News from Rohde & Schwarz

Audio measurements
Analysis, monitoring, data transmission

EMC test cell
Favourably priced alternative to anechoic chambers

Customized radiomonitoring
from 10 kHz to 18 GHz

151

ROHDE & SCHWARZ

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Audio Analyzer UPL is able to perform practically all audio measurements on analog and digital interfaces. As the "younger brother" of the internationally successful UPD, which still holds the top position in audio measurements, UPL is *the* solution for budget-conscious users. For more details see article on page 4. Photo 42 458 (Beethoven picture: Amadeus-Verlag, Winterthur)

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Regular features

Because of their low operating costs radiopaging services are becoming increasingly popular worldwide, with more and more new standards (eg ERMES, POCSAG) being established. Paging System P2000 from Rohde & Schwarz is a flexible, multiprotocol radiopaging system that meets all present and future requirements of network operators (see article on page 25).
Photo 42 457/1

Imprint

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Audio Analyzer UPL

Audio analysis today and tomorrow

Rohde & Schwarz has extended its range of audio analyzers by UPL, the "younger brother" of UPD, which still holds the top position in audio measurements. UPL is mainly for use in production tests on digital and analog audio units both in the consumer and professional sectors.

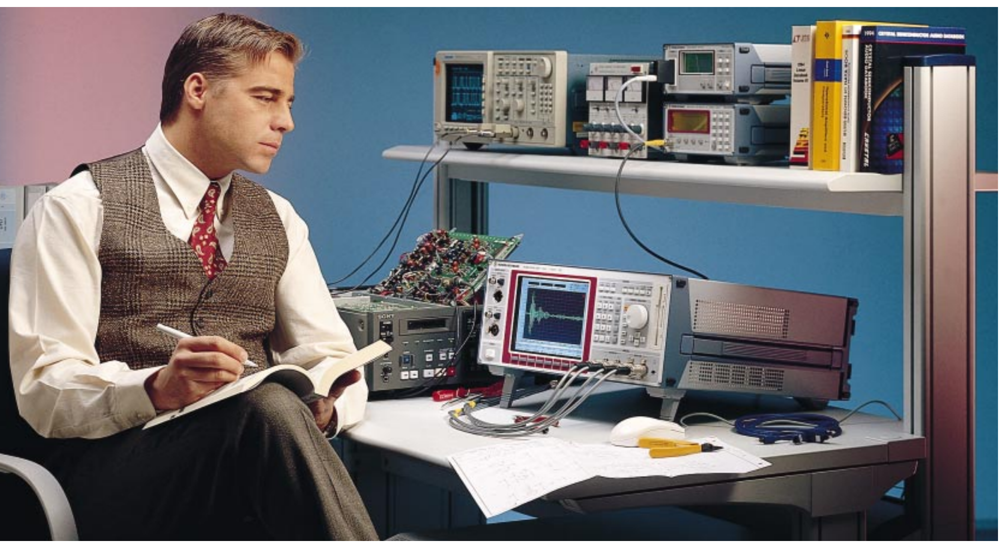


FIG 1 Audio Analyzer UPL, specialist for all analog and digital audio signals
Photo 42 383/2

While audio-signal processing is no longer conceivable without the use of digital techniques, analog techniques continue to exist and undergo constant improvement – the human ear is analog after all. A state-of-the-art audio analyzer like UPL (FIG 1) must therefore be able to handle both analog and digital signals. UPL is capable of fast and accurate frequency-response measurements, spectrum display of demodulated wow-and-flutter signals, generation of multitone signals comprising several thousand spectral lines, output of digital audio signals via loudspeaker, jitter measurements on digital audio signals, and so on. In short, there is hardly any task UPL cannot solve. And on top of this, UPL offers excellent technical data: analog sinewave generation with harmonics suppressed by typically 115 dB, spectrum displays with a noise floor as low as –140 dB at analog and –160 dB at digital interfaces, and fast Fourier transform with maximum frequency resolution of 0.05 Hz.

Analysis concept

UPL performs all its measurements using digital signal processing. Analog signals to be tested undergo extensive preprocessing on analog modules before they are digitized and measured by means of digital routines. This concept provides an extended dynamic range and guarantees performance and flexibility far superior to instruments performing purely analog or digital measurements.

The test routines performed on analog and digital interfaces are identical. This allows, for example, direct comparison of results obtained ahead of and after a converter. All test functions and test signals are available both at the analog and the digital interfaces. This makes it possible to measure at any point of a combined analog and digital transmission path. Only this ensures efficient and complete testing. The filters too are implemented digitally, resulting in an almost infinite number of filters, and this also for measurements on analog interfaces. All the user has to do is choose the type of filter (highpass, bandpass, etc), frequency and attenuation to loop a new filter into the test path (FIG 2).

The measurement speed provided by UPL is as a rule higher than that achieved with analog techniques since digital test routines can adapt their speed to the input frequency. Operation is the same for the analog and the digital interfaces – a feature that should not be underestimated, especially if different types of application are to be handled.

UPL offers the following **analysis functions:**

- selective and broadband level measurements with rms, peak or quasi-peak weighting,
- up to three filters of the integrated digital filter bank can be looped into the signal path (14 weighting filters in addition to user-programmable filters),
- intermodulation measurements (total harmonic distortion (THD), modulation distortion, difference frequency distortion); each type of intermodulation can also be represented as a bar chart,
- wow-and-flutter measurements to DIN/IEC, NAB, JIS or 2-sigma method with additional spectrum display of the demodulated signal,
- frequency, phase and group-delay measurements,

- waveform function for representing test signals in the time domain with optional smoothing of waveform by interpolation and compression of slow sequences (eg for tests on AGC circuits),
- spectral analysis (FFT) with zoom function for maximum frequency resolution of 0.05 Hz (FIG 3).

The following **test signals** are available:
- sinewave that can be applied to an equalizer with user-selectable nominal frequency response, eg for compensating the frequency response of a test setup,
- two-tone signal for intermodulation measurements (amplitude ratios and frequencies continuously adjustable),
- multitone signal comprising up to 7400 frequencies with selectable amplitude distribution (frequency spacing can be linked to resolution of fast Fourier transform, thus enabling rapid and accurate single-shot measurement of frequency response of EUT),
- arbitrary signal for generating any trace of up to 16,384 points,
- sine burst and sine^2 burst signal with adjustable interval and on-time,
- noise with a variety of amplitude distributions,
- dither with adjustable level and selectable amplitude distribution to be added to digital audio signals.

UPL is able to perform amplitude and frequency sweeps for all test signals and in addition interval and on-time sweeps for bursts.

Use in production

UPL is particularly attractive for applications in production. For example, it can perform all test functions simultaneously in two channels. This feature alone reduces the time for stereo measurements by 50% compared with most analyzers available on the market. Intermodulation measurements are carried out using patented, digital procedures that combine high accuracy with high measurement speed. Fast frequency-response measurement using a special, FFT-coupled multitone signal affords a decisive time advantage especially in intermodulation measurements, which are often required. Digital signal processing reduces setting and transient times as against those achieved with comparable, purely analog instruments.

An integrated program generator, which translates each manual control step into a complete IEC/IEEE-bus program line of correct syntax in the logging mode, considerably speeds up control-program generation. Furthermore, instrument setups generated on Audio Analyzer UPD [1; 2] in the development lab can be used on UPL in production, which substantially reduces the time for test-program generation. Long calibration intervals, resulting from the extensive use of digital circuits, make for high availability of the instrument.

Measurements on digital audio interfaces

UPL has **balanced, unbalanced and optical inputs and outputs** for connecting consumer electronics and professional studio equipment. Additional inputs and outputs allow the analyzer and generator to be synchronized to the digital audio reference signal (DARS), and the generator to wordclock, video sync signals and to 1024-kHz reference clocks. The generator and the analyzer can be driven at separate, variable clock rates between 27 and 55 kHz. This allows the use of non-standard clock rates as encountered in sample converters, which are employed to an increasing extent, and in multimedia applications.

Of course UPL is also capable of analyzing **additional data** of the digital audio signal and **physical interface parameters.** For example, channel-

FIG 2 Easy definition of filters by means of a few entries

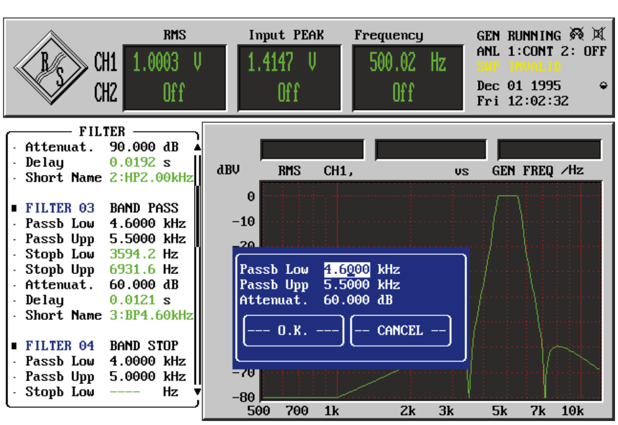
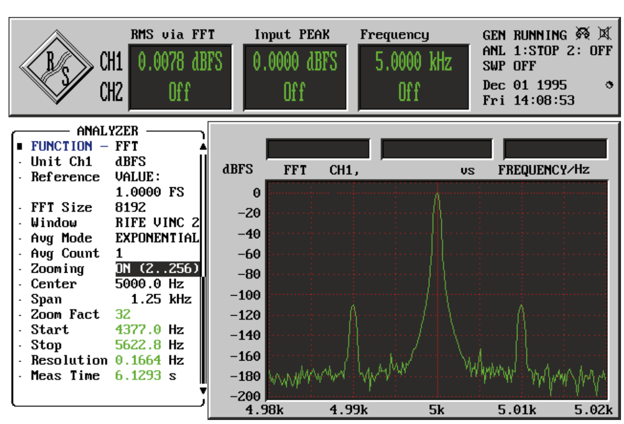


FIG 3 Zoom FFT function for displaying sidebands just a few hertz from main line of audio signal



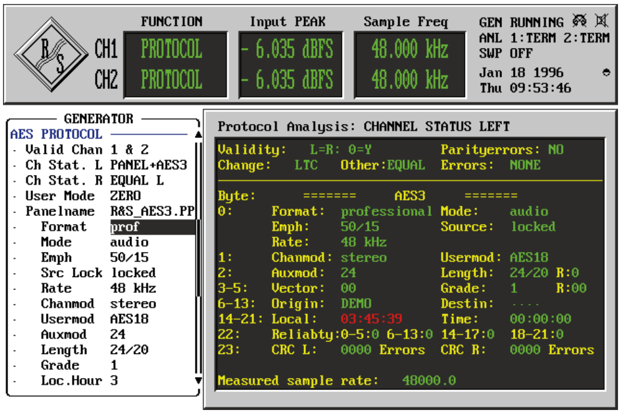


FIG 4 Analysis of additional data of digital audio signal coded in professional format

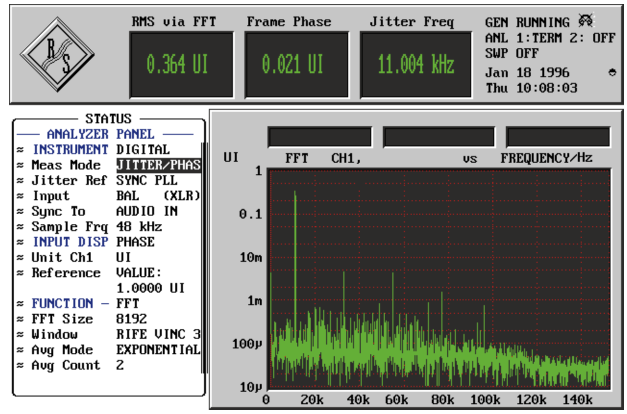


FIG 5 Jitter spectrum of digital audio signal

status data can be input and output in binary form or coded to professional, consumer or any user-defined format (FIG 4). UPL further provides display of jitter spectrum (FIG 5), measurement of jitter amplitude, generation of jittered output signals and is able to remove jitter from input signals.

Bit- and word-synchronous sync signals allow accurate analysis of digital audio signals on an oscilloscope. The preamble, eye pattern and superimposed noise can be displayed, for example. Moreover, the phase difference between the audio and the reference input can be measured, and a phase difference can be generated between the audio and the reference output. Delay times of equalizers, audio mixers, etc can be determined by measuring the time difference between the output and the input signal. Common-mode signals at the balanced input (frequency, amplitude, spectrum) can be analyzed and a common-mode signal can also be superimposed on the output signal. Audio Analyzer UPL further provides measurement of input-pulse amplitude and sampling frequency. The adjustable output level makes it possible to determine the sensitivity of digital audio inputs. Long cables can be simulated by means of a switchable cable simulator.

Future-proof investment

Who can predict for sure today what effects growing digitization will have on the audio world and what test requirements will result from this? In this respect there will be no problems with Audio Analyzer UPL. With all test functions implemented digitally, UPL can be adapted to changing requirements by simply loading the necessary software – and this also for the analog interfaces.

Wolfgang Kernchen

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Condensed data of Audio Analyzer UPL

Analog analyzer	
Frequency range	10 Hz to 110 kHz
Voltage range	0.1 µV to 35 V (rms, sine)
Inherent distortion (THD)	typ. <–115 dB
Analog generator	
Frequency range	10 Hz to 110 kHz
Voltage range	0.1 mV to 20 V (rms, sine, open-circuit)
Harmonics	typ. <–115 dB (<–120 dB at 1 kHz)
Digital analyzer and generator	
Clock rate	27 to 55 kHz
Frequency range	10 Hz to 21.75 kHz
Inputs and outputs	XLR, BNC, optical
Inherent distortion (THD)	typ. <–130 dB

Reader service card 151/01

EMC Test Cell S-LINE

Compact EMC test cell of high field homogeneity and wide frequency range

In S-LINE, Rohde & Schwarz offers a favourably priced test cell for measuring susceptibility to electromagnetic fields in the frequency range 150 kHz to 1 GHz in the development phase. The test cell, which comes in two sizes, is an attractively priced alternative to compact anechoic chambers. By generating the field using a symmetrical line, S-LINE offers a larger test volume than conventional cells.

With the expiry of the transitional period for the electromagnetic compatibility law at the beginning of this year, all manufacturers of electrical and electronic products in Europe are now required to supply EMC conformity declarations for their products and label them with the CE mark. Small and medium-sized businesses in particular have to decide which of the required measurements they can perform on their own with due consideration of their facilities and budget. Test setups and systems conforming to standards call for relatively high investment. Particularly interesting, therefore, are solutions that offer low-cost EMC measurements in preliminary testing, ie precertification, prior to acceptance testing. Such measurements can further provide proof of the effectiveness of EMC measures already at the development stage, so standard-conforming measurements performed by external test houses can be reduced to a minimum.

EMC measurements are divided into electromagnetic interference (EMI) and electromagnetic immunity or susceptibility (EMS) measurements. For EMI measurements, test receivers or spectrum analyzers are required. Many users have already invested in instrumentation of this type. Rohde & Schwarz offers the budget-priced Test Receiver ESPC [1], for example, which was presented in the spring of 1995 at the EMC show in Zurich.

For susceptibility measurements, signal generators and power amplifiers are needed and, like in EMI measurements, coupling networks or antennas in addition. Unlike EMI measurements, electromagnetic susceptibility measurements must be carried out in shielded enclosures. Standards stipulate a shielded (anechoic) chamber as test environment, which must be partially fitted with absorbers to achieve the required uniform field strength (referred to as uniform area). Since the construction and furnishing of anechoic chambers involve a lot of technology and expense, cheaper alternatives have already appeared on the market. Examples of this are TEM cells or GTEM (GHz Transverse Electromagnetic) Cells, compact anechoic chambers and precompliance test cells [2].

S-LINE, developed by Rohde & Schwarz, is a new type of EMC test cell (FIG 1) offering the user decisive **benefits:**

- substantially lower costs compared with anechoic chambers,

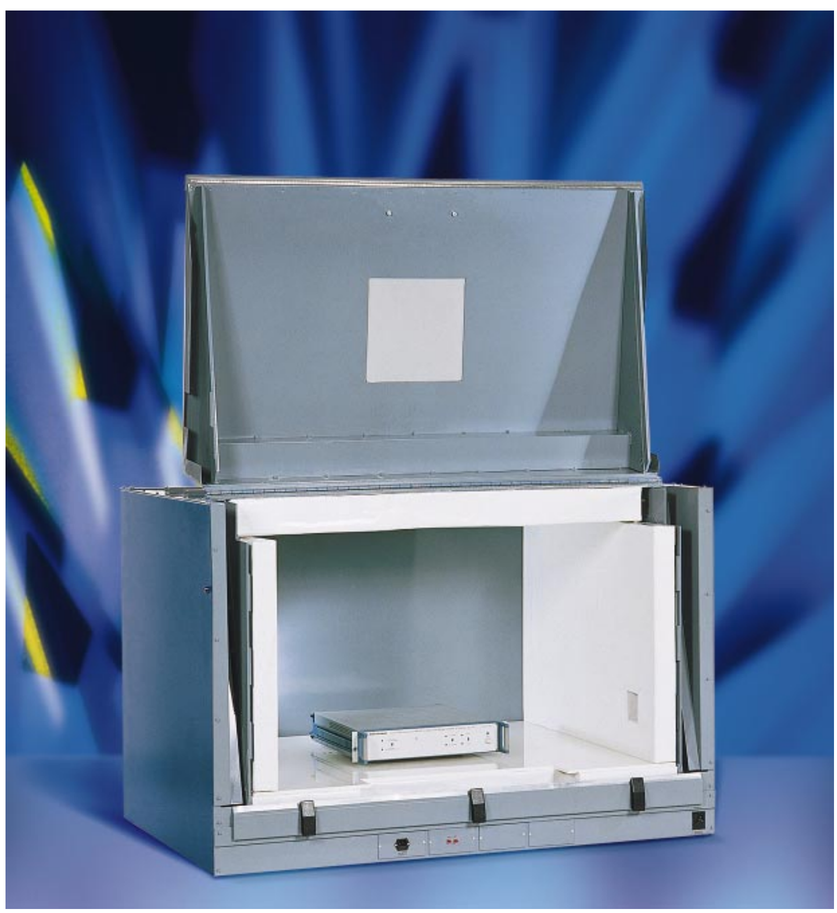

FIG 1 EMC Test Cell S-LINE, favourably priced alternative to anechoic chambers
Photo 42 456

- uniform field strength throughout test volume,
- highly compact size allowing easy installation in existing rooms,
- correlation with standard-conforming test methods.

Mechanical design

S-LINE comes in two sizes. The larger model with dimensions of 1.5 m x 1 m x 1 m offers a test volume comparable to that of compact anechoic chambers. This small size makes S-LINE suitable for use in any development lab. Compared with conventional precompliance cells, S-LINE has clear advantages with respect to radio-frequency characteristics. The enclosure prevents the emission of electromagnetic energy into the surroundings. It is fitted with an RF-shielded door which provides easy access to the inside. The EUT is taken up by a level worktop in the cell. Since the EUT functions must be monitored during measurements in S-LINE, a shielded window is fitted in the door and the cell can be illuminated inside for visual monitoring. For electrical monitoring, standard filtered feed-throughs are provided and, in addition, screwed-on access panels allowing the cell to be configured as required.

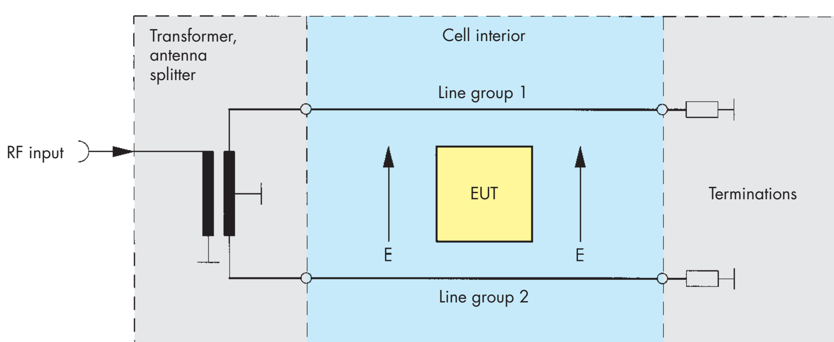

FIG 2 Electrical design of EMC Test Cell S-LINE (block diagram)

Operation

Conventional test cells can be regarded as widened unsymmetrical coaxial lines with the EUT exposed to the EM field between the inner and the outer conductor. By contrast, S-LINE consists of symmetrical, two-wire TEM lines provided in the electrically shielded enclosure (FIG 2). The lines are fed with an RF signal at one end and terminated with their characteristic impedance at the other. In this case too, the EM field generated between the lines is used for determining the electromagnetic susceptibility of the EUT. However, due to the symmetrical arrangement, a much greater test volume is obtained than with conventional cells of the same size.

A theoretical assessment of the field distribution in a transverse plane of S-LINE can be made using a simple charge distribution model. The enclosure surfaces form the mirror lines in the transverse plane. The potential field and consequently all other field parameters are obtained by superimposing the potentials of all charges. In the case of TEM transmission, this assessment can be applied to the E-field components. FIG 3 illustrates the area of the ±3-dB and ±6-dB limits of the relative field strength determined in the way described over the complete transverse plane of S-LINE. This is the plane in which the uniform area is to be proven in accordance with IEC 1000-4-3. S-LINE fulfills the standard requirements over an area of 50 cm x 50 cm. Practical measurements confirm the calculations and show that the requirement for a uniform area is fulfilled even in a volume of 50 cm x 50 cm x 50 cm almost in the entire frequency range.

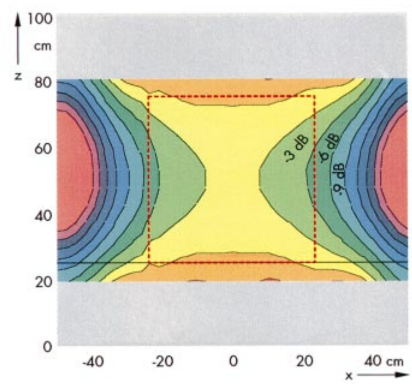

FIG 3 Field distribution in transverse plane of test cell. Coloured areas show regions of constant field strength, lines mark constant field strength in steps of 3 dB. Dotted red lines indicate uniform area of approx. 50 cm x 50 cm with relative field-strength variation of less than 6 dB.

FIG 4 shows the relative field strength measured in S-LINE as a function of height above EUT worktop. This height is normalized to the total height of the cell. The values measured in a conventional precompliance test cell are shown for comparison. It can clearly be seen that with a conventional cell a field-strength variation of almost 20 dB is to be expected, whereas with S-LINE the variation is just about 4 dB.

EMC systems and setups with S-LINE

S-LINE can be used to complement existing measuring equipment. Rohde & Schwarz also offers complete EMC test setups incorporating S-LINE. For example, an EMC test system for the frequency range 150 kHz to 1 GHz can be implemented with Signal Generator SMY, Power Meter NRVD,

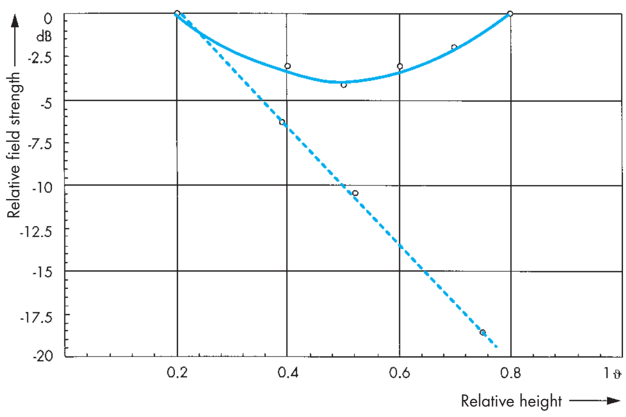

FIG 4
Relative field strength as function of height above cell base. Test positions are referred to total height of cell (continuous line: S-LINE with symmetrical lines, dotted: unsymmetrical lines).

a power amplifier and S-LINE. System Software EMS-K1 [3] allows fully automatic tests to be performed.

