News from Rohde & Schwarz

Portable receiver and directional antennas for mobile radiomonitoring

Redefining the boundaries of test and measurement: first spectrum analyzer all the way up to 67 GHz

Compact, economical signal generator for all broadcasting standards used today

2007/III
194

ROHDE & SCHWARZ

By offering an unrivaled scope of functions, the new R&S®PR100 revolutionizes the market for portable monitoring receivers: Together with the R&S®HE300 portable directional antenna, the R&S®PR100 is ideal for close-range and far-range radiomonitoring, e.g. for frequency monitoring or tracking telltale signals emitted by active electronic equipment (page 74).

44704/11a

Good spectral purity, high output power, and short settling times are features to be associated with the new analog R&S®SMB100A signal generator (page 18).

Unprecedented – a spectrum analyzer that covers the entire frequency range up to 67 GHz (page 24).

The new R&S®ZVA-Z110 converters from Rohde&Schwarz expand the R&S®ZVA24, R&S®ZVA40, and R&S®ZVT20 vector network analyzers by adding millimeter-wave measurement capability with maximum dynamic range from 75 GHz to 110 GHz (page 27).

Multistandard realtime coding, integrated baseband source, excellent RF characteristics – all this in a compact box with a convenient graphical user interface: This is the new R&S®SFE broadcast tester (page 44).

BROADCASTING

FOCUS

RADIOMONITORING

MISCELLANEOUS

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From SISO to MIMO – taking advantage of everything the air interface offers (2)

Part 1 of this article in number 192 discussed SISO, SIMO and MISO systems (see box below) and how they are used in GSM, WCDMA and WiMAX. The tests defined as part of the certification process were also discussed along with how they can be implemented using instruments from Rohde & Schwarz. Part 2 will cover MIMO systems, i.e. the variants used in the different standards, the relevant test scenarios and their implementation.

MIMO (multiple transmitting and receiving antennas)

MIMO systems have also made their way into test specifications, and the day when these multiple antenna systems will actually see real-world implementation is nearing. In MIMO, N transmitting antennas provide signals to M receiving antennas (FIG 2). In general, the transmission channel in a MIMO system can be characterized using the following $N_r \times N_t$ channel matrix $\mathbf{H}(\tau,t)$:

$$\mathbf{H}(\tau,t) = \begin{bmatrix} h_{1,1}(\tau,t) & h_{1,2}(\tau,t) & \cdots & h_{1,N_t}(\tau,t) \\ h_{2,1}(\tau,t) & h_{2,2}(\tau,t) & \cdots & h_{2,N_t}(\tau,t) \\ \vdots & \vdots & & \vdots \\ h_{N_r,1}(\tau,t) & h_{N_r,2}(\tau,t) & \cdots & h_{N_r,N_t}(\tau,t) \end{bmatrix}$$

The elements of the main diagonal $h_{i,i}$ characterize the direct transmission paths between the antennas, and the remaining elements characterize the mixing products. We thus obtain the received signal $\mathbf{r}(t)$ as follows:

$\mathbf{r}(t) = \mathbf{H}(\tau,t) \times \mathbf{s}(t) + \mathbf{n}(t)$,

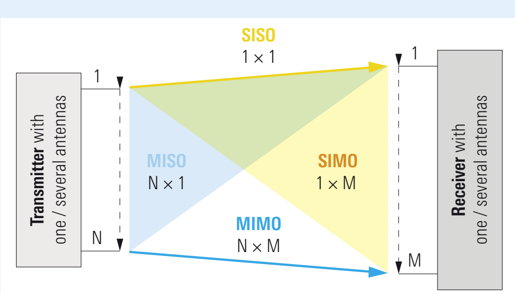
where $\mathbf{H}(\tau,t)$ channel matrix
$\mathbf{s}(t)$ transmitted signal
$\mathbf{n}(t)$ additive noise

In MIMO, all of the basic concepts discussed in Part I are combined in different ways. Depending on the actual technique, the result is either higher data throughput or more robust transmission.

Logically, it makes sense to exploit favorable transmission conditions to increase the transmission rate by selecting the corresponding technique. Under less favorable transmission conditions, however, this does not produce the desired result. In these cases, we need to choose a technique that increases the transmission reliability. Increased transmission reliability also has a positive effect on the data throughput since less channel capacity is wasted to repeat blocks with errors.

Since the properties of a transmission channel can fluctuate very quickly, any change in the transmission technique must be carried out quickly as well. This requires fast feedback of the channel properties from the receiver to the transmitter, which means that the timing needs for such feedback must be properly defined.

FIG 1 The different diversities at a glance.
The terms input and output always refer to the transmission channel. For the downlink (transmission channel from base station to mobile station), an input is a transmitting antenna of the base station and an output is a receiving antenna of the mobile station.



From SISO to MIMO – diversities at a glance

SISO Single Input Single Output The classic and easiest way: one transmitting and one receiving antenna.

SIMO Single Input Multiple Output One transmitting and several receiving antennas. Is also often referred to as receive diversity. With reference to the downlink, this means one transmitting antenna at the base station and more than one receiving antenna at the mobile radiotelephone.

MISO Multiple Input Single Output Several transmitting antennas and one receiving antenna. Is also referred to as transmit diversity. With reference to the downlink, this means more than one transmitting antenna at the base station and one receiving antenna at the mobile radiotelephone.

MIMO Multiple Input Multiple Output Complete expansion: N transmitting antennas provide signals to M receiving antennas.

Transmit diversity with space time block coding

The same data stream is transmitted using different antennas with different encoding (STTD – space time transmit diversity or space time block coding as described by Alamouti). This means that the receiver receives multiple copies of the same signal due to multipath propagation. This improves the signal-to-noise (S/N) ratio and makes the connection more stable. The less correlated the fading channels are, the greater the improvement. Note that it is not possible to continue improving the S/N ratio by adding more and more antennas. The system tends to become saturated.

Spatial division multiplexing

In this technique, the transmitting antennas simultaneously transmit multiple different data streams to one receiver. The receiver receives parallel data streams on each of its antennas. "All" the receiver has to do is separate these data streams. This is possible only under the assumption that channels with different fading are present on the different antennas (i. e. the lower the correlation, the better). This technique increases the data throughput, but it makes sense only under favorable transmission conditions. Here, too, the possible gain is limited by the correlation of the transmission paths.

Beamforming

In this case, signals are not transmitted omnidirectionally. Instead, antenna arrays produce an individual beam for each mobile station. This means that the base station orients its antenna array so that its transmission lobe tracks the movements of the mobile station. This, however, requires a signal that can be assigned by frequency and / or time to a mobile station. Otherwise stated: Each mobile station must have its own lobe. With GSM, for example, each mobile station is assigned a frequency (ARFCN, absolute radio frequency channel number) for a certain number of timeslots so that beamforming is possible. This is not the case with WCDMA since a mobile station is identified only by its code within a frequency or time range which it shares with other mobile stations. This makes it impossible for the base station to use its transmission lobe to track different mobile stations as they move about. As a basic prerequisite, the properties of the transmission channel must be known at the transmitter for a base station to be able to direct its antenna array toward a specific mobile station.

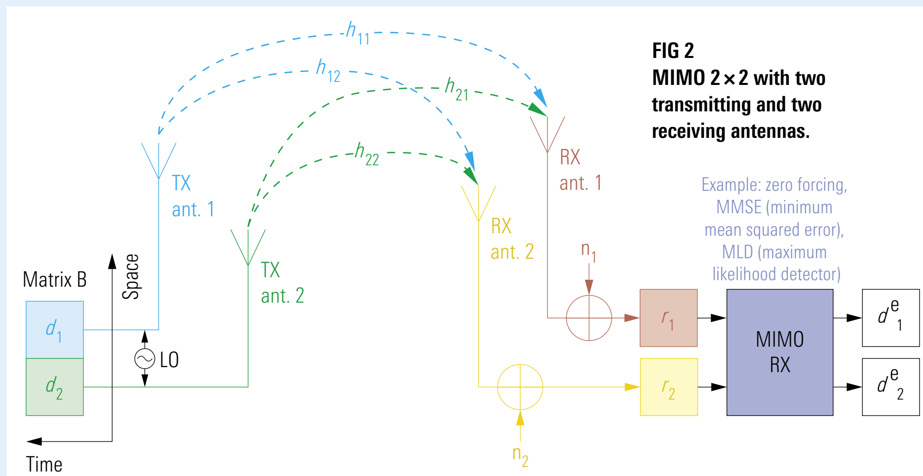
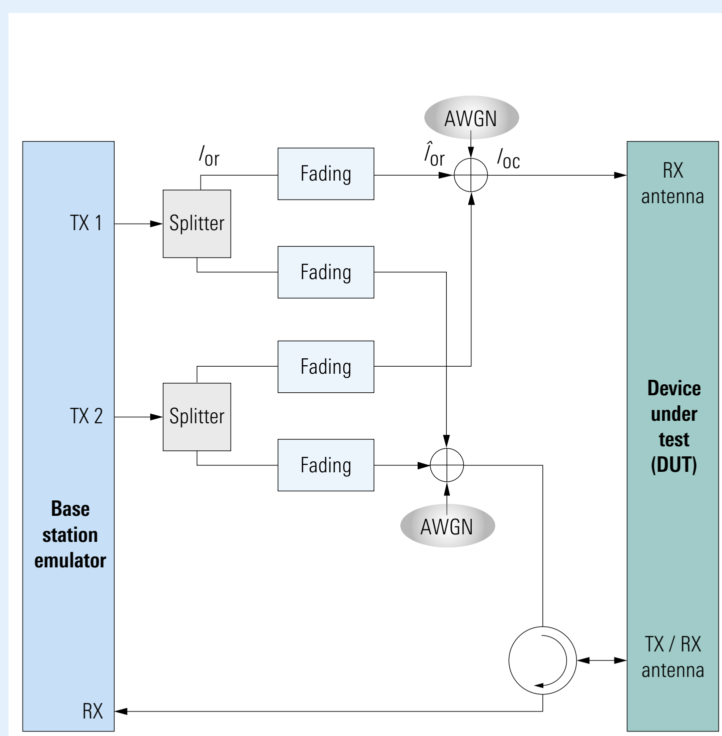


FIG 2
MIMO 2 × 2 with two transmitting and two receiving antennas.

FIG 3
Test setup for WCDMA MIMO in the downlink under multipath propagation conditions with transmit and receive diversity.



Currently defined test scenarios

GSM

After the test scenarios for a SIDO system (DARP phase 2), no additional steps toward MIMO are currently planned for GSM.

WCDMA

With its diversity performance tests 9.2.2C, 9.2.3C and 9.4.2A from release 7, WCDMA is introducing MIMO in the downlink (FIG 3). These tests are also part of work item 26 of the Global Certification Forum (GCF). Transmit diversity is used to improve the reception for a specific connection in the downlink. From the network operator's perspective, transmit diversity has the benefit that it does not require any changes in the transmission scheme used by the base stations.

Unlike the tests for DARP phase 2 in GSM, the fading channels are not correlated. Apart from an AWGN signal, no interferers are provided so far. FIG 4 shows the implementation of tests in accordance with WCDMA WI-26 using the R&S®TS8950W (FIG 4). With long term evolution (LTE) defined in release 8 of the 3GPP specifications, WCDMA continues to progress. The specifications for LTE are scheduled for completion in March 2008 and the associated tests should be ready by December 2008.

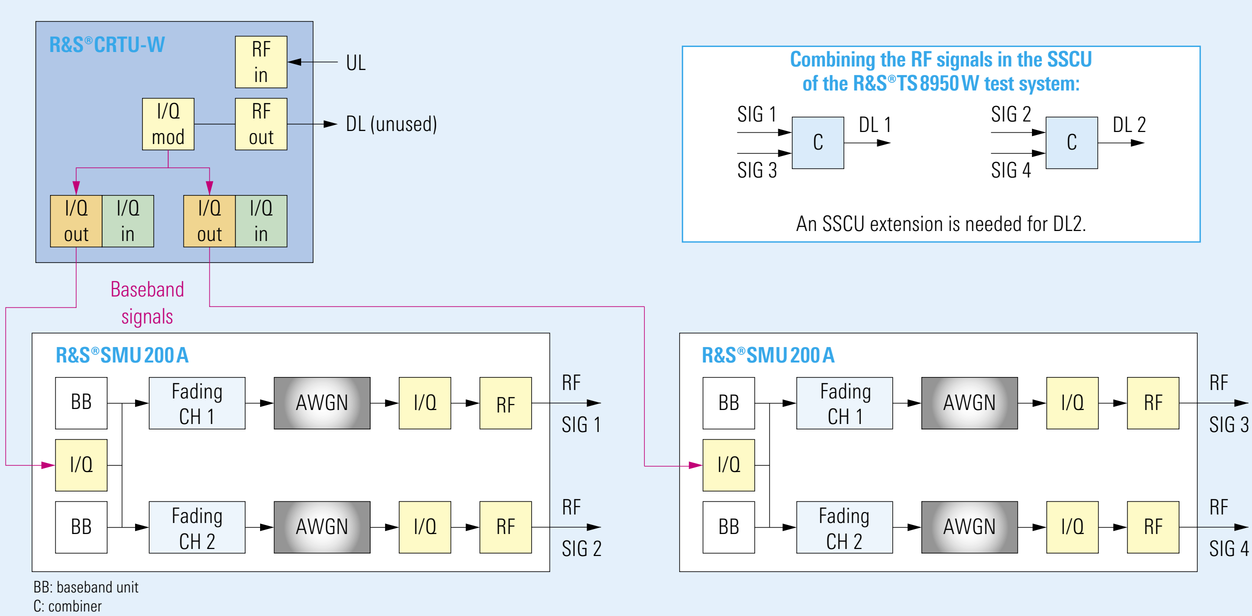
Since LTE, like WiMAX (IEEE 802.16e), is based on OFDMA, test scenarios similar to those described below for WiMAX Wave 2 will probably be used.

WiMAX (IEEE 802.16e)

The tests defined in Wave 1 are based on SISO (one transmitting antenna and one receiving antenna). According to the system profile for Wave 2, MIMO 2×2 will be used with two transmitting antennas and two receiving antennas including beamforming. An enhancement to MIMO 4×4 is already included in the IEEE 802.16e standard, and MIMO 8×8 is currently under discussion in the WiMAX® Forum. Since the principle is the same, we will not discuss these implementations in further detail here. The test scenarios for beamforming assume usage of up to four transmitting antennas per transmitter in the base station.

WiMAX makes a distinction between two MIMO modes: matrix A and matrix B. **Matrix A** is a transmit diversity mode in the downlink using space time coding in accordance with Alamouti which increases the stability of the connection under unfavorable conditions. **Matrix B** is a spatial multiple access technique that includes single as well as multiple code word transmission (also known as vertical and horizontal encoding) and increases the data rate under favorable transmission conditions. Switching between matrix A and matrix B depends on the properties of the transmission channel. The base station determines how long to use each mode. For

FIG 4 An R&S®CRTU-G /-W protocol tester and two R&S®SMU200A generators (also used as faders) generate the two downlink signals. An extension is needed in the signal switching and conditioning unit (SSCU) in the R&S®TS8950W test system to add up the two downlink RF signals and to provide a second DUT interface.



this purpose, it must know the transmit channel. Feedback of the reception quality is included in the signaling from the mobile station to the base station.

The approval tests that are specified verify the performance gain achieved by MIMO, e. g. the sensitivity with different modulation types, as well as the correct implementation of matrix A and matrix B and the switchover between them.

Beamforming

Beamforming tests for base stations use an approach that involves combining all antenna outputs of a transmitter in the test system with different electrical lengths. The base station needs to compensate for the different delays so that all signals arrive at the mobile station emulator (MSE) with the same phase and add up there. In the ideal case, the MSE then “receives” a multiple of the power corresponding to the number of antennas. Beamforming functionality is verified by assessing the gain in sensitivity.

MIMO 2 × 2 tests for WiMAX

The Wave 2 MIMO tests involve a 2×2 channel model using correlated fading (FIG 5). An R&S®AMU 200 A equipped with two external I/Q inputs and the -K74 option (“fading split mode”) can perform a complete 2×2 MIMO channel simulation in conjunction with two RF output stages (FIG 6). The complex correlation matrix can be programmed as required. The WiMAX® Forum has defined three different matrices (low, medium and high correlation).

Summary

More than half a year has elapsed since Part I of this article was published. In the meantime, many tests have been defined (and many have also been discarded). Clearly, however, there is sustained forward momentum. Many ideas await their implementation. One thing is clear, however: Rohde & Schwarz is continuously developing its measuring instruments and approval test systems so as to always provide the required test capabilities plus future viability.

Josef Kiermaier

FIG 5 Setup with 2 × 2 channel model and correlated fading for testing a base station with the R&S®TS 8970 test system.

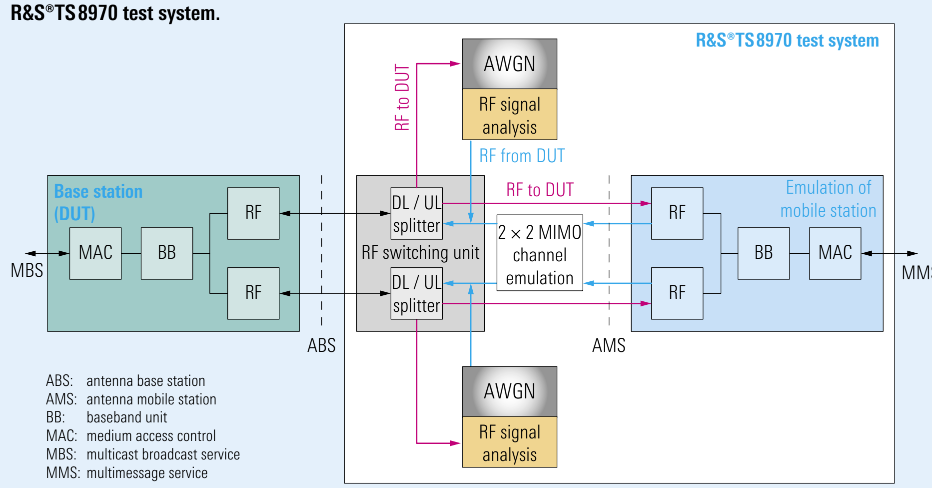
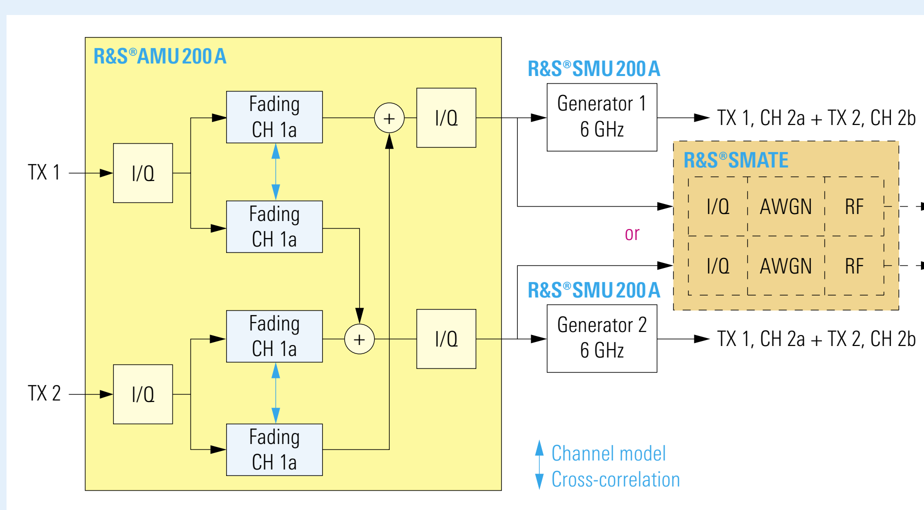


FIG 6 An R&S®AMU 200 A generator and two RF output stages simulate a 2 × 2 MIMO channel (the two R&S®SMU 200 A generators can also be replaced by an R&S®SMATE generator).



R&S®CRTU Protocol Test Platform

2G and 3G interoperability tests – from real networks to the lab

In addition to conformance tests, interoperability tests (IOT) are becoming increasingly important. R&S®CRTU users have an advantage in this respect: They can transfer these tests from real networks to the lab and perform them in an altogether quicker and more cost-efficient manner. The new R&S®ITS replay tool in conjunction with the R&S®ROMES coverage measurement software makes this possible.

For network operators and platform or chip manufacturers

Error-free operation in the real network – this is the primary requirement demanded by mobile phone users and thus also by network operators and platform or chip manufacturers. Comprehensive tests must ensure correct functioning. Since processes in real networks are often more complex than the lab simulation performed during development, interoperability tests are of major importance for development purposes and prior to the market launch of mobile phones.

IOTs are performed either in IOT labs of the network infrastructure manufacturers or in real networks under the conditions present there. However, these tests carry the disadvantage of being very expensive owing to the unavoidable costs for renting test networks. Moreover, errors that occur due to the constantly changing general conditions in these networks (cell power, timing, load, etc.) can no longer be reproduced.

Rohde & Schwarz has therefore developed the R&S®ITS replay tool for its interoperability tool suite (ITS) [1] software application. The tool allows you to use data about conditions and scenarios that appear only once in a real network or in an IOT lab and simulate these conditions and scenarios on the R&S®CRTU protocol test platform in the lab.

From field test to simulation in the lab

However, before you can perform realistic tests in the lab, it is first necessary to carry out drive tests in real mobile radio networks. You can use the R&S®TSMx radio network

More information and data sheet at www.rohde-schwarz.com (search term: type designation)

REFERENCES
[1] R&S®CRTU Protocol Test Platform: User-friendly definition of 2G and 3G signaling scenarios. News from Rohde & Schwarz (2007) No. 193, pp 21–23
[2] R&S®TSMx Radio Network Analyzers: Radio network analyzers for all tasks and any budget. News from Rohde & Schwarz (2007) No. 192, pp 4–8
[3] R&S®ROMES3 Coverage Measurement Software: Acquisition, analysis, and visualization of data in coverage measurements. News from Rohde & Schwarz (2000) No. 166, pp 29–32

FIG 1 Section of an export report with the public land mobile network (PLMN) ID replaced and the determination of the network mode of operation (NMO).

FTP_Transfer.f2l.txt

```
Phylis2XMLExporter running using following configuration:
   Replay hardware: 1xCRTU-W
   Power replay: off
   print cell activity intervals: off
   print cell events: off
   debug level: off

MibManipulationAgent: MIB changed MCC:MNC from (262:1) to (1:1)
Cell::verifySIB: cell=159/10836 has no SIB 1
Cell 159/10836 has not all it needs
Cell 94/10836 has  all it needs
Cell::hasAllNeededMIBSIB: cell=137/10836 has no MIB
Cell 137/10836 has not all it needs
Cell::hasAllNeededMIBSIB: cell=334/10836 has no MIB
Cell 334/10836 has not all it needs
Configuration: Power replay is off
Registration (SysInfo1) Mode: NMO2
```

analyzers [2] and the R&S®ROMES coverage measurement software [3] from Rohde & Schwarz to conveniently handle these tests. R&S®ROMES records the data that is generated by the analyzer or test phone during the drive test and saves it on the hard disk (see box on page 11) in a proprietary format (*.rscmd). The data is exported and analyzed via the software's export function and combined into a field test scenario (f2l file), which is then played back to the R&S®CRTU by means of the R&S®ITS replay software option. The software generates a report that documents in detail all required changes of the scenario during the export process (FIG 1). If the measurement data is not sufficient for a simulation, the reason why the scenario cannot be simulated is automatically determined. If all prerequisites are met, R&S®ITS replay accepts the field test scenario and plays it back. By using the graphical user interface, you can also make changes to layer 3 messages, e.g. skip, copy, insert, or delete, if necessary. The tried-and-tested Message Composer from Rohde & Schwarz makes it possible to edit individual messages. As usual, result analysis is performed using the Message Analyzer (FIG 2).

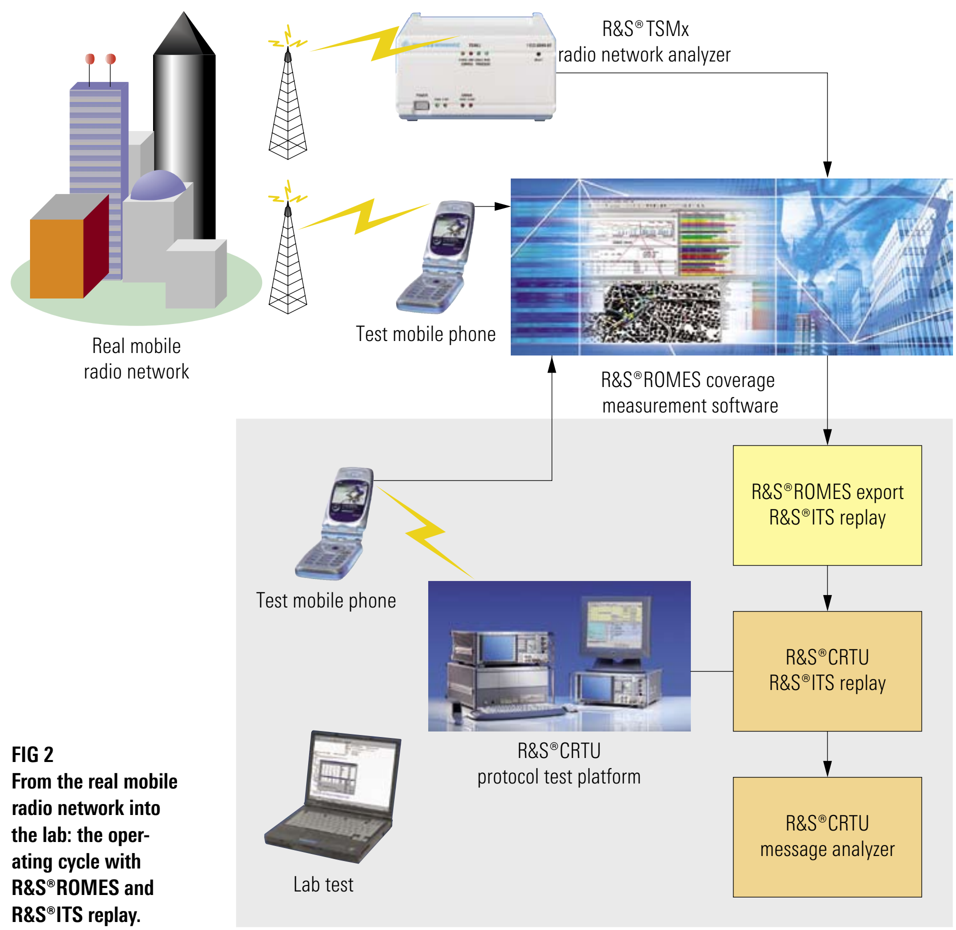


FIG 2
From the real mobile radio network into the lab: the operating cycle with R&S®ROMES and R&S®ITS replay.

Field tests in the lab

The R&S®ROMES coverage measurement software allows the initial analysis of the recorded scenarios. You can perform a virtual simulation of field tests on the PC in the lab and select and export the signaling sequences that are of interest to you. The processes executed during the export of the recorded field tests analyze the available measurement data and prepare it for R&S®ITS replay. This includes the following:

- Determination of all necessary cells and associated cell parameters (e.g. cell timing in UMTS). Cells are set up as needed and then cleared down again as well. Thus, any number of cells of a scenario can be played back on the simulator.
- Determination of the necessary registration. If no registration is included in the sequence to be simulated, the actual scenario is preceded by a standard registration.
- Export of all required layer 3 messages.
- Export of all cell information necessary for the simulation of the cell power.
- Inclusion of real time sequences.
- Simulation of security algorithms. Since the algorithms used in the network are proprietary, R&S®ITS replay uses a standardized test-purpose universal subscriber identity module (USIM) and the algorithms based on the TS 34.108 test specification.

After an export has been performed, these and many other processes ensure that a field test scenario that can run on the R&S®CRTU is generated without manual interaction. You can thus press the start button of the R&S®ITS replay application and the simulation will begin. The result is saved together with the simulated scenario and managed in a result overview. In contrast to tests in real networks, these scenarios are reproducible.

Two modes for various requirements

To take the various requirements into account, there are two different ways of playing back an R&S®ITS replay scenario (FIG 3).

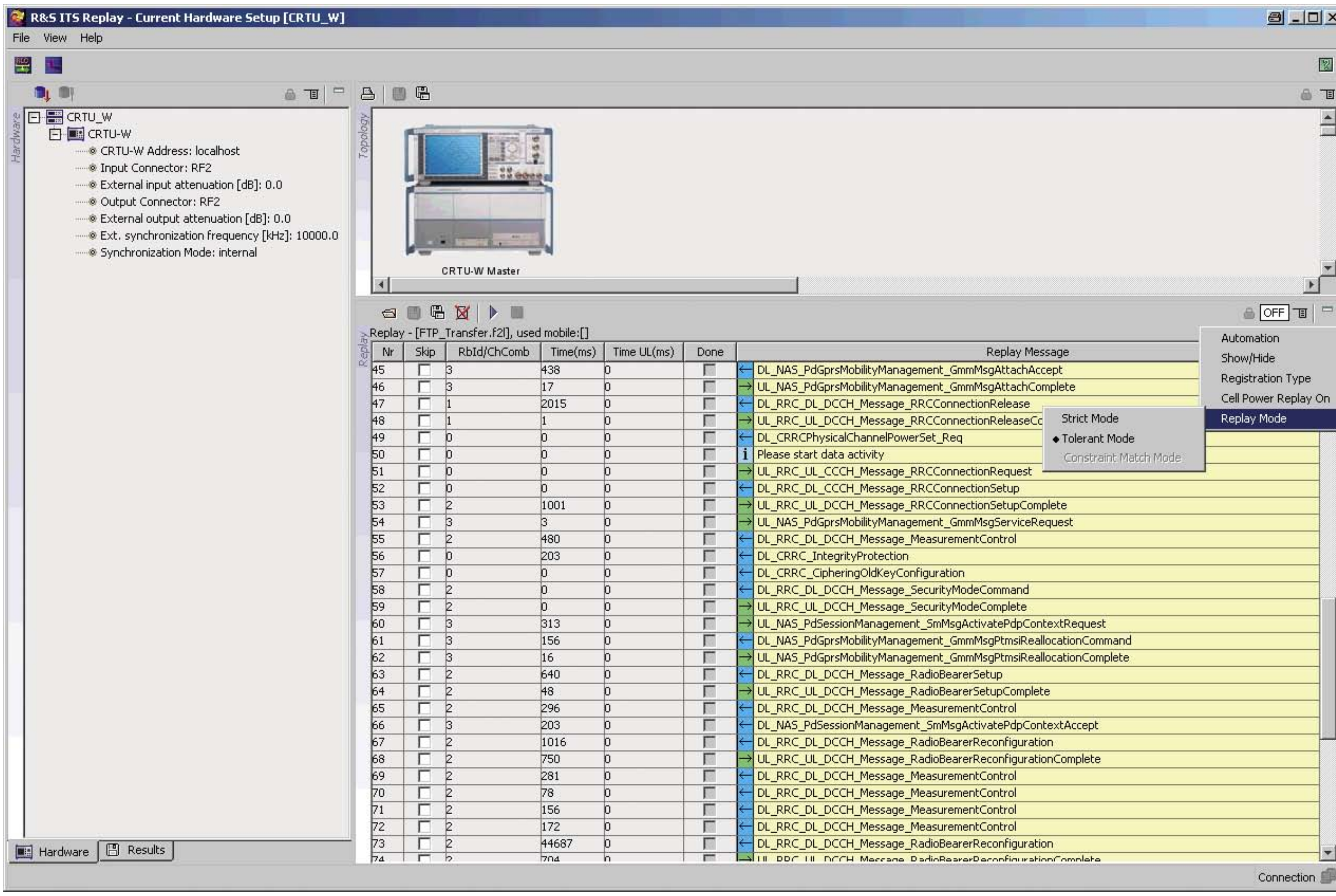


FIG 3 **R&S®ITS replay: Its graphical user interface provides all functions that are necessary for flexibly playing back field test scenarios in the lab.**

In **Strict Mode**, the simulator expects every single message present in R&S®ITS replay exactly as it was received when recorded in the real network. If a message is missing or an unexpected message is received, the scenario will be immediately terminated. You can thus reproduce network scenarios in the lab with absolute sequence accuracy.

In contrast, **Tolerant Mode** provides flexibility in the sequence as well as in the order the messages arrive. This is advantageous when different mobile phones behave slightly differently and the R&S®ITS replay scenarios are used for regression tests on various types of mobile phones.

In both modes, you can also activate *Constraint Matching*, which allows the bit-accurate comparison of complete uplink messages on the basis of individual messages.

Another important point for reproducing a field scenario in the lab is the simulation of the cell power on the R&S®CRTU. In many cases, it may be sufficient to simulate only the signaling process in order to detect a mobile phone malfunction. To handle cases where the transmit power of the cells has a decisive impact, R&S®ITS replay can also adapt the power of the most important cells every 100 ms in accordance with the recorded cell power. However, in this special case the mobile phone should be placed in a shielded chamber, since the interfering effects in the lab would otherwise distort the result.

In addition to interactive operation, R&S®ITS replay of course also supports automatic tests. In this case, the R&S®CRTU handles the task of operating the mobile phone by means of software remote control.

Precise and complete measurements with the R&S®TSMx

For cost and implementation reasons, the receiver sections of mobile phones are generally rather simple in design. Therefore, they can neither perform calibrated measurements of the surrounding cell environment during a field test nor analyze the large number of surrounding cells with sufficient accuracy. This is where an R&S®TSMx radio network analyzer comes in handy – it can carry out these measurements more quickly, more thoroughly and more precisely. Irrespective of the test mobile phone, the R&S®TSMx measures the system information and power of all cells to be received. Normally, no information is lost when this is done, and the simulation in the lab corresponds even closer to the field conditions. Moreover, data from neighboring cells of other systems, e.g. GSM, can also be included in this way – even if the measurements were not performed by the DUT itself.

Nothing comparable on the market

For reproducing field tests, no other mobile radio protocol tester on the market provides a comparable solution that combines high accuracy, flexibility, and simple operation. By using the R&S®ITS replay software package presented here, you have to record the real network data only once and can simulate the scenarios in the lab with exact reproducibility, thus eliminating the high costs associated with renting test networks.

If you assemble a comprehensive test suite over an extended period, software release cycles can be significantly reduced since real network behavior can be tested systematically in the lab in advance.

The process described here as an example of how to reproduce field tests using the R&S®CRTU and the advantages that this offers apply without any restrictions also when it comes to reproducing IOT lab tests.

Rolf Huber

Three different ways of converting measurement data to the Rohde & Schwarz rscmd format

1. For many conventional mobile radio device platforms, Rohde & Schwarz offers drivers that allow the signaling protocols saved in the mobile phone to be used in the R&S®ROMES coverage measurement software.
2. Using the R&S®ROMES mobile driver development kit (DDK), you can develop customer-specific R&S®ROMES drivers for GSM and WCDMA.
3. Rohde & Schwarz also offers a programming interface (C++ API) for R&S®ITS replay that allows you to quickly convert protocol files of the mobile phones to the R&S®ROMES format.

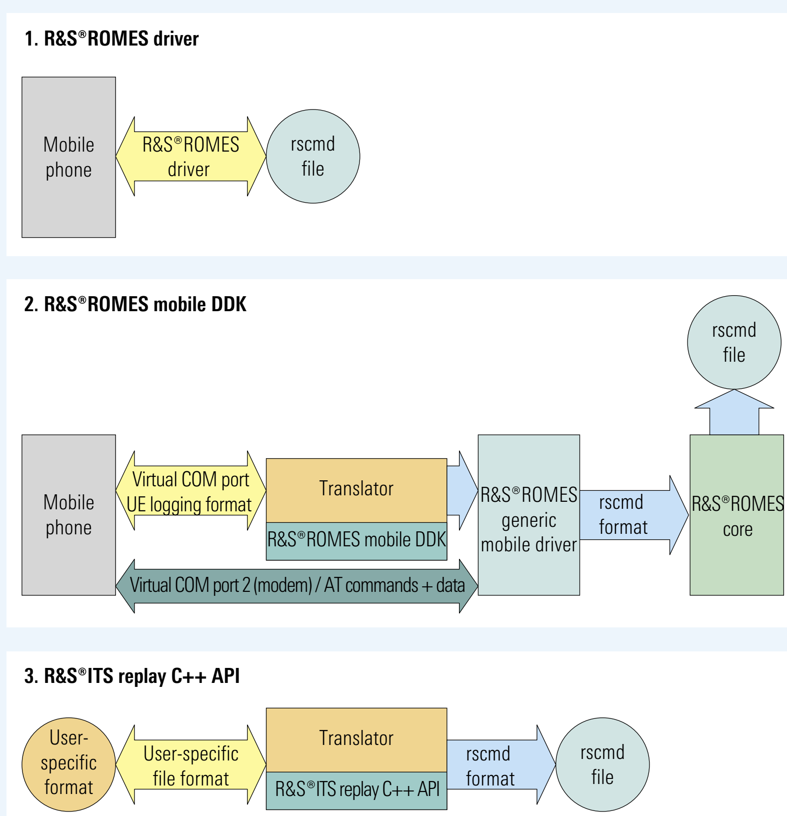


FIG 4
There are three ways of converting log data to the Rohde & Schwarz rscmd format.

