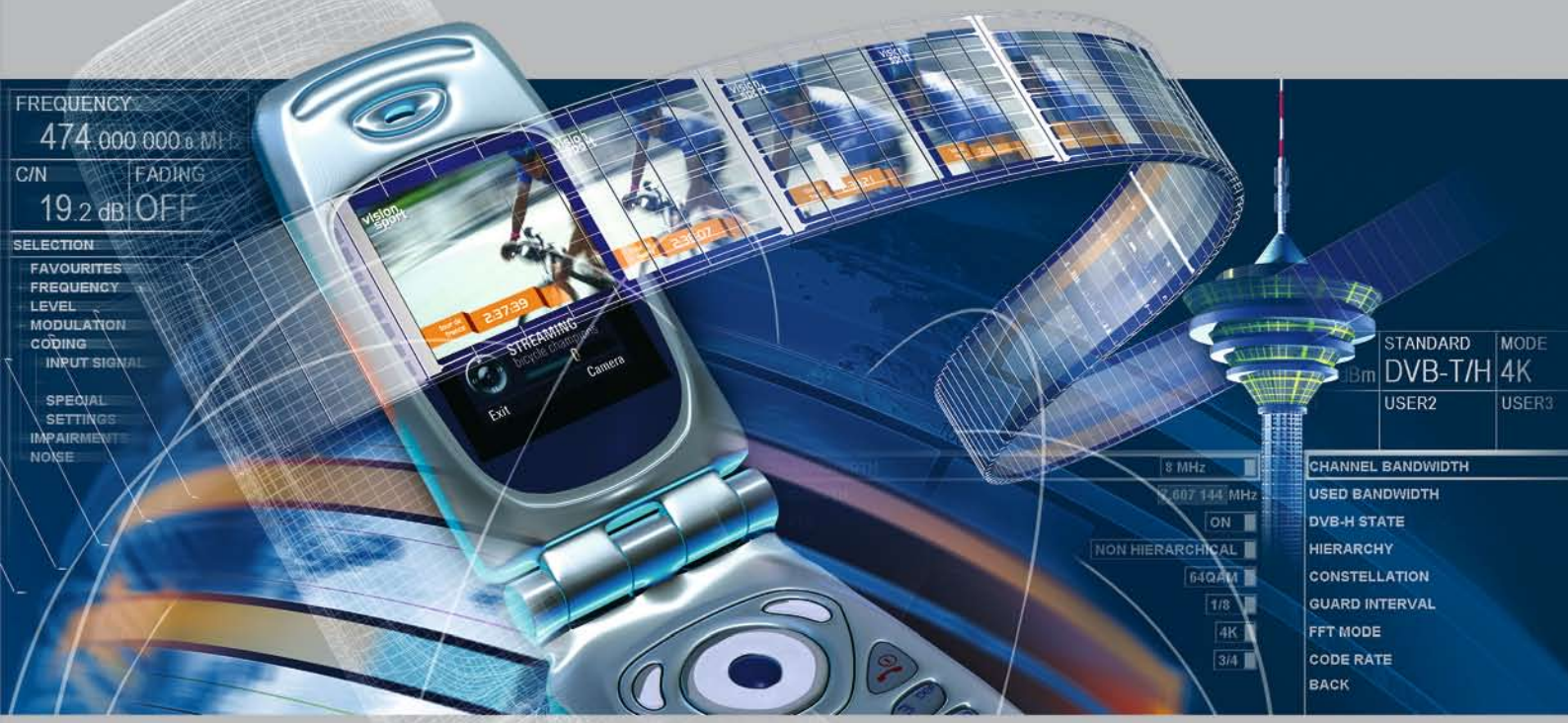
News from Rohde & Schwarz



Universal test platform
for digital television

Vector network analyzers
for balanced measurements

Up to the limits – new
benchmark in audio analysis

2004/III
183

ROHDE&SCHWARZ

The combination of Internet and broadcast technologies is creating new multimedia services for mobile phone owners: DVB-H will be the basis for future mobile IP-based datacasting applications. As a result, video streaming will soon be available for mobile battery-operated devices.

The new Broadcast Test System R&S®SFU fully integrates the DVB-H standard with DVB-T. But the R&S®SFU has a lot more to offer: It is a comprehensive system for all TV test and measurement applications (page 39).

44240

The R&S®ZVB family is a new generation of vector network analyzers for universal measurements – also on multiports and balanced DUTs (page 10).

The Audio Analyzer R&S®UPV sets absolutely new standards in audio test and measurement (page 16).

The Broadcast Test System R&S®SFU covers virtually all areas of digital TV: research and development, production, quality assurance, service, propagation and reception tests performed by network operators as well as EMC measurements (page 39).

The German Regulatory Authority for Post and Telecommunication (RegTP) operates the Direction Finders R&S DDF®0xM to carry out its governmental tasks (page 56).

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Universal Radio Communication Tester R&S®CMU 200

HSDPA – accelerator for WCDMA

HSDPA[1], the expansion of WCDMA[2] in third-generation mobile radio, increases transmission rates in data links from base stations to UMTS user equipment to more than 10 Mbit/s. Such high transfer rates allow fast loading of videos to mobile radio equipment, for example.

This article examines new principles that are being applied to expand a defined mobile radio standard in this way, and which requirements they place on T&M equipment.

Faster with HSDPA

WCDMA FDD (frequency division duplex) was designed for a useful data rate of 384 kbit/s, or 2 Mbit/s if the multiple code method is used. If the chip rate on the air interface remains unchanged (3.84 Mchip/s), up to 14.4 Mbit/s can additionally be transmitted in HSDPA channels in the downlink. This is feasible because of the highly sophisticated communications principles applied in the lower layers (physical layer and MAC layer) of the two communicating partners, i.e. the base station and the mobile radio user equipment.

The key elements of this new standard are as follows:

- Intelligent use and reduction of frames for information units from 10 ms (15 timeslots) to 2 ms (three timeslots).
- Optional use of a higher-level modulation mode (16QAM).
- Fast and optimized adaptation of modulation, channel coding and power in the downlink (adaptive modulation and error coding) to meet current radio channel conditions.
- Continuous and fast feedback of the reception quality in the user equipment (channel quality indication – CQI).
- Short response times have been defined in the physical layer of the mobile radio user equipment. During this time, the equipment acknowledges whether an HSDPA data packet was "understood" (ACK / NACK process).
- Information retransmission with changed coding (incremental redundancy): The mobile radio user equipment intelligently superimposes fragments that were received at different times (soft combining) and thus tries to decode the complete information.
- Division of the transmission subframes into parallel processes that are controlled independently of each other (hybrid automatic repeat request – HARQ).

HSDPA expands the channel structure of the previous WCDMA system (FIG 1). User equipment for HSDPA processes up to four control channels (HS-SCCH) in addition to the known physical channels of a WCDMA cell in the down-

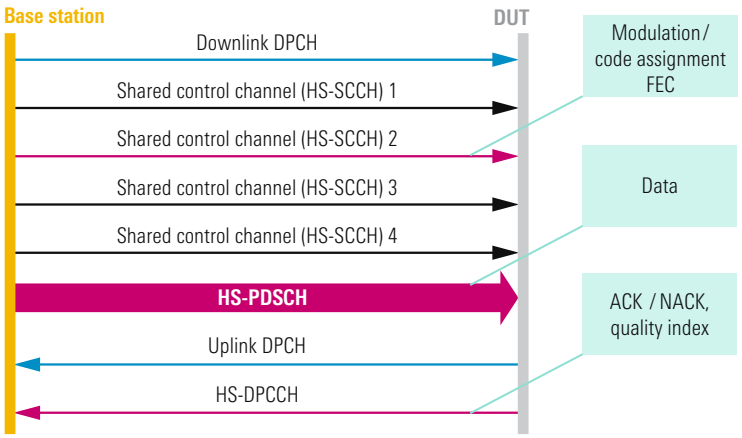


FIG 1
Channel structure of the physical channels with HSDPA.

1) High-speed downlink packet access.
2) Wideband code division multiple access.

HS-DSCH category	Max. number of HS-DSCH codes that can be received	Min. inter-time transmission interval	Max. number of bits in an HS-DSCH transport block during an HS-DSCH TTI	Total number of soft channel bits
1 (1.2 Mbit/s)	5	3	7298	19200
2	5	3	7298	28800
3	5	2	7298	28800
4	5	2	7298	38400
5 (3.6 Mbit/s)	5	1	7298	57600
6	5	1	7298	67200
7 (7 Mbit/s)	10	1	14411	115200
8	10	1	14411	134400
9 (10 Mbit/s)	15	1	20251	172800
10	15	1	27952	172800
11 (QPSK only)	5	2	3630	14400
12 (QPSK only)	5	1	3630	28800

FIG 2 Categories for HSDPA mobile radio user equipment.

link. Each channel contains information about which user equipment (user equipment identity – UE ID) is addressed by the HSDPA transmission and where the data packet that is transmitted a few moments later can be found in the code domain. Plus, the control channel describes the modulation and coding that are used and indicates whether this information is new or a repetition of a previously transmitted packet.

The carriers for the coded and modulated payload are the HS-PDSCH channels, each of which physically occupies the same space in the code domain since they are spread with a fixed factor (SF = 16). A base station can distribute a maximum of 15 HS-PDSCH channels during a transmission to one or more units of user equipment.

The transmission of the control channels and of the associated data channels requires three timeslots each, i.e. 2 ms. It should be noted that the data identifier on the HS-PDSCH channels starts with the third timeslot of the HS-SCCH channel, so there is a time overlap. Thus, the receiver in the mobile radio UE must start processing data even before it receives all the control information it requires.

The 3GPP standard divides mobile user equipment into different categories on the basis of HSDPA performance (FIG 2). The categories indicate which transport block size the equipment offers (a quantity for the maximum information data rate), whether the equipment supports 16QAM, the maximum number of HS-PDSCH channels the equipment can handle and how often the equipment is able to process HSDPA packets consecutively (minimal inter-time transmission interval – TTI).

As you can see from FIG 1, a new HS-DPCCH physical control channel has also been added to the uplink, i.e. the transmission from mobile radio UE to base station. This is the channel on which the mobile radio UE confirms whether it "understood" an HSDPA packet (acknowledged) or not (not acknowledged) so that the packet will be repeated if necessary. Moreover, the mobile radio UE continuously assesses the quality of the transmission path and cyclically transmits this information to the base station as a quality index (CQI) on this channel. Having this information, the base station can quickly define a favourable configuration for the downlink. The response time of an addressed mobile radio UE is precisely specified: no more than 5 ms after a message has been received (FIG 3).

HSDPA with the R&S®CMU 200

If the R&S®CMU-K64 software option is added to a Universal Radio Communication Tester R&S®CMU 200 (featuring WCDMA functions), the tester can handle HSDPA signal generation and evaluation. At the generator end, you will find ready-to-use scenarios (fixed rate channel test, CQI test, etc) and configuration elements (e.g. parameter sets for HSDPA tests). These scenarios are derived from 3GPP documentation

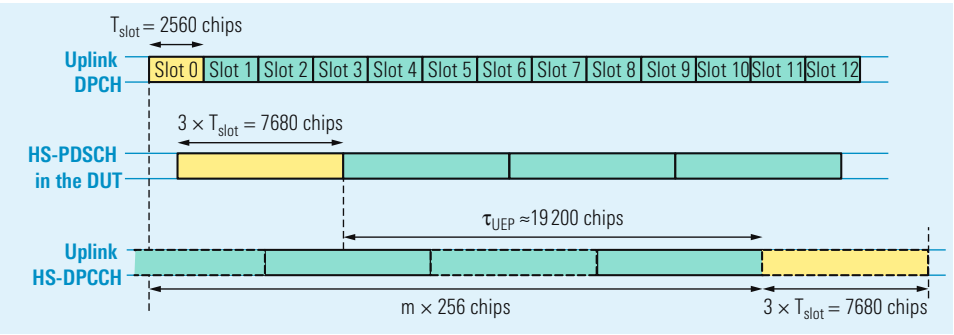


FIG 3 Time correlation in the uplink and downlink (ACK/NACK processing time in the DUT ≈ 5 ms).

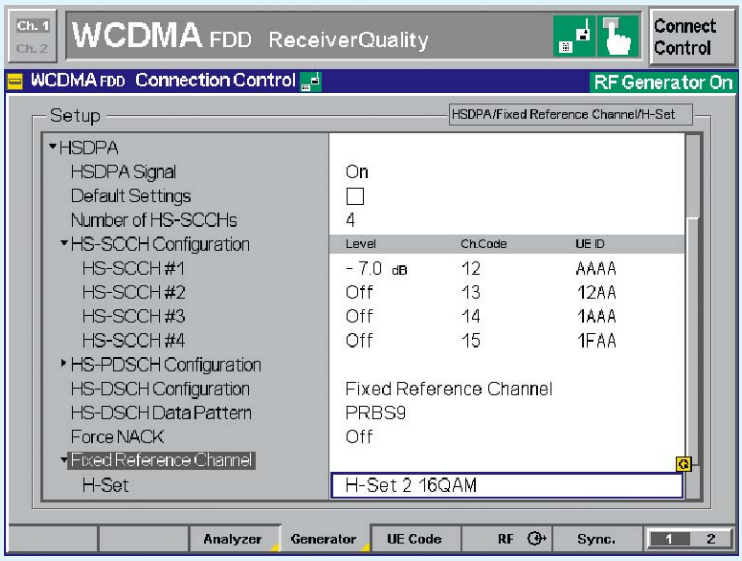


FIG 4
Section of the HSDPA generator menu.

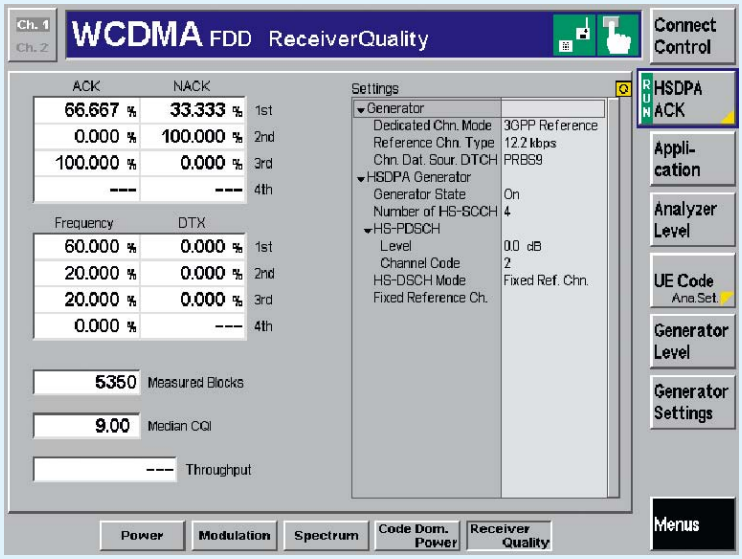


FIG 5
Section of the HSDPA receiver quality menu.

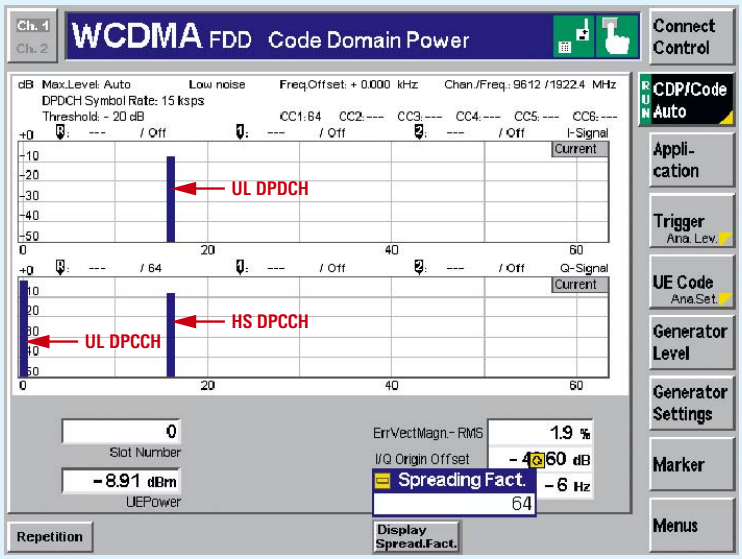


FIG 6
Code domain measurement in the uplink: DCCH, DPDCH and HS-DPCCH.

for minimum DUT requirements (3GPP TS 25.101) or, to some extent, from existing measurement procedures for RF conformance tests (3GPP TS 34.121).

For expert users, the R&S®CMU 200 user interface offers downlink parameters that can be configured manually or via remote control. You can thus define basic parameters such as level and code channel, but also modulation mode (QPSK or 16QAM), number of HSDPA channels, transport block size, response in the case of retransmission and much more (FIG 4).

The R&S®CMU-K64 software option in the receive section of the R&S®CMU 200 includes evaluation of the HS-DCCH uplink channel. The tester decodes both the ACK/NACK fields and the CQI information, which it assigns on-screen to the matching transmission in the downlink. Within the instrument, the receiver in the R&S®CMU 200 forwards the control data to the transmitter, thus defining the characteristics of the next downlink transmissions. The complex and time-critical interaction between transmitter and receiver on the tester end must run smoothly to ensure dynamic testing. This is the only way to evaluate the quality of operations such as retransmissions for various test signals and to measure data throughput, for example (FIG 5).

In addition to the HSDPA-specific tests described above, the required expansion of the existing RF test technology in the uplink is also worth mentioning. The modulation and code domain evaluation in the R&S®CMU 200 functions correctly irrespective of whether the additional uplink HS-DPCCH channel is present or not and evaluates the quality of the transmitter in the DUT (FIG 6).

Pirmin Seebacher

TETRA Mobile Radio System *ACCESSNET*®-T

Reliable use on oil fields all over the world

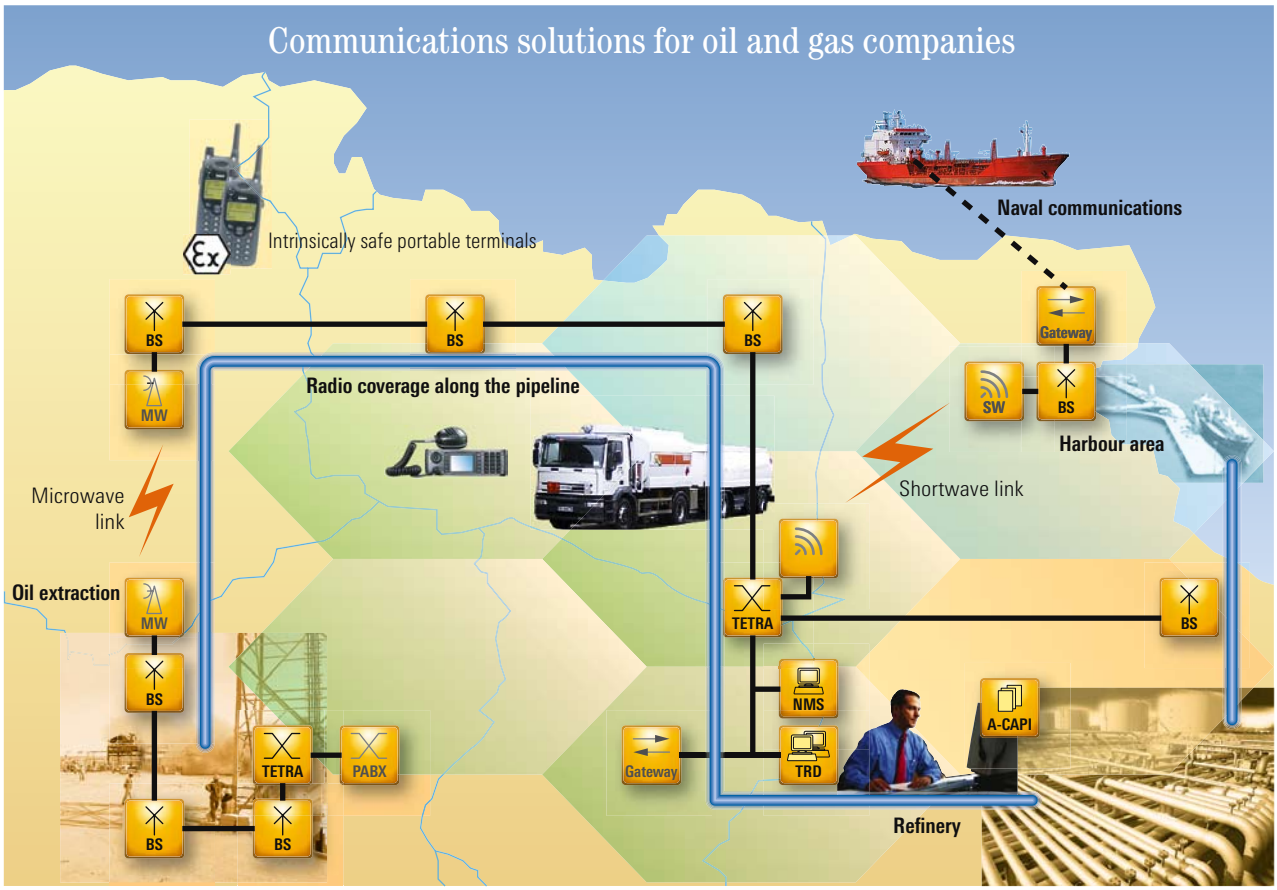
Digital *ACCESSNET*®-T TETRA mobile radio systems from Rohde&Schwarz have long been meeting the most stringent of requirements on oil fields in Russia – including Siberia –, Libya, Algeria, Oman, Saudi Arabia, the Ukraine and Kuwait.

A true test of communications equipment

Crude oil, often referred to as black gold, is more important than ever; the entire world economy depends on a regular oil supply. This explains the high demands that are placed on technical facilities to be used in oil extraction, processing and transport. Security and availability are top priorities, and this also applies to communications equipment, which must function reliably even if environmental conditions are highly adverse, e.g. at extreme temperatures or in sandy or humid areas. Moreover, individual components must satisfy a key requirement: approval for use in explosion-prone environments.

Digital *ACCESSNET*®-T TETRA mobile radio systems from Rohde&Schwarz [*] have long featured a flexible system design, sophisticated redundancy capabilities and high applications compatibility. Thus, they long ago met all requirements for being deployed in the world's oil industry (FIG 1).

FIG 1 Communications facilities for oil fields must satisfy the highest of requirements yet be flexibly adaptable to diverse tasks. *ACCESSNET*®-T is the ideal solution.



Flexible system design – 100% redundant

PMR systems, one of which is *ACCESSNET*®-T, were specifically developed for security-related operations. To satisfy demanding requirements, 100% redundancy can be achieved with *ACCESSNET*®-T: the exchange (R&S®DMX), base stations (R&S®DTX) and systems equipment are provided in duplicate. In the unlikely event that one of the network elements fails, the redundant component will immediately handle the defective element's function. Even if a connecting line is interrupted, the communications system will not fail because all network elements are connected in duplicate.

A line network is better suited for communications along a pipeline than any other structure. The multiplexers integrated in the base stations from Rohde&Schwarz permit a highly cost-efficient setup of such line structures; external multiplexers are not required.

Customized solutions

A "communications solution" would be the most appropriate and comprehensive description of the *ACCESSNET*®-T TETRA mobile radio system from Rohde&Schwarz, since its unique A-CAPI application interface provides numerous ways to economically achieve customer-specific solutions. These include, for example, the following applications that Rohde&Schwarz has implemented for the oil industry all over the world:

Automatic vehicle location

If service or maintenance work becomes necessary, it is useful and, in emergency cases, even indispensable to know the whereabouts of the service personnel so they can be efficiently deployed. The coordinates of their whereabouts are determined by GPS receivers that are connected to the TETRA user equipment via the PEI interface and are then transmitted to the control center via *ACCESSNET*®-T. Here, the locations of the vehicles are displayed on a map on the monitor. The vehicle closest to the site of operation can be sent there immediately without losing valuable time.

Remote monitoring system

Usually, oil extraction systems, pipelines, loading stations and refineries are located at large distances from each other. A high number of staff would be necessary to handle the numerous controlling and monitoring tasks across these distances. Even more critical are emergency situations. In such a case, it would be impossible to take countermeasures in time without specific technical precautions.

With *ACCESSNET*®-T from Rohde&Schwarz, you are on the safe side when performing such tasks, because *ACCESSNET*®-T can be complemented with the RMS telemetry system from Rohde&Schwarz, which is a controlling and monitoring system that exchanges messages and commands via a mobile radio system. For example, if pressure loss occurs in a pipeline, the valve leading to it can be closed from a distance. In another scenario, the system sends an alarm to the control center if a remote space is entered without authorization. These

FIG 2 Service personnel on oil fields is often scattered across large areas. In such a case, it is beneficial if the operator works with *ACCESSNET*®-T: The automatic system for vehicle location helps to efficiently coordinate operational forces.

