News from Rohde & Schwarz

Compact EMI test receiver
redefines 3 GHz class

Cost-efficient *Bluetooth*® RF testers
for R&D and production

Reliable determination of
vessel bearings in coastal waters

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ROHDE&SCHWARZ

The new standard-conforming EMI Test Receiver R&S®ESCI sets new standards in terms of measurement speed, accuracy and scope of functions in the instrument class up to 3 GHz (page 40).

44211

MOBILE RADIO

Radiocommunication testers

Protocol testers

TETRA radio systems

Reference

The R&S®CBT und R&S®CBT32 are two favourably priced *Bluetooth*® RF testers that take into account the ever tighter budgets for *Bluetooth*® test modules (page 4).

GENERAL PURPOSE

Spectrum analyzers

Reference

Signal generators

The R&S®FSH6 (third from left) is the world's first 6 GHz handheld spectrum analyzer that can directly measure WLAN 802.11a signals, for example (page 26). The article on page 30 provides an overview of the wide range of Rohde&Schwarz analyzers.

The MPEG-2 Monitoring Systems R&S®DVM 100 / DVM 120 have been joined by a new member of the R&S®DVM family – the Digital Video Measurement System R&S®DVM 400 (page 46).

To reliably establish the bearings of ships in distress in coastal waters, Rohde & Schwarz developed the Digital Direction Finder R&S DDF®100 M that has already been a resounding success in a large project (page 54).

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Bluetooth® RF Production Testers R&S®CBT / R&S®CBT 32

Fast Bluetooth® RF testers compatible with the R&S®CMU 200

When manufacturers purchase test tools, the manufacturing costs of *Bluetooth*®* modules are an important consideration. Increasing integration means falling sales prices, which, in turn, means ever tighter budgets for testing. To meet this trend, Rohde & Schwarz offers two economical *Bluetooth* RF testers for production – the R&S®CBT and the R&S®CBT 32. Both instruments contain the same high-quality and fast T&M technology but are designed for different applications.

FIG 1 The *Bluetooth* RF Production Tester R&S®CBT for laboratory use.

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

For laboratories and production

The R&S®CBT is designed primarily for development and secondarily for production. It occupies four height units and $^{7}/_{8}$ the width of a 19" rack, and it features control elements and a large colour display (FIG 1).

In contrast, the R&S®CBT 32 (FIG 2) occupies only two height units and is a full 19" in width. It is lower in price and is designed solely for production. Of course, you can also connect it to an external monitor for tasks such as debugging remote control operations.

Both testers (here collectively referred to as the R&S®CBT) support the entire *Bluetooth* frequency range of 2402 MHz to 2495 MHz at a channel spacing of 1 MHz and levels between –90 dBm and 0 dBm. They provide tests for power, modulation and bit error ratio for the various frequency hopping schemes specified in the *Bluetooth* standard. To allow quick adjustments of *Bluetooth* modules in preproduction, the testers

* The Bluetooth word mark and logos are owned by the Bluetooth SIG, Inc., and any use of such marks by Rohde & Schwarz is under license.

contain not only a generator but also a universal power meter and a frequency counter.

For remote control, the testers provide both a GPIB (IEEE 488/IEC 60625) and an RS-232-C interface. At no extra charge, Rohde&Schwarz also offers the R&S®CBTGo Windows™ software, which enables you to easily create complex measurement sequences. Thus, you can quickly and conveniently carry out and evaluate a number of test scenarios specified in the standard. These two *Bluetooth* testers support almost all receiver and transmitter tests stipulated by *Bluetooth* specifications 1.1 and 1.2.

The R&S®CBT is always the master

To set up a connection, the R&S®CBT and the DUT must be made "aware" of each other. You can do this either by using the inquiry protocol or – to save even more time – by manually setting the device address (BD address) of the DUT. If you are operating several R&S®CBT testers, you can also set different BD addresses for each one. This enables you to test several DUTs side-by-side without them affecting each other if limited shielding is used, for example.

The R&S®CBT always serves as the master of a connection. It allows you to set up a connection with the DUT either in ACL mode (asynchronous connectionless link) or by immediately activating the test mode. You can then activate the various submodes, i.e. Audio, Park, Hold or Sniff.

You do not need any special test adapters since every *Bluetooth* device supports ACL-mode connections, and the R&S®CBT can also determine power and frequency accuracy in this type of connection.

If your DUTs support the standard host controller interface (HCI) protocol via a serial interface, Rohde&Schwarz offers the R&S®DUTControl software as a download. This software enables you to change the DUTs to the various submodes without having manufacturer-specific test adapters. Many DUTs also support a variety of different audio codecs but do not allow activation via the RF interface. R&S®DUTControl enables you to activate the required audio mode even in these cases.

Typical tests

The production of *Bluetooth* modules usually includes checking various RF parameters and making any necessary corrections (such as adjusting the transmitter power). In most cases, the DUT's transmitter power is tested and the modulation is analyzed. You can also determine the RF spectrum that is used.

The R&S®CBT's modern concept enables you to measure the power and perform modulation analysis at the same time by using a combined measurement application. You can typically perform a complete RF test in less than three seconds. Such a test involves measuring the transmitter power and essential modulation characteristics by evaluating ten DH5 packets on each of three channels. If you also need information about the receive quality of the DUT (RX test), the test will take a total of four to five seconds. These measurement times also include connection setup time.

To determine receiver quality, the R&S®CBT offers measurements for bit error ratio (BER) and packet error ratio (PER), plus an automatic BER search routine for determining the typical sharp increase in bit errors starting at a specific low level.

The R&S®CBT spectrum measurement consists of two applications. The OBW measurement, also known as the –20 dB measurement, determines the DUT's occupied bandwidth. The ACP measurement determines adjacent channel power. These measurements are particularly important given the steadily growing market for instruments of the +20 dBm power class. At these power levels, instruments with impure RF can significantly impair signals for other

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Fig. 2 Size comparison of the R&S®CBT and R&S®CBT32.

users who are operating at the same frequencies nearby (FIG 3).

By implementing a "dirty Transmitter" (dirty TX) in the R&S®CBT, Rohde & Schwarz now offers for the first time a mixture of signal impurities in accordance with the *Bluetooth* specification. Dirty TX defines several RF parameters that intentionally create impurities in the transmit signal of the production tester both statically and dynamically:

- Frequency offset from the start of a packet (±250 kHz)
- Modulation index (0.20 to 0.44)
- Symbol time error (±20 ppm)
- Sinusoidal frequency drift across the entire TX packet

The modulation index is calculated from the ratio of the frequency deviation of the R&S®CBT to a deviation of 500 kHz. For example, a modulation index of 0.22 indicates a frequency deviation of 110 kHz for the tester's transmit signal.

The R&S®CBT provides two dirty TX tables: a fixed one in accordance with the *Bluetooth* specification and one derived from the fixed table which you can modify. The ten rows of these tables are superimposed on the transmit signal one row at a time in 20 ms intervals. As an alternative to these tables, the R&S®CBT also allows you to statically define the three key parameters (FIG 4).

Further details

If the test mode is active for a DUT, you can set the packet type and the corresponding payload size using the R&S®CBT. The supported packet types are DH1, DH3, and DH5, with a payload of 0 bytes to 339 bytes. You can also set the transmitted data pattern. The R&S®CBT provides predefined data patterns ("1010", "0000", etc, user-defined) plus two pseudo-random sequences (static and dynamic). The data pattern selected controls the volume of valid results that the instrument determines. For example, choosing the data pattern "1111" would not yield any valid conclusion about the DUT's frequency deviation since the deviation remains constant for the entire payload of the data burst. FIG 5 shows the evaluations that are possible for each data pattern. To determine the initial frequency accuracy, the R&S®CBT requires only the four-bit preamble of a *Bluetooth* packet (content "1010"), which has a duration of only 4 µs (FIG 6).

To test audio applications, the R&S®CBT can set up a synchronous connection-oriented (SCO) link with the DUT in addition to the ACL connection. The quality of audio processing in the DUT can be checked using external generators and audio analyzers. Internally, the R&S®CBT supports three *Bluetooth* audio codecs: CVSD, A-law and µ-law. For audio tests, the AF signal is coupled in and out via two BNC connectors on the front panel of the instrument.

The R&S®CBT can switch a DUT to one of the three power-saving modes Park, Hold or Sniff at the press of a button or via a remote control command. This enables you to determine the reduction in power consumption – one of the critical components in battery-operated devices – by using an external measur-

FIG 3 OBW spectrum of a typical *Bluetooth* DUT with PRBS data.

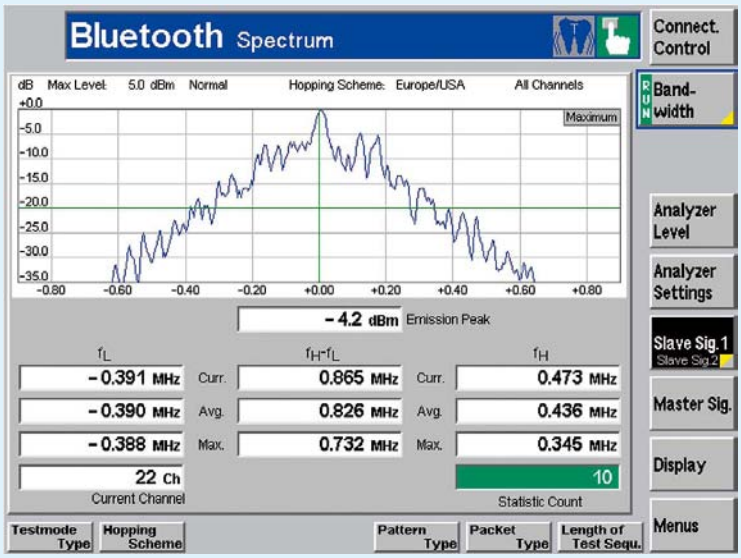
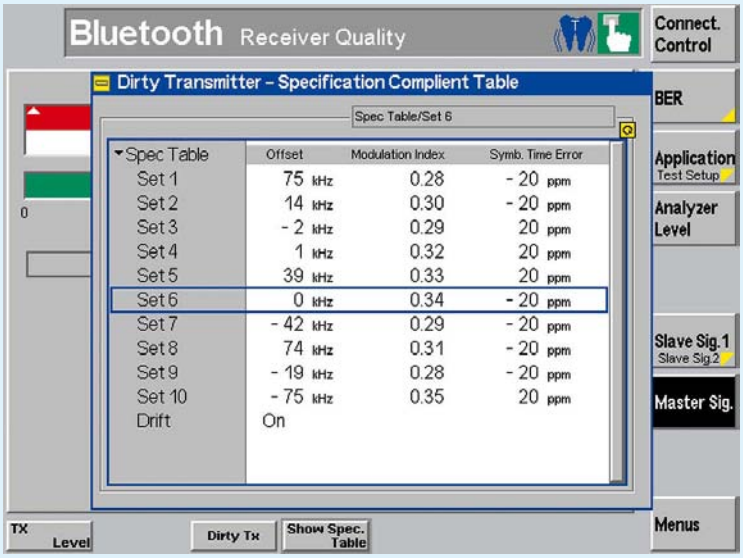


FIG 4 Dirty TX table in accordance with the *Bluetooth* specification.



Spec Table	Offset	Modulation Index	Symb. Time Error
Set 1	75 kHz	0.28	- 20 ppm
Set 2	14 kHz	0.30	- 20 ppm
Set 3	- 2 kHz	0.29	20 ppm
Set 4	1 kHz	0.32	20 ppm
Set 5	39 kHz	0.33	20 ppm
Set 6	0 kHz	0.34	- 20 ppm
Set 7	- 42 kHz	0.29	- 20 ppm
Set 8	74 kHz	0.31	- 20 ppm
Set 9	- 19 kHz	0.28	- 20 ppm
Set 10	- 75 kHz	0.35	20 ppm
Drift	On		

	Data "10101010"	Data "11110000"	PRBS, etc
Frequency accuracy	●	●	●
Frequency drift	●	–	–
Maximum drift	●	–	–
Average frequency deviation	●	●	–
Maximum frequency deviation	●	●	–
Minimum frequency deviation	●	●	–

FIG 5
Evaluations supported under the various data patterns.

ing instrument. The R&S®CBT can also send user-defined data to the DUT via the ACL connection. Thus, each manufacturer can send any commands to its instrument in order to activate special DUT functions such as controlling an LED of a headset or adjusting RF parameters via software.

In Power Control mode, the R&S®CBT sends commands to the DUT by means of the link manager protocol (LMP) in order to increase or decrease the output power in accordance with specifications. At each step, the R&S®CBT displays the difference. If saturation occurs, a message appears via a dialog window.

All measurements can be performed using normal frequency hopping as well as with reduced channel utilization:

- **All channels**: hopping covering all channels defined in the specific scheme
- **Simultaneous**: hopping covering five different channels via the reduced hopping method defined in the standard
- **Single**: measurement of a single channel

You can check the DUT quality across the entire *Bluetooth* frequency range by using both the "All channels" method and the function for stopping measurements when limits are exceeded. You can examine the results in closer detail by using the graphical analysis feature in the modulation and power measurement menus. You can zoom in at any resolution between 1/16 of a timeslot and five timeslots. Both RX and TX measurements can be performed by means of the channel utilization explained above (FIG 7).

As a special bonus for users of the "big brother" R&S®CMU 200, Rohde & Schwarz developers have provided the R&S®CBT with complete emulation of the R&S®CMU 200 remote control command set. This allows you to use the same control software in laboratories and production lines that have mixed equipment. Of course, this emulation does not cover the expanded capabilities that the R&S®CBT offers when compared to the *Bluetooth* option in the R&S®CMU (e. g. dirty TX).

Robert Macketanz

FIG 6 Frequency accuracy in an ACL connection within the 4 µs preamble.

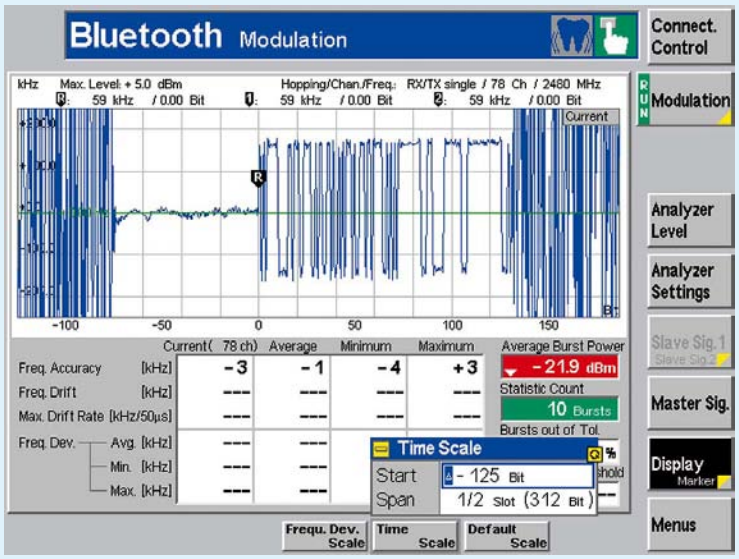
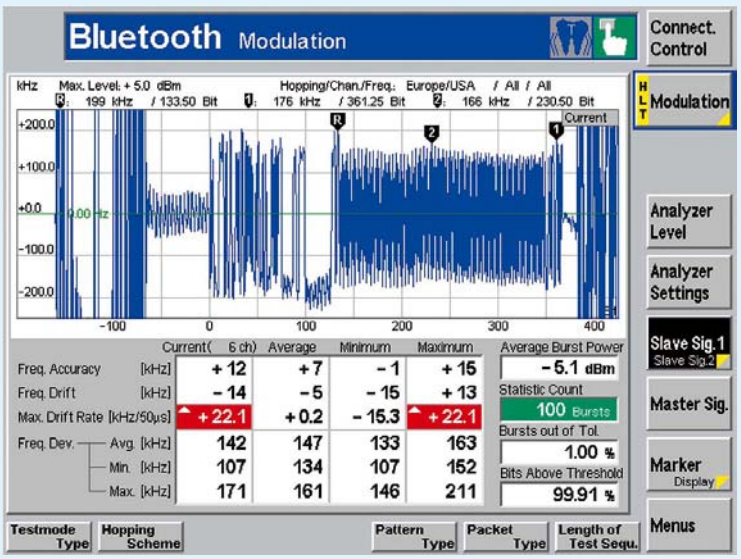


FIG 7 Modulation measurement, stopped when limit exceeded.



Universal Radio Communication Tester R&S®CMU 200

UE measurement reports: checking mobile phone measurement accuracy

Mobile phones have to measure characteristics such as the pilot channel power of the base station and then send the results to the radio network. Such measurements strongly affect the distribution of resources at the radio interface. The R&S®CMU 200 triggers the mobile phone to carry out these measurements and presents the results in a clear-cut manner. The R&S®CMU 200 can also set the mobile phone to compressed mode, in which the phone performs measurements on neighbour frequencies.

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UE measurement reports

Mobile phones perform measurements for determining link quality in a radio network and then send the results to the network as UE measurement reports. These reports provide vital information for dynamic network planning and the distribution of resources at the radio interface (radio resource management). The measurements and the mode of signalling are defined in the 3GPP specifications [1, 2]. Mobile phones have to be tested to verify this functionality and the stipulated measurement accuracy [3].

A mobile phone measures important characteristics such as the power on the frequency currently in use (intra-frequency measurements), on UMTS neighbour frequencies (inter-frequency measurements) and on GSM frequencies (inter-RAT measurements; RAT: radio access technology). These measurements are used to determine which neighbour cell offers the best radio link quality; a link is then set up to this cell (FIG 1).

During signalling, it is also possible to query the current transmit power of the mobile phone, the timing of its transmit and receive signals, and the block error ratio (BLER) of a data channel. To prepare for handover between UMTS cells, the mobile phone can determine the frame timing of its current link and of its target cell.

Additional articles on the R&S®CMU 200 can be found on pages 11 and 14 of this issue.

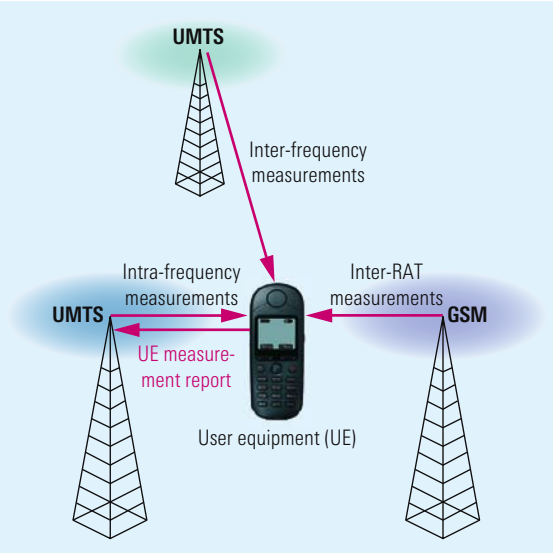


FIG 1 A mobile phone can carry out power measurements on the frequency currently in use, on UMTS neighbour frequencies and on GSM frequencies. It sends the results to the network on the current link. A new link is established to the neighbour cell that offers the best radio link quality.

The base station requests the measurements and the UE measurement reports from the mobile phone by sending a measurement control message. The R&S®CMU 200 can activate the various measurements independently of each other (FIG 2). Depending on the selected measurements, the R&S®CMU 200 automatically sends the required measurement control message(s) and displays the returned results on a clear-cut screen (FIG 3).

Compressed mode

In contrast to TDMA signals, WCDMA signals are continuous (see box). This means that the mobile phone transmits and receives signals without interrup-

tion. How, then, can the mobile phone carry out measurements on other frequencies? One solution would be to equip the mobile phone with a second receiver, although this would be complicated and expensive. Moreover, the effect of the mobile phone's own transmit signal would have to be taken into account, an effect that becomes increasingly problematic the closer the frequency to be measured is to the transmit frequency.

To solve this problem, the 3GPP standard provides for a specific operating mode referred to as compressed mode. In this mode, gaps are inserted into the mobile phone's transmit and/or receive signal without impairing the useful data rate (see box).

The compressed mode is activated in the mobile phone by way of signalling during call setup or while a measurement is being configured. The settings for this mode are made in a compressed mode pattern sequence that comprises more than 20 parameters.

Characteristics of WCDMA signals

In WCDMA (UMTS-FDD), a continuous signal is transmitted and received on a dedicated link. The division of the signal into frames and slots is based on the signal concept and does not serve the purpose of multiplexing signals of different users, which is the case in GSM.

Compressed mode

The compressed mode inserts gaps into the mobile phone's transmit and receive signals. This can be done in various ways, e. g. by **reducing the spreading factor**. The spreading factor indicates the ratio of CDMA chips to data bits and is typical of CDMA systems. Reducing the spreading factor usually results in a higher data rate. When the spreading factor is reduced, the data rate is briefly increased immediately ahead of and after the signal gap. Another way of implementing the compressed mode is to **reduce the number of redundant bits** that the channel coder inserts into the data stream. This method, which is also known as puncturing, can be used only for signals transmitted to the mobile phone. The third way of generating gaps in the signal is by **higher layer scheduling**, which however is less relevant for measurement purposes and is therefore not implemented in the R&S®CMU 200.

The parameters for the compressed mode are communicated to the mobile phone in the "DPCH compressed mode info" signalling element [2]. These parameters determine factors such as where gaps should be inserted into the continuous WCDMA signal. A compressed mode pattern sequence may include two compressed mode patterns with up to two gaps each. Mobile phones are required to support up to six sequences for the various measurements.

FIG 2 The R&S®CMU 200 can request the mobile phone to send the measured powers of a UMTS and a GSM neighbour cell independently of each other. The compressed mode can be activated separately for each measurement.

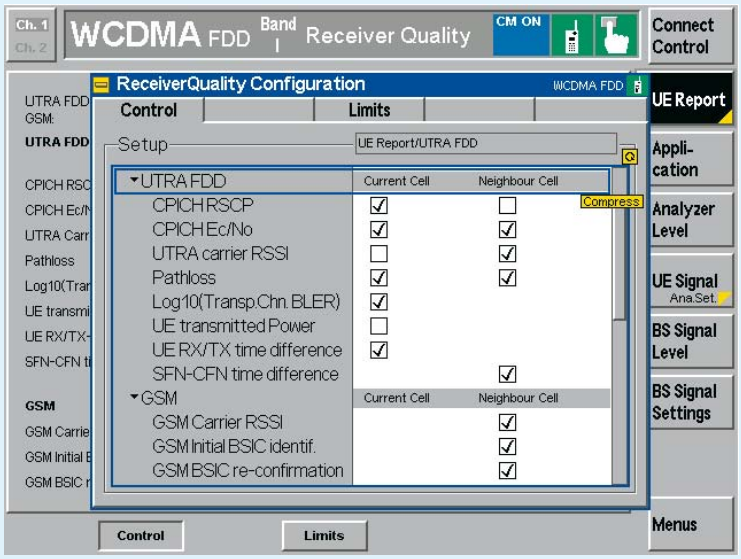
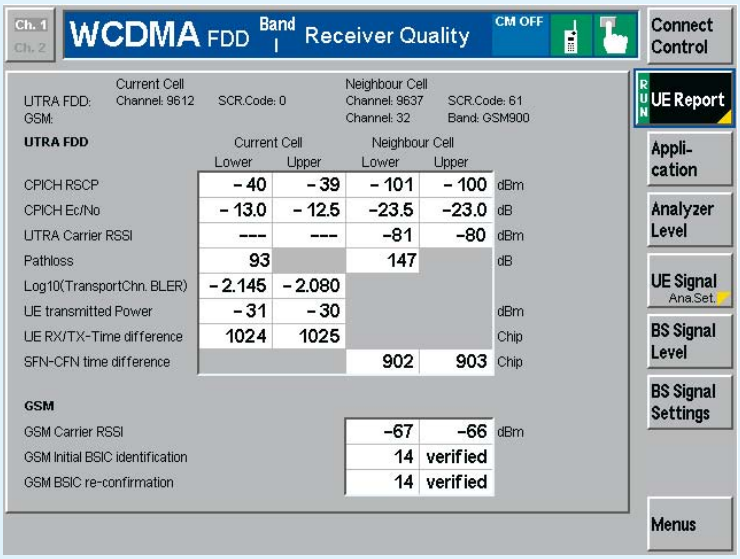


FIG 3 The R&S®CMU 200 displays the results received from the mobile phone on a clear-cut screen. The value ranges and intervals for measured values are defined in the 3GPP specification [3].



The R&S®CMU 200 offers a largely user-definable sequence as well as a number of predefined sequences that comply with the stipulated 3GPP measurements (FIG 4). This provides the user with an optimal combination of flexibility and ease of operation. There are sequences for measuring UMTS cells on neighbour frequencies as well as sequences for measuring GSM cells. It is also possible to activate several compressed mode sequences simultaneously.

Measurements on GSM frequencies are of particular importance since most WCDMA mobile phones can also handle the GSM standard. Especially in the startup phase of UMTS, smooth handover of a call from a WCDMA cell to a GSM cell is of vital importance. Based on the measurements carried out by the mobile phone, handover is optimally prepared, i.e. the mobile phone is not handed over to the GSM cell "blindly". The R&S®CMU 200 is also capable of testing the handover function. With an UMTS call established, the R&S®CMU 200 generates a GSM signal using an optional second transmitter; the GSM signal is then measured by the mobile phone. The call can subsequently be handed over to the GSM cell [4].

Summary

The Universal Radio Communication Tester R&S®CMU 200 offers numerous functions for testing the measurement accuracy of mobile phones. Its elaborate test sequences in compressed mode enable you to check the mobile phone's measurements on neighbour UMTS and GSM cells.

Uwe Bäder

More information and data sheet at www.rohde-schwarz.com (search term: CMU200)

REFERENCES
[1] 3GPP Specification TS 25.215 "Physical Layer Measurements (FDD)"
[2] 3GPP Specification TS 25.331 "Radio Resource Control (RRC)"
[3] 3GPP Specification TS 25.133 "Requirements for Support of Radio Resource Management (FDD)"
[4] Handover scenarios in GSM systems. News from Rohde & Schwarz (2003) No. 180, pp 12–13

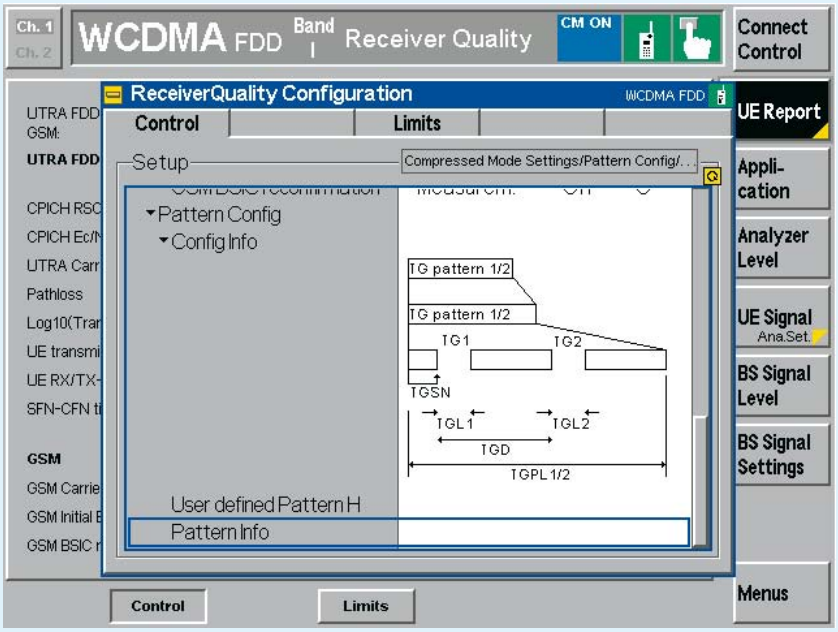


FIG 4
The compressed mode can conveniently be configured using predefined sequences. Sequences in compliance with the 3GPP specification are available for the various types of measurements. Moreover, you can parameterize a compressed mode sequence to fit your needs and activate it on the R&S®CMU 200. By providing access to the main parameters of the compressed mode, the R&S®CMU 200 offers maximum flexibility. The graphical representation of the compressed mode sequence makes configuration easier.