The R&S®SMU / R&S®AMU 200 A / R&S®AFQ Generators

Standard-compliant DVB-H signals for all tests on mobile devices

The signal generators of the R&S®SMU* family as well as the R&S®AMU 200 A and R&S®AFQ from Rohde & Schwarz are capable of generating all of the signals needed to test the latest generation of mobile radio devices with DVB-H functionality.

* This family includes the R&S®SMU 200 A, R&S®SMJ 100 A and R&S®SMATE generators.

Combined: mobile radio and mobile television

Owing to the pilot project during the Football World Cup 2006, the new DVB-H television standard for mobile terminals (Digital Video Broadcasting Handhelds) has made its way into the public consciousness. Many mobile phones with DVB-H capabilities have already been presented as well. As mobile radio and mobile television converge, there is increasing demand for additional tests among producers who need to perform functional testing of DVB-H and mobile radio components.

The necessary standard-compliant DVB-H test signals (in accordance with ETSI EN 302 304) can now be generated using new options for the R&S®SMU generator family. Available options are:

- R&S®SMJ-K52 for the R&S®SMJ 100 A vector signal generator
- R&S®AMU-K52 for the R&S®AMU 200 A baseband signal generator
- R&S®AFQ-K252 for the R&S®AFQ 100 A arbitrary waveform generator using R&S®WinIQSIM2™

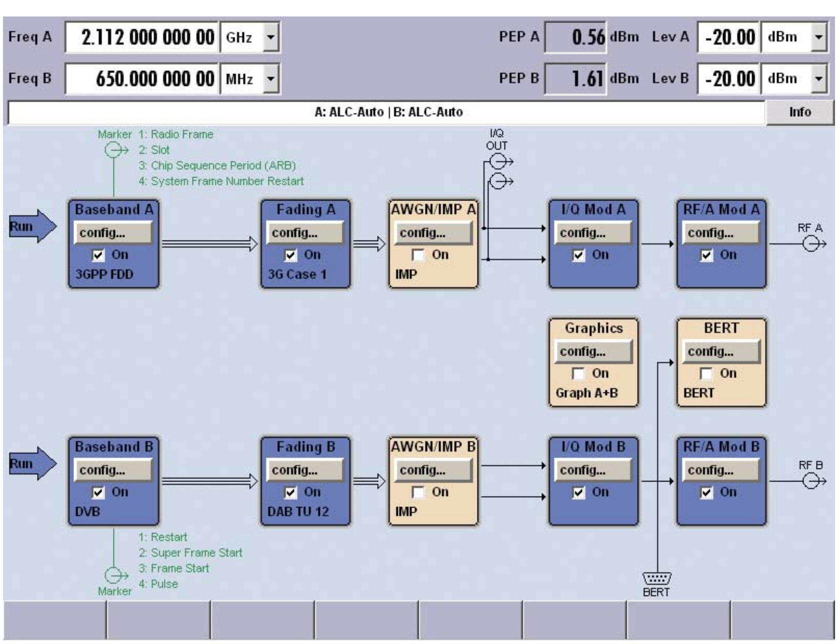
Test signals for all DVB-H scenarios

These generators can deliver signals that comply with all common mobile radio standards (such as 3GPP and WiMAX). In combination with their new DVB-H functions, they provide an ideal test platform for DVB-H-compatible mobile phones. For tests involving combined scenarios with mobile radio and DVB-H, now only a single signal generator is needed to generate both signal types, either one at a time or simultaneously. Due to their extensive remote control capabilities, the Rohde & Schwarz generators can be used for automated tests in production.

Since DVB-H receivers are sometimes transported at higher speeds (e.g. in automobiles) so that Doppler effects and reflections have to be taken into account, the optional R&S®SMU-B14 fading simulator is recommended to simulate distorted channels. The simulator allows you to study how different DVB-H settings influence reception in terminals moving at higher speeds.

The R&S®SMU 200 A delivers its top performance when simulating co-existent mobile radio and broadcast standards in the configuration with two paths (R&S®SMU-B202 / -B203 option). This

FIG 1 User interface of the R&S®SMU 200 A in the version with two paths. The upper path generates a 3GPP signal, and the lower path a DVB-H signal. Fading simulators are used in both paths.



means that two complete vector signal generators are available in one instrument, each of which has the functions and capabilities described above.

A generator configured in this manner can generate a DVB-H signal on one path and a mobile radio signal on the other. Each signal is output on a separate RF connector. These two signals can then be used for testing DVB-H-compatible mobile phones for simultaneous reception of mobile radio and broadcast services (FIG 1).

If you need to simulate DVB-H on multiple channels, you can generate a DVB-H signal using both paths and implement test scenarios with adjacent channels structured to meet your requirements, for example.

If the memory depth of the R&S®SMU 200 A (i.e. the approx. 28 s duration of a test signal with the R&S®SMU-B9 memory option) is not adequate for certain applications, you

DVB-H versus DVB-T

DVB-H is the latest extension of the DVB standards (in addition to DVB-T, DVB-C, DVB-S) and expands the range of functions provided by DVB-T. DVB-H was created in response to new requirements. Compared to a television set in your living room at home, a mobile phone that is expected to deliver TV service has a much smaller display and must use much less power due to its battery. The appearance and ergonomics of DVB-H-compatible mobile phones must also meet minimum requirements. For example, a long rod antenna is unacceptable for reception so that the transmitted power is subject to careful consideration. These phones are also expected to provide satisfactory television reception in trains and automobiles, which means that the transmission technology must be designed to accommodate high speeds. DVB-H satisfies all of these requirements.

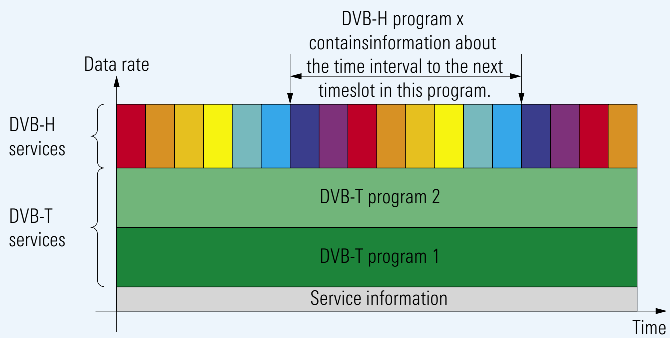


FIG 2 Schematic diagram of a DVB multiplex signal consisting of two DVB-T sections and eight DVB-H components with time division multiplexing.

The DVB standard is based on orthogonal frequency division multiplexing (OFDM), a technique used in all of the state-of-the-art radio standards. With OFDM, the transmitted signal is modulated onto multiple carriers (instead of just a single carrier). This makes the system less susceptible to in-channel distortion and other interference.

OFDM also makes it possible to set up single frequency networks (SFN) in which adjacent transmitters output signals on the same frequency and are time-synchronized. This permits larger cells with higher output power levels since cell interference is not a problem to be considered. In addition, constructive superposition of signals from two different transmitters at cell boundaries can boost the received power level.

There exists a relationship between the number of OFDM carriers used for transmission, the maximum possible speed of the terminal and the cell size of an SFN. The more OFDM carriers there are, the lower the maximum speed. On the other hand, additional OFDM carriers increase the range of a cell. DVB-T has two transmission modes with different numbers of carriers: 2K (1705 carriers) and 8K (6817 carriers). To provide a design compromise in networks between the maximum speed and the cell size, DVB-H also offers a 4K mode with 3409 carriers.

In order to decrease the susceptibility to interference at high speeds, it is possible to encode data over multiple OFDM symbols (one symbol represents the data of all carriers in a timeslot).

There are also certain distinctions in terms of power consumption. In DVB-T, the different services in a channel are transmitted continuously using a fixed data rate. This means that the receiver unit must continuously be active. In DVB-H, however, time slicing is used to achieve the longest possible battery life: A DVB-H data stream contains a specific service only in a periodically repeated timeslot in which it is transmitted with a selectively high data rate (FIG 2). It also contains information about when the next timeslot will be received. The data of a timeslot is buffered and routed to the video decoder at the actual data rate. During the time interval between two timeslots, the receiver unit powers down, which in theory can produce power savings of up to 90 %.

Information about when the next timeslot can be expected is transmitted in the data link layer (instead of the physical layer). This represents a significant difference compared to DVB-T. The terrestrial variant of the standard provides for direct transmission of video streams, while DVB-H transmits the content in IP packets. Packetization involves the use of multiprotocol encapsulation (MPE), and then the content undergoes forward error correction (MPE-FEC). The time slicing functionality is implemented as part of this process. The resulting transport stream consists of MPE-FEC frames and can be inserted directly into a DVB-T multiplex. This serves as a basis for the co-existence of DVB-H and DVB-T.

can use the new R&S®WinIQSIM2™ tool for signal generation. The DVB-H signals generated with this Windows® software can be replayed as a baseband signal using the R&S®AFQ100A arbitrary waveform generator and then converted to the RF by means of the R&S®SMU200A. This is a way to generate transmit sequences lasting up to one and a half minutes.

For test applications requiring sequences of user-definable length, Rohde&Schwarz offers the R&S®SFU broadcast test system [*] which is capable of generating the necessary DVB-H signals in realtime.

Clear and convenient menus, as always

The menus used to make settings for the DVB-H option are seamlessly integrated into the user interface of the Rohde&Schwarz signal generators. The number of DVB-H superframes to be generated (which determines the duration of the transmit sequence) is specified in the main menu (FIG 3). This menu provides information about the main signal parameters such as sample rate, data rate and duration of a repetition cycle.

The System Configuration menu displays the DVB-H signal path with the relevant components (FIG 4). All system parameters can be set by the user at precisely the locations in the signal flow where they have their actual effect. This presentation format also helps less experienced users to easily make settings, e.g. regarding the data sources, for which there are two variants:

- A standard-compliant DVB-H transport stream (ts or tps file or Rohde&Schwarz gts format) can be fed in and the video contained in the stream will be reproduced on the terminal. The R&S®DV-ASC advanced stream combiner software tool makes it possible to generate transport streams from IP streams in ip4 or ip6 format with unique contents.
- Standard-compliant null packets containing PRBS data can be used for non-content-dependent analysis of the transmitted signal.

Users who want to know exactly which system parameter settings cause which changes in the TPS bits can simply click "TPS Settings" in the main menu to view the transmission parameter signaling bits (TPS).

Summary

The signal generators of the R&S®SMU family as well as the R&S®AMU200A are already equipped to handle the latest challenges resulting from the convergence of mobile radio and DVB-H. These generators provide a convenient set of test features in a single instrument.

Volker Ohlen

More information and data sheet at www.rohde-schwarz.com (search term: SMU-K52)

REFERENCES
[*] R&S®SFU Broadcast Test System: Universal test platform for digital TV. News from Rohde&Schwarz (2004), No. 183, pp 39–43

FIG 3 Main menu of the DVB-H option.

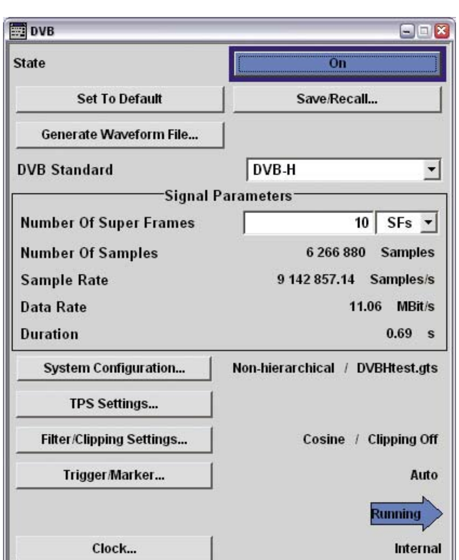
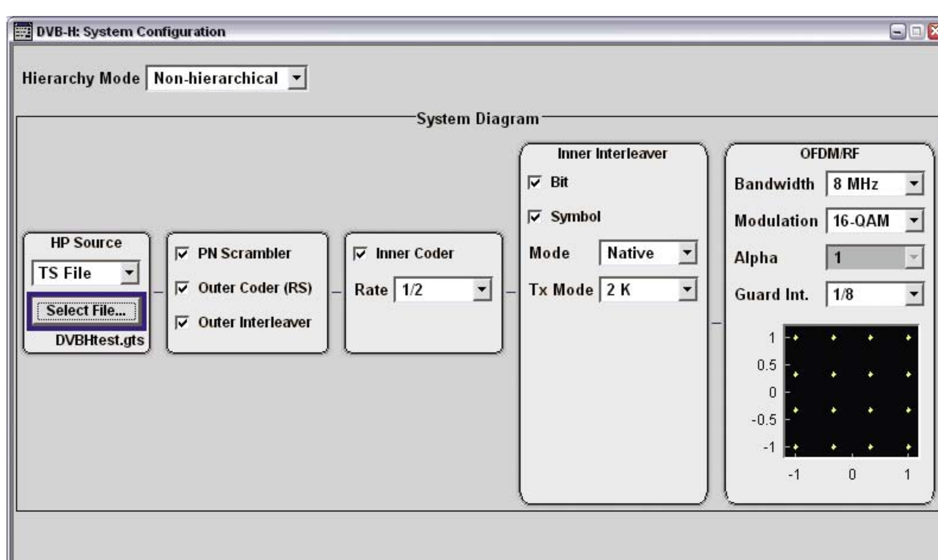


FIG 4 Menu allowing easy setting of all parameters in the system diagram.



R&S®TS 8970 WiMAX Radio Conformance Test System

State-of-the-art: all WiMAX RF certification tests

The R&S®TS 8970 WiMAX radio conformance test system [1] certifies WiMAX end products on the basis of validated test cases. And it keeps pace with the rapid development driven by the WiMAX Forum®.

The WiMAX Forum® certification program

WiMAX (Worldwide Interoperability for Microwave Access) is synonymous with the implementation of the IEEE 802.16 standard, which enables mobile, wireless broadband access to data networks (e.g. to IP or ATM networks).

The objective of the WiMAX Forum® is to deploy the IEEE 802.16 standard in real applications. The certification program for WiMAX products (base stations and mobile stations) constitutes a major part of the Forum's work, and its purpose is to ensure worldwide availability and reliability of WiMAX services. The R&S®TS 8970 WiMAX radio conformance test system performs all RF certification tests defined by the WiMAX Forum®.

WiMAX profiles organize the multitude of parameters

WiMAX RF certification tests are used to verify the conformity of radio transmitters and receivers in base and mobile stations at the OFDMA air interface. OFDMA signals are characterized by a vast number of parameters; the WiMAX Forum® has therefore defined profiles that facilitate categorizing WiMAX products as well as the main WiMAX RF parameters. The following key parameters are defined by assigning them a profile:

- **Operating frequency spectrum** (e.g. 2.3 GHz to 2.4 GHz)
- **Nominal bandwidth of signal** (e.g. 10 MHz)
- **Duplex mode** (TDD, FDD, or H-FDD)

Defining the nominal bandwidth implicitly determines the number of OFDMA subcarriers, and thus the transmission capacity of a signal. FIG 1 shows the TDD profiles so far defined by the WiMAX Forum® [2], [3]; further profiles – in particular also FDD profiles – will follow as soon as further frequency ranges are made available. This is definitely to be expected, especially since the ITU (International Telecommunication Union) adopted the WiMAX OFDMA technology only recently as part of the IMT-2000 family of 3G technologies (including, for example, WCDMA).

The R&S®TS 8970 test system supports all conceivable profiles up to 6 GHz; there will be no profiles for mobile WiMAX beyond this frequency.

FIG 1 RF profiles for mobile WiMAX.

Profile name	Channel bandwidth (MHz)	f_{start} (MHz)	FFT length
1A	8.75	2304.5	1024
1B	5	2302.5	512
	10	2305	1024
2A	3.5	2306.75 and 2346.75	512
2B	5	2307.5 and 2347.5	512
2C	10	2310 and 2350	1024
3A	5	2498.5	512
	10	2501	1024
4A	5	3302.5	512
4B	7	3303.5	1024
4C	10	3305	1024
5A	5	3402.5	512
5AL	5	3402.5	512
5AH	5	3602.5	512
5B	7	3403.5	1024
5BL	7	3403.5	1024
5BH	7	3603.5	1024
5C	10	3405	1024
5CL	10	3405	1024
5CH	10	3605	1024

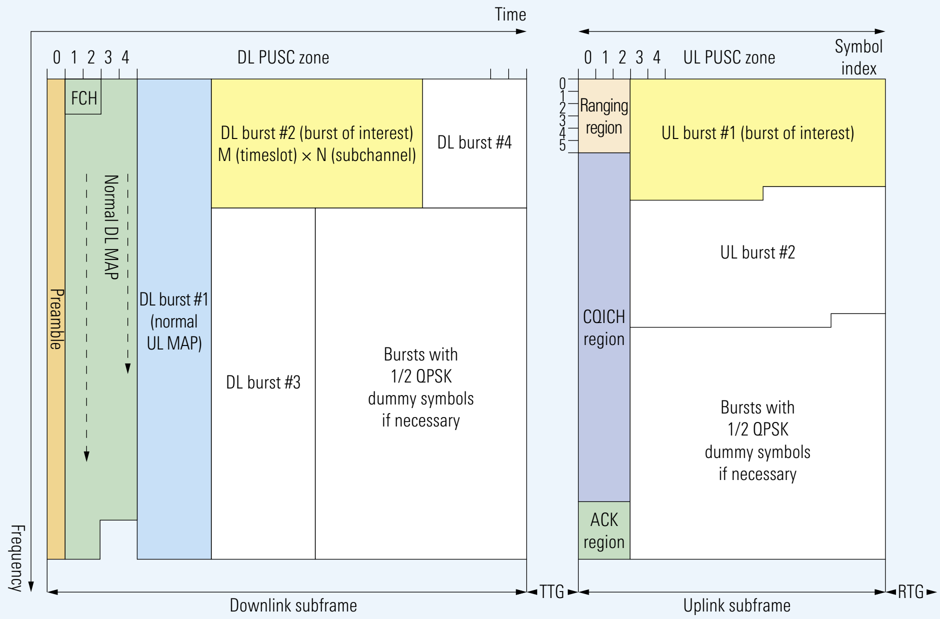


FIG 2 Reference signals for mobile WiMAX.

Reference signal	Description
MS-01.1	MS Receiver Maximum Tolerable Signal
MS-02.1	MS Receiver Preamble
MS-04.1	MS Receiver RSSI Measurement
MS-05.1	MS Receiver Physical CINR Measurement
MS-07.1	MS Receiver Selectivity
MS-08.1	MS Receiver Maximum Input Signal
MS-09.1	MS Receiver Sensitivity
MS-10.1	MS Transmit and Receive HARQ
MS-11.1	MS Receiver Support for Handoff
MS-12.1	MS Transmitter Modulation & Coding, Cyclic Prefix and Frame Timing
MS-13.1	MS Transmit Ranging Support
MS-15.1	MS Transmit Power Dynamic Range and Relative Step Accuracy
MS-16.1	MS Transmit Power Control Support
MS-17.1	MS Transmitter Spectral Flatness
MS-18.1	MS Transmitter Relative Constellation Error
MS-19.1	MS Transmit Synchronization
MS-20.1	MS Transmit / Receive Switching Gap

FIG 3 Wave 1 RF certification tests for mobile stations.

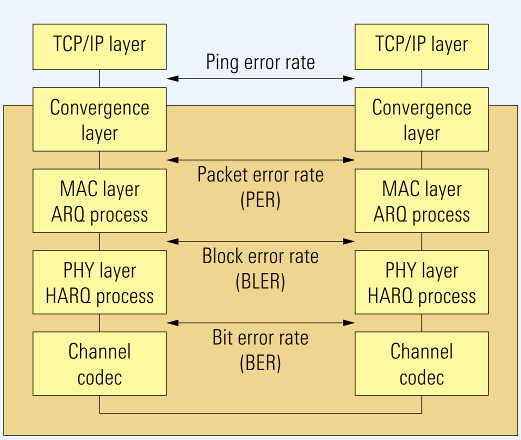


FIG 4 WiMAX receiver test methods.

Reference signals for certification

In document [3], the WiMAX Forum® defines reference signals for RF certification measurements. FIG 2 shows as an example a reference TDD frame, which is divided into a downlink subframe and an uplink subframe with the corresponding two-dimensional data regions (bursts) typical of OFDMA in the frequency and the time domain. All test signals for RF certification are derived from this reference frame. It goes without saying that the R&S®TS8970 test system provides all the defined reference signals.

RF certification measurements

Document [3] defines RF certification tests for mobile and base stations. Certification tests are currently organized in two successive groups referred to as "Waves". Wave 1 includes the first, basic RF measurements on single-transmitter or single-receiver implementations (key word: SISO [4]). The test cases of Wave 2, which is to be released soon, will cover RF measurements on multi-antenna implementations (key word: MIMO [4]). The R&S®TS8970 test system architecture supports both Wave 1 and Wave 2 test cases. FIG 3 lists, as an example, all Wave 1 RF test cases for mobile stations. The RF test cases for base stations are in part identical as far as measurements are concerned, but they take base-station-specific aspects into account.

Transmitter conformance tests

Transmitter tests of WiMAX stations focus on the transmitter's OFDMA signal characteristics:

- WiMAX signal composition (including channel coding, two-dimensional OFDMA symbol arrangement, TDD frame structure)
- Modulation quality (EVM, RCE)
- Spectral flatness
- Transmitter power control

All these measurements are performed by means of the R&S®FSQ vector signal analyzer and are described in [5] and [6].

Receiver conformance tests

Receiver measurements on digital systems are based on the classic bit and block error rate measurements. The WiMAX certification tests also rely on these methods. In addition to bit and block error rate measurements – which are based on ARQ or HARQ handshaking between the lower WiMAX protocol layers – document [3] also defines ping error measurements (see box at top), which do not form part of the WiMAX system but are commonly used at the ICMP/IP layer (FIG 4). The above methods can be used alternatively to test the sensitivity, selectivity, and maximum input dynamic range of WiMAX receivers. The R&S®TS 8970 test system provides all the described test methods, and thus the right solution for every implementation.

Conformance tests of important PHY procedures

The lowermost protocol layer of the WiMAX air interface, i. e. the PHYsical layer, not only services the higher layers but, most importantly, performs physical synchronization with the peer station at the other end of the radio link.

Ping error measurements

The ping test is a standard method used to determine whether a specific host in an IP network is accessible. When measuring the ping error rate, the host with known IP address is the DUT. For the ping test, an ICMP echo request packet is sent to the target address, i. e. the DUT. If the DUT supports the ICMP protocol (this is the prerequisite for the measurement), it will return an echo with identical data content. It is thus possible to test the performance of the entire receive path of the DUT including the convergence layer (interface between the WiMAX protocol stack and the Internet protocol layer) exclusively via the air interface. This method thus employs – though with a time delay – a loopback mode provided in IP networks.

Physical synchronization in the case of WiMAX means that the mobile station unilaterally adapts to the transmit and receive timing, the transmit and receive frequency, and the transmit and receive level of the base station. In addition to initial synchronization (initial ranging) of a mobile station to a base station – e. g. after switch-on – periodic synchronization (periodic ranging) is required, i. e. the three above physical parameters have to be periodically checked and adapted in order to maintain a functional radio link in a mobile environment. The complex algorithm employed to this effect is of vital importance for the successful operation of a WiMAX link and is therefore thoroughly tested during RF certification by means of the R&S®TS 8970. Tests also cover handover ranging, which takes place when a WiMAX mobile station is handed over from one radio cell to another.

Heinz Mellein

More information at www.rohde-schwarz.com (search term: type designation or WiMAX)

REFERENCES

[1] R&S®TS 8970: Benchmark for the certification of WiMAX end products. News from Rohde & Schwarz (2006) No. 191, pp 26–28

[2] WiMAX Forum® Mobile System Profile document

[3] WiMAX Forum® Mobile Radio Certification Testing document

[4] From SISO to MIMO – taking advantage of everything the air interface offers. News from Rohde & Schwarz (2007) No. 192, pp 16–19

[5] R&S®SMU 200 A / R&S®FSQ: Complete test solutions for WiMAX applications. News from Rohde & Schwarz (2005) No. 187, pp 33–37

[6] R&S®SMx / R&S®FSQ / FSL: WiMAX goes mobile – new T&M solutions are required. News from Rohde & Schwarz (2006) No. 190, pp 24–27

Abbreviations

ACK	Acknowledgment
ARQ	Automatic repeat request
ATM	Asynchronous transfer mode
CQICH	Channel quality indicator cHannel
EVM	Error vector magnitude
FCH	Frame control header
FDD	Frequency division duplex
HARQ	Hybrid ARQ
H-FDD	Hybrid frequency division duplex (combined TDD and FDD mode)
ICMP	Internet control message protocol (at same layer as Internet protocol (IP))
MIMO	Multiple input multiple output
OFDMA	Orthogonal frequency division multiple access
PUSC	Partially utilized subchannelization
RCE	Relative constellation error
RTG	Receive transition gap
SISO	Single input single output
TDD	Time division duplex
TTG	Transmit transition gap

R&S®SMB100A Signal Generator

Whether broadcast, aerospace and defense, or EMC: analog signals for every application

Good spectral purity, high output power, and short settling times are features that make the analog R&S®SMB100A signal generator exceptional in its class. The signal generator offers not only excellent specifications but also a compact and modular design.

The R&S®SMB100A at a glance

The new analog R&S®SMB100A signal generator (FIG 1) offers performance that is unrivaled in its price class:

- **Wide frequency range from 9 kHz to 6 GHz** – covers all frequency bands important for RF applications
- **Best spectral purity in its class** – ensures high measurement accuracy in a wide variety of applications
- **Highest output power in its class** – eliminates the need for external amplifiers
- **Very fast frequency and power setting times** – supports high throughput in production
- **Easy on-site servicing** – ensures low operating costs as well as maximum instrument availability
- **Wide temperature range, operating altitude up to 4600 m, fast pulse modulation** – meets the special requirements in aerospace and defense applications
- **Compact design, low weight** – for tight space requirements and easy transport

Best spectral purity in its class

Phase noise, harmonic spurious and nonharmonic spurious, as well as wideband noise are the most important parameters characterizing the spectral properties of analog signal generators. The R&S®SMB100A features very good performance in all these respects. In particular, the instrument displays its full strength in receiver blocking tests, where noise and nonharmonic spurious produced by the interfering signal generator in the receiver channel bandwidth degrade the measurement accuracy.

A major factor contributing to the signal generator's good spectral properties is its RF synthesizer, which is implemented as a DDS-based single-loop synthesizer. A new patented algorithm for DDS frequency generation enables the synthesizer to achieve spectral properties that were previously not attainable with conventional single-loop synthesizers. In the frequency range up to 1500 MHz, the generator achieves nonharmonics suppression of typ. –85 dBc while providing excellent phase noise characteristics (FIG 2). The R&S®SMB100A exhibits such outstanding spectral properties over the entire frequency range. FIG 3 shows the simplified architecture of an instrument outfitted with the R&S®SMB-B106 6 GHz frequency option.

In conventional generators, a downconverter is used to generate frequencies below a specific limit (typ. 100 MHz to 250 MHz). This downconverter mixes the frequency-synthesized signal with a fixed-frequency signal (LO) of typ. 1 GHz. However, this method has the substantial drawback that the spectral purity of the resulting signal is degraded by the SSB phase noise of the LO.

The R&S®SMB100A takes a different approach. Its divider range has been expanded down to 23 MHz; below this value, the DDS synthesizer generates the output signal directly. FIG 4 makes the advantages of this concept obvious. The phase noise at low signal frequencies is significantly reduced compared

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FIG 1 Excellent specifications and the capability to perform instrument maintenance yourself make the R&S®SMB100A a valuable general-purpose instrument.

FIG 2 Typical SSB phase noise at various RF frequencies (with optional R&S®SMB-B1 reference oscillator).

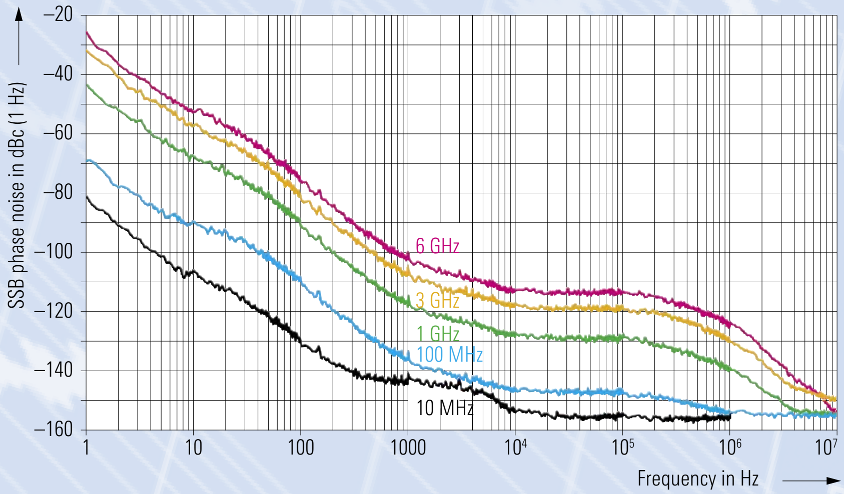
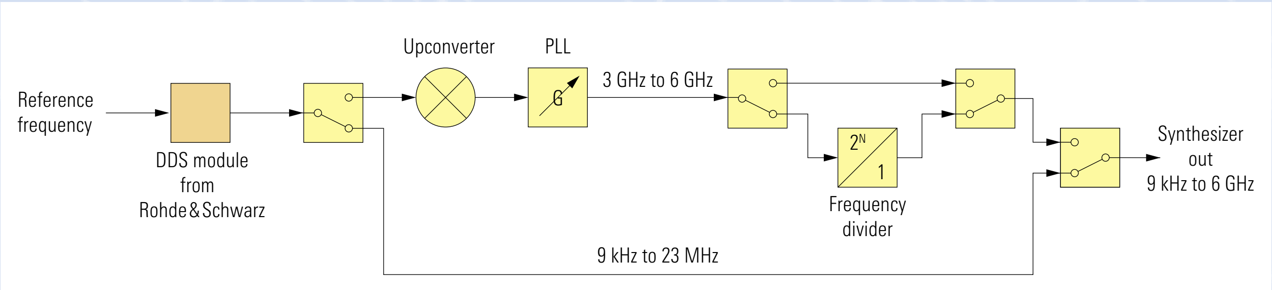


FIG 3 Simplified block diagram of the frequency generation architecture of the R&S®SMB100A with the R&S®SMB-B106 frequency option.



to conventional designs based on a downconverter.

This makes the R&S®SMB100A an ideal substitute for reference oscillators or for all applications that require a low-jitter signal (e.g. A/D and D/A converter testing).

The DDS-based synthesizer generates both frequency and phase modulation directly in digital form, thus enabling the R&S®SMB100A to achieve excellent modulation characteristics. In the frequency range below 23 MHz, it also generates amplitude modulation directly in digital form. It thus provides amplitude modulation of higher accuracy than available from conventional generators in this frequency range, which enables highly accurate measurements on radio receivers in the shortwave range (FIG 5).

Highest output power in its class

The R&S®SMB100A provides maximum output power of typ. +25 dBm over the frequency range from 1 MHz to 6 GHz (FIG 6). The generator's wear-free electronic step attenuator extends its dynamic range down to –145 dBm, thus making it ideal for receiver measurements. However, since the insertion loss of the attenuator reduces the output power, a subsequent wideband output amplifier in the R&S®SMB100A compensates for this loss and provides additional gain. This results in the very high output power available at the RF output (FIG 7), which usually eliminates the need for an additional external output amplifier to compensate for high cable losses toward the DUT or for controlling a power amplifier.

The wideband output amplifier is only switched into the signal path at high output levels. At low output levels, this amplifier is not used, since it would degrade the wideband noise of the output signal due to its noise factor. A PIN attenuator connected in series to the wideband output amplifier is analog-controlled by the output frequency and the amplifier temperature. This PIN attenuator compensates for the first-order temperature drift of the gain of the wideband output amplifier. Thus, a highly stable output level is obtained even if the wideband output amplifier is active.

Another special feature of the R&S®SMB100A is its reverse power protection up to 6 GHz. This mechanism includes a pair of limiter diodes for limiting any RF power or voltage transient unintentionally applied at the generator's RF output. If the control circuit detects such an error condition, a relay disconnects the RF output from the output connector. While the instrument is being powered down, this relay also remains open, thus protecting the output from damage. This overvoltage protection comes in handy especially in the lab or during servicing, when measurements on the receiver section of a transceiver may accidentally cause the equipment to start transmitting.

Very short settling times for frequency and level

Automatic test systems for production require especially short settling times in the test equipment in order to keep test time short, thus ensuring high throughput. The R&S®SMB100A excels in this area with an average power level settling time of 1.2 ms and an average frequency settling time of 1.6 ms. FIG 8 shows the distribution of the settling times in remote control operation for 10000 random changes in power level and an equal number of changes in frequency.

The level settling time is defined as the time the R&S®SMB100A requires for its output level to settle to a deviation of 0.1 dB from its final value. This is achieved through the use of a fast level control and fast CMOS RF switches. These highly reliable RF switches do not exhibit the long level settling times that are common with GaAs switches.

In addition, the generator signals completion of the settling transient at its Signal Valid output. By means of this signal, you can immediately trigger the measurement of the DUT, thus ensuring the fastest possible test sequences. To address the needs of highly time-critical applications such as measurements

Condensed data of the R&S®SMB100A

Frequency	
Frequency range	9 kHz to 6 GHz
Settling time	<3 ms, typ. 1.6 ms
Level	
Level range	–145 dBm to +18 dBm (overrange up to typ. 25 dBm)
Settling time	<2.5 ms, typ. 1.2 ms
Spectral purity (f = 1 GHz)	
SSB phase noise (20 kHz carrier offset, 1 Hz measurement bandwidth)	<–122 dBc, typ. –128 dBc
Nonharmonics (carrier offset > 10 kHz)	<–70 dBc, typ. –85 dBc
Wideband noise (carrier offset > 10 MHz, 1 Hz measurement bandwidth)	<–142 dBc, typ. –152 dBc
Modulation modes	AM, FM / φM, pulse
Interfaces	IEC 60625 (IEEE 488) Ethernet (TCP/IP) USB

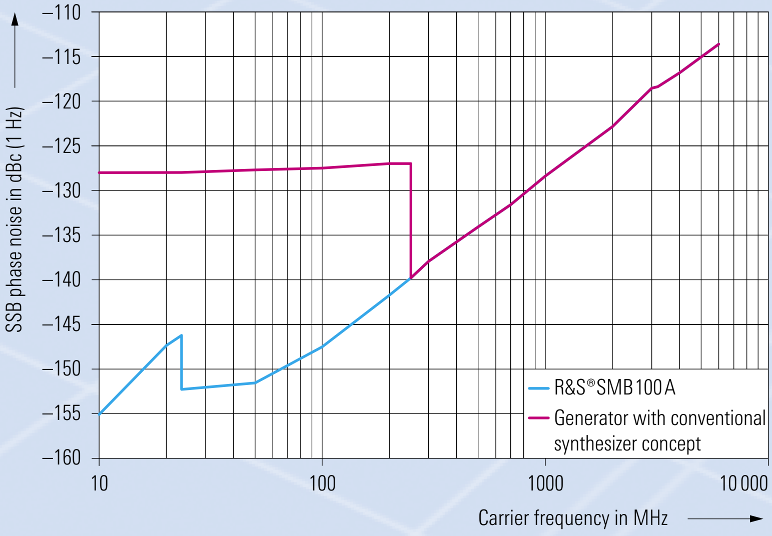


FIG 4
SSB phase noise at 20 kHz offset from carrier frequency: comparison between the R&S®SMB100A and a generator with conventional synthesizer concept.

