News from Rohde & Schwarz

Test system for *Bluetooth*™ qualification in development and quality assurance

Trunked radio technology for Europe's most advanced combat training center

Secure mobile telephone – no chance for data thieves

2001/III

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An essential precondition for the success of *Bluetooth* ™ technology is the interoperability and undisturbed function of different products. The Test System TS 8960 has been designed for RF measurements in line with the *Bluetooth* qualification program and for in-depth measurements in development and quality assurance (page 4).

Photo: Author

The „Letzlinger Heide" training area of the German Armed Forces is the most advanced combat training center in Europe. The center uses the TETRA System *ACCESSNET* ®-T, which was developed by the Rohde & Schwarz subsidiary R&S BICK Mobilfunk GmbH as a professional trunked radio system for civil applications (page 8).

With the addition of the SMV 03, which comprises a vector modulator with analog I/Q inputs for the frequency range 9 kHz to 3.3 GHz, Rohde & Schwarz has extended its range of successful economy Signal Generators SML (page 24).

Photo 43 792/1

MOBILE RADIO

Test systems

Trunked radio systems

Test signals

Radiocommunication testers

GENERAL PURPOSE

Reference

Test methods


Photo 43 777

The changeover from analog to digital TV transmission is well under way. Receivers and set-top boxes for digital reception are being produced in large quantities for the consumer market. The TV Test Transmitter Family SFL has been developed by Rohde&Schwarz to test these receivers (page 30).


Photos Autor

Heat, sand and dust: the Australian outback is a demanding environment for electronic measurement equipment. The rugged Spectrum Analyzer FSP has proved that it can take the strain (page 20).

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RF Test System TS 8960

Bluetooth™ qualification in development and quality assurance

An essential precondition for the success of *Bluetooth technology is the interoperability and undisturbed function of different products. To ensure this, the Special Interest Group (SIG) has defined a qualification program that has to be passed by every product to be marketed under the *Bluetooth* label. The Test System TS 8960 (FIG 1) has been designed for RF measurements in line with the *Bluetooth* qualification program and for in-depth measurements in development and quality assurance.**

Photo 43434/1

FIG 1 RF Test System TS 8960: all required *Bluetooth* test cases are preset. Test case parameters can be modified and adapted as required.

RF measurements in line with the Bluetooth qualification program

16 test programs for measuring the RF characteristics of an EUT in line with the *Bluetooth* test specifications run on the Test System TS 8960. The RF measurements are organized into transmitter, receiver and transceiver tests.

Transmitter tests determine the output power of the EUT, the quality of the RF output spectrum, and modulation parameters such as frequency deviation, frequency accuracy and drift.

A transmitter test in the TS 8960 starts with a call setup and the TEST_MODE_ACTIVATE command, which switches the EUT into the test mode. Call setup and the transmitter measurements have to be performed in ▶

* *Bluetooth* is a trademark owned by Bluetooth SIG, Inc., USA, and licensed to Rohde & Schwarz.

Design and characteristics of the TS 8960 test system

Bluetooth operates in the license-free ISM (industrial scientific medical) band at 2.4 GHz. A data rate of 1 Mbit/s makes this standard ideal for wireless data communication in many applications.

The Test System TS 8960 has been designed for RF measurements in line with the *Bluetooth* qualification program and for in-depth measurements in development and quality assurance. According to the specification, two test modes are available for RF measurements, the Tx test mode and the loopback test mode. In the Tx test mode, the EUT sends a settable data pattern; in the loopback test mode, the data pattern sent by the test system to the EUT is returned and is thus available for evaluation.

The instruments in the test system are controlled by a system controller via the IEEE bus and an Ethernet link. The signalling unit in the system is responsible for call setup, test mode selection and the BER measurement. It contains an RF front-end for transmission and reception.

Two Vector Signal Generators SMIQ 03 are provided in addition. One produces the useful signal, the other the *Bluetooth*-modulated interference signal for receiver tests. A third generator provides the unmodulated interference signal for measuring blocking and intermodulation suppression. The spectrum analyzer measures the power, the modulation spectrum and the spurious emissions.

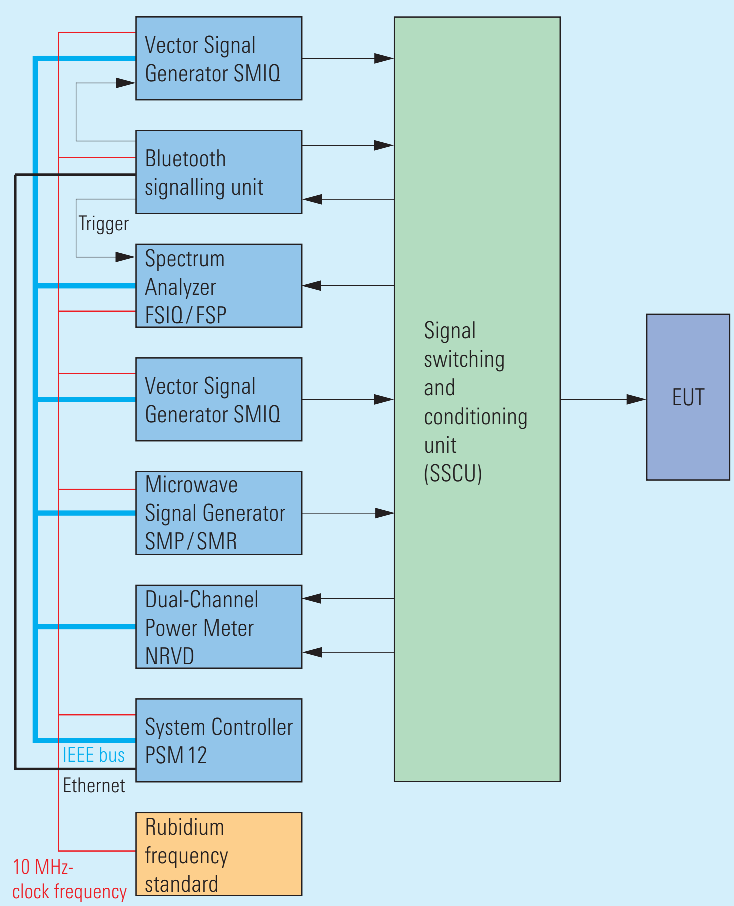
All signals are amplified and filtered in the signal switching and conditioning unit (SSCU), which contains relays, directional couplers, combiners, amplifiers and several filters. Since accurate level values are required for RF measurements, the Test System TS 8960 performs fully automatic path compensation to minimize measurement errors. For this purpose, two RF probes are installed at essential test points in the SSCU. Channel A of the Dual-Channel Power Meter NRVD is used for monitoring the transmit level of the simulator, channel B for monitoring the received levels. Any level errors that occur in the current measurements are automatically corrected with the aid of stored reference values.

A Rubidium frequency standard supplies the highly accurate reference frequency. The system can optionally be equipped with power supply units for the EUTs.

Main characteristics of TS 8960

- All test cases are in line with *Bluetooth* test specifications
- Test mode signalling
- Dirty transmitter
- Comprehensive system selftest
- High measurement accuracy due to automatic path compensation
- Many auxiliary programs for everyday use
- Upgradable (e.g. for remote control of power supply units, climatic cabinets, etc)

FIG 2 Block diagram of TS 8960



Straightforward measurements for quick results

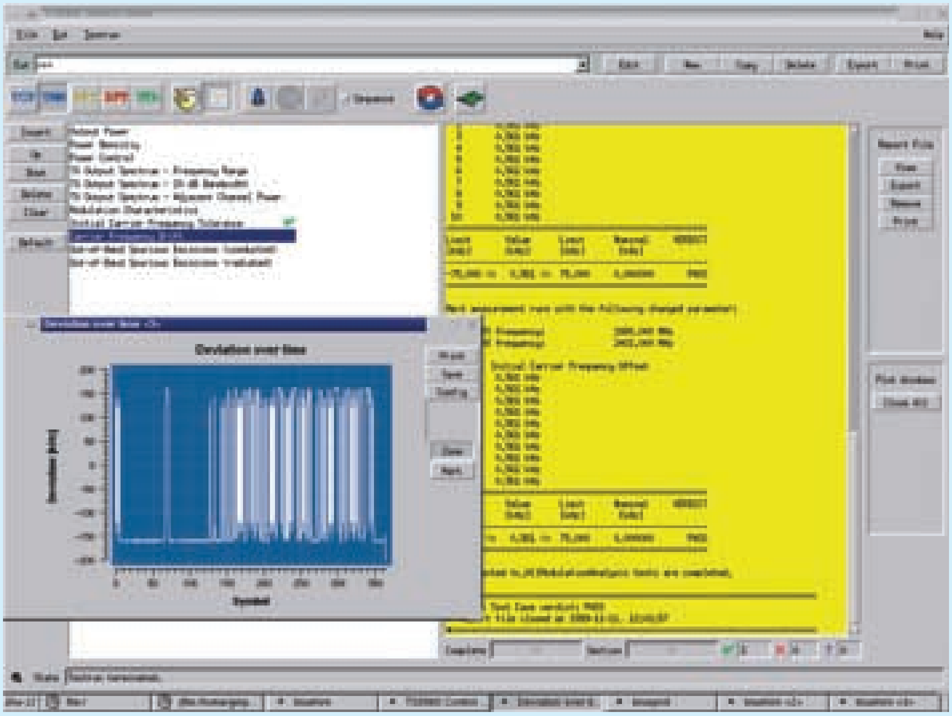


FIG 3 Straightforward control of test system via graphical user interface

An **easy-to-use graphical user interface** ensures straightforward operation of the TS 8960 (FIG 3). Menus are available for equipment under test (EUT), test cases (TCF, TMM), path compensation (RFC), selftest (SFT) and utilities (UTL).

In the EUT menu, the characteristics of the EUT, such as power class, *Bluetooth* address, signalling information, supported data packets, antenna gain, etc, must be entered. Subsequently, one or more test cases can be selected and executed in the test case menu. When the selftest menu is selected, a comprehensive system selftest is performed.

Path compensation The measurement accuracy can be increased in many ways in the path compensation menu. Path compensation takes into account all losses within the test system up to the antenna connector of the EUT; i.e. also line losses between the test system and the EUT.

Documentation After the test has been completed, the system documents all the main measurement results in a comprehensive test report and in plots. Zoom and marker functions allow fast and accurate evaluation of graphs.

▶ the hopping mode which means that the EUT carries out 1600 frequency hops per second within the 79 channels of the frequency band.

Since the spectrum analyzer cannot synchronize to the hop sequence of the EUT, it is set to a fixed frequency. With all measurements in the time domain, the *Bluetooth* signalling unit emits a trigger signal at the moment the EUT sends on the analyzer receive frequency, and thus starts the measurement in the analyzer. This method is used to carry out the power measurement, for example.

A special feature of **modulation analysis** is that the spectrum analyzer acts as an I/Q demodulator for the measurements. The demodulated I/Q data is applied on the IEEE bus to the system controller, where it is processed. This is necessary because the spectrum analyzer performs only 4-fold sampling at the most. According to the *Bluetooth* test specifications, this is sufficient, but because the sampling time and the symbol time are not in sync, the reproducibility of measurement results is limited. For this reason, the I/Q data in the TS 8960 is interpolated to a sampling rate of up to 64 by fast Fourier transform.

The sensitivity of the *Bluetooth* **receiver** and its immunity to modulated and unmodulated interfering signals in the useful and adjacent channels are measured in the receiver tests. The main difference between these tests and the transmitter tests is that all receiver tests are carried out in the non-hopping mode, i.e. the EUT sends only at a fixed frequency. To meet the high demands on stability and spectral purity of the test signals required for receiver tests, a Vector Signal Generator SMIQ 03 is used instead of the RF frontend of the signalling unit.

Switchover from the internal frontend to the external signal generator is performed after call setup. Baseband data (data, clock and frame clock) is applied to the external interface of the modulation coder of the SMIQ03. Since this switchover is carried out within one timeslot, the EUT is not affected.

The EUT is in the loopback test mode and returns the data sent by the TS8960. The signalling unit receives this data and evaluates it in a bit error rate (BER) measurement.

"Dirty transmitter" Since *Bluetooth* units are normally stationary, there are no fading effects. However, the signals used for measuring the receiver sensitivity are not completely undisturbed. The *Bluetooth* specification defines a dirty transmitter, the signal of which features a drift for many parameters such as frequency, symbol duration, deviation and modulation index. The dirty transmitter is realized in the TS8960 by the interplay of several components. The *Bluetooth* signalling unit produces the symbol drift, and the SMIQ03 varies the deviation, frequency and modulation index.

Other receiver tests are the measurement of carrier/interference performance, blocking performance and intermodulation performance.

The specification defines an **"out-of-band spurious emissions"** transceiver test. According to the European standard, spurious emissions are searched for "only" in a frequency range of up to 12.75 GHz, but the American standard prescribes measurements up to 25 GHz.

The standard model of the Test System TS8960 is designed for fully automatic measurements of conducted interference up to 12.75 GHz. Options are available for measurements up to 25 GHz and for measurements of radiated spurious emissions.

Additional measurements for development and quality assurance

All parameters can be varied All test cases can also be performed with parameters that differ from those in the test specification. For example, the level and frequencies of the test signal and noise signal generators can be varied in a wide range for receiver tests. Packet types and even signalling parameters can also be changed.

Other tests can be performed in addition to the measurements defined by the test specification. For example, the **"search sensitivity test"** can be used to determine the current receiver sensitivity. For this measurement, the test signal level can be reduced until the bit error rate just exceeds the 0.1% defined by the specification. The level at which the BER is still within the 0.1% limit corresponds to the receiver sensitivity. Another example is the **"free receiver measurement"**, which permits user-configured receiver tests to be performed.

The test system also provides a **number of auxiliary programs**, e.g. the program for measuring the unmodulated part of the burst, the inquiry scan program for determining the EUT address and also complementary test methods with a great variety of setting capabilities.

User-specific test programs The Linux operating system, a fast C compiler and a wide selection of debugging capabilities allow efficient and fast development of user-specific test programs.

Wilfried Tiwald

More information and test systems for *Bluetooth* at www.rohde-schwarz.com (search word: Bluetooth)

***Bluetooth* measurement solutions for R&D, qualification, type approval and production**
Overview of main measuring instruments and test systems from Rohde&Schwarz for measurements on *Bluetooth* equipment.

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- Protocol Tester PTW60 for *Bluetooth* applications – Comprehensive protocol tests to *Bluetooth*™ qualification program. News from Rohde&Schwarz (2000) No. 169, pp 8–10
- *Bluetooth* RF Test Specification 1.1, Revision 0.91, 02 July 2001
- *Bluetooth* Core Specification, Revision 1.1, 22 February 2001

TETRA Trunked Radio System *ACCESSNET*®-T

Trunked radio technology for Europe's most advanced combat training center

The "Letzlinger Heide" training area of the German Armed Forces is the most advanced combat training center in Europe. Up to 2500 soldiers can practise with their vehicles within an area of approx. 500 sq km. Their combat activities are recorded and monitored fully electronically under realtime conditions.

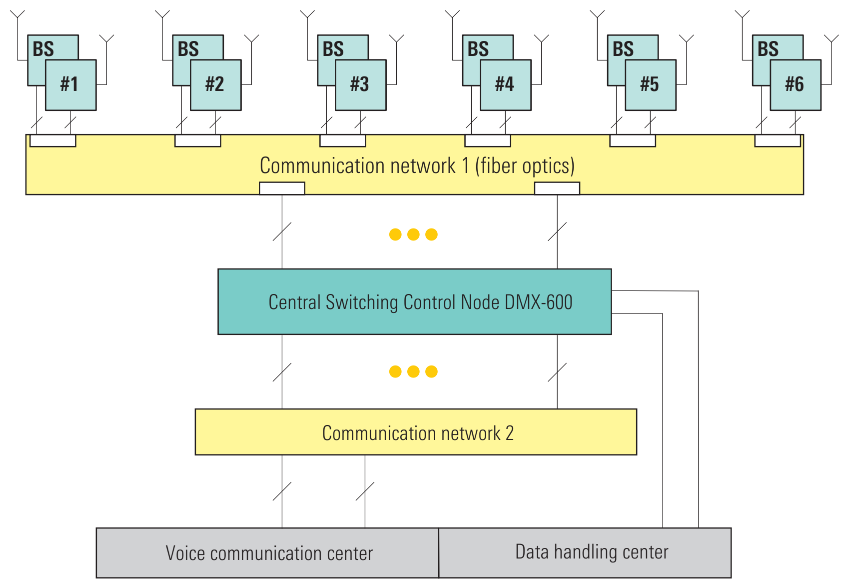


FIG 2 Communication infrastructure of combat training center

FIG 1 The compact and lightweight subscriber unit is usually mounted on the back

Photo 43717/14N

Electronic duel: radio-monitored and radio-controlled

The activities of the exercising soldiers are recorded and monitored fully electronically under realtime conditions. All of this is made possible by the "electronic duel", on which training in the army's combat training center is based. The combat situation is simulated with the aid of laser beams and optimized sensors. The lasers are fixed to the soldiers' weapons and vehicles, and the sensors are suitably distributed over the soldiers' clothes and vehicle surfaces. Each soldier and each vehicle are provided with a subscriber unit which electronically registers all operations such as opening of fire, hits and movements of the soldier or vehicle, and transfers the information via radio to the command and control center (FIG 1).

With TETRA (terrestrial trunked radio), a digital non-military radio technology is used, which is based on a European standard and was developed by Rohde&Schwarz under the product name *ACCESSNET*®-T as a professional trunked radio system for civil applications [1, 2]. *ACCESSNET*®-T, a COTS (commercial off-the-shelf) product developed primarily for use in public networks, industrial enterprises, public transport systems and security organizations, has proven itself in this purely military application. The subscriber unit also uses a commercial TETRA unit as radio modem. There were various reasons why the German Armed Forces represented by EADS decided in favour of *ACCESSNET*®-T. The main reasons are stated in the box on page 6.

For full radio coverage of the area, base stations with transceivers are installed at six sites. Each site has its own set of frequencies. The cellular organization of the radio network ensures that a subscriber unit is always in contact with that base station whose radio signals are best received, as the subscriber unit moves around within the radio network. In addition to data transfer, voice communication for the observer / controller is also handled via these sites with transceivers specially reserved for this purpose.

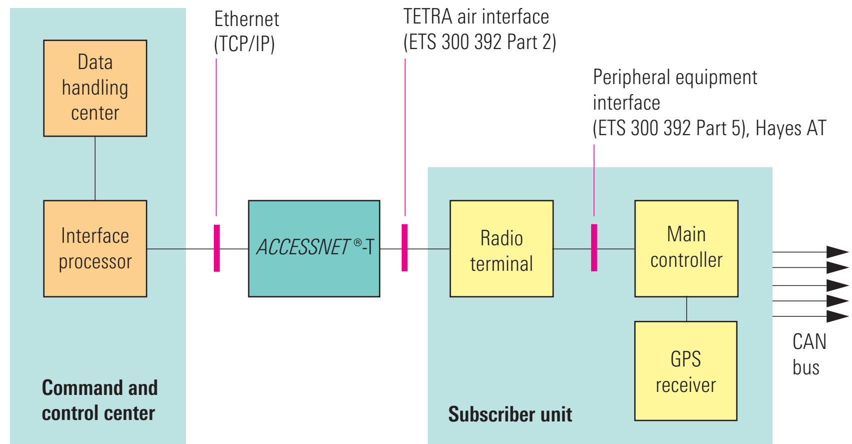


FIG 4 The complete data communication chain

The communication infrastructure

Networks

The Trunked Radio System *ACCESSNET*®-T from Rohde & Schwarz is embedded into the fixed network infrastructure of the combat training center. The existing fiber-optic network is used for networking the base stations with the central switching control node of the trunked radio system (FIG 2). As shown in the block diagram, connection to the voice communication center is also handled via the fiber-optic network. Connection to the data handling center is made via a computer network (LAN with Ethernet and TCP/IP).

The subscriber unit

The subscriber unit shown in FIG 1 is a lightweight, compact unit fixed to the sensor carrying harness on the back of the soldier. It consists of the electronic components of a commercial TETRA handheld transceiver with an RF output power of 1 W, a microprocessor and a GPS receiver. The sensors are connected via the CAN (controller area network) bus. This bus is also suitable for downloading new software into the TETRA radio module and microprocessor.

Focus on data communication

Data communication is the main focus of the trunked radio system of the combat training center, which can be fully controlled and monitored by the command and control center (FIG 3). The logical connection of the data communication chain is shown in FIG 4.

Up to 95 % of the data traffic in the trunked radio system is triggered by events from the subscriber units such as position changes or lasers hitting the sensors on the soldiers and vehicles. The Trunked Radio System *ACCESSNET*®-T serves as a transparent transport vehicle for data transfer to the command and control center.

Photo 43 717/12

FIG 3
The command and control center has everything under control: it monitors, records and evaluates all activities in the combat training area

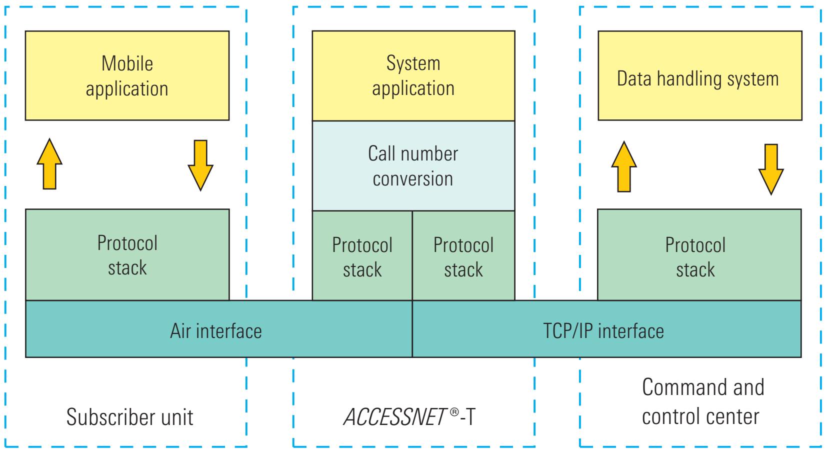


FIG 5 OSI layer model of data communication system

Further data traffic is generated, for example, by the reference information for the differential GPS (global positioning system) and the general position information usually communicated by the command and control center to the subscriber units as a broadcast call.

The layer model shown in FIG 5 illustrates this configuration. The task of the mobile application in the subscriber unit is to collect data and control the sequence of operations. The system application in the Trunked Radio System *ACCESSNET®*-T integrates the GPS, generates the reference signal and initiates regular transmission of the reference signal. This is also where the call number conversion occurs for the recoding of military tactical numbers into physical TETRA addresses and vice versa. The LAN interface to the command and control center and its protocol are also handled here. The data handling system is a stationary application in the command and control center.

Why the German Armed Forces decided in favour of TETRA and *ACCESSNET®*-T

Data communication with the subscriber units and observer/controller voice communication should by no means technically affect tactical radiocommunication of the exercising units. The TETRA standard of ETSI (European Telecommunication Standards Institute), which is specified for frequencies of approx. 400 MHz and above, meets these requirements. Thanks to the flexibility of *ACCESSNET®*-T, it was possible to fulfill the customer's special request for extending the frequency range to 366 MHz to 371 MHz for this project: a typical example of a COTS product like *ACCESSNET®*-T offering sufficient possibilities for adaptation.

In particular, *ACCESSNET®*-T and TETRA technology support integrated voice and data communication. Instead of two independent radiocommunication systems as was originally intended, it was therefore possible to set up a single system in which both services are integrated, thus providing an additional economic benefit.

The TETRA standard describes the most advanced technology currently available for professional mobile radio. The main physical features of the air interface and the essential voice and data services are shown in FIG 6. Based on expected future market development, it is assumed that this technology will have a lifespan of at least 20 years.