Photo: R&S BICK Mobilfunk GmbH

few examples show the outstanding importance Rohde&Schwarz attaches to operational reliability. A SCADA interface has recently been provided for *ACCESSNET*®-T to connect it to other remote monitoring systems.

Voice recording system

The key features of *ACCESSNET*®-T include security for voice and data transmission as well as the system's operational reliability. Nevertheless, malfunctions in operating processes cannot always be prevented. In this event, a voice recording system can seamlessly reproduce communications. For recording purposes, Rohde&Schwarz uses the TETRA-coded signal with streams of 8 kbit/s and is thus able to simultaneously record up to 240 channels on one E1 line (2 Mbit/s). In addition to voice, user data such as SDS (short data service with TETRA) is also recorded. Compared to previous methods, this method is eight times more effective and minimizes the investment required. The minimum storing capacity is another advantage.

TETRA feature DGNA

Operators of pipelines, oil fields and similar facilities do everything in their power to prevent emergencies. If an emergency situation occurs all the same, service and maintenance staff, rescue teams and security staff must work hand in hand without any difficulties. *ACCESSNET*®-T provides the ideal support.

Communications within TETRA networks occur mainly in group mode, i.e. groups are formed for teams that are working together such as service teams or rescue teams. There may even be several groups with the same tasks but at different locations. In cases of emergency, the control center, using the R&S®TRD-500 dispatcher system, can now very quickly bring together any individual subscribers from the existing groups to form a special task group which can then be addressed by a newly assigned group ID. *ACCESSNET*®-T informs the subscribers about their new group assignment via the air interface and is immediately available upon reception. If a unit needs to be temporarily switched off, e.g. for changing the batteries, the received information will still be available.

Summary

The *ACCESSNET*®-T mobile radio system complies with the TETRA standard, which was initially defined for use by government authorities and organizations with security missions. *ACCESSNET*®-T has proven itself not only in the area of public safety but is also used in the oil industry, the military as well as local public transport and industrial companies. *ACCESSNET*®-T is the ideal solution for all of these organizations because they all have the same requirement – maximum safety and reliability under any conditions. When particularly sensitive applications are involved, *ACCESSNET*®-T is also available with encryption mode.

Harald Haage

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

LITERATUR

[*] *ACCESSNET*®-T – the digital mobile radio system from Rohde&Schwarz. News from Rohde&Schwarz (2003) No. 178, pp 6–13

Abbreviations

A-CAPI	*ACCESSNET*®-T common application programming interface
BS	Base station
DGNA	Dynamic group number assignment; a function that allows authorized users of a TETRA system to dynamically set up or modify groups; information is transmitted via the air interface to the relevant user equipment
NMS	Network management system, for subscriber management, configuration, data acquisition, service and maintenance in *ACCESSNET*®-T systems.
PABX	Private automatic branch exchange
PEI	Peripheral equipment interface; for applications (ETS 300 392-5)
PMR	Professional mobile radio
RMS	Radio monitoring system; telemetry system from R&S BICK Mobilfunk
SCADA	Supervisory control and data acquisition; management and process visualization systems; fulfill versatile tasks for visualizing, controlling and integrating technical facilities
TRD-500	Trunked radio dispatcher (R&S BICK Mobilfunk product designation)

FIG 1 **The new Vector Network Analyzer R&S®ZVB, here with four-port configuration.**

Vector Network Analyzers R&S®ZVB

Fast network analyzers – also for balanced measurements

The R&S®ZVB family is a new generation of vector network analyzers for universal measurements – also on multiports and balanced DUTs. Featuring outstanding specifications, high measurement and data transfer speed plus various data evaluation capabilities, they are ideal for use in development and production.

Versatile, fast and compact

The R&S®ZVB family consists of two- and four-port models, ranging from 300 kHz to 4 GHz or to 8 GHz respectively (FIG 1). The frontend receivers use a fundamental mixing concept that has already been a success with the R&S®ZVR family and which ensures a wide dynamic range of typ. 130 dB as well as low trace noise at large measurement bandwidths. The receivers exhibit a high compression point. At each measurement port, the maximum output power exceeds 13 dBm (typ. 16 dBm to 4 GHz). The output level can be electronically varied over 50 dB so that nonlinear parameters of active components can be determined quickly and without wear. In addition to RF test ports with bias tees for feeding active components, the R&S®ZVB has two other inputs at the rear for measuring low-frequency AC voltages.

The R&S®ZVB family offers considerably more display and evaluation capabilities than its predecessors. The number of test points per trace has been increased to 20001, and the sum of the traces and diagrams is limited only by memory. Several channels can be created in the R&S®ZVB for testing DUTs under various operating conditions. A channel contains all settings by means of which the analyzer samples the data of the DUT, such as sweep type (frequency, level, etc), number of test points, source level, IF bandwidth or the calibration. Several traces can be assigned to each channel, to simultaneously display, for example,

S-parameters, output power, DC power consumption or stability factors under different operating conditions.

Simple operating concept for stress-free work in the lab

Complex measurement tasks in network analysis, especially with multiport applications, call for an intuitive and straightforward user interface. The R&S®ZVB has a great advantage since it allows you to easily handle even the most demanding of measurement tasks despite the numerous ports, measurement parameters, diagrams and traces as well as extensive functions. Its easy-to-grasp concept is especially beneficial for untrained or infrequent users. But even network analysis experts will appreciate the sophisticated and intuitive user interface.

In addition to the tried-and-tested operation via hardkeys and softkeys, the R&S®ZVB also provides a Windows®-like user interface and can be fully mouse-operated using pull-down menus. The mouse operation and the hardkey/softkey concept share identical structures so that you will find all functions at exactly the same positions both in the pull-down and in the softkey menus (FIG 2).

With the aid of dialogs, you can conveniently manage high numbers of measurement ports, measurement parameters and traces. User-friendly wizards in the R&S®ZVB support complex operating sequences such as calibration or measurements on balanced devices.

Unlike numerous other network analyzers on the market, the R&S®ZVB allows you to quickly configure the display by arbitrarily assigning traces to specific diagrams and channels with only a few keystrokes and without complicated menu changes.

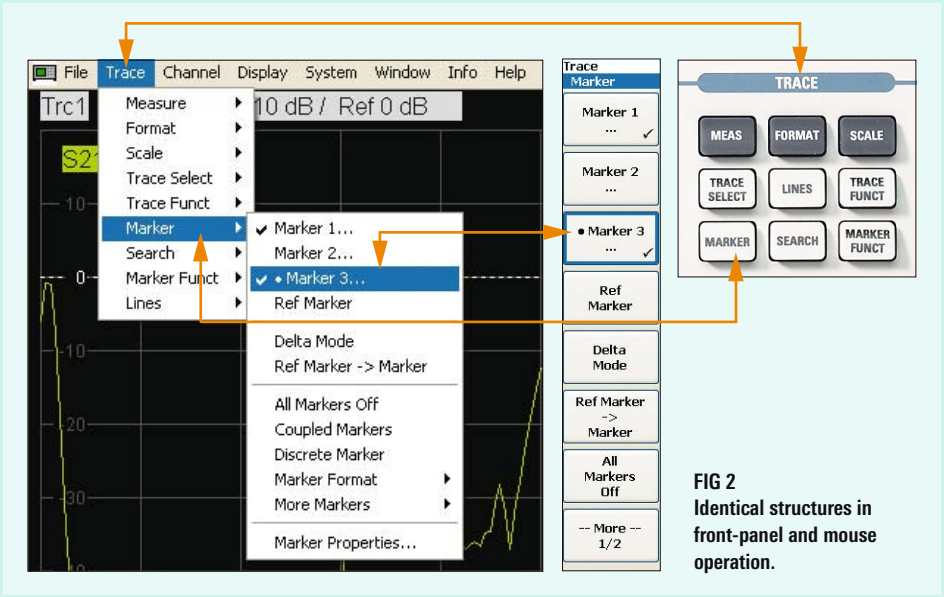


FIG 2
Identical structures in front-panel and mouse operation.

FIG 3
If you click on the right-hand mouse button, context-sensitive menus open up.

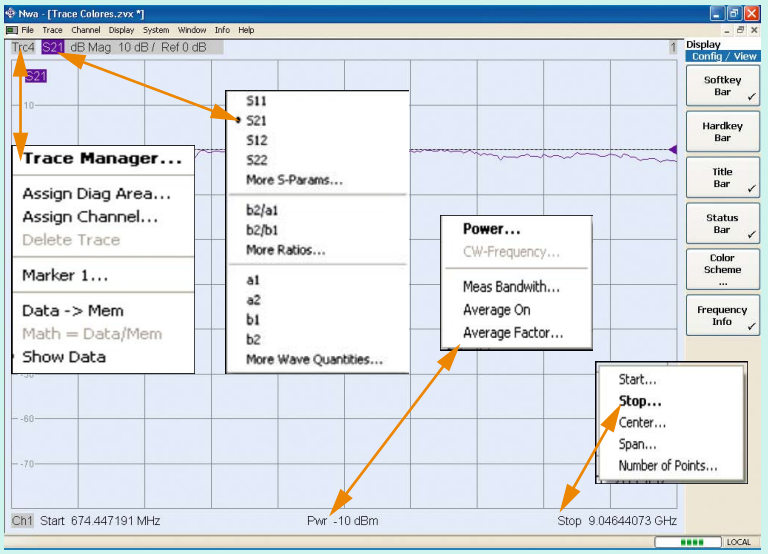


FIG 4
With the R&S®ZVB, you can load several setups and then quickly switch between them.

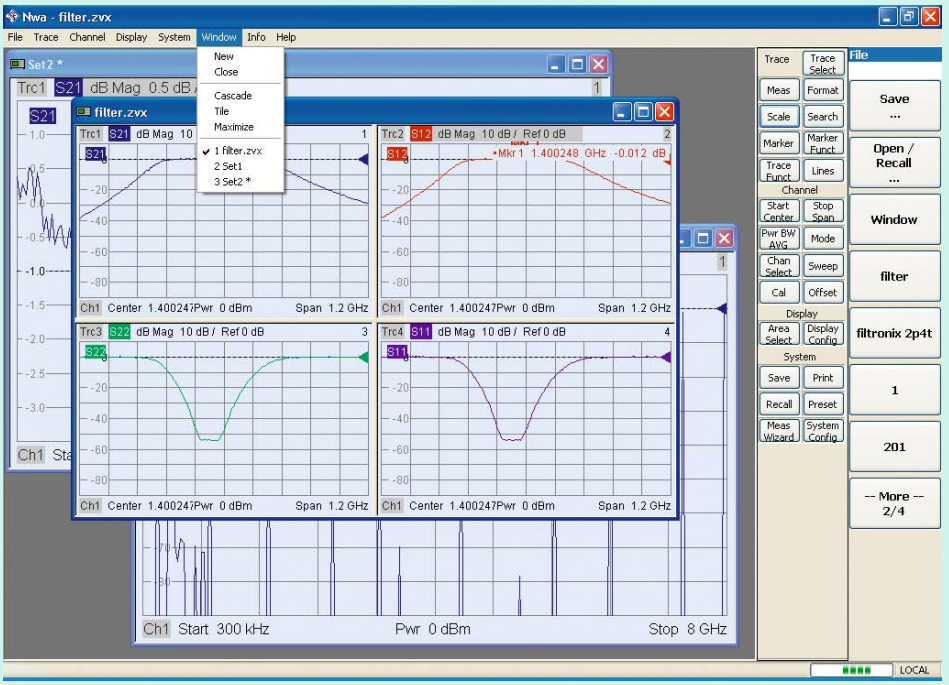


FIG 5 The support keys – powerful aid for difficult measurements.

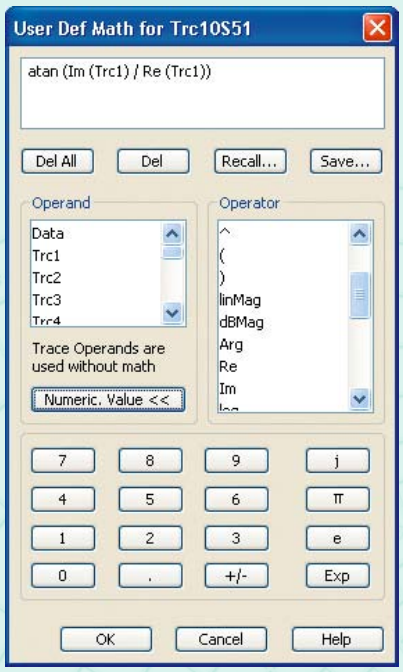


FIG 6 Using the mathematical editor, traces with complex mathematical functions can be linked.

FIG 7 Using the calibration unit (here the four-port model), the R&S®ZVB can be automatically calibrated at all ports within 20 seconds.

FIG 8 Examples of balanced components.

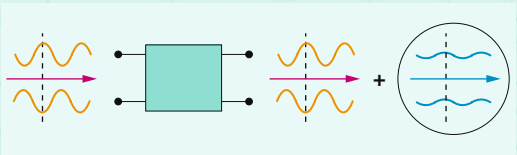


FIG 9 Common-mode signals generated by mode conversion.

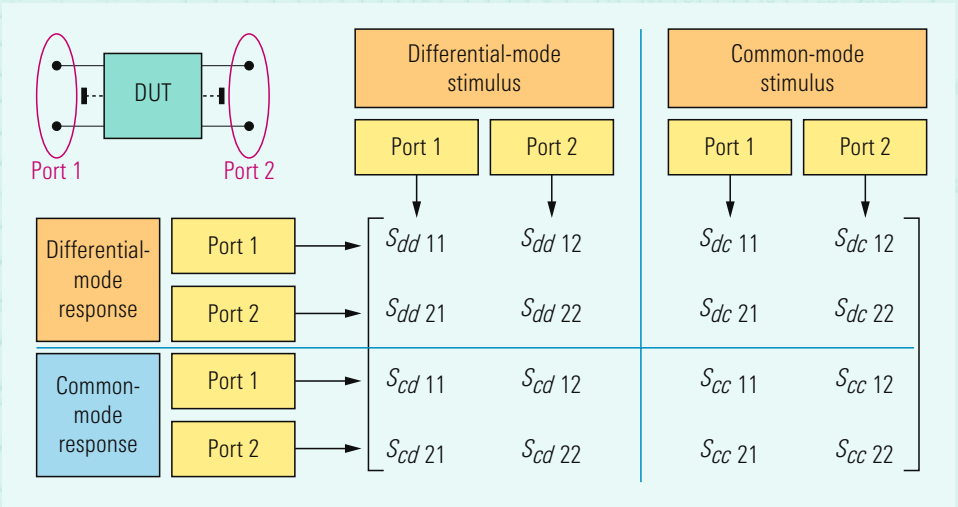


FIG 10 Matrix with 16 mixed-mode S-parameters of a balanced two-port.

Condensed data of the R&S®ZVB

Frequency range	300 kHz to 4 GHz (R&S®ZVB4) 300 kHz to 8 GHz (R&S®ZVB8)
Number of test ports	2 or 4
Dynamic range at 10 Hz	>123 dB up to 4 GHz
Bandwidths	1 Hz to 500 kHz
Number of test points	20001 per trace
Measurement time with 201 points and 500 kHz IF bandwidth	<8 ms
Output level	13 dBm, typ. 16 dBm at 50 MHz to 4 GHz
Display parameters (examples)	S-parameters, mixed-mode S-parameters, impedance, admittance, Y- and Z-parameters, stability, PAE, power

If you prefer using the mouse, you will quickly find all necessary functions without having detailed knowledge of the hardkey and softkey menu structure: By clicking on a screen element with the right-hand mouse button, you open the required context-sensitive menu (FIG 3). You can assign meaningful individual names to the numerous possible traces, measurement channels and markers to keep an overview.

You can load different complete instrument setups – in Windows® applications they are called files – to memory (FIG 4). With manual operation, you then use the mouse and simply select from among the windows of the loaded setups. With remote control, this setup swapping considerably reduces the time for switching between the different setups. Since, in this case, the data of all loaded setups, including the calibration data, is already in memory, switching between these instrument setups takes no more than 10 ms. This is no time at all considering that recalling setups from the hard disk previously took up to one second in most cases.

Auxiliary functions such as online help, retrieving information via hardware, or current measurement setups are available as hardkeys (FIG 5). The context-sensitive online help is part of the software update and thus always state-of-the-art. A completely new feature is the R&S®ZVB's ability to reverse several operating steps by using the UNDO key. This even applies to presets. Time-consuming reconfigurations of instrument setups after an operator mistake are now a thing of the past.

The R&S®ZVB provides extensive functions for reading measurement data in and out, processing it further and linking it with other trace data. It offers various formats for exporting measurement data: MatLab® or files compatible with the Advanced Design System ADS simulation program with the extension *.snp as well as ASCII, making the analyzer compatible with conventional simulation programs. Since the data of these files can be ported to memory traces, you can directly compare measurement traces on the network analyzer online with the data obtained from simulations.

Moreover, a versatile mathematical editor permits nearly any links of the measurement traces with complex mathematical functions (FIG 6). The expressions generated can be stored and transferred to other instruments.

Versatile innovative calibration methods

The test set configuration in the R&S®ZVB satisfies all requirements placed on today's calibration methods. The analyzer provides a versatile portfolio of innovative calibration routines whose ease of operation, high measurement accuracy and special suitability for calibrations in test fixtures are outstanding. A calibration unit, available in different port number and connector type configurations, provides maximum calibration convenience and speed (FIG 7). After being connected to the USB interface, the calibration unit is immediately ready for operation, and it takes only 20 seconds for the network analyzer to be automatically calibrated. Compared to conventional manual calibration, this method saves a lot of time and considerably minimizes the risk of operating errors, especially if a complete four-port calibration is required, for example for measuring balanced two-port devices.

Balanced devices – conveniently measured

The R&S®ZVB comes with special features for measuring balanced or differential devices. Balanced devices such as amplifiers, filters and data bus systems are used to an increasing extent in mobile radio and the computer industry. Their advantages include lower sensitivity to EMI signals plus lower emission of EMI signals, thus helping to achieve higher integration density.

The most common components are those with two balanced ports and those with one balanced and one single-ended port (FIG 8). Instead of a signal with ground reference, two signals with the same amplitude, but 180° phase shift, are fed to the input of balanced components; this operating mode is referred to as differential mode. An ideal balanced two-port that is fed at the input with a differential-mode signal or wave quantity generates only reflected and transmitted differential-mode wave quantities at its inputs and outputs. In practice, however, a DUT also generates common-mode wave quantities due to mode conversion. They exhibit the same amplitudes at a port and no phase shift (FIG 9).

Mixed-mode S-parameters describe the transmission characteristics of such balanced components; a balanced two-port can be characterized by 16 of these parameters, for example. The matrix in FIG 10 consists of four quadrants, each of which indicates the different operating modes. The indices of the S-parameters describe the mode of the relevant wave quantity. For example, S_{dd21} characterizes the ratio of the transmitted differential-mode wave quantity at port 2 to the differential-mode wave quantity injected into port 1. The first quadrant usually describes the ideal operation of the balanced two-port.

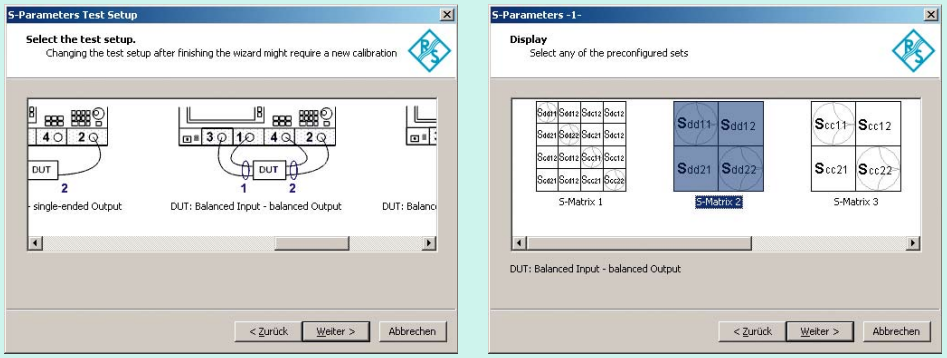


FIG 11 The S-parameter wizard (excerpt) conveniently guides you through complex measurements.

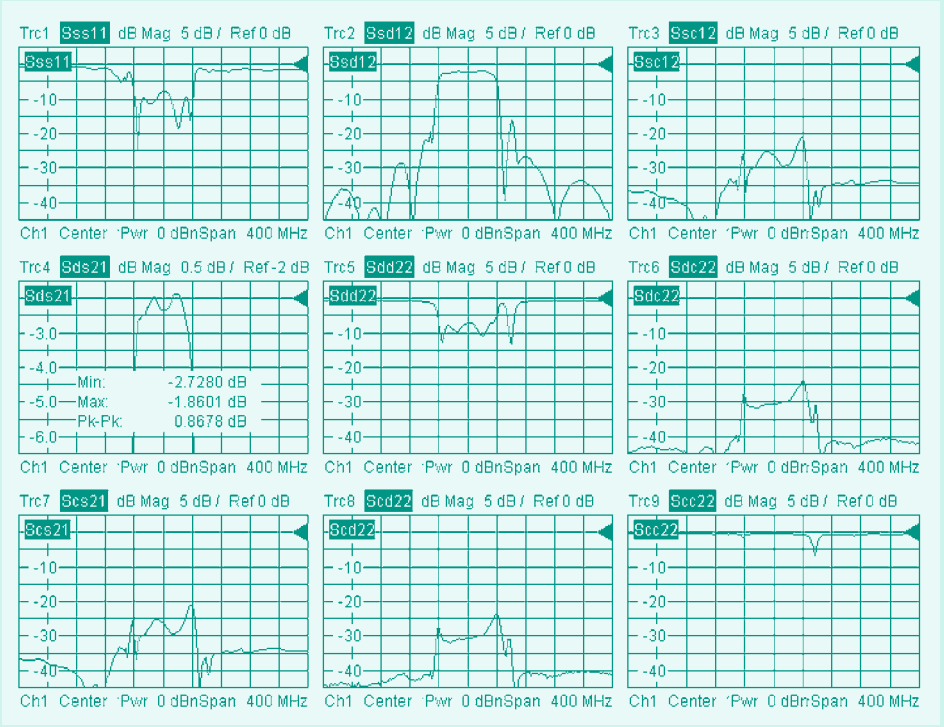


FIG 12 Mixed-mode S-parameters of a diplex filter.

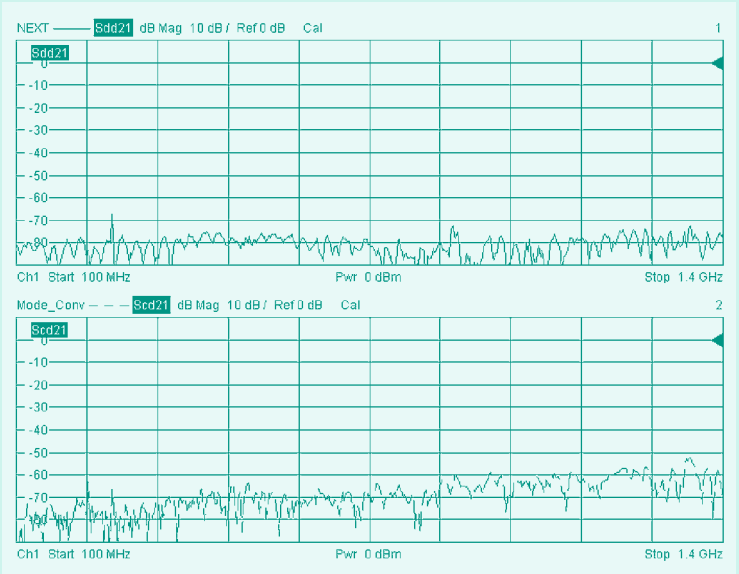


FIG 13 NEXT and unbalanced attenuation between two cable pairs.

The second and third quadrants characterize the mode conversion of the DUT where it converts differential-mode wave quantities into common-mode wave quantities and vice versa, i.e. they usually describe unwanted behaviour. The fourth quadrant indicates the ratio of transmitted or reflected common-mode wave quantities to common-mode wave quantities fed in at one of the ports.