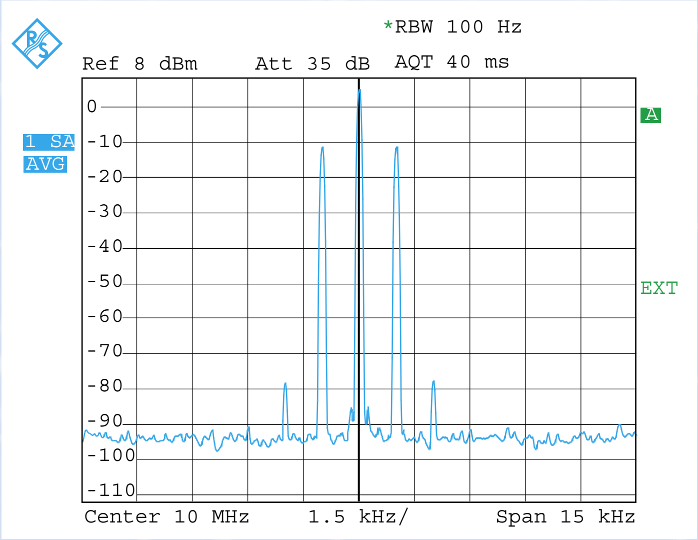


FIG 5 Amplitude-modulated spectrum at f = 10 MHz with low total harmonic distortion.

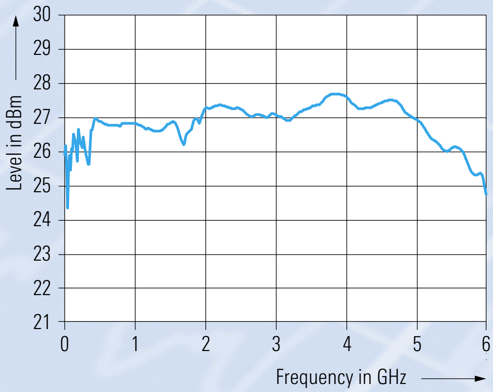


FIG 6 Measured maximum output level of the R&S®SMB100A.

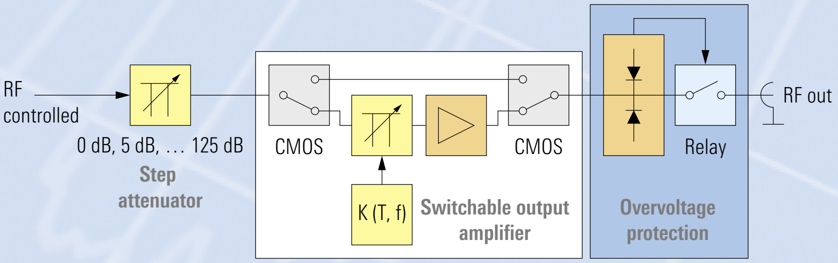
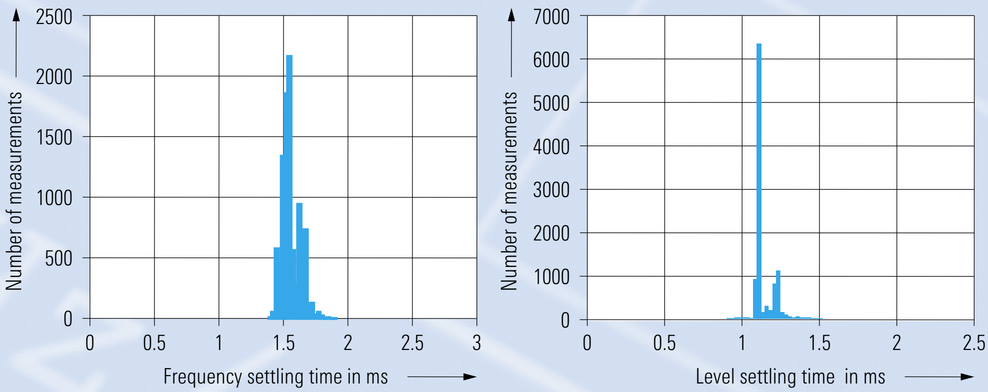


FIG 7 Output circuit of the R&S®SMB100A .

FIG 8 Statistics for the level and frequency settling times (10 000 measurements each).



on frequency-hopping systems, the R&S®SMB100A supports the List mode as a standard feature enabling an average settling time of 650 µs.

Easy on-site servicing

During the development of the R&S®SMB100A, particular emphasis was placed on high reliability and simple design. The generator therefore consists of only four modules (FIG 9):

1. Power supply
2. Processor module including all digital internal and external interfaces
3. Front panel unit including display, keypad, and rotary knob
4. RF board including the entire RF test and measurement equipment

However, if the instrument should nevertheless malfunction, its straightforward design will facilitate the localization of the defective module. The built-in selftest, which automatically checks instrument functions, helps with troubleshooting. Since the instrument is easy to take apart and put back together, on-site module replacement is possible. This keeps downtime to a minimum and generator availability high.

After module replacement, the instrument is immediately ready for use again, since replacement modules come from the factory fully adjusted and tested. No additional external adjustment of parameters is necessary – a simple functional test is usually sufficient. You can calibrate the signal generator on your own; a calibration interval of three years is recommended.

To achieve optimal power level accuracy after servicing, a fully automatic power level correction can be performed by means of an R&S®NRP-Z92 power sensor connected to the generator output (FIG 10).*

Special requirements for aerospace and defense

The R&S®SMB100A is suitable for mobile use in aerospace and defense applications not only due to its low weight and compact design. Additional attributes such as its highly robust design, generously dimensioned power supply, and cooling controlled by the instrument temperature enable operation up to 4600 m above sea level and an operating temperature range from 0 °C to 55 °C.

The integrated high-quality pulse modulator with rise and fall times of typ. <10 ns is exceptional in this instrument class and is usually available only in significantly higher price classes. FIG 11 shows an example of the signal amplitude of a 20 ns pulse at 6 GHz. Besides the very clean characteristic, the pulse dynamic range with an on / off ratio of typ. 90 dB is also very good.

Owing to its fast internal pulse generator, which can generate not only single pulses but also double pulses, the R&S®SMB100A is also ideal for radar applications.

Compact design, low weight

With its compact dimensions of 344 mm × 112 mm × 368 mm, the generator requires only a small amount of space on crowded lab benches and service tables. Its convenient size and low weight of only 5.3 kg make it particularly well-suited for mobile use.

* Available as of January 2008 via firmware update.

Variety of remote control capabilities

The PC module, which has been specially designed for the R&S®SMB100A, includes as standard the IEC/IEEE bus interface customarily used in test and measurement as well as a USB and a LAN interface. The generator can thus be easily integrated into the individual setup. If you want to operate the R&S®SMB100A from your computer via the LAN interface, you can do so by means of a conventional web browser or via the supplied virtual network computing (VNC) software.

Summary

The R&S®SMB100A complements the portfolio of analog signal generators from Rohde & Schwarz. It is a mid-range instrument that stands alongside its well-established high-end brother, the analog R&S®SMA100A signal generator. The R&S®SMB100A will also impress you with its highly attractive price/performance ratio. Moreover, it features excellent spectral purity, very high output power, short settling times, as well as a compact and robust design.

Günther Klage; Dr. Joachim Danz

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FIG 9
The R&S®SMB100A is designed for ease of service and consists of only four modules.

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FIG 10 The R&S®SMB100A performs automatic level correction when an R&S®NRP-Z92 power sensor is connected.*

More information, brochure, and data sheet at www.rohde-schwarz.com (search term: SMB100A)

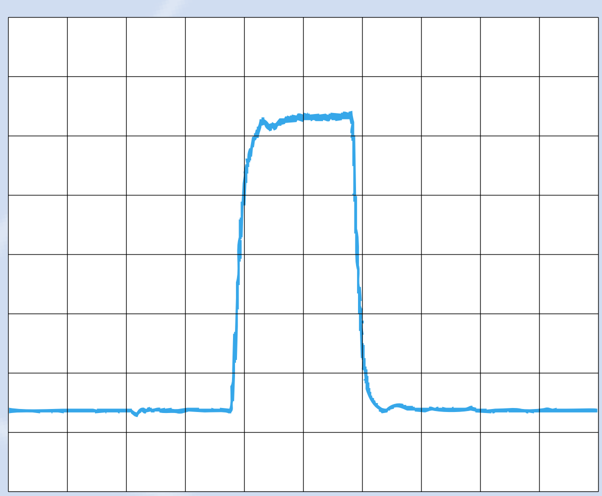

FIG 11
Signal amplitude of a 20 ns pulse at 6 GHz with 0 dBm level.

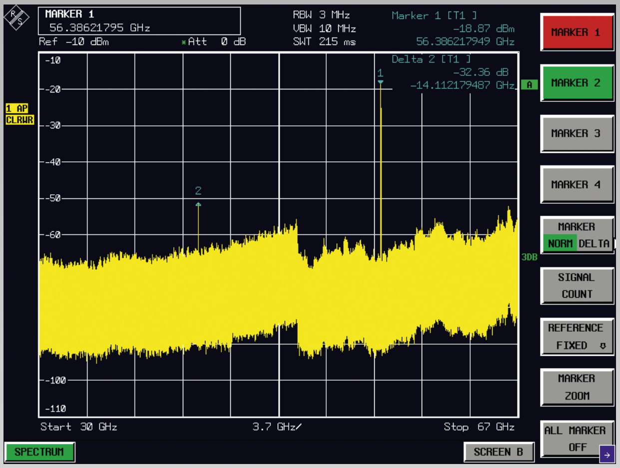

FIG 1 Measurement of a multiplier signal using the R&S®FSU67.

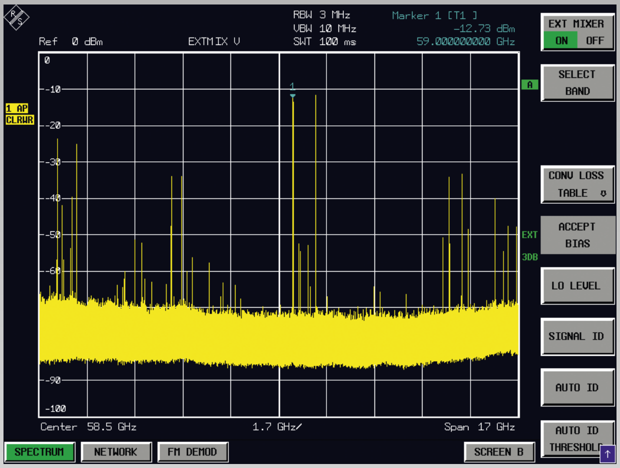

FIG 2 59 GHz signal, measured with an external mixer without software preselector.

FIG 3 The same 59 GHz signal, measured with an external mixer and software preselector.

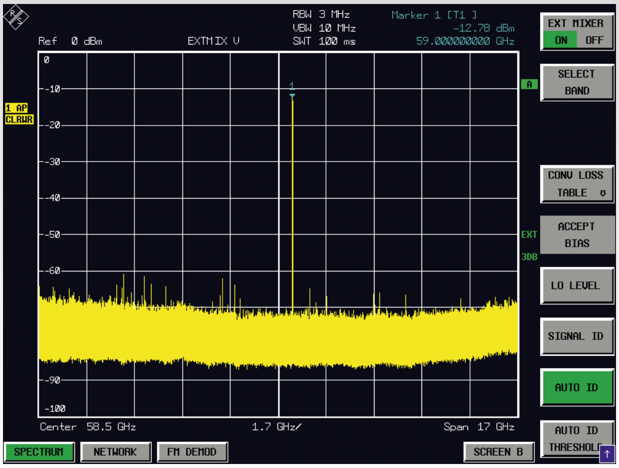

FIG 4 The 59 GHz signal, measured with the R&S®FSU67.

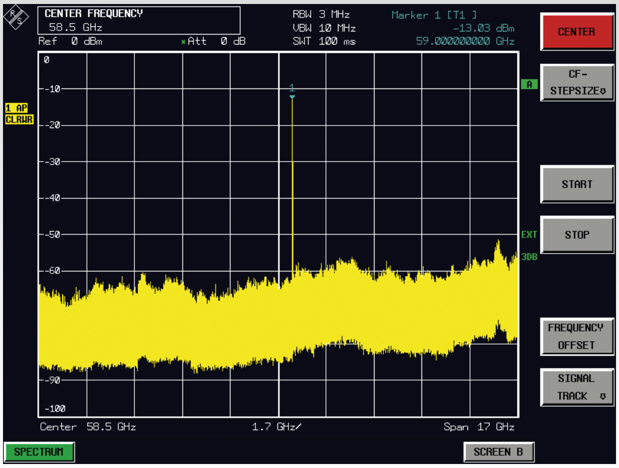

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FIG 5
R&S®FSU67: the first spectrum analyzer worldwide for the frequency range from 20 Hz to 67 GHz.

Spectrum analysis – entire frequency range now covered from 20 Hz to 67 GHz

This is the world´s first spectrum analyzer that covers the entire frequency range up to 67 GHz. The R&S®FSU 67 now even makes the range between 50 GHz and 67 GHz available for spectrum analysis free of image response and thus clearly expands the limit at which cumbersome setups with external harmonic mixers become necessary.

Expanding the limits of conventional T&M technology

In the past, measurements in the spectral range were possible only up to 50 GHz when using conventional and easy-to-operate test setups. To measure frequencies beyond this limit, you usually had to expand the test configuration to a complex test setup by adding external harmonic mixers.

These days are over. With its R&S®FSU 67 (FIG 5), Rohde & Schwarz is the first manufacturer worldwide to offer a spectrum analyzer in coaxial design that covers the entire frequency range up to 67 GHz and thus clearly goes beyond the conventional limits of T&M technology. The analyzer simplifies measurements in this frequency range as it is able to eliminate all the drawbacks of harmonic mixers (see box below). The frequency concept of the analyzer with fundamental mixing and image rejection up to 67 GHz ensures unambiguous signal representation right from the start, thus preventing problems in signal identification.

In addition, the complete frequency range is measured via one input connector, i. e. no additional cabling of the test setup is required. FIG 1 shows this for a multiplier: Its output signal is already filtered for harmonics but subharmonics are still present. The R&S®FSU 67 uses one sweep to measure these subharmonics, even for signals up to 67 GHz.

FIGs 2 to 4 show the measurement of a signal at 59 GHz with an external mixer as well as with or without a software preselector in comparison with the measurement of the same signal with the R&S®FSU 67. The difference is significant: Even if the software preselector is used, you can still see a considerable number of unwanted signals when the measurement is performed with an external mixer (FIG 3); in contrast, nothing but the real signal is displayed when the measurement is carried out with the R&S®FSU 67.

The internal step attenuator, which covers a range from 0 dB to 75 dB, optimally adapts the analyzer to the level of the input signal. The level measurement range is thus covered from 30 dBm to inherent noise without needing additional hollow waveguide step attenuators. And the R&S®FSU 67, like all members of the R&S®FSU family, has a calibrated level measurement accuracy. This means that the measurement uncertainties that occur when working with external mixers are now a thing of the past in the frequency range up to 67 GHz.

Good reasons to avoid external mixers:

- External harmonic mixers have no image rejection and generate a variety of signal responses. The correct mixture product can only be determined by filtering or shifting the local oscillator frequency. This procedure is used by software preselectors. With non-stationary, e. g. pulsed, signals, however, such signal identification routines quickly hit their limits.
- The connection of external harmonic mixers requires additional cabling for IF and LO signals and calls for a separate setup. Harmonics measurements must therefore often be performed in two stages (without and with an external mixer).
- The conversion loss of the external mixers is affected by the accuracy of the mixer calibration, the additional cabling, and the correct setting of the LO level. Despite careful measurements, the resulting level measurement uncertainty is greater than that produced with a spectrum analyzer that has a similar frequency range.
- When using external mixers, the measurement signal is directly applied to the mixer input. If a level decrease is necessary in order to operate the mixer in the linear range, additional hollow waveguide step attenuators are required.

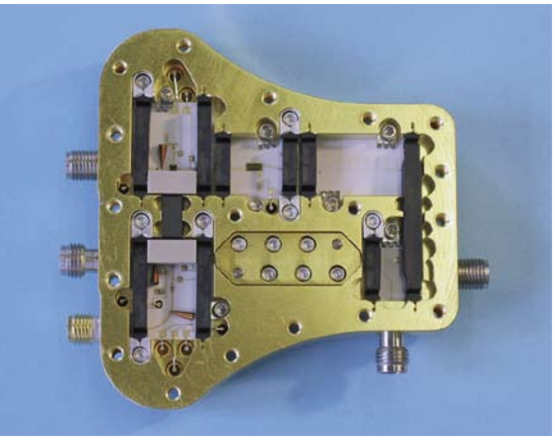

FIG 6 Heart of the R&S®FSU67: the microwave frontend module with an input frequency from 50 GHz to 67 GHz.

Microwave technology at its best

The conversion of signals above 50 GHz to the range below 26.5 GHz is performed by an additional frontend provided in the R&S®FSU67. The components used in this frontend were developed by Rohde&Schwarz in collaboration with the Chair for Microwave Engineering and High Frequency Technology at the University of Erlangen-Nuremberg.

Local oscillator design

A fractional N synthesizer forms the basis of the local oscillator. This synthesizer consists of a proprietary Rohde&Schwarz ASIC, a VCO up to 12 GHz as well as various dividers and other components from the microwave production department at Rohde&Schwarz. The frequency synthesis of the LO is implemented on ceramic substrates in microwave technology. This ensures the amplification of the signal generated by the synthesizer and the multiplication to the required frequency range from 39 GHz to 45 GHz.

Frontend design

To suppress unwanted spurious response, a preselection filter must be part of the heterodyne receiver concept. In the new frontend, this preselection filter is implemented in the form of a special fixed-frequency filter with a passband from 50 GHz to 67 GHz. Good spurious suppression is attained by skillfully setting the LO frequency and IF. The production of the fixed-frequency filter that is used places the highest of demands on mechanical precision: Milling tolerances of 20 µm have to be met for the filter housing.

The mixer that is used to convert the applied signals in the range from 50 GHz to 67 GHz is also a Rohde&Schwarz product and meets the highest of requirements:

- Fundamental mixing at input frequency 50 GHz to 67 GHz
- Minimum conversion loss
- Excellent spurious suppression
- Production-friendly and reproducible circuit design

The result is a completely integrated circuit design that is embedded as a ceramic substrate in the frontend module (FIG 6). The specifications attained for the overall instrument are quite impressive: With a displayed average noise level (DANL) of <–130 dBm (typ. –136 dBm) referenced to a 1 Hz resolution bandwidth in the frequency range from 51 GHz to 57 GHz and <–120 dBm (typ. –124 dBm) up to 67 GHz, the R&S®FSU67 surpasses external mixers in level stability, ease of operation, and spurious suppression.

More information and data sheet at www.rohde-schwarz.com (search term: FSU67)

Application-oriented measurement functions

Measurements on microwave components or systems are typical applications for the R&S®FSU67. The instrument makes these measurements much easier by offering a variety of measurement functions:

Phase noise measurements on oscillators up to 67 GHz are supported by the R&S®FS-K40 option. This option not only determines the phase noise over a selectable frequency offset range up to 1 GHz and displays it with a logarithmic frequency axis but also calculates the residual FM and φM as well as jitter based on the result.

The R&S®FS-K7 option is available for **measuring analog-modulated AM, FM, and φM signals**. It allows you to comprehensively analyze the transients in the frequency and time domain.

The R&S®FSP-B10 option and an external generator such as the R&S®SMR or R&S®SMF make the R&S®FSU67 a scalar network analyzer. The **transmission characteristics of filters and amplifiers**, for example, can thus be determined very easily. The spectrum analyzer also supports generators of other manufacturers.

Measurements with harmonic mixers beyond the 67 GHz limit are carried out by the R&S®FSU67 (as also done by the 26.5 GHz, 46 GHz, and 50 GHz models) with the R&S®FSU-B21 option. The R&S®FS-Z75, -Z90, and -Z110 harmonic mixers as well as customer-specific mixers can be used. When equipped with the R&S®FSU-B21 option, the R&S®FSU67 operates with three-port and two-port mixers. In this case, a software preselector supports you in identifying the signals.

Dr. Wolfgang Dressel; Herbert Schmitt

Millimeter-wave network analysis with maximum dynamic range

The new R&S®ZVA-Z110 converters from Rohde & Schwarz expand the R&S®ZVA 24, R&S®ZVA 40, and R&S®ZVT 20 vector network analyzers by adding millimeter-wave measurement capability with maximum dynamic range from 75 GHz to 110 GHz (W band).

Perfectly integrated into the analyzer firmware

The R&S®ZVA-Z110 converters (FIG 1) expand the high-end network analyzers from Rohde & Schwarz by adding the frequency range from 75 GHz to 110 GHz, thus covering important frequency bands, e. g. the forthcoming vehicle distance radar (77 GHz), or applications in the defense sector (94 GHz). The converters, which are also intended for use in wafer probers and are appropriately dimensioned for this application, are simply connected to the base unit; no additional hardware is required.

As a unique feature worldwide, the converters are fully integrated into the network analyzer firmware, i. e. the converters can be operated as if they were an integral part of the analyzer. By selecting the appropriate cabling scheme in the analyzer firmware, all the required parameters will be set automatically (FIG 2). These include the frequency limits of the WR10 band, the multiplication factors for the RF and the LO signals, the power values of these signals, and the receiver frequency. The correct setting menus, measured-value indications, frequency limits, etc. will thus always come up, reducing setting errors to a minimum. The network analyzer includes an output power limiting function, which prevents damage to the converters caused by unduly high RF or LO input powers.

FIG 1 By combining a high-end network analyzer with the R&S®ZVA-Z110 converters, Rohde & Schwarz is the first T&M manufacturer to offer an all-in-one, single-source solution for network analysis in the millimeter-wave range (WR10 band).

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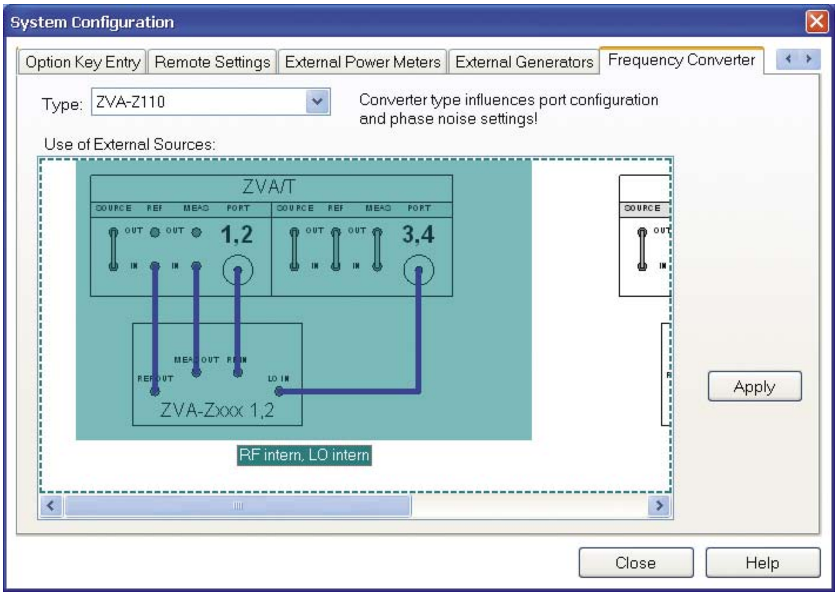

FIG 2 Selection of converter type in the instrument firmware and display of required connections.

Functional description

The R&S®ZVA-Z110 converters are based on frequency multiplication of the RF and LO input signals. RF signals are generated in the range 12.5 GHz to 18.33 GHz and multiplied by a factor of six to the range 75 GHz to 110 GHz; LO signals are generated in the range 9.34 GHz to 13.71 GHz and multiplied by a factor of eight. Harmonics mixers downconvert the measurement and reference signals to be output by the converters to a fixed IF in the megahertz range and apply them to the network analyzer's MEAS IN and REF IN inputs. Bidirectional measurements are possible as the converters contain directional couplers separating forward and reflected power.

Each converter features an integrated attenuator that allows manual reduction of the converter output power by up to 25 dB, which is necessary for characterizing low-noise amplifiers, for example.

Ultra-wide dynamic range

The converters offer an excellent, unrivaled dynamic range of typically >110 dB. This speeds up measurements, as it enables the use of wider IF bandwidths, and allows high-blocking filters to be analyzed.

Easy to handle

The converters' waveguide test ports are arranged on a bar extending from the converter to provide easy access to the screw-connected flange joints. The converters can be set up on three or four feet that can be separately adjusted in height. Using three feet in particular allows the optimal alignment of the waveguide flanges relative to one another. Differences in height and the cocking of flanges relative to each other can be balanced out with high precision, thus enabling tight and stable screw connections – which is an important prerequisite for correct calibration.

Easy and fast test setup

When using an R&S®ZVA 24 or R&S®ZVA 40 four-port network analyzer or an R&S®ZVT 20 with at least four ports, no external generator is needed for delivering the LO signals required by the converters. Four-port analyzers have two internal signal generators, one generating the RF signals and the other the LO signals. No further hardware is required, which greatly facilitates and, most importantly, speeds up the test setup, since the second internal generator operates in parallel with the first one and need not be remote-controlled via the IEC/IEEE bus.

Alternatively, an R&S®ZVA 24, R&S®ZVA 40, or R&S®ZVT 20 two-port network analyzer can be used. In this case, an external R&S®SMF 100 A signal generator is additionally required to provide the LO signal. The signal generator's output signal is distributed to the two LO inputs of the converters via a suitable power splitter.

FIG 3 R&S®ZV-WR10 calibration kit – version with sliding match.

Calibration

After selecting the converter type, the R&S®ZV-WR10 waveguide calibration kit (FIG 3) is set automatically, and the corresponding calibration data is loaded. Calibration kits from other manufacturers can also be used.

Calibration is performed by means of the short, offset short (consisting of a short and a shim), and match waveguide calibration standards. Alternatively, an optionally available sliding match can be used, which is useful especially when high-precision reflection measurements are to be performed. The through calibration standard is implemented by directly screwing together two waveguide test ports.

Test port adapters, which are supplied as standard with the converters, protect the converters' waveguide connectors against wear and at the same time allow the connection of calibration kits from other manufacturers.

Multiport measurements

Using an R&S®ZVT 20 six-port network analyzer with three internal signal generators, you can perform tests on three-port DUTs without an external generator. This test configuration allows you, for example, to measure all S-parameters of a waveguide directional coupler simultaneously after performing full system error correction. Four-port DUTs can be tested using four R&S®ZVA-Z110 converters, an R&S®ZVA 24, R&S®ZVA 40, or R&S®ZVT 20 four-port network analyzer, and an external generator for delivering the LO signal.

Andreas Henkel

More information at www.rohde-schwarz.com (search term: ZVA-Z110)

Application Note 1EZ55

Application Note 1EZ56

Condensed data of the R&S®ZVA-Z110

Frequency range	75 GHz to 110 GHz (WR10 band)
Output power (with +7 dBm input power from the R&S®ZVA / R&S®ZVT network analyzer)	+2 dBm
Manual power attenuation	0 dB to 25 dB using adjustable power control screw
Dynamic range	>95 dB, typ. >110 dB
Connector	compatible with UG-387 flange

Measurement example

An 80 GHz notch filter is to be measured using two R&S®ZVA-Z110 converters. First, full two-port calibration is performed. Then the filter is connected to the waveguide test ports of the converters. All four S-parameters of the filter can be measured and displayed in one or more diagrams on the analyzer screen (FIG 4). By using multiple measurement channels, it is possible, for example, to display the filter transmission characteristic across the entire WR10 band from 75 GHz to 110 GHz and at the same time the filter passband alone.

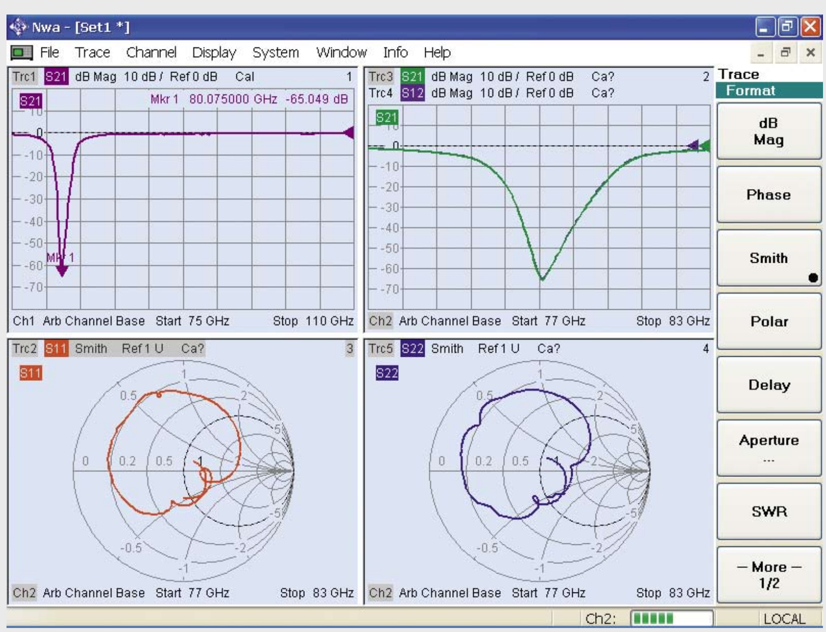

FIG 4 Measurement of an 80 GHz notch filter.

R&S®EVS300 ILS/VOR Analyzer

High-precision level and modulation analysis of ILS and VOR signals

The R&S®EVS300 level and modulation analyzer is used for checking and servicing ILS and VOR installations. Its manifold new functions make it now also optimally suited for flight inspections.

More information at www.rohde-schwarz.com (search term: EVS300)

For maximum precision on the ground and in the air

Its new functions enable the R&S®EVS300 level and modulation analyzer (FIG 1) to perform both ground-based and airborne measurements on ILS and VOR installations with maximum accuracy. The R&S®EVS300 allows for the first time the direct comparison and analysis of the results of both ground and flight inspection. The correlation of these two measurements complies exactly with the requirements of the International Civil Aviation Organization (ICAO, Doc. 8071). Despite its compact design, the R&S®EVS300 works with a measuring accuracy matching that of the best laboratory equipment and provides a convincing number of outstanding features:

ILS signal analysis

- Highly accurate localizer, glidepath, and marker beacon measurements
- Parallel localizer and glidepath measurements (second independent signal processing channel, R&S®EVS-B1 option)
- Simultaneous course/clearance measurement with one signal processing channel (R&S®EVS-K3 option)
- Realtime distortion measurement of ILS signals (K2, K3, THD)

VOR signal analysis

- Accurate checking of CVOR / DVOR antenna systems in the field
- Selective modulation depth and deviation measurements, and display of useful and interfering signals

FIG 1 The R&S®EVS300 is rugged and extremely compact. Nevertheless, it stands out because of its excellent measurement features and comprehensive analysis functions.

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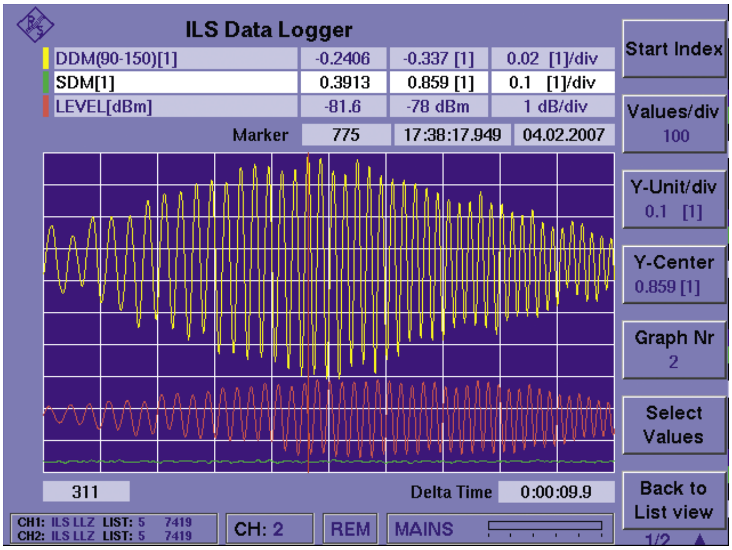


FIG 2 The ILS Data Logger display shows graphical representations of the DDM sequence, for example.

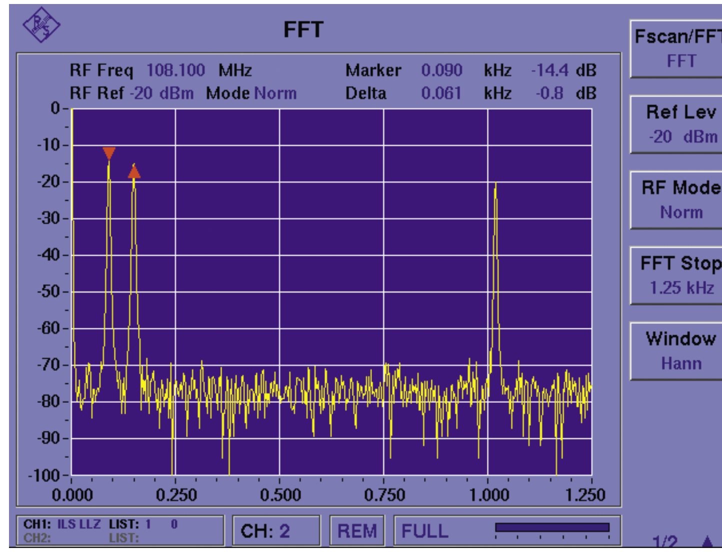


FIG 3 FFT analysis with the R&S®EVS-K4 option.

Additional special characteristics

- Steep-edge preselector filters for high immunity to interference
- Frequency scan (R&S®EVS-K1 option) with a dynamic range of up to 100 dB
- FFT analysis of AM signals (R&S®EVS-K4 option)
- Realtime logging of all measured values (max. 100 measurements per second)
- Mains-independent operating time of 8 h to 10 h during continuous measurements
- Rugged and compact design for use in the field
- Embedded web server enabling easy remote access
- Feeding of GPS time and position information based on the NMEA 0183 protocol (R&S®EVS-K2 option)

Multitalent for ground-based ILS measurements

Although ILS installations feature integrated monitoring functions, the regular measuring and servicing of these systems using independent equipment is an absolute must in modern air traffic control (ATC). In particular the dynamic measurement of ILS signals by means of runway measurements with vehicles is a core task of ATC organizations. The R&S®EVS 300 is just made for these challenges as it offers numerous functions such as integrated logging of all relevant measured values including GPS position data, remote triggering, and graphical display of the DDM sequence (FIG 2). In combination with the R&S®HF 108 antenna that has specifically been designed for these applications, it forms the core component of the measuring system. The R&S®EVS-K3 option enables simultaneous and independent measurements of level and phase relations of course / clearance signals of an ILS system during operation. Due to the high measuring speed and fast data logging, this option helps to save valuable time when the runway has to be closed for performing the measurements.

Ideal for use in flight inspection aircraft

Time is money – this is especially true for flight inspections. When equipped with a second measuring channel (R&S®EVS-B1 option), the R&S®EVS 300 is capable of performing two independent measuring tasks on any frequencies in parallel, e. g. the measurement of localizer and glideslope signals during a landing approach or the checking of two CVOR / DVOR systems.

When employed in a flight inspection aircraft, the R&S®EVS 300's steep-edge preselector filters prevent the development of intermodulation products in the vicinity of high-power VHF FM transmitters. In measurements along the edge of the coverage area, the low-noise frontend ensures a stable display even with signals far below the specified measurement range.

Because each measured value is correlated with the corresponding GPS position (R&S®EVS-K2 option), additional measuring instruments in the aircraft are basically not required. The R&S®EVS 300 also provides realtime storage of the results in its internal data memory. Thus, everything has been taken into consideration: Its numerous functions drastically reduce the complexity of measurement systems to be used for checking radio navigation systems in line with the ICAO Doc. 8071 recommendation.

Options for every application

Various options allow the R&S®EVS 300 to be optimally adapted to the measuring task at hand: The R&S®EVS-K1 option features an additional continuous frequency scan in the range from 70 MHz to 350 MHz. The dynamic range extends up to 100 dB, and the start/stop frequencies are user-selectable. The noise floor is below –130 dBm.