Channel spacing	25 kHz
Modulation	π/4-DQPSK
Channel data rate	36 kbit/s
Voice coder	approx. 4.8 kbit/s
Channel access	TDMA, 4 timeslots
Usable data rate	7.2 kbit/s per timeslot
Variable data rate	2.4 kbit/s to 28.8 kbit/s
Voice services	individual call, group call, broadcast call
Data services	status message, short data message

FIG 6
Main physical features of air interface and services of TETRA

Photo: Author

FIG 8 Central Switching Control Node DMX-600

An excellent communication platform

The German Armed Forces have decided in favour of *ACCESSNET*®-T, a modern digital TETRA trunked radio network available as a COTS product that can be used without any adverse effects on tactical radiocommunication equipment. In addition to the favourable price/performance ratio, the high flexibility and easy adaptability of the system to special requirements are further benefits.

Max Zerbst

More information on *ACCESSNET*®-T at www.rohde-schwarz.com (Homepage – Products & More – Trunked Radio)

REFERENCES

[1] Countrywide *ACCESSNET*® trunked radio system in South Siberia. News from Rohde & Schwarz (1999) No. 162, pp 30–32

[2] A vision comes true – trunked radio for United Arab Emirates. News from Rohde & Schwarz (1995) No. 151, pp 50–51

FIG 7 TETRA Base Station DTX-500

Photo: Author

The components of *ACCESSNET*®-T

The Base Stations DTX-500 (FIG 7) and the Switching Control Node DMX-600 (FIG 8) are referred to as subsystems. The base stations are accommodated in shelters. Three transceiver modules each are provided for voice and data communication. The maximum output power of each transmitter radiated via a common antenna is 25 W.

The Switching Control Node DMX-600 is accommodated in the central building of the combat training center and is connected to the data handling center via a LAN. FIG 8 shows that for redundancy reasons, two GPS receivers (yellow modules) are provided in the DMX-600.

Application Software SMIQ-K5

Standard-conforming Bluetooth™ tests with Signal Generator SMIQ

The *Bluetooth* Test Specification [1] stipulates defined procedures for tests on *Bluetooth* transmitter and receiver modules. To test such modules in line with the specification, standard-conforming data packets are needed. With the PC-based Application Software SMIQ-K5 and the Vector Signal Generator SMIQ, it is now easy to generate the most common data packets for receiver measurements.

SMIQ and SMIQ-K5 – unbeatable team in receiver tests

Application Software SMIQ-K5 (FIG 1) for the Vector Signal Generator SMIQ has been created to offer chip designers as well as R&D teams a convenient tool for carrying out numerous receiver tests in line with the *Bluetooth* standard. The *Bluetooth* RF Test Specification [2] stipulates, for example, the following measurements on *Bluetooth* receiver modules:

- Bit error rate (BER)
- Receiver sensitivity
- C/I (carrier-to-interference) performance
- Intermodulation performance
- Blocking performance

The main RF characteristics of a transmitter/receiver module are shown in FIG 2.

Main applications of SMIQ-K5

With the aid of Software SMIQ-K5, the Vector Signal Generator SMIQ can generate RF test signals conforming to the *Bluetooth* standard. To this effect, SMIQ-K5 generates data and control lists, which are transferred to the SMIQ. The software can also control parameters such as the power ramping of packet bursts as well as modulation parameters in the SMIQ. These parameters can be user-defined within certain limits. The parameters selected for packet generation are calculated, and the resulting values transferred to and set on the SMIQ together with the modulation parameters and the selected power ramp.

The intuitive user interface of the software supports the user in configuring type DH1, DH3, DH5 and AUX1 data packets. An integrated packet editor (FIG 3) makes it easy to edit practically each information element of a selected packet section. In addition, the software automatically calculates the checksums for error correction required for the packet in question, for example the header redundancy checksum (HRC) or the cyclic redundancy checksum (CRC). The sync word is likewise calculated automatically after entering the *Bluetooth* Device Address (BD_ADDR), which unambiguously identifies each *Bluetooth* module.

Via SMIQ-K5, the user can at any time adjust the power ramps for the bursts as well as the modulation parameters in the SMIQ and transfer any modifications to the generator.

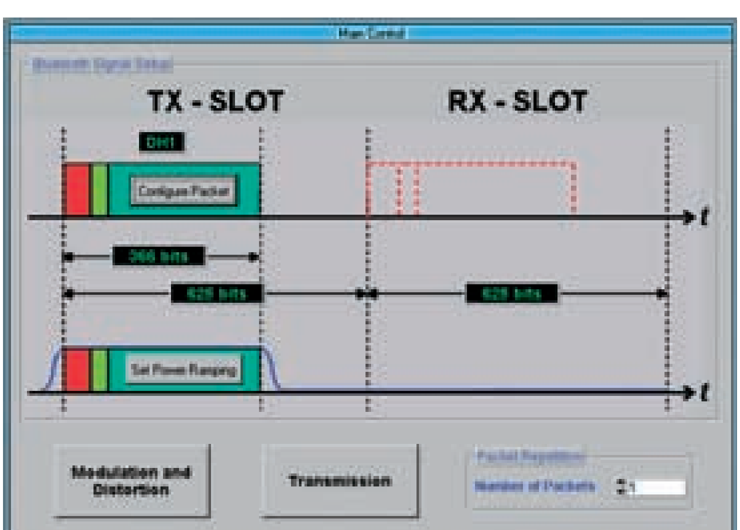


FIG 1 Straightforward user interface: with just a few mouse clicks, the SMIQ can be prepared to deliver *Bluetooth* packets conforming to standards.

* *Bluetooth* is a trademark owned by Bluetooth SIG, Inc., USA, and licensed to Rohde&Schwarz.

Key functions of Application Software SMIQ-K5

- The contents of a data packet can be created either from pseudo-random binary sequences (PRBSs), or "all 0", or "all 1" patterns, or data sequences compiled in a file. Alternatively, a data packet can be configured and calculated with the aid of the packet editor.
- Apart from configuring the data packet as a whole, the packet editor allows setting of the payload data in a separate payload configurator (FIG 3) window that can be called from the packet editor. The payload bit stream can be generated same as for the packet contents above.
- The innovative configuration display of the packet editor, which shows the bit stream for each packet section, indicates any changes or recalculations of packet sections resulting from modifications to the configuration.
- The packet-burst power ramps can be conveniently controlled by means of SMIQ-K5. No further changes or settings are required on the SMIQ. Parameters like the offset for the rising or falling edge can be shifted symbol-wise, and the ramp slope may be selected as a $\cos^2$ function or a linear function. The ramp rise and fall times can be set with symbol accuracy.
- The packet repetition counter can generate a number of packets of the same type; the payload contents (e.g. PRBS sequences) are continued in the next packet in each case.

Parameter	Data
Carrier frequencies used	◆ 2400 MHz to 2483.5 MHz (ISM radio band) ◆ 79 communication channels ◆ Channel spacing 1 MHz
Transmission type	◆ TDMA system ◆ TDD bursts ◆ Time division multiplex: via timeslots organized in 625 µs raster (625 µs per timeslot) ◆ Frequency hopping spread spectrum (FHSS) mode ◆ 1600 frequency hops/s (number of hops in frequency hopping sequences may vary depending on packet type used: 625 µs corresponds to 1600 hops/s)
Modulation	◆ Modulation mode: 2FSK ◆ parameters Symbol rate: 1 Msymb/s ◆ Modulation index: 0.28 to 0.35 (basic setting 0.32) ◆ Max. frequency shift: 140 kHz to 175 kHz (basic setting 160 kHz) ◆ Baseband filtering: Gaussian, B · T = 0.5
Power class	◆ Power class 1: 1 mW (0 dBm) to 100 mW (+20 dBm) ◆ Power class 2: 0.25 mW (–6 dBm) to 2.5 mW (+4 dBm) ◆ Power class 3: 1 mW (0 dBm)
Transmission range	10 cm to 100 m Power class 1 modules cover distances up to 100 m.
Max. data throughput	The asynchronous channel can support an asymmetric link of max. 721 kbit/s in either direction, while permitting max. 57.6 kbit/s in the return direction, or a symmetric link of 432.6 kbit/s.

FIG 2 Main RF parameters defined by *Bluetooth* standard

Use of SMIQ-K5 in practice

The *Bluetooth* Test Specification for the generation of burst test signals for receiver measurements defines the RF setting parameters and the contents of the payload. SMIQ-K5 offers all the payload contents required for payload data testing in the loopback mode. Plus, the user is free to configure payload contents of his own as required for his application. In addition, SMIQ-K5 automatically calculates the correct signals for masking the packet bursts of the data sequences transmitted to SMIQ, as well as the signal for masking the payload, which is required for BER measurements on certain modules.

With the optional Data Generator (SMIQB11) as a data source and the associated Memory Extensions SMIQB12, up to 80 Mbit *Bluetooth* test sequences (data packet sequences) can be stored. In this way, a number of test sequences can be calculated in advance with SMIQ-K5 and transferred to the SMIQ. The stored sequences can be activated on the SMIQ for later measurements and for production purposes.

The SMIQ-K5 functionality described here by far exceeds the capabilities outlined in Application Note 1MA31 [4] for the generation of *Bluetooth* RF test signals for the Signal Generator SMIQ. SMIQ-K5 is the first software to enable the complete and free configuration of *Bluetooth*-conforming data packets for RF test signal generation. The sync word and the checksums for error correction are calculated in compliance with the standard. Flow-control and reception-acknowledgement bits can be switched on or off.

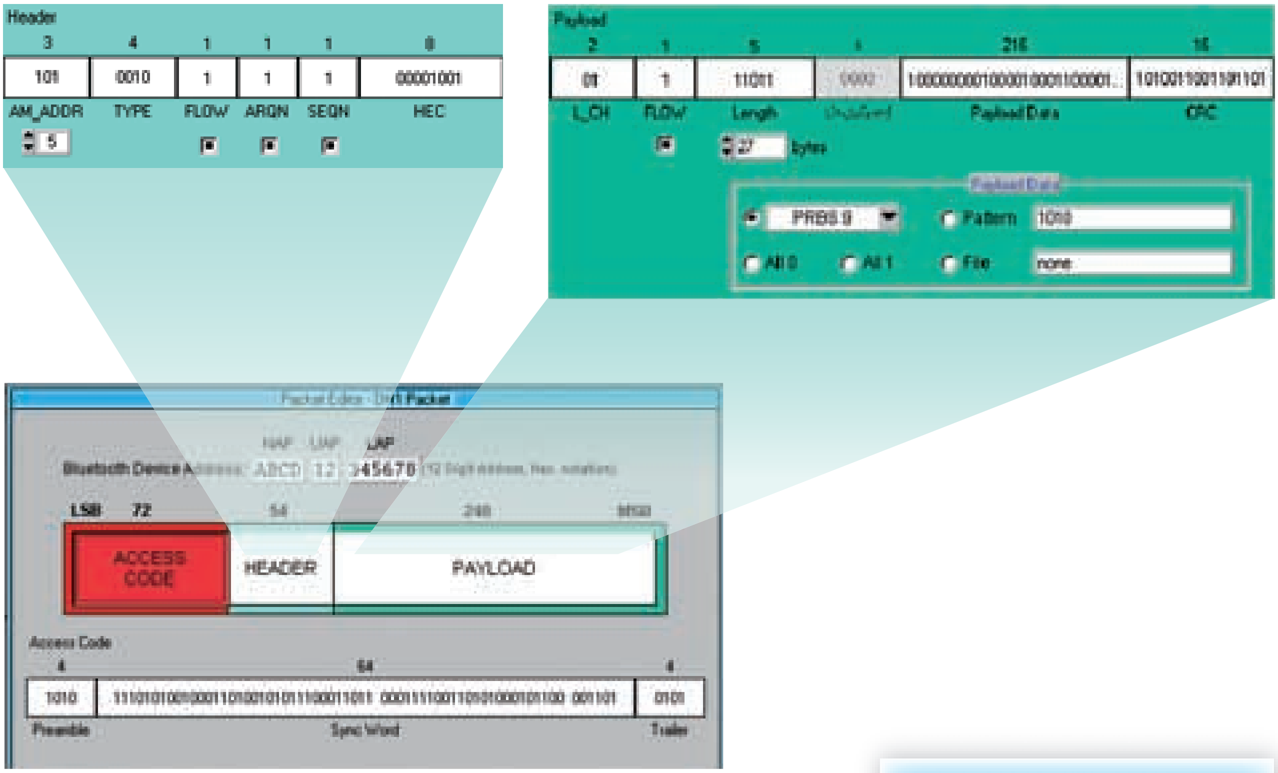


FIG 3 The packet editor configuration panel makes it very easy and convenient to configure data packets tailored to user's application

Application Software SMIQ-K5 now free of charge on the Internet

Application Note 1GP48 [5] describes the configuration of a DH1 packet for special requirements. The procedure for packet generation outlined there is also valid for all other packet types supplied by SMIQ-K5. The application note further contains straightforward and detailed guidelines for carrying out BER measurements, including a block diagram illustrating how the DUT should be connected to the SMIQ. Application Software SMIQ-K5 and Application Note 1GP48 can be downloaded free of charge from the Rohde&Schwarz web site.

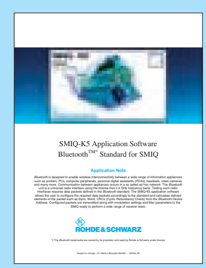
Summary

SMIQ-K5 is a highly versatile tool for the generation of test signals with the Signal Generator SMIQ in conformance with the *Bluetooth* standard. The SMIQ with Application Software SMIQ-K5 is an optimal RF signal source for carrying out *Bluetooth* receiver tests or BER measurements on *Bluetooth* modules. In addition, the SMIQ can be used as an RF signal reference in transmitter measurements [6, 7] performed by means of a spectrum analyzer.

The capability of storing test sequences and configuration setups in the SMIQ allow the subsequent use of the generator as a stand-alone unit in production and R&D applications.

Dr Markus Banerjee

Application Note on SMIQ-K5 and data sheet on SMIQ at www.rohde-schwarz.com (search word: SMIQ-K5)



Application Note 1GP48

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[3] Generating *Bluetooth* RF Test Signals with Signal Generator SMIQ. Application Note 1MA31 from Rohde&Schwarz

[4] Test tip: Generating *Bluetooth*™ RF test signals quickly and easily. News from Rohde&Schwarz (2001) No. 171, pp 50–51

[5] Generating *Bluetooth* signals with SMIQ and Application Software SMIQ-K5. Application Note 1GP48 from Rohde&Schwarz

[6] Transmitter measurements on *Bluetooth* modules. Application Note 1MA26 from Rohde&Schwarz

[7] Transmitter measurements on *Bluetooth* modules with FSP. Application Note 1MA33 from Rohde&Schwarz.

Universal Radio Communication Tester CMU200

Multislot measurements on HSCSD and GPRS mobile phones

There is an increasing trend in mobile radio towards fast data transmission. Mobile Internet access, in particular, opens up new applications for network operators. Here, too, the CMU200 offers full test functionality for HSCSD and GPRS mobiles in development and production.

Photo 43238/16N

Testing HSCSD and GPRS links in mobile phone production

In voice communication tests it is obvious: the microphone, loudspeaker and the RF are the mobile's interfaces, and these are tested in production. This is different in the case of data links like HSCSD and GPRS (see box on page 17). The voice communication standards are not appropriate for carrying out production tests on data-transmitting mobiles, so the standardization bodies have defined special test modes. Because in data transmission, the mobile is just a link in a long chain (PC – mobile – Internet – server).

Analogously to the loops known from bit-error-rate measurements, multislot loops were defined for HSCSD. Via these loops, the mobile is informed of the downlink timeslots in which data should be received, and of the uplink timeslots in which data should be returned. This allows bit-error-rate measurements to be performed in configurations with more downlinks than uplinks.

The situation is somewhat more complicated with GPRS. Unlike HSCSD with constant data transmission during which transmitter and receiver measurements can be performed, transmission in GPRS is activated only if there is actually something to transmit. To enable GPRS measurements, the standardization bodies have specified two link modes, i.e. GPRS test mode A and GPRS test mode B. In test mode A, the mobile constantly transmits a temporary block flow (TBF) that carries user data in the form of pseudo-random bit sequences. In test mode B, the TBF received in the downlink is returned in the uplink. In test mode B, too, the uplink slots can be defined in which downlink data should be returned. The two test modes allow transmitter and receiver measurements to be carried out, since the mobile is continuously transmitting and receiving, same as in circuit-switched links.

BLER measurements – problematic in production

The BLER (block error rate) measurement is the relevant receiver measurement in conformance tests on GPRS mobiles. With GPRS, retransmission is requested for such data blocks (RLC blocks) that are not received error-free by the mobile. The BLER is the ratio of received errored blocks (for which retransmission is requested) to the total number of data blocks transmitted. In production, BLER measurements have two major disadvantages, however. Firstly, they do not furnish information that is statistically conclusive. There is only the result OK or not OK for each data block, but no information on the number of errored bits in a data block. It is precisely this parameter, however, that provides information on the physical quality of a receiver.

See page 18 ff for audio measurements on mobile phones with the CMU200.

This can be demonstrated by a numerical example. With coding scheme CS-4, 400 information bits are transmitted in a data block. To yield the same conclusive statistical information as a BER measurement, the BLER measurement would have to be at least 400 times as long as the BER measurement.

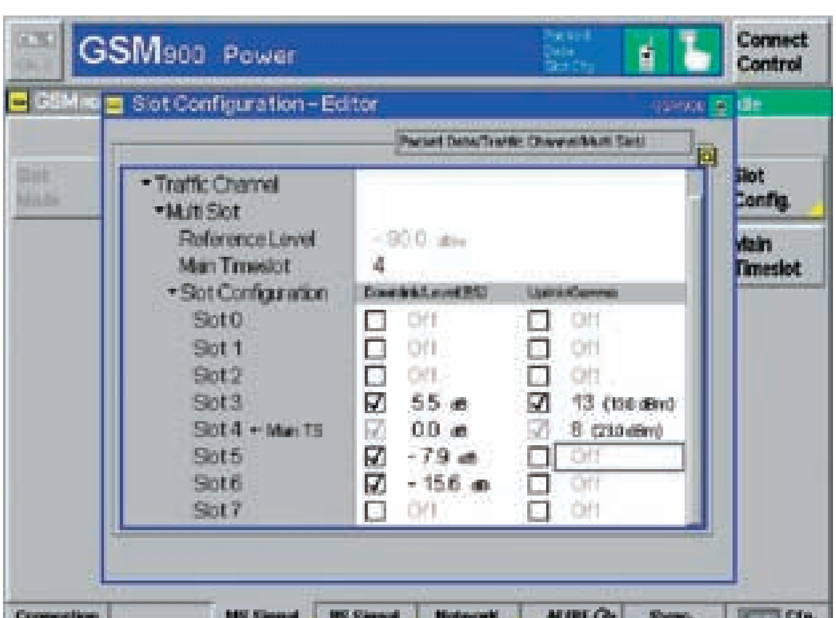
The second disadvantage of BLER measurements in production is that they may stagnate for procedure-inherent reasons, so prolonging measurement time indefinitely. It is even possible that a measurement stops completely.

Notwithstanding this, BLER measurements offer advantages too. For example, data blocks are transmitted distributed over all downlink timeslots, and the mobile can deliver an OK/NOT OK statement simultaneously for all timeslots even if it supports only one uplink timeslot. However, taking into account the poor statistical information obtained with the BLER method, it is obvious that performing several single BER measurements in test mode B will lead to satisfactory results considerably faster. To sum up, it can be said that BLER measurements are unsuitable for production with its requirement for extremely short measurement times.

HSCSD and GPRS measurements with the CMU 200

The CMU 200 allows any desired slot configurations to be set for HSCSD and GPRS. The active uplink and downlink timeslots can be defined conveniently in a selection box (FIG 1). Whether the selected slot configuration will actually be activated depends on the multislot class of the mobile under test. It is advantageous that the CMU 200 transmit level can be set separately for each timeslot. Worst-case scenarios for the mobile's receiver can thus be created very easily. The mobile transmit level too can be defined separately for each active uplink timeslot.

FIG 1 The CMU 200 makes it very easy to define an uplink and downlink configuration. The downlink level (transmit level of the CMU 200) and the uplink level (transmit level of the mobile) can be selected separately for each timeslot.



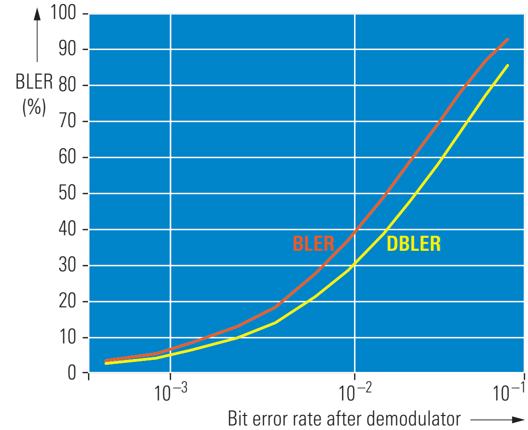


FIG 2 Relationship between BLER and DBLER measurement with coding scheme CS-1. In the case of CS-2, CS-3 and CS-4, the difference is even considerably smaller.

When setting up a HSCSD call, the CMU 200 closes the multislot loop on the mobile, so enabling all transmitter and receiver measurements to be carried out.

With GPRS, the CMU 200 automatically performs the attach, routing area update and detach, and displays the status in each case. The mobile under test can then be switched to GPRS test mode A or B at a keystroke. In test mode A, all transmitter measurements can be performed, and in test mode B all receiver measurements (BER/DBLER). The CMU 200 supports all GPRS coding schemes (CS-1 to CS-4).

Apart from switching to a GPRS test mode, the CMU 200 can perform measurements also without signalling. This is enabled simply by sending a TBF. The mobile can synchronize in time via the BCCH channel and then change immediately to the TBF. Mobile manufacturers supporting this mode benefit from the shorter production test time which is reduced by the signalling period.

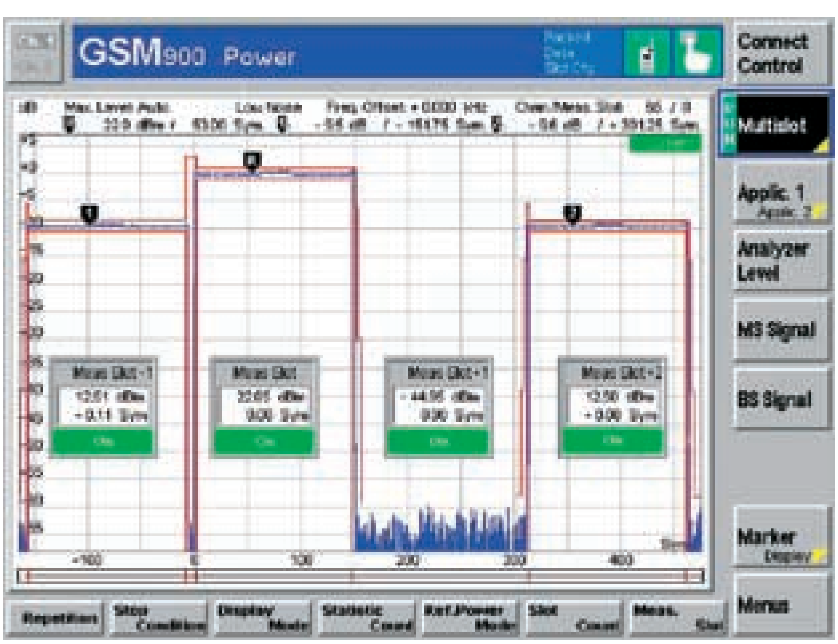
BER/DBLER measurements

In GPRS test mode B, the CMU 200 also performs BER measurements, and in addition determines the DBLER (data BLER). With DBLER, only the data bits proper are analyzed, whereas with BLER the block headers and the USF flag are analyzed as well. The two measurements do not differ appreciably (FIG 2), even though DBLER does not consider all bits that may lead to a block error. The advantage of DBLER over BLER is that it does not come to a halt.