Testing cdma2000 data applications

With the commercial launch of third-generation mobile radio network standards, there is an increasing demand for test equipment to verify the proper functioning of data applications. This presents a new challenge to mobile radio testers that falls between pure RF parameter tests and sophisticated protocol tests. Standard cdma2000 mobile radio networks have already been in commercial use since 2000 in many Asian countries (e. g. Japan and South Korea), the Americas (e. g. the USA and Canada), as well as in Eastern Europe. The R&S®CMU 200 [1] now offers extensive test capabilities for data applications for this important global 3G standard.

Extensive test capabilities

The cdma2000 1x mobile radio standard, which was developed by the 3GPP2 standardization body, is officially recognized by the ITU as an IMT-2000 standard for the third mobile radio generation (3G). Revision 0 (or A), which is now in commercial use, allows data rates of up to 307.7 kbit/s in a 1.25 MHz frequency channel. Once further optimization stages have been completed, Revision D (also known as 1xEV-DV) will allow a maximum data rate of 3.09 Mbit/s in the forward link (base station to mobile station) and 1.53 Mbit/s in the reverse link (mobile station to base station).

In 3G networks, data links based on the Internet protocol are playing a more and more significant role. This calls for new test procedures designed to verify the functionality of IP-based links. For example, the TIA/EIA standard TIA-898 [2] specifies data rate measurements for FTP links.

Numerous test scenarios are conceivable, including data rate measurements under ideal RF conditions, as well as with fading or during handoff, and various application tests (e. g. access to mail servers, web meetings, etc). In the past, such tests required access to a real network. Now, you can perform these tests without a network by using the Universal Radio Communication Tester R&S®CMU 200, which offers a wide range of configuration options.

Service Option 33

In its Service Option 33, the TIA/EIA standard IS-707-A-1 [3] specifies IP-based data links for the cdma2000 standard. The R&S®CMU 200 provides all parameters required for this service option, ranging from traffic channel configuration (data rates of up to 153.6 kbit/s can be set for the supplemental channel (SCH) both for the forward and the reverse link) through to the parameters for mobile IP and authentication (FIG 1).

PPP authentication

For setting up a point-to-point protocol (PPP) link, the R&S®CMU 200 can be configured to request PPP authentication from the mobile phone. The R&S®CMU 200 supports two methods of authentication: CHAP (challenge handshake authentication protocol) and PAP (password authentication protocol).

Required options for cdma2000 application tests

R&S®CMU-B83	cdma2000/IS-95 signalling unit
R&S®CMU-U65	3G measurement DSP and performance accelerator
R&S®CMU-B87	message monitor
R&S®CMU-K83 to -K86	software options for the various cdma2000 bands: 450 MHz / cellular / PCS / IMT-2000
R&S®CMU-K87	cdma2000 data test

On receiving the authentication request, the mobile phone returns the user name and the password entered for the link setup. The tester checks whether the user name and password are valid. For the CHAP protocol, periodically repeating authentication can be configured. For mobile IP links, the mobile IP standard stipulates that authentication be deactivated.

Mobile IP

Mobile IP is an addition to the conventional Internet protocol. It makes the movements of a mobile computer (mobile node, i.e. in this case a mobile phone) transparent for data applications and the higher protocol layers. In addition to its home IP address, to which all data packets are sent, the mobile phone is assigned a care-of address when changing to a foreign network. The mobile phone automatically registers with its home agent, i.e. a computer in its home network, by using this care-of address. All data packets received at the home IP address are then forwarded to the care-of address by the home agent.

A mobile IP environment involves two new network elements – the home agent and the foreign agent. The home agent is located in the mobile phone's home network; it knows the mobile phone's current location and "tunnels" data packets directed to the mobile phone's home address to the mobile phone's current location. The foreign agent assigns the mobile phone a temporary address (foreign agent care-of address) in the foreign network and functions as the terminal point of the tunnel departing from the home agent.

The IP addresses for the mobile phone's foreign agent and home agent can be defined on the R&S®CMU 200, thus allowing data packets to be exchanged between the foreign agent and the mobile phone.

Alternatively, the R&S®CMU 200 can simulate part of the mobile phone's IP functionality when no external foreign or home agent is available. A standalone mode for mobile IP links can thus be implemented, substantially simplifying test setup.

PPP link status

During periods in which the mobile phone is not transmitting or receiving data, it switches to an idle state referred to as dormant mode. In this mode, the PPP link is maintained, but no traffic channel connections are set up in the cdma2000 network. The R&S®CMU 200 indicates the various PPP states the mobile phone can assume:

Registered mobile phone is registered, no PPP link is established

FIG 1 Data link configuration options of the R&S®CMU 200.

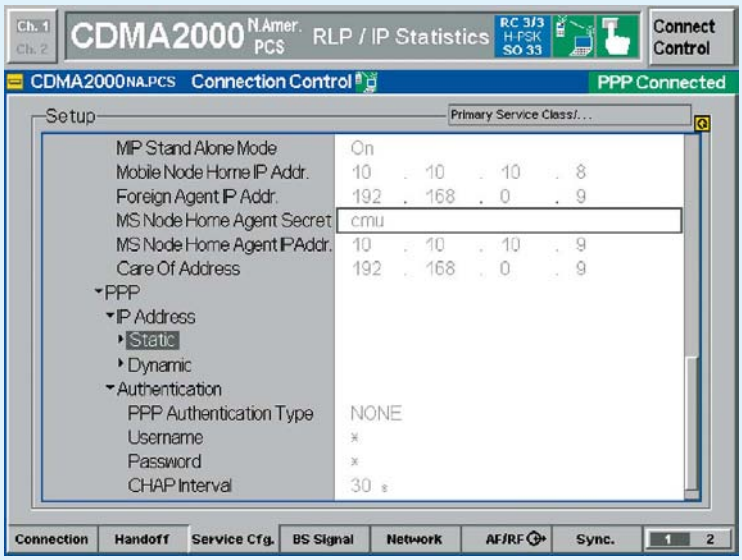
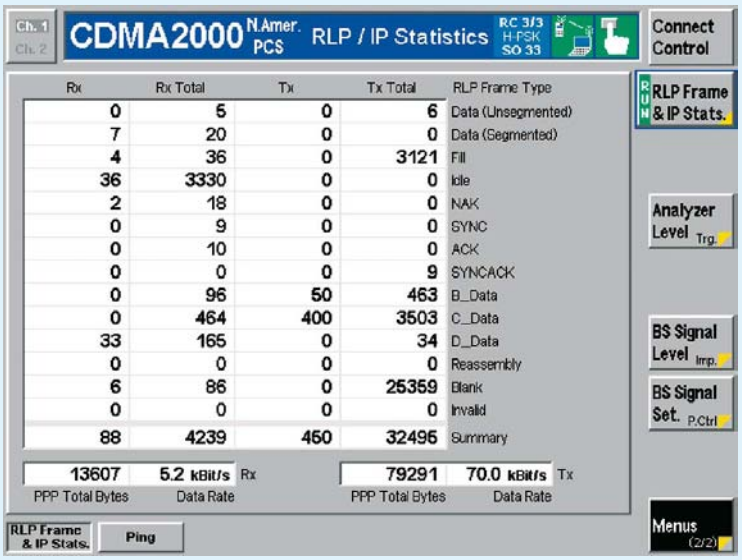


FIG 2 Generation of RLP statistics with the R&S®CMU 200.



PPP Connected PPP link is established, traffic channel connections are set up, mobile phone transmits/receives data

PPP Dormant PPP link is established, no traffic channel connections are set up, mobile phone does not transmit/receive data

TX/RX RLP frame and IP packet statistics

A statistical evaluation based on counts of the different parameters makes it possible to track the data flow through the base station, i.e. the R&S®CMU 200. The following types of data are counted separately for the TX and RX directions (FIG 2):

- RLP frames
- The different RLP frame types (IDLE, FILL, ACK, etc)
- Total PPP bytes
- Total PPP packets
- Total TX/RX data rate

Application scenarios

The R&S®CMU 200 allows different test setups to be implemented for different application scenarios. In the simplest case, you can operate the tester in the standalone mode to perform data rate measurements on the mobile phone under test. For this purpose, the tester incorporates an internal FTP server that allows test files to be exchanged.

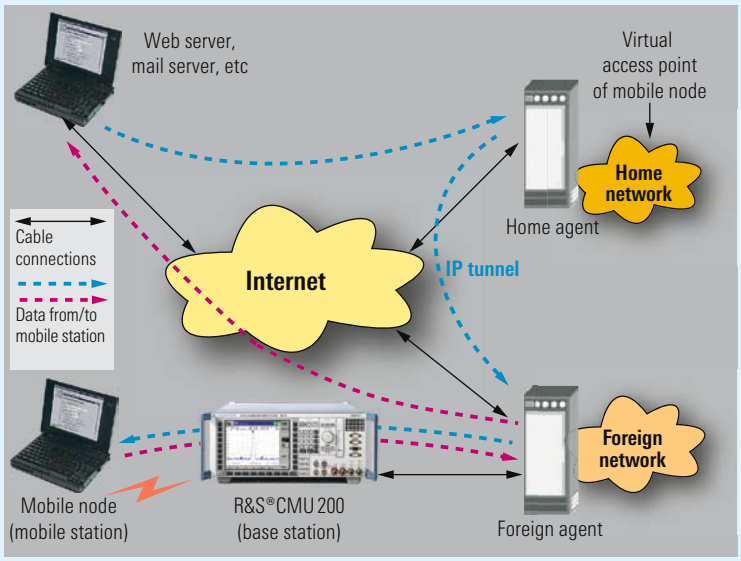
By using a more complex test setup including an external home agent and foreign agent, you can set up mobile IP links to points such as a web server or a mail server, enabling you to test complex applications (FIG 3). You can verify whether links to individual network nodes can be established by using the R&S®CMU 200's PING function.

Thomas Rösner

Important terms used in data application tests

CHAP	Challenge handshake authentication protocol
PAP	Password authentication protocol
Mobile node	Network node that can change between networks without having to change its IP address
Home agent	Unit in the mobile node's home network (typically a router) that tracks the mobile node's current location and tunnels IP data packets to the care-of address
Foreign agent	Unit in the foreign network in which the mobile node is currently located (typically a router). This unit assigns the mobile node a care-of address, forwards data packets sent to the care-of address to the mobile node, and in most cases also acts as a default router for the mobile node.
Care-of address	Address of the tunnel terminal point currently valid for the mobile node. The IP interprets this address to be the current location of the mobile node.

FIG 3 Typical test setup for mobile IP link.



More information and data sheet at www.rohde-schwarz.com (search term: CMU200)

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Universal Radio Communication Tester R&S®CMU 200

GSM spectrum measurements that meet today's requirements

As the GSM standard evolves, the hardware and software for the Universal Radio Communication Tester R&S®CMU 200 must keep pace. This popular tester now features new adjacent channel power measurements (ACP) and a faster DSP as an option, making it a state-of-the-art universal analysis tool for GPRS and EGPRS.

Faster with more features

Firmware version 3.50 for the Universal Radio Communication Tester R&S®CMU 200 is a major step forward in GSM spectrum measurements. In addition to bringing a new look to the instrument, it offers state-of-the-art features. Measurements now accommodate the full scope of current multislot requirements and reflect the significantly greater complexity of the GSM standard. The era in which a single GMSK-modulated timeslot was sent in the downlink is now gone.

In addition, the instrument's measurement speed is much faster. A new measurement DSP, available as an option, offers a very high level of performance even when faced with today's requirements.

New time domain representations

To make measurement results more transparent, you can now display time domain traces of selected frequency offsets in addition to spectrum measurement results. When you measure the modulation spectrum, the selected timeslot of this adjacent channel is also displayed. Within this timeslot, the area that contributes to the evaluation is marked. This enables you immediately to see the relationship between the time domain and frequency domain results (FIG 1).

When measuring the transient spectrum, you can select the number of timeslots to be evaluated. The measurement results are based on the maximum within this time window at the specific frequency

FIG 1 Modulation spectrum with time domain representation.

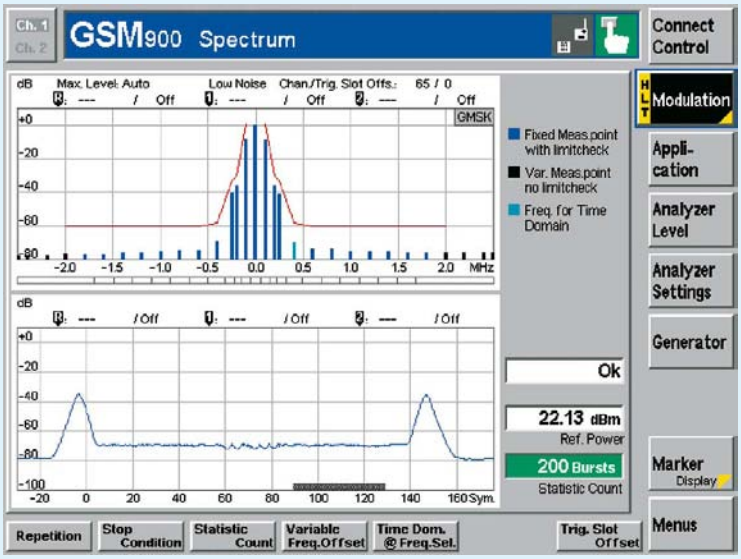
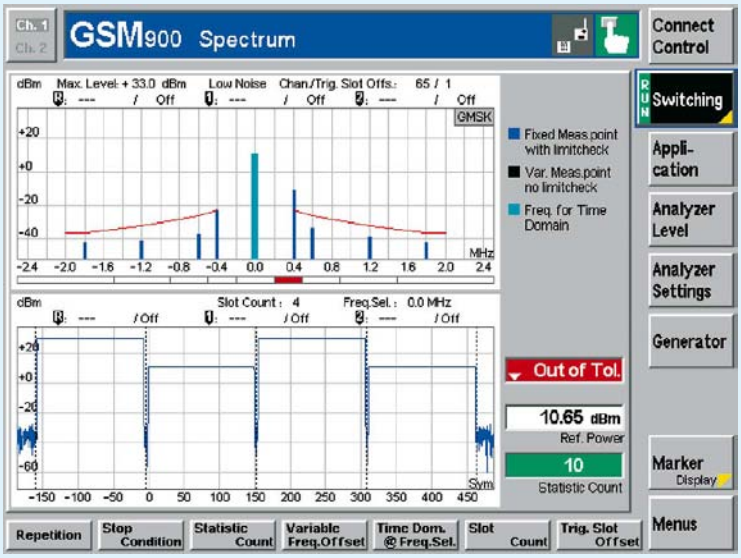


FIG 2 Transient spectrum with time domain representation on carrier.



offset. Particularly the new generation of GSM telephones with their sometimes highly variable timeslot combinations (changing power, modulation and burst type) present new challeges for developers with regard to switching transients. The time domain representation provides you with a flexible and powerful means of error analysis (FIGs 2 and 3).

Parallel measurement of modulation spectrum and transient spectrum

The new parallel measurement feature enables you to analyze and display the results of both spectrum measurements at the same time. The diagrams are based on the same data. If you have applied the condition "Stop on Limit Failed", you will obtain a consistent measurement result in which the effect of the error is shown on both diagrams. If you use remote control, parallel measurement improves performance because you no longer have to request each measurement separately (FIG 4).

High flexibility with no loss of convenience

The same application now handles GMSK and EDGE modulation. The actual analysis remains the same, while the limit check varies. The R&S®CMU 200 still provides separate parameter sets, which you can apply either automatically or by presetting them. Experienced users can adapt the limits as necessary, while occasional users can rely on the standard-conforming application.

In addition to using the fixed frequencies, you can also select frequency offsets as needed within the measurement bandwidth of approx. 4 MHz.

Exceptional measurement speed

The new and fast ACP measurements make both developers and production happy. For example, the modulation spectrum measurement at 22 frequency offsets analyzes one timeslot per GSM frame in realtime. This tremendous speed requires the option U65v04, which is a measurement module that performs the calculations using state-of-the-art ASICs. This option speeds up both the ACP measurements and all other transmitter measurements. Thus, if speed considerations allow only partial spectrum measurements, standard-conforming measurements are still possible.

Rolf Lorenzen

FIG 3 Transient spectrum with time domain representation on adjacent channel.

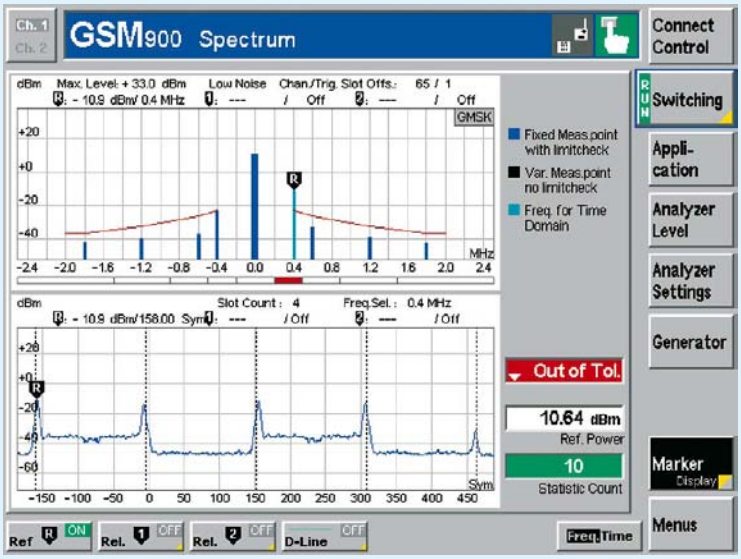
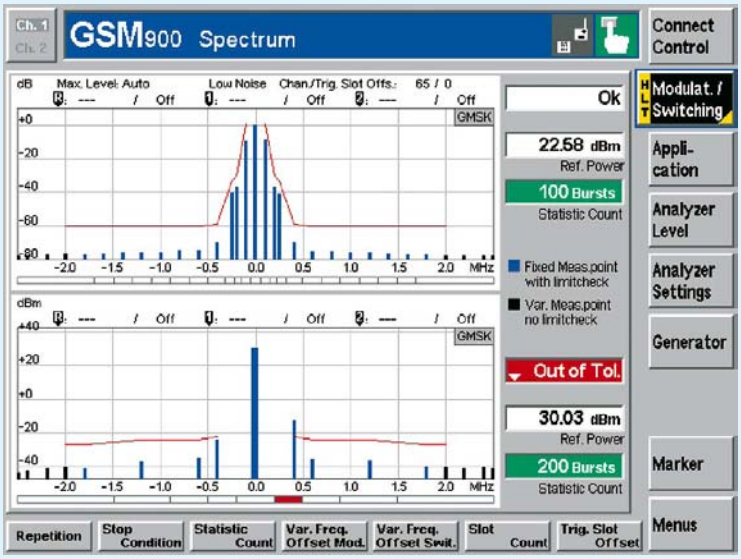


FIG 4 Parallel measurement of modulation spectrum and transient spectrum.



Protocol Tester R&S®CRTU-G

Reducing test time through automation

Being able to reduce test time is increasingly important in development laboratories. Completely automated test sequences are an effective means of achieving this goal. In addition, tests can be performed at off times – at night, for example. The operational software supplied with every R&S®CRTU-G contains a preconfigured solution for such scenarios. It can significantly contribute to shorter test time.

Fully automated tests

Type approval tests of mobile phones can take several hours or even days. Without automation, much of this time is wasted as idle time or merely on switching the mobile phone on and off. For (E)GPRS test cases in particular, additional time-consuming manual operations must be performed, e. g. "Initiate GPRS Attach" or "PDP Context Activation".

You can fully automate such operations via remote control of the mobile phone by using AT commands such as specified in 3GPP 07.05 und 07.07, as well as by using a handful of proprietary AT commands*. You can then let the test run automatically without having to monitor it or take any further steps.

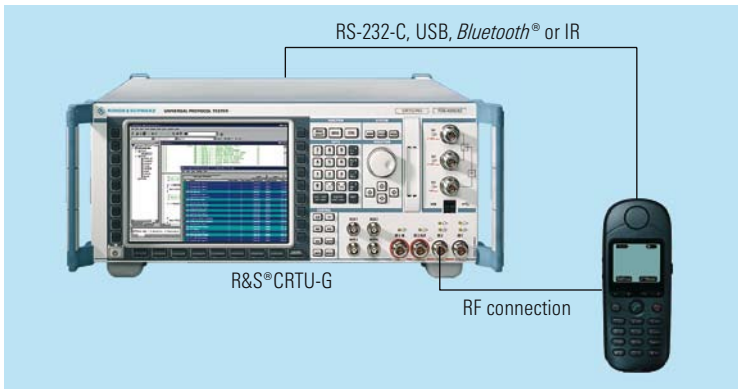
Customer Automation DLL

The R&S®CRTU-G (see figure below) automates test sequences by using the sequencer and a special Customer Automation DLL (dynamic link library). This DLL contains all functions for remote control of the mobile phone via an interface during testing. You can define any interface you want (RS-232-C, USB, IR, *Bluetooth*®, etc) when you compile the DLL.

Another advantage of this concept is that you can separate the Customer Automation DLL from the Applics Common Code Library (ACCL), which contains the information required for the actual test case. This eliminates the time-consuming task of having to compile the test case again. Expansions to the ACCL do not affect existing DLLs. You can continue to use these DLLS, yet you can also adapt them to the expanded functionality of the ACCL as necessary. In addition, you can maintain separate DLLs for different mobile phones.

Msproc.lib library

The test sequence to be carried out is assembled in the sequencer of the R&S®CRTU-G. From the sequencer, you can select the default setting Auto Test Mode to automate the test. When a test case issues a message or request such as "Please select 1234" on the display of the R&S®CRTU-G during runtime, this is done by means of the Msproc.lib library. This library contains the functions that access the Customer Automation DLL based on the context. An example of such a DLL is supplied in each protocol tester. It uses exclusively



The R&S®CRTU-G performs fully automated testing of a mobile phone by using the sequencer and a special Customer Automation DLL.

* For example, switch-on and switch-off commands not specified in 3GPP.

3GPP-specific commands and must be adapted to the specific mobile phone being tested by means of proprietary commands. This requires a knowledge of Visual C++. It should also be mentioned here that the Automation DLL project basically contains two modules: the comport.c module, which contains all functions that involve the COM port, and the MS_Auto_RS232.cpp module, which contains all mobile-phone-specific commands. For details, refer to the R&S®CRTU-G software manual.

Adapting this DLL to the DUT takes relatively little time if you consider that this up-front work reduces test time and that no personnel is needed during testing. This means that you can use the protocol tester virtually around the clock.

You can monitor the commands exchanged between the R&S®CRTU-G and the mobile phone by using the AutoDLL Traffic Viewer. This tool is also helpful when developing a Customer Automation DLL.

Summary

By providing test-case automation, Rohde & Schwarz has increased the value of the R&S®CRTU-G even further. A universal mechanism that requires only a little up-front effort saves substantial time later on. For details, refer to the R&S®CRTU-G documentation.

Gerhard Götz

Protocol Tester R&S®CRTU-W

Efficient programming interface for UMTS protocol development

The R&S®CRTU-W (FIG 1) has long been known for its convenient and powerful *TTCN* interface, which was designed and optimized for conformance testing. Research and development, however, require a flexible yet easy to operate programming interface. The new *MLAPI* software option (R&S®CRTU-WT02) now provides you with the right tool for R&D applications.

Intelligent compromise

The use of the R&S®CRTU-W as a test tool in *UMTS* protocol development places very high demands on the programming interface. The vast number of parameters specified by the *3GPP* standard as well as the variety of applications call for an intelligent compromise between flexibility and convenience. The R&S®CRTU-W now comes with a new software option – *MLAPI* (Medium Level C++ Programming Interface) – that provides the right answer.

FIG 1 The Protocol Tester R&S®CRTU-W – a flexible test platform for the development and certification of WCDMA user equipment.

Convenience and flexibility

The test cases specified by *3GPP* for conformance testing of *UMTS* mobile phones [1, 2] are already implemented in the R&S®CRTU-W. Research and development, however, require a programming interface that offers greater flexibility and convenience. It must be able to handle the constraints inherent in the *TTCN* programming language as well as in the architecture of the *3GPP* test suites and the extra tools required.

To meet this need, Rohde & Schwarz has developed the *MLAPI* programming interface. It enables you to create protocol layer 3 user-defined scenarios in the C++ programming language. The meth-

ods of handling protocol messages as well as the modelling of dynamic operation cover a wide range of applications, from simple to very powerful. For example, you might want to set a mobile phone to a defined signalling state by using a simple sequence of messages and then implement a desired application in this state. Or, you might employ complex alternatives or deliberately cause a faulty response in order to test the signalling function.

Concept of automatic configuration

Due to the quality of service (*QoS*) architecture of the *UMTS* standard, higher protocol layers request the transmission quality for a specific application in abstract form, whereas the actual parameters for channel configuration are known only in the lower layers (referred to as access stratum, *AS*). These parameters are very numerous, however, and can be combined in a variety of ways. *UMTS* differs from GSM in that the top *AS* layer, i.e. the *RRC* [3], is responsible for managing these parameters and their combinations. The strategy for assigning these parameters is implemented by the network operator. The parameter information is coded as *RRC* protocol data (*PDU*s) using complex elements described in the *ASN*.1 language and transmitted to the mobile phone. The base station and the mobile phone must configure their lower protocol layers accordingly before data can be transmitted at the required *QoS* (FIG 2). Similar processes take place during handover and other main procedures.

In contrast to other layer 3 messages, the *RRC PDU*s therefore contain information not only for the peer station but also for local configuration. The configuration interfaces of the lower layers are usually proprietary, whereas the *RRC PDU* is defined by the *3GPP* standard [3]. Since users of the C++ programming interface are usually interested in the detailed definition and full flexibility of the *RRC PDU* covering all parameters rather than in the complex configuration of the lower layers, offering the actual *RRC PDU* as a "single-source" interface is a good approach.

As a result, the *MLAPI* protocol stack provided by Rohde&Schwarz contains not only the lower protocol layers but also the part of the *RRC* layer that is responsible for the configuration of the lower layers, hence the designation "Medium Level". Thus, when you send an *RRC PDU* from your scenario, the required information is automatically extracted and passed on to the lower layers. This considerably reduces error rate and program size without any loss of flexibility.

New dimensions in protocol message handling

The basic software for the R&S®CRTU-W provides a library (*MDDB*) for handling protocol messages. The library is automatically generated from the message specifications and includes all methods of handling such messages. For example, the Message Analyzer uses the *MDDB* to completely decode recorded protocol messages and interpret subelement values in text form.

All *MDDB* methods are available for the C++ pogramming interface, including read and write access to any desired subelements, cloning of substructures, reading and storage of message instances – in hexadecimal or XML format – and many more. Simple macros are available for transmitting and receiving any layer 3 *PDU*.

Being able to define message instances is one of the programming interface's main features. Therefore, a graphical tool which is also based on the *MDDB* has been implemented for this purpose – the Message Composer (FIG 4). This tool enables you to conveniently perform any modifications to the scenario behaviour that are coded in the protocol messages without having to recompile the scenario.