The R&S®EVS-K4 option allows the FFT analysis of demodulated RF signals or signals at the baseband input at a dynamic range above 90 dB (FIG 3). ILS / VOR /marker beacon modulation signals including their harmonics can thus be analyzed as easily as nonharmonics.

Both for frequency scan and FFT, the R&S®EVS 300 offers convenient visualization of the spectrum via a marker/delta marker function, as well as via the clear/write, average, and peak hold trace modes.

Large data memory and clearly structured visualization

The large internal data memory enables the R&S®EVS 300 to simultaneously store all 50 measured values in a single data set at the highest data rate of 100 measurements per second. For every mode (ILS/VOR/marker beacon) up to 999 individual lists with up to 1000 000 data sets each can be managed. The R&S®EVS 300 visualizes the stored measured values quickly in a clearly structured graphical representation. This unique feature enables, for example, the immediate verification of runway measurement data on board the measuring vehicle without the need to use an external PC or additional software. For archiving or further processing the measurement results can be transmitted from the data memory via standard interface (LAN, RS-232-C, GSM) or simply copied to a USB memory stick.

High-convenience operation

Despite its multitude of functions, the R&S®EVS 300 is convenient to operate. Its low weight and the rechargeable batteries' operating time of eight to ten hours during continuous measurements ensure mains-independent applications. It can be completely remote-controlled via one of the standard interfaces by means of remote-control commands. This allows automatic ILS or VOR measurements to be performed under constant measurement conditions.

Summary

The R&S®EVS 300 with its extensive scope of functions represents an ideal instrument for 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.

Klaus Theissen; Benjamin Marpe

General R&S®EVS 300 characteristics

- High-contrast TFT color display (16.4 cm / 6.4")
- Wide operating temperature range of –10 °C to +55 °C
- Low weight (approx. 5.7 kg)
- High mechanical resistance
- Analog output enabling subsequent analysis of received signals in the baseband
- Analysis of external baseband signals
- Selftest (BITE)
- LAN, RS-232-C, and GSM interface for remote control of all functions and for measurement data output
- USB connector for easy data export and software updates

Condensed data of the R&S®EVS 300

Frequency range	70 MHz to 350 MHz
Absolute level	–120 dBm to +13 dBm
Deviation at –30 dBm	<0.8 dB
Linearity error (–40 dB to +30 dB)	<0.5 dB
Inherent noise (BW 16 kHz)	typ. –119 dBm
ILS	
DDM measurement, localizer mode	
Deviation ≤±10 % DDM	≤0.04 % DDM ±0.1 % of reading
Deviation >±10 % DDM	<0.04 % DDM ±0.2 % of reading
DDM measurement, glideslope mode	
Deviation ≤±20 % DDM	<0.08 % DDM ±0.1 % of reading
Deviation >±20 % DDM	<0.08 % DDM ±0.2 % of reading
VOR	
Azimuth resolution	0.01°
Azimuth deviation	≤+0.1°

FIG 1 **R&S®ESPI3 precompliance test receiver.**

R&S®ESPI Precompliance Test Receiver

Convenient software simplifies EMI measurements

The new R&S®ES-SCAN precompliance software is a user-friendly and cost-efficient tool for computer-controlled EMI measurements with the R&S®ESPI3 (FIG 1) and R&S®ESPI7 test receivers. It simplifies and speeds up both lab-based precompliance measurements and the preparation for the final certification measurement.

Avoiding expensive follow-on developments …

The trend of performing fully automatic software-controlled measurement sequences is widespread in the field of EMI measurements. Many certification measurements run fast and accurately on computer-controlled EMI test systems [1]. However, EMI measurements do not start only when a product is to be certified; EMC aspects must be considered early on to ensure electromagnetic compatibility. But extensive software system solutions for product certification do not focus on quick overview measurements during the development phase of a product. The use in labs calls for easy operation, minimum measurement time and low costs.

… by using powerful precompliance software

Rohde&Schwarz has designed its new economical R&S®ES-SCAN EMI precompliance software – the successor of the R&S®ESxS-K1 EMI software – specifically for lab-based measurements during the product development phase. This 32-bit software runs under Windows® XP SP2 and supports the R&S®ESPI3 and R&S®ESPI7 precompliance test receivers [2].

The software proves its powerful capabilities through the fast and uncomplicated acquisition, evaluation and documentation of RFI voltages, powers and field strengths. Its well arranged and clearly structured user interface provides ▶

only those functions that are required for diagnostic and preview measurements; the software does not include the remote control of mast, absorbing clamp / slideway and turntable systems as its functionality has specifically been tailored to development lab requirements.

The development-related examinations and precompliance measurements are performed either interactively or automatically in line with commercial EMC standards; the computer-controlled process ensures reproducible results. The easy-to-program software saves valuable development time and costs as it performs measurements efficiently and economically and offers numerous advantages:

- Short learning phase and easy handling owing to a well arranged structure and clear operating concept
- Time-saving preconfigured default settings for the various EMI measurements
- Efficient storage and management of all measurement data, settings and parameters on the controller including limit lines and transducer factors
- Flexible and fast generation of informative test reports in diverse layouts
- Complete and reliably reproducible measurement results

Measurements and documentation

The precompliance software sets all parameters for a measurement at the R&S®ESPI test receiver (e. g. frequency range, measurement bandwidth, step width, measurement time) and collects and analyzes the data obtained. The intuitive graphical user interface is clearly and logically structured; even newcomers or occasional users operate it quickly and correctly so that they can fully concentrate on their measuring tasks. The extensive context-related help function offers further support in case of questions. In addition to catchword and index search, it also features a measurement wizard that guides the user, if required, through all phases of the measurements (FIG 2). This ensures optimum support when EUTs are examined and evaluated – without time-consuming flicking through the user manual.

The input masks for the frequency scan table and the associated receiver settings are clearly visualized (FIG 3). The software displays the results in tabular and graphical form; marker and zoom functions support the precise evaluation of the graphically displayed values (FIG 4).

Predefined limit lines, transducer tables and default measurement settings for a large variety of commercial EMI standards are further advantages.

An R&S®ES-SCAN measurement sequence typically consists of several phases:

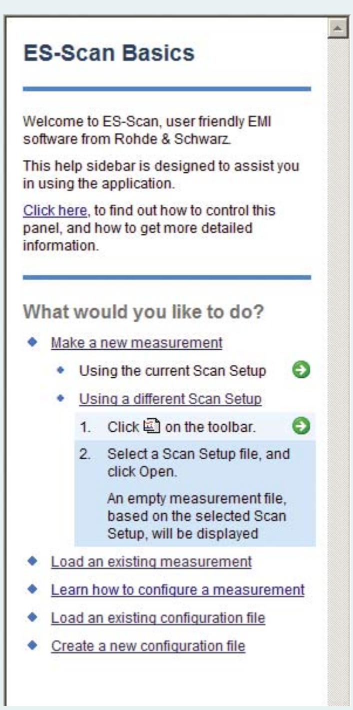
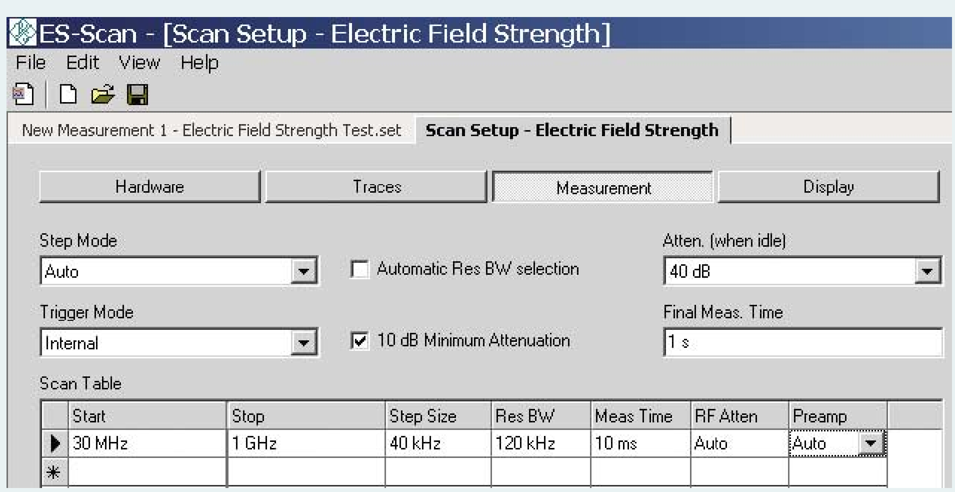


FIG 2
An optional assistant (Help Sidebar) guides the user conveniently through all phases of a measurement.

FIG 3 Input mask for scan table and receiver parameters. An automatic setting in line with the CISPR standard may be preselected (Automatic Res BW selection; Auto step mode).

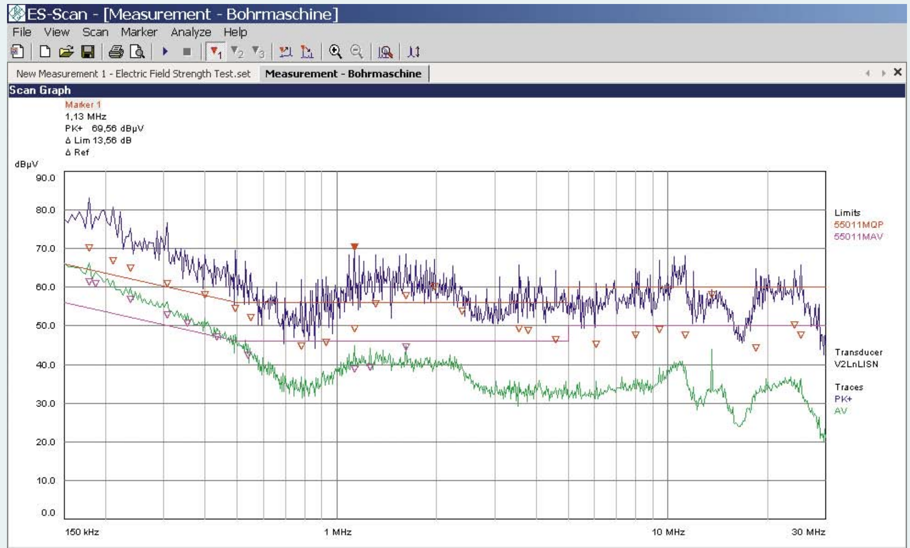


- Preview measurement in line the with scan table
- Determination of all significant interfering signals with subsequent data reduction (frequency list for the final measurement)
- Optional optimization measurements (fine tuning)
- Final measurement in line with the (editable) frequency list
- Report generation

Two final measurement modes are available for selection (FIG 5). In the **Automatic Measurement** mode, the software processes the peak value list step-by-step and determines the level at each frequency by using the detectors and measurement times selected in the measurement settings. In the interactive **User Assisted Measurement** mode, first the Fine Tuning function is activated for each final measurement frequency. This function allows the user to preselect the local maximum by fine-tuning the receiver and, in case, manually changing the position of the EUT, absorbing clamp / slideway and / or antenna (FIG 6).

Producing an informative documentation of settings and measurement and analysis results is in most cases quite time-consuming. Also in this respect R&S®ES-SCAN simplifies and reduces the work of the user. A clearly structured report configurator compiles the individual components of the documentation (general information, receiver settings, graphics, final measurement result) as required. Before being printed the layout can be checked by means of a preview function (FIG 7).

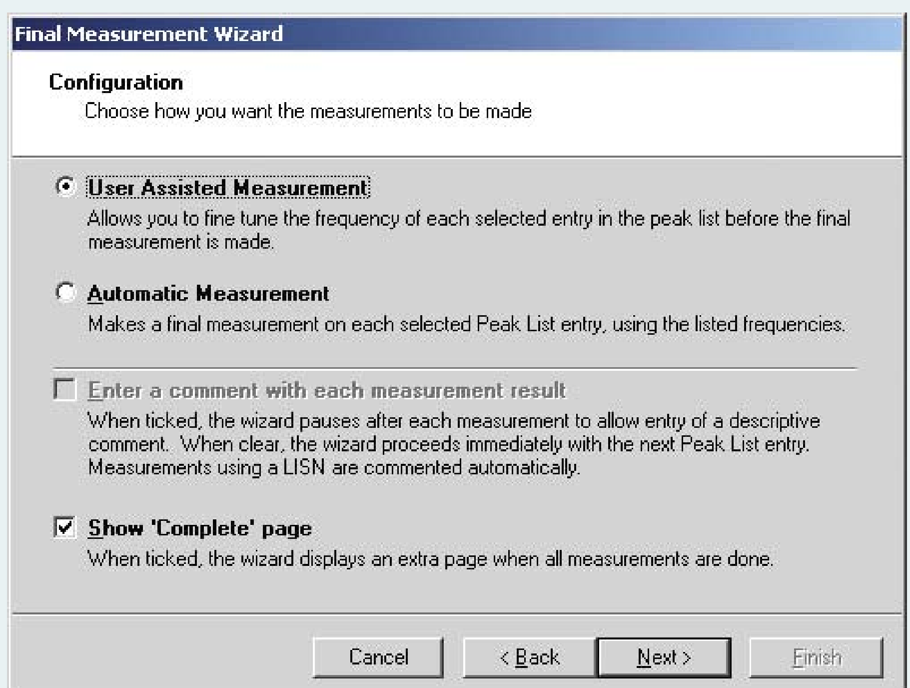
The software controls the R&S®ESPI receiver either via the IEC/IEEE bus interface or via the optional Ethernet interface (R&S®FSP-B16 option) as soon as the hardlock copy protection supplied with the software has been plugged into a USB interface of the controller.



Trace	Frequency	Level	Limit	Delta Limit	Delta Ref	Comment
1 QP	178 kHz	69,31 dBµV *	64,58 dBµV	4,73 dB		N on
2 AV	178 kHz	60,54 dBµV *	54,58 dBµV	5,96 dB		L1 on
2 AV	186 kHz	60,01 dBµV *	54,21 dBµV	5,80 dB		L1 on
1 QP	210 kHz	66,02 dBµV *	63,21 dBµV	2,81 dB		N on
1 QP	238 kHz	64,20 dBµV *	62,17 dBµV	2,03 dB		L1 on
2 AV	238 kHz	56,02 dBµV *	52,17 dBµV	3,85 dB		L1 on
1 QP	306 kHz	59,97 dBµV	60,08 dBµV	-0,11 dB		L1 on
2 AV	306 kHz	52,01 dBµV *	50,08 dBµV	1,93 dB		L1 on
2 AV	354 kHz	49,93 dBµV *	48,87 dBµV	1,06 dB		N on
1 QP	398 kHz	57,12 dBµV	57,90 dBµV	-0,78 dB		L1 on
2 AV	434 kHz	46,29 dBµV	47,18 dBµV	-0,89 dB		N on
1 QP	494 kHz	53,67 dBµV	56,10 dBµV	-2,43 dB		L1 on
2 AV	538 kHz	41,52 dBµV	46,00 dBµV	-4,48 dB		N on
1 QP	550 kHz	51,31 dBµV	56,00 dBµV	-4,69 dB		N on
1 QP	782 kHz	43,84 dBµV	56,00 dBµV	-12,16 dB		N on
1 QP	930 kHz	44,90 dBµV	56,00 dBµV	-11,10 dB		N on

FIG 4 **Result of an RFI voltage measurement in the range 150 kHz to 30 MHz: preview measurement (graphics: PK+ and AV) and final measurement (graphics and table: QP and AV) with automatic phase switchover of the line impedance stabilization network (Comment column) via the R&S®ESPI test receiver.**

FIG 5 **The Final Measurement Wizard provides both an automatic and an interactive (User Assisted) procedure for the final measurement.**



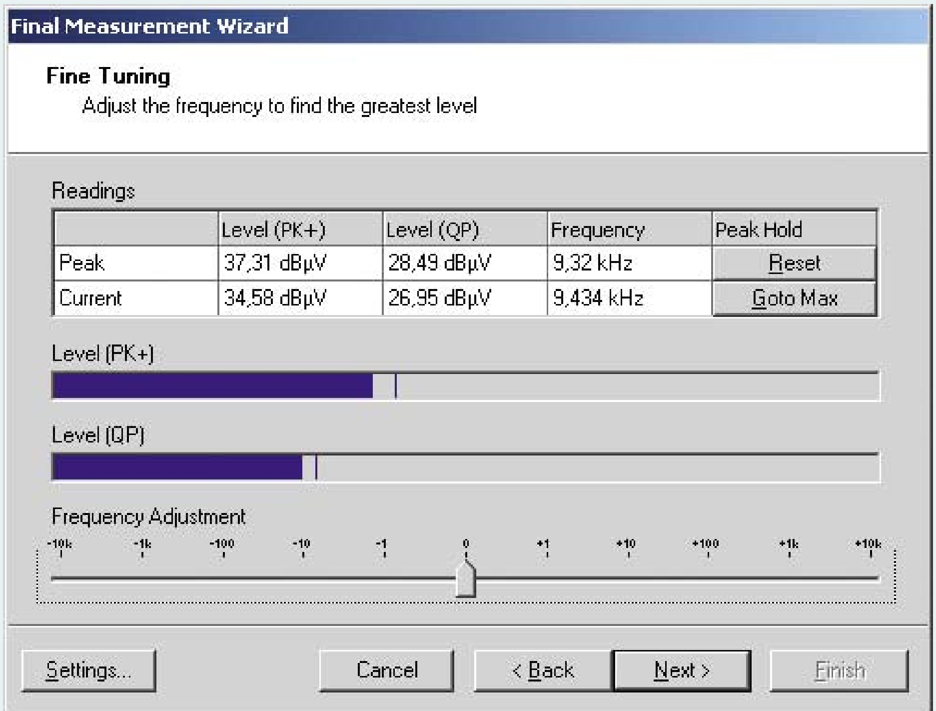
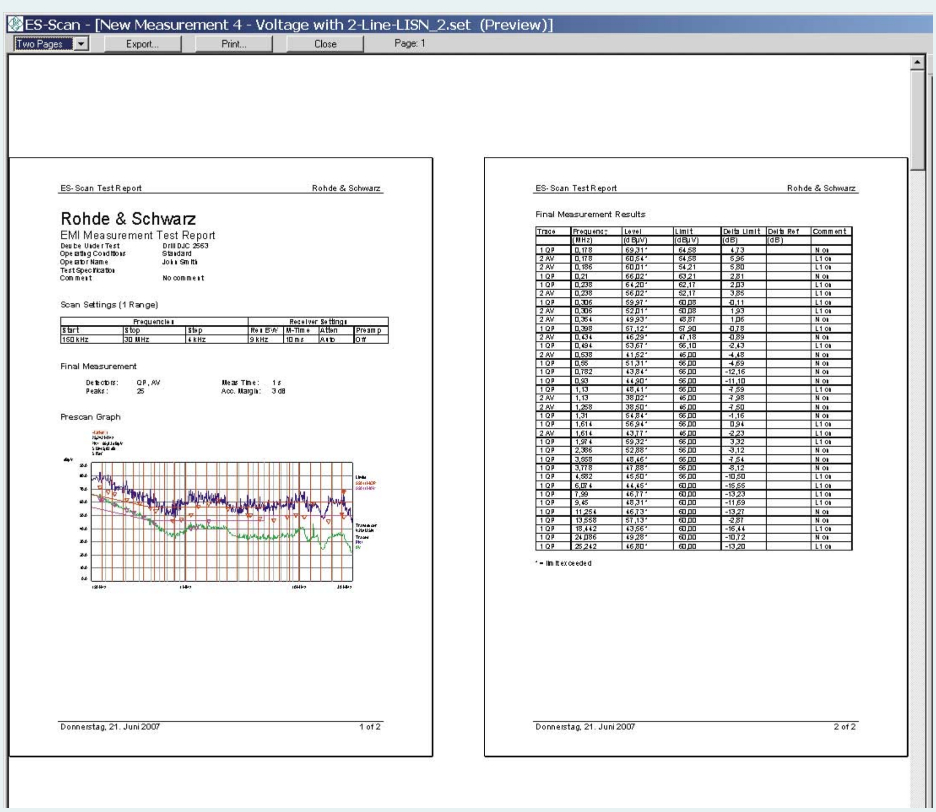


FIG 6 **The Fine Tuning function with its additional Maximum Hold display supports interactive measurements.**

FIG 7 **The Preview function enables the user to review the test reports before they are printed.**



In the absence of a test receiver, the software simulates all functions in the demo mode in which the user may, for example, generate measurement settings, limit lines, transducer tables and reports or evaluate stored measurement results.

Summary

There is frequently the demand for an efficient and economical application software whenever the EMI measurement task at hand is not the final certification of a product but the examination of the EMC properties of a product under development or the preparation of compliance measurements. In this case, the new R&S®ES-SCAN software in conjunction with the R&S®ESPI test receivers represents an excellent solution that makes final certification measurements a pure formality.

Karl-Heinz Weidner

More information and data sheet at www.rohde-schwarz.com (search term: ES-SCAN)

REFERENCES

[1] R&S®EMC 32-E+ EMI Measurement Software: All-purpose software for complete EMI measurements. News from Rohde & Schwarz (2004) No. 184, pp 42–45

[2] R&S®ESPI Precompliance Test Receiver: Multitalent in the development lab. News from Rohde & Schwarz (2001) No. 171, pp 33–38

R&S®NH/NV8600 UHF Transmitter Family

High efficiency reduces energy costs by up to 25%

The new liquid-cooled R&S®NH/NV8600 family of high-power transmitters (FIG 1) for analog and digital TV in band IV/V represents a quantum leap in transmitter technology. The transmitters offer an unprecedented level of cost-optimized, long-term operation. Clearly a new generation of transmitters, they fulfill all major requirements demanded by transmitter operators: maximum power density in a minimum of space – and unsurpassed efficiency.

Amplifiers – opening up a new dimension in power

The liquid-cooled R&S®VH8600A1 power amplifiers (FIG 2) are the core of the R&S®Nx8600 transmitter system. Compared to their predecessor used in the R&S®Nx7000 transmitter family, their power density is significantly greater – 40% higher power per volume, – and they offer 30% higher efficiency. This space- and power-saving design can be attributed to the state-of-the-art LDMOS transistors, which allow such high power

44951/3

FIG 1
The new R&S®Nx8600 transmitter family permits the implementation of transmitter concepts that were not feasible in the past (the figure shows the R&S®NV8610 transmitter with a power of 6 kW for DVB-T).

FIG 2 The liquid-cooled R&S®VH 8600 A1 power amplifier.

density. Various advantages are interwoven here: The optimum transfer of dissipated heat to the coolant decreases the junction temperature and increases the service life by simultaneously reducing flow rate and pump power. The efficiency of the amplifier cooling system is equally impressive.

As with all Rohde & Schwarz amplifiers, the failure of individual components (e. g. transistors) does not affect the transmission characteristic: All power amplifiers and transistors remain exactly in the specified operating point since they are optimally decoupled from each other. As a result, the intermodulation characteristics also remain unchanged, and a precorrection – once set – in the exciter continues to be applied also in these cases and does not have to be corrected.

All operating parameters of the transmitter output stage, e.g. transistor currents as well as forward and reflected power are transmitted to the control unit. These parameters can also be retrieved remotely, which means that any servicing that may be needed can be planned efficiently.

Since a power amplifier usually attains optimum efficiency only at full output power, it has always been relatively uneconomical to operate a transmitter system at reduced output power. This drawback has now been overcome by a special feature of the R&S®VH 8600 A1 amplifier: Its DC parameters (like those of the medium-power R&S®VH 8200 A1 amplifier) can be adapted to power-reduced operation.

For example, if you want an R&S®NV 8610 transmitter system rated for 6 kW DVB-T operation to output only 3 kW, you merely need to set a modified DC mode for all amplifiers by means of a menu in the R&S®NetCCU 800 transmitter control unit. Subsequently, the transmitter efficiency remains largely the same as at full output power.

If an amplifier is replaced, the modified DC parameters are communicated to the new amplifier. No further settings are required – and this also means that no subsequent module-specific adjustments of gain and phase are necessary. Thus, servicing becomes an even easier matter.

Tried-and-tested control components

The new R&S®Nx 8600 transmitter family is equipped with R&S®Sx 800 exciters [1] and the R&S®NetCCU 800 control unit [2] – components that are already successfully used by the well-established air-cooled R&S®NH / NV 8200 transmitter family for the medium-power segment [3]. All digital and analog standards are implemented in the R&S®Sx 800 TV exciters, which occupy only one height unit. The R&S®NetCCU 800 control unit is the command center of the transmitter. It monitors the transmitter components that are connected, handles internal control and communications and is the user interface for the transmitter operator. In remote operation, all transmitter parameters can be set via the Internet (web browser or SNMP agent).

Modular transmitter power

Since the transmitters are modular in design, they can be configured as required by the transmitter operators. Two to ten power amplifiers can be integrated into a transmitter rack and – owing to the excellent decoupling of the power combiners – the operation of the intact output stages is not impaired if one or more output stages fail. All quality parameters remain unchanged.

Like in the R&S®Nx 7000 transmitter family, the amplifier modules can also be replaced during operation. No reassembly work is required since the coolant is routed via quick-release couplers. AC and RF connectors as well as control lines can be plugged and removed automatically.

A harmonics filter integrated in the transmitter, broadband lightning protection (in band IV/ V), and directional couplers compensated for frequency response complement the complete package. The frequency-response-compensated directional couplers do not have to be readjusted when the frequency is changed. Changing the frequency or upgrading the system from analog combined to digital is thus possible without virtually any adjustment.

Of course, transmitter systems with multiple racks for higher output power as well as redundant systems such as active / passive standby and (n + 1) standby are also available.

Engineered for intelligent cooling

When it comes to an efficiency-optimized transmitter system, the overall concept is what really matters – and the cooling system plays a major role here. Rohde & Schwarz has optimized the cooling system, which utilizes the particularly economical electronic commutated (EC) motor system design. Compared to a three-phase motor system, the EC motor system is slightly more expensive but quickly breaks even: It saves power, simplifies the overall concept of the cooling system, and offers additional potential for saving energy. Other advantages include long service life and the use of preselectable operating modes (cooling power, noise generation).

Summary

With the new R&S®Nx 8600 transmitter family, you can implement transmitter concepts that were not feasible in the past: high power density in a minimum of space, easy maintenance, and exceptionally high savings in energy costs due to optimum efficiency. These advantages make future-oriented network planning reliable and may result in significant savings in energy costs (up to 25 %). Moreover, the new transmitters require minimum space (up to 50 % less) and make installation easy. Worldwide service, local contacts, adherence to delivery deadlines, and high quality round out the benefits that come with the R&S®Nx 8600 family of transmitters.

Uwe Dalisda; Friedrich Rottensteiner

More information and data sheet at www.rohde-schwarz.com (search term: NH8600 / NV8600)

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[2] R&S®NetCCU 800 Control Unit: Common control unit for FM and TV transmitters. News from Rohde & Schwarz (2005) No. 188, pp 44–45

[3] R&S®NH / NV 8200 UHF TV Transmitters: Air-cooled transmitters for the medium-power segment. News from Rohde & Schwarz (2005) No. 185, pp 40–42

Condensed data of the R&S®NH / NV 8600

Standards	
Analog	B/G, I, M, N, K
Color transmission	PAL, NTSC, SECAM
Sound modulation	dual-sound in accordance with IRT, mono, stereo, NICAM
Digital	DVB-T/H, ATSC, MediaFLO™, T-DMB, DMB-T, ISDB-T, AVSB, ISDTV
Output power (one transmitter rack)	
Analog combined	1.7 kW to 17 kW
Analog split	2.5 kW to 20 kW
DTV	1.2 kW to 7 kW (depending on MER))
RF connector	EIA 1 5/8" or 3 1/8"
Dimensions (W × D × H)	600 mm × 1100 mm × 2000 mm

Full DVB-T coverage of the Netherlands

After successfully participating in phase 1 and phase 2 when DVB-T was introduced in the Netherlands, Rohde&Schwarz was selected in fall 2005 as the exclusive supplier for the third expansion phase (FIG 1). During this project, more than 105 DVB-T high-power transmitters had to be installed to provide full coverage of the Netherlands.

Go-ahead issued at IBC 2005

The official contract for expansion phase 3 was signed with network operator Nozema in Amsterdam during the International Broadcasting Convention (IBC) in September 2005. The original starting date for the project had to be delayed, however, and the first shipments were then planned for mid-2006. Since the political decision-making process in the Netherlands had to take the shutdown of analog TV transmitters into account, the rollout had to be considerably accelerated in contrast to the original planning since some on-air dates had already been firmly set. Within about a year, Rohde&Schwarz then installed 105 DVB-T high-power transmitters including accessories and put them into operation.

Full coverage owing to flexible transmitter design

The 21 stations were equipped each with a 4+1 transmitter system (four main transmitters to broadcast the programs to four multiplexers and one standby transmitter) in the power range between 400 W and 3.4 kW (FIG 2). Nozema decided to exclusively use the high-power transmitters of the R&S®NV7000 family from Rohde&Schwarz since their flexible design can handle different power levels within a 4+1 system. This is essential in the Netherlands as the range can vary greatly depending on the channel. The fact that individual transmitter models can be easily upgraded to handle other power levels is a further important feature. It proved to be beneficial throughout the project as the coverage planning frequently had to be changed – especially due to the results of the Regional Radio Conference (RRC) in Geneva.

Turnkey shelter solutions

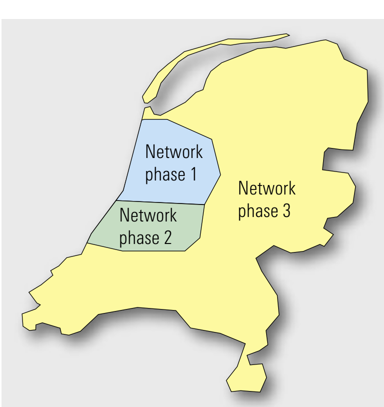
Fourteen of the 21 stations had to be provided in shelters. Rohde&Schwarz was in charge of planning and presented turnkey solutions to the customer. The transmitter systems including the cooling equipment and accessories were accommodated efficiently and in an easy-maintenance manner in double-unit shelters. The shelters had a floor space measuring 3 m × 7 m and were joined together on site to form a transmitter room (FIG 3). The size of and equipment in the shelters are specially adapted to customer requirements. All shelters were fully preassembled in Germany. The only work that had to be done on site was to join the two shelter halves and to install the heat exchangers outside.

Comprehensive project handling with up to three teams

The project involved a lot more than the mere delivery of transmitters. Rohde&Schwarz examined the stations in advance and – based on its findings – planned the station upgrading, which it documented thoroughly for the customer.

The supplying of materials had to be coordinated in the next step. In addition to the actual transmitters, the various subcontractor products also had to be handled. The accurate coordination helped ensure that all components required for the individual stations were always supplied together. Owing to careful installation planning, it was

FIG 1 Coverage area of the DVB-T network in phase 3.



possible to set up the transmission systems quickly. Following their installation, they were put into operation by Rohde & Schwarz engineers trained for this purpose. Up to three installation and system startup teams were on the ground in the Netherlands during the busiest phases of the project in order to move things along rapidly.

Additional offer for DVB-H

In the course of the project, the customer decided to use a further multiplex for DVB-H operation and contracted Rohde & Schwarz to add one transmitter to each of the stations equipped in phase 3. To handle this task as efficiently as possible, Rohde & Schwarz readied the stations for the additional multiplex even before the actual DVB-H rollout was started. The combining and switching system, for example, was equipped at the start for an additional channel in order to minimize downtimes for further expansions. The first DVB-H transmitters were shipped while the DVB-T rollout was still in progress. The last shelter was supplied in fall 2007.

Robert Bleicher; Simone Gerstl

Photo: authors

FIG 2 **Front view of one of the 5+1 DVB-T/DVB-H transmitter systems.**

FIG 3 **Two shelters were combined on site to create a single transmitter room.**

Photo: authors

The first T-DMB broadcast network in South Korea

T-DMB is in the process of revolutionizing transmitter technology in South Korea: A state-of-the-art broadcast network derived from the "old" DAB technology is now using a new encoding method to transmit moving pictures to mobile devices. This is the world's first T-DMB network and it uses broadcasting equipment from ROHDE & SCHWARZ FTK GmbH.

Photo: FTK

Three T-DMB transmitter stations on the mountains around the capital city of Seoul ensure coverage.

Following a successful test deployment in 2005, South Korea decided to set up a nationwide network. During the initial stage of deployment, the region around the capital city of Seoul was equipped with T-DMB transmitters. The network operator Korean Broadcasting System (KBS) initially ordered liquid-cooled T-DMB high-power transmitter systems. This was followed by additional orders for transmitters from the R&S®NA / NL 6000 series with air cooling as well as the R&S®NA 7000 series with liquid cooling. The operators are continuing to expand the country's network with full nationwide coverage expected by 2009. Rohde & Schwarz is supplying the broadcasting equipment for all six T-DMB networks.

T-DMB transmitters from Rohde & Schwarz

	R&S®SLA 8000	R&S®NA 6000	R&S®NL 6000	R&S®NA 7000
Frequency	VHF band III	VHF band III	L band	VHF band III
Output power	75 W to 300 W	150 W to 2500 W	115 W to 1600 W	900 W to 7200 W
Cooling	air	air	air	liquid

Digital multimedia broadcasting (DMB) allows transmission of television programs to mobile devices such as mobile phones, handhelds and pocket PCs. The information is transmitted in MPEG-4 AVC format via digital audio broadcasting (DAB). A DAB data stream contains a bouquet with up to three TV programs, each of which can be encoded using a data rate of up to 700 kbit/s. In South Korea, DAB frequencies were available in band III, and thus ready for use.

ROHDE & SCHWARZ FTK GmbH with 80 employees in Berlin is well acquainted with the new technology due to its many years of experience with audio broadcasting, datacasting and R&D services. It began business in 1992 with transmission systems for FM and later added DAB. In 2000, South Korea became interested in digital broadcasting. Jens Stockmann, product manager at Rohde & Schwarz FTK, recalls: "DAB in South Korea? That made me curious. The DAB standard had been developed in Europe in the 1980s and by 2000 had reached a low point in Germany. And now South Korea was interested in it."

But it was more than mere interest. The South Koreans adapted the idea behind DMB and enhanced the technology on the basis of new coding methods. The result was the South Korean T-DMB standard, and Rohde & Schwarz FTK got involved again. "What impressed me was the South Korean government's broad support for driving this development", says Stockmann. The standard was nearly finished when a T-DMB test run was to be performed in Seoul. Two major manufacturers, Samsung and LG, developed the required receivers.

Elsewhere Rohde & Schwarz was involved in the introduction of DAB right from the start. The company played an active role in the early days in Germany and in many other European countries such as Great Britain and Belgium. The equipment and the know-how for the entire DAB transmission path were available. Suitable equipment was available in the form of T-DMB transmitters with their wide range of output power and the liquid-cooled transmitters with high output powers and compact dimensions.

KBS was also the first broadcast operator interested in implementing this technology. A delegation from KBS did very extensive research, traveling across Europe and contacting a number of institutions, companies and network operators to obtain detailed information about DAB and investigate the possible partners. The delegation visited Rohde & Schwarz again to discuss the specifications in greater detail. At the same time, Rohde & Schwarz expanded its South Korean office and was able to provide the necessary on-site assistance. After all, a broadcasting network operator that has to be on the air 24 hours a day needs direct contact to support and service with rapid access to spare parts.

The city of Seoul has a population of over 10 million and lies in a valley. To suit this topography, three transmitter stations were set up in the neighboring mountains, ensuring full coverage of the region. The equipment was transported by a funicular railway and helicopters. The T-DMB transmitters and all the associated system components were customized to suit local conditions. The existing buildings saw optimal usage due to the space-saving, flexible design of the equipment. The transmitter systems were connected to existing antenna installations, and the GPS antennas were positioned for free reception to suit local conditions. Other broadcasters can be smoothly integrated into the system. One challenge, however, was related to the very close spacing of transmit frequencies in adjacent DAB channels.

The cooling systems were specially adapted to handle the climatic conditions so that operations would not be impaired by cold weather or high temperatures. Due to space constraints, some cooling units/aggregates were housed separately from the transmitters outside of the buildings. For this reason, additional pumps were necessary. All of the transmitters were implemented with passive standby to ensure high failsafety. Rohde & Schwarz has also developed a special redundant system of combiners to further increase reliability.

Depending on the region, the broadcasters provide at least three video programs as well as numerous audio programs and data services. The TV broadcasters are committed to developing new content that is different from normal TV programs. The main focus is on the needs of the different users and their mobility. In South Korea, T-DMB programs are currently free of charge to everyone and many types of receivers are available. Besides mobile phones, there exist integrated solutions for navigation devices and handheld computers.

