NEWS

199/09

ROHDE&SCHWARZ

A new dimension in compactness

Ultracompact and energy-efficient low-power UHF TV transmitters in weatherproof enclosures, as well as handheld TV analyzers for all on-site quality and service measurements

WIRELESS TECHNOLOGIES

Network operators focus on keeping a close eye on mobile radio network quality

FOCUS

How the RF power measurand is traced back to the national primary standard

RADIOMONITORING / RADIOLOCATION

A clear view of the frequency spectrum: convenient signal analysis at the symbol and bit stream level

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NEWS

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Editor and layout: Ludwig Drexl, Redaktion – Technik (German)
English translation: Dept. 9MC7
Photos: Rohde&Schwarz
Printed in Germany
Volume 49

Circulation (German, English, French and Chinese) 80000
approx. 4 times a year
ISSN 0028-9108
Supply free of charge through your nearest
Rohde&Schwarz representative

PD 5214.0701.72

Cover feature

Full-coverage, terrestrial TV networks include not only large-scale sites equipped with high-power transmitters, but normally also a wide variety of lower-power transmitters that help ensure optimal reception in the coverage area. The new R&S®SCx8000 low-

Antenna courtesy by Kathrein-Werke KG

to medium-power transmitters (pages 66 and 84) are especially cost-efficient in achieving this goal.

Another benefit is the possibility to install the transmitters in weatherproof enclosures, which in the case of wireless program feed eliminates the need for additional infrastructure apart from the power supply.

The R&S®SCx8000 multistandard transmitter also supports the brand-new ATSC Mobile DTV standard (page 60), co-developed by Rohde&Schwarz and currently being implemented in the United States.

The R&S®ETH handheld TV analyzer (see page 54) offers all the measurement functions needed for carrying out on-site quality and service measurements on low-power transmitters.

Contents

Network operators must continuously monitor the quality of their networks. Two articles starting on pages 7 and 11 describe how coverage measurement systems from Rohde&Schwarz help to ensure QoS.

The new R&S®NRP-Z31 AVG power sensor covers the entire Ka band for satellite radio: for general applications in the lab, in production, and in service as well as for monitoring the power of satellite systems (page 38).

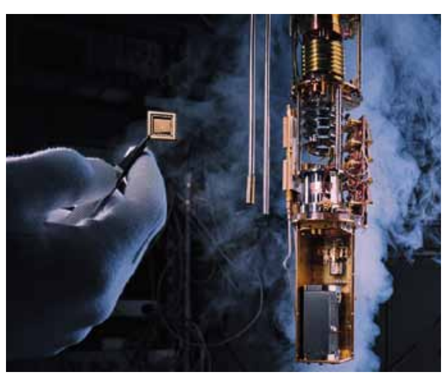


Photo: Marc Steinmetz / VISUM

Spotlight on measurement accuracy: Two articles – one from the German metrology institute (Physikalisch-Technische Bundesanstalt, PTB) – deal with RF power, an extremely important measurand for Rohde&Schwarz, and how it is traced back to the national primary standard of the Federal Republic of Germany (pages 28 and 34).

Small, lightweight, and extraordinarily versatile: The R&S®ETH handheld TV analyzer offers the complete measurement functionality needed for carrying out on-site quality and service measurements on low-power transmitters (page 54).

BROADCASTING

R&S®SX801 multistandard exciter.

RADIOMONITORING / RADIOLOCATION

MISCELLANEOUS

Driving quality – operators need to keep their mobile networks up to speed

Mobile operators carry out drive tests to optimize their networks and identify problem sources. By using the R&S®ROMES network problem analyzer software, they have a tool that can rapidly analyze the mass of data that drive tests typically generate (see article at right). And the report beginning on page 11 describes how operators can identify GSM interferences quickly and automatically with radio network analyzers from Rohde & Schwarz.

Turning raw drive test data into actionable information

The new R&S®ROMES network problem analyzer software analyzes the large volumes of data captured in drive tests and breaks it down into relevant problem spots to help operators identify and clearly document weak points in mobile radio networks.

Gaining and maintaining a clear picture

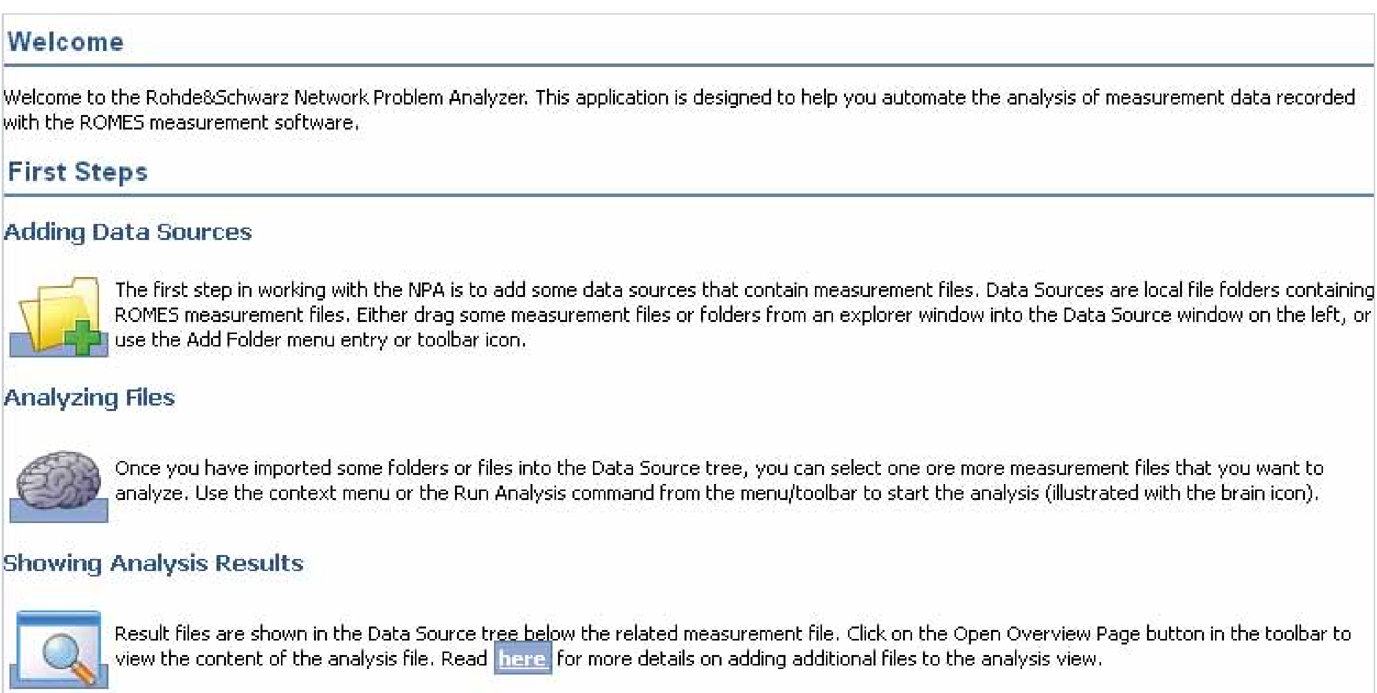
It is a problem that mobile network operators know all too well: Drive tests generate vast quantities of data that need to be analyzed to identify weak points and gaps in network coverage. Manually analyzing data on this scale can be a laborious process — one that calls for special tools. For R&S®ROMES users, though, life is a whole lot easier, because the drive test software provides a useful array of tools designed to sequentially analyze individual measurements.

With the R&S®ROMES network problem analyzer (NPA) software, things are simpler still. This new tool can automatically evaluate mass test data and even entire drive test campaigns, either on a computer in the vehicle during an actual drive, or later, back in the office. Resorting to manual evaluation is only necessary in rare instances.

The software consists of a core analysis engine (which processes the test data from R&S®ROMES and dispatches it to a number of analysis plug-ins) and a user interface that displays the results in a clearly organized form.

The NPA uses dedicated analysis plug-ins for each of the tasks involved in post-processing the data. This modern architecture means that the software can be expanded quickly and easily to handle new or highly specialized tasks — by creating special analysis plug-ins (e.g. to identify uplink interference or to support new standards like LTE) or by implementing new views in the user interface to enhance the presentation of results. The optional software development kit (SDK) is also simple to use, enabling even users with a limited knowledge of programming to create their own plug-ins for any kind of drive test data processing.

FIG 1 A section of the page displayed when the R&S®ROMES NPA starts: It explains the basic workflow to help users familiarize themselves with the software quickly.

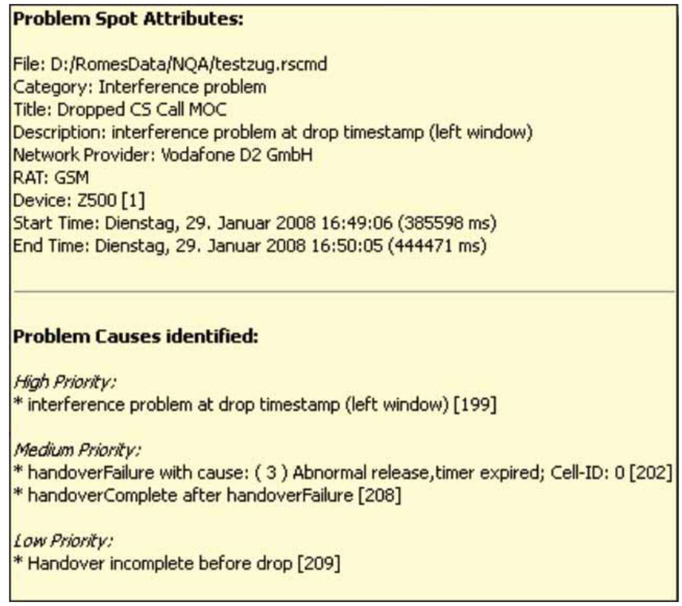


Easy-to-use interface …

The R&S®ROMES network problem analyzer software has a user-friendly browser-like interface designed to guide network optimizers and field engineers easily through the workflow. The start page contains all of the main functions and explains how these work together (FIG 1). It also includes links that display detailed views. This makes learning to use the software a simple process and enables users to produce usable results exceptionally fast. The results are displayed as problem lists, as tables of transactions, and as pie and bar charts of statistics (FIG 2).

Users can run the R&S®ROMES drive test software directly from any item in the problem lists. The software presents a problem area as a combination of time and location information, ready for deeper analysis. Due to this drill-down ability, which is performed automatically via a menu entry, it is not necessary to replay the test file at the desired point. This significantly accelerates file loading, especially with large files (FIGs 4 and 5). Users can increase and reduce the content of individual pages easily using drag-and-drop. For instance, they can drag additional results into the analysis view and extend tables and charts by inserting more data.

FIG 2 An overview of results from a statistical analysis of several drive test files.



Problem Spot Attributes:

File: D:/RomesData/NQA/testzug.rscmd
Category: Interference problem
Title: Dropped CS Call MOC
Description: interference problem at drop timestamp (left window)
Network Provider: Vodafone D2 GmbH
RAT: GSM
Device: Z500 [1]
Start Time: Dienstag, 29. Januar 2008 16:49:06 (385598 ms)
End Time: Dienstag, 29. Januar 2008 16:50:05 (444471 ms)

Problem Causes identified:

High Priority:
* interference problem at drop timestamp (left window) [199]

Medium Priority:
* handoverFailure with cause: (3) Abnormal release,timer expired; Cell-ID: 0 [202]
* handoverComplete after handoverFailure [208]

Low Priority:
* Handover incomplete before drop [209]

FIG 3 A prioritized list of a problem spot's causes.

The analysis modules (called test data processors) are configured through the user interface. The settings for these modules can be combined to create comprehensive analysis configurations — e.g. to evaluate specific campaigns at a lower or higher threshold, or to confine processing to specific types of analyses.

… and highly analytical core

The NPA's core analysis engine processes the R&S®ROMES test files, then conditions and passes the data to the analysis modules. The NPA can be expanded with little effort through its lean C++ programming interface. The software library supplied eases implementing new modules, because all the user needs to do is define the specific analysis logic. This means network operators and service providers can create their own NPA expansions — a valuable capability that makes sure in-house expertise stays in-house and that engineers can rapidly produce specially tailored analyses when they have to fix specific network problems quickly.

The basic version of the NPA provides comprehensive analysis functionality for voice calls in GSM/WCDMA networks. Depending on the outcome of voice call analysis, the software can run various problem detectors — to examine handover procedures, check coverage and interference, and identify network and mobile handset malfunctions, for example. This produces a catalog of problem spots, plus a prioritized list of causes identified for each problem spot (FIG 3).

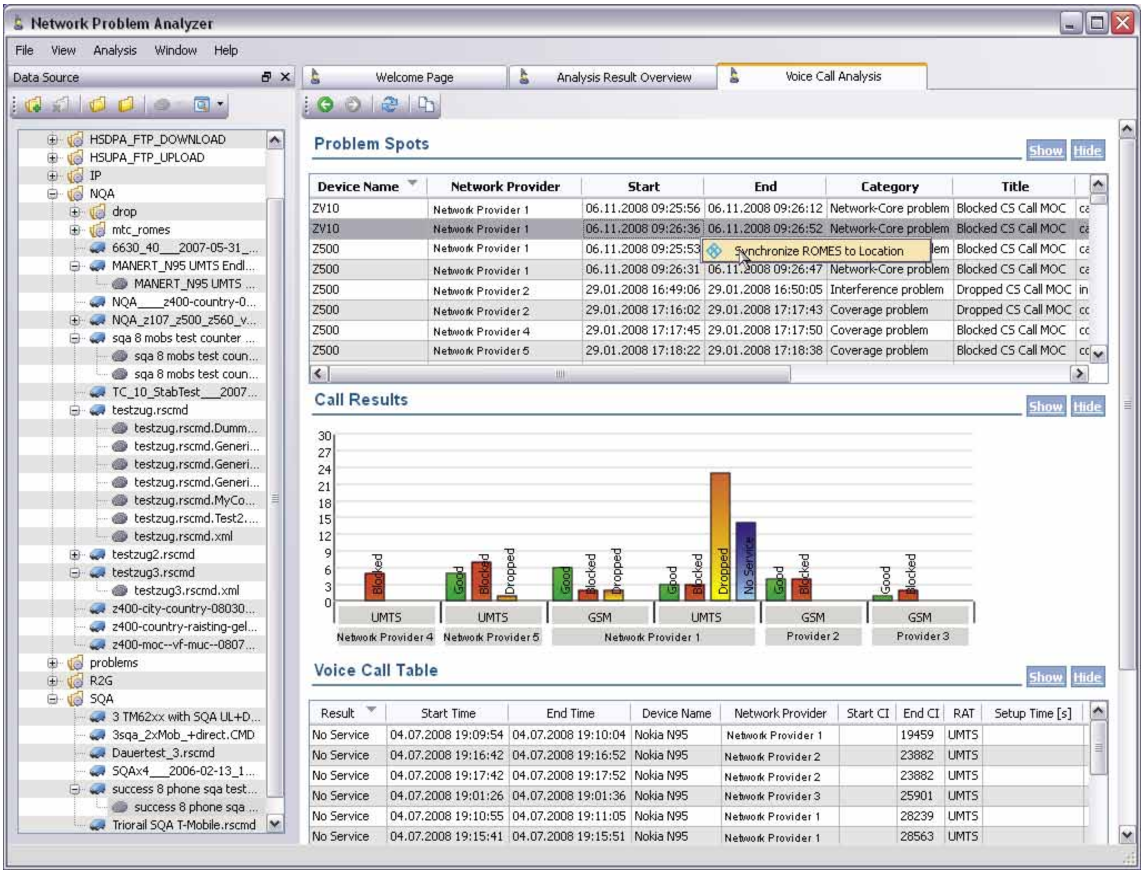


FIG 4 A simple mouse click is all it takes to drill down from a problem spot into a detailed R&S®ROMES analysis.

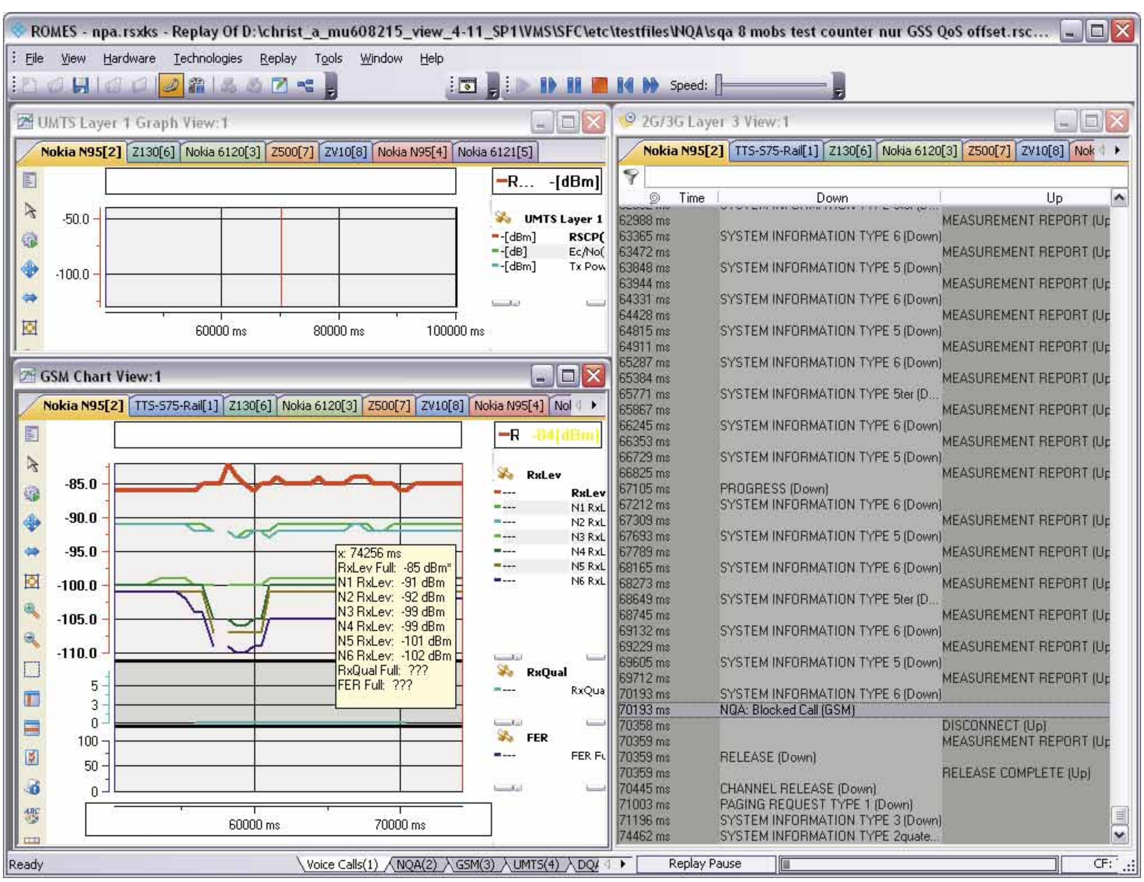


FIG 5 R&S®ROMES synchronizes instantly with the NPA.

Other analysis modules can extract ETSI key performance indicators (KPIs) identified by R&S®ROMES and condition them so that they can be grouped and combined according to a variety of criteria. And if data throughput problems and their causes need to be identified, data transactions over HSDPA and HSUPA can be analyzed separately. The software assigns identified causes to different categories so that users can see which element in the network is causing a specific throughput problem.

In contrast to the analysis modules described above, the generic signal processor in the NPA enables the modules available in R&S®ROMES to be combined with mathematical and logical operators to create complex test data processors. These can either compile new problem lists or, alternatively, generate statistics from the signal processing results (FIG 6). This means that, in principle, there are no limits on how data acquired in drive tests can be post-processed.

Summary and future developments

The R&S®ROMES NPA greatly simplifies working with large volumes of drive test data. Its ability to access numerous powerful tools in the R&S®ROMES drive test software leverages capabilities in order to create a feature-rich solution that is greater than the sum of its parts. This new and powerful tool from Rohde&Schwarz delivers advanced post-processing functionalities that complement R&S®ROMES and R&S®ROMES2GO* to create a comprehensive drive test portfolio.

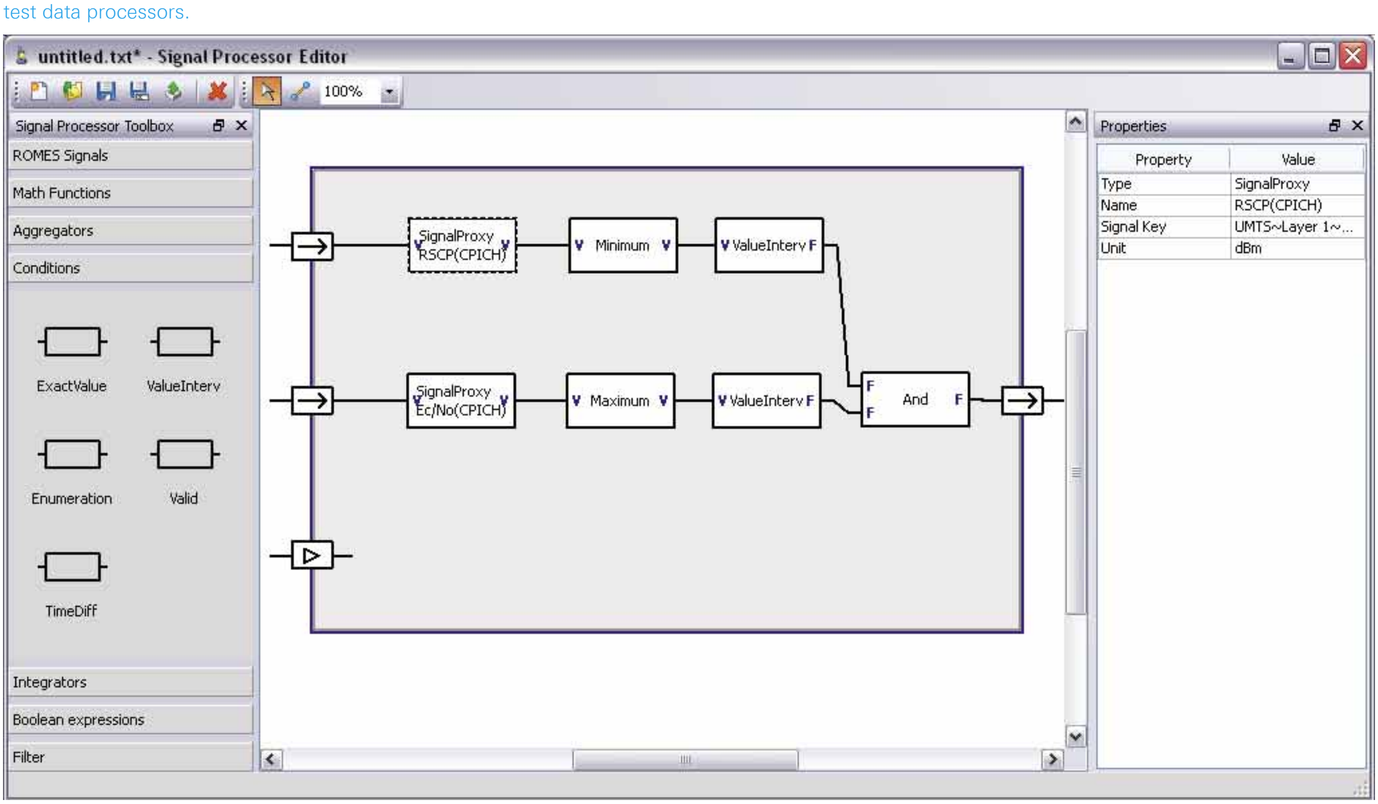
Additional analysis modules are currently being developed. These include a module for problem analysis during LTE network setup and an IP analyzer for failed data transactions that can identify where precisely a problem has occurred during call setup or data transmission, along with possible causes.

Likewise in the pipeline are new visualizations for the user interface, additional filtering options, and user-configurable views. The software will also include print-ready views to enable users to produce reports based on R&S®ROMES data and will allow analysis results to be stored in a database to enable even larger volumes of drive test data to be managed and evaluated efficiently.

Andreas Christiansen

* All the trumps in one hand — with R&S®ROMES2GO. News from Rohde&Schwarz (2008) No. 198, pp 6–9

FIG 6 The editor for the general signal processor enables users to create their own analysis modules by combining basic components to form complex test data processors.



Automatic measurement and detection of GSM interferences

Poor speech quality and dropped calls in GSM networks may be caused by interferences as a result of high traffic load. The radio network analyzers from Rohde & Schwarz make the detection of such sources of error quick and efficient. A new algorithm automatically analyzes measurement results and, in addition, unambiguously identifies interferers.

Detection of GSM interferences – more important than ever

GSM networks are still the workhorses of network operators, as the expansion of WCDMA networks is lagging behind. However, the higher the traffic load in such GSM networks – primarily as a result of voice telephony – and the higher the number of carrier frequencies added per sector, the greater the risk of problems caused by interferences. This translates into poor speech quality and dropped calls.

GSM interference measurement systems from Rohde & Schwarz support users in detecting such sources of interference: One outstanding example is the R&S®TSMU radio network analyzer, which was launched in 2003. Together with the R&S®ROMES coverage measurement software, the analyzer helps to quickly and efficiently measure GSM interferences and to identify potential interferers in the individual network [1]. While the basic test setup and T&M method remain the same, the following innovations/enhancements have been introduced over the past two years:

The R&S®TSMx radio network analyzers are extremely powerful. The R&S®TSMQ radio network analyzer, for example, (see FIG below) not only supports networks of all standards (WCDMA, GSM, CDMA2000®) but can also simultaneously perform measurements in all standards.

- The R&S®TSMQ radio network analyzer [2] (see box on left) is one of these new products. Compared to the R&S®TSMU, it provides a higher measurement speed in GSM networks (100 channels/s instead of 80) and thus maximizes the chance of detecting interferers.
- The new R&S®ROMES4COI GSM interference software option unambiguously identifies interferers based on power measurements performed in timeslots, thus eliminating the time-consuming testing of potential interference frequencies displayed on the list of interfering signals.
- Owing to an improved GUI, operation has become even easier.

New software option analyzes measurement results fully automatically

Previously, the GSM network scanner within the R&S®TSMU / R&S®TSMQ platform could only measure BCCH or C0 channels. It was not able to detect traffic channels (Cx) or individual timeslots. Although the R&S®ROMES coverage measurement software did provide a selection of potential interferers together with current receive levels, the displayed measurement results still had to be evaluated by the user.

Now, the new algorithm can fully automatically analyze measurement results and unambiguously identify interferers. For details on the new measurement method, see box on pages 13 and 14. A completely new method developed by Rohde & Schwarz, which has been implemented in the R&S®ROMES coverage measurement software and in the firmware of the GSM network scanners, now enables users to individually measure the power in specific timeslots while using the same hardware configuration. If the measured signal component (i.e. the cell causing the interference) is strong enough, the source of error can be detected. This is done by identifying the training sequence code (TSC), which, using the base station list, can unambiguously be assigned to a base station color code (BCC) and thus to a cell.

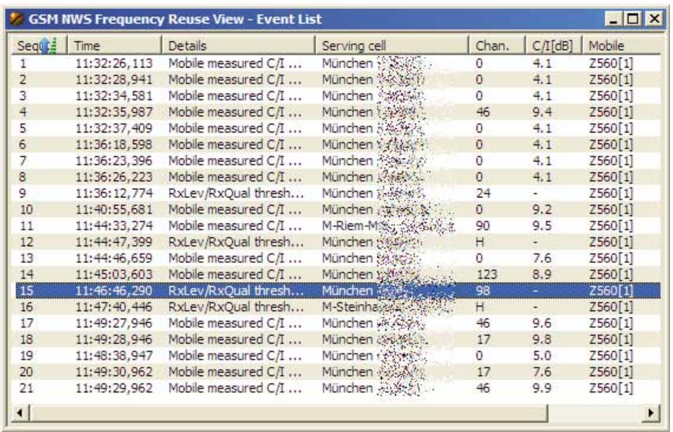
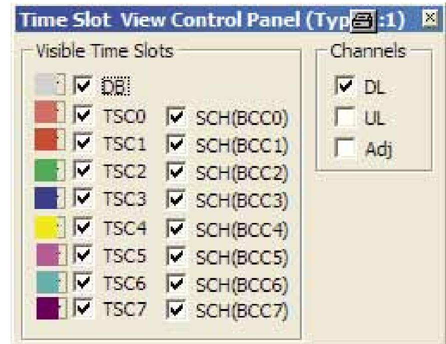


FIG 3 If the defined limits for RxLev/RxQual are reached, an error message will be output in the event list.

FIG 4 This window defines the display of identified training sequences in the timeslot view.



Finding interferers

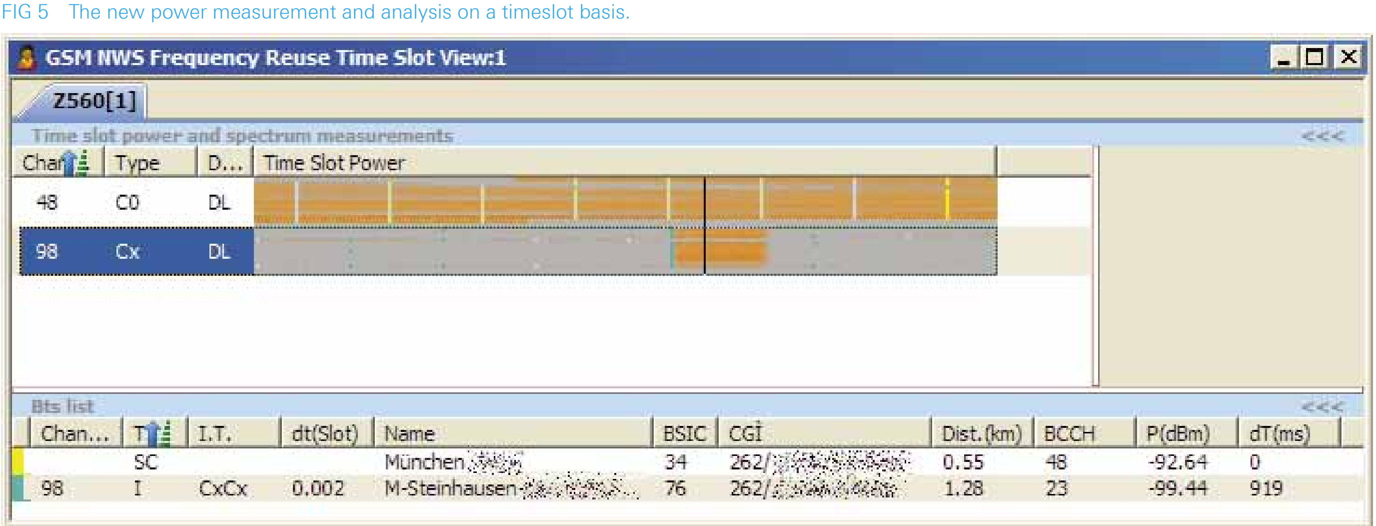
As in the past, the test mobile phone is operated in the endless call mode while the measurement is performed. If a defined minimum/maximum value of C/I or RxLev/RxQual is exceeded, an error message will be output in the event list. For example, in FIG 3, the values for RxLev/RxQual in the Time 11:46:46,290 column violate the limits set for channel 98.

The upper section of FIG 5 shows the results of the measurements that are performed in the timeslots: the impaired channel 98 (Cx) is highlighted in blue at the beginning of the timeslots and the associated C0 on channel 48 in yellow at the beginning of the timeslots. These highlighted areas represent the training sequences of the measured timeslots. The degree of saturation highlighted in orange corresponds to the relative receive power in the corresponding timeslot in this channel (to provide a better overview, the power display was normalized).

The timeslot view control panel (FIG 4) defines how identified training sequences are displayed in the timeslot view. The timeslot view thus displays the training sequences of different base stations in different colors. Since each cell broadcasts the same color code (BCC) on all carriers, a second color in the timeslot view indicates that a second base station was received. The example in FIG 5 shows timeslots that are highlighted in yellow (BCC 4) and in light blue (BCC 6): This reveals that they originate from different base stations.

If the black vertical line is positioned on the impairing timeslot using the cursor, the loaded BTS list of the operator allows the received cell to be identified unambiguously and displayed in the lower part of the window shown in FIG 5 (M-Steinhausen…, BCC 6 (light blue), power, distance, etc.). In addition, two different timeslot offsets between the channels are present, as displayed in the "dt(Slot)" column. This indicates two different interferers (with identical BCC but different timing offset) as all carriers of a cell are synchronized.

FIG 5 The new power measurement and analysis on a timeslot basis.



The new measurement method in detail

The ever increasing demand for transmission channels in GSM mobile radio networks and limited frequency resources call for the multiple re-use of frequencies. As a consequence, transmission channels are often impaired by a high number of co-channel and adjacent-channel interferences. As the structure of wanted and unwanted signals is basically the same, it is quite difficult to determine and discriminate between wanted and unwanted signal components. While mobile phones cannot be used for such tasks, the R&S®TSMx radio network analyzers from Rohde & Schwarz are ideal for such interference measurements.

Which signal structures are best suited for performing interference analysis?
Every base transceiver station (BTS) uses specific auxiliary signals to support the synchronization of the mobile phones with the network. Each cell broadcasts these auxiliary signals via a radio channel, which is usually referred to as the BCCH of the cell (or even more precisely, as the BCCH carrier or C0). The auxiliary signals are referred to as a frequency correction burst (FB) and synchronization burst (SB). All other frequencies used in the cell serve as traffic channels (TCHs or Cx) to transmit voice or data.

The FB is a frequency-shifted sinusoidal signal sent periodically on the BCCH carrier. This signal is a reference signal that supports the synchronization of the mobile phone in the frequency domain. The SB contains information that is used for synchronization in the time domain. Such information includes a characteristic bit sequence, also referred to as the extended training sequence (ETS), frame numbers, and the base station identity code (BSIC). This code offers one of the first means of differentiating between different signal sources.

The ETS is stored in each GSM mobile phone and is a unique parameter in the GSM world. Its length and uniqueness optimally support the synchronization process of a mobile phone. An impaired ETS on the transmission path enables GSM equipment to draw conclusions about potential losses in useful data. Actually, recognizing such an impaired ETS makes it possible to correctly decode the BSIC and the frame number (equalizer principle). Each cell broadcasts the FB and SB in a regular predefined time pattern (51 multiframe structure, FIG 1). This pattern is the key to determining or distinguishing between different signal components within a channel.

How do signal components from different sources differ in the receive channel?
Depending on how far various transmitting stations are located from the measurement system, signals using an identical pattern that are broadcast from different cells are received by the measurement system with different timing offsets and receive levels. In case of a fixed measurement location, the starting time of this characteristic 51 multiframe

Frame structures / timeslots in the BCCH (carrier) of a base station

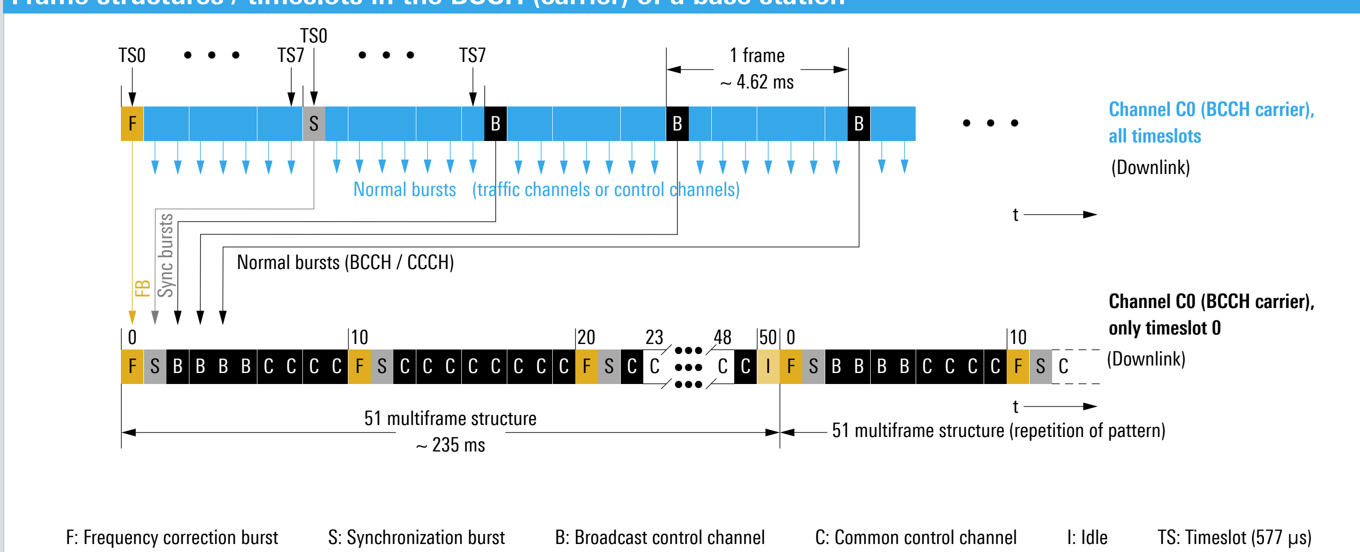


FIG 1 BCCH carriers transmit the frequency correction and synchronization burst as well as additional auxiliary signals in timeslot TS0.

structure always has the same timing offset provided that it originates from the same source. A different timing offset thus indicates that the received signal was broadcast from a different source (FIG 2).

If the measurement position and thus signal delays and levels change, the software compensates for such changes by processing position information, e.g. originating from a GPS receiver. Analysis is relatively easy if the sources are BCCH carriers.

