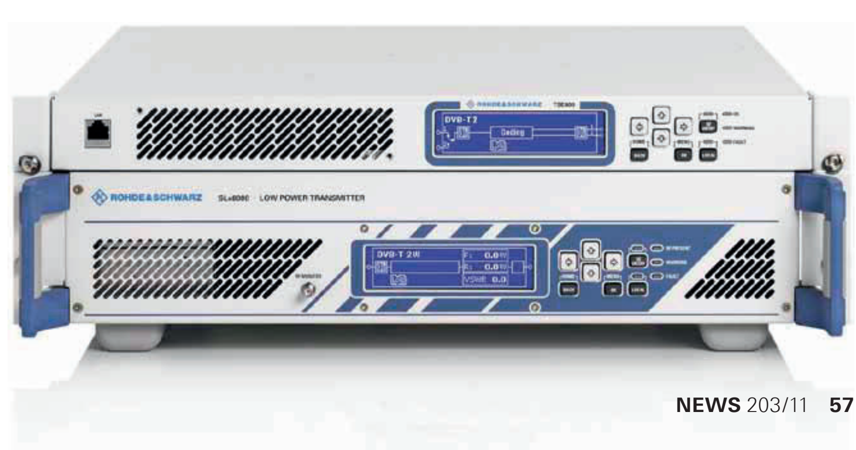


FIG 1 The R&S®TSE800 transmitter system extension together with a low-power transmitter from the R&S®SLx8000 family.

Measurements on FM sound broadcasting signals with the R&S®ETL TV analyzer

Analyzing FM sound broadcasting signals with a TV analyzer – a contradiction? Not with the R&S®ETL as it is now equipped with suitable options. This versatile instrument also covers DAB(+) as well as analog and digital television – all in a single compact instrument.

Despite digitization, FM sound broadcasting remains the leading radio standard worldwide

Digitization of TV and sound broadcasting transmission paths shows no signs of slowing down worldwide. This is seen in the rapid development of DVB-T2 transmitter networks and the increasing prevalence of DAB(+) sound broadcasting networks. But despite this development, analog FM sound broadcasting is still the leading radio standard. The main reason is probably the large number of receivers used in vehicles and homes and integrated in the popular smartphones.

Broadcasting network operators often need extensive T&M equipment to install, service and repair analog and digital sound broadcasting and TV transmitters at one and the same site. The R&S®ETL TV analyzer is ideal for such environments. With its new options for FM sound broadcasting and its flexible scalability, the R&S®ETL covers all T&M requirements – in a single, efficient, multifunctional instrument.

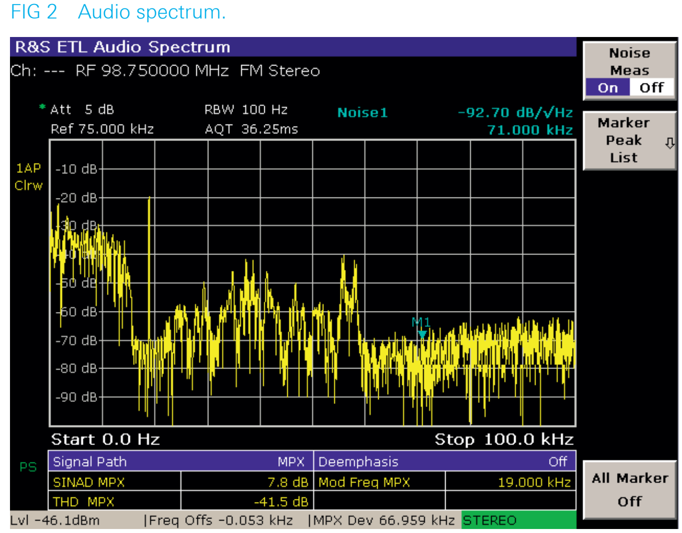
High-quality FM sound broadcasting signal analysis

The R&S®ETL-K110 option was specifically designed for analyzing and demodulating FM sound broadcasting signals. An overview window shows the most important parameters such as level, frequency offset, information about pilots and radio data systems (RDS) and frequency deviations (FIG 1). In addition, the audio spectrum display (FIG 2) and an audio oscilloscope offer a quick overview of the basic properties of an FM sound broadcasting signal.

Transmission of FM sound broadcasting signals should not interfere with adjacent channels. Accurate MPX power and MPX peak deviation measurements (FIG 3) help determine compliance with the legal and regulatory requirements in accordance with the ITU-R SM.1268-1 standard.

FIG 1 Overview of the most important FM sound broadcasting signal parameters.

FIG 2 Audio spectrum.



Optional input section for high S/N

High-quality transmission of an FM sound broadcasting signal places high demands on a transmitter's signal-to-noise ratio (S/N). The same applies to the T&M instrument used to measure if the S/N is sufficient. The R&S®ETL can be equipped with the R&S®ETL-B110 high SNR FM frontend which, when used together with the optional audio analysis, increases the measurement range to an S/N of ≥ 80 dB.

Integrated audio analysis

Information about MPX power, frequency deviations and pilots alone is not sufficient to comprehensively evaluate the signal quality of an FM sound broadcasting signal. Further measurements need to be performed on demodulated audio signals. The R&S®ETL-K111 FM (radio) audio analysis / generator option offers elementary measurements for the detection of crosstalk, audio frequency response, harmonics (FIG 4) and mixed products that result from non-linear components in the signal path. The integrated audio analysis option is easy to use and it eliminates the need for a separate audio analyzer.

Integrated audio generator

The user-installable R&S®ETL-B201 universal interface extends the functionality of the R&S®ETL-K111 FM (radio) audio analysis / generator option to include an audio generator function. This option generates signals tailored to the measurements needed for audio analysis. These signals can be fed directly into the exciter to be tested. For every audio measurement, the signal parameters can be adjusted individually according to the requirements and measurement specifications (FIG 5). This increases the ease of use and decreases the risk of operator errors. A separate audio generator is no longer required. The audio generator in the R&S®ETL can generate both normal audio signals and complete MPX signals to stimulate the transmitter that is to be tested.

Summary

Equipped with the new FM sound broadcasting options, the R&S®ETL TV analyzer offers all the functions needed to test and document the quality of FM sound broadcast transmitters. Its integrated audio analysis function, integrated audio generator, outstanding measurement accuracy and its ability to combine analysis functions for DAB(+), analog and digital TV in a single instrument assure high flexibility and economic efficiency in everyday use.