Multislot power ramp measurements

Measurements to HSCSD or GPRS standards are characterized by transmission and reception taking place in several timeslots simultaneously. This is of interest in power ramp measurements. The specified power time template varies depending on whether the preceding or following timeslot is active or not. In the transition region between two active timeslots, the power may be max. 3 dB higher than in the useful part of the timeslot with the higher power. The time position of the templates, too, may vary from timeslot to timeslot depending on the GSM method used by the mobile. The user need not bother about any of this since it is all handled by the CMU 200. The instrument represents four timeslots in a single display, and automatically determines the correct position of the templates along the X and the Y axis for each timeslot (FIG 3). The CMU 200 further determines the correct template in the transition region between two active timeslots. Plus, the instrument detects the modulation mode used (GMSK or 8PSK) and automatically selects the right power time template.

FIG 3 In multislot power ramp measurements, up to four timeslots can be displayed simultaneously. The number of timeslots shown is selectable, and the user can zoom in as desired in the X or Y direction. The power time templates are automatically adapted to the signal received, so that the user need not bother about selecting the right templates.



Summary

The CMU 200 shows its strengths also with HSCSD and GPRS data communication. The user benefits from convenient measurements and can create test scenarios of his own. This makes the CMU 200 the prime choice for these standards not only in production but also in RF development.

Rudolf Schindlmeier

HSCSD and GPRS

HSCSD (high-speed circuit-switched data) relies on the same technique as normal GSM voice transmission. Instead of voice information, data contents are transmitted. Data is sent in several timeslots, which means that several parallel data links exist for each mobile. HSCSD offers the advantage of constant data rate thanks to the fixed assignment of timeslots. Assigned transmission resources have to be paid for however, whether data is transmitted or not.

GPRS (general packet radio service) uses the same technique as the Internet. Data is transmitted in the form of packets on variable channels, i.e. the transmission rate decreases as available transmission resources become scarcer. With GPRS, too, several timeslots are used simultaneously for communication between the mobile and the base station. The advantage with GPRS is that transmission resources are assigned only if data is to be sent, so that a subscriber pays only for the data volume actually transmitted.

Universal Radio Communication Tester CMU 200

Audio measurements on mobile phones

Audio measurements on mobile phones are highly important because voice transmission quality is a significant factor in the users' satisfaction with the day-to-day use of their mobiles. Moreover, an increasing number of mobile phones are fitted with additional audio components such as FM stereo radios, MP3 players or voice recorders. Using the CMU-B41 audio option, the Universal Radio Communication Tester CMU 200 performs virtually all audio measurements on mobile phones quickly and precisely.

Voice codec for GSM and TDMA

The audio quality of digital mobile phones is mainly determined by the voice codec and the analog components such as microphone, loudspeaker and amplifier.

In digital mobile radio, voice transmission is, of course, digital. This means that a mobile phone has to convert the audio signals picked up by the microphone into digital signals before transmitting them to the base station. In the opposite direction, the mobile phone converts the digitally coded audio signal back into an analog signal for output via the loudspeaker. The voice codec converts analog into digital signals and vice versa. To carry out measurements on the voice codec, the tester must be also fitted with a voice codec to convert analog test signals to digital. To perform these measurements, the CMU 200 can be equipped with various voice codecs, for instance with the CMU-B52 option for GSM and TDMA.

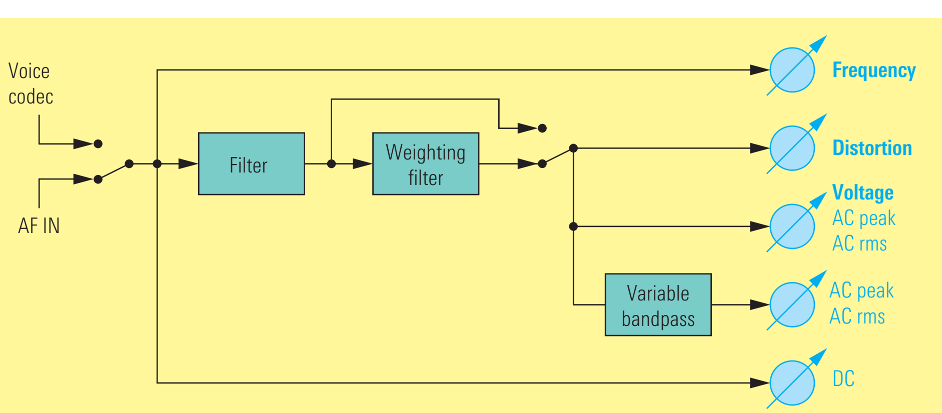


FIG 1 Block diagram of an analyzer channel of the CMU-B41 audio option

Wide variety of test options with the CMU-B41 audio option

A two-channel audio analyzer and audio generator in the CMU-B41 option allow the evaluation of analog audio components. The two audio analyzer channels can be fitted with different filters, independently of each other. The block diagram of an individual channel illustrates the wide variety of test functions (FIG 1). All bandwidths relevant for audio measurements can be set via the input filter.

An optional weighting filter ensures the perceptive measurement of audio signals, with the weighting made either by a C message or CCITT filter. This measurement path enables parallel measurement of the rms and peak voltage values of the AC component and the distortion of the audio signal. The frequency to be used by the distortion meter is user-selectable between 20 Hz and 20 kHz.

Moreover, this measurement path contains a further test point with variable bandpass, the center frequency of which can be set between 20 Hz and 20 kHz, and its bandwidth between 10 Hz and 1 kHz. This additional test point provides the rms and peak voltage values of the signal filtered by the bandpass, parallel to the values mentioned above. Furthermore, each of the two audio analyzer channels is fitted with a frequency counter up to 200 kHz and a voltmeter to determine the DC voltage component. Both audio generators can be set independently of each other in the frequency range 20 Hz to 20 kHz and in the level range 10 µV to 5 V.

Multitone audio analysis

Besides these basic measurements, the CMU-B41 audio option generates and analyzes multitone audio signals. In the multitone audio measurement, the CMU 200 creates up to 20 sinewave signals simultaneously with user-definable frequencies and levels. At the same time, the tester analyzes an audio signal applied with up to 20 narrowband filters, whose center frequencies comply with the frequencies produced by the generator.

For fast and easy determination of the frequency response, the generator output should be connected to the input, and the analyzer to the output of the DUT. The CMU 200 compares the measured values to the user-specified tolerance limits and marks out-of-tolerance values (FIG 2). The tolerance limit is user-definable for each individual test frequency.

The new test functions of the CMU 200 are rounded off by a facility for adapting audio signals not only externally via audio connectors, but also by connecting generator and analyzer directly to the voice codec within the tester.

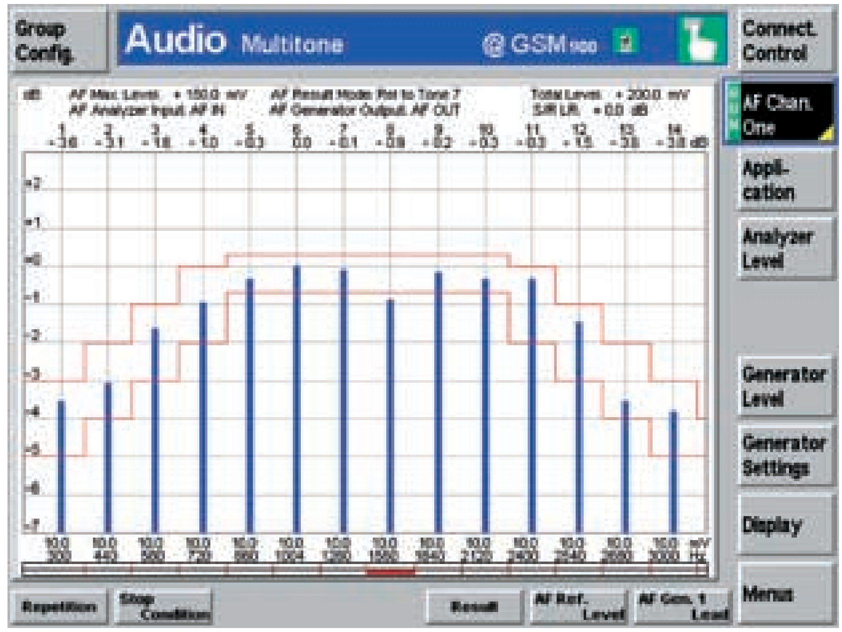


FIG 2 The multitone audio measurement allows very fast measurement of the audio frequency response with up to 20 user-definable frequencies. Values exceeding the user-specified tolerance limits are marked in red at the bottom of the screen.

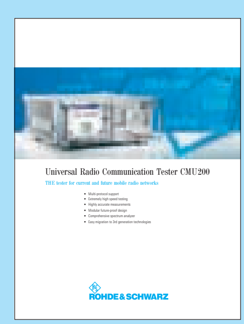
A glance at the specifications of the CMU-B41 audio option (see box below) shows that, with the CMU-B41, the CMU 200 performs not only extensive, but also high-end audio measurements which optimally meet the requirements of the mobile radio market as regards quality, measurement range and speed, and combine short test times with high-quality measurement results in mobile phone production.

Rudolf Schindlmeier

Specifications Audio Option CMU-B41

Generator	
Frequency range / resolution	20 Hz to 20 kHz / 0.1 Hz
Level range / resolution	10 µV to 5 V / 0.1% for levels ≥ 10 mV
Level error	≤ 1.5% (for levels ≥ 1 mV and frequencies ≤ 10 kHz)
Distortion	≤ 0.05% (for levels ≥ 100 mV and 600 Ω load, measurement bandwidth 21.9 kHz)
Voltmeter	
Frequency range	50 Hz to 20 kHz
Level range / resolution	50 µV to 30 V / 0.1% for levels ≥ 1 mV
Level error	≤ 1.0% + resolution at 1 mV ≤ level ≤ 2 V
Distortion meter	
Measurement bandwidth	21 kHz
Frequency range	100 Hz to 10 kHz
Level range	10 mV to 30 V
Resolution	0.01% distortion
Frequency counter	
Frequency range	10 Hz to 200 kHz

More information and data sheets at www.rohde-schwarz.com (search word: CMU 200)



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Rohde & Schwarz is constantly adapting the Universal Radio Communication Tester CMU 200 to technical developments. Since its first presentation in News from Rohde & Schwarz No. 165 (1999), the test options and innovations surrounding this state-of-the-art radio tester have featured in almost all editions.

Spectrum Analyzer FSP

FSP goes outback – tough test in Australia

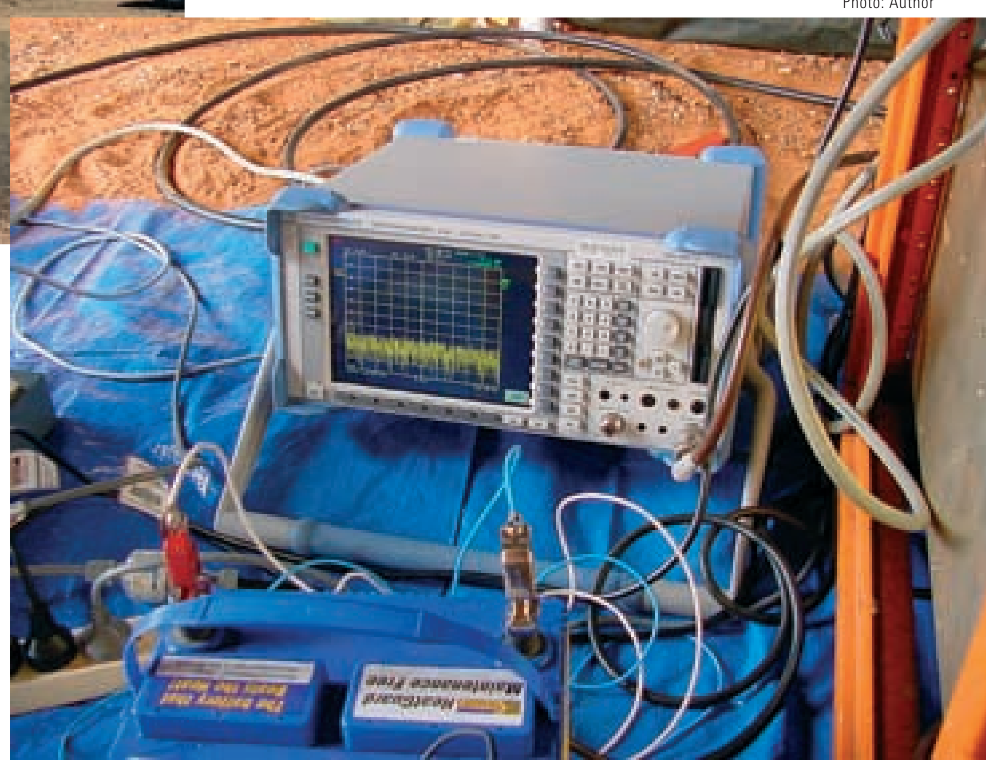
The global positioning system (GPS) provides precise navigation data and time information throughout the world. Unfortunately, however, the system is susceptible to electromagnetic interference. In large-scale trials recently carried out in the Australian outback, members of the US and Australian armed forces examined ways of locating sources of such interference in order to take counter-measures.

The global positioning system (GPS) is used in a very wide variety of applications, including air, sea, and land navigation, and intelligent transport systems, as well as in telephone or electrical power grid synchronization. However, GPS is highly susceptible to electromagnetic interference. GPS receivers can be rendered ineffective with simple, inexpensive pocket-size jammers, or by signals from TV antennas, radar, and communications towers, and this can seriously impair their functionality both in civil and military applications. It is therefore essential to find techniques to counteract intentional and unintentional GPS interference.

Photo: Author

Heat, sand, dust and rough terrain: a tough test, which the Spectrum Analyzer FSP passed with flying colours

Photo: Author



More than 30 US and Australian military and civilian personnel were involved in the GPS Jammer Locator (JLOC) trials in Woomera, South Australia, in March 2001. The trials were a joint demonstration between the United States Air Force Operational Test and Evaluation Center (AFOTEC), Australia's Aircraft Research and Development Unit (ARDU), the Defence Science and Technology Organisation (DSTO), and Air Services Australia (ASA).

The JLOC system, under development through a US Air Force Research Laboratory (AFRL) contract to the American company NAVSYS, is designed to locate GPS jamming or interference sources and provide data to assist tactical or strategic planners in minimizing the influence of such interference sources. At Woomera, the JLOC system was used to locate ground-based GPS interferers provided by the DSTO from a combination of ground and airborne platforms.

The trials demonstrated that GPS interferers can be located and identified, and interference prevented, thus making for more reliable and effective deployment of the GPS navigation system.

Thanks to its outstanding features, the Spectrum Analyzer FSP from Rohde & Schwarz played a key role in the trials. The compact dimensions of the FSP, its low weight, rugged design, high input sensitivity and ability to process data without an additional PC made it ideally suited to the tough conditions at the test site. As the DSTO's Chris Pitcher put it: "Environmental conditions in Woomera are testing for any instrumentation, with a combination of heat, dust and difficult terrain; the FSP took it all in its stride."

It is practically impossible to mount trials on this scale in the USA. Due to the effects on GPS-dependent civil infrastructures, there is simply no empty area large enough to support such an exercise.

At Woomera, however, there are virtually no GPS users within a 450 km radius. Moreover, the weather is clear, support facilities are good, and there is also an airfield, allowing several aircraft the freedom to fly around the Woomera region locating multiple interferers on the ground.

Some of the material in this article was provided by the Defence Science and Technology Organisation (DSTO) in Salisbury, South Australia, with additional contributions by the author.

Martin Scholla, Rohde & Schwarz Australia

The main characteristics of the FSP

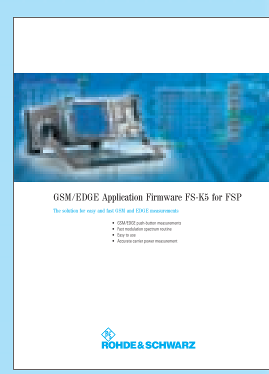
- Resolution bandwidths from 1 Hz to 10 MHz
- Highly selective digital filters and FFT
- Quasi-peak detector and EMI bandwidths
- Interfaces: GPIB, Centronics, RS-232, LAN (optional)
- Automatic measurement routines for determining IP3, OBW, phase noise, ACP(R)
- Split screen with independent settings and up to three measurement traces per screen
- Editable limit lines including PASS/FAIL display
- Fast time domain measurement: minimum sweep time 1 μs
- Gated sweep for measurements on TDMA signals

Additionally, the FSP comes standard with:

- An RMS detector for quick and reproducible power measurement on digitally modulated signals in the frequency and time domain
- A statistical measurement function for determining the crest factor and CCDF (complementary cumulative distribution function)

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

Data sheet FSP



Data sheet TV Trigger / RF Power Trigger for the FSP

Microwave Signal Generator SMR

Ideal calibration source for weather radar receivers

Calibrated weather radar equipment is indispensable for precisely determining the precipitation probability, as well as the density of rain, snow or fog. The calibration method necessary for these applications requires a signal generator with a highly accurate output level. Thanks to its carefully thought-out design with firmware-supported level correction, the Microwave Signal Generator SMR (FIG 1) is the ideal signal source for this task.

Photo 43 264/3

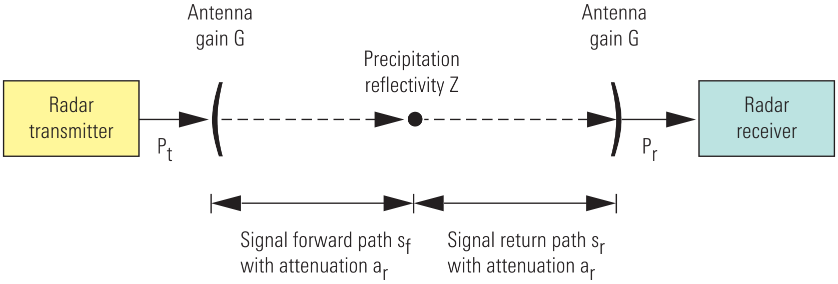
FIG 1 The Microwave Signal Generators SMR [*] are sought-after signal sources in research, development and production as well as in EMC measurements

What has radar to do with the weather?

Meteorologists use weather radar equipment primarily to analyze the dynamic structure of individual clouds or cloud systems, and for exhaustive, continuous precipitation measurement. An important parameter for exact weather forecasts is the precipitation intensity or rate of rain, which indicates the amount of rainwater that falls per time and square measure unit. Weather radar enables the precipitation activities to be monitored with high temporal and spatial resolution. Although radar equipment cannot measure precipitation intensity, it can directly measure reflectivity. Reflectivity is a unit for the backscattering cross section of targets, which can be monitored by means of radar equipment. It is proportional to the energy which is backscattered from all scattering particles in the radar beam to the antenna. The greater the number and size of raindrops in the air, the higher the reflectivity.

As FIG 2 shows, the quantitative determination of reflectivity is basically a two-port measurement with the radar transmitter as the signal source and the receiver as the selective power meter. The magnitude of the transmission factor of the transmission path from transmitter output to receiver input can be calculated from the known transmitted power P_t and the measured received power P_r. In addition to the antenna gain and the attenuation factor of the signal path from the antenna to the radar target, this transmission factor includes

FIG 2 Situation to determine the reflectivity Z



the target reflectivity to be determined. Since the antenna gain and the transmission loss are known, the reflectivity can be calculated. Antenna gain and transmission loss must be counted twice, because the radar signal passes through the antenna and the transmission path both on its way back and forth.

Radar transmitters usually generate sufficiently accurate output power to determine reflectivity according to the above method. With the receivers, this is more difficult. Their level change monitoring is usually highly accurate, but they are characteristically too inaccurate for absolute level measurements. However, since the behaviour of high-end receivers is in all other respects stable, accuracy can be increased by calibrating them with a Microwave Signal Generator SMR (with optional attenuator), which provides a precise output level.

How to calibrate

The radar signal received usually passes from the antenna directly to the receiver input via a circulator, which decouples transmitter and receiver. This connection is separated, and a directional coupler looped in. The SMR output signal thus reaches the receiver input virtually without interaction. The receiver sensitivity is only imperceptibly decreased due to the small transmission loss of the directional coupler. Of course, the transmission loss must be known so that it can be taken into account when the level of the signal generator is set, and the same applies to the total attenuation from the output of the signal generator to the receiver input. This calls for exact measurement.

A 16 dB coupler is recommended for looping-in. A 3 dB attenuator should be inserted between the coupling port of the directional coupler and the RF output of the SMR. In conjunction with the lines required, a total attenuation of almost exactly 20 dB is attained from the SMR RF output to the input of the radar receiver. If the RF level of the SMR is then varied from +10 dBm to –90 dBm, the range of –10 dBm to –110 dBm is covered, which is optimal for most radar receivers. As FIG 4 shows, the SMR has an accuracy of typically <0.45 dB (measured at 5620 MHz and room temperature, measurement accuracy 0.2 dB) for these levels.

If the directional coupler and attenuator have been correctly built in and measured, a receiver calibration can be performed. This is done as follows:

- Switch off transmitter of weather radar equipment
- Set the SMR to the frequency required (e.g. to 5620 MHz)
- Set sufficiently high SMR level (e.g. –10 dBm)
- The level value determined by the receiver is read via the control unit of the weather radar, which calculates a correction value for the receiver from this value and stores it
- Set sufficiently low level at the SMR (e.g. –70 dBm). The radar control unit again calculates a correction value and stores it
- Switch off the SMR. The radar equipment is again ready for regular operation

Since the receivers typically exhibit good relative level accuracy, the twoport calibration described is completely sufficient. Otherwise, it is advisable to use further calibration ports. Due to the high level accuracy of the SMR, even the lower sensitivity limits of the receiver (–110 dBm, for instance) can be reached. If the control unit of the weather radar does not support monitoring and storing of correction values for the receiver, an external PC with an appropriate program is necessary. The calibration intervals depend on the receiver's stability; they are usually monthly.

Wilhelm Kraemer

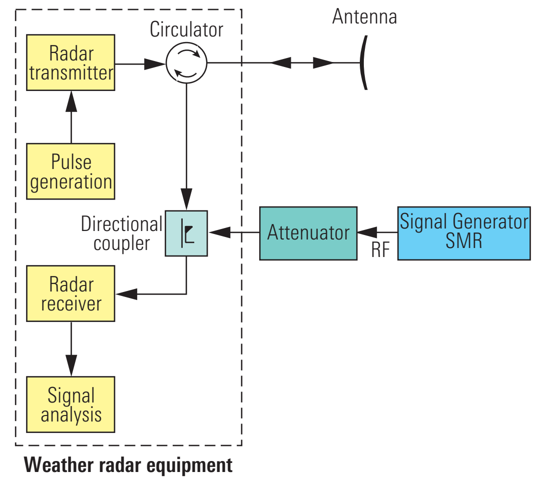


FIG 3 Calibrating the weather radar receiver

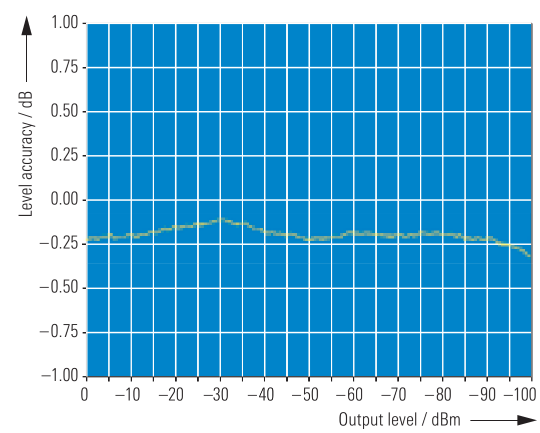
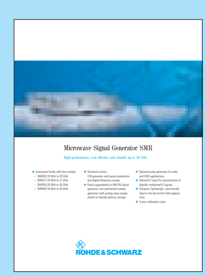


FIG 4 SMR level accuracy at 5620 MHz

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



Data sheet SMR

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[*] Microwave Signal Generators SMR: Microwave in handy size. News from Rohde & Schwarz (1999) No. 162, pp 4–6

Vector Signal Generator SMV 03

Allrounder with excellent vector modulator

Photo 43 792/1

FIG 1 The Vector Signal Generator SMV 03 is the allrounder among the economy generators from Rohde & Schwarz

With the addition of the SMV 03 (FIG 1), which comprises a vector modulator with analog I/Q inputs for the frequency range from 9 kHz to 3.3 GHz, Rohde & Schwarz has extended its range of successful economy Signal Generators SML [1]. The RF modulation bandwidth of 100 MHz makes the new generator the ideal choice for all applications involving high data rates.