Since network analyzers have single-ended ports, common- or differential-mode signals can neither be fed to DUTs nor directly measured. To characterize balanced components, baluns (balanced-unbalanced transformers) were previously used to generate and measure differential- and common-mode signals also with a single-ended network analyzer. However, this measurement method is unsuitable for higher frequencies since neither baluns of the quality required nor the necessary calibration standards are available. Therefore, a different approach is being taken. Instead of analyzing the balanced two-port with the aid of baluns with balanced signals, the balanced two-port is measured as a single-ended four-port with a (single-ended) four-port network analyzer. The mixed-mode S-parameters can be calculated from the unbalanced S-parameters. Two physical ports of the network analyzer form a logical balanced port. Therefore a four-port network analyzer has to be used to measure a balanced two-port device.

An S-parameter wizard in the R&S®ZVB supports these highly complex measurement tasks. It conveniently takes you step by step through the measurement setups and, if required, also offers a suitable calibration method (FIG 11). Thus, you can configure the entire display of all 16 mixed-mode S-parameters error-free in less than 30 seconds.

Examples of measurement using the R&S®ZVB

Measurements on SAW filters

Matching networks transform the impedance of balanced components, such as high-impedance SAW filters, to the lower impedances of the circuit. Users and manufacturers of SAW filters are thus interested in the behaviour of these components together with the suitable matching network. With the aid of virtual (calculated) matching networks in the R&S®ZVB, you can avoid time-consuming setup of these physical networks. The R&S®ZVB measures the DUT without matching networks and mathematically adds these networks. The network analyzer virtually embeds the SAW filter into the desired ideal matching circuit, taking into consideration also different impedances for the differential and the common mode (FIG 12).

Measurements on symmetrical cables

Since the applications of symmetrical cables extend to the GHz range, they can only be measured using virtual baluns. In addition to reflection and transmission parameters, knowledge of crosstalk and mode conversion between two different cable pairs is necessary. Differential-mode crosstalk between two cable pairs measured at the same cable end is referred to as NEXT (near-end crosstalk); the differential-mode crosstalk between two cable pairs, measured at distant cable ends, is referred to as FEXT (far-end crosstalk). The R&S®ZVB with four ports determines these parameters quickly and easily (FIG 13).

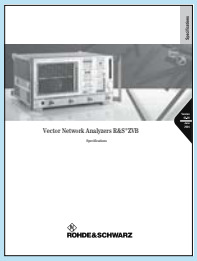
Measurements on amplifiers

The R&S®ZVB provides numerous features for measurements on amplifiers: In addition to S-parameters, it also determines output power, stability factors, power consumption, power added efficiency (PAE, quotient of generated RF power and consumed DC power), impedances and Z-parameters as a function of frequency or level. The high output power of typ. 16 dBm and the large sweep range of the source exceeding 50 dB permit fast and wear-free (i.e. without switching mechanical level attenuators) amplifier measurements under different load conditions. In addition to the amplifier's input power and output power, you also need to know the DC supply currents and voltages to measure the PAE. The R&S®ZVB measures the DC supply currents and voltage with two DC inputs. One of the DC inputs tolerates a voltage range of ±10 V for measuring the supply voltage, the second a voltage range of ±1 V with a resolution ten times higher to measure small voltages that drop at a current sense resistor. The necessary proportion factors for the different test configurations can be entered by means of a dialog.

The R&S®ZVB can handle many traces and measurement channels, limited only by memory. Thus, all requested parameters can be displayed versus frequency and level virtually in realtime and adjusted, if required.

Thilo Bednorz

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



Specifications R&S®ZVB

Product Brochure R&S®ZVB

FIG 1 **The Audio Analyzer R&S®UPV shows what is possible today in audio measurements.**

Audio Analyzer R&S®UPV

The benchmark in audio analysis

High-resolution digital media such as audio DVD place extremely high requirements on T&M equipment. The new Audio Analyzer R&S®UPV meets these requirements across the board – and also sets new standards in audio analysis.

Up to the limits

The Audio Analyzer R&S®UPV (FIG 1) is a new compact instrument for any type of audio measurement. If you work in a studio or develop and produce hi-fi and audio equipment, the R&S®UPV can handle any measurement task up to the limits of what is technically feasible. High-resolution digital media such as DVD can thus be mastered as perfectly as analog measurements up to 250 kHz. The analyzer's outstanding technology is easy to operate and ready for future applications. For example, future audio interfaces can easily be added via plug-in cards.

The **analyzer in the R&S®UPV** measures level, frequency, phase and distortion. It can perform fast and accurate frequency response measurements and simultaneously display the signals in the frequency and time domains. Moreover, it can replay audio signals via a loudspeaker and perform a wide range of other tasks. A digital filter bank with weighting filters and user-definable filters can handle virtually any requirement.

The **generator in the R&S®UPV** produces all signals up to 80 kHz required in the audio field, ranging from sinewave and intermodulation signals up to noise signals and multisine signals with several thousand single lines. If you need more, you can use the built-in arbitrary waveform generator or replay signals in WAV format from the hard disk.

All these signals can be output by using an additional digital equalizer with user-definable nominal frequency response or filtered in the time domain.

With the Digital Audio I/O R&S®UPV-B2 option, this variety of signals is also available at the digital audio interfaces (AES/EBU, S/P-DIF and optical). In addition, physical parameters such as level, jitter or sample frequency can be analyzed.

Landmark analysis concept

The entire analog measurement path from the input to the A/D converter and the DSP is truly dual-channel. In stereo measurements, this eliminates time-consuming switchover and settling operations. The R&S®UPV performs all measurements using digital signal processing. Signals to be measured are first subjected to complex preprocessing (fine-resolution levelling and fundamental rejection for distortion measurements) using analog measurement modules before they are digitized and fed to digital measurement routines. This concept allows a higher dynamic range than that offered by the internal 24-bit converter. It also ensures a level of performance and versatility that is far superior to that offered by pure analog or digital measuring instruments.

Numerous highlights

- Measurement bandwidth up to 250 kHz
- Dual-channel signal processing for maximum measurement speed
- Simultaneous performance of several measurements
- Graphical representation of all measurement results (FIG 2)
- FFT analysis up to 256 k points
- Generator for all audio signals up to 80 kHz
- Dual-channel analog generator
- Sinewave up to 200 kHz
- Filters for analyzer and generator
- Digital audio interfaces with sampling rates from 30 kHz to 200 kHz
- Plug-in cards for additional audio interfaces, e.g. for I^2S

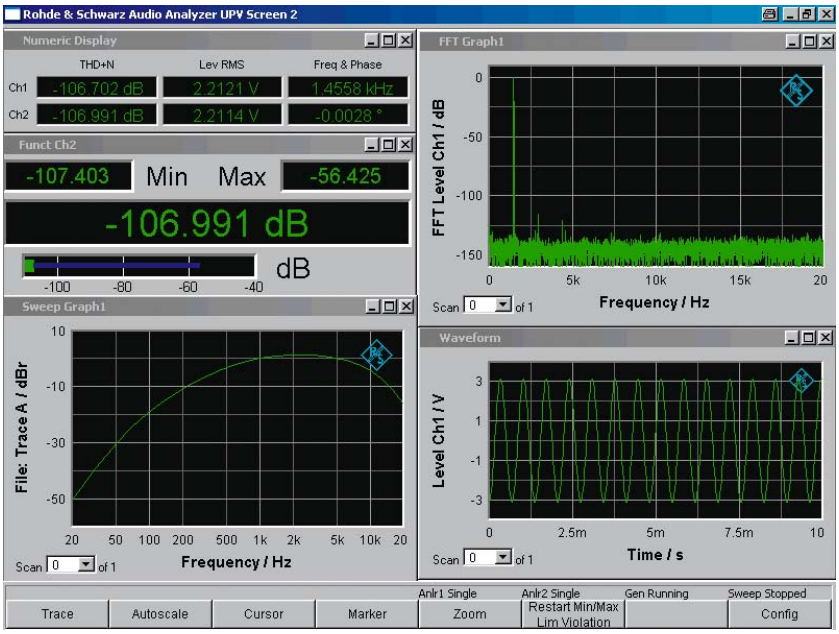
Analyzer operation and measurement methods are always the same no matter whether measurements are performed on analog or digital interfaces. This is truly a benefit for a variety of applications. For example, you can directly compare measurement results obtained in front of or after a converter. All measurement functions and test signals are available on both the analog and digital interfaces, enabling you to perform measurements at any point on a mixed analog/digital transmission path. This ensures efficient and comprehensive troubleshooting.

Since digital measurement routines can continuously adapt their measurement speed to the current input frequency, far higher measurement speeds than those known for analog measurements are achieved.

Wide range of measurement functions

- **Level**, both selective and wideband with rms, peak or quasi-peak weighting.
- **S/N ratio**
- **Distortions** (harmonic distortion, THD+N, SINAD). The individual harmonics can be displayed as a bargraph, or the complete frequency spectrum of distortions can be displayed.
- **Intermodulation** (modulation distortion, difference frequency distortion, dynamic intermodulation). The individual noise components can be displayed as a bargraph.
- A **digital prefilter** can be looped into the signal path irrespective of the measurement function. One example is an A-weighting filter for acoustic weighting. Up to three further filters can be looped into the measurement path depending on the measurement function.

FIG 2 The R&S®UPV displays measurement results in easy-to-read numeric values and graphs.



- **Frequency, phase and group delay**.
- **Complex FFT** (magnitude and phase) up to 256 k points.
- **Post FFT** for level, distortion and intermodulation measurements.
- **Waveform function** for displaying the measurement signals in the time domain.

Several measurement functions can be performed simultaneously. For example, you can measure the output level, frequency and phase as well as distortions on a DUT and, at the same time, graphically display the output signal in the time domain (waveform analysis) and in the frequency domain (FFT analysis).

Every filter is digital

The digital implementation of filters used in the R&S®UPV makes a virtually infinite number of filters available, even for measurements on the analog interfaces. You merely have to select the type of filter (e.g. highpass/lowpass filter, bandstop filter, etc) as well as frequency and attenuation in order to loop a new filter into the measurement channel of the analyzer or into the path of the generator signal. In addition to these user-definable standard filter functions, the R&S®UPV of course offers all common weighting filters (e.g. A-weighting, CCITT-weighting or CCIR-2k-weighting) for standard-conforming measurements.

Test signals for any application

- **Sinewave signals**. You can insert an equalizer with user-selectable nominal frequency response after these signals in order to compensate the frequency response of the test setup, for example.
- **Stereo sine**. Frequency, level and phase are user-selectable in any channel. With the R&S®UPV-B3 option, this function is also available on the analog outputs.
- **Two-tone signals**. These signals are useful for intermodulation measurements (amplitude ratios and frequencies can continuously be adjusted).
- **Test signal**. You can use this signal to measure dynamic intermodulation distortion (DIM).
- **Multitone signals** of up to 7400 frequencies with selectable amplitude distribution can be generated. You can couple the frequency spacing to the analyzer resolution of the fast Fourier transform and thus quickly and accurately determine the frequency response of the DUT in a single shot.
- **Arbitrary signal**. The R&S®UPV can generate any voltage characteristic of up to 16384 points.

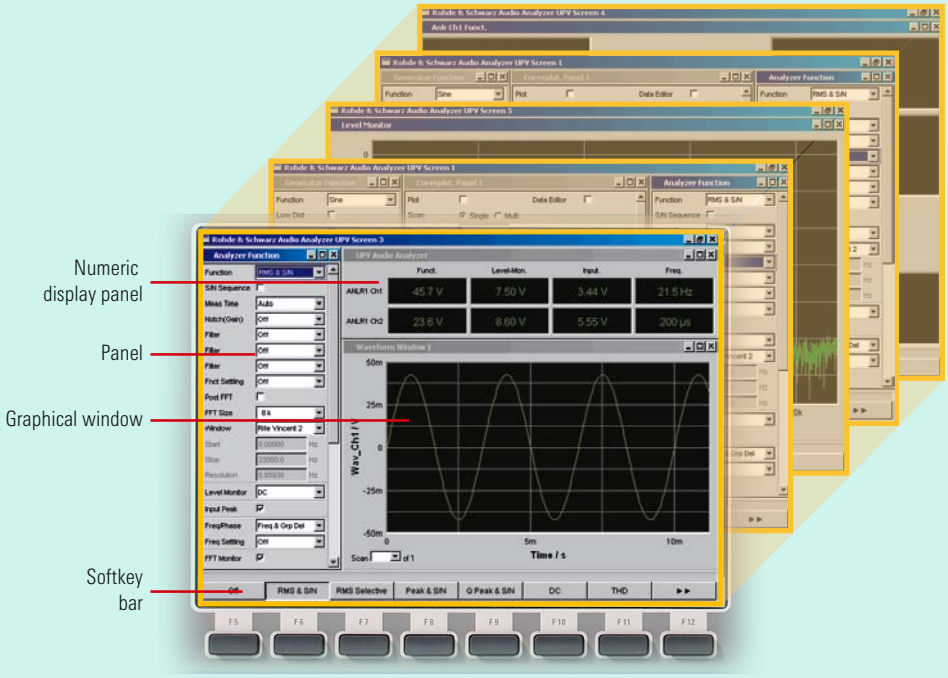


FIG 3 Convenient: You can select up to five virtual screens in no time by pressing a key.

Superb operating concept

The R&S®UPV is based on the Windows XP® Embedded operating system and thus offers a modern and intuitive user interface. When developing the instrument, Rohde&Schwarz kept its long-standing customers in mind. We retained many important features of the R&S®UPL operating structure as well as the names of parameter fields and functions. Users familiar with the R&S®UPL will therefore quickly master the new instrument.

- All settings are made in panels that contain all relevant functions and settings. They can be arranged and scaled as desired (and minimized or closed) on the colour SVGA LCD.
- To get a better overview, you can distribute the panels on up to five virtual screens and quickly switch from one screen to another by simply

- **Sine burst and sine^2 burst**. The R&S®UPV enables you to set the interval and on-time and to select the low level.
- **Noise**. You can generate noise with different amplitude distribution functions.
- **AM and FM**. You can set AM and FM for sinewave signals.
- **DC voltage**. You can set the DC voltage, including an offset for the other signals.
- **Dither**. You can generate dither at the level and amplitude distribution you need. Dither can be applied to the digital audio signals.

Excellent specifications

- Level uncertainty 0.05 dB
- Frequency response 0.01 dB
- Input noise typ. 1 µV
- SINAD typ. 115 dB (analog), 145 dB (digital)
- Analog sinewave signals with harmonic suppression of typ. 120 dB
- Noise floor for FFT typ. –140 dB (analog), –170 dB (digital)
- Maximum frequency resolution of fast Fourier transform of 0.2 Hz

Linear or logarithmic sweep

The frequency and level of signals can be swept with linear or logarithmic sweep stepping. The generator can be synchronized to the measurement function of the analyzer, which makes sweeps as fast as possible. Also, a time grid (fixed or variable, read from a file) can be set or the swept parameter can be manually stepped by using the rotary knob.

pressing a key (FIG 3). Thus, for example, you can place infrequently needed configuration panels all on one screen and use another screen to display a fast Fourier transform in full-screen mode.

- The instrument can be operated entirely from the front panel. The rotary knob (FIG 4) plays an important role. You can navigate within the panels by using only one hand and select the desired function by pressing the rotary knob. You can vary numeric values directly by using the rotary knob. This is of enormous advantage when making adjustments.
- Softkeys at the bottom of the screen give you fast access to changing functions. The contents of a selection field are displayed in this area, enabling you to also select the parameter without having to open the field.

FIG 4 The rotary knob, which can also be pressed, enables you to conveniently navigate within the panels.

Measurements at digital audio interfaces

The R&S®UPV-B2 option provides the instrument with balanced, unbalanced and optical inputs and outputs for connecting professional studio and consumer equipment. Additional inputs and outputs on the rear panel allow you to synchronize operation to audio reference signals, to word clocks or to bit clocks and to generate such synchronization signals. The generator and analyzer can be operated independently of each other with variable clock rates from 30 kHz to 200 kHz.

In addition to the audio content, the R&S®UPV can also analyze physical interface parameters. This enables you to display the jitter spectrum, to measure the jitter amplitude and frequency, to generate output signals with jitter and to unjitter input signals.

Moreover, the new analyzer can measure the phase between the audio input and reference input and generate a phase shift between the audio output and reference output. The common-mode signal at the balanced input can be analyzed (frequency, amplitude, spectrum), and a common-mode signal can be superimposed on the output signal.

The R&S®UPV measures the input pulse amplitude and the sampling frequency. Since you can select the output level, you can analyze the sensitivity of digital audio inputs. A cable simulator can be added to the generator to simulate long cables.

Integrated PC

Neither a keyboard nor an external monitor is required for analyzer operation but can be connected. In addition to a hard disk, the R&S®UPV features a DVD drive and a CD burner. Large volumes of data

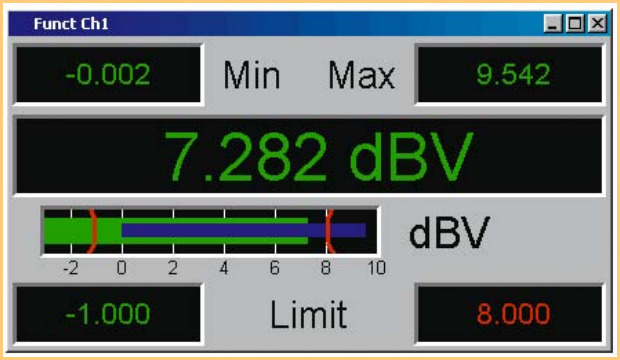


FIG 5
Comprehensive information: Min and Max values, tolerance limits, etc.

can be transferred conveniently and quickly by using a USB stick. Software updates are child's play owing to the familiar Windows®concept: you simply start the required installation file from the USB stick, CD or a network drive.

The R&S®UPV can be remote-controlled via IEC/IEEE bus, RS-232-C and LAN, as well as from a detached PC via LAN by using Windows®Remote Desktop. All common interfaces are provided:

- Four USB connectors for mouse, external keyboard, USB stick, etc
- Connector for external monitor
- Parallel interface for connecting a printer
- LAN interface for connecting a network and for remote control
- IEC/IEEE bus and RS-232-C interface

Effective visualization of measurement results

The numeric display panel shows up to eight results in realtime for one or both channels and for several measurement functions. If a measurement function is switched off, its display field will also be deactivated. Any representation can be visualized with bars and limit value violations, and you can also add Min/Max values (FIG 5). You can open several graphical windows and thus simultaneously visualize a sweep, the fast Fourier transform and the waveform, for example. If you change the size of the display field, the analyzer automatically adapts legends, font sizes, gridlines, etc.

You can measure the graphical display of a trace with vertical and horizontal cursors. You can also superimpose limit lines and stored measurement results on a trace and perform comparisons. You can display, store or evaluate groups of traces for both measurement channels.

Valuable tool in production

Many of its features make the R&S®UPV particularly useful in production:

- All measurement functions run simultaneously on both channels. Compared to other instruments on the market, this alone cuts the measurement time required for stereo measurements in half.
- In distortion and intermodulation measurements, the R&S®UPV provides digital methods that combine high accuracy with high measurement speed.
- Frequency response measurements which are performed using the special multitone signal and coupled FFT analysis are fast. Since these measurements are very frequent, total time is significantly reduced.
- Due to digital signal processing, the internal setting and settling times are shorter than those obtained with purely analog instruments.
- An integrated program generator which, in the logging mode, generates a complete and syntactically correct IEC/IEEE-bus program line from each manual operating step minimizes the time required for creating control programs.
- Calibration intervals are lengthy due to the large number of digital components, yielding high instrument availability.

Ready for the future

As digitization progresses, it will bring about changes in audio technology and produce new measurement methods and interfaces. The Audio Analyzer R&S®UPV is ready to meet these challenges. Since all of its measurement functions are implemented digitally, they can easily be adapted to changing requirements by simply updating the software. Two plug-in cards at the rear of the instrument can accommodate additional hardware, e.g. new digital audio interfaces.

Walter Nestler

More information and data sheet at www.upv.rohde-schwarz.com

FIG 1 The new Spectrum Analyzer R&S®FSU50 expands the product family to 50 GHz.

Spectrum Analyzer R&S®FSU50

Excellent measurement accuracy up to 50 GHz and higher

The new Spectrum Analyzer R&S®FSU50 extends the upper frequency limit of the successful product family to 50 GHz. While the existing members of the R&S®FSU family offer top-quality characteristics with respect to dynamic range, measurement speed and accuracy at lower frequencies, the R&S®FSU50 provides these same excellent characteristics for frequencies that extend into the microwave range. Options for the rest of the product family can, of course, also be added to the R&S®FSU50, enabling it to handle a wide range of applications.

Top-quality characteristics in the microwave range

The growing demand for radiocommunications calls for higher frequencies since all lower-range frequencies have already been allocated worldwide. Frequency bands above 40 GHz have traditionally been reserved mainly for military applications due to the highly sophisticated technology involved. Advances in technology will, however, result in the commercial use of the higher microwave bands. For example, a frequency range from 10 GHz to 66 GHz is planned as part of network standardization for point-to-point connections.

The commercial use of higher microwave ranges and the mass production of corresponding components present new challenges for T&M equipment. These challenges have been taken into account by Rohde&Schwarz in the development of its new Microwave Spectrum Analyzer R&S®FSU50 (FIG 1).

The analyzer is largely based on the lower-frequency models of the R&S®FSU family [*]. It offers the same top-quality characteristics as well as the same operation and measurement functions. In addition to highly sensitive spectrum analysis with a wide dynamic range, the analyzer features top-quality characteristics with regard to measurement accuracy.

Dynamic range is one of the most important characteristics of a spectrum analyzer and is influenced by several parameters such as sensitivity, compression point (1 dB compression) and phase noise. The R&S®FSU50 provide excellent performance with any of these. To achieve high sensitivity, the analyzer uses fundamental mixing in the entire frequency range from 20 Hz to 50 GHz. This means that the mixer uses the fundamental of the local oscillator to mix the input signal to the first IF, which yields very low conversion loss and thus very high sensitivity. In comparison, many other microwave spectrum

analyzers use a harmonic mixing method starting at a specific input frequency. This method significantly reduces sensitivity, which means that you cannot measure low level signals. The high sensitivity of the R&S®FSU50 also offers an advantage in speed. For achieving a specific degree of sensitivity, its low inherent noise allows the use of a filter with a high resolution bandwidth. Since measurement speed depends on the square of the resolution bandwidth, doubling the bandwidth yields a fourfold increase in measurement speed. When very small signals are measured, the low inherent noise of the R&S®FSU50 produces a large S/N ratio and thus results in excellent measurement accuracy (FIG 2).

But the R&S®FSU50 is a top-class analyzer also in other respects since the measurement accuracy of a microwave spectrum analyzer is significantly influenced by tracking preselection (YIG filter). For many analyzers, compliance with specifications regarding level measurement accuracy depends on the use of preselector peaking. In this technique, preselection is tuned to the highest level reading by means of an applied input signal. In contrast, the R&S®FSU uses a patented frequency response correction mechanism and internal automatic adjustment to correctly set the preselection filter. This approach yields very good stability and repeatability of the measurement results even without the use of peaking. You can therefore achieve considerable savings in time, especially when you use the analyzer in production.

Applications up to 50 GHz and higher

Typical application examples of the R&S®FSU50 are measurements on microwave components and systems used in radio relay and radar links. It provides a number of built-in measurement routines that enable you to perform complex measurements such as C/N or determine the intermodulation point by pressing a single key (FIG 3). In this case, the analyzer is not limited to frequencies under 50 GHz. Its frequency range can be extended beyond 50 GHz by means of the option External Mixer R&S®FSU-B21. Rohde&Schwarz offers the Harmonic Mixers R&S®FS-Z60 / -Z75 / -Z90 / -Z110, which cover all frequency bands from 40 GHz to 110 GHz (FIG 4). However, operation is not limited to these external mixers. The R&S®FSU50 can also be operated with any conventional mixer you may already have. It supports both three-port and two-port mixers, and the diplexer required for operation has already been integrated. Since all important parameters are displayed in the setup summary, you can quickly configure external mixing in the R&S®FSU50 (FIG 5). Preconfigured settings are available for microwave bands up to 330 GHz, but you can also generate and store

FIG 2 Inherent noise of the R&S®FSU50 over the entire frequency range, measured with a bandwidth of 1 MHz.