What is different with interferences caused by traffic channels?

If the wanted / unwanted signals are traffic channels, characteristic recognition structures such as FB and SB are not present. The only way to identify and distinguish between signal components in traffic channels is to evaluate the normal training sequences (TSC) contained in every timeslot (burst).

However, an analysis based on normal training sequences requires more effort than that based on FB and SB. To perform a correct measurement, all TSCs must be analyzed and considered on a timeslot basis.

Due to the high measurement speed of the R&S®TSMx family of radio network analyzers and the new R&S®ROMES4COI software option, this is not a problem. These systems now enable users to measure and identify different signal components in the impaired channel also on a timeslot basis. The same principle also applies to traffic channels in the uplink, thus allowing uplink timeslots to be analyzed, too. By using the R&S®ROMES coverage measurement software and a base station list, users can quickly and efficiently identify which unwanted GSM signal components occur in a receive channel, how strong they are, and which station is broadcasting the signal.

Kurt Gstattenbauer

Different periodic timing offset at measurement location for BCCH (carrier) from different stations

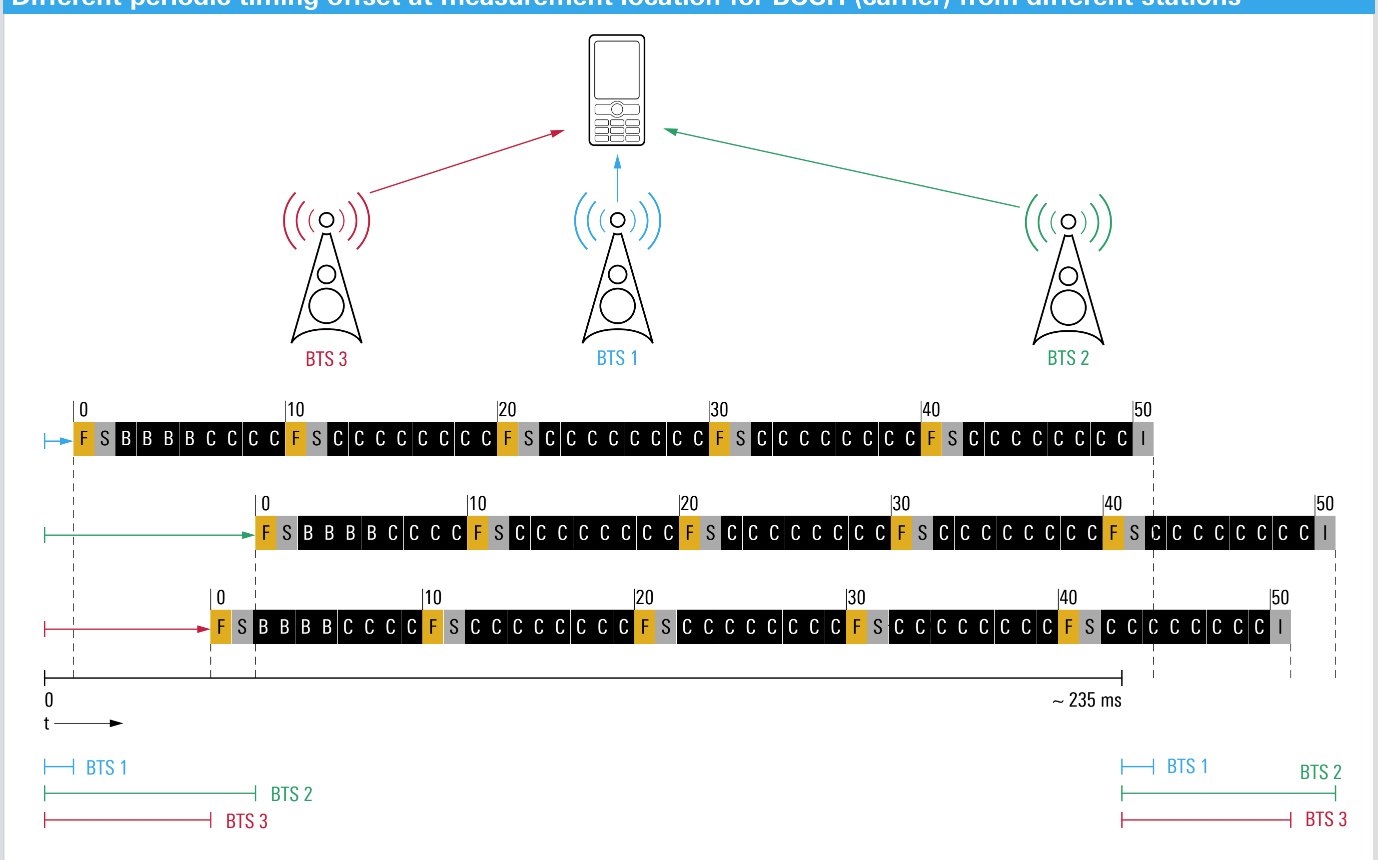


FIG 2 The different timing offset of the 51 multiframe structures shows that the received signals have a different source.

If the black vertical line is moved to another timeslot, the second interferer will also be displayed (FIG 6). In this example, the C0 of the "M-Moosfeld- …" cell impairs traffic channel 98 of the test mobile phone.

Summary

As in the past, the latest method also enables users to measure and analyze interferences. And it allows "What if … " ways of looking at detailed problems by modifying corresponding trigger thresholds. The system records initial measurement data, thus enabling users to run the algorithm at any time with modified limits.

The new implementation provides important additional information: Although the measurement time is the same, the new implementation considerably reduces the effort to analyze and verify the interfering cells and also reduces troubleshooting times. Since the time-consuming testing of multiple frequencies displayed on the list of interfering signals is no longer required, the staff in the operation and maintenance center also have a lot less work to do.

Current R&S®ROMES users merely need to perform a simple software upgrade. GSM network scanners that are already available simply need to update their firmware to the latest version.

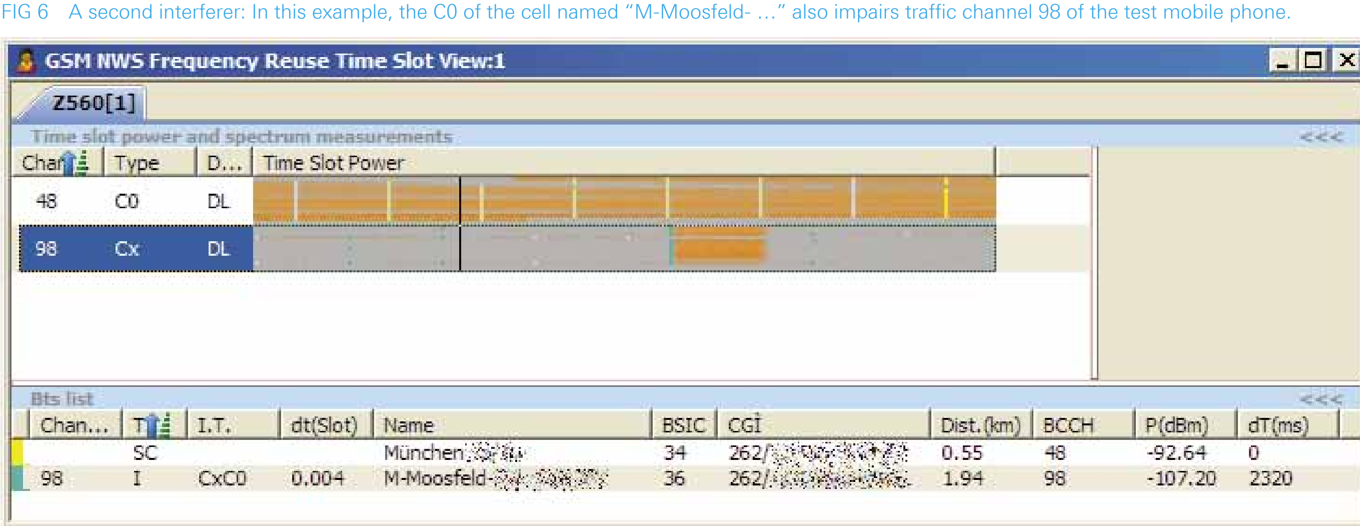
Christian Fischer

Abbreviations

BCCH	Broadcast control channel (also C0)
BSIC	Base transceiver station identity code (= NCC + BCC)
	NCC network color code
	BCC BTS color code
BTS	Base transceiver station
CCCH	Common control channel
C/I	Carrier-to-interference performance
ETS	Extended training sequence
FB	Frequency correction burst
FCCH	Frequency correction channel
RxLev	Reception level
RxQual	Reception quality
SB	Synchronization burst
SCH	Synchronization channel
TCH	Traffic channel (also Cx)
TSC	Training sequence code

REFERENCES
[1] Radio Network Analyzer R&S®TSMU: Automatic detection of interferences in GSM networks. News from Rohde&Schwarz (2006) No. 190, pp 4–9
[2] R&S®TSMx Radio Network Analyzers: Radio network analyzers for all tasks and any budget. News from Rohde&Schwarz (2007) No. 192, pp 5–8

FIG 6 A second interferer: In this example, the C0 of the cell named "M-Moosfeld- …" also impairs traffic channel 98 of the test mobile phone.



LTE protocol tests for IO(D)T and R&D using the R&S®CMW500

The standardization of layer 3 signaling for the new UMTS long term evolution (LTE) standard is almost complete, and Rohde & Schwarz is ready with test scenario packages for the R&S®CMW500 test platform as well as with a powerful programming interface for creating customized tests. The LSTI-defined IODT tests play a significant role here.

The LTE/SAE Trial Initiative

The LTE/SAE Trial Initiative (LSTI) is a group of network operators and manufacturers whose goal it is to drive the implementation of the 3GPP LTE/SAE standard. The particular focus is on demonstrating the performance of LTE and SAE. LSTI has agreed on a selection of essential LTE functions that are being verified as part of the interoperability development testing (IODT) and interoperability testing (IOT). IODT represents early testing of a subset of LTE/SAE functions on the air interface and is a preparatory step for interoperability testing between manufacturers of network infrastructure and of wireless devices. The individual tests are defined in the LSTI common test descriptions. Rohde & Schwarz became a member of LSTI in February 2008 and has contributed significantly toward the definition of these descriptions.

LSTI IODT test scenarios

Rohde & Schwarz offers the LTE IO(D)T and field trial test scenario package for the R&S®CMW500 test platform. The availability of IODT tests in a lab environment makes it possible to prepare fully for testing in trial networks of an LTE/SAE infrastructure implementation. Additional advantages of the IODT test scenarios on the R&S®CMW500 include:

- Convenient setting of network parameters
- Detailed analysis of test results
- Simple reproducibility of results
- Availability of test scenarios' source code to allow users to modify and expand test scenarios as required

Of particular interest is that the test scenarios in this package can be run on both the R&S®CMW500 hardware protocol tester (FIG 1) and the R&S®CMW-KP502 virtual LTE test environment as pure protocol stack software tests.

FIG 1 The universal R&S®CMW500 wideband radio communication tester addresses the complete test scenario from development through to production. It covers all layers and all relevant standards.

R&S®CMW500: multistandard platform for measurement tasks of the wireless future

The R&S®CMW500 wideband radio communication tester is the first all-in-one solution on the market that covers all phases of development and production. It unifies unique advantages, making it a secure investment for many years to come.

Multistandard platform for development and production

As a true one-box tester, the R&S®CMW500 meets the increasing requirements in the development and production of chipsets and mobile UEs. This is why it supports all production-relevant cellular and noncellular standards. And in development, it offers the advantage of being able to test all the functional layers of a mobile UE, from RF parameters and protocols to the actual applications. Featuring a frequency range up to 6 GHz, it is also fully ready to handle future technology developments.

Compared to existing technologies such as WCDMA or GSM, standards such as LTE and HSPA+ place more stringent requirements on T&M equipment, due to more complex modulation methods (64QAM), multi-antenna systems (MIMO), and expanded layer 1 configuration capabilities. Processes are becoming more complicated in the protocols as well. As a result, Rohde&Schwarz has tailored the R&S®CMW500 specifically to meet these requirements, in close cooperation with wireless device manufacturers and chipset designers. The R&S®CMW500 combines RF generator and RF analyzer functionality and, by means of signaling, can control the interplay of downlink and uplink signals.

The R&S®CMW500 at a glance

- Scalable wideband radio communication tester for development and production
- Multistandard tester
- Supports all layers (RF, protocol, application)
- Future-oriented hardware (frequency range optionally up to 6 GHz, MIMO-capable)
- Reduced test times and costs (alignment up to 10 times faster than with conventional methods)
- High precision and reproducibility

Supported standards

- GSM/(E)GPRS
- WCDMA/HSPA
- LTE
- TD-SCDMA
- CDMA2000® 1xRTT/CDMA2000® 1xEV-DO
- Mobile WiMAX™
- WLAN
- Bluetooth®
- DVB-T
- GPS

In production, time and cost savings are paramount. Rohde&Schwarz has developed special approaches to this: By utilizing the R&S®Smart Alignment test concept, the R&S®CMW500 makes alignment up to ten times faster than with conventional methods. Plus, the tester is optionally equipped with two channels, which allows parallel measurement of two DUTs using different standards. Since a maximum first pass yield is necessary in order to achieve minimum production costs, high standards were placed on absolute accuracy, repeatability, and linearity during the development of the tester.

Consistent test concepts from development to production

One advantage that has been given hardly any attention to up to now is the use of consistent test concepts in all phases involved in the creation of a product. Since the R&S®CMW500 can be used from development to production, it provides consistent, comparable results throughout. Errors that occur in production can be easily reproduced in development. Conversely, test scripts or alignment routines that were written during development can be used again later for the integration phase or in production.

From RF to protocol to end-to-end application testing

The transmission of high data rates via the (less than ideal) radio interface channel involves highly complex processes at the protocol layers of the mobile station. Errored data packets must be corrected and parallel data streams processed. These extremely fast processes such as hybrid automatic repeat request (HARQ) and MIMO run on layer 1. Since the R&S®CMW500 performs protocol analysis as well as hardware-oriented RF measurements simultaneously, it makes troubleshooting much simpler.

Already in the early phases of development, the test plans of manufacturers include RF parameter measurements of the layer 1 unit and protocol analysis. To achieve test scenarios as realistic and practice-oriented as possible, solutions are required that allow end-to-end performance measurements across all layers. The high test depth provided by the R&S®CMW500 – achieved through the combination of RF, protocol, and application tests – is ideal for this purpose.

Summary

The R&S®CMW500 provides chipset and mobile phone manufacturers as well as network operators with a flexible, scalable platform for performing all of the relevant tests. Its modular concept yields minimum test costs plus high investment safety. The tester is a single-box solution that performs all tasks that usually require multiple test instruments. It is thus a cost-efficient and space-saving solution that promises a high return on investment for many years to come.

Additional articles on the R&S®CMW500:

- Breakthrough in scalability and speed in production. NEWS (2008) No. 195, pp. 4–9
- UMTS LTE protocol tests for all phases of development. NEWS (2008) No. 196, pp. 10–15
- Versatile and precise signals for the production of wireless devices. NEWS (2008) No. 197, pp. 15–17

LTE R&D test scenario framework for the R&S®CMW500

The R&S®CMW500 provides two programming interfaces for implementing LTE R&D protocol tests:

- Low-level application programming interface – LLAPI (R&S®CMW-KP501)
  LLAPI-based test scenarios directly control the lower layers of the network end LTE protocol stack. Some layers, like the RLC, can be switched to be transparent. This allows precise testing of the lower protocol layers as well as negative testing, making it possible to verify layers 1 and 2 in a UE early on in development, even before signaling functionality is available.
- Medium-level application programming interface – MLAPI (R&S®CMW-KP500)
  An MLAPI test scenario utilizes a single service access point (SAP) in the RRC implementation of the R&S®CMW500 for signaling. This SAP is mainly used for exchanging the peer-to-peer messages transmitted via the air interface. The RRC configurator automatically configures the lower protocol layers and keeps them consistent with the signaling messages exchanged between the LTE UE and the network end. The use of MLAPI is recommended when testing the entire protocol stack in the UE. The spectrum of applications extends from higher-layer signaling (including handover and inter-RAT procedures) to end-to-end testing of IP applications.

FIG 2 shows a comparison of the two programming interfaces. MLAPI scenarios interface with the RRC configurator implemented in the LTE protocol stack, while LLAPI scenarios directly control the individual protocol layers.

MLAPI – automatic protocol stack configuration

The RRC configurator helps ensure consistent configuration of the LTE protocol stack and also evaluates the protocol messages exchanged between the MLAPI test scenario and the UE. While the MLAPI test scenario includes only the transmission of and response to layer 3 messages, the RRC configurator in the protocol stack – which is the base of the MLAPI – controls the lower protocol layers. The R&S®CMW-KT012 message composer allows convenient editing of the layer 3 signaling message contents. Only a single file needs to be edited to keep both the message itself and the configuration of the protocol stack consistent.

Since the protocol message contents are saved as XML files and not interpreted until the MLAPI test scenario runs, the configuration can be modified without recompilation. As long as the dynamic response of the test scenario – i.e. the sequence of the various message types – remains constant, new test scenarios can be created without modifying the C++ source code. This makes it easy for new users to begin working with MLAPI, even without any knowledge of C++ (FIG 3).

LLAPI and MLAPI

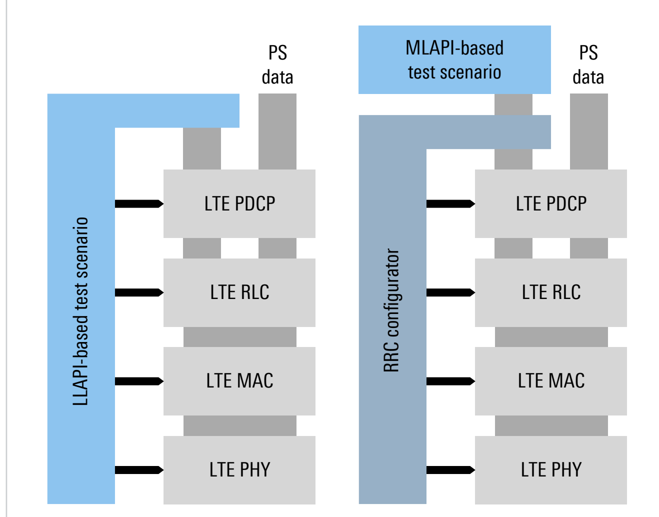


FIG 2 Comparison of the LLAPI and MLAPI interfaces.

The LTE MLAPI state machine library: building blocks for LTE test scenarios

To simplify the generation of layer 3 signaling scenarios, a C++ class library is supplied together with the LTE example test scenarios (R&S®CMW-KF500). The C++ class library contains the building blocks in which the RRC and NAS procedures are implemented as state machine classes. FIG 4 illustrates how a test scenario can be implemented simply by calling four of these MLAPI state machine classes. During these tests, the UE registers, activates, and deactivates a packet data connection, and at the end of the tests initiates a detach procedure. The MLAPI state machines are constructed in a modular way, i.e. procedures that are used in multiple MLAPI state machines are encapsulated in separate state machines.

MLAPI users benefit because complex signaling tests can be implemented very quickly without having to re-implement all of the procedure components. Object-oriented programming helps ensure that the C++ source code remains clearly structured. The source code is provided for all of the state machines supplied, and advanced users can take these as basic classes for their own state machines. Both the MLAPI state machines and the protocol messages used in them are provided in the form of XML files.

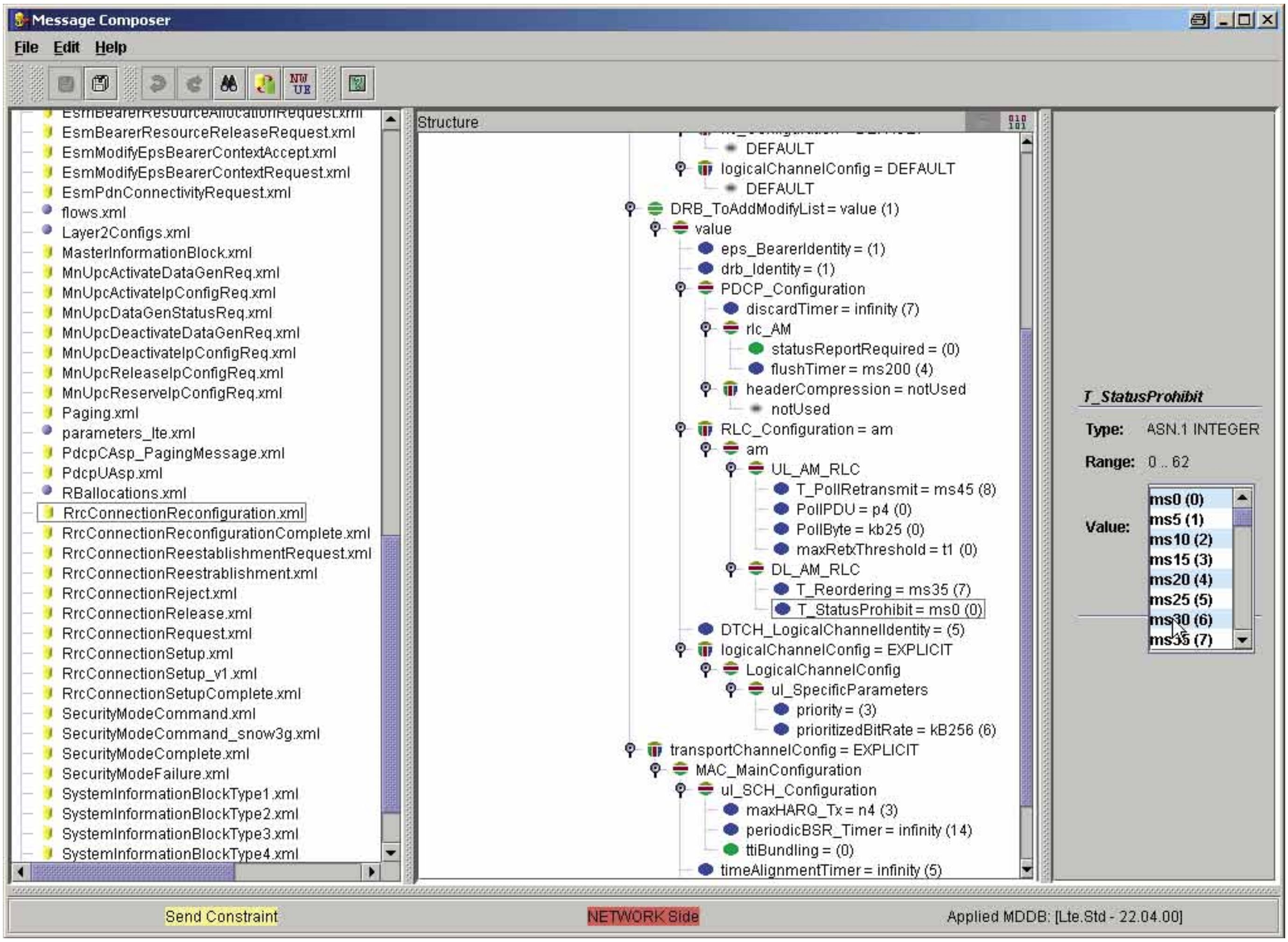


FIG 3 Simple editing of signaling messages in the message composer.

Combining LLAPI and MLAPI in one test scenario

LLAPI and MLAPI are components of a consistent test scenario framework for the R&S®CMW 500 that allows users to combine both worlds in a single test, and thus profit equally from the strengths of the respective interface. For example, the MLAPI state machines described in the previous section can serve to register a UE on the network and perform the signaling for activating a packet data service. In a second test step, the LLAPI functionality can then be used to manipulate the RLC and MAC in a targeted manner. FIG 5 shows how this type of scenario is organized in an MLAPI preamble, LLAPI body, and MLAPI postamble. This approach saves time when implementing signaling that might already have been verified during other tests, and allows focus on the implementation of the actual layer 1 or layer 2 oriented test purpose.

Hierarchy of test scenario building blocks

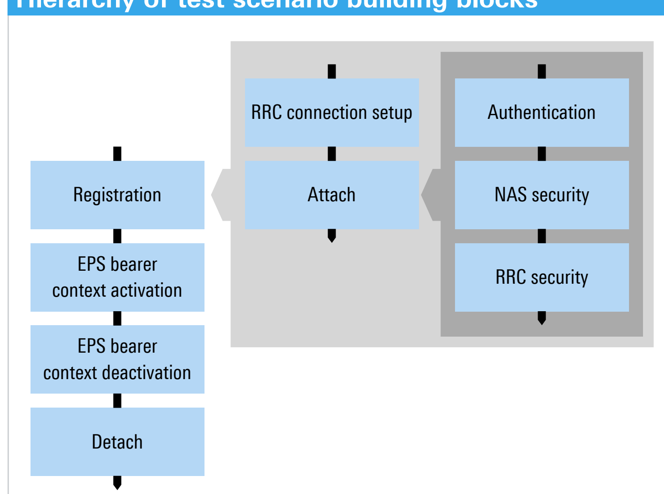


FIG 4 The substeps of the RRC connection setup and the actual attach procedure are organized in separate state machines. The state machine attach is subdivided into further state machines for authentication and for security procedures.

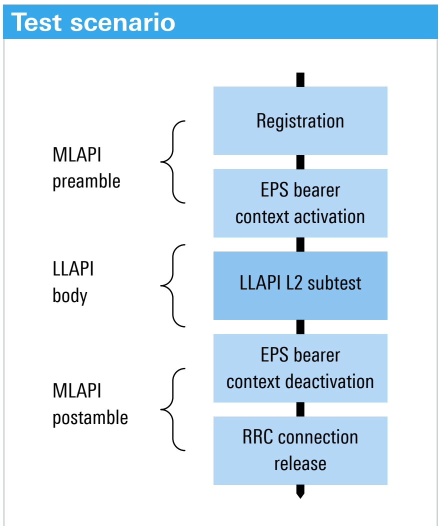


FIG 5 A combined LLAPI/MLAPI test scenario.

R&D test scenario packages for the R&S®CMW500

As the base for more than 1000 commercially available R&D and IOT test scenarios on the R&S®CRTU-W protocol tester for 3G WCDMA, MLAPI has proven its worth. In addition to the R&S®CMW-KF505 IODT test scenario packet discussed, four additional product options are now available for LTE protocol testing:

- R&S®CMW-KF500 – LTE sample scenarios
  LLAPI and MLAPI example scenarios for visualizing the use of the MLAPI framework and the state machine classes
- R&S®CMW-KF502 – basic LTE procedures
  Basic LTE RRC and NAS procedures, including attach, detach, EPS bearer connection setup, GUTI reallocation, and tracking area update
- R&S®CMW-KF503 – EPS bearer verification
  Activation and verification of various radio bearer configurations
- R&S®CMW-KF504 – intra-LTE mobility and handover
  Handover and mobility within LTE, intrafrequency and interfrequency handover, adjacent cell measurements

Applications include integrating and verifying protocol stack functionality, as well as UE regression tests that permit a comparison of various UE software versions. The close cooperation with key customers ensures the selection of relevant test purposes and the practical applicability of the different test scenario packages from Rohde&Schwarz.

Summary

By using the R&S®CMW500 wideband radio communication tester, the powerful LLAPI/MLAPI programming interfaces, and customized LSTI IODT test scenario packages, Rohde&Schwarz makes a perfect combination of test equipment and test cases available to mobile phone manufacturers to ensure that their LTE signaling tests are performed quickly, efficiently, and cost-effectively.

Michael Dreimann

Abbreviations

EPS	Evolved packet system
GUTI	Globally unique temporary identifier
IODT	Interoperability development testing
IOT	Interoperability testing
LLAPI	Low-level application programming interface
LSTI	LTE/SAE Trial Initiative
LTE	Long term evolution
MLAPI	Medium-level application programming interface
PHY	Physical layer
RAT	Radio access technology
RLC	Radio link control
RRC	Radio resource control
SAE	System architecture evolution
SAP	Service access point
UE	User equipment

IP-based application testing on WiMAX™ mobile stations

Application-level testing – based on data transmission or video streaming, for example – plays a crucial role in the process of designing WiMAX™ mobile stations. This form of testing delivers valuable results when it comes to optimizing parameters that are of major importance for network operators and end users alike in their daily work.

The challenge of high data rates

The WiMAX™ mobile communications standard, in line with IEEE 802.16e-2005, enables wireless Internet access at high data rates. It offers an alternative to DSL networks in places where laying cables is uneconomical – for example, on the periphery of cities or in rural areas. But it also presents manufacturers of WiMAX™ mobile stations with a special challenge: They need to optimize their product designs to make sure their devices are capable of supporting the high volumes of data commonly associated with services such as FTP or video streaming.

The R&S®CMW270 WiMAX™, one of a new generation of wireless communications testers from Rohde&Schwarz, is a first-rate tool for this purpose. With its functions for testing

The R&S®CMW270 WiMAX™ communication tester is the first real all-in-one solution for the cost-optimized mass production of WiMAX™ mobile stations. It was first presented in News from Rohde&Schwarz 196 / 08, p. 22–27.

Test setup and layer model

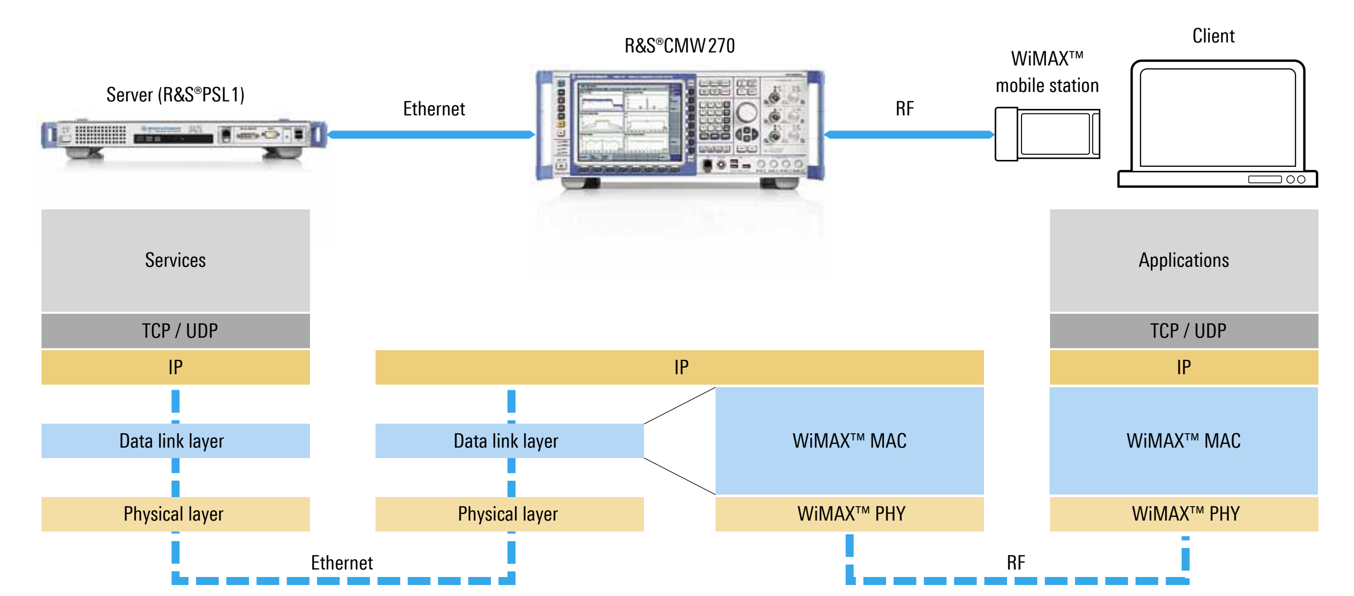


FIG 1 The setup for end-to-end testing of WiMAX™ mobile stations and the layer model.

both the physical layer (PHY) and the protocol layer (MAC) and with its integrated signaling unit (used to emulate a base station), it offers an easy-to-configure, affordable alternative to real WiMAX™ base stations and delivers stable, reproducible test results.

In combination with the R&S®CMW-KA700 application enabler option, the R&S®CMW270 tests the downlink and uplink data rates that WiMAX™ mobile stations can achieve and helps to optimize the products for typical end-to-end testing applications, where maximum throughput is particularly important for users and network operators. The mobile station needs to be able to receive incoming data without interruption or retransmission. Otherwise, the allocated transmission capacity is not utilized properly, which reduces the data rates at the user end, and decreases the economic efficiency of network operation.

Application tests are the only way to verify the overall performance of mobile stations

Most Internet applications operate over the Internet protocol (IP) on a client/server basis. The client uses a WiMAX™ mobile station to access services provided by a server via a network (FIG 1). In this test setup, an external server is connected to the R&S®CMW270 via Ethernet. The tester emulates a WiMAX™ base station located between the server and the client and transmits data packets from the server to the client over the WiMAX™ air interface. The open architecture means that there are numerous possibilities to test the design using typical end-to-end applications such as the following:

- Web browsing (http)
- Video streaming
- Data transfer (FTP)
- Voice over IP (VoIP)

An IP performance testing tool such as Iperf can be used to measure TCP and UDP data throughput between the server and the client. The results can help to identify performance bottlenecks.

Comprehensive RF and protocol analyses

During the end-to-end tests, essential RF parameters of the mobile station such as EVM, burst power and spectral flatness can be tested concurrently using WiMAX™ measurement functions in the R&S®CMW270 (by means of the R&S®CMW-KM700 and R&S®CMW-KM701 options) (FIG 3). This enables design flaws that adversely affect RF performance to be identified quickly.

Errors and delays that diminish performance may also occur as a result of repeat transmissions or high processor load in the WiMAX™ mobile station. Analyzing and remedying this kind of problem involves examining the stream of messages between the base station and the mobile station. This is what the R&S®CMW-KT700 message analyzer does. This software option seamlessly logs all of the downlink and uplink messages in realtime and with time stamps. The data flow on the transport layer can be displayed and analyzed with user-defined filters (FIG 2), enabling errors in the WiMAX™ MAC layer to be quickly identified and corrected using simple methods.

Summary

The new R&S®CMW-KA700 application enabler option expands the R&S®CMW270 WiMAX™ communication tester's scope of applications and enables comprehensive end-to-end performance tests. Users are able to modify parameters on both the physical layer (PHY) and the protocol layer (MAC) and create test scenarios that simulate live operation in a WiMAX™ network. Design flaws can be identified extremely quickly and WiMAX™ mobile stations can be optimized for practical applications that rely on high data rates.