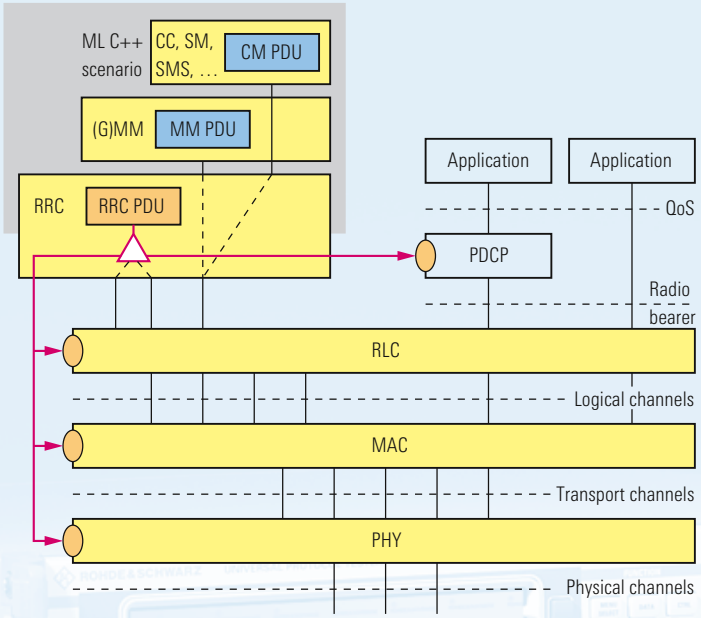
To allow received messages to be checked against predefined receive constraints, they are not stored in purely hexadecimal format. Rather, they must support wildcards that, for example, allow a defined list of values or any value (ANY) to be assumed by a specific subelement. These values can also be graphically defined with the Message Composer and are highlighted in colour (FIG 4). The C++ programming interface also offers a simple macro that performs the comparison automatically. If there is no match, the discrepancy will be indicated in the subelement tree.

Intelligent organization of dynamic behaviour

The *MLAPI* offers simple macros for defining state machines to enable efficient programming even for complex, branched operations. The reception of a message – or more generally speaking an event – is represented by a transition within a state. If and to what extent different states or state machines are actually used is up to you.

Further powerful functions are available for optimizing scenario modularity. State machines can be run in parallel or be derived from one another, making it easy for you to define a common means of handling exceptions for a specific number of procedures, for example. Moreover, state machines can mutually call each other, allowing you to design a procedure-oriented scenario. The programming interface further provides convenient means of defining timers, delays,

FIG 2
QoS and *UMTS* protocol structure.



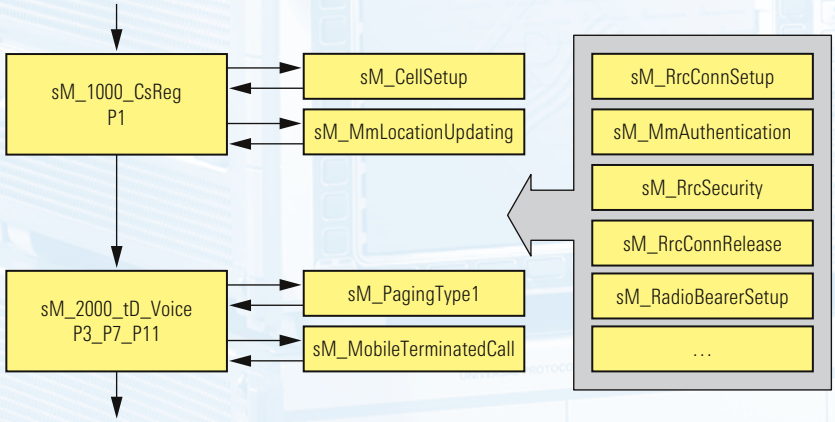
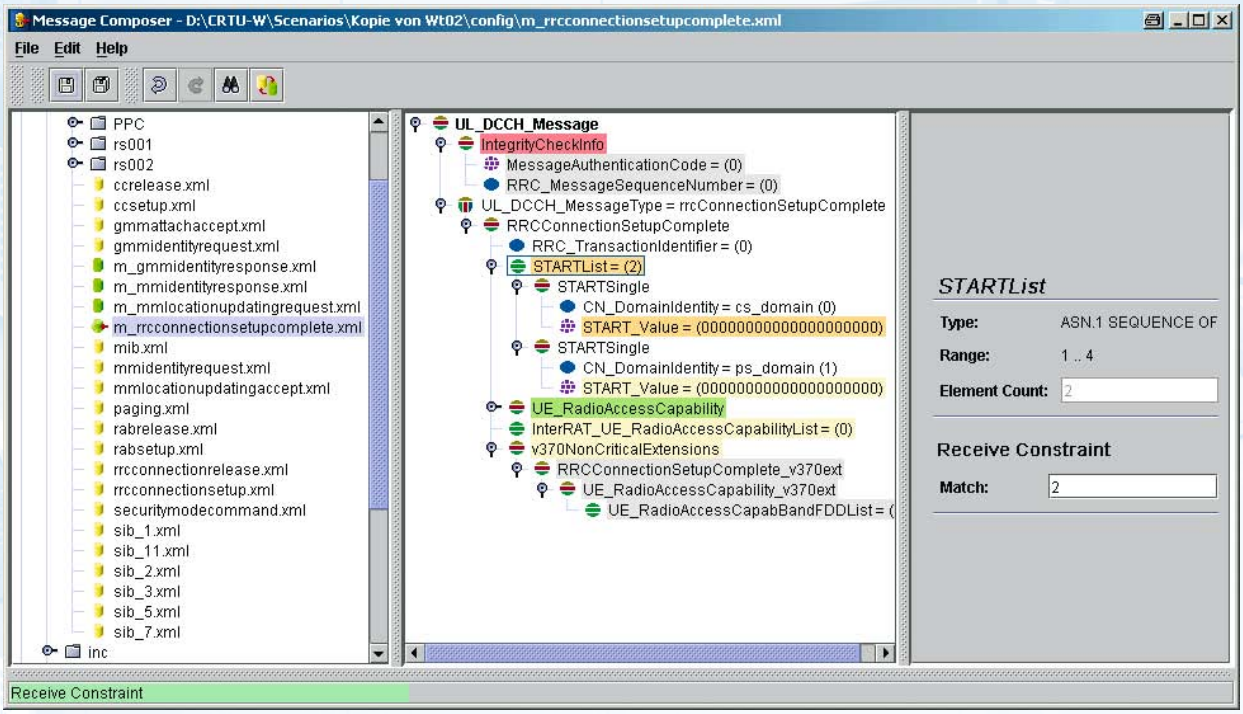


FIG 3 Modularization of the dynamic behaviour of a scenario.

Important abbreviations

3GPP	3rd Generation Partnership Project
AMR	Adaptive Multirate
AS	Access Stratum
ASN.1	Abstract Syntax Notation One
CS	Circuit Switched
EMMI	Electrical Man-Machine Interface
HSDPA	High Speed Downlink Packet Access
IP	Internet Protocol
MAC	Medium Access Control
MDDB	Message Description Data Base
MLAPI	Medium Level C++ Programming Interface
MMS	Multimedia Message Service
PDCP	Packet Data Convergence Protocol
PDU	Protocol Data Unit
PS	Packet Switched
QoS	Quality of Service
RAT	Radio Access Technology
RLC	Radio Link Control
RRC	Radio Resource Control
TTCN	Tree and Tabular Combined Notation
UMTS	Universal Mobile Telecommunications System
WAP	Wireless Application Protocol

FIG 4
Message Composer with receive constraints check.



triggers, as well as the parameterization for passing messages or other information to additional state machines.

The *MLAPI* software option already contains a number of example scenarios in the form of compilable source code. These scenarios show how to use all essential interface elements. They also implement standard applications such as *CS* registration and *PS* attach, *AMR* speech call, *PS* data call, *CS*/*PS* multicall, soft and hard handover. Being of modular design (FIG 3), the scenarios can easily be expanded. To make this possible, the state model described in the *3GPP* test specification [4] has been expanded to create a modular system.

All actions carried out by macros of the programming interface are written to a log file that can be decoded by the Message Analyzer. This keeps you constantly informed of what is happening – in the state involved and the scenario activity – in the lower protocol layers. You can also send information of your own to the log file while your scenario is running.

Tools and peripherals

The generated programs run under Windows® 2000; the programming interface is integrated into Microsoft® VisualStudio .NET© IDE. User-created scenarios can be organized by means of the TestSuite Explorer and Project Explorer tools included in the R&S®CRTU-W basic software. An example project is also supplied.

The *MLAPI* supports linking to the *EMMI*, enabling automatic control of the mobile phone by means of AT commands [5]. It also allows preliminary and final verdicts to be output like in conformance testing. The above functions employ the same modules as those used in the *TTCN* test cases.

Summary and future developments

The *MLAPI* is a tool for *UMTS* protocol development that optimally combines flexibility with convenience. Due to the unique interface design, test scenarios can be created with considerably less effort. The concept of automatic configuration of the lower protocol layers further contributes to efficiently generating and maintaining test scenarios. Plus, you can easily integrate your own protocol behaviour into the C++ program source code that is supplied. This enables you to simulate incorrect protocol behaviour, for example.

The versatile capabilities of the base unit are also reflected by the programming interface. The convenient use of *IP*-based data services (http, *WAP*, audio/video streaming, *MMS*) and video conferences will soon be possible, as well as the scaling of several protocol testers for multicell and handover scenarios. Moreover, Rohde&Schwarz plans to expand the programming interface to enable you to control a Protocol Tester R&S®CRTU-G using the same philosophy as for the R&S®CRTU-W. This will allow you to define 2G3 inter-*RAT* handover scenarios [6].

Rohde&Schwarz increasingly offers packages of ready-to-run scenarios that simulate typical applications in real networks, i.e. applications in the field of interoperability testing.

Future expansions include the *HSDPA* standard, interfaces for stimulating a specific behaviour in layer 2, and a convenient graphical user interface for interactively creating scenarios from existing procedures.

Stephan Sandhäger

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

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[2] Protocol Tester R&S®CRTU-W: Future-proof tool for testing WCDMA terminals. News from Rohde&Schwarz (2002) No. 175, pp 4–7
[3] 3GPP TS 25.331: 3GPP Radio Access Network – Radio Resource Control (RRC) Protocol Specification
[4] 3GPP TS 34.108: 3GPP Radio Access Network – Common Test Environments for User Equipment (UE) Conformance Testing
[5] 3GPP TS 34.109: 3GPP Radio Access Network – Terminal Logical Test Interface; Special Conformance Testing Functions
[6] Protocol Tester R&S®CRTU-G/-W: 2 in 1: Software option for 2G/3G system simulation. News from Rohde&Schwarz (2003) No. 178, pp 22–24

44000/2

TETRA Mobile Radio System *ACCESSNET*®-T

Faster than the standard – higher data rates with TETRA

The TETRA Memorandum of Understanding (TETRA MoU) association is currently expanding the TETRA standard for higher transmission rates. The new standard TETRA V2 will not be ready for quite a while. However, Rohde & Schwarz already offers a solution.

Increasing requirements

The current transmission data rates specified in the TETRA standard (max. 28.8 kbit/s) are adequate for many applications. However, the advent of new techniques for increasing speed inspires the imagination. When "data transmission" was first introduced, many users were satisfied with being able to send short text files. Today, however, users want or need to quickly transmit large quantities by radio. As a result, they are now demanding higher transmission rates. Recognizing this need, TETRA MoU is currently expanding the standard (TETRA V2). But this expansion will not be available for a while to come.

The Rohde & Schwarz solution

In the meantime, Rohde & Schwarz has devised a solution that can meet these requirements today. Since we are experts in numerous fields in radio und broadcasting, our specialists joined together to create an application for high-speed data transmission. This application is based on the TETRA radio

* Glossary on page 23.

FIG 1 Basic setup of the mobile receiver end.

system *ACCESSNET*®-T from Rohde & Schwarz [*] and the broadcast standards DAB-T/DVB-T*. It operates using asynchronous transmission.

DAB/DVB radio networks are pure broadcast networks. They do not have a return channel via which customer-specific requests, for example, can be carried out. The application described here combines the advantages of both network types, opening up new possibilities in data transmission. The main principle is as follows: The request to transmit a data record via DAB/DVB is initiated by a TETRA network. It is then sent to a streaming or data server via the TETRA network *ACCESSNET*®-T and a gateway. These servers send the data to the DAB/DVB network. The data is then routed to DAB/DVB receivers, which forward it to the final destination for evaluation and processing.

* The abbreviation DAB/DVB is used in this article.

DAB or DVB?

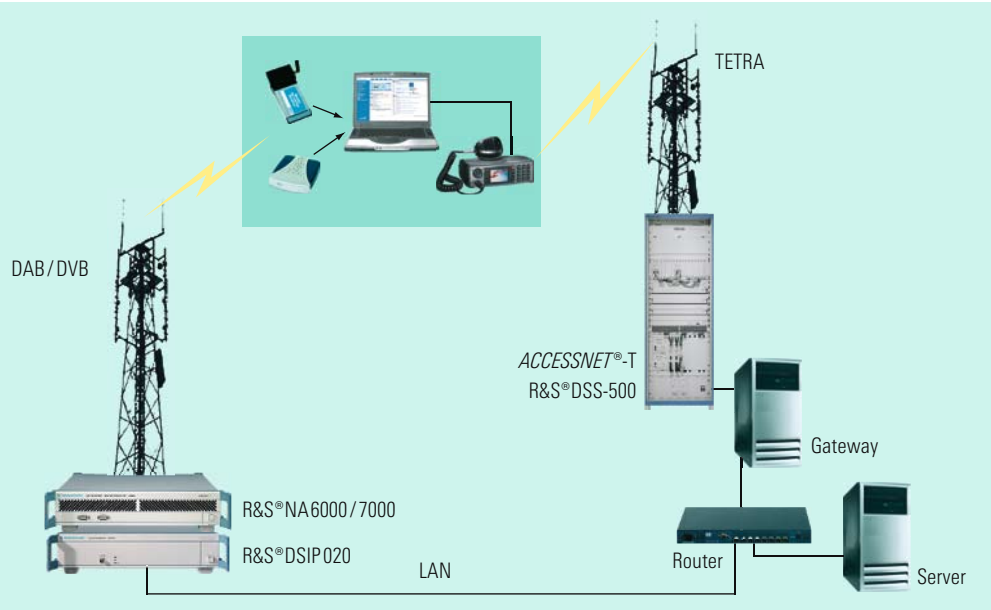
Depending on the specific requirements, *ACCESSNET*®-T is linked to a DAB or DVB network. The primary factor determining which of the two is used is the maximum data rate needed. DAB provides a rate of approx. 1.8 Mbit/s (net), and DVB provides a rate between 5 Mbit/s and 34 Mbit/s. Two other important factors are whether you need mobile operation in vehicles and the maximum speed that has been planned. DAB is highly suitable for mobile purposes and can also be used at speeds >300 km/h. DVB reception is limited in mobile operation and performs well only up to speeds of 130 km/h.

How it works

FIG 1 shows the setup at the mobile receiver end. The serial interface connects the laptop with the TETRA terminal. The peripheral equipment interface (PEI) of the terminal is used to control the instrument. The DAB/DVB receiver is connected to the laptop via the USB interface or via a PCMCIA plug-in card.

A gateway and LAN provide the TETRA network *ACCESSNET*®-T with access to the DAB/DVB network (FIG 2). To enable rapid transmission, the receiver end initiates a request over *ACCESSNET*®-T by

FIG 2 Radio infrastructure of the application.



means of SDS or via a CMD connection to the data or streaming server. The server acknowledges the request via the TETRA network. Together with the request, the encryption parameters for the data to be sent are transmitted over an intercept-proof network. The requested data is routed over the LAN to the DAB / DVB network and transmitted. If encryption parameters are transferred, the transmission is encrypted. The DAB / DVB receiver receives the requested data and makes it available for further processing. If the data is received without errors, the receiver end sends an acknowledgement to the server via the TETRA system. If the received data contains errors, the system sends information about the missing or defective data packets back to the host via the TETRA network. The host then tries to retransmit the missing data.

Numerous applications

High-speed data transmission can be highly beneficial, such as within a BOS network that must be secure. For example, site and building plans can be sent to fire fighters. Or photos of individuals or stolen vehicles can be transmitted during an investigation. It is even possible to transmit video sequences.

You can also use this application to transmit large volumes of data in local public transportation, e. g. commercials or information for commuters. In industrial networks, just one of the many possible applications is to call up data about monitored machines and systems. The possibilities are virtually endless.

Summary

TETRA's flexibility makes it right for numerous applications. Even tasks that do not appear to closely fit the standard become possible at an affordable price by using *ACCESSNET*®-T and applying new ideas. One of the major cost advantages is that standardized interfaces and commercially available components are used, underscoring the benefits of an open standard.

You can also implement an existing DAB / DVB network with this application if needed. If you do not have access to a DAB / DVB network, we can devise cost-effective solutions using your own infrastructure.

Harald Haage

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

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[*] *ACCESSNET*®-T – the digital mobile radio system from Rohde & Schwarz. News from Rohde & Schwarz (2003) No. 178, pp 6–9

The articles on pages 24 and 25 describe projects in Croatia and Bangkok where *ACCESSNET*®-T has been implemented successfully.

Glossary

ACCESSNET®-T	Digital trunked radio system from Rohde & Schwarz in accordance with the TETRA standard
BOS	Government authorities and organizations with security missions
CMD	Circuit Mode Data (circuit-switched data service in the TETRA standard)
DAB-T	Digital Audio Broadcasting Terrestrial (standard)
R&S®DSIP020	Digital Sound Broadcast Data Inserter from Rohde & Schwarz
R&S®DSS-500	Digital Small System, TETRA base station with exchange and power supply from Rohde & Schwarz
DVB-T	Digital Video Broadcasting Terrestrial (standard)
LAN	Local Area Network
PCMCIA	Personal Computer Memory Card International Association: industry standard for memory cards and other peripheral devices in check-card format
PEI	Peripheral Equipment Interface: standardized interface for TETRA terminals
R&S®SDB601	DAB Transmitter from Rohde & Schwarz
SDS	Short Data Service: service for transmitting short data packages with TETRA
TETRA	Terrestrial Trunked Radio: only digital trunked radio standard adopted by the European Telecommunications Standards Institute (ETSI)
TETRA MoU	TETRA Memorandum of Understanding: association of manufacturers and users of the TETRA standard that are responsible for establishing the standard on the market

Mobile Radio System *ACCESSNET*®

High quality and flexibility mean customer satisfaction

As a network operator and service provider, the private Croatian telecommunications company Radioplus offers its customers a public trunked mobile radio service. In the past six years, Radioplus has consolidated its position on the Croatian market by establishing close and trusting partnerships with its customers. The network provided by Radioplus is based on the MPT1327 *ACCESSNET*® mobile radio system from Rohde & Schwarz. In this article, Davor Jarnak, Managing Director of Radioplus, talks about his experiences.

Choosing the right supplier for the network infrastructure was one of the key decisions that we had to take within our overall business strategy. The marketing concept called for the best network infrastructure available on the market and premium service for the end user. Since Radioplus wanted to achieve a very high level of customer satisfaction, there was no room for compromise. This is why we chose the *ACCESSNET*® solution from Rohde & Schwarz. What tipped the scale in favour of Rohde & Schwarz was the company's worldwide renown for high quality in design, installation and customer support. Another convincing factor was the long list of references Rohde & Schwarz presented in the field of trunked mobile radio, and the long-standing experience that goes with it. We did not want to subject either ourselves or our customers to any solution that had not been proven. An aspect of equal importance was Rohde & Schwarz's long-term commitment in the field of professional mobile radio.

Quality and reliability are key criteria in a system since they determine the quality of service of a communications system. With its extremely smooth and reliable operation, the *ACCESSNET*® system gives Radioplus – and its customers – a clear competitive edge.

One quality criterion that is vital to a radio network's reliability is redundancy. Offering a variety of options for fallback operation, *ACCESSNET*® meets the most exacting requirements for redundancy in the event the system goes down or under difficult operating conditions.

The use of an open standard and the high flexibility of *ACCESSNET*® made it possible to design a telecommunications service tailored to customer requirements. *ACCESSNET*® has a proven track record of being able to provide interoperability and seamless communication between various types of mobile terminals from different manufacturers in everyday operation. This is a strong marketing argument for Radioplus. After all, customer satisfaction is a decisive factor when it comes to the quality of a service – a point that has always been of primary importance to Radioplus. After several years of experience with *ACCESSNET*®, we are happy to say that the system has met – and even surpassed – our expectations with respect to the three vital criteria of quality, redundancy and flexibility.

Davor Jarnak
Managing Director of Radioplus

***ACCESSNET*® system in a raised facility providing trunked mobile radio service for Radioplus customers.**

Photos: Autor

TETRA Mobile Radio System *ACCESSNET*®-T

Complete radio solution for Bangkok's underground train system

For years, the inhabitants of Bangkok have been suffering from daily traffic chaos. To tackle this problem, the Thai government drafted ambitious plans to build an underground train system. Siemens was commissioned to provide the trains and infrastructure, including signalling technology, power supply, depot equipment and communications system. Siemens in turn contracted R&S BICK Mobilfunk GmbH to furnish a complete radiocommunications solution, consisting of the *ACCESSNET*®-T TETRA mobile radio system, a control center and the radiocommunications equipment on the trains.

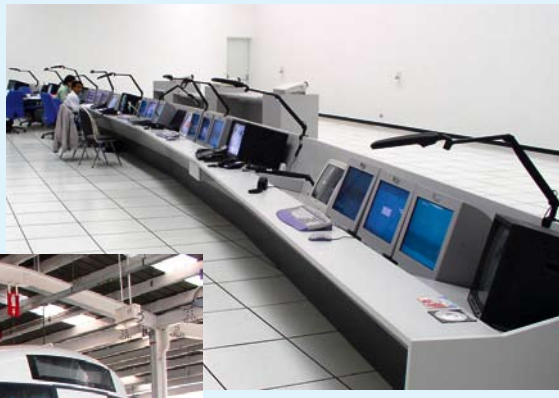
Reliable means of communication are indispensable for operating an underground train system. The people in charge of planning Bangkok's underground project therefore selected the *ACCESSNET*®-T TETRA mobile radio system from Rohde & Schwarz, which can cite numerous reference projects in which the system has fulfilled maximum security requirements. In Bangkok, the system was once again able to prove its flexibility.

The local TETRA mobile radio system consists of an exchange and several radio base stations. A network management system and clients were provided for managing the network. They are used to quickly adapt the system's configuration to altered conditions. All communications with train conductors and underground staff are handled via a control center. For security reasons, seamless traceability of all radiocommunications had to be ensured, which is why voice recording was integrated. Implementation was no problem owing to the ACAPI interface in *ACCESSNET*®-T and the multiposition R&S®TRD-500 dispatcher system plus a connected voice recorder.

Radio coverage of the tunnels was set up using a specially developed inhouse coverage system which also includes leakage cable monitoring. Radiocommunications with the trains are via train radio subracks, which were specifically developed for this project and which take into account operator-specific requirements. The system is equipped with SCADA interfaces for connecting it to a main alarm system. To ensure smooth operation and maintenance, Rohde & Schwarz trained operators and service staff in a special seminar.

The underground train system was officially opened on 12 August 2004, the birthday of Thailand's queen. An underground train with *ACCESSNET*®-T – a truly royal present.

Harald Haage



Photos: R&S BICK Mobilfunk

The control center (top), where all communications are controlled via *ACCESSNET*®-T.

Handheld Spectrum Analyzer R&S®FSH6

Award-winning spectrum analyzer now up to 6 GHz

The R&S®FSH6 is the world's first 6 GHz handheld spectrum analyzer that can directly measure WLAN 802.11a signals, for example. It is the follow-up to the successful 3 GHz model R&S®FSH3 [*], which won the NAB2004 Pick Hit Award (see page 63).

The latest firmware version now adds new functionality to all R&S®FSH models, including for example receiver mode and frequency tuning based on channel lists.

FIG 1 The Handheld Spectrum Analyzer R&S®FSH6 provides a frequency range of up to 6 GHz.

Ideal for numerous applications

With a frequency range of up to 6 GHz, the R&S®FSH6 (FIG 1) is ideal for installing, optimizing and servicing WLAN 802.11a networks. It is also the right tool for general lab applications in the higher frequency ranges and for measuring mobile phone local oscillator frequencies between 3.4 GHz and 3.9 GHz. The R&S®FSH6 is just as handy and robust as the R&S®FSH3. Both models also feature a straightforward operating concept, a long battery operating time of up to 4 h, an ample range of measurement functions, plus a wide choice of accessories. FIG 2 provides an overview of the R&S®FSH family.

The new spectrum analyzer is available with or without an internal tracking generator. The tracking generator covers the frequency range from 5 MHz to 6 GHz. With the generator included, the analyzer can be used for distance-to-fault (DTF) measurements, scalar and vector network analysis, and one-port cable loss measurements. A VSWR bridge of

Model	Frequency range	Tracking generator	Output power of tracking generator	Preampli-fier	Resolution bandwidth
R&S®FSH3 model 03	100 kHz to 3 GHz	–	–	●	100 Hz to 1 MHz
R&S®FSH3 model 13	100 kHz to 3 GHz	●	–20 dBm	–	1 kHz to 1 MHz
R&S®FSH3 model 23	100 kHz to 3 GHz	●	–20 dBm / 0 dB selectable	●	100 Hz to 1 MHz
R&S®FSH6 model 06	100 kHz to 6 GHz	–	–	●	100 Hz to 1 MHz
R&S®FSH6 model 26	100 kHz to 6 GHz	●	–10 dBm (f < 3 GHz) –20 dBm (f > 3 GHz)	●	100 Hz to 1 MHz

FIG 2 Overview of the R&S®FSH models.

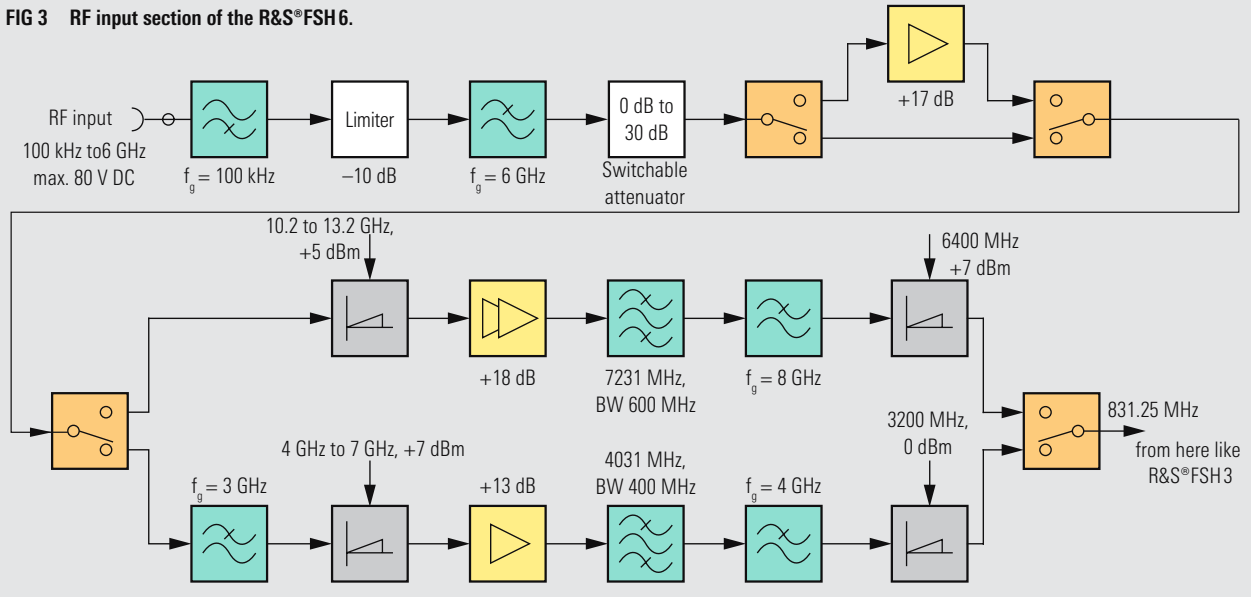
up to 3 GHz is available; a 6 GHz version is currently being developed. Both models come standard with a switchable preamplifier, making them suitable for measuring very weak signals throughout the analyzers' frequency range. With the preamplifier switched on, the displayed average noise level (DANL) of the instrument is typically –135 dBm (10 MHz to 2.2 GHz, resolution bandwidth 100 Hz). Featuring a level measurement uncertainty of <1.5 dB (typ. 0.5 dB), the R&S®FSH6 is every bit as good as the 3 GHz model, and this value is maintained even up to 6 GHz. The R&S®FSH6 stands out for its wide dynamic range of typically 80 dB up to 2.2 GHz for scalar transmission measurements. With vector transmission measurements, typically 90 dB can even be achieved, which makes the instrument suitable for critical antenna isolation measurements on base stations.