The allrounder

The SMV 03 is the allrounder among the economy signal generators from Rohde & Schwarz. Excellent RF characteristics with versatile vector and analog modulation modes, short frequency and level setting times, an amazingly attractive price and, last but not least, compact dimensions and low weight make the SMV 03 the ideal generator for production, service and laboratory applications.

RF characteristics

Thanks to its wide frequency range from 9 kHz to 3.3 GHz, the SMV 03 covers all important frequency bands for communication, WLAN and ISM applications* as well as for EMC measurements. The frequency synthesis is based on a tried-and-tested DDS concept, which allows crystal-controlled frequency settings with a resolution of 0.1 Hz. With the SML-B1 option (OCXO reference oscillator), frequency accuracy fulfills even the most exacting requirements. The synthesis concept also makes for the excellent SSB phase noise of typically –128 dBc (at 1 GHz, carrier offset 20 kHz, 1 Hz measurement bandwidth), short frequency setting times (typ. 7 ms) and high spurious suppression (typ. –70 dBc up to 1.1 GHz).

* ISM applications: industrial, scientific and medical high-frequency applications

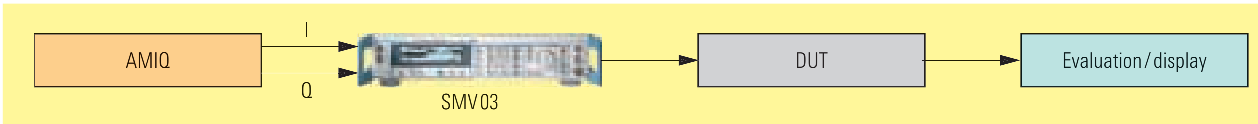

FIG 2 Signal Generator SMV 03 in conjunction with the I/Q Modulation Generator AMIQ: component test application example

The RF level, too, meets all requirements. Using a wear-free electronic attenuator, which has a setting time of typically 5 ms, the RF level can be varied in 0.1 dB steps between –140 dBm and +13 dBm (+11 dBm below 5 MHz). In the overrange, even +19 dBm are available. All in all, the RF characteristics correspond to those of the proven Signal Generator SML 03 [2] with analog modulation capability.

Vector modulation

The vector modulator of the SMV 03 owes its excellent characteristics to a patented integrated circuit developed by Rohde & Schwarz. The analog I and Q inputs can be controlled by any external I/Q signal sources, in particular by the I/Q Modulation Generator AMIQ [3] (FIG 2). The AMIQ and its WinIQSIM software make it exceptionally easy to generate all possible digitally modulated I/Q signals.

The RF modulation bandwidth of the SMV 03 is typically 100 MHz for RF frequencies from 500 MHz to 3 GHz (FIG 3) – a value previously reserved for high-end generators. High data rates, such as those in WLAN applications, are therefore no problem. The modulation bandwidth of the SMV 03 is more than adequate for measuring components for WCDMA applications. FIG 4 shows the output spectrum of the SMV 03 at 2.14 GHz, i.e. the center frequency of the 3GPP downlink band 2.11 GHz to 2.17 GHz. With an offset of 5 MHz, the typical ACP value of the generator is –62 dBc. In this case, the SMV 03 was modulated using an AMIQ, test model 1 (64DPCH, crest factor 10.7 dB).

Analog modulation modes

In addition to vector modulation, the SMV 03 features all classic modulation modes, which are available in the SML family as standard. The SMV 03 can consequently generate amplitude-, frequency- and phase-modulated RF signals, and also (with the SML-B3 option) pulse-modulated RF signals; the generator can thus perform all classic receiver measurements. The FM modulator is also suitable for externally fed stereo multiplex signals. The SMV 03 contains an AF generator with a frequency range from 0.1 Hz to 1 MHz to generate sinewave modulation signals. If the optional pulse modulator has been built-in, the associated pulse generator is also available. AM, FM / φM and pulse modulation can be performed simultaneously. The same applies to vector modulation, FM / φM and pulse modulation.

As with the RF data, the analog modulation characteristics of the SMV 03 correspond to those of the SML 03.

Low cost of ownership

Not only its versatility and attractive price, but also the low follow-on costs make the SMV 03 a highly attractive investment. These low costs are ensured

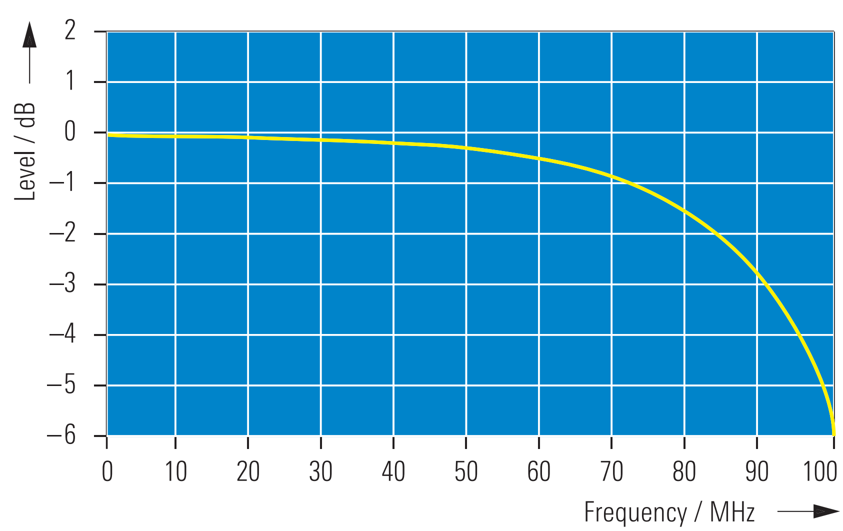

FIG 3 Typical I/Q modulation frequency response of the SMV 03 at 1 GHz

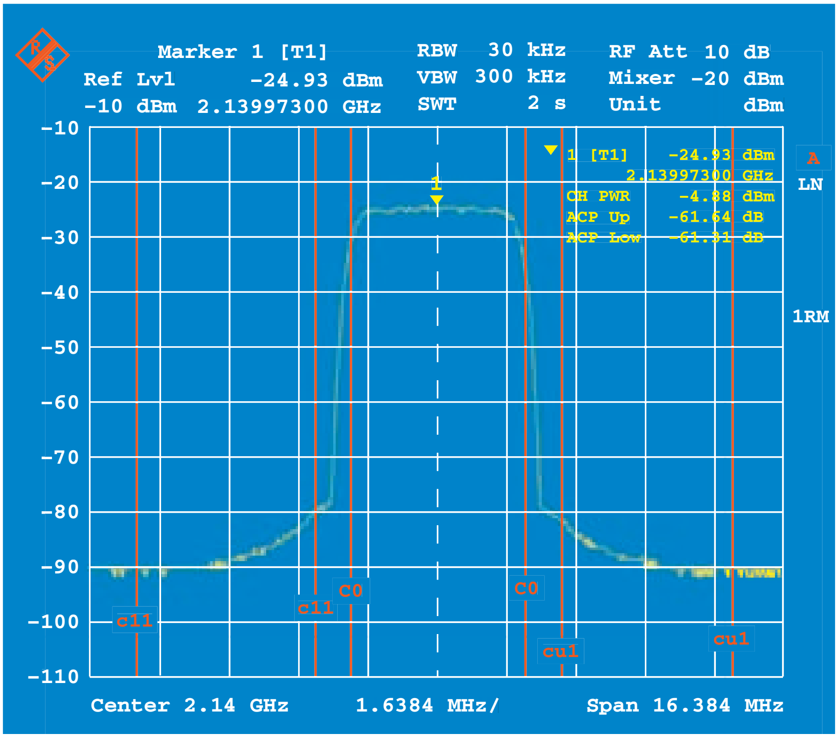

FIG 4 Typical WCDMA output signal at 2.14 GHz (test model 1, 64DPCH, crest factor 10.7 dB)

by the signal generator's high reliability, its short repair times in the event of a failure (thanks to built-in diagnostics), and, last but not least, the calibration cycle of three years.

Wilhelm Kraemer

Condensed data of the Signal Generator SMV03

Frequency range	9 kHz to 3.3 GHz
Resolution	0.1 Hz
Setting time	<10 ms
Harmonics	<–30 dBc
Subharmoniscs	none (f ≤ 1.1 GHz)
	<–50 dBc (f > 1.1 GHz)
Spurious	<–70 dBc (f ≤ 1.1 GHz)
	<–64 dBc (>1.1 GHz to 2.2 GHz)
	<–58 dBc (f > 2.2 GHz)
SSB phase noise	<–122 dBc (f = 1 GHz, 20 Hz carrier offset, 1 Hz bandwidth)
Level	–140 dBm to +13 dBm (>5 MHz to 3 GHz)
	–140 dBm to +11 dBm (f ≤ 5 MHz , f > 3 GHz)
Resolution	0.1 dB
Vector modulation	
Static error vector	< 0.5% (rms value), < 1% (peak value)
I/Q bandwidth (3 dB)	DC to 30 MHz (f ≤ 500 MHz , f > 3 GHz)
	DC to 50 MHz (>500 MHz to 3 GHz)
Residual carrier	<–45 dBc
AM (3 dB bandwidth)	0 to 100% (DC to 50 kHz)
FM (3 dB bandwidth)	deviation up to 4 MHz (DC to 500 kHz)
φM (3 dB bandwidth)	deviation up to 40 rad (DC to 100 kHz)
	deviation up to 8 rad (DC to 500 kHz)
Pulse modulation (option SML-B3)	
On/off ratio	> 80 dB
Rise/fall time	< 20 ns
AF generator	0.1 Hz to 1 MHz
Pulse generator (option SML-B3)	
Pulse period	100 ns to 85 s

More information at www.rohde-schwarz.com (search word: SMV 03)

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[2] Signal Generators SML 02/03 – Economy class extended to 3.3 GHz. News from Rohde & Schwarz (2000) No. 169, pp 18–20

[3] I/Q Modulation Generator AMIQ: Convenient generation of complex I/Q signals. News from Rohde & Schwarz (1998) No. 159, pp 10–12

EMC Measurement Software EMC 32

Comprehensive EMI and EMS measurements at a keystroke

Photo 43 632/2

The EMC Measurement Software EMC 32 combines electromagnetic interference (EMI) and electromagnetic susceptibility (EMS) measurements under an intuitive user interface, and is provided with an open interface for further processing and archiving of the measurement results.

For use in development, compliance and batch testing

The powerful EMC Measurement Software EMC 32 running on 32-bit Windows® operating systems has been designed for controlling and monitoring Rohde & Schwarz EMC test systems, as well as for convenient recording and processing of the measurement results.

Thanks to its flexible configurability, the EMC 32 software can easily be adapted to the (civil) test specifications for many product groups, e. g. consumer goods, mobile radio, automotive products or ISM instruments*. The EMC 32 software fulfills all measurement requirements for:

- **Tests during development**
  EMC 32 is ideally suited for measurements in development since a frequency scan can be carried out automatically or interrupted at any time to switch to the interactive measurement mode. In the interactive mode, the equipment under test (EUT) can be checked in detail at the critical frequencies previously determined during the automatic scan.
- **Compliance tests**
  Measurements can be standardized with the aid of predefined test templates and by using the automatic EUT monitoring option for EMS measurements.
- **Batch tests**
  The measurements results of several tests can be combined in a graphical display, allowing equipment from the same batch to be compared with one another.

* ISM instruments: industrial, scientific and medical RF instruments.

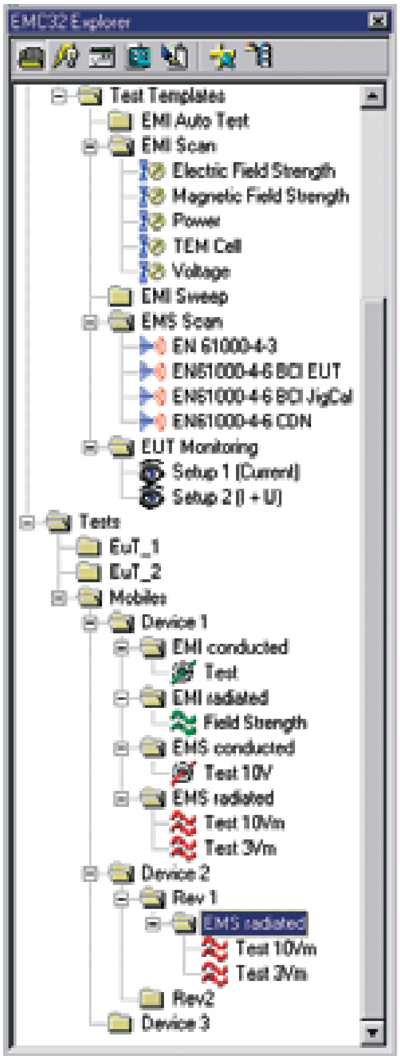


FIG 1 EMC32 stores all measurements in an EUT-specific directory

Clearly structured measurement results

Archiving and further processing of the measurement results is extremely convenient with the EMC32 software: all results and the associated settings for testing an EUT are stored in an EUT-specific directory similar to the Windows® Explorer (FIG 1). This ensures that all the necessary settings are documented and tests are thus reproducible at any time, and that stored tests can be repeated on a mouse click.

Convenient, intuitive operation

The intuitive operating concept of EMC32 enables users to quickly familiarize themselves and makes for great ease of operation: self-explanatory icons, clear dialogs and context-sensitive menus accessible via the right mouse key provide a clear structure.

The results are graphically displayed in the center of the main window (FIG 2). The control elements are arranged around this display, for example the test component explorer, which allows fast access to the measurement results in tabular form and to the settings. Further elements are provided for controlling the test run, the receiver for EMI measurements or the interference parameter for EMS measurements, as well as for controlling the accessories (turntable, antenna, LISN).

Open interface for measurement results

The report editor in the EMC32 software helps to generate comprehensive reports (FIG 3), which can be output in HTML format for further electronic processing. The measurement results and settings are stored in text format so that they can also be used in other applications.

Simple configuration

EMC32 features extremely simple installation and configuration. Only three steps are required before the first test can be carried out: installing the software, calling up the configuration wizard and starting the new test.

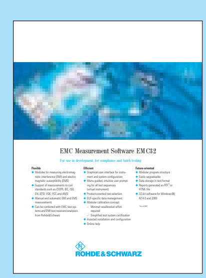
The configuration wizard, a utility program with graphical display, adapts EMC32 to the measurement system in interactive mode with the user. The hardware configuration is graphically displayed for modifications or manual configuration (FIG 4).

EMS measurements

The EMC32 software provides predefined configurations for the EN61000-4-3/6 and ISO11452 standards. The efficient querying of test parameters for the EN61000-4-3 standard, for example, allows reference calibration as well as measurements to be performed with only one template.

For automatic EUT monitoring, it is only necessary to adapt a generic device driver to any IEC/IEEE-bus or RS-232-C measurement devices. An external EUT monitoring system can also be integrated into EMC32 and synchronized to the frequency scan.

More information and data sheet at www.emc32.rohde-schwarz.com



Data sheet EMC32

EMI measurements

In addition to the interactive functions, such as scan, sweep and single measurement with frequency zoom, EMC 32 features numerous evaluation functions for detecting critical points in recorded spectra or for applying correlation algorithms to test cells.

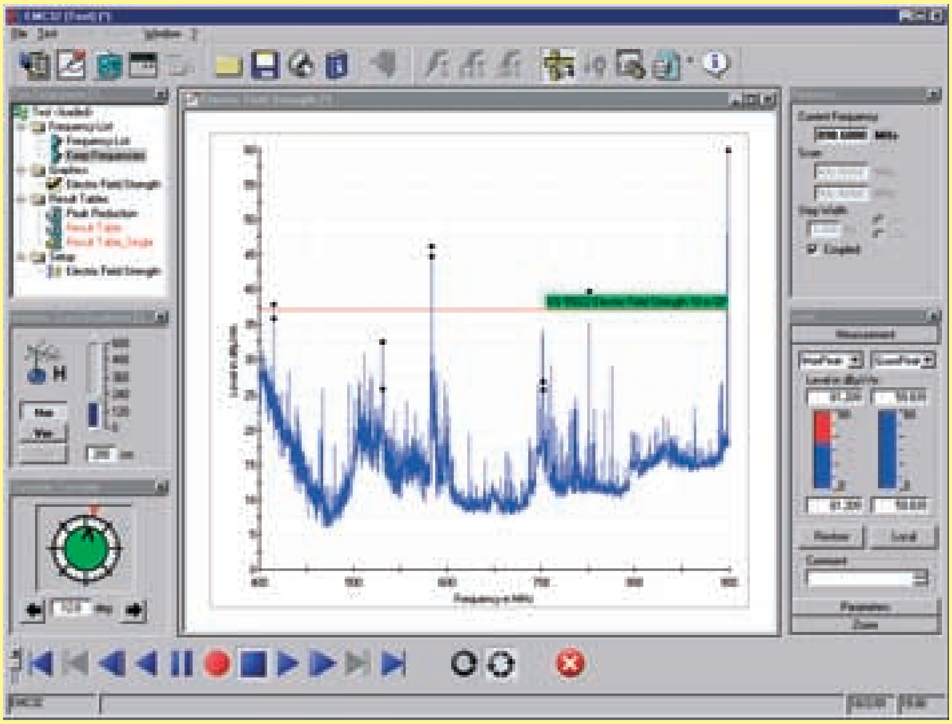
Automated routines are available for measuring the RFI voltage with a line impedance stabilization network or the RFI field strength in test cells. These routines detect and evaluate critical points in the frequency spectrum and summarize the results in a test report.

Versatile modifications

The modular calibration and device driver concept allows easy system upgrading or modification. The system's signal paths can be recalibrated at any time by clicking on the relevant path in the system configuration. Due to the modular calibration concept, for example, it is not necessary to recalibrate the complete system if only the antenna cable has been replaced. Additional instruments can readily be integrated into the configuration via device drivers.

The EMC 32 software is available either as a complete package or as single packages for EMI or EMS measurements. The uniform operating concept ensures that users will be immediately familiar with the new measurement applications when they buy the second package.

Robert Gratzl, Rolf Peterknecht



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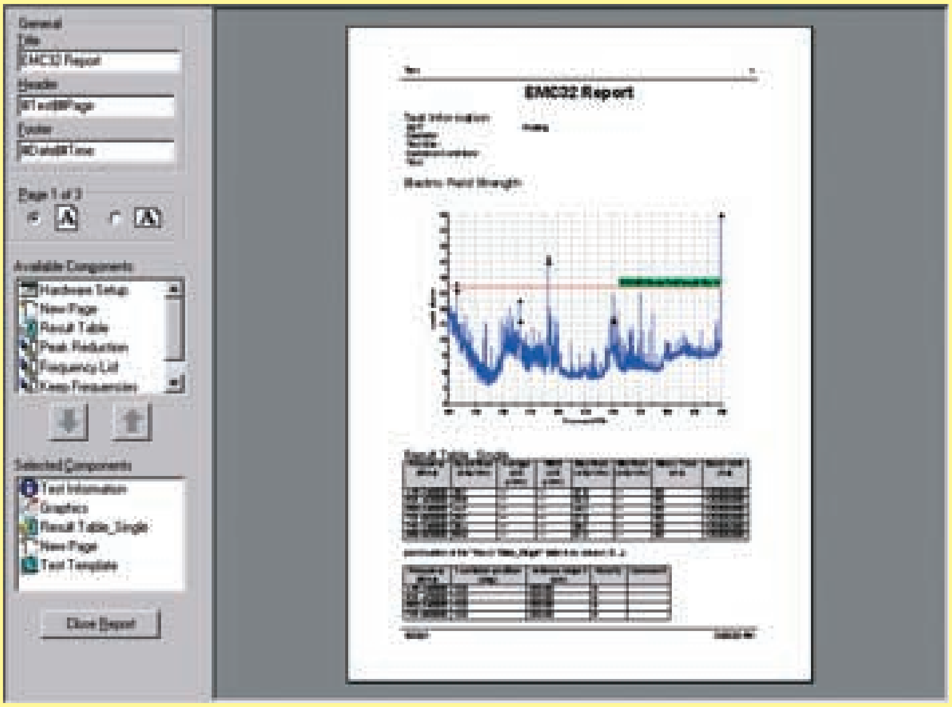

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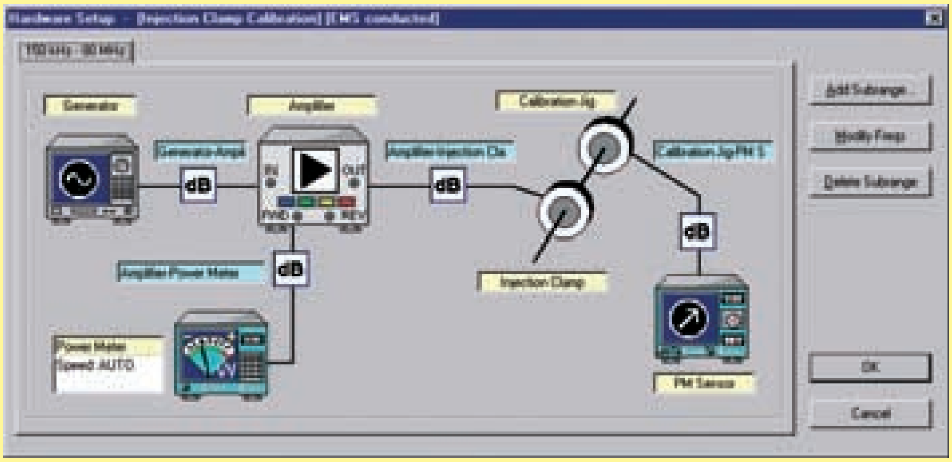

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FIG 2 Main window of EMC 32 during ongoing EMI measurement
FIG 3 Test report editor for EMI measurement
FIG 4 Configuration wizard for EMS test system

TV Test Transmitter SFL

Five specialists in production: test signals for all digital standards

In broadband communication networks and in satellite and terrestrial transmission, the changeover from analog to digital TV transmission is well under way. Receivers and set-top boxes for digital reception are being produced in large quantities for the consumer market. The TV Test Transmitter Family SFL has been developed by Rohde & Schwarz to test these receivers. The SFL test transmitters offer all the features required of modern test transmitters in production: wide frequency range, comprehensive modulation modes, high reliability – and all this at an attractive price.

Photo 43772/1

FIG 1 Fully-fledged DVB-T test transmitter in a compact case (here: DVB-T model SFL-T)

All digital modulation modes

The different SFL models (FIGs 1 and 2) cover all digital modulation modes relevant in broadcasting in the frequency range 5 MHz to 1.1 GHz (model SFL-S up to 3.3 GHz). Where frequency accuracy and spectral purity are concerned, the SFL family is a perfect match for the universal TV Test Transmitter Family SFQ [1, 2, 3] from Rohde & Schwarz. Frequency setting is crystal-controlled with resolution of 0.1 Hz. Excellent SSB phase noise and spurious values are ensured by direct digital frequency synthesis (DDS), which not only makes for outstanding noise characteristics but also short frequency setting times – vital features in production environments.

New approaches were also taken in I/Q modulation. The SFL modulates the carrier directly at its output frequency. This is possible thanks to an integrated circuit developed by Rohde & Schwarz.

In the I/Q modulator, the orthogonal I and Q components of the RF signal are controlled in amplitude and phase by the analog I and Q signals from the coder. The two RF components are added to give an output signal that can be amplitude- and phase-modulated as required.

High demands are placed on the I/Q modulator, particularly with regard to high-order quadrature amplitude and COFDM modulation. The internal calibration of the SFL ensures that the I and Q paths have identical gain, the phase is exactly 90° and maximum carrier suppression is attained.