Christian Hof; Erwin Böhler

Abbreviations

DSL	Digital subscriber line
EVM	Error vector magnitude
FTP	File transfer protocol
HTTP	Hypertext transfer protocol
IP	Internet protocol
MAC	Medium access control
TCP	Transmission control protocol
UDP	User datagram protocol
WiMAX™	Worldwide interoperability for microwave access

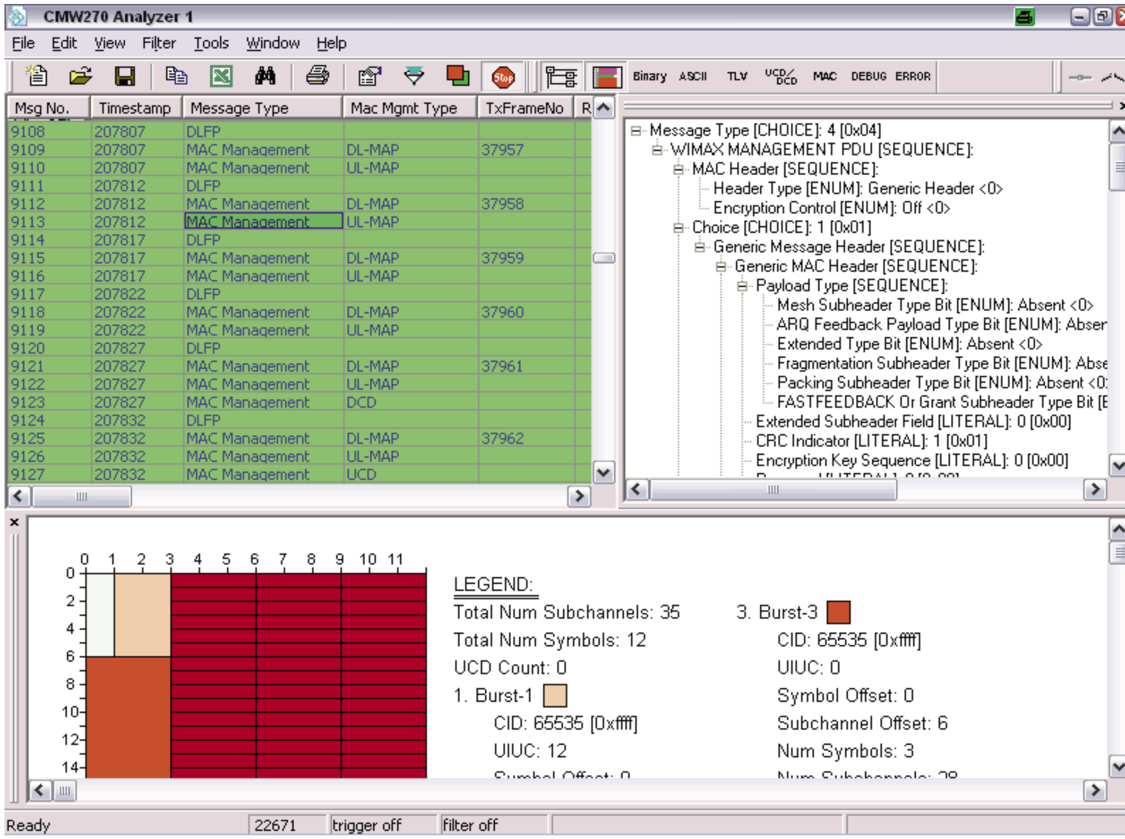


FIG 2 The R&S®CMW-KT700 message analyzer in action …

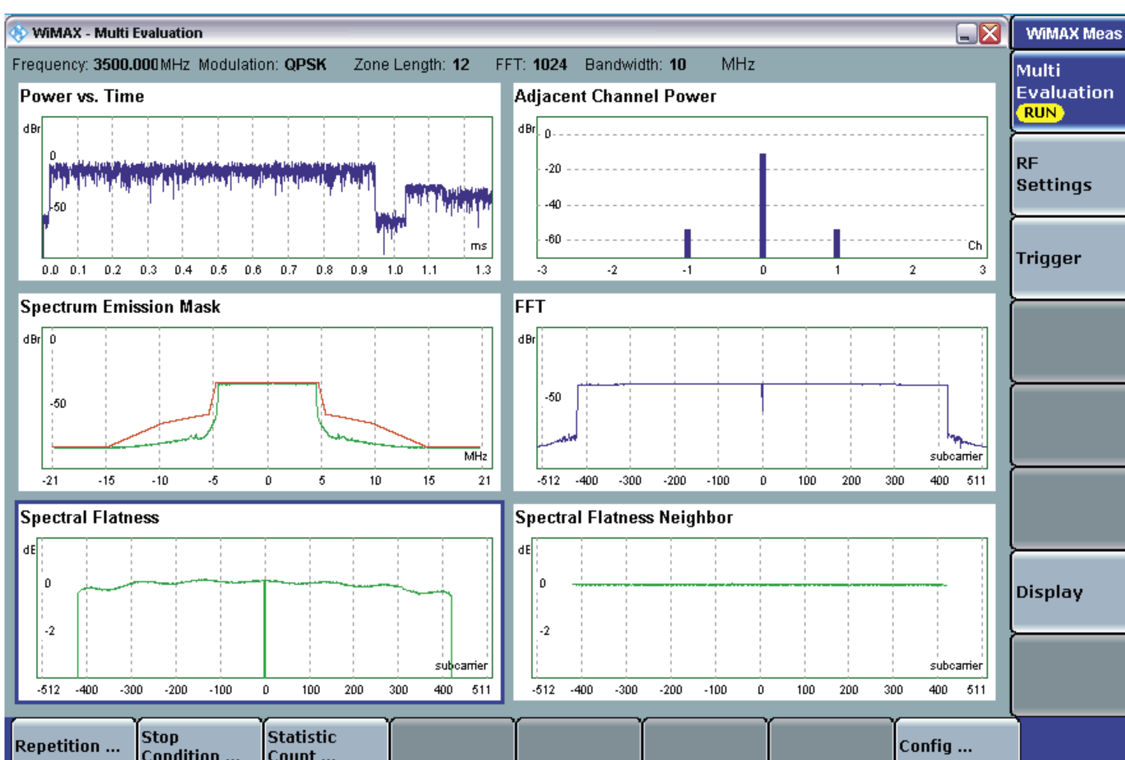


FIG 3 … and the correlated RF measurements.

Bluetooth® enhanced data rate (EDR) – signals for development and production

Two new options for Rohde&Schwarz vector signal generators generate test signals for all EDR packet types.

Two modulations in one data packet

Bluetooth® technology, which is commonly found in mobile phones, offers easy-to-use wireless connections to nearby telephones or laptops. The Bluetooth® specification 2.0 has increased the achievable gross data rate from previously 1 Mbit/s up to 3 Mbit/s. Although these data rates may seem low when compared to forthcoming standards such as LTE, very high data rates are not the decisive factor for most Bluetooth® applications, where low energy consumption is crucial.

In order to ensure downward compatibility to the original standard (version 1.0), Bluetooth® EDR employs two completely different modulations in one data packet: GFSK in the packet header and π/4-DQPSK or 8DPSK in the data sections. Intensive testing is the only way to ensure that the receivers are capable of reliably mastering this sophisticated switching task when receiving data.

Software options for all applications

The new R&S®SMx-K60 and R&S®SMx-K260 software options for vector signal generators from Rohde&Schwarz generate test signals for all EDR packet types: 2-DHx with a data rate of 2 Mbit/s and π/4-DQPSK modulation as well as 3-DHx with 3 Mbit/s and 8DPSK modulation (FIG 1). A convenient packet editor with a graphical display provides comfortable access to all of the packet's relevant data content (FIG 2). The software automatically calculates the access code from the Bluetooth® Device Address. In addition to standard PN sequences, user-defined data is also adjustable for the packet's payload section. However, there are also options that support all previous packet types of the Bluetooth® 1.0 standard such as DM, DH, HV, EV, and FHS.

* Options are available for the R&S®SMU200A, R&S®SMJ100A, R&S®SMATE200A, R&S®SMBV100A, R&S®AMU200A, R&S®AFQ100A, and R&S®AFQ100B signal generators.

FIG 1 The generator only transmits in TX timeslots, seen here as a graphic representation in the R&S®SMx-K60 option's main menu.

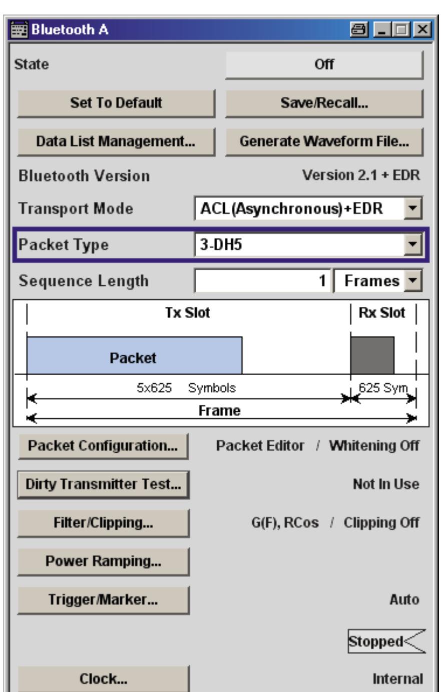
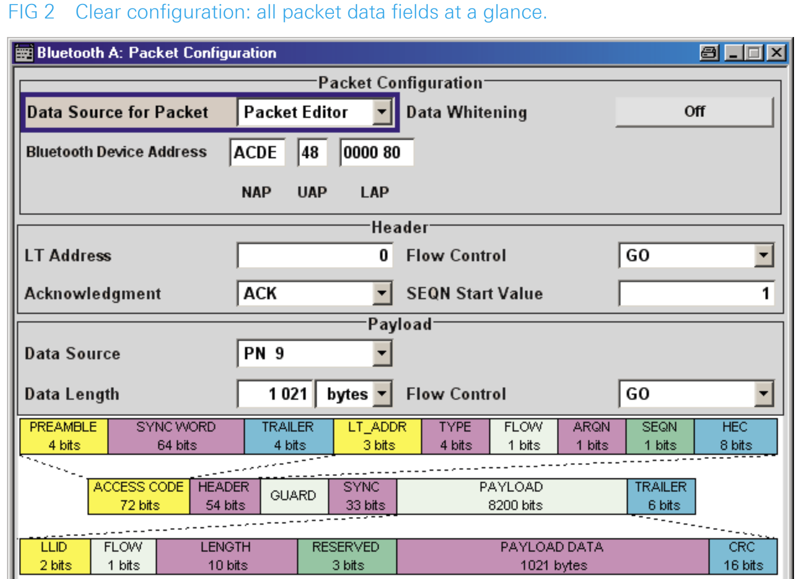


FIG 2 Clear configuration: all packet data fields at a glance.



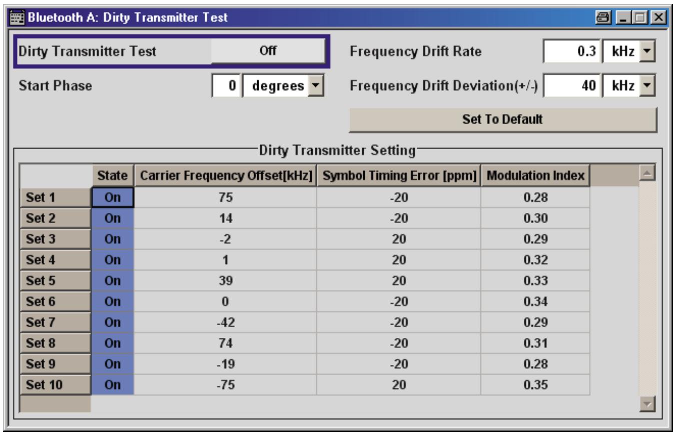


FIG 3 The dirty transmitter test: specific degradation of the signal quality.

Dirty transmitter tests – receiver quality put to the test

The R&S®SMx-K60 and R&S®SMx-K260 options also allow dirty transmitter tests to be performed. Here, the transmit signal is specifically impaired, as required for receiver sensitivity tests in line with the official test specification (RF.TS.2.1) (FIG 3). Receivers must not exceed the prescribed bit error rate of 0.1 % under these complicated conditions.

Impairments include

- Frequency offset of the RF carrier (carrier frequency offset)
- Frequency offset of the symbol timing (symbol timing error)
- Drift in the GFSK frequency deviation (modulation index)
- Sinusoidal drift of the carrier frequency, for which frequency (frequency drift rate) and deviation (frequency drift deviation) can be entered (FIG 4)

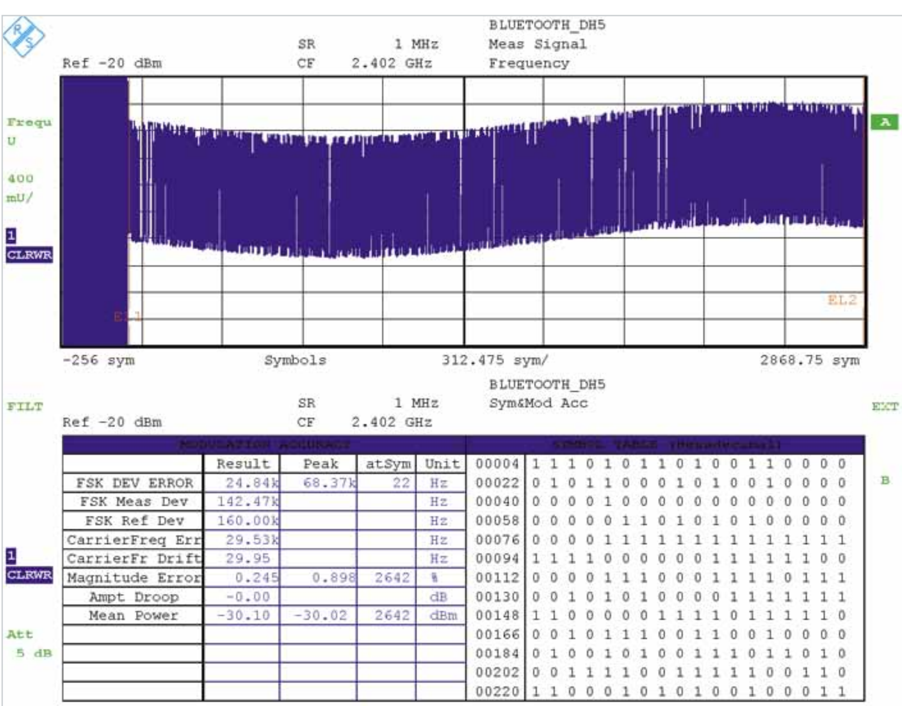
In addition, the parameters of these signal distortions are only valid for 20 ms; a new set of parameters is used for each additional 20 ms. Up to 10 such parameter sets are entered in a table.

Summary

Equipped with the new R&S®SMx-K60 and R&S®SMx-K260 options, Rohde & Schwarz signal generators are fit for all current Bluetooth® test requirements. The specification committee announced new expansions of the Bluetooth® standard such as ultra low power (ULP). As always, Rohde & Schwarz will be quick to offer an appropriate solution.

Gernot Bauer

FIG 4 Frequency demodulation using the R&S®FSQ signal and spectrum analyzer clearly shows the sinusoidal drift of the RF carrier caused by the dirty transmitter test.



Abbreviations

8DPSK	8-phase differential phase shift keying
π/4-DQPSK	π/4-rotated differential quaternary phase shift keying
BER	Bit error rate
DH	Data – high-rate data packet type
DM	Data – medium-rate data packet type
EDR	Enhanced data rate
EV	Enhanced voice packet
FHS	Frequency hop synchronization
GFSK	Gaussian frequency shift keying
HV	High-quality voice, e.g. HV1 packet
PN	Pseudo-random noise
RX	Receive
TX	Transmit
ULP	Ultra low power

Test signals for the EDGE Evolution enhancements to the GSM standard

GSM is still the world's most important mobile radio standard. Now, in response to the increasing requirements for greater transmission capacities, the GSM standard specifies higher data rates. The new R&S®SMU-K41 option, which is available for the entire R&S®SMx generator family, provides the manufacturers of mobile and base stations with the signals they need to develop and produce devices with EDGE Evolution capability.

EDGE Evolution – doubling the data rate

After the introduction of EDGE the GSM standardization body is taking another step toward higher data rates with its recently released EDGE Evolution specification. The following is at the core of the technological enhancements:

- Additional, higher-order, crest-factor-optimized modulation modes, such as rotating QPSK (FIG 1), rotating 16QAM, and rotating 32QAM
- Besides the standard GSM symbol rate of 270.833 ksymbol/s, there is an option for an increased symbol rate of 325 ksymbol/s – combined with a spectral adaptation to the existing GSM channel spacing using the newly defined spectrally narrow/spectrally wide pulse shape filters
- Downlink dual carrier (DLDC): The base station simultaneously transmits data to a mobile receiver on two frequency channels, thus doubling data throughput in the downlink
- Mobile station receiver diversity (MSRD): By employing multiple built-in antennas (antenna diversity), mobile receivers improve the receive signal quality

FIG 2 uses the example of a packet data traffic channel (PDTCH) to provide an overview of the data rates that can be achieved with EDGE Evolution compared to those reached using GSM with GMSK and 8PSK modulation. Compared to EDGE, EDGE Evolution doubles the data rate again; compared to the original GMSK modulation, this even represents a six-fold increase.

The R&S®SMU-K41 software option gets generators ready for EDGE Evolution

The R&S®SMU-K41 software option enhances the R&S®SMU-K40 GSM/EDGE software option that is already established on the market. Primarily, it can, of course, be used for all conventional receiver tests. Furthermore, due to the use of higher-order modulation modes, the transmitter amplifiers must satisfy higher linearity requirements.

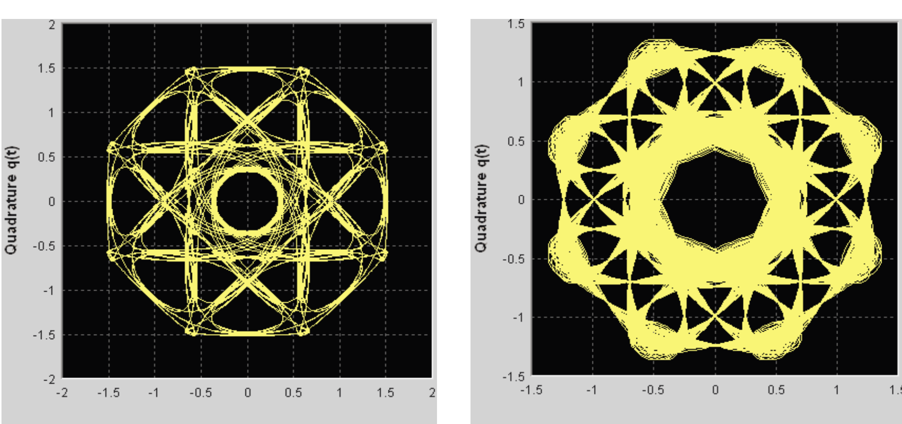


FIG 1 Rotating QPSK EDGE modulation at 325 ksymbol/s generated by means of R&S®WinIQSIM2: with a spectrally narrow pulse shape filter on the left and a spectrally wide pulse shape filter on the right.

The parameters that are typical of EDGE Evolution are set via the software's graphical user interface. For the optional higher symbol rate of 325 ksymbol/s, for instance, it is possible to select the newly defined burst types "higher symbol rate for QPSK/16QAM/32QAM" as well as the desired filter type (FIG 3). For the common symbol rate of 270.833 ksymbol/s, the burst types "normal burst for 16QAM/32QAM" have been added. These new types, can, of course, be combined in a frame with the previous burst types such as SCH or FCH.

The R&S®SMU-K41 software option is available for the following generators: R&S®SMU200A, R&S®SMATE200A, R&S®SMJ100A, and R&S®AMU200A. A comparable solution for the R&S®AFQ100A arbitrary waveform generator or for the ARB generators from the R&S®SMx family is available in the form of the R&S®WinIQSIM2 waveform creation tool with the R&S®SMU-K241/R&S®AFQ-K241 software option.

Typical application-specific configurations for EDGE Evolution

Besides the above-mentioned improvements regarding modulation modes and symbol rates, EDGE Evolution employs other processes for boosting network capacity. As an all-purpose instrument, the R&S®SMU200A allows these new techniques to be tested without extensive equipment requirements:

- Downlink dual carrier (DLDC): The signal generator simulates a base station and supplies the required double signal on two carriers to a mobile station by adding two basebands with a frequency offset (FIG 4)
- Mobile station receiver diversity (MSRD): At its two RF outputs, the signal generator provides a statistically uncorrelated diversity signal that results in improved BER values for receivers with antenna diversity

The base stations continue to emit the SCH and/or FCH synchronization channels with the standard symbol rate of 270833.33 symbol/s. Therefore, for some applications, it is also necessary to simultaneously combine normal symbol rate bursts (270.833 ksymbol/s) with higher symbol rate bursts (325 ksymbol/s) in one frequency channel through the addition of two baseband signals. This can be done easily and immediately with an R&S®SMU with two channels (where $\Delta f = 0$ Hz) (FIG 4).

Users can also simulate DLDC signals or combine different data rates in a single frequency channel by means of the R&S®WinIQSIM2 waveform creation tool. To do this, they simply add several baseband signals in the multicarrier menu either with or without frequency offset or time offset.

Dr. Karlheinz Pensel

Modulation	Standard symbol rate (270.833 ksymbol/s)	Higher symbol rate (325 ksymbol/s)
GMSK	22.8	–
QPSK	–	55.2
8PSK	69.6	–
16QAM	92.8	110.4
32QAM	116.0	138.0

FIG 2 Maximum instantaneous bit rate in kbit/s for a packet data traffic channel (PDTCH) per frequency carrier in line with 3GPP TS 45.002; (blue: the enhancements brought by EDGE Evolution).

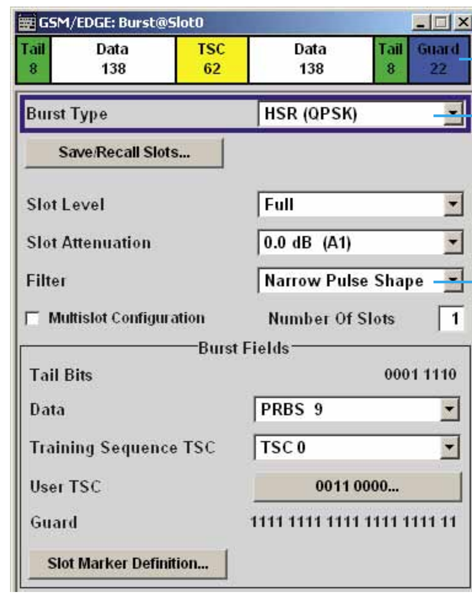


FIG 3 Entry field for a higher symbol rate burst.

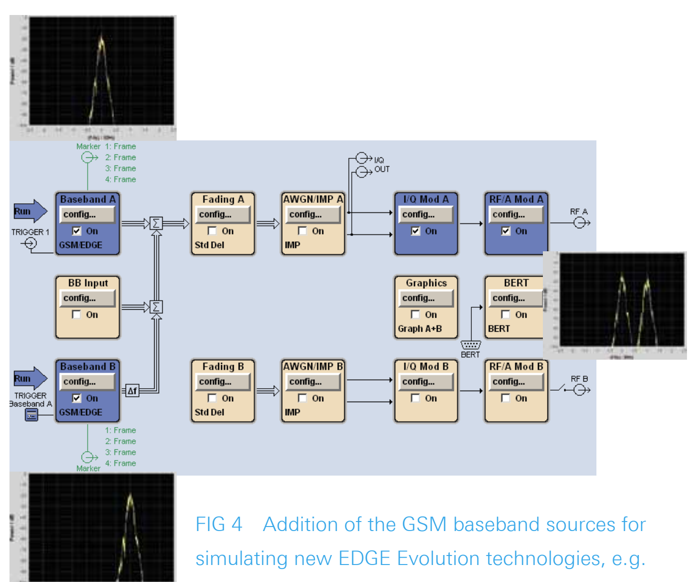


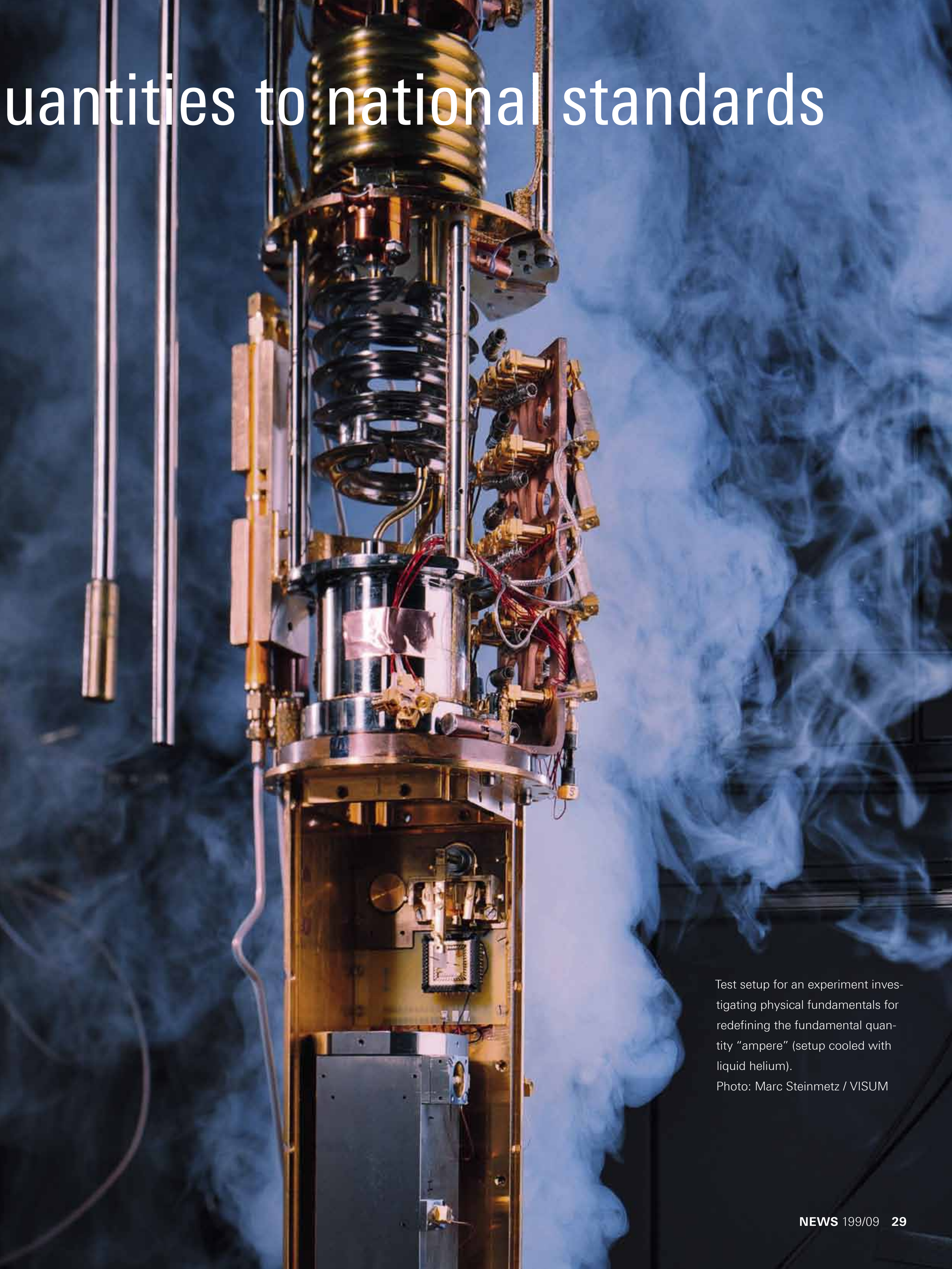
FIG 4 Addition of the GSM baseband sources for simulating new EDGE Evolution technologies, e.g. DLDC, on the R&S®SMU.

Traceability of RF measurement q

This article by Germany´s National Metrology Institute (Physikalisch-Technische Bundesanstalt, PTB) describes how RF power, an important measurand for Rohde & Schwarz, is traced back to the national primary standard of the Federal Republic of Germany.* The article illustrates the enormous test effort required to produce precision T&M instruments with competitive features.

* Using RF power as an example, the article starting on page 34 describes the efforts Rohde & Schwarz undertakes to ensure that the relevant measurands of its RF T&M instruments are fully traceable to recognized national standards with minimal loss of accuracy.

uantities to national standards



Test setup for an experiment investigating physical fundamentals for redefining the fundamental quantity "ampere" (setup cooled with liquid helium).
Photo: Marc Steinmetz / VISUM

Traceability of industrial calibrations – a prerequisite for high quality and improved competitiveness

Precision measurements represent an important part of industrial quality assurance and are a prerequisite for top-quality industrial production. In accordance with international standards for quality management systems (DIN EN ISO 9000) as well as requirements from the areas of product liability and environmental protection, measuring instruments must be calibrated and be traceable to national standards. Moreover, test results are reliable only if they are obtained through the use of calibrated measuring instruments.

The National Metrology Institute PTB is the primary metrology laboratory in Germany, representing the top of the calibration hierarchy (FIG 1). The PTB performs fundamental research and development work in the field of metrology as a basis for all the tasks it has to accomplish with regard to the determination of fundamental and natural constants, the realization, maintenance and dissemination of the legal units of the SI. For this purpose, the PTB operates physical setups that allow the most important measurement quantities to be realized with maximum accuracy (primary standard). The German Calibration Service (DKD), which is jointly operated by government and industry, represents the next level in the calibration hierarchy. With more than 300 accredited calibration labs, it is responsible for calibrating industrial T&M equipment and particularly for the calibration of working standards used by industry for internal quality assurance. The reference standards used in the DKD labs are calibrated by the PTB with reference to the primary standards. The PTB and DKD thus promote test and measurement infrastructure, improve industry's ability to compete, and make an essential contribution to technology transfer.

The DKD labs operated by Rohde & Schwarz in Munich, Memmingen, and Cologne provide traceability to national standards of all measurands (FIG 2) that are important for test instruments from Rohde & Schwarz. These labs make a critical contribution to the company's quality assurance efforts.

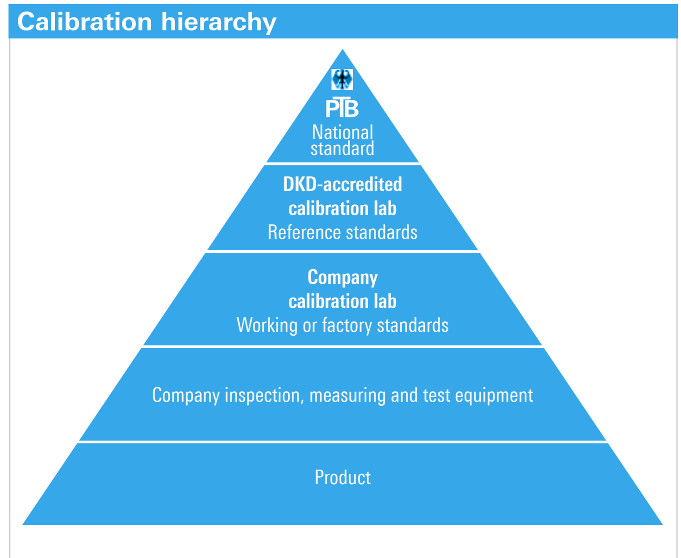


FIG 1 The calibration hierarchy in Germany.

DC quantities	Direct voltage, direct current, DC resistance
	Capacitance
LF quantities	Alternating voltage, alternating current
	AC-DC voltage transfer difference
	AC-DC current transfer difference
RF quantities	RF power, RF attenuation, RF impedance
Time	Time interval, frequency

FIG 2 Accredited measurands of the DKD labs at Rohde & Schwarz.

Thermistor power sensors as reference standards for RF power

Traceability of RF power, a measurand that is very important to Rohde & Schwarz, is ensured by the PTB through calibration of special power sensors that the DKD labs at Rohde & Schwarz send in at defined intervals. There are five different types that cover the frequency range from 100 kHz to 50 GHz. Above 18 GHz, only power sensors with waveguide connectors are used, which – except in one case – are thermistor power sensors. This type of power sensor disappeared from industrial testing decades ago, but due to its outstanding long-term stability it is still ideal for calibration applications.

This capability results from the functional principle underlying a thermistor power meter: Instead of a termination with a fixed resistance value as its power-absorbing element, it uses a highly temperature-dependent resistor (negative temperature coefficient, NTC), commonly known as a thermistor. This thermistor is heated up using a DC voltage generated in the power meter so that its resistance value adjusts to that of an ideal termination (i.e. 50 Ω in the case of coaxial connectors). If RF power is fed to the power sensor, a control loop reduces the DC voltage so that the thermistor retains its resistance value and its temperature. Thus, the power converted into heat in the thermistor remains constant. Based on the difference between the two DC voltages, the power meter can

Physikalisch-Technische Bundesanstalt (PTB) – Germany's National Metrology Institute

The PTB provides scientific / technical services to Germany and simultaneously serves as the country's top authority in the area of metrology. It was originally founded in Berlin in 1887 as the Physikalisch-Technische Reichsanstalt (PTR) based on the initiatives and ideas of Werner von Siemens and Hermann von Helmholtz. The PTB belongs to the area of competence of the Federal Ministry of Economics and Technology. Through its activities, the PTB ensures and promotes the development and use of advanced, reliable test and measurement equipment, which is important in all areas of society, industry, and science (FIG 3).

Correct measurement results and reliable T&M equipment

The public's interest in correct dimensions and reliable test equipment extends to numerous areas of everyday life. For example, this includes all official measurements made for collection of customs duties or for monitoring traffic on roadways, measurements required in the commercial domain where consumers expect correct measurement results, and measurements used in medicine as well as in environmental protection, radiation protection and occupational safety. This is why these areas are regulated under national and European law. Measuring instruments that are placed on the market must receive a relevant pattern approval. In Germany, pattern approval is required for scales, fuel dispensers, gas and electric meters, taximeters, and traffic radar equipment, for example. The PTB performs a number of statutory tasks in this area by performing pattern approval tests of measuring instruments.

Fundamentals of metrology and technological innovations

Fundamental research into the physical aspects of metrology plays an important role in the PTB's work and is the basis for all of its activities. Focus areas include development of national standards, determination of fundamental constants, exploitation of quantum effects for representing units, creation of reference materials and determination of the properties of materials.

Fundamental constants are quantities that do not change with respect to time and space. Their immutability makes them suitable for realizing and reproducing the legal SI units (FIG 4).

Examples of the traceability of SI units to natural constants are the realization of the volt voltage unit by means of the Josephson effect and of the ohm resistance unit by means of the quantum Hall effect. Realization of fundamental units at the highest level is the basis of metrology and is one of the PTB's core activities. Through its long-term research activities, the PTB secures the fundamentals of metrology, gains extended scientific insights in the area of physics, and contributes to technical innovation.

FIG 3 Statutory activities of the PTB (selection).

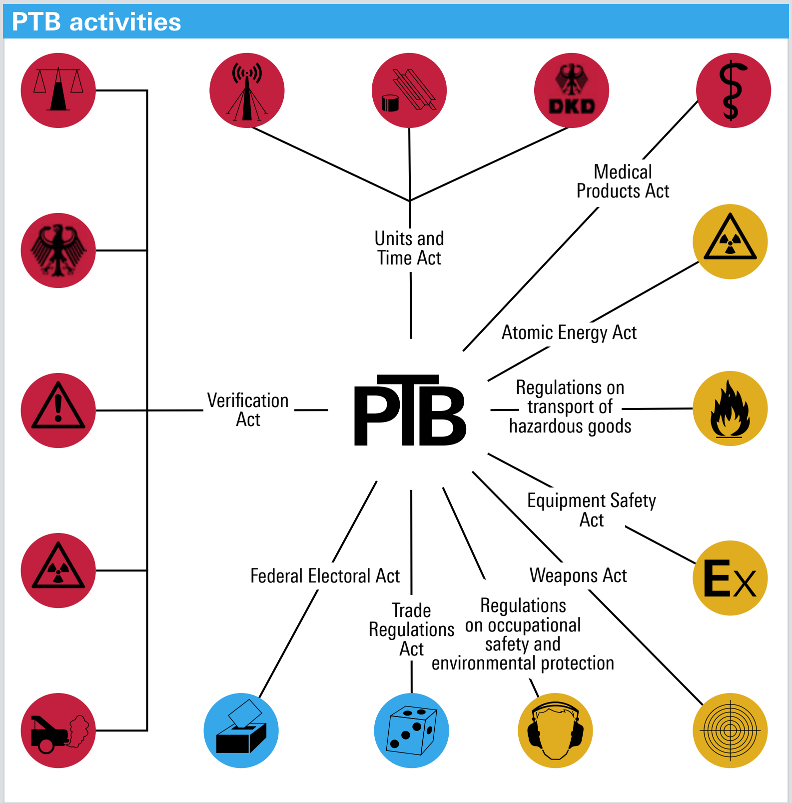
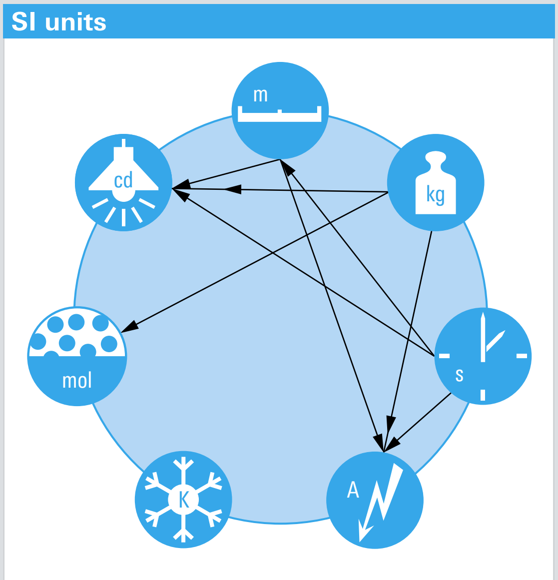


FIG 4 The legal SI units.



measure the DC power substituted with the RF power and thus approximately determine the absorbed RF power. The properties of the thermistor, and particularly the stability of its I/V characteristic, do not play any role.

Since only a fraction of the absorbed RF power reaches the thermistor, RF power can only be measured approximately unless an additional correction is performed. Instead, power is partly converted into heat along the feed line to the thermistor due to the skin effect. The control loop is not capable of compensating for this part so that it remains unknown initially. Without additional correction, the power meter will therefore display a decrease in power level as the frequency increases. To take this effect into account in a measurement, the absorbed RF power losses along the feed line must be determined. The PTB determines these losses by using microcalorimeters to calibrate thermistor power sensors.

Microcalorimeter as a primary standard

Using a microcalorimeter (FIGs 5 and 6) consisting of a thermally well insulated receptacle, it is possible to determine the losses along the feed line and the conversion losses in the thermistor as well as their relationship to the absorbed RF power. The temperature increase generated by the power sensor within the calorimeter is determined, first with the RF power switched off and then switched on. The measurement is performed using an electric thermometer consisting of series-connected thermoelements (thermopile) and is referenced to a second passive thermistor sensor. When the RF power is switched off, the heating is caused exclusively by the DC power that raises the thermistor to the nominal temperature. When the RF power is switched on, additional heating is caused by RF power absorption. The change in temperature and DC voltage that occurs after applying the RF power yields the effective efficiency as follows:

$$\text{Effective efficiency} = \frac{\text{DC substitution power}}{\text{total absorbed RF power}}$$

As soon as this quantity is known, the displayed result of a thermistor power meter can be corrected as a function of frequency. In T&M applications, the effective efficiency as the correction quantity is converted into the calibration factor, which takes into account the reflection of the sensor and is referenced to the power of the incident wave.

Due to the large mass of the sensor, the temperature changes are in the order of only one millikelvin (thousandths of a degree) and the time required to reach thermodynamic equilibrium during the measurement ranges from 60 to 90 minutes per frequency point. Accordingly, complete calibration of a power sensor with typically 40 frequency points takes several days if multiple frequency sweeps are performed.

To minimize unwanted heating of the setup due to RF feed line losses outside of the sensor, thermal insulation sections are built into the RF feed lines. The remaining heat flow is modeled using sophisticated computer simulations and is also determined experimentally and corrected through measurements.

Based on this functional principle, the PTB carries out power calibrations in the frequency range from 10 MHz to 50 GHz. Different types of microcalorimeters are available, including one for the 7 mm coaxial system and three for the waveguide bands from 18 GHz to 50 GHz. Additional calorimeters for higher frequencies are currently in preparation.