Dr. Klaus-Dieter Göpel

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Condensed data of EMC Test Cell S-LINE

Frequency range	150 kHz to 1 GHz
Input power	max. 100 W CW
Input impedance	50 Ω
VSWR of empty cell	<2.5; typ. <1.5
Size of uniform area	
Large model	approx. 50 cm x 50 cm
Small model	approx. 35 cm x 35 cm
Field strength	10 V/m at 20 W input power (large model, calculated in center of S-LINE)
Dimensions (L x W x H)	
Large model	1.5 m x 1 m x 1 m
Small model	1.0 m x 0.7 m x 0.7 m
EUT monitoring and supply	visually through shielded window, electrically via access panel with integrated filters, AC: 220 V/4 A, DC: 12 V/2 A, 5 V/4 A

Reader service card 151/02

Rohde & Schwarz now on Internet

Since the beginning of March, Rohde & Schwarz has been using its own Web site, ie a server for World Wide Web. The network address is:

http://www.rsd.de

The **offer** comprises **four categories** of information, mostly in English:

- "What's new" offers the latest news such as the press releases of the past months in German and English.
- "About Rohde & Schwarz" comprises general information about the company, history, technical milestones and international marketing addresses.
- The third category "Products" is the key offer and is arranged according to activity fields and applications. Written and display information about products can be called up.
- "Events" presents the complete Rohde & Schwarz training program in German and English and a list of known participation in shows for a whole year in advance.

Online information thrives on news. For this reason our pages are continually revised so that they are always right up-to-date.

We recommend use of the Netscape Navigator as an access program (Browser). This program ensures troublefree display of data. Ba

Signal Generator SME06/SMT06

Analog and digital signals for receiver measurements up to 6 GHz

The boom in the communications sector is continuing. More and more mobile-radio networks and new radiocommunication applications are being devised. As the frequency bands below 3 GHz are already densely occupied, increasing use will have to be made of the region above 3 GHz. Rohde & Schwarz has responded to this trend by extending its line of signal generators by two new models: SME06 and SMT06 for the frequency range up to 6 GHz.

FIG 1 Externally identical models SME06 and SMT06 extend signal-generator family to cover analog and digital receiver measurements up to 6 GHz. Photo 42 455

Since 1993, Rohde & Schwarz Signal Generators SME and SMT for up to 3 GHz have been highly successful on the market. Now this signal-generator family has grown by two new members: models SME06 (FIG 1) and SMT06 for applications up into the 6-GHz range. Good news for customers who have to meet requirements which stipulate immunity to interference tests on electrical equipment up to 4 GHz. SMT06 is an ideal and at the same time cost-effective signal source for this purpose. Further applications will open up in the 5-GHz range, where intensive R&D is under way on new systems such as WLAN (wireless local area network), WLL (wireless local loop) and electronic road toll systems.

With SME06 and SMT06, the measurement technology for these applications is in place well ahead of time.

The two new models are based on their lower-frequency "brothers" and were developed using frequency doubling. In other words, SME06 and SMT06 are identical to SME03 and SMT03 up to 3 GHz except for overvoltage protection, which is not provided on the new models since it would result in a considerable deterioration of the output reflection coefficient at 6 GHz. Despite this, reflected RF power up to 1 W is permissible with SME06 and SMT06. To eliminate any danger when working on transceivers, which often have RF output powers above 1 W, an external high-power attenuator (eg 10 or 20 dB) can be switched in. This external attenuation can be taken into account in SME and SMT as an offset, and the signal generator then indicates the level after the attenuator. In this way measurement errors are prevented.

Synthesizer concept

The market success of the Rohde & Schwarz signal generators proves that the right concepts were chosen. This holds both for SMT, which is a budget-priced solution with a single-loop synthesizer, and for SME, which features direct digital multiloop frequency synthesis, short settling times and digital modulation. From the different synthesizer concepts, different fields of application are obtained.

SMT covers the complete range of conventional analog receiver and EMC measurements, while SME is capable of both analog and digital modulation. Moreover, thanks to its fast frequency synthesis, SME is ideal for measurements on frequency-hopping systems and for tasks where every millisecond counts, eg tests on integrated circuits, since test time for the IC manufacturer is equivalent to test costs. A reduction of test time from 20 to a few milliseconds, for example, will substantially reduce manufacturing costs. With 500 µs settling time in the list mode, SME offers an excellent prerequisite for cutting down on these costs.

The difference between the two synthesizer concepts can clearly be seen, for example, from the SSB phase noise (FIG 2), where SME features excellent values close to the carrier up to 10 kHz. With –115 dBc at 1 kHz from a 1-GHz carrier, SME can compete with the very best of today's low-noise generators. Its favourable SSB phase-noise values make SME ideal for substituting a local oscillator, especially when it comes to critical applications in digital transmission and radar systems. SMT, on the other hand, shows its strength at more than 100 kHz from the carrier. With SSB phase noise of –150 dBc at 1 MHz from a 1-GHz carrier, SMT is suitable for blocking measurements even on high-end receivers.

Modulation

SME and SMT feature versatile modulation modes for tests on communications, navigation, telemetry and broadcast receivers. The generators are capable of simultaneous **AM, FM (φM) and pulse modulation.** For two-tone modulation, internal and external sources can be combined. The AM frequency range is DC to 100 kHz, the FM range DC to 8 MHz (SMT) or 2 MHz (SME) with maximum deviation of 40 MHz (SMT) and 4 MHz (SME). A special control circuit ensures high carrier-frequency accuracy in the FM DC mode. DC coupling is possible also with phase modulation. The φM bandwidth is 2 MHz for SMT and 100 kHz for SME. Another valuable feature is the high-quality pulse modulation, featuring a rise/fall time shorter than 10 ns and an on/off ratio better than 80 dB.

The versatile modulation capabilities are backed up by a variety of modulation sources. In addition to a fixed-frequency generator incorporated as standard, an LF generator can be fitted to SME/SMT to supply **sinewave, triangular, squarewave and noise signals.** The maximum frequency for sinewaves is 500 kHz. A multifunction generator provides the same signals as the LF generator over an extended frequency range up to 1 MHz and, in addition, **stereo multiplex and VOR/ILS modulation signals.** The multifunction generator makes SME/SMT suitable even for highly demanding measurements on FM stereo and VOR/ILS navigation receivers. A pulse generator supplies single and double pulses up to 10 MHz. It can be internally or externally triggered. The pulse delay can be selected between 40 ns and 1 s. The signals generated by SME/SMT are available at separate outputs for external applications so that in some cases there is no need for an external AF or pulse generator.

Besides the analog modulation modes named above, SME06 provides virtually all types of **digital modulation** used in today's mobile-radio networks: GMSK, GFSK, FSK, FFSK, 4FSK, QPSK, O-QPSK and π/4-DQPSK, the data of the QPSK-based modulation modes degrading in the range above 3 GHz. The bit rate, filters and frequency deviation can be selected over a wide range, and a variety of combinations is possible. With 4FSK and QPSK, the bit rate can be set in the ranges 1 to 24.3 kbit/s and 27 to 48.6 kbit/s [1].

PRBS sequences can be selected as fixed standard patterns of various lengths or user-programmed with the aid of a list editor. Moreover, externally generated data sequences up to a length of 8 Mbits can be stored in SME. Such sequences are needed, for example, for propagation measurements in GSM networks. In SME, spurious AM and FM can be added to the digital modulation. This allows receivers to be tested not only with virtually ideal signals but also with interference signals as encountered in practice [2].

Ease of operation

Despite the wealth of functions provided, operation of SME is extremely easy thanks to a well thought-out operating concept featuring a large LCD display and menu guidance. All parameters and conditions selectable for a specific function are logically arranged in a single display. The user can be sure of not overlooking any hidden criteria or options associated with a particular function.

Another feature that greatly facilitates operation is the patented, magnetically locking tuning knob. Although smooth-running, it provides fine stepping which the user can clearly distinguish. As a result, the display of SME/SMT need not be watched all the time, eg in stepwise tuning. Tiresome turning from one

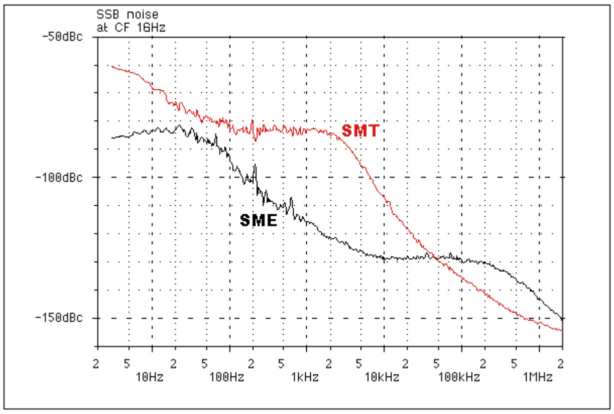

FIG 2
SSB phase noise
of SME and SMT
at 1 GHz

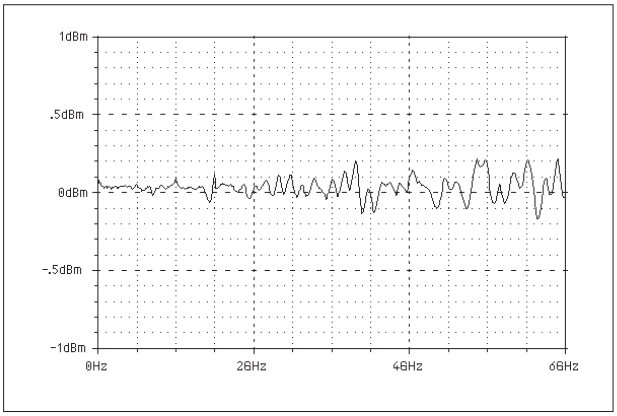

FIG 3
Level frequency response of SMT06 at 0 dBm output level

display to another, eg when operating SME/SMT and another instrument at the same time, is a thing of the past.

Operator convenience is further enhanced by a variety of useful features. Every RF specialist is aware of the problem: the higher the operating frequency in a test system, the more difficult it is to apply the RF signal to the EUT without any losses or appreciable frequency response occurring on the connecting lines. Here the **user correction** function is helpful: level correction values for up to 160 frequency points can be stored in SME/SMT, the values between these points being determined automatically by interpolation (FIG 3). This allows the frequency response of external cables to be corrected and the level at the EUT to be kept constant. The user correction function is equally valuable in EMC measurements, where the frequency response of amplifiers, antennas or TEM cells connected after the signal generator are to be compensated. This does away with complicated, external level controls or test routines.

For frequently repeated measurement series or sequences of different types of single measurements, the **memory sequence** function affords convenience otherwise obtained only through processor control. Up to 50 instrument settings can be stored in nonvolatile memory. After programming the sequence of measurements (up to 256 steps) and the step time in a list, the automatic test run can be started.

Remote control of SME/SMT is normally via the IEC/IEEE-bus interface. If no IEC/IEEE-bus interface is available on the external PC, the RS-232-C interface can be used instead. This is expedient, for example, if a long data sequence has to be reprogrammed in SME and SME should remain in the test system. In such cases SME can be reprogrammed on site via the RS-232-C interface with the aid of a laptop.

Future-proof investment

It is difficult to say at present what new applications lie ahead in radiocommunications. There are however two reasons pointing to a strong increase in the demand for test equipment for the 3-to-6-GHz range: first, the range up to 2.7 GHz is already densely occupied so that higher frequencies will have to be used to an increasing extent. Second, the trend towards higher frequencies is being speeded up through new technologies allowing the use of small, favourably priced components. With its Signal Generators SME06 and SMT06, Rohde & Schwarz takes account of this trend already now, making sure that the right instrumentation is ready and in place.

Johann Klier

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Condensed data of Signal Generator SME06/SMT06

Frequency range	5 kHz to 6 GHz
Setting time SME06/SMT06	<10 ms (<500 µs in list mode) / <15 ms
Spurious (f < 1.5/3/6 GHz)	<–80/–74/–68 dBc
SSB phase noise (f = 1 GHz, at 20 kHz from carrier) SME06/SMT06	<–126 dBc/<–116 dBc
Level range	–144 to +13 dBm (overrange 16 dBm)
AM/FM/φM SME06	DC to 100 kHz/2 MHz/100 kHz
AM/FM/φM SMT06	DC to 100 kHz/8 MHz/2 MHz
Digital modulation (SME only)	GMSK, GFSK, FSK, FFSK, 4FSK, QPSK, O-QPSK and π/4-DQPSK
Pulse modulation	
On/off ratio	>80 dB
Rise/fall time	<10 ns
Pulse generator	single pulse, double pulse, external trigger
Pulse repetition period	100 ns to 85 s
Pulse width	20 ns to 1 s
Pulse delay	40 ns to 1 s
Multifunction generator	sinewave, triangular, squarewave, noise, VOR/ILS modulation signals, stereo MPX signals

Reader service card 151/03

Satellite Receiver CT200RS

TV reception with analog and digital sound from outer space

As an extension to the CATV Headend Equipment CT200, Rohde & Schwarz now offers a satellite receiver for analog TV programs able to receive both conventional two-channel analog and digital ADR programs. Thanks to the comprehensive remote-control capabilities of the system components, a new concept for broadband cable networks can be implemented.

FIG 1 Satellite Receiver CT200RS used as component of Rohde & Schwarz CATV Headend Equipment CT200 or as stand-alone unit
Photo 42 440

A large number of TV programs are broadcast in Europe via the satellites Astra and Eutelsat. Normally, stereo sound programs are also transmitted with the satellite signal. It seems therefore expedient to abandon the use of expensive modulation lines, interference-prone terrestrial relay receivers or complex microwave links for feeding signals, for example, to CATV headend equipment and terrestrial transmitters and to utilize satellites that can be received everywhere with a minimum of outlay. For this purpose Rohde & Schwarz developed the Satellite Receiver CT200RS (FIG 1). It extends the CATV Headend Equipment CT200 [1] and, like the latter, can be remotely controlled and monitored via a Windows user interface. But stand-alone operation is possible too, without restrictions.

Function

The satellite signal arriving from the antenna on the first IF is converted in a tuner module with high image-frequency rejection to an internal (second) IF and then frequency-demodulated (FIG 2). This second satellite IF is available for monitoring and external processing. An AGC (automatic gain control) circuit matches the gain in a wide input-level range (–65 to –20 dBm). The switchable AFC (automatic frequency correction) compensates frequency offsets even in case of weak input signals (eg signals impaired by heavy rain) and thus ensures optimum picture quality.

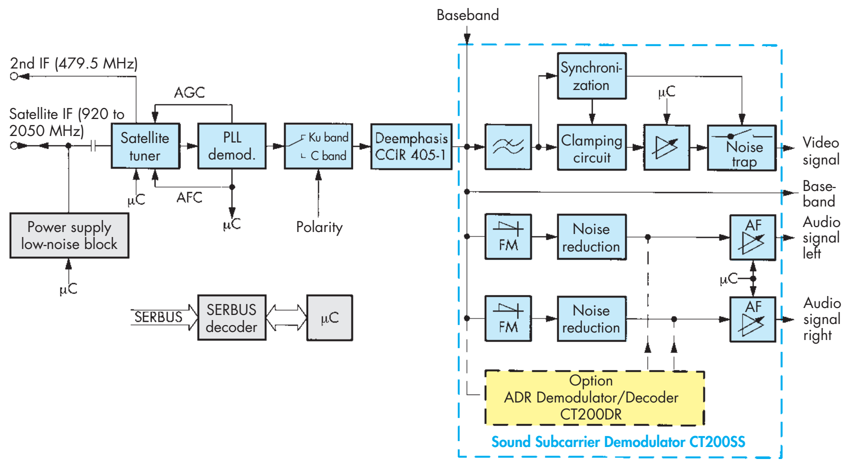

FIG 2 Block diagram of Satellite Receiver CT200RS and Sound Subcarrier Demodulator CT200SS

The subsequent polarity switch makes Satellite Receiver CT200RS also suitable for C-band reception (3/4 GHz) which, contrary to the Ku band (11/12 GHz) commonly used in Europe, employs inverted deviation. After the deemphasis circuit prescribed by CCIR Rec. 405-1 the baseband signal consisting of a video component (0 to 5 MHz) and subcarriers (6 to 9 MHz) is available for video and sound signal processing.

In the **video section** of the receiver the sound subcarrier is separated and only the video signal is allowed to pass through. A clamping circuit removes the super-imposed energy-dispersal signal, which ensures that intermodulation products generated in the satellite transponder do not cause visible interference on the transmission link. If the input level is too low or if no sync signal is received, a noise trap switches off the video signal at the program output. The monitoring output remains active for measurements.

The **sound section** of Satellite Receiver CT200RS consists of two FM subcarrier demodulators which receive the analog sound signal accompanying the TV signal or one of the audio programs as a mono or stereo signal. CT200RS may optionally be equipped with **ADR Demodulator/Decoder CT200DR** for retrieving the digital ADR-modulated subcarriers (ADR = Astra Digital Radio [2]). The option comprises the QPSK demodulator required for ADR, a Viterbi decoder (error protection) and the MUSICAM decoder. Ancillary data transmitted with ADR signals are available for further processing, eg for an RDS coder.

Since it is common for sound programs to be transmitted in the satellite signal as subcarrier pairs besides the TV sound signals, it would seem appropriate to use the baseband of Satellite Receiver CT200RS several times. For this reason, one of the CT200RS models, **Sound Subcarrier Demodulator CT200SS,** comprises only the sound section of the satellite receiver and is fed from the baseband output. Thus several subcarrier demodulators can be operated from one baseband signal. The ADR demodulator/decoder option may also be fitted in the subcarrier demodulator.

With several satellite receivers connected to one antenna, **Active Satellite Splitter CT200A8** provides eight outputs each for horizontal and vertical polarization and covers the frequency range 920 to 2050 MHz. A low-noise amplifier compensates for the distribution loss. Redundant power supplies ensure optimum operational reliability. CT200A8 may optionally be equipped with an (n+1) output giving access to the two types of polarization.

Uses

CATV headends mostly handle several signals from a satellite. Active Satellite Splitter CT200A8 distributes the vertically and horizontally polarized IF signals from the antenna to seven channel paths (FIG 3). The eighth output is required for the (n+1) standby channel. A Satellite Receiver CT200RS is connected to each of the two times seven direct outputs of CT200A8, each of which provides a TV program consist-

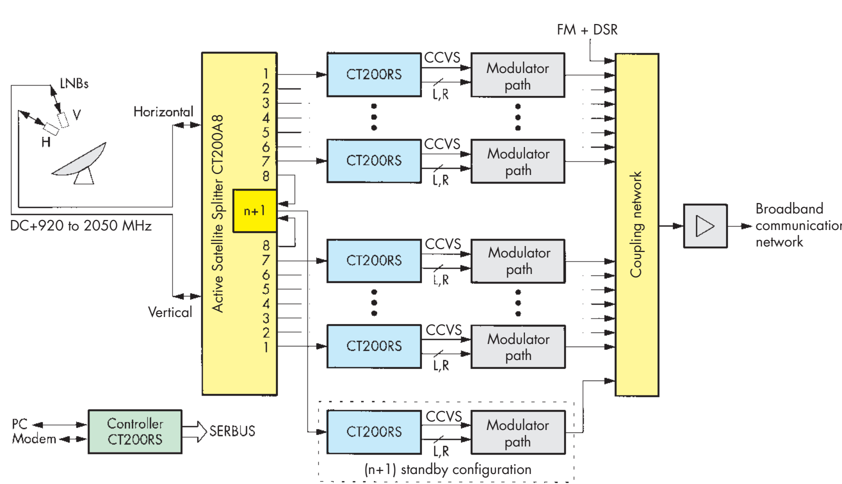

FIG 3 Satellite Receiver CT200RS in CATV headend equipment with (n+1) standby

ing of a video and stereo signal or a two-channel sound signal. Each satellite receiver is followed by a CT200 modulator comprising Vision-Sound Modulator CT200VS, Sound-2 Coder Modulator CT200S2 and Upconverter CT200UP. If additional IF inputs and RF outputs or higher output level are required, CATV Interface CT200CI may be added. TV signals, FM sound programs and possibly a DSR signal are combined by passive or active coupling networks (eg CT200C6, CT200A4) and the sum signal is forwarded to the broadband communication network.

Satellite Receiver CT200RS and Sound Subcarrier Demodulator CT200SS may be used not only in CATV headend systems but also in **converter systems** and **gap-filler transmitters.** Since nowadays many broadcasting authorities emit their TV programs together with their own sound programs via satellite, a TV and FM converter system or gap fillers fed from satellites can easily be set up (FIG 4). Satellite Receiver CT200RS receives the signals from the desired satellite transponder and, in addition to the video signal with two-channel sound, it provides a baseband signal comprising the FM programs in the form of analog or digital (ADR) subcarriers. This baseband signal is looped through Sound Subcarrier Demodulators CT200SS, each of which retrieves one of the three FM programs shown in the example. In the case of ADR subcarriers, QPSK demodulation as well as Viterbi and MUSICAM decoding are performed in the optional ADR Demodulator/Decoder CT200DR.

Gregor Kleine

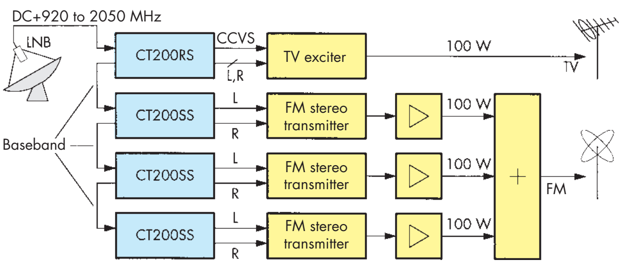

FIG 4
Example of converter system for one TV program and three FM programs

Comprehensive monitoring and remote-control capabilities of all active CT200 components permit for the first time an **(n+1) standby** configuration to be implemented. The supplementary channel (satellite receiver and modulator) may replace any of the operating channels. The software used by Controller CT200CO holds the configuration of the headend equipment. The controller monitors the whole headend system. If a component fails, the standby transmitter can be remotely tuned to the respective satellite transponder. CT200RS selects one of the two polarizations with the aid of its LNB (low-noise block) feed voltage and the (n+1) option in the IF satellite splitter. The controller finally tunes the standby modulator to the required output frequency and connects it through. The inoperative channel path is remotely switched off and signalled defective to the control center. The (n+1) standby configuration can be retrofitted any time in existing systems.