Additional receive path of up to 6 GHz

The R&S®FSH6 features an additional receive path from 3 GHz to 6 GHz that shifts the upper frequency limit to 6 GHz. Either of the two signal paths can be used, and also switched to idle, which means that the R&S®FSH6 consumes virtually the same amount of power as the R&S®FSH3. The analyzer can thus be operated for four hours with the tracking generator switched off or 3.5 hours with the tracking generator switched on without having to recharge the battery.

FIG 3 shows the RF input section of the R&S®FSH6. A 10 dB attenuator and limiting diodes protect the RF input against power peaks and high input loads of up to approx. 36 dBm. Then, the level of the first mixer is set in accordance with the selected reference level, using an electronically switched attenuator and a preamplifier that can be bypassed. Via a switch, the 3 GHz or the 6 GHz path is activated, depending on the measurement frequency. In either signal path, the first IF is above the receive band, so

FIG 3 RF input section of the R&S®FSH6.



that only a simple input lowpass filter for image frequency rejection is required. The local oscillator frequencies for the 6 GHz path are obtained by doubling and filtering the oscillator frequencies from the base unit.

Expanded firmware provides new functionality

The new firmware version 7.0 – which can be downloaded free of charge from the Rohde&Schwarz website – adds new functionality to all models of the R&S®FSH family.

Tuning by means of channel tables

As an alternative to entering frequencies, the new firmware allows the analyzer to be tuned by means of channel numbers, as is common practice in TV and mobile radio applications. The instrument then displays the channel number instead of the center frequency (FIG 5). The channel tables are generated with the R&S®FSH View software supplied with the R&S®FSH and loaded on the analyzer (FIG 6). Up to 15 subranges with different channel spacings and channel names can be defined for each channel table, allowing frequency ranges that are of no interest – e. g. gaps in transmission systems – to be skipped, for example (FIG 4). Virtually all TV channel tables in use around the world are supplied with the R&S®FSH. If no external PC is available, channel tables can also be defined directly on the instrument by entering the first channel number with the associated frequency, number of channels and channel spacing, with the constraint that no subranges or frequency gaps can be defined in this case (FIG 6).

Receiver mode

When equipped with the R&S®FSH-K3 option, all R&S®FSH models can be operated as receivers for monitoring and pre-compliance EMC applications. In the receiver mode, the analyzer measures the signal level at a selected frequency or channel for a definable measurement time (FIG 7). Measurement frequencies are selected at the spacing defined in the channel tables described above.

In the scan mode, the R&S®FSH sequentially measures the level at various frequencies defined in a channel table, and displays the results in graphical form. FIG 8 shows the results of a receiver measurement on GSM mobile radio channels in the uplink band. Each vertical line represents a GSM transmission channel; the channels are spaced 200 kHz apart. The line height represents the signal level in each case. In addition, the CISPR bandwidths (6 dB) 200 Hz, 9 kHz, 120 kHz and 1 MHz are available for EMI measurements. The R&S®FSH offers peak, average, RMS and quasi-peak detectors in the receiver mode.

Optimized dynamic range

The dynamic range can be optimized as required for a specific application. You can choose between maximum sensitivity (low noise) or minimum intermodulation products (low distortion) for your measurement. In low distortion mode, the RF attenuator is set 10 dB higher than in low noise mode. The low distortion mode is important for measurements on CATV systems, for example.

User-defined PRESET settings

If you want the instrument to have default settings different from the factory settings after a preset, you can modify the preset settings. For example, you can set the R&S®FSH to operate at an input impedance of 75 Ω rather than 50 Ω after a preset. The preset settings can be defined by means of the R&S®FSH View software.

Auto save function

The R&S®FSH View software version 7.0 allows automatic saving of results at predefined intervals using various ASCII or graphics formats. This simplifies result logging over an extended period of time.

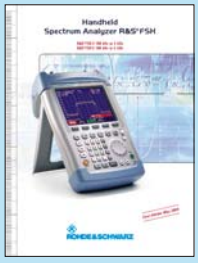
New accessories for field use

A sturdy aluminum case with edge protectors is available for field applications of the R&S®FSH. This case accommodates not only the analyzer but also all accessories (FIG 9).

The Calibration Standard R&S®FSH-Z29 has been specially designed for field use (FIG 10). It includes all calibration standards (short, open and 50 Ω load) required for network analysis and DTF measurements. Worn around the user's neck, it is always at hand when needed for calibration.

Alexander Roth; Rainer Wagner

More information and data sheet at www.rohde-schwarz.com (search term: FSH6)



REFERENCE

[*] Handheld Spectrum Analyzer R&S®FSH3: New mobility in spectrum analysis. News from Rohde&Schwarz (2002) No. 175, pp 20–25

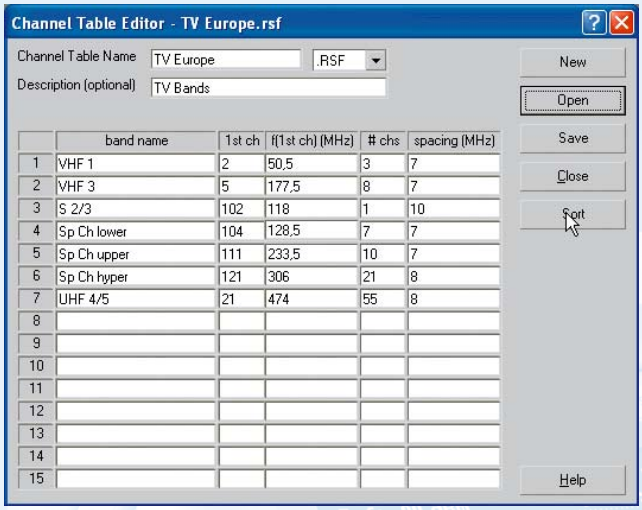


FIG 4 Channel tables with up to 15 subranges can be generated with the R&S®FSH View software.

Condensed data of the R&S®FSH6

Frequency range		100 kHz to 6 GHz
Resolution bandwidths	(3 dB)	100 Hz to 1 MHz
	(6 dB), optional	200 Hz, 9 kHz, 120 kHz and 1 MHz
Video bandwidths		10 Hz to 1 MHz
SSB phase noise		<–100 dBc at 100 kHz from carrier
Displayed average noise level (DANL)		typ. –135 dBm (100 Hz)
Detectors		sample, max/min peak, auto peak, RMS optional: average, quasi-peak
Level measurement uncertainty		<1.5 dB, typ. 0.5 dB, up to 6 GHz
Tracking generator (model 26 only)		5 MHz to 6 GHz

FIG 10 Calibration Standard R&S®FSH-Z29 designed for field use.

FIG 9 Transit Case R&S®FSH-Z26.

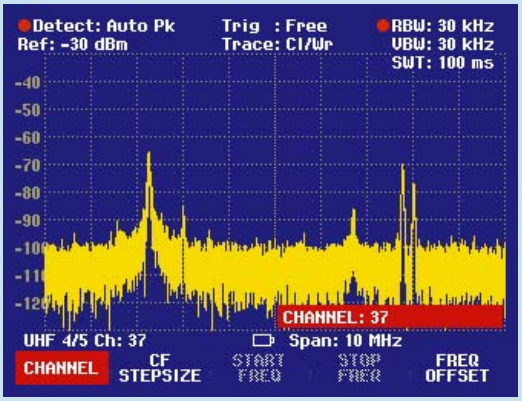


FIG 5 Spectrum measurement of a TV signal with frequency tuning based on a channel table.

FIG 6 Up to 15 channel tables can be loaded on the R&S®FSH.

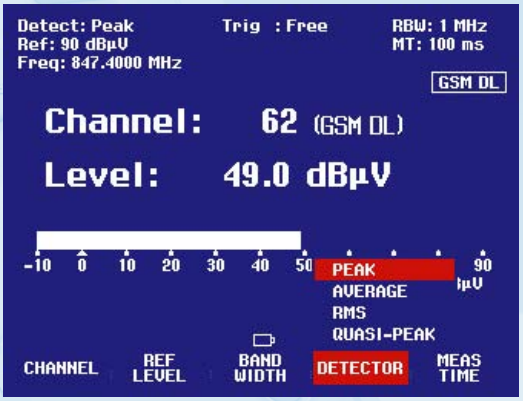


FIG 7 Level measurement at a selected channel in the receiver mode.

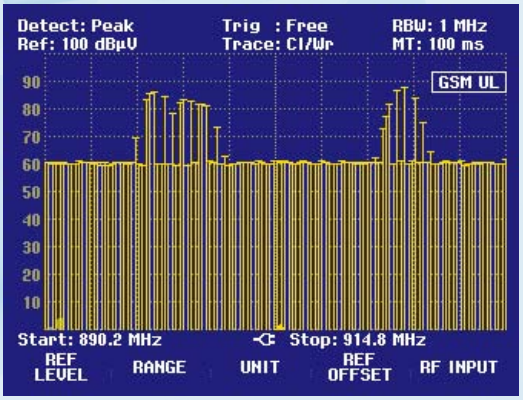


FIG 8 Receiver measurement in scan mode in the GSM uplink band.

Spectrum and signal analyzers for every requirement – an overview

The introduction of the Handheld Spectrum Analyzer R&S®FSH6 (page 26) expands an already full range of analyzers from Rohde&Schwarz, covering virtually every requirement with regard to level of performance, frequency range and functionality. You can find the right equipment for your development, production or installation needs from among our wide selection of instruments and options. Most of the instruments are identical in functionality and operation, allowing you to easily transfer programs or operating know-how from one instrument to the next.

The world of analyzers from Rohde&Schwarz

Since first entering the spectrum analyzer market, Rohde&Schwarz has continuously expanded its range of analyzers. The R&S®FSH, R&S®FS300, R&S®FSP, R&S®FSU, and R&S®FSQ families of instruments now cover the full scope of performance and frequency ranges. We offer virtually any type of instrument you need, from handheld spectrum analyzers up to high-end signal analyzers. Our instruments are designed for frequencies up to 50 GHz and higher (FIGs 1 and 2). FIG 3 provides an overview of the frequency ranges for the various families of instruments. FIG 4 compares the most important specifications.

New mobility in spectrum analysis – the R&S®FSH

The R&S®FSH is a handheld spectrum analyzer designed for measurement tasks in the field (see [1] and article on page 37). The brand-new model R&S®FSH6 (page 26) offers a frequency range of 100 kHz to 6 GHz. The strengths of this family of instruments are easy operation, sturdy housing, and low weight. In addition, a built-in tracking generator and an integrated VSWR bridge enable you to perform DTF measurements on cables. You can use these analyzers to check antenna installations such as found at base stations and to analyze the spectrum for interference. The instruments even display antenna matching in vector format in a Smith chart.

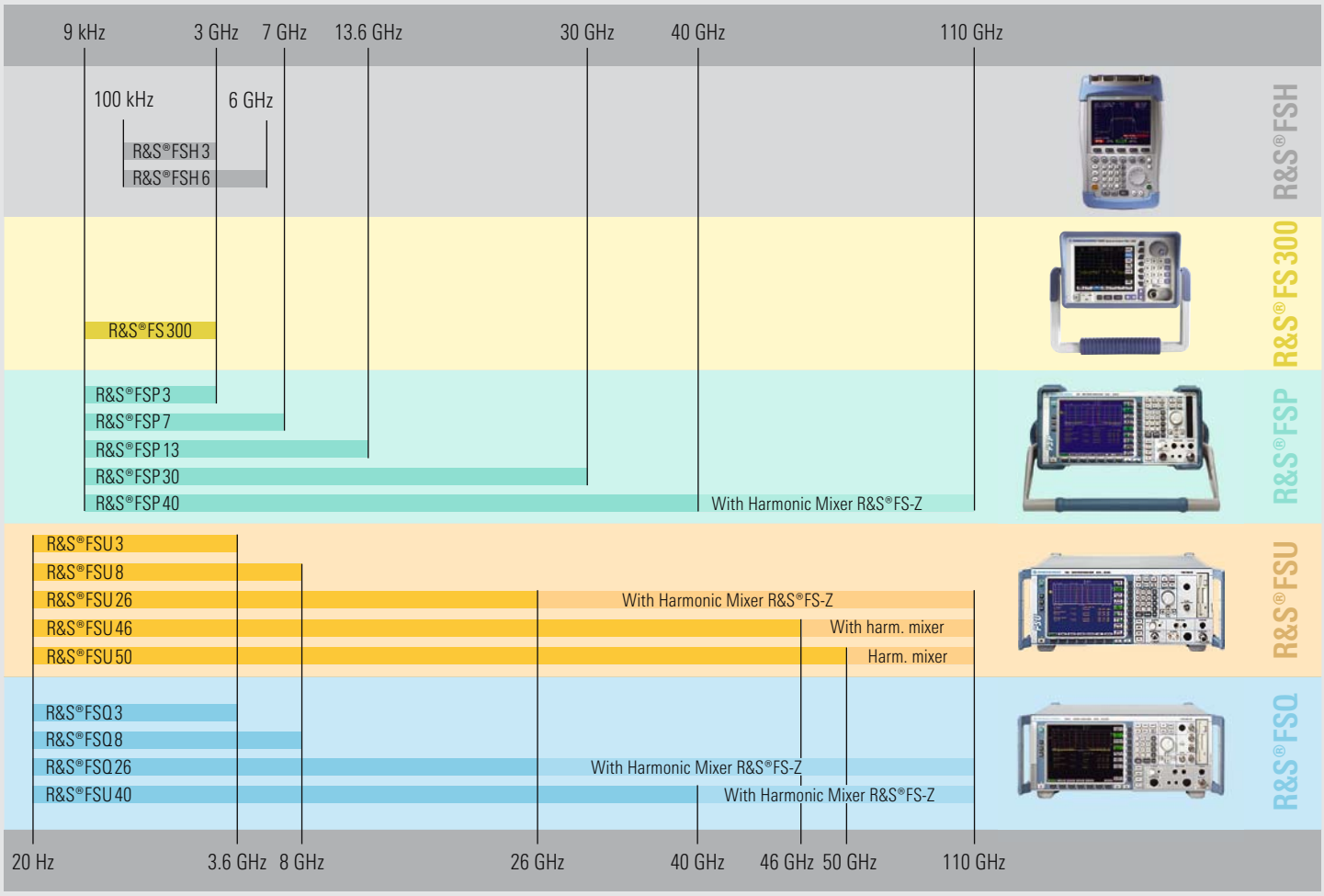
The functionality of the R&S®FSH matches that of conventional lab instruments. Each instrument is equipped with an RMS detector for precise power measurements, channel power measurements, and burst power measurements in the time domain, plus an AM/FM audio demodulator, versatile marker functions and a port for connecting a power sensor. An increasingly important application is EMF analysis: The R&S®FSH has been combined with an antenna and software to create a separate test system for this purpose – the new R&S®TS-EMF [2].

R&S®FSH	3 GHz/6 GHz handheld spectrum analyzer for mobile use in service and installation
R&S®FS300	Economical 3 GHz spectrum analyzer for universal applications in service and production
R&S®FSP	Medium-class spectrum analyzer up to 40 GHz for most laboratory applications, service and measurement tasks in production
R&S®FSU	Spectrum analyzer with highest dynamic range up to 50 GHz for laboratory applications and for production when dynamic range requirements are high
R&S®FSQ	Signal analyzer with integrated spectrum analyzer up to 40 GHz (corresponding to the R&S®FSU) and up to 120 MHz I/Q demodulation bandwidth

FIG 1 Analyzers from Rohde&Schwarz.

FIG 2 The full range of analyzers from Rohde & Schwarz covers virtually every requirement with regard to level of performance, frequency range and functionality.

FIG 3 Overview of the various frequency ranges.



For all RF tasks – the R&S®FS300

The R&S®FS300 is a compact, universal and economical spectrum analyzer with properties previously found only in more expensive instruments [3]. The maximum permissible signal level is 33 dBm (2 W), which is more than most modern mobile phones are capable of, for example. This means low risk of destruction if power that is too high is unintentionally applied. For remotecontrol operation, this instrument relies on the widely used USB interface, eliminating the need for an IEC/IEEE bus card in the remote controller.

Medium-class instruments redefined – the R&S®FSP

The R&S®FSP is far more that just the right analyzer for general applications in the laboratory, in service and in the field. It is also the fastest RF spectrum analyzer currently available [4]. This makes it of particular interest for use in production and manufacturing. The following benchmarks show its enormous speed potential.

Its sweep rate in manual operation – i.e. the number of possible sweeps per second, including all processing time and return time – is 100 sweeps/s in zero span. This is faster than is necessary even for adjustment purposes. This high speed is useful, for example, if averaging over a large number of sweeps is necessary.

A common benchmark in remotecontrol operation is the sweep rate when transmitting all trace data via the IEC / IEEE bus. Capable of up to 80 sweeps/s in zero span and up to 55 sweeps/s for spans <10 MHz, the R&S®FSP is probably today's fastest analyzer.

In addition, integrated complex measurement and analysis routines significantly speed up measurements. This includes the List mode, which enables you to perform an entire series of measurements at various frequencies and different settings by using a single remotecontrol command. By using this function together with many different kinds of channel filters, the R&S®FSP operates like a very fast, accurate and selective power meter. You can also use the R&S®FSP's Fast ACP function to measure adjacent channel power with channel filters in the time domain. In accordance with the selected standards, the analyzer tunes to different channel frequencies one after the other, where it measures the power in the predefined measurement time using the channel filters specified for each frequency. Compared with conventional integration methods, performing measurements with the channel filters is approx. 10 times faster. The VCO synthesizer concept makes frequency switching so fast that total measurement time is hardly affected.

Both high measurement speed and intelligent analysis routines shorten test times and increase throughput, yielding highly effective production. Reliability is another major concern in production. Instruments must hold up well during continuous operation. The optional electronic attenuator ensures high reliability. It can even cope with the largest of switching cycles without experiencing wear.

The remaining functionality, which is on par with any high-end instrument, makes the R&S®FSP the ideal analysis tool in development if an extremely high dynamic range is not required, for example in the development of mobile phones. When it comes to application-specific firmware, the R&S®FSP is also comparable to the R&S®FSU and R&S®FSQ. For example, firmware is available for measuring code domain power on 3GPP/WCDMA, cdma2000 or TD-SCDMA signals, for measuring the signal parameters of GSM or EDGE signals, and even for measuring EVM on WLAN signals in accordance with IEEE802.11a.

The analyzer is optimally suited for use in the field since its weight is very low for an instrument of its class. With the optional battery power supply, it can also be battery-operated.

High-end for any requirement – the R&S®FSU

The primary difference between the high-end Spectrum Analyzer R&S®FSU [5] and the R&S®FSP is that the R&S®FSU offers an expanded dynamic range and RF performance, right up to the limit of what is feasible. This is evident in its phase noise, intermodulation properties and 1 dB compression point. In the frequency range around 1 GHz and up to 2 GHz, which is important in mobile communications, it reaches a TOI of typically +25 dBm to +27 dBm. These values are well in line with many high-end communications receivers. With a 1 dB compression point of +13 dBm, it can measure signals with a power of up to +5 dBm at an RF attenuation setting of 0 dB, i.e. without impairment of the displayed average noise level. This factor and the instrument's excellent phase noise of –160 dBc (1 Hz) at 10 MHz from the carrier allow the R&S®FSU to measure spurious emissions even on GSM or WCDMA base stations with minimum use of filters. There is no need for expensive, tunable notch filters.

Another example of the advantages of its high dynamic range is its capability to measure adjacent channel power on a 3GPP WCDMA signal. Its value of 77 dB for a four-carrier signal is sufficiently different from the values commonly encountered in base stations and

	R&S®FSH	R&S®FS300	R&S®FSP	R&S®FSU	R&S®FSQ
Type	Handheld spectrum analyzer	Universal spectrum analyzer from the Family 300	General-purpose spectrum analyzer	High-performance spectrum analyzer	High-performance signal analyzer
Frequency range	100 kHz to 6 GHz	9 kHz to 3 GHz	9 kHz to 40 GHz	20 Hz to 50 GHz	20 Hz to 40 GHz
With external mixer	–	–	up to 1.12 THz[1)]	up to 1.12 THz[1)]	up to 1.12 THz[1)]
Frequency uncertainty at 1 GHz	2000 Hz	2000 Hz	1000 Hz	180 Hz	180 Hz
Optional	–	–	180 Hz	50 Hz	50 Hz
Resolution bandwidths					
Standard filter	100 Hz to 1 MHz 1 kHz to 1 MHz (model .13)	200 Hz to 1 MHz	10 Hz to 10 MHz	10 Hz to 50 MHz	10 Hz to 50 MHz
FFT filter	–	–	1 Hz to 30 kHz	1 Hz to 30 kHz	1 Hz to 30 kHz
Channel filter	–	–	100 / 200 / 300 / 500 Hz, 1 / 1.5 / 2 / 2.4 / 2.7 / 3 / 3.4 / 4 / 4.5 / 5 / 6 / 8.5 / 9 / 10 / 12.5 / 14 / 15 / 16 / 20 / 21 / 25 / 30 / 50 / 100 / 150 / 192 / 300 / 300 / 500 kHz, 1 / 1.2288 / 1.5 / 2 / 3 / 5 MHz		
RRC filter	–	–	18 / 24.3 kHz, 1.28 / 3.84 / 4.096 MHz		
EMI filter	–	–	200 Hz, 9 kHz, 120 kHz		
Displayed average noise level[2)]					
At 1 GHz	–114 dBm (1 kHz)	–120 dBm (300 Hz)	–145 dBm (10 Hz)	–148 dBm (10 Hz)	–148 dBm (10 Hz)
At 26 GHz	–	–	–128 dBm (10 Hz)	–138 dBm (10 Hz)	–136 dBm (10 Hz)
At 40 GHz	–	–	–120 dBm (10 Hz)	–133 dBm (10 Hz)	–
Third order intercept (TOI)[2)]	13 dBm	5 dBm	15 dBm	27 dBm	27 dBm
Dynamic range for 3GPP ACLR in adjacent channel[2)]	–	–	66 dB	84 dB	84 dB
Phase noise (10 kHz offset)[2)]	–85 dBc (1 Hz), 30 kHz offset	–90 dBc (1Hz)	–113 dBc (1 Hz)	–123 dBc (1 Hz)	–123 dBc (1 Hz)
Measurement uncertainty	1.5 dB	1.5 dB	0.5 dB	0.3 dB	0.3 dB
Linearity of display			0.2 dB	0.1 dB	0.1 dB
Bandwidth of I/Q demodulation	–	–	8 MHz	8 MHz	28 MHz, as option up to 120 MHz
I/Q memory	–	–	128 ksamples	512 ksamples	16 ksamples
Speed					
Sweep time, span >10 Hz	100 ms to 1000 s	100 ms to 1000 s	2.5 ms to 16000 s		
Zero span	1 ms to 100 s	100 µs to 20 s	1 µs to 16000 s		
Measurement rate on IEC/IEEE bus[3)]	–	–	80/s	70/s	70/s
Preamplifier	models .03 and .23		up to 7 GHz	up to 26 GHz	up to 26 GHz
Tracking generator					
Internal	models 13 and 23: up to 3 GHz	–	up to 3 GHz	up to 3.6 GHz	–
External	–	–	with External Generator Control R&S®FSP-B10 and signal generators such as the R&S®SMR, R&S®SMP, R&S®SMIQ		
LAN	–	–	optional	standard	standard
Battery operation	standard	–	optional	–	–
Connector for power sensor	standard	–	optional	optional	optional

1) With Rohde&Schwarz Harmonic Mixers R&S®FS-Z60, R&S®FS-Z90 and R&S®FS-Z110 up to 110 GHz.
2) Best performance, typical.
3) Zero span, 1 sweep including trace data transmission.

FIG 4 Comparison of the analyzer´s main specifications.

power amplifiers to yield adequate measurement uncertainty. In the case of one-carrier signals, it can achieve adjacent channel power ratios of up to 84 dB.

If you operate the R&S®FSU together with the application firmware packages for GSM/EDGE, 3GPP or cdma2000, it is the ideal analyzer for base station tests, both in development and in production.

The microwave models R&S®FSU26, R&S®FSU46, and R&S®FSU50 have been optimized for the special requirements in this frequency range. The low displayed average noise level of typ. –148 dBm in a 1 Hz bandwidth at 26 GHz, and –138 dBm (1 Hz) at 46 GHz, supports precise and sensitive measurements. Sophisticated YIG filter corrections, which are critical to high measurement accuracy, ensure the repeatability and stability of measurements.

Broadband communications firmly under control – the R&S®FSQ

The Signal Analyzer R&S®FSQ is based on the R&S®FSU and combines its excellent RF characteristics with the versatility of a broadband signal analyzer. The main difference is the digital signal analysis, which was developed for the large demodulation bandwidth of 28 MHz and provides additional DSP computing capacity.

This large demodulation bandwidth makes the R&S®FSQ precisely the right instrument for measurements on 3GPP WCDMA multicarrier signals, whether for determining the amplitude statistics via the CCDF measurement function or for measuring the code domain power. As for the adjacent channel power ratio, the R&S®FSQ reaches the same values as the R&S®FSU, e. g. 77 dB in the adjacent channel of a four-carrier WCDMA signal.

The R&S®FSQ shows its particular strengths when used together with the general vector analysis option, which is available only for the R&S®FSQ. This option features not only a large bandwidth, as evident from the high symbol rate of up to 25 Msymbol/s. Measurement rates of up to 40 measurements/s on GSM or EDGE signals are also possible. Conventional modulation types up to 256QAM are supplied with the instrument. Special software tools enable you to even design modulation constellations or to use self-designed baseband filters, increasing the instrument's versatility. A new measurement function is particularly of interest to developers of highly linear amplifiers: By analyzing a demodulated signal such as a 64QAM signal, the vector signal analysis option determines the distortion characteristic of the amplifier inserted between a transmitter and the analyzer and then displays it directly as an AM/AM and AM/φM characteristic.

When performing measurements at the chip level, you often need to analyze baseband signals. You can do this with the R&S®FSQ by adding the baseband input option, whose baseband inputs can be switched between balanced and unbalanced.