Waveguide microcalorimeter

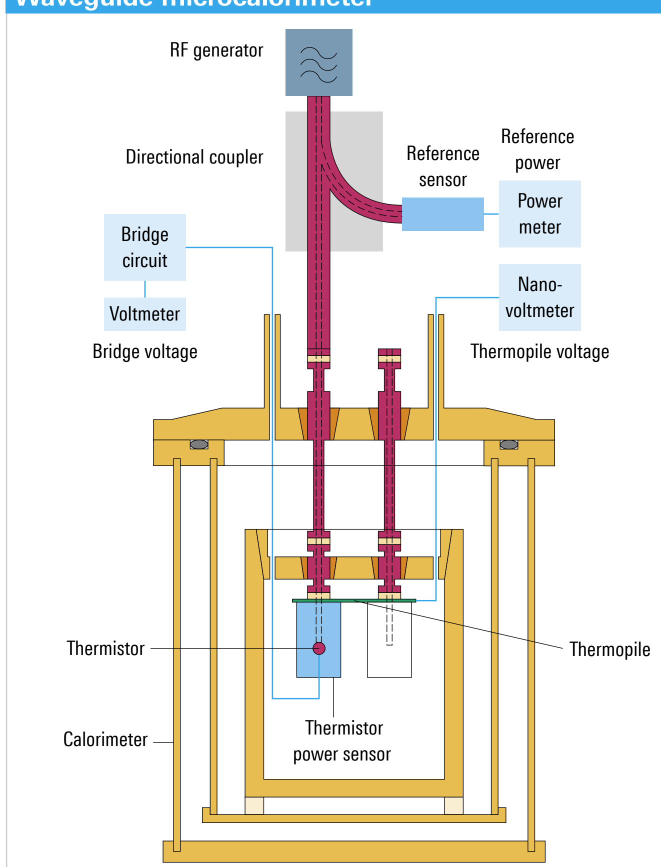


FIG 5 Waveguide microcalorimeter for determining the effective efficiency of thermistor power sensors.

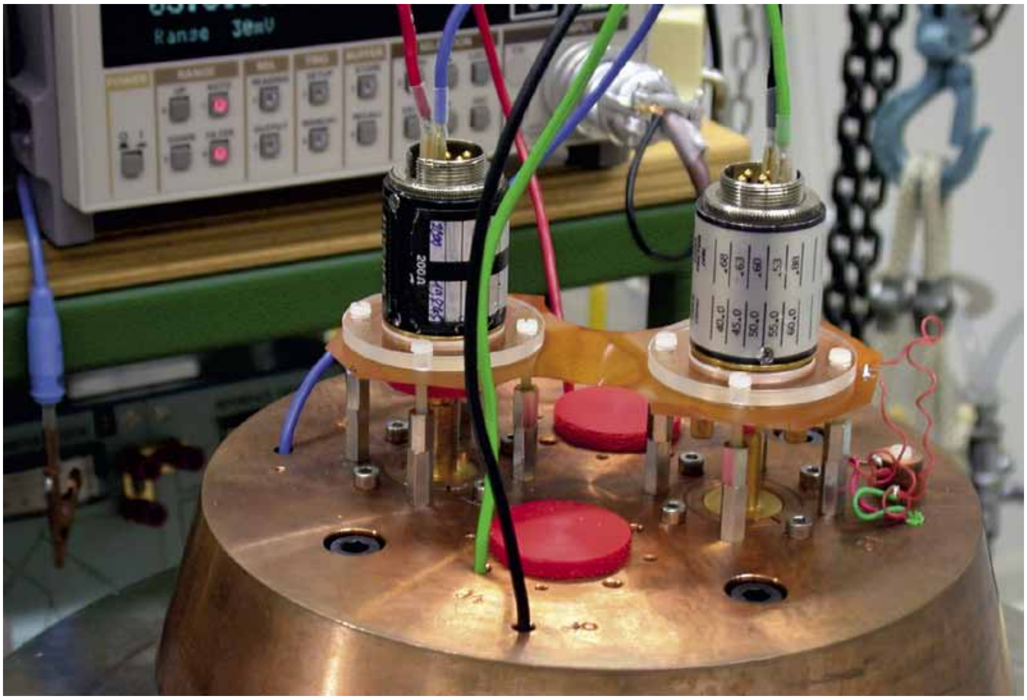


Photo: PTB

FIG 6 Waveguide microcalorimeter insert with thermistor power sensors.

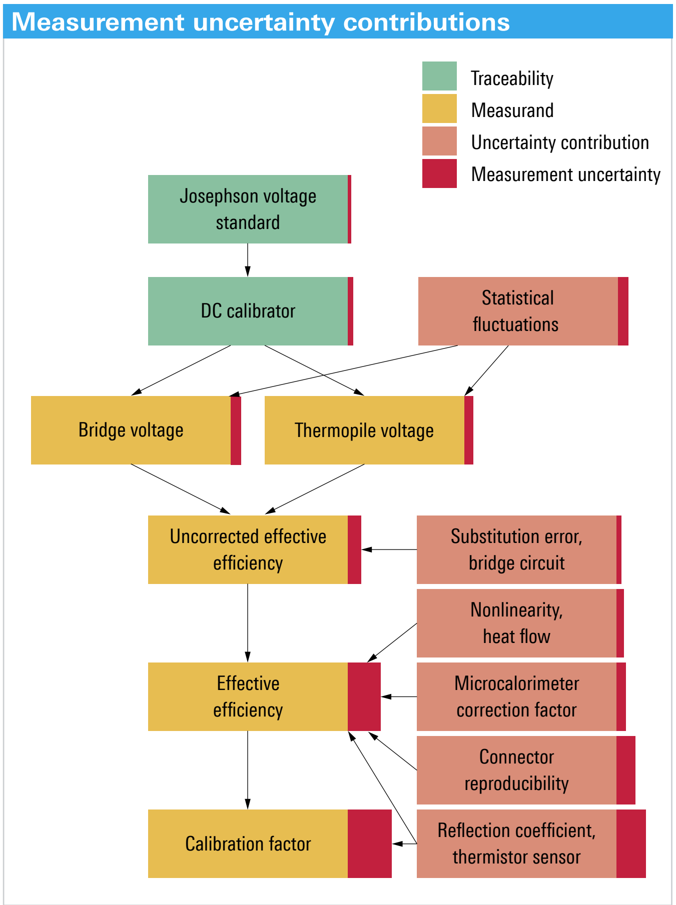


FIG 7 Traceability and measurement uncertainty contributions during calibration of the effective efficiency in the microcalorimeter.

Traceability chain and measurement uncertainty

FIG 7 illustrates how the bridge voltage and the thermopile voltage, i.e. measurands that occur during microcalorimeter calibration, are traced back to voltage as the fundamental quantity, which is realized by means of the Josephson effect. Moreover, the dominant measurement uncertainties and their contribution to the overall measurement uncertainty are also shown in qualitative terms. Note that the ratio between the expanded relative measurement uncertainties of voltage (in the order of 10^{-9}) and the effective efficiency of thermistor sensors (in the order of 5×10^{-3}) is equal to multiple orders of magnitude. This is due to characteristics of RF circuits such as mismatch, power loss, and limited connector reproducibility which cannot be eliminated even by using sophisticated test procedures and equipment.

Dr.-Ing. Rolf Judaschke,
Physikalisch-Technische Bundesanstalt
(National Metrology Institute of Germany)

RF power calibration at Rohde & Schwarz

During development of its RF T&M equipment, Rohde & Schwarz takes great care to ensure that the displayed measurands are perfectly traceable to recognized national standards. This article* discusses the calibration of the measurand referred to as RF power. Since time is of the essence in a production environment, Rohde & Schwarz has developed a new technique that makes it possible to calibrate production systems significantly faster – with even higher accuracy.

RF power – an essential physical quantity for T&M equipment from Rohde & Schwarz

Spectrum analyzers, signal generators, radiocommunications testers, and network analyzers all have one thing in common: They can be used to measure the absolute power level of RF signals or to generate such signals with an exact level. Since high level accuracy – like high frequency accuracy – is a key property for many RF T&M instruments, power calibration plays an important role at Rohde & Schwarz. It must fulfill three conditions:

1. Power calibrations (like other calibrations as well) must be fully traceable to the standards of a national metrology institute.
2. When transferring power, the accuracy loss must be minimized at each stage of the calibration chain.
3. Power calibrations must be performed quickly but with the required accuracy since they represent the largest share of the total calibration effort.

All three conditions can be best fulfilled using power meters, which is why these instruments are encountered at many points in the production process. Calibration of the power of RF T&M instruments almost always involves a simple power comparison between the power meter and the device under test. In the case of sources, the power sensor is connected directly to the output. For receiver calibration, either a power divider is inserted or the measurement is made using a level control sensor from the R&S®NRP-Z28/-Z98 series. That is all that is actually involved in calibrating an RF T&M instrument. However, calibrating the power sensors themselves requires considerably more effort.

* An article by Germany´s National Metrology Institute (Physikalisch-Technische Bundesanstalt, PTB) starting on page 28 discusses how RF power, an important measurand for Rohde & Schwarz, is traced back to the national primary standard of the Federal Republic of Germany.

Traditional approach: the classic calibration chain at Rohde & Schwarz

The classic calibration chain for thermal power sensors of the R&S®NRV family has two stages (FIG 1): Depending on the frequency range, the sensor to be calibrated is tested using one or more calibration systems. These calibration systems are directly traceable to primary standards, e.g. to standards of Germany´s National Metrology Institute (Physikalisch-Technische Bundesanstalt, PTB) or the American National Institute of Standards (NIST). To ensure their traceability, these calibration systems are regularly compared with highly accurate reference standards which themselves are sent every one or two years to one of the national institutes where they are calibrated with considerable effort. Basically, this process is still in place today. Although this concept might sound appealing due to the short calibration chain, it is no longer up-to-date – mainly because of the reference standards that are used.

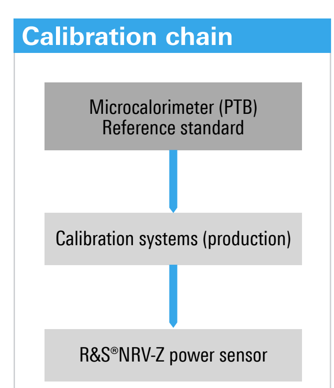


FIG 1 Calibration chain for power sensors of the R&S®NRV family. Microcalorimeter and reference standard form a national primary standard.

These reference standards must meet high requirements. First, they need to be reproducible, stable over the long term and compatible with the primary standards from national institutes. Second, they need to make it possible to test the company's internal calibration systems quickly and, most importantly, without major loss of accuracy. It is difficult to fulfill both requirements at the same time for two reasons: Compatibility with the calibration equipment used by national institutes means that only very specific types of power sensors can be used as reference standards, i.e. power sensors based on thermistors, which have not been used in industrial testing for many years now. Calibration of a production system also requires a large number of measurements in order to ensure the necessary process reliability or to cover wider frequency ranges. However, the slow thermistor power sensors need a great deal of time to accomplish these tasks. Another problem is that due to the close connection to the reference standards, each of the existing calibration systems only covers the frequency range of the reference standard. For example, to calibrate a 40 GHz R&S®NRV-Z55 sensor, the sensor had to be connected to three different systems.

In terms of accuracy, the result is also less than first-rate. Since thermistor power sensors are poorly matched by their very nature, relatively large mismatch uncertainties arise when calibrating production systems. This means that even immediately after calibration, these systems are significantly less accurate than the corresponding reference standards.

Faster and more accurate with gamma correction

In production, however, calibration time and achievable accuracy are both critical. To reduce the accuracy losses and calibration time, the only solution is therefore to test the calibration systems for power sensors using state-of-the-art power sensors instead of classic reference standards. However, this actually lengthens the calibration chain – an apparent paradox.

The key to solving this problem involves correcting the measurement errors caused by mismatch. These measurement errors can be computed with great accuracy if the complex reflection coefficients of the sensor and the calibration system are known. Then, the results only have to be taken into account in the final result. This technique is known as gamma correction – from the Greek uppercase letter gamma (Γ) that is the usual symbol for complex reflection coefficients. This technique makes it possible to rapidly perform power calibrations with extremely low loss of accuracy.

For an impressive example, see FIGs 2 and 3. If the output power of conventional RF or microwave generators is measured using a power sensor, the mismatch on both ends will normally make the largest uncertainty contribution, which is typically well above the measurement uncertainties specified in the sensor data sheet. Using gamma correction, this error source disappears almost completely, and the overall measurement uncertainty is equal to the power sensor's measurement uncertainty.

The obvious question at this point is: Why was gamma correction not used earlier for power calibrations? The reason is that not the actual correction but rather the determination of the complex source reflection coefficients caused problems. This measurement places specific demands on the source and

Level calibration of a generator

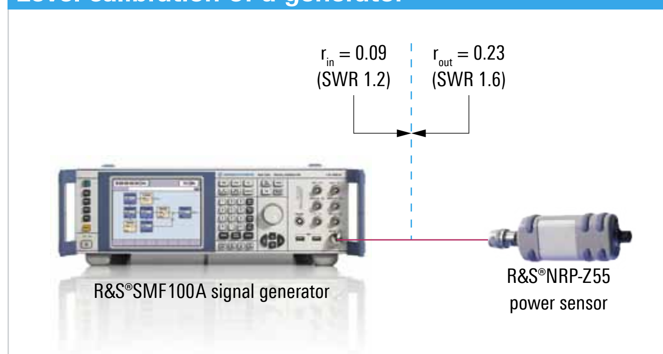


FIG 2 Level calibration of an R&S®SMF100A generator using an R&S®NRP-Z55 power sensor as the reference. The maximum measurement error due to mismatch is 0.18 dB at 18 GHz (without gamma correction).

Measurement uncertainty with / without gamma correction

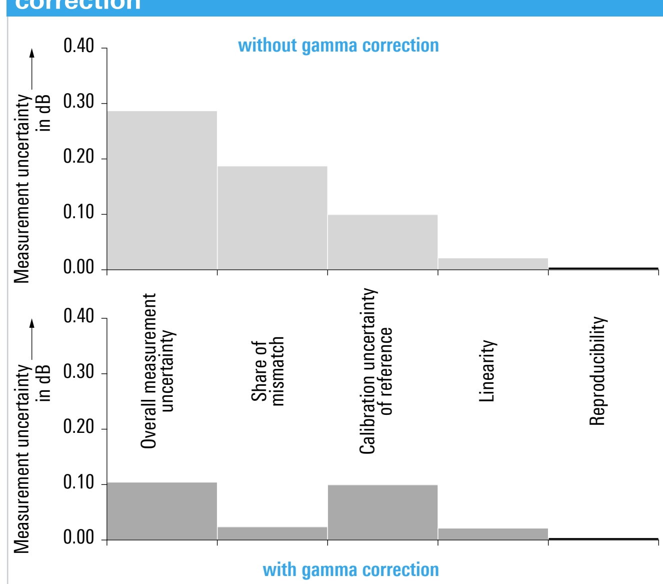


FIG 3 Measurement uncertainty with and without gamma correction for the example in FIG 2 (calibration level –10 dBm).

must also be performed with great accuracy since otherwise a contrary effect will occur. Rohde&Schwarz has managed to overcome this problem through its pioneering work. The power sensors of the R&S®NRP family can now be calibrated with great accuracy and at high speed using entirely redesigned calibration systems.

The new technique in detail: the calibration chain for power sensors of the R&S®NRP family

Through consistent correction of the mismatch influence, it is possible to introduce two additional calibration steps without causing an increase in the measurement uncertainty of the power sensors (FIG 4). The test systems are no longer calibrated using the old, time-consuming method involving reference standards with their associated loss of accuracy. Instead, company-internal transfer standards are used based on state-of-the-art power sensors. Since today's production systems are also designed to provide the entire frequency range of a sensor type on one test port, it is an obvious choice to also perform the calibration of the production system in one step. In the case of a 40 GHz system, for example, the benefit is that instead of three reference standards for the frequency bands from 10 MHz to 18 GHz, 18 GHz to 26.5 GHz, and 26.5 GHz to 40 GHz, only a single transfer standard needs to be connected for the entire frequency range.

A specially designed reference system has been developed to allow calibration of the highly accurate transfer standards based on the thermal sensors from the R&S®NRP family. This reference system is operated by German Calibration Service (DKD) laboratory 16101 at Rohde&Schwarz in accordance with purely metrological criteria (see box on right). The reference system contains a specially configured power reference for each reference standard. This is a source that can be calibrated and that has the same frequency range and the appropriate connector. Above 18 GHz, waveguides must be used. Currently, the system contains five power references covering the frequency range from 100 kHz to 75 GHz. The measurement uncertainties of the power references are only slightly above those of the reference standards since gamma correction is used in the calibration process and calibration is based on multiple reference standards of the same type. This increases the reliability of the process (keyword: outliers) and reduces the effects of stochastic influences.

Depending on the frequency range, the company's internal transfer standards are calibrated on one or more power references. Different adapters must be used depending on the connector type used by the coaxial transfer standard. However, since the adapter influences can be taken into account almost fully using an enhanced gamma correction, the transfer standards also achieve an extremely low measurement uncertainty. As a result, calibration of the production systems

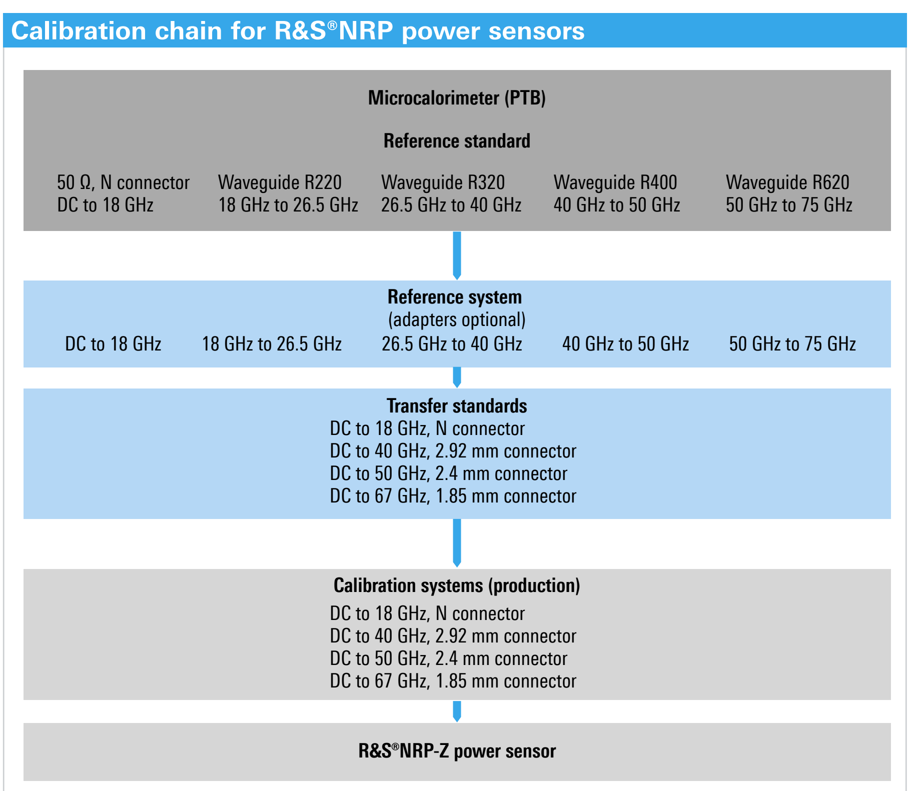


FIG 4 Calibration chain for power sensors of the R&S®NRP family. The calibration stages that are new in comparison to the classic approach are shown with a blue background.

for R&S®NRP sensors is fast and broadband and uses the connector type of the test system. This helps to considerably reduce downtime in production and also simplifies recalibration and improves reliability by eliminating the need for adapters. Moreover, the method is more accurate than the previous approach.

To prove the correctness of the calibration technique, the measurement method and the measurement uncertainties it produces were checked and confirmed by independent experts who performed comparison measurements as part of the accreditation process for the German Calibration Service (DKD).

Dr. Gerhard Rösel

Power references – highly accurate signal sources and one-port vector network analyzers all in one

The power references now used in DKD laboratory 16101 at Rohde & Schwarz have little in common with the systems used around the world until now as the standard setup for accurate power calibration. One-port vector network analyzers are used, and their output level is stabilized using built-in power sensors (FIGs 5 and 6). Accordingly, these systems are suitable for performing power comparisons and can also determine the reflection coefficient of the connected sensor and their own source reflection coefficient (both in complex notation). This means that everything needed for gamma correction is already available, helping to achieve the highest level of accuracy.

The RF power (measurand) is transferred from the reference standard to a company-internal transfer standard in four steps:

1. Determination of the complex reflection coefficients of the sensors and the source. The equivalent source reflection coefficient is determined using a Juroshek setup where a one-port calibration with OSM impedance standards is performed on the test port.
2. Calibration of the power reference using multiple reference standards of the same type, and averaging of the calibration factors.
3. Calibration of all four S-parameters of the adapter (if needed for the transfer standard).
4. Calibration of the transfer standard. To cover the entire frequency range of a transfer standard, the standard is connected to multiple power references in sequence.

FIG 5 Part of the reference system at Rohde & Schwarz.

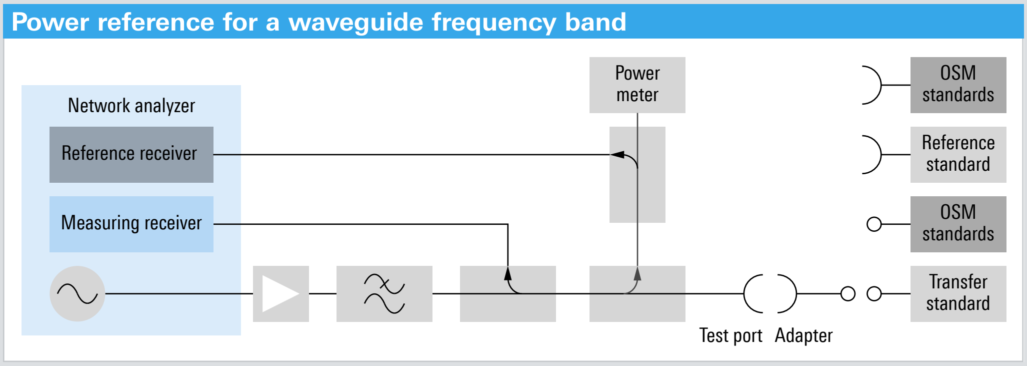


FIG 6 Block diagram of a power reference for a waveguide frequency band.

33 GHz power sensor for measurements on satellite systems

Today, RF power measurements are easier, faster, and more accurate than ever before. This is made possible by developments such as multipath technology as well as by integrating the complete power meter functionality into the sensor. Previously, these types of sensors were only available for frequencies below 26.5 GHz. The new R&S®NRP-Z31 AVG power sensor, however, covers the entire Ka band for satellite radio. It supports general applications in the lab, in production, and in service and makes it possible to monitor the power of satellite systems. The newly launched sensors are already being integrated into the first systems.

Excellent measurement characteristics – the best of two worlds

Modern power sensors like the R&S®NRP-Z31 (FIG 1) combine the accuracy of classic thermal sensors with the measurement speed and dynamic range of CW diode sensors. In addition, they can be easily remote-controlled via a USB interface, which allows them to be integrated into test systems and connected to other T&M equipment from Rohde & Schwarz. The new power sensors are no larger than their predecessors and currently represent the most economical solution for professional measurement tasks. They replace the base unit, reduce measurement time in production environments, and eliminate the need to use different sensors. Users previously required both a diode and a thermal power sensor to cover the level range from –40 dBm to +20 dBm that is important for T&M applications. Today, they only need a single R&S®NRP-Z31. In addition, the new sensor type offers features that are required for TDMA or modulated signals and are normally provided only by peak power meters, including power measurement in gates and the ability to show power as a function of time (trace mode). Power measurement in gates means that average power can be measured not only continuously but also over signal-synchronous, user-definable timeslots.

This is possible because of the patented Rohde & Schwarz three-path technology that has been successfully implemented for many years in the sensors of the R&S®NRP-Z11 / -Z2x / -Z9x family. The test signal is simultaneously processed in three overlapping measurement paths with different power ranges, which ensures that a valid measurement result is constantly available even without range switching. The result is a continuous total measurement range of 90 dB for unmodulated carriers and modulated signals of any kind. The lower measurement limit is –67 dBm, i.e. it comes very close to the theoretical minimum for diode sensors.

FIG 1 The R&S®NRP-Z31 power sensor with a frequency range from 10 MHz to 33 GHz and a total measurement range from –67 dBm to +20 dBm.

In addition to its excellent measurement characteristics, the R&S®NRP-Z31 AVG power sensor offers features that facilitate its practical use and are unique to the power sensors of the R&S®NRP family. The most important ones are embedding and fixed noise averaging. Embedding involves integrating an upstream attenuator pad or a directional coupler into the measurement path for power reduction or for signal tapping, respectively. The S-parameter data set of these components must be permanently stored in the sensor for all frequencies so that it can be easily activated for the measurement. There is no easier way of measuring – and none that is more precise because interaction with the sensor input is taken into consideration in the measurement. Fixed noise averaging automatically sets the noise component in the measurement result to a user-selectable value, which is particularly advantageous when programming remote-controlled applications, and spares the user the effort of performing elaborate trials or complex calculations.

The right sensor for every task – it pays to take a second look

The best way to find out whether a power sensor is suitable for a specific measurement task is to check whether its measurement accuracy and test speed satisfy the requirements. FIG 2 shows that these requirements are normally met for only part of the power range specified by the manufacturers. It also illustrates that the new R&S®NRP-Z31 power sensor closes the gaps left by other sensors.

The lower measurement limit that can be attained by using a specific sensor technology mainly depends on the inherent noise of the sensor: The lower the noise, the better the reproducibility at a specific power level and the wider the total measurement range. The fact that the lower measurement limit increases as the measurement time decreases (smaller averaging factor) is due to physical reasons and is unavoidable.

Modulation of the signal envelope, as assumed in the example, is another challenge that must be mastered to obtain accurate measurement results. Although signal envelope modulation is absolutely not critical with thermal sensors, it may cause considerable measurement errors in diode sensors if the power exceeds a value of 10 µW (–20 dBm). In the case of multipath sensors, however, appropriate subdivision of the measurement paths and the use of diode stacks can help ensure that the measurement errors due to modulation are so small that they are almost negligible compared with other error sources.

Power range of different sensor technologies

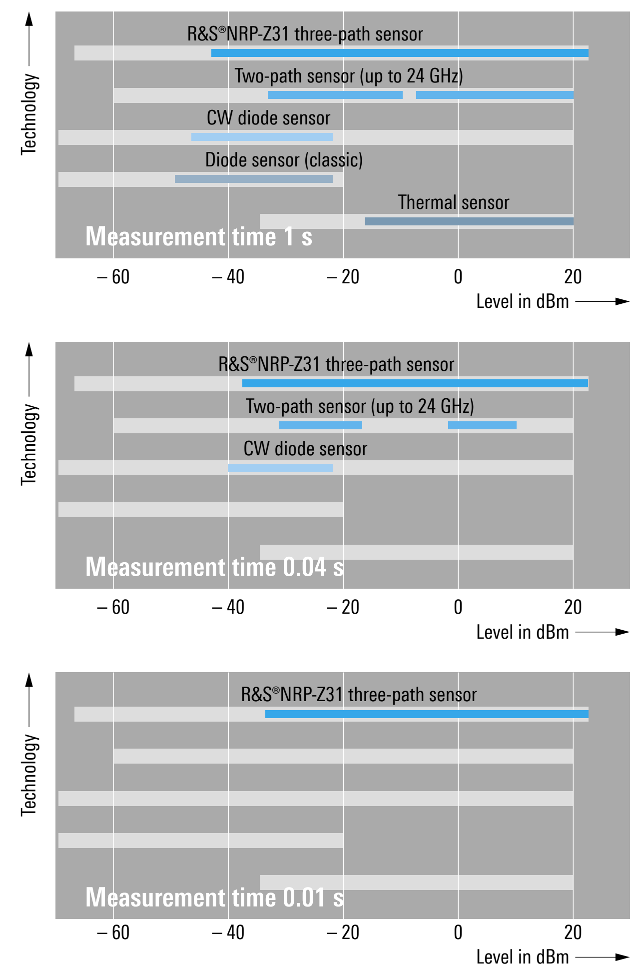


FIG 2 Realistic power range provided by different sensor technologies with user-defined measurement accuracy and time for obtaining settled results. When combining zero offset and noise as the stochastic influence quantities, their uncertainty contribution (k = 2) should be less than 0.4 % (0.017 dB), and the influence caused by modulation (16QAM) should not exceed a systematic measurement error of ±1.2 % (±0.05 dB). Only commercially available sensors for the satellite Ka band are taken into consideration. To make comparisons possible, the maximum achievable measurement range specified by the manufacturers is indicated for each sensor type.

When additional criteria such as the measurement functionality of the R&S®NRP-Z31 power sensor are taken into consideration (e.g. the trace mode for measuring the peak envelope power, its capability to perform measurements in timeslots, embedding of upstream components or fixed noise averaging), it becomes easy to decide in favor of the newest member of the R&S®NRP family.

Thomas Reichel

The R&S®FSUP signal source analyzer provides new measurement capabilities

The R&S®FSUP is the only instrument on the market that unites a high-end signal and spectrum analyzer with a phase noise tester in a single box. Now, it also offers impressive new measurement capabilities for parameters such as residual phase noise and AM noise, along with an expanded frequency range for cross-correlation that enables greater dynamic range in microwave measurements.

Cross-correlation from 1 MHz to 50 GHz

Cross-correlation eliminates uncorrelated noise from the two independent internal reference sources by means of averaging. This can improve the dynamic range by as much as 20 dB, depending on the number of averages. With the new R&S®FSUP-B60/-B61 hardware options for the R&S®FSUP, this method can now be used with input frequencies between 1 MHz and 50 GHz, a range that is especially interesting when measuring signal sources in radar and microwave link applications and in satellite communications. This is a welcome addition for developers and production managers because, even in the case of challenging measurement requirements, the necessary phase noise measurements can now be carried out at the push of a button. The test setup is simple and no longer requires costly reference sources. FIGs 1 and 2 show a typical measurement on a high-quality signal source at 25.2 GHz. Although it takes more than 1000 averages to measure this signal source at a frequency offset of 10 kHz, the R&S®FSUP only needs a few seconds. The new hardware option also permits measurements with cross-correlation at input frequencies of less than 10 MHz. This is a capability that should particularly interest OCXO manufacturers because, to date, there is nothing comparable on the market in terms of ease-of-use that would allow them to test their entire product portfolio (with frequencies from a few megahertz through to the 100 MHz range) simply by pressing a button.

Measuring residual phase noise

With RF transmitters, the oscillator is not the only source of phase noise. Particularly in high-end applications, it is helpful to know which other components – amplifiers and frequency dividers, for example – contribute to phase noise. The R&S®FSUP has all the capabilities and the flexibility to carry out these complex measurements. They can be performed by using an external phase shifter, with the software in the R&S®FSUP conveniently guiding the user through the entire calibration process. An external phase detector can also be used in addition to the internal detector, enabling users to continue working with older, more complex phase noise test setups, particularly in cases where the internal phase detector is not sufficiently sensitive.

R&S®FSUP: a unique combination of phase noise tester and signal and spectrum analyzer

The R&S®FSUP is a high-end signal and spectrum analyzer combined with a PLL-based phase noise tester. It is currently the only complete, single-box solution of its kind on the market and can be used at frequencies up to 50 GHz (or 110 GHz with external mixers). Besides these capabilities, the R&S®FSUP can also fully characterize VCOs. Its integrated, exceptionally low-noise DC sources support oscillator operation and tuning. At the press of a button, it analyzes the frequency range, the tuning slope, the influence of the supply voltage, the behavior of upper harmonics, transient response, and more. For users testing the direct impact of phase noise on modulation quality, special analysis options are available for a number of digital mobile radio standards, including WCDMA and GSM. The R&S®FSQ-K70 vector signal analysis option expands the R&S®FSUP to support the universal demodulation and analysis of digital radio signals down to the bit stream level. The R&S®FSUP was featured in detail in News from Rohde&Schwarz (2006) No. 190, pp 30–33.

FIG 1 Phase noise measurement on a quality signal source at an input frequency of 25.2 GHz: without cross-correlation (blue), with approx. 1000 averages (green), and with approx. 20000 averages (yellow).

FIG 2 Results of a phase noise measurement with the R&S®FSUP on a quality signal source.

	Specification in signal source data sheet	R&S®FSUP measurement without cross-correlation	R&S®FSUP measurements with cross-correlation based on different numbers of averages		
			100	1000	20000
Phase noise at 25.2 GHz with frequency offset of 10 kHz	–122 dBc/Hz	–102.7 dBc/Hz	–113.6 dBc/Hz	–117.3 dBc/Hz	–125.9 dBc/Hz

AM noise and baseband noise

Phase noise measurements with a spectrum analyzer always show the sum of phase noise and amplitude noise – the two usually cannot be measured separately. With the phase detector method, though, amplitude noise is suppressed, making separate phase noise measurements possible. However, in many applications (digital I/Q modulation, for example), amplitude noise is a relevant factor and therefore needs to be specified. Amplitude noise could be measured in the AM/FM demodulator, but only with a limited dynamic range. With the new R&S®FSUP and the R&S®FSUP-Z1 external diode, however, amplitude noise can be measured at a dynamic range that is expanded by 30 dB to 40 dB. This makes it possible to test the specifications of transceiver chips for modern wireless communications standards, for example.

The residual noise input or AM noise input can also be connected directly to a signal source, in which case the instrument shows the (noise) power at the various offset frequencies. This new capability can be especially valuable for users who want to measure DC sources, which have a major impact on oscillator characteristics.

An advanced processor platform for greater speed

With its new hardware options and measurement capabilities, the R&S®FSUP is not just more versatile. It also runs on a new processor platform that provides significantly more speed in compute-intensive measurements – a benefit that can be crucial in production environments, for example, where every second saved is a plus.

Dr. Wolfgang Wendler

R&S®SMF100A microwave signal generator: lowest phase noise ever

No matter where signal generators are used – for civil or military applications, when characterizing rapid A/D converters or developing highly sensitive Doppler radar equipment – there is an increasing need for signal sources with the lowest possible single sideband phase noise. The R&S®SMF100A microwave signal generator offers values that are unmatched on the market.

Down with noise ...

It is primarily the technological progress in microwave components over the past few years that has enabled the development of instruments that are able to handle increasingly demanding tasks. Users in the communications field, in particular, have demanded ever-lower single sideband phase noise values at carrier offsets from 1 kHz to 100 kHz. The Rohde & Schwarz portfolio includes the right generator for this application: the R&S®SMF100A microwave signal generator. An uncompromising frequency synthesis design together with a single sideband phase noise of typ. –120 dBc (1 Hz) at 10 GHz and a carrier offset of 10 kHz make it the leader of its class.

And the trend toward ever more complex RF test and measurement tasks continues. Radar specialists from the civil and A&D fields, in particular, require even lower single sideband phase noise at carrier offsets below 100 Hz. This is because the Doppler radar equipment being developed for these fields is becoming increasingly sensitive, allowing reliable detection even of slowly moving objects. For example, in railway applications, these instruments can be used to warn about people or animals on the tracks. Similar applications exist in A&D.

Signal quality, speed, and flexibility – three key areas where the R&S®SMF100A microwave signal generator really shines (see News from Rohde & Schwarz (2007) No. 192, pp. 21–24).

Slow objects detected by radar generate low-frequency Doppler signals that are always near the carrier, which is why these applications require low single sideband phase noise. This type of high-end radar equipment can be developed, manufactured, repaired, and maintained only with the aid of suitable signal generators.

It is also becoming increasingly important for general T&M applications to have signal sources with the lowest possible single sideband phase noise near the carrier. This requires precise characterization of ever faster A/D converters, for example. That is possible only if low-jitter microwave signals, i.e. signals with low single sideband phase noise – particularly near carrier – are available.

... by more than 8 dB!

Rohde & Schwarz responds to these new challenges from the microwave market by offering the R&S®SMF-B22 enhanced phase noise performance option for the R&S®SMF100A signal generator. It typically improves the single sideband phase noise at carrier offsets of < 100 Hz by more than 8 dB. Every R&S®SMF100A can be equipped with this option, regardless of the selected frequency option.

FIG 1 shows the single sideband phase noise with and without the R&S®SMF-B22 option. At carrier offsets of about 1 kHz and higher, the generator behavior is virtually the same with and without the option. However, the lower the offsets from the carrier, the more significant the influence of the new option. This is seen clearly in both the measured values in FIG 1 and the data sheet values at 10 GHz in FIG 3.

FIG 2 shows the typical single sideband phase noise with the R&S®SMF-B22 option at 1 / 3 / 10 / 22 GHz, and 40 GHz. This type of performance makes the R&S®SMF100A together with the R&S®SMF-B22 option the first choice for local oscillator replacements and for performing transmitter and receiver measurements on modern radar instruments and microwave communications systems. It is also an excellent reference source for measuring the single sideband phase noise.