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[2] Kleine, G.: Astra Digital Radio – Die Technik. Funkschau 68 (1995) No. 10, pp 44–47

Condensed data of Satellite Receiver CT200RS and Sound Subcarrier Demodulator CT200SS

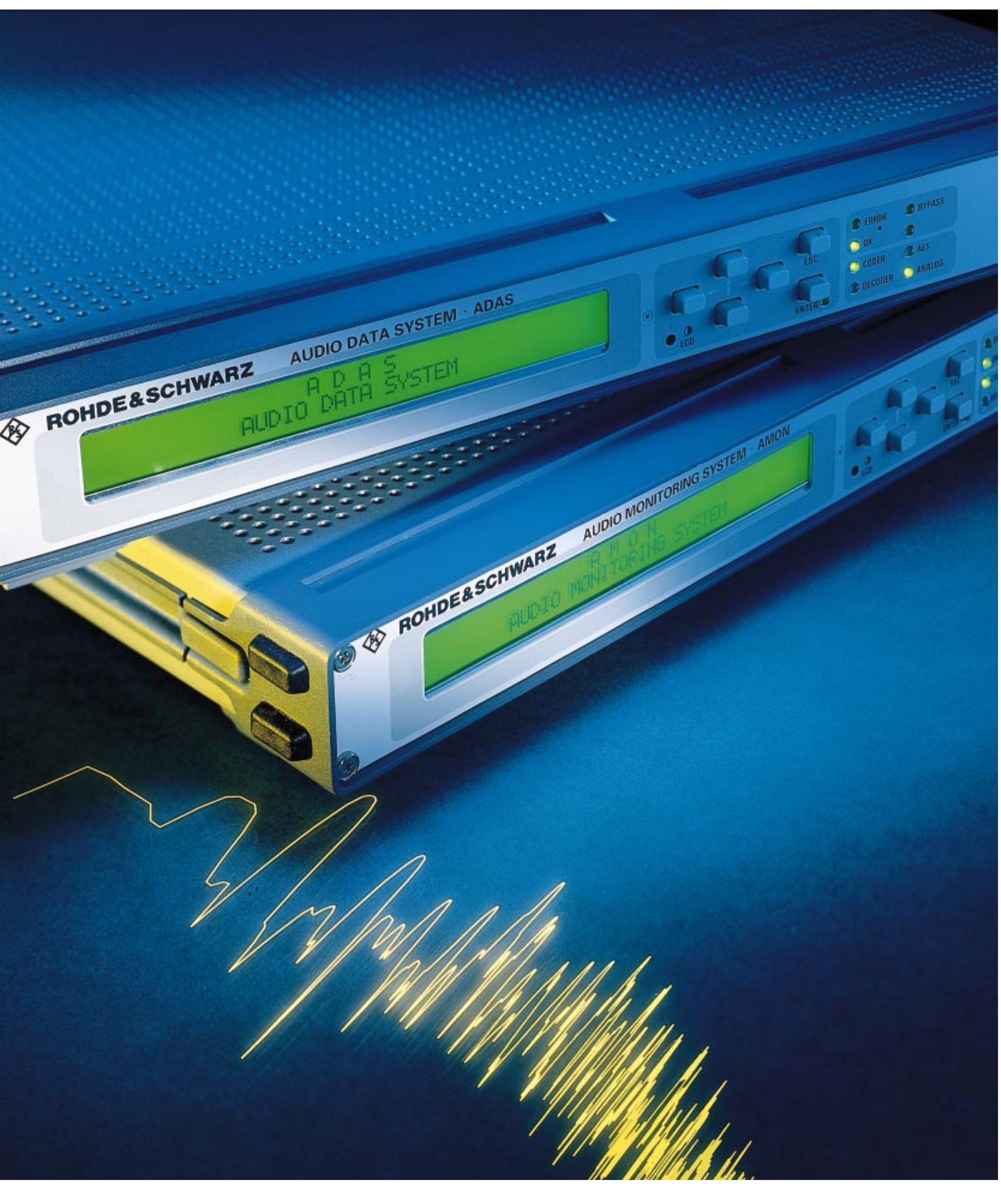
Frequency range	920 to 2050 MHz
Input sensitivity	−65 to −20 dBm/50 Ω
Image-frequency rejection	>45 dB
AFC capture range	±10 MHz
IF bandwidth	27/32 MHz, selectable
Video polarity	selectable for C and Ku band
Video deemphasis	CCIR Rec. 405-1
Video S/N ratio	>60 dB
Video output voltage	1 V_{pp} into 75 Ω
Subcarrier frequency range	5.5 to 9.99 MHz
Stereo channel separation	>80 dB
Unweighted S/N ratio	>64 dB
Audio deemphasis	50 µs/75µs, J.17
Audio output level	+9 dBm into 600 Ω

Reader service card 151/04

Audio Data Transmission System ADAS and Audio Monitoring System AMON

Data transmission without data line, audio measurements without program interruption

Broadcasting 24 hours a day leaves no time for classic transmitter measurements. With Audio Monitoring System AMON it is now possible for the first time to monitor the quality of the supplied and transmitted television/radio program during program time. This means programs no longer have to be interrupted to carry out measurements, not even for a short time. Moreover, no additional data lines from the studio to the transmitter are required since additional data – such as dynamic RDS data – are transmitted via modulation feed lines by AMON and/or Audio Data Transmission System ADAS.



Operation

Audio Data Transmission System ADAS (FIG 1) is used for transmitting additional data from the studio to the transmitter site via the program feed on analog modulation lines. Data are inserted into the program signal at the upper end of the audio band at 14.85 kHz and use a bandwidth of 300 Hz per sound channel at a bit rate of 400 bit/s. The data are removed at the end of the transmission link (input of sound-broadcast transmitter) by means of a steep-edged lowpass filter. In addition to the data transmitted via the serial interface, an 8-bit data word is available for each sound channel for remote-control applications. The inputs at the studio are ungrounded (optocoupler) and the outputs are floating relay contacts.

For Audio Monitoring System AMON, which includes the functions of ADAS, the audio signal is subjected to an FFT analysis at the beginning and end of a transmission link to obtain its audio spectral components. To reduce the volume of measured data, the signal is distributed in 14 frequency bands, for which the corresponding rms level is determined and transmitted to the decoder (FIG 2). The phase difference of the two channels is transmitted to the decoder to determine any polarity errors for stereo signals. The decoder also analyzes the incoming signal and compares it with the data of the source. The characteristics of the transmission link are obtained by subtraction. Each measurement, carried out once per second, generates 15 values.

FIG 1
Audio Data Transmission System ADAS and Audio Monitoring System AMON for quality control of audio transmission equipment without program interruption
Photo 42 442

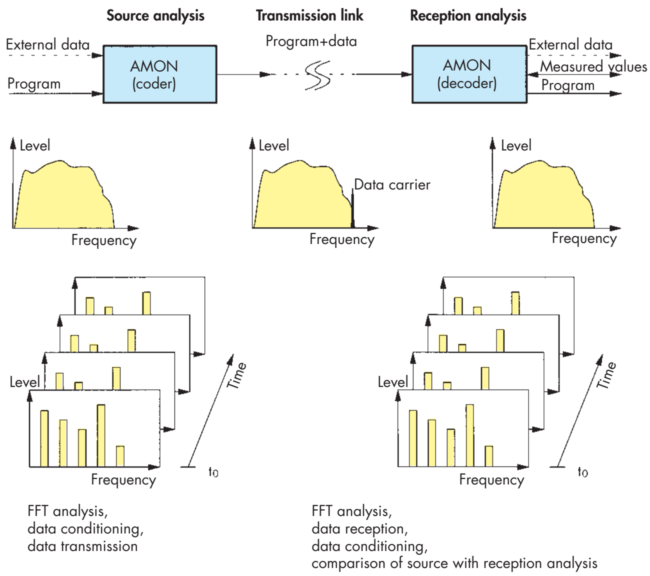


FIG 2 Principle of audio monitoring by means of program signal

This enables the following **transmission parameters** to be determined depending on the program signal:

- level error,
- frequency response,
- S/N ratio,
- polarity (phase L/R),
- channel interchange,
- program interchange.

An additional stereo test input at the AMON decoder serves for monitoring transmission equipment located at the same site. The signal at this input is directly compared with the program input, through which the quality of a sound-broadcast transmitter can be checked. If a data channel with a defined delay to the program signal is available, the system can also be used for digitally coded audio links. The signals are compared in the analog domain.

The test results are compared with selectable tolerance tables. Inner and outer tolerance limits are determined for each test parameter. If any of the limit values is exceeded, a message will be sent via a relay contact. Each limit value has a hysteresis to avoid frequent messages being issued if a measured value fluctuates around a tolerance limit. An optional automatic measurement according to CCITT 0.33 allows measurements to be made on audio transmission equipment during program breaks. This option can be used both in the AMON coder and AMON decoder and enables separate measurements of the transmission line and the sound-broadcast transmitter.

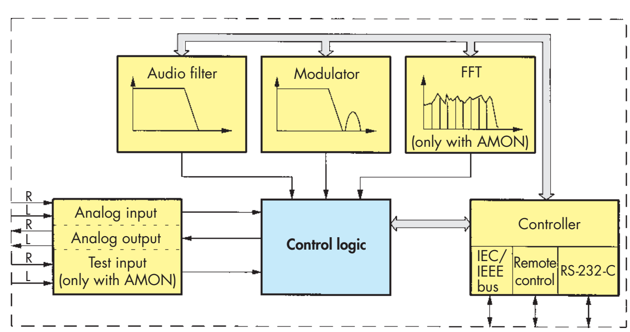


FIG 3 Block diagram of AMON and ADAS

Configuration

Although these two units offer a variety of functions, they only require a minimum of space. The standard configuration is a 19-inch desktop (1 height unit, approx. 44 mm), which is also suitable for installation into system racks. This compact size is due to modern modular design, which allows upgrading of Audio Data Transmission System ADAS to a full-featured Audio Monitoring System AMON at any time. The AMON/ADAS hardware with high-resolution sigma-delta A/D converters in the audio paths provides for high quality without comprehensive analog signal pre- and postprocessing being required. Customer requirements can easily be met thanks to digital signal processors that are used for filtering, modulation, demodulation and FFT.

A separate process controller serving the serial and parallel interfaces as well as the IEC/IEEE bus and the display (FIG 3) controls communication with external units. The two units can also be conveniently integrated into a test and monitoring system via IEC/IEEE bus. The complete test and monitoring values can be queried and displayed via IEC/IEEE bus. Software updates can easily be carried out via the RS-232-C interface from the front panel using flash EPROMs without any removal or replacement of units being required.

Uses

Continuous quality control of the modulation-line network and the broadcast transmitters during the ongoing program is indispensable to ensure high program availability. This is state of the art for picture transmission with use of the test-signal-insertion technique [1].

With **Audio Monitoring System AMON** it is now also possible to monitor the quality of audio transmissions while the program is on the air. Thanks to its integrated monitoring functions (independent limit monitoring of measured values for program and test input, monitoring of program identification, time-controlled start of a CCITT 0.33 sequence) issuing warnings via relay contacts AMON is an optimized, independent monitoring system. Even higher functionality (operation, statistics, etc) can be achieved by integration into a monitoring system such as TS6100 [2]. FIG 4 gives an example for a favourably priced vision/sound monitoring system including program-feed check at the transmitter site in combination with Video Measurement System VSA with built-in Test Receiver option VSA-B10 [3], which may, in the simplest case, use the integrated PC to control the whole monitoring system. If data-carrier insertion into the sound channel is not possible or not desired, the source data can be transmitted via an external data channel. This may be done in the data line while monitoring the television sound (FIG 5).

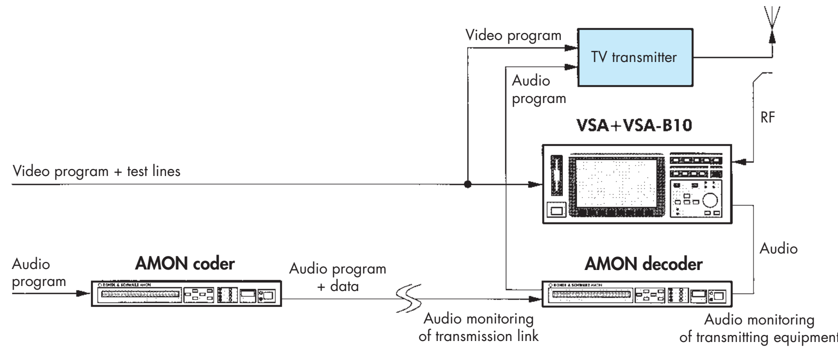


FIG 4 Monitoring of transmission link and TV transmitter by means of test-signal-insertion technique and Audio Monitoring System AMON

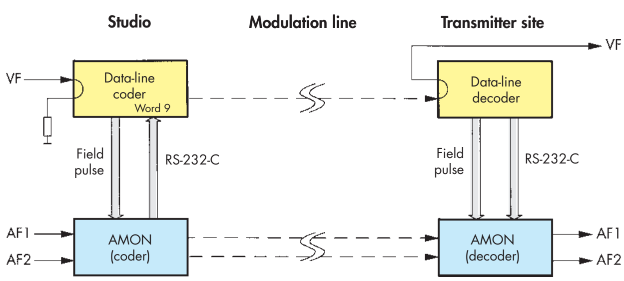


FIG 5 Monitoring of television sound with Audio Monitoring System AMON and transmission of source data in data line (line 329, word 9)

Audio Data Transmission System ADAS is employed wherever data have to be transmitted to a transmitter site. These data can be program identification or transparent serial data such as RDS data or remote-control data for controlling any functions at the transmitter site. Thus, for example, the stereocoder can be controlled or traffic announcement identification can be activated. Transmitter remote control is also possible. Multilevel addressability allows access to individual units or unit groups, ie all the decoders of a program, all the decoders of a site or individual decoders.

Audio Monitoring System AMON is also equipped with these functions. The capacity of the data channel is partly utilized for transmitting the measurement data.

Peter Singerl; Christian Krawinkel

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Condensed data of Audio Data Transmission System ADAS and Audio Monitoring System AMON

ADAS and AMON	
Data transmission program signal path	4DPSK
Frequency response (40 Hz to 14.5 kHz)	+0.1/–0.2 dB
Stopband attenuation above 14.71 kHz	>70 dB
AMON only	
Analyzer level range	+9 to –74 dB
Monitoring measurement time	approx. 200 ms
Measurement speed	approx. one measurement/s
Measurement parameters	level error, frequency response, S/N ratio, channel interchange, program interchange
Optional measurement functions	CCITT 0.33, program no. 01

Reader service card 151/05

Radiomonitoring System RAMON

Customized radiomonitoring from VLF through SHF

Radiomonitoring System RAMON from Rohde & Schwarz detects and monitors emissions in the frequency range 10 kHz to 18 GHz. Made up of tried and tested standard components, it allows comprehensive radiomonitoring systems to be set up to customer requirements. A graphics user interface ensures easy-to-learn and convenient operation.

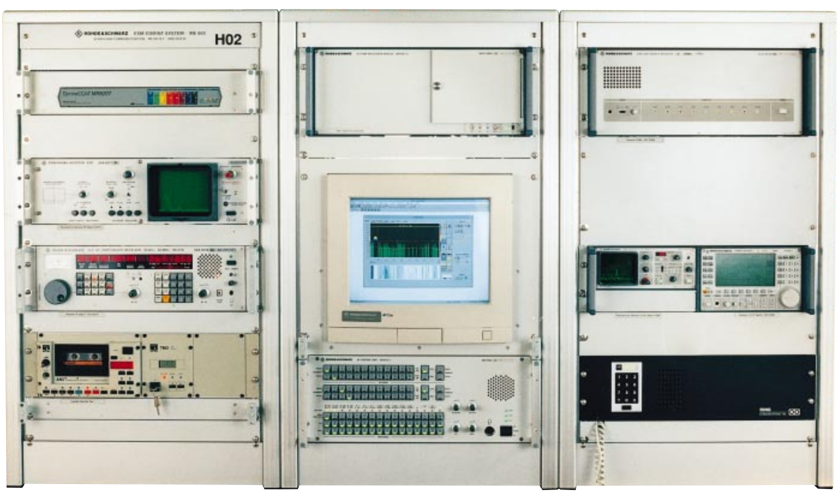


FIG 1 Radiomonitoring System RAMON-search with application-specific add-ons as desktop Photo 42 134/2

The purpose of interception and monitoring is to provide information about radiocommunications for the determination of a scenario (systems, positions, movements, distribution, concentrations, intentions). A few **typical activities of radiomonitoring** are:

- searching for known and unknown signals,
- monitoring of radiocommunication activities and alarm frequencies,
- identification, detection or recognition of transmitters,
- direction finding and location of radio stations,
- aural monitoring and recording of radio messages,
- analysis under technical and textual aspects,
- preparation of reports,
- evaluation and comparison of obtained data,
- setting up and updating of a database,
- preparation of statistics.

Modular design

To permit the great variety of tasks to be performed, Radiomonitoring System RAMON is of modular design. The number of modules used and their associated tasks vary depending on application. RAMON may be configured as required from a compact system with only one operator position through to a hierarchical system with an appropriate number of operator positions (FIG 1). Thus each system can be optimally adapted to the desired application and reliability is ensured through the use of tried and tested modules. The following **modules** are available:

- RAMON-supervise,
- RAMON-search,
- RAMON-monitor,
- RAMON-analyze,
- RAMON-locate,
- RAMON-compact.

Each module is a configurable unit comprising radiomonitoring equipment, a controller and software tailored to the particular application and complement. Operators of the individual modules exchange data within the system via LAN for sending messages, giving orders or storing reports. The variety of systems that can be set up with the aid of these modules ranges from single-position systems (RAMON-compact) through medium-sized systems

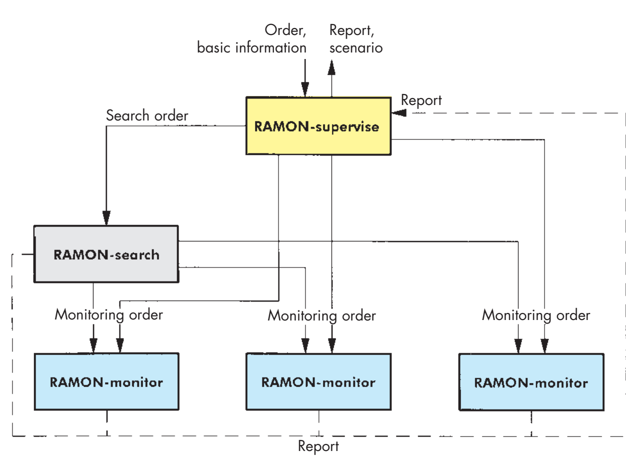


FIG 2 Block diagram of medium-sized radiomonitoring system

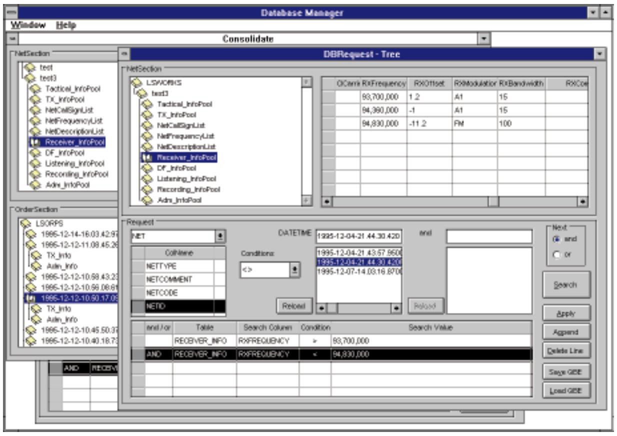


FIG 3
Evaluation of reports using database

(FIG 2) to large, hierarchically organized systems made up of several subsystems.

The operator position **RAMON-supervise** offers functions allowing the supervisor to control radiomonitoring and prepare reports. Thus assignments can be issued, their handling checked, reports or results examined and allocated to individual radio stations. The supervisor is the interface with the superordinate level, from where he receives orders and further information. The supervisor prepares search and monitoring orders and passes them on to the operators. Results obtained by the operators are stored as reports in a database. If the results are not post-processed, the supervisor carries out evaluation with the aid of the database and supporting functions (FIG 3). He utilizes the information obtained to control monitoring activities. Based on this information and his specialist knowledge and experience he prepares reports for the superordinate level, which is his contribution to fixing the scenario. All his activities are supported by the graphics user interface of RAMON-supervise, permitting fast acquisition of results.

RAMON-search (FIG 4) comprises a Search Receiver ESMA [1] and one or more Compact Receivers ESMC [2]. The module permits a fast search through frequency bands and rapid signal identification. The search operator scans specified frequency bands for active transmitters with his receiver in the overview mode (see box). In this mode the search receiver scans the defined range at maximum speed. Detected signals are shown in a panoramic display. Frequencies of interest are marked in the display and sent at a click to the compact receiver, where they are aurally identified and measured. If a signal is to be further monitored and analyzed, he sends an automatically prepared order to the monitoring operator by a single keystroke. Supported by RAMON-search the operator is able to respond quickly to

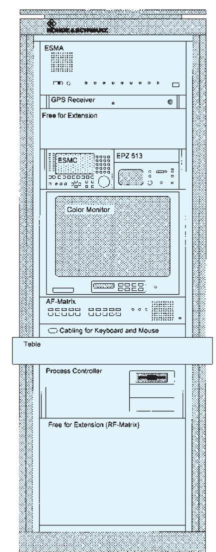
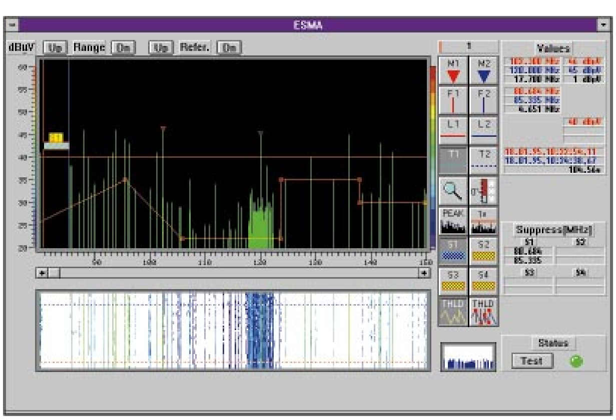


FIG 4 Single-rack operator position RAMON-search

Overview mode in search operation
The figure shows a snapshot of a search receiver operating in overview mode. Single frequencies and frequency bands are combined to a scan sequence of up to 10,000 channels. Known signals or unwanted bands may be suppressed. The overview provides tools permitting signals to be measured or the display to be zoomed or frozen. Recommended search receivers are ESMA and ESMC.



new signals, identify a multitude of emissions and execute a great number of search orders.

RAMON-monitor (FIG 5) contains several aural-monitoring receivers and at least one recorder. The software of the position guarantees efficient monitoring performance. The monitoring operator receives an order from the supervisor or search operator and the system immediately tunes a receiver to the frequency to be monitored. He records the detected signal and notes down important information in a report in which receiver settings are automati-

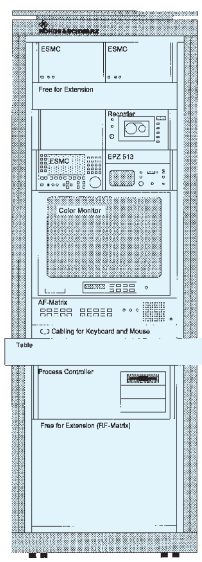


FIG 5 Rack layout of RAMON-monitor

cally included. The operator locates the transmitter with the aid of direction finders and is able to view the position on his map (FIG 6). Detected emissions are recorded on tape for subsequent evaluation. Depending on the technical facilities of his position, the operator may carry out detailed signal measurements. The results are also noted down in the report. RAMON-monitor allows the operator to monitor several frequencies simultaneously and speedily prepare detailed reports.

The single-position system **RAMON-compact** includes a search receiver, an

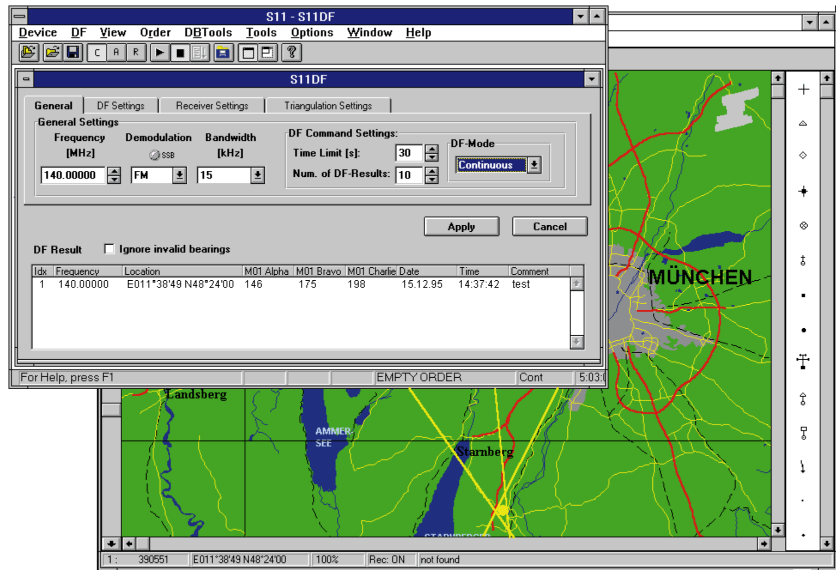


FIG 6 Direction finding and radiolocation in monitoring mode with map (R&S MapView software)

aural-monitoring receiver and a recorder. The software includes all main functions of RAMON-supervise, -search and -monitor. The tasks normally performed at the supervisor, search and monitoring positions are concentrated in one position. Procedures are similar to those performed at the separate positions but the individual tasks are carried out at a less detailed level. This makes system software support so particularly important. With RAMON-compact a single operator is able to obtain all essential information by means of radiomonitoring and to add this information to the scenario.

Optimization and upgrading

Rohde & Schwarz continuously enhances existing modules and is developing new ones like RAMON-analyze and RAMON-locate. This allows systems in use to be upgraded and improved by updates. Thanks to the modular design, upgrading may be carried out in steps so that even a small installation can be expanded to an increasingly powerful radiomonitoring system.