Werner Dürport

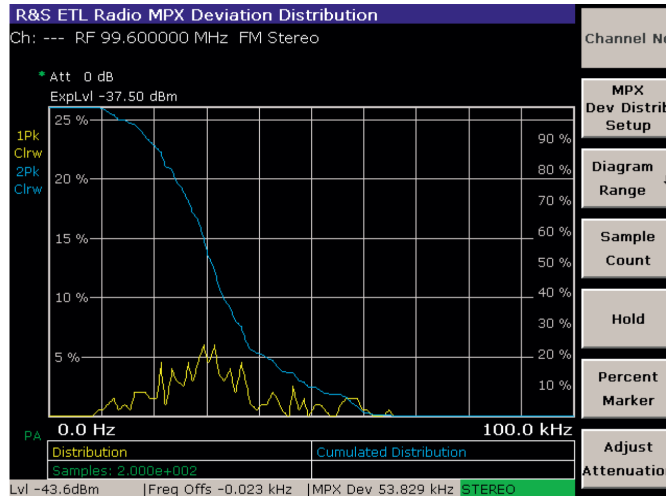


FIG 3 Cumulated MPX distribution.

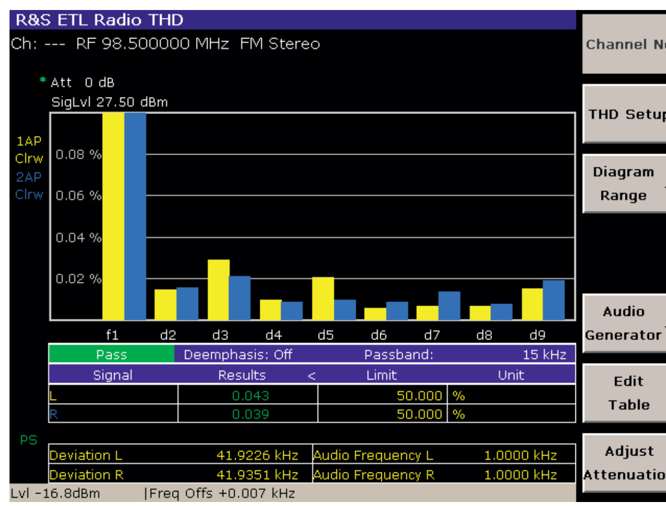


FIG 4 Total harmonic distortion (THD) measurement.

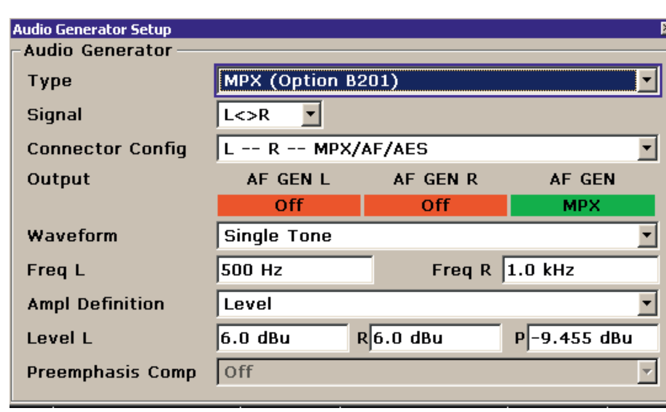


FIG 5 Audio generator settings.

Air traffic control: new VoIP-based voice communications system takes off

With the transition to broadband transmission infrastructures and the demand for interoperable radiocommunications networks, air traffic control authorities are facing formidable tasks. The technologically superior VoIP-based communications systems from Rohde & Schwarz can help manage these tasks. The new R&S®VCS-4G fully IP-based voice communications system rounds out the product portfolio. ATC organizations can now rely on voice communications systems from a single source – from the microphone to the antenna.

VoIP is the future

Voice over IP (VoIP) is the technology of the future in air traffic control (ATC) and air defense (AD) sectors. After years of transferring radar data for air traffic management over IP networks, IP technology is now expanding its way into voice communications. Reduced infrastructure costs are one benefit: If a common network is used to transport voice and data, only a single network needs to be planned, installed and operated. The trend towards VoIP will be accelerated by the successful standardization of VoIP in the ATC sector by the EUROCAE Working Group (WG67) and the adoption of these standards by the ICAO.

Leading air traffic control authorities worldwide, including Europe's EUROCONTROL and the US Federal Aviation Administration (FAA) have spoken out in favor of deploying VoIP in ATC voice communications systems in the future. Other ATC authorities such as ROMATSA in Romania have been successfully operating VoIP-based ATC systems for some time now using products from Rohde & Schwarz and Rohde & Schwarz Topex SA.

FIG 1 Rohde & Schwarz systems are used at more than 200 airports in more than 80 countries. ATC organizations can now rely on voice communications systems from a single source – from the microphone to the antenna.