Wilhelm Kraemer

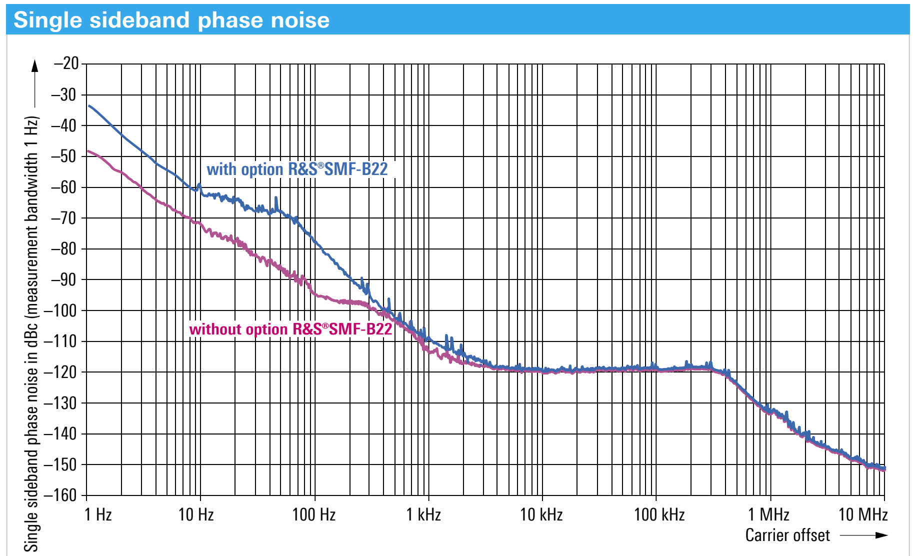


FIG 1 Measured single sideband phase noise with and without the R&S®SMF-B22 option.

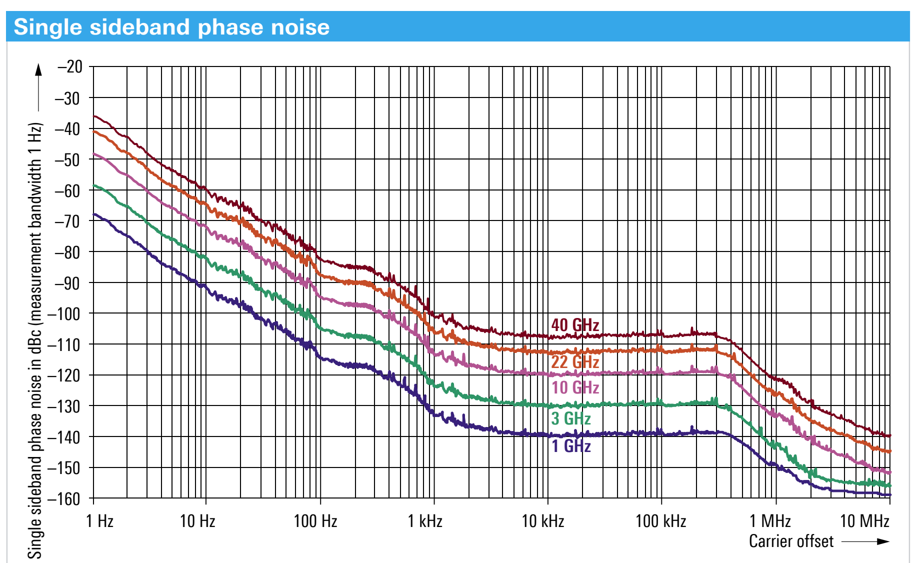


FIG 2 Measured single sideband phase noise with the R&S®SMF-B22 option at various frequencies.

FIG 3 Single sideband phase noise with the R&S®SMF-B22 option, test bandwidth 1 Hz, CW. Blue: values without option at a carrier frequency of 10 GHz.

	Offset from carrier					
Carrier frequency	1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz
250 MHz	< –52 dBc	< –80 dBc	< –97 dBc	< –116 dBc	< –126 dBc	< –128 dBc
1 GHz	< –57 dBc	< –85 dBc	< –101 dBc	< –121 dBc	< –132 dBc	< –133 dBc
2 GHz	< –51 dBc	< –79 dBc	< –96 dBc	< –115 dBc	< –128 dBc	< –127 dBc
4 GHz	< –45 dBc	< –73 dBc	< –89 dBc	< –109 dBc	< –122 dBc	< –121 dBc
10 GHz	< –37 dBc	< –65 dBc	< –81 dBc	< –101 dBc	< –115 dBc	< –113 dBc
	–	< –57 dBc	< –75 dBc	< –100 dBc	< –115 dBc	< –113 dBc
20 GHz	< –31 dBc	< –59 dBc	< –75 dBc	< –95 dBc	< –109 dBc	< –107 dBc
40 GHz	< –25 dBc	< –53 dBc	< –69 dBc	< –89 dBc	< –103 dBc	< –101 dBc

Analog and digital audio broadcast signals with the R&S®SMx family of generators

Various audio broadcasting standards, GPS reception with navigation, and Bluetooth® interface: Leading-edge mobile radio equipment and car radios boast a wide range of features. As a result, manufacturers must perform ever more complex tests and therefore require generators that are able to provide all the usual standards in a single box, thereby simplifying system tests.

Rohde&Schwarz signal generators for almost all requirements

Analog audio broadcasting continues to be an attractive choice since it offers the best network coverage worldwide. Even these days, it is hard to imagine a radio receiver without analog reception. Still, there is no stopping the transition from analog to digital standards in sound broadcasting. The world of digital broadcasting has become quite diverse: Just consider the various broadcast standards and system providers such as XM Satellite Radio™ or SIRIUS Satellite Radio™ – both operating the satellite digital audio radio services (SDARS) in North America. The providers not only define broadcast technology, they also deliver content. Technical broadcast standards – e.g. digital audio broadcasting (DAB) and HD Radio™ – only define the broadcast technology, while content is delivered by independent providers.

End-user hardware is just as multifaceted. Car radio manufacturers, for instance, integrate different broadcast standards into their devices or offer different radio configurations depending on the target market. This immensely increases test requirements; manufacturers need measurement equipment that ensures simple and trouble-free system tests using a minimum of devices. Here it is important to have signal generators that are easy to operate and – in a single box – provide all necessary test signals in the very best quality.

With its R&S®SMx signal generators, Rohde&Schwarz offers a comprehensive generator portfolio to meet almost any requirement. New options enable the R&S®SMx family of signal generators to generate test signals for all important audio broadcast systems/standards (FIG 1, left):

- HD Radio™
- SDARS with XM Satellite Radio™ and SIRIUS Satellite Radio™
- DAB
- FM stereo and RDS/RBDS

FIG 1 Rohde&Schwarz is the only manufacturer in the world to offer a portfolio of generators that covers all major standards: from analog and digital audio broadcasting to mobile TV and mobile radio.

Options for the established R&S®SMU200A and R&S®SMJ100A generators are already available or are currently being certified by the radio operators; the options for the newcomer, the R&S®SMBV100A, will follow soon.

FM stereo with the versatile R&S®SMX-K57 option

The basic operating principle of the FM stereo option is shown in FIG 2. All important parameters/data can be adjusted, making it possible to test the analog radio receiver to the limit. Audio data is either generated by an internal AF generator or fed in via the S/P DIF input. In addition, it is possible to read in audio files in WAV format and use them as an audio source. This makes it convenient for the user to choose music or audio contents on the PC and then generate an FM broadcast signal later on using the generators.

A special feature of the FM stereo option is the wide range of possibilities it offers for generating RDS/RBDS signals. This is where the R&S®SMx generators with their intuitive user interface really show their strength. All the usual parameters can be entered via the menus. FIG 3 shows group type 0 as an example. The RDS standard defines 16 different message formats, which are designated as group type 0 to 15. Due to its flexibility, the option even makes it possible to enter open data application (ODA) and traffic message channel (TMC) data. FIG 4 shows the input dialog for ODA in group type 8.

R&S®SMX-K57 option for FM stereo

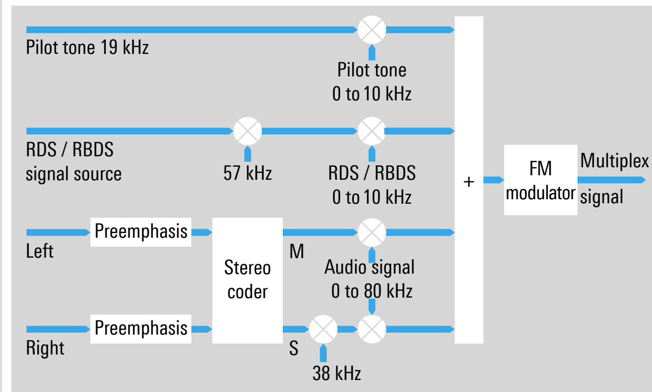


FIG 2 The principle behind the R&S®SMU-K57 FM stereo option.

DAB / T-DMB – using the R&S®SMX-K53 option for music and data services via VHF FM

DAB has become an established standard for broadcasting digital terrestrial audio broadcast programs and covers many European countries. In addition to audio data, DAB can also transmit auxiliary services and information as desired. Based on OFDM technology, the standard achieves a net data rate of 1.824 kbit/s at a bandwidth of 1.536 MHz. The programs are logically grouped to form services and ensembles.

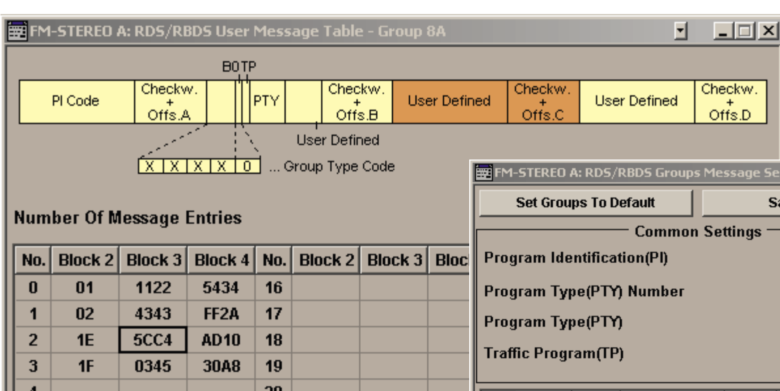


FIG 4 FM stereo: user mode for entering useful data for group type 8 / ODA.

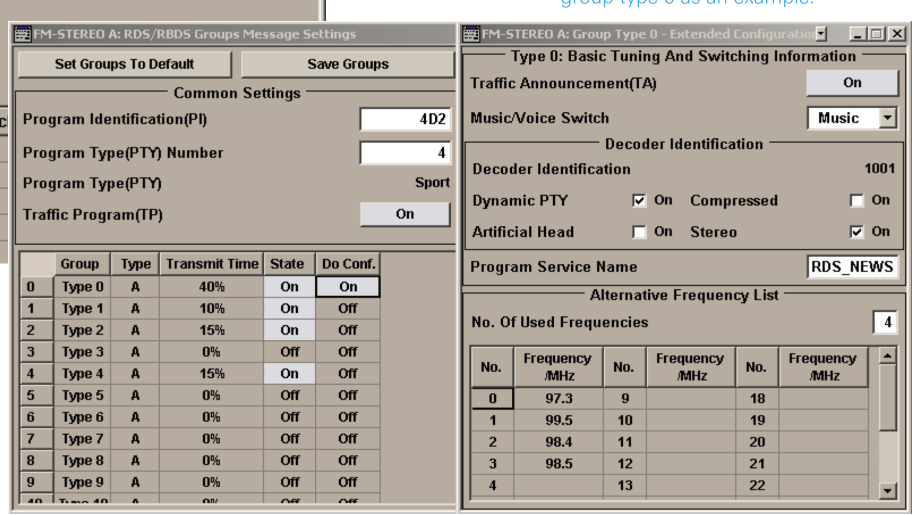


FIG 3 FM stereo: dialogs for setting the RDS/RBDS parameters using group type 0 as an example.

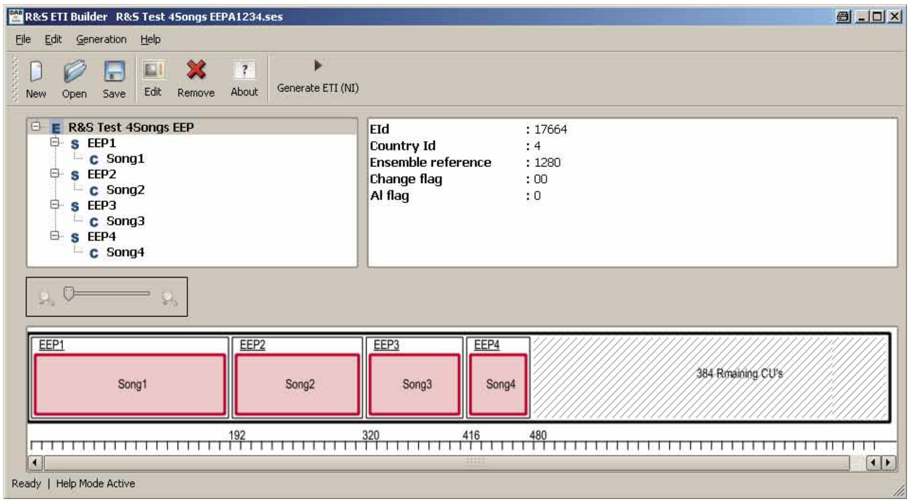


FIG 5 The ETI builder's main window, which shows an ensemble with four services. The upper left window shows the ensemble's tree structure; information about the ensemble can be found to the right. The lower window shows the position of the individual services (with different error protection) in the payload area of the DAB frame, just as they are to be transmitted later.

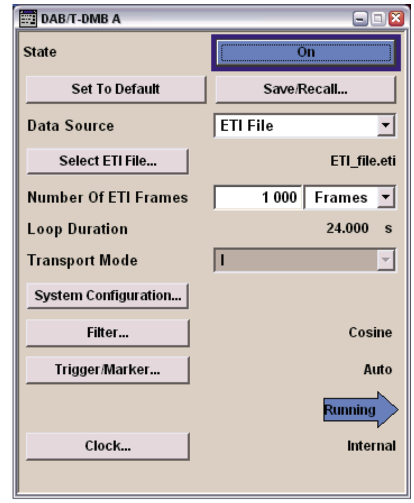


FIG 6 DAB: main dialog box of the R&S®SMU-K53 option.

The interface between the broadcasters and the broadcast network is described by the ensemble transport interface (ETI). The R&S®SMX-K53 DAB/T-DMB option uses the ETI as its input data format and transmits the included streams as DAB signal. In doing so, it supports all standard-defined transport modes and error protection methods. FIG 6 shows the main menu in which the ETI file is selected. Provided the format is valid, information such as the transport mode detected from the ETI frames and the duration of the selected frames is displayed.

In order to generate ETI data streams, Rohde & Schwarz offers the ETI builder software free of charge (FIG 5). This software makes it possible to convert music files into ETI streams, which can then be played by the R&S®SMx generators.

HD Radio™ – digital radio in parallel to analog AM and FM radio broadcasting

HD Radio™, also known as in-band on-channel (IBOC), was developed by the iBiquity corporation and is primarily being used in the United States. This method uses the same frequency bands as analog AM/FM broadcasting and can – unlike DAB – be operated in parallel as a hybrid variation. FIG 7 illustrates this for the FM frequency band. In hybrid mode, the OFDM-modulated HD Radio™ signal is additionally broadcast to the left and right of the analog FM signal.

The R&S®SMx generators have already been certified for HD Radio™ by iBiquity. The R&S®SMX-K352 option encompasses the complete set of AM and FM test vectors for all test categories, i.e. functional, bit error rate (BER) test pattern, analog only, non-IBOC, and production.

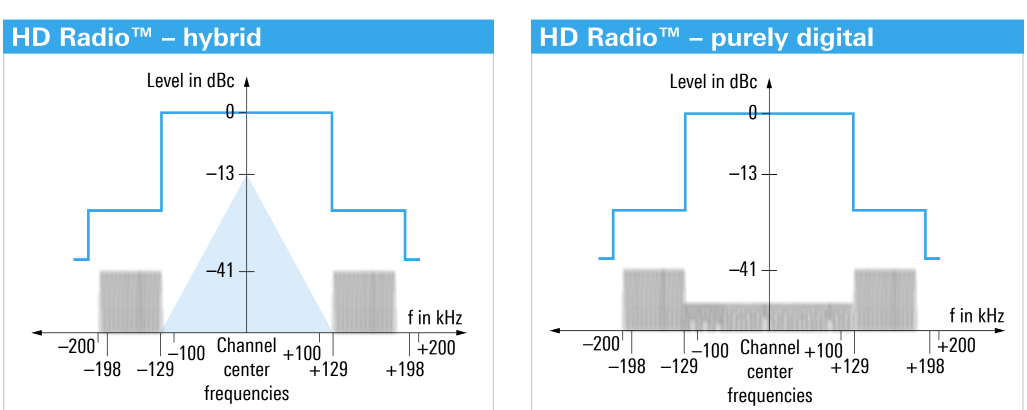


FIG 7 HD Radio™: FM frequency band as a hybrid (left) and as a purely digital system.

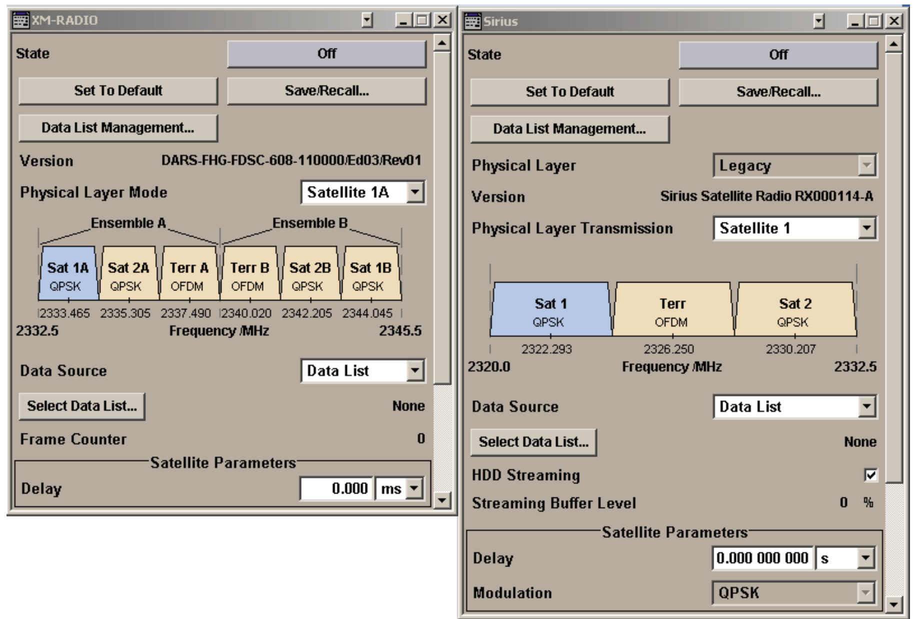


FIG 8 Main dialog box for SIRIUS Satellite Radio™ and XM Satellite Radio™.

XM Satellite Radio™ and SIRIUS Satellite Radio™ with the R&S®SMX-K56 and R&S®SMX-K58 realtime options

The two most important SDARS systems are XM Satellite Radio™ and SIRIUS Satellite Radio™. These two providers merged in 2008. SDARS systems broadcast a QPSK-modulated signal over satellites and a COFDM-modulated signal over terrestrial repeaters. This broadcast technology provides good reception in both thinly populated and in metropolitan areas. The assigned frequency bands are in the 2.3 GHz range.

For XM Satellite Radio™, the frequency band is divided into two subbands referred to as ensembles. Each ensemble includes two QPSK-modulated satellite carriers and one COFDM-modulated terrestrial carrier. Currently both ensembles transmit the same content. In the future, it will also be possible to transmit different content. The frequency band of SIRIUS Satellite Radio™ is divided into two QPSK-modulated satellite carriers and one COFDM-modulated terrestrial carrier. The complete frequency band of both SDARS systems is 12.5 MHz wide.

The R&S®SMx generators were type-tested by the system provider and validated for XM Satellite Radio™ and SIRIUS Satellite Radio™, which means that they generate standard-conforming signals (FIG 8). The generators' powerful baseband provides safety of investment because it makes them well-equipped for any future expansions by the system providers. As the first in their class, the R&S®SMx generators offer dynamic reloading of the modulation data directly from the internal hard drive. The data length is only limited by the size of the internal hard drive.

Summary

With its range of signal generators, Rohde&Schwarz covers all relevant standards and frequency ranges. The R&S®SMx generators are specialists for almost every mobile radio standards as well as for GPS simulation and – as described here – now also support the most important analog and digital audio broadcasting standards – all in one box. Two options round off the wide range of functions of the R&S®SMx family: the AWGN (additive white Gaussian noise) generator for artificially interfering with the useful signal and the fading simulator for simulating multipath propagation.

Gerhard Miller; Volker Ohlen

In addition to the solutions described, Rohde&Schwarz offers other products that are able to generate signals for some of the analog and digital broadcasting standards specified above. The R&S®SMB100A supports FM stereo/RDS, the R&S®AFQ100A supports XM Satellite Radio™, and the R&S®SFx family of generators is able to support FM stereo/RDS, DAB, and HD Radio™. Further information can be found on the Rohde&Schwarz homepage.

Automatic pulse analysis with the R&S®SMA100A RF signal generator

With the R&S®SMA-K28 power analysis option, the R&S®SMA100A RF signal generator not only helps to measure frequency responses and compression curves, it also becomes a full-fledged pulse analyzer.

Signal generators and power sensors – an intelligent combination

It has already been possible for some time now to operate the R&S®NRP-Zxx power sensors on all Rohde&Schwarz signal generators. This is useful, for example, for correcting the test setup's frequency response. The R&S®SMA100A and R&S®SMF100A generators, together with the R&S®SMA-K28 power analysis option, can also be employed to accomplish demanding tasks, such as measuring the frequency response or compression behavior of a DUT.

On the other hand, with pulsed signals, such as the ones used in radar technology or in avionics for distance measurement equipment (DME), it is primarily the pulse parameters (FIG 1) that have to be measured. Such measurements are preferably performed completely automatically. This measurement function is included in the current firmware, which can also be used to quickly and easily retrofit existing equipment. The R&S®NRP-Z81 wideband power sensor is the prerequisite for performing such measurements.

The basics of pulse analysis

Pulses are measured in line with the international IEC 469 standard. The algorithm in the R&S®NRP-Z81 first determines the pulse amplitude of the measured trace by establishing the distance between top power and base power. This pulse amplitude then serves as the basis for the percentage values of three reference levels that can be preset – distal, mesial, and proximal. These three levels are used to measure the pulse (FIG 1). Typical values are 90 %, 50 %, and 10 % (for example, for measuring DME double pulses, see article beginning on page 50). While the distal and proximal reference levels are only employed to determine the pulse's rise and fall times, the mesial reference level is used to determine all other timing parameters.

The analog R&S®SMA100A signal generator creates signals of the utmost spectral purity up to 6 GHz. With the new R&S®SMA-K26 firmware option, it can also generate DME signals and, together with the R&S®NRP-Z81 wideband power sensor, it can analyze the most important parameters for a DME ground station (see article beginning on page 50).

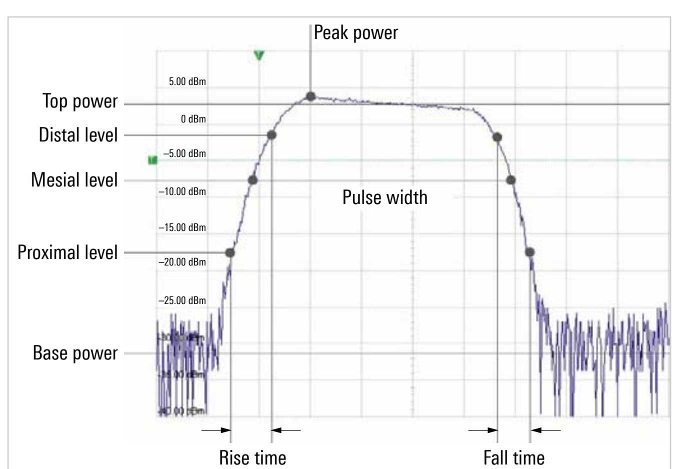


FIG 1 Definition of the pulse parameters in line with the IEC 469 standard.

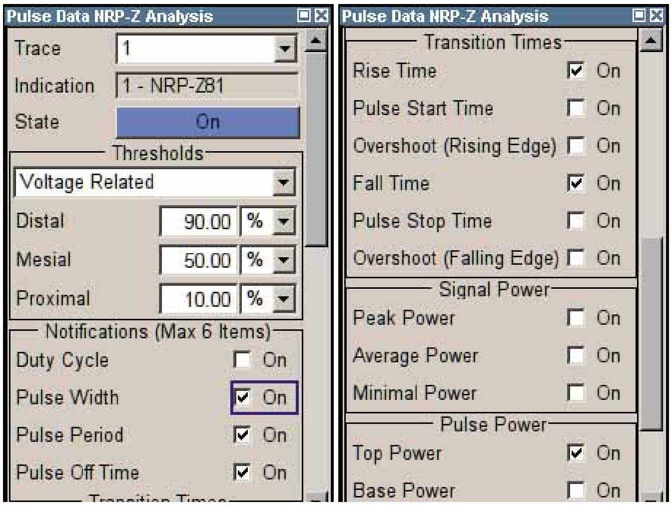


FIG 2 Setting the parameters for pulse analysis.

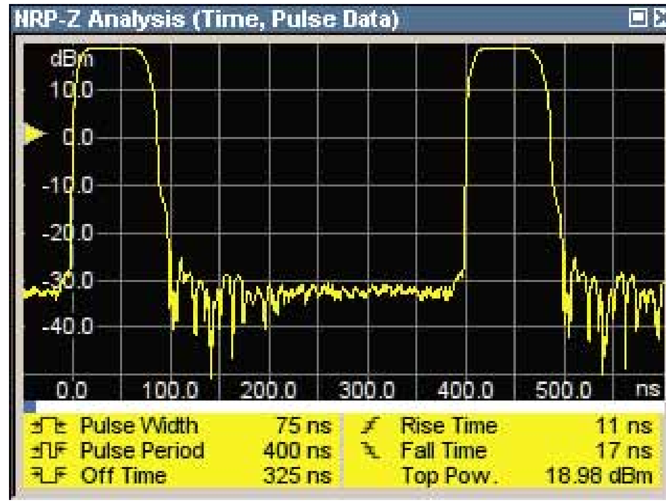


FIG 3 Representation of the measured pulse parameters on the R&S®SMA100A signal generator's display.

Fast operation

FIG 2 shows all of the setting options for automatic pulse analysis. The system continuously measures 18 parameters (FIG 4), six of which can be selected for the display of the measurement values (FIG 3). In order to ensure ideal use of the screen space and simultaneously be able to operate the instrument quickly, the established R&S®SMA100A operating philosophy has been expanded. When the analysis results are displayed in full-screen mode (as in FIG 3), it is possible, for instance, to use the BACKSPACE key to very quickly trigger automatic scaling of the level axis. All settings and measurement results are, of course, also available via the remote-control interfaces (GPIB/LAN/USB). The results can be stored as diagrams or as Excel® data records.

Summary

This expansion of the R&S®SMA-K28 power analysis option combined with the R&S®NRP-Z81 wideband power sensor turns the R&S®SMA100A RF signal generator into a versatile single-box solution for numerous applications that simultaneously require ultra-pure test signals and the ability to quickly characterize pulsed signals with great precision. This option is also available for the R&S®SMF100A microwave signal generator.

Thomas Braunstorfinger

Parameter	Meaning
Duty cycle	Ratio of the pulse width to the pulse period, expressed as a percentage $\frac{\textit{pulse width}}{\textit{pulse period}} \times 100\%$
Pulse width	See FIG 1
Pulse period	Distance between a rising edge and the next rising edge
Pulse off time	Distance between two pulses; distance between a falling edge and the next rising edge
Rise time	Pulse rise time, see FIG 1
Pulse start time	Beginning of the pulse, relative to the time at which the pulse was triggered
Overshoot (rising edge)	Overshoot on the rising edge, expressed as a percentage $\frac{\textit{peak power} - \textit{top power}}{\textit{top power} - \textit{base power}} \times 100\%$
Fall time	Pulse fall time, see FIG 1
Pulse stop time	End of the pulse, relative to the time at which the pulse was triggered
Overshoot (falling edge)	Overshoot on the falling edge, expressed as a percentage $\frac{\textit{base power} - \textit{minimal power}}{\textit{top power} - \textit{base power}} \times 100\%$
Minimal power	Minimum power measured anywhere in the measured trace
Peak power	Maximum power measured anywhere in the measured trace, see FIG 1
Average power	Average power for the pulse
Top power	Maximum power, adjusted to remove consideration of possible transient processes; this is often determined using an amplitude histogram, see FIG 1
Base power	Average power during the interpulse period
Mesial / proximal / distal power	Absolute power at the time at which the envelope trace reaches the defined reference level

FIG 4 These 18 different parameters are measured continuously with the automatic pulse analysis.

The R&S®SMA100A signal generator creates and analyzes DME signals

The new R&S®SMA-K26 firmware option upgrades the R&S®SMA100A analog signal generator to include a function for generating DME signals for air navigation. When combined with the R&S®NRP-Z81 wideband power sensor and the R&S®SMA-K28 power analysis firmware option, the generator can also analyze DME signals. This means it is a universal measurement instrument for testing DME equipment in aircraft (DME interrogators) and on the ground (DME transponders)

Generating DME signals

The R&S®SMA100A is able to both generate DME aircraft interrogator signals and perform the somewhat more complex simulation of a DME ground station, including the associated squitter pulses and identification pulses. Users can select all parameters in the clearly structured operating menu (FIG 1). Moreover, for testing purposes, these parameters can be changed to deviate from the values prescribed by the International Civil Aviation Organization (ICAO) in Annex 10. In this way, it is possible, for instance, to feed a non-compliant signal into a DME ground station and check to see if a reply is sent to this invalid signal.

In order to test aircraft interrogators in laboratories, the R&S®SMA100A can also be used to simulate a DME ground station. To do this, an R&S®NRP-Z81 [2] wideband power sensor, which serves as a receiver for the DME interrogation pulses from the aircraft interrogator, is connected to the signal generator. The power sensor triggers signal generation in the generator. The reply delay that occurs between reception of the interrogation pulse and the sending of the reply pulse can be varied as desired in order to simulate a distance of 0 NM to 400 NM (nautical miles; 1 NM = 1.852 km) between the aircraft and the transponder. The distance is set directly in the graphical user interface as a value in nautical miles. Following this reply delay, the generator delivers the corresponding reply pulses to its RF output and inserts them into the squitter pulses, which are generated constantly and randomly. In real-world applications, a DME ground station constantly sends squitter pulses in order to generate a minimum amount of transmission pulses and to be able to constantly monitor its own transmission parameters. The distribution of the random distances between the squitter pulses from the R&S®SMA100A corresponds to the probability distribution prescribed by the European Organization for Civil Aviation Equipment (EUROCAE) in ED-54.

A brief overview of radio navigation

In international air traffic, distance measurement equipment (DME) is used to measure the distance between an aircraft (interrogator) and a DME ground station (transponder). Together with VHF omnidirectional radio range (VOR), which serves to determine the azimuth direction, DME enables complete navigation of an aircraft in the airspace. In the future, DME will be used increasingly during approach for measuring the distance between the airplane and the runway. As a result, working in combination with the instrument landing system (ILS), DME creates the prerequisites for a precise automatic runway approach when visibility is poor [1]. DME operates in the frequency range between 962 MHz to 1213 MHz with shaped double pulses and is based on a measurement of the time that the pulses require to travel from the aircraft to the ground station and back. The DME ground station receives the DME pulses sent by the aircraft and returns them to the aircraft with a defined reply delay of 50 μs or 56 μs depending on the channel used. The aircraft interrogator measures the overall time between transmission of the interrogation pulses and arrival of the reply pulses. It subtracts the defined reply delay in the transponder and is then able to calculate the slant distance to the ground station.

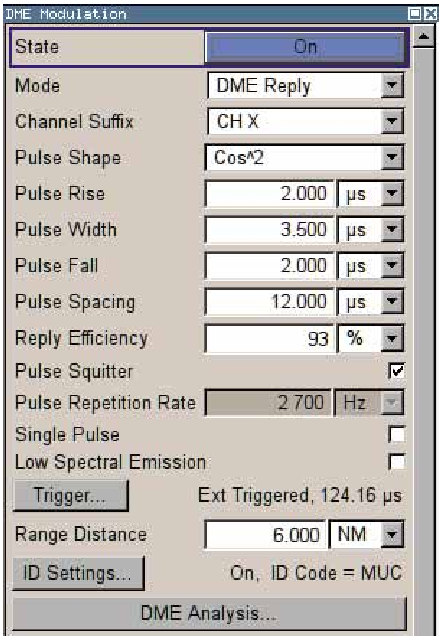


FIG 1 Operating menu for the DME reply mode.

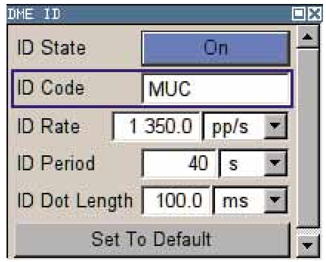


FIG 2 Setting parameters for the transponder's ID.

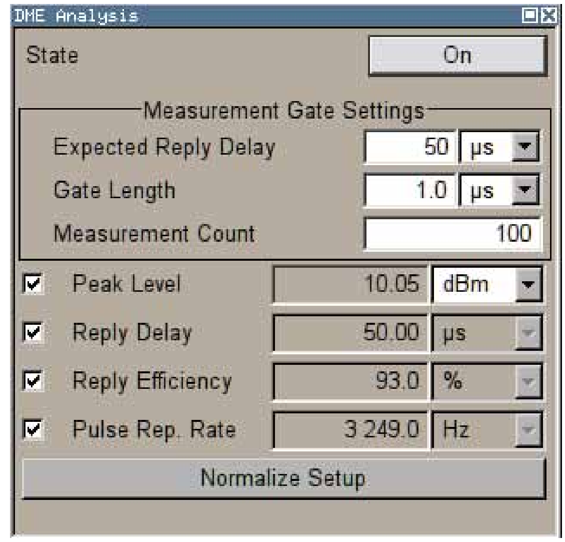


FIG 3 Analysis of DME signals using the R&S®NRP-Z81 wideband power sensor.

An important characteristic of DME ground stations is their efficiency, which refers to the correlation between the reply pulses that are sent and the corresponding interrogation pulses from an aircraft. If the receiving level for an aircraft signal at the DME ground station is just barely above the minimum receiver sensitivity, the system no longer sends a reply pulse for every interrogation pulse, which lowers the DME transponder's efficiency. Users can also set the R&S®SMA100A to imitate this behavior. The values can be set to efficiency levels between 0 % and 100 %.

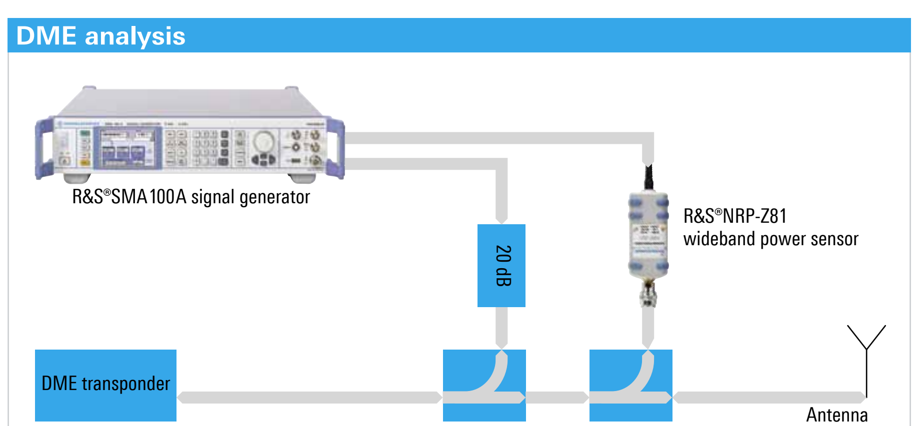
In order to test a DME interrogator's behavior with regard to reply signals from a TACAN ground station (military DME version), it is possible to superimpose the DME pulses generated by the R&S®SMA100A with a two-tone AM signal (15 Hz and 135 Hz) with user-defined modulation frequencies and deviations.

Furthermore, in reply mode, it is also possible to generate and send identification pulses. These pulses are used to transmit the international identifier code for a DME ground station (such as MUC for Munich airport); they are sent approximately every 40 s. On the R&S®SMA100A, the user can configure all the parameters for these identification pulses in a separate dialog box, and – if required – switch them on by keystroke (FIG 2).

Testing and calibrating DME transponders

Connecting an R&S®NRP-Z81 wideband power sensor to the R&S®SMA100A turns the signal generator into a DME analyzer. This analyzer can determine the most important parameters of a ground station's DME transponder (FIGs 3 and 4), such as pulse peak power, average pulse rate, efficiency, and

FIG 4 Test setup for DME analysis of a DME transponder.



delay. To make this possible, the signal generator feeds DME interrogation pulses to the DME transponder's receiver via a coupler and, via an additional coupler, uses the R&S®NRP-Z81 wideband power sensor to detect the pulses sent by the ground station. The generator software analyzes the measured pulses and displays the parameters that have been determined. In this way, it is possible, for instance, to verify the DME transponder's reply delay, which is crucial for the system's overall accuracy. Although these parameters are constantly being measured and monitored in the ground station using built-in test equipment (BITE), it is not possible to detect any errors in the BITE itself. This means that it might go unnoticed if the base station outputs faulty signals. For this reason, the ground station's most important parameters are also verified at regular intervals with the aid of external measuring equipment. Until now, this always required a complex test setup.