You can achieve even higher demodulation bandwidths of 60 MHz (up to 3.6 GHz) or 120 MHz (above 3.6 GHz) by using the baseband expansion option. In vector signal analysis, you can therefore directly measure symbol rates of up to 81.6 Msymbol/s. When operated with this option, the R&S®FSQ26 or the R&S®FSQ40 is optimally suited for analyzing broadband satellite signals and microwave signals.

Functions supplied with the R&S®FSP, R&S®FSU, R&S®FSQ

The R&S®FSP, R&S®FSU and R&S®FSQ all feature the same user interface and remote control commands. This makes important, complex measurement routines the same in all three families. Once you learn one instrument, you know them all. You can also use most programs without making changes.

A short list of functions includes the following:

- Fast ACP and List mode
- CCDF measurement
- Versatile measurement functions for channel and adjacent channel power, including for multicarrier signals with up to 12 payload carriers
- 23 predefined standards for adjacent channel power measurements
- Probably the widest choice of filter characteristics available, ranging from FFT and channel filters up to RRC filters
- Full range of detectors, including RMS and quasi-peak
- TOI measurement function
- Rapid frequency counter (1 Hz resolution at a measuring time of 30 ms)
- Occupied bandwidth
- Split-screen display with independent measurement settings in both windows
- Automatic output of all signals in the spectrum as a list, e. g. for spurious measurements
- Noise and phase noise markers
- C/N and C/N_0 measurement functions
- Command-set compatibility with HP 8566A/B und HP 8563

Standard	Measurements on mobile stations	Measurements on base stations
GSM/EDGE	R&S®FS-K5	R&S®FS-K5
WCDMA 3GPP UMTS	R&S®FS-K73	R&S®FS-K72
HSDPA for 3GPP	R&S®FS-K73	R&S®FS-K74
cdma2000	R&S®FS-K83	R&S®FS-K82
cdma2000 1xEV-DV	R&S®FS-K83	planned for R&S®FS-K82
cdma2000 1xEV-DO	R&S®FS-K85	R&S®FS-K84
TD-SCDMA	R&S®FS-K77	R&S®FS-K76

FIG 5
Mobile-radio-specific application firmware packages.

Application		Type designation	R&S®FSP	R&S®FSU	R&S®FSQ
Mobile radio					
GSM/EDGE	Modulation and spectrum measurements on mobile and base stations	R&S®FS-K5	●	●	●
3GPP	Modulation, code domain and spectrum measurements on base stations	R&S®FS-K72	●*	●	●
HSDPA	Expansion for R&S®FS-K72	R&S®FS-K74	●*	●	●
3GPP	Modulation, code domain and spectrum measurements on mobile stations	R&S®FS-K73	●*	●	●
TD-SCDMA	Modulation, code domain and spectrum measurements on base stations	R&S®FS-K76	●	●	●
TD-SCDMA	Modulation, code domain and spectrum measurements on mobile stations	R&S®FS-K77	●	●	●
cdma2000 IS-95/cdmaOne	Modulation, code domain and spectrum measurements on base stations	R&S®FS-K82	●	●	●
cdma2000 incl. 1xEV-DV	Modulation, code domain and spectrum measurements on mobile stations	R&S®FS-K83	●	●	●
cdma2000 1xEV-DO	Modulation, code domain and spectrum measurements on base stations	R&S®FS-K84	●	●	●
cdma2000 1xEV-DO	Modulation, code domain and spectrum measurements on mobile stations	R&S®FS-K85	●	●	●
Other wireless applications					
Bluetooth		R&S®FS-K8	●	●	●
WLAN 802.11a/b/g/j		R&S®FSQ-K91			●
WLAN 802.11a		R&S®FSP-K90	●		
General measurement applications					
AM/φM/FM demodulator, including THD and SINAD measurement		R&S®FS-K7	●	●	●
Measurements with power sensors		R&S®FS-K9	●	●	●
Noise factor and gain measurements		R&S®FS-K30	●	●	●
Phase noise measurements		R&S®FS-K4	●	●	
General vector signal analysis		R&S®FSQ-K70			●

FIG 6 Overview of application-specific options for the R&S®FSP, R&S®FSU, and R&S®FSQ families.

* Requires additional hardware: R&S®FSP-B15/FSP-B70.

To the extent allowed by the bandwidth, the numerous application-specific firmware packages that are available are also highly similar. They cover all common mobile radio standards (2G, 2.5G, 3G) plus the data rate increase for 3GPP, HSDPA or the new TD-SCDMA standard, as shown in FIG 5. In addition, packages for general-purpose measurement applications are available, e. g. for measuring noise factors, phase noise, or a general-purpose AM / FM / φM measurement demodulator. FIG 6 provides a full overview.

Important options

A few of the numerous options available for the analyzers are highlighted here:

External generator control

This option enables you to use commercially available signal generators in scalar network analysis as tracking generators for transmission measurements and – with an additional bridge – for reflection measurements. This expands the frequency range for scalar network measurements beyond the range of installable tracking generators (up to 3 GHz in the R&S®FSP, and up to 3.6 GHz in the R&S®FSU and R&S®FSQ). Since frequency generation in the generator is completely separate from that in the analyzer in such cases, you can easily perform measurements on frequency-converting DUTs with almost any offset. This also enables you to quickly and easily determine characteristics such as filter passband characteristics or cable loss in the microwave range (for example, up to 40 GHz with the R&S®FSP40 and R&S®SMR40). You can often use an existing generator since this option supports generators from Rohde & Schwarz and other manufacturers.

Power sensor measurements

This option allows you to connect the Power Sensors R&S®NRP-Z11 and R&S®NRP-Z21 via the USB interface. The measurement result is displayed either by itself in the split-screen mode or, like a marker result, directly on the analyzer display. When you measure absolute power, the high accuracy of the sensors is thus available in the analyzer for applications in which the instrument's own low measurement uncertainty of 0.3 dB (R&S®FSU and R&S®FSQ) is not sufficient. This may be the case, for example, when calibrating the output level of generators. The power sensors enable you to precisely determine the absolute power at a level as a reference and then measure the other level stages with the high linearity of the relative level display of the analyzer (R&S®FSU and R&S®FSQ <0.1 dB).

Analysis in the frequency range above 46 GHz

Frequencies in the high GHz range still require the use of external harmonics mixers even today. You can connect external mixers to the R&S®FSP40, R&S®FSU26, R&S®FSU46, R&S®FSU50, R&S®FSQ26, or R&S®FSQ40 provided that these are equipped with the option LO/IF Ports for External Mixers. Mixers available from Rohde & Schwarz cover the frequency range up to 110 GHz. If you use other suitable mixers, a range of up to 1.1 THz is possible. When you use external mixers, you normally have to determine and suppress unwanted intermodulation products, which can take a lot of effort. The R&S®FSP, R&S®FSU, and R&S®FSQ do this automatically by using a software preselector.

Herbert Schmitt

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

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[2] Portable System for EMF Measurements R&S®TS-EMF: Even more universal: EMF measurements from 100 kHz to 40 GHz and for UMTS. News from Rohde & Schwarz (2004) No. 181, pp 39–41
[3] Spectrum Analyzer R&S®FS300: Favourably priced and universal for laboratory, service and production. News from Rohde & Schwarz (2003) No. 177, pp 20–23
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Handheld Spectrum Analyzer R&S®FSH3

Hard at work in the Andes regions of Peru

In the remote Andes regions of Peru, a radio is often the only means of contact with the outside world. Many villages are a day's hike from the nearest highway and are not served by electrical power lines. The villagers use small, battery-operated radios to listen to radio programs and obtain important information. For this reason, improving radio reception is of fundamental importance to the development of these regions.

The Peruvian development aid organization CEPESMA has tasked electronics engineer Eduardo Zevallos with finding better reception solutions as part of a development project. One of the villages included in his work is Viraco, located 3500 m above sea level in the Andes. The local population derives its livelihood primarily from agricultural terraces which rely on a complex, shared irrigation system. An irrigation commission decides which day and hour a specific piece of land can be irrigated. To obtain this information, farmers residing outside the transmitter range must travel for hours by foot or donkey to Viraco each Sunday. A wider transmitter range can spare them this arduous journey. To make this possible, Zevallos replaced the simply designed 50 W transmitter with a new 250 W unit. He used the Handheld Spectrum Analyzer R&S®FSH3 to locate and eliminate interference factors of the local radio transmitter. Now, a significantly greater number of remote settlements in the mountains around Viraco can receive signals from the local radio transmitter.

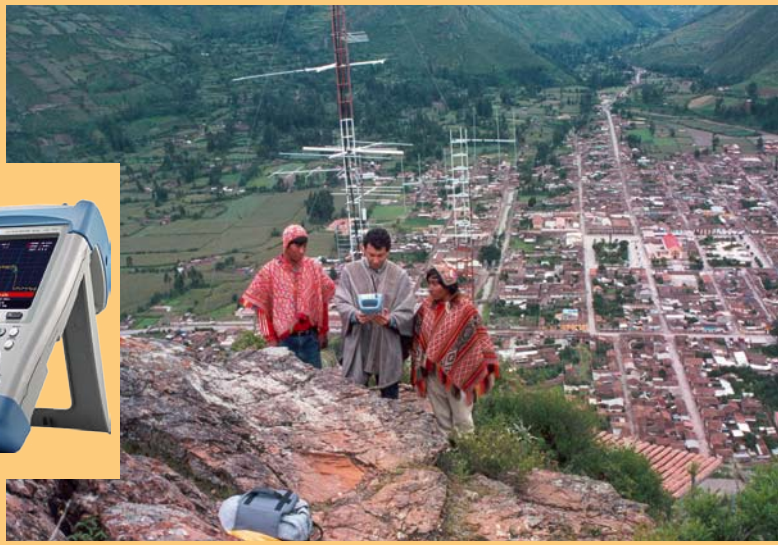
Zevallos also tackled problems in the village of Calca, which can receive signals from not only the local transmitter but also regional radio and TV transmitters in the nearby city of Cuzco. Various types of radio interference were occurring. For example, one radio transmitter impaired the frequency of a TV transmitter. By performing calibrations using the R&S®FSH3, Zevallos eliminated overmodulations in various transmitters and installed the appropriate filters. The primary beneficiaries are the remote Indian communities around Calca, because they now have better reception of the local transmitter signal. This transmitter provides the local mountainous areas with entertainment programs and important information. For example, men in outlying regions are notified when temporary jobs are available in Calca, an important source of additional income for the often very poor families.

Zevallos was highly pleased with the Handheld Spectrum Analyzer R&S®FSH3. He particularly liked the instrument's light weight and its sturdy housing. In addition, it is easy to operate and has a long battery operating time. The instrument's wide scope of functions also impressed him – truly exceptional for a portable unit.

Dr Maren Mohr de Collado, ethnologist

High-tech meets low-tech: Transmitters in this region are often simple in design. The primary reasons are low costs for purchase, repair and maintenance.

Eduardo Zevallos with the two guards of the antenna station in Calca. They are wearing the traditional handwoven caps and ponchos for which this region is known throughout Peru.



Vector Signal Generator R&S®SMU 200 A

Noise – an annoyance? Not with the new noise option!

With its outstanding signal quality, the Vector Signal Generator R&S®SMU 200 A meets all expectations even in the most demanding applications [*]. Users frequently need to intentionally apply noise to – or otherwise affect – the "ideal" signal from this generator. The secret is additive white Gaussian noise (AWGN). Yet, even this noise signal needs to be "ideal". A contradiction in terms? Not with the new option Additive White Gaussian Noise R&S®SMU-K62 for generating noise.

Intentional noise

The predefined AWGN signal of the option Additive White Gaussian Noise R&S®SMU-K62 is typically superimposed on the ideal signal generated in the baseband by the Vector Signal Generator R&S®SMU 200 A. Many telecommunications standards require precisely this combination of ideal and noise signals. This makes AWGN signals extremely important in telecommunications.

Superimposing white Gaussian noise on transmitter signals is an important standard method used in tasks such as determining receiver sensitivity. "White" indicates a constant spectral power density, i.e. successive noise values are statistically independent of each other. The noise power density is Gaussian and equally distributed across the frequency (FIG 1). Typical applications for R&S®SMU-K62 are bit error or block error measurements as a function of the defined C/N ratio, such as required when testing 3GPP FDD base stations in accordance with TS25.141.

The R&S®SMU-K62 software option offers two modes. In the first, you can add the noise signal to the baseband signal (Additive Noise mode). In the second, you can modulate the noise signal as a noise-only signal on the carrier (Noise Only mode). In the two-path configuration, R&S®SMU-K62 provides two independent noise generators, thus making many new applications possible.

You can easily perform a visual inspection of the cumulative signal obtained from the ideal signal and noise signal without additional measurement devices. One alternative is to display the cumulative signal as a small graphic in the block diagram, providing you with a simple overview (FIG 2). Another is to display the cumulative signal in a separate window as a large diagram containing detailed information (FIG 3). With its state-of-the-art FPGAs, R&S®SMU-K62 can also handle future requirements.

Gerhard Miller; Frank-Werner Thümmler

"Ideal" properties due to signals that are generated completely digitally

- **Wide, scalable noise bandwidth** 1 kHz to 60 MHz
- **Barely detectable ripple in the noise power density spectrum** 0.01 dB within the selected bandwidth
- **Variable over broad range** C/N or E_b/N_0 ratio between –30 dB and +30 dB
- **Crest factor of 18 dB** Significantly exceeds the requirements of current mobile radio standards, which require min. 12 dB
- **Minimum deviations** Close adherence to the defined ideal/noise power (< 0.1 B)
- **Independent** Since no A/D and D/A converters are required, independent with respect to temperature drift, frequency response and nonlinearities
- **Important** Uncorrelated I and Q paths
- **Decisive** Reproducible tests due to internal digital signal generation with pseudo-noise generators and simultaneous large period length of the AWGN signal
- **Virtually unbelievable** Internal period between 317 years at minimum bandwidth and approx. two days at maximum bandwidth (for 3GPP FDD with a bandwidth of 3.84 Mchip/s, the period is approx. one month; for GSM with 270.833 ksymbol/s, the period is 427 days)

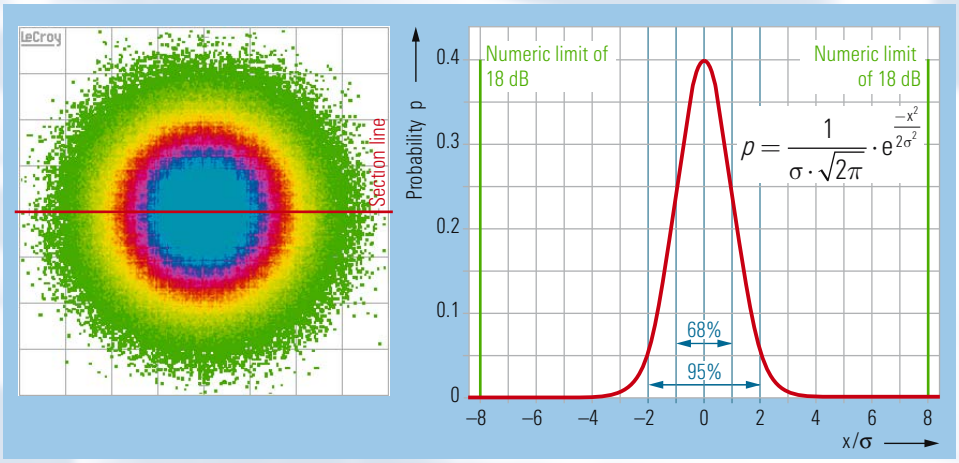
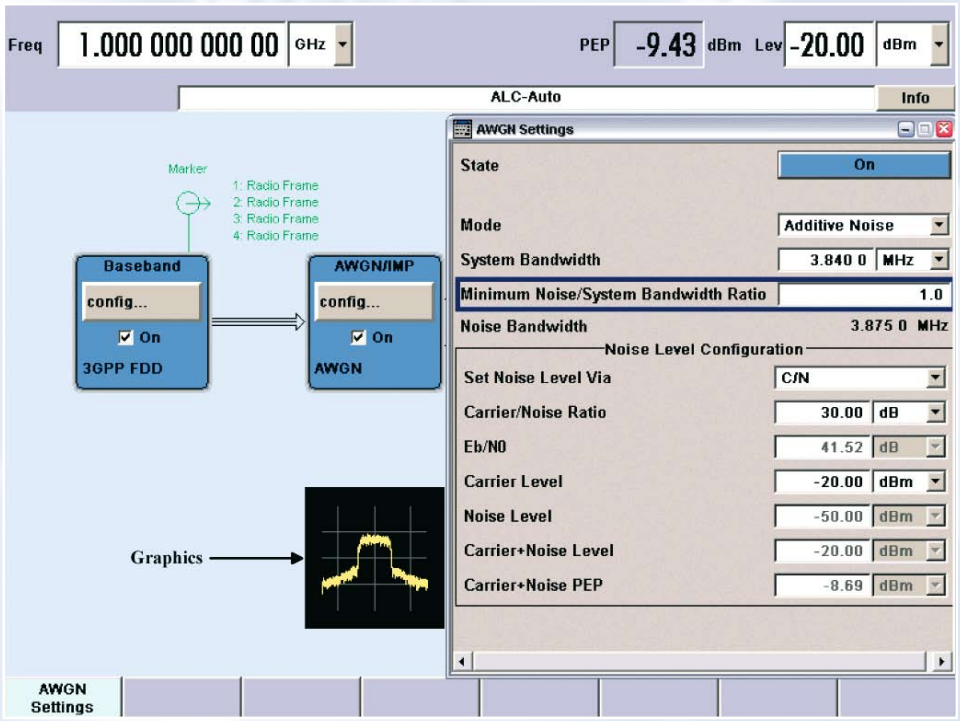


FIG 1
Left: I/Q plot of a noise signal from R&S®SMU-K62. The colours indicate the frequency distribution, with decreasing frequency from inside to outside. Right: Section through the I/Q plot, with a numeric limit of 18 dB.

FIG 2 Additive White Gaussian Noise R&S®SMU-K62 is easy to operate. You can display the output signal from the baseband as a graphic on the block diagram, or you can display it in large format in a separate window (FIG 3).



More information and data sheets plus an electronic configurator at www.rohde-schwarz.com (search term: SMU200A)

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FIG 3 Left: 3GPP ideal signal (bandwidth 3.84 MHz); center: noise signal (bandwidth 12.4 MHz); right: cumulative signal.

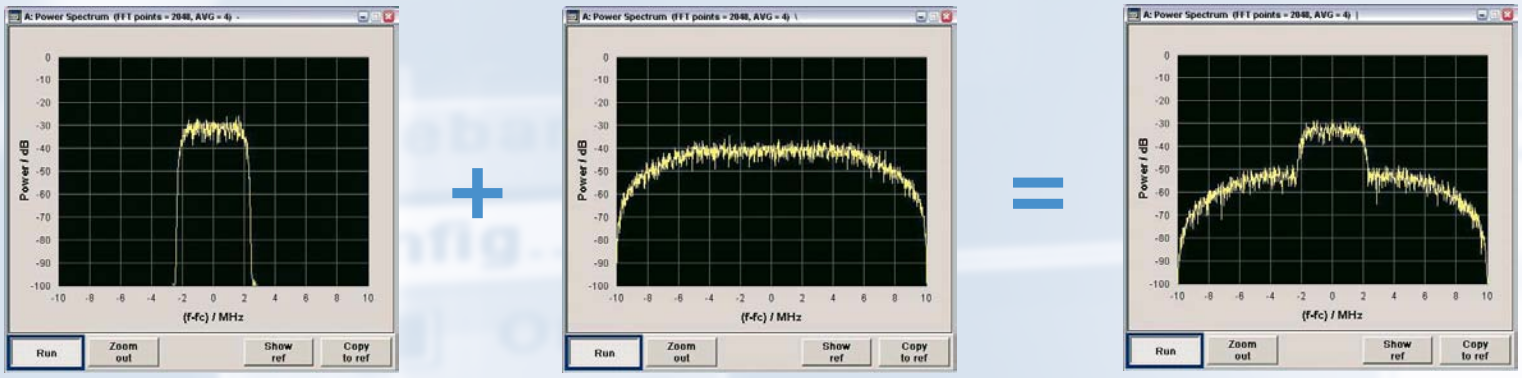

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FIG 1 The new EMI Test Receiver R&S®ESCI for compliance measurements to all commercial standards from 9 kHz to 3 GHz.

The new EMI Test Receiver R&S®ESCI (FIG 1) is the successor to the EMI Test Receiver R&S®ESCS, which was launched in 1996 and became a measurement standard for EMC certification to commercial requirements. The R&S®ESCI sets new standards in terms of measurement speed, accuracy and scope of functions in the instrument class up to 3 GHz.

EMI Test Receiver R&S®ESCI

Compact test receiver for full-compliance measurements up to 3 GHz

Test receiver or analyzer?

EMI full-compliance test receivers are needed when certification in accordance with relevant standards is to be obtained. Featuring a pulse-resistant attenuator, preselection with a 20 dB preamplifier and a frontend withstanding high loads, the EMI Test Receiver R&S®ESCI fully meets the requirements of the CISPR, VDE, ANSI, FCC, EN and VCCI commercial standards and is thus ideal for this type of measurement.

The R&S®ESCI adheres to the proven concept of combining a test receiver and an analyzer in a single unit. While typical EMC parameters such as RFI voltage, RFI power and RFI field strength can be measured both with the analyzer and the test receiver, each mode has its strengths and weaknesses. The analyzer comes into its own where fast prescan sweeps have to be performed and evaluated with marker functions. The test receiver, on the other hand, offers the more sophisticated techniques for data reduction and standard-conforming final measurements. The R&S®ESCI

combines the two operating modes in its mixed mode function, allowing the user to optimally benefit from the advantages of either mode.

A number of operating parameters can be coupled or decoupled for test receiver mode and spectrum analyzer mode. When the same center frequency is set in the two windows, for example, IF analysis will be displayed automatically (FIG 2). For a test sequence using the spectrum analyzer in the prescan measurement and the test receiver in the final measurement, it is useful to couple the resolution bandwidths.

Added functionality through analyzer platform

Like the precompliance Test Receiver R&S®ESPI [1], the full-compliance Test Receiver R&S®ESCI was designed on the basis of the R&S®FSP family of spectrum analyzers. As a result of this close relationship, the R&S®ESCI not only offers the comprehensive standard functionality of a spectrum analyzer, but also many special functions such as adjacent channel power (ACP) measurement and statistics functions (APD, CCDF), which considerably expand the test receiver's range of applications.

Full-compliance measurements

EMI measurements conforming to CISPR 16-1-1 place exacting demands on T&M equipment, since it must be capable of handling a wide variety of signals. These include pulse-shaped and sinusoidal signals as well as modulated and intermittent signals, all of which have to be weighted accurately. In this scenario the R&S®ESCI comes into its own, with an excellent total measurement uncertainty of the amplitude of <1 dB (up to 3 GHz) and a noise figure of typ. 7 dB (at 1 GHz with the preamplifier switched on). This makes the new test receiver ideal for use in development, EMC laboratories, mobile applications or certification measurements in conformance with commercial standards.

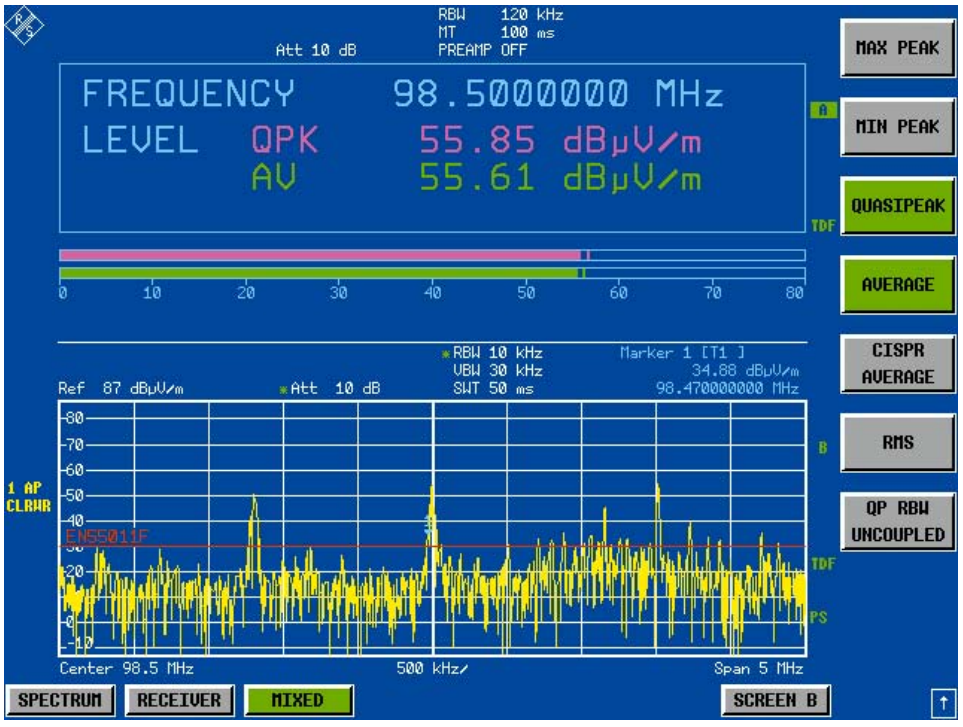
The R&S®ESCI performs measurement tasks fast and reliably by means of selectable detectors, including max/min peak, quasi-peak, RMS, average and CISPR-AV. Up to three detectors may be switched on simultaneously for each trace. The test receiver stores up to 100 000 points per trace. The displayed frequency range always shows real results, even when zooming in closely (for example during subsequent analysis by the user).

The analysis of results is based on a test method patented for Rohde & Schwarz, involving the sequence of **prescan measurement**, **data reduction** and **final measurement**. Results are compared with EMC limit lines; common limit values are stored in the test receiver's internal database. The values to be used in the final measurement are listed in a frequency table that can be edited manually, e. g. further critical frequencies can be added or known harmonics deleted. After completion of the prescan measurement, the final measurement with standard-conforming measurement time is started, using the quasi-peak and/or the average detector.

Based on this method, the following measurements can be performed at low effort and with good reproducibility, using accessory equipment:

- RFI voltage (with line impedance stabilization network)
- RFI power (with absorbing clamp)
- RFI field strength (with antennas for magnetic and/or electric fields)

FIG 2 The R&S®ESCI in MIXED mode: standard-conforming measurement with bargraph display (top), and spectrum obtained with fast sweep (bottom).



The bargraph display with Max Hold indication proves very useful in these measurements as it allows you, for example, to align the antenna in the direction of maximum field strength emitted by a DUT.

Functions such as marker track and marker frequency, coupled with the center frequency in split screen mode, make the final measurement easier and more reliable, as hidden spurious and other unwanted emissions can be detected with higher resolution.

Frequency-dependent transducer tables

To take into account the frequency response of accessory test equipment and thus minimize total measurement uncertainty, correction values can be entered into transducer tables and considered in the calculation of the current trace. Several transducer tables can be combined into a set. In this case, the sum of the individual correction values of, for example, an absorbing clamp, a cable and an extra attenuator will be considered in the result displayed.

CISPR-AV average detector

CISPR 16-1-1 (2003-08) stipulates an average detector with modified time constants to increase the amplitude with low pulse repetition rates [2]. The R&S®ESCI already includes this detector. Many of the instruments available on the market will have to be retrofitted to meet this new requirement, as far as this is technically feasible. The EMI test receivers from Rohde & Schwarz are state of the art or optimally prepared for an easy upgrade.

Time-domain measurements

Devices with thermostatic or program control generate discontinuous interference. CISPR 14 and EN 55014 therefore specify limit values for RFI voltage with click rate weighting in the range 0.15 MHz to 30 MHz. A critical factor in measurements with conventional click rate analyzers is the occurrence of successive pulses. The individual pulse amplitudes cannot be exactly allocated due to the time constants used in quasi-peak weighting, which may result in limit values being exceeded.