Application examples of VoIP systems from Rohde & Schwarz

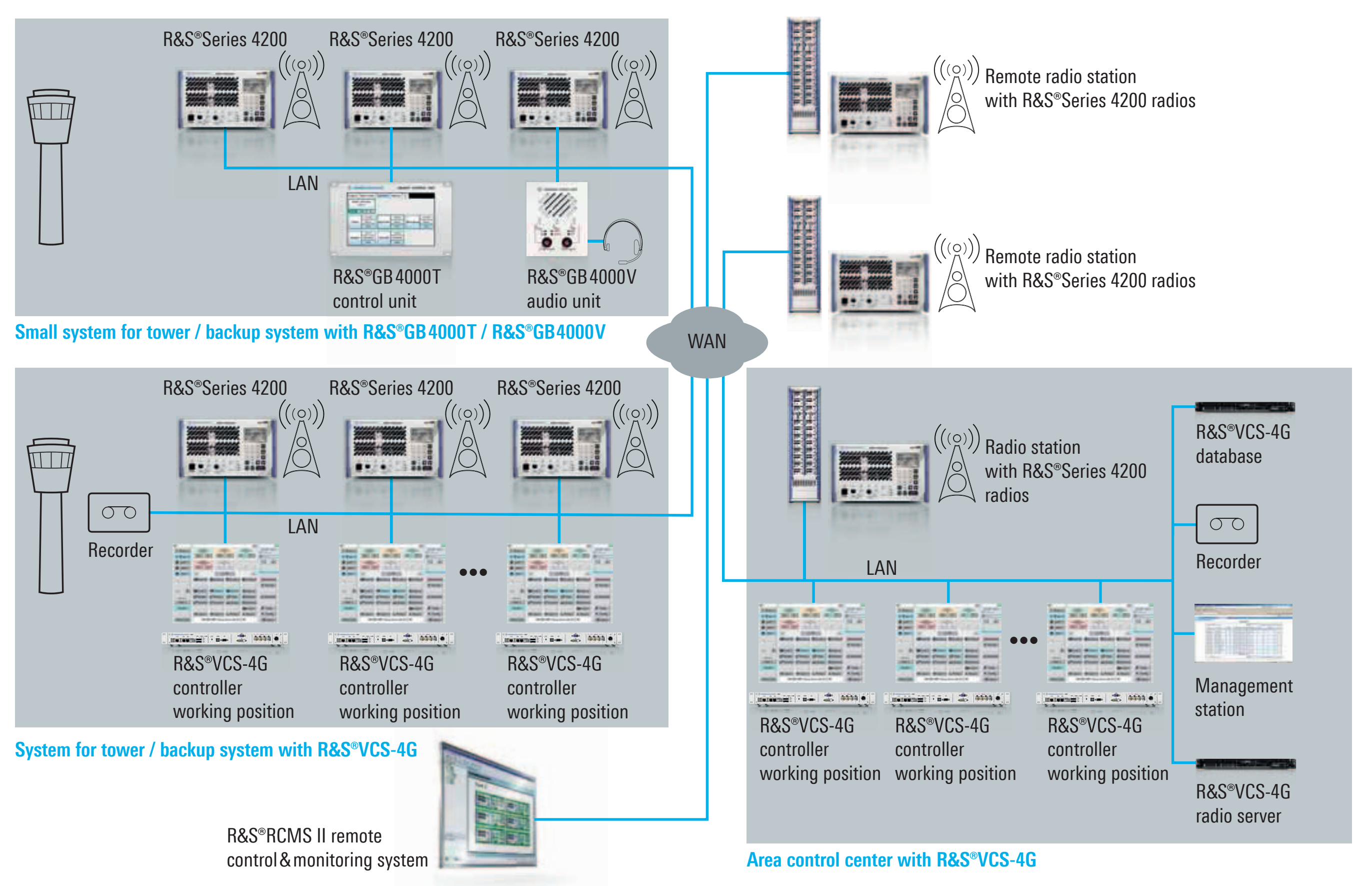


FIG 2 ATC authorities can scale the R&S®VCS-4G according to their needs, from single controller working positions to complete area control centers. The R&S®GB4000T and R&S®GB4000V are available for small systems.

The R&S®VCS-4G voice communications system: IP-based, scalable, decentralized

The new R&S®VCS-4G is an enhancement of a voice communications system developed by Rohde & Schwarz Topex SA (see box). The system provides the complete infrastructure, from the controller working positions to the radio stations, which are usually physically separate from each other. In addition to communications between air traffic controllers and pilots, the system supports the full range of ATC features, even beyond the borders of individual ATC systems. The R&S®VCS-4G is fully IP-based and fulfills the EUROCAE ED137 standard. ATC authorities now have access to a solution that offers all of the benefits of VoIP and ensures interoperability worldwide between different parties.

Conventional TDM-based voice communications systems have a central switching center. If this central switching center fails, several or even all controller working positions are affected. The decentralized architecture of the R&S®VCS-4G prevents this from occurring. Each controller working position routes its traffic independently. Since there is no dependency on central switching centers, the voice communications system from

Rohde & Schwarz and Topex:

Rohde & Schwarz took a major step forward in the expansion of its product range for ATC with its acquisition of a majority stake in the Romania-based company Topex, a manufacturer of telecommunications equipment for government organizations and private enterprises. The company's products include voice communications systems for ATC authorities, which Rohde & Schwarz has now integrated into its product portfolio as the R&S®VCS-4G. The two companies are a perfect match, particularly in the ATC sector: Rohde & Schwarz possesses solid expertise in radios and RF systems, while Topex is experienced in voice communications systems. Both companies offer innovative, technologically advanced products and have used VoIP in ATC applications for some time now. In the future, Topex will operate under the name Rohde & Schwarz Topex SA.

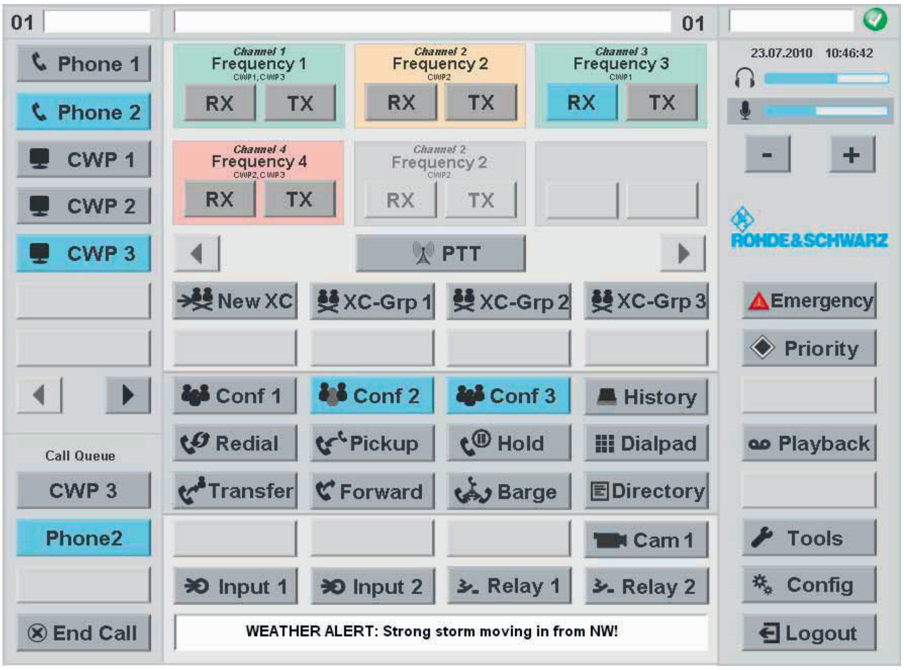


FIG 3 Example of a graphical user interface for a controller working position using the R&S®VCS-4G.

Rohde&Schwarz is highly available and extremely fail-safe. ATC authorities can scale the flexible R&S®VCS-4G to meet their requirements, from a single controller working position to a complete area control center (FIG 2). This decentralized system can be easily expanded when more capacity is needed. In a centralized architecture, future expansion must be taken into account from the start, which in turn entails making the necessary investments up front.

The graphical user interface of the R&S®VCS-4G can be configured for each customer (FIG 3). In addition to voice communications, data applications such as airport video surveillance, weather information and alarm functions can also be integrated. Air traffic controllers can use this additional information to assess and quickly respond to critical situations.

The R&S®VCS-4G also protects earlier investments since it can be integrated into existing infrastructures with radios with analog audio interface, TDM-based voice communications systems or conventional telecommunications networks.

Single source solution: from the microphone to the antenna

The R&S®VCS-4G rounds out the Rohde&Schwarz portfolio of future-oriented, IP-based voice communications systems for ATC and air defense. ATC authorities benefit from dealing with a single provider who can offer everything from a single source – from the microphone to the antenna. System integration is simpler and less expensive, and project risks are reduced to a minimum.