Versatile input interfaces

The SFL input is capable of handling MPEG transport streams of 188 byte or 204 byte packet length (see block diagram, FIG 3). The SFL ensures a standard-conformant output symbol rate for virtually any input data rate. This is achieved by means of the stuffing functionality of the SPI (synchronous parallel interface) and the ASI (asynchronous serial interface), which allows setting of the output symbol rate independently of the input data rate. A synthesizer generates the exact symbol rate even if no transport stream is present at the input. This enables any desired symbol rates to be generated independently of the input data rate. The following input interfaces are available:

- Synchronous parallel interface (TS parallel or SPI)
- Asynchronous serial interface (ASI) with up to 270 Mbit/s
- Externally clocked asynchronous serial interface (ASI ext. clock)
- Externally clocked parallel interface (SPI ext. clock)
- SMPTE-310 interface for ATSC (optionally with ext. clock)

Instead of an external transport stream, internal data sources can be used, e.g. PRBS sequences for bit-error-rate measurements on receivers.

Processing useful data in line with standards

The I/Q coder of the TV Test Transmitter SFL encodes the incoming transport stream in line with standards for transmission via antenna, satellite or cable, and processes it so that I and Q signals are obtained. For optimal protection of the data streams during transmission, they are subjected in the coder to forward error correction (FER), which widely varies between standards.

First, sync detection is usually performed, then a randomizer adds a random bit sequence to the signal. The next FEC steps are Reed-Solomon coding and interleaving. With DVB-C, these steps are followed by mapping to generate the I and Q signals, whereas in the case of the other standards, convolutional encoding and puncturing or trellis encoding come first.

With DVB-S and 8VSB/J.83/B, mapping is performed after convolutional encoding and puncturing/trellis encoding. With the American cable standard [1], trailer symbols are inserted in addition ahead of the trellis encoder or, with the American terrestrial standard [2], a field sync after the trellis encoder. These measures improve synchronization at the receiving end.

Model	Test signals for	Standard	Modulation modes
SFL-T	Terrestrial transmission	DVB-T	COFDM (coded orthogonal frequency division multiplexing)
SFL-V	Terrestrial transmission	ATSC/8VSB	8VSB (eight-level trellis-coded vestigial sideband)
SFL-J	Cable transmission	ITU-T J.83/B	64/256QAM
SFL-C	Cable transmission	DVB-C, J.83/A/C	16/32/64/128/256 QAM
SFL-S	Satellite transmission	DVB-S (DSNG)	QPSK, 8PSK, 16QAM

FIG 2 Five models are available to optimally suit your application. The I/Q modulator of the SFL of course also supplies signals to any other digital standards with the aid of an external I/Q signal.

Photo 43777

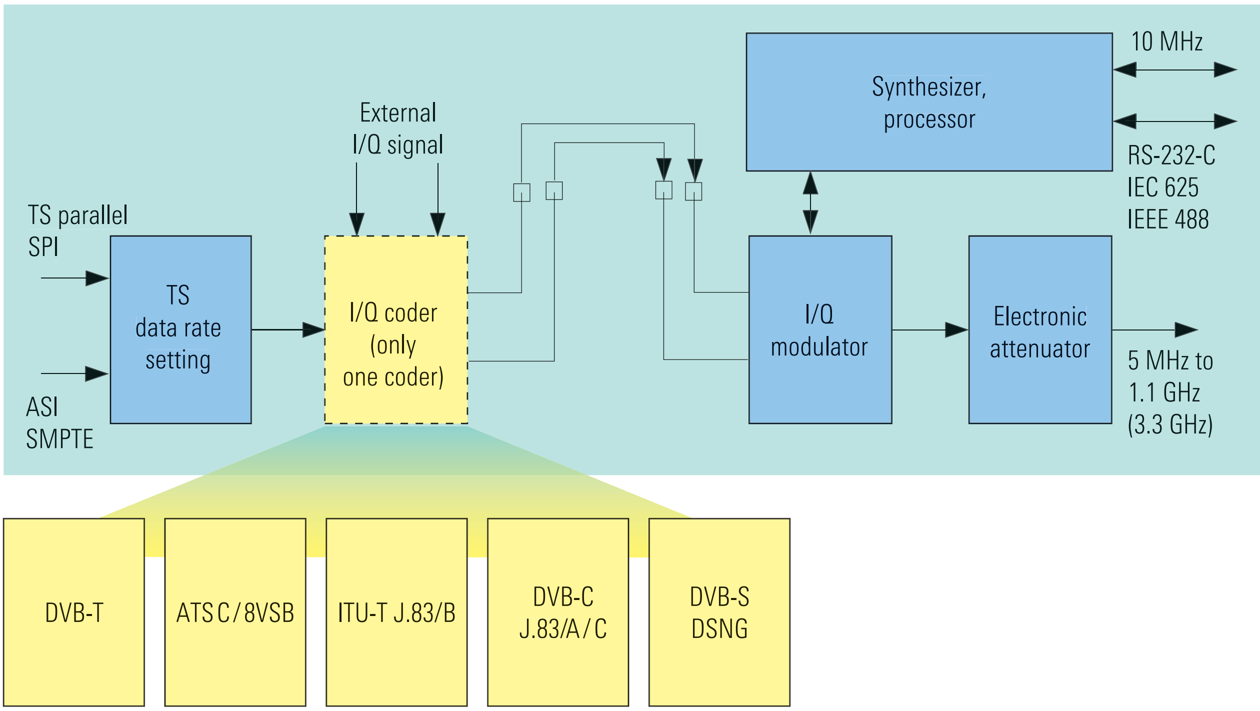


FIG 3 Block diagram of TV Test Transmitter SFL

With the terrestrial system DVB-T [3], convolutional encoding is followed by an additional interleaver, then come mapping, framing, and OFDM modulation with 1705 or 6817 carriers generated by an inverse Fourier transform.

As a final step, all coders carry out FIR (finite impulse response) filtering of the I and Q signals before these are further processed in the modulator.

Electronic level setting

Tough production environments place heavy demands on the attenuator in the output of a test transmitter. Precision and speed are called for, and above all maximum reliability.

That is why the TV test transmitters are fitted with an electronic attenuator. Any number of levels may be set without causing wear, and setting times are very short. The high-precision frequency response correction ensures the same high levels of accuracy as provided by conventional test transmitters with mechanical attenuators.

Mechanical attenuators do not perform continuous level setting, nor do electronic attenuators. The SFL, therefore, like test transmitters with a mechanical attenuator, offers a "non-interrupting level setting" mode. In this mode, the level can be decreased over a range of 20 dB, starting from a user-selectable value between 0 dBm and –140 dBm. This makes the SFL ideal for sensitivity measurements.

Realistic test conditions

Standard-conformant signals are useful in go/nogo tests but in most cases do not adequately reflect realistic transmission conditions. The SFL can simulate the errors occurring in practice, thus enabling the error limits and performance limits of devices under test to be determined. The following functions make the SFL an ideal choice for such tests:

- It can generate output signals with I/Q modulation, thus allowing sideband switchover (IF/RF inversion)
- The residual carrier, I/Q phase and I/Q imbalance can be set deviating from the optimal value
- The high-precision digital Noise Generator SFL-N (option) allows bit error ratio (BER) characteristics of receivers to be recorded for quality classification
- All important steps of FEC can be disabled. This is necessary in the development of receivers and decoder chips and facilitates troubleshooting in servicing
- The data signal applied to the SFL can be replaced by internally generated test signals at various points of

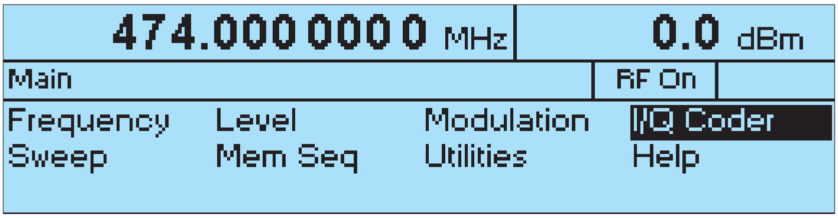


FIG 4 Menu concept for operation of TV test transmitter: straightforward as in all instruments from Rohde & Schwarz

the encoder. The following test signals are available:

- null TS packets,
- null PRBS packets ($2^{15}-1$ or $2^{23}-1$),
- PRBS before / after convolutional/ trellis encoder,
- PRBS before mapper for simple BER measurements on receivers.

The wide output frequency range of the SFL models enables tests far beyond the frequency ranges defined by the standards. The wide output level range allows measurements on high-sensitivity receiver modules as well as transmission measurements at high levels.

To obtain reliable information as to the quality of components or modules, high output level accuracy is required. The SFL perfectly meets this requirement thanks to its close-tolerance level deviation and high level reproducibility. The extremely short setting times for frequency and level are unmatched among competitors. They allow short test times and make the SFL an optimal test transmitter in production.

In the unlikely event of a fault, built-in diagnostics help cut time to repair to a minimum. Not only an extremely attractive price but also low follow-on costs make the SFL a sound investment.

The logically structured menu system (FIG 4) makes operation very convenient. Complex test sequences are executed automatically at a keystroke in the integrated list mode.

In production environments, space is often at a premium. Here, the SFL's compact size is a particular plus. The solid mechanical construction ensures high RF shielding of the enclosure, which is especially important in measurements on highly sensitive receivers.

Summary

Like the successful SFQ models, the SFL offers many proven features: user-friendly operation, messages indicating non-standard settings or operating states, status menu, online help, IEC/ IEEE bus and RS-232-C interfaces as well as firmware updates via PC.

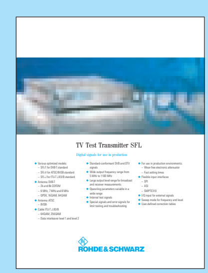
As an alternative to the universal Test Transmitter Family SFQ, the SFL offers single-standard functionality optimized for production. The SFL is thus a budget-priced and future-proof investment.

Albert Dietl

Condensed data of SFL

Frequency range	5 MHz to 1.1 GHz (SFL-S: 3.3 GHz)
Level range	–140 dBm to 0 dBm
Data inputs	TS parallel (LVDS), SPI, ASI, SMPTE 310
Option	Digital Noise Generator SFL-N
Remote control	IEC-625 (IEEE 488) and RS-232-C

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



Data sheet SFL

REFERENCES

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[2] SFQ goes North American – with digital TV standard ATSC. News from Rohde & Schwarz (2000) No. 166, pp 13–15

[3] SFQ Model 20 – TV via antenna: digitally fit. News from Rohde & Schwarz (1999) No. 161, pp 4–6

TV Test Receiver EFA

Digital multistandard platform for the analysis of QAM-modulated signals

When it comes to selecting TV programs, digital cable TV provides many consumers with an alternative to the digital terrestrial TV networks and the established DVB-S standard. Digital cable technology allows a return channel[1] to be used within the same physical layer (coaxial cable), enabling consumers to send back information to the cable headend (e.g. for Internet access, video on demand, etc). The barrier between data communication equipment and TV networks is now smaller than ever before. As a result, there is an increasing demand for measuring instruments capable of performing a wide variety of measurements in a very short time. The new Test Receivers EFA are fully fit to perform these measurements.

FIG 1 The new TV Test Receivers EFA: currently the only test receivers in the world capable of demodulating, analyzing and monitoring signals in realtime and in parallel, which is ideal for cable headends, for example

Digital multistandard platform for maximum versatility

The new digital TV Test Receivers EFA cover both the DVB-C standard[2] (models 60 and 63) and the American digital cable TV standard ITU-T J.83/B (models 70 and 73). Models 60 and 63 replace the tried-and-tested models 20 and 23. FIG 2 shows a comparison of the two model generations, while FIG 3 compares the cable standards.

The new generation features outstanding versatility: with modules from this new digital multistandard platform, existing analog TV demodulators can be upgraded to analog/digital two-in-one units. Moreover, all digital demodulation standards can be implemented within the same hardware [3]. Finally, the optional MPEG2 Analyzer/Decoder EFA-B4 enables implementation of a complete measuring tool that covers all functions from frequency domain analysis to MPEG2 baseband protocol monitoring.

Parallel signal processing in realtime

The new Test Receivers EFA are the first measuring instruments worldwide to demodulate, analyze and monitor signals in realtime and in parallel. Their capability to deal with multichannel occupancy – in the high adjacent channel mode even with high-level adjacent channels – as well as their spectrum measurement and history function make them unique measurement solutions for cable headends (FIG 1). In addition, the high accuracy, reproducibility of measurements, and measurement speed of the EFA models open up new applications in the production of QAM modulators. Thanks to the high-quality front-end and the large dynamic range for modulation error ratio (MER) measurement (MER can be measured up to 42 dB), the new EFA models are the reference demodulators in research and development.

1) See also Euro DOCSIS / DVB RCC ES 200 800 standards.
2) Digital Video Broadcast over Cable – EN 300 429.
3) Except DVB-T demodulation.

	EFA 20/23	EFA 60/63
Simultaneous demodulation/analysis	✗	✓
Calculation of BER	BER before Reed-Solomon decoder, no calculation in background	✓ BER before/after Reed-Solomon decoder
Constellation diagram	✓	✓ including histograms for I and Q
Spectrum measurements	✗	✓ including shoulder attenuation measurement
Calculation of transmission channel	amplitude and phase (frequency response)	amplitude, phase and polar plot (frequency response)
Impulse response	channel impulse response	channel impulse response numerical values/zoom/in µs to km
Crest factor	✗	✓ amplitude distribution, CCDF
Eye monitoring	✗	✓
History	✗	✓
QAM parameters	✓	✓
Noise generator	✓	✓

FIG 2 Comparison between the most important features of the EFA models 20/23 and the new models 60/63 (green: available, yellow: limited; orange: not possible)

FIG 3 Comparison between different cable standards

	J.83/B		DVB-C J.83/A/C
Mode	64QAM	256QAM	16, 32, 64, 128, 256 QAM
QAM constellation, symbol length	6 bit/symbol, 3 each for I and Q	8 bit/symbol 4 each for I and Q	4 to 8 bit/symbol 2 to 4 bit each for I and Q
Channel spacing	6 MHz	6 MHz	8 MHz (J.83/A) 6 MHz (J.83/C)
Roll-off filter	root-raised cosine 0.18	root-raised cosine 0.12	0.15 (J.83/A) 0.13 (J.83/C)
Symbol rate	5.056941 Msymb/s	5.360537 Msymb/s	settable (up to 7 Msymb/s)
Transport stream bit rate	26.970352 Mbit/s	38.810701 Mbit/s	settable (up to 56 Msymb/s)
Channel coding FEC	concatenated coding RS (128, 122)	concatenated coding RS (128, 122)	RS (204, 188)

Calculation of TS bit rate (J.83/B):

$$\textbf{TS bit rate (64QAM)} = 5.056941\ \text{Msymb/s} \cdot \frac{6\ \text{bit}}{\text{Symb}} \cdot \frac{14}{15} \cdot \frac{60 \cdot 128 \cdot 7\ \text{bit}}{60 \cdot 128 \cdot 7\ \text{bit} + 42\ \text{bit}} \cdot \frac{122}{128} = \textbf{26.970352 Mbit/s}$$

$$\textbf{TS bit rate (256QAM)} = 5.360537\ \text{Msymb/s} \cdot \frac{8\ \text{bit}}{\text{Symb}} \cdot \frac{19}{20} \cdot \frac{88 \cdot 128 \cdot 7\ \text{bit}}{88 \cdot 128 \cdot 7\ \text{bit} + 40\ \text{bit}} \cdot \frac{122}{128} = \textbf{38.810701 Mbit/s}$$

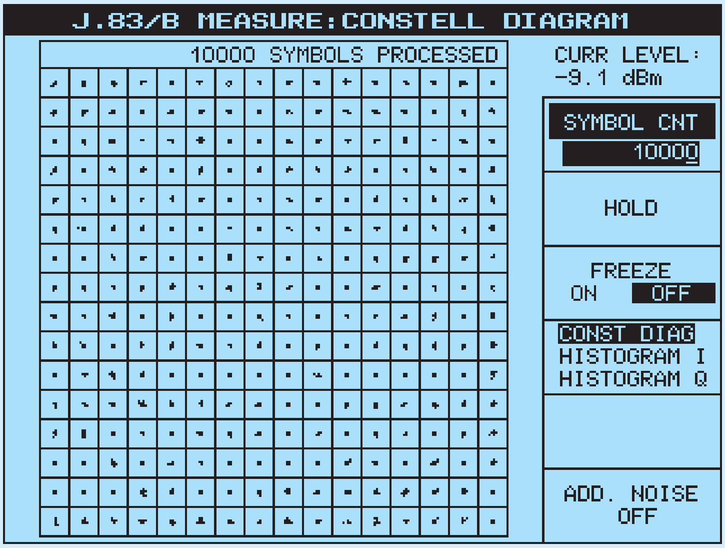


FIG 4
Constellation diagram for 256QAM: the instrument shows high performance margins even in this difficult operating mode; 10 000 I/Q values are displayed

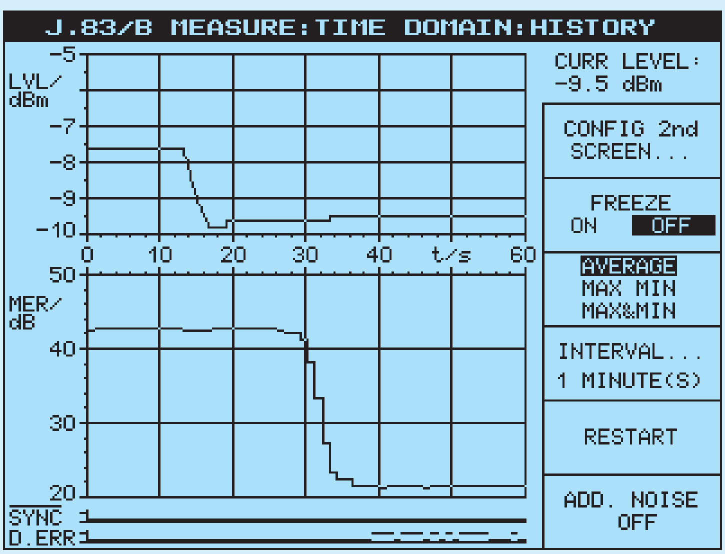


FIG 5
History display with cable channel amplifier failure: the level loss resulting in deterioration of both modulation error ratio (MER) and transmission error (indicated by D.ERR at bottom left of diagram) is clearly visible

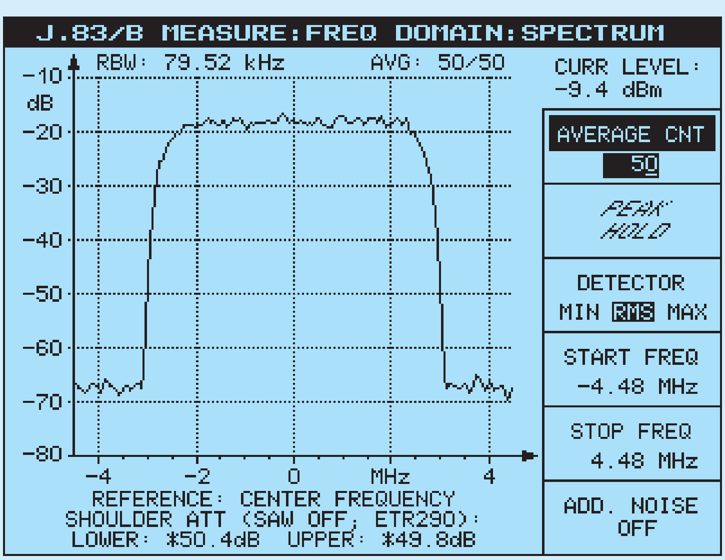


FIG 6
The integrated spectrum analysis function enables the shoulder attenuation of the QAM signal to be measured fully automatically to ETR 290 specifications

Frontends for any task

The modular platform concept of the EFA family provides a suitable frontend for any task. Three versions are available:

- The standard frontend is ideal for on-site measurements where selectivity is required
- The high-end non-selective frontend consists of a wideband RF downconverter, which is compulsory for performing high-quality measurements directly on the transmitter or modulator output and where no other signals can impair the demodulation
- The high-end selective frontend consists of a high-end non-selective frontend and an RF preselector. It allows very accurate measurements to be performed, even if high sensitivity is required

High performance margin for 256QAM

In modern cable systems, a great number of channels are used to transmit information. More than 100 channels (analog TV, 64QAM, 256QAM as well as sound broadcasting) are implemented in some of these cable systems. To ensure always correct and troublefree measurements in these channels, the receive path of the test receiver must have a high performance margin as regards intermodulation and inherent noise. Moreover, the signals in the digital section of the receiver must be formed to precisely defined filter functions (roll-off filter).

The new QAM Test Receivers EFA meet these requirements in every respect. When it comes to digital modulation of higher orders (e.g. 256QAM), they offer features that represent the limit of what is technically feasible with today's real-time analyzers (FIG 4).

Simultaneous processing of the most important key parameters

The test receiver simultaneously detects and stores the most important parameters of a digitally modulated signal, such as level, modulation error ratio (MER), error vector magnitude (EVM), bit error ratio (BER), synchronization and transmission errors. These parameters are continuously monitored in the background, independently of the individual measurement currently being performed, and, if required, can be output graphically versus time or numerically by means of the history function (FIG 5).

Parallel to the history function, all the parameters mentioned are also compared with programmable limit values. If the limit value is exceeded, an entry with date and time is made in the alarm register. An overview of the alarm values allows valuable conclusions to be drawn about the availability of the transmitted signal.

The ease of operation you expect

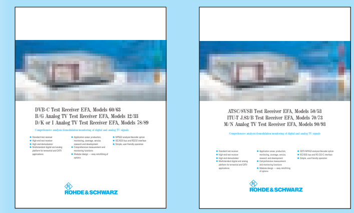
The operating structure of the new QAM test receivers is simple and logical. In addition to the basic measurements (level, bit error ratio, offsets, synchronization, etc), the measurement menu is subdivided into four groups:

- **Constellation diagram**: representation of the constellation diagram and the distribution functions (I and Q histograms)
- **Frequency domain**: all measurements in the frequency domain, such as spectrum display (FIG 6), amplitude, phase and group delay within the transmission channel
- **Time domain**: all measurements in the time domain, such as echo pattern (channel impulse response), amplitude distribution and CCDF, eye monitoring as a function of time as well as graphical and numerical monitoring of key parameters, i.e. level, modulation error ratio (MER), error vector magnitude (EVM), bit error ratio (BER), synchronization and transmission errors, in the history function with long-term monitoring (trend analysis, up to 1000 days)
- **QAM parameters**: numerical display of results based on the mathematical/statistical evaluation of I/Q constellation data: modulation error ratio (MER), error vector magnitude (EVM), signal/noise ratio (SNR), phase jitter, I/Q amplitude imbalance, I/Q quadrature error, and carrier suppression

The integrated noise generator can be switched on in all measurement menus. This allows important conclusions to be easily drawn about the behaviour of the transmission system if white noise is additionally applied.

Yann Auffret, Christoph Balz

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



Various data sheets on the EFA family can be downloaded.