Another important characteristic of a DME ground station is its efficiency. Under certain operating conditions, this parameter must be checked to ensure that specific limit values are being complied with. For example, the transponder's efficiency must not fall below 70 % at the minimum specified receiving level, which can be easily verified by utilizing the DME analysis functionality and the R&S®SMA100A's high degree of level accuracy.

In addition, the R&S®SMA-K28 power analysis software option (page 48 in this issue) makes it possible to analyze the DME pulses in the time domain and to verify the most important pulse parameters such as rise and fall times, pulse width, and pulse spacing. A software algorithm constantly calculates these parameters, and the results are shown on the display without the user having to position peak and delta markers (FIG 5). This type of signal analysis is described in detail in an application note [3].

Condensed data of the R&S®SMA100A with the R&S®SMA-K26 option

Signal generation	
Frequency range	960 MHz to 1215 MHz
Level range	–120 dBm to +18 dBm
DME channel	X; Y
Pulse parameters	user-defined
Squitter pulses	in line with EUROCAE ED-54
Efficiency	0 % to 100 %
Identification pulses	user-selectable
Signal analysis with the R&S®NRP-Z81	
Reply delay	0 µs to 150 µs
Efficiency	0 % to 100 %
Pulse peak power	–10 dBm to +20 dBm
Average pulse rate	2 Hz to 10 kHz

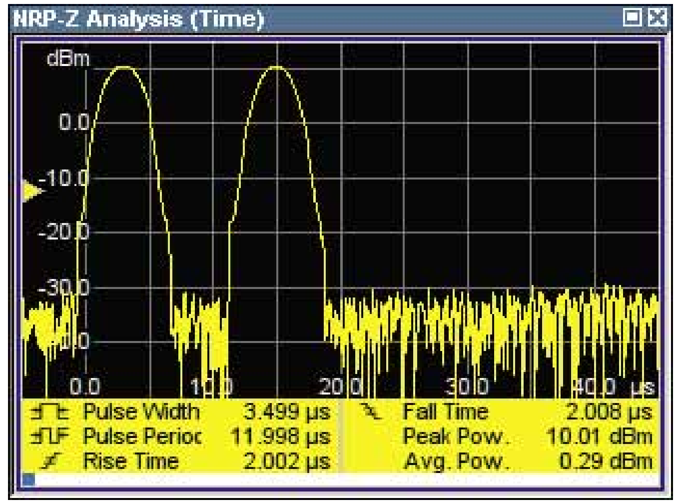


FIG 5 Analysis using the R&S®NRP-Z81 power sensor and the R&S®SMA-K28 software option.

Due to the compact design, the signal generator only requires two height units when installed in a rack. Owing to its low weight of less than 10 kg, it is easy to transport, which makes it suitable for a wide variety of uses. When equipped with the R&S®SMA-B46 option, it also complies with the MIL-PRF-28800F standard for operating altitudes of up to 4600 m.

Summary

The R&S®SMA-K26 firmware option enables the R&S®SMA100A signal generator to generate DME signals and simulate both a DME aircraft interrogator and a DME ground station (transponder). When combined with the R&S®NRP-Z81 wideband power sensor, the generator can also analyze the most important parameters of a DME ground station.

Jürgen Ostermeier

REFERENCES
[1] R&S®SMA100A signal generator – Precise signals for testing air navigation receivers. News from Rohde & Schwarz (2007) No. 192, pp 25–27
[2] R&S®NRP-Z81 wideband power sensor – State-of-the-art technology for wireless digital communications. News from Rohde & Schwarz (2007) No. 192, pp 33–37
[3] Application Note 1GP74: Test of DME/TACAN transponders http://www.rohde-schwarz.com (search term: 1GP74)

Nationwide DVB-T network for Norway

After initial testing conducted during 1999 and a subsequent call for tenders, by 2006 Rohde & Schwarz was the only company to have won the contract to set up a nationwide DVB-T network for Norway.

Enormous task – experienced company

Setting up a transmitter network for an entire country is an enormous task, but one that could almost be called routine for Rohde & Schwarz. After all, Rohde & Schwarz has already equipped a number of countries with complete digital TV networks, including Great Britain, Germany, Spain, and Taiwan.

The contract with the Norwegian operating company Norkring AS includes all types of transmitters, transposers, gap fillers, and retransmitters with power levels between 10 W and 5 kW, as well as monitoring systems for RF / ASI interfaces and single-frequency networks (SFN). The network is made up of approximately 40 main and more than 400 low-power transmitter stations, as well as numerous satellite shadow transmitter stations.

The low-power transmitters were housed in compact shelters. To minimize the space requirements for the transmitters, Rohde & Schwarz developed a special prewired cabinet, making it possible to install up to four transmitters in a single 19" rack in the shelters.

At present, three multiplexes are monitored. This task is handled by one R&S®DVM100 and one R&S®DVM120 MPEG-2 monitoring system each. An ASI analyzer with optional demodulator monitors the RF interfaces, while R&S®ETX-T DTV monitoring receivers located in the five primary transmitter stations monitor the single-frequency network. The system also includes R&S®EFA TV test receivers, R&S®ETL TV analyzers, and a large number of R&S®NRP-Z51 thermal power sensors.

From spring to fall 2006, the specialists at the Rohde & Schwarz Teisnach plant trained the customer's installation personnel. Commissioning of the network started in November of the same year, and was in full swing by January 2007. The first official broadcast took place on September 1, 2007, in Stavanger, known as Norway's oil capital. The country's capital, Oslo, followed a few days later, and by mid-November 2007, most of Southern Norway had access to digital television, which is received in approximately 70 % of all households. The rollout continues, with 95 % of all Norwegian households now capable of receiving digital television. When the analog network is decommissioned in 2009, sufficient bandwidth will be available for two additional multiplexes.

A logistical challenge

- 1000 m² storage area for network components
- 2000 km to the individual radio stations in Northern Norway
- Innumerable trucks to transport all of the equipment and systems
- One transmitter put into operation every day throughout the entire rollout time

In a subsequent agreement, Rohde & Schwarz was contracted to supply half of the transmitters that will allow reception of digital audio broadcasting (DAB) programs throughout the country. This is being put into place in parallel to the rollout of the DVB-T network. Enough transmitters have already been delivered to supply 80 % of the population with digital audio programs.

Tor Andresen

Innumerable trips were needed to get all of the equipment and system components to their destinations.

Photo: author

DVB-T / DVB-H handheld TV analyzer for mobile use

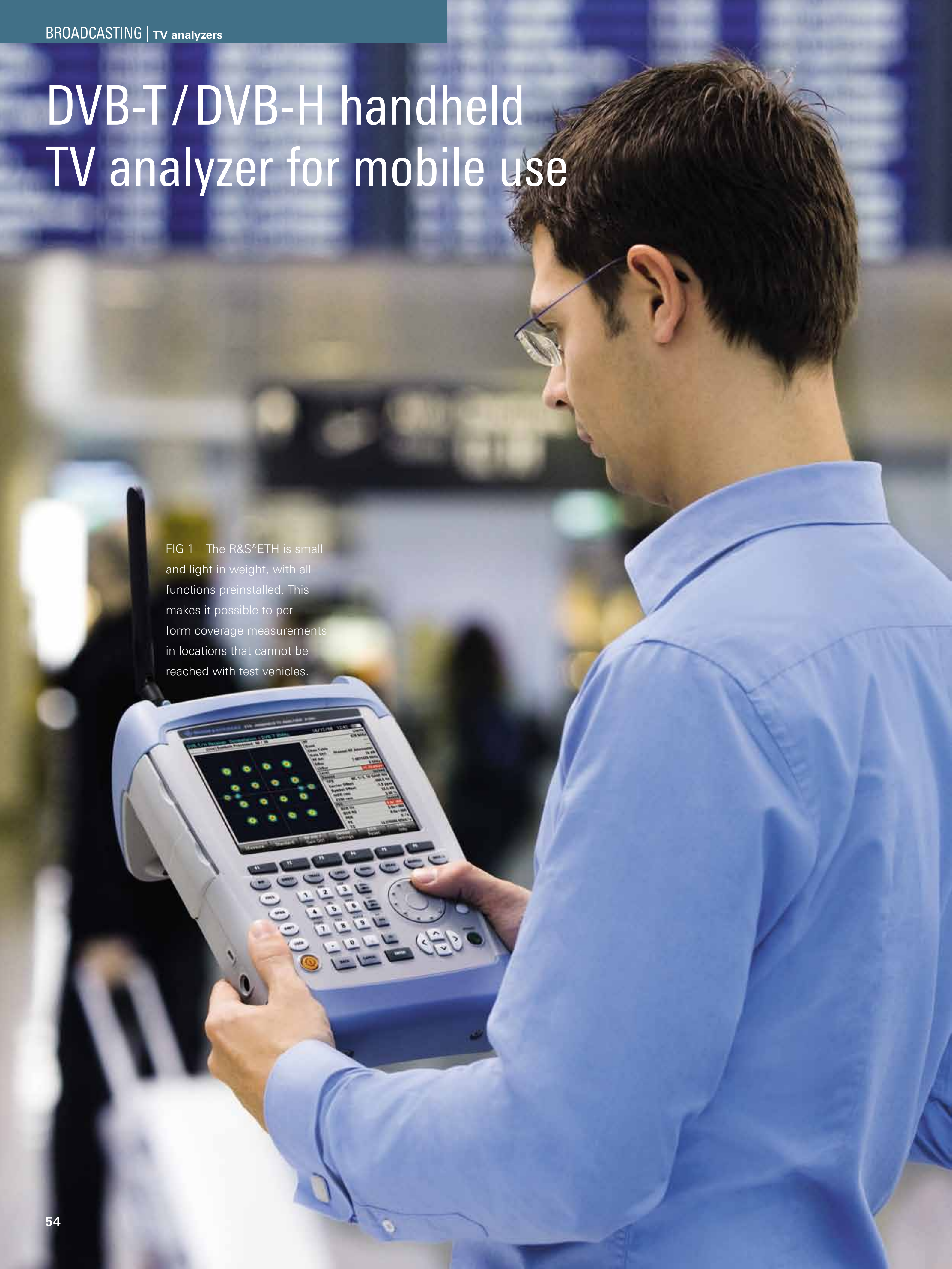


FIG 1 The R&S®ETH is small and light in weight, with all functions preinstalled. This makes it possible to perform coverage measurements in locations that cannot be reached with test vehicles.

Small, light in weight, and extraordinarily versatile – that's how the new R&S®ETH can be characterized. For example, it offers all measurements needed to detect coverage gaps in DVB-T and DVB-H networks, as well as those needed to install and maintain low-power transmitters or transposers. All these are tasks that many network operators face when filling coverage gaps or optimizing network coverage.

Versatility in a compact package – for measurements on low-power transmitters, for example

Especially when working in the field, it is important to carry along all necessary measurement instruments; as a result, each instrument should be as light, robust, and space-saving as possible. Qualifications that the new R&S®ETH handheld TV analyzer (FIG 1) is custom-tailored to. It combines the functions of a TV analyzer, a spectrum analyzer, and a vector network analyzer in a compact housing that is specially designed for demanding day-to-day work in the field.

Relatively few parameters are measured on low-power transmitters as compared to high-power transmitters, but there is no difference in the demands placed on the measuring instruments with respect to measurement tolerances and limits. For example, to measure the lower/upper shoulder attenuation, the "DVB Spectrum" measurement function in the R&S®ETH *DVB-T/H Receiver* mode performs the measurements exactly in line with the criteria defined in the ETSI TR 101290 DVB measurement guidelines (FIG 2). Predefined settings make these measurements equally reproducible for less experienced users. And the powerful spectrum analyzer in the R&S®ETH – which is based on the R&S®FSH4/8* family of spectrum analyzers – additionally allows users to determine the shoulder attenuation via markers as well as to test them using self-defined limit lines.

Various methods are available for measuring the transmitter output power using the R&S®ETH. The "DVB Spectrum" function measures not only the shoulder attenuations, but also the channel power and the amplitude frequency response. The R&S®ETH measures the spectrum within the channel with a relatively small resolution bandwidth – as compared to the channel bandwidth – and then integrates the measured values to obtain the channel power. The channel power can also be measured in demodulation mode (using the "Measurement List" and "Constellation Diagram" measurement functions). In this case, the transmit power is measured together with several basic parameters, including modulation error ratio (MER), carrier frequency offset, symbol rate offset, various bit error ratios (BER), and others, and then output in a clearly organized list (FIG 3).

The R&S®ETH is characterized by a very high degree of measurement accuracy for its instrument class. Users who need more accuracy for power measurements can connect the (directional) power sensors of the R&S®FSH family. The frequency measurement accuracy can be improved by applying an external 10 MHz reference signal via the built-in port.

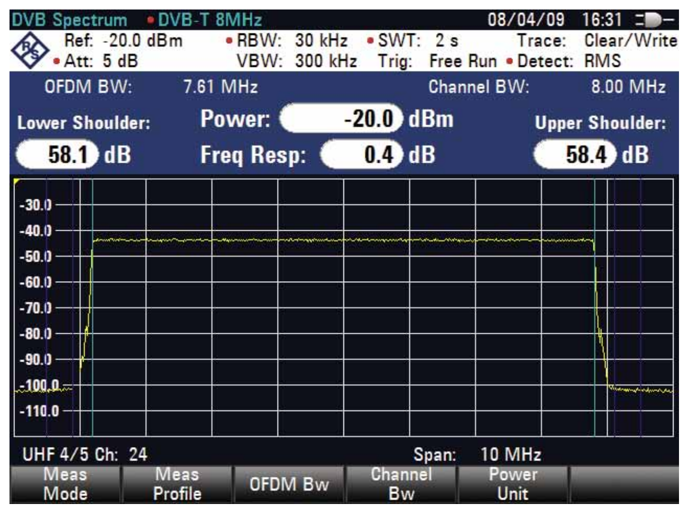


FIG 2 Shoulder attenuation measurement in line with ETSI TR 101290.

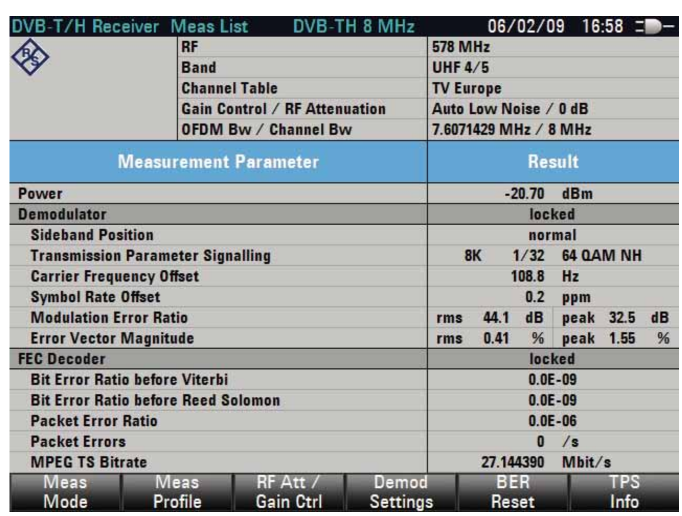


FIG 3 Overview of the main signal parameters.

* R&S®FHS4/FSH8: Next generation of handheld spectrum analyzers. NEWS from Rohde&Schwarz (2008) No. 198, pp. 30–35.

Many negative influences on the signal quality can be expressed numerically, but their origins are not always immediately obvious. In these cases, it helps to display the measurements as a constellation diagram because this provides a quick visual impression of both the quality of the transmit signal and the modulation of the OFDM carrier (FIG 4).

Low-power transmitters, in particular, are set up in locations where installed components such as antennas, channel filters, and the associated cabling are exposed to extraordinary stress. This is why it is advisable to check the system components not only immediately after installation, but also from time to time during normal operation. The R&S®ETH is especially suited for this purpose because it offers an optional tracking generator that converts it into a vector network analyzer. This makes it possible to check filters, amplifiers, and antennas quickly and easily.

The R&S®ETH at a glance

- DVB-T/DVB-H test receiver from 4.5 MHz to 3.6 GHz or 8 GHz
- Spectrum analyzer from 100 kHz to 3.6 GHz or 8 GHz
- Vector network analyzer (model with built-in tracking generator)
- FPGA-based DVB-T/DVB-H demodulator in realtime with TS-ASI output
- Internal RF preselection (optional)
- Receiver noise factor with RF preselection 11 dB (RF < 3 GHz)
- High level measurement accuracy (measurement uncertainty < 1 dB)
- MER performance > 40 dB (RF < 1 GHz)
- Anti-glare color display (6.5")
- LAN and USB ports
- SD card port
- USB memory stick port
- Replaceable lithium-ion battery
- Splash-proof housing
- Low weight (3.3 kg)
- Extensive accessories

Coverage gaps detected under real-world conditions

Test vehicles are usually employed when determining the quality of coverage within a transmission area. However, these are not easily driven into pedestrian zones, train stations, or airports – areas where today's users demand reliable coverage. This is where the R&S®ETH comes in, as it is designed for portable use (FIG 1) and can easily be brought into all environments where terminal equipment for receiving DVB-H can be used. Its low weight, compact dimensions, anti-glare color display, and replacement batteries for up to four hours of operation make it perfect for these applications.

To suppress interfering receive signals, the R&S®ETH offers an internal RF preselection. When activated, it allows a higher level of the useful RF signal, thereby increasing the dynamic range. To increase receiver sensitivity, signals are passed through a low-noise amplifier after preselection.

To ensure that the field strength of transmitter signals can be determined correctly at the site of reception, the R&S®ETH takes the characteristics of the connected antenna into consideration. The antenna factors for Rohde & Schwarz measurement antennas are stored on CD, but antenna factor tables for other antennas can also be generated using R&S®ETH View and then saved in the instrument.

FIG 4 Constellation diagram of a DVB-T/DVB-H signal.

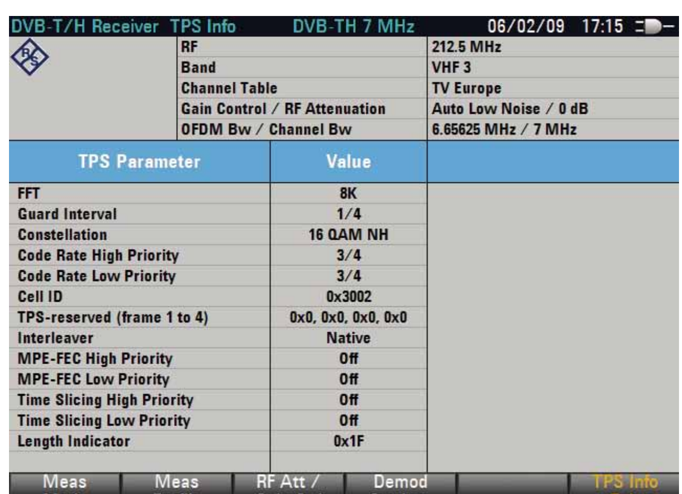


FIG 5 Transmission parameter signaling (TPS) in detail.

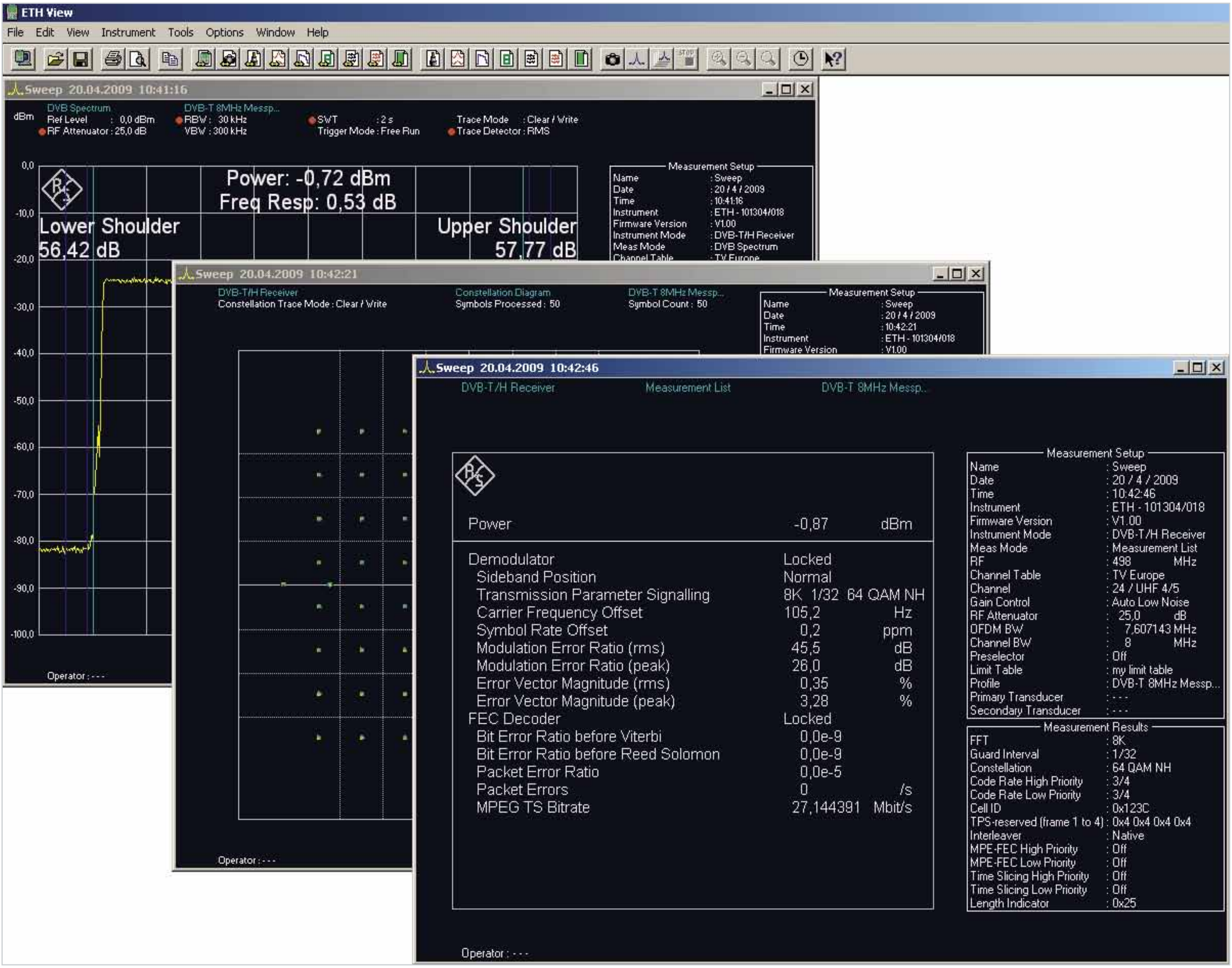


FIG 6 The R&S®ETH View PC software can be used to manage measurement results and device setups conveniently.

In addition to the essential measurements characterizing the signal quality, the R&S®ETH also offers a detailed listing of the TPS information (FIG 5). Important information, such as cell ID or modulation parameters of the received signal, can be derived from this list. By using an R&S®ETH, users can thus determine the causes of coverage gaps and take the appropriate actions to fill them.

Convenient documentation and configuration

Regardless of where measurements are taken, at the transmitter or in the field, readings should be quick and easy to document. With the R&S®ETH, a simple press of the screen capture button stores the screen contents as a graphics file. Alternatively, the measurement results can be saved together with the device setup, which comes in handy when measurements need to be reproduced at a later time.

The R&S®ETH handheld TV analyzer includes the R&S®ETH View PC software, which can be used to configure the TV analyzer perfectly (FIG 6). R&S®ETH View can be used to generate information regarding antennas, limit lines, channel tables, or predefined device settings and measurement profiles, which are then transmitted to the analyzer. Saved measurement results or screen captures can be accessed via the LAN or the USB port in the R&S®ETH for further processing.

Werner Dürport

R&S®SX801 multistandard exciter for ATV, DTV, and digital sound broadcasting

Innovative and slim: Although its housing occupies only one height unit, the new R&S®SX801 multistandard exciter performs full signal processing from input signals (video/audio or transport streams) to the RF output signal – and still offers room for a variety of options.

Compact and versatile

The demand for compact TV and sound broadcast transmitters of the low-power and medium-power class is increasing worldwide. This is a market for which the new R&S®SX801 (FIG 1) is tailor-made. It is the first exciter to combine both analog and digital TV with digital radio on one universal platform and can be used for a wide range of requirements.

The exciter takes up only one height unit and – like the well-known R&S®SX800 exciter – is modular in design. It mainly includes the following modules: coder, RF modulator, display with control panel, and power supply (FIG 2). The wide-range power supply (90 V to 260 V AC) operates reliably – even under highly fluctuating input voltages. Users can switch from analog to digital standards at any time using software (local or remote control).

Options for adapting to many tasks

Despite its compact design, the slim housing offers room for various options (see box at top right). The following options are among the most important:

The GPS receiver synchronizes the exciter in single-frequency networks or serves as an accurate reference frequency. It is also possible to apply a 10 MHz or 5 MHz reference clock to the exciter.

The RF receivers for DVB-T / DVB-H monitor the transmitted signal or can be used in regenerative retransmitters.

The DVB-S / -S2 receiver receives satellite signals that can then be retransmitted terrestrially.

The MPEG decoder enables users to digitally feed TV signals that can then be retransmitted as standard-conforming ATV signals. Therefore, operators do not have to install expensive analog signal feeds and can concentrate on future-ready digital transmission.

Integrated transmitter control unit

A powerful microcontroller controls and configures the R&S®SX801. It initializes the hardware from a compact flash memory that contains all the required software and firmware as well as all settings. Even standby systems such as passive dual drives can be implemented without a central control unit. As shown by the new R&S®SCx8000 UHF TV family of transmitters (see front and back of this magazine as well as article on page 66), complete transmitters can be set up without using any external control components. In order to manage complex standby systems, the R&S®SX801 can be connected to the R&S®NetCCU800 transmitter control unit via Ethernet.

FIG 1 The R&S®SX801 exciter combines both analog and digital television with digital sound broadcasting on one universal platform.

Special features
- Automatic ATV/DTV switchover without hardware replacement
- VHF, UHF, and L band
- Common exciter platform for DAB and TV
- Suitable for use in single-frequency and multifrequency networks
- Hierarchical modulation
- Seamless input switching
- All ASI modes and SMPT-310M
- Integrated linear and nonlinear precorrector
- Wide-range power supply

Options
- GPS receiver
- DVB-T / DVB-H receiver
- DVB-S/-S2 receiver (in preparation)
- Parallel I/O (internal and external)
- MPEG decoder (in preparation)
- Air filter
- SNMP

R&S®SX801 exciter

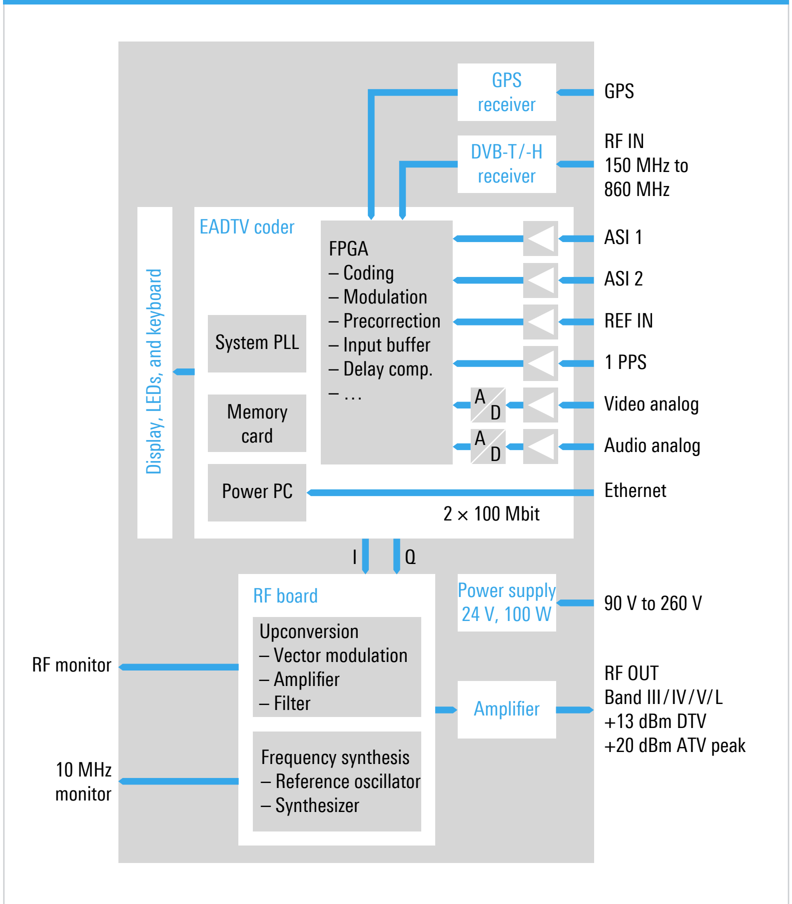


FIG 2 The R&S®SX801 exciter offers the full range of signal processing plus room for options.

The new exciter is operated using pushbuttons and the front-panel display or with a commercial web browser and Java™ technology. The user interface has the same design as the family "8000" of transmitters. As an option, the exciter can be remotely monitored and controlled via SNMP or floating contacts.

Summary

Since the R&S®SX801 is compatible with the R&S®SX800 and includes a large number of new features, it can be integrated into existing transmitter families and provides an excellent basis for expanding the Rohde&Schwarz transmitter family.

Wolfgang Marchl

Condensed data of the R&S®SX801

ATV standards	B/G, D/K, M/N, I
Color transmission	PAL, SECAM, NTSC
Sound transmission	IRT dual sound, FM single sound, FM single sound with NICAM 28 (optional), BTSC
Standards	DVB-T / DVB-H, ATSC, MediaFLO™, DTMB, ISDB-T_B, DAB, T-DMB
Frequency range	Bands III, IV, V, L
Output power	ATV: +20 dBm peak envelope power DTV: +13 dBm, RMS

Mobile television with the new ATSC Mobile DTV standard

The ATSC Mobile DTV standard, in whose development Rohde & Schwarz plays a significant role, provides classic TV providers with new business models for mobile TV services. TV station operators can already benefit from a complete solution consisting of encoders, a multiplexer, a transmitter, and the associated T&M equipment, needed to enter into the mobile television market.

The next stage of development for the ATSC standard

The new ATSC Mobile DTV standard, which is based on the terrestrial ATSC A/53 TV standard (see box on page 62 for a history of its development), now also includes mobile TV receiver services utilizing a portion of the ATSC 8VSB data stream (19.39 Mbit/s). The standard ensures that neither the high-definition (HD) nor the various standard-definition (SD) TV services are compromised. An ATSC Mobile DTV transmission system includes an ATSC service multiplex that carries the conventional digital TV programs as well as a mobile DTV service multiplex for mobile services (FIGs 1 and 2). The mobile DTV services offer, for example, pulsed transmission for data that can switch mobile receivers into energy-saving mode between transmissions (time slicing).

Standard ATSC signal processing

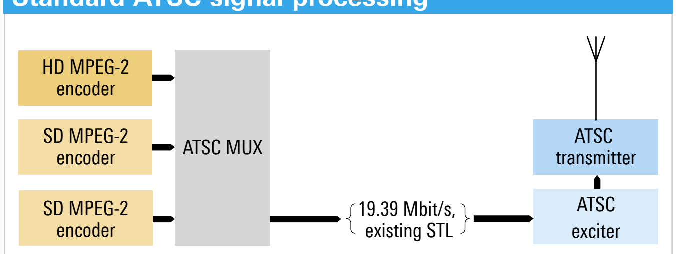


FIG 1 Typical ATSC transmission system for single transmitters as used in the USA so far. One HD program and two SD programs are combined using a multiplexer; data rate 19.39 Mbit/s, ATSC transmitter. STL: studio transmitter link.

Signal processing for ATSC Mobile DTV

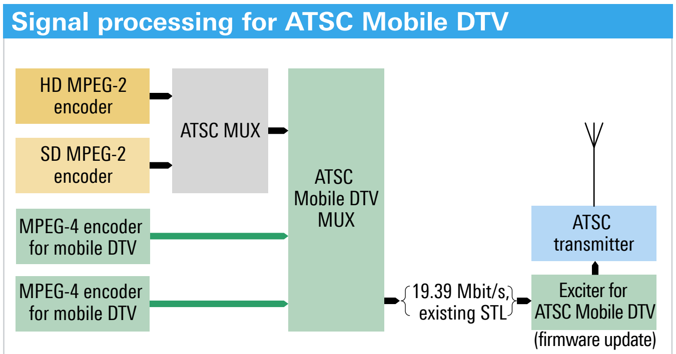


FIG 2 Typical ATSC transmission system for single transmitters with integrated mobile DTV services (green: the required new components / firmware updates).

The data structure of the new standard

In the ATSC Mobile DTV standard, all transmitted data is packed into a fixed structure, i.e. the mobile/handheld (M/H) slots. An M/H slot is the smallest logical unit in the ATSC Mobile DTV data stream (FIG 3). This synchronous, deterministic process, combined with a supplemental error protection of the data used for mobile reception, ensures that the data stream is processed in the receiving instrument in a simple and secure manner.

The M/H slots carry the data for mobile reception as well as the ATSC programs for stationary reception. Unused M/H slots can be completely filled with ATSC program data for stationary reception. Backward compatibility with existing ATSC receivers must always be maintained to prevent errors when displaying ATSC programs. For high-definition channels in particular, packet shifting is linked with the dimensioning of the current ATSC receivers' input buffers and the buffer model being used.

In the ATSC Mobile DTV standard, the data intended for mobile reception is transported via RTP/UDP/IP protocols. These protocols permit flexible mobile service structures, increase flexibility in feeding data to the headend, and support the modular development of software for user equipment. The coding method used for the video data in mobile programs is MPEG-4 Part 10 (H.264) in the baseline profile. The resolution is 416 x 240 pixels, while the maximum data rate is 768 kbit/s. Audio data is transmitted in the MPEG-4 Part 3 (HE-AACv2) format.

The data for mobile reception is particularly well protected by means of complex error protection methods such as interleaving, Reed-Solomon, and turbo coding. Additional training sequences for channel estimation are also added to the ATSC Mobile DTV signals. Signaling takes place in three separate layers (FIG 4).

The advantages of ATSC Mobile DTV

- Introduction costs are kept low by preserving the existing infrastructure
- Simple, robust receivers can be deployed because a deterministic transmission method is used to broadcast the data for mobile reception
- Multipath reception is improved by the M/H training sequences included
- Interactive multimedia services are available with an existing back channel
- Data transmission (non-realtime data) and IP broadcasting are possible

FIG 3 The data structure of the ATSC Mobile DTV standard.

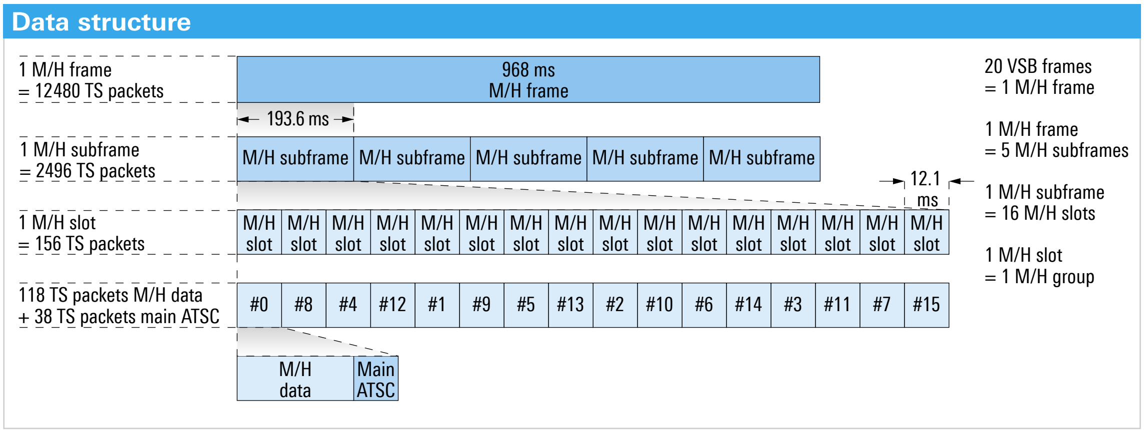
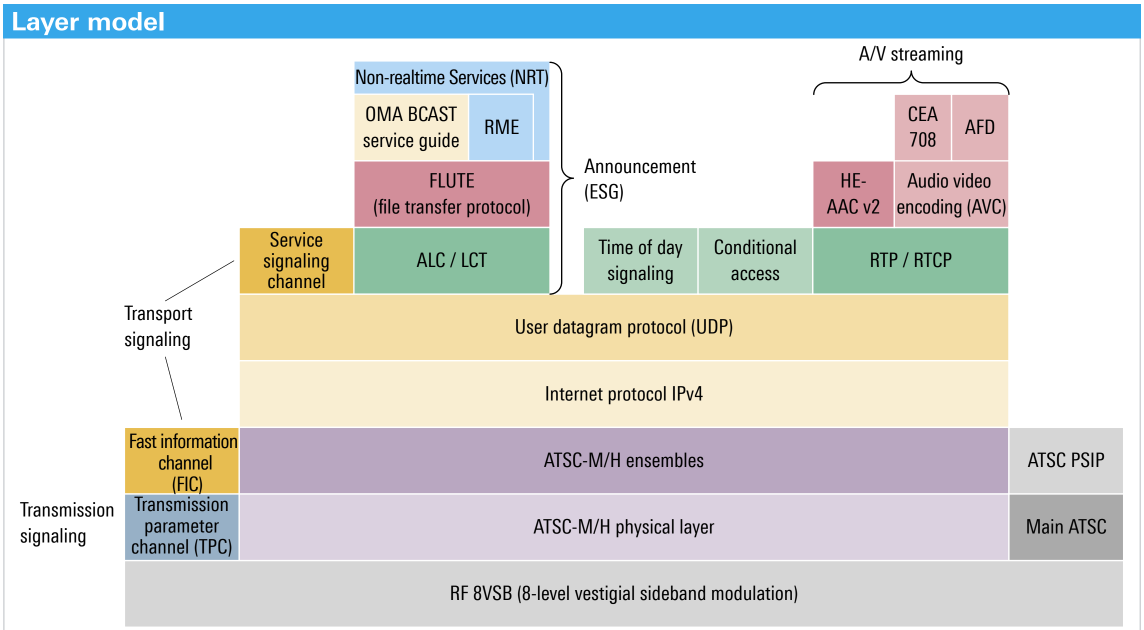


FIG 4 Detailed layer model for the ATSC Mobile DTV standard.