Alternatively to the R&S®VCS-4G, Rohde&Schwarz offers very compact solutions for VoIP-enabled communications for small systems with one or only a few controller working positions: the R&S®GB4000V audio unit and the R&S®GB4000T control unit (both shown in FIG 2). Using these system components, it very easy to implement VoIP-based communications systems for ground-to-air communications such as are needed in a small tower or for apron control.

The R&S®RCMS II IP-based remote control and monitoring system provides a software solution for monitoring and controlling the entire voice communications network from a single central location or from several distributed workplaces. Monitoring encompasses both the R&S®Series4200 radios and the R&S®VCS-4G VCS system.

Summary

The new R&S®VCS-4G voice communications system rounds out the portfolio of ATC and AD communications system solutions available from Rohde&Schwarz. From the controller microphone to the radio antenna, the company's product portfolio has the right solution to meet the individual requirements of ATC authorities. Rohde&Schwarz is also assuming technological leadership in the area of IP-based solutions for ATC voice applications. In this complex field with its growing technological demands, ATC authorities can now refocus on their primary task: air traffic safety. Because the fact is, systems from Rohde&Schwarz simply work.

Jörg Kilpert

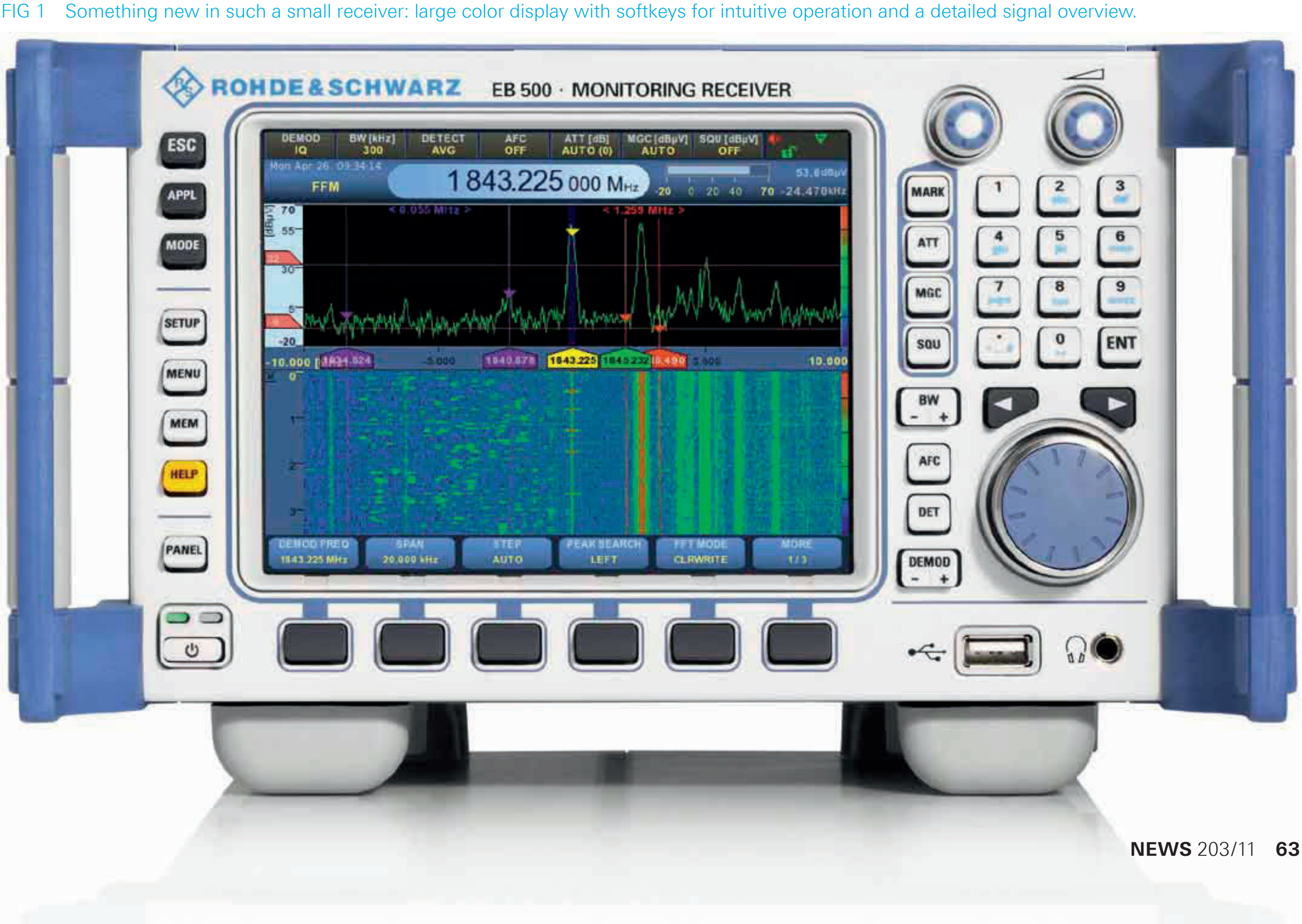
Perfectly positioned: the new, compact R&S®EB 500 monitoring receiver

With its fine balance of technical specifications, dimensions, power consumption and price, the new R&S®EB 500 monitoring receiver is well positioned between the R&S®PR 100 portable receiver and the high-end R&S®ESMD wideband monitoring receiver. From this trio of receivers, users can choose the right receiver to handle any radiomonitoring task.

R&S®EB 500 – the perfect blend of form and functionality

The new R&S®EB 500 monitoring receiver (FIG 1) which covers the frequency range from 9 kHz to 6 GHz has now closed the gap between the R&S®PR 100 portable receiver and the high-end R&S®ESMD wideband monitoring receiver (see box on page 64). The new receiver inherits the intuitive operation of the R&S®ESMD along with the bulk of its rich set of features. The new R&S®EB 500 replaces the tried-and-tested, ITU-compliant R&S®ESMB wideband monitoring receiver. The R&S®EB 500 has identical dimensions so it can easily take the place of the former instrument in current rack installations or vehicular installations. The R&S®EB 500 addresses more applications than its predecessor and offers enhanced performance, e. g. polychrome and waterfall diagram, 20 MHz realtime bandwidth, 5 MHz demodulation bandwidth and fast panorama scan up to 12 GHz/s (R&S®ESMB: 1 MHz realtime bandwidth, 300 kHz demodulation bandwidth, scan speed up to 3 GHz/s). The receiver has a special frontend that simultaneously delivers high sensitivity with a good third order intercept point (IP3), making a separate low noise mode unnecessary. Accordingly, the R&S®EB 500's quality coefficient (IP3 minus noise figure) is comparable to the performance of the R&S®ESMD in the corresponding frequency ranges.

FIG 1 Something new in such a small receiver: large color display with softkeys for intuitive operation and a detailed signal overview.