The new broadcast system has enjoyed a successful startup in South Korea, and this trend is expected to continue. For example, there has been regular T-DMB service in the L band in 17 major cities in Germany since Football World Cup 2006.

Elke Schulze

Rohde & Schwarz customers in South Korea have been very happy with the development of the T-DMB project so far. During the launch celebration held by operator U1media, Rohde & Schwarz received an award for outstanding service during the installation phase. This award also cited the excellent cooperation between Rohde & Schwarz FTK, the production facility in Teisnach and the on-site team.


ROHDE&SCHWARZ
SFE · BROADCAST TESTER
FREQUENCY
474.000 000 MHz
-30.0 dBm
DVB-T/H
8K
NOISE
OFF
SELECTION
FAVORITES
FREQUENCY
LEVEL
MODULATION
DIGITAL TV
INPUT SIGNAL
CODING
SPECIAL
SETTINGS
NOISE
CHANNEL BANDWIDTH
USED BANDWIDTH
FFT MODE
GUARD INTERVAL
DVB-H STATE
SYMBOL INTERLEAVER
HIERARCHY
CONSTELLATION
NON HIERARCHICAL
RF ON/OFF
MOD ON/OFF
SET TO STANDARD
ERROR DETAILS
USB
RF OUT 50 Ω
MENU
TV

45066/1

Compact signal generator for all current broadcasting standards

Multistandard realtime coding, integrated baseband source, excellent RF characteristics – all this in a compact box with a convenient graphical user interface. The new R&S®SFE broadcast tester offers all important functions of a state-of-the-art broadcast signal generator – at a favorable price.

Signal generators for state-of-the-art broadcasting

The conversion to digital TV has created a boom in consumer electronics. More and more innovative products are being launched: from the HD-ready LCD TV set with integrated DVB-T / DVB-C receiver, PCMCIA cards, and USB sticks to the portable media player and mobile TV phone. To keep pace with this development, you need specially optimized signal generators. With its high-end R&S®SFQ and R&S®SFU broadcast signal generators, Rohde & Schwarz has been successful for many years in this market segment. As digital TV receivers evolve from an exotic high-tech device to a mass-market product, the requirements that instrument and component developers place on signal generators also change. In addition to the high-end test system for development, an increasing number of simpler and cost-efficient instruments are required that can be used not only in the laboratory, but also in quality assurance, service, and production.

Rohde & Schwarz meets this challenge by offering its new signal generator for broadcasting standards – the R&S®SFE broadcast tester (FIG 1), a compact yet powerful multistandard generator at an attractive price. Despite its reduced scope of functions and smaller size, the R&S®SFE largely maintains the successful concept of the high-end R&S®SFU.

Many standards – one signal source

Analog television systems offer a variety of different transmission methods. In addition to the three color transmission systems PAL, NTSC, and SECAM, a number of standards such as B/G, D/K, I, M/N, and L/L' are used. When combined with the different sound

FIG 1
The R&S®SFE generates all signals for analog or digital terrestrial TV, cable TV, satellite TV, and mobile TV, or digital sound broadcasting.

FIG 2 Overview of the most important digital broadcasting standards.

Transmission	Standard	Europe	North America	South America	Asia	Australia	Africa
Terrestrial TV	DVB-T	●				●	●
	ATSC / 8VSB		●				
	ISDB-T			●	●		
	DTMB				●		
Cable TV	DVB-C	●					
	J.83/B		●				
	ISDB-C				●		
Satellite TV	DVB-S	●			●		
	DVB-S2	●			●		
	DirecTV		●	●			
Mobile TV	DVB-H	●	●			●	●
	T-DMB	●			●		
	ISDB-T 1 seg				●		
	DMB-TH				●		
	MediaFLO™		●				
Sound broadcasting	DAB	●				●	
	DRM	●					
	ISDB-Tsb			●	●		

transmission systems, you have to cope with an almost unmanageable number of TV standards.

Anyone who thought that digital TV would simplify matters now knows that things turned out to be quite different: There are different transmission methods for satellite, cable, terrestrial, and mobile TV due to technical reasons, and the individual countries have totally different standards in some cases (FIG 2).

This presents quite a problem for the instrument and component manufacturers who want to produce for the world market: They have to provide a number of different test signals both in development and in production. The solution can be found in multistandard signal generators such as the new R&S®SFE broadcast tester. It has a powerful universal hardware platform for baseband signal processing, allowing you to switch between the various transmission standards by reloading FPGA firmware.

FIG 3 shows three typical TV signal spectra generated by the R&S®SFE. The baseband signal is coded in realtime so that video sequences of any length can be transmitted without interruption. Modulation parameters such as constellation, FFT mode, and code rate can be set irrespective of the transport stream to be transmitted. You can thus switch quickly and easily between the different transmission standards and select any conceivable configuration of the standard.

From the IF to the S band: The RF section is the key

Digital signal processing is definitely important, but the key component of the signal generator is the RF section. The RF section of the R&S®SFE consists of a high-stability synthesizer, a broadband I/Q modulator, and an electronic attenuator.

With a frequency range from 100 kHz to 2.5 GHz, the R&S®SFE covers all bands that are relevant for broadcasting applications: IF, VHF, and UHF as well as the L band, and the lower part of the S band, which are becoming increasingly attractive for future broadcasting services.

The dynamic range of the output level (100 dB) allows you to test the complete drive range of a receiver – from the sensitivity threshold up to saturation. The generator uses a totally wear-free electronic attenuator that enables a practically unlimited number of switching cycles. This is a significant advantage for applications in production where downtimes would involve high costs.

Modern COFDM modulation methods place high demands on the stability and spectral purity of the oscillator signal. The RF synthesizer of the R&S®SFE sets new standards in its class. Not only the low SSB noise but also the low broadband noise and excellent harmonic suppression of the generator are impressive. The R&S®SFE thus attains the required high modulation error ratio (MER) of more than 40 dB (FIG 4).

MPEG-2 player and ARB generator incorporated

To generate a test signal with specific contents, e.g. a test pattern, you need a baseband signal which is modulated to the RF in accordance with the selected transmission standard. Digital broadcasting standards use transport streams as a baseband signal. Most of the methods implement the widely used MPEG-2 format. But there are also other formats such as the ETI format for T-DMB and DAB or proprietary formats, e.g. those used by the American satellite operator DirecTV. For analog TV, on the contrary, you need an audio/video baseband signal in CCVS format. As a baseband source, you would thus need at least one transport stream generator for digital TV and one test pattern generator for analog TV. Since the R&S®SFE allows you to integrate both an analog and a digital baseband generator, the number of instruments required is clearly reduced.

Rohde & Schwarz also offers a large number of signal libraries for digital and analog TV standards. They include test patterns and test sounds as well as live audio and video sequences. FIG 5 shows a typical HDTV test pattern and the FuBK test pattern known from analog TV, both of which can be generated by the R&S®SFE. All the functions starting from baseband signal generation and coding to RF modulation are thus provided by a single instrument. The integration of a high-quality RF generator and a powerful baseband signal source is the main benefit of broadcast signal generators from Rohde & Schwarz.

The R&S®SFE can also use an arbitrary waveform generator (ARB) as a baseband signal source. In this case, you benefit from a variety of additional applications since the ARB generator can generate signals irrespective of the installed realtime coders. Any signal form is possible, limited only by the sample rate and the memory depth of the ARB generator and the bandwidth of the I/Q modulator.

The baseband signal must be available in the form of an I/Q waveform file, which can be calculated, for example, with the R&S®WinIQSIM™ simulation software or with common commercial software tools such as MATLAB®. Yet, things can be done a lot more easily: For the ARB generator, Rohde & Schwarz offers a variety of signal libraries with complete test signals for many applications.

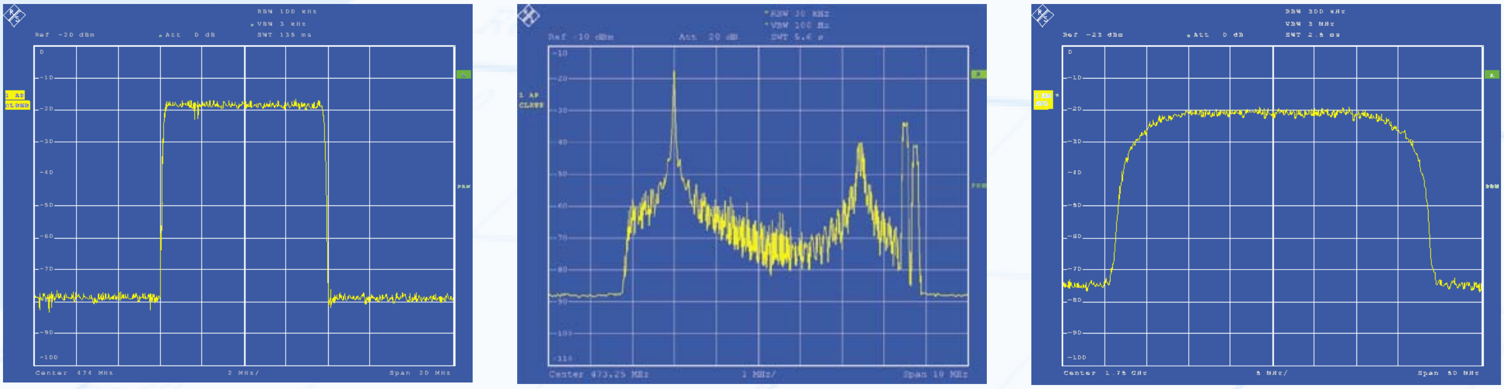
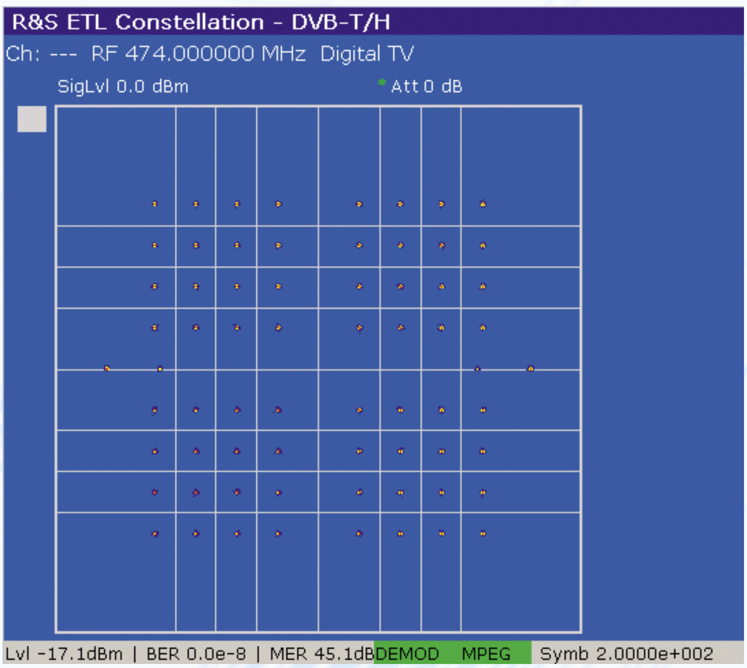


FIG 3 Analog and digital TV signal spectra – the R&S®SFE can generate them all.

FIG 4 DVB-T constellation diagram of the R&S®SFE with very high MER.



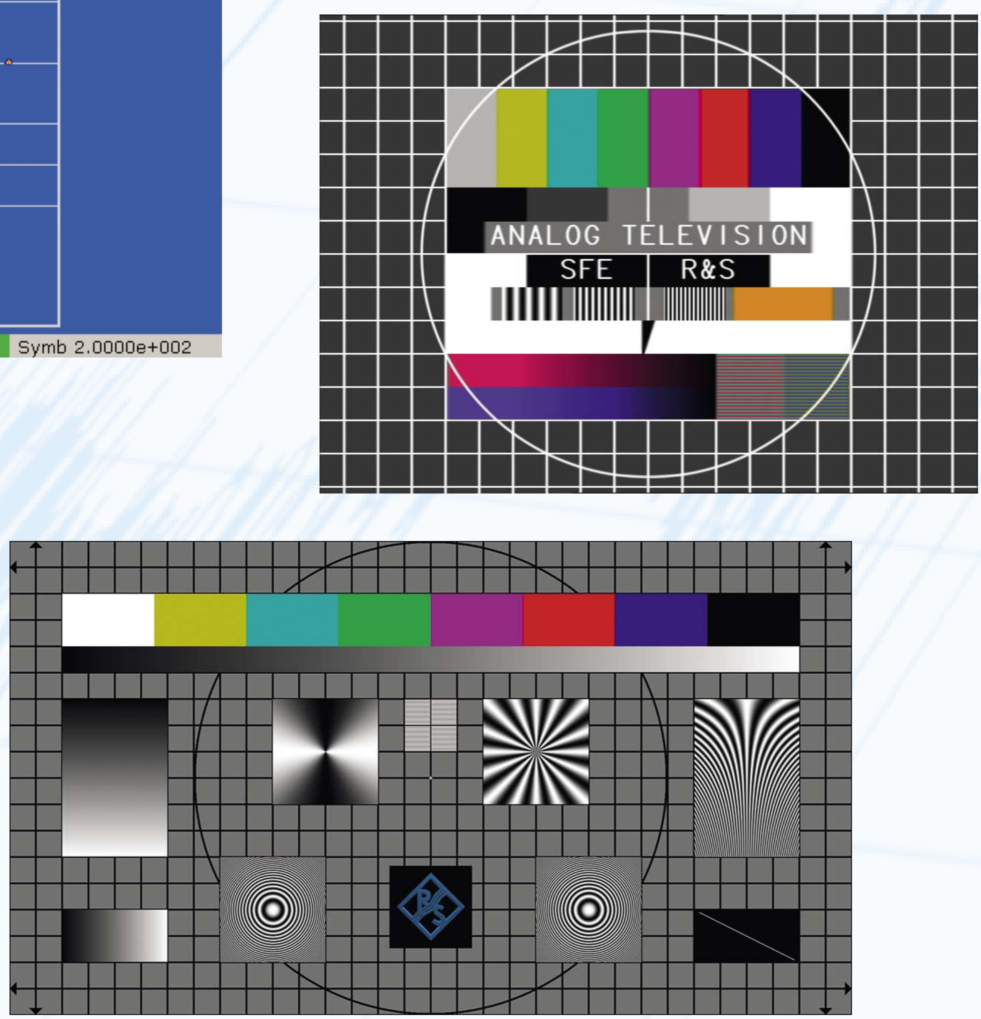


FIG 5 Test patterns for analog and digital TV originating from the signal libraries from Rohde & Schwarz.

Optional noise source and BER measurement

When developing and testing receivers, you must check the impact of additive white Gaussian noise on the receiver function. To do so, the R&S®SFE can be equipped with a broadband noise source so that the S/N ratio of the output signal can be set over a wide range (FIG 6).

Another optional feature, the bit error ratio (BER) measurement, allows you to upgrade the generator to form a simple but powerful receiver test system. To measure the BER, the R&S®SFE makes use of a baseband signal with a pseudo random bit sequence (PRBS) as payload. Either the demodulated bit stream or the decoded transport stream can be looped back from the receiver under test to the R&S®SFE which automatically determines the number of corrupted bits. FIG 7 shows the BER measurement principle using the R&S®SFE. The noise generator and the BER measurement function now enable you to record the familiar BER-over-C/N curves for a receiver – with only a single measuring instrument.

Tried-and-tested concept in a new form

Since the R&S®SFU broadcast test system has proven very successful throughout the last two years, it has gained a certain reputation as a reference instrument for broadcast receiver testing. The R&S®SFE has similar characteristics and will continue this success. Special care was placed on adopting the successful R&S®SFU concept as far as possible. The result is obvious: The R&S®SFE looks like the little brother of the R&S®SFU. Despite its compact design in ½×19" housing, the R&S®SFU operating concept including keypad, rotary knob, hardkeys, and softkey was fully duplicated. The graphical user interface is also identical, both on the large, easy-to-read color display and for remote control via a PC (FIG 8). Users already familiar with the R&S®SFU will be able to operate the R&S®SFE immediately and without any additional training. And what is even more: The remote-control commands of the two instruments are also compatible.

Software options for quick and easy expansions

The R&S®SFE broadcast tester is fully modular in design. Both the realtime coder for the various transmission standards and the additional features such as baseband generators, noise source, or BER measurement are implemented as software options. You can enable these options any time on site by entering a license code. Cumbersome hardware modifications, which may have a negative impact on the calibration of the instrument, are not required. As far as application and functions are concerned, the R&S®SFE can be easily adapted to meet specific customer requirements – now or in the future.

Peter Lampel

The "inconspicuous" feature: remote-control compatibility

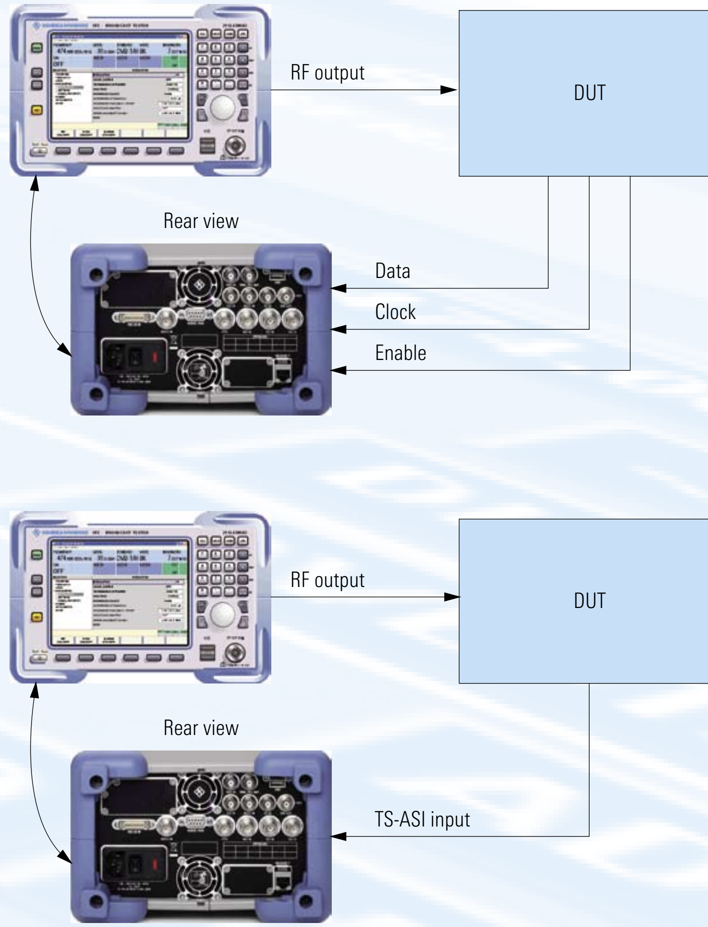
The R&S®SFE can be remote-controlled via a LAN in accordance with the VXI11 protocol. The same SCPI control commands are used as in the programs written for the R&S®SFU in the development laboratories. You can thus use the test programs written for the R&S®SFU in the new R&S®SFE, which can be easily integrated into production test systems.

More information, brochure and data sheet at www.rohde-schwarz.com (search term: SFE)

R&S®SFE brochure

R&S®SFE data sheet

FIG 7
BER measurement principle using the R&S®SFE.



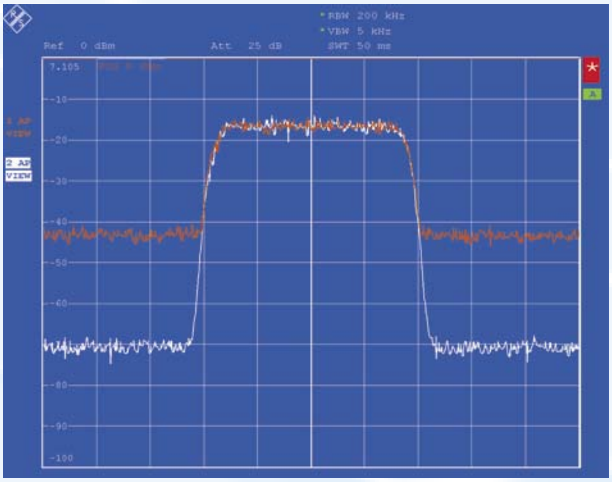


FIG 6 Signal spectrum with and without additive white Gaussian noise.

FIG 8 Remote control of the R&S®SFE via a PC.

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R&S®DVM 400 Digital Video Measurement System

T&M equipment for IPTV

The Gigabit Ethernet interface option for the R&S®DVM 400 digital video measurement system monitors and analyzes IP connections and makes the contained transport streams available for additional measurements.

IP-based networks distribute TV programs

IP-based networks already common in the telecommunications area are increasingly being used to distribute TV programs – not only for direct transmission to the consumer or TV transmitter / cable headend but also for local connections between transmission equipment. Rohde & Schwarz has taken this into account by its new Gigabit Ethernet interface option for the R&S®DVM 400 digital video measurement system (see box below).

Applications of the Gigabit Ethernet interface option

The new Gigabit Ethernet interface option as well as the R&S®DVM 400 monitor and analyze IP connections and the contained transport streams. The option is, for example, suited to monitor IP networks handling signal contribution (FIG 2) – i. e. the feeding of TV signals to distribution stations – or to analyze the signals at the IP interfaces of digital TV signal processing equipment (e. g. encoders or multiplexers).

Functionality

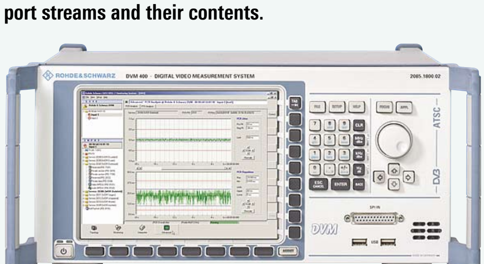
The new interface is a hardware option completely embedded in the monitoring and analysis application of the R&S®DVM 400. The system's entire signaling and alarm functionality has thus been made available including report entries, error counter, SNMP traps and visual representation. Various signal properties such as MDI (FIG 3), jitter and data rate are analyzed in realtime. The system automatically monitors all signals of a Gigabit Ethernet up to the full bandwidth and indicates the measured values in a table (FIG 4). In addition to monitoring IP connections, it graphically displays the measured values of a selected IP data stream (FIG 3).

IPTV – moving pictures via IP networks

Numerous articles and specifications are dealing with the IPTV topic. However, an unambiguous definition or a commonly recognized standard is still missing although a heterogeneous variety of offers already exists: It ranges from streaming short low-resolution video clips to PCs over the Internet up to transmitting TV programs to Ethernet-capable set-top boxes via wideband DSL connections. In addition, network operators are using this technology in their backbones to provide TV signals to their transmitters or cable headends, for example.

R&S®DVM 400 digital video measurement system

FIG 1 The R&S®DVM 400 digital video measurement system is a portable instrument to measure MPEG-2 transport streams and their contents.



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In addition to general transport stream monitoring and analysis, the R&S®DVM 400 (FIG 1) also supports the detailed analysis of elementary video and audio streams (MPEG-2, H.264 / MPEG-4, AAC and AC-3), of diverse data services and of DVB-H-specific properties including time slicing. Extensive additional functions such as recording, generation and playback of transport streams as well as video decoding and streaming are also provided. Various interfaces for the different digital TV standards including the new DVB-S2 satellite standard make it a universal measuring instrument for digital TV. Despite its great variety of functionalities the R&S®DVM 400 features compact size and low weight, which makes it also ideally suited for portable use. Its new Gigabit Ethernet interface now also allows you to perform measurements in IPTV systems.

FIG 2 An example of five typical DTV network test points at which the R&S®DVM 400 with its various interfaces and its capability of monitoring multiple signals in parallel can very well be employed. The IP data stream and the DVB-T signal are monitored at test points 3, 4 and 5. The DTV feeds are additionally monitored at test point 1.

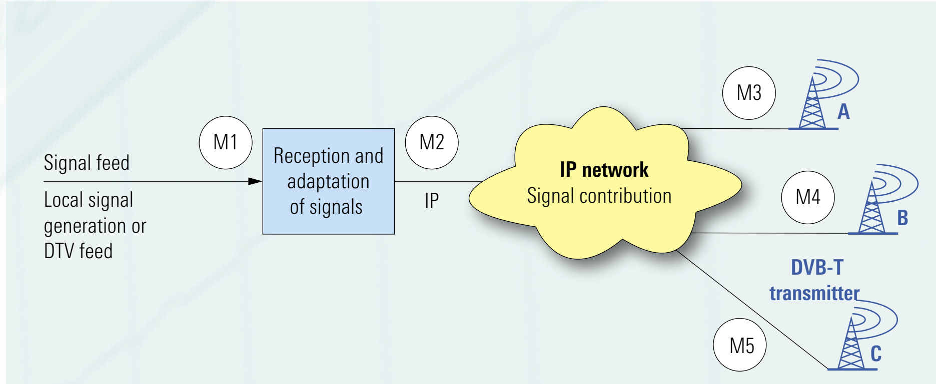


FIG 3 Detailed visual representation on the R&S®DVM 400 of the measured IP values for a selected connection. The MDI (delay factor and loss rate) versus time (upper part) as well as various other details (lower part) are displayed.

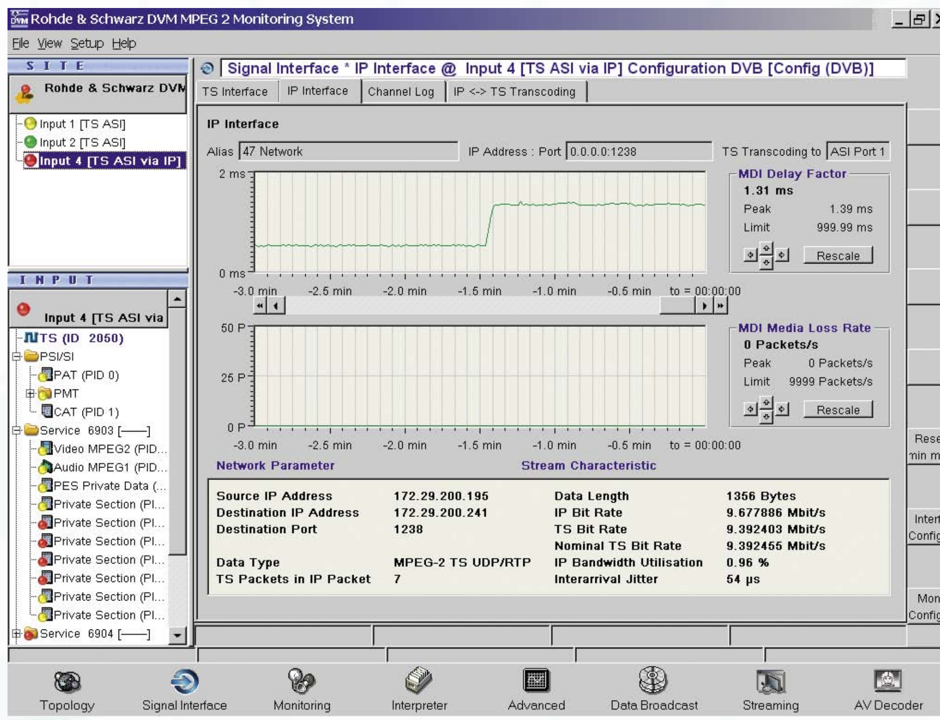


FIG 4 Tabular representation on the R&S®DVM 400 of the values measured on all monitored IP connections.

IP Channel Log

	1 Channel 8	2 IP Channel	3 **47 Network**	4 Channel 52	5 Fast Network	6 Free TV
IP to TS Transcoding	to ASI Port 2	to ASI Port 1	to ASI Port 3			
Source IP Address	172.29.200.195	172.29.200.195	172.29.200.195	172.29.200.195	172.29.200.195	172.29.2(
Destination IP Address	172.29.200.241	172.29.200.241	172.29.200.241	172.29.200.241	172.29.200.241	172.29.2
Destination Port	1236	1234	1238	1232	1230	
Protocol	UDP/RTP	UDP/RTP	UDP/RTP	UDP/RTP	UDP/RTP	UDF
Data Type	MPEG-2 TS	MPEG-2 TS	MPEG-2 TS	MPEG-2 TS	MPEG-2 TS	MPEG
TS Packets in IP Packet	7	7	7	7	7	
Data Length [Bytes]	1356	1356	1356	1356	1356	
IP Bit Rate [Mbit/s]	3.252474	34.817886	9.679189	.252474	34.817886	34.8
TS Bit Rate [Mbit/s]	3.156530	33.790810	9.393667	6.156530	33.790810	33.7
Nominal TS Bit Rate [Mbit/s]	3.156534	33.790808	9.392905	6.156534	33.790808	33.7
IP Bandwidth Utilisation [%]	0.32	3.48	0.96	0.32	3.48	
MDI DF (peak) [ms]	3.54 (3.56)	0.52 (0.53)	1.34 (1.39)	6.54 (3.56)	0.32 (0.53)	2.52
MDI MLR (peak) [TS-Pkt/s]	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
Interarrival Jitter (peak) [µs]	48 (6919)	488 (5659)	52 (626)	58 (3919)	88 (569)	38
Last Update	12:39:14	12:39:14	12:39:14	12:39:14	12:39:14	12

Measuring the media delivery index (MDI)

In the area of TV measurements, the MDI is measured in order to assess the transport quality of a network. It is represented by two measured values separated by a colon: MDI = DF : LR (delay factor : loss rate). The delay factor defines the maximum delay of a byte received in the receive buffer based on a constant output data rate in one measuring interval (compensation of the irregular transmission times of individual packets). The loss rate indicates the number of packets lost per measuring interval. The measuring interval is usually one second for the two values.

Abbreviations

DF	Delay factor
DSL	Digital subscriber line
IGMP	Internet group management protocol
IPTV	Internet protocol television
LR	Loss rate
MDI	Media delivery index
RTP	Realtime transport protocol
RTSP	Realtime streaming protocol
TCP	Transmission control protocol
TS	Transport stream
UDP	User datagram protocol
VoD	Video on demand

The option can extract the transport streams of three IP connections at the same time and feed them directly to the R&S®DVM400 via the ASI interfaces for monitoring and analysis. A special feature of the option is its capability to "stream" the transport streams via the Gigabit Ethernet interface, i.e. to forward them to any location in the network for further analysis or for decoding the contained TV programs, for example. These transport streams may either be received via the IP network or input locally via the ASI interface. Even transport streams that the R&S®DVM400 has received via the RF options (e.g. DVB-T or DVB-S2) can be streamed.

As the R&S®DVM400 can be equipped with a transport stream generator, it may also be used as a "TS over IP" generator. Both RTP via UDP and pure UDP are supported for this application.

Thomas Tobergte

More information and data sheet at www.rohde-schwarz.com (search term: DVM)

Principles of transmission in IP networks

Transport

IP networks transmit data in separate packets. Usually data of different applications is transmitted on the same network so that it must occasionally share network sections dynamically. Moreover, single packets of a specific application can be transported through the network using different routes (via different nodes). It may therefore occur that the packets of a specific application transmitted through IP networks arrive at irregular times at their destination, that the sequence of the packets changes and even that some packets are lost in case of temporary local network overload. The intensity and frequency of these effects may fluctuate depending on network load and situation.

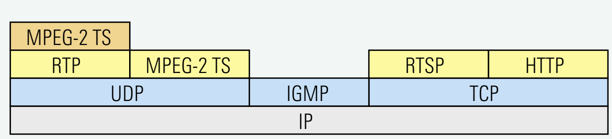
To transport data through IP networks in realtime, e.g. video or audio programs, the user datagram protocol (UDP) is almost exclusively used. This protocol has a short overhead, and because it is a connectionless protocol (unlike e.g. the TCP) it does not require control mechanisms such as packet retransmissions. On the other hand, it does not guarantee the completeness of the data packets arriving at the addressee. To counteract at least certain irregularities such as wrong IP packets at the receiver end or highly irregular transmission rates, the application layer mostly employs an additional control protocol. This is usually the RTP, a protocol governing temporary buffering and, if required, sorting of data packets. FIG 5 provides an overview of the protocol layers.

Signaling

Current network technology allows each terminal to be provided with an individual signal; each consumer can therefore receive their own TV program. As a consequence, the network load increases in proportion to the number of viewers. Possible network overload is prevented by the multicast method that transmits programs designated for multiple consumers only once on common network sections. This, however, is only possible on the basis of uniform starting times (thus assuming that the viewers watch the programs at the same time). To receive such programs, the terminal must join a multicast group enabled by the IGMP.

The RTSP is used to control VoD applications in which every viewer receives his / her "own" signal. The respective programs are transmitted to the consumer as unicast.

FIG 5
The protocol layers in IP networks.



Efficient and to the point: monitoring of digital TV signals (2)

Part 1 of this two-part article – published in number 192 – explained how to determine monitoring points in digital TV networks plus the measurements that have to be performed. Part 2 now explains the requirements placed on state-of-the-art monitoring instruments and shows that efficient monitoring requires not only the measurement functions but many other instrument characteristics as well.

User-friendly: One instrument performs all tasks

In Part 1 of this article, the section "Measurements in practical applications" (page 46 in number 192) gave a detailed overview of the measurement functions required when monitoring digital TV signals. Since these different measurements may involve the monitoring of RF characteristics, the transport stream, and perhaps even individual programs or data services, etc., it is particularly beneficial if you can perform all of them simultaneously and with only one instrument. This considerably simplifies configuration and operation since you have to become familiar with only one user interface. Moreover, it is much easier to integrate only one instrument interface into computer networks.

A clear advantage: high-end measuring equipment

Measurement values should only be compared if they were determined in compliance with standards. Especially data rate and PCR jitter measurements frequently reveal that measurement methods applied by different manufacturers are incompatible. Some manufacturers do not even indicate them. The various instruments clearly differ if you concentrate on the accuracy of RF measurements. Any shortcoming in this respect can be disadvantageous. If you want to determine the MER, for example, this important measurement must detect the slightest change in a signal (which might indicate that a failure is about to occur) at the transmitter end as early as possible. Doing so will enable you to respond in due time and minimize downtimes. Only high-end instruments offer the dynamic range necessary for performing this sophisticated measurement.

Configuration: maximum flexibility and capability

Monitoring is considered to be efficient if all true errors are detected and no false alarms are triggered. However, monitoring tasks vary greatly and the definitions of errors or false alarms are not necessarily standardized. A precondition for efficient monitoring is that you can configure monitoring functions to meet individual requirements and adapt them to each signal.

Monitoring instruments should allow you to activate each measurement individually and to adapt the limit values for alarm generation. To make the interpretation of measurement results easier, it is useful to be able to classify the individual measurements, e. g. in "Alarm", "Warning", or "Info". This classification can then be used by the monitoring instrument or the external software for all further signaling options, e. g. for class-specific icons on the graphical user interface, filter criteria in SNMP traps, and explanations in reports.

Indispensable: in-depth configurability

In-depth configurability is required particularly at the transport stream level, e. g. when a network operator transmits additional data in unreferenced transport stream packets with known PIDs. These PIDs are of course not supposed to provoke the error message "unreferenced PID". But the monitoring instrument must indicate other unreferenced PIDs in the transport stream as erroneous. The situation is similar when the transport streams transmitted by a

Abbreviations

MIB	Management information base
MER	Modulation error ratio
PID	Packet identifier
PCR	Program clock reference
SNMP	Simple network management protocol

network operator include known, sporadic errors that are to be ignored as long as they only last for a specified period of time. Otherwise, too many alarms would be triggered.

State-of-the-art monitoring systems such as the R&S®DVM digital video measurement system from Rohde & Schwarz allow you to define a period of time for a measurement during which detected errors are to be "hidden". The PIDs of the transport stream packets concerned can also be entered. FIG 1 shows the configuration of the "Hiding of Events" function provided by the R&S®DVM for such cases.

Template monitoring

When using the template monitoring function described in Part 1 (pages 47/48 in number 192), you have to store numerous characteristics of the signals to be monitored. Since template creation is very time-consuming, things should best be kept simple and easy. The most convenient way would be to let the monitoring instrument do this. The signal is fed to the monitoring instrument for analysis purposes and the template is automatically created based on the data obtained. An additional editing function is required for manual modifications. FIG 2 shows the editor of the R&S®DVM with an open template. The automatic template creation function can directly be accessed from the editor. It is started with the "Create Template from current TS "Golden Stream" …" key.