The R&S®ESCI's time domain analysis function can determine the pulse amplitude and duration and can thus prove very useful in such cases. It satisfies the requirements of CISPR 16-1-1 in terms of accuracy of the pulse duration measurement when the pulse duration is 10 ms or longer (FIG 3).

The result memory can store 1.44 million measured values per trace in time domain analysis. The user can, for example, subsequently zoom in on these values and analyze them by means of various marker functions. Each individual click interferer can thus be evaluated in detail if necessary. At a measurement time of 5 ms per measured value, the memory depth is large enough to record the peak values and quasi-peak values continuously for two hours. Thus, DUTs such as washing machines can be evaluated for click interference [3].

Automatic measurements with EMC software

Using the R&S®ES-K1 and R&S®EMC32-E EMI software packages [4], you can perform fully automatic and standard-conforming EMC measurements with external equipment such as absorbing clamps/slideways, masts and turntables. The required drivers for the R&S®ESCI are also provided. In addition, the software packages provide support in generating test reports which can, in the case of R&S®EMC32-E, for example, be stored as PDF, HTML or RTF files.

Sturdy construction – for use under any conditions

For outdoor applications, the R&S®ESCI is also available with a rugged case with shock-absorbing corners and a carrying handle (FIG 4). In vehicles, the test receiver can be operated from 12 V to 28 V using an optional DC power supply (R&S®FSP-B30). At outdoor test sites, the R&S®ESCI can perform measurements for several hours if equipped with the optional R&S®FSP-B31 battery pack. Additional battery packs can be used to extend the operating time, if necessary.

In the R&S®ESCI standard unit, the vast amount of data collected is stored on a hard disk. For use in vehicles, a flash disk can be used instead of the hard disk to withstand significant temperature fluctuations (0°C to 55°C) and higher levels of shock and vibration (R&S®ESCI-B20 option).

The optional internal tracking generator from 9 kHz to 3 GHz (R&S®FSP-B9) and the optional external generator control (R&S®FSP-B10) extend the R&S®ESCI to include scalar network analyzer functionality. Detailed information on these and other options can be found in the R&S®ESCI data sheet, which you can download from the Rohde & Schwarz website.

Volker Janssen; Matthias Keller

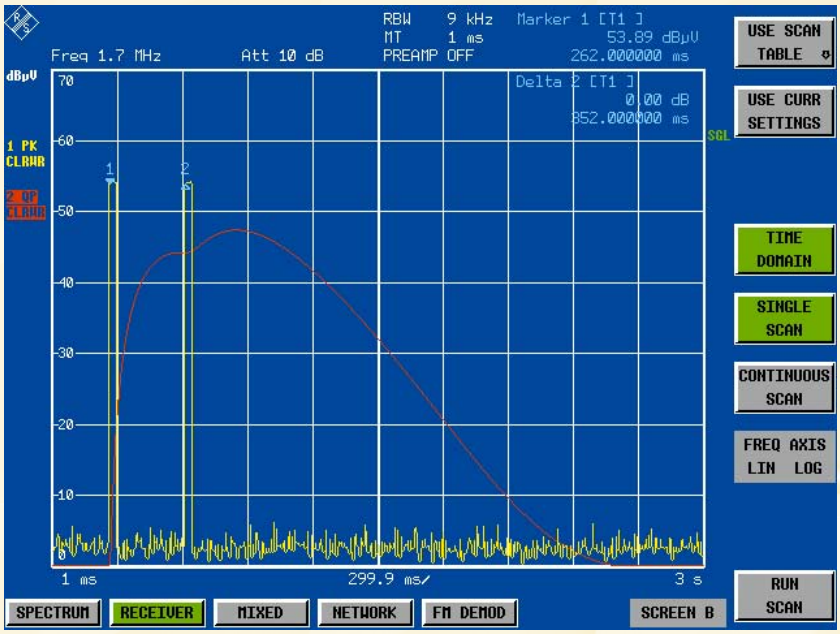


FIG 3
Two click interferers at an interval of 352 ms, with peak value shown in yellow and quasi-peak value in red.

Condensed data of the R&S®ESCI

Frequency range	9 kHz to 3 GHz
Amplitude measurement uncertainty	<1 dB up to 3 GHz in receiver mode
1 dB compression	typ. +6 dBm
RF attenuation	0 dB to 75 dB in steps of 5 dB
Pulse resistance	150 V (10 µs) 10 mWs (20 µs)
Test procedure	
in receiver mode	scan table of up to 10 subranges with independent settings; measurement time per frequency point 50 µs
in analyzer mode	sweep time (span > 10 Hz, 2.5 ms to 16000 s zero span (0 Hz): 1 µs to 16000 s
Detectors	Max/Min Peak, Quasi Peak, RMS, Average, CISPR-AV
Bandwidths	200 Hz, 9 kHz, 120 kHz, 1 MHz (EMI bandwidths) 10 Hz to 3 MHz (–3 dB bandwidths)
Displayed average noise level (DANL) (1 Hz RBW)	
without preamplifier	–45 dBµV (typ. –48 dBµV)
with preamplifier	–55 dBµV (typ. –60 dBµV)

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

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[1] Precompliance Test Receiver R&S®ESPI: Improved, patented EMC test method for drifting interference signals. News from Rohde&Schwarz (2004) No. 181, pp 42–43

[2] International Basic Standard CISPR 16-1-1, Chapter 6 "Average Measuring Receiver", and Chapter 6.4.3 "Response to Intermittent, Unsteady and Drifting Narrowband Disturbances"

[3] International Basic Standard CISPR 16-1-1, Chapter 10 "Disturbance Analyzers"

[4] EMC Measurement Software R&S®EMC32-E: Automatic RFI field strength measurements. News from Rohde&Schwarz (2003) No. 179, pp. 23–25

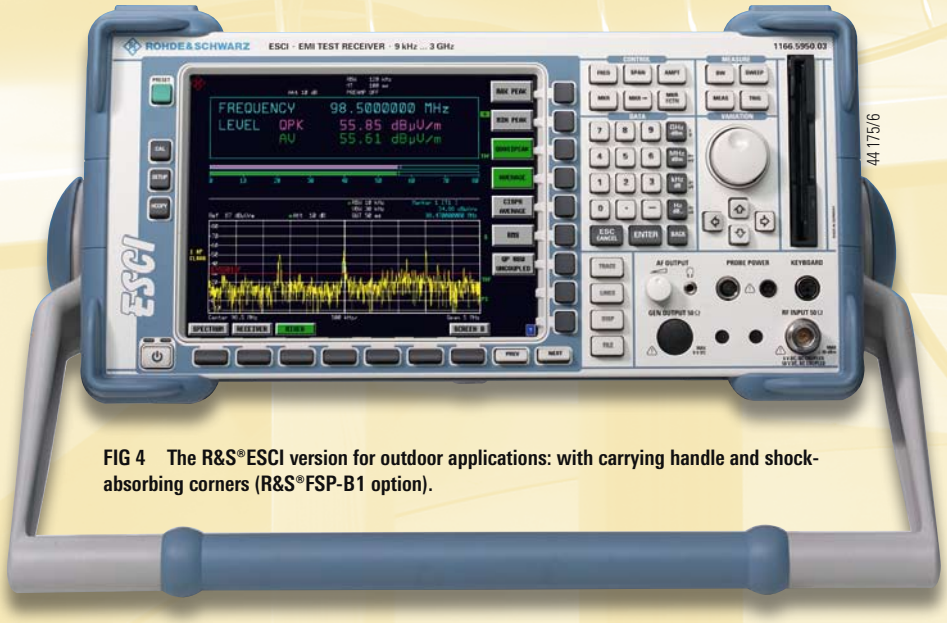


FIG 4 The R&S®ESCI version for outdoor applications: with carrying handle and shock-absorbing corners (R&S®FSP-B1 option).

VHF/UHF TV Transmitters R&S®NM 7000 C / NH 7000 C

Securing your investments

In the years ahead, more and more TV networks will be retrofitted for digital operation. This means that investments still being made in analog networks need to be secured for the digital age. All analog TV transmitters of the R&S®7000 family [1, 2] can be retrofitted for digital operation. This is particularly easy with the Transmitters R&S®NM/NH 7000 C (C stands for combined). They are available for the power ranges 3.5 kW to 10 kW for VHF (band III) and 3.5 kW to 20 kW for UHF (band IV/V).

Vision and sound amplified together

Analog high-power TV transmitters amplify vision and sound signals separately. In contrast, digital transmitters combine vision and sound signals in a single digital signal, which is amplified in an amplifier.

The more similar analog transmitters are to digital transmitter in design, the easier it is to retrofit them for digital operation. It therefore makes sense to design analog transmitters in accordance with digital ones. Precisely this has been done with the new Transmitter Families R&S®NM 7000 C (VHF) and R&S®NH 7000 C (UHF).

These two families of transmitters are available for the power ranges 3.5 kW to 10 kW for VHF (band III) and 3.5 kW to 20 kW for UHF (band IV/V). You can achieve a maximum output power of 10 kW with just one rack.

Easily retrofitted for digital operation

Since the new "combined" transmitters are designed just like digital transmitters, retrofitting them for digital operation merely requires exchanging the encoder/modulator set in the exciter (see block diagram). None of the other modules need to be changed. In the case of transmitters in which vision and sound are amplified separately, you would have to remove or bypass a vision/sound diplexer and you could no longer use the sound amplifiers.

For "combined" transmitters to stay within the limits of the channel mask, you must install an additional band-pass filter. If a six- or eight-cavity filter is selected, it can also be used later in digital operation, thus incurring no additional costs.

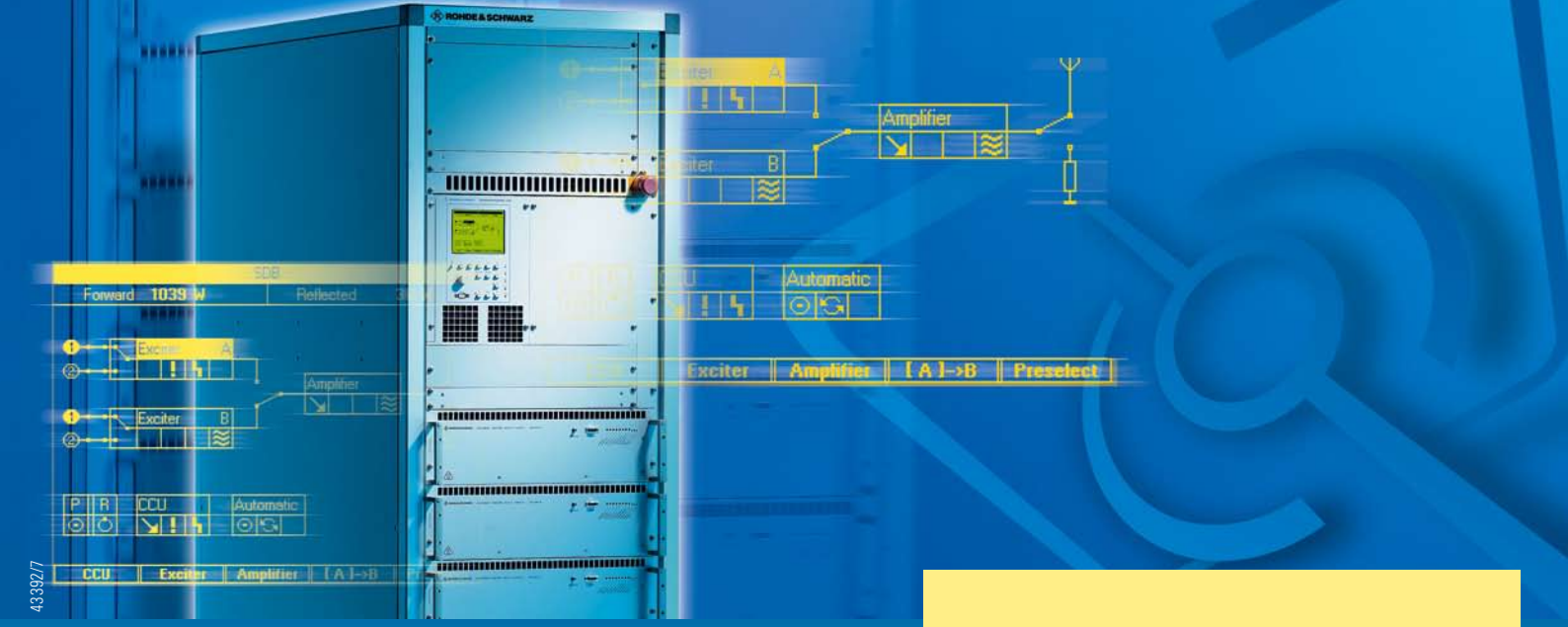
Uniform family concept

All TV transmitters from Rohde & Schwarz are based on a uniform concept. Since the individual models are highly similar, network operators need to invest very little in replacement parts and in the training of service technicians. All standby concepts of the R&S®Nx7000 family are also available for the "combined" transmitters (exciter standby, active, passive and N+1 standby).

The new TV transmitters offer maximum investment security especially when it comes to analog networks that will be retrofitted for digital operation in the short or medium term. A simple and cost-effective means of converting from analog to digital operation minimizes total costs.

Of course, the Transmitter Families R&S®NM 7000 and R&S®NH 7000 will continue to be available with separate vision and sound amplification.

Simone Gerstl;
Friedrich Rottensteiner



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R&S®NM 7000 / NH 7000 Combined

- Future-proof investment in analog transmitters
- Simple retrofitting for digital operation
- Numerous standby concepts
- Uniform family concept

More information and data sheets at www.rohde-schwarz.com (search term: NM7000 / NH7000)

Data sheet R&S®NM / NW 7000

Data sheet R&S®NH / NV 7000

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[1] VHF Transmitter Family R&S®NM/NW 7000: Liquid-cooled VHF TV transmitters. News from Rohde & Schwarz (2002) No. 173, pp 37–39

[2] UHF Transmitter Family R&S®NV/NH 7000: Liquid-cooled TV transmitters for terrestrial digital TV. News from Rohde & Schwarz (1999) No. 165, pp 11–13

Condensed data of the R&S®NM 7000 C / NH 7000 C

Frequency range	VHF: 170 MHz to 250 MHz UHF: 470 MHz to 860 MHz
Power ranges	VHF: 3.5 kW to 10 kW UHF: 3.5 kW to 20 kW
TV standards	B, G, D, K, I, M, N
Cooling concept	liquid cooling

Block diagram of an analog "combined" TV transmitter with 10 kW output power.

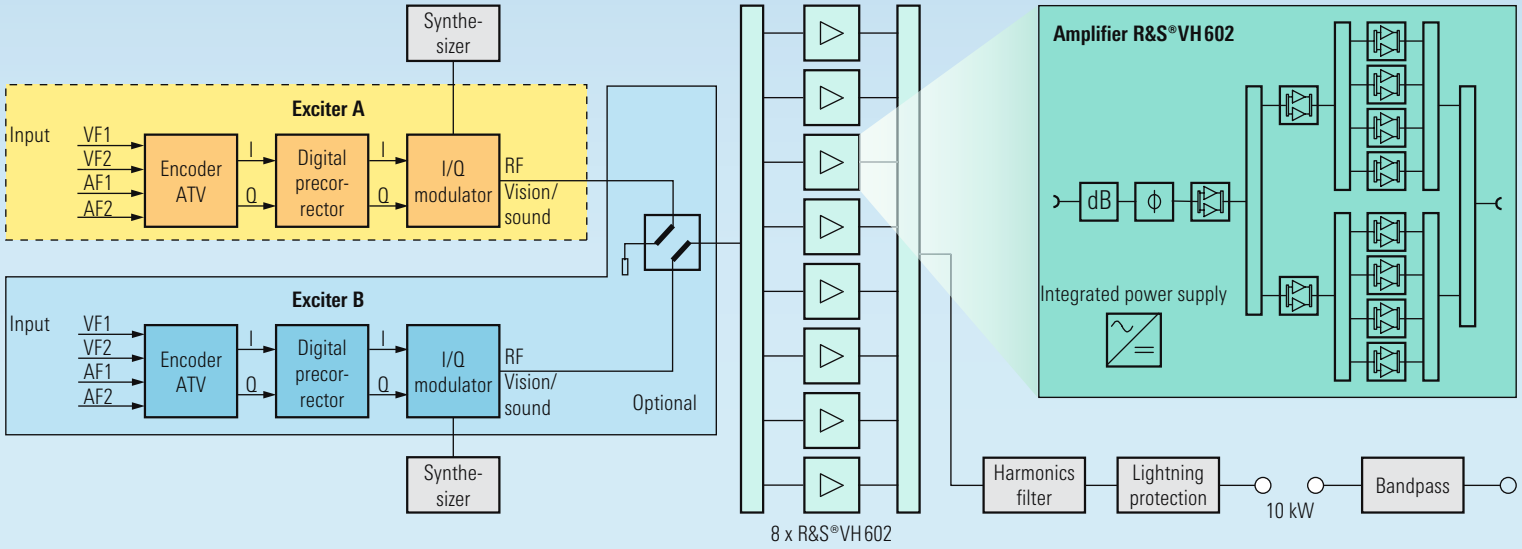


FIG 1 The Digital Video Measurement System R&S®DVM 400 provides a wealth of test, analysis and monitoring functions for digital TV.

Digital Video Measurement System R&S®DVM 400

Comprehensive MPEG-2 analysis – also for mobile use

The MPEG-2 Monitoring Systems R&S®DVM 100/DVM 120 [*] have been joined by a new member of the R&S®DVM family – the Digital Video Measurement System R&S®DVM 400 (FIG 1). This highly compact portable MPEG-2 test platform offers a wide variety of test, analysis and monitoring functions for digital TV.

Adaptable to customer requirements

The R&S®DVM 400 is a compact, portable MPEG-2 test platform that offers a wealth of test, analysis and monitoring functions for digital TV. You require neither a laptop nor an external monitor to operate the system since it comes equipped with an integrated, high-resolution colour display. Due to its modular design and versatile options, it can be customized to meet your needs.

The measurement system includes a powerful computer platform with all common interfaces and three slots for optional boards. A broadband recorder and generator board can be installed in the first slot. A fast analyzer board as used in other systems of the R&S®DVM family is available for the second slot. It can be used to optionally monitor up to four transport streams simultaneously. The third slot has been designed for future add-ons. Since both optional boards function independently of each other, the R&S®DVM 400 can be configured either as a pure recorder and generator or as a pure analyzer. If both boards are installed, special features are available. For example, a recorded signal can be sent directly within the system to the analyzer board for later analysis. Or, if a signal is monitored, the analyzer board can directly trigger the recorder and generator board to perform event-driven recording.

The R&S®DVM 400 measurement system is the right instrument for numerous applications. Its large scope of functions make it an effective tool in the research and development of DTV components.

Due to its compact size, it is also ideal for mobile use, for example for trouble-shooting in DTV networks. Since the R&S®DVM400 includes all the functions of the R&S®DVM100, it can also be used for monitoring transport streams (TS). It can be expanded by the MPEG-2 Monitoring System R&S®DVM120 to monitor more than four TS.

Robust and modular

For operation purposes, the R&S®DVM400 is equipped with a high-resolution colour display, keys and a rotary knob as well as a fast computer with a large hard disk for the system software. In addition to the conventional USB and Ethernet PC interfaces, alarm outputs for signalling are available. An input for an external 10 MHz reference clock is available for measurements that require precise time referencing. The base unit has two parallel interfaces (input and output) for transport stream data. They are complemented by switchable ASI/SMPTE-310M transport stream interfaces on the optional boards.

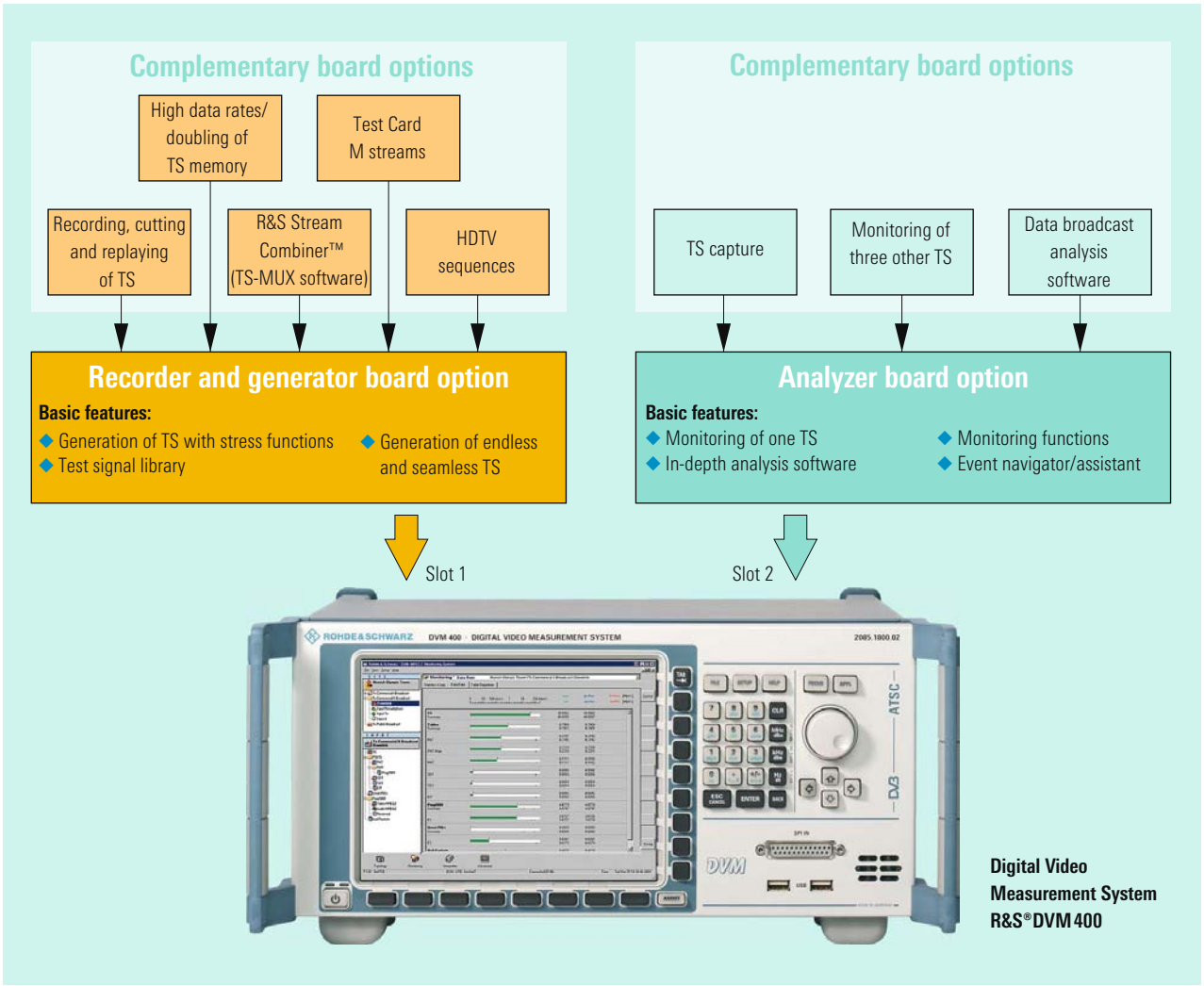
Once the analyzer base option or the recorder and generator base options has been installed, the MPEG-2 functions become available. Other board options ideally adapt the measurement system to user-specific tasks (FIG 2).

Comprehensive monitoring functions

The system monitors more than 120 parameters of each transport stream and records them in the event of an error. The following monitored parameters are worth particular mention:

- Data rates of individual element types of the transport stream (video, audio, data, PAT, PMT, etc)
- Conditional access status
- MIP parameters (used for single frequency networks)
- Transport stream modifications (addition or omission of elements and more)

FIG 2 By adding two optional boards and complementary options, the R&S®DVM400 can be expanded to handle customer-specific tasks.



Digital Video Measurement System R&S®DVM400

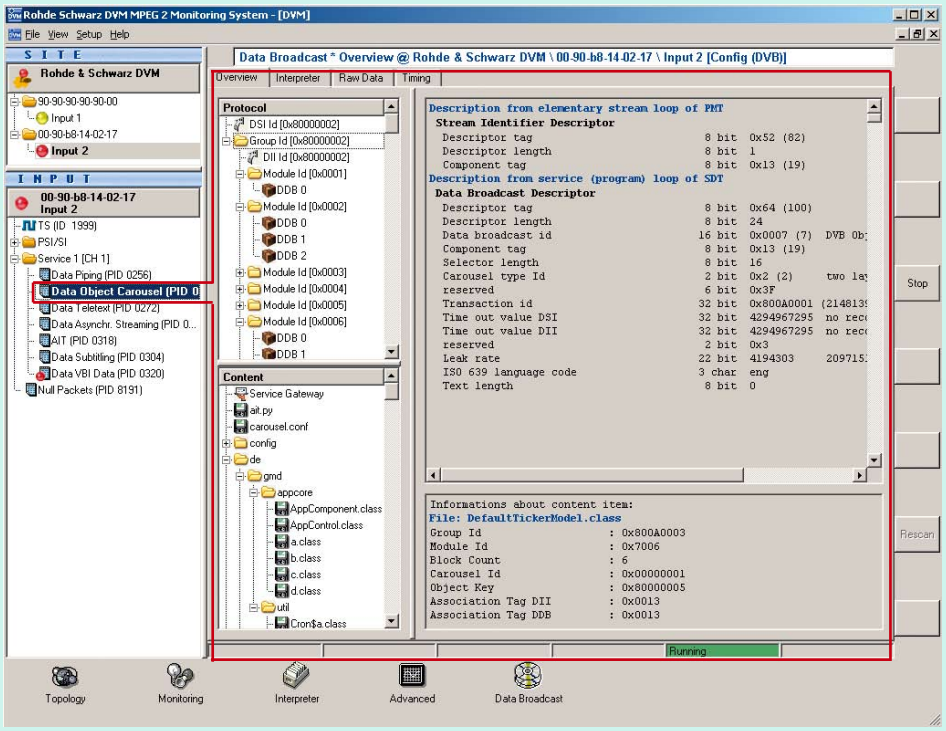
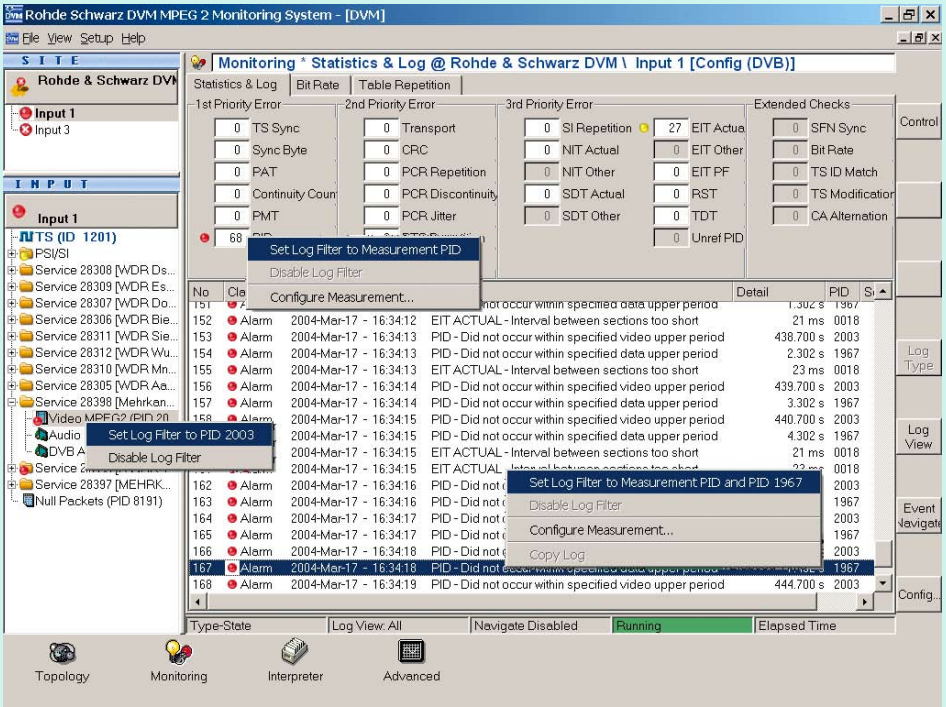


FIG 3 In-depth analysis functions for data broadcast applications. The screenshot shows the analysis of the Object Carousel data service that is used for transmitting MHP applications, for example. The "Overview" (red) lists all the descriptors referring to this data service.