R&S®EB500 stationary applications – versatile and cost-effective

With a densely populated network of stations, the level of confidence in the monitoring results during interception and detection of interfering signals increases drastically. Due to its excellent price/performance ratio, the R&S®EB500 can be used cost-effectively to create a large nationwide network of stationary monitoring stations. In difficult terrain such as mountain areas and in urban environments, a large network of monitoring stations is an absolute must. This is true especially in the VHF and UHF frequency ranges and above. To reduce costs, the R&S®EB500 can be offered with or without front panel and can be operated locally via the front panel or remotely via a PC and a control software. This flexible approach makes it possible for just a few operators to monitor nationwide networks, leading to lower overall operating costs.

Different receivers are sometimes used in a network as a result of varying local requirements. However, the actual implementation is transparent to the users since all of the Rohde&Schwarz monitoring receivers have similar operating concepts and user interfaces that are designed for remote or manual operation.

R&S®EB500 mobility – convenience by vehicle-based stations

Monitoring tasks are handled primarily by fixed stations. However, it is not possible to detect all interfering signals even with a dense network of fixed stations, especially in the VHF / UHF range. In these cases, additional vehicle-based monitoring stations are used to get closer to the signal source. Nevertheless, vehicular radiomonitoring should not entail

The trio in comparison

These three receivers from Rohde&Schwarz have the performance and design needed in different application areas (FIG 2). For monitoring tasks in a harsh outdoor environment, the compact R&S®PR100 is the best choice due to its low weight, display with adjustable brightness control, good RF characteristics and a built-in mapping feature.

The new R&S®EB500 with its high scan speed and excellent RF characteristics is the ideal receiver for monitoring tasks in a signal environment up to 6 GHz and for different scenarios, including stationary, vehicular as well as transportable applications. It can be used as a desktop receiver or in a network via remote control. Using its remote control interface, the R&S®EB500 is ideal for use as a handoff receiver in conjunction with a powerful search and monitoring receiver such as the R&S®ESMD. Whereas receivers with less dynamic range would be quickly overwhelmed in such an application, the R&S®EB500 has adequate performance to ensure optimum reception of the signals of interest.

The R&S®ESMD wideband monitoring receiver is the ideal choice for extremely demanding monitoring tasks in difficult signal scenarios, e.g. in urban environments. Strong signals can be very challenging for the receiver's frontend, especially when powerful transmitters are situated in the vicinity of the monitoring station. Despite the presence of strong signals, the stationary receivers, which are typically connected to large antennas with high gain, must still be capable of detecting very weak emissions. In this application, the R&S®ESMD stands out with its excellent RF characteristics. In addition, there are numerous options available for this receiver, e.g. an SHF frequency range extension up to 26.5 GHz, an option for the very highest scan speed in its class, an 80 MHz realtime bandwidth and a module to speed up signal analysis.

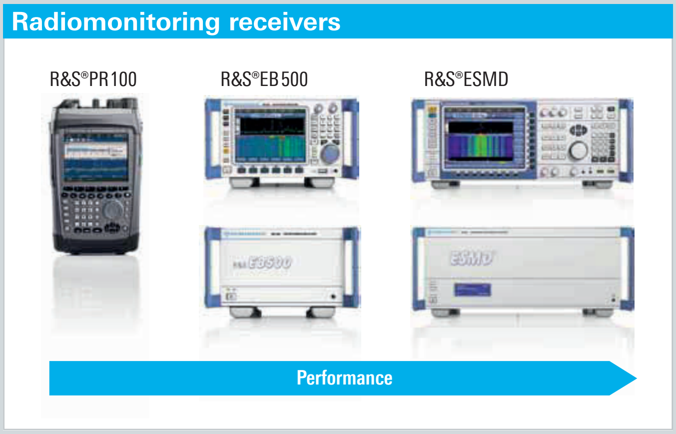


FIG 2 Overview of the radiomonitoring receivers.

compromises in the monitoring capabilities. The recommended procedure is to install the same receiver type in the vehicle that is used in the fixed stations. The R&S®EB500 represents an ideal choice due to its compact dimensions (½ 19" width, 3 height units), integrated wide-range power supply (+10 V DC to +32 V DC) and low power consumption (starting at approx. 50 W).

The identical user interfaces in the fixed and mobile stations are another benefit since the need for additional operator training to master different receivers is eliminated. Due to its versatility, the R&S®EB500 can be deployed in large quantities to handle diverse tasks and scenarios, thereby simplifying service and spare part handling in the context of repairs and maintenance.

R&S®EB500 transportability – autonomous and remote-controllable

In cases where the place of origin of an emission of interest is not accessible by vehicle and monitoring is required over several hours, the R&S®EB500 is also a good choice. The receiver's good balance between performance, size, weight and power consumption makes it easy to integrate into a transport case with its own power supply. An integrated PC can be included to store the monitoring results. No separate antenna selector is needed to select different antennas since the R&S®EB500 already has a space-saving, built-in antenna selector (1 × HF, 1 × HF / VHF / UHF).

An all-in-one system of this type could be installed, for example, on the flat rooftop of a building and configured for monitoring using the convenient R&S®EB500-Control remote

In applications where such high-end features are not required, the R&S®EB500 is recommended as a comparable yet more economical alternative. FIG 3 summarizes and compares the key parameters and features of these three outstanding radiomonitoring receivers, helping to select the right receiver for a particular task.

FIG 3 Comparison of the key specifications for the three receivers.

Parameter	R&S®PR100 / R&S®EM100 	R&S®EB500 	R&S®ESMD 
Frequency range	9 kHz to 7.5 GHz	(9 kHz) 20 MHz to 3.6 GHz (6 GHz)	(9 kHz) 20 MHz to 3.6 GHz (26.5 GHz)
Realtime bandwidth	10 MHz	20 MHz	20 MHz (80 MHz)
Demodulation bandwidth	500 kHz	5 MHz	20 MHz (80 MHz)
Panorama scan speed	up to 2 GHz/s	up to 12 GHz/s	up to 43 GHz/s
Noise figure (VHF / UHF range)	< 12 dB, typ. 10 dB (ATT off, equivalent to normal mode)	< 14 dB, typ. 10 dB (normal mode)	< 12 dB, typ. 9 dB (low noise mode) < 16 dB, typ. 12 dB (normal mode)
IP3 (VHF / UHF range)	> –6 dBm, typ. –3 dBm (ATT off, equivalent to normal mode)	> 7 dBm, typ. 10 dBm (normal mode)	> 8 dBm, typ. 13 dBm (normal mode)
LAN interface	100 Mbit Ethernet	1 Gbit Ethernet	1 Gbit Ethernet (10 Gbit Ethernet)
Digital downconverter	–	yes (end of 2011)	yes
Direction finder upgrade kit	yes (middle of 2011)	yes (middle of 2011)	yes
ITU-compliant specifications	–	yes	yes
Portable	yes		
Space required for rackmounting		low	
Recommended as handoff receiver		yes	