ALC – Asynchronous layered coding
AFD – Active format description
CEA 708 – Consumer Electronics Association / closed captioning standard
FLUTE – File delivery over unidirectional transport
HE-AAC – High-efficiency advanced audio coding
LCT – Layered coding transport
OMA BCAST – Open Mobile Alliance – mobile broadcast services enabler suite
PSIP – Program and system information protocol
RME – OMA BCast rich media environment
RTP – Realtime transport protocol
RTCP – Realtime control protocol

FIG 5 The R&S®SX800 multi-standard exciter is easily converted to the ATSC Mobile DTV standard with a firmware update.

Firmware update for Rohde & Schwarz transmitters

All currently available Rohde & Schwarz Series 800 multistandard exciters (FIG 5), used in transmitters of all power classes, can be converted to ATSC Mobile DTV via firmware update. The standard is already integrated in the new Rohde & Schwarz transmitters – available since April 2009 – and can be activated with a software key. All Series 7000 transmitters can also be updated to the new standard using a retrofit kit – more proof that Rohde & Schwarz transmitters are a secure investment for the future.

Seamless integration: Rohde & Schwarz multiplexers

A multiplexer for the new standard is already available: the R&S®AEM100 from Rohde & Schwarz. Based on a powerful server, it allows network operators to expand their ATSC transmission systems quickly, reliably, and with full compatibility. The existing infrastructure remains usable because the multiplexer is simply integrated into the unmodified system. It adds the data required for mobile reception to an inbound ATSC transport stream. The generated transport stream can be transmitted over ASI or IP (as TSoverIP). To allow its use in redundant networks, the R&S®AEM100 has four network interfaces for receiving and transmitting data separately. The integrated signaling generator can be used to generate baseband signaling made up of transmission and transport signaling. The multiplexer is completely configured, controlled, and monitored via SNMP or via a web-based graphical user interface.

Torsten Görig; Reinhard Scheide

The long road from analog TV to the digital ATSC standard

In 1987, the Federal Communications Commission (FCC) decided to introduce a digital TV standard in the USA. In September 1995, the ATSC A/53 standard was proposed by the Advanced Television Systems Committee, an industry organization concerned with all aspects of television, and of which Rohde & Schwarz is a member. The plan that FCC subsequently presented to Congress provided for the introduction of the standard in the American market over a nine-year period starting in November 1998, with analog service being completely decommissioned in 2007. Approximately 1600 class A stations were impacted. At the same time, the frequency range between 700 MHz and 806 MHz was to be made available for other services, e.g. mobile television. The plan has experienced delays, and the transition is now scheduled to be completed by June 2009.

The available frequencies were auctioned off starting in 2006. As an example, Qualcomm was able to purchase channel 55 (716 MHz to 722 MHz) and use it to set up a nationwide mobile television network based on the MediaFLO™ COFDM standard.

The development of ATSC into ATSC Mobile DTV

ATSC signals cannot be used for mobile reception because their error protection is designed for stationary reception. The increasing demand for mobile reception of television programs and the existence of competing standards such as DVB-H and MediaFLO™ increased the pressure to expand the standard. The most important requirements were the following:

- Complete backward compatibility with ATSC A/53
- Station operators must continue to be able to use existing broadcasting licenses without regulatory obstacles
- The mobile services must work on a single frequency (i.e. without a cellular network)
- Existing receivers must continue to provide classic ATSC reception

Rohde & Schwarz partnered with Samsung at an early stage in order to enhance the ATSC standard. Employees of both companies from Korea, the USA, and Germany worked out a proposal that permitted mobile reception of ATSC and also made it possible to set up efficient single frequency networks (SFN). Of the ten different proposals presented, the ATSC Mobile DTV standard was selected. It will be approved soon.

The R&S®NA8200 family of transmitters: setting standards in energy efficiency and signal quality

The new transmitters designed for the DAB(+) and T-DMB standards transmit very high-quality digital audio broadcasting (DAB) signals in VHF band III. Featuring unusually high efficiency combined with space-saving design, the transmitters reduce investment and operating costs.

FIG 1 The transmitters of the R&S®NA8200 family impress with efficiency and compact design (shown here: the 2400 W model R&S®NA8206 with exciter standby).

Digital audio broadcasting DAB(+) and T-DMB – entering markets with new vigor

The introduction of DAB+, the allocation of new frequencies in band III, and the increase in the permissible radiated power to 10 kW have all lent new vigor to the DAB/DAB+/T-DMB standards, especially in Europe. New networks can now be set up using transmitters with power over 1 kW. In many large markets, including France, Italy, Germany, and Switzerland, new DAB(+) and T-DMB networks are to be set up, and plans are in place to increase the transmit power for existing networks. The use of high-power transmitters is particularly important during the initial phases of network setup and when increasing network power in order to be able to quickly cover large areas.

In response to this situation, Rohde & Schwarz has presented a family of new, compact transmitters so far unmatched on the market with respect to energy efficiency and signal quality.

Based on a market-proven platform

Rohde & Schwarz has been continuously involved in the DAB transmitter market since the beginning, building up its market share for DAB/T-DMB medium- and high-power transmitters over the past few years, leading to its current position as the market leader in this segment. By using the new air-cooled R&S®NA8200 DAB(+)/T-DMB medium-power transmitters (FIG 1), customers worldwide can now choose transmitters in the power range from 400 W to 2400 W with a future-oriented design that meets changing market requirements.

The R&S®NA8200 transmitters are a good example of Rohde & Schwarz's flexible platform strategy. They are based on the air-cooled platform of the R&S®Nx8000 family of transmitters. The transmitters in this family handle both analog and digital TV standards and are already successfully positioned on the market.

The most important characteristics of the R&S®NA8200 transmitters are:

- Excellent efficiency
- Best signal quality on the market (MER)
- High output power in a rack

Peak position on the market: total efficiency up to 25 %

Featuring a total efficiency of up to 25 % while simultaneously ensuring a high shoulder distance of typically 37 dB, the R&S®NA8200 transmitters have carved out a peak position on the market. The results are very satisfying for operators because, over a ten-year period, each percentage point of efficiency for a 2.4 kW transmitter will save nearly 44000 kWh of energy. As typical networks range anywhere from 10 to over 100 transmitters, the savings can be enormous. And the lower energy consumption significantly reduces not only costs, but also CO_2 emissions, thus contributing to climate protection.

This high efficiency is possible because of the clever low-loss design of the R&S®VM8350A1 VHF power amplifier, which is compactly fitted onto a single board. Short signal paths and extensive use of direct connectors instead of cables contribute toward the high efficiency of the overall system. This design also requires less cooling effort. In addition, a specially developed heat sink helps ensure effective heat dissipation from hotspots in the amplifier even at high power densities. The resulting low junction temperature extends the life of the transistors considerably.

FIG 2 Featuring an MER of typ. 33 dB, the R&S®NA8200 family of transmitters provides excellent signal quality (measured in this example using the R&S®ETL TV analyzer connected to the R&S®NA8206 model, with 2400 W on channel 12D).

Ch: --- RF 229.072000 MHz T-DMB/DAB

*Att 25 dB
SigLvl -12.5 dBm

MER (rms) **33.0 dB**

Ensemble: Rohde&Schwarz		Date & Time(UTC)---		
Pass	Limit <	Results	< Limit	Unit
Level	-60.0	-1.5	10.0	dBm
Sideband		Normal		
Transmission Mode		Mode I, 1536 carriers		
Carrier Freq Offset	-30000.0	0.4	30000.0	Hz
Bit Rate Offset	-100.0	-1.6	100.0	ppm
MER/EVM (rms)	24.0	33.0	-----	dB
MER/EVM (peak)	10.0	22.0	-----	dB
BER before Viterbi		0.0e-7(37/100)	1.0e-2	
FIB Errors		0	1	/s

PS

Subchannel parameters (SubChId ---, Type ---)				
BER before RS		Not applicable	2.0e-4	
Packet Error Ratio		Not applicable	1.0e-8	
Packet Errors		Not applicable	1	/s
MPEG Ts Bitrate		Not applicable		kbit/s

Lvl -1.5dBm | BER 0.0e-7 | MER 33.0dB DEMOD FIC

Best signal quality on the market

What's behind the excellent signal quality of the new transmitters? First, there is the low-loss and low-distortion RF design of the R&S®VM8350A1 amplifier as described above. But another component also provides a significant advantage: the new R&S®SX801 multistandard exciter (page 58 in this issue). Because of its excellent signal quality and very short processing time (turnaround time), this exceptional instrument is installed in all new families of DAB(+)/T-DMB transmitters from Rohde&Schwarz.

After field strength, signal quality is the most important quality parameter for reliable coverage in a DAB(+)/T-DMB transmitter network. The indicator for the quality of the RF signal is the modulation error rate (MER) in dB. The MER value covers all disturbances that may affect the modulation signal, including noise, jitter, or I/Q imbalance. The higher the MER, the better the signal quality and the greater the margin the transmitted signal has against disturbance when it comes to propagation in the RF field. The method used to measure MER is similar to that used for DVB-T. However, because of the differential modulation used for this standard, the measurable MER value is about 3 dB lower than for DVB-T.

The R&S®NA8200 family of transmitters exhibits a typical MER of 33 dB for DAB(+)/T-DMB, and thus transmits with the best signal quality on the market (FIG 2). This was determined using the R&S®ETL TV analyzer, the only instrument on the market that can measure the MER for DAB(+)/T-DMB in realtime.

In a single 19" rack: power densities up to 2400 W in increments of 400 W

Space in transmitter stations is typically tight and costly. The new transmitters are designed to perfectly meet these requirements: They allow one to six amplifiers of up to 400 W each to be installed in a single 19" rack, including the internal cooling system. The R&S®NA8200 transmitters thus achieve DAB output power levels of up to 2400 W. That is double the power density of the previous model, and exceptional for air-cooled transmitters currently on the market. Even when fully configured, there is sufficient space for a dual drive, and three additional height units remain available; for example, for installing accessories.

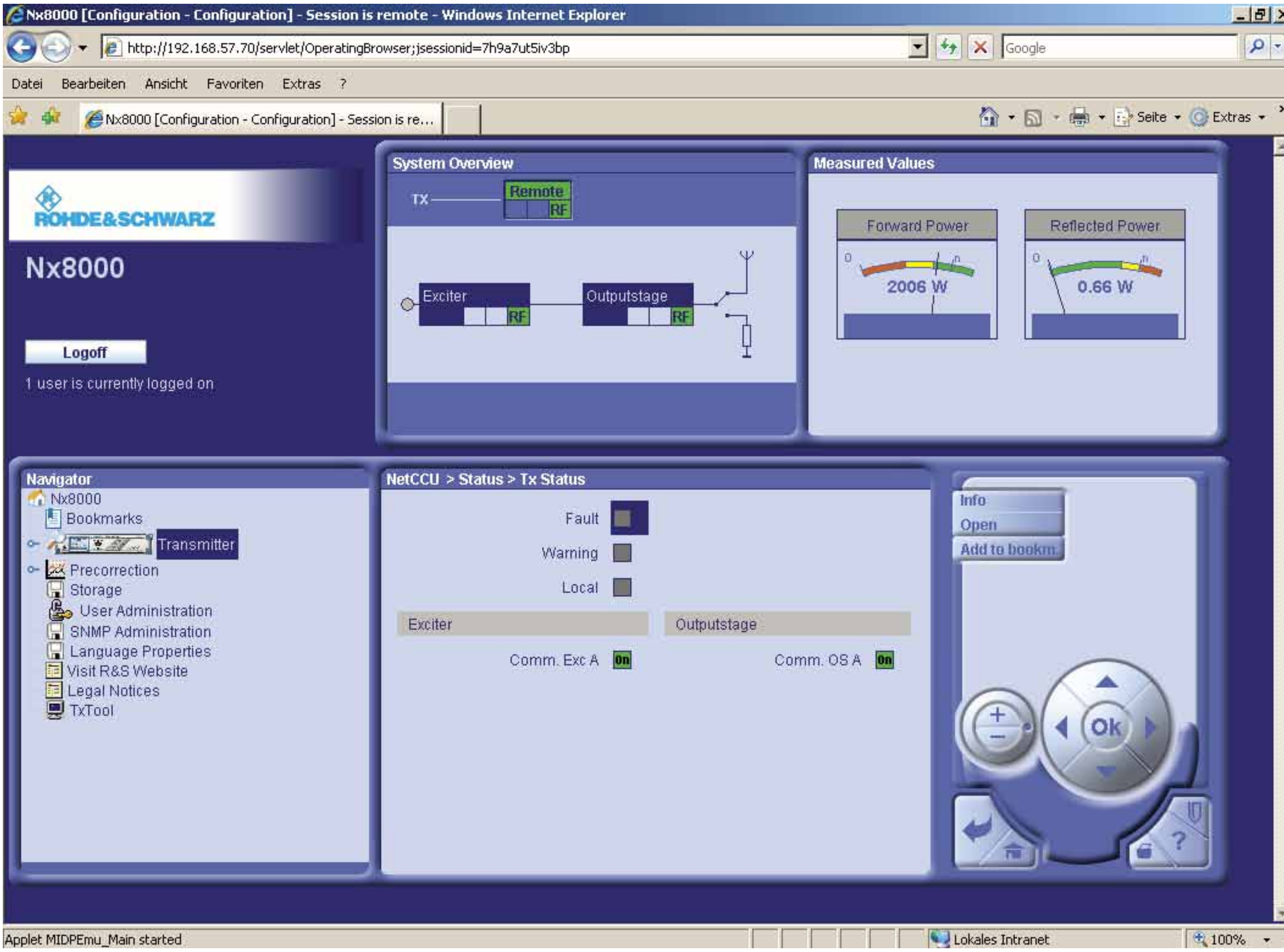


FIG 3 Up-to-date: The new transmitters can be controlled via a normal web browser.

More interesting characteristics

By redundantly feeding a signal to the transmitter, it is possible to switch seamlessly between two ETI input signals. In each case, the better of the two signals is used automatically. The user can define the input of preference.

The new, highly-sensitive R&S®SX801-B13 GPS receiver now offers significantly shorter synchronization times of no more than three minutes, which helps ensure quick and reliable operational readiness for the transmitter in single-frequency networks. The GPS receiver is now integrated into the R&S®SX801 exciter.

The R&S®NA8200 transmitters can be monitored and configured from a center at any time via IP-based networks using a web browser or optional SNMP (FIG 3). Alternatively, remote monitoring can also be performed by means of floating contacts (optional).

Jens Stockmann; Falko Hesse

The R&S®SCx8000 family of UHF transmitters for TV: a new dimension in compactness

The R&S®SCx8000 is the most compact and efficient low- to medium-power TV transmitter on the market. It was developed specifically with an eye toward digital TV standards like ATSC, ATSC Mobile DTV, DVB-T, DVB-H, and MediaFLO™, but is also well suited for analog TV. In addition to offering innovative redundancy concepts, its large-scale integration design reduces infrastructure, leasing, and installation costs, and its high efficiency saves energy. All this makes it the ideal transmitter for broadcasting and mobile radio network operators who want to build or expand networks cost-effectively.

Most compact transmitter in its power class

The R&S®SCx8000 TV transmitter (FIG 1) achieves its compact design by integrating components that have so far been required as external devices. The new R&S®SX801 exciter, for example, allows the transmitter to be controlled and monitored directly from the instrument display without any additional components (see also page 58 of this issue). The base amplifier also includes an exciter switch and a signal splitter. In systems with two amplifiers, an expansion amplifier with an internal power combiner is added. Both the base and the expansion amplifier come with an integrated standalone cooling system, each featuring two fans mounted on the rear of the amplifier (FIG 2). The ultracompact system with one amplifier requires only four 19" height units. This makes it possible to install multiple transmitters in a single rack, or even into unused space in existing racks. Due to its compact design, the transmitter can also be installed in outdoor racks that are available from Rohde & Schwarz (see cover page).

FIG 1 The R&S®SCx8000 TV transmitter configured as R&S®SCV8301EA with the R&S®SX801 exciter and the R&S®VH8301C1 base amplifier.

FIG 2 The integrated cooling system features two fans (the R&S®SCx8000 transmitter configured as R&S®SCV8302EA with the R&S®SX801 exciter, the R&S®VH8301C1 base amplifier, and the R&S®VH8301C2 expansion amplifier).

New redundancy concepts increase availability and save space

The new backup exciter system design allows complete RF redundancy of the exciters in minimal space. The master exciter serves as the signal source and the backup exciter as the transmitter control unit. If the master exciter fails, the backup exciter automatically takes over signal transmission. This design not only opens up more space, but because of the reduced number of components, it also increases system availability and reduces the number of spare parts.

An intelligent power supply concept ensures reliable power supply for the amplifiers. Each amplifier contains two power supplies as standard, each supplying one half of the transistors in the amplifier output stage. The power for the remaining amplifier components is provided by both power supplies redundantly, helping to reduce the risk of interruptions during transmission. An optional third power supply can be integrated for a full 2+1 power supply redundancy, ensuring uninterrupted transmission without power loss even if one of the two power supplies fails.

Efficiency in power and operation

With an efficiency of up to 22 %, the new family of transmitters significantly decreases energy costs over the lifetime of the system and is therefore considered the benchmark in its power class. The power output stage of the R&S®SCx8000 comes equipped with the set & go feature, a broadband precorrection for the customer´s preferred digital standard. This eliminates the need for manual precorrection on-site and allows the transmitter to be put into operation faster. If the output power is reduced at a later time (up to 6 dB) or the frequency changed, the system automatically loads the appropriate precorrection curves, thus ensuring an MER of at least 33 dB.

The R&S®SCx8000 base amplifier provides output power levels of up to 300 W for DVB-T, DVB-H, and MediaFLO™, up to 450 W for ATSC and ATSC Mobile DTV, and up to 700 W for ATV. Adding the expansion amplifier and its integrated combiner provides up to 600 W for DVB-T, DVB-H, and MediaFLO™, up to 900 W for ATSC and ATSC Mobile DTV, and up to 1400 W for ATV.

Analog to digital in no time

The transmitters offer intelligent concepts for network operators planning the transition from analog to digital transmission. A combined ATV/DTV coder board in the R&S®SX801 with the respective physical interfaces allows both analog and digital input signals to be delivered. The desired input signal and the corresponding analog or digital modulation standard can be selected at any time, either locally or remotely.

The MPEG decoder option allows digital input signals to be fed as transport streams. These streams are converted into analog signals by the FPGA in the exciter, and then modulated and transmitted as analog signals. If digital transmission is desired at a later date, switchover from analog to digital transmission can be made easily and without any hardware modifications, even remotely. This is a definite advantage during the transition phase to digital.

In spite of its compact design, the exciter can be expanded to include various options, including a GPS receiver for synchronization in single-frequency networks or a DVB-T/DVB-H receiver for monitoring or retransmitter purposes.

The transmitter is described in detail on the Rohde&Schwarz website.

Christian Wachter

Measuring video quality objectively using a single-ended method

Rohde & Schwarz makes it possible: With a new method, the picture quality of H.264- or MPEG-2-coded videos in SDTV and HDTV resolution can be monitored and recorded in realtime at any point during the digital transmission chain.

Quality of service

Program providers as well as operators of broadcasting networks and playout centers must objectively monitor and assess the quality of the picture presented to viewers (quality of service). This is necessary so that quality problems can be corrected quickly during live video streams, and also in order to obtain reliable quality data provided during a specific time interval.

PSNR – an objective measurement value

Ever since the start of digital TV, the peak signal-to-noise ratio (PSNR) value has been firmly established as an objective and verifiable method for assessing the coding quality of compressed videos. This value is a measure of the differences between the original picture and the compressed picture; calculating this value had always required the availability of the uncoded, original material. This is why the calculation had to take place in realtime directly on the video encoder, where every pixel of the original was compared against every pixel of the compressed video – hence its designation as a double-ended process.

qPSNR analysis at every point in the transmission chain

The new quasi PSNR (qPSNR) analysis from Rohde & Schwarz, on the other hand, can monitor and record in realtime the picture quality of H.264- or MPEG-2-coded videos in SDTV and HDTV resolution. This single-ended method measures the PSNR value by calculating it extremely accurately using only the coding parameters of the compressed video (FIG 1). The R&S®DVM MPEG-2 monitoring systems use this innovative process to calculate the PSNR values at every point in the digital transmission chain – depending on the optional inputs installed (FIG 2).

FIG 1 There is a high degree of correlation between the PSNR values calculated using the time-consuming double-ended method and the qPSNR values for I frames calculated by the R&S®DVM in realtime from the coding parameters using the single-ended method.

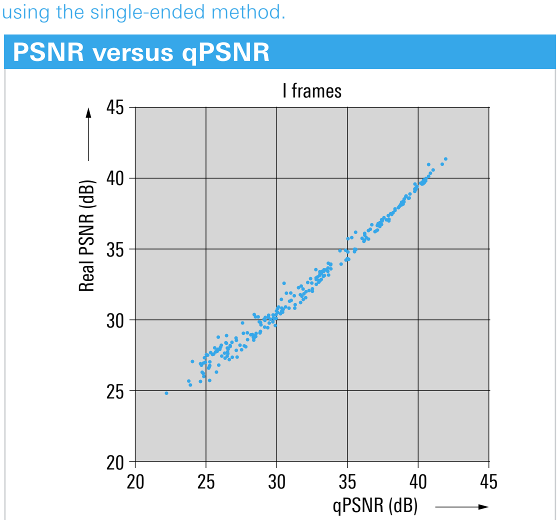


FIG 2 The R&S®DVM can measure the qPSNR value at any point during transmission, whether it is in an IP data stream during signal feed, in a transport stream at the multiplexer, or in the RF signal at the transmitter. The only requirement is that the appropriate optional input be installed.

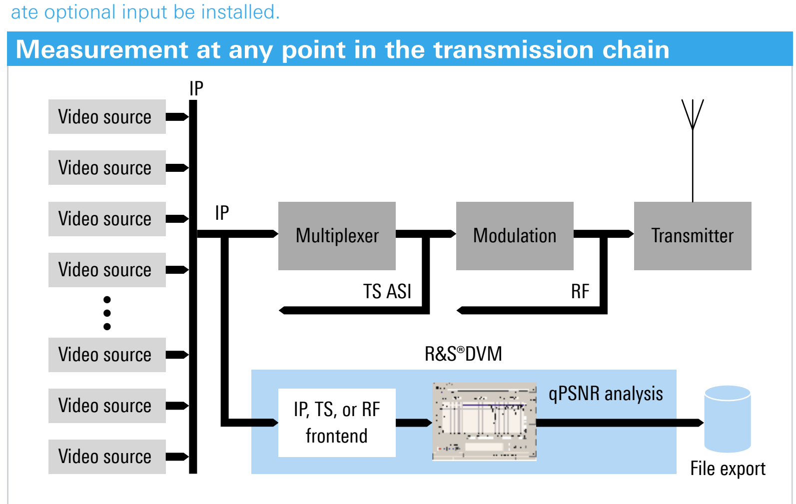
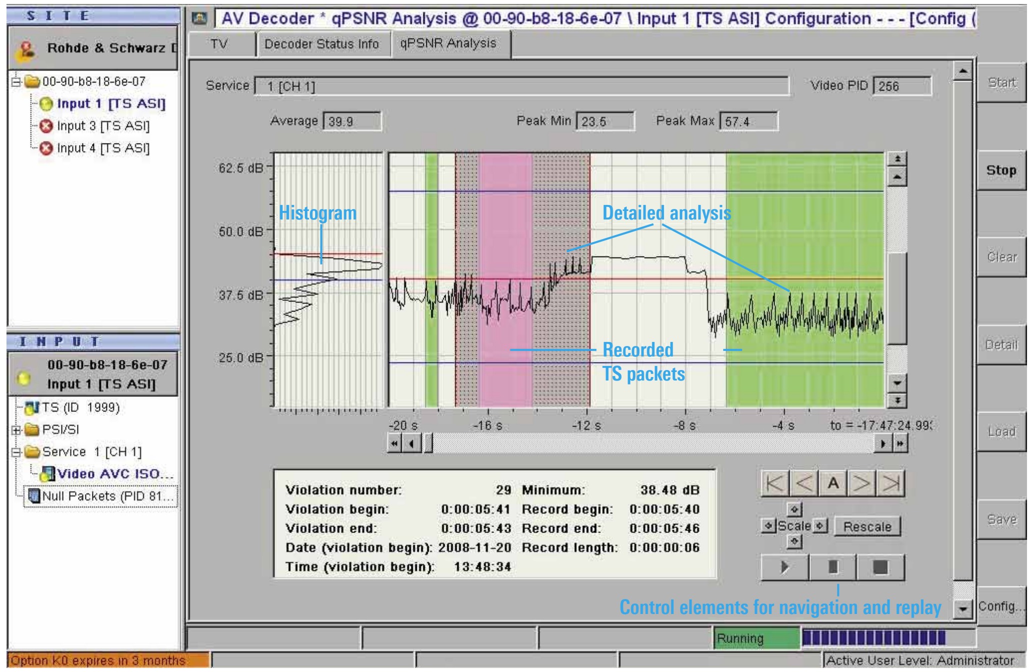


FIG 3 The user interface shows both the time progression as well as the frequency distribution (histogram) of the qPSNR values. Locations at which the transport stream packets are recorded are identified in color. The results of the detailed analysis are integrated into the existing qPSNR graphs. Browsing between the recorded transport stream segments is accomplished quickly to allow detailed analysis or replay.



Detailed analysis – in realtime

The R&S®DVM performs a realtime analysis of the I frames contained in the video stream and displays the progression of the qPSNR values graphically versus time and as a histogram (FIG 3). Extensive zoom and scroll functions provide the user with a continuous overview during measurements. It does not matter which inputs receive the video stream (ASI, IP, or RF), whether H.264 or MPEG-2 coding is involved, or whether the resolution is SDTV or HDTV.

When a definable qPSNR value falls below the permissible limit, the R&S®DVM records the transport stream packets of the monitored video stream on the built-in hard disk. The configurable pretrigger helps ensure that sufficient transport stream data is available for subsequent detailed analysis. The R&S®DVM can also be set to perform a subsequent detailed qPSNR analysis of the recorded segments, including all I, P, and B frames. This makes it possible to calculate the qPSNR value for each individual picture. The results of the detailed analysis are automatically added to the graphic at the appropriate location (FIG 3). All results can be stored and then reloaded into the R&S®DVM for viewing and further analysis. Since the R&S®DVM stores all results transparently in CSV files, other tools can easily be used for subsequent analysis of the qPSNR data.

Display of transport stream segments

All recorded transport stream segments can, of course, be displayed using the R&S®DVM400 transport stream generator option to allow detailed analysis. The R&S®DVM400 hardware decoder option is also available for visual display of the video streams. Finally, the qPSNR option for all instruments in the R&S®DVM family includes a software decoder for subsequent display of SDTV video material, allowing the quality perceived by television viewers to be reproduced at any time.

Christian Zühlcke

The qPSNR analysis is available as a software option for all instruments in the R&S®DVM family, and can also be installed on many instruments already supplied:

R&S®DVM50	model .02 and .03
R&S®DVM100	model .03
R&S®DVM100L	model .02
R&S®DVM400	model .03

Abbreviations

I frame	Intra-coded frame
P frame	Predictive coded frame
B frame	Bi-directional coded frame
CSV	Comma separated values
PSNR	Peak signal-to-noise ratio

The world between 3 GHz and 300 GHz: services and applications

The range between 3 GHz and 300 GHz is extremely crowded, with countless services and applications even occupying the same frequencies in many cases. This multipart article discusses how to bring order to this chaos, the issues to be monitored, and the role that systems from Rohde & Schwarz are playing for regulatory authorities and network operators.

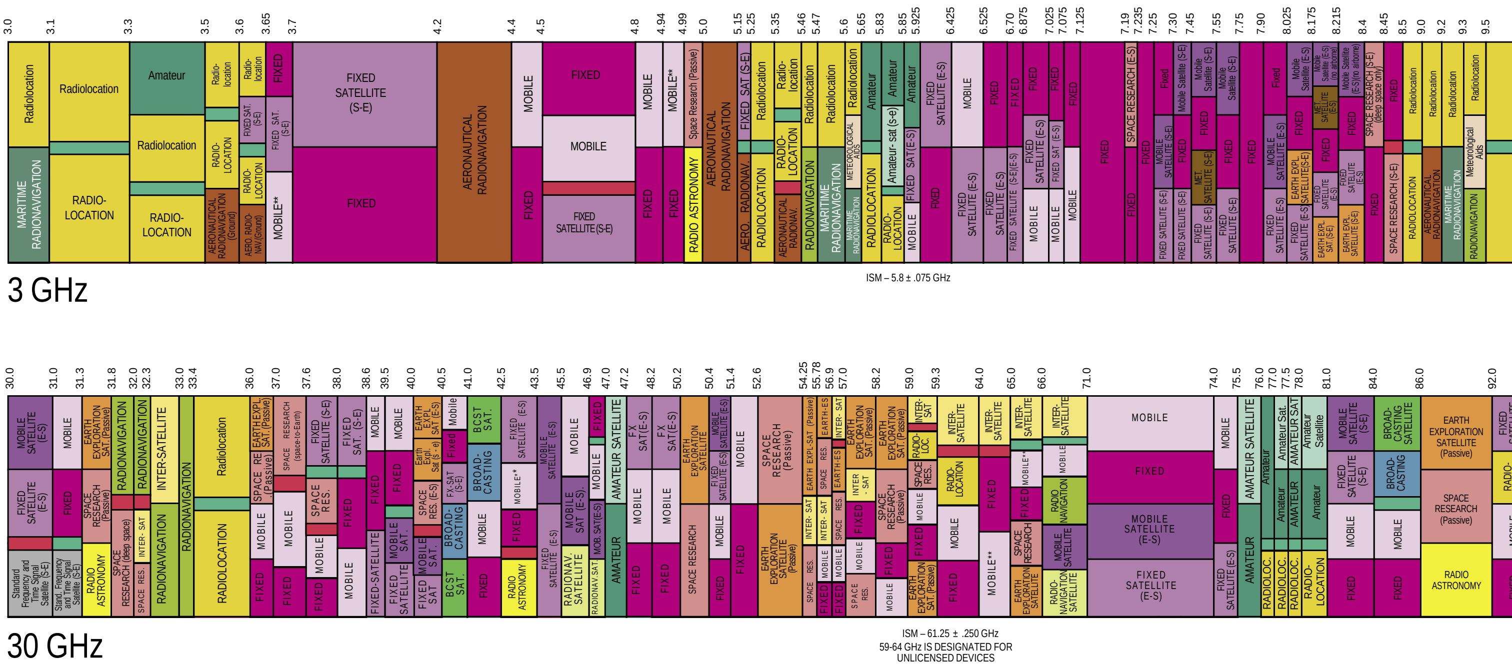
Bringing order to chaos — regulation makes it possible

Without the strong hand of regulation, the world would surely sink into frequency chaos. National regulatory authorities manage allocation of the frequency spectrum within an international context through the International Telecommunication Union (ITU), which is a suborganization of the United Nations (UN) and has its headquarters in Geneva. The ITU divides the world into three regions and issues mandatory frequency allocations for all member states. See FIG 1 for an example.

Services and applications in the frequency range from 3 GHz to 300 GHz

Within the ITU regions, the frequency spectrum between 9 kHz and 275 GHz is allocated to different services, e.g. "fixed", "aeronautical", "satellites", and "space" (FIG 2). The actual services are divided into applications in which the usable frequency ranges are defined for the end users. Examples of applications include WLAN/WPAN, WiFi, WiPro, WiMAX™, radar (civil, military), radio broadcasting and television (satellite) as well as traffic telematics. There are more than 200 different applications which are combined into application groups for the sake of clarity.

FIG 1 Densely occupied: The example illustrating national frequency allocation between 9 kHz and 300 GHz on the right (top) shows just how extensively the frequency bands are used and how many different services must be accommodated. The detail below shows the range between 3 GHz and 300 GHz.




3 kHz
300 kHz
300 kHz
3 MHz
3 MHz
30 MHz
30 MHz
300 MHz
300 MHz
3 GHz
3 GHz
30 GHz
30 GHz
300 GHz
ISM – 24.125 ± 0.125 GHz
30 GHz
ISM – 122.5 ± .500 GHz
ISM – 245.0 ± 1GHz
300 GHz

The frequency spectrum between 9 kHz and 3 GHz is completely occupied, which means that new services or services that need more bandwidth must use the range above 3 GHz in order to meet requirements for bandwidth, data rate, reliability, and interference-free transmission in the RF field.

FIGs 1 and 2 illustrate the basic problem: Since frequency is a limited resource and worldwide demand for it is huge, frequencies are commonly allocated to multiple services. Interference and impairments affecting individual frequency users are therefore more or less inevitable. This becomes even more apparent if the individual services are combined into main groups and their allocation is plotted on the frequency axis, as shown in FIG 3. It is no surprise that mutual impairments or interference can occur (FIG 4). It is also not enough to simply have the individual frequencies exclusively allocated on a planned basis by national regulatory authorities. Instead, these authorities must additionally create measurement capabilities to make it possible to regulate the frequency spectrum between 3 GHz and 300 GHz. This includes localizing the sources of interference when they occur and documenting them so they can be eliminated.

Services and applications

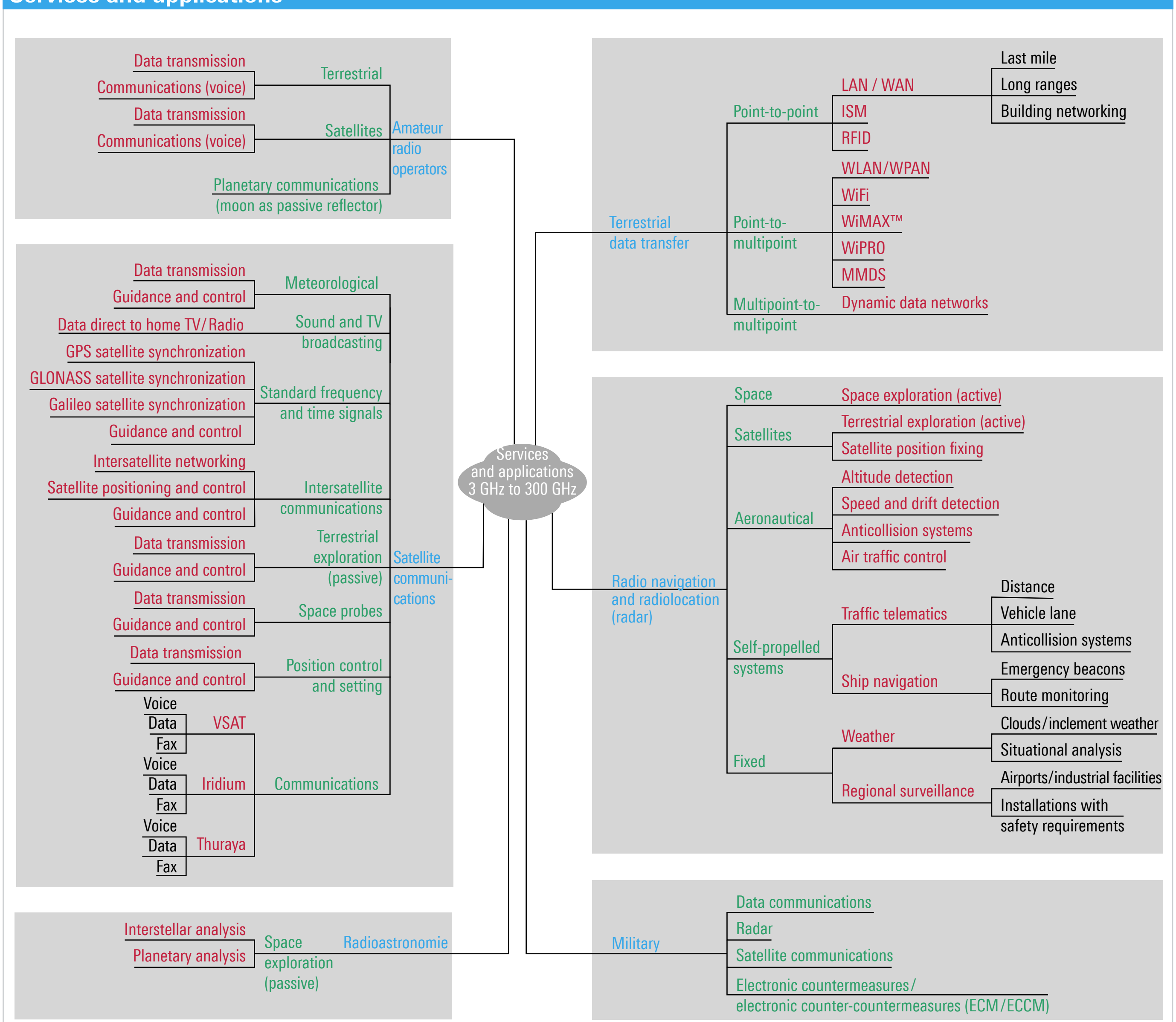


FIG 2 Main groups of services (blue), services (green), and application groups (red and black) in the frequency range from 3 GHz to 300 GHz.