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- ATSC Test Receiver EFA: All measurement functions for North-American digital TV standard. News from Rohde & Schwarz (2000) No. 167, pp 11–13
- CCDF determination – a comparison of two measurement methods (in this issue, pp 52–53)

Condensed data of Test Receiver EFA, models 60/63/70/73

Transmission standards	DVB-C, ITU-T J.83/A/C according to EN 300429 (models 60/63); ITU-T J.83/B (models 70/73)
Frequency range	48 MHz to 862 MHz (models 60/70); 45 MHz to 1000 MHz (models 63/73); 5 MHz to 1000 MHz (models 63/73 with EFA-B3 option)
Input level range (64QAM)	–74 dBm to +20 dBm (models 60/70); –50 dBm to +20 dBm (models 63/73); –74 dBm to +20 dBm (models 63/73 with EFA-B3 option)
Bandwidths (SAW filter)	2/6/7/8 MHz
Modulation	4, 16, 32, 64, 128 and 256QAM
BER analysis	before and after Reed-Solomon decoder
Measurement functions	level, frequency offset, symbol rate offset, MPEG2 TS bit rate, bit error ratio (BER) before and after Reed-Solomon decoder, carrier suppression, quadrature error, amplitude imbalance, phase jitter, error vector magnitude (EVM), modulation error ratio (MER), signal/noise ratio (SNR), shoulder attenuation (to ETR 290), crest factor
Graphical representation	constellation diagram, I or Q histogram, spectrum, amplitude frequency response, phase frequency response, group delay frequency response, polar plot, echo pattern (channel impulse response), amplitude distribution (RF), CCDF (RF), eye monitoring, history
Output signals	MPEG TS: ASI (BNC), SPI (LVDS)
Options	MPEG2 Analyzer/Decoder EFA-B4, RF Preselection EFA-B3

(n+1) standby configuration of TV transmitters

Always “on air” through automatic switchover

Network operators require their programs to be almost 100% available “on air”. This applies to public broadcasting companies, which have to fulfill public functions, and to commercial service and program providers with their own networks, who are liable to considerable penalties or loss of earnings from advertisements if their programs are not constantly available. Reliability is a particularly critical point in digital TV where several programs are transmitted by a single transmitter station. This high level of program availability is ensured by the modern, favourably priced (n+1) standby transmitters from Rohde & Schwarz.

How to increase the availability of DAB transmitter networks is described in the article on page 42.

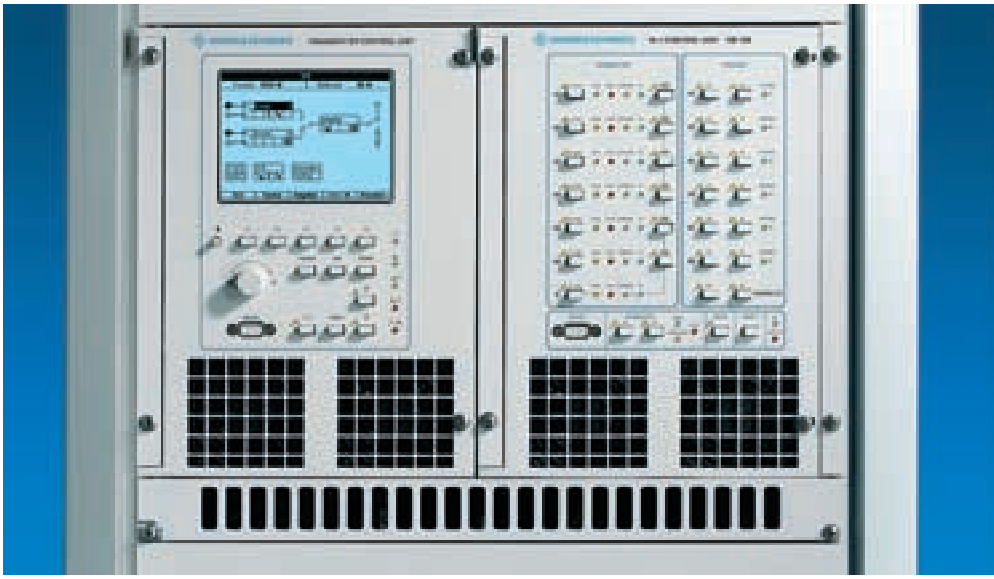


Photo 43703

FIG 1 Control Unit GB 700 (on the right) is the “switching center” in (n+1) standby systems

The objective: always “on air”

To ensure maximum program availability, different standby systems with a high redundancy of critical components or whole subsystems have been developed over the years. The proven standby configurations used in analog transmission, such as passive exciter standby or active output stage standby, are often unable to satisfy the requirements of today’s network operators with regard to reliability and cost.

Particularly if several programs are to be emitted by a single transmitter station, (n+1) standby configurations are an almost ideal solution. These comprehensive standby transmitter systems ensure reliable program availability, and can be realized with Rohde & Schwarz transmitters of the new generation at fairly low cost.

In contrast to passive standby transmitter systems, the (n+1) configuration is also an attractive option if further channels are to be added in the future.

In the (n+1) standby transmitter configuration, the program of a faulty transmitter is switched to the standby transmitter. In this case, not only the RF but also the transmitter input signal is switched over, and channel-specific parameters such as frequency and precorrection are set on the standby transmitter. The block diagram in FIG 2 shows a DVB transmitter system in (n+1) standby configuration.

The programs can be assigned different priorities for a switchover. This ensures that the standby transmitter is always available when the program with the highest priority has to be switched over.

Everything under control with the (n+1) Control Unit GB 700

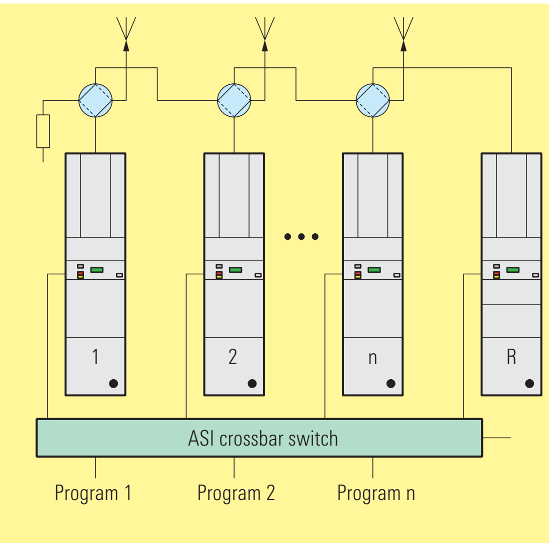
The Control Unit GB 700 (FIG 1) is the "switching center" of these (n+1) standby systems. It was developed specifically for the latest generations of the analog and digital transmitters of the Nx 700x family [1, 2] and for the DAB Transmitter Family NA / NL 6000. The control unit is based on the monitoring and control concept of these transmitters and perfectly complements their functions and construction.

Data communication between the individual system components, i.e. between control unit, transmitters and antenna switches, is carried out on two data buses. The control unit acts as the master on the serial bus (RS-485), which features extremely high immunity to RF interference. The transmitters respond as slaves to the cyclic poll of the control unit. The polled status data contains not only criteria required for a switchover (transmitter fault), but also warnings, local and remote control status information, messages such as "RF present", etc. The second bus is a parallel bus on which commands are sent to the antenna switches and switching states are returned. The switch positions are evaluated by a programmable gate array in the GB 700.

The GB 700 controls the operating transmitters (transmitter connected to antenna) and the standby transmitter (transmitter connected to dummy antenna). Any transmitter may be connected to the dummy antenna, but only one at a time.

The Control Unit GB 700 is based on the CCU in the exciter of NX 7000 transmitters. The power supply, motherboard and control panel are matched to the transmitter hardware. The GB 700 can be readily inserted in existing exciter frames – which proves the great flexibility of the new solution.

FIG 2 Example of an (n+1) standby system of DVB transmitters



Advantages of the (n+1) standby system from Rohde & Schwarz

Flexible design

Up to six DVB or DAB transmitters or four analog TV transmitters can be combined to form one (n+1) standby system. The open bus structure also permits subsequent extensions.

Central remote-control interface

As in the above-mentioned TV and DVB transmitters, the following remote-control interfaces are available in the Control Unit GB 700:

- Serial interfaces RS-232-C and RS-485
- Parallel remote-control interface
- NetLink interface [3]

It is of particular importance that the whole (n+1) standby system can be remotely monitored via a single interface. If NetLink is used, monitoring can even be performed with the modern network capabilities of a web server or SNMP agent.

The Control Unit GB 700 is more than just a simple (n+1) switchover unit and ideally complements the new transmitter program from Rohde & Schwarz.

Johannes Leitenstorfer

More information and data sheet at www.rohde-schwarz.com. (search words: NH 7000/7001 or NV 7000/7001)

Data sheets NA / NL 6000 and NH / NV 7001

Data sheets NM / NW 7000 and NH / NV 7000

REFERENCES

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

[2] UHF Transmitter Family NV / NH 7001 – Medium-power transmitters for terrestrial digital and analog TV. News from Rohde & Schwarz (2001) No. 171, pp 39 – 41

[3] NetLink – Remote control and monitoring of transmitters on the Internet. News from Rohde & Schwarz (2001) No. 170, pp 27 – 29

Exciter SV 700

Digital TV standard ATSC for Transmitter Family Nx 700x

With the market launch of the TV Transmitter Family Nx 700x [1, 2], a new exciter has been introduced which is capable of handling the European DVB-T standard for terrestrial broadcasting of digital programs in addition to analog TV standards. The range of transmission methods supported by this exciter has now been completed by an encoder for the digital terrestrial ATSC standard currently used in the United States and parts of Asia, which will replace the analog NTSC standard in the medium term.

Upgradable to all standards thanks to modular design

Due their modularity and appropriate interfaces, the exciters for the individual standards differ only by the encoder used. In addition to the new ATSC encoder, the exciter comprises the following tried-and-tested components:

- Digital equalizer
- I/Q modulator
- Synthesizer
- Central control unit (CCU) with control panel
- Motherboard and power supply

The user interface for the whole transmitter system is also of uniform design and can be operated from the CCU control panel (FIG 2), a local PC, or optionally via modem or Internet. It can be updated any time by means of software.

Coding and modulation by the ATSC encoder

FIG 1 shows the block diagram of the exciter. All functions of the ATSC encoder are in line with the ATSC DOC. A/53 standard. Important components of the ATSC encoder have been taken from the successful TV Test Transmitter SFQ [3], which many manufacturers of electronic consumer goods use for testing ATSC receivers.

The input interface includes two inputs for MPEG2 transport streams with a packet length of 188 bytes. The inputs can be configured independently of each other.

- Asynchronous serial interface (ASI) to EN 50083-9 (1999) with a variable data rate of up to 19.392658 Mbit/s
- Synchronous serial interface to SMPTE 310 M with a constant data rate of 19.392658 Mbit/s

If the signal at the connected input fails, the active standby input is automatically switched into operation. If the transport stream fails at both inputs, a pseudo random bit sequence (PRBS) with frame is generated instead. This ensures that the receivers can synchronize at any time.

The parallel data stream from the input interface is processed in the ATSC coder / modulator. Several functional units ensure a constant power density in the spectrum, perform inner and outer error correction coding, and

FIG 1
Block diagram of Exciter SV 700

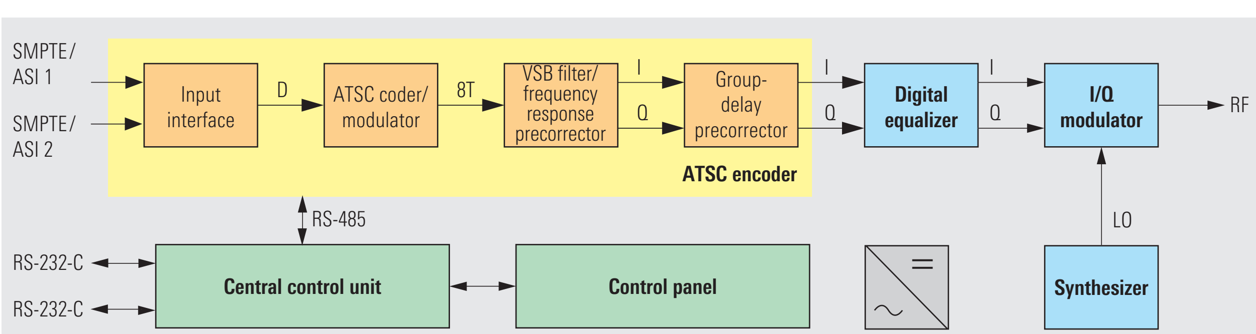


Photo 43795

FIG 2 The transmitter is controlled via the user interface in the control panel of the Exciter SV 700 or from an external PC

modulate the signal according to the 8VSB mode. For details on the ATSC coder/modulator refer to [3].

A subsequent digital filter carries out vestigial sideband (VSB) filtering and Hilbert transform. The signal is band-limited to 6 MHz with the aid of the specified roll-off characteristic and is available at the filter output as an inphase and quadrature signal.

Optimum precorrection under the most adverse conditions

Because of the narrow channel spacing and the adjacent analog and digital channels, channel combiners with extremely steep edges must be used at the transmitter outputs. These combiners cause a ripple in the frequency response and considerable group-delay differences in the channel.

To achieve optimum correction in the transmitter system even under such adverse conditions, the ATSC encoder offers further resources in addition to those of the digital equalizer. The digital filter for VSB filtering is also used for linearizing the frequency response. Another digital filter module is provided for group-delay precorrection.

An investment for the future

Since changeover between the different transmission standards is straightforward and requires little effort, the TV Transmitter Family Nx 700x is ideal for NTSC radio broadcasting networks that have to be adapted to ATSC or DVB-T in the future.

Thanks to its modular design and future-oriented signal processing, the exciter will continue to meet the most stringent requirements in the future, and can be upgraded to meet new modulation methods.

Heiner Dost

More information and data sheet at www.rohde-schwarz.com. (search words: NH 7000/7001 or NV 7000/7001)

REFERENCES

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

[2] UHF Transmitter Family NV/NH 7001 – Medium-power transmitters for terrestrial digital and analog TV. News from Rohde & Schwarz (2001) No. 171, pp 39–41

[3] TV Test Transmitter SFQ – SFQ goes North American – with digital TV standard ATSC. News from Rohde & Schwarz (2000) No. 166, pp 13–15

Condensed data of ATSC Exciter SV 700

Frequency range	174 MHz to 240 MHz, 470 MHz to 860 MHz
Data inputs	2, can be separately configured as ASI or SMPTE 310 M input
Input signal	MPEG2 transport stream with max. 19.392658 Mbit/s and a packet length of 188 bytes
Modulation mode	8VSB
Channel bandwidth	6 MHz
S/N ratio	>35 dB
Shoulder distance	>50 dB
Ripple of frequency response	<0.2 dB
Group delay differences	<10 ns
Output level	13 dBm rms

DAB Redundancy Concept DM 001-R

Increasing DAB availability, decreasing downtime cost

If a multiplexer in a DAB transmitter network fails, this may have fatal consequences. Depending on the network's architecture, a multiplexer failure may cause a local, regional, or even countrywide loss of programs. The DAB Multiplexer DM 001 from Rohde & Schwarz (FIG 1) is the central element in a DAB transmitter chain. High availability of the multiplexer is vital for reliable operation. The use of the service transport interface (STI) in the new DM 001/STI and a redundancy concept offer network operators many advantages.

DAB Redundancy Concept DM 001-R – versatile all-in solution

The DM 001-R is a comprehensive solution from Rohde & Schwarz. Two DAB Multiplexers DM 001/STI form a 1+1 hot standby redundancy, so ensuring continuous availability of the multiplexer, which is vital for the functioning of a complete transmitter network (FIG 2). After changeover to include the second multiplexer, the redundant system behaves like a single multiplexer in the DAB network so that no changes are required to the STI feeder network or the DAB transmitter network. Independently of the standby concept, further elements of the DAB transmitter chain can be designed for redundant operation (additional service providers or transmitters may be included, for example).

The package offered by Rohde & Schwarz includes a comprehensive system manual which enables the user to:
- determine and, if desired, order all required system components and
- install the system or
- expand existing systems, for example if a multiplexer is already in use.

The solution comprises the DAB Multiplexer DM 001/STI from Rohde & Schwarz and all required switchover facilities. It can of course be custom-tailored, and additional or alternative components may be integrated if desired.

The evaluation and procurement of third-party products can be ordered optionally from Rohde & Schwarz, as well as system installation and configuration. System acceptance testing and commissioning are included as standard. The changeover and commissioning of the system necessitate an interruption of transmission of no more than four hours.

The core of the redundancy package is the central control unit (CCU), an industrial PC with software for system control. It performs the following functions:
- coordination of operation of the two multiplexers,
- control of switchover facilities,
- analysis of signal monitoring results,
- automatic switchover,
- status signalling to a quality management system,
- generation of event log.

Key features of redundancy concept

In the event of a malfunction, the software switches the signal paths for the ETI output signal and the STI back channel from the faulty operational component to the standby component. To prevent switchover in the event of short-term faults, a user-defined delay is introduced. It is ensured that switchover is effected after a maximum period of one minute, the exact time depending on the type of fault.

Photo 43442/3

FIG 1 The DAB multiplexer is a central element in a DAB network. It combines the incoming audio and data channels to form the ensemble transport interface (ETI), which drives the subsequent COFDM modulators and thus the complete transmitter network. If the multiplexer fails, the network is "dead".

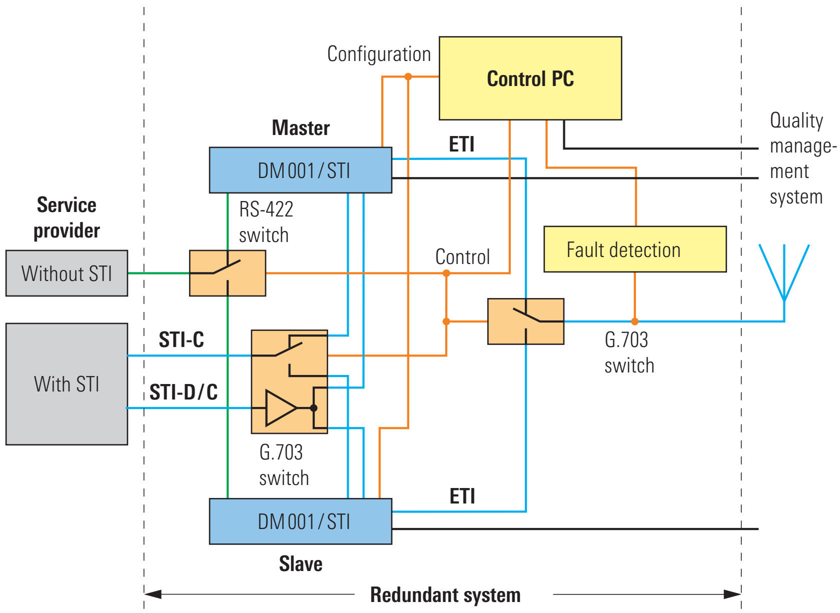


FIG 2 Block diagram of 1+1 hot standby redundancy concept

If one of the two DAB multiplexers has to be removed for maintenance, switchover can be made to the standby component without interrupting operation.

The quality management interfaces remain unchanged. In addition, remote control and signalling contacts are provided for status control of the automatic switchover system and status monitoring of the system and its components.

The system and the control software also allow only one multiplexer to be used initially, and adding a second unit for redundant operation later.

Who benefits from this solution?

Now that standardization of the service transport interface is completed, there is an increasing demand for this flexible technology. The DM001/STI from Rohde&Schwarz is the first DAB ensemble multiplexer to offer standard-conformant STI functionality. The DAB Redundancy Concept DM001-R increases overall system availability and helps operators avoid network failures, so increasing their earnings and enhancing their public image.

The system is therefore an attractive proposition for all users who already have a DM001 or who wish to use the new STI interface, as well as for network operators, for whom the failsafe operation and high availability of their DAB networks is particularly important.

Torsten Jäkel

How to increase the availability of TV transmitter networks is described in the article on page 38.

DAB Multiplexer DM001 – now even more attractive through redundancy and STI

The use of the service transport interface (STI) in the DM001 places particularly high demands on a redundancy concept. The STI enables service providers to dynamically and interactively influence the contents of the DAB ensemble.

To start a reconfiguration, the service provider transmits the time and type of an intended parameter change to the ensemble multiplexer by describing, in a message format, the number, type, data rate and error protection of the audio channels concerned, as well as the organization of the services for which the channels are used.

The reconfiguration request is checked by the ensemble multiplexer. If the multiplexer allows for the desired reconfiguration, it determines the exact time for the parameter change. The data in the redundant multiplexer is adjusted to match that of the active DM001 communicating with the service providers so that, after a switchover, the standby unit can continue with the same configuration as the previously active multiplexer.

Data sheet at www.rohde-schwarz.com (search word: DM001)

Data sheet DM001

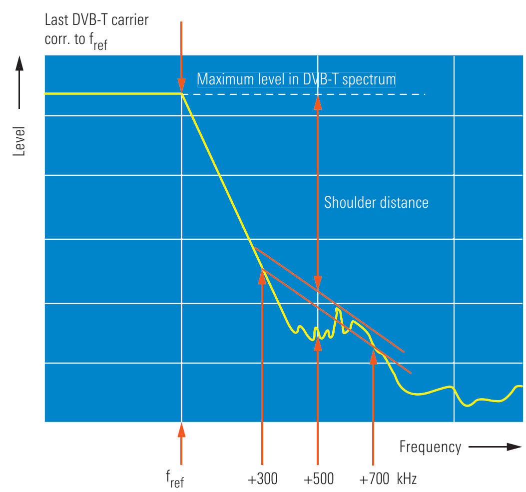
REFERENCES

- STI makes DAB more user-friendly. News from Rohde&Schwarz (1998) No. 159, p 21
- DAB multiplexer completes product line for digital audio broadcasting. News from Rohde&Schwarz (1997) No. 153, p 35

Continued from No. 170

Measurements on MPEG2 and DVB-T signals (4)

Part 3 of this refresher topic dealt with masks for out-of-band components and the measurement of the shoulder distance. In this contribution, the emphasis is on the determination of the crest factor and power measurements on medium-power DVB-T transmitters.



To refresh your memory: in part 3 of this topic, measurement of the shoulder distance to ETR 290 was discussed

See also test tip on page 52: "CCDF determination – a comparison of two measurement methods".

Crest factor of DVB-T signal

Definition

The crest factor K_{CREST} is the quotient of the peak voltage value V_p and the root-mean-square voltage value V_{rms} expressed as a logarithmic ratio:

$$K_{CREST} = 20 \cdot \log(V_p/V_{rms})\ \text{dB}$$

The crest factor directly indicates the drive level up to which an amplifier used in a DVB-T transmitter is in the linear range and the point at which signal limiting becomes active.

For measurements with a spectrum analyzer featuring CCDF (complementary cumulative distribution function) capability, it should be taken into account that an instrument of this type measures the peak envelope power (PEP) rather than the absolute voltage peaks that occur in the amplifier. The measured value, therefore, has to be corrected by a factor of $\sqrt{2}$ or 3.01 dB. The test tip on page 52 describes in detail the different weighting applied to the signal. In this topic, only the crest factor derived from the absolute voltage peaks will be discussed.

Crest factor and level limiting in DVB-T transmitters

In the theoretical case that all carriers of the COFDM signal, which is very similar to white noise, attain their maximum amplitudes with identical phase at the same time, all carrier amplitudes add up to give the maximum possible peak amplitude $V_{p\,max}$. In the 8k mode this peak amplitude yields a crest factor of

$$K_{CREST\,max.} = 20 \cdot \log\sqrt{6817} = 38.3\ \text{dB}$$

and in the 2k mode

$$K_{CREST\,max.} = 20 \cdot \log\sqrt{1705} = 32.3\ \text{dB}.$$

These maximum values will, however, not occur in practice. So, a realistic maximum value of $K_{CREST} \geq 15.7$ dB is assumed for both modes for an amplitude probability distribution of $1 \cdot 10^{-7}$. This corresponds to a V_p/V_{rms} ratio of approx. 6.1 (FIG 25). For the transmitter power this means that a peak power of 37.2 times the mean power would have to be provided as a safety margin. Using such a margin, virtually all signal components could be transmitted, with favourable effect on the BER. This is not acceptable in terms of efficiency however. Investigations have shown that with a crest factor of approx. 13 dB there will be no appreciable impairment of the BER.

A safety margin of 20 times the mean transmitter power, however, is economically impractical either. For this reason, the crest factor is limited to approx. 10 dB to 11 dB in all DVB-T transmitters. A spectrum analyzer with CCDF function will indicate for such limitation a crest factor of about 7 dB, which is a typical and internationally valid value. This crest factor, however, means an appreciable degradation of the BER. A BER (before the Viterbi decoder) of $1 \cdot 10^{-5}$ to $1 \cdot 10^{-6}$ is obtained at the transmit antenna, with channel filtering for boosting shoulder distance taken into account.