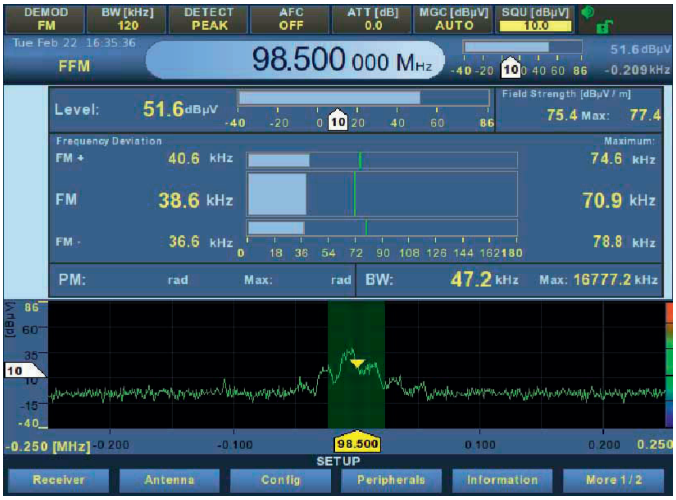


FIG 4 Determination of the bandwidth occupancy of an FM broadcast transmitter using the R&S®EB500-IM option for measurements in line with ITU standards.

control software. After the system has been left on the rooftop for a few hours to capture data, it can be removed. The collected monitoring results are then available for subsequent analysis. If the system includes components for setting up a radio link (e. g. via GSM), its monitoring parameters can even be modified remotely.

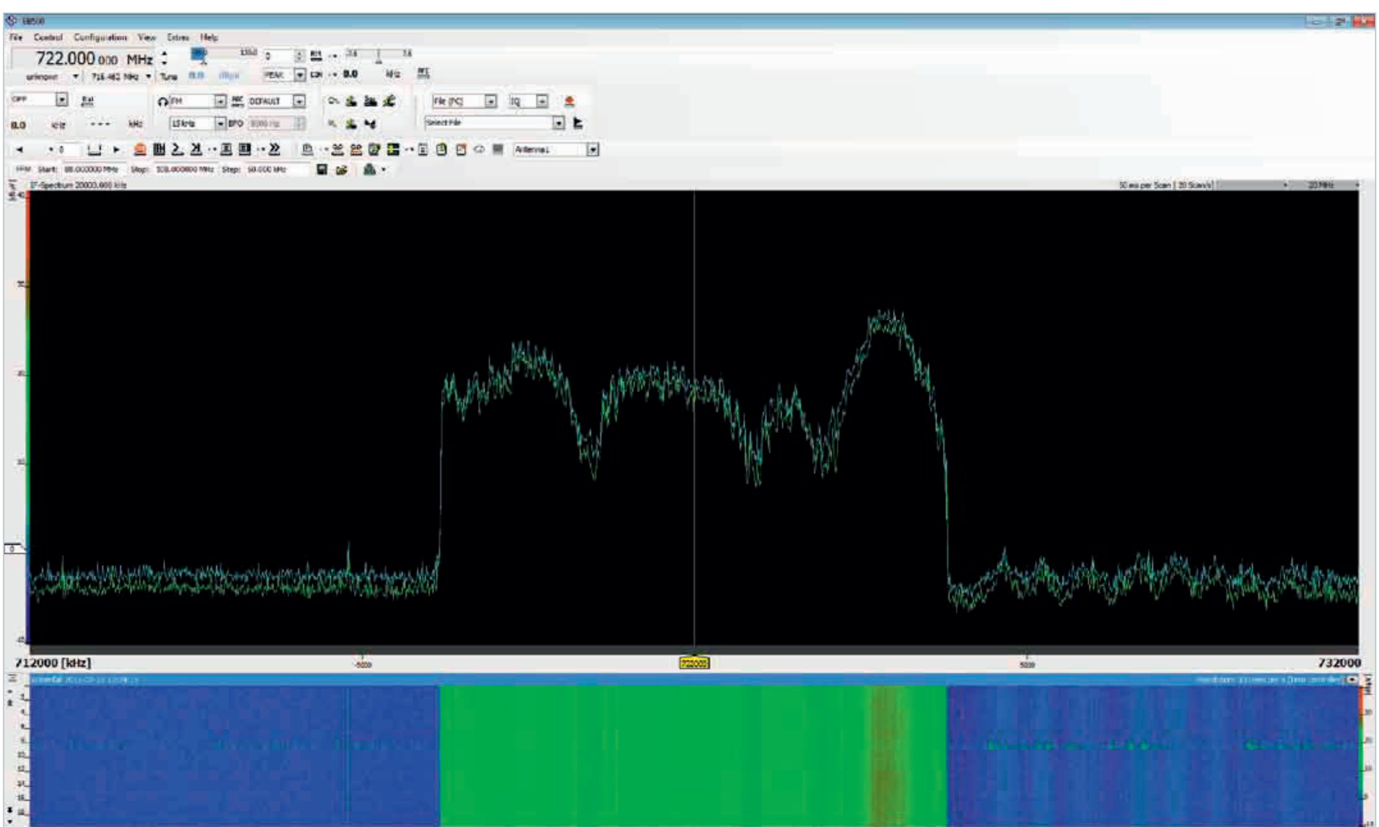
R&S®EB500 standard-compliance – all important ITU measurements

Frequency regulatory authorities require ITU-compliant receivers with predefined automatic measurement functions. When equipped with the R&S®EB500-IM ITU measurement option, the R&S®EB500 is able to measure the following:

- AM modulation index
- FM frequency deviation
- PM phase deviation
- Occupied bandwidth

These measurements help regulatory authorities to decide whether a given emission is in compliance and simplify the job of identifying unusual emissions. For example, in FM broadcasting the maximum frequency deviation must not exceed 75 kHz according to ITU recommendations (including the radio data system (RDS)). The deviation is easy to measure automatically using the R&S®EB500-IM option (FIG 4).

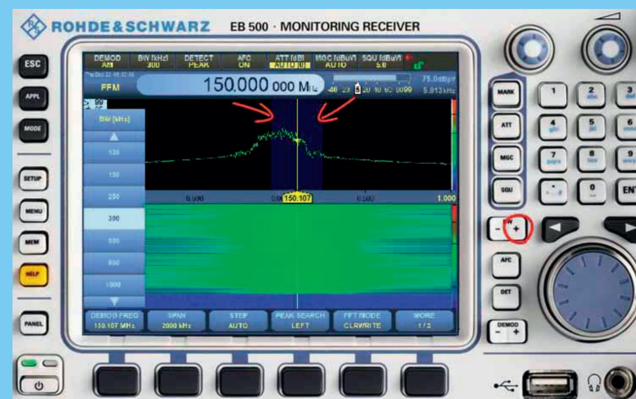
FIG 5 The R&S®EB500-Control remote control software supports all of the receiver's features during remote control operation. A single-user license is included with each receiver.