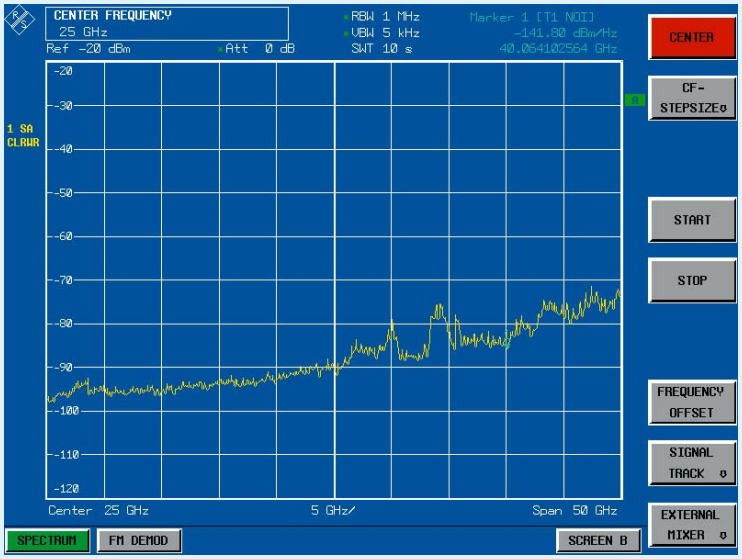
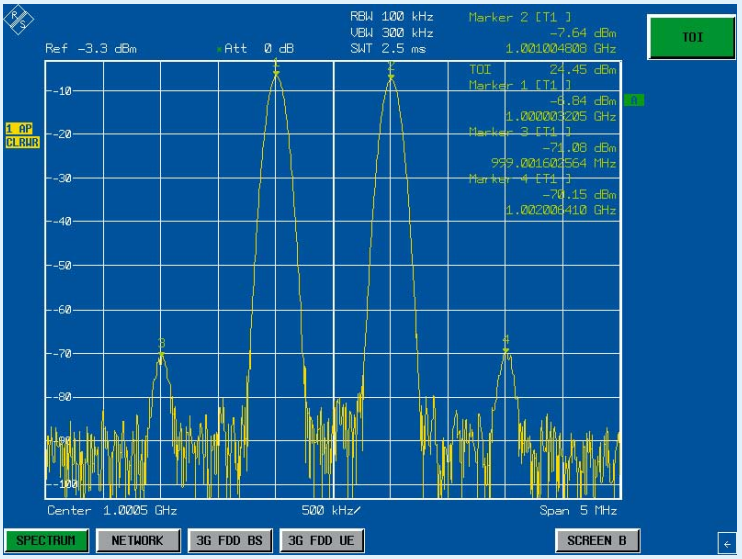


FIG 3 Measurement of the third-order intercept point.



the specific settings you need. The harmonic that is used is especially important for measurements at very high frequencies since it influences the sensitivity and the phase noise of the measurement. And this is where the R&S®FSU50 shows its particular strength. Its internal local oscillator covers the frequency range from 7 GHz to 15 GHz. Thus, the R&S®FSU50 uses a harmonic with a far lower order than that used by conventional microwave spectrum analyzers.

Kay-Uwe Sander

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

Condensed data of the R&S®FSU50

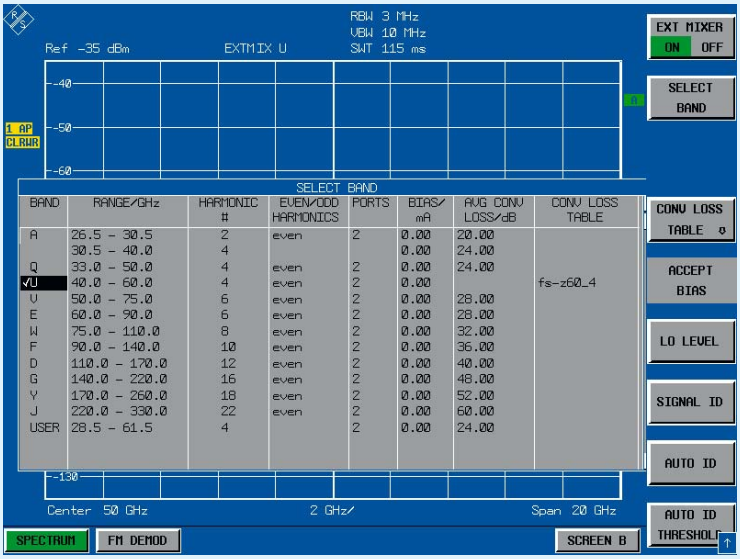
Frequency range	20 Hz to 50 GHz
Resolution bandwidths (–3 dB)	1 Hz to 50 MHz
Video bandwidths	1 Hz to 10 MHz
SSB phase noise (10 kHz offset)	–120 dBc (1 Hz) at 640 MHz
Displayed average noise level	<–142 dBm (10 Hz) at 1 GHz <–118 dBm (10 Hz) at 50 GHz
Level measurement uncertainty	<0.3 dB (f <3.6 GHz)
Detectors	Max / Min / Auto Peak, Sample, AVG, RMS, Quasi Peak

REFERENCE

[*] Spectrum and signal analyzers for every requirement – an overview. News from Rohde & Schwarz (2004) No. 182, pp 30–36

FIG 4 The harmonic mixers from Rohde & Schwarz cover all frequency bands from 40 GHz to 110 GHz.

FIG 5 Configuration menu for external mixing in the R&S®FSU50.



The R&S®FS-K7 firmware option for the R&S®FSP, FSU and FSQ [*] families of spectrum and signal analyzers enables you to measure analog modulation types such as AM, FM and φM. In addition to being able to measure modulation depth or frequency deviation, the latest version of this demodulator also measures modulation distortion such as SINAD or THD. It even performs frequency-selective measurements of modulation harmonics and measures frequency or phase settling.

Spectrum and Signal Analyzers R&S®FSP / FSU / FSQ

Extended measurement functions for analog modulation analysis

AF analysis with the AM/FM / φM Measurement Demodulator R&S®FS-K7

The trend in communications has long been toward digital transmission methods. Yet many applications such as broadcast transmission or radiotelephony still make use of traditional analog transmission with AM or FM. To determine the modulation quality of an analog-modulated signal source, the distortion of the modulation signal is of interest in addition to measuring the modulation depth for AM or the frequency deviation for FM.

By offering the R&S®FS-K7 measurement demodulator option, Rohde & Schwarz long ago made it possible to analyze analog-modulated signals in a spectrum analyzer. The measurement demodulator is based on digital processing of the sampled IF signal and allows comprehensive measurements of AM, FM and φM signals. The latest firmware version of this measurement demodulator provides extensive function expansions.

With its new and sophisticated AF analysis function, the AM / FM / φM Measurement Demodulator R&S®FS-K7 also offers **frequency-selective measurements in the modulation domain**. These measurements are especially of interest with signals that are simultaneously modulated with several AF signals (e.g. stereo broadcasting or subcarrier modulation). While a conventional modulation analyzer only measures the sum of all modulations, an additional AF analyzer enables you to separate individual signals and to measure individual modulation depths. However, this AF analyzer must first be calibrated with a known modulated signal. The inte-

grated AF analyzer in the R&S®FS-K7 option is based on an FFT of the demodulated input signal and enables you to measure frequency-selective modulation depth and distortion. This eliminates any need for an additional AF analyzer and elaborate calibration, even in the case of sophisticated modulation analysis. The result of the FFT is displayed as an AF spectrum. Modulation results can directly be read by using the marker and delta marker. Based on the measured AF spectrum, measurement routines determine the total harmonic distortion (THD) and signal to noise and distortion (SINAD) (FIG 1). Tuning to the fundamental frequency is performed automatically. The bandwidth of the AF analyzer can be set as desired. It is limited only by the maximum possible AF bandwidth (5 MHz in the R&S®FSP / FSU; 14 MHz in the R&S®FSQ). Various highpass and lowpass filters as well as deemphasis are available for filtering the demodulated signal.

A further typical application of a demodulator is to **measure settling on oscillators**. Frequency hopping methods require a specific frequency or phase accuracy after the settling time has elapsed. Previously, this measurement was expensive and effort-consuming and required several instruments. With the AM / FM / φM Measurement Demodulator R&S®FS-K7, you can perform highly accurate frequency or phase settling measurements in a single unit (FIG 2). The large bandwidth of the demodulator (in the R&S®FSQ up to 120 MHz) allows measurements with very high time resolution. The sampling rate is up to 256 Msample/s (time resolution ≈4 ns). The settling measurement is triggered either by an external signal or in response to the demodulated signal (frequency, phase or level).

All new functions can be added to an existing instrument simply by upgrading the firmware.

Kay-Uwe Sander

For further articles regarding the Signal Analyzers R&S®FSQ, see pages 26, 28 and 31.

Condensed data of the R&S®FS-K7 with the R&S®FSP and R&S®FSU (values in parentheses apply to the R&S®FSQ)

Demodulation bandwidth (–3 dB)	100 Hz to 10 MHz (28 MHz, 120 MHz with the R&S®FSQ-B72 option)
AF frequency range	DC to 5 MHz (14 MHz)
Frequency deviation	max. 5 MHz (14 MHz)
Amplitude modulation depth	0% to 100%
Measurement uncertainty	3%
Measurement range THD, SINAD	0 dB to 80 dB

More information and data sheet at www.rohde-schwarz.com (search term: FS-K7)

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[*] Spectrum and signal analyzers for every requirement – an overview. News from Rohde&Schwarz (2004) No. 182, pp 30–36

FIG 1 AF spectrum display with THD and SINAD measurement.

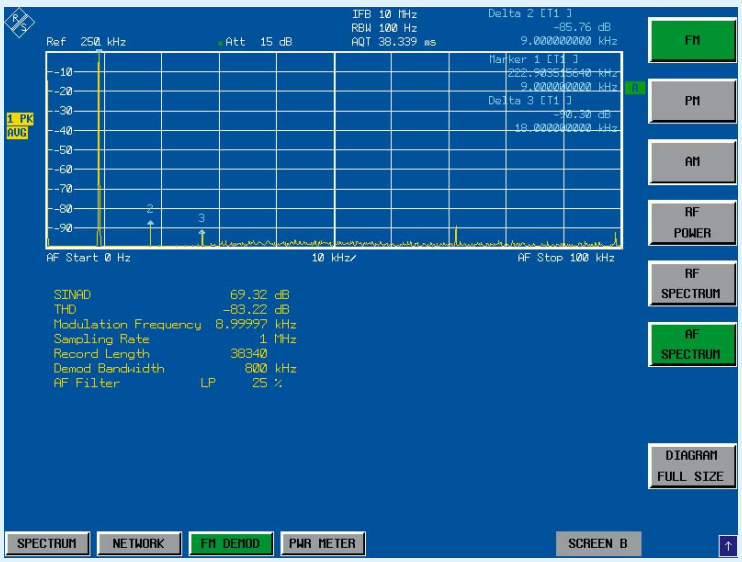


FIG 2 Frequency settling measurements on a synthesizer.

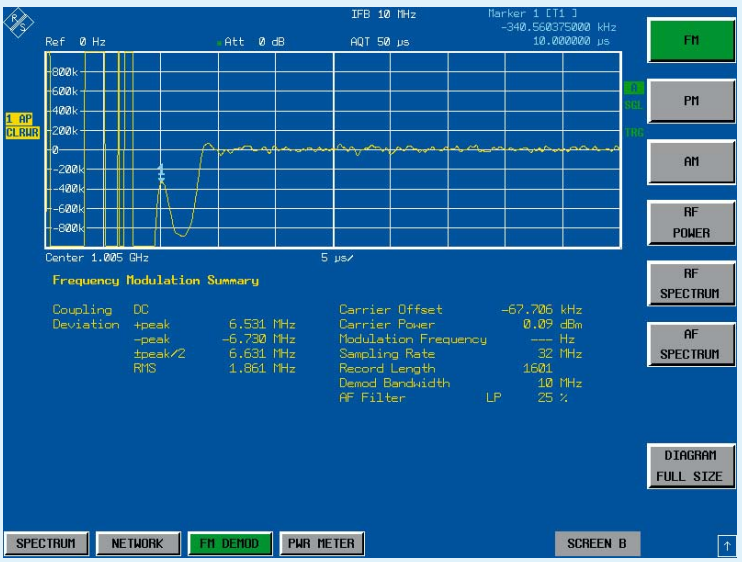


FIG 1 New member of the family: the microwave Signal Analyzer R&S®FSQ40.

The new Signal Analyzer R&S®FSQ40 (FIG 1) expands the product family in the upper microwave range. Large analysis bandwidths, very high dynamic range and sensitivity as well as unique measurement functions – e.g. the Vector Signal Analysis R&S®FSQ-K70 – are now also available in the frequency range up to 40 GHz.

Signal Analyzer R&S®FSQ40

Signal analysis now up to 40 GHz

Excellent RF characteristics for signal analysis

The Signal Analyzer R&S®FSQ40 is based on the tried-and-tested models of the R&S®FSQ family and offers their outstanding characteristics, convenient operation and the complete range of measurement functions [1]. The concept behind the RF section of the signal analyzer largely corresponds to that of the R&S®FSQ26. Fundamental mixing yields excellent sensitivity over the entire frequency range up to the highest input frequency of 40 GHz (FIG 2). With a wide dynamic range, low phase noise (typ. 110 dBc (1 Hz) with 100 kHz carrier offset, at 26 GHz) and analysis bandwidths up to 120 MHz (with the R&S®FSQ-B72 option), the R&S®FSQ40 meets all requirements for signal analysis on broadband transmission systems extending even into the microwave range.

Ready for new challenges

The number of microwave links has clearly increased over the past several years. This increase is a direct result of the infrastructure networks of mobile radio companies [2]. However, since the capacities of the frequency bands for microwave links are far from sufficient

for the new networks, new bands in the 28 GHz and 32 GHz range have recently been introduced. These bands are primarily reserved for quickly setting up the infrastructure required for the UMTS networks.

The situation is quite similar for satellites. In both cases, the dense occupancy of the spectrum places high requirements on transmission system transmitters and receivers, and the standardization bodies frequently permit only very small tolerances. To prove compliance with these specifications, you need a signal analyzer that has excellent characteristics in the relevant frequency range. Owing to its fundamental mixing, the Signal Analyzer R&S®FSQ40 ensures very high sensitivity in the complete frequency range up to 40 GHz.

The trend in digital communications – especially as far as high transmit frequencies are concerned – has been toward increasingly higher data rates and thus larger bandwidths in transmission channels. With satellites for example, transponders still operate at a bandwidth of 36 MHz, although a bandwidth of up to 72 MHz will soon be available. Apart from the bandwidth, high linearity, amplitude and phase accuracy requirements have also to be met by amplifiers and mixers. The R&S®FSQ40, when equipped with its R&S®FSQ-B72 broadband option, is one step ahead of current development [3]. Analysis bandwidths up to 120 MHz enable you to perform modulation measurements even on extremely broadband transmission links.

Condensed data of the R&S®FSQ40

Frequency range	20 Hz to 40 GHz
Displayed average noise level 2 / 26.5 / 40 GHz	–146 dBm / –136 dBm / –128 dBm (measured at a bandwidth of 10 Hz)
Resolution bandwidths	10 Hz to 50 MHz in steps of 1 / 2 / 3 / 5
Analysis bandwidth (I/Q data)	28 MHz in base unit (up to 120 MHz with option R&S®FSQ-B72)
Total amplitude error	<0.3 dB to 3.6 GHz <3 dB to 40 GHz

Level errors within the analyzer bandwidths are <0.3 dB for frequencies up to 3.6 GHz and typ. <1 dB for frequencies up to 40 GHz.

To assess the quality of digitally modulated signals, you have to measure the deviation of the transmit signal from the ideal comparison signal. This measurement, which is referred to as error vector magnitude (EVM), characterizes the distortions that occur during the transmit process and on the transmission path. With the R&S®FSQ40 and the option Vector Signal Analysis R&S®FSQ-K70,

FIG 2 Inherent noise of the R&S®FSQ40 over the complete frequency range, measured with a bandwidth of 1 MHz.

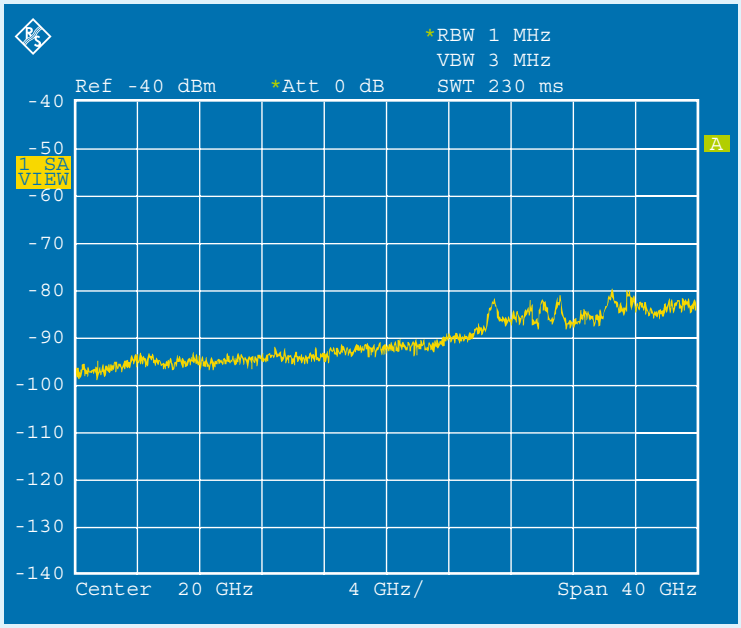
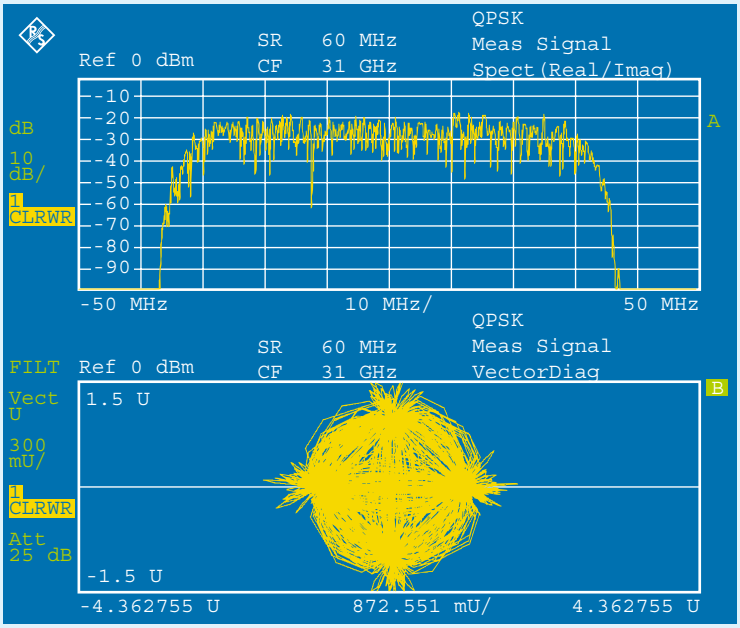


FIG 3 Spectrum and vector diagram of a QPSK signal with a symbol rate of 60 MHz.



you can now measure EVM on transmit frequencies up to 40 GHz [4]. The R&S®FSQ40 is thus ideal for performing measurements on broadband and digitally modulated signals. FIG 3 shows measurements on a QPSK-modulated signal sent with a frequency of 31 GHz and a symbol rate of 60 MHz (72 MHz RF bandwidth) as may be required in satellite systems.

Summary

The Signal Analyzer R&S®FSQ40 sets new standards in the spectral and modulation analysis of broadband digitally modulated signals in the frequency range up to 40 GHz. It will therefore become an indispensable tool in microwave and satellite communications.

Michael Wöhrle

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

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[1] Signal Analyzers R&S®FSQ: Bandwidth and dynamic range for future systems and technologies. News from Rohde & Schwarz (2002) No. 174, pp 17–21

[2] Strategische Aspekte zur Frequenzregulierung der Regulierungsbehörde für Telekommunikation und Post (Strategic aspects for frequency regulation of the German Regulatory Authority for Post and Telecommunications (www.regtp.de)

[3] Signal Analyzer R&S®FSQ: Broadband signal analysis up to 120 MHz. News from Rohde & Schwarz (2004) No. 181, pp 30–31

[4] Signal Analyzer R&S®FSQ: Application software for precise vector signal analysis. News from Rohde & Schwarz (2003) No. 178, pp 32–35

Signal Analyzer R&S®FSQ

The complete family of wireless LAN standards: 802.11 a, b, g, j, n

The option R&S®FSQ-K91 combines the complete family of WLAN standards in one analyzer and offers standard-conforming measurements as well as diverse analysis features for tasks in development labs.

Analyzer subject to numerous requirements

The IEEE802.11 family of wireless LAN standards covers both single-carrier and multicarrier methods with data rates from 1 Mbit/s to 54 Mbit/s. Future enhancements that can double the data rate to 108 Mbit/s are already planned. A WLAN module that is equipped with all functions for standard 802.11g must, for example, be able to switch between the modulation modes DSSS, CCK, PBCC, OFDM and DSSS-OFDM and support 14 different data rates (FIG 1). The WLAN option R&S®FSQ-K91 for the high-end Signal Analyzer R&S®FSQ follows the DUT by automatically detecting all modulation modes and adapts standard-specific measurements to the transmission standard that is detected.

The R&S®FSQ is a powerful tool for analyzing WLAN signals. It can perform diverse tasks such as detailed analyses of the outer carriers of a OFDM burst or automatic checks of the spectral mask of standard 802.11b. It offers numerous convenient measurements and the complete functionality of a spectrum analyzer.

FIG 1
All standards supported by the option R&S®FSQ-K91.

Standard	Modulation mode	Channel bandwidth	Data rate in Mbit/s
802.11 a	OFDM	20 MHz	6 to 54
802.11 b	DSSS, CCK, PBCC	20 MHz	1 to 11
802.11 g	DSSS, CCK, PBCC	20 MHz	1 to 33
	OFDM, DSSS-OFDM		6 to 54
802.11 j	OFDM	10 MHz	3 to 27
		20 MHz	6 to 54
Turbo mode	OFDM	40 MHz	12 to 108

Intelligent burst detection

As an example of how the R&S®FSQ works when combined with the option R&S®FSQ-K91, consider a typical measurement case for standard 802.11g: WLAN module A communicates with WLAN module B via the fast 54 Mbit/s OFDM method. WLAN module C, which is of an earlier design, is added and all three modules drop back to the slower CCK mode with 11 Mbit/s. The R&S®FSQ measures directly at the antenna of module A.

After evaluating the signal field of each recorded burst, the option R&S®FSQ-K91 will output an overview of the data rates used (FIG 2) at the press of a button. If automatic demodulation is on, the first burst in the capture buffer determines the modulation type and the data rate for further measurements. Thus, no manual readjustments are necessary when changing the transmission mode since both single-carrier and OFDM methods are reliably detected. In addition, an auto-level function ensures optimum modulation of the input signals during the entire measurement, thus freeing you from having to make complex level and attenuation settings.

In addition to automatic evaluation, bursts of a certain modulation type and length can be specifically analyzed. You can easily exclude the short acknowledge bursts from the evaluation by predefining a minimum length for the useful range. Moreover, you can define the number of bursts to be evaluated. Thus, you need to make only a few settings if you want to analyze, for example, 500 bursts at 11 Mbit/s CCK and a short preamble whose useful range is between 100 µs and 150 µs.

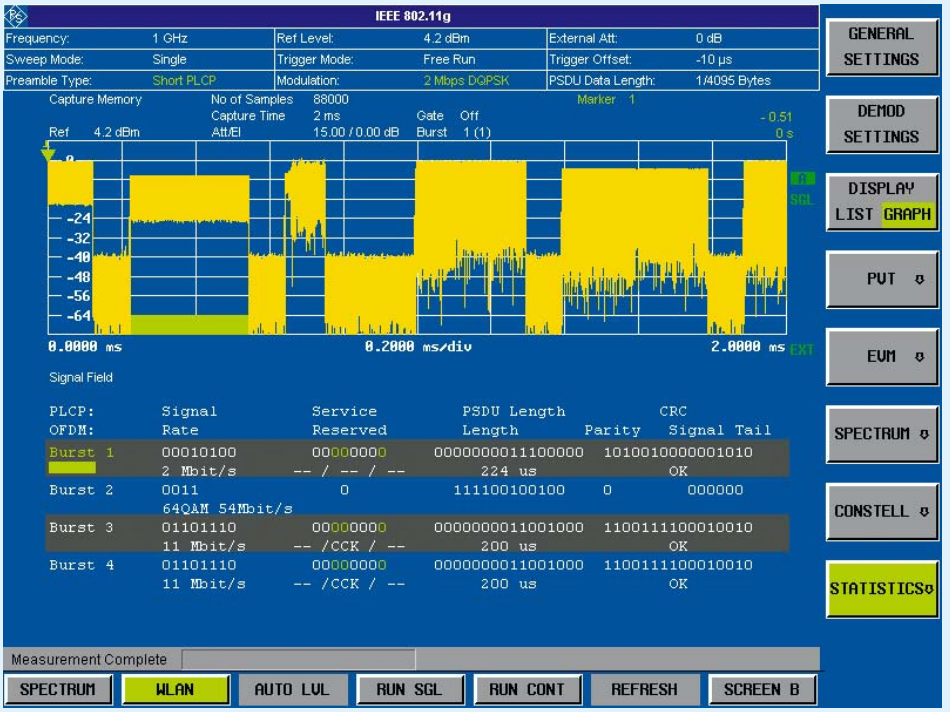


FIG 2 Four detected bursts in the capture buffer. The signal field indicates the data rates.