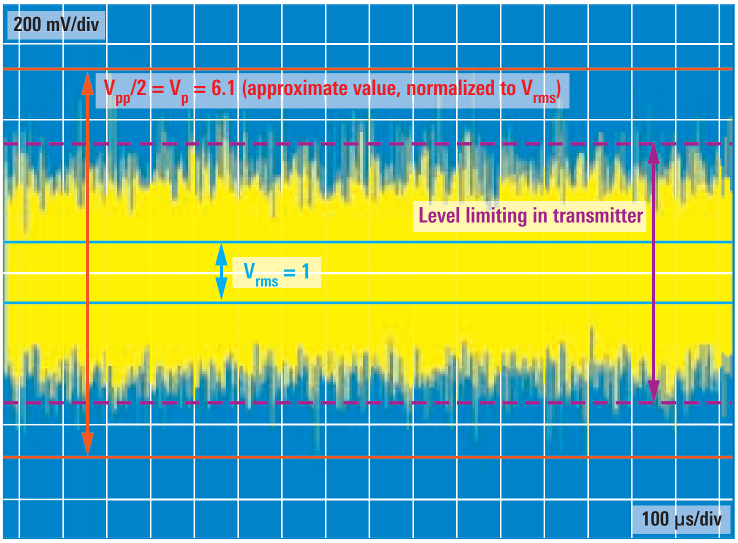


FIG 25
Time-domain signal in DVB-T

The new solid-state amplifier generations from Rohde & Schwarz employ highly linear LDMOS transistors. This means that demands on digital precorrectors are less stringent than with predecessors using bipolar or MOS technology. Limitation of the crest factor to approx. 10 dB to 11 dB safely prevents voltage peaks and so reliably protects the transistors. Determining the crest factor at the transmitter output is, therefore, indispensable as it is crucial for power transistor lifetime.

Crest factor measurement

This measurement is performed with the DVB-T Test Receiver EFA, model 40 or 43. The EFA calculates the crest factor based on the amplitude probability distribution (CCDF). The display indicates the current crest factor during the measurement ($10.24 \cdot 10^6$ samples), the maximum crest factor since the beginning of the measurement, and the margin active for the test configuration (FIG 26).

Power measurements on DVB-T transmitters

Mean power measurements

In the case of analog transmitters, signal power is determined by measuring the peak power of the sync pulse floor of the modulated CCVS signal. The sync pulse floor is always the reference in analog TV because this signal component must be transmitted without compression or distortion.

In DVB this is different: the "Sync 1 Inversion and Randomization" block of the DVB modulator (see EN 300 421, EN 300 429 or EN 300 744) ensures constant mean power of the transmitter output signal. In DVB, therefore, it is not the peak power that is measured, based on the crest factor, but the mean output power. Three methods are available:

1. Mean power measurement with Power Meter NRVS and thermal power sensor (FIG 27)

Thermal power sensors supply the most accurate results if there is only one TV channel in the overall spectrum, which is nearly always the case at the DVB-T transmitter. Plus, they can easily be calibrated by performing a highly accurate DC voltage measurement, provided the sensor is capable of DC measurement.

2. Mean power measurement with Spectrum Analyzer FSEx or FSP

A frequency cursor is placed on the lower and another one on the upper frequency of the DVB channel. The spectrum analyzer calculates the power for the band between the cursors (FIG 28). The method provides sufficient accuracy as in DVB-T normally no signals are put on the air in the adjacent channels.

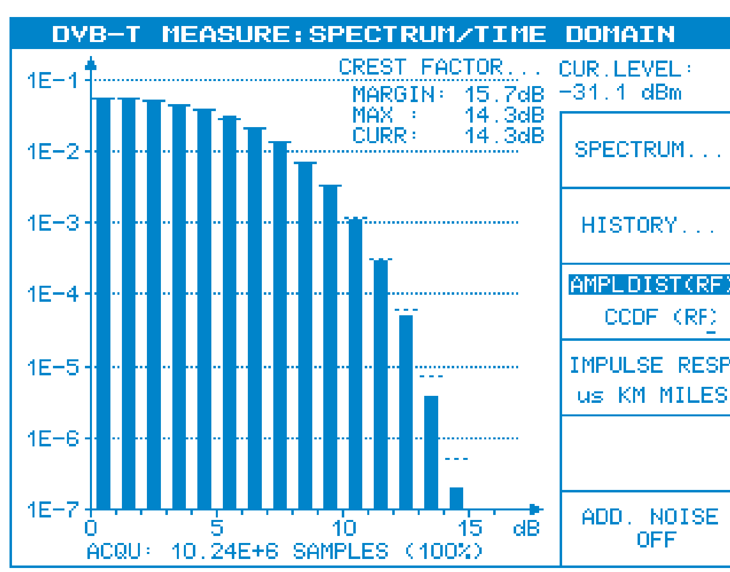


FIG 26
Crest factor measurement with DVB-T Test Receiver EFA

Photo 43 225/3

FIG 27
Power Meter NRVS (data sheet PD 0756.3182)

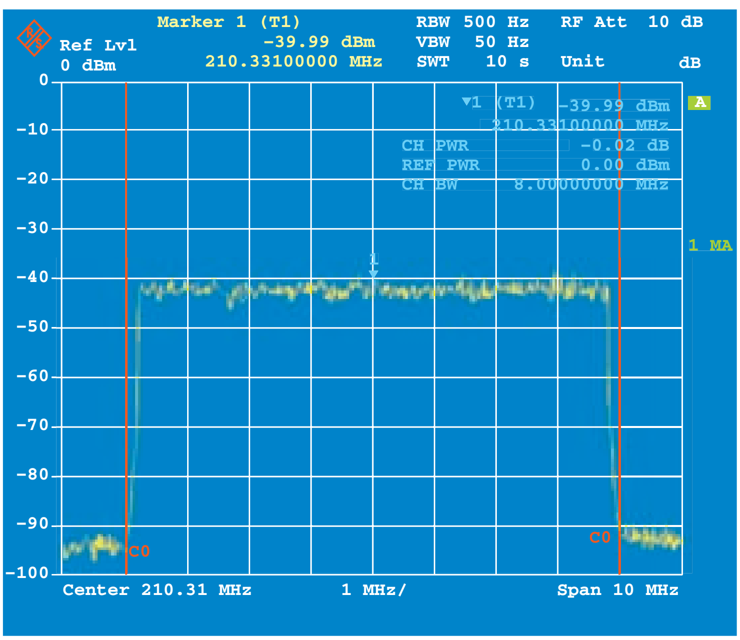


FIG 28
Measurement of mean transmitter power with a spectrum analyzer

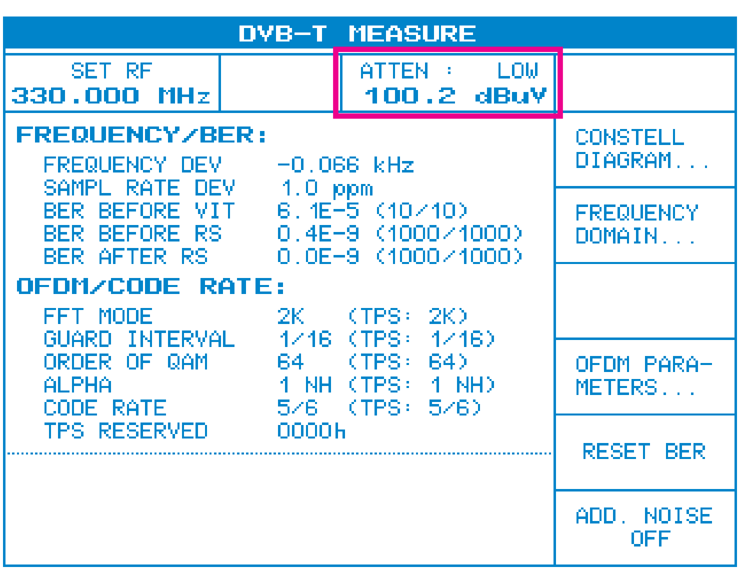


FIG 29
Display of DVB-T Test Receiver EFA. Marked red: mean transmitter power

3. Mean power measurement with DVB-T Test Receiver EFA

The test receiver displays all important signal parameters in a status line. For example, the righthand upper status field indicates the mean power in various switchable units (FIG 29). Investigations on channel spectra revealing pronounced frequency response have shown the high measurement accuracy of the test receiver. A comparison of levels obtained with the EFA on the one hand and the NRVS with thermal power sensor on the other hand yielded a maximum difference of 1 dB – comparison measurements being performed with various EFA models at different channel frequencies and on different, non-flat spectra. Thanks to the EFA's built-in SAW filters of 6 MHz, 7 MHz and 8 MHz IF bandwidth, highly accurate results are obtained even if the adjacent channels are occupied.

Example of above comparison test series

An echo with 250 ns delay and 2 dB attenuation relative to the original signal is generated by means of the TV Test Transmitter SFQ with the fading simulator option. The echo plus the signal sent via the direct path produce the fading spectrum shown in FIG 30 with pronounced dips in the frequency response characteristic. The maximum difference between the results obtained with the NRVS and the EFA occurred at –33.79 dBm for the NRVS and –33.0 dBm for the EFA. The results of the above level measurements are stated in detail in [11].

Output power in the event of amplifier failure

In the state-of-the-art transmitters from Rohde & Schwarz [12], the Exciter SV 700 feeds the DVB-T signal to the power splitter that drives the power amplifiers. These are designed as twin amplifiers. The amplifier output stages, likewise designed as twin stages, are LDMOS power transistors (FIG 31). Depending on the required transmitter power, a number of amplifiers operate in parallel. Two amplifiers are combined via a coupler in each case. The coupler output signal is bandpass-filtered to increase the shoulder distance and taken to the transmit antenna. Depending on the degree of suppression of the stopband of the bandpass filter, an extra filter may be required to suppress local oscillator harmonics.

If one of the twin amplifiers fails, half of the power of the other twin is terminated by an absorber which is cooled to prevent overheating. The residual output power of a transmitter after an amplifier failure is calculated as follows:

$$P_{out} = P_{nominal} \cdot \left(\frac{m-n}{m}\right)^2$$

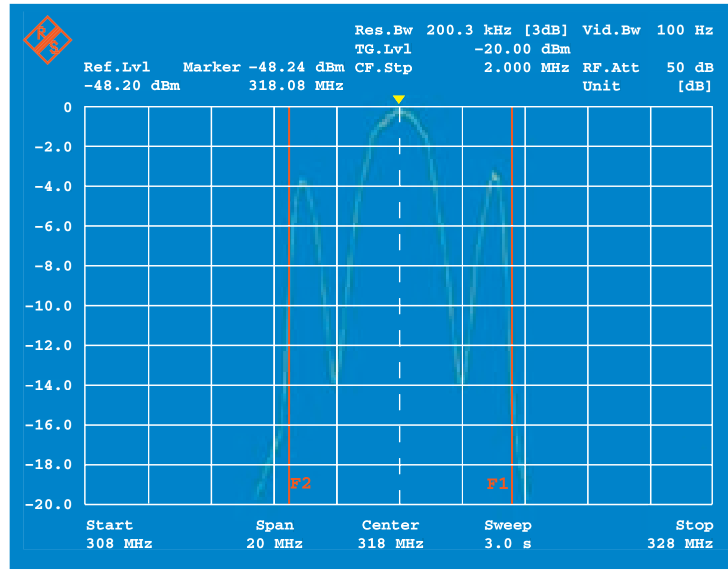
where P_{out} is the real output power, $P_{nominal}$ the nominal output power, m the number of amplifiers fitted, and n the number of defective amplifiers.

Example: In a 2.5 kW DVB-T transmitter with a total of six amplifiers, one amplifier has failed. The transmitter continues operation with reduced power as follows:

$P_{out} = P_{nominal} \cdot 0.694$
(with m = 6 and n = 1).

The transmitter characteristic remains the same, it is merely shifted – parallel to the previous characteristic – towards the lower power value. All other quality parameters remain unchanged. This also applies if individual power transistors of an amplifier fail. The advantage is that neither the amplifiers nor the power transistors are overloaded, i.e. the MTBF (mean time between failures) of the operational elements is not affected.

FIG 30
Fading spectrum



Amplifier replacement

Long-term measurements

FIG 32 illustrates the setup for a long-term measurement with the DVB-T Test Receiver EFA. A defective amplifier can easily be identified in remote monitoring from the transmitter power histogram

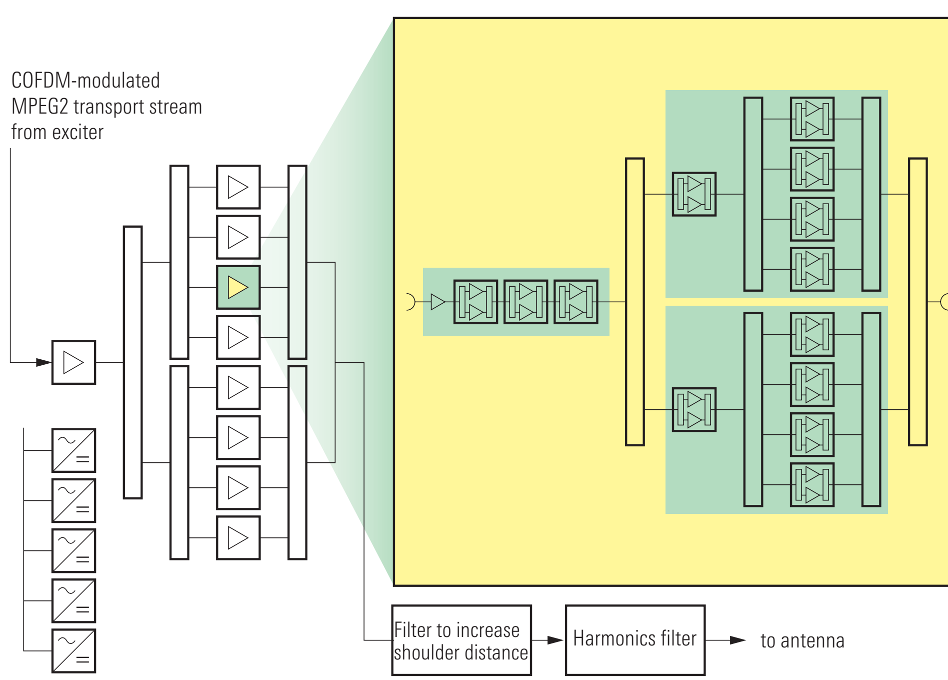


FIG 31 Basic design of state-of-the-art solid-state transmitters from Rohde & Schwarz

displayed on the test receiver (FIG 33). If the transmitter power is reduced by a constant 1.59 dB, e.g. with DVB-T Transmitter NV 7250, this means that one of the six amplifiers has failed. At higher transmitter powers the difference is smaller but still clearly identifiable from the histogram. The power drop in each case can be calculated with the above equation.

What to do if an amplifier fails?

First, remove the defective amplifier plug-in from the transmitter rack and insert a replacement. The Rohde & Schwarz transmitters allow replacement also during operation. Next, match the level and phase of the replacement amplifier to that of its twin amplifier. To do this, use a Spectrum Analyzer FSEx or FSP or a Test Receiver EFA as employed in DVB-T transmitter monitoring. The procedure is very simple: with optimally matched phase, the transmitter will output maximum power. Therefore, adjust the phase until maximum transmitter output power is attained.

Sigmar Grunwald

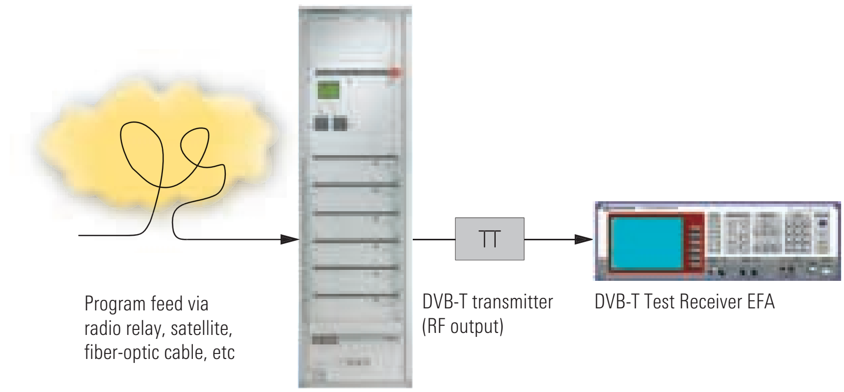


FIG 32 **Long-term measurement of transmitter power**

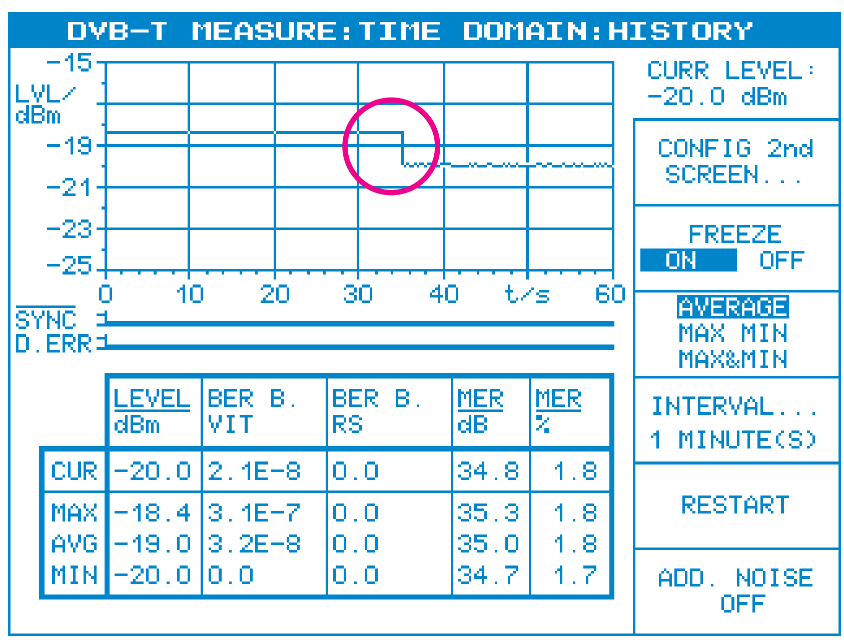


FIG 33 **Power histogram generated by DVB-T Test Receiver EFA. Marked red: power drop after failure of one of the six amplifiers is clearly identifiable.**

REFERENCES
[11] Application Note 7BM12 (for free-of-charge download from Rohde & Schwarz web site)
[12] UHF Transmitter Family NV / NH 7000 – Liquid-cooled TV transmitters for terrestrial digital TV. News from Rohde & Schwarz (1999) No. 165, pp 11–13

Crypto Mobile Phone TopSec GSM

Secure communication – protected against data thieves

Flexibility and mobility are key factors to success; up-to-the minute information and quick decisions have become more important in industry and politics than ever before. Mobile phones are often used to pass on information quickly. Users become more and more aware of the fact that enormous security problems may arise. The usual means of communication – telephone, mobile phone, fax, mail – are the main sources that attract data thieves. Damage caused by industrial espionage in Germany is estimated to run into at least 20 billion marks every year.

Photo 43756/2

FIG 1 The TopSec GSM looks like an ordinary GSM mobile phone. Inside, however, a complex crypto processor provides extremely secure encryption.

A risk to be taken seriously

One of the security problems in GSM mobile radiocommunications is that calls are only encrypted between mobile phone and base station. From the base station, the calls are routed without any protection via the normal fixed network – often via microwave link. In commercial and governmental environments, efficient encryption should therefore be used to protect confidential communication.

The best way of protecting confidential information against unwanted eavesdroppers and thieves is the use of high-quality encryption devices as offered by Rohde & Schwarz SIT GmbH: their "TopSec" product family ensures extremely secure voice and data communication in ISDN and GSM networks.

This article deals with the TopSec GSM mobile phone (FIG 1) for tap-proof mobile communication.

TopSec GSM: mobile and confidential

The TopSec GSM crypto mobile phone was originally developed by Siemens. In May 2001, Rohde & Schwarz SIT GmbH took over from Siemens the hardware encryption business segment with the associated range of products. Since then Rohde & Schwarz SIT is responsible for further development and marketing of the crypto mobile phone.

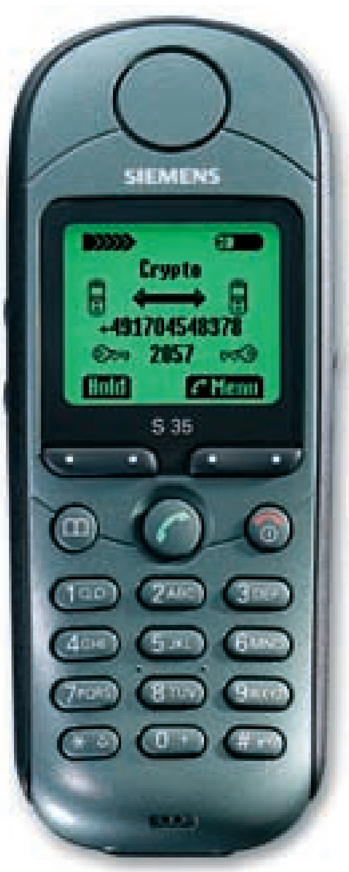


Photo 43 756/4

FIG 2 The activated crypto mode is indicated on the display

The TopSec GSM mobile phone looks exactly like the commercial Siemens dual-band mobile phone S 35i, and also has the same performance features: low weight, high speech quality, long talk and standby times, Internet access via WAP, IR interface, etc. Inside, however, it has a crypto module in the size of a postage stamp.

Confidential communication in mobile radio and ISDN networks

The TopSec GSM mobile phone is suitable for encrypted end-to-end voice communication in the GSM frequency ranges of 900 MHz and 1800 MHz and with the ISDN network. The only prerequisite for encrypted calls is that the called station must also be equipped with a TopSec device, which means that end-to-end encryption is not only possible between two TopSec mobile phones, but also between a TopSec GSM phone and an ISDN network subscriber terminal that is protected by a TopSec crypto box. The TopSec 703 from the TopSec product family is a suitable ISDN encryption unit, for example. This encryption unit is connected between the NTBA and the ISDN terminals. Mobile subscribers can make tap-proof calls from their TopSec GSM phones to their office numbers in the fixed network.

Complex, extremely secure crypto technology

A complex crypto processor is the core of the TopSec GSM. For encrypted calls, the GSM data channel with a bandwidth limited to 9600 bit/s is used instead of the voice channel. To enable transmission via the data channel, the voice signal is first compressed by a GSM half-rate vocoder; information for error detection and correction is then added to the signal before it is encrypted. The data protected in this way is provided with further information for synchronization of the called station and sent via the data channel. The speech quality is as excellent as in non-encrypted mode.

The high level of security is ensured by a combination of two algorithms: an asymmetrical algorithm with a 1024-bit key for key agreement, and a symmetrical algorithm with a 128-bit key for voice encryption. For each call, the 128-bit key is randomly selected from 10^{38} possibilities. Security is extremely high: even in 10 million years, 1000 Pentium PCs could test only a very small part of the vast number of possible keys.

In addition to encryption, the TopSec GSM provides authentication as an optional security function. With the aid of special software, several TopSec GSM phones can be combined in closed user groups, allowing encrypted communication only within the same group.

Absolute confidentiality at a keystroke

Of course, the TopSec GSM can also be used for making non-encrypted calls to any partner. It is operated exactly like the Siemens S 35i mobile phone. An encrypted connection can be established at a keystroke. After pressing the call setup key, the calling person only has to activate the crypto function by pressing the appropriate softkey (FIG 2). Everything else is automatic: a data call is initiated and the key is exchanged within 15 seconds.