FIG 4 The event navigator with three application examples.



It is particularly helpful to monitor transport stream modifications if these modifications are correctly signalled but are not intended. This may be the case, for example, if a program fails completely, including PMT and the reference in the PAT.

Detailed analysis functions

For transport stream analysis, the R&S®DVM400 provides different interpreters for packets and tables, analysis tools for PTS and PCR as well as graphical displays of bit rates and table repetition rates. A special feature consists of the new analysis functions for data broadcast applications (FIG 3). Versatile measurements and display formats for the transmission methods are available, e. g. multiprotocol encapsulation and Data or Object Carousel. Thus, transmission of IP over DVB, SSU, MHP, teletext, VPS and many more data services can be analyzed; plus, the structures used can be visualized in an easy-to-comprehend manner.

Recorder and generator functions*

In combination with the monitoring and analysis options, the recorder and generator functions make the R&S®DVM400 a versatile MPEG-2 test platform. Thus, the system can be used for monitoring and as a powerful recorder and generator with the following features (and numerous others that are familiar from the R&S®DVG and R&S®DVRG):

- Seamless and endless transport stream generation
- Data rates of up to 214 Mbit/s
- Hard disk space of up to 160 Gbyte

* Expected to be available as of the end of 2004.

Effective and convenient operation

Numerous sophisticated features and functions of the R&S®DVM family help users to manage complex test tasks and facilitate operation:

- Structured, clear and flexible configuration of the system and monitoring parameters
- Signalling of events/errors with the aid of specific colour symbols in the transport stream element list and other displays
- Graphical display with zoom function of the PCR values of a program with a duration of up to one hour
- Straightforward dialog for configuring the monitoring parameters
- Possible deactivation of the monitoring activities for individual parameters and/or TS elements

Other examples are the event navigator and the assistant, which are described in the following.

Event navigator

As a special feature, the R&S®DVM400, together with the event navigator, supports filter functions for report entries (FIG 4). It is thus possible to quickly find the following entries:

- Entries for a PID (e.g. all entries for PID 100 of a video)
- Entries of the same type (e.g. all entries for an incorrect PMT repetition period)
- Entries for a PID and of the same type

Moreover, all entries can be filtered according to their classification (alarm, warning and information).

Assistant

The powerful assistant makes the use of the different analysis tools highly effective and easy. When a transport stream element is selected, the assistant suggests all analyses or measurement result displays useful for this element. Especially if an error is detected, fast and detailed analysis becomes possible. The assistant is ideal for less experienced users because it enables them to easily obtain the required measurement results.

Summary

Regardless of the requirements placed on the measurement function and measurement scope of MPEG-2 transport streams, the Digital Video Measurement System R&S®DVM400 is the ideal tool. It is easy to operate and, owing to its compact design, highly suitable for mobile use. Since options can be added easily and as needed, it can be equipped to match specific tasks at the time of purchase and then expanded to handle additional customized tasks that arise in the future.

Thomas Tobergte

Abbreviations

DTV	Digital television
DVB	Digital video broadcasting
IP	Internet protocol
MHP	Multimedia home platform
MIP	Megaframe initialization packet
MPEG	Moving Pictures Experts Group
PAT	Program association table
PCR	Program clock reference
PID	Packet identifier
PMT	Program map table
PTS	Presentation time stamp
SSU	System software update
TS	Transport stream
VPS	Video program system

More information and data sheet at www.rohde-schwarz.com (search term: DVM400)

REFERENCES

[*] 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

DVB-H – new digital multimedia services for mobile terminals

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. These services can be received in existing terrestrial DVB (DVB-T) networks for extended periods owing to the energy-saving DVB-H method and in mobile operation even at high speeds. Rohde&Schwarz already supports its customers with equipment during the pilot phase.

Mobile video streaming

Following the introduction of SMS and MMS, the next goal of the mobile radio industry is to offer video services for mobile terminals. The technical possibilities are highly diverse. For example, video streaming to mobile terminals in UMTS networks is possible, but this is a typical broadcast service without a reverse channel and consumes substantial bandwidth in mobile radio networks.

A further obstacle in TV reception arises when a TV receiver card is installed in mobile terminals. This card increases energy consumption and offers only limited reception capabilities at high speeds. Although digital TV receivers support mobile reception, they tie the user to the TV content.

In contrast, DVB-H technology allows video streaming to be implemented efficiently for mobile reception with small devices. The DVB-H specification, issued in December 2003, calls for the use of an expanded DVB-T standard for broadcasting multimedia services by using Internet technology.

The use of Internet technology makes it possible to implement multimedia services quickly and reliably. Video coding can be performed by using state-of-the-art compression technologies such as H.264/AVC (MPEG-4, Part 10), which provide very good picture quality. This also holds true at lower data rates in the range of 64 kbit/s.

Although DVB-H video streaming supplements terrestrial DVB (DVB-T) for use with battery-operated terminals, it cannot replace DVB-T because the video quality of DVB-H video streaming is not acceptable as a TV service on a stationary TV receiver. For mobile operation, however, DVB-H offers numerous advantages:

- Power consumption of the complete receiver of <100 mW
- Data rates of 15 Mbit/s
- Reception at fast driving speeds with a small rod antenna
- Depending on the service model, operation in a large single-frequency network or in a network with cell structure

Fundamentals of DVB-H technology

The core aspects of DVB-H technology originated from discussions on how energy can be saved, performance increased and mobility improved. They were documented in the ETSI specification EN 300 192 (FIG 1). The key new aspects are:

Time slicing

The data of a DVB-H service is not broadcast continuously but, rather, is bundled in "bursts" at a high data rate. In mobile terminals, this makes it possible to switch off the battery between data bursts, saving up to 90% in energy. Time slicing permits simple handover during switch-off phases.

Reed-Solomon (RS) coding

Data is furnished with additional error protection. Powerful forward error correction (FEC) improves reception quality even in the event of high packet loss.

Information notification table (INT)

Signalling data services via INT makes it possible to configure receivers to replay the services.

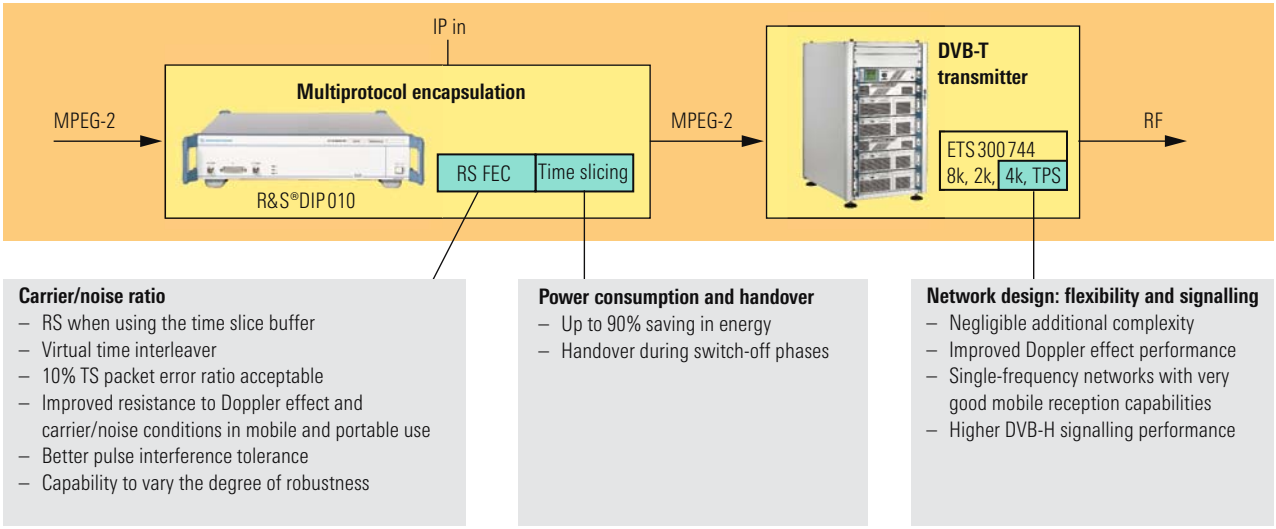


FIG 1 **The most important features of DVB-H.**

4k modulation mode

In addition to the 2k and 8k modes, the 4k modulation mode was defined for DVB-H. It features optimum characteristics for the planning of mobile radio cells. It offers better RF performance and allows mobile reception at high speeds.

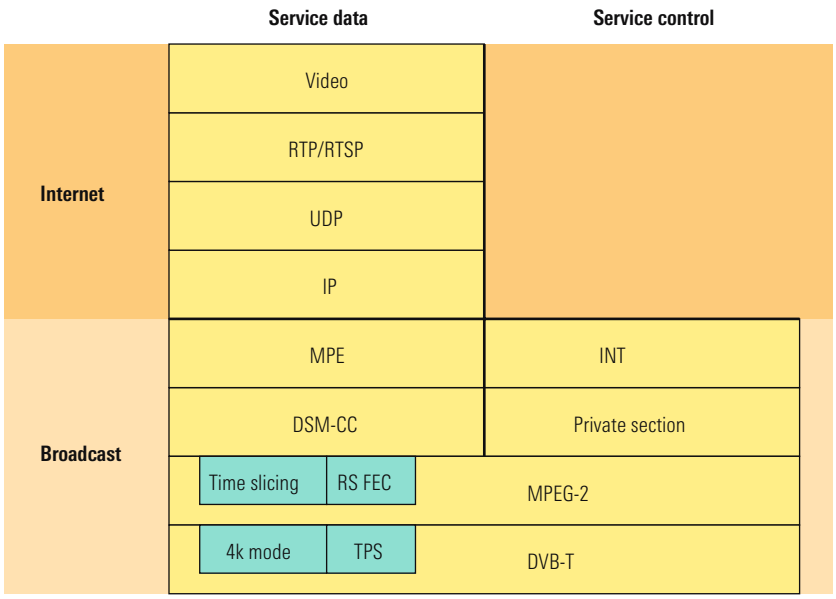
TPS bits

The use of TPS bits to signal the DVB-H features that are used allows the receiver to find the video streaming services faster.

DVB-H is a fusion of Internet and broadcast technologies. Using tried-and-tested Internet technology has the following advantages:

- **Low bandwidth** The multimedia services for mobile terminals have a bandwidth of approx. 128 kbit/s or 256 kbit/s. Thus, approx. 10 to 20 video streaming services, rather than regular digital TV service, can be implemented at a quality that is matched to the mobile terminals.
- **Simple integration into existing infrastructure** IP-based video streaming can easily be implemented with streaming servers at a cost that is relatively economical. Modern terminals have TCP/IP stacks which allow IP packets to be processed (FIG 2).
- **Use of state-of-the-art efficient coding methods** The H.264/AVC video coding standard, which is specially optimized for low resolutions, makes it possible to transmit video material matched to mobile radio devices with very low resolutions, e. g. at 180 × 144 pixels at very low data rates in the range of 64 kbit/s.

FIG 2 **DVB-H protocol stack.**



Rohde & Schwarz contributions to DVB-H technology

The market needs T&M equipment for DVB-H earlier than the DVB-H equipment itself. To meet this need, Rohde & Schwarz is ready to provide its customers with DVB-H-compatible equipment even during the initial pilot trials. This means that both operational and T&M equipment for implementing DVB-H systems will be available.

FIG 3 The Data Inserter R&S®DIP010 provides all features important for DVB-H.

Operational equipment

For **terrestrial transmitters configured for DVB-H**, operational equipment will be offered in various power classes as customary. This equipment will provide the 4k modulation mode and additional TPS signalling.

As a multiprotocol encapsulator, the **DVB-H-compatible Data Inserter R&S®DIP010** will support time slicing and Reed-Solomon coding and include the required features for signalling the services.

T&M equipment

A special version of the **TV Test Transmitter R&S®SFQ** for simulating DVB systems will be available as loan equipment for the evaluation phase of DVB-H networks.

The **TV Test Receiver R&S®EFA** for measuring DVB parameters can already evaluate the TPS carriers.

The **MPEG-2 Recorder Generator R&S®DVRG** will be equipped with DVB-H data streams for simulation purposes and enable users to create such streams at the press of a button.

Data Inserter R&S®DIP010

The heart of the DVB-H systems will be the Data Inserter R&S®DIP010 (FIG 3). It meets the three most important DVB-H criteria: time slicing, Reed-Solomon coding, and signalling of services.

The DVB-H standard provides significant leeway in how time slicing is structured. For this reason, the R&S®DIP010 will offer variable configuration capabilities (FIG 4).

By using the R&S®DIP010, the DVB-H operator can control the length of the time slices via the burst size or burst duration. The time slicing duration is specified as the total time of a time slice (delta T) or as the time between two data bursts (off time).

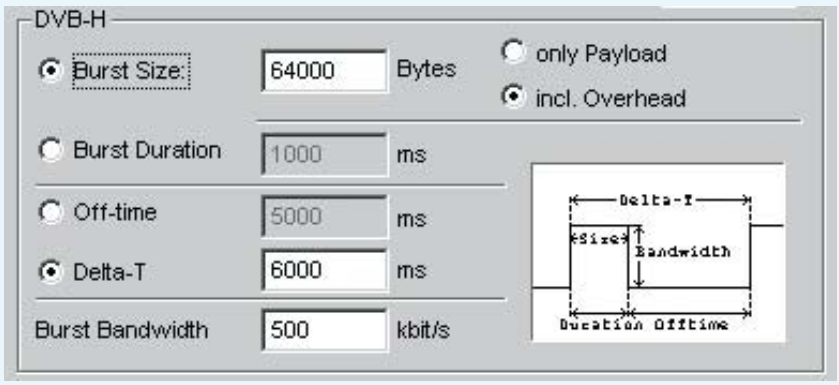


FIG 4 Configuration of time slicing with the Data Inserter R&S®DIP010.

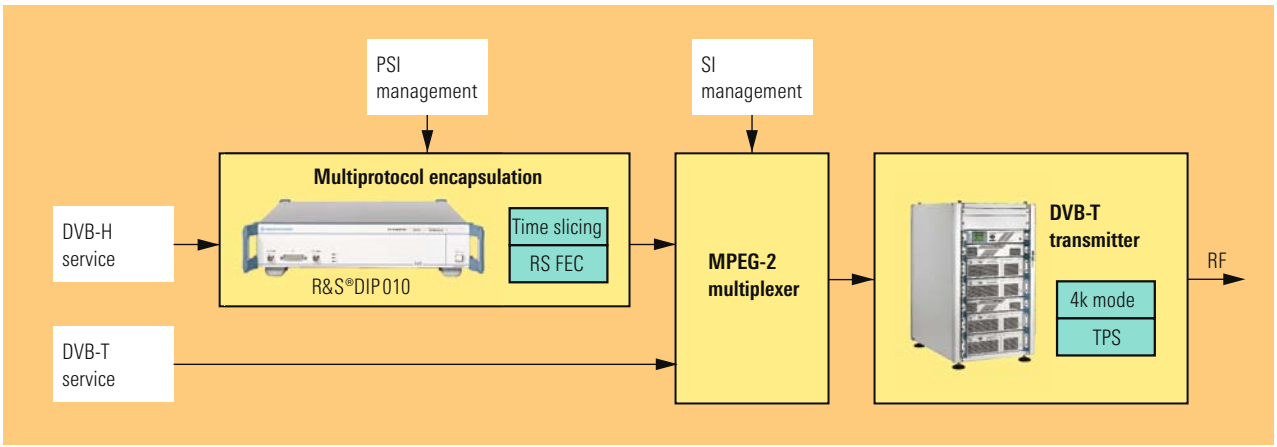


FIG 5 Structure of a transmitter system for mixed DVB-T / DVB-H operation.

More information and data sheets at www.rohde-schwarz.com (search term: DVB-H or type designations)

Implementation of DVB-H networks

In the initial phase, the existing terrestrial DVB infrastructure will be used to implement DVB-H systems. As a result, mixed DVB-T / DVB-H scenarios will be highly likely (FIG 5).

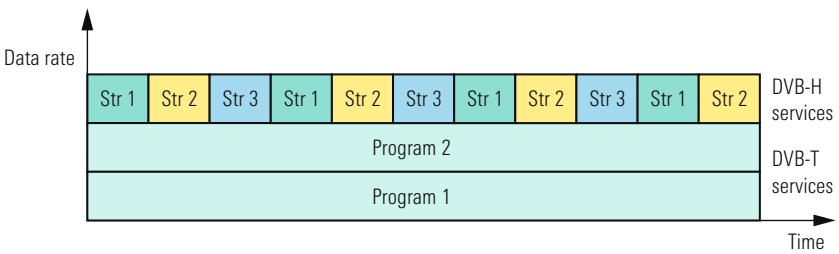
For a DVB-H transmitter system, a multiprotocol encapsulator must be added to a DVB-T transmitter system, e. g. the Data Inserter R&S®DIP010.

The DVB-H standard allows for the coexistence of DVB-T and DVB-H services in the same DVB system. The optimum situation for DVB-H services is when all services have the same bandwidth and fill the MPEG-2 signal without any gaps (FIG 6).

The first DVB-H pilot projects will be carried out this year. Regular operation will probably start in 2006. Rohde&Schwarz is at the forefront and already supports its customers with equipment during the pilot phase.

Jacek Schwiertz

FIG 6 Coexistence of DVB-T and DVB-H services in a mixed multiplex.



ETSI	European Telecommunications Standards Institute
DSM-CC	Digital storage media Command and control
DVB-H	Digital video broadcasting for handhelds
DVB-T	Digital video broadcasting for terrestrial
INT	Information notification table
IP	Internet protocol
MMS	Multimedia messaging service
MPE	Multiprotocol encapsulation
MPEG	Moving Pictures Experts Group
PDA	Personal digital assistant
PER	Packet error ratio
PSI / SI	Program service information / service information
RS	Reed-Solomon
RTP/RTSP	Realtime protocol / Real-time streaming protocol
SMS	Short message service
Str x	Multimedia video stream x
TPS	Transport parameter signalling
UDP	User datagram protocol

Digital Direction Finder R&S DDF®100 M

Reliable determination of vessel bearings in coastal waters

To establish the bearings of ships in distress in coastal waters, you need a reliable direction finder. That's why Rohde & Schwarz developed the Digital Direction Finder R&S DDF®100 M. It has already been a resounding success in a large project.

More information and data sheet at
www.rohde-schwarz.com
(search term: DDF100M)

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FIG 1 The new Digital Direction Finder R&S DDF®100 M consists of the DF Processor R&S®EBD 100 M, a modified VHF/UHF Monitoring Receiver R&S®ESMB and a DF antenna (here the R&S®ADD 090 as an example).

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FIG 2 The DF Antenna R&S®ADD 090 M for installation around a mast.

Direction finders indispensable during distress situations

In coastal areas, vessels and land-based stations communicate on defined radio channels in the VHF range (156 MHz to 163 MHz). Communications are carried out both in duplex and simplex modes and at a channel spacing of 25 kHz. Direction finders often play an important role. Most vessels today have GPS receivers, enabling them to transmit their location via radio if they are in distress. However, many cases still require using land-based direction finders to determine a vessel's position. Only then can search and rescue efforts be initiated and coordinated. Direction finders are critical not only for coastal vessels. They can also detect the distress frequencies of aircraft.

Primary radar is largely used to monitor heavily travelled shipping lanes and coastal waters. Only the radar echo reflected by the vessel shows up on screen. In aviation, secondary radar is used. An onboard transponder gen-

erates an "echo" and simultaneously transmits an identification code and the altitude. During vessel traffic management, you can display the bearings determined during communications between the vessel and the land-based station as a line on the (primary) radar screen. This line intersects a radar target on the screen, identifying the current source of the signal.

Rohde&Schwarz developed the Digital Direction Finder R&S DDF®100M for use in a large project. The R&S DDF®100M is based on the tried-and-tested R&S DDF®190/DDF®195 direction finders. It operates on the principle of correlative interferometers and consists of the DF Processor R&S®EBD100M and a modified version of the VHF/UHF Monitoring Receiver R&S®ESMB (FIG 1).

Choice of two DF antennas

The DF Antenna R&S®ADD090 is available for installation on mast tops. It has a frequency range of 118 MHz to 250 MHz. It consists of nine dipole elements arranged in a circle two meters in diameter. A lightning rod is mounted in the center. The Antenna Interface R&S®GX090, which is usually integrated into a DF antenna, is housed in a separate, weatherproof unit beneath the DF antenna. This makes it easier to access in the event of service or repair (FIG 1).

If the mast top is not accessible, e.g. because a communications antenna has been installed there, you can implement the DF Antenna R&S®ADD090M by using the Antenna Interface R&S®GX090M. This antenna has eight dipoles arranged in front of a perforated reflector wall, which can be installed in an octagonal configuration around a mast. You can use the antenna in a frequency range of 118 MHz to 250 MHz (FIG 2).

The DF Processor R&S®EBD100M has an RS-232-C system interface via which you can operate the entire direction finder, even at great distances.

By design, the Digital Direction Finder R&S DDF®100M constantly switches between two frequencies and dwells on each frequency for 300 ms. This concept ensures that even signals with a transmission duration of only 1 s are reliably detected. In most cases, channel 1 carries maritime distress channel 16 (156.8 MHz), and channel 2 is set to any other frequency based on the range of the DF antenna. You can also assign the frequency for channel 1 via remote control. In special situations, you can operate the direction finder at only one frequency and optimize it either for very short signals or high sensitivity.

In some cases, antennas for transmitting signals in the useful range of the direction finder are also attached to the DF antenna mast. They can cause significant intermodulation or even block the direction finder. To solve this problem, Rohde&Schwarz offers an adaptive interference canceller device as an option. It enables you to perform direction finding without much interference even if transmitters (max. 6) are in operation. The interference canceller also allows you to provide an additional interference-free monitoring channel for connecting receivers (for voice recording, for example).

The direction finders are usually unattended and operated remotely. Information from the DF stations is received at the control center via the RS-232-C interface and directed to a computer, which processes the data for the individual operator positions. When you purchase an R&S DDF®100M from us, you also receive a software package that enables your service technicians to operate the direction finder on-site via a laptop and check the DF results (FIG 3).

Ulrich Unselt

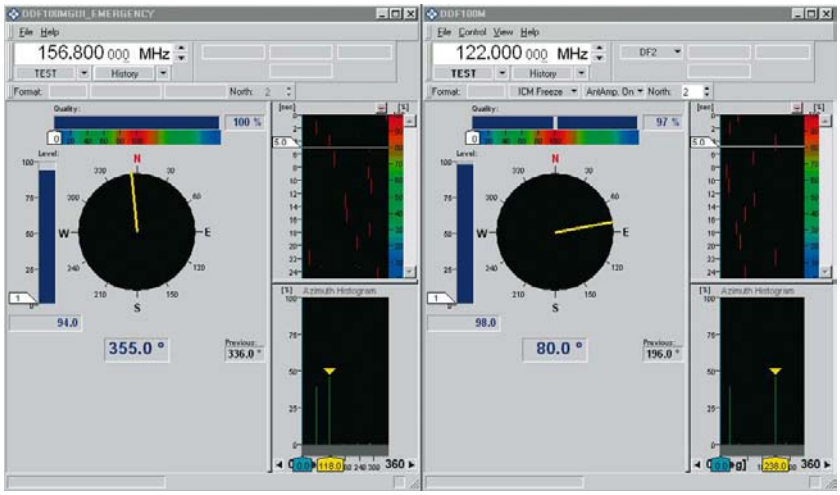

FIG 3 On-site verification of DF results on a laptop.

Spectrum Monitoring and Management System R&S®ARGUS-IT

Nationwide spectrum monitoring system for Hungary

In December 2002, Rohde & Schwarz was contracted by the Hungarian regulatory authority NHH (NEMZETI HÍRKÖZLÉSI HATÓSÁG) to supply ten spectrum monitoring stations. The order included setting up an integrated national Spectrum Monitoring and Management System R&S®ARGUS-IT that had to incorporate the existing central station in Budapest, two monitoring vehicles from Rohde & Schwarz and several fixed stations from another manufacturer. The decision in favour of Rohde & Schwarz followed a thorough evaluation of solutions from different suppliers that NHH had operated in parallel.

Comprehensive solution made to order

By using R&S®ARGUS-IT, the regulatory authority is now able to perform all necessary analyses in the 20 MHz to 3 GHz frequency range in line with International Telecommunication Union (ITU) recommendations, including:

- Analysis of radio interference
- Determination of technical parameters of transmitters and their comparison to the limit values as specified by the licence
- Performance of frequency occupancy measurements
- Distinction between authorized and unauthorized emissions
- Localization of transmitter sites, especially in order to prevent unauthorized transmissions

Powerful technical equipment

In the unattended fixed stations, one Monitoring Receiver R&S®ESMB and one Signal Analyzer R&S®FSIQ3 each, together with horizontally and vertically polarized antennas (FIG 1), provide accurate measurement results in line with ITU recommendations. In addition, an R&S DDF®05M direction finder determines the exact angle of incidence of a signal. A data line with a data rate of 2 Mbit/s ensures smooth communications with the central station, from where all equipment can be remote-controlled by Spectrum Monitoring Software R&S®ARGUS [*]. This user-friendly software has proven successful for nearly 20 years and is continuously updated; it permits easy and intuitive operation of the equipment, ranging from interactive mode through to fully-automated complex measurement tasks (FIG 2).

Integrating the newly supplied system parts and existing components from other manufacturers into one system was a special challenge for Rohde & Schwarz. Together with the customer, the requirements were defined in a detailed specification. The following modules, available as add-ons as of R&S®ARGUS version 5, solve the specified tasks:

- **Spectrum management database interface (SMDI)**: Via this open interface, R&S®ARGUS is provided with

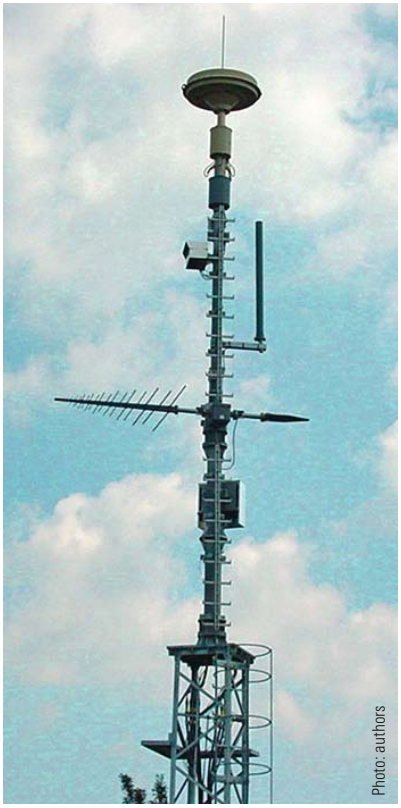

FIG 1 Monitoring station: Versatile antenna equipment is the key to conclusive measurements.