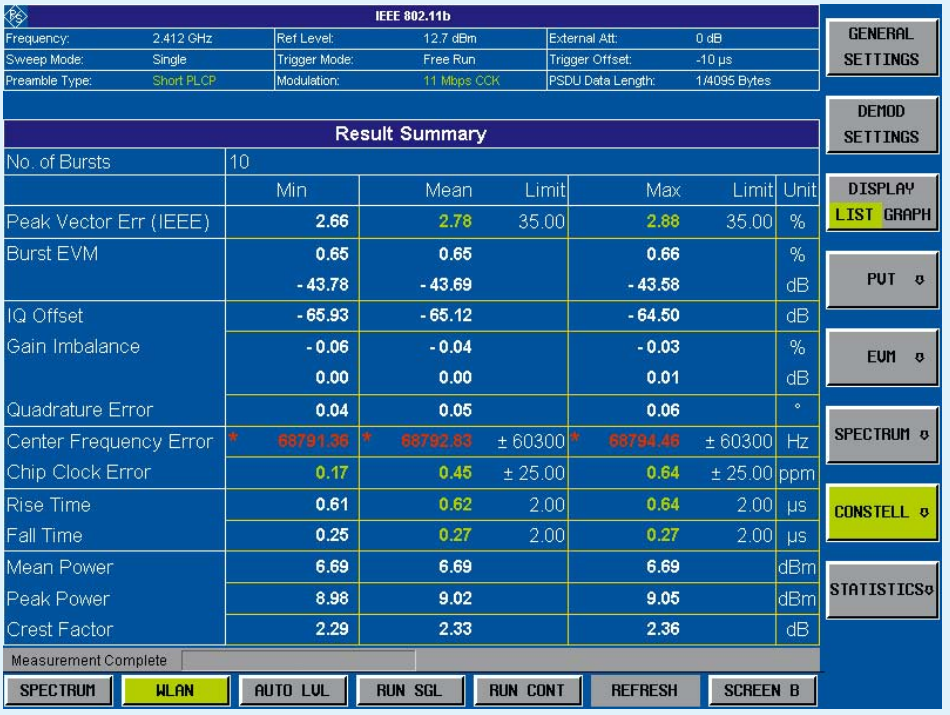


FIG 3 Overview of the most important measurement results for standard 802.11b. The frequency error has exceeded the permissible absolute limit and is shown in red.

Convenient measurements

A detailed result list provides the most important parameters at a glance (FIG 3). The limit values specified in the standard are checked, and deviations are marked in red. Moreover, you can edit all limit values. The measurement results are statistically evaluated over a definable number of bursts, which enables you to spot any outliers by displaying the average, minimum and maximum.

For more accurate spectrum analysis, graphical evaluations for any type of measurement are available. Variations in transmission frequency that occur at start of burst, for example, cause compatibility problems with the receivers. Since the frequency error and phase error in the preamble are displayed, such transients are immediately visible (FIG 4).

Although the single-carrier methods of standards 802.11b and 802.11g do not specify any special transmit filters, the transmit signal must comply with the standard-conforming spectral mask. Merely by pressing a button, you can instruct the spectral measurements of the WLAN option to display the signal spectrum and the associated mask on the screen and automatically check whether the mask limits have been exceeded. The gating function enables you to select and analyze specific areas of a burst. You can use either a level-adjustable power trigger or an external trigger as a time reference.

Constellation diagram or error vector magnitude (EVM) over all symbols plus numerous other measurements meet almost every requirement. Additional OFDM subcarrier evaluations complement the range of measurements for multicarrier methods.

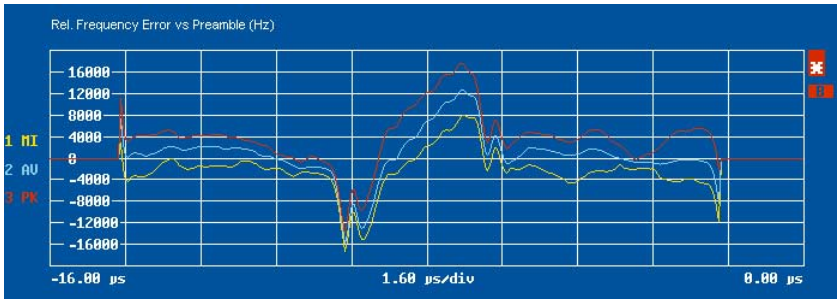


FIG 4 Unwanted frequency variations in the preamble of an OFDM signal.

Ready for the future

An expanded setting menu in standard 802.11a enables you to change the sampling rate and thus the OFDM carrier spacing. This allows you to develop customer-specific WLAN systems with flexible data rates. Even today, WLAN modules are already in use that make data rates of up to 108 Mbit/s possible by doubling the carrier spacing from 312.5 kHz to 625 kHz. These modules also occupy a bandwidth of 32 MHz. With the optional Bandwidth Extension R&S®FSQ-B72, the R&S®FSQ analyzes signals with bandwidths of up to 60 MHz ($f_c \leq 3.6$ GHz) or 120 MHz (fc > 3.6 GHz). Therefore, it is ready to handle future expansions of the standard, such as 802.11n.

The OFDM method with double carrier spacing is already integrated in the WLAN option as “turbo mode”. It is just as simple to choose the 10 MHz mode of standard 802.11j, which reduces the carrier spacing by half. Both modes offer the same full measurement convenience available for the standard 802.11a. Time and frequency specifications are adapted to the standard-specific carrier spacing.

Summary

By offering a large number of convenient measurement functions, the combination of the R&S®FSQ and the option R&S®FSQ-K91 is a must in every WLAN development project. With its flexible sampling rates and bandwidths of up to 120 MHz (when equipped with the option R&S®FSQ-B72), the signal analyzer is ready today for the future expansions of the standard.

Dr Gregor Feldhaus

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

REFERENCES
See box on page 28.

Expanded recording length for vector signal analysis

Firmware version 3.45 for the Signal Analyzer R&S®FSQ significantly increases the maximum data recording length possible with the option Vector Signal Analysis R&S®FSQ-K70. The new memory management mechanism now allows up to 16 Msamples of measurement data to be recorded with only one trigger event.

The primary advantage of the additional memory is that 15.4 seconds of a GSM or EDGE signal can now be stored without interruption. This considerably simplifies the detection and evaluation of signal transients, especially when no trigger signal is available at the time of interference.

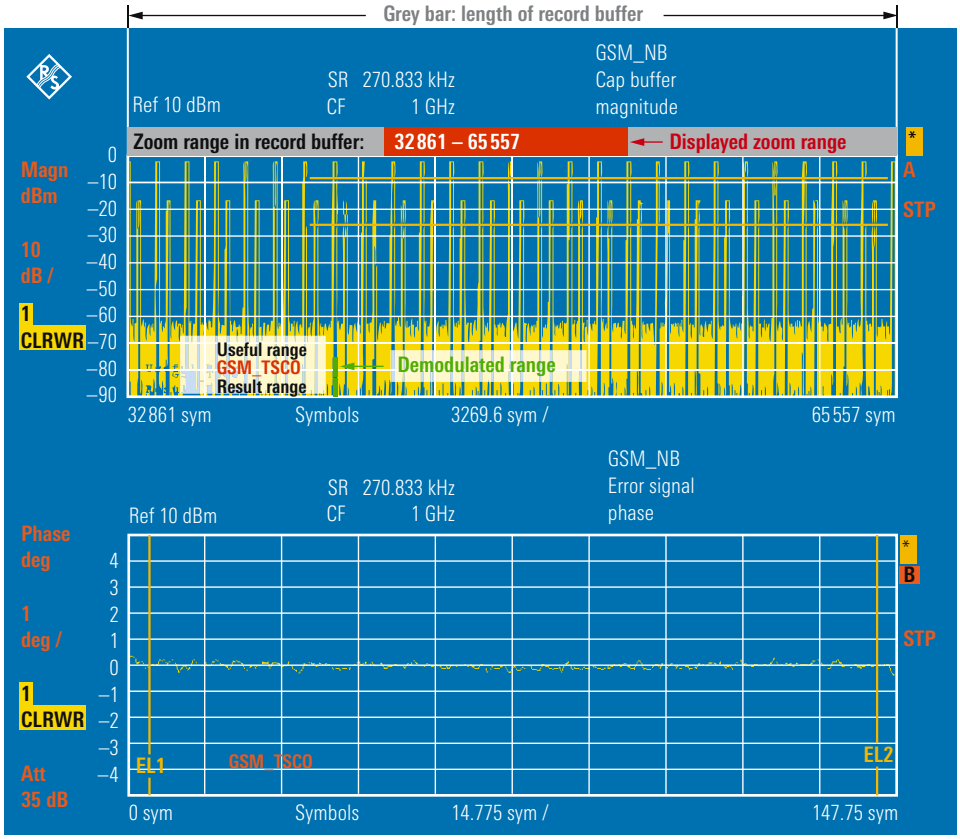
After data is recorded, you can select the memory areas to be demodulated by the analyzer. Likewise, you can repeat the demodulation of a recorded signal either with modified demodulation parameters or result displays. Thus, you can change parameters such as result lengths or synchronization patterns or adapt thresholds used to search for bursts. The expanded memory is, of course, useful not only for burst signals. Continuous signals can also be processed.

The R&S®FSQ marks the position of the displayed section of the record memory (max. 32 ksamples) with a red bar at the top edge of the diagram. The upper measurement window (figure) shows the memory area evaluated by the analyzer. In this example, the memory area contains a series of GSM bursts. The area demodulated by the R&S®FSQ is marked with a green bar. The lower measurement window shows the phase error.

The enhanced recording capability opens up new applications not only in development labs but in radiomonitoring as well. In production, a DUT no longer needs to be connected during the entire evaluation of the measurement data. Instead, it can be moved immediately after the data is recorded, and contact with a new DUT can be set up. This saves process time and increases the throughput of the automatic measuring system.

The new functions are available in the Signal Analyzer R&S®FSQ as of firmware version 3.45.

Hagen Eckert



The R&S®FSQ marks the displayed section of the record memory and the demodulated area in different colours.

FIG 1 The Industrial Controller R&S®PSL1 comes with a wealth of equipment, yet takes up only one height unit.

Industrial Controller R&S®PSL1

Compact yet sophisticated

Controllers are expected to ensure smooth operation, making them a pivotal part of complex measurement systems. The R&S®PSL1 from Rohde & Schwarz, the latest member of the R&S®PSL industrial controller family, is a controller that satisfies ambitious requirements and whose low height is virtually unrivalled.

Purchase with the future in mind

Today you can buy a controller at the electronics supermarket rather than develop or produce it yourself. This solution is tempting in an age when computers are available at almost every corner and often at rock-bottom prices. But what happens just six months later if you require a controller of the same type or a spare part for the PC on which complex and expensive system software has run smoothly to date? You will usually have a hard time finding a suitable replacement, and the allegedly compatible new controller may interact in a completely different way with software that worked fine in the past. You may suddenly find yourself forced to make expensive and lengthy software adaptations and modifications that no one was expecting. This is the nightmare of every system provider. Such situations make you even more appreciative of having a manufacturer that offers powerful industrial controllers that remain reliable for a long time to come. Rohde & Schwarz is now introducing the R&S®PSL1, the latest addition to the R&S®PSL [*] industrial controller family. This powerful controller with flat 19" housing takes up only one height unit and is thus ideal for installations where space is limited (FIG 1).

Emission impossible

Systems for measuring, analyzing or locating electromagnetic signals must contain equipment with minimum radiated emission. However, unwelcome surprises may be in store for you if a controller does not live up to the promises made in the EMC specifications of its data sheet. The R&S®PSL1 won't let you down: Owing to comprehensive testing in the Rohde&Schwarz EMC labs and its sophisticated design, the controller verifiably radiates minimum emission to the outside (FIG 2). For example, when the motherboard was designed, it was crucial that it comply with EMC requirements. The numerous inputs and outputs were complemented by EMC filters and the entire housing was designed as a metal cage. Controller components such as a keyboard or mouse were checked and, if necessary, modified and adapted to meet the desired quality standard. Such refined shielding prevents any unwanted radiated emission and, vice versa, protects the R&S®PSL1 and its internal modules against strong electromagnetic fields. This ensures smooth operation even when it is close to antennas of powerful transmitter systems.

Long-term failsafety

The core of each controller is the motherboard and its CPU. This sensitive component must function reliably and without errors to ensure long-term smooth operation of the entire system. The R&S®PSL industrial controller family uses the same computer kernels that are used in T&M equipment from Rohde&Schwarz, which have been tried-and-tested ten thousands of times. Thus, the controllers in this family achieve above-average meantime between failure (MTBF) values and significantly contribute to the failsafety of a system. Each motherboard is populated with high-end components, and the other device components such as power supply or drives must meet the high quality criteria that Rohde&Schwarz stands for.

Wealth of interfaces

Despite its compact size, the R&S®PSL1, which is primarily used as a central controller, comes with a wide variety of interfaces. In addition to several Ethernet and USB connections, it also provides an IEC/IEEE bus or five serial interfaces plus an audio input/output, depending on the model. Even with this wealth of equipment, the instrument is so compact in design that it offers an internal PCI slot for installing an additional expansion board.

Low power dissipation

Since its motherboard is populated with power-saving components, the R&S®PSL1 has very low power consumption. This drastically reduces power dissipation and minimizes warm-up of the surrounding environment. Since failure rate, which is strongly temperature-dependent, and susceptibility of the system devices to interference need to be kept to a minimum, this is a significant advantage.

Thomas A. Kneidel

More information at www.rohde-schwarz.com (search term: PSL1)

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[*] Industrial Controller R&S®PSL3: New controller generation provides ideal characteristics for industry. News from Rohde&Schwarz (2003) No. 179, pp 16–18

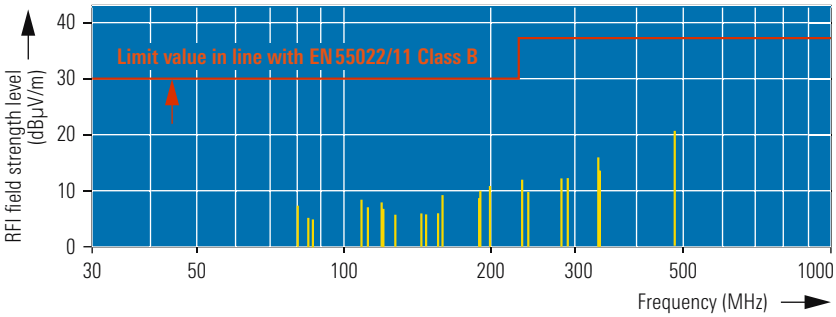

FIG 2 Typical interference level of the R&S®PSL1.

Condensed data of the R&S®PSL1

Processor	latest generation of Intel™ processors
Drives	hard disk and combined DVD/CD-RW disk drive
Interfaces	PCI slot VGA, DVI-D 2 × Ethernet, 4 × USB, 1 × RS-232-C and IEC/IEEE or 5 × RS-232-C and Audio-In/Out, Mic-In
Dimensions	19", 1 HU
Power supply	100 V to 240 V
Power consumption	approx. 35 W

New Power Sensors for R&S®NRP, NRT und FSH

When it comes to power measurements, a reliable sensor is a must

Power measurements are pivotal in RF and microwave. Even though frequency-selective measurements with spectrum analyzers are gaining in importance, broadband power sensors will remain your first choice when it comes to high measurement speed, low measurement uncertainty and a favourable price/performance ratio. Rohde & Schwarz has again expanded its sensor families by adding four new types (FIGs 1 and 2).

Highly efficient

The four new sensors have one characteristic in common: They all feature rms detectors that ensure "correct" measurements even with modulated, harmonic and spurious signals. Correct, in this case, means that the detectors provide an output signal that is proportional to the average power or, as is the case with the R&S®NRT-Z14 and R&S®FSH-Z14 sensors, that follows the envelope power. The envelope power is the signal power during a carrier period, and the average power is an integral value during a modulation period or a first-order expected value for stationary nonperiodic signals. Average power and peak envelope power (PEP) are key parameters for RF and microwave signals. The average power directly determines the propagation range, and the PEP is a quantity for the electrical loads of the components involved in signal transmission and signal generation.

R&S®NRP-Z55

Thermal sensors have traditionally been used for power measurements. Despite their relatively small dynamic range, they are still the first choice when it comes to high measurement accuracy. This is especially true for the thermal sensors from Rohde & Schwarz, which feature very low measurement uncertainties over the entire frequency and power range because of their outstanding matching and their customized linearity. Yet the Thermocouple Power Sensor R&S®NRP-Z55 goes even a step further – neither measurement range selection nor the base unit impair the power sensor's measurement accuracy. It is thus a highly accurate reference sensor with a continuous frequency range from DC to 40 GHz. And by controlling the sensor directly via the USB interface of a PC, you obtain a measurement solution with an unrivalled price/performance ratio.

R&S®NRP-Z91

This new power sensor is highly versatile. Featuring a dynamic range of 90 dB and a frequency range of 9 kHz to 6 GHz, it is ideal for anyone who needs to measure and control RF. Like all other R&S®NRP sensors, it can be directly operated from the USB interface of a PC and is thus suitable for integration into price-sensitive EMC measurement systems. From a technical standpoint, this new sensor represents an innovative multipath architecture [*] that is currently available only from Rohde & Schwarz. Three simultaneously functioning measurement paths and special detector diodes with a large square-law region ensure

FIG 1 The new sensors at a glance.

Type	Function/technology	Frequency range	Power range	Measurement functions
R&S®NRP-Z55	Thermocouple terminating sensor	DC to 40 GHz	1 µW to 100 mW	Average power
R&S®NRP-Z91	3-path diode terminating sensor	9 kHz to 6 GHz	200 pW to 200 mW	Average power
R&S®NRT-Z14 and R&S®FSH-Z14	Directional power sensor for power and matching measurements	25 MHz to 1 GHz	30 mW to 300 W	Average power, peak power, matching

FIG 2 **Rohde & Schwarz again expands its families of sensors by adding four new types.**

accurate measurement results plus short measurement times. Moreover, intelligent noise filtering, settable integration times, and gamma and S-parameter correction combine to provide the measurement convenience that is to be expected from a state-of-the-art power meter.

R&S®NRT-Z14 and R&S®FSH-Z14

These two intelligent sensors are actually small measurement systems. Equipped with a double directional coupler and power sensors for forward and reflected power, they can perform power and matching measurements in the classic radiocommunications frequency bands. The R&S®NRT-Z14 can be operated either on the R&S®NRT base unit or a PC, while the R&S®FSH-Z14 has been designed for use on the Handheld Spectrum Analyzer R&S®FSH. The power sensor was designed to permit direct measurements on transmitters and antennas in field applications, production and research and development without having to insert additional directional couplers or attenuator pads. The new sensors are based on the same concept used with the successful R&S®NRT-Z43 / -Z44 sensors and, like them, offer outstanding measurement characteristics: 30 dB directivity for accurate matching and power measurements, immunity to harmonics and spurious (they can therefore be used directly at amplifier output stages), low calibration uncertainty and possible peak power measurement with a settable video bandwidth (4 kHz / 200 kHz / 600 kHz). Moreover, the R&S®NRT-Z14 sensor can measure the average power of modulated and unmodulated RF bursts as well as the amplitude distribution (CCDF). Both sensors are, of course, virtually free of interaction with the measurement setup. Due to low insertion loss and excellent matching, they do not affect a test setup any more than does a segment of a coaxial cable of the same length. This makes the sensors ideal for monitoring applications.

Thomas Reichel

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

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[*] Power Meter R&S®NRP – Evolution in power measurement – intelligent sensor technology. News from Rohde & Schwarz (2002) No. 174, pp 12–16

Vector Signal Generator R&S®SMU200A

Complex signal scenarios at almost no effort

The high-end Vector Signal Generator R&S®SMU200A can house two complete generators with digital modulation capability in a single instrument [1]. This design not only saves 50% in space but also enables you to use applications that have previously either not been possible at all or only at high cost and effort.

Fast, two-path solution

A fully two-path R&S®SMU (i.e. with two baseband generators and two RF paths, FIG 1a) instead of two separate generators offers significant advantages. A classic application is the testing of receivers by superimposing an interfering signal. One path of the R&S®SMU generates the useful signal, the other the interferer. You can thus carry out tests on 3GPP base stations in accordance with TS25.141, for example, using both unmodulated and QPSK-modulated interferers. Also, the addition of noise (AWGN) is possible in both paths [2].

A high-end generator like the R&S®SMU, however, enables you to use measurement methods far beyond such standard scenarios. Every R&S®SMU baseband generator contains a powerful arbitrary waveform generator (ARB) which is fully supported by Simulation Software R&S WinIQSIM™. You can even use multicarrier signals as interferers. For example, the receiver of a 3GPP mobile station can be tested during high network activity (i.e. the base station is transmitting on adjacent carrier frequencies simultaneously). A further application is the simultaneous simulation of different mobile radio standards, e.g. one path generates a 3GPP signal while the other generates a GSM carrier.

You can also route two baseband generators of an R&S®SMU to one RF path (FIG 1b). Their signals can be digitally added including power and frequency offset. The generator thus produces extremely complex signal scenarios that are highly similar to real conditions.

One scenario currently of great importance is the coexistence of different data transmission systems such as WLAN 802.11 or *Bluetooth*®*. Like WLAN 802.11 b and g, *Bluetooth*® uses the 2.4 GHz ISM band. Thus, if a WLAN

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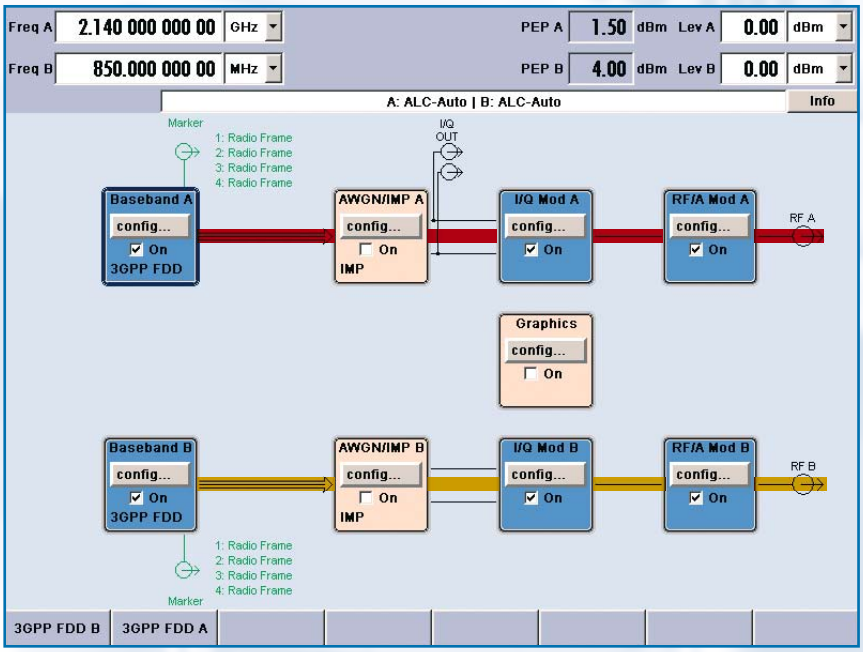

The two basic configurations of the two-path R&S®SMU:

FIG 1a
The R&S®SMU is a fully two-path vector signal generator, i.e. it has two baseband generators and two RF paths (two signal generators in one instrument). This is the ideal configuration if you want to use two paths independently of each other. This is also the optimum configuration for many receiver tests in which the useful signal and the interfering signal greatly differ in power and frequency offset (e.g. out-of-band blocking).