Reiner Ehrichs; Claus Holland; Günther Klenner

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Modules of Radiomonitoring System RAMON

RAMON-supervise	coordinator position
RAMON-search	search and identification position
RAMON-monitor	monitoring position
RAMON-analyze	analyzer position (in development)
RAMON-locate	radiolocation position (in development)
RAMON-compact	compact single-position system

Reader service card 151/06

BTS Antennas HF…/HK…

The right antenna for every mobile-radio base station

Besides offering the complete range of test equipment required for radio networks, Rohde & Schwarz supplies antennas for base stations providing radio coverage for assigned areas. Directional and omnidirectional antennas from Rohde & Schwarz can be used in all networks operating in the 900-MHz or 1800-MHz band: GSM, DCS1800 (PCN), TACS, Qualcomm, NMT900, NTT etc, thus opening up a virtually unlimited range of customers.

FIG 1 Examples from Rohde & Schwarz BTS antenna program: sector antennas providing coverage in mobile-radio networks
Photo 41 835/7

Mobile-radio networks are spreading at breakneck speed, meeting the growing demand worldwide for speech and data communication that is affordable and possible for everyone and everywhere using small, favourably priced terminals. Standards GSM and DCS1800 for digital modulation are becoming more and more popular. GSM networks are in operation in well over 50 countries, often several networks are installed in a country, and there is a strong upward trend. DCS1800 networks are already in use in Great Britain, Switzerland, Thailand, Malaysia and Germany, and introduction is imminent in another 15 countries.

Standards GSM and DCS1800 differ basically in their frequency band (GSM: 900 MHz, DCS1800: 1800 MHz) and the transmitting power of base stations and terminals. In DCS1800 networks, which are mainly intended for communication via hand-held phones, transmitting power is lower and coverage area smaller than in GSM networks. Modern mobile-radio networks are organized in cells of varying size depending on the topography of the area in question and the traffic volume to be handled.

To reliably eliminate coverage gaps and thus prevent the interruption of radio links for an area, the directional patterns of antennas installed at BTS stations (base transceiver stations) must fulfill stringent requirements. Further criteria of interest to network operators are reliability and – last but not least – economy. Based on these requirements, Rohde & Schwarz has developed two families of antennas for the 900-MHz and 1800-MHz bands. These omnidirectional (HK...) and directional (HF...) antennas come in a variety of types of various gain levels, allowing for all conceivable applications of network operators (FIG 1).

Design

Basically, BTS antennas are made up of vertically stacked dipoles [1]. If coverage is to be provided not for the whole surrounding area but only for a sector of it, the dipoles are mounted in front of a reflector. Antennas of this type are commonly classified by the horizontal half-power beamwidth of their directional patterns. For example, one speaks of 65° antennas (FIG 2). Another parameter determining the characteristics of a BTS antenna is its gain. The gain is proportional to the number of stacked dipoles and thus to the total length of the antenna. The gain and half-power beamwidth to be selected for a specific coverage area mainly depend on the topography and on the expected traffic volume (see table in blue box). Omnidirectional antennas are mainly used in areas with low traf-

FIG 2 65° Sector Antenna HF065E1 for 1800-MHz band Photo 41 835/5

fic volume and often replaced by directional antennas (sector antennas) as the number of subscribers increases.

Radiation patterns

The vertical pattern of a BTS antenna is shaped by the type of feed used for the vertically stacked dipoles. If all dipoles are fed with signals of the same amplitude and phase, maximum gain will be obtained. But this is not always the optimum solution. For example, it is often an advantage to lower the main lobe of the antenna electrically (down tilt) to achieve better illumination of the coverage area and reduce the risk of interference with an adjacent cell (FIG 3). The down tilt is usually between 1° and 6°. In practice, sector antennas often use a combination of electrical and mechanical down tilt. The latter is implemented by means of a swivel holder, which is of course included in the Rohde & Schwarz range of accessories.

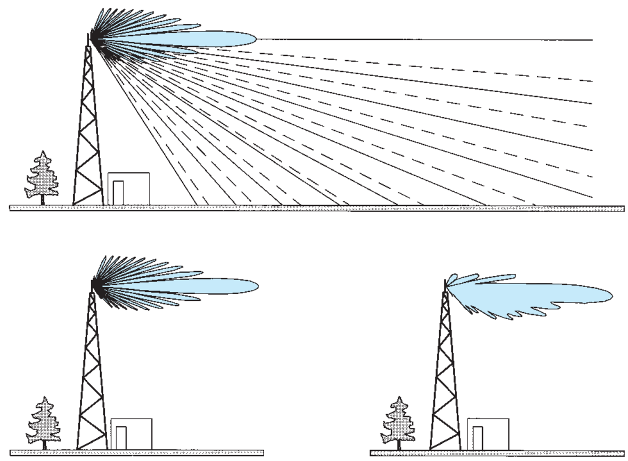

FIG 4 Null fill-in and side-lobe suppression (schematic)

Apart from down-tilting, further measures are recommended for optimizing the radiation characteristics of BTS antennas (beam forming, beam shaping). It is generally true that not only gain increases with the number of stacked dipoles but also the number of side lobes and minima (nulls). The side lobes above the main lobe provide no coverage but increase the risk of interference with adjacent cells; it is therefore advisable to suppress them as far as possible, which may afford higher gain at the same time. By contrast, the minima located between the side lobes below the radiation peak result in coverage gaps especially in the vicinity of the base station, which may cause breakdown of links even in digital networks. Therefore, BTS antennas are required not only to feature side-lobe suppression but also a certain amount of null fill-in (FIG 4). Carefully designed null fill-in contributes considerably towards reliable coverage, which has been verified not only in theory but also by numerous mobile tests [2] (FIG 5).

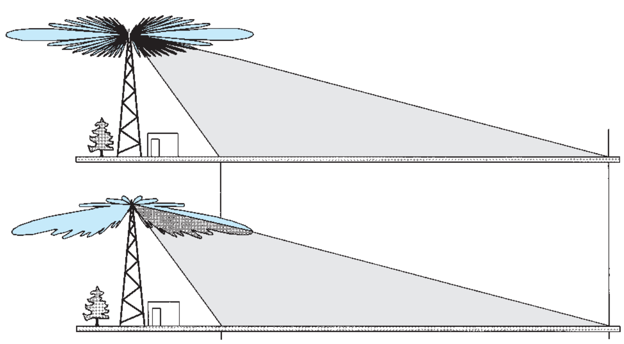

FIG 3 Electrical down tilt (bottom) focuses energy to coverage area (schematic)

Half-power beamwidth	**Topographical conditions**	**Traffic volume**
Omnidirectional antennas	rural	low
160° and 120° antennas	mountains, national borders	random
120° and 90° antennas	rural	high
65° antennas	urban	high
33° antennas	traffic routes	random

It goes without saying that Rohde & Schwarz antennas meet the standard requirements of network operators with regard to null fill-in and side-lobe suppression. In most cases much better specifications are achieved than those stipulated. Omnidirectional Antenna HK612, for example, fulfills particularly stringent requirements with respect

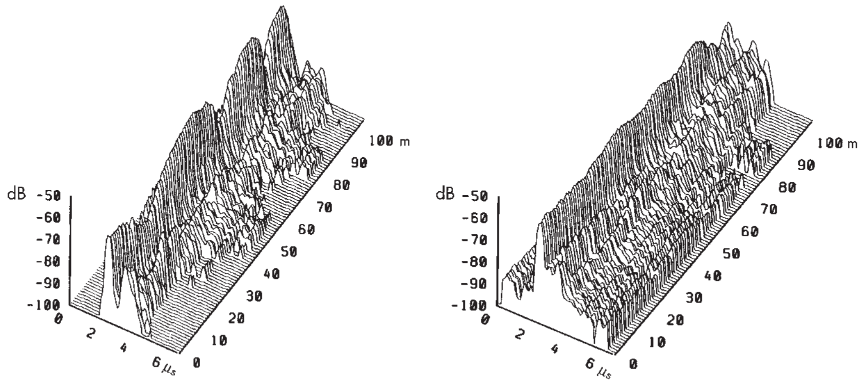

FIG 5 Received signal level in vicinity of mobile-radio base station (right with and left without null fill-in on BTS antenna)

to vertical radiation pattern shaping. Generally it can be said that all BTS antennas from Rohde & Schwarz are the result of elaborate optimization [3] and meet all of the described requirements.

Antenna feed

The antenna dipoles are fed with voltages of defined amplitude and phase via a power distribution network designed as a stripline. The stripline is an integral part including all junctions, phasing lines, transformers and matching pads required, doing away with error-prone adjustments and alignments and allowing high manufacturing precision to be maintained throughout a batch. Only a single solder joint is required between the antenna input and the stripline. This and the use of snap-in connections have drastically reduced the failure rate in production and increased MTBF by a factor of 80 compared with antennas featuring conventional coaxial-line connectors. Another essential advantage afforded by this concept is the extremely low intermodulation.

The stripline is fitted between two metal plates and fixed in position by dielectric supports. This design, which is known as a triplate line, makes for extremely low-loss feed of the dipoles and was therefore given preference over the commonly used method of depositing the stripline directly on a dielectric as in the case of PCBs. Another advantage of this feed concept is the small parameter spread of the antennas in production.

Characteristics

Through complete simulation of all parameters relevant to antenna characteristics, including dipoles, reflectors and distribution networks, the following **features and benefits** were achieved in all BTS antennas from Rohde & Schwarz:

- modularity, allowing application-specific gain figures to be implemented,
- effective suppression of radiation in unwanted directions,
- compact size,
- pattern shaping to avoid coverage gaps,
- extremely high reliability,
- favourable price/performance ratio.

Finally it should be emphasized that it is not only the electrical data of the BTS antennas but also their high resistance to environmental stresses that plays a decisive role for network operators. Accommodated in a weatherproof radome, all parts of the antenna are perfectly protected against environmental effects. Due to their very slim design, the antennas resist wind speeds up to 200 km/h without any appreciable impairment of their radiation patterns and thus of coverage (for example, a hurricane of wind force 12 has a speed of about 125 km/h). And, last but not least, the high quality standard maintained at Rohde & Schwarz – certified to ISO 9001 – guarantees not only the electrical and mechanical data but also a long service life for all BTS antennas.

Dr. Christof Rohner

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[1] Stark, A.; Nielsen, L.; Rohner, C.: Favourably priced omnidirectional and sector antennas for PCN base stations. News from Rohde & Schwarz (1993) No. 143, p 35

[2] Schmitz, U.: Zwei Tage Stress an den Schaltknöpfen der mobilen Kommunikation – Unterwegs im Funk-Messmobil. VDI-Nachrichten No. 3 (21.1.1994), p 11

[3] Stark, A.; Rohner, C.: Optimizing the Coverage of DCS1800 Base Stations by Radiation Pattern Forming. Microwave Engineering Europe (Oct. 1994), p 59

Condensed data of BTS Antennas HF... / HK...

Frequency band	860 to 960 MHz, 1710 to 1880 MHz
VSWR	≤1.3
Max. permissible wind speed	200 km/h
MTBF	40,000,000 hrs

Reader service card 151/07

Paging System P2000

Flexible, multiprotocol radiopaging system

Radiopaging services are becoming more and more popular worldwide. System operators are continuously expanding their existing networks and installing new facilities. R & S BICK Mobilfunk offers a complete service package covering planning, installation, training and maintenance. A new generation of radiopaging systems meets world-market requirements for a multiprotocol infrastructure.

Doctors, fire brigades and business people too want to be or have to be available at all times and wherever they may be. This is made possible by modern mobile-radio systems. The advantages of a radiopaging system are relatively low costs for the user in comparison with a cordless phone for example, small size and light weight and very long operating times of the battery-operated pagers. The beepers, as they are usually called, come in a variety of models. There are even watch-integrated beepers. The required system infrastructure generally remains hidden to the public.

FIG 1 shows the structure of a simple paging system with which a city can be covered from a high antenna site, for example. It consists of a network control center with access controller and a paging base station. A public national radiopaging system comprises a multiple of these individual elements. The aim of optimizing the network topology is to minimize the investment and operational costs of radio coverage and the network.

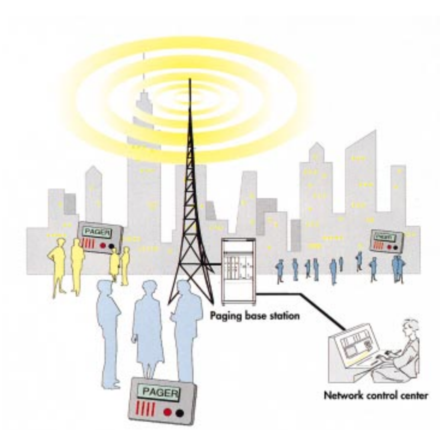

FIG 1 Structure of simple paging system

R & S BICK Mobilfunk is the right partner for the network operator as it not only provides complete radiopaging infrastructures but also individual components such as paging base stations or paging centers for the professional network operator. The compliance of the systems with all important paging standards allows their integration in already existing networks. In addition to the hardware Rohde & Schwarz also offers accompanying services such as planning and optimization of the system concept and radio coverage, site acquisition as well as training and maintenance.

Paging System P2000 (FIG 2) is the first model of a new generation of multiprotocol radiopaging systems covering current **paging standards** in the frequency bands commonly used for mobile radio. The most widespread standard in Europe for the air interface is the POCSAG code (Post Office Code Standardization Advisory Group), a standard that was already recommended in 1982 by ITU and allows data rates of up to 2400 Baud. The European Telecommunications Standards Institute (ETSI) passed the European Radio Messaging Standard (ERMES) in 1992. This standard specifies not only the air interface with a data rate of 6250 Baud but also the used frequencies and the interfaces between the individual system components with the aim of implementing a European-wide paging-system network.

FIG 2 Base station of Paging System P2000
Photo 42 441

Elements of radiopaging system

The professional **Paging System P2000** consists of four **basic elements** (FIG 3):

- access systems,
- network control center including operation administration and maintenance accesses,
- distribution system between network control center and base stations,
- paging base stations ensuring defined radio coverage.

Access systems

The call requests are routed to the system via different accesses. The network operator can select any combination from a large variety of different access systems.

Network control center

The basic software package supports the standard functions of a public radiopaging system. Extending the number of subscribers is optional just as additional features. All the system elements are integrated into a general operation administration and maintenance concept. Subscriber handling and billing systems are incorporated into the system via open interfaces.

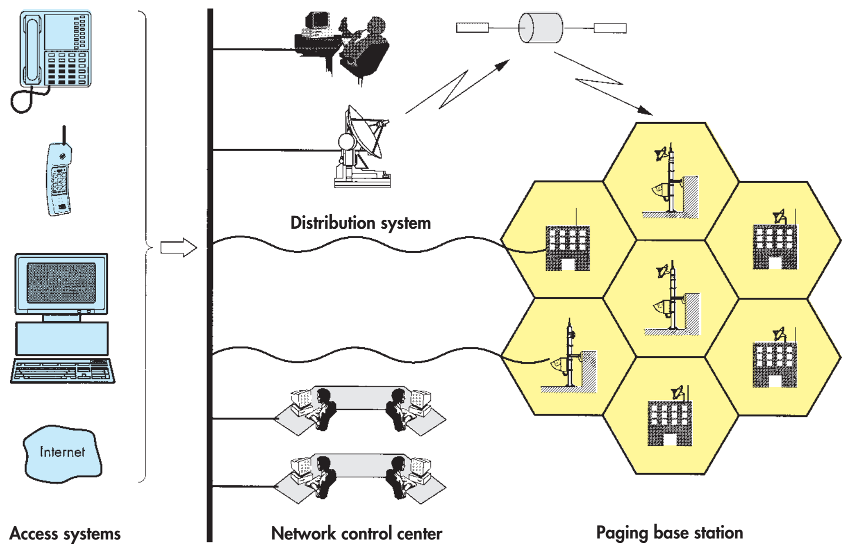

FIG 3 Structure of complex radiopaging network

Distribution systems

Different distribution media and networks can be used according to network operator requirements to distribute calls from the control center to the transmitters and to route back operational and maintenance messages from the base stations.

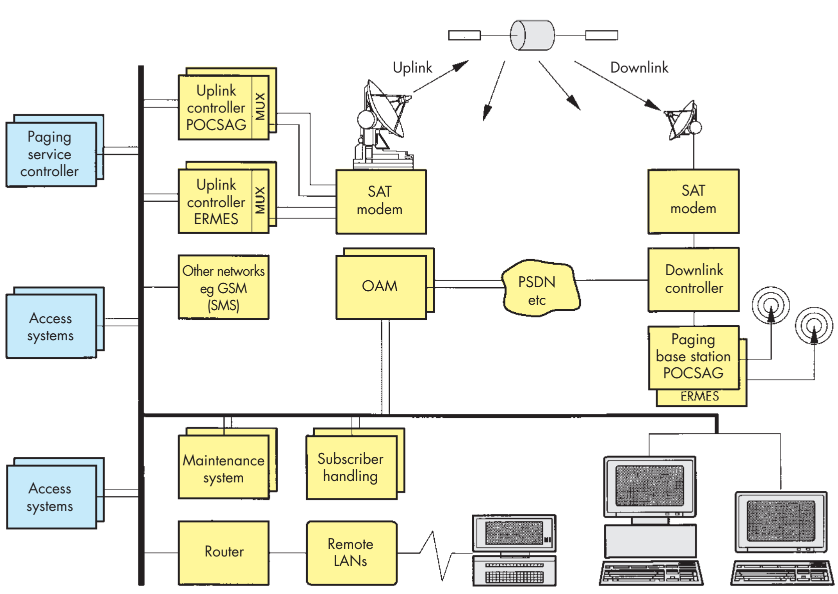

FIG 4 National satellite-supported radiopaging network

Paging base stations

The number and sites of paging base stations depend on area coverage planning. Well over 1000 paging base stations can be installed according to the configuration level of the paging system.

The connection of the access systems to the network control center and the distribution system is via industrial computer networking in cooperation with ATM of Constance, Germany. The principle of distributed processing can thus also be fully utilized in paging systems. Moreover, a distributed information system is a convenient platform for the static and dynamic division of the functionality of a complex system into several principally independent system units. The capacity of the access systems, the network control center as well as the distribution system can be extended in economical stages so that the requirements of national network operators using several radiopaging frequencies on which different paging standards are possible can be fully met without causing capacity bottlenecks.

Characteristics

In addition to basic features such as high availability and operation on all international frequencies in the VHF and UHF band, features minimizing the cost of ownership for the network operator are major **highlights** of Paging System P2000:

- market-oriented scaling from less than 100 to more than 5 million subscribers,
- linking of different accesses via open interfaces,
- traffic-load distribution and redundancy through decentralized, distributed call-data processing,
- distribution networking both terrestrial and via satellite,
- support of different paging protocols and baud rates by software download,
- cost-optimized and unobtrusive outdoor installation of base stations,
- requirement-oriented solutions for in-house coverage and on-site paging,
- intelligent and comprehensive operation administration and maintenance concept down to component level,
- easy servicing of base stations by electricians.

Standardized **interfaces** between certain system units allow for flexible upgrading or retrofitting of units. An interface between different paging systems is of course available and allows messages to be sent either via an ERMES, POCSAG or another high-speed paging system. A further interface is provided for external and cost-effective satellite uplink. The interface between the downlink controller and the radio-paging transmitter is configured so that existing transmitters from other manufacturers can easily be connected to the new infrastructure.

FIG 4 illustrates the structure of a national paging system for standards POCSAG and ERMES with satellite uplink of the individual paging base stations for call distribution as well as a terrestrial communication channel for operation administration and maintenance. Thanks to consistent use of the distributed data-processing principle, any access system such as an operator workstation, Internet access or speech-recognition system can accept paging calls for any subscriber authorized in the paging system and forward them in the system. Prior to call-acceptance acknowledgement to the calling parts, the subscriber number and the type of pager is checked for validity.

All the services including cascading of different functions are basically available to any subscriber. Which of the services may be used by the individual subscriber depends on authorization by the system operator and the technical facilities of the pager itself. The paging call is converted into the format required prior to sending the call via one or several paging transmitters in the downlink controller. The necessary transmission bandwidth of the satellite link is thus drastically reduced, which substantially cuts the operating costs of the whole paging system.

Thomas Rieder

Combinations and functional scope of Paging System P2000

Access system	Network control center	Distribution network	Paging base station
Voice access	**Services**	**Satellite**	**Frequency bands**
Operator	High calling-rate subscriber	VSat	VHF
Phone (DTMF)	Calling party pays	SCPC	UHF
Voice box	Calling party contributes	**Data networks**	**Output power**
Data access	Receiving party pays	HDLC	25 W
Modem	Info call/news	TCP/IP	200 W (400 W)
X.25	Call diversion	**Leased lines**	**Paging standards**
X.400	**Paging standards**	CCITT M.1020	ERMES
Internet / WWW	ERMES	ISDN	POCSAG
T-online	POCSAG	**Dial-up lines**	High-speed paging
Fax access	High-speed paging	Analog	**Mechanical design**
Fax box	**Operation administration**	ISDN	Rack
Fax → text	**and maintenance (OAM)**	**Microwave links**	Unobtrusive outdoor cabinet
	SW download/parametrization		Compact cabinet for indoor coverage
	Remote control/service		**Service concept**
	Subscriber handling		Continuous built-in test
	Authorization		Service by electricians
	Billing data		

Reader service card 151/08

Testing GSM/PCN/PCS base stations in production, installation and service with CMD54/57

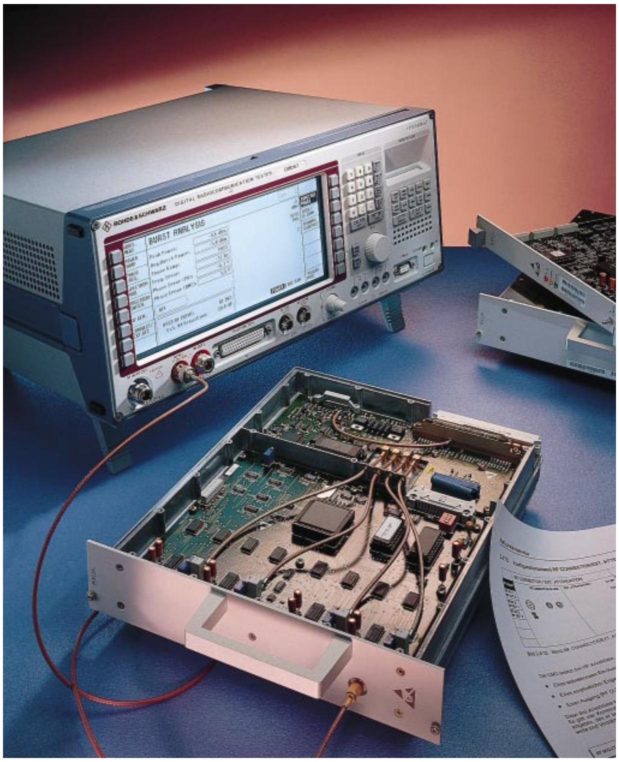

FIG 1 Digital Radiocommunication Tester CMD57, ideal compact tester for production, installation and service of GSM/PCN/PCS base stations
Photo 42 362/1

Base stations for digital mobile radio must function reliably at all times. To guarantee this, the transceivers are subjected to stringent quality tests at all stages of production from the individual module to the ready-made product, and key RF parameters are measured during on-site installation and during service. However different the measurement tasks may be, they can all be performed with a single compact test system – Digital Radiocommunication Tester CMD54/57 (FIG 1)*. It covers the frequency ranges for GSM, PCN (DCS1800) and optionally also PCS (DCS1900). With the aid of an option the two models can also be used in the field of European train radio. Since signalling has not yet been defined for this application, measurements are in compliance with current GSM specifications.

The following **features** make CMD54/57 ideal for measurements in the applications outlined above:
- flexibility for production,
- A_{bis} control for installation and final testing in production and,
- unique worldwide, uninterrupted operation while checking or retrofitting transceiver modules during servicing.