Comprehensive computer-based training for the R&S®EB500

This computer-based training (CBT) program provides step-by-step instructions on using the receiver's functions. The program demonstrates the effects of different receiver settings in a clear and detailed manner and recommends relevant settings to allow optimum detection of different signals. The CBT on DVD is available free-of-charge from any Rohde&Schwarz office (Order No.: 5214.3800.52).

The CBT for the R&S®EB500 monitoring receiver provides a step-by-step introduction into the receiver's functions and operation. A screenshot of the start page is shown here.



Example from the CBT: Effects of the modulation bandwidth setting when AFC is switched on.

R&S®EB500 compatibility – good integration with Rohde&Schwarz software

The R&S®EB500 is fully compatible with the relevant software packages from Rohde&Schwarz:

- R&S®GX430 analysis software for automatic signal search and classification
- R&S®ARGUS spectrum monitoring software for systems all the way up to nationwide installations in line with ITU recommendations
- R&S®RAMON operating software for radiomonitoring including convenient master/slave capabilities

Existing receivers such as the R&S®ESMB can be easily replaced by the R&S®EB500 due to the compatible remote control interface. In addition, each R&S®EB500 comes with a single-user license for the R&S®EB500-Control remote control software which is based on R&S®RAMON. This software enables complete remote control of the receiver and storage of the monitoring results on the control PC (FIG 5).

Additional information

Although it is already packed with features and functions, the R&S®EB500 is continuously being enhanced. Additional information is available on the Internet (search term: EB500). A comprehensive computer-based training program is available on DVD (see box above).

Nellie Pang; Peter Kronseder

Measured against the best – Teisnach plant is "2010 Factory of the Year"

Measuring itself against the very best – that was the idea that prompted Rohde&Schwarz Teisnach to take part in one of Germany's toughest industrial benchmark competitions. And Teisnach came out the winner: The manufacturing plant took first place in the "Excellent Small Series Production" category. Receiving this long-standing industry benchmarking award was the culmination of many years of hard work put into optimizing manufacturing processes.

Knowing where you stand

Rohde&Schwarz, a leading worldwide supplier of instruments and systems for T&M, broadcasting, secure communications, radiomonitoring and radiolocation, manufactures its high-tech products in its own production plants. Because what holds true for the products, applies even more to their production. It must fulfill the highest requirements. This is why sophisticated production chains that ensure highest quality, efficiency and on-time delivery are in place in the Teisnach, Memmingen and Vimperk (Czech Republic) plants (FIG 1).

Such high standards are just begging to be measured against others. And so the plant management decided to take part in the toughest industrial benchmark competition in Germany, which is held under the auspices of the business magazine "Produktion" in cooperation with the consulting firm A.T. Kearney. The result was impressive: The Teisnach plant was named "2010 Factory of the Year" in the "Excellent Small Series Production" category. The award ceremony took place at the two-day "Factory of the Year / GEO Congress" held in Esslingen, Germany. This longest-standing industry

FIG 1 All manufacturing and servicing facilities for transmitter production are located at the Teisnach plant.

Memmingen and Vimperk plants also receive awards
The other Rohde&Schwarz manufacturing plants also demonstrated award-winning form: For the first time in 2010, the Memmingen plant won the **Bavarian Quality Award**, which was established in 1993. Memmingen had to prove its superiority in a number of disciplines, including strategy, procurement, production and order processing.

The Vimperk plant was named **Vodafone Firma Roku 2010 / Vodafone Company of the Year 2010**. This award was first conferred in 2006 and is awarded on the basis of a company's expertise in areas such as production technology, flexibility, quality and delivery reliability.

Throughput times for transmitters

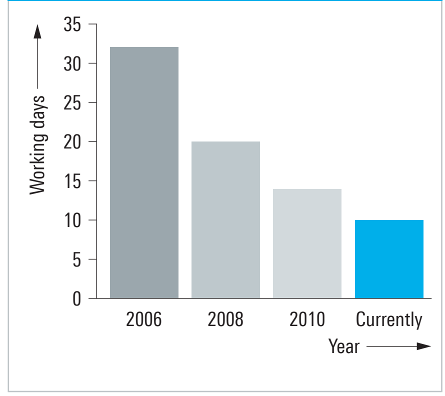


FIG 2 Comprehensive optimization of the value chain led to a drastic reduction in the time needed for the final assembly of transmitters.

benchmarking competition takes place annually and is open to all manufacturing plants in German-speaking countries as well as the new EU accession countries.

Nothing would be possible without a corporate culture that values self-initiative

Manufacturing excellence cannot be purchased, it is the result of ongoing internal restructuring and continual optimization of manufacturing processes. Employees put their expertise and flexibility to work and practically redefined manufacturing as the plant knew it. They succeeded in breaking up structures established over years and reorganizing workflows. Changes in responsibilities and at the management level were necessary. The productive corporate culture provided the necessary basis: Respect for the individual, self-initiative and a flexible, flat organization led to fast, unbureaucratic decisions. Know-how and the ideas of individuals were what counted.

Recipe for success: continuous-flow manufacturing

The jury was especially impressed with the Rohde&Schwarz value-added system. The key to success was the switch from a job-shop approach to continuous-flow manufacturing based on a value stream map. Production islands were created for product families. Materials are supplied from a two-container kanban (just-in-time) system connected to decentralized goods supermarkets instead of from a central warehouse. Transport routes were shortened and the inventories in the value chain were reduced. In addition, preliminary testing was integrated into the production line and final testing in test bays was automated. Even small production lots are now "flow" manufactured. During development, developers and manufacturing specialists work hand in hand to ensure manufacturing feasibility so that production will run smoothly around the clock. Working times were revolutionized as well. Extremely flexible working times resulted in production coverage 24 hours a day, 6 days a week.

These measures were a resounding success: Comprehensive optimization of the value chain, for example, reduced the final assembly throughput time of the in-demand radio and TV transmitters from 33 to just 10 working days (FIG 2).

The high degree of manufacturing depth at Rohde&Schwarz demonstrates the company's commitment to the highest level of quality – down to the smallest detail. An example is the plant's RF expertise when manufacturing waveguides for the aerospace industry. Production uses a new type of galvanic etching technology which allows surface finishing on thin-walled, geometrically complex components.