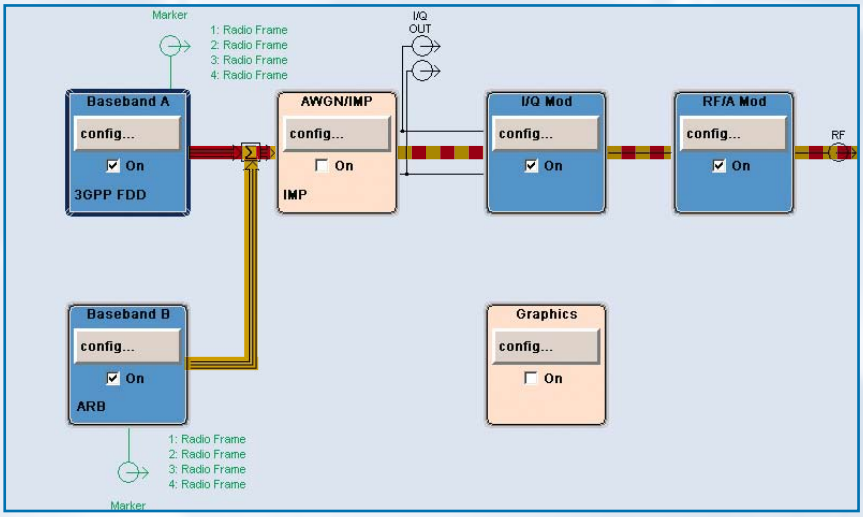

FIG 1b
You can also route two baseband generators to one RF path to generate very complex signals on one carrier frequency. In this case, no second RF path is required, as shown in the figure. If a second path is available however, you would even be able to generate another (unmodulated) signal.

FIG 2
With a two-path R&S®SMU, you can test the receiver quality of a WLAN card if a *Bluetooth* network is active in the same environment. In this case, a signal scenario like that shown in the time / frequency diagram will be generated. Baseband A generates the *Bluetooth* signal including the frequency hops (here, one *Bluetooth* master [yellow bar] and one *Bluetooth* slave [red bar]). Baseband B generates a WLAN signal at 2462 MHz (indicated by the light blue area).

receiver is implemented in an environment in which a *Bluetooth* network is active, the receiver must be tested to ensure that it functions properly (and vice versa). An R&S®SMU with two baseband generators can provide the test signal needed (WLAN useful signal with *Bluetooth* interferer) (FIG 2).

Bluetooth operates with frequency hopping in a band that is 79 MHz in width. The channel spacing is 1 MHz. Since the R&S®SMU is able to generate digitally modulated signals that are up to 80 MHz in width with the internal baseband, the entire *Bluetooth* band, including the frequency hops, can be simulated with an R&S®SMU baseband generator. The signal is then calculated with R&S WinIQSIM™ and played in the ARB of the baseband generator. The second baseband generator produces the 802.11 useful signal for the receiver test.

Although you could certainly generate a combined WLAN *Bluetooth* signal with one ARB, using the two baseband generators of the R&S®SM offers several advantages. For one, it keeps the large amount of data involved from presenting problems. Specifically, receiver tests usually require frame sequences that are 1000 frames or more in length. If these long sequences are combined with a background signal that is 79 MHz in width, the resulting waveform files are so large that many PCs cannot handle them. It would therefore be better to process the two signal components separately and subsequently add them together in realtime in the baseband section of the R&S®SMU.

The greatest benefit of the R&S®SMU solution, however, is being able to define the power and frequency offset in realtime. Thus, the S/N ratio can be varied without having to recalculate the signal each time. You can also repeat the tests for different WLAN carrier frequencies without any recalculation being required.

The comprehensive trigger and synchronization capabilities of the R&S®SMU baseband section offer further applications. For example, one baseband generator can be triggered by the other and the trigger time can be varied in realtime. The R&S®SMU can thus simulate timing errors in GSM systems, for example. This involves baseband A generating the master frame and baseband B a single timeslot (FIG 3). If B is now triggered by A and this trigger is slightly delayed, the timeslot generated by B is slightly delayed with respect to the frame time grid. This is another realistic scenario for receiver tests.

These are just a few examples of the many applications that are possible with the two-path Vector Signal Generator R&S®SMU. Additional applications are described in [3]. An R&S®SMU with two paths thus not only contains two complete signal generators but can also generate complex signal scenarios that have previously not been possible at all or only at a high cost and effort.

Dr René Desquiotz

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

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[1] Vector Signal Generator R&S®SMU 200A: The art of signal generation. News from Rohde & Schwarz (2003) No. 180, pp 21–27

[2] Vector Signal Generator R&S®SMU 200A: Noise – an annoyance? Not with the new noise option. News from Rohde & Schwarz (2004) No. 182, pp 38–39

[3] New Dimensions in Signal Generation with the R&S®SMU 200A. Rohde & Schwarz Application Note 1GP50 (to be published in autumn 2004).

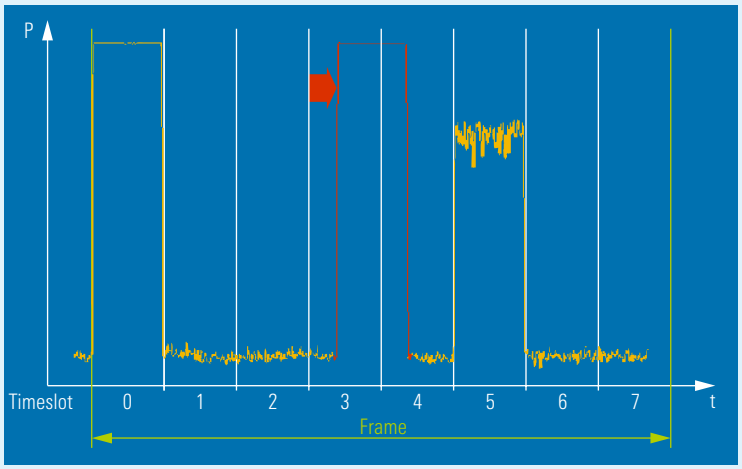


FIG 3
Simulation of a GSM timeslot with incorrect timing. Baseband A generates the master frame and triggers baseband B, which provides the timeslot to be analyzed. When the trigger is delayed, this timeslot can be shifted with respect to the time axis of the master frame.

FIG 1 The Broadcast Test System R&S®SFU: A comprehensive system for all test applications related to digital TV.

At NAB 2004, Rohde & Schwarz presented the Broadcast Test System R&S®SFU as a "test transmitter for innovative TV standards" (FIG 1). Yet the very name of this innovation already led people to suspect "test transmitter" to be an understatement. At IBC 2004 in Amsterdam, Rohde & Schwarz then brought all facts to light: The R&S®SFU showed its true colours as a comprehensive system for all test applications related to TV. This article now provides a detailed look at this future-oriented platform.

Broadcast Test System R&S®SFU

Universal test platform for digital TV

Absolutely convincing

Of course, one of the instrument's most important functions was presented at NAB 2004: the R&S®SFU as a TV test transmitter. In this application, it knows neither geographical borders nor limits defined by standards. It supports the latest standards: DVB-H* is already fully integrated with DVB-T, offering 4K mode, an in-depth interleaver and signalling of the DVB-H options via TPS carrier (FIG 2). With 4K mode and the in-depth interleaver, MPE-FEC (IP error protection ahead of the IP in MPEG-2 encapsulation) ensures a very high degree of safety with mobile reception. Time slicing saves power when handhelds are used, because data is transmitted in bursts and the signal is switched on for only a short time. DVB-H technology allows video streaming to be implemented efficiently for portable and mobile reception with small devices and mobile phones [*]

For satellite operation, the DVB-S2 standard is available with the broadcast services application in the R&S®SFU. DVB-S2 provides network operators with considerably more transmission capacity. The method is extremely robust and ensures reliable reception even with C/N ratios of –2 dB.

With DMB-T (TDS-OFDM), the R&S®SFU is a step ahead of the standard. China is awaiting the introduction of a DTV standard and is already performing field tests. DMB-T provides high-quality digital TV in the living room, but also exhibits outstanding characteristics for mobile and portable reception and supports

* Abbreviations, see page 43.

power-saving reception for handhelds with its spread-spectrum function.

Several international standards – DVB-C, DVB-S, DVB-DSNG, ITU-T/J.83/B, ATSC/8VSB and ISDB-T – will soon be available in the R&S®SFU. The nice thing about this is that these codings – as with future standards – can be loaded very easily as software options.

Comprehensive diversity

Since the R&S®SFU provides space for numerous enhancements, it can fully replace a test system consisting of diverse single units. An internal test signal generator provides transport streams in the baseband. The generator allows high-bit-rate MPEG-2 transport streams to be replayed without interruption. MPEG-2 transport streams with IP content (encapsulated MPEG-4, H264) for DVB-H applications are also available.

The familiar options from the predecessor model, the R&S®SFQ, are available on the RF end. A channel (fading) simulator provides sophisticated capabilities for simulating multipath and mobile reception. Up to 40 paths with all known profiles such as pure doppler, Rice, Rayleigh and constant phase are no problem. The simulator uses dynamic fading and fine delay to meet even special requirements. All parameters – such as attenuation, phase, delay and Doppler speed, frequency and direction – can be varied until reception is no longer possible.

A digital AWGN generator allows measurements with a precise C/N ratio, regardless of whether it involves a one-path signal or a multipath signal from the fading simulator. A new characteristic is the simulation of phase noise. This signal is used in the lab to simulate real oscillators and synthesizers with non-ideal phase noise (FIG 3).

RF signals can be generated and added to the useful signal with the integrated ARB generator, allowing effects from the adjacent channel and in the channel to be simulated. This makes an additional RF generator unnecessary in many cases.

The BER measurements option tests the effect of noise, single interference signals and poor channel conditions on the receiver. Two different measurements are available. A measurement with pure PRB sequences can check the demodulation component of the receiver; this involves feeding the data and the associated clock of the receiving component back to the R&S®SFU. The error rate of the decoding path can be measured by feeding the MPEG-2 transport stream back from the DUT to the R&S®SFU. In this case, the test signal comprises an MPEG-2 TS that contains a PRBS as payload. If path measurements on a live MPEG-2 signal are desired, this is easy to do if the null packets contain a PRBS as payload.

Open – especially for the future

The R&S®SFU's tightly sealed housing, of course, counters all interfering effects that often occur when a number of devices are coupled with each other by cable.

In contrast, the system is absolutely open for all applications. You can use the internal MPEG-2 generator, but do not have to, since all conventional input interfaces – including ASI/SPI with and without stuffing functionality, and SMPTE 310M – are available, some redundantly. Without stuffing, the R&S®SFU passes the input signal through transparently; with stuffing, the data rate is adjusted to match the necessary symbol rate.

The digital internal I/Q signal is processed by the I/Q modulator. Externally the I/Q signal is available for applications in both digital and analog form. Externally coded signals can be fed in or special interference signals added at an analog and a digital I/Q input. The internal I/Q modulator's high modulation bandwidth of 200 MHz is designed for future applications and can be used to maximum advantage with the aid of the external wideband analog I/Q input.

The R&S®SFU is also open for applications of the future. With its numerous interfaces and ARB generator, from which samples or symbols can be replayed, it is the right tool for evaluating new or modifying pending standards.

The output signal of the R&S®SFU is not limited to the RF signal of the modulator; it also supplies internal signals such as the MPEG-2 transport stream, the noise signal and the ARB signal.

The future has already been built into the R&S®SFU: A base unit with a coder can be the start. With only a few exceptions, all enhancements can be quickly and easily activated later by the user by means of a firmware update / license code.

Multitalented universal instrument

The R&S®SFU covers virtually all areas of digital TV: research and development, production (FIG 4), quality assurance, service, propagation and reception tests performed by the network operator and EMC measurements. Together with the R&S®CMU 200, it can handle transmission simulations for mobile communications, coupled with DVB-H reception (FIG 5).

Its digital signal processing in the baseband provides excellent signal quality in the frequency range from 100 kHz to 3 GHz and ensures exact measurements.

FIG 2
DVB-H / DVB-T:
The R&S®SFU supports the latest standards.

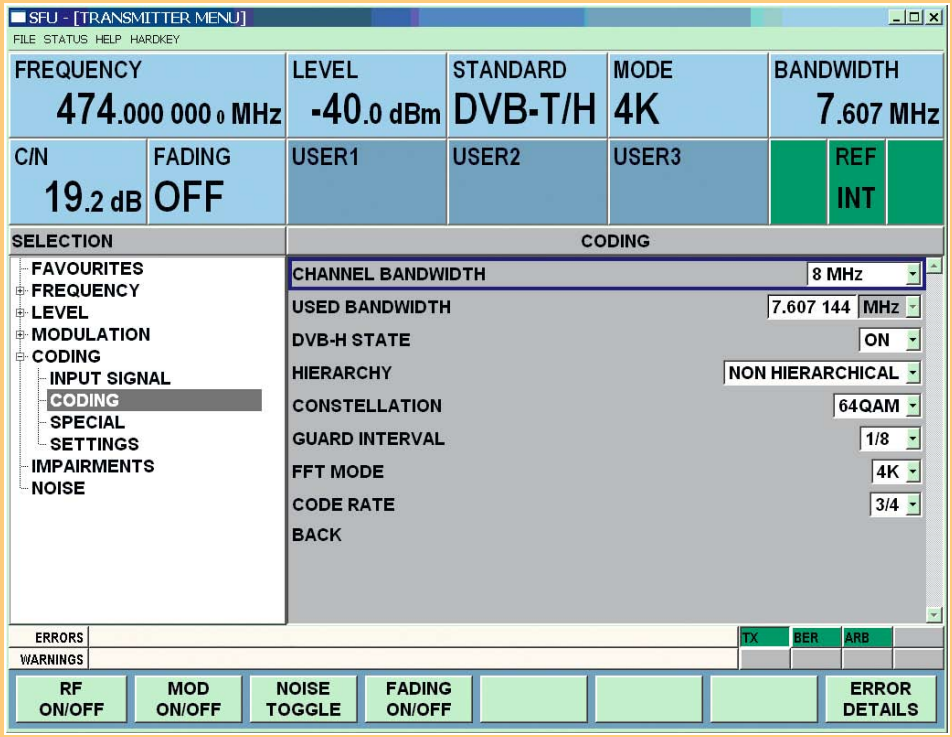


FIG 3
With its capabilities to modify and impair signals and to simulate interference, the R&S®SFU simulates rough ambient conditions in the lab under which chips and tuners can be tested to the limits of their functionality.

FIG 4
The exceptional simulation capabilities and the short setting times of the R&S®SFU allow it to be used for flexible tests that cover all requirements in modern production.

A new type of digital level control ensures high level accuracy. The repeatability of the test system attains an outstanding level of 0.05 dB even with modulated signals. The overall level uncertainty is less than 0.5 dB.

The optional power sensor can be used not only for power measurements on equipment but also for making precise measurements of the output power of the system itself. The inherent noise of the synthesizer in the R&S®SFU is typically less than –135 dBc (1 Hz) at 1 GHz and 20 kHz offset and ensures the lowest possible modulation error in the near-carrier range. Yet many other advantages make the system ideal for use in development:

- Wide variation range of all parameters
- Standard coder functions that can be switched off
- Signal impairment capabilities in the modulator
- Carrier manipulation in the RF range
- Noise generator
- Fading
- Interferer
- External I/Q inputs and outputs

A high output level is required in the development of TV equipment and in production; the R&S®SFU supplies +13 dBm. The high power and overvoltage protection option permits +19 dBm for production lines or distribution networks, and up to +26 dBm in the overrange. The wear- and maintenance-free electronic attenuator, which ensures fast switching and a long life under all conditions, is specially designed for production. For chip tests, the level can be reduced to –120 dBm.

Attractive and responsive

The R&S®SFU has an attractive design and is extremely user-friendly. Operation is based on the Windows® XP Embedded operating system together with a finely structured directory tree. The high-resolution colour display shows all information of the selected application but does not forget applications running in the background. If one of these applications is not correctly set or if problems arise, this is indicated in the selected screen. Hardkeys provide direct access, softkeys are used to operate the selected application, and the rotary knob allows all parameters to be set quickly. If you prefer a keyboard and mouse, no problem – just use the USB connectors. Settings that are frequently needed can be grouped together in the "Favorites" menu, allowing quick access via the Home key, regardless of the application. If something is unclear, simply press the Help key to open a context-sensitive menu that contains the operating manual (FIG 6).

If you cannot or do not wish to make settings directly on the instrument, you have different choices: The R&S®SFU can be fully operated from any PC, either directly via an Ethernet connection or by remote control within a LAN network via the IP. This is easy to do using the preinstalled Remote Desktop software or the VNC software that comes with the instrument. The R&S®SFU is also preconfigured with the DHCP; it is automatically assigned an IP address in these networks. The instrument can be integrated into existing test systems via an IEC/IEEE bus.

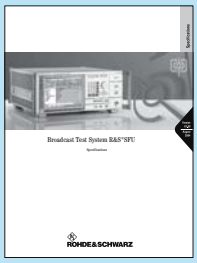
Have all the facts been put on the table?

For now, yes. But as far as the future is concerned, no. This article shows in detail that even today the R&S®SFU is more than a mere successor to the tried-and-tested R&S®SFQ. For the future, Rohde&Schwarz is already working on a series of enhancements.

This modular platform is designed with sufficient capacity for challenges that are still unknown today, so stay tuned for further innovations to the Broadcast Test System R&S®SFU.

Albert Dietl; Josef Handl; Ralph Kirchhoff

More information and specifications at www.rohde-schwarz.com (search term: SFU)

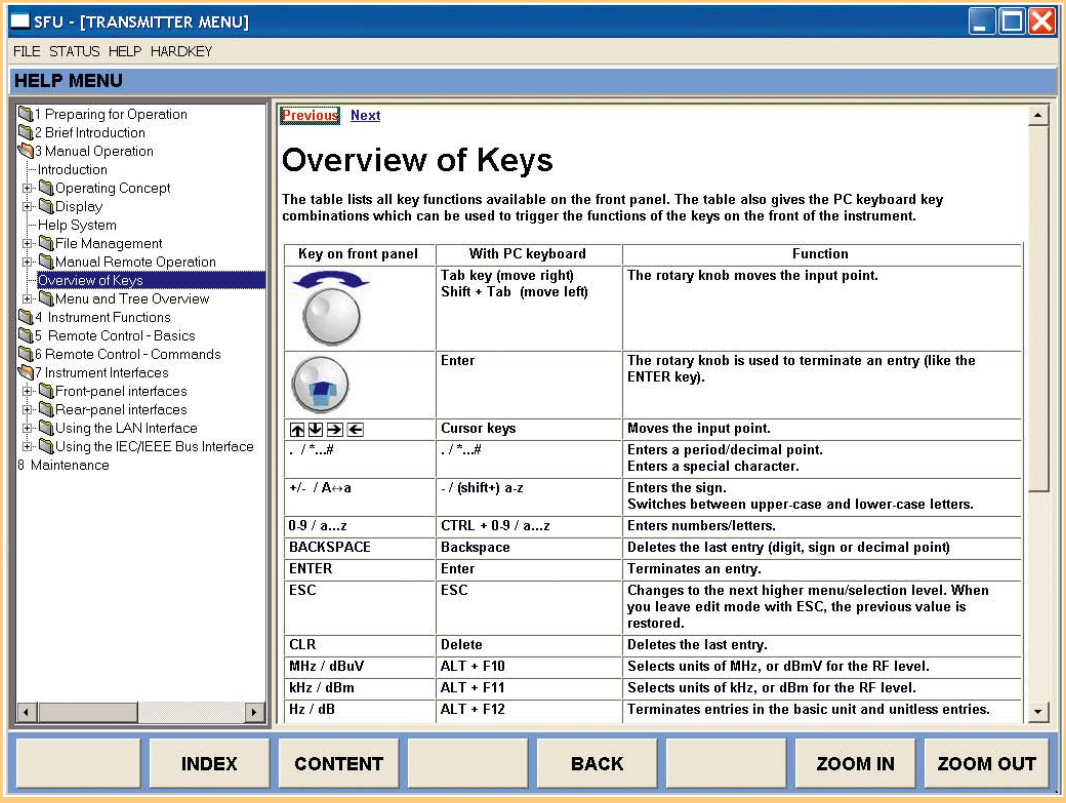


Specifications of the R&S®SFU

REFERENCE
[*] DVB-H – new digital multimedia services for mobile terminals. News from Rohde&Schwarz (2004) No. 182, pp 50–53

FIG 5
A perfect couple: The Broadcast Test System R&S®SFU and the Universal Radio Communication Tester R&S®CMU 200 – transmission simulation for mobile communications, together with DVB-H reception.

FIG 6
The straightforward help menu – which can also be zoomed – provides users with comprehensive information as well as background material that goes well beyond pure instrument operation.

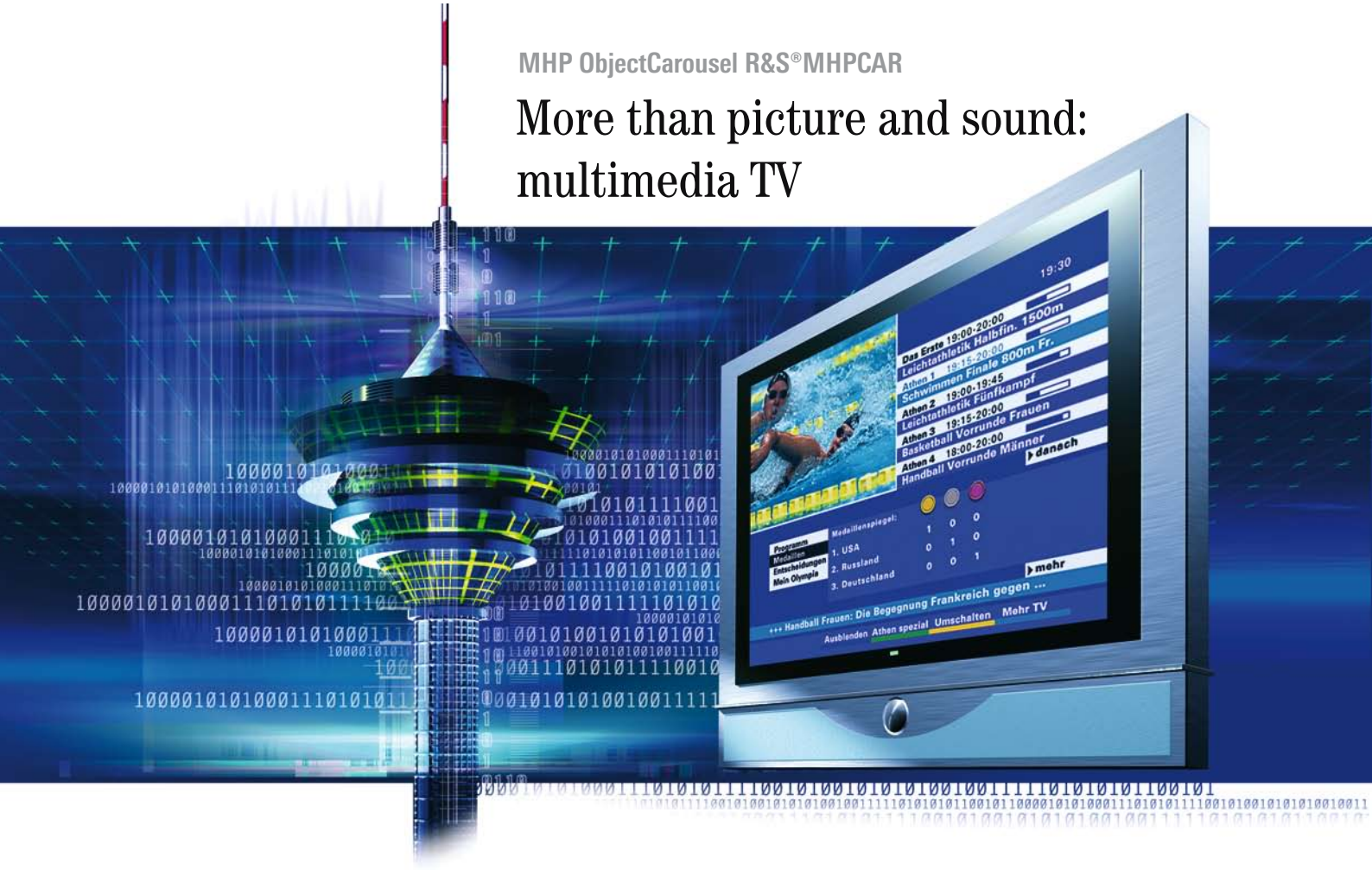


Abbreviations

ARB	Arbitrary waveform (generator)
ASI	Asynchronous serial interface
ATSC	Advanced Television System Committee
AWGN	Additive white Gaussian noise
BER	Bit error ratio
C/N	Carrier-to-noise ratio
DHCP	Dynamic host configuration protocol
DMB-T	Digital Multimedia Broadcast – Terrestrial
DTV	Digital television
DVB	Digital video broadcasting
DVB-C	DVB – Cable
DVB-DSNG	DVB – Digital Satellite News Gathering
DVB-S	DVB – Satellite
DVB-H	DVB – Handhelds
DVB-T	DVB – Terrestrial
EMC	Electromagnetic compatibility
FEC	Forward error correction
H264	Advanced video coding AVC/H264
IP	Internet protocol
ISDB-T	Integrated Services Digital Broadcasting – Terrestrial
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
ITU-T/J.83B	ITU-T Recommendation J.83 Annex B
LAN	Local area network
MPE-FEC	Multiprotocol encapsulation (FEC)
MPEG	Moving Picture Expert Group
OFDM	Orthogonal frequency division multiplexing
PRBS	Pseudorandom binary sequence
SMPTE	Society of Motion Picture and Television Engineers
SPI	Synchronous parallel interface
TDS-OFDM	Time-domain synchronous OFDM
TPS	Transmission parameter signalling
TS	Transport stream
VNC	Virtual Network Computing (software from AT&T)
VSB	Vestigial sideband
8VSB	8-level VSB

MHP ObjectCarousel R&S®MHPCAR

More than picture and sound: multimedia TV



The transition to digital TV will offer new services and applications that will make TV more versatile, more exciting and more informative. The multimedia home platform (MHP) is the basis for these additional functions. R&S®MHPCAR makes it possible to expand digital TV systems to MHP cost-efficiently and within a short amount of time.