The following **parameters** of the **base station** (BTS = base transceiver station) can be measured with the radiocommunication tester:

Transmitter
- Transmitter power to an accuracy of ± 0.6 dB with integrated peak-power meter
- Power ramping at full dynamic range (72 dB) using the zoom function
- Phase and frequency errors with graphic and numeric display
- Modulation spectrum in only 60 s for 500 bursts on 23 frequencies (FIG 2)
- Switching spectrum

Receiver
- Bit error rate (BER) (single or continuous) with various evaluation and connection capabilities, eg loopback in CMD, loopback in BTS, A_{bis} monitoring, IEC / IEEE-bus or RS-232-C interface
- Bit pattern to CCITT standard
- Transmitter level with high accuracy (eg error <1 dB at –104 dBm).

Use in module production

Important aspects for selecting test equipment in production are easy integration into existing production lines and measurement speed. Thanks to a great variety of synchronization and trigger facilities and a number of analog measurement functions, CMD can be matched optimally to the DUT. The SCPI-compatible IEC/IEEE bus

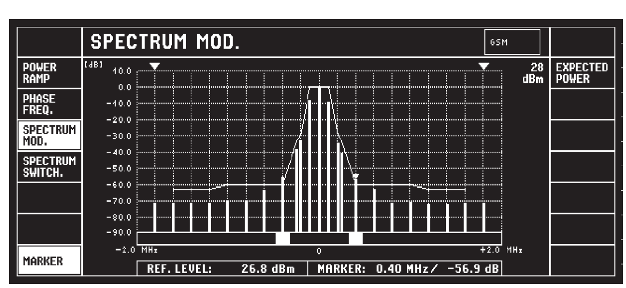

FIG 2 Modulation spectrum of base-station transmitter

* Schindlmeier, R.: Digital Radiocommunication Tester CMD54/57 – GSM/PCN base-station testers for production, installation and service. News from Rohde & Schwarz (1994) No. 146, pp 16 – 18

ensures fast remote control (FIG 3). Transmitter measurements are possible without signalling – an indispensable feature in module testing – with triggering to pulsed and non-pulsed signals. The built-in RF signal generator allows measurements to be carried out on receiver modules. The DC ammeter and voltmeter of CMD are optimized for measuring pulsed signals and an optional AF generator/analyzer is provided for AF measurements including frequency measurements.

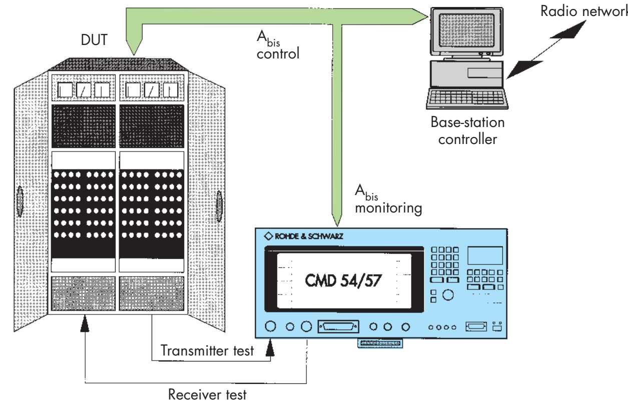

FIG 5 CMD54/57 servicing base station on the air

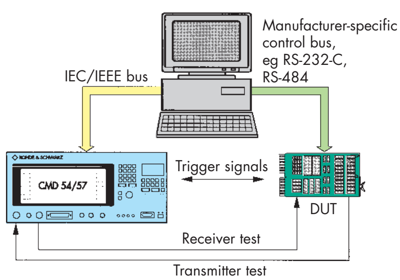

FIG 3 Typical test setup in module production

Use in final testing in production and installation

Main tasks of CMD54/57 for final tests in production and on-site installation of a BTS are measurements with signalling, call setup for signalling tests, audio check, control of the complete BTS system via the A_{bis} interface and automatic testing.

In final testing **measurements on active base stations** have to be carried out, ie stations which, driven by external equipment, emit RF carriers with signalling information. Even the CMD basic model evaluates and indicates important network codes, permits synchronization to the C0 carrier (broadcast carrier) and gives an overview of RF parameters. Optionally, software permitting complete call setup with signalling to the RF interface can be loaded into CMD. Supported are incoming and outgoing calls, location update, call cleardown, frequency hopping, channel and time-slot changing. With the **realtime speech encoder/decoder option** (CMD-B5) integrated, the audio quality of the base station can be tested.

CMD offers an interesting concept for **A_{bis} control** for final testing in production and installation. The A_{bis} interface is a digital interface with a data rate of 2048 kbit/s capable of handling up to 120 voice channels of 16 kbit/s each and two 64-kbit/s signalling channels. Equipped with an A_{bis} plug-in card and a BTS-specific control software, CMD performs the following functions via the A_{bis} interface: BTS reset, BTS configuration, software download, BTS reconfiguration as well as transmitter/receiver activation and deactivation.

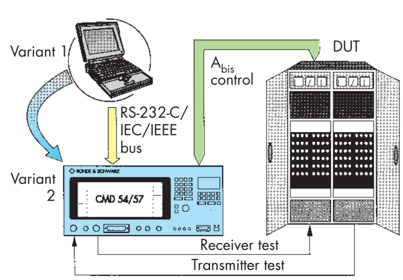

FIG 4 A_{bis} control with external notebook or CMD54/57

A_{bis} control comes in two variants, either for control via an external controller or by CMD alone (FIG 4). With variant 1, CMD executes A_{bis} application programs remotely controlled, eg from a notebook. The application programs serve for controlling the BTS. If special measurement tasks are to be carried out, the user may modify in any way the application program supplied by Rohde & Schwarz. Once the program on the external controller matches the user's requirements, it can be loaded into CMD for controlling the BTS from CMD (variant 2). The menus of the external controller will be displayed on CMD. The supplied software comprises an application program for variants 1 and 2 for manual BTS control. Switchover between A_{bis} control and RF measurement is possible by means of a softkey. An application program permitting fully automatic BTS measurements is supplied in addition.

Use in service

Once a base station has been put into operation, it should only be switched off in cases of emergency. This means that any service work is to be performed with the transceiver in full operation. CMD is worldwide the first compact radio tester to carry out transmitter and receiver measurements on base stations in operation. CMD permits even transmitter and receiver modules to be retrofitted without interrupting the operation. For this application CMD has been upgraded by a number of important functions making it a test mobile phone. CMD is connected to the RF interface of the base station, a call is set up and then all RF parameters are measured (FIG 5).

The **signalling software** performs call setup, holding (even under adverse conditions) and cleardown. It also supports, for instance, a change of channel and time slot as well as authentication. Signalling protocols complying with the OSI reference model required for the measurements are implemented in CMD.

Like a real telephone, the test mobile phone CMD54/57 obtains access to the network only via a registered SIM card. The required **SIM-card reader** is fitted below the instrument without enlarging the size of the basic unit.

After call setup CMD allows **$\mathbf{A_{bis}}$ monitoring.** To do so it feeds RF signals modulated with a CCITT bit pattern to the base-station receiver. Depending on the quality and sensitivity of the receiver, the bits are received correctly or with errors. The BTS forwards the received bits via the A_{bis} interface to the base-station controller and then to the network. CMD connected with high impedance to this line measures the received bits at the respective time slot. Errors detected between the transmitted and received bits are displayed as bit error rate on CMD.

In the GSM network up to 16 RF carriers with a channel spacing of 600 kHz may be on the air simultaneously. One of these carriers is assigned to the test mobile phone CMD54/57 and has to be measured selectively. For this reason all other channels are suppressed by means of a special **SAW (surface acoustic wave) filter** so that they cannot impair measurement results.

Frank Körber

Reader service card 151/09 for further information on CMD54/57

Container location from space

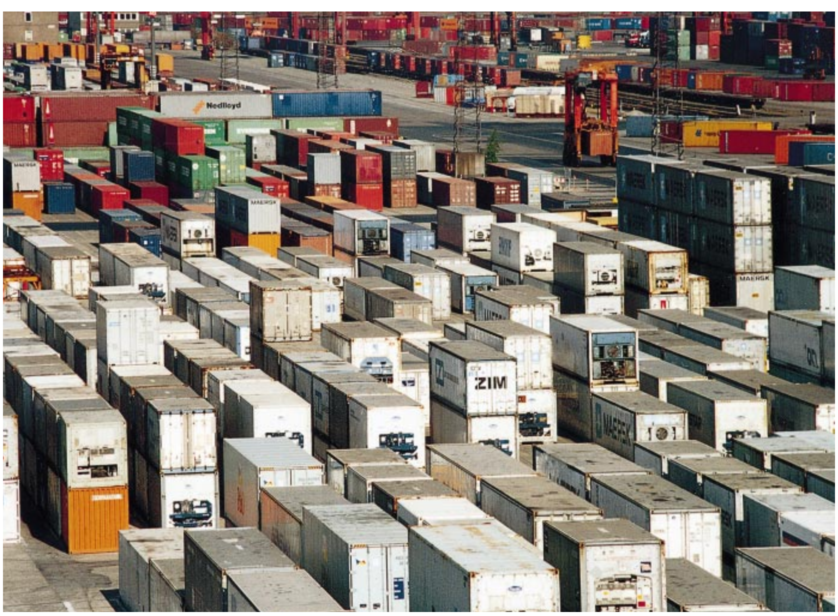

FIG 1 Container terminal of Hamburger Hafen- und Lagerhaus AG
Photo: Author

In COLOS (Container Location System) Rohde & Schwarz offers one of the most advanced and powerful systems for locating straddle carriers. Rohde & Schwarz is the first company worldwide to install an automatic, satellite-based position location system of this type in a container terminal, situated at the Buchard quay in Hamburg, with turnover of around 15 million tons of goods and space for 35,000 standardized containers (FIG 1). These figures make the Hamburger Hafen- und Lagerhaus AG (HHLA = Hamburg port and warehouse company) Hamburg's leading port and transport enterprise.

At the container terminal of the HHLA, where around 1.5 million standardized containers are handled per year, and in ports of comparable size, additional costs incurred in the search for misplaced containers are considerable. Expenses for a single day of lay-off per ship amount to around 100,000 DM, which makes searching for a misplaced container a costly business. A search becomes necessary every time a straddle carrier operator fails to deposit a container at the assigned location. At a terminal where 70 vehicles are used around the clock, this happens on

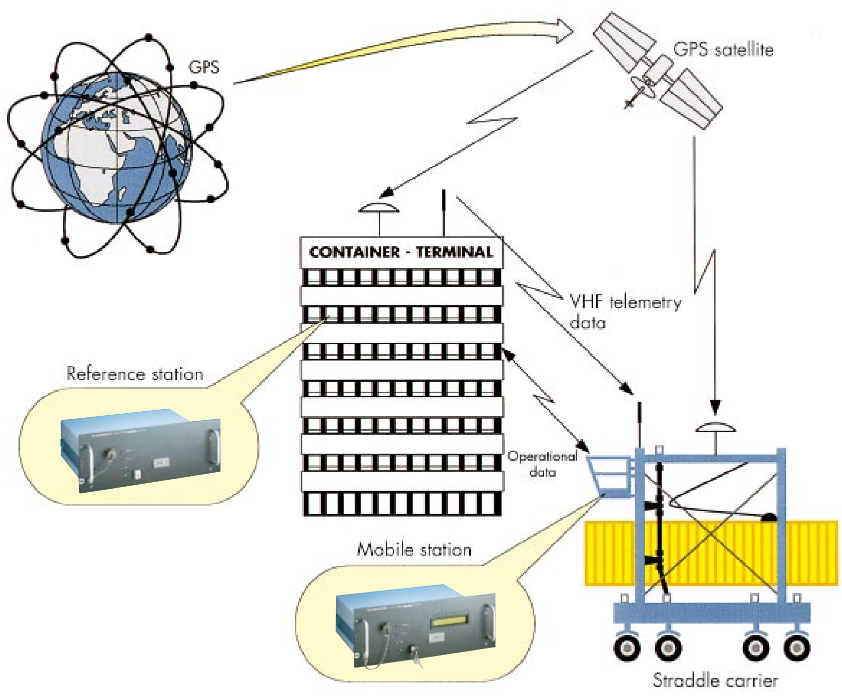

FIG 2 Principle of container location with COLOS

the average twice a day. The HHLA came to the conclusion that looking for containers occurs too often and is too expensive. So it ordered the satellite-based Container Location System COLOS from Rohde & Schwarz. COLOS automatically identifies the position of the containers and provides information on weight, length and stacking level whenever a container is deposited or picked up at the terminal.

Another benefit of knowing the exact position of all containers is that storage capacity can be increased. So far the top level of the terminal had to remain empty so as not to obstruct access by carriers. If a container were to be lifted over two vertically stacked containers, the third level had to be left free for manoeuvring. With all container positions and the loading sequence known, an intelligent storage management system can also use the top level for storage. In the described example this corresponds to an increase in storage capacity of 50% in the ideal case.

Container Location System COLOS is based on the Global Positioning System (GPS). This satellite-based location system allows positioning on the ground within a circle with a radius of 100 m around the actual position. The Differential Global Positioning System (DGPS)*, evolved from GPS, ensures considerably better positioning accuracy (uncertainty less than 1 m). It is due to this development that the system can now fulfill the stringent requirements of container positioning at a terminal.

DGPS corrects the received GPS position data by using correction data obtained from a reference station. The correction data are transmitted from the reference station to the mobile units (at 9600 Baud) via a telemetry link (FIG 2). The carrier vehicles can thus improve their GPS position data. Position and other data of the containers deposited at the terminal are transmitted to the control center via an operational data link. Here the position and other data of all containers are handled and all actions relating to these data are coordinated. Conversely, the carrier operators are informed via this channel of where to move next.

As the positions of the straddle carriers are dynamically determined with pinpoint accuracy, these data can basically also be used to ward off collisions. This is of particular interest at terminals using unmanned carriers. Dynamic positioning of the vehicles is also a prerequisite for effective fleet management. This means that the movement of empty carriers is reduced to a minimum, distances to be covered are optimized and capacities are used as required. The utilization of available transport capacities is thus increased.

Use of the DGPS location system is not limited to container positioning. It is suitable for all applications requiring dynamic and highly accurate location such as, for instance, piloting of vehicles at airports, locating well holes on oil fields or positioning bucket-wheel excavators in brown-coal open-pit mining.

Rohde & Schwarz offers a series of satellite-based location systems with various degrees of positioning accuracy. COLOS offering pinpoint accuracy to within 1 m is the most accurate DGPS system from Rohde & Schwarz.

Thomas Kneidel

* Krüger, G.; Springer, R.: Highly precise localization on land, at sea and in the air with GPS and DGPS. News from Rohde & Schwarz (1993) No. 140, pp 26–27

Reader service card 151/10

Automatic measurements on tape recorders using Audio Analyzer UPD

Live transmission of sound and TV programs tends to be the exception. Normally programs are stored on magnetic tapes and replayed whenever required or when broadcast. Sound and TV programs are also filed away on magnetic tapes. It must be ensured, of course, that this conservation does not impair audio or video quality. In large broadcasting stations several hundred of these tape recorders and video recorders may be in permanent use. They are subject to wear and tear, so they require regular maintenance to preserve the quality of reproduction. Depending on the complexity of the equipment, manual measurements on a recorder may take several hours and in the case of regular maintenance of a great number of units this may lead to capacity problems – not to speak of the costs involved for the service personnel. In the past a number of computer programs were available for automatic measurements on tape recorders but, as a great number of measuring instruments and a PC were required, they could only be used in a stationary role.

In Audio Analyzer UPD an instrument is available which is able to carry out practically all necessary audio measurements [1]. Whole test sequences can be performed automatically with the aid of the optional Universal Sequence Controller UPD-K1 [2]. The application software "Automatic measurements on tape recorders" makes use of this capability and allows even custom program functions to be included in the automatic sequence. The large numbers of Sony Betacam recorders used in broadcasting stations can thus be remotely controlled by UPD and measurements are carried out fully automatically. No other measuring instruments or an additional PC are required. Tape recorders can thus be measured directly on site (FIG 1). The program allows automatic checking and documentation of the recording and reproduction quality of tape recorders and of the sound section of video tape recorders with the aid of industrial standard reference tapes, custom recordings or custom test tapes.

FIG 1
Automatic measurement on tape recorder with Audio Analyzer UPD
Photo 42 400/2

The **control program TAPE.BAS** comprises the following **selectable menus:**

- Measure with reference tape
- Record with tape monitoring
- Record without measurement
- Measure with recorded tape
- Read stored test data
- Manual single measurements

For measurements with reference tapes no manual action of any kind is required. In the case of a Betacam recorder with remote control and a reference tape with time code, the necessary testpoints on the tape are automatically selected in CUE-UP mode. Without remote control, the reference tape has to be rewound and started at the beginning. The required testpoints on the tape are automatically selected and the measurement is performed.

Recording with simultaneous tape monitoring is possible with a user-defined sequence and usually done without remote control. Remote control is required however for measuring erasure attenuation, as in this case the particular tape section has to be tracked several times.

Recording without simultaneous measurement with a user-definable sequence allows the generation of a test tape for recorders without tape monitoring.

The "Measure with recorded tape" menu is called up for testing reproduction with a previously recorded tape (eg a custom reference tape).

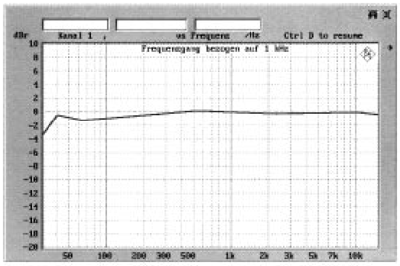

FIG 2 Result of frequency-response measurement

Loading and reading of stored measurement data is required for display or comparison with current measurements.

Manual measurements are required, for instance, for service settings or adjustments.

The following **single measurements** can be combined into **any sequence:**

- output level,
- azimuth (10 kHz),
- reference level for frequency-response measurement,
- frequency response with reference tape (definition acc. to reference tape table),
- frequency response short (63 Hz/ 1/2/4/10/12.5/15/20 kHz),
- frequency response long (31.5/40/ 63/125/250/500 Hz/1/2/4/ 6.3/8/10/12.5/14/15/16/17/ 18/19/20/22 kHz),
- S/N ratio (weighted and unweighted),
- FM S/N ratio (60 Hz/–20 dB with 400-Hz highpass filter),
- distortion d3 (1 kHz or depending on reference tape),
- crosstalk 1 > 2 (1 kHz),
- crosstalk 2 > 1 (1 kHz),
- crosstalk 1 > 2 (10 kHz),
- crosstalk 2 > 1 (10 kHz),
- wow & flutter CCIR and unweighted (3150 Hz),
- pitch error (3150 Hz),
- channel selection (mono)
- channel selection (channels 1+2)
- channel selection (channels 3+4)
- distortion d3 (1 kHz) at nominal level +3 dB
- erasure attenuation + output level at 1 kHz.

After the selection of mode and sequence the measurement is started automatically. If the recorder is remotely controlled, no further action is required. Without remote control the operator is requested to rewind the tape and press Play or Rec+Play. Measurement results can be stored together with the test report information for documentation (FIG 2), postprocessing or comparison. Results can also be subjected to an automatic tolerance check with the aid of a user-defined tolerance mask. Values within the tolerances are marked and will not be shown in the printout. This allows a very fast go/ nogo test or a short test report to be made.

The test program considerably simplifies the maintenance of tape recorders and therefore improves performance reliability while at the same time reducing workload. Users of UPD may obtain the respective Application Note (1GPAN19) together with the program free of charge from their local Rohde & Schwarz representative.

Tilman Betz

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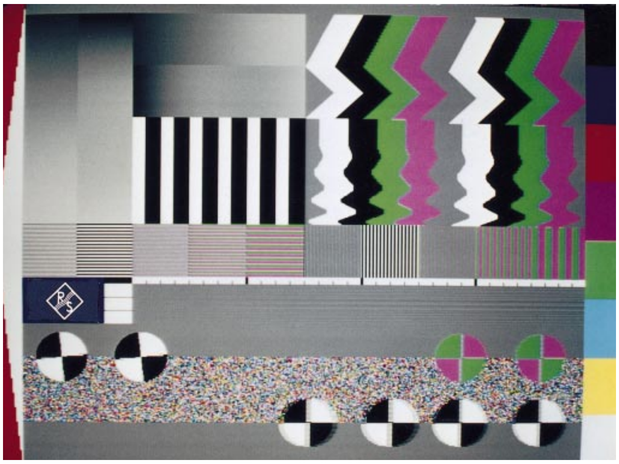
[2] Hempel, J.: Automatic audio measurements with user-friendly control system of Audio Analyzer UPD. News from Rohde & Schwarz (1993) No. 143, pp 29–30

Reader service card 151/11

DVTS – video sequence for assessing MPEG encoders

What is picture quality? How do you define TV picture quality? Up to now things were relatively simple. The picture quality determined in subjective tests with large groups of viewers on representative examples was closely correlated with a number of measurement results, the assessment of which allowed reliable conclusions to be drawn. That was the world of analog TV.

The TV pictures of the future will be digitally coded. They will be data-reduced and compressed and show characteristics that cannot yet be assessed in every detail. And this future has already started. For Rohde & Schwarz as a manufacturer of TV test and measuring instruments the question is: how can the quality of TV pictures be assessed under these new conditions? To tackle this question a number of problems have to be defined and solved first.



DVTS test pattern

An initial step towards finding an answer is to assess the influence of the encoder on the picture components.

The type of coding entailed by MPEG-2 [1] is mainly based on the reduction of redundant and irrelevant information contained in consecutive TV pictures, for instance, on the minimum resolution required for the human eye to discern moving elements on the screen. By eliminating these redundant and irrelevant components, and particularly by an intelligent combination of different data-reduction methods, compression factors of the order of 50:1 to 100:1 are obtained depending on the source material and the desired picture quality of the coded signal. This means, for example, that a TV signal to CCIR 601 of 216 Mbit/s is compressed to around 4 to 2 Mbit/s. Since different reduction and compression methods are combined in this case, greatly varying results are obtained after encoding depending on the individual parameters selected.

The tools that can be used in the encoder are described in detail in the MPEG-2 standard. The efficiency of the combined tools for the source material can be globally assessed by visually examining the encoded signal, but a differentiated evaluation was so far doomed to failure because of the considerable effort involved in a statistically sound, subjective quality assessment. For this reason Rohde & Schwarz has developed a product in close cooperation with the communications institute of Braunschweig Technical University as a first attempt to solve these problems.

The **Encoder Test Sequence DVTS** (FIG) consists of stationary and moving picture elements that stringently test the various capabilities of an encoder. It allows assessment with the aid of the artefacts typical for this kind of hybrid coding. The test sequence in line with CCIR 601 is stored on tape in the D1 or Betacam SP format. The test sequence is used as an input signal to the encoder. The encoded signal is then decoded and displayed on a monitor. By using the same decoder the differences between different encoders can be determined. Theoretically the decoder should have no influence on signal quality, so even different decoders may be used.

The following **parameters** can be assessed in this way:

- global quantization factor (for JPEG, MPEG-1 [2], MPEG-2) indicated as a relative quantity (0 to 31) on a scaled bar display,
- quantization error at grey-scaled, neutral wedges; the block artefacts examined in this case permit conclusions to be drawn on DCT (digital cosine transform) parameters,
- quantization error at edges; this error is to be assessed separately for the luminance and chrominance components,
- quantization error for moving objects; at high compression factors, in particular the artefacts moving in front of a background which corresponds to a noise signal can be clearly distinguished,
- prediction errors; they allow conclusions to be drawn on the sequence of I, P and B frames (intracoded, predicted and bidirectionally predicted picture elements).

Information on preprocessing is provided in addition:

- subsampling of luminance and/or chrominance components in the vertical direction,
- subsampling of luminance and/or chrominance components with prefiltering with/without separation of picture elements,
- discarding of luminance and/or chrominance components.

With the Encoder Test Sequence DVTS the first of many steps has been taken towards objective assessment of picture quality for heavily compressed video signals. Updates will be regularly issued to include the latest findings of experts and users alike. Through cooperation with its customers Rohde & Schwarz would like to find a solution to the problem of objective assessment of TV picture quality.