Manufacturing optimization: never stand still

It was clear that the Teisnach plant would not stop at these successes. Constant technological advancement in production is at the top of its priority list. The Bavarian Research Foundation, for example, is currently supporting Rohde&Schwarz in its work on a groundbreaking printed board project. Objective: To unlock new signal frequencies in the high, two-digit GHz range by using new materials, an adapted design methodology and innovative manufacturing processes. The results will open up new approaches, especially for T&M instruments with their high accuracy and dependability requirements.

The Teisnach plant is ideally prepared for the future and the competition – not just for Rohde&Schwarz requirements. Teisnach generates around 20 percent of its revenue by providing manufacturing services for other companies.

Thomas Gierl

ITU Secretary-General visits Rohde&Schwarz

Gerhard Geier, member of the Rohde&Schwarz Executive Board; Dr. Hamadoun Touré and his wife, ITU; Achim Klein, President of Rohde&Schwarz Vertriebs-GmbH (from left).

For the first time in company history, a Secretary-General of the International Telecommunication Union (ITU) visited Rohde&Schwarz in Munich. In September 2010, Dr. Hamadoun Touré and his wife were received by Corporate Management and taken on a half-day tour of the company. The two guests from Mali were very open and showed great interest. ITU and Rohde&Schwarz want to continue vigorously pursuing their common goals, with focus on civil radiomonitoring, wireless communications and digital TV. Rohde&Schwarz and ITU have been engaged in efficient and friendly cooperation for decades. ITU is the leading UN agency for information and communications technology issues. Its main goal is to secure a globally uniform and interference-free use of the electromagnetic spectrum. Along with 700 other scientific and industrial organizations, operators and regulators, Rohde&Schwarz is a member of the three ITU sectors Radiocommunication, Standardization and Development.

More radios for the Eurofighter Typhoon

At the end of 2010, Rohde&Schwarz received an additional order for VHF/UHF airborne radios for the Eurofighter Typhoon aircraft. The company's close involvement with the project, which began when the series went into production in 1999, has now been extended to the first batch of the third production tranche. Each of the 88 aircraft ordered in this batch will be equipped with two VHF/UHF radios from Rohde&Schwarz. Delivery is scheduled to begin in 2012. The radios for the Eurofighter Typhoon belong to the successful R&S®M3AR family that is used in other major projects such as the Airbus A400M military transport aircraft.

Rohde&Schwarz takes over DVS Digital Video Systems AG

In December 2010, Rohde&Schwarz integrated Hanover-based DVS Digital Video Systems AG into the Rohde&Schwarz group. The company, which was founded in 1985 and now has 110 employees, is the leading international manufacturer of hardware and software for professional film and video postproduction. "We are confident that this partnership will result in the transfer of valuable technology from the studio to broadcasting," comments Jürgen Nies, Head of the Rohde&Schwarz Broadcasting Division. DVS produces digital video and storage systems for the film and TV industry, for example.

R&S®RTO oscilloscope named product of the year

Readers of the German trade journal Elektronik have rated the new Rohde&Schwarz oscilloscope family number one. The R&S®RTO was the top choice in the "Test and Measurement" category. This year, for the 13th time, the trade journal's readers voted for their favorites in ten categories from among the 111 most innovative products. Rohde&Schwarz has already received several prizes in the "Test and Measurement" category.

Elektronik, with a circulation of 31,100, is one of the industry's most important German-language trade media.

Dr. Markus Freidhof, Guido Schulze, Sylvia Reitz and Christian Mokry accepted the trophy and certificate from Elektronik editor Wolfgang Hascher (from left).

ATSC transmitters ordered for Mexico

The Mexican regional TV operator Multimedios has ordered six R&S®NV8600 ATSC high-power transmitters and five R&S®NH8300 medium-power transmitters. The high-power transmitters will be installed in cities that will change to digital transmission this year. The medium-power transmitters will operate in areas in which the NTSC standard is still commonly used today and where the move to ATSC will not take place until after 2011. Mexico plans to switch entirely from analog TV to the digital ATSC standard by 2015.

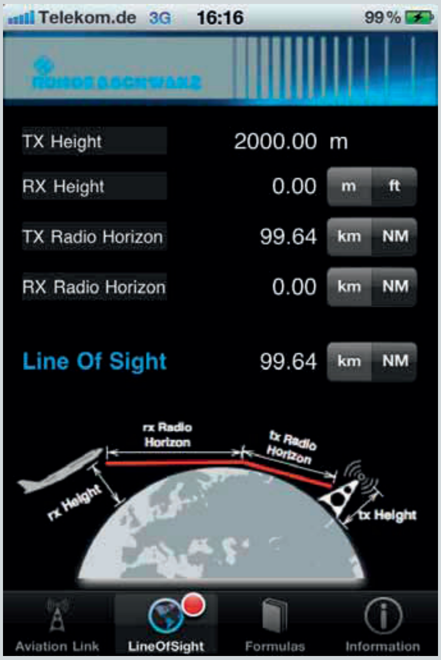
Colombia enters digital TV era with Rohde&Schwarz transmitters

Public and private TV stations in Colombia rely on Rohde&Schwarz to implement their digital TV plans. The extremely popular nationwide private stations will use the R&S®NV8600 high-power transmitters. Twelve transmitters will give initially about 25 percent of the population access to DVB-T. Bogotá's most popular local TV channel, Canal Capital, decided in favor of the R&S®SCx8000 transmitter family, today's most compact and efficient transmitters of their class.

iPhone app by Rohde&Schwarz

Air traffic control organizations must adhere to certain reference values of the International Civil Aviation Organization (ICAO) when planning ground-to-air communications systems. The electric field strength measured at the aircraft antenna, for example, must comply with a certain minimum value to secure a reliable radio link. The actual value can be calculated using the radiated RF power at ground level and the measured distance. The range may deviate strongly from the radio horizon (line of sight, LOS), which is determined by the altitude of the aircraft and the antenna site.

The "Aviation RF Link" app supports these calculations and is available from the AppStore at no charge.



Ceremony for the EEEfCOM Innovation Award winners 2010

For the ninth time, GEROTRON COMMUNICATION GmbH awarded practical ideas in communications technology with the EEEfCOM Innovation Award. The award is aimed at solutions from industry, research institutions and universities. The winners were honored during the RadioTecC trade show in Berlin in November 2010. First prize went to a German-Austrian team. The four researchers developed a new OFDM modulation method that significantly improves the system performance at constant transmit power. The brand-new method will be used in future adaptations of data transmission standards such as WLAN or LTE. The winners were rewarded with a R&S®NRP-Z57 power sensor, sponsored by Rohde&Schwarz.

Georg Schmid of Gerotron; Christian Hofbauer (winning team); key speaker Georg Fischer; Mario Huemer, Alexander Oni and Johannes Huber of the winning team; Alexander Wörner of Rohde&Schwarz (from left).