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

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

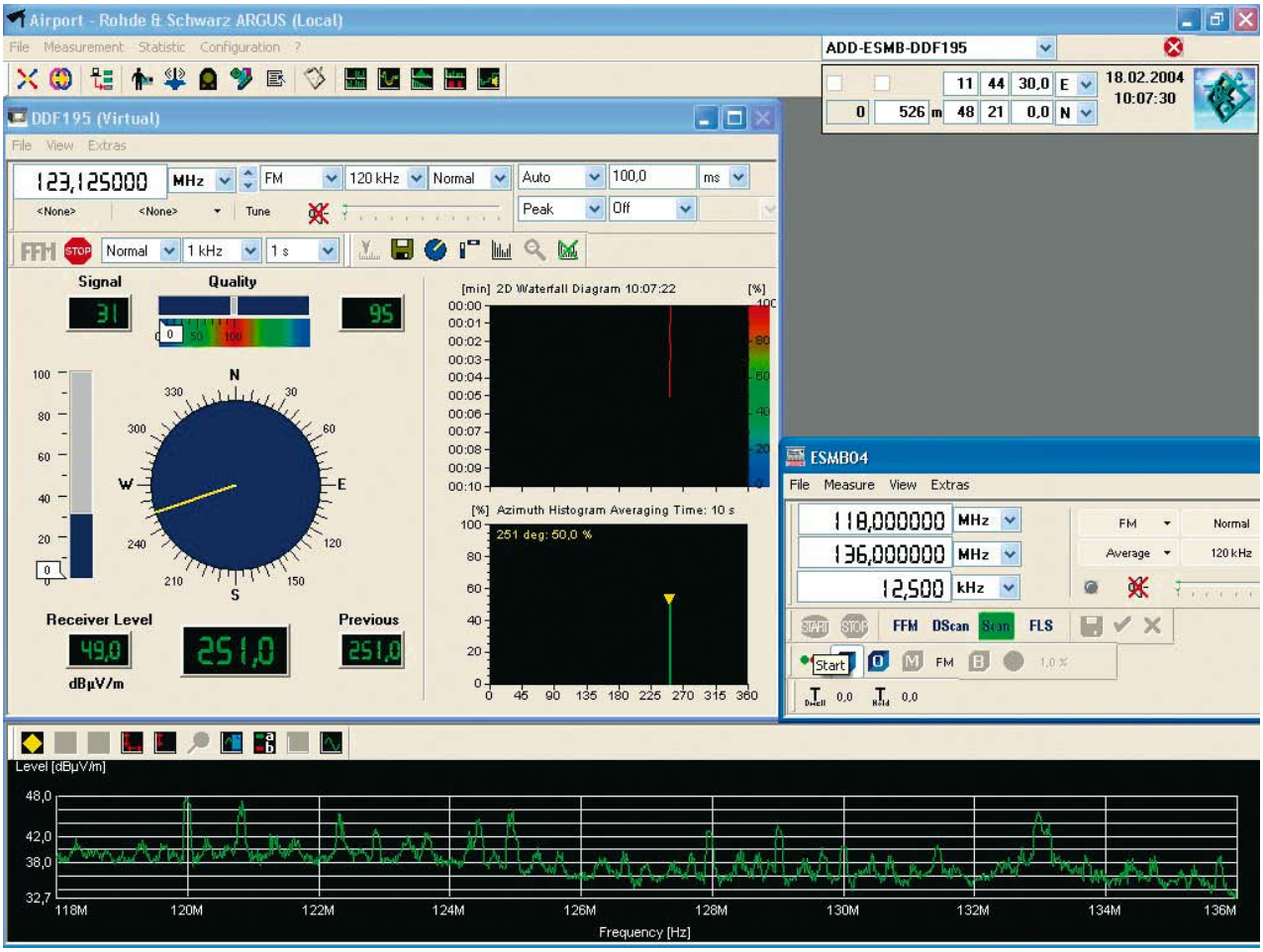

FIG 2 R&S®ARGUS software: The operator conveniently controls the unattended stations from the central station.

information such as frequency lists and technical parameters from the licence databases for performing specific measurements. In return, the software provides the spectrum management databases with the measurement and evaluation results for updating and completion.

- **Order/report module (ORM)**: This open interface permits any application, for example spectrum management systems, to allocate measurement tasks to the R&S®ARGUS-IT system. The software processes an order independently and then provides the "client" with a report containing the results.
- **Open interface for device drivers (DCI)**: This interface makes it possible to integrate equipment from any manufacturer (e. g. receivers, analyzers, direction finders) for which an R&S®ARGUS device driver is not yet available.

Smooth teamwork

Without the close cooperation between the project teams of NHH and Rohde & Schwarz, it would hardly have been possible to complete the delivery and commissioning of the entire system within the very narrow time frame that was stipulated. Since the antenna systems were supplied in advance, the outdoor assembly of the fixed stations in Hungary was possible at an early stage. Parallel installation work ensured that acceptance of the stations was achieved hand-in-hand with the customer already at the end of July 2003. In August 2003, the system proved its operational reliability during a contractually agreed test run.

On 1 September 2003, after a project time of only nine months, NHH officially accepted the Spectrum Monitoring and Management System R&S®ARGUS-IT. Their own operators were then trained on how to operate the monitoring system.

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Reinhard Göster

Software defined radios – overview and hardware (1)

Software defined radios combine a broad scope of complex radio techniques in one instrument. You can expand them for future techniques, reconfigure them for modified application profiles, and switch them between different radio services. Are they the ready-made solution or merely the concept of things to come?

The changing world of radiocommunications

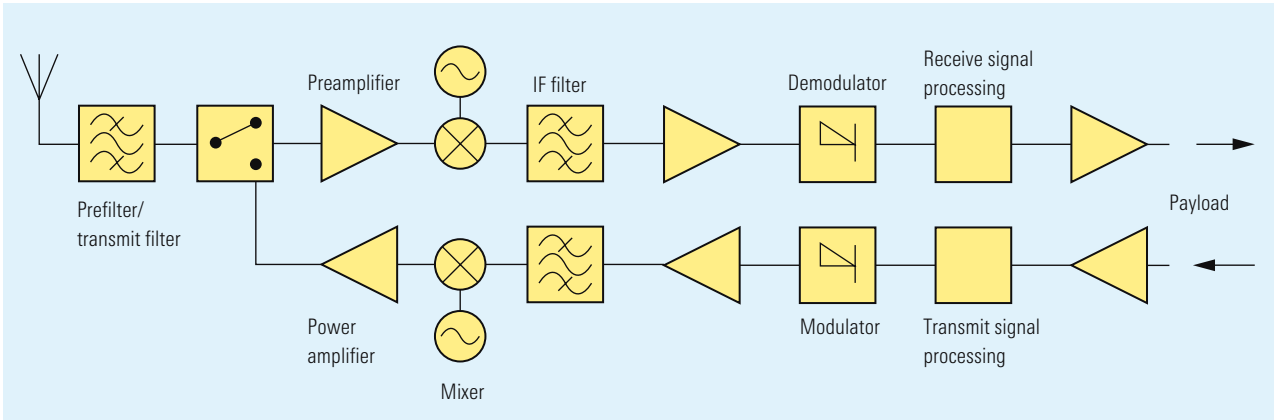
Radiocommunications and radios themselves have been around for more than 100 years. It all started with the trailblazing experiments of Marconi and others. Device architectures were developed soon thereafter, particularly the concept of the superheterodyne receiver. For decades, these architectures were considered optimal for most applications. Until just a few years ago, these analog-based architectures were state of the art (FIG 1).

Digital technology initially found its way into radiocommunications around 1980. The first components to be digitally controlled were primarily audio signal processing units, modulators, demodulators, filters and mixers. They were later implemented as digital. Today, the main functions of radios are controlled by software, which has led to the term "software defined radio" (or "software radio").

An ideal software radio does not have any analog stages for signal processing, except antenna, power amplifier and microphone/loudspeaker (FIG 2). In this model, the analog signals in the receive branch are converted to digital virtually right next to the antenna. These signals can then be modified as necessary in processors.

As the name "ideal software radio" implies, this device is not yet feasible – at least not with today's technology. However, software defined radios (SDRs) are feasible. In SDRs, analog components still handle important tasks. The definition of the Software Defined Radio Forum (SDRF) is useful here:

FIG 1 State-of-the-art architecture of traditional radios as it existed until a few years ago.



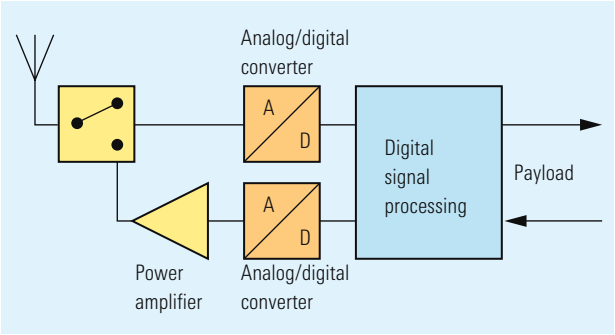


FIG 2
The "ideal" software defined radio does not have any analog components except antenna, power amplifier and microphone/loudspeaker.

SDRs provide software control of a variety of modulation method, wideband or narrowband operation, communications security functions (such as frequency hopping), and waveform requirements of current and evolving standards over a broad frequency range. The frequency bands covered may still be constrained at the frontend requiring a switch in the antenna system.

FIG 3 shows one possible SDR design. In this example, the first frequency conversion on the receiving end is still analog, while all subsequent signal processing steps are digital. On the transmitting end, the digital-to-analog conversion is followed by another frequency conversion to the transmit frequency and power amplification.

Why are SDRs so appealing?

The main appeal of SDRs is that you can set or change a radio's properties (e. g. transmission method) without having to modify or replace the hardware.

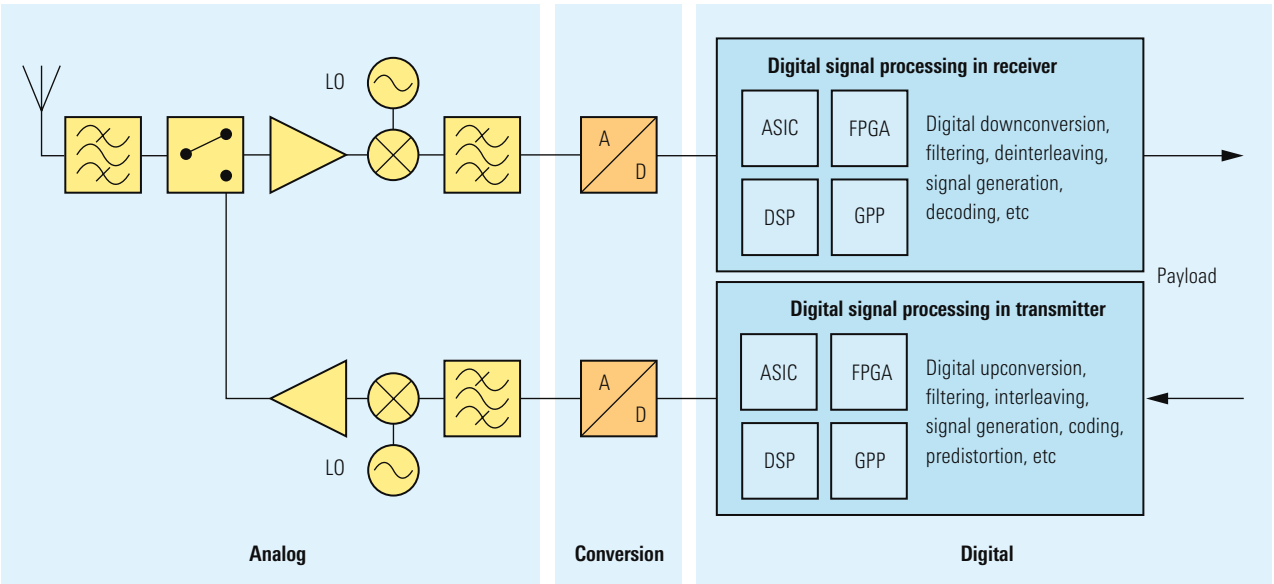
A good example is the use of SDRs by rescue services. Using just one radio, rescue services can access multiple transmission method in different frequency ranges simply by switching between them. This enables one rescue team to reach other rescue teams, the police, fire department, medical service teams or armed forces with just one radio unit. Furthermore, this applies even if these services use different radiocommunications techniques, which is usually the case.

In addition, you can easily modify radios that are already in use. For example, you can install bug-fixes, modify a protocol stack or download a complete, new transmission method. This flexibility means substantial economic benefits.

SDR components

SDR components can be divided into analog and digital (FIG 3). Even in the age of digital technology, the analog components in SDRs such as antennas, prefilters, switches, preamplifiers und power amplifiers play a critical role and determine a radio's technical properties. Compared with traditional radios, analog components in SDRs are usually subject to higher – not lower – requirements.

FIG 3 Possible design of a software defined radio.



This is because each SDR must offer the full scope of technical properties provided by the radios to be replaced, e. g. frequency range, sensitivity, dynamic range and adjacent channel separation.

The main digital hardware components are the following:

- GPPs (general-purpose processors)
- DSPs (digital signal processors)
- FPGAs (field-programmable gate arrays)
- ASICs (application-specific integrated circuits)

These computational and control components are used to implement the various functions in the radio, e. g. modulation, demodulation, filtering and coding. The specific requirements determine which types of components are used. FIG 4 provides a comparison of the basic properties of the various categories of signal processing chips.

	ASIC	FPGA	DSP	GPP
Power consumption	+ +	–	❍	❍
Cost for large quantities	+ +	–	❍	❍
Computing power for signal processing	+ +	+	❍	❍
Cost for small quantities	– –	–	❍	❍
Flexibility	– –	+	+ +	+ +
Reusability of programs	❍	❍	+	+ +

FIG 4 Comparison of the various categories of signal processing components.

ASICs merit a special note because they are not programmable, which in principle contradicts the basic concept of SDRs. However, their special characteristics have made them a standard part even of the newest generation of SDRs. ASICS must be specially developed for each application, after which they can be manufactured economically in large numbers. They are highly valued because they offer high computing power, low manufacturing costs when produced in large numbers and low power consumption. This makes them ideal for products such as mobile phones.

FPGAs are useful in applications in which you need high computing power and flexibility at relatively low unit production quantities. The computing power of FPGAs is very high in comparison to

Software Defined Radio Forum (SDRF)

The SDRF was founded in 1996 to promote SDR technology and use. Today, this international forum has approx. 120 members from industry, research institutes and government offices. In conjunction with the Object Management Group (OMG), the SDRF is the most important international organization that focuses on software defined radios.

The SDRF handles market, regulation and technology issues for software defined radios in civil and military applications. One of its current objectives is to define radio-internal interfaces that allow software to be kept independent of the computational hardware (e. g. processor type).

Software-Based Communication Domain Task Force of the OMG

The OMG is the world's largest software consortium. It consists of members from the software industry and end users. In the past, it defined software standards such as UML (unified modelling language) and CORBA (common object request broker architecture).

The Software-Based Communication Domain Task Force was formed by the OMG to develop specifications that support development, deployment, operation and maintenance. One of its tasks is to define software interfaces (APIs) for SDR applications.

DSPs and GPPs because they permit quasi-parallel processing. In contrast, DSP and GPPs are essentially serial in operation, and, in some cases, iterative.

The main strengths of DSPs and GPPs are their flexibility and easy configurability. One of their most important benefits is that they allow better reuse of existing programs for other purposes.

The art of implementation

In comparison to radios with traditional architecture, software defined radios present special challenges for developers:

- The significantly greater complexity of SDRs is comparable to that found in computer technology. Compared to the development of traditional radios, this places especially high requirements on a structured approach.
- Like in PCs, software has a longer lifespan than hardware. To ensure portability, the software to be developed must be kept decoupled from the hardware as far as possible.
- Analog/digital conversion is still a technical bottleneck. The requirements for higher bandwidths (e. g. for UMTS) and higher dynamic range (to eliminate effort-consuming analog prefiltering) are diametrically opposed. Achieving both at the same time is difficult.
- The analog frontend, which includes the antenna and is still required, must meet high RF requirements, since state-of-the-art digital signal processing still has a long way to go before it can ensure a high performance radio.
- Many multifunction radios require particularly low power consumption and low weight combined with high performance and flexibility. This can be achieved only through intelligent architecture and carefully selected computational components.

More information at www.rohde-schwarz.com (search term: M3AR / M3SR / M3TR)

REFERENCES

[*] Series 4400 (R&S®M3SR): Software-based radios for professional use. News from Rohde&Schwarz (2000) No. 166, pp 8–9

Rohde&Schwarz is one of the first companies that has developed software defined radios. One example is the R&S®M3SR [*], which covers a number of different communications standards and waveforms in different frequency ranges (FIG 5).

Dr Rüdiger Leschhorn;
Dr Boyd Buchin

(Part 2 in next issue)

FIG 5 The Software Defined Radio R&S®M3SR from Rohde&Schwarz covers a number of different communications standards and waveforms in different frequency ranges.

Cooperation at the highest level

German Federal Ministry of the Interior and Rohde & Schwarz enter into security partnership.

"The growth of secure encryption in Germany needs to be actively promoted", asserts the German Federal Government in its "Guidelines for German Crypto Policy". As a step in this direction, the German Federal Ministry of the Interior (BMI) and Rohde & Schwarz SIT GmbH founded a security partnership at CeBIT 2004 in Hanover. The objective is to promote national encryption techniques for protecting sensitive governmental communications.

According to the agreement, Rohde & Schwarz will keep the German Federal Government continuously abreast of what is currently possible in the field of powerful encryption. This will allow the current national requirements to be converted into products more quickly. Shared initiatives and projects will raise awareness of information security, thus promoting the implementation of secure encryption products in Germany. As a result, government authorities, industry and society in general can be protected against eavesdropping and the resulting economic and personal damage.

"The commitment of the German Federal Government is an important step toward establishing information security in Germany", says Henning Krieghoff, President of Rohde & Schwarz SIT. "Within this partnership, we will make our own contribution by applying our know-how."

The security partnership between the Ministry of the Interior and Rohde & Schwarz SIT was signed at CeBIT 2004 by the Minister of the Interior, Otto Schily, and Henning Krieghoff, President of Rohde & Schwarz SIT GmbH.

Rohde & Schwarz expands its production sites in Memmingen and Teisnach

Rohde & Schwarz is investing more than 3 million euros in Teisnach and 8 million euros in Memmingen to build new logistics and production facilities.

The groundbreaking ceremony was the first step in the general restructuring of the Rohde & Schwarz logistics system. The objective is to provide production with the required materials faster, more efficiently and on time. In addition, shipping can be expedited if products go directly from final production to the customer. Headquarters in Munich no longer need to be involved.

In addition, the production infrastructure in Memmingen is being expanded. In future, more products for the fields of broadcasting, radiocommunications, radiomonitoring and radiolocation as well as information security for the world market will be produced here.

These new construction projects underscore Rohde & Schwarz's intention to fortify its presence in Germany. "We must continue to be better than the competition. We are willing to invest in Germany if we have concepts that ensure our competitiveness," states President and CEO Friedrich Schwarz. Although the company sells 75% of its products abroad, 85% of its employees are in Germany.

The two-story building in Teisnach is scheduled to be opened in October 2004. The 8400-sqare-meter production building in Memmingen is scheduled for completion in April 2005.

VHF transceivers for Australian air traffic control

Rohde & Schwarz has received an order for more then 600 VHF Transceivers R&S®XU 250 A from NEC Australia Pty Ltd. Airservices Australia will deploy the transceivers to modernize the air traffic control (ATC) system across the continent. Airservices Australia is Australia's national, continent-wide organization for ATC, air rescue, radar communications and fire fighting. With a total value of several million euros, the transceivers are to be delivered by the end of 2005 and will be installed at 160 locations in Australia.

Taiwan selects DVB-T transmitters from Rohde & Schwarz

Taiwan's public broadcaster Public Television Service Foundation (PTS) has commissioned Rohde & Schwarz to deliver 16 DVB-T transmitters of the R&S®NV 7000 family. PTS selected Rohde & Schwarz because of short delivery times and its positive experience with earlier orders.

As part of this project, DVB-T transmitters will also be delivered to broadcasters such as China Television Company (CTV), Taiwan Television Company (TTV), Formosa Television Network (FTV) and Chinese Television Service (CTS) and supported by PTS. Each transmitter is remote-controlled or monitored via the Internet by the corresponding operating station using a network interface (NetLink). The transmitters are equipped with the tried-and-tested R&S®GB 700 automatic switchover unit, which switches on the standby transmitter at the operating frequency if a program transmitter fails. The operating data of the failed transmitter is transferred to the standby transmitter.

Rohde & Schwarz Taiwan is responsible for all local services such as transport, installation and commissioning of the DVB-T transmitters. The local Rohde & Schwarz subsidiary also handles the integration of additional components, thus providing the end customer with a turnkey project.

By landing this order, Rohde & Schwarz has expanded its market share for DVB-T high-power transmitters in Taiwan to more than 90%.

Rohde & Schwarz implements 3G test cases for NTT DoCoMo

Together with the Japanese telecommunications giant NTT DoCoMo, Inc., Rohde & Schwarz has started developing test scenarios for global roaming of third-generation mobile radio (3G). The goal is to achieve interference-free operation of various mobile radio devices under real network operating conditions defined by NTT DoCoMo. By the end of July 2004, Rohde & Schwarz plans to have converted the test specifications developed by NTT DoCoMo into 80 executable test scenarios that ensure interference-free global roaming in 3G networks. Thus, both companies support the fast introduction of third-generation mobile radio.

R&S®FSH3 – small but tops

Rohde & Schwarz has received the NAB2004 Pick Hit Award for its Handheld Spectrum Analyzer R&S®FSH 3. The prize is one of the most prestigious awards handed out at NAB.

Each year, the technical publication "Radio Magazine" hands out the award for 15 new products from the field of radiocommunications. The award is in recognition of products that feature significant technological improvements and also simplify product use. A group of technical experts from the radiocommunications industry select the winners.

This year, the compact and favourably priced R&S®FSH 3 from Rohde & Schwarz convinced the jury in the T&M field. With its broad spectrum of use and innovative solutions, the instrument was one of the industry's favourites at NAB 2004.

You can read the report of an enthused user of this "ingenious little device" on page 37.
In addition, page 26 introduces the instrument's new and larger brother, the R&S®FSH 6, which is the world's first 6 GHz handheld spectrum analyzer. For an overview of analyzers available from Rohde & Schwarz, turn to page 30.

Rohde & Schwarz takes over sales and service for its T&M products in North America

Rohde & Schwarz personally commits itself to its most important growth market – North America. Since 1 June 2004, Rohde & Schwarz personally handles all sales and service activities for its T&M products in the US and Canada. Since 1993, these activities were handled by its partner Tektronix, Inc. (NYSE: TEK), headquartered in Beaverton, Oregon. By taking this step, Rohde & Schwarz can now provide its customers with on-site presence and address market-specific requirements without delay. The Rohde & Schwarz US subsidiary, which will now also take care of T&M products, has been active in the US market for 25 years, handling the broadcasting and communications products from Rohde & Schwarz. Last year, Rohde & Schwarz Inc. already took over service activities from Tektronix for its T&M products in the US. Columbia, Maryland is home to Rohde & Schwarz headquarters in the US. In addition, Rohde & Schwarz has offices in Dallas (Texas), Irvine (California) and Ottawa (Canada), plus a service center in Beaverton (Oregon).

Rohde & Schwarz sets up sales and support network in Japan

Rohde & Schwarz and Advantest are ending their T&M distribution agreement for the Japanese market. Since 1 May 2004, Rohde & Schwarz personally handles marketing, sales and support activities for all its products in this region. By providing direct customer care, Rohde & Schwarz wants to gain an even better understanding of the specific requirements of this growth market and thus further strengthen its market position in Japan. Advantest has held exclusive sales rights for Rohde & Schwarz T&M products in Japan since 1992. Rohde & Schwarz already expanded its presence in Japan in 2003, when it established the Support Center Japan (SCJ) in Tokyo. Rohde & Schwarz is now setting up new sales offices in Shin-Yokohama, Osaka and Tokyo. The distribution agreement under which Rohde & Schwarz sells Advantest T&M products in Europe will remain unaffected.

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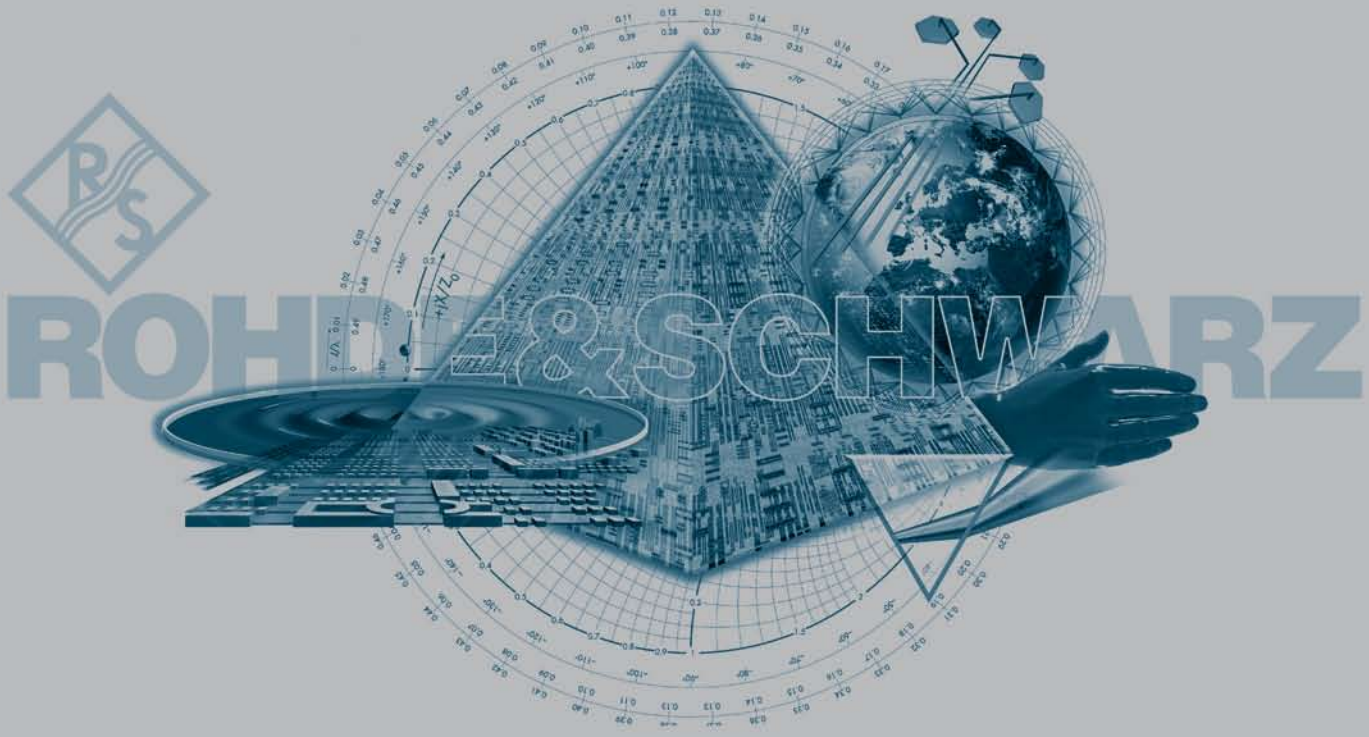

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