Dr. Jürgen Lauterjung

REFERENCES

[1] ISO/IEC 13818-2: Information Technology – Generic coding of moving pictures and associated audio information, Part 2: Video

[2] ISO/IEC 11172-2: Information Technology – Coding of moving pictures and associated audio for digital storage media at up to about 1.5 Mbit/s, Part 2: Video

Reader service card 151/12

RF switch units simplify type-approval tests for mobile radio

A variety of measurements are stipulated for type-approval tests of mobile radios and base stations. The specifications of the European Telecommunication Standards Institute (ETSI) define measurements of RF parameters and measurements at different layers. These can be carried out fully automatically by systems for mobile-radio type-approval testing from Rohde & Schwarz. FIG 1 shows a configuration based on Test System TS8510 for base stations [1]. The DUT is integrated into the test procedure via three different interfaces: a digital interface with 2.048 Mbit/s (A_{bis}) and two RF interfaces for DUT transmitter and receiver. The two RF interfaces and the digital interface are operated by separate units – in TS8510 by Digital Radiocommunication Test Set CRTP04 from Rohde & Schwarz [2] for the RF interfaces and a Siemens protocol tester for the A_{bis} interface. This configuration meets all the requirements for RF tests with standard accuracy and for classic protocol tests.

In addition to protocol tests, ETSI specifications also stipulate parametrical RF measurements with partly very high demands on DUT and test system. These **parametrical RF measurements** comprise:

- receiver dynamic range from –104 to –15 dBm,
- susceptibility of receiver:
  intermodulation suppression,
  adjacent-channel suppression,
  co-channel suppression,
  blocking,
  spurious response,
- spurious emission of transmitter,
- intermodulation attenuation of transmitter.

In many of these cases, RF signals from different sources are to be applied to the DUT very accurately or the test signal or sections of it have to be measured and detected precisely. This will be illustrated by two typical tasks of type-approval test systems: measurement of receiver RFI immunity and transmitter spurious emissions.

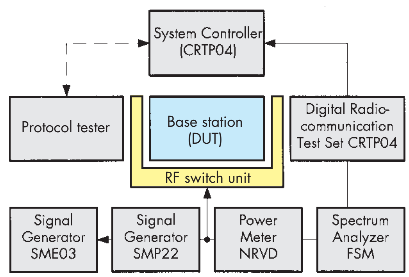


FIG 1 Block diagram of Test System TS8510 for base stations

In testing the **RFI immunity of base stations** a wanted signal of very low level (eg –104 dBm) is applied to the DUT and at the same time an unwanted signal of very high level (eg +8 dBm) in the range 100 kHz to 12.75 GHz. With a receiver input bandwidth of 200 kHz a signal/noise ratio of >170 dBc is obtained. Even given the best generators, this is only possible with the use of filters. Three filters are required for the large frequency range from 100 kHz to 12.75 GHz: a lowpass filter and a highpass filter for frequencies outside the receiving range and a notch filter for frequencies within the receiving range. As the receive frequency of the DUT has to be variable, a tunable notch filter is used for measuring blocking signals in its vicinity. To ensure accurate stimulation of the wanted signal to within ±1 dB, it is adjusted at a high level with a precision power meter and then reduced to the required level of –104 dBm via an attenuator.

The **spurious emissions of base stations** have to be measured in the frequency range 100 kHz to 12.75 GHz. Their level must not exceed –36 dBm in this range (–30 dBm from 1 GHz). The base stations are operated at full power level – for TS8510 this means output power up to +43 dBm, which corresponds to a dynamic range of 79 dB. Testing is made difficult (as far as the spectrum analyzer is concerned) by the fact that ETSI standards stipulate test bandwidths of up to 3 MHz. This

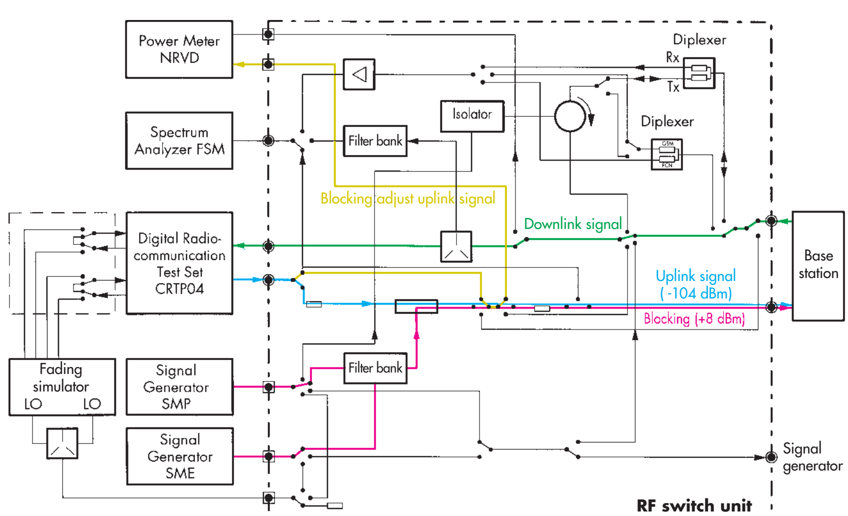


FIG 2 Block diagram of RF switch unit for type-approval test systems

cannot be managed by the spectrum analyzer without filters, which is why three filters are required for each receiving range (a lowpass and highpass filter each as well as a notch filter), ie a total of six filters for GSM and PCN. As GSM and PCN signals have the same coding apart from the frequency, the spurious emissions of GSM stations in the PCN band and those of PCN base stations in the GSM band must not exceed –98 dBm at full output power. The required dynamic range of >140 dB can only be produced using a special duplex filter and an amplifier.

For manual switching, all these measurements require a lot of hardware for the test setup, measurement and compensation of the individual paths. Moreover, the setups have to be documented very precisely for type-approval testing so that measurements may be repeated under the same conditions any time. An RF switch unit offers an alternative: measurements are carried out fully automatically and can be repeated and verified any time under exactly the same conditions – even in other labs. FIG 2 illustrates the principle of such a switch unit used by Rohde & Schwarz in its GSM Simulator, ITA Test System TS8910, PCN Simulators TS8920 and TS8925, DECT Test System TS8930 as well as in Test System TS8510 for base stations mentioned above.

Michael Manert

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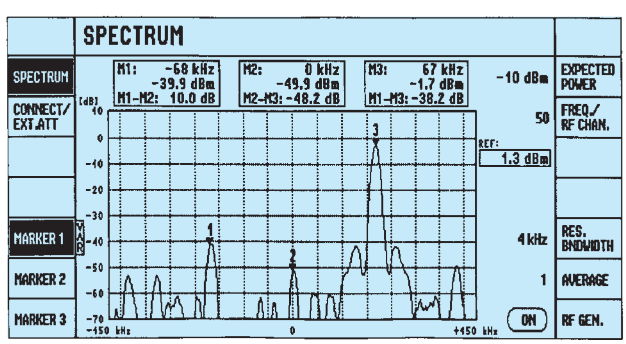
[2] Schubert, W.: Digital Radiocommunication Test Set CRTP04 – Test set for base stations to new PCN/DCS1800 mobile-phone standard. News from Rohde & Schwarz (1993) No. 143, pp 8–10

Reader service card 151/13

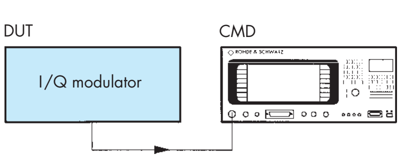
Test hint

Alignment of I/Q modulators by narrowband RF spectrum analysis

Rohde & Schwarz offers a narrowband RF spectrum analyzer (option CMD-K43) for the **GSM/PCN/PCS test sets of the CMD family.** With a frequency span of ±130 kHz and selectable resolution filters, spectral lines can be measured in a dynamic range of up to 60 dB. This analyzer is especially suitable for the alignment of I/Q modulators. For a GSM modulator, for example, the RF signal to be tested is modulated with +67.7 kHz frequency offset. By adjusting the gain, offset and quadrature, signal components at –67.7 kHz and at the carrier center can be reduced to minimum.



After alignment compliance with specifications of I/Q modulator can be verified using two measured values and two difference markers.



For this purpose Digital Radiocommunication Tester CMD has three additional markers that also operate as difference markers. The quality of alignment can thus be checked very easily.

Werner Mittermaier

Reader service card 151/14 for further information on CMD-K43

Digital modulation and mobile radio (II)

2 Basic modulation techniques

The amplitude, frequency and/or phase of the RF or baseband signal described by equations (2) to (6) are modified by the data signal so that the information it represent is impressed on the RF signal. The terms M-ary amplitude, frequency or phase modulation are used to indicate which parameter is varied to represent the information. The term keying is used for digital modulation. The abbreviations ASK for amplitude-shift keying, FSK for frequency-shift keying and PSK for phase-shift keying are widely used internationally.

Straight ASK has ceased to have any significance in practice, but FSK and PSK are widely used in their binary and M-ary forms. With M-ary PSK, the upper limit for M is 8 because noise susceptibility rises disproportionally as M increases. A combination of ASK and PSK is used for M >8. This leads to M-ary quadrature amplitude modulation (QAM). In this case the carrier can assume M states or, as has already been explained, there exists a set of M time-domain signals, each of which represents a digital word ld(M) bits in length (ld = logs to base 2).

The actual modulation process involves multiplying an RF carrier of the form $A \cdot \cos[(2\pi f_c t + \varphi(t)]$, which can also be expressed in complex form as $A \cdot \exp(j2\pi f_c t) \cdot \exp[j\varphi(t)]$, by the baseband signal. A simple ring mixer can be used to perform straightforward types of modulation like binary ASK or PSK. The data sequence is converted into a unipolar (ASK) or bipolar (binary PSK) NRZ signal. With M-ary PSK and QAM, the signal to be modulated must be split into its I and Q components. Both components are modulated by two different time-domain signals $c_I(t)$ and $c_Q(t)$, which are derived from the data sequence a(n). However, it turns out that these two time-domain signals are identical to the real and imaginary parts of the complex, equivalent baseband signal to within the sign of the imaginary part. Modulation is then essentially a process of mapping the data sequence a(n) to be transmitted onto the complex envelope of the modulated RF signal.

2.1 Amplitude-shift keying

Amplitude-shift keying (ASK) is the simplest way of modulating digital information onto a carrier. Even though on/off keying (OOK), the original version of ASK, is no longer commonly used, it is the key to understanding the fundamentals of digital modulation.

To simplify the discussion, we shall assume that the data stream which modulates the (real) carrier $A \cdot \cos(2\pi f_c t)$ is a sequence a(n) with $a \in \{0, 1\}$ comprising an alternating sequence of 1s and 0s, ie a(n) = 1, 0, 1, 0, 1, 0, ... This sequence is converted into a unipolar NRZ signal by a digital interpolation filter with

$$h(t) = \begin{cases} \frac{1}{T} \text{ for } -\frac{T}{2} \le t \le \frac{T}{2} \\ 0 \text{ elsewhere} \end{cases}$$

After D/A conversion, a signal with the Fourier series

$$u(t) = \frac{1}{2} A \cdot \left[1 + \frac{2}{\pi} \cdot \cos\left(2\pi\left(\frac{1}{2} f_{bit}\right) t\right) - \frac{2}{3\pi} \cdot \cos\left(2\pi\left(\frac{3}{2} f_{bit}\right) t\right) + \ldots\right] \quad (7)$$

is obtained.

The DC component is half the amplitude (A/2) and there are spectral lines at odd half-integer multiples of the bit rate, ie $(2n+1) f_{bit}/2$. There are no spectral lines at whole integer multiples of the bit rate $n \cdot f_{bit}$ $(n \neq 0)$. If the data sequence is a random, uniformly distributed sequence of 1s and 0s, a good assumption for actual data transmissions, the discrete spectrum tends to a continuous spectrum in the limit. Again there is a DC component of A/2 and zeroes at multiples of the bit rate. This signal is fed to the modulator.

It is easy to see that the carrier is, in effect, turned on and off when it is multiplied by the unipolar NRZ signal. If modulation is taken to be the assignment of a symbol a_i from an alphabet comprising N symbols to a signal s_i from a set of N signals (in this case N = 2), the signal $s_1 = \cos(2\pi f_c t)$ is assigned to the symbol 1 and the signal $s_2 = 0$ to the symbol 0.

As the carrier signal and the baseband signal are multiplied together, it follows from the shift theorem for Fourier transforms that the spectrum of the modulated RF signal is

$$s(t) = \frac{1}{2} A \cdot \left[\cos(2\pi f_c t) + \frac{1}{\pi} \cdot \cos\left(2\pi\left(f_c \pm \frac{1}{2} f_{bit}\right) t\right) - \frac{1}{3\pi} \cdot \cos\left(2\pi\left(f_c \pm \frac{3}{2} f_{bit}\right) t\right) + \ldots\right] \quad (8)$$

for the sequence a(n) = 1, 0, 1, 0, 1, 0 ...... and a continuous spectrum in the form of a symmetrical mapping of the baseband spectrum into the RF band for a random sequence a(n). In both cases the carrier frequency is present in the spectrum but at half its original amplitude. The spectrum has zeroes at the frequencies $f_c \pm n f_{bit}$ (FIG 3).

Equation (8) shows that both halves of the spectrum centered on the carrier frequency would, in theory, be infinitely wide. Therefore, to ensure efficient use of the RF band, the spectrum must be bandlimited. This is best done in the baseband. Specifically, all frequencies in the baseband signal up to at least $f_{bit}/2$ must be allowed through. This is equivalent to limiting the bandwidth of the RF signal to $fc \pm f_{bit}/2$, in other words to f_{bit}.

Abrupt limiting of the baseband at $f_{bit}/2$ is counterproductive because large signal delays are introduced. The filter that is used should, therefore, have a continuous transition from the passband to the stopband which follows a cosine function for example.

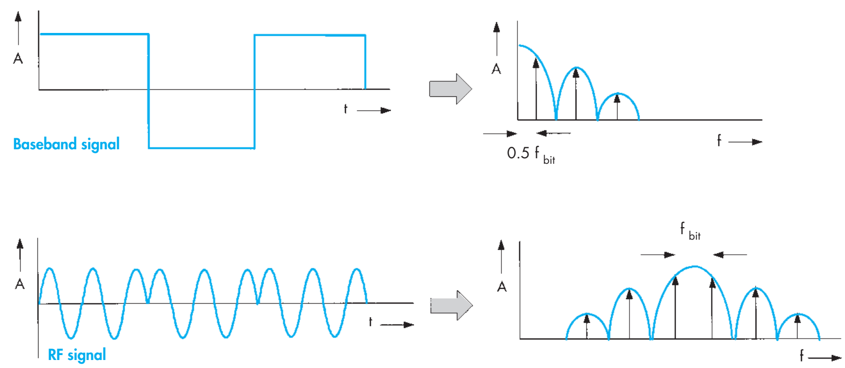


FIG 4 Time-domain signals and spectra with binary phase-shift keying

$$H(f) = \begin{cases} 1 & \text{for } 0 \le f \le \dfrac{(1-\alpha)}{2T} \\ \dfrac{1}{2}\left\{1-\sin\left[\dfrac{\pi(2fT-1)}{2\alpha}\right]\right. & \text{for } \dfrac{(1-\alpha)}{2T} < f \le \dfrac{(1-\alpha)}{2T} \\ 0 & \text{for } \dfrac{(1-\alpha)}{2T} < f \end{cases} \qquad (9)$$

This filter replaces the sin x/x lowpass which was mentioned previously. The RF signal now has a bandwidth B which is a function of the roll-off factor α and in fact when $\alpha = 0$, $B = f_{bit}$ and when $\alpha = 1$, $B = 2f_{bit}$. In practice roll-off factors between 0.35 and 0.5 are widely used; this corresponds to RF bandwidths between $1.35f_{bit}$ and $1.5f_{bit}$. It is then possible to define a bandwidth efficiency which indicates what bit rate per Hz of bandwidth can be transmitted. The theoretical upper limit for ASK is 1 bit/s/Hz, but in practice efficiencies between 0.65 and 0.8 bit/s/Hz are encountered.

2.2 Binary phase-shift keying

If the data sequence a(n) is mapped to a sequence of delta functions $a(n) \cdot \delta(nT) \in \{+1;-1\}$, an NRZ signal is output by the sin x/x lowpass. This signal, unlike the modulation signal for ASK, is bipolar (binary phase-shift keying, BPSK). If the NRZ signal is used to modulate a carrier of the form $A \cdot \cos(2\pi f_c t)$, an RF signal which is phase-shifted by 180° as compared to the modulating signal is obtained. This means that $s_1(t) = -s_2(t)$ and this type of modulation is called antipodal.

The (real) spectrum of the baseband signal is given by

$$u(t) = A \cdot \left[\frac{4}{\pi} \cdot \cos\left(2\pi\left(\frac{1}{2} f_{bit}\right)t\right) - \frac{4}{3\pi} \cdot \cos\left(2\pi\left(\frac{3}{2} f_{bit}\right)t\right) + \ldots\right]. \qquad (10)$$

and has no DC component.

The spectrum of the modulated carrier

$$s(t) = A \cdot \left[\frac{2}{\pi} \cdot \cos\left(2\pi\left(f_c \pm \frac{1}{2} f_{bit}\right)t\right) - \frac{2}{3\pi} \cdot \cos\left(2\pi\left(f_c \pm \frac{3}{2} f_{bit}\right)t\right) + \ldots\right], \qquad (11)$$

is obtained by multiplying the baseband signal and the carrier together. The spectrum does not contain the carrier frequency (FIG 4). The occupied bandwidth is the same as that for ASK and has been limited by passing the baseband signal through a lowpass filter with a cos roll-off before modulation. Consequently, ASK and BPSK have the same theoretical maximum bandwidth efficiency of 1 bit/s/Hz and a bandwidth efficiency between 0.65 and 0.8 bit/s/Hz in practice.

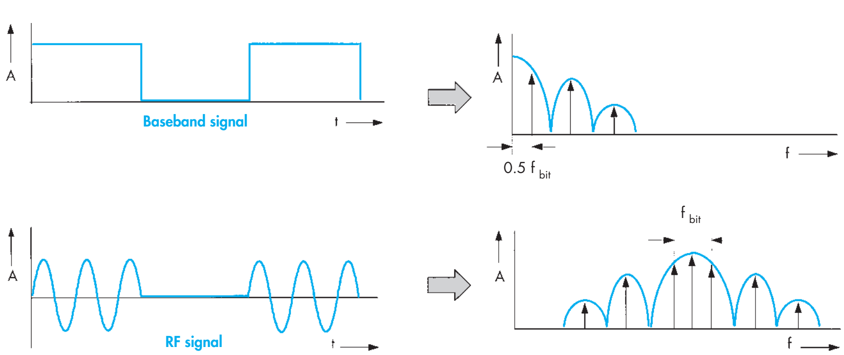


FIG 3 Time functions and spectra with amplitude-shift keying

2.3 M-ary quadrature amplitude modulation

To increase bandwidth efficiency, two, three or in general k consecutive bits from a data sequence a(n) can be combined to form a new symbol b(m) by means of serial/parallel conversion. As a result, the symbol rate is reduced to f_{bit}/k. The new symbols are referred to as dibits, tribits, quadbits or k-bit words in general. The modulation process requires $M = 2^k$ RF signals, each with a different phase and/or amplitude. The $M = 2^k$ possible symbols b(m) are mapped onto these signals.

An I/Q modulator is the best type of modulator to use. First of all, it splits the unmodulated RF signal into two components. The quadrature or Q component is phase-shifted by 90° with respect to the in-phase or I component. Therefore the unmodulated I component is described by $\cos(2\pi f_c t)$ and the unmodulated Q component by $-\sin(2\pi f_c t)$. Both components are fed to mixers, where they are multiplied with the modulating signals $c_I(t)$ and $c_Q(t)$; $c_I(t)$ and $c_Q(t)$ are derived from the symbol sequence b(m) and to within the sign of the Q component are identical to the real and imaginary parts of the complex envelope of the modulated RF signal. The products $c_I(t) \cdot \cos(2\pi f_c t)$ and $c_Q(t) \cdot [-\sin(2\pi f_c t)]$ are added together to give the modulated RF signal. The modulation process is reduced to mapping the symbol sequence b(m) onto the two baseband components. In the case of unfiltered quadrature amplitude modulation (QAM), staircase signals in the time domain with M/2 possible values are produced (FIG 5).

By passing the baseband signal through a filter with a cutoff frequency equal to half the symbol rate, the bandwidth of the RF signal is limited to the symbol rate = bit rate/k, which means that the bandwidth efficiency is k times better than for BPSK. Quadrature phase-shift keying (QPSK) is the first step in this direction. Two consecutive bits are combined to form a dibit which can represent one out of $M = 2^2 = 4$ symbols. These symbols are mapped onto the phases $\varphi_i \in \{45°, 135°, 225°, 315°\}$ of the RF signal or onto the four time-domain signals $s_i(t) = A \cdot \cos[2\pi f_c t + (2i + 1) \cdot \pi/4]$ with $i \in \{0, 1, 2, 3\}$. TABLE 1 shows how the bit sequences, the dibits, the modulation signals and the phases of the RF signal are related. FIG 6 shows the signals in the time domain, in the frequency domain and by means of a phase state diagram. It should be noted that in this case too there is no carrier-frequency component in the spectrum.

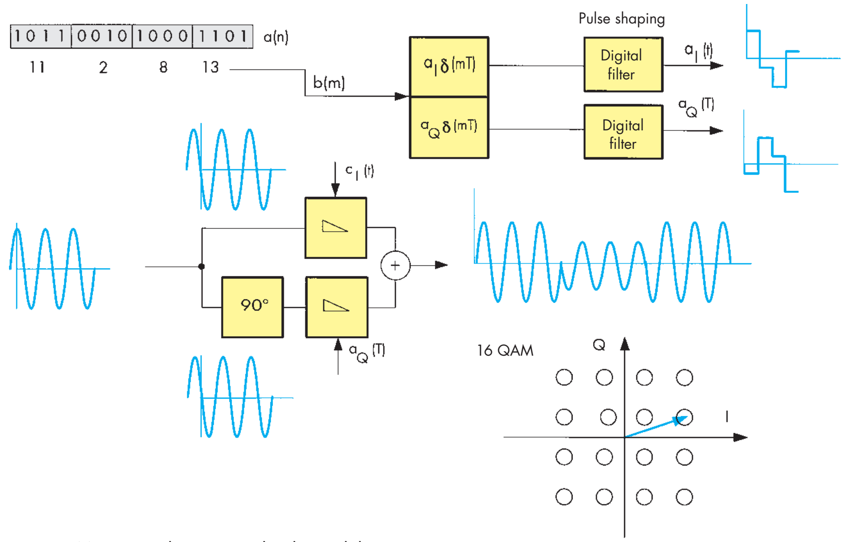


FIG 5 M-ary quadrature amplitude modulation

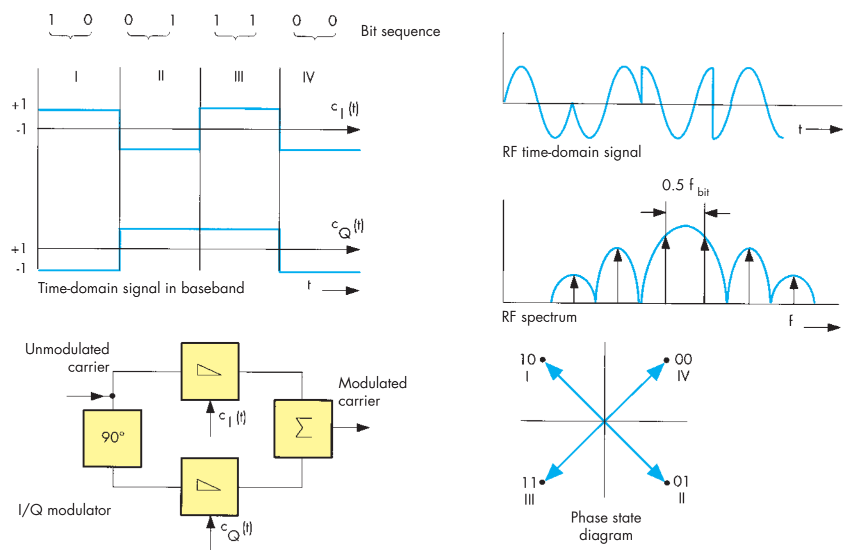


FIG 6 Quadrature phase-shift keying

Bit sequence	Dibit	$c_I(t)$	$c_Q(t)$	φ
00	I	1	1	45°
10	II	–1	1	135°
11	III	–1	–1	225°
01	IV	1	–1	315°

TABLE 1 Modulation parameter assignments

Theoretically, the bandwidth efficiency can be increased to 2 bit/s/Hz and so is twice the maximum bandwidth efficiency for ASK and BPSK. In practice, values between 1 and 1.5 bit/s/Hz can be obtained.