Since the time-specific structure of transport streams may vary, the monitoring instrument must be able to automatically switch between different templates. This should be supported by the remote-control interface and a Scan mode provided by the instrument.

Scan mode

If you do not have a budget to buy monitoring systems that are able to monitor all signals at the same time, you can monitor the signals one after the other using one measurement and demodulator unit. The unit must be equipped with a function to allow the time-based switchover of modulation parameters and of the complete measurement configuration. This mode, which is referred to as the Scan mode, calls for options for setting a time-specific sequence and for defining multiple measurement configurations. This mode can also be used if the transport stream structure of the same channel changes on a time basis.

State-of-the-art interface reduces effort

When you have such a large number of functions and related configuration options, you need a perfectly intuitive operating concept. This includes context-sensitive menus and convenient Help functions which make operation easier. The user interface should be similar to conventional standard software so that no extra effort is required in order to become familiar with the instrument. Information must be clearly displayed in one window at a defined screen position and should not be spread over several windows. Another important aspect is that the overall status of each measured signal is permanently displayed even if detailed results are being displayed or in-depth analyses are being performed.

Alarm generation over any distance

If errors occur in signals, you have to be informed immediately and in complete detail. This allows you to quickly respond in case of emergency. An alarm can be indicated, for example, by a clearly visible graphical display on the screen. If alarms are triggered in another room, e. g. via acoustic or optical signaling devices, the monitoring instrument must be equipped with relay contacts. If the monitoring instrument is at a remote location, it must be equipped with a network interface including the corresponding protocol to trigger alarms. The SNMP protocol is used as standard.

Wide variety of report functions facilitate operation

All errors detected by the monitoring instrument must be recorded and automatically archived to help ensure a detailed analysis or in order to provide proof for contracting partners. In combination with advertising contracts, for example, you can thus prove the availability of a system. Sorting and filtering functions for report entries facilitate the analysis. Statistics, e. g. in the form of counters for the individual error types, are also convenient.

In addition to solely documentating measurement results, the recording of a transport stream segment at the occurrence of the error is also important. It may prove helpful during error analysis or serve as relevant proof for third parties. The essential aspect about this recording function is that the error is part of the recorded segment and that the recording is archived automatically.

Indispensable: Monitoring instruments must be communicative

Monitoring instruments must be operable by remote control and they must be able to report errors themselves. That's because users who need access to the monitoring results or have to perform in-depth signal analyses are not always present at the site of the monitoring instrument. And in some cases, monitoring instruments may be located at unattended stations or stations that are difficult to access. If multiple, spatially separated monitoring points are involved, the best solution is to route all measurement results to a central PC. For this reason, monitoring instruments must be equipped with a network interface that supports a corresponding protocol. Ethernet with 10, 100, or 1000 Mbit/s is regarded as standard.

Manual remote control and query of measurement results

State-of-the-art monitoring instruments are equipped with an integrated web server allowing you to conveniently access the instrument via a conventional browser. If the web server is configured in such a way that, on access, a Java application is downloaded from the monitoring instrument to the client PC and then started, operation is particularly convenient and the graphical display on the client PC is optimized. FIG 3 shows the Java-based display of measurement results of the R&S®DVM digital video measurement system on the client PC as an example – with the data rate displayed in a graphical form. Moreover, the display on the client PC should correspond to that of the monitoring instrument so that you do not have to familiarize yourself with two different forms of displays and operating concepts.

Of course, the remote-control interface must be protected against unauthorized access. This can be implemented via passwords and different user rights. For example, a user with a low authorization level may only have read access to measurement results. In the next-higher level, you are authorized to change configurations, and as a fully authorized user, you are authorized to modify the entire system. The remote-control interface must also support the simultaneous access to the monitoring instrument by multiple users.

Integration into network management systems

SNMP is used as standard to integrate the monitoring instrument into network management systems. This protocol anables you to read and write individual variables in the monitoring instrument, and thus query measurement results and modify configurations. If monitoring instruments are equipped

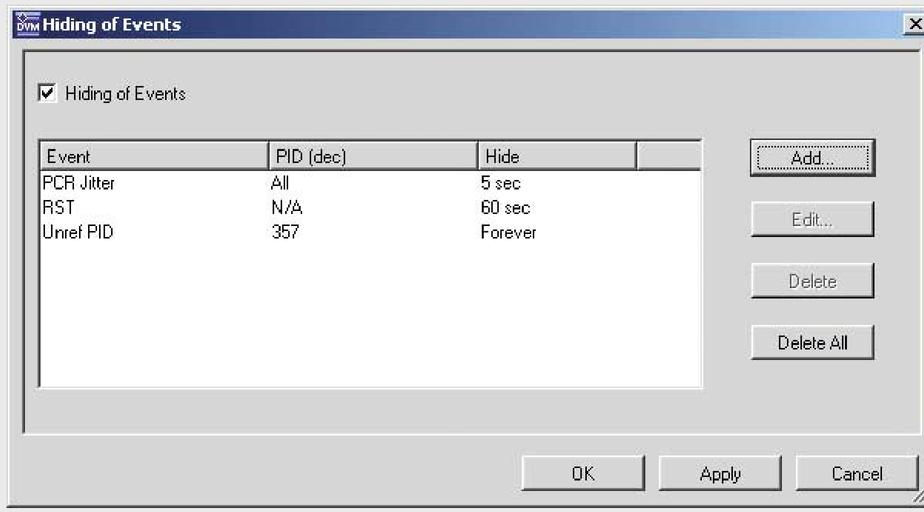


FIG 1 Configuration of the "Hiding of Events" function in the R&S®DVM digital video measurement system from Rohde & Schwarz.

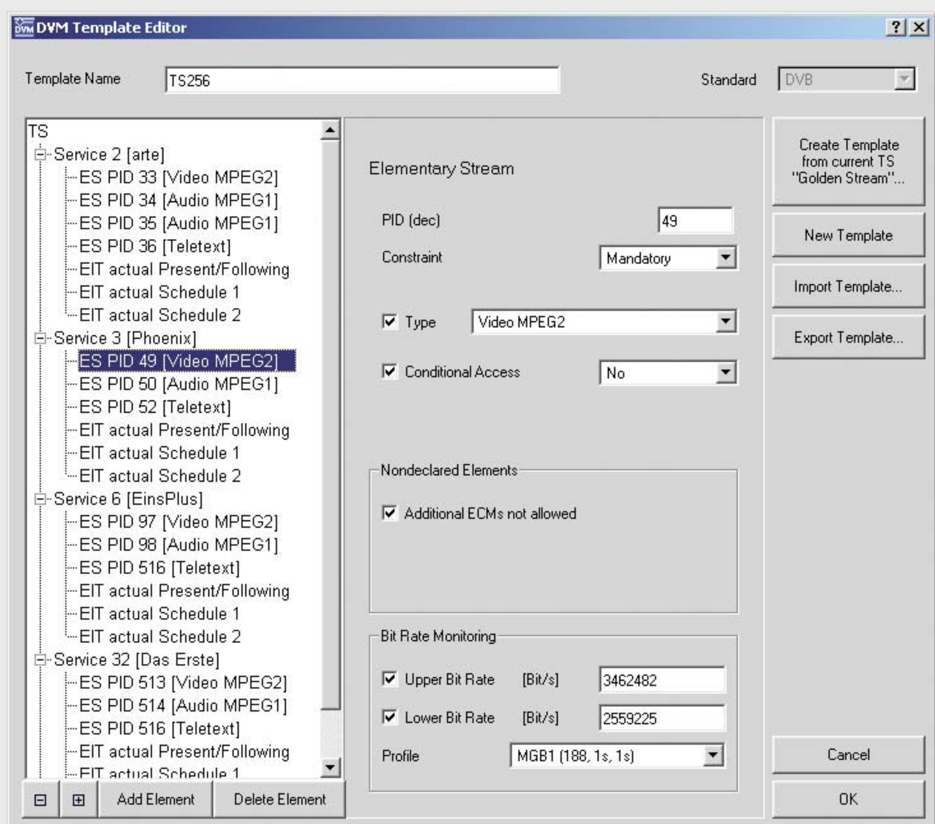


FIG 2 Template editor of the R&S®DVM.

this way, errors detected by the instrument can be sent as traps, i. e. information units describing an error, to previously specified client PCs in the network. This function is used to notify you at a remote location and to trigger an alarm, if required.

The functionality of an SNMP interface is described by a file, the management information base (MIB). The MIB should cover all relevant device functions as only these functions are supported by the remote control interface.

FIG 4 shows how all monitoring results from multiple instruments are displayed on a single monitor. This application is fully based on SNMP. You can click one of the location symbols to connect to the web server of the corresponding monitoring instrument.

Analysis functions are convenient

It is often convenient if the monitoring instrument allows you to graphically display the measurement results and to perform in-depth analyses, like the R&S®DVM (FIG 5) does. In this case, the monitoring functions must not be interrupted.

Same program display as on TV set

It is convenient to display the picture contents of the program in the same way as on the TV set, i. e. as watched by the television viewer. At a mere glance, you can thus see whether the transmission system fulfills its major task. The programs can directly be displayed on the instrument itself or – via a physical interface – on an external monitor. If you want to display the programs on an external monitor, you need a hardware decoder. The picture quality can also be evaluated far better than with a software decoder. Either you select the program, or the monitoring instrument automatically switches from one program to the next. The "Thumbnail Display" function simultaneously displays multiple programs in a very small format and cyclically refreshes the display.

When a monitoring instrument is operated via the remote-control interface, it would be convenient to have a function for streaming all program-specific data to the client PC on which the program is visualized.

Wide scope of functions at minimum space requirements

The space for monitoring instruments is frequently limited, i. e. the instruments have to be quite small. If an instrument can simultaneously monitor multiple signals and standards, operation and integration is further optimized since you only have to work with one operating and one remote-control interface. If a network has to be subsequently expanded to broadcast further programs, it should be easy to upgrade the monitoring instrument accordingly.

Summary

This article shows that monitoring the transmission and distribution of digital TV signals is a complex task. When the specifications for a monitoring system are being defined, the monitoring objectives as well as the function and structure of the network to be monitored are the key aspects. Measurement functions and measurement points can be derived from them. The higher the number of measurement points and the more complex and detailed the measurements, the better the information about signal characteristics, signal errors, and their cause – and – likewise, the more specific and faster the response to alarms. The installation and configuration effort as well as the required budget are opposed to the number of measurement points, the measurement effort, and the measurement depth. A monitoring system is considered to be good if you can strike the best compromise among the above and select the correct monitoring instruments. The monitoring instrument must provide the required monitoring functions as well as simple and flexible configuration options to meet the specific requirements of the signals to be monitored. The effort and flexibility required for integration and operation depend to a great extent on the additional functions and characteristics provided by the monitoring instruments.

Thomas Tobergte

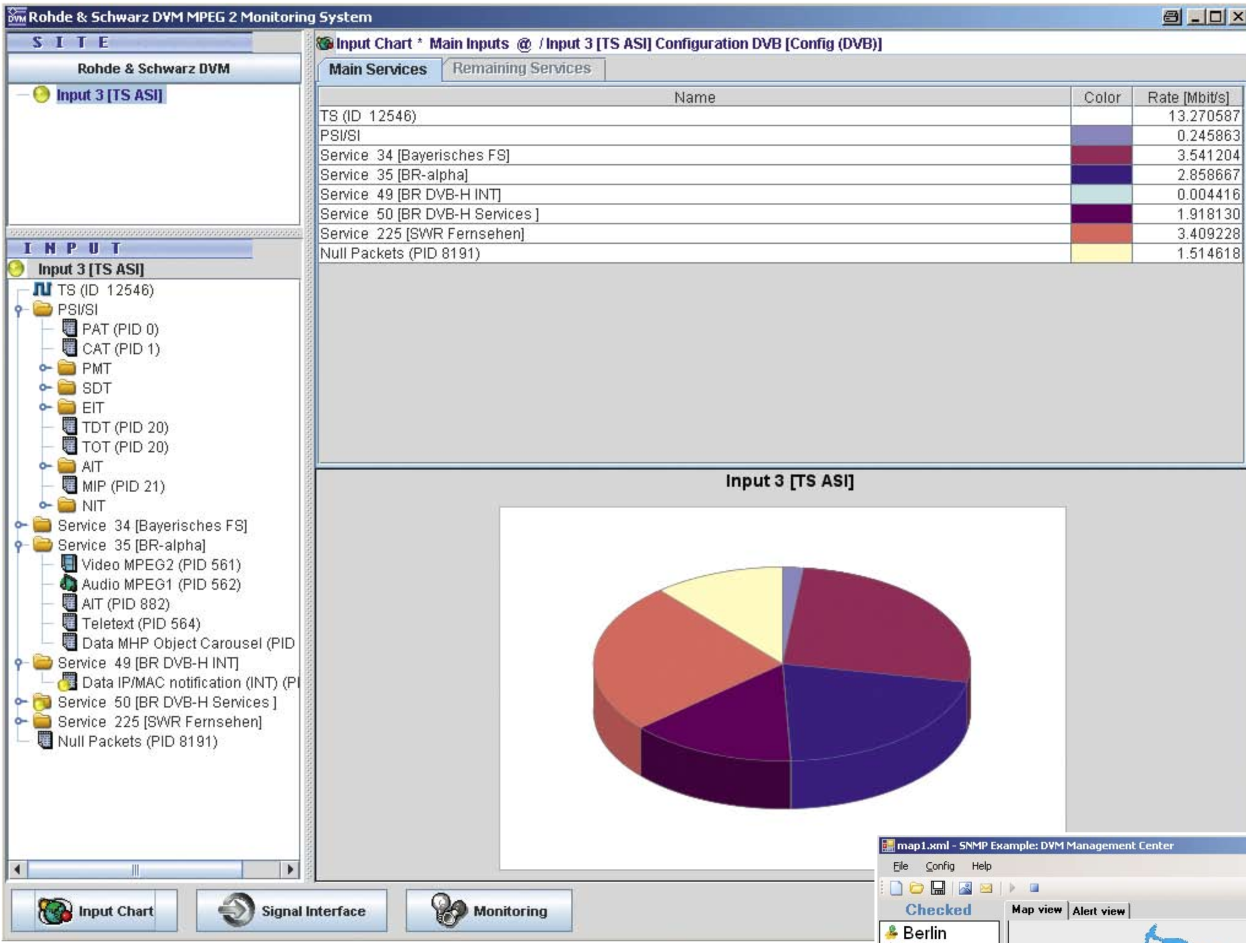


FIG 3
Display of R&S®DVM measurement results on the client PC.

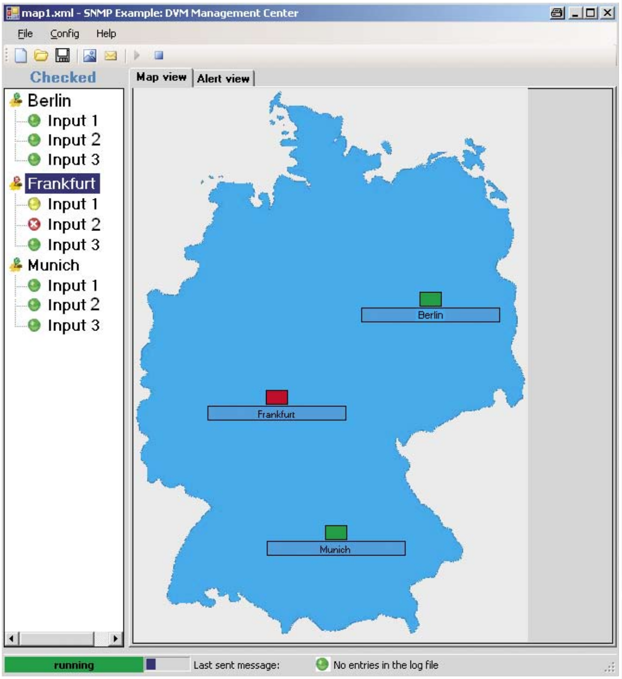
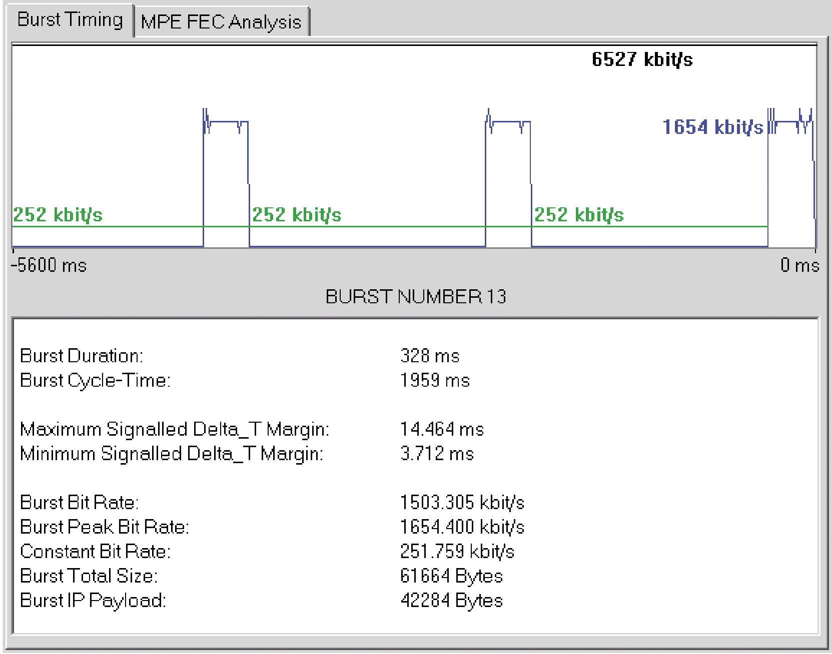


FIG 4 Example showing the measurement results of multiple monitoring instruments displayed in a single window.

FIG 5 Time slicing analysis of a DVB-H service.



More information and data sheets at www.rohde-schwarz.com (search term: DVM)

REFERENCES

Application Note 7BM65 (search term: 7BM65) provides an introduction to SNMP with examples and information on useful software tools.

Customer support centers: available around the clock worldwide

Communications and T&M products from Rohde & Schwarz help users throughout the world to solve increasingly complex tasks that have to be completed in less and less time. But what if a malfunction occurs or expert advice is required? There's no reason to panic: The Rohde & Schwarz regional customer support centers deal with such problems 24 hours a day – and even offer a number of other services.

Competent partners – 24 hours a day

The Rohde & Schwarz customer support centers have established themselves as competent partners for fast and sound solutions. You can contact three Rohde & Schwarz support centers with a total of 28 staff members in three different regions around the world.

Service-related questions from Asia are handled by engineers in Singapore and China who work in the local time zone. Munich is primarily responsible for Europe, Latin America, Africa and the Middle East, while the customer support center in Maryland, USA, deals with service-related questions from North America.

You don't have to worry about internal organizational structures or the availability of specialists: Incoming e-mail and voice recorders are continuously checked around the clock. If you leave a message in English on the voice recorder outside local work hours, don't despair: It will be handled by a center in a different time zone. Urgent questions or emergencies are, of course, addressed immediately.

As a user of Rohde & Schwarz products, you can be assured of receiving fast and effective technical support in your local time zone. The engineers in the technical customer support centers are familiar with the internal Rohde & Schwarz organizational structures and have the required expertise and experience to solve problems quickly in most cases.

Michael Vohrer, Chairman of Executive Board:

"Aspects common to all our products are high quality and technical features at the limits of feasibility. A wide range of products offers the best possible choice for each application, complemented by our services to provide a comprehensive, customer-specific solution. The worldwide support we offer our customers with advice and service ensures maximum benefit from our products over their entire life."

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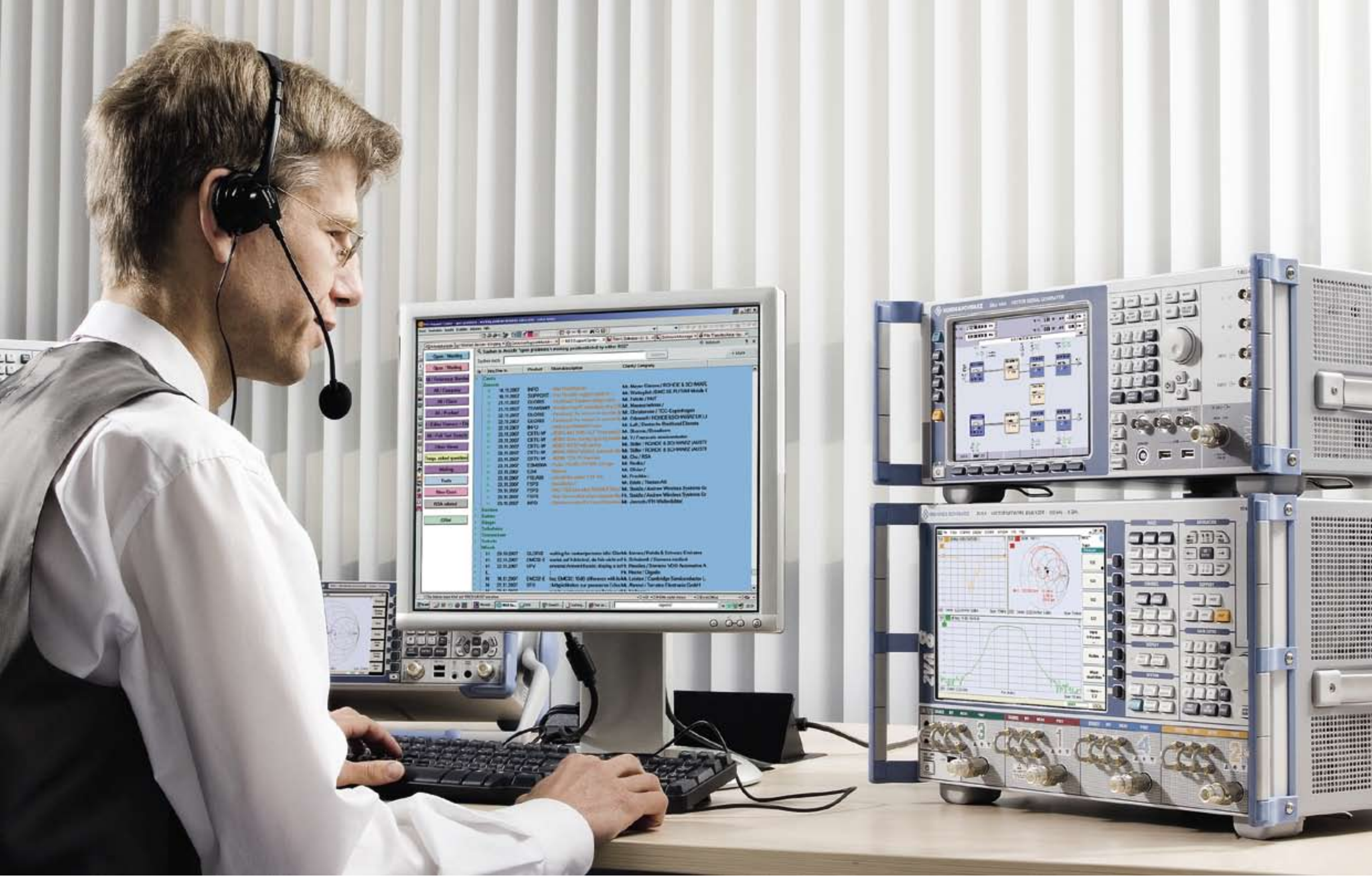
Customer Support Asia / Pacific
Phone: +65 65 13 04 88
Fax: +65 68 46 10 90
E-mail: customersupport@rohde-schwarz.com



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If you need expert advice, you can always reach a Rohde&Schwarz customer support center.

Close cooperation with Sales

Since the customer support centers closely cooperate with Sales in all countries, you in effect have two contacts in the Rohde&Schwarz network. Questions about quotations, additions, or expansions can thus be handled promptly. Since the customer support centers work closely together with application engineers, you can also be assured of yet another layer of assistance.

Comprehensive instrument pool

Due to the complexity of our instruments and systems, it is sometimes difficult to immediately determine whether you are dealing with a defect, a malfunction, or a desired function. The customer support centers therefore have a large inventory of instrument and system pools at their disposal. If a defect is apparent, the customer support center immediately works in close cooperation with the service centers.

Wide-ranging service portfolio

Yet the service portfolio of the Rohde&Schwarz customer support centers offers even more: The centers not only deal with technical matters. Questions regarding human resources, marketing, non-R&S production, logistics, training, health, invoices, service, etc., are forwarded to the appropriate department in next to no time: The center staff members know all company contacts throughout the large Rohde&Schwarz organization, and these contacts can then respond as quickly as called for.

Queries for manuals are usually handled quickly by providing the latest version or a firmware update. The instrument pools in the customer support centers allow our experts to immediately simulate application-related or program-related questions, promptly answer questions regarding operation, or offer solutions.

Moreover, the customer support centers regularly notify you about new application notes as well as firmware or software for your instruments. You can subscribe to this information service by phone, e-mail, or the Rohde&Schwarz website.

Heinz Semmerow

R&S®AMMOS R&S®AMLAB Laboratory

Compact system for wideband interception and technical analysis

R&S®AMLAB – an essential module of the extensive R&S®AMMOS system family – is a compact solution for the technical analysis of signals.

Complex: R&S®AMLAB's fields of application

R&S®AMLAB is an essential component of the R&S®AMMOS [*] radiomonitoring system family and is Rohde & Schwarz's universal and system-open solution for the technical analysis of both analog and digital signals. The system will be used whenever unknown signals or complex signal scenarios can no longer be processed online. The analysis of technical parameters by means of a wideband spectrogram and diverse time domain representations provides data for measuring, categorizing and classifying unknown signals. Signal sections of any bandwidth can be extracted from the wideband overview for analysis. The information collected using

FIG 1 Two screens offer optimum overview (from left): R&S®AMLAB displays a wideband overview in the form of a spectrogram (here a 20 kHz signal scenario), the timing analysis for

R&S®AMLAB can be integrated as basic data into search and production systems to enable more targeted monitoring or interception of specific signals.

Compact: R&S®AMLAB's components

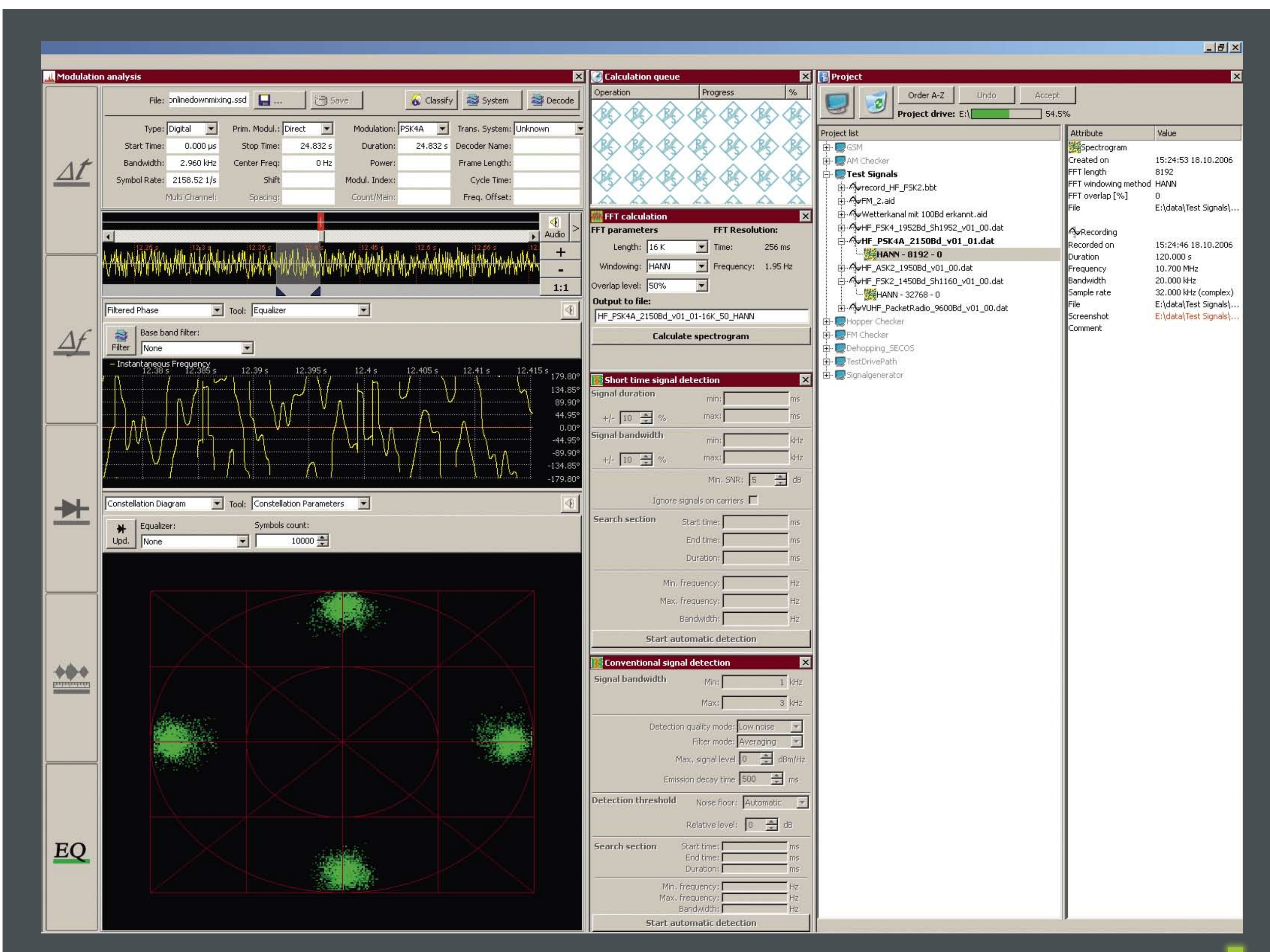
R&S®AMLAB (R&S®GX410) for signal interception and analysis The analysis software runs on a multiprocessor computer that comes standard with two screens for data display and application control (FIG 1). R&S®AMLAB processes signal samples (digital IF data) that are either provided directly by R&S®AMMOS wideband receivers or by the R&S®AMREC (R&S®GX420) IF recording / replay system or imports these samples from servers in the network. The system can immediately process signal samples imported in the R&S®AMMOS IF data format while other formats must first be converted. WAV files can be imported by default.

R&S®AMREC (R&S®GX420) signal recording / replay system In this configuration, the system serves as a hard disk storage device that ensures digital and realtime recording of the signals (20 MHz bandwidth) supplied by the R&S®AMMOS wideband receivers with up to 1 Gbit/s via optical data link (SFP/FPDP).

R&S®GX400 monitoring system Sensor subsystem with R&S®AMMOS narrowband and wideband receivers for the HF and / or VHF / UHF ranges.

The three components mentioned above have been integrated in a Gigabit Ethernet LAN controlled by R&S®AMLAB (FIG 2). For archiving larger amounts of data, it is advisable to add a file server to the system and to use the archiving functions of R&S®AMREC.

the accurate measurement of the signal, the control interfaces for devices and algorithms as well as the navigation center with the result database.



Realtime signal interception and recording

R&S®AMLAB can directly control the wideband receivers in the R&S®GX400 monitoring system and record wideband signal scenarios. Concurrently with the digital IF data stream the receivers also provide spectra which R&S®AMLAB represents in the form of waterfalls (adjustable from 30 FFT/s to 200 FFT/s). The user thus obtains an overview of the current signal scenario and can trigger, if required, the recording of digital IF data (FIG 3). For better visualization of short-time signals a Max Hold function can be activated in the waterfall representation to make even fast hoppers or extremely short burst signals clearly recognizable.

The digital IF data provided by the wideband receivers are stored in realtime in the R&S®AMREC recording / replay system. Here data rates of up to 100 Mbyte/s (with an IF bandwidth of 20 MHz) may occur that the system processes continuously. The capacity of an R&S®AMREC module provides a recording time of 2.5 hours at an IF bandwidth of 20 MHz or of 50 hours at an IF bandwidth of 1 MHz. In addition, the device also features a ring buffer mode which reserves storage space on the system for a defined period of time at a specific bandwidth. This ring buffer records the data endlessly so that the last few minutes or hours of a signal scenario can be retrieved at any time.

In addition to the representation of wide signal scenarios, processing in R&S®AMLAB allows the automatic detection of continuous signals (search parameters: bandwidth, SNR) and of short-time signals (search parameters: duration, bandwidth, SNR).

High-resolution analysis of signal samples

The collected emission data can statistically be evaluated, which is especially of advantage for the analysis of a large number of short-time signals. Moreover, individual emissions of any bandwidth can be mixed into the baseband to make them available for modulation analysis.

To analyze the modulation, the wideband signal sample is displayed as a zoomable and scrollable spectrogram with a timing resolution <100 µs (VHF / UHF) or a frequency resolution <100 Hz (HF) (FIG 3). Graphical cursors support the measurement of duration, bandwidth and level ratio of emissions.

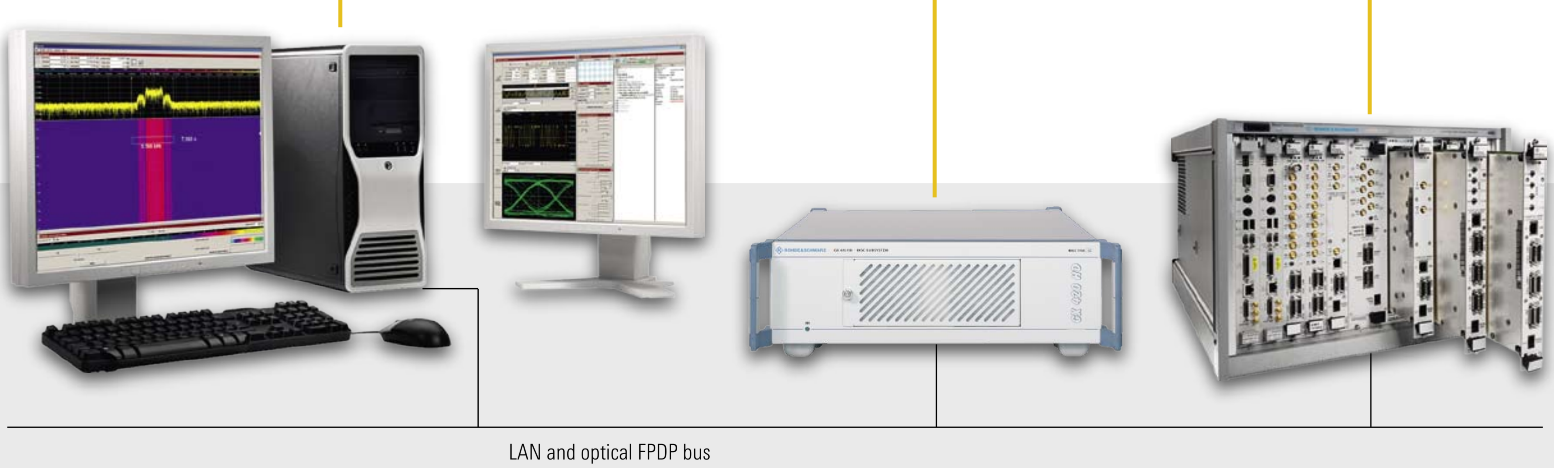
To enable the analysis of the properties of individual emissions, narrowband signals are extracted from the wideband recording using a digital downconverter

FIG 2 The components of the compact system for the wideband interception and technical analysis of signals.

R&S®AMLAB (R&S®GX410) System for wideband signal interception and analysis.

Hard disk module of R&S®AMREC (R&S®GX420HD). An additional controller module provides diverse interfaces, e.g. Gigabit Ethernet or an optical serial front-panel data port (FPDP).

R&S®GX400 monitoring system configured with HF and VHF / UHF wideband receivers (20 MHz realtime bandwidth).