MHP in detail

The MHP software interface for set-top boxes has been defined as an add-on to the DVB digital TV standard. MHP supports all additional TV data services, e.g. videotext as well as completely new applications. The new applications range from detailed program information (electronic program guide, EPG) and text tickers up to games or even interactive TV. With future versions of MHP implementations, it will also be possibe to seamlessly incorporate Internet technologies.

MHP services use software objects, pictures, audio files and commands that are broadcast parallel to the TV signal. MHP-compatible set-top boxes are able to receive these objects and store them temporarily. Subsequently, the loaded programs are executed, and the objects are activated and displayed. The programs are based on the powerful and platform-independent Java programming language.

An example of a potential MHP application is text tickers. Currently, text tickers are inserted directly into the TV picture at the studio. However, this method is less suitable in digital TV since picture content is compressed and every movement in the picture increases the compression effort and the required rate of transmission.

In contrast, MHP services transmit the text separately from the picture. Therefore, only short programs and the text itself are necessary. The ticker is not

inserted into the TV picture until it reaches the set-top box. Stream events defined in the MHP standard make it possible to precisely synchronize picture content and ticker insertion.

This technology opens up a new range of features for TV viewers. For example, viewers can choose not only whether they want to display a news ticker, but also the language they prefer. In addition, they can select a specific type of news.

MHP playout solution from Rohde & Schwarz

MHP is a software platform with defined interfaces for set-top boxes. However, the multimedia content itself must first be added to the digital TV programs on the transmitter end. To provide a means of transmitting MHP content, an expansion of the data transmission formats in MPEG-2 transport streams has been defined – the ObjectCarousel. Additional signalling and program service information (SI/PSI) make it possible to detect MHP services and to synchronize TV programs, MHP content and desired time sequence. Moreover, remote-controlled or automatic activation is possible.

The Data Inserter R&S®DIP010, complemented by MHP ObjectCarousel R&S®MHPCAR, is a simple solution for expanding existing digital TV systems to transmit MHP services. The advantage is that no new program multiplexers nor any system reconfigurations are necessary.

The data inserters are installed between the studio and the transmission equipment (FIG 1). The TV program passes through the inserter without being changed. Instead, the MHP data is merely added, the signalling information is supplemented and a standard-conforming signal that is ready to broadcast is generated. The cyclical insertion of the data and the software objects is handled by ObjectCarousel R&S®MHPCAR. You can update the content at any time.

The desired MHP applications are implemented and generated on external systems, and the generated Java objects and files are transmitted to the data inserter. The data inserter converts the data into TS packets and handles the generation of the signalling as well as the cyclical transmission. Thus, you can set up a MHP playout center without having to change the existing infrastructure substantially or make additional investments.

Bandwidth is everything

You can use this MHP playout solution for all DVB-based TV standards – terrestrial broadcasting (DVB-T), distribution via cable networks (DVB-C) or satellite (DVB-S). The transport stream signals, which contain the TV programs and MHP signals, are passed to the corresponding modulators and transmitters.

MHP applications are gaining in favour worldwide because of their performance and flexibility. Even countries that use other TV standards – the USA, for example, which uses ATSC – have selected MHP as a multimedia and interactive expansion of TV. Thus, MHP will soon be implemented in cable networks in North America, under the name OpenCable Application Platform (OCAP).

The MHP playout solution from Rohde & Schwarz, which is based on the Data Inserter R&S®DIP010 and on the software option MHP ObjectCarousel R&S®MHPCAR, can make available resources usable as opportunistic data for MHP and can be operated with guaranteed parameters. When operated together with MediaRouter™ from Rohde & Schwarz, the MHP playout solution provides a flexible means of managing bandwidths and connections. Thus, you can also implement MHP

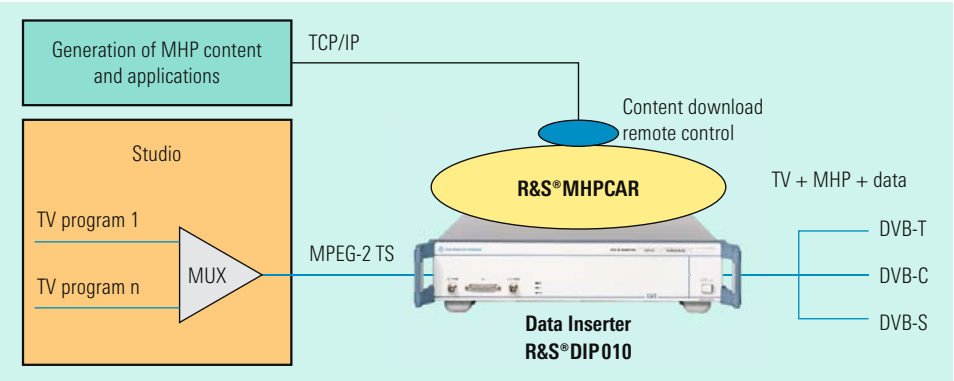


FIG 1
Expansion of a DVB system for the MHP playout solution.

applications with very low and variable transmission rates. This is especially important for terrestrial transmissions in accordance with the DVB-T standard, and it simplifies the introduction of MHP as an additional service.

Further data services possible

In addition to being able to activate multiple MHP services for different applications simultaneously, you can also implement other data services. R&S®SSUCarousel, for example, is a valuable addition for inserting and broadcasting operating software for set-top boxes via the broadcasting systems. Thus, you can add new features to your existing set-top box or download new versions of the MHP software stack. Since you can receive the software updates parallel to TV programs, it is not necessary to exchange or send in the box or perform complicated installation routines.

R&S®SSUCarousel is a versatile expansion for MHP playout systems. It allows you to insert different versions of software and it supports set-top boxes from different manufacturers. A remote-control interface enables you to adapt services to one another, activate them at specific times and manage them. Moreover, you can adjust services to the limited transmission capacity in digital TV systems.

Testing of set-top boxes

The implementation of the operating software in set-top boxes is complex. Therefore, it is necessary to carry out extensive tests during the development of the receiving devices and especially of the MHP services. To meet this need and to enable you to perform comparative evaluations of the MHP compatibility of set-top boxes, Rohde&Schwarz offers an MHP playout test system for use in laboratories.

This solution consists of combining the Data Inserter R&S®DIP010 with the DTV Recorder Generator R&S®DVRG. The generation of the required transport streams is described in the Application Note titled "MHP and SSU test", which can be downloaded from the Rohde&Schwarz Internet site (search term: FTK02). In combination with a TV test transmitter for the corresponding transmission technology – for example, the R&S®SFQ or the R&S®SFL from Rohde&Schwarz – an MHP application can be sent to a set-top box without requiring any other accessories (FIG 2). Likewise, new operating software can be downloaded by means of an update function.

Torsten Jäkel

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

Data sheet R&S®MHPCAR

Data sheet R&S®SSUCAR

FIG 2 Test system for MHP set-top boxes and for updating the operating system.

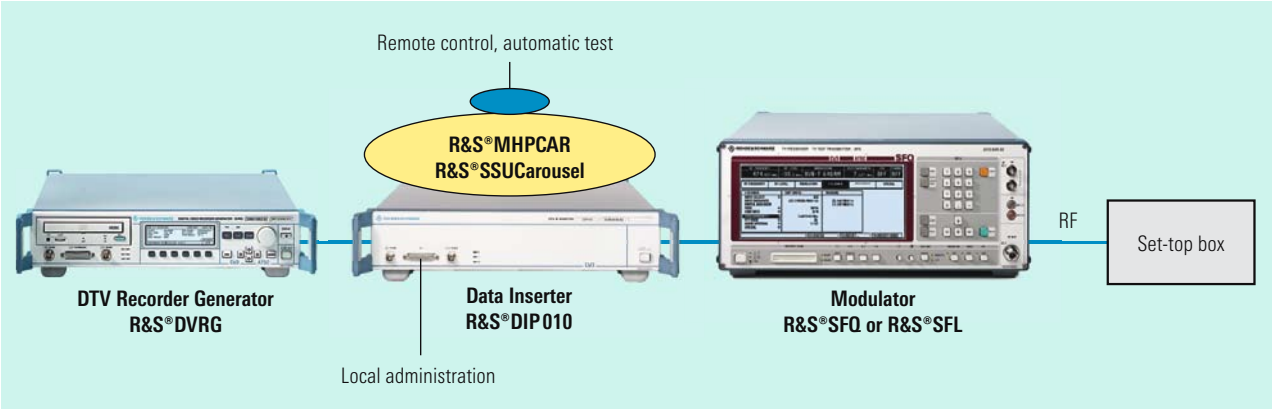


FIG 1 The MPEG-2 Monitoring System R&S®DVM 50 is cost-efficient and compact.

The new MPEG-2 Monitoring System R&S®DVM 50 (FIG 1) can monitor up to two MPEG-2 transport streams and integrates seamlessly into the R&S®DVM family.

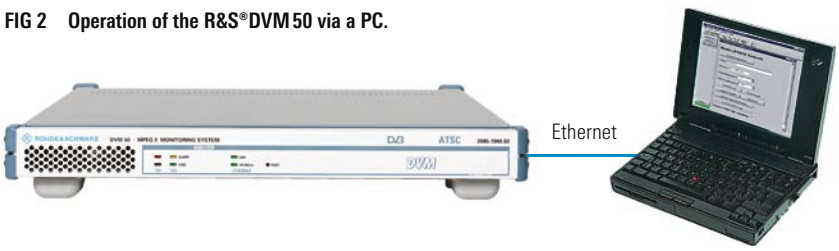
MPEG-2 Monitoring System R&S®DVM 50

Cost-efficient monitoring of up to two transport streams

Systems for any task

With its outstanding price/performance ratio, the new MPEG-2 Monitoring System R&S®DVM 50 is designed primarily for users who wish to monitor up to two MPEG-2 transport streams at a favourable price, such as terrestrial broadcasting network operators. To read about other members of the DVM family, the R&S®DVM 100 / R&S®DVM 120, refer to [1]. News No. 182 focused on the family flagship, the R&S®DVM 400 [2]. For an overview of the main differences between the systems, see page 48.

FIG 2 Operation of the R&S®DVM 50 via a PC.



R&S®DVM 50: seamlessly integrated

Occupying only one height unit, the R&S®DVM 50 is equipped with a fast analyzer board and monitors one transport stream and optionally two in parallel. It is operated either locally on a PC –

Instruments of the R&S®DVM family in comparison

The **R&S®DVM400** was designed specifically for use in development and for portable use at different points in the network. It features a high-resolution colour display and a keypad, making it easy to operate without additional accessories. It also has a parallel transport stream interface (*SPI*) and a reference clock input for high-precision time measurements such as *PCR* jitter and data rates. It can be expanded into a powerful recorder and generator by adding the necessary options.

The **R&S®DVM100** and **R&S®DVM50** are especially suitable for monitoring transport streams. The R&S®DVM100 can – together with the R&S®DVM120 and other options – monitor up to 20 transport streams in a minimum of space. The R&S®DVM50 is designed for cost-efficient monitoring of one or two transport streams in one place. Operation of the R&S®DVM50 requires a local PC.

The **R&S®DVM120** is not a stand-alone unit; it is used to expand the R&S®DVM100 and R&S®DVM400 for monitoring additional transport streams and is operated via the R&S®DVM100 or the R&S®DVM400.

Despite their focus on monitoring applications, the R&S®DVM100 and R&S®DVM50 also provide detailed analysis options. The analysis functions of the R&S®DVM100 and R&S®DVM400 can also be used for the transport streams monitored by the R&S®DVM120.

Main differences between the instruments of the R&S®DVM family.	R&S®DVM50 	R&S®DVM100 	R&S®DVM400 
Height	1 unit	1 unit	4 units
Number of transport streams monitored in parallel	1 to 2	1 to 4 (2 in basic version); expandable to 20 with 2 × R&S®DVM120 and options	1 to 4 expandable to 20 with 2 × R&S®DVM120 and options
Local operation	PC required	via external monitor, keyboard and mouse	integrated colour display, keypad and rotary knob; external keyboard and mouse if necessary
Signalling of results:			
User interface	●	●	●
Front panel LEDs	●	●	–
Alarm relay	–	●	●
SNMP	● (via local PC)	●	●
Remote control	via *VNC* server on local PC	via *VNC* server on the instrument	via *VNC* server on the instrument
Monitoring and analysis functions	available with all models		
***TS* capture (automatic recording of *TS* with up to 384 Mbytes)**			
Recorder and generator options	–	–	●
Reference clock input	–	–	●
***SPI* input and output**	–	–	●

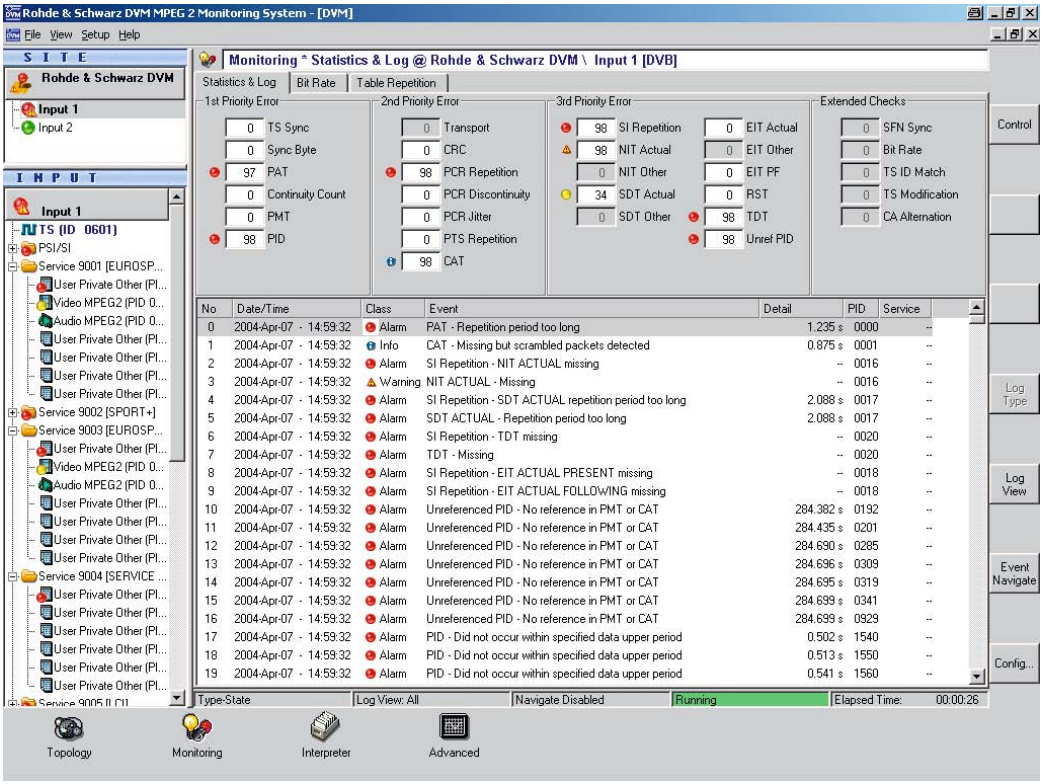


FIG 3
Graphical user interface of the R&S®DVM50 with report and error counter display.

with which it is connected via Ethernet – or remotely via network access to this PC. It can also be easily integrated into a network management system via the *SNMP*; the control software running on the PC supports this protocol (FIG 2).

The graphical user interface – which is identical on all the instruments of the R&S®DVM family – provides a straightforward display of the measurement results in different views and allows the system to be easily operated and quickly configured (FIG 3).

The measurement functionality is also as extensive as that of the R&S®DVM100. The system monitors all parameters listed in the Measurement Guidelines TR 101 290*) under priorities 1, 2 and 3 plus many other parameters necessary for effective monitoring. Analysis functions that can be optionally activated allow the R&S®DVM50 to be used for detailed analyses of *PCR* jitter, table contents and many other parameters, including data broadcast applications such as *MHP* transmissions or *SSU*.

Abbreviations

MHP	Multimedia home platform
PCR	Program clock reference
SNMP	Simple network management protocol
SPI	Synchronous parallel interface
SSU	System software update
TS	Transport stream
VNC	Virtual Network Computing (remote-control software from RealVNC company)

Summary

The R&S®DVM family from Rohde&Schwarz provides flexibly configurable instruments for MPEG-2 monitoring, development and production applications: from the favourably priced monitoring instrument for one or two transport streams to the portable MPEG-2 allrounder. Additional functions can be added later – often simply via a key code.

Thomas Tobergte

Data sheets and Technical Information on the R&S®DVM50 at www.rohde-schwarz.com (search term: DVM)

REFERENCES

[1] MPEG-2 Monitoring System R&S®DVM100/120: Comprehensive monitoring of MPEG-2 transport streams. News from Rohde&Schwarz (2003) No. 179, pp 29–33

[2] Digital Video Measurement System R&S®DVM400: Comprehensive MPEG-2 analysis – also for mobile use. News from Rohde&Schwarz (2004) No. 182, pp 46–49

*) The only measurement not supported is the buffer fill (priority 3.3).

DVB-T in Germany – the second setup phase is in full swing

Digital terrestrial TV in Germany – there's no turning back now. In a concerted effort, a new chapter in terrestrial DVB transmission is being written. Network operators, media companies, program providers, politicians, suppliers and, last but not least, consumers are making DVB-T a full success. The evolution of DVB-T in Germany proves that new transmission methods can be successfully introduced, provided the political environment is favourable, i.e. the transition periods must be clearly defined and predictable. As a leading supplier of DVB-T transmission and T&M equipment, Rohde&Schwarz is right at the forefront.

Right on time

Following the successful expansion of the DVB-T network in Germany's capital Berlin (a project equipped exclusively with Rohde&Schwarz transmitters, see [*]), the next phase is now underway. Since 24 May 2004, up to 20 TV programs on five channels can be received in the Cologne / Bonn area, and up to 16 TV programs on four channels each in Hanover / Braunschweig and Bremen / Unterweser. In November 2004, additional channels will start operation; the areas to be covered include the Düsseldorf area / Ruhr district, Hamburg, Lübeck, Kiel and the Rhine-Main area. The final expansion of this phase in these areas, with up to 24 programs, is scheduled for April 2005.

The launch date for DVB-T in Bavaria is planned for 31 May 2005. In the course of 2005, the network will be further expanded in the reception areas of Rostock / Schwerin, Kassel, Erfurt / Weimar, Halle / Leipzig, Ludwigshafen / Mannheim as well as Stuttgart.

Success is no accident

Rohde&Schwarz is the leading supplier of DVB-T transmitters. For the DVB-T expansion in Germany, single transmitters with exciter standby, N+1 standby systems and specially designed container solutions with minimum space requirements, where a dual transmitter can be accommodated in one rack, are used (FIG).

Manfred Maiböker* from T-Systems comments on the partnership with Rohde&Schwarz:

"Important reasons for choosing the DVB-T transmitters from Rohde&Schwarz included their straightforward design and ease of service as well as their compact and space-saving size since space can be very limited at some sites.

By meeting the very narrow time frame for implementing the project in the Cologne / Bonn area, Rohde&Schwarz has proven its expertise and performance: The date for the scheduled launch of the project, 24 May 2004, was met reliably and without any technical glitches.

We will continue the good and professional partnership with this company also in the Düsseldorf area / Ruhr district; together, we will successfully complete the entire project in North Rhine-Westphalia."

* Manfred Maiböker is head of the project office at T-Systems in Cologne and is responsible for the DVB-T setup of the network operator T-Systems in North Rhine-Westphalia. T-Systems Media&Broadcast and WDR are the two DVB-T network operators in North Rhine-Westphalia.

The reasons for selecting Rohde&Schwarz were obvious: the company's adherence to delivery deadlines, its complete product portfolio matching all necessary requirements, its ability to handle large quantities for diverse requirement profiles, an excellent price/performance ratio plus a transmitter setup that is easy to maintain.

In Germany, roughly 180 DVB-T transmitters of various power classes (100 W to 9.3 kW) were installed and put into operation in the transmitter networks of the existing stages. Rohde&Schwarz provides more than 70% of the products used in the networks of the two operators ARD and T-Systems.

The project was quite a challenge for Rohde&Schwarz because of the short delivery times for production, the punctual delivery of the transmitter systems plus on-time installation, and all programs were simultaneously switched "on air". Also in the future regions, i.e. Munich, Nuremberg, Leipzig, Schwerin / Rostock and Stuttgart, where DVB-T and DVB-H expansion is progressing, Rohde&Schwarz will remain a reliable partner, offering high-end products at competitive prices and meeting demanding schedules without delay. True to its motto "More than a supplier, always a partner", Rohde&Schwarz was able to prove its outstanding performance.

The comprehensive product portfolio of Rohde&Schwarz puts the company in a leading position for supplying not only transmitters, but also T&M and monitoring equipment. Numerous test and monitoring receivers as well as transport stream analyzers are used in this area.

Volker Klose

Setup of a turnkey lightweight cabinet with DVB-T transmitters of the R&S®NV/NW7000 family for the Braunschweig site. Two transmitters each with exciter standby are accommodated in one rack to ensure optimum usage of space. In the cabinet, three racks were fitted with two transmitters each and one rack with one transmitter. Three separate cooling circuits supply the transmitters.

More information about the seamless portfolio of transmitters and T&M equipment for digital TV from Rohde&Schwarz at www.rohde-schwarz.com

REFERENCES

[*] Rohde&Schwarz supplies transmitter systems for first German DVB-T transmission region. News from Rohde&Schwarz (2002) No. 176, p 46 (Newsgrams)

Software defined radios – software aspects and the future (2)

Part 1 of this article in the previous issue of News from Rohde & Schwarz (No. 182) discussed the effect of the software defined radio concept on radio equipment architecture. This follow-up article examines the effect on software structure and the software development process. It also provides a brief look at the future.

A forward-looking concept

By definition, all main tasks in software defined radios (SDRs) are software-dependent. In the receive path, these tasks include analog/digital conversion, downconversion (by digital downconverters), intermediate frequency filtering, demodulation, decoding and voice signal processing. The reciprocal tasks are performed in the transmit path, plus additional tasks such as linearization of the transmitter output stage.

Increasingly, encryption and other security functions are also handled by software on processors suitable for this purpose. In the past, such functions were largely relevant only for military applications. Today, however, they are of great importance in the civil sector as well.

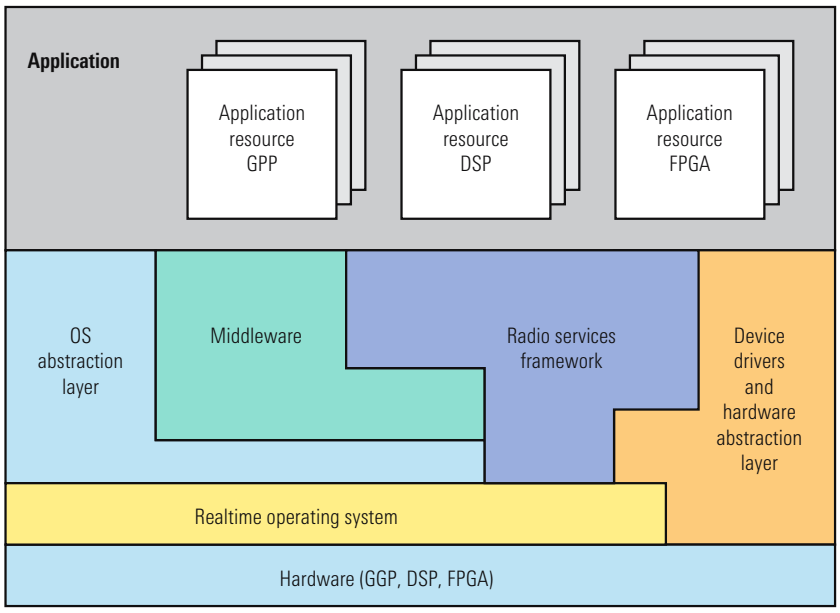
Other SDR tasks that often go unnoticed include the calibration and monitoring of the radio and the provision of user interfaces and remote control.