Typical monitoring systems

The national regulatory authorities use the following typical monitoring systems in the frequency range from 9 kHz to 3 GHz:

- Fixed monitoring systems (FMS) (manned or unmanned)
- Mobile monitoring systems (MMS) (manned), installed on mobile platforms, e.g. in vehicles
- Portable monitoring systems (PMS) based on handheld equipment
- Universal monitoring systems (UMS) (unmanned), which are permanent, e.g. installed on roofs but also mobile or transportable
- Transportable monitoring systems (TMS) (manned), installed for temporary use

Starting at 3 GHz: monitoring limited to line-of-sight links

Due to the propagation conditions that prevail in the frequency range from 3 GHz to 300 GHz (radio links are basically limited to line-of-sight communications), fixed monitoring systems (FMS) are not useful for detecting interference due to their limited range. Mobile monitoring systems (MMS) are also usable only to a limited extent unless they are situated at an exposed location. Moreover, the typically very low transmitted power levels of spurious emissions in this frequency band limit the range of conventional microwave monitoring systems.

Despite all of these challenges, Rohde&Schwarz offers monitoring systems that are well suited to handling the special propagation and background conditions encountered in the microwave range. By using system components that are specially configured to meet these requirements, the monitoring range that is achieved is twice as large as that of competing products.

Main groups of services

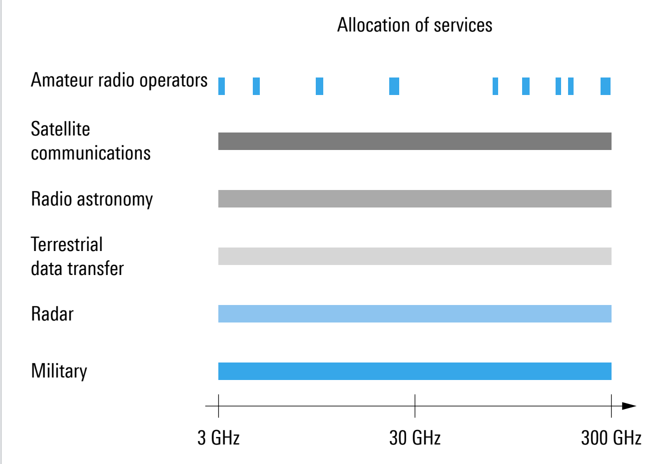


FIG 3 Combination of the services into main groups and allocation vs. frequency clearly shows the multiple allocations.

Customized: systems from Rohde&Schwarz

The highly specialized test and monitoring systems developed by Rohde&Schwarz cover practically all of the possible applications and can be used to find and document interference sources quickly and reliably.

Portable monitoring systems (9 kHz to 18 GHz)

Portable systems are used to identify nearby transmitters, meaning at a distance of a few meters to several hundred meters depending on the frequency range, e.g. in buildings, on roofs, or in hard-to-access places.

For a system that is small, light in weight, and easy to carry, the R&S®PR100 portable receiver is recommended for the range between 9 kHz and 7.5 GHz with the R&S®HE300 directional antennas (FIG 5). A frequency extension is under

FIG 4 Through simultaneous usage of very different applications in identical frequency bands, significant mutual impairment or interference can occur.

Examples of applications used in parallel	Possible consequences
Simultaneous usage of satellite downlink frequencies and terrestrial WiFi systems at 3.7 GHz in the C band	Failure of satellite communications
Impairment of civil air traffic control radar by microwave link systems	Possible impairment of aviation safety
Defective VSAT terminals disrupt terrestrial microwave link systems	Failure of communications systems
Impairment of satellite TV reception at 12 GHz in the Ku band due to terrestrial microwave link systems	Failure of TV transmission
Automatic anti-collision systems aboard vehicles are disrupted by satellite uplink signals or by microwave link systems used for data transmission	Impairment of vehicle safety

development for this receiver using the R&S®HF907 double-ridged waveguide horn antenna (DC to 18 GHz). It expands the portable monitoring system to include searching for VSAT transmitters or microwave links at close range, for example.

Universal monitoring systems (100 kHz to 18 GHz)
Universal monitoring systems are used to automatically monitor the spectrum in a range between a few meters and a few kilometers, depending on the frequency range, and to clearly identify any emissions. Such systems can also be used for automatic long-term spectrum monitoring, automatic measurement of band occupancy or identification of unused frequencies, which can then be reallocated by the regulatory authorities. Rohde&Schwarz offers the universal R&S®UMS1x0 monitoring systems for such applications (FIGs 6 and 7). These systems can be mounted on roofs or masts, for example, to provide a relatively large coverage range for signal interception. For details on the versatility of the R&S®UMS100 monitoring systems, read the article starting on page 76.

Transportable monitoring systems (9 kHz to 300 GHz)
These systems are designed for short-term local use and can clearly identify transmissions in a range between a few meters and a few kilometers, depending on the frequency range. For the frequency range from 9 kHz to 26.5 GHz (expandable up to 300 GHz), Rohde&Schwarz offers the R&S®TMS500 microwave monitoring systems (FIG 9) which can be transported by two persons.

They can be set up, e.g. on roofs, balconies or ridges, meaning any elevated location where a large signal interception range can be achieved. When installed in vehicles, the range increases and universal applications are possible.

At frequencies above 26.5 GHz, all of the components have a high insertion loss. Microwave converters are required for measurements at such high frequencies. Rohde&Schwarz offers converters that have been specially optimized for this application area. They have special filters, mixers, and amplifiers directly in the antenna to help ensure that the converter output frequency is below 26.5 GHz. This technique provides compensation for the cable losses that occur between the antenna and the receiver. To provide for the frequency stability of the monitoring system, the microwave converters are linked to the R&S®TMS500 using a 10 MHz reference frequency.

Five different microwave converters suitable for outside usage along with the associated antennas are available to extend the frequency range of the R&S®TMS500 transportable microwave monitoring systems (FIG 8):

R&S®MW-40	26.5 GHz to 40 GHz
R&S®MW-58	40 GHz to 58 GHz
R&S®MW-75	58 GHz to 75 GHz
R&S®MW-90	75 GHz to 90 GHz
R&S®MW-110	90 GHz to 110 GHz

FIG 5 The R&S®PR100 portable receiver with the R&S®HE300 antennas.

Module for 9 kHz to 20 MHz.

Module for 20 MHz to 200 MHz.

Module for 200 MHz to 500 MHz.

Module for 500 MHz to 7500 MHz.

Customer-specific frequency expansions up to 300 GHz are available on request.

Using the converters allows the R&S®TMS500 monitoring system to operate in its frequency range from 9 kHz to 26.5 GHz without any modification. Expansion is also possible at a later time by purchasing converters. The frequency ranges that are used do not have to be directly adjacent to one another.

Integration into higher-ranking measurement systems and frequency-allocation systems

The microwave monitoring systems from Rohde&Schwarz can be independently operated as separate systems. They can also be seamlessly integrated into existing spectrum monitoring systems by using the R&S®ARGUS software. R&S®ARGUS also allows them to be integrated into spectrum management systems so that, for example, the universal R&S®UMS1xx monitoring systems can be used for automatic monitoring of the frequency spectrum or for determining band occupancy.

FIG 8 R&S®MW-40 microwave converter.

Outlook

Additional articles are planned which will discuss the frequency range from 3 GHz to 300 GHz in particular:

- Wave propagation and measurement capabilities
- Professional system design
- Interaction between spectrum management and spectrum monitoring

Michael Braun

FIG 6 R&S®UMS100 monitoring system (100 kHz to 6 GHz).

FIG 7 R&S®UMS180 monitoring system (10 MHz to 18 GHz).

FIG 9 R&S®TMS500 transportable monitoring system.

R&S®UMS100 monitoring systems: the perfect addition to nationwide networks

Now another country is acquiring a full-coverage automatic system from Rohde & Schwarz to provide ITU-compliant monitoring of the frequency spectrum: Belarus. A special feature in Belarus is that numerous additional R&S®UMS100 monitoring systems ideally complement the main stations in peripheral regions and in remote areas.

R&S®UMS100 monitoring systems – autonomous but with solid integration

SENCOM Systems Ltd. is currently setting up a nationwide system for the Belarusian civil regulatory authority BelGIE to monitor the frequency spectrum. Rohde & Schwarz is supplying the complete system. Higher-ranking manned and unmanned (main) radiomonitoring and DF stations help ensure almost full-coverage radiomonitoring in areas with high radio traffic and in important sectors such as border regions. These stations are complemented by a network consisting of more than 50 unmanned R&S®UMS100* monitoring systems from Rohde & Schwarz. The network will be completed by the end of 2009. These autonomous subsystems are installed outside the coverage area of the main stations, e.g. in administrative districts in peripheral regions or in other remote areas. They handle the following tasks:

- Systematic monitoring and measurement of basic electromagnetic radiation parameters: frequency standards and offsets, field strength, bandwidth, utilization of radio frequency spectrum, etc., in the frequency range from 100 kHz to 6 GHz; these systems are operational around the clock in either automatic or interactive mode;
- EMC measurements: detection of radiated disturbance, identification of the characteristics and cause of radiated disturbance sources
- Identification of AM and FM audio signals, e.g. from radio and TV transmitters (in accordance with ITU recommendations)

The R&S®UMS100 monitoring systems are also used in all of the main stations in the administrative district centers. There, they are primarily operated in scan mode to monitor wide frequency ranges. If they detect a spurious emission, they forward the relevant information to a direction finder so that the emission can be localized.

* R&S®UMS100 Monitoring System: A new generation of fully automatic radiomonitoring systems. News from Rohde & Schwarz (2006) No. 191, pp. 46–49

Installation and control of the R&S®UMS100

When used in the main stations, the R&S®UMS100 monitoring systems are usually installed on the common antenna mast below the DF and monitoring antennas and the rotor. In case of remote operation, the systems are often attached to masts or towers of base stations used by mobile radio operators. When installed on the roofs of tall buildings, a tripod can be used for mounting (FIGs 1 to 3). To provide protection against overvoltages, all of the tower, mast, and tripod constructions are grounded, as is the enclosure used for these systems.

The remotely operated subsystems used in less populated regions or in border regions are arranged in a hierarchy underneath the main stations for the corresponding administrative districts. It is also possible to directly control each subsystem from a special workstation in the Minsk-Priluki radiomonitoring control center.

FIG 1 R&S®UMS100 monitoring systems integrated into main stations are mounted on the common antenna mast below the DF and monitoring antennas and the rotor.

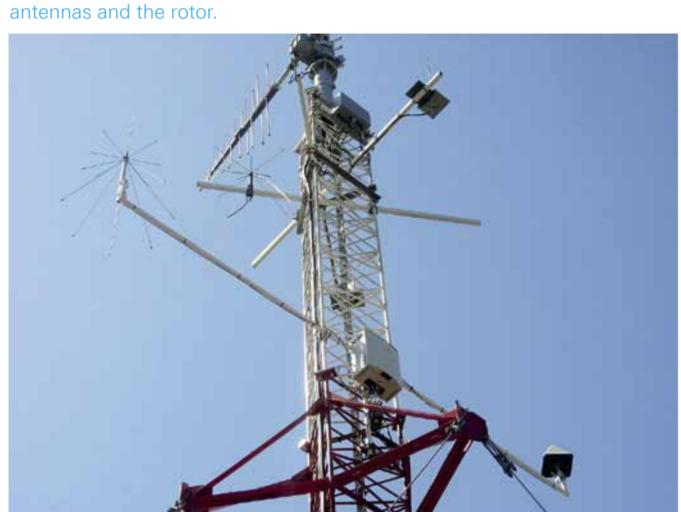


Photo: authors

Remote control of the subsystems

The outlying R&S®UMS100 monitoring subsystems are remotely controlled via various wired and wireless data transmission channels. Broadband communications standards such as G.SHDSL and CDMA2000® 1xEV-DO are preferred. The modems are connected via a LAN interface (Ethernet 10/100BaseT) to the R&S®UMS100 monitoring systems using a shielded cable to provide an average data transmission rate from 128 kbit/s (CDMA2000® 1xEV-DO) up to 512 kbit/s (xDSL). This is clearly enough bandwidth to reduce the time needed for transmitting the measurement results and system control commands to a minimum.

The equipment used for data transmission via radio is installed on the mast in a compact, climate-controlled enclosure below the R&S®UMS100 main module. A simple GSM controller is also included, making it possible to remotely switch the power supply on and off for the wireless modem and the R&S®UMS100 monitoring systems via SMS (cold reboot).

In areas without adequate CDMA2000® 1xEV-DO coverage and no opportunity to lay a connecting cable, the GSM modem is used with a data transmission rate of 9.6 kbit/s. Despite the low data rate of the GSM channel, the modem makes it possible to output commands for automatic measurements and to receive processed and compressed measurement results. Currently, attempts are underway to connect the remotely operated R&S®UMS100 subsystems using long-range Ethernet radio.

Uninterruptible power supply (UPS)

The unmanned R&S®UMS100 monitoring systems consume less than 100 W and are connected to the conventional AC power supply along with the data transmission systems. They also have a UPS. This helps ensure the following:
- Protection of the equipment against voltage fluctuations and disruptions in the external power grid
- Continuation of automatic radiomonitoring with no interruption for at least two hours in case of a main power supply outage

Automatic or interactive measurement mode

Two modes are available for either automatic or interactive operation. The R&S®UMS100 monitoring systems are used for the most part in automatic mode. An operator working in the control center creates a measurement task and forwards it to the desired station, which then processes it automatically and transmits the results to the control computer. This mode enables uninterrupted radiomonitoring of large areas with high efficiency using a minimum of resources.

Automatic mode (FIG 4) is especially useful for locating illegally operated transmitters. This mode is also ideally suited to detect signal parameters that deviate from the nominal values since in this mode, the measured signal parameters are compared with the reference data that is specified in the form of threshold values or limit lines. The system automatically transmits a warning signal to the control center and begins in-depth analysis of the radio signal.

FIG 2 In this example, an R&S®UMS100 monitoring system is mounted on the mast of a mobile radio operator.

Photo: authors

FIG 3 A tripod can be used to easily install the R&S®UMS100 monitoring systems on the flat roof of a tall building.

Photo: authors

Interactive mode enables direct measurement of the signal parameters (FIG 5). The results are presented on the control PC with a time delay that is dependent on the data transmission rate of the connecting channel. Frequency band scanning, frequency recording, and measurements on a specified frequency are all possible. This mode is useful for functional evaluation of the electromagnetic environment in the coverage area of the unmanned monitoring station and for measurement of signal parameters such as level, nominal value, carrier frequency offset, and signal bandwidth. Due to integrated audio compression, demodulated AM and FM signals (e.g. from sound and TV broadcast transmitters) can be transmitted live to the control center, even with narrowband GSM connections. This allows the civil regulatory authority to identify the radio signals to be analyzed in accordance with ITU recommendations.

Summary

The experience gained during the setup of a nationwide automatic system for frequency spectrum monitoring in Belarus has shown that the R&S®UMS100 monitoring systems from Rohde&Schwarz ideally complement the higher-ranking radiomonitoring systems due to their versatility and universal applicability. The systems handle all of the necessary measurements in areas outside the coverage area of the main stations.

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M. E. Medvedev; V. A. Oleshkevich
(SENCOM Systems Ltd.)

FIG 4 Automatic mode: synchronized playback of all of the saved measurement data.

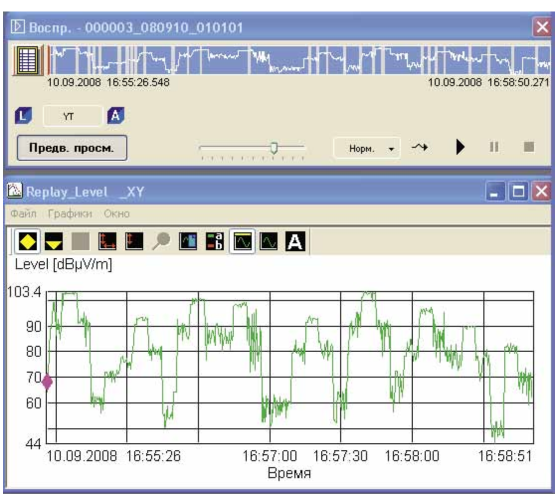
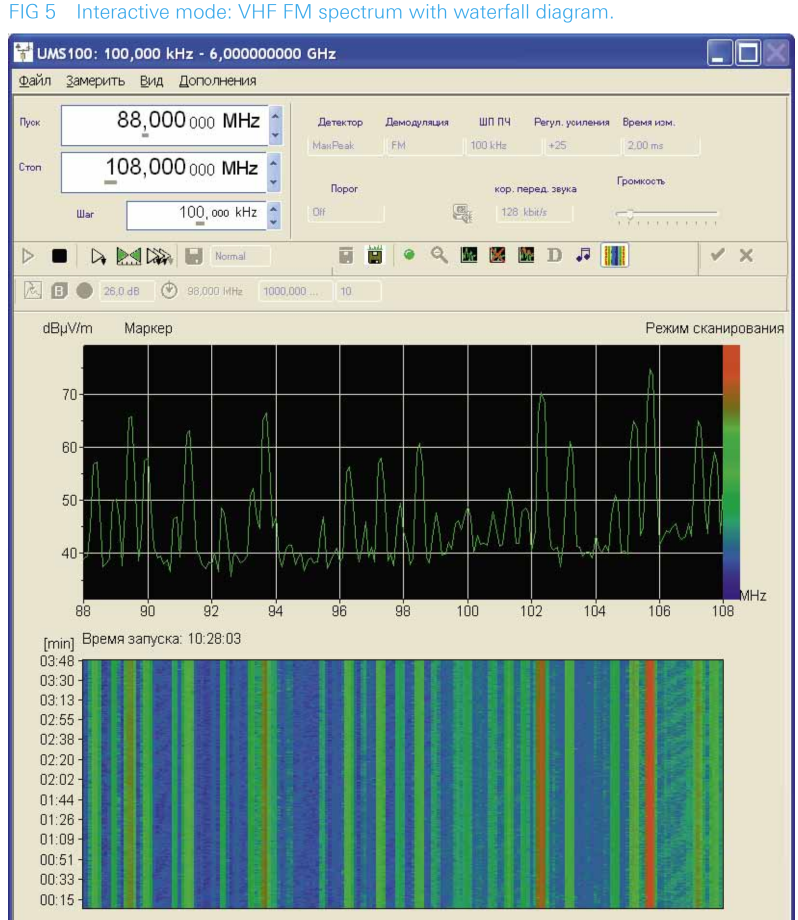


FIG 5 Interactive mode: VHF FM spectrum with waterfall diagram.



Convenient signal analysis at the symbol and bit stream level

One of the main jobs in radiomonitoring involves categorizing emissions as accurately as possible in order to assign them to individual users or groups of users. This requires detection and processing of channel codings and protocols. Rohde & Schwarz has developed the R&S®CA 250 bit stream analysis software as a powerful tool that can be used to even cope with new or unknown techniques.

For tough cases: bit stream analysis

Advanced radiomonitoring systems provide support to their users – fully automatically in some cases – during the entire radiomonitoring process. Rohde & Schwarz offers a complete line of products covering everything from reception to detection, direction finding, classification, and demodulation all the way through to decoding. The portfolio ranges from innovative portable receivers through to fully automatic radiomonitoring systems.

However, automatic processing of symbol streams reaches its limits when it encounters radio techniques that are either partially or entirely unknown. In such cases, experienced users with expert knowledge must be consulted. Powerful offline tools such as the new R&S®CA 250 bit stream analysis software provide support in the form of comprehensive functions for analysis, processing, and decoding of unknown bit streams that are recorded. FIG 1 shows one possible system configuration.

The first step in bit stream analysis involves viewing the demodulated data segment. R&S®CA 250 displays the information the demodulator provides about the quality of the data so the user can concentrate on an area with a low bit error rate during the analysis and obtain better analysis results faster (FIG 2). In addition, the diverse display options for bit streams provide a good overview of the complexity and structure of the bit stream under analysis. They make even regular structures such as preambles recognizable in the bit stream by means of suitable visual processing (FIG 3).

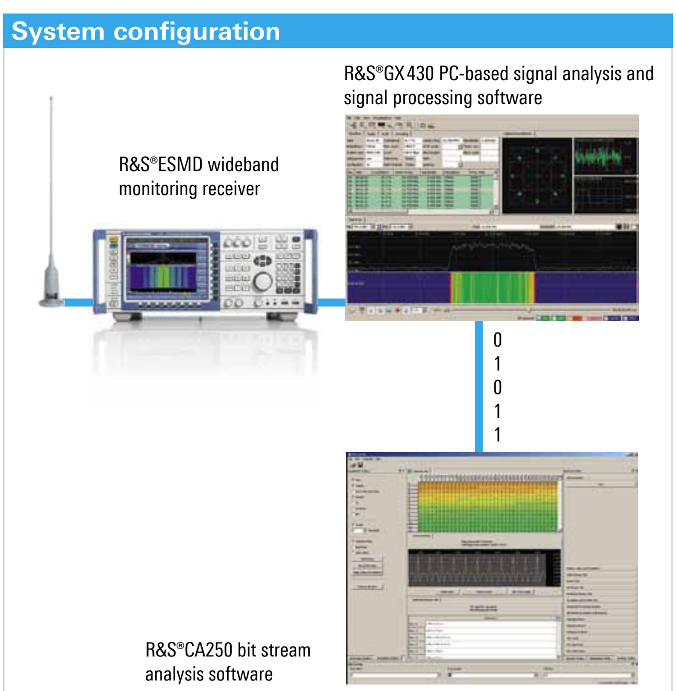


FIG 1 Example of a system configuration that allows the user to analyze signals down to the bit stream level.

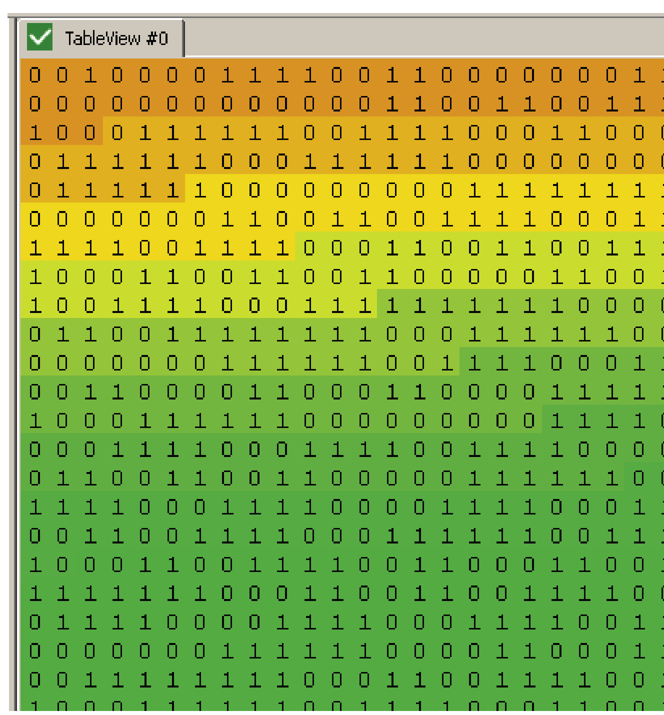


FIG 2 Color-coded bit-error probability, from green (lowest) to yellow, orange, and red (highest).

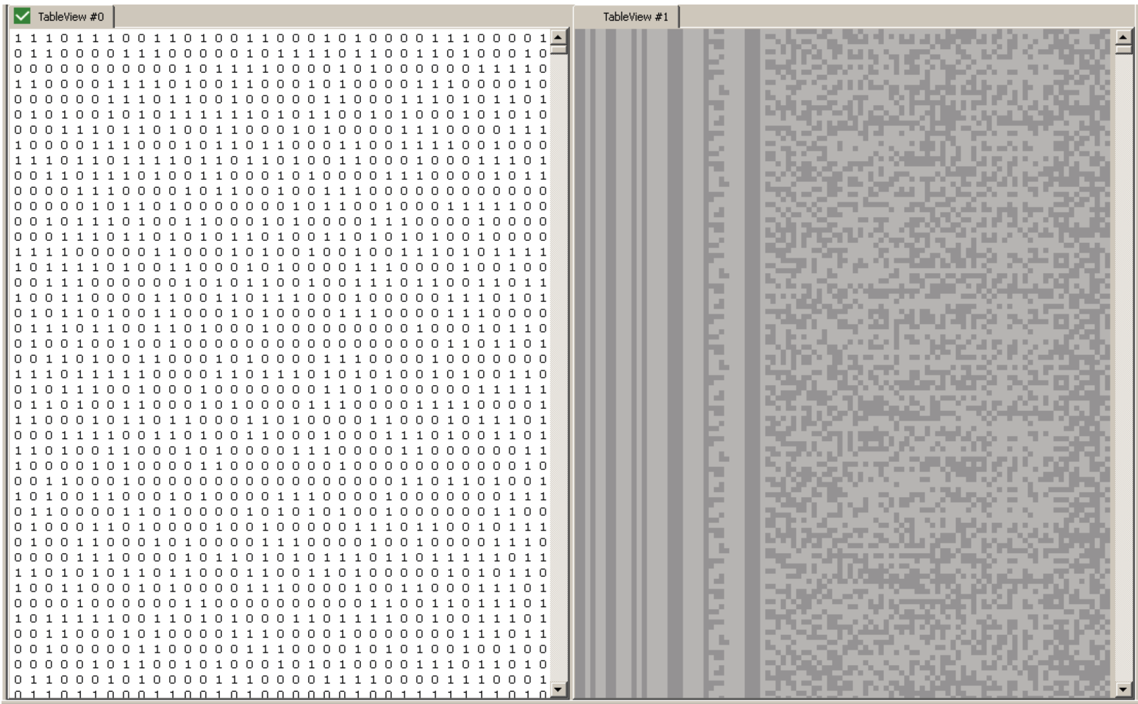
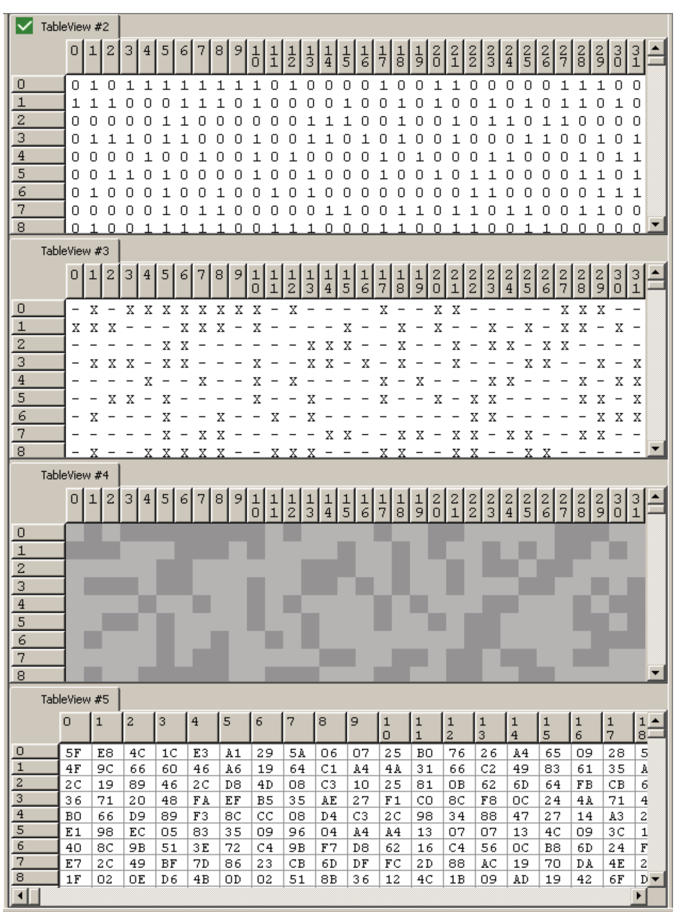


FIG 3 These two displays represent the same bit stream. However, after special processing by the R&S®CA250 bit stream analysis software, the frame structure is easily visible in the right half.

FIG 4 Different display modes simplify the detection of structural features.



Sophisticated: handling frame structures

Overall, several display modes are available to allow improved recognition of structural features (FIG 4). For each of the display modes, grid lines and row or column labels can be enabled optionally.

This initial view is obviously no substitute for in-depth technical analysis, but it does provide a rough idea of the structure and complexity of the data stream.

For comprehensive analysis of frame structures, the following algorithms are available:

- Autocorrelation and cross-correlation
- Tsallis entropy analysis
- Maurer test
- Chi-square analysis
- Configurable pattern search (with analysis of the periodicities of patterns that are detected)

Based on the insights gained by analyzing the structure, the frame content can be extracted. Here too, R&S®CA250 has all of the required tools such as demultiplexers and multiplexers as well as intuitive functions for deleting sections that do not represent any data content.

Challenge: analysis of channel codings

Another major challenge in bit stream analysis involves detecting and processing channel codings. Many of these techniques such as convolution and block codes often occur in the form of non-systematic codings. Unlike systematic channel codings in which user data is clearly delimited from the checksum, no such relationship exists with non-systematic codings since the user data is computed with the checksums.

In the case of systematic codes, user data can be recognized even without decoding through simple removal of the checksum; however, decoding is always required with non-systematic codes. This makes algorithms for automatic detection of the channel coding crucial when it comes to selecting the proper decoder. The R&S®CA250 bit stream analysis software automatically detects convolution, Reed-Solomon, BCH, Hamming, and CRC codes.

In addition to the type of channel coding, the automatic algorithm also provides (in the case of convolutional code analysis, for example) the code rate, the generator polynomials, and any relevant puncturing patterns (FIG 5). Of course, R&S®CA250 has a suitable decoder for each analysis algorithm. It also covers the interleavers commonly used in conjunction by offering channel codings by offering a wide spectrum of different types.

A further mechanism that is frequently used in data transmission is scrambling, which involves overlaying a pseudo-random sequence on top of a data sequence. Such pseudo-random sequences are mostly generated using linear feedback shift registers. They simplify clock recovery and help ensure a more uniform spectrum. At first glance, such bit streams appear to be random sequences. However, due to its efficient algorithms, the R&S®CA250 bit stream analysis software can automatically detect the scrambler polynomials that are used. Following successful identification of the scrambler in use, suitable descramblers allow continuation of the analysis process.

Comprehensive: tools for source decoding

The range of applications for the R&S®CA250 bit stream analysis software includes channel decoding as well as the analysis of source codings. A wide range of tools is available to help present the original message in text or audio form. Text data can be decoded using ASCII, ITA alphabet code, Huffmann alphabet code, and many other techniques.

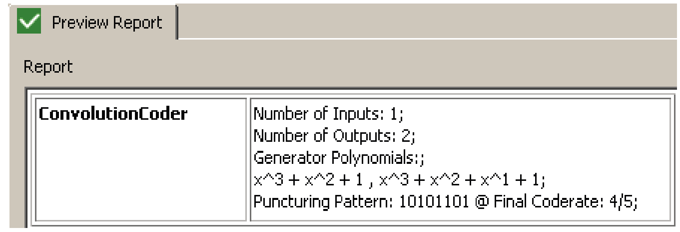


FIG 5 In the case of convolutional codes, for example, the automatic algorithm also provides the code rate, the generator polynomials, and any relevant puncturing patterns.

The following codecs are available for recovering voice signals transmitted in digital format:

- A-law / µ-law (in accordance with ITU G.711)
- ADPCM (in accordance with ITU G.726)
- LD-CELP (in accordance with ITU G.728)
- CVSD (in accordance with STANAG 4209)
- LPC-10 (in accordance with STANAG 4198)
- MELP (in accordance with MIL-STD-3005)

Expandable: script and programming interfaces

Since advanced transmission techniques typically interleave multiple channel coding mechanisms within one another, many analysis and decoding steps can be required to achieve success. However, the user does not have to pay attention to each of these steps since the R&S®CA250 bit stream analysis software fully logs all of the operations with the relevant parameters to allow full concentration on analysis of the respective channel coding layer.

For use in automatic processing of repetitive analysis routines, R&S®CA250 provides a script interface based on the Python script language. This allows the user to quickly and easily enter sequences of analysis tasks, particularly if they are iterative. The clearly structured C++ programming interface allows the user to integrate independently developed algorithms and decoders into the R&S®CA250 bit stream analysis software in an uncomplicated manner.

Summary

By providing a unique range of analysis capabilities combined with a number of decoders and an intuitive user interface, the R&S®CA250 bit stream analysis software is an indispensable tool in radiomonitoring since it helps the user to keep an overview even in heavily occupied frequency bands.

Jörg Biedermann

Premiere for the Rohde & Schwarz trade fair booth

Rohde & Schwarz presented its new exhibit concept to the public at the electronica trade fair in Munich. The modular booth system has been developed to provide cost-efficiency, flexibility, and functionality. The new system presents the products in a more straightforward way and places emphasis on the applications and highlights.

New colors, distinct shapes, and ample light for the new trade fair booth.

Rodenstock commissions Rohde & Schwarz

The Rohde & Schwarz plant in Teisnach received a major order from Rodenstock, Germany's largest manufacturer of lenses and glasses, to design and manufacture the ImpressionIST® Avantgarde service terminal. The terminal yields extremely precise measurement data that enables ophthalmic opticians to adapt glasses and lenses to specific customer requirements and thus ensure optimum comfort. Delivery is planned for late 2009.

Rohde & Schwarz China partners with Signalion

Rohde & Schwarz signed a distribution agreement with Signalion for its LTE UE simulator. The simulator is used for testing LTE base stations in China, also known as eNodeB (eNB). As part of the agreement, Rohde & Schwarz China is also responsible for on-site technical support as well as maintenance and repair of Signalion's simulator. This cooperation is intended to promote LTE technology in China.

Rohde & Schwarz was the first company to supply test solutions for LTE FDD and TD LTE signal generation and signal analysis. In addition, Rohde & Schwarz was the first manufacturer to offer LTE protocol test solutions for the development of mobile UE.

Rohde & Schwarz develops SDR base unit for the German Armed Forces (Bundeswehr)

The Federal Office for Information Management and Information Technology of the German Armed Forces has commissioned Rohde & Schwarz to develop a base unit for the Bundeswehr's joint radio systems (SVFuA). These systems are the basis for the Bundeswehr's future generations of software defined radios. The aim of the project is not only to develop the base unit, but also to demonstrate that it can be series-produced. SVFuA will provide the key technology for future command and control of modern armed forces. This system will contribute decisively to the Bundeswehr's participation in an joint, interoperable information and communications network.

Signing the contract (from left): Brigadier Klaus Veit, Vice President, Bundeswehr IT Office; Herbert Rewitzer, Head of the Radiocommunications Systems Division at Rohde & Schwarz; Wulff Sellmer, Bundeswehr IT Office.

New Managing Director at Rohde & Schwarz Japan

Managing Director Nobuhiro Kasai took over as the new head of the Japanese subsidiary on January 1, 2009. The newcomer to Rohde & Schwarz thus succeeds Akihiko Yoshimura, who retired on April 1, 2009. He was responsible for business operations together with Günther Loll until January 2009. Rohde & Schwarz Japan has been operating as an independent office since 2003, steadily increasing the company's market share and brand awareness.

Nobuhiro Kasai took over the Rohde & Schwarz office in Japan on January 1, 2009.

HF radio family receives IAC certification in Moscow

The Russian Interstate Aviation Committee (IAC) in Moscow tested and certified the radios of the R&S®Series 2000 for terrestrial ATC operations in the HF range. This included the transceiver and receiver systems of all power classes (150 W, 500 W and 1000 W), as well as antenna tuning units, the remote control unit and the splitter controller for remote transmitter / receiver operation. The radios can thus be used at civil airports to monitor and control air routes in Arctic regions for example.

Memorandum of understanding with KT Freetel (KTF)

Rohde & Schwarz Systems & Communications Asia in Singapore signed a memorandum of understanding with KTF, the largest Korean 3G operator. The objective of this close cooperation is to define interoperability testing (IOT) test specifications. The IOT specification is the basis for the technology and applications of the next mobile radio generation in Korea. Rohde & Schwarz will develop an interface between the protocol tester and the KTF test cases. KTF will be responsible for validating all final releases for the relevant IOT test cases.

Mobile air traffic control tower for Australia

Rohde & Schwarz (Australia) Pty Ltd and the Ground Telecommunications Equipment Systems Program Office (GTESPO) have signed a contract covering the supply of three transportable air operations towers (TAOT) for the Royal Australian Air Force (RAAF). These towers will be available to assist local and international out-of-area operations during natural disasters and other humanitarian relief efforts.

The R&S®MX400 air traffic control tower for the RAAF.

Communications systems for the Royal Netherlands Navy

The Defense Material Organization (DMO) commissioned Rohde & Schwarz to deliver four integrated internal and external communications systems for the new patrol vessels of the Royal Netherlands Navy. Each system consists of an integrated radio intercom system (IRIS), a modem and crypto subsystem, an MF / HF transmitter and receiver system as well as a VHF / UHF transmitter and receiver system.