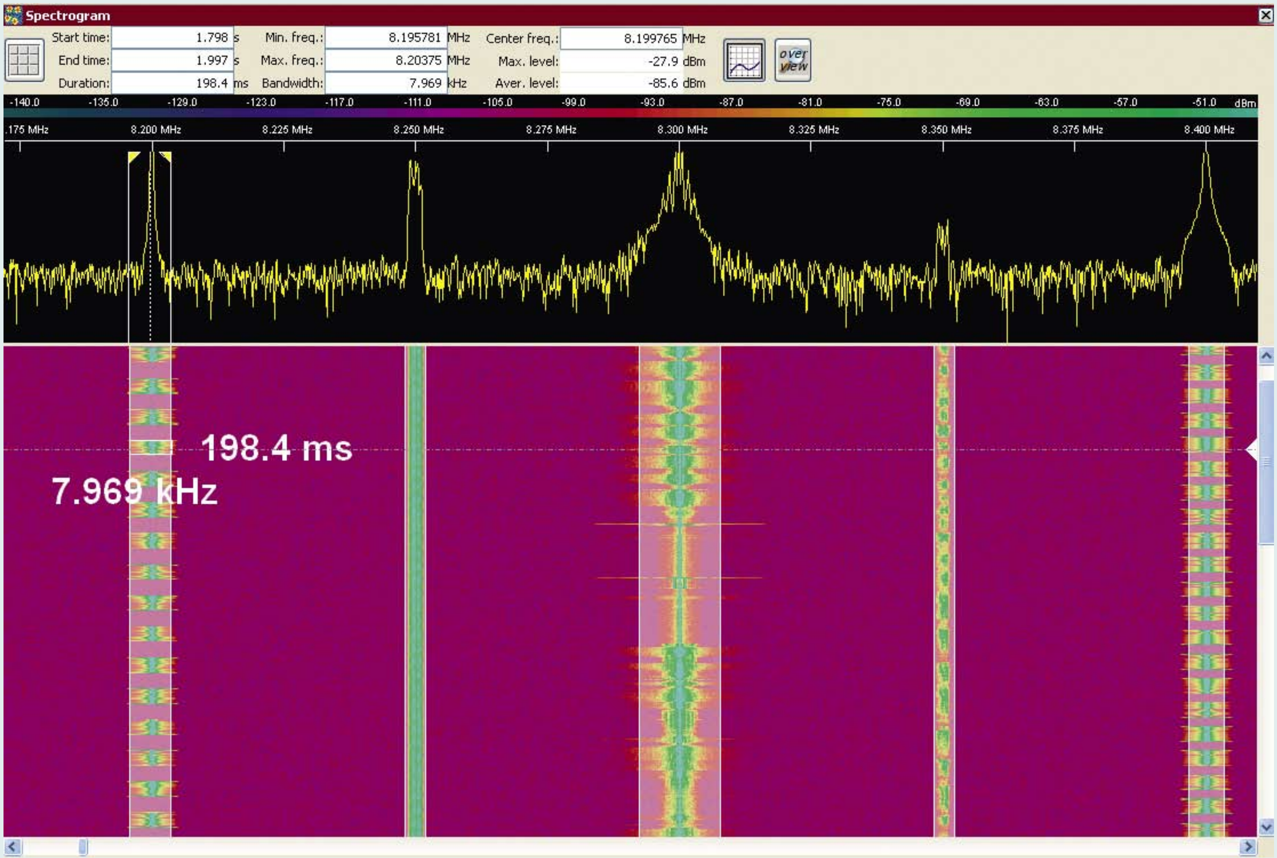


FIG 3 R&S®AMLAB spectrum / spectrogram representation. The data was obtained from an HF wideband receiver. A segment with 225 kHz bandwidth is shown in which all existing signals have already been automatically detected and segmented according to their different bandwidths (highlighted by the framed areas in the spectrogram). Cursors enable measurements of signal durations, signal bandwidths and signal levels.

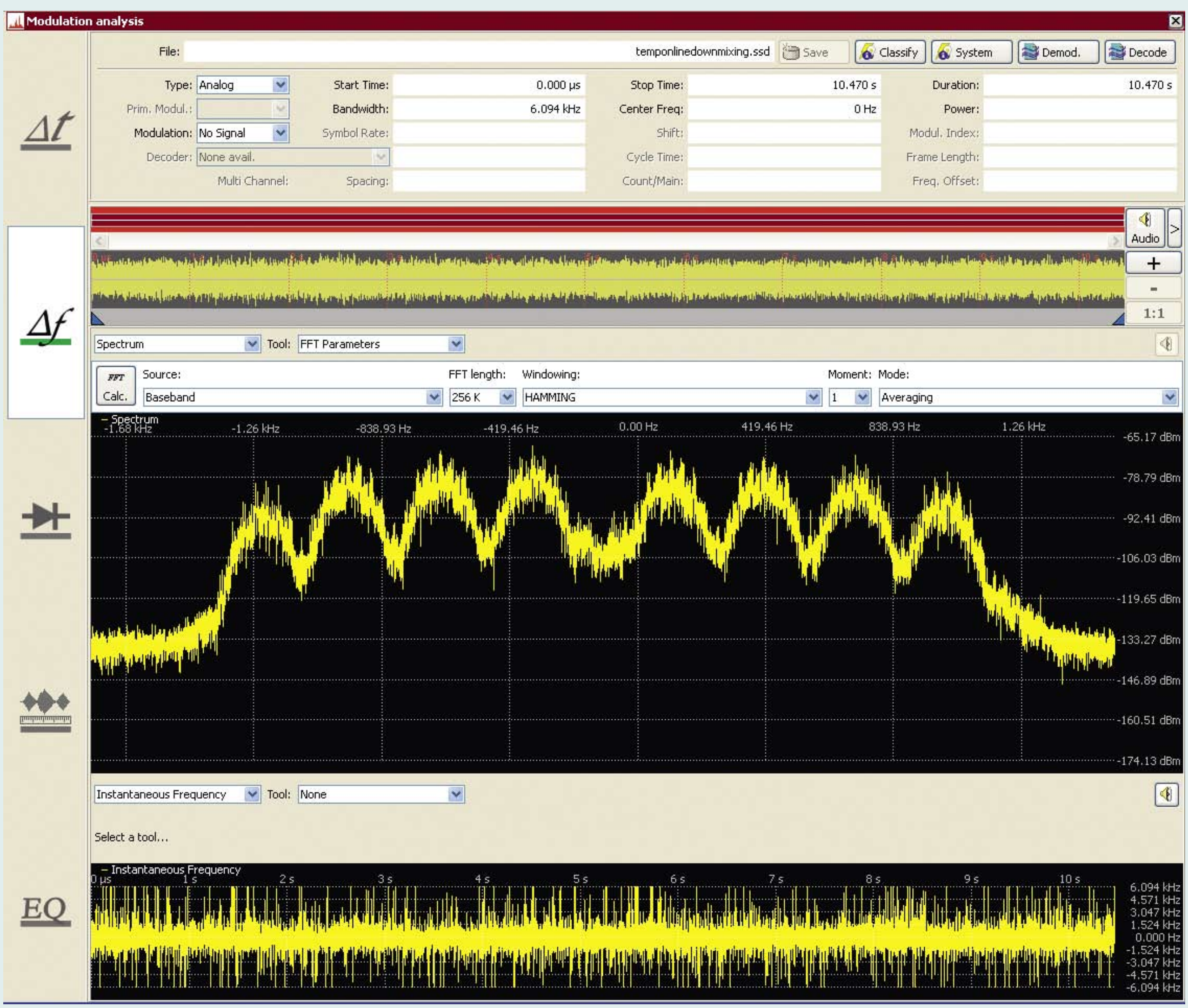


FIG 4 Selected signal segment in the spectrum representation of R&S®AMLAB (256 k FFT length). A signal segment with a width of 6.1 kHz and a length of 10.5 s was selected for time domain analysis.

(DDC) to make them available in the form of digital IF signals for automatic or manual modulation analysis (FIG 4).

The modulation type identifier analyzes emissions automatically (FIG 5). It uses a spectral representation that it subdivides into segments. It identifies, for example, the following types of modulation: A3E, J3E, ASK2, FSK2, FSK4, multitone and multichannel systems, MSK / GMSK, OQPSK, PSK2 / 4 / 8 (A and B variants respectively), QAM16, burst methods.

The measuring results provided by the modulation type identifier include center frequency, bandwidth, modulation type and, depending on the type, additional parameters such as shift, symbol rate, number of channels, channel spacing and burst length. A quality value is allocated to each result.

If the automatic modulation type identifier fails to achieve a satisfactory result (e. g. because the intercepted emission is too short or the signal is unknown), it is possible to analyze the signals manually in the time domain. For this purpose, they can simultaneously be displayed in the following zoomable diagrams (FIG 6), each of which provides extensive manual measuring tools:

- Timing diagram (oscilloscope)
- Envelope (amplitude versus time)
- Frequency versus time
- Phase versus time
- Baseband and envelope spectrum of different moments
- I/Q and eye pattern

To still increase efficiency, the user can support the automatic work flow of the modulation type identifier by manually checking and, if required, correcting individual intermediate results (e. g. by defining the segmentation) in case of complicated signal scenarios. All other working steps will continue to be performed automatically – by taking the manually determined values into account.

R&S®AMLAB optionally allows the use of a combination of demodulation and bit stream analysis. The results gained serve, for example, as a basis for the development of (HF) decoders using the R&S®GX400ID decoder development environment.

The bit stream analysis is used to identify known codes or analyze unknown codes. The demodulated symbol/bit stream is visualized in different representations (e. g. in a pulse duration diagram). The bit stream can undergo deeper structural analyses, e. g. block code analysis, preamble search, analysis of synchronization structures as well as convolutional code and scrambling analyses. Additionally, R&S®AMLAB offers autocorrelation and cross-correlation functions, entropy tests and scrambler polynomial searches (FIG 7).

A large number of bit stream manipulation tools is available, e. g. duration code transformation, bit erasure, bit inversion, demultiplexing and multiplexing as well as the application of standard alphabets.

R&S®AMLAB offers several output interfaces for further processing the obtained results and extracted signals. Results and signals can be output at an analog variable intermediate frequency (max. 1 MHz) and used as input signals for a special external demodulator / decoder. They can also be exported in digital form in order to deepen the analysis with other tools (e. g. MATLAB®).

Summary and prospects

R&S®AMLAB is an essential module of the R&S®AMMOS system family for strategic and tactical radio interception. In combination with the R&S®GX400 monitoring system, which may include different receivers for multichannel search and monitoring, and the R&S®AMREC signal recording / replay system, it is the tool of choice for the technical analysis of both continuous and frequency-agile signals. All analysis functions have been designed for a wide signal bandwidth range. The continuous further development of these functions (e. g. all measuring functions in line with ITU recommendation ITU-R SM.1600 will in the future be adapted to also enable OFDM signal measurements) ensures that the user will be able to perform detailed analyses of new methods and complex signal scenarios in the future as well.

Jürgen Modlich

More information and data sheet at www.rohde-schwarz.com (search term: AMLAB)

REFERENCES
[*] R&S®AMMOS Automatic Modular Monitoring System: Seeing clearly through the thicket of signals. News from Rohde & Schwarz (2003) No. 178, pp 56 – 60

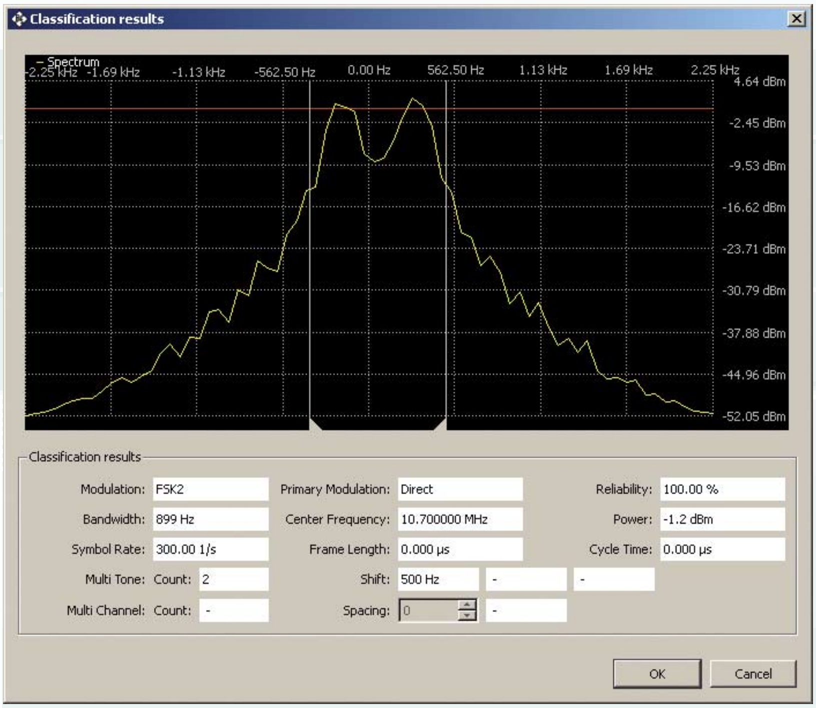


FIG 5 The modulation type identifier has identified an FSK2 signal and automatically determined all relevant parameters.

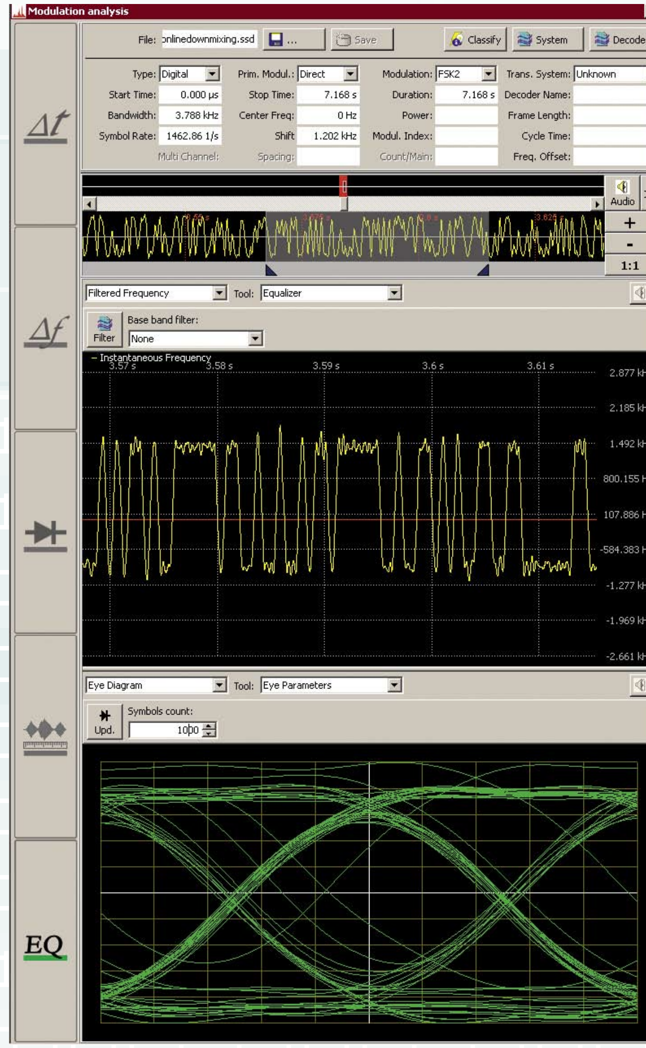


FIG 6
The time domain analysis provides different views and measuring functions for the manual analysis of modulation parameters (here oscilloscope, frequency versus time and eye pattern of an FSK2 signal).

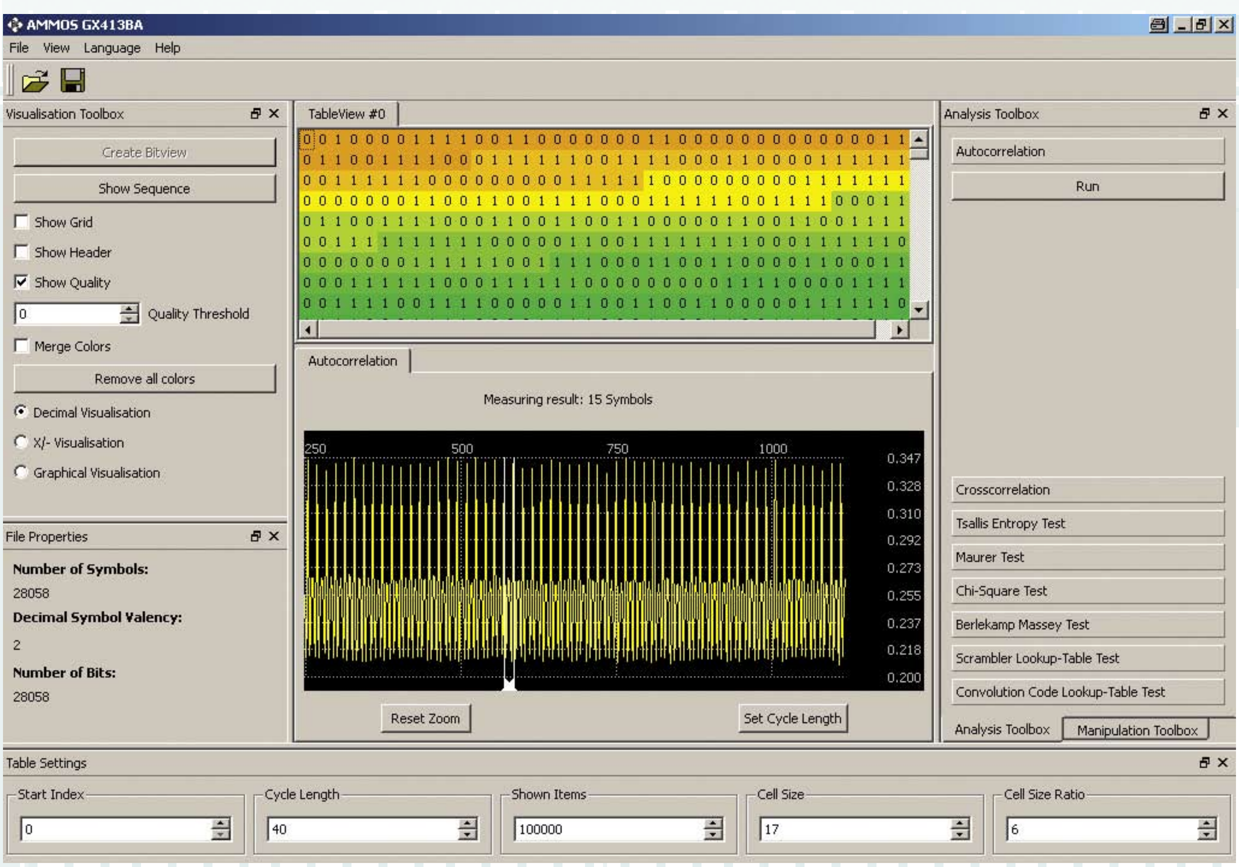


FIG 7
The bit stream analysis allows the manipulation and analysis of bit streams. The differently colored bits indicate the quality information allocated to every bit during demodulation so that the user can select qualitatively good segments for analysis.

R&S®ARGUS Spectrum Monitoring Software

New identification module with more than 120 decoding modes

The new R&S®ARGUS IDNT identification module is a software-based demodulator, decoder, and analyzer. It allows you to decode the signals of a data transmission and to display the contents in plain text so that a transmitter can unambiguously be identified. Technical parameters required to successfully decode an unknown emission can also be determined, partly even fully automatically.

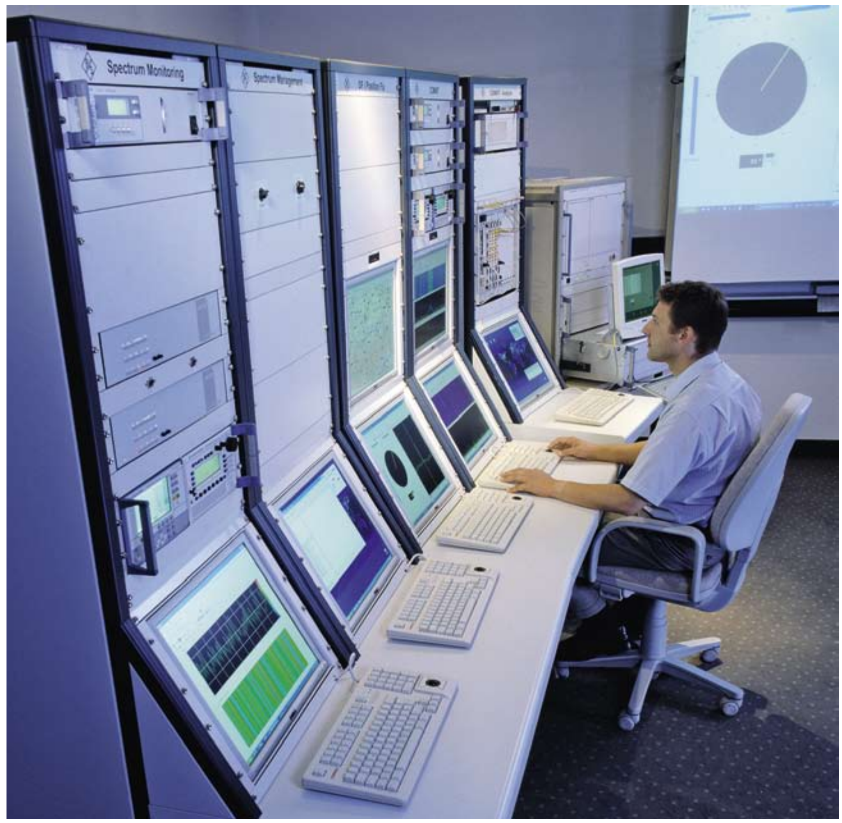


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FIG 1 In radiomonitoring stations, the tried-and-tested R&S®ARGUS spectrum monitoring software supports you with a variety of convenient functions to identify unknown emissions.

When conventional parameters are no longer sufficient

Conventional parameters such as frequency, level, or bandwidth are often insufficient for identifying a transmitter. This is especially true if several transmitters share a frequency, e. g. in amateur radio or in ISM bands. If you want to unambiguously recognize signals of data transmissions, you have to determine additional technical parameters and analyze the decoded contents of the emission.

The most important requirements and methods for the international regulatory authorities are stipulated in the ITU recommendations ITU-R SM.1052 "Automatic Identification of Radio Stations", ITU-R SM.1600 "Technical Identification of Digital Signals", and in the current ITU Spectrum Monitoring Handbook 2002, section 4.8 "Identification". But authorities and organizations with security missions are also more and more often faced with the challenge of determining and analyzing the contents of specific emissions.

A variety of analysis options

To meet these specific requirements, a further high-performance module has been integrated into the tried-and-tested R&S®ARGUS [*] spectrum monitoring software: the IDNT identification module (FIGs 1 and 2). It offers a variety of analysis options with more than 120 different decoding modes in the HF and VHF / UHF range. Moreover, it provides numerous tools to automatically or interactively determine the modes. All the R&S®ARGUS advantages and functionalities are also offered when performing the analysis with IDNT. This includes intuitive control of the instruments, automated routines, and a variety of measurement and evaluation options. Yet, the main focus is the user: R&S®ARGUS offers a maximum of support and help. During guided measurements, for example, the system suggests the required instruments and optimum settings to handle the task and frequency range at hand.

The input signal is the demodulated audio signal of a receiver, direction finder, or spectrum analyzer. When using the R&S®EB200, R&S®ESMB, R&S®EM510, or R&S®EM550 receivers from Rohde & Schwarz, which provide a digital audio signal, this audio signal is directly transmitted via the LAN connection. But you can also use instruments that only provide an analog audio signal: Their audio output is simply connected with the line-in input of the controller sound card. To perform the analysis, R&S®ARGUS then directly accesses the sound card, which operates as an A/D converter.

Analysis mode / production mode

There are two types of modes: the **analysis mode and the production mode**.

If the parameters are not known at all or not fully known, the **analysis mode** is used. The identification module provides a number of options for determining all data required for successful decoding. You can choose between automated routines and interactive procedures. During autoclassification (FIG 3), the system first determines the center frequency, baud rate, shift, and offset based on the audio spectrum. With these values, it then selects probable modes which are systematically analyzed by means of internal standard tables and / or bit pattern analysis. You will finally be provided with the automatically determined mode. The corresponding decoder window opens after clicking a button. The correct parameter values are set and you can start decoding.

The most important and most frequently used frequency- and phase-shift systems can thus be determined quickly and efficiently. Under special receiving conditions, e. g. a very low S/N ratio, selective fading, or co-channel interference, the autoclassification may not be able to provide a reliable result or no result at all. In this case, further functions allow you to manually determine the mode and the settings. These visualization tools include graphical displays such as the phase spectrum, phase constellation, eye diagram, various oscilloscopes, and the straddle (mark-space diagram). They also allow you to distinguish FSK signals from PSK signals or to determine symbol rates. If you observe the phase shifts over time in the phase oscillogram, you can clearly distinguish the 2PSK signals from the 4PSK or 8PSK signals. If the signal was sufficiently analyzed and ▶

FIG 2 **Dialog window of the IDNT identification module in R&S®ARGUS.**

FIG 3 **Autoclassification.**

recognized by means of these functions, more tools are provided for data analysis in a next step. Sophisticated modules such as bit, speed bit, or correlation bit analysis but also character-specific and alphabetical analysis are important and valuable tools for checking, verifying, and fine-tuning the settings.

Another simple but very efficient tool is the character counter, which determines how often a letter or a number occurs in the decoded text. The relative occurrence of letters is an indicator for a specific language. The character counter thus supports you in determining the language in which the decoded text was written.

In the **production mode**, the signal to be examined is known. Characteristic parameters such as center frequency, shift, offset, or baud rate are therefore directly set. This can be done most effectively and in a user-friendly manner by clicking the mouse in the graphics including the audio spectrum or by directly entering the appropriate values in the decoder window. The signal is demodulated and the decoded contents are immediately displayed. Depending on the emission, the contents may be either plain text or a graphics, e. g. a weather map (FIGs 4 and 5). If the contents are also encrypted, some modes allow you to forward the decoded data stream to another application where the contents are decrypted. If required, both the contents and the original signal can be stored.

Advantages of the new module

The integration of the new module into R&S®ARGUS has many advantages. The most important ones are listed below:

- Uniform, integrated solution
- Simple storage of raw data for subsequent offline analysis
- Detailed documentation of measurement and analysis
- Automated routines

You can thus benefit from a program with a uniform interface for receiver control, analysis, and data storage. Plus, you do not have to buy, learn, maintain, and simultaneously operate several applications. This frees you from having to worry about the compatibility of data formats.

Raw data from the receiver can be stored and replayed. This is particularly convenient for unknown transmitters or signals of poor quality: Data can be "sent" as long as the analysis has been successfully completed.

All relevant technical parameters are documented in the result files for raw data and for decoded contents. You can thus find out at any time how information was obtained. If the same

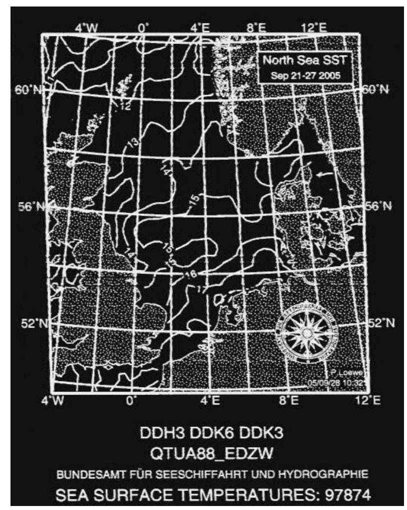
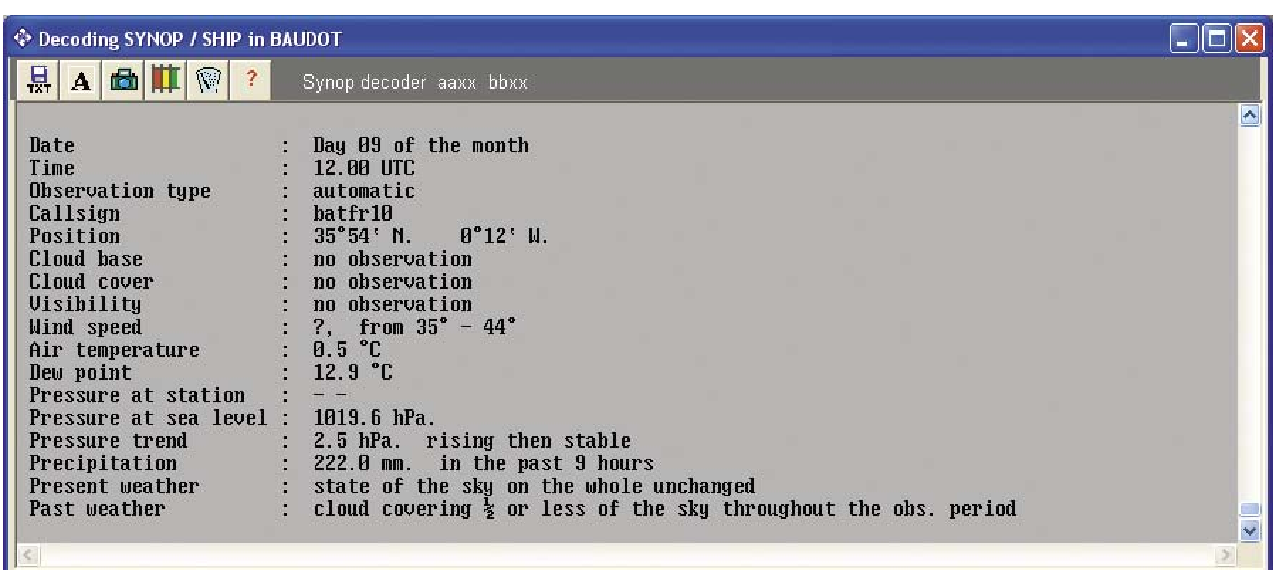


FIG 4 Example of a decoded fax (isotherms in the North Sea).

FIG 5 The synoptic Baudot decoder decoded the data of a weather station with current weather information.



transmitter is again on air at a later time, all settings are close at hand and you can immediately decode the live data stream.

One of the most important and practical functions is the automatic measurement mode (AMM). You can define when, where, and how each measurement task is to be performed. The instrument settings are made at the defined time and the measurements are started fully automatically. You can also define various criteria (i.e. alarm conditions). If these criteria are met, other, user-selectable actions are performed. A typical sequence would be as follows: A specific frequency range is systematically scanned at defined times. As soon as a new transmitter is activated, the system measures parameters such as frequency, level, bandwidth, or the IF spectrum of this signal and stores them together with the audio signal for identification purposes. If the transmitter is no longer active, the system automatically stops recording. Thus, data is only recorded if a signal is applied.

Since the system is implemented as a pure software solution, purchasing costs for additional hardware are not incurred. The advantage of a software-based solution becomes obvious when integrating the system into vehicles: Typical hardware problems such as space requirements, power supply, and vehicle compatibility are no longer a concern.

Summary

One of the main reasons why the R&S®ARGUS spectrum monitoring software has been successful for the last 20 years is its continuous and systematic expansion with new functionalities. The new IDNT identification module is a further milestone to strengthen the position of Rohde & Schwarz as a world market leader.

Thomas Krenz

More information and data sheet at www.rohde-schwarz.com (search term: ARGUS)

REFERENCES

[*] R&S®ARGUS Spectrum Monitoring Software: The successful "classic" now available as version 5. News from Rohde & Schwarz (2003) No. 177, pp 46–50

R&S®ARGUS IDNT includes the following decoding modes:

Selective call
ARINC ANNEX 10, CCIR 1, CCIR 2, CCITT, CODAN 8580 / CCIR 493-44, CTCSS, DCSS, DTMF, EEA, EIA, EURO, NATEL, TT classification, VDEW, ZVEI 1, ZVEI 2, ZVEI 1 –13 BIIS, ZVEI ITA xtone.

VHF-UHF mode
ACARS SITA, ATIS GMDSS, Cityruf, ERMES, FLEX, FMS-BOS, INMARSAT-C TDM, INMARSAT-C TDMA, MDT, MPT 1327, POCSAG.

General mode
ASCII, AUTOSPEC, BAUDOT, BAUDOT SYNCHR, BF6 BAUDOT, CW, CW-F1b, Fax-AM, Fax-FM, Hell, PACKET AX-25, PACTOR I, PACTOR II, PSK-31, SITOR A/B auto, SSTV.

Special mode
AUM 13, DGPS-SC 104, EPIRB, G-TOR, GMDSS HF, GW-Dataplex, HF Datalink, IRA ARQ, Merod, NUM-13, Skyfax, Twinplex, VISEL.

FEC mode
FEC 100, FEC 100 dirty, FEC 100 interleaved, FEC 100 raw, FEC-A, FEC-B SITOR-B, FEC-S, HNG-FEC, ROU-FEC.

MFSK mode
Coquelet-8, Coquelet-13, Coquelet-8 FEC, Coquelet-8 FEC auto, Coquelet-8 FEC autostart, CROWD 36, FIRE, MFSK 16, MFSK 18, MFSK 20, Piccolo 6, Piccolo 12, RF7B.

CIS mode
405-395, 81-29, 81-81, Baudot-F7B, BEE 36-50, CIS-11 TORG-10 / 11, CIS-12 Fire, CIS-14 TORG-14, R 37.

ARQ mode
ARQ-2 TDM-242, ARQ-4 TDM-342, ARQ6-70, ARQ6-90 / 98, ARQ 625 SITOR A, ARQ-DUPLEX, ARQ-E, ARQ-E3, ARQ-Pol, ARQ-S, ARQ-1000, ARQ-Swed, HC-ARQ, RS-ARQ, RS-ARQ Merlin, TOR Dirty.

MIL-STD-188 Series
MIL-STD-188-110 39-tone, MIL-STD-188-110 serial, MIL-STD-188-110 141 ALE, STANAG-4285, STANAG-4529.

R&S®DDF0xA/E and R&S®DDF195 Digital Direction Finders

The world's first VHF-UHF direction finding antennas for all polarizations

The R&S®ADD157/R&S®ADD197 dual-polarized VHF-UHF DF antennas are the world's first antennas of their kind that can receive both vertically and horizontally polarized signals.

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FIG 1 The R&S®ADD157 dual-polarized VHF-UHF DF antenna.

Why horizontal polarization?

Direction finders are normally equipped with vertically polarized antennas, making it impossible for them to perform accurate direction finding when they encounter signals with strictly horizontal polarization. For example, this is what happens in direction finding involving FM and TV transmitters which are commonly equipped with horizontally polarized antennas (see box).

Normally, of course, there is no need for direction finding with FM and TV transmitters since their locations are well known. However, in the case of illegal transmitters using horizontally polarized transmitting antennas, vertically polarized DF antennas and triangulation do not work. In these cases, DF antennas with vertical and horizontal polarization are needed.

One obvious (but very poor) solution would be to simply rotate the vertically oriented dipole antenna elements by 90° so that they are horizontal. However, this results in an overly directional receiving characteristic. The DF accuracy and sensitivity would be inadequate in certain directions and it would not be possible to aurally monitor signals from those directions.

The solution: dual polarization

Rohde & Schwarz is now the first manufacturer worldwide to develop DF antennas that combine both types of polarization while maintaining compact dimensions (FIG 1). In the free space between the nine vertically polarized dipole antenna elements, nine additional horizontally polarized loop antennas have been inserted that are selected using

More information about our extensive portfolio of direction finders at www.rohde-schwarz.com switches. These loop antennas are significantly more complex than simple wire loops and have been extensively optimized. Using the tried-and-tested correlative interferometer DF method, their performance exceeds all expectations and is nearly identical for both types of polarization.

The new R&S®ADD157 (for the R&S®DDF0xA/E direction finder family) and R&S®ADD197 (for the R&S®DDF195 direction finder) dual-polarized VHF-UHF DF antennas have a wide frequency range from 20 MHz/40 MHz to 1300 MHz. The frequency range for horizontal polarization begins at 40 MHz. With both polarization types, high DF accuracy of 1° RMS is achieved above 200 MHz (2° RMS below 200 MHz). The DF sensitivity and the immunity to reflections clearly surpass the typical values for commercially available equipment due to the two nine-element antenna arrays. FIG 2 shows the DF sensitivity of the R&S®ADD157 versus frequency for horizontal and vertical polarization.

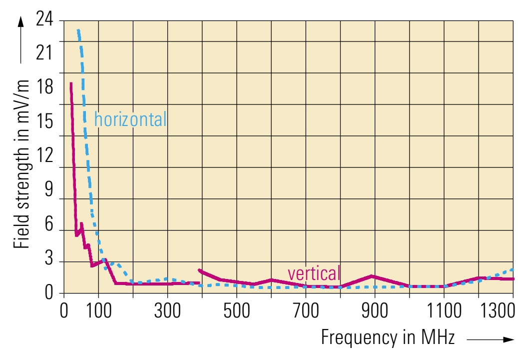
The user can conveniently set the type of polarization using the direction finder's graphical user interface. The correct setting can be determined quickly and reliably by comparing the DF quality. If the DF value changes significantly after the polarization type has been changed, then a reflection was measured first, followed by the direct wave from the direction of the transmitter.