SDRs also involve various tasks that are relevant to internal organization and sequence control. A primary example is resource management, which includes assigning memory and managing computing power when configurations are changed.

New directions in software development

SDR software must be planned and developed with design goals in mind. The ultimate objective is to achieve and optimize short development times, low development costs, compliance with specifications, low manufacturing costs, etc.

FIG 1 Software architecture in SDRs with abstraction layers.



Experience has shown that optimizing design goals solely within a single development project is not sufficient. This is made clear especially by the fact that software has a significantly longer lifespan than hardware. Thus, it makes economic sense to create reusable software. But software is reusable only if it is relatively easy to port and modify. In other words, you must be able to transfer it between platforms that may have very different processors and data transport architectures. In addition, you must be able to integrate new customer requirements quickly and easily. As a rule of thumb, porting costs must not exceed 10% to 20% of the original development costs.

One method frequently used in computer science to reduce porting costs is the abstraction of functionalities. In this method, a software application (e.g. software for generating a waveform in the air) does not directly access the hardware or the operating system. Instead, it communicates via an intermediate layer (abstraction layer) that describes a generalized model of the functionality made available by the hardware. If the application program interfaces (APIs) of the intermediate layer have been standardized, the functionality can be addressed in the same way on any platform. FIG 1 shows this principle, which is also used in radios from Rohde&Schwarz.

The Software Communications Architecture (SCA) of the Joint Tactical Radio System (JTRS) initiative of the US Department of Defense is an important step toward standardizing software interfaces and thus toward improving software portability. At least some parts of the SCA are also expected to find use in civil applications. A brief description of the SCA is provided in the box on page 55.

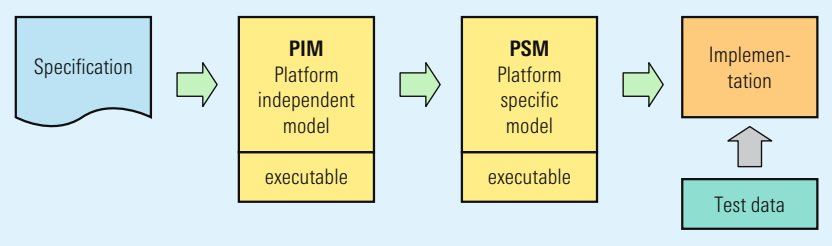


FIG 2 Software development process.

Model Driven Architecture

Since software can be highly complex and since it needs to be reusable, you must apply a structured approach ("process") when developing it. By developing the Model Driven Architecture (MDA), the Object Management Group (OMG; see part 1 of this article) has standardized a software development process that is extremely valuable for developing not only SDRs. This process provides multiple models that build upon each other (FIG 2).

First, you create the specification and use it to develop the platform independent model (PIM), which defines the software functionalities independent of the implementation. In some cases, you also develop an executable version of the PIM. You can do this by using tools such as UML (unified modelling language), MATLAB® und Simulink®.

The next step is to create the platform specific model (PSM). In this model, the software is partitioned to various computing components such as GPPs, DSPs or FPGAs – while taking into account a model for the middleware. You can also produce an executable version of the PSM. Automatic generation of code from the PSM is also a good feature to have, since it allows you to create components that can serve as the basis for implementation. The objective is to reduce manual code generation in the implementation phase to a minimum.

The last step in creating the product is the test phase, which is for verifying that the software adheres to specifications. This requires developing test strategies, defining test stimuli and automating the tests to the extent possible.

New tools

To write software for SDRs, you need to use development tools. When you are developing waveform software, you need these tools even when defining the waveform to be developed. In addition to the standard tools already available, description languages and concepts are being developed that will probably mature over the next few years and then find wide application. Two examples are the waveform description language WDL and the radio description language RDL (The VANU Radio Description Language™). The underlying principle of these languages and the corresponding waveform development tools is to use components (for specific modulation and coding methods or protocols, for example) to create the required waveform.

Added value through software downloads

A significant benefit of SDRs is the broad flexibility made possible through software downloading. Software downloading is the capability of a radio system to significantly change the char-

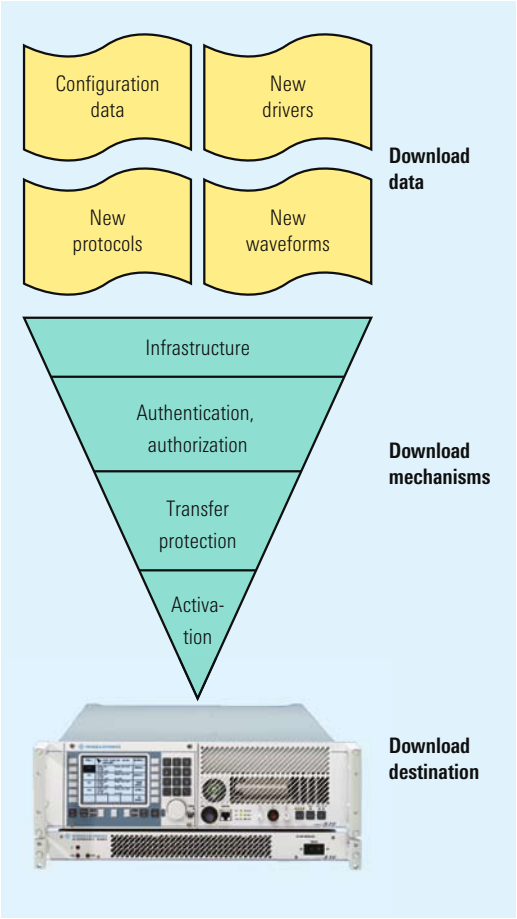


FIG 3 Mechanisms and objects for software download.

acteristics of a radio by transferring programs, parts of programs and data (FIG 3). Examples include updating parameter tables for handoff algorithms, updating driver software and expanding functionality by downloading a software package containing a new waveform.

Of course, the usability of each download varies from application to application. For example, the requirements and permissible solutions specific to a remote military radio station or a mobile radio base station will be different from those for a mobile phone, which has special requirements for power consumption and manufacturing costs.

There are two basic types of software downloads. Their main difference is how data is transferred to the radio. Local downloads are performed on-site, e.g. from a laptop via a USB interface or from a server via a LAN. In contrast, wireless remote downloads are performed via the radio's air interface. Both download types require that suitable mechanisms be available in order to transfer data to the destination in a secure manner. The first criterion is having the infrastructure that provides the link for transferring data from the control center to the radio. The download must then be authenticated to ensure that data is from an authorized source. Since the data to be transferred is frequently executable code, ensuring error-free transmission is also necessary. This is achieved by using special codings and transmission protocols.

Trends and advances

SDRs will continue to penetrate markets for radios worldwide. In the civil sector, the leading market will definitely continue to be the market for base stations. Users are highly interested in software downloads since downloads mean cost savings due to the large number of transfer methods, wide distribution of stations and the frequent need to update and modify software. In contrast, the concept of a pure SDR will catch on less quickly in the area of mobile phones. These devices place extremely high requirements on miniaturization, manufacturing costs and power consumption, and they have a short lifespan. Yet, software downloads are also of commercial interest here, which means that certain aspects of SDRs will also come into use at an early stage.

The first generation of SDRs consisted of early developments of software-based products and demo models resulting from various research programs. The second generation of SDRs is already on the market (e.g. mobile radio base stations or the Software Defined Radio Family R&S®M3xR from Rohde & Schwarz). The third generation is now in development and will implement advanced technologies in the hardware and software.

Improvements in analog/digital converters will make it possible to increase an instrument's dynamic range and sampling rate, thus allowing you to shift the point of A/D conversion closer to the antenna. However, even these instruments will also contain analog components in the frontend.

According to Moore's Law, which will remain valid in the foreseeable future, the available computing power of components will rise continuously and significantly. Thus, improvements in the bandwidth and quality of the signal processing section are only a matter of time. In addition, new types of components such as micro-electromechanical systems (MEMS) and super-conducting components will become available as off-the-shelf products. MEMS enable you to implement switches and filters with technology used in the production of semiconductors (application of material layers, etching, etc). Such switches and filters have characteristics that cannot be achieved with conventional methods. Superconducting elements take advantage of the extremely low losses, e.g. when it comes to implementing filters of extremely high quality or to implementing tunnel effects for very fast switches (Josephson elements).

With regard to software, third-generation SDRs will significantly improve the portability of radio software as a result of internationally coordinated architectures. An important point is the standardization of the operating systems, the middleware layers and the APIs of the functional units. An important milestone in this direction is the previously mentioned SCA of the JTRS initiative and

the related OMG industry standards, e.g. Minimum CORBA™ und SWRADIO.

The second generation of SDRs is already on the market and very successful. The use of new technologies – both in hardware and in software – will lead to the gradual transition to the third generation. For users, the most important factor will be how industry translates experience obtained during the development of the second generation into innovative solutions for the third generation.

Dr Rüdiger Leschhorn;
Dr Boyd Buchin

Software Communications Architecture (SCA)

FIG 4 shows the architecture of a radio designed in line with the SCA standard. The SCA is based on five principles. First, the interfaces to the operating system are standardized. A subset of the POSIX standard, which is derived from UNIX, is defined. The applications (e.g. waveform software) are allowed to use only this subset for system accesses. Second, CORBA™, which is an objected-oriented communications standard for distributed systems, is generally used for communications between software components. Third, the mechanisms for loading and changing waveforms and other applications are precisely defined. The instance that handles this task is the core framework. Fourth, the manner in which the radio-specific hardware is mapped in the software is defined. This uniform abstraction of the hardware is called the hardware abstraction layer (HAL). Fifth, the rough modularization of the software applications is specified, and even the APIs for some of the software components are defined.

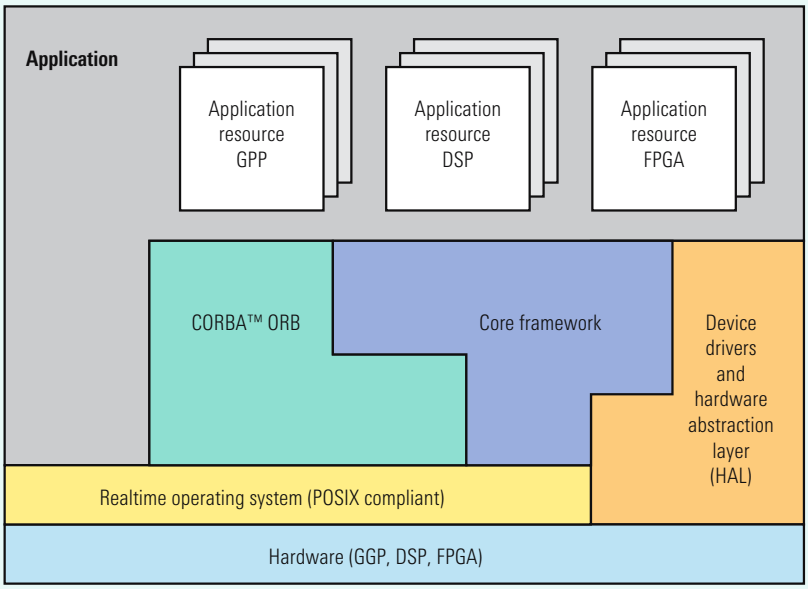


FIG 4 Architecture of a JTRS/SCA radio (simplified).

FIG 1 The Direction Finders R&S DDF®0xM help the German Regulatory Authority for Post and Telecommunication (RegTP) to perform its tasks.

VHF/UHF DF network of German RegTP subject to nationwide modernization

For decades, the German Regulatory Authority for Post and Telecommunication (RegTP) has operated a network of VHF/UHF direction finders to carry out governmental tasks defined within the scope of the International Telecommunication Union (ITU). In 1995, 1997 and 2000, the RegTP issued international tenders for modernizing its DF network. Rohde & Schwarz was selected over international competitors.

Nationwide VHF/UHF DF network

Prior to the reunification of Germany, the country's DF network was limited to the former Federal Republic of Germany and was operated by the Telecommunication Engineering Center of the German Federal Post. This body was later called the Federal German Post and Telecommunications Office and finally the German Regulatory Authority for Post and Telecommunication (RegTP). In the former GDR, its post authority also operated a number of VHF/UHF direction finders.

In 1995 and 1997, the RegTP issued two international tenders for modernizing its VHF/UHF DF network which was based on the Doppler Direction Finders R&S®PA055 from Rohde & Schwarz.

The basic agreement included the delivery and installation of a total of 14 VHF/UHF direction finders for the frequency range 20 MHz to 3000 MHz over a period of several years. With its offer to deliver Direction Finders R&S DDF®05M, Rohde & Schwarz won this project.

Each direction finder (FIG 1) consists of the following components:

- **VHF/UHF DF Antenna System R&S®ADD051**
  containing:
  – VHF DF Antenna R&S®ADD050 (20 MHz to 200 MHz)
  – VHF/UHF DF Antenna R&S®ADD150 (20 MHz to 1300 MHz)
- **UHF DF Antenna R&S®ADD070**
  (1300 MHz to 3000 MHz)

- **VHF/UHF DF Converter R&S®ET050**
  20 MHz to 1300 MHz)
- **UHF DF Converter R&S®ET070**
  1300 MHz to 3000 MHz)
- **Digital Processing Unit R&S®EBD060**

In 2000, the RegTP issued another international tender for five stationary and seven mobile direction finders for the frequency range 0.5 MHz to 3000 MHz.

The stationary direction finders are distributed throughout Germany. Special care was taken to provide good coverage in large urban areas. The Berlin area alone has three systems, for example. The systems are almost exclusively operated in unattended mode. Data is transmitted via ISDN dialled lines. It is generally possible to operate any of those direction finders from any station of the Test and Measurement Department ("PMDr"). The RegTP has seven of these stations throughout Germany: in Itzehoe, Krefeld, Darmstadt, Berlin, Leipzig, Constance and Munich.

In addition to the fixed stations, the RegTP operates a larger number of vehicle-installed mobile VHF/UHF Direction Finders R&S DDF®190, R&S DDF®195 and R&S DDF®05M. They are available at the individual Test and Measurement Department sites.

Designed for true operating conditions

Since the wave propagation in the VHF / UHF range is quasi-optical – in contrast to shortwave – the height of the DF antenna above ground largely determines the receiving range coverage of a direction finder. To attain good coverage, the DF antennas were installed on mountains and/or high masts where possible. When the antenna is installed on a mast, which can be up to 140 m in height, considerable attenuation can occur especially in the upper frequency range due to the length of the antenna cable. To prevent this, Rohde&Schwarz installed an air-conditioned weather protection cabinet for the DF Converters R&S®ET050 and R&S®ET070 on the platform of each mast top and connected the converters to the DF antennas via a short antenna cable set. The equipment is connected to the Digital Processing Unit R&S®EBD060 in the equipment building at the base of the mast via three coaxial cables for the IF of 768 kHz and via two fiber-optic cables for data communication.

When the DF antennas and equipment were developed, an overvoltage protection concept was integrated. This concept has proven to be highly effective at these installations – not one of the systems has yet been severely damaged by lightning.

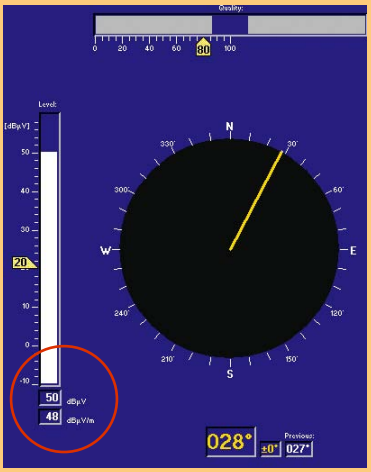


FIG 2 Both the input voltage of the received signal (in dBµV) and its field strength (in dBµV/m) are displayed.

A long-standing tradition at Rohde&Schwarz is to learn from everyday experience and to incorporate this knowledge into the latest versions of software. Just a few examples include being able to set the amount of time that DF values are displayed after the end of a signal, providing faster access to specific submenus and developing ink-saving screen backgrounds for printing screenshots. The DF Family R&S DDF®0xM also offers a special feature in the fixed frequency mode. It displays not only the input voltage of the received signal (in dBµV) but also its field strength (in dBµV/m) which is calculated using the k factor of the DF antenna (FIG 2).

Moreover, the RegTP has a dense network of unattended, remote-controlled test and receive stations which can also be called up from any Test and Measurement Department center. The VHF/UHF DF network has already been integrated into this network. At some sites, it is possible to simultaneously display the information of multiple DF stations on an electronic map and thus present position finding results.

Direction finders from Rohde&Schwarz support not only the RegTP. Equivalent regulatory authorities in more than 60 countries also use direction finders from Rohde&Schwarz.

Ulrich Unselt

More information on individual components at www.rohde-schwarz.com (search term: type designation)

New Rohde & Schwarz subsidiary founded in Finland

Since 1 July 2004, the new subsidiary has been responsible for operations in Finland for all Rohde & Schwarz divisions. The previous sales partner, Orbis Oy, remains an authorized service partner for Rohde & Schwarz as a result of the good long-standing relationship between the two companies.

Finland is a very important market for Rohde & Schwarz. The new subsidiary with a highly qualified staff of 15 employees enables Rohde & Schwarz to intensify its customer relationships on-site. "Our objective is to be the first choice of our customers and partners in Finland", says Tom Granvik, General Manager of Rohde & Schwarz Finland and Head of Operations. Rohde & Schwarz Finland is responsible for marketing equipment and systems from the Test and Measurement, Radiomonitoring and Radiolocation, Radiocommunications Systems, Digital Broadcasting and IT Security Divisions. Orbis Oy handled these responsibilities very successfully for the past 53 years. It will remain the authorized service partner of Rohde & Schwarz and, as a preferred supplier, will be responsible for system integration in projects in the Nordic region (Denmark, Finland, Norway and Sweden).

Rohde & Schwarz Finland is headed by Managing Director Markus Becker.

Rohde & Schwarz strengthens its presence in Asia

In addition to its subsidiaries in Indonesia, the Philippines, Taiwan and Japan, Rohde & Schwarz has now set up its own offices in Malaysia and Vietnam.

Rohde & Schwarz Malaysia Sdn. Bhd. has been responsible for marketing T&M and broadcasting equipment since 1 July 2004. The subsidiary also provides service for the entire Rohde & Schwarz product portfolio. Tony Fogl is Managing Director and Alan Seah General Manager.

The Malaysian company DAGANG TEKNIK SDN. BHD. had held exclusive marketing rights in Malaysia for all Rohde & Schwarz divisions since October 1990. This distribution agreement was terminated by mutual agreement on 30 June. DAGANG will remain the

Rohde & Schwarz invests in its Munich headquarters with a new technology center

Rohde & Schwarz is setting up an ideal working environment for its high-tech specialists by building a new office complex. In doing so, the company is supporting the Bavarian capital's urban development project in the area around the city's east train terminal.

Covering an area of 16000 m², the customized room concepts will allow the center to be configured in line with user-specific needs. Construction is expected to be completed by December 2005.

Rohde & Schwarz is thus expanding its headquarters in Munich. "Our well trained and committed employees are a decisive argument for our presence in Germany", says President and CEO Friedrich Schwarz. "They are just as important for us as our closeness to colleges and universities and reliable general conditions."

44300/1

The new Rohde & Schwarz technology center in Munich (computer model).

By building the new technology center, the company is making a major contribution to modernizing the area around the east terminal. The building, which was designed by the Munich architect Lutz Heese, is the fulfillment of an intelligent architectural concept: Two structural units, connected by an atrium, are cooled in summer and heated in winter by a complex system of ground water utilization. A cafeteria adjacent to the entrance area offers employees a place for creative breaks plus small snacks. The purpose of the new building is to provide the company's specialists with an ideal environment for developing innovations.

Rohde&Schwarz sales partner for radiocommunications systems as well as for radiomonitoring and radiolocation equipment.

The newly established Rohde&Schwarz Representative Office Vietnam in Hanoi and Ho Chi Minh City is a subsidiary of the Rohde&Schwarz Regional Headquarters Singapore Pte. Ltd. As of 1 July 2004, it has been supporting and promoting product marketing for all Rohde&Schwarz divisions. Sales is handled by distributors or via the Rohde&Schwarz Regional Headquarters Singapore. Franz Schäffler is the subsidiary's Chief Representative.

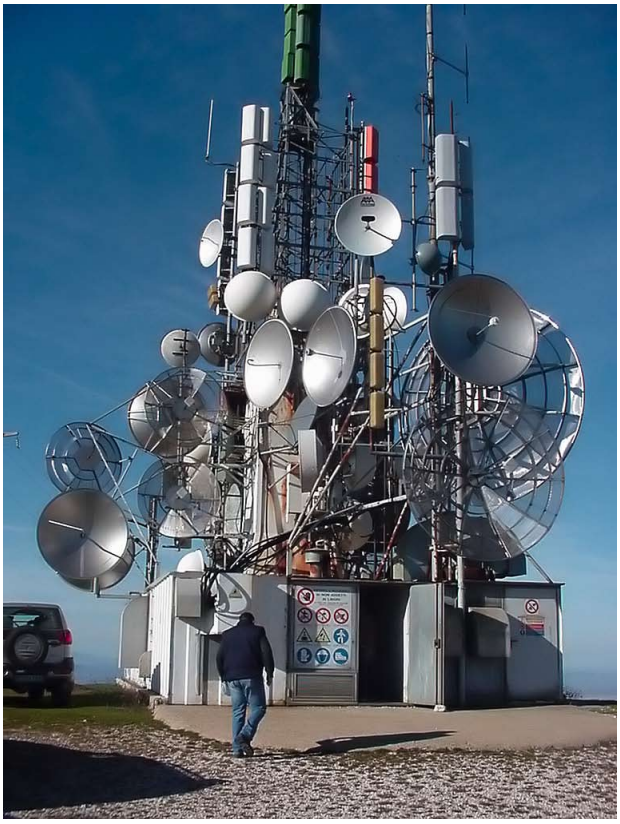
Until recently, Rohde&Schwarz International GmbH and Schmidt Vietnam Co., Ltd., had a sales agreement, which was terminated by mutual agreement on 30 June 2004. Schmidt Vietnam will continue to handle service activities in Vietnam and act on a case-to-case basis as a distributor together with the Rohde&Schwarz Representative Office Vietnam.

Transmission and monitoring equipment for digital TV in Italy

Digital terrestrial television in Italy uses DVB-T transmitters from Rohde&Schwarz.

By July 2004, Rohde&Schwarz had supplied virtually all transmitters for the two network operators Elettronica Industriale and RaiWay and completed their installation. The company also supplied RaiWay with a complete monitoring system for all locations. By the end of this year, 70% of the Italian population is scheduled to have digital TV. The network operators have ordered from Rohde&Schwarz several million euros worth of R&S®SV7002 low-power transmitters, R&S®NV7001 medium-power transmitters, R&S®NV7000 liquid-cooled high-power transmitters as well as the DTV Monitoring Receiver R&S®ETX-T.

Rohde&Schwarz has already delivered roughly 90 digital transmitters to Elettronica Industriale, Mediaset's network operator, plus approximately 45 transmitters to RaiWay. RaiWay is the privatized subsidiary and network operator of the public company RAI. Together with its partner Sirti, Rohde&Schwarz will install about 70 transmitters with output power ranging from 25 W to 5 kW by the end of this year.



Diverse services in a tight space: The antennas for the DVB-T transmitters on Monte Martano in Giano d'Umbria (near Perugia) must share the space with many other antennas.

One of the transmitter stations with antenna for program feed via satellite.

Nationwide TV and sound broadcasting network for Ghana

Rohde&Schwarz has been commissioned to set up a nationwide TV and sound broadcasting network in Ghana.

In its role as the consortium leader, Rohde&Schwarz will work with T-Systems International GmbH to set up state-of-the-art transmitter systems including antennas and satellite feeds at a total of 31 sites.

The German Federal Government supports the order with a Hermes export credit guaranty. Setup of the broadcasting network will be completed in April 2005. By then 90% of Ghana's population will have access to sound broadcasting and television. FM transmitters of the R&S®SR600 and R&S®SR500 families and liquid-cooled TV transmitters of the R&S®NM7000 family are being used in Ghana. T&M equipment from Rohde&Schwarz will also be supplied as part of this project.

www.rohde-schwarz.com

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