To be continued Peter Hatzold

ESxS-K1 – attractively priced Windows software for EMC measurements

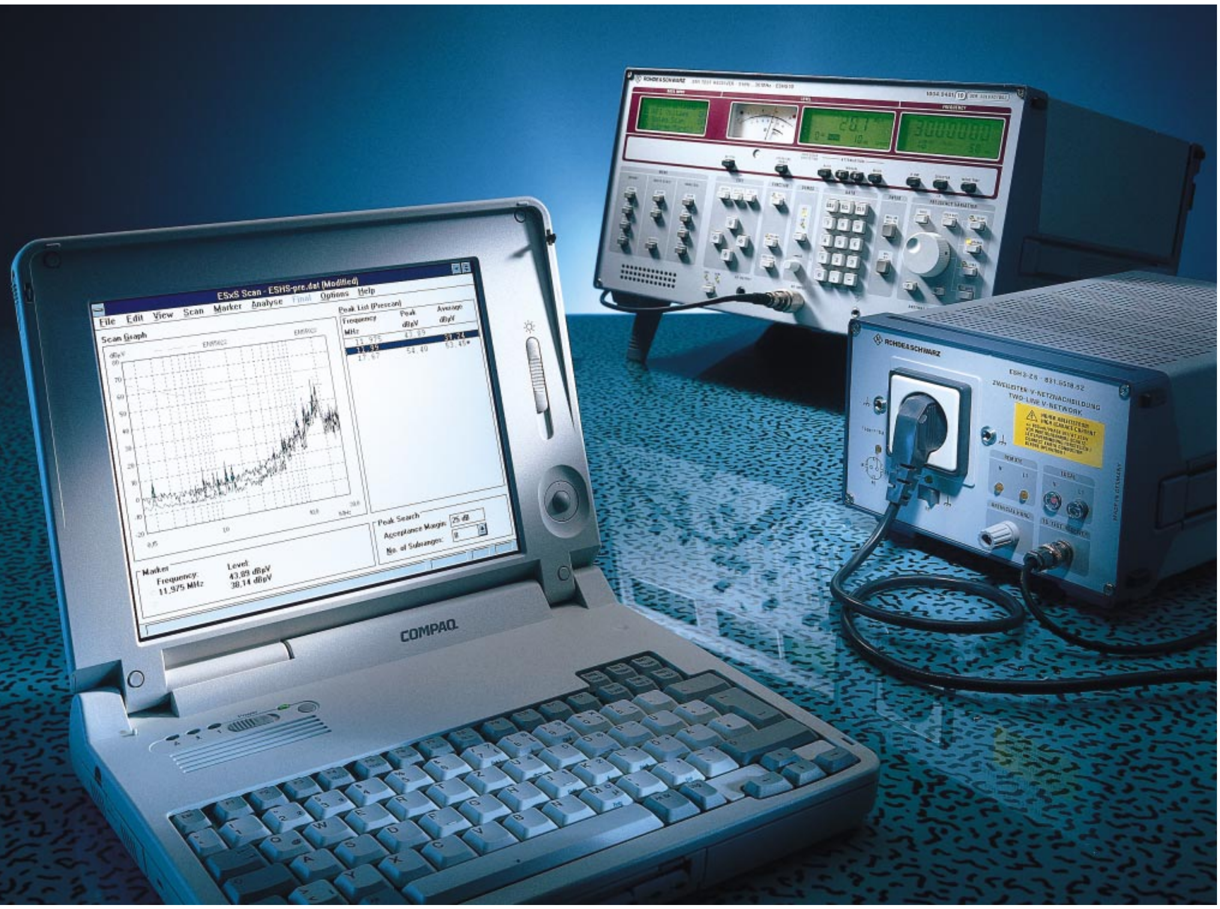


FIG 1 Fully automatic RFI test system with Test Receiver ESHS, V-Network ESH3-Z5 and computer with EMI Software ESxS-K1
Photo 42 219

The automation of EMC measurements in development and production has become a topic of interest since the coming into force of the electromagnetic compatibility law (European EMC Directive 89/336/EEC) this year. Labelling electrical and electronic products with the CE mark is now stipulated by law to indicate compliance with international standards for electromagnetic interference and susceptibility. Rohde & Schwarz, a leading enterprise in the field of EMC, offers – in addition to advanced EMI/EMS Software Package ES-K1 [1] with modular, flexible and extendable architecture under Windows – a budget-priced EMI software intended in the first place for small and medium-sized enterprises to provide fast, reliable and reproducible EMC measurements.

Software Package ESxS-K1 supports both Rohde & Schwarz compliance-class Test Receivers ESHS/ESVS/ESS and Test Receivers ESVD/ESVB/ESN/ESVN, which measure useful signals in line with the EN standard [2]. The dialogs and masks for defining test setups, scan modes, measurements, evaluation and report generation are straightforward and simple, making it easy to get acquainted with the program even for those working with it for the first time. In addition, EMI Software ESxS-K1 offers **measurement and evaluation functions** frequently needed by experienced EMC users including:

- measurements at a keystroke (configuration and loading of setups, scan start),
- graphic display of results and scan data,
- comparison of limit lines with peak and average detection,
- standard-conforming evaluation with quasi-peak and average detector,
- data reduction by subranging and/or acceptance margin selection,
- peak-list edit function, peak list can be modified for automatic and semi-automatic measurements,
- marker functions and zoom function.

Frequency sweeps can be stopped, a facility that is often needed in practice. Sweeps can be restarted at the marker frequency, the current receive frequency or at the point they were stopped.

After completion of a frequency sweep, selected subranges can be examined in detail using the zoom function. For this, the Find Worst Case function offers the current and the maximum level values, while the user performs fine-tuning of the receiver, determines the EUT position for the Worst Case mode and, at a keystroke, initiates final measurement with quasi-peak and average detection. The final result is automatically added to the frequency list.

Three options are available for **final measurement:**

- automatic measurement; this means cycling with a defined test setup through the frequency list obtained from peak measurements,
- semiautomatic measurement; same as automatic measurement but with Find Worst Case function activated,
- manual measurement; maximum level indication is obtained through fine-tuning of receiver and positioning of EUT.

ESxS-K1 of course allows complete setups to be loaded into the receiver and current setups to be stored in the PC under 'Receiver Setup'. Using editable limit lines and tables with correction values for frequency-dependent transducer factors, reproducible, standard-conforming measurements can be made. It is also possible to integrate V-Networks ESH3-Z5 (two-line) and ESH2-Z5 (four-line), which are controlled by R&S receivers via the user port, allowing the phase and PE wire setting to be recorded along with the frequency and level information.

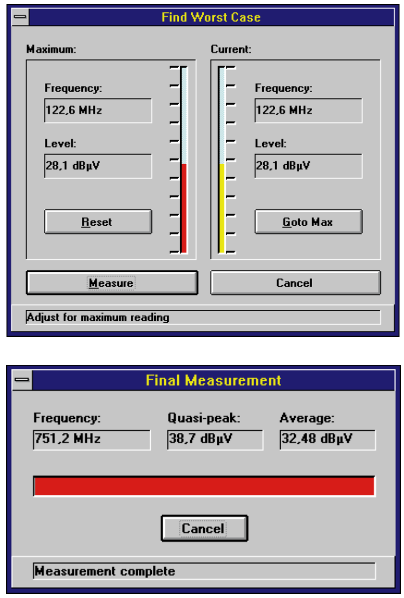


FIG 3 Final measurement with Find Worst Case function activated and measurement using quasi-peak and average detectors

The **reports** generated have the same layout as receiver reports, including all settings relevant to measurement reproducibility. Reports can be displayed before they are printed using the Print Preview function. Reports can be output to any printer or plotter supported by Windows™ 3.1. Individual report fields can be transferred via DDE (dynamic data exchange) to other Windows applications such as Winword or Excel, allowing the user to generate reports in any desired form. Moreover, detailed online help is available in English and German for all software functions.

EMI Software ESxS-K1 can be installed on any Windows-compatible computer with 80386 processor or higher with IEC/IEEE-Bus Interface Card PS-B4 from Rohde & Schwarz or PCII/IIA or AT-GPIB from National Instruments.

The software package is available for precertification Test Receiver ESPC (9 kHz to 2.5 GHz) [3] under the designation EMI Software ESPC-K1 (supplied as accessory with ESPC). The functions and features of this software are identical to those of ESxS-K1, but ESPC-K1 only supports Test Receiver ESPC.

Volker Janssen

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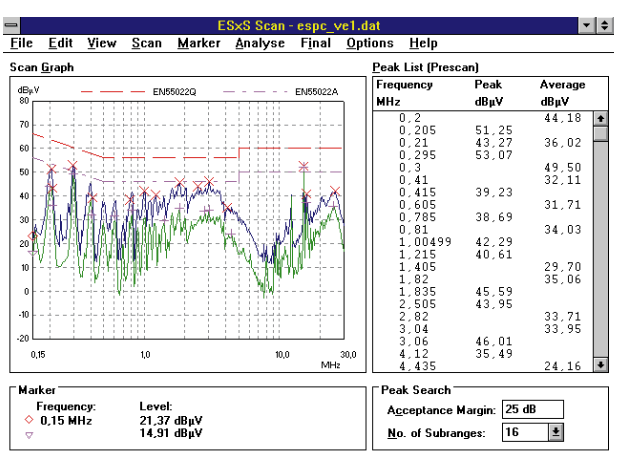

FIG 2 Curves measured with peak and average detectors, with limit lines conforming to EN55022 and associated frequency list

Reader service card 151/15

ALADIN and ARAMIS message-handling software – convenient data transmission by shortwave

It is a popular fallacy that data transmission by shortwave is unreliable, complicated and out of date. With the aid of Message-Handling Software Packages ALADIN (Automatic Link And Data Interchange Network) and ARAMIS (Automatic Radio Message Interchange System), shortwave becomes increasingly attractive in the modern communications world. ALADIN and ARAMIS provide reliable, loss-free and free-of-charge data transmission no matter whether in a building or over thousands of kilometers. Besides conventional text files, fax messages and video stills can be produced and transmitted. The menu-controlled user interface makes it easy to get familiarized with the system (FIG 1).

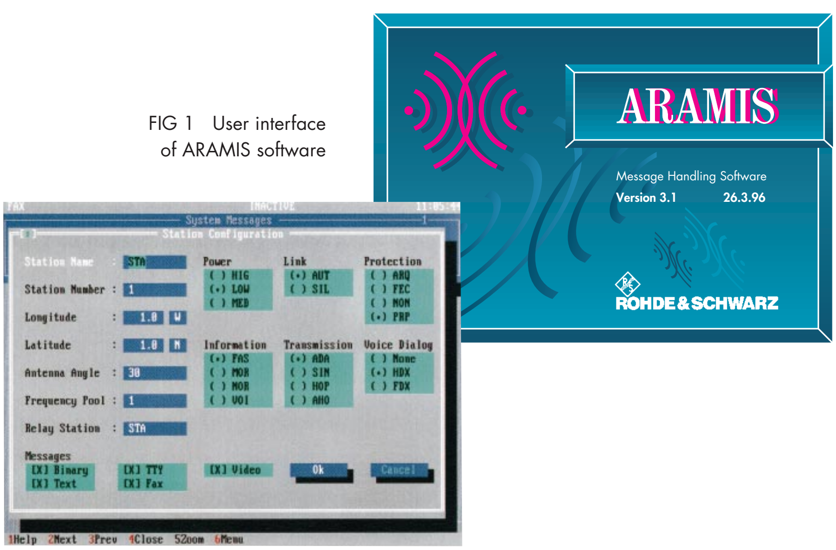

FIG 1 User interface of ARAMIS software

If no cable connection exists between parties located at a large distance from each other or if communication independent of a network operator or telephone company is desired, this is where shortwave comes into its own. In the frequency range 1.5 to 30 MHz, communication links can be set up worldwide at low operating costs. For example, many foreign ministries communicate with their representations all over the world via shortwave, independent of service providers [1], and research institutes use this medium to keep in touch with their remote field bases [2].

ALADIN and ARAMIS automatically transmit and receive messages so that the user requires no in-depth knowledge of the shortwave medium. When the user issues an addressed message, link setup and data transmission to the counterstation will be performed automatically. The two software packages provide a modern workstation (FIG 2) with a clear-cut, menu-controlled user interface for the generation, editing and transmission of ASCII texts, fax files and video stills. Basically any binary files can be transmitted. The user is supported especially in the management, storage and archiving of large quantities of incoming and outgoing messages. Possible I/O devices include camcorders, fax machines, printers and teletypewriters.

To prevent data losses during transmission, ALADIN and ARAMIS use the software-implemented Z-modem protocol in addition to data-link protocols FEC (forward error correction) and ARQ (automatic repeat request) implemented in the hardware components. If a link breaks down or is disturbed, data transmission will be continued from the point of disturbance. Successfully transmitted data will not be sent again. Encryption algorithms are available to provide increased security against the interception of sensitive data.

The two software packages ALADIN and ARAMIS make it possible to implement **communication networks** where each station can communicate with any other station. Alternatively, any user-defined organization structure, eg a star configuration, can be implemented (FIG 2).

ARAMIS was designed especially for the requirements of **small and medium-sized networks.** It is the simpler of the two systems and restricted to the shortwave medium. In an ARAMIS station, the antenna is automatically aligned in the direction of the station called to make the maximum use of transmitted and received power.

ALADIN was designed for the implementation of **worldwide communication networks.** In addition to shortwave, it allows alternative transmission media to be integrated such as Satcom terminals [3], telephone networks or LANs. If a communication link is disturbed, switchover can be made to another medium without interrupting the transmission – a unique and so far unrivalled feature of ALADIN. Successfully transmitted data will not be sent again. In addition, for each medium, alternative communication paths between the sender and the addressee (eg via a relay station) are offered to which

FIG 2 Modern shortwave workstation
Photo 42 295

switchover is made automatically in the event of a failure.

For shortwave transmission, the core of the system is formed by a special **HF data modem** [4]. The 2700-bit/s modem provides an effective throughput rate of up to 2150 bit/s at 100% data transmission reliability (corresponding to 2690 bit/s at an asynchronous PC interface with a start and a stop bit).

FIG 3 Typical structure of shortwave network

ALADIN and ARAMIS are based on an **operating system with multitasking capability.** This means that a large number of automatic processes can be performed simultaneously. For example, while a received message is output to a fax machine, a text file can be transmitted to another station and at the same time a picture recorded with a camcorder. The software packages run on System Processor MERLIN [5] or a standard PC meeting specific environmental requirements (shock and vibration resistance, EMC).

Message-Handling Software Packages ALADIN and ARAMIS make long-distance shortwave links as reliable as wired phone and fax connections but are far more economical.

Thomas Kneidel

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Reader service card 151/16

Object-oriented software development for computer-aided, mobile data transmission

Object-oriented software development is in part based on concepts already known for some time; it is however only in the past five years that it has become a topic of general interest. There are various definitions as to when an approach can be regarded as object-oriented. In contrast to the commonly employed function- or data-oriented approaches, object-oriented software development combines data and functions in such a way that they reflect as closely as possible the concrete and abstract objects of the real world.

Rohde & Schwarz has, for a customer-specific project, systematically and consistently implemented an object-oriented concept. The result is a flexible, easy-to-service **ship communication system** for the exchange of radar data, electronic mail and files of virtually any size [1]. The whole system is extremely immune to interference for two reasons:

1. use of high-quality Tx/Rx components such as VHF-UHF Transceiver XT452 and HF Transceiver XK855 with integrated FSK modem and ALIS processor [2],

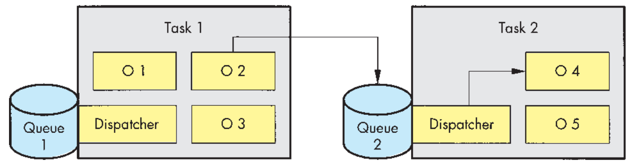

FIG 2 Typical inter-task communication via message dispatcher (O2 sends message to O4)

2. use of reliable system software that automatically responds to disturbance or interference from the environment not only by changing the frequency but also by effecting handover between the HF and VHF Tx/Rx components. The software design is based on **object-oriented software engineering** according to Jacobson [3], since this method enables a smooth transition from design to implementation.

Design steps

Object-oriented software development is implemented in several steps.

Step 1: Definition of functions
Based on the customer's requirements and the resulting specifications, all desired system functions – referred to as use cases – are recorded. The objective is to describe as completely as possible all functions required in a system. Following are four examples from the ship communication system:
"StartSupercycle" starts the super cycle, ie the central sequencing control for radio data transmission.
"StopSupercycle" stops the super cycle and allows radiotelephone communication.
"MakeLink" starts the procedure for a X.25 link setup.
"SendMessage" starts radio data transmission.

Step 2: Finding objects
In this step you determine what objects are necessary for system operation and what relationships exist between these objects. As a result the software architecture is obtained, ie the organization of the software into tasks and components (FIG 1). For example, the message dispatcher developed by Rohde & Schwarz plays an important role in the system because it extends the multitasking capability of the operating system (multi-user DOS) by simulated multitasking at the application level. While the major tasks are handled by the multitasking function of the operating system, the message dispatcher manages the objects within the tasks. For this the objects must register with all their methods (messages) at the message dispatcher during runtime. This procedure is employed not only for inter- but also for intra-task communication and for communication with device drivers (FIG 2).

Step 3: Description of interaction between objects
Object-oriented programs are based on the exchange of messages between ob-

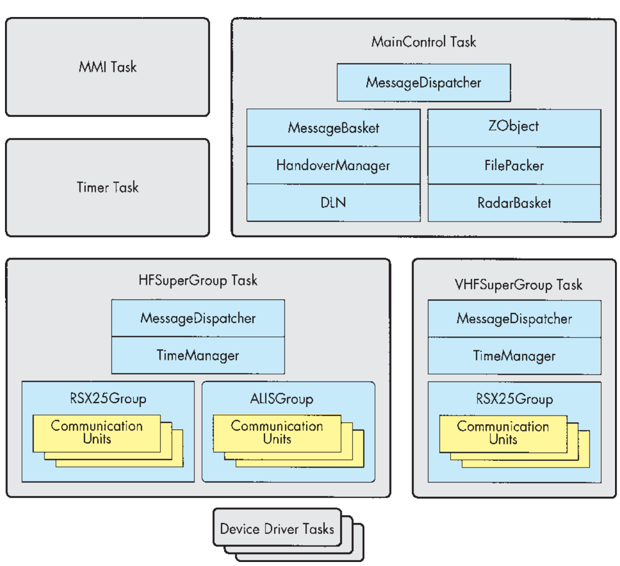

FIG 1 Software architecture for communication system

jects. A commonly employed method of illustrating the message flow is by means of message sequence charts (interaction diagrams). The message sequence charts enable the functional interfaces of the objects to be defined (FIG 3).

Step 4: Specification of objects
The majority of the objects used in the ship communication system were implemented in the form of status automatons as is common practice in communications engineering. State transition diagrams are used for the specification of the objects. The diagrams allow a smooth transition from design to implementation (FIG 4).

Coding and quality

About 20 new objects (classes) were defined for the above communication system. Part of the objects was later implemented from C++ using inheritance. Most of the objects can be re-used, eg the message dispatcher, as well as classes employed for system configuration and a timer class for time monitoring, to name just the most important ones. But not only have new classes been generated, old ones were used as well. The latter mainly included container classes and classes for the configuration of the user interface and were taken from the Borland library of classes.

High-quality software is characterized, among other features, by stability, maintainability and testability. Rohde & Schwarz created high quality in its ship communication system by following a strategy based on three mainstays:

Precondition and postcondition checks
Each object ensures as far as possible that its data are consistent by checking them during runtime. Checking is performed twice, ie on entering a method (precondition check) and on leaving a method (postcondition check). The concept is simple [4] but it markedly enhances quality and productivity as it requires developers to specify classes accurately to be able to define the conditions (invariants) for these checks. This makes codes maintainable and also extends component testing, which substantially reduces the probability of runtime errors.

Exception handling
Exception handling causes the program to go to a recovery routine in the event of an error. This feature of C++ is another powerful tool for the determination of runtime errors. It is used for cushioning protocol errors, for example.

Trace mechanism
Each object of a task writes messages into a file during runtime. The messages are classified according to contents and can be filtered as required. System operation is recorded in this way, and any malfunctions are traceable. This feature can be disabled for reasons of system performance.

Through the use of object-oriented techniques in conjunction with measures aimed at the improvement of software quality, Rohde & Schwarz has developed a product that meets even the most exacting requirements. Not without reason is the object-oriented approach regarded as a quantum leap in terms of productivity and maintainability in professional software development. Exception handling as well as pre- and postcondition checks have been incorporated into modern programming languages [5] and make for considerably increased reliability, stability and testability.

Jürgen Rauch; Karl Scalet

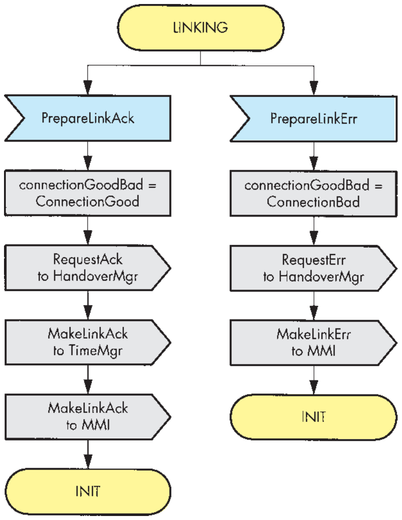

FIG 4 Detail of state transition diagram (object: RSX25Group; state transition: linking → init)

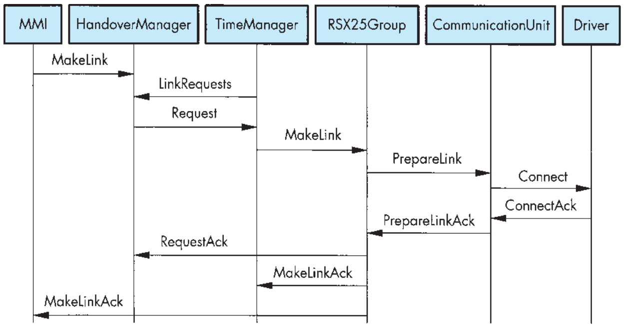

FIG 3 Message sequence chart for MakeLink system function

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Reader service card 151/17

Mass Spectrometer Airsense 500 – fast gas analyzer for automobile industry

Airsense 500 (FIG 1) is an extremely fast, selective and highly sensitive gas-analysis system for use in the automobile industry. Modern motorcar engines should have low fuel consumption and minimum exhaust emission. Moreover, drivers expect their cars to have a long service life and adequate engine performance. These requirements can be met by optimizing the combustion processes in the engine and by the use of a catalytic converter. For this, appropriate geometry of the combustion chamber, correct ignition timing and the right combustion mixture are required. Combustion processes today are microcomputer-controlled, which necessitates a thorough knowledge of the complex chemical and physical processes taking place in the engine and in the catalytic converter.

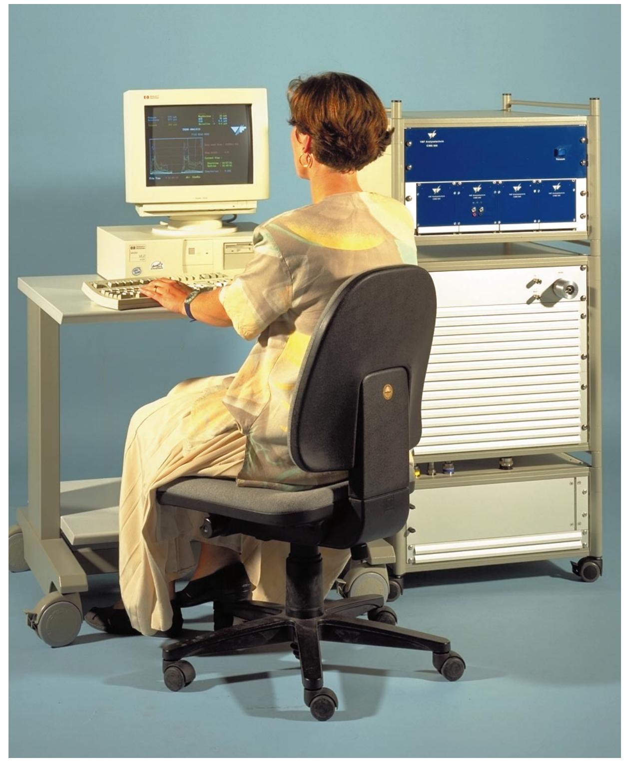

FIG 1 Multicomponent gas analyzer Airsense 500: sturdy, turnkey system configurable to customer requirements
Photo 42 459

Any variation of engine load has an immediate effect on the composition of the exhaust gases. For example, in a diesel engine more benzene can be produced with than without a catalytic converter if the engine is idling. As the composition of gases is highly complex and the processes take place at high speeds, just a few exhaust-gas components (eg NO_x, CO, SO_2, total hydrocarbons) have been analyzed so far. The processes taking place in the engine can be optimized through detailed analysis of the composition of exhaust gases and its variation with time. Mass Spectrometer Airsense 500 meets the exacting requirements as to selectivity, speed and sensitivity involved in an analysis of this kind.

A mass spectrometer is an analysis system that identifies substances by their mass. To this end, gaseous ions are generated in an ion source from a sample gas. The ions are separated in an analyzer according to their mass and charge and recorded by means of a detector. In classical mass spectrometry, ions are generated through the collision of fast electrons with the sample. This takes place in small chambers in which electrons emitted from a cathode are accelerated towards the anode, ionizing gas particles on their way. Often, more energy is transmitted in this process than required for ionization, with the result that the ions break up into smaller, likewise charged particles (fragmentation). A large number of different ions of equal mass is thus obtained in a mixture of gases, which makes qualitative and quantitative analysis impossible, ie the process is not very selective.

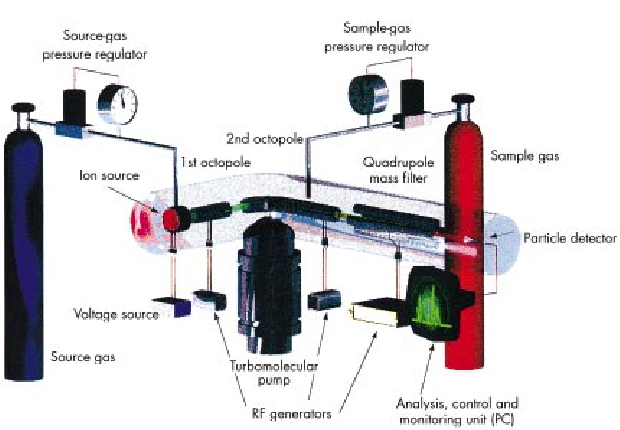

FIG 2 Basic design of Mass Spectrometer Airsense 500

Airsense 500 avoids fragmentation by employing a special ionization method. A gas sample is ionized through the

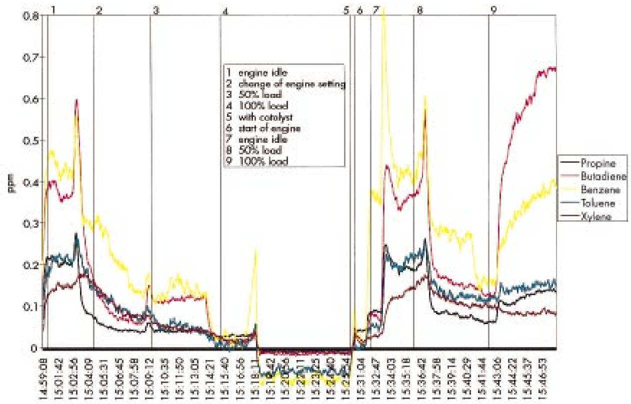

FIG 3
Exhaust-gas concentration as function of engine load

exchange of charges between charged source-gas ions (eg Xe^+) and the molecules under examination (secondary-ion mass spectrometer). Each type of source-gas ion has its characteristic energy. Using suitable source gases, the ionization energy can be exactly determined and fragmentation avoided. Airsense 500 in this way provides interference-free analysis of complex gas mixtures.

The source-gas ion current is focussed in the first octopole (FIG 2) using high-frequency fields in an ultra-high vacuum and transported to a chamber where charge exchange takes place, ie the gas sample is ionized. The ions obtained are focussed in a second octopole. The ion streams are separated according to their masses in a quadrupole filter using crystal-stabilized high-frequency fields. The particle detector consists of a secondary-ion multiplier (Channeltron), a fast preamplifier and an electronic GHz counter. This special system affords detection limits far below one ppb (part per billion) and measurement times below 100 ms. This allows even extremely small changes in the concentration of a substance to be detected on-line (FIG 3). Using different ionization gases in rapid succession, it is possible to extend the spectrum of measurable components.

The gas-analysis system Airsense 500 has proved its value under adverse conditions such as exist on engine test stands as well as in garbage-incinerating plants, coal-fired power stations and in the food-processing industry.

Dr. Andreas Waßerburger

Reader service card 151/18

The “lifeline” to rescuers in the air

In summer 1995 Rohde & Schwarz won the order to supply a blanket radio network for the SAR service (search and rescue) of the German Air Force. This organization of the Federal Armed Forces is primarily a service to support military operations. And as part of the national search and rescue service of the Federal Republic of Germany, it helps any aircraft and – in cooperation with Deutsche Gesellschaft zur Rettung Schiffbrüchiger (German society for rescuing shipwrecked persons) – any vessel in an emergency situation. In addition to these tasks it supports the civil rescue service in case of acute emergencies (FIG 1), provided there is no conflict of interest with the military tasks and requirements of the SAR service [1].

FIG 1
SAR helicopter of German Air Force on duty
Photo: Armed Forces Office

The Federal Republic of Germany is divided into SAR areas (FIG 2). Search and rescue activities are managed by the rescue coordination center. This center of the German Air Force is responsible for the whole of Germany except for its northern state Schleswig-Holstein. This belongs to the SAR area of Glücksburg and comes under the jurisdiction of the German Navy, which has its own radio network.

More than 30 air-control radio stations are set up to ensure blanket VHF-UHF

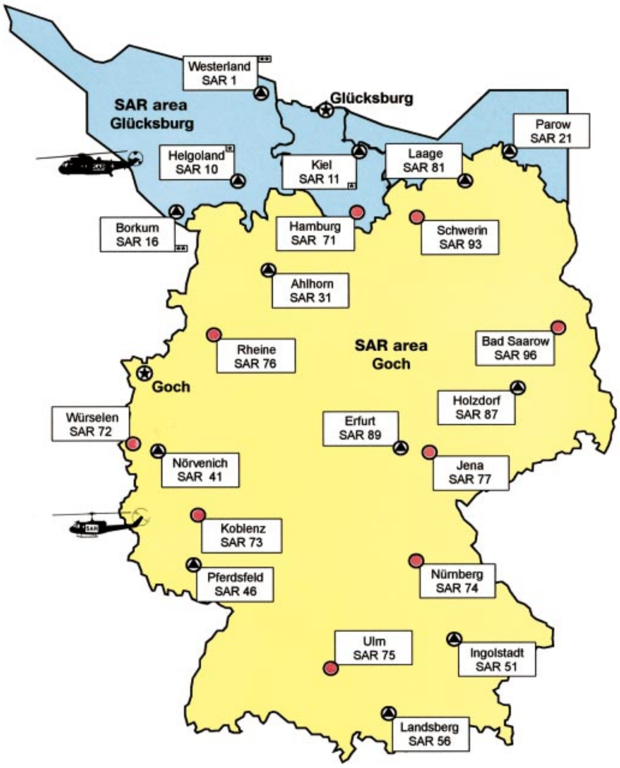

FIG 2 SAR areas of German Armed Forces (asterisk = rescue coordination center, triangle = SAR helicopter, red circle = SAR helicopter with doctor on call)

radio coverage for the operation area of the German Air Force. These stations comprise two radio systems based on equipment of series 400 (FIG 3) [2]. They can be operated in the VHF or UHF aeronautics band and allow data transmission in both frequency bands from an air-control radio station. Stations already operating VHF-UHF radio services are provided with separate transmitters and receivers with associated antennas. This is usually the case with local military ATC centers and air-defense radar stations. Stations of the German Air Force Automated Communications System are normally equipped with transceivers only. The rescue coordination center operates, monitors and controls the radio network via a central system.

One of the radios of the air-control radio stations is linked to the monitoring and control system in the rescue coordination center via a semipermanent line. Communication with such radios is thus always possible on the set frequency. The second radio is elected as an ADS (automatic direct subscriber) via the German Air Force Automated Communications System so that a second frequency in the VHF-UHF band can be used at the same time. The operational equipment (primary units) of all the air-control radio stations are normally operated on a common frequency. However, the frequency can be changed by remote control to deal with major incidents.

The semipermanent lines of all the air-control radio stations are linked to the rescue coordination center. Moreover, ADS links are set up between the rescue coordination center and the nearest switching center. The control of radios including all the required device settings as well as the output of device messages is via three independent data-processing workstations. The whole radio system can be accessed from any of these workstations. The radio network can be divided into subnetworks. Access to the primary unit of an air-control radio station is computer-controlled, ie access is possible by clicking the selected air-control radio station on the graphic display of the radio network. The secondary unit is selected by means of the direct access key.

Project planning provides for step-by-step implementation and startup of the radio network. The complete system is intended to be available in 1998. Thus, SAR will receive a tool that considerably facilitates and speeds up operating routines in radiocommunication, improves availability and last but not least reduces operating costs.

Franz Ketterle

FIG 3 Transceiver of Rohde & Schwarz radio equipment series 400
Photo 40 903

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Reader service card 151/19

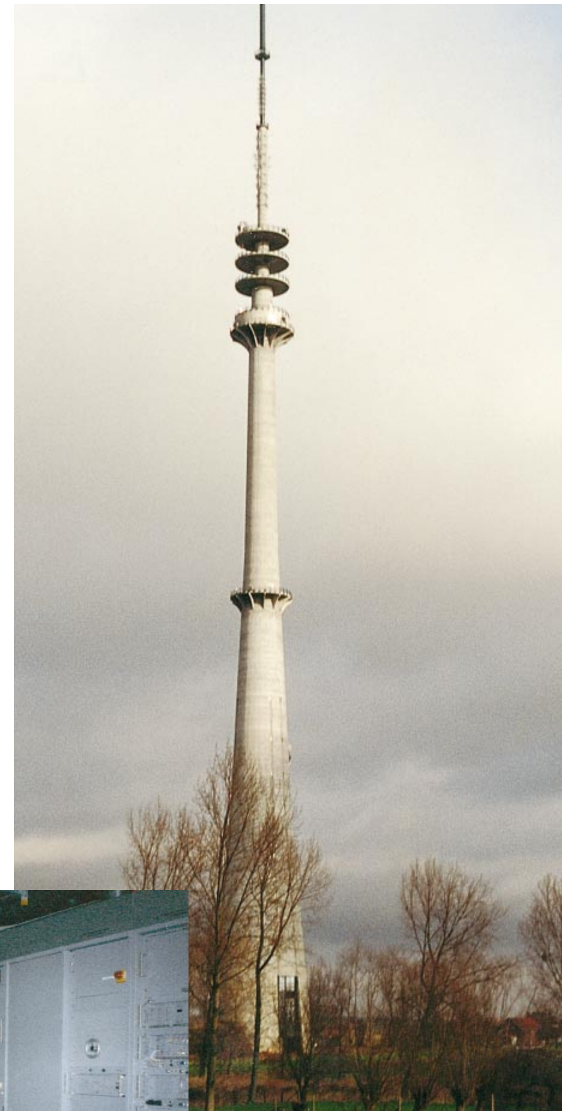
Rohde & Schwarz FM and TV transmitters provide Greater Brussels with entertainment

It can hardly be overlooked, the 300-m high tower in a rural area around Leeuw-Saint-Pierre, directly located on the route to Pepingen in the heartland of Flemish Brabant (FIG). Extremely powerful sound-broadcast and TV transmitters from Rohde & Schwarz are operated in this tower. The whole story began because of an accident. In autumn 1983 a heavy storm destroyed the antenna mast of BRTN (Belgian TV and broadcasting company of the Flemish community) and RTBF (Belgian TV and broadcasting company of the French community) at the Wavre broadcast station. BRTN chose Leeuw-Saint-Pierre to set up a new mast now providing Greater Brussels with the FM programs Radio 1, Radio 2, Radio 3, Studio Brussels and Radio Donna and with the two TV programs TV1 and TV2.

The transmitters are located in a huge hall on the second platform of the tower at the base of the antenna mast. The FM transmitters have a power of 10 kW each and a common standby transmitter. Radio Donna, the fifth program, transmits with 2.5 kW and has a standby transmitter of the same power. The different radio programs are taken via a transmitter-combining filter and emitted from a common antenna. The FM transmitters are solid-state throughout, which keeps operating costs at a minimum. The transmitters are air-cooled and the recovered heat is used to warm the rooms in winter.

The transmitter for TV1, the most modern in Europe according to Paul Desmet, advisor to the head of program services, consists of two 10-kW solid-state transmitters that are used together. The system thus corresponds to a 20-kW transmitter operating with integrated active standby. The system for TV2 consists of two identical transmitters yielding a total power of 40 kW. These are operated in turns, ie in passive standby. In contrast to the transmitters for TV1, those for TV2 have klystron tubes and are extremely reliable.

Rohde & Schwarz, which is firmly established in Belgium's FM network, won the order in the face of competition from four other well-known European transmitter producers. "It was the most favourable offer for BRTN", confirms



Broadcasting tower of Belgium's BRTN at Leeuw-Saint-Pierre in Flemish Brabant and view of hall with TV transmitters from Rohde & Schwarz
Photos: BRTN

Paul Desmond. The high-quality systems are in compliance with all standard specifications and completely meet user requirements, especially with regard to price, ease of maintenance and repair as well as safety regulations.

Leo Terneven (BRTN)

Reader service card 151/20 for further information on FM and TV transmitters

A vision comes true – trunked radio for United Arab Emirates

The United Arab Emirates (UAE) with approx. 2.2 million inhabitants are a federation of seven emirates (Abu Dhabi, Dubai, Sharjah, Ras Al Khaimah, Fujairah, Um Al Qaiwain, Ajman) that were united in a common state in 1971. The Emirates stretch over an area of 90,600 km^2. Since the foundation of the state, Sheikh Zayed bin Sultan Al Nahyan (head of state, president and also sovereign of Abu Dhabi) has been transforming the country at a breathtaking speed together with the heads of all the other emirates from a barren desert landscape into a prosperous, modern state thanks to immense technological and infrastructural investments.

Current investments include the updating of telecommunication facilities. In early 1990 it was recognized that investment spent on different, incompatible radio systems with limited coverage and of different performance data for daily use coupled with the special demands in emergency situations would be absolutely unsuitable. Trunked-radio systems were winning through more and more and finally turned out to be the ideal solution for the realization of the vision of **one** radio system for **all** parties concerned.

At the end of 1993 Rohde & Schwarz received an order to install a national, blanket turnkey trunked-radio system based on ACCESSNET® [1]. The first planning stage was successfully implemented in close cooperation with the UAE Ministry of the Interior within six months. Another stage was completed half a year later so that complete coverage of all the important regions/cities stretching from Abu Dhabi, Ras Al Khaimah to Fujairah, where 90% of the people live, was ensured (FIG 1).

The graduated, modular and hierarchical switching concept of ACCESSNET® with its outstanding software functions (signalling standard MPT 1327/1343) is the ideal key technology to meet all the operational requirements of security organizations, coastguard, civil defence, police, customs, immigration authorities, fire brigades, ambulances, etc. Thanks to ACCESSNET® these user groups can now effectively carry out their specific tasks independently or, if required, together for the benefit of the inhabitants or maintaining internal security.

An optimum, decentralized switching concept was implemented by the installation of a master system controller which, as a central switching unit, is networked with five regional trunked site controllers via wired lines. Twenty "dislocated" radio base stations (FIG 2) controlled by the trunked site controllers via terrestrial lines ensure full cellular coverage and provide excellent grade of service and high traffic capacity with a large number of radio channels. The whole network infrastructure can of course be monitored by a central maintenance computer system or by regional maintenance terminals. 100% availability is thus guaranteed.

FIG 2 Example of ACCESSNET® radio base station in United Arab Emirates Photo: Author

The users have powerful trunked-radio sets, which are installed in vehicles and ships (FIG 3) and can also be used as desktop units in local centers of operation. Hand-held radios with special accessories are for use in and outside vehicles. About 2000 trunked-radio sets are currently used by the different organizations and are not only used for speech communication but also for data transmission. A sophisticated scheme for call numbers and task-oriented release of certain functions for

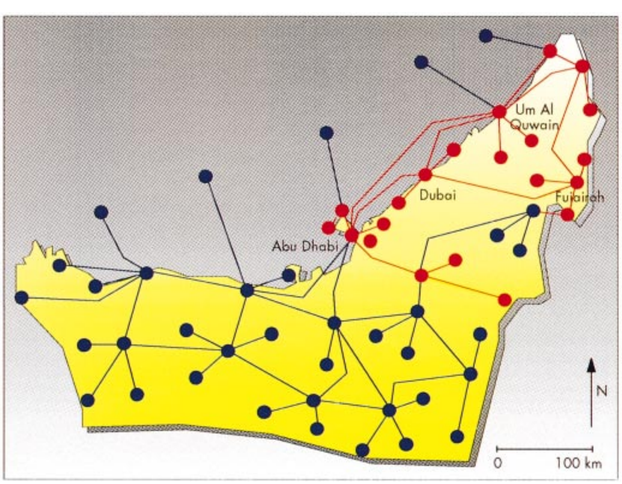


FIG 1 System design of trunked-radio network ACCESSNET® in United Arab Emirates (red: locations of phase 1, blue: phase 2)

particular subscribers/subscriber groups optimize the deployment of people and material in day-to-day and emergency situations. Dispatcher terminals in regional centers allow rapid task allocation to operational units.

ACCESSNET® is in operation around the clock and the network will be extended successively. The tactical demands of coastguards and other security organizations will thus be met by equipping all the present and additional sites along the coast and on the islands with digital switching and radio technology to allow encrypted, ie absolutely intercept-proof, end-to-end communication. A new generation of digital shipboard radios with integrated encryption is also part of the extension. ACCESSNET® thus follows the trend from purely analog to fully digital technology with application-tailored speech and data encryption [2]: an indispensable precondition for organizations with security tasks.

ACCESSNET® fulfills the vision of the United Arab Emirates: this powerful trunked-radio system will not only master today's needs but also those of tomorrow and the day after. As the operator of ACCESSNET® the UAE Ministry of the Interior has undoubtedly set a notable example and received attention and won recognition. Consequently, the trunked-radio system ACCESSNET® is offered at low cost to all national organizations with a view to becoming independent user groups. A large number of these organizations are expected to take advantage of the attractive offer in the near future.

Karl-Heinz Wagner


FIG 3 Patrol boats of coastguard of United Arab Emirates
Photo: Gulf News

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[2] Schinke, U.; Klier, W.: Radiocommunication System ACCESSNET®-D – Trunked radio goes digital. News from Rohde & Schwarz (1995) No. 149, pp 28–31

Reader service card 151/21 for further information on ACCESSNET®

R&S signal generators at Finnish Institute of Technology

In the field of RF design, manufacture or maintenance, talented and well-educated engineers are the most valuable resource of any company or public institution. For creating such resources, extensive laboratory exercises have been included in the training program of technical institutes and universities. The teaching environment sets specific demands on the laboratory equipment in terms of RF specifications as well as mechanical and electrical stability at an adequate price, as the instruments must frequently be transported between labs and test sites and students often lack experience on how to deal with measuring equipment.

The **Kotka Institute of Technology** in Finland decided to use Rohde & Schwarz equipment for many of their measurements. FIG 1 shows a test setup with Signal Generator SMT [1] and Spectrum Analyzer FSEA [2] for general measurement tasks. But it was found that the more favourably priced Signal Generators SMX and SMY [3; 4] also maintain their specifications even in harsh environments, are well-protected against accidentally applied external voltages and extremely rugged thanks to their sturdy metal cabinets.

FIG 1 High-quality test setup comprising Signal Generator SMT and Spectrum Analyzer FSEA used for measuring antenna radiation patterns
Photo: Huurrekorpi

Another advantage of **R&S signal generators** is their **simple operation** – an important aspect in university applications, as many students are afraid of making operating errors and, after all, the main focus of learning is somewhere else. If the student must first read and learn for several hours about how to tune the instrument to the right frequency, he will be distracted. Happily enough, there is test gear with a better design approach. Take Signal Generator SMY: via a large spinwheel the student has immediate control of carrier frequency and level. Changing steps or units is performed by hardkeys below the display, and activating modulation is also very easy. And if, according to Murphy's law, the student pushes the wrong button anyhow, he simply gets a clearly indicated error message. The plastic guide card below Signal Generators SMX and SMY is a valuable aid for the average student (FIG 2) and normally no handbook is needed because IEC/IEEE-bus commands are also included.

Test equipment used for teaching should be of a high **quality standard.** Many facts of modern telecommunications and RF engineering cannot be demonstrated or tested with simple instruments because power level, frequency and modulation tolerances, eg of hand-held phones, are very tight. On the other hand it is not advisable to purchase the most expensive and luxurious instruments for a teaching lab. Besides the financial risks in maintenance, calibration and repair, there is the fact that these devices are simply overspecified and have a lot of features which are never used. When dealing with RF, one way to save is to set a suitable frequency limit. The benefit is felt in costs, and most of the phenomena encountered in radio engineering can be still demonstrated and measured. For many purposes Signal Generator SMY is a suitable choice with its upper frequency of 2 GHz instead of a microwave unit, which would cost at least three times as much. In a normal teaching environment basic specifications should be maintained within reasonably tight limits if financial limits demand, and instruments be chosen that can be upgraded at a later date.

All the mentioned aspects demonstrate that Signal Generator SMY is a good solution for measurements in training institutes. Its excellent features and modulation variety show that the instrument is intended for the professional market, but it is nevertheless within the means of the not-so-wealthy customer – like most of the academic teaching branch tend to be nowadays.

Dr. Pekka Eskelinen
(Kotka Institute of Technology, Finland)

FIG 2 Signal Generator SMX with plastic guide card – so normally no handbook is needed
Photo 42 445

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[3] Lüttich, F.: SMX, a cost-effective signal generator for 100 kHz to 1000 MHz. News from Rohde & Schwarz (1986) No. 115, pp 13–15

[4] Klier, J.: Signal Generator SMY – The signal source within everybody's means. News from Rohde & Schwarz (1994) No. 144, pp 8–10

Reader service card 151/22 for further information on SMY

New radio stations for Belgian Navy

The new radio stations installed by Rohde & Schwarz onboard the Belgian ships Zinnia and Godetia are used to ensure a permanent link between national authorities and naval forces as well as other vessels, search and rescue organizations, aircraft and helicopters. These two command vessels of the Belgian naval forces, which also perform logistic tasks, are named after the two escort planes of the British Flower Class. The two giant vessels that were used to transport the Belgian troops of the British Royal Navy and offered to Belgium at the end of WW2 are also in operation as minehunters and minesweepers and proved to be very successful during the Iraq-Iran conflict, the Gulf War and during a mission in Somalia. "Thanks to the excellent technical equipment and a very competent crew we succeeded in finding and destroying about 270 mines without any accidents or casualties," says the Belgian Navy.

It is obvious that an extremely high-performance radio station is a prerequisite for such missions. Rohde & Schwarz was thus asked to replace a large part of the outdated equipment installed at the end of the 60s. The new radio station (FIG 1) comprises six receivers and four transceivers as well as a number of radio sets specially designed for mobile land and maritime radio services. It also contains a microprocessor for controlling data exchange between the modules. The most powerful transceiver onboard the vessels (1 kW) allows long-distance links over continents and also automatic setup of shortwave links and maintains them in case of interference. The other three transceivers are mainly used for vessel-to-vessel or vessel-to-land links. All the transceivers operate in