Since the two new DF antennas can precisely locate any horizontally polarized transmitter, signals from FM and TV transmitters can be used to orient the direction finder to north and to check it. Transmitters of this type are ideal since they continuously broadcast a strong, undistorted signal from a known location, making it easy to check the DF accuracy and north setting.

Another frequent signal type with horizontal polarization comes from radar systems. Using the new R&S®ADD157/197 dual-polarized DF antennas, it is now possible to perform direction finding on radar systems too. With these capabilities, the two new DF antennas represent a new standard in this frequency range.

Philipp Strobel

FIG 2 Typical DF sensitivity of the R&S®ADD157 DF antenna versus frequency (for 2° RMS, 600 Hz bandwidth, 1 s averaging).



Why normal DF antennas are incapable of receiving horizontally polarized signals

Around the world, direction finders used for locating transmitters are typically equipped with a vertically polarized DF antenna. These DF antennas usually consist of multiple vertical dipole antennas arranged in a circular array. For example, FIG 3 shows the R&S®ADD050 from Rohde&Schwarz, a DF antenna that has nine elements for the frequency range from 20 MHz to 200 MHz and a diameter of 3 m.

Direction finders with vertically polarized antennas are not capable of accurately taking bearings on signals with strictly horizontal polarization. This is the case, for example, in DF applications involving FM and TV transmitters which are usually equipped with horizontally polarized transmitting antennas and mounted on high masts for better coverage. If the DF antenna is also located in an elevated position on a mast or on a roof, it will have more or less line-of-sight contact with the transmitting antenna.

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FIG 3 R&S®ADD153 DF antenna (top of mast) and R&S®ADD050.

Under these circumstances, erroneous results can be produced as the undistorted, horizontally polarized FM/TV signals reach the vertically polarized DF antenna. There are basically two effects that cause problems in this scenario:

- The received signal induces currents in the electrically conductive antenna structure. The vertical components of the resulting secondary fields disrupt the DF process.
- In addition to the direct wave, the DF antenna also receives reflected waves with a combination of vertical and horizontal polarization. Direction finders are normally better at measuring the vertical components of reflections than the directly received signal. This can produce extremely erroneous results due to the reflections. However, the poor DF quality usually provides a warning about this problem when it is present.

R&S®DDF0xA/E Digital HF/VHF/UHF Direction Finders

Super-resolution DF method identifies co-channel signals

A super-resolution DF method is now available as an option for the R&S®DDF0xA/E family. It can determine the bearings of multiple emissions on the same frequency and adds to the existing DF methods.

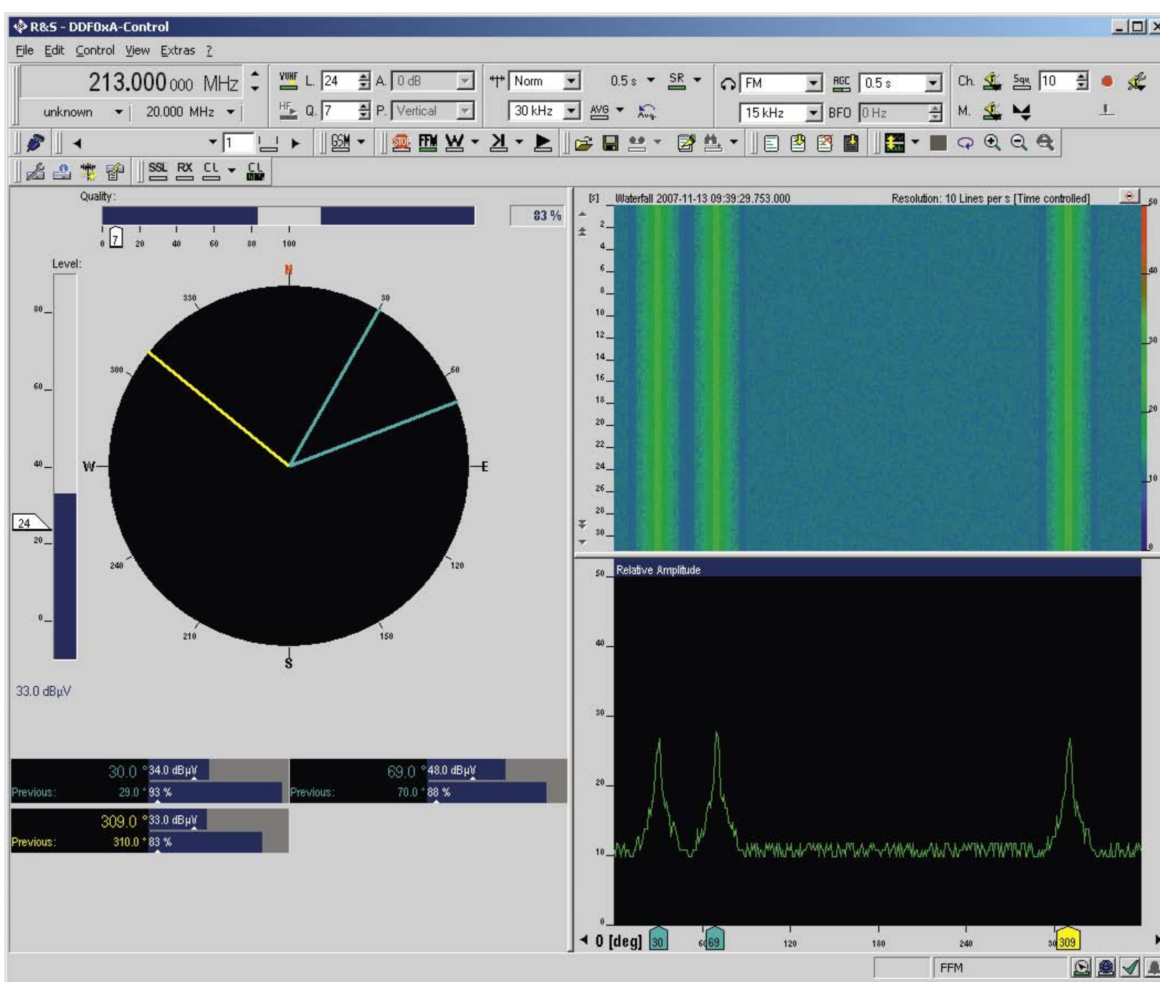
The challenge: co-channel interference

Most radio DF methods are based on the assumption that a specific frequency is occupied exclusively by the transmitter of interest. However, if additional transmitters are operating on the same frequency, direction finding may be impaired – a problem referred to as co-channel interference. In this case, the DF result depends on the level ratio of the transmitters. If one of the transmitters is clearly stronger than the others, its direction is displayed with slight DF errors. If the transmitters have similar levels, the DF result is normally incorrect. This applies equally to all conventional DF principles including correlative interferometer, Doppler, and Watson-Watt methods.

Co-channel interference regularly occurs in practice. In fact, it is partly even a characteristic of a transmission method:

- In the HF range, propagation characteristics are continuously changing. Emissions may sometimes travel much farther than originally planned and thus be received in areas where a different station transmits on the same frequency.

User interface of the R&S®DDF05A direction finder with the R&S®DDF-SR super-resolution option when determining the bearings of three co-channel signals.



- Defective electronic devices may produce electromagnetic interference that occurs on the frequency of transmitters.
- In single-frequency networks such as those used in DAB / DVB, multiple transmitters transmit the same signal on the same frequency from different sites. This is done to improve the transmission quality.
- Sometimes, specific transmitters are intentionally jammed. In this case, an interfering signal is sent on the same frequency.
- When working with the code division multiple access (CDMA) method, which is used by the Universal Mobile Telecommunications System (UMTS) mobile radio standard, many stations simultaneously transmit signals in the same frequency range. The receivers can distinguish the different signals by means of the spreading code which is superimposed on the message.

Up to seven co-channel signals can be identified

To allow the bearings of co-channel signals to be taken, Rohde & Schwarz is now making a super-resolution DF method available for its R&S®DDF0xA / E family [*]. This method is offered as the R&S®DDF-SR option and supplements the DF methods already available. As “super-resolution” in its name implies, this DF method is able to resolve a wave field with multiple signals on the same frequency. The number and angle of incidence of the waves are first calculated precisely and then displayed. The new option allows you to take the bearings of up to seven different signals on the same frequency. The number depends on the angle of incidence and the S/N ratio.

An excellent price/performance ratio is attained by cleverly using the three receive channels of the R&S®DDF0xA / E DF family. To make this possible, DF antennas whose antenna elements can be combined into various subgroups must be utilized. The new R&S®ADDxxxSR DF antennas are ideal for this task.

The figure illustrates the user interface of the R&S®DDF05A direction finder with the R&S®DDF-SR super-resolution option. In the example, the direction finder receives three transmitters on the same frequency. The algorithm automatically recognizes the number of transmitters and displays the results as follows:

- All DF results are simultaneously displayed in the azimuth dial. The selected result is highlighted in yellow.
- The bearing, receive level, and DF quality (as a numeric value) for all signals are displayed.
- The receive level and the DF quality of the selected signal are displayed as a bargraph.

More information about our extensive portfolio of direction finders at www.rohde-schwarz.com

REFERENCES

[*] R&S®DDF0xE: Complex radio scenarios at a glance. News from Rohde & Schwarz (2003) No. 180, pp 54–57.

You can activate the new super-resolution DF method by means of a mouse-click in the R&S®DDF Control graphical user interface if you suspect that multiple transmitters are transmitting on the same frequency. Low DF quality often in conjunction with a strong fluctuation in the DF value is a reliable indicator.

By offering its new R&S®DDF-SR option, Rohde & Schwarz for the first time provides an economical method for taking bearings in accordance with the super-resolution DF method. In addition to high immunity to reflections and immunity to strong transmitters, the R&S®DDF0xA / E direction finders thus lay claim to yet another unique aspect by including this new method.

Philipp Strobel

Technical background

Conventional DF methods are based on the assumption that the frequency channel of interest has only one dominating wave. However, this may not be the case due to factors such as the following:

- Spectral overlapping (e. g. CDMA) occurs among the wanted signals being evaluated.
- High-amplitude interferers also occur in addition to the wanted signal (e. g. electromagnetic interference).
- Multipath propagation is present (e. g. reflections off buildings).

The DF errors that arise will make the results unusable.

Conventional DF technology offers two countermeasures:

- If the interferer component is lower in power than the wanted signal component, the DF error can be minimized by dimensioning the direction finder accordingly – in particular by selecting an antenna aperture that is large enough.
- If the interferer component is equal to or greater than the wanted signal component, you can take separate bearings of non-correlated signals using high-resolution wideband direction finders. You can benefit from the spectral differences of the signals.

Super-resolution DF methods offer a systematic solution to this problem: They allow you to calculate the number of waves involved and their angle of incidence. This is done either model-based by using the maximum likelihood method or by means of principal component analysis (PCA) of the antenna data. The new R&S®DDF-SR super-resolution option makes use of PCA.

Mobile radiomonitoring – portable, precise, fast

The R&S®PR100 receiver in conjunction with the R&S®HE300 portable directional antenna (page 79) is an ideal choice for close-range and far-range radiomonitoring, e.g. for frequency monitoring or tracking telltale signals emitted by active electronic equipment. The receiver offers an unrivaled scope of functions, and revolutionizes the market for portable monitoring receivers.

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Compact and versatile

The R&S®PR100 (FIG 1) has been tailored for tasks that call for low weight, rapid deployability, and the efficient handling of tasks in a wide variety of signal and frequency scenarios. As the first monitoring receiver of its kind, the R&S®PR100 covers the extremely wide frequency range from 9 kHz to 7.5 GHz, and offers high sensitivity despite its compact design.

The receiver's realtime bandwidth of 10 MHz – which is unique for mobile equipment – and its powerful digital signal processing allow the detection of short-duration signals (e.g. of classic push-to-talk communications) or frequency-hopping signals.

FIG 1 The R&S®PR100 portable receiver.

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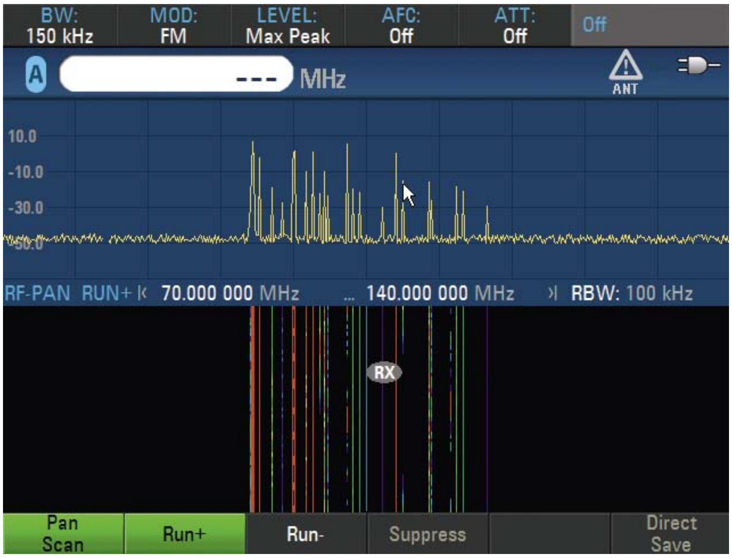

FIG 2 **Broadband panorama scan mode for identifying and delimiting a frequency range of interest.**

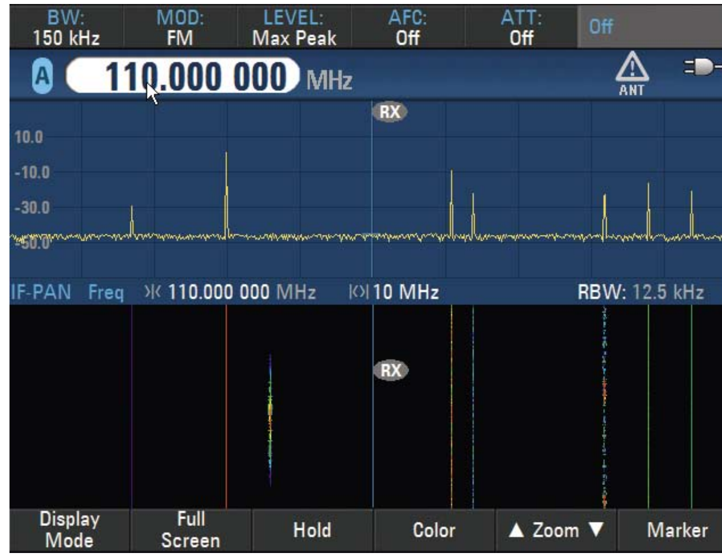

FIG 3 **After identifying and delimiting a frequency range of interest, the IF panorama mode is used for realtime monitoring of a range of max. 10 MHz.**

▶ The brilliant, extremely large 6" color display provides all required information at a glance. It offers high contrast and good readability even in outdoor measurements under daylight conditions.

The broadband panorama scan allows frequency ranges of interest to be detected quickly (FIG 2). After marking the center frequency of a range of interest, you switch to the 10 MHz IF panorama mode (FIG 3), where you can optimally display and analyze the selected signal by choosing the appropriate IF bandwidth from a wide range of available values (10 kHz to 10 MHz).

Radiomonitoring

The receiver's built-in demodulators allow signals with analog modulation as well as unencrypted signals to be audio-monitored on site. The spectrum display provides information on the signal modulation. You can then activate the corresponding demodulator and set the optimal demodulation bandwidth. All demodulation parameters can be set independently of the selected IF bandwidth. The demodulated audio signals can be monitored and analyzed via the loudspeaker on the receiver or by means of headphones.

In stationary radiomonitoring applications, the following data is output via the receiver's integrated LAN interface:

- Complex baseband data (I/Q data) up to 500 kHz bandwidth
- Digital video data (demodulated signal) up to 500 kHz bandwidth
- Digital audio data up to 12.5 kHz bandwidth
- Spectra obtained in panorama scan mode
- Spectra obtained in IF panorama mode
- Measured signal level
- Measured offset value
- Measured field strength (taking into account antenna factors of antenna used; stored in receiver memory)

In mobile radiomonitoring and for subsequent offline analysis or documentation, the information obtained can be stored in the receiver. The following storage media are available:

- 64 Mbyte internal RAM
- 4 Gbyte SD card (can be expanded to 8 Gbyte)

The data stored to the SD card in the receiver (e.g. I/Q data up to 500 kHz bandwidth, audio data up to 12.5 kHz bandwidth, spectra, measured values) can be transferred to a PC via USB or LAN or the SD card itself. The R&S®GX430 analysis software can be used for the offline extraction of a variety of signal parameters such as modulation modes, coding, plain text, etc. For stationary or remote applications, the receiver can be fully remote-controlled by means of SCPI commands via its LAN interface.

Detection of extremely weak signals

The R&S®PR100 features exceptionally powerful RF signal processing, which allows even extremely weak signals to be captured and displayed in the frequency domain. Telltale emissions thus become visible in the frequency spectrum – e.g. the emissions of a bug – and countermeasures can be initiated. The receiver includes a built-in, powerful preselection, which makes it suitable for use even in scenarios with high communications density (strong adjacent-channel interferers).

Communications planning and monitoring

The receiver's powerful panorama scan provides a detailed picture of the activities taking place in the frequency range of interest. The waterfall diagram displays frequency activities as a function of time. The results thus obtained can be used in communications or network planning. In the field, the receiver can then be used to verify that allocated frequency bands are complied with. The R&S®PR100 is thus also a valuable tool for ensuring the interference-free operation of an organization's own communications networks.

In the memory scan mode, up to 1024 frequency channels can be selected and checked for communications activities. This function allows, for example, the allocation and checking of all GSM communications channels.

Channel monitoring and acoustic source location

The cyclic monitoring of frequencies is indispensable for the quick detection of emergency calls, for example. With its frequency scan mode, the R&S®PR100 is optimally suited for this task. The user can promptly respond to incoming emergency calls and initiate appropriate action. If the R&S®PR100 is used together with the R&S®HE300 portable directional antenna, emergency calls can be quickly located on site. Transmitters can be tracked not only visually, i.e. by displaying the received signal level or the spectrum, but also acoustically by means of the tone function. This function outputs a whistling tone whose pitch varies with the level of the signal received.

This is very useful in practical scenarios. For example, if a transmitter has been identified at a specific frequency, the tone function can be used to determine the transmitter's direction of incidence by pointing the antenna in various directions. During this operation, all important receiver functions can be adjusted both on the front and the top side of the

FIG 4 All important functions can also be set via the receiver's top control panel – a highly useful feature in the field.

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receiver due to its dual operating concept (FIG 4). The user can fully concentrate on the terrain when approaching the transmitter, as there is no need for continuously monitoring the receiver display. This function is also very useful for tracking miniature transmitters (e.g. bugs), thus ensuring the confidentiality of an organization's own information (e.g. in conference rooms).

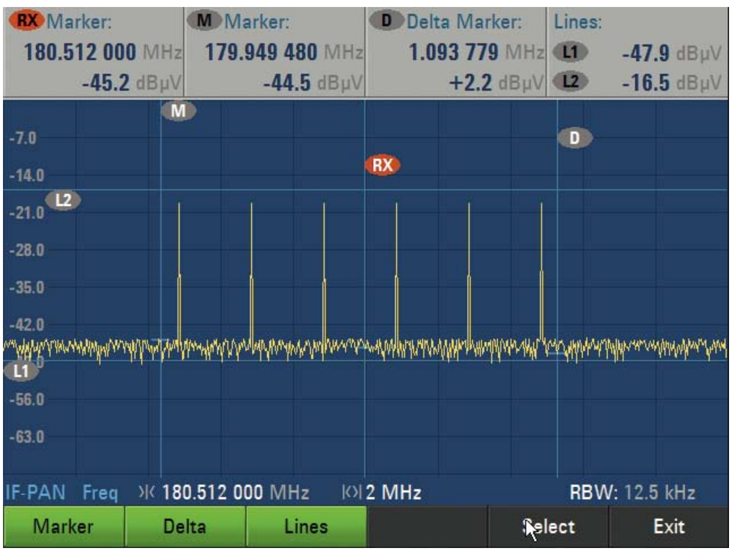

FIG 5
Testing radios for proper functioning by means of the spectrum display – the received signal should be within the limits defined by the markers.

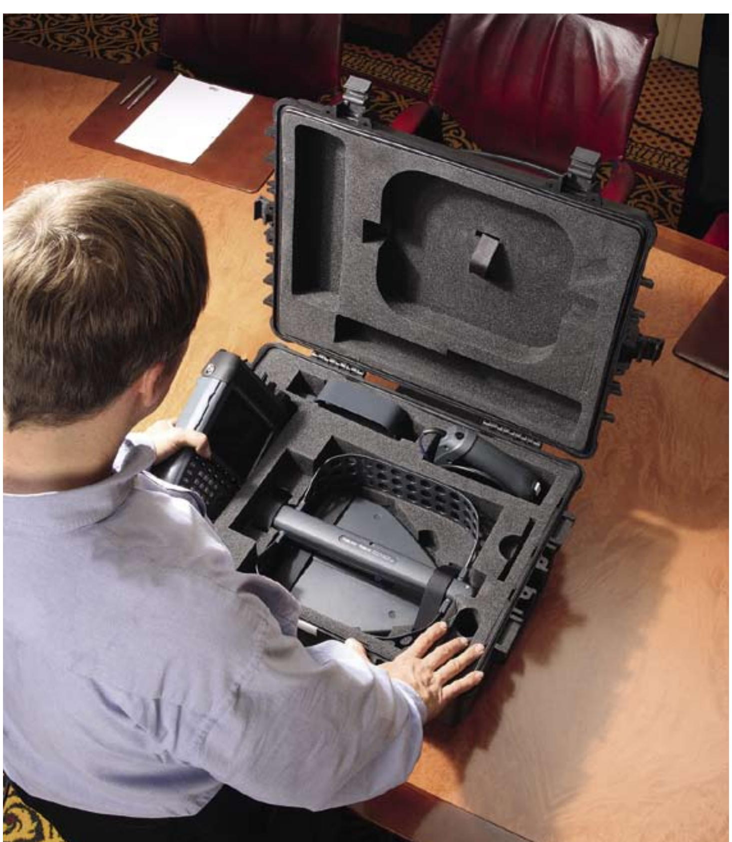

FIG 6
The R&S®PR100 receiver and the R&S®HE300 antenna with its various modules are accommodated in a rugged transit case.

Quick and easy functional tests on radio equipment

With its great ease of operation, large and straightforward display, and easy retrieval of instrument settings, the R&S®PR100 also provides quick and easy functional tests on radio equipment installed, for example, in a vehicle. Before operation is started, the receiver is switched to the desired mode by calling predefined settings (recall function) from the SD card; then a test sequence is emitted by the radios to be tested. If the received signal spectrum is within the limits defined by markers on the receiver display, the radios have passed the functional test and are ready for deployment (FIG 5). Such tests can be performed by the user prior to each operation; there is no need for on-site service technicians.

Optimized for mobile use

The receiver and the R&S®HE300 antenna are stored together in a rugged, waterproof transit case with rigid, snug-fitting plastic-foam compartments that provide perfect protection against vibration (FIG 6). The individual compartments are clearly arranged in the case, so that the user can see at a glance whether the equipment needed for a specific task is complete.

The R&S®PR100 operates for a period of up to four hours on a single battery charge. The battery can be exchanged quickly and easily without requiring any tools. If several charged batteries are available, the receiver operating time can be extended accordingly. Current settings are automatically written to the internal memory when the receiver is switched off. Operation can thus be resumed immediately after a battery change or extended periods of non-use.

The receiver can be suspended from the user's chest by means of a carrying strap. The user can thus control the receiver with both hands, or operate the receiver together with the antenna. The R&S®PR100 receiver and the R&S®HE300 antenna together form a compact, easy-to-carry receiving system that offers major advantages. For example, very weak signals can be detected, as the user can approach signal sources very closely even in difficult terrain.

Due to its ultra-wide frequency range, the R&S®PR100 is unrivaled among portable receivers when it comes to radiomonitoring applications. Its favorable price/performance ratio makes it an indispensable tool for all monitoring tasks where mobility and cost effectiveness are essential. From classic RF applications to frequencies extending far beyond the range used by current communications systems, the receiver meets all relevant requirements and offers ample capacity for future expansions.

Peter Kronseder; Dr. Thomas Nicolay

Condensed data of the R&S®PR100

Frequency range	9 kHz to 7.5 GHz
Realtime bandwidth	10 MHz
Third-order intercept (TOI)	
9 kHz to 30 MHz	typ. +20 dBm
30 MHz to 1.5 GHz	typ. +15 dBm (attenuator on)
1.5 GHz to 3.5 GHz	typ. +17 dBm (attenuator on)
3.5 GHz to 7.5 GHz	typ. +18 dBm
Noise figure	
9 kHz to 30 MHz	typ. 16 dB
30 MHz to 1.5 GHz	typ. 14 dB (attenuator off)
1.5 GHz to 3.5 GHz	typ. 14 dB (attenuator off)
3.5 GHz to 7.5 GHz	typ. 18 dB
Demodulation bandwidth	500 kHz
Digital demodulation filters	15 filters, 150 Hz to 500 kHz
Demodulation modes	AM, USB, FM, LSB, PULSE, CW, I/Q, ISB
RF spectrum scan (panorama scan)	max. 2.0 GHz/s
Outputs/data outputs	FFT and IF spectra; digital I/Q baseband; analog and digital audio; IF uncontrolled

More information at www.rohde-schwarz.com (search term: PR100)

R&S®HE300 Active Directional Antenna

Level measurements, monitoring and transmitter location

The R&S®HE300 active directional antenna uses four exchangeable modules to cover an extremely large frequency range from 9 kHz to 7.5 GHz. When combined with a portable receiver such as the R&S®PR100, the result is a very effective mobile receiving system for locating transmitters.

Monitoring of wide frequency ranges

Modern communications scenarios involve increasingly high frequencies. This boosts the need for monitoring and checking such emissions in order to detect interference or locate illegal transmitters in these new frequency ranges. Mobile systems in vehicles or portable devices are used in such applications. Portable solutions are particularly useful for detecting and locating signal sources in unnavigable places including areas of dense construction, inside of rooms, between equipment or systems producing spurious emissions, in planes and on ships. In all of these applications, special attention must be paid to the antennas that are used. They need to be small and easy to use while exhibiting reliable electrical characteristics.

Further development of tried-and-tested equipment

Rohde & Schwarz developed the R&S®HE 300 portable directional antenna based on its years of success with the R&S®HE 100 and R&S®HE 200 antennas. The development objective for the new antenna was to obtain an extended upper frequency range compared to the older model while retaining the outstanding electrical specifications. The antenna uses four exchangeable modules (FIGs 1 to 4) to cover an extremely large frequency range from 9 kHz to 7.5 GHz. The three modules covering the range from 20 MHz to 7.5 GHz are supplied with the antenna as standard. The HF module for the 9 kHz to 20 MHz range can be ordered separately.

Portable monitoring and measuring system

Combining the antenna with the new R&S®PR 100 portable receiver or another portable receiver or spectrum analyzer yields a very powerful receiving system for determining the position of transmitters. A lightweight, portable equipment combination of this kind can perform measurements inside of buildings or in tough terrain that even all-wheel-drive vehicles cannot access. This cost-effective monitoring concept, which enables directional assessment and level measurements, is also extremely useful since it can be transported and deployed relatively inconspicuously.

In long-term monitoring applications at fixed locations, the antenna can be mounted on a tripod. The connecting thread on the grip piece matches the mounting bolts of conventional camera tripods.

A built-in, selectable low-noise amplifier further enhances system sensitivity at low signal field strengths, thus increasing the probability of intercept (active mode). In passive mode, the amplifier is bypassed so that the antenna can even be used close to powerful signal sources (FIGs 5 and 6).

Ergonomic design for practical use

Particular attention during the development of the antenna was paid to achieving a practical design. The design of the grip piece and the operating elements underwent extensive ergonomic testing by experienced designers. The exchangeable antenna modules are simply plugged into the grip piece according to the desired polarization direction (vertical or horizontal) and mechanically locked.

All components of the R&S®HE 300 including the optional R&S®HE 300 HF antenna module fit into the supplied hardshell case, providing suitable protection for this high-grade antenna even under challenging transport conditions (FIG 6, p. 78).

Herbert Steghafner; Klaus Fischer

More information at www.rohde-schwarz.com (search term: HE300)

Condensed data of the R&S®HE 300

Frequency range	
Antenna module 1	20 MHz to 200 MHz
Antenna module 2	200 MHz to 500 MHz
Antenna module 3	500 MHz to 7500 MHz
Optional antenna module	9 kHz to 20 MHz
Polarization	linear
SWR	<2.5 (typ.)
RF output	N connector
Power supply	rechargeable cells or batteries
Weight	
Total weight	approx. 6 kg (including case)
Operational weight	<1 kg (handle with one module)

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FIG 1 Module for 20 MHz to 200 MHz.

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FIG 2 Module for 200 MHz to 500 MHz.

44956/11

FIG 3 Module for 500 MHz to 7500 MHz.

FIG 4 Optional module for 9 kHz to 20 MHz.

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FIG 5 Antenna factor of the R&S®HE300 in passive mode.

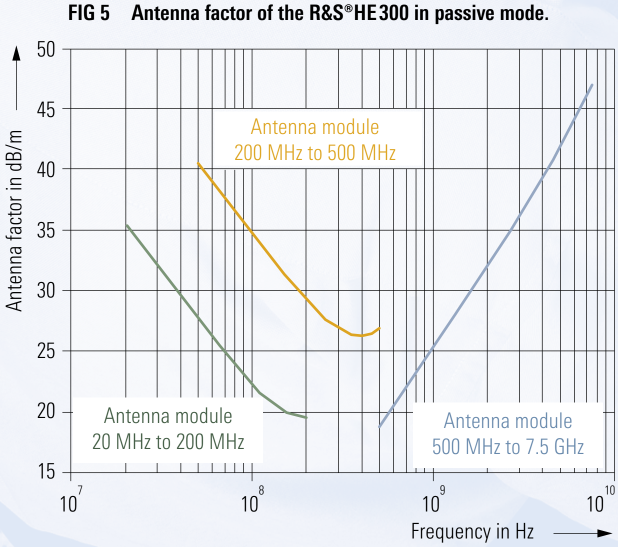
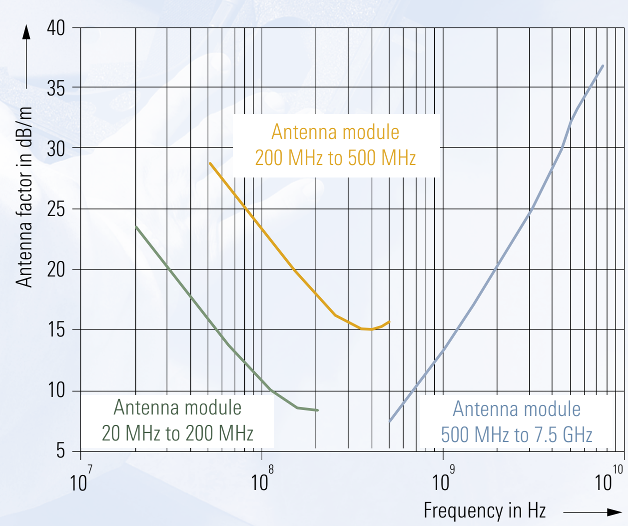


FIG 6 Antenna factor of the R&S®HE300 in active mode.



Joseph Soo, Managing Director Malaysia; Y.B. Dato' Seri Rafidah Aziz, Minister of International Trade and Industry; Christian Leicher, President and COO of ROHDE & SCHWARZ GmbH & Co. KG; Dr. Erich Freund, Head of Sales Asia / Pacific; Alan Seah, General Manager of Rohde & Schwarz Malaysia at the official opening (from left to right).

Stronger local presence in Malaysia

Already represented in Malaysia for 20 years, Rohde & Schwarz moved into a new office in Kuala Lumpur in September 2007. The subsidiary ROHDE & SCHWARZ Malaysia Sdn Bhd was established in June 2004. The new premises in Temasya Industrial Park, Glenmarie, Shah Alam, mean that service and local support in particular can expand.

ROHDE & SCHWARZ Service Center Philippines Inc. founded

Rohde & Schwarz has founded its own service center in the free-trade zone Biñan, Laguna. This service center will in particular benefit the many semiconductor manufacturers that have been attracted to the Philippine location. A large number of them are American companies with local production facilities. Previously, customers had to send their equipment to Singapore for servicing. With its new service center, Rohde & Schwarz is reducing turnaround times (TAT) for repair.

Founding of ROHDE & SCHWARZ Pakistan

Since 2004, Rohde & Schwarz has been represented by a liaison office in Pakistan. By establishing ROHDE & SCHWARZ Pakistan on May 17, 2007, in Islamabad, Rohde & Schwarz now has its own subsidiary with a total of 50 employees. Ahmad Jawad will assume the position of Managing Director. Patrick Pötschke, Dr. Erich Freund, Franz Schäffler and Franz Kern (responsible for Rohde & Schwarz sales acitivities in Asia) are members of the Board of Directors.

New subsidiary in Greece

After many years of cooperation with the distributor Mercury S.A., Rohde & Schwarz has established its own national company in Greece. ROHDE & SCHWARZ HELLAS (RSGR) is based in Athens. Management is in the hands of Peter Spanakos (photo 2nd from left), owner of Mercury S.A., and Gregor Rapf.

ROHDE & SCHWARZ Pakistan is located in this building in Islamabad.

ROHDE & SCHWARZ HELLAS: Peter Spanakos (2nd from left) together with colleagues.

User Club Meeting in Yunnan (China)

More than 100 representatives of the local regulatory authority RMC were present at the 7th User Club Meeting. Rohde & Schwarz China and Gerhard Geier, Head of the Radiomonitoring and Radiolocation Division, presented numerous new developments. The latest receiver solutions for portable and stationary operations as well as new direction finding antennas and methods sparked great interest among the attendees. The meeting, where this Division presents its products and solutions every two years, is thus becoming an even more firmly established event.

User Club Meeting in Yunnan.

Successful radiomonitoring workshop in Bahrain

The radiomonitoring workshop, which took place in Manama, Bahrain, in July 2007,was attended by 52 participants from the GCC states.

The workshop was organized by the Telecommunications Bureau of the Cooperation Council for the Arab States of the Gulf, which is a multinational organization for coordinating the tasks in the field of telecommunications. At the workshop, speakers from Rohde & Schwarz presented applications, solutions and logistics in accordance with ITU recommendations. One focal point was the monitoring of digital signals. The presentations were accompanied by a number of live measurements. The attendees were able to get a first-hand look at the receivers, spectrum analyzers, monitoring systems and associated software from Rohde & Schwarz.

Mahmood M. Sayyar (left), Director of the Telecommunications Bureau of the GCC, presents a Certificate of Gratitude to speaker Hans von Geldern, ITU Liaison Officer at Rohde & Schwarz.

Digital TV for New Zealand

Rohde & Schwarz has been contracted by Kordia Group Limited to supply DVB-T transmitters. During the initial phase of the DVB-T expansion, the New Zealand broadcaster intends to use the transmitters to provide approximately 75 % of the population with digital terrestrial TV. Since the transmitters from Rohde & Schwarz can be remote-controlled, they are ideal for such a topographically diverse country as New Zealand with its many islands and inaccessible sites in the mountains.

Latest generation of ATC radios for Swedish Air Force

The Swedish Air Force will be equipped with Rohde & Schwarz radios for military air traffic control (ATC).

The Swedish Defence Materiel Administration (FMV) has placed an order for about 90 transmitters and 90 receivers of the R&S®Series 4200 as well as 56 transceivers of the R&S®Series 4400. The radios will be installed at six air bases and three mobile bases, where they will provide secure ground-to-air communications with Swedish Air Force helicopters and tactical / transport aircraft as well as with civilian aircraft.

ILS/VOR analyzers for French ATC

In conjunction with an invitation to tender, the French air navigation service provider DSNA/DTI has decided to buy a total of 68 R&S®EVS300 ILS/VOR* analyzers.

The first 30 instruments have already been delivered in August 2007. The DSNA/DTI is responsible for checking terrestrial radio navigation equipment in France as well as in the French overseas regions. In future, the mobile R&S®EVS300 analyzers will be used to maintain the equipment. The high safety requirements placed on instrument landing can thus be met. The R&S®EVS300 is the only instrument worldwide that can be used both for ground-based measurements and in flight inspection aircraft.

* ILS: instrument landing system; VOR: VHF omnidirectional range

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