Key features of the TopSec GSM

- High security level
- Top-quality voice encryption for end-to-end voice communication
- Same high speech quality in encrypted and non-encrypted mode
- Simple handling
- Recommended by the German Information Security Agency

The TopSec GSM features all the benefits of a modern mobile phone

- Ease of operation
- Voice dialling
- Small size
- Low weight
- Internet access via WAP browser
- Soft modem
- IR interface for mobile data transfer

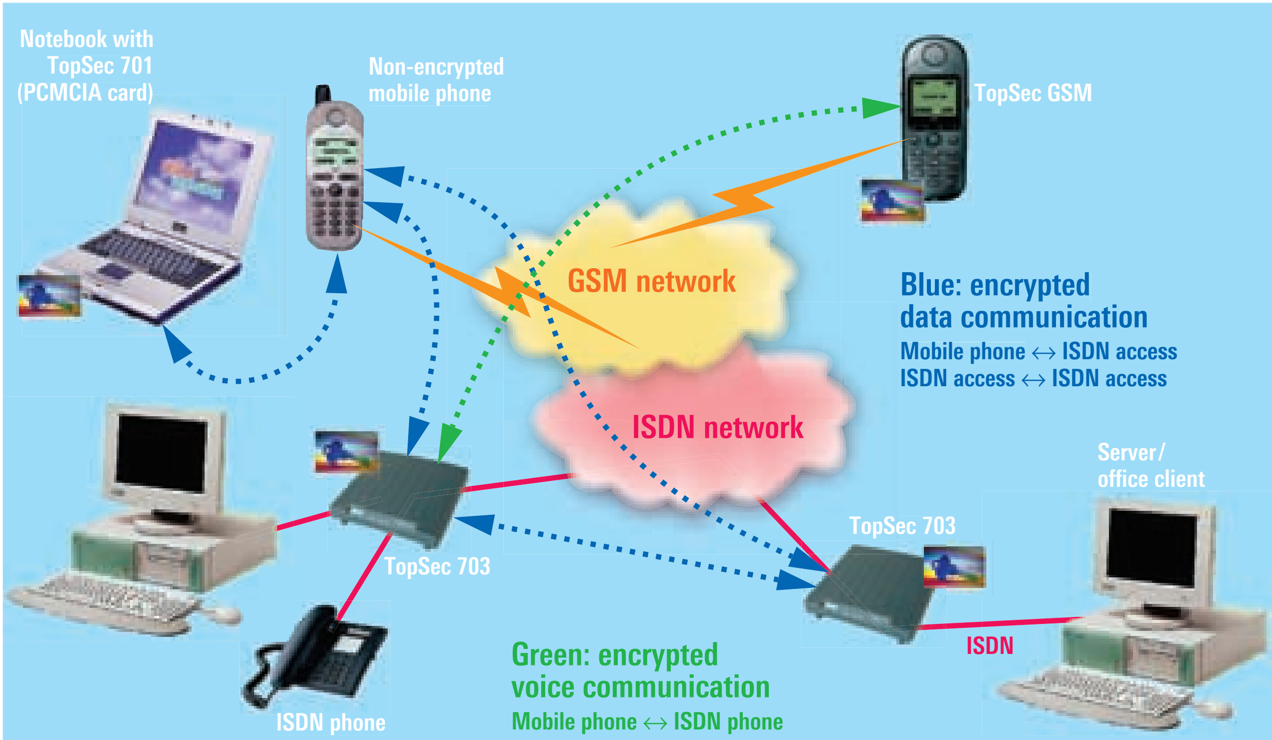


FIG 3 **Crypto products from the TopSec family allow secure voice and data communication under any technical conditions**

Encrypted calls can be terminated exactly like normal calls by pressing the clear key. Upon termination of the call, the initially generated key is deleted, which is a significant security factor in addition to the enormous key length.

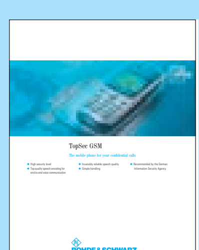
The TopSec product family

Besides the TopSec GSM, the TopSec family comprises the TopSec 703 for ISDN base rate access S_0, the TopSec 730 for ISDN primary rate access S_{2M}, and the TopSec 701 for data transfer. The TopSec 703 and the TopSec 730 can be used for encryption of all services transmitted via ISDN: voice, fax, video and data.

The TopSec 701 is a PCMCIA card for insertion in laptops. It allows encrypted data to be transferred from a laptop via mobile phone to a TopSec 703 or TopSec 730 in a fixed network, or between two TopSec 701 via an analog link using a modem. FIG 3 shows the various possibilities of encrypted voice and data communication provided by the TopSec product family. The whole crypto family will be described in detail in one of the following issues.

Christine Hagn

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



Data sheet TopSec GSM

CCDF determination – a comparison of two measurement methods

Measurement of the CCDF (complementary cumulative distribution function) is often used for evaluating nonlinearities of amplifiers or transmitter output stages, for instance (see also refresher topic on page 44). This measurement indicates how often the observed signal reaches or exceeds a specific level. From a physical point of view, the CCDF measurement is the integral of the distribution function versus the level (integration of the observed level to infinity). Comparison of measured values and theoretical reference values (which can be determined for OFDM or mQAM/VSB) quickly yields information on the nonlinear response of all types of active elements. However, the great advantage of the CCDF measurement is that the useful signal itself is analyzed; as a result, it is not necessary to transmit complex test sequences. This test tip compares two different measurement methods.

CCDF determination – an important measurement in RF transmission systems

To minimize the overall signal degradation on the path to the receiver, amplification of the transmitted RF signal should be as pure as possible. However, it is necessary to limit the power of the transmitted signal (clipping) to avoid unnecessarily reducing the lifetime of the transistor output stages of the transmitter. For this reason, particular attention is given to the CCDF measurement as well as to the related crest factor $\hat{u}/u_{rms}$ in the development and operation of high-power transmitters. In practice, two different measurement methods are used, which produce different results.

Method 1: Sampling of the RF/IF signal – using the TV Test Receiver EFA, for example

In the TV Test Receiver EFA [1], the modulated signal is converted to an appropriate intermediate frequency and digitized (FIG 1, left). The digital samples are evaluated, and the CCDF represented. For an ideal CW (continuous wave) signal, this method yields a crest factor of 3 dB. The IF filtering occurs via a SAW filter adapted to the signal bandwidth; video filtering of the signal is not carried out, and thus the signal itself is not modified (FIG 2).

Method 2: Sampling the envelope – using the Spectrum Analyzer FSP, for example

The central element in a spectrum analyzer is the envelope detector. Via appropriate time filtering, the modulated signal is assigned a level value (FIG 1, right). The high-frequency modula-

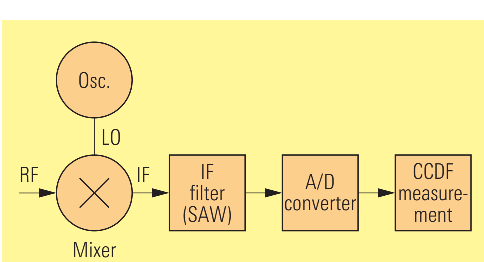
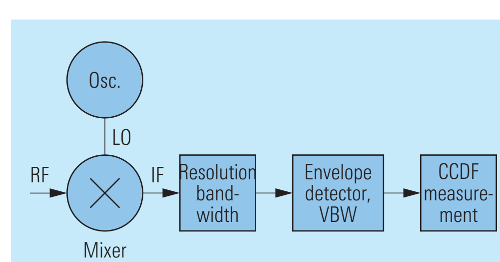


FIG 1
Simplified representation of the signal path to determine the CCDF via the TV Test Receiver EFA (left) and the Spectrum Analyzer FSP (right)



tion is eliminated from the signal; only the "envelope" signal is used (FIG 2). The measured values of a pure CW signal always have the same amplitude; it has thus a crest factor of 0 dB. In the case of IF and video filtering, it must be ensured that the resolution bandwidth (RBW) and the video bandwidth (VBW) do not distort the signal:

$$BW_{Resolution} > BW_{Signal}, \; BW_{Video} \geq 3 \cdot BW_{Resolution}.$$

Differences in the results of the two methods

The TV Test Receiver EFA analyzes the signal exactly as it is present at the RF input. According to its definition, a pure CW signal has a crest factor of 3 dB. The spectrum analyzer, on the other hand, analyzes the signal as it is present in the baseband (i.e. prior to modulation by the RF carrier), which in the case of the CW signal results in a DC voltage and consequently in a crest factor of 0 dB (ideally). Investigations have shown that the crest factors of both methods vary by 3 dB also in the case of random signals. However, the results of the CCDF measurements according to methods 1 and 2 cannot be converted one into the other simply by taking into account the difference of 3 dB. FIGs 3 and 4 show examples of the CCDF measurement using the Spectrum Analyzer FSP and the TV Test Receiver EFA.

Conclusion

Measuring the CCDF is a simple and effective method of determining the nonlinear characteristics of active elements. If the measurement of the CCDF is to be referred to the signal actually transmitted (instead of to the envelope), it is advisable to use the TV Test Receiver EFA.

Christoph Balz

REFERENCES

[1] TV Test Receiver EFA: see article on page 34 in this issue

[2] Spectrum Analyzer FSP: see article on page 20 in this issue

◆ The refresher topic "Measurements on MPEG2 and DVB-T signals" starting on page 44 covers the crest factor in detail

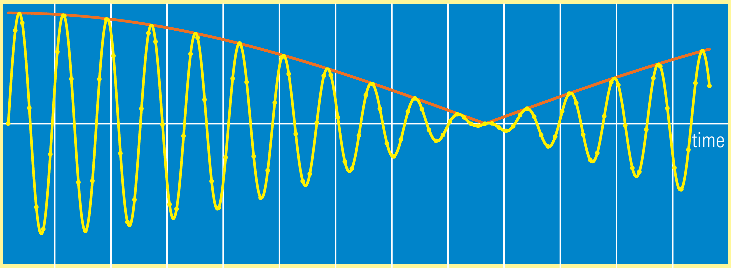


FIG 2 Time characteristic of a modulated signal; yellow: original signal, yellow dots: measured values used by the TV Test Receiver EFA to calculate the CCDF (measurement method 1); red: measured values used by a spectrum analyzer (measurement method 2).

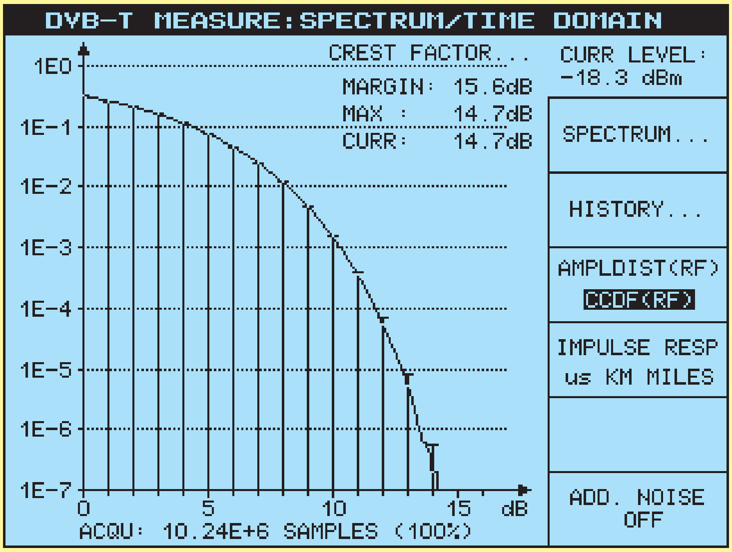


FIG 3 CCDF measurement with the TV Test Receiver EFA (method 1). Signal: OFDM with 64QAM; both the measured values (continuous line) and the theoretical values of an ideal signal are shown. The limitation of the signal in the case of high crest factors is clearly discernible.

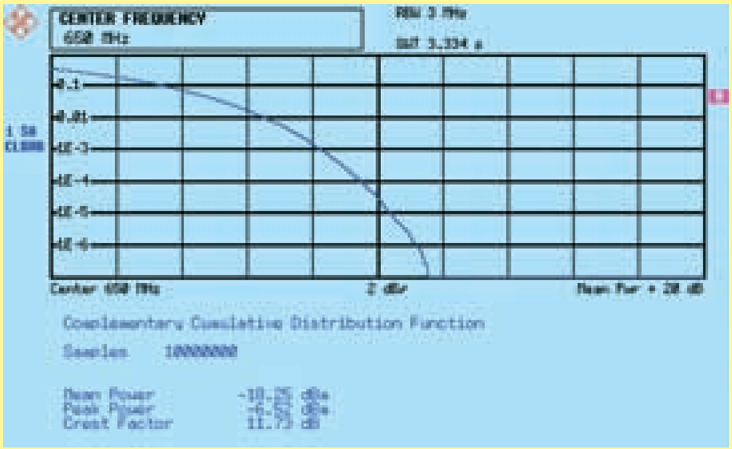
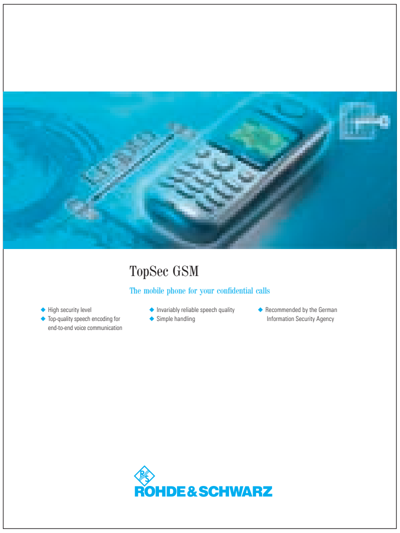


FIG 4 CCDF measurement with the Spectrum Analyzer FSP (method 2). Same signal as in FIG 3; the crest factor (11.73 dB) is 3 dB lower than in the measurement according to method 1 (14.7 dB, FIG 3).



TopSec GSM Crypto Mobile Phone See article on page 49.

Data sheet PD 0757.6904.21

Digital Reprogrammable Software Radios M3SR M3SR (multiband, multimode and multi-role surface radio) represents an innovative and versatile generation of software radios for use in the navy, in civil and military air traffic control, air defence, and in stationary applications. In addition to M3TR and M3AR, the M3SR series is the third element of a new radio equipment generation. All three feature a functionality that can be varied by means of software.

Data sheet PD 0757.6691.21

Phase Noise Measurement Software FS-K4 Replacement for FSE-K4. The new software can be used with the Spectrum Analyzers FSE/FSIQ/FSP/FSU and the EMI Test Receivers ESI/ESPI.

Data sheet PD 0757.6727.21

Digital Standards GPS, TETRA, WCDMA 3GPP (TDD), TD-SCDMA Supplementary data for Vector Signal Generator SMIQ.

Data sheet PD 0757.6885.21

EMC Measurement Software EMC32 EMC32 is an EMC test program which runs on 32-bit operating systems from Microsoft. A common user interface is available for electromagnetic interference (EMI) and electromagnetic susceptibility (EMS) measurements, see article on page 27.

Data sheet PD 0757.6779.22

Measurement Software ROMES3 The new Measurement Software ROMES3 provides the platform for many systems from Rohde&Schwarz, which allow most problems in communication networks to be detected and analyzed. ROMES3 collects data quickly and conveniently during test tours and offers versatile visualization to meet the user's requirements (see also News from Rohde&Schwarz (2000) No. 166, pp 29–32).

Data sheet PD 0757.6679.21

CMU200 WCDMA – The 3G Tester Another CMU200 model, focusing on WCDMA.

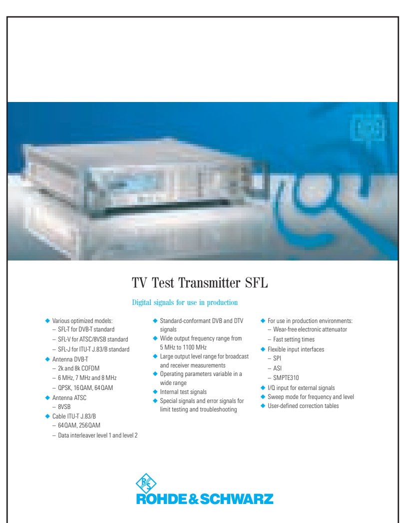
Data sheet PD 0757.6456.21

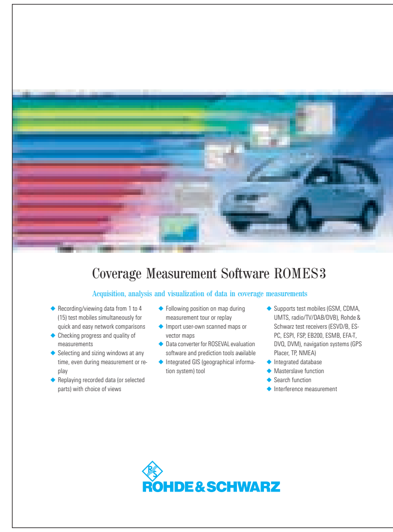
VHF FM Solid-State Transmitters SR500E1 As an extension of the successful fourth generation of Solid-State Transmitters SR600E1 (power range 2.5 kW to 10 kW), Rohde&Schwarz now also offers a new transmitter family for the medium power range (500 W to 1 kW). Like the high-power transmitters, the new SR500E1 transmitter generation is characterized by a very compact and clear design. The FM Transmitters SR505E1 and SR510E1 are ideal for local broadcasting stations. Like all Rohde&Schwarz transmitters, they are designed for unimpaired operation at high power and low cost while in use. They are therefore the ideal choice for unattended stations, since they can also be remotely monitored.

Data sheet PD 0757.6733.21

TV Test Transmitter SFL The new test transmitter – ideally suited for use in production – generates signals for testing digital TV receivers and digital TV links (terrestrial antenna, North American cable), see article on page 30.

Data sheet PD 0757.6962.21





Multichannel Digital Video Quality Analyzer DVQM The DVQM is a multichannel extension of the successful Digital Video Quality Analyzer DVQ. The DVQM can combine the performance of up to twelve DVQs. The resulting wide variety of configurations allows the DVQM to be optimally adapted to different requirement profiles.

Data sheet PD 0757.6510.21

DV-HDTV Transport and Elementary Stream Collection Describes a collection of high-resolution elementary and transport streams for use with DVG and DVRG.

Data sheet PD 0757.6979.21

Universal Radio Communication Tester CMU300 The CMU300 is the counterpart of the CMU200. It tests base stations for 2nd generation (GSM with GPRS and EDGE) and 3rd generation WCDMA (see also article in News from Rohde&Schwarz (2001) No. 170, pp 4–6).

Data sheet PD 0757.6091.21

New application notes

Noise Power Ratio (NPR) is an add-on software tool for the I/Q Simulation Software WinIQSIM, which allows the generation of an NPR signal and the measurement of the resulting NPR of a DUT with Rohde&Schwarz measuring instruments via the IEC/IEEE bus. This measurement method determines the linearity of broadband amplifiers versus a defined frequency range. The NPR considerably shortens the measurement times compared to conventional sweeping and is thus of particular interest in production.

Application Note 1MA29

Snell & Wilcox and Rohde & Schwarz agree to cooperate in the field of broadcasting T&M products

The two leading suppliers of solutions for digital TV agreed on a worldwide cooperation at this year's International Broadcasting Convention in Amsterdam.

As the first outcome of this cooperation, Rohde & Schwarz will integrate a special version of the well-known TestCard M (TCM) from Snell & Wilcox as an option in its MPEG Generators DVG and DVRG. Further joint projects are planned. Due to the wide variety of signals encountered in development, the combination of the TCM signals and Rohde & Schwarz products is ideal for integrating decoder chips in digital TV receivers and for verifying set-top boxes. "The cooperation we have entered into enables us to join our strengths in order to offer the market better solutions than any other competitor," declared Michael Vondermaßen, Head of the Broadcasting Division at Rohde & Schwarz.

Rohde & Schwarz at SYSTEMS 2001

Rohde & Schwarz presented a number of communication security solutions in the IT security area of this year's SYSTEMS trade fair.

The Rohde & Schwarz subsidiary SIT presented the new crypto solutions of the TopSec product family, including the world's first tap-proof mobile telephone TopSec GSM (page 49). The TopSec 703 encryption unit, which was also introduced, not only enables tap-proof connections to be established between fixed-network ISDN telephones, but also allows confidential phone conversations using the TopSec GSM crypto mobile. Other products for secure communication via leased line, modem, and ISDN, as well as for data encryption were also on display.

Rohde & Schwarz and GigaWaveTech develop *Bluetooth*™ test solutions

Rohde & Schwarz SCA Singapore and GigaWaveTech (Pte) Ltd. have agreed on a cooperation to jointly develop *Bluetooth* test solutions.

Since April 2001, both companies have been jointly working on a test setup for GigaWaveTech's *Bluetooth* designs. At the Taitronics trade fair held in Taipeh in October, the partners presented their first results: a *Bluetooth* production test setup based on the Rohde & Schwarz Radio Communication Tester CMU 200.

Stefan Böttinger

High-power TV transmitters for South Africa

The renowned South-African operator Sentech and Rohde & Schwarz have concluded a two-year basic agreement for the delivery of analog high-power TV transmitters. Since the deregulation of the South-African broadcasting market, Sentech has been modernizing and expanding the available infrastructure. The high technical level maintained by Sentech also places exceptionally high demands on the suppliers. Rohde & Schwarz will deliver the first 14 analog high-power VHF and UHF transmitters by the end of the year. The crucial factor for Sentech's decision was the similarity of two transmitter series with respect to functionality, maintenance and operation. The excellent price/performance ratio was another convincing argument in their favour. The new agreement makes Rohde & Schwarz the main supplier of Sentech's high-power broadcasting equipment.

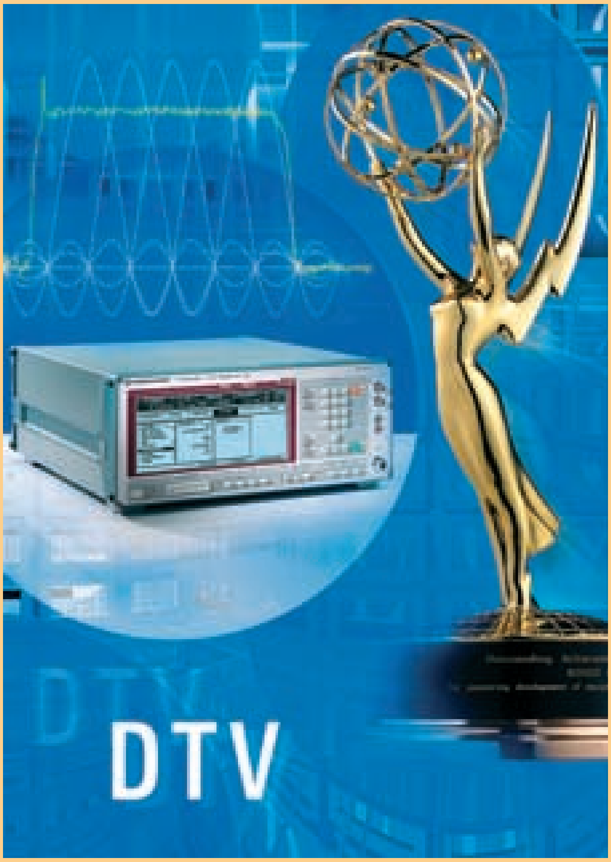
Monika Roth

EMMY award for the TV Test Transmitter SFQ

The National Academy of Television Arts and Science has presented the prestigious EMMY award to Rohde & Schwarz. The award went to the TV Test Transmitter SFQ for its unique capabilities and its contribution to the further development of digital TV.

The EMMY is awarded annually for outstanding artistic and technical achievements in the field of television. Not only actors and TV stars receive the award, but also innovative technical equipment which contributes to the further development of TV. The TV Test Transmitter SFQ from Rohde & Schwarz received the prestigious award for its capability of generating signals of the major modulation modes to all broadcasting standards, thus enabling the fast development and production of digital TV receiver chips and set-top boxes in line with future requirements. This unique functionality was considered worthy of the EMMY by the National Academy of Television Arts and Science. During the award ceremony in New York on 16 October, the famous golden statue was handed over to Michael Vondermaßen, Head of the Rohde & Schwarz Broadcasting Division.

Last year, the EMMY also went to a Rohde & Schwarz measuring instrument. The Digital Video Quality Analyzer DVQ received the award for its revolutionary picture quality measurement principle according to subjective assessment criteria. The second award for Rohde & Schwarz measurement technology demonstrates the high technological level of the equipment, which is also reflected by the company's position as the world market leader for digital TV transmission and measuring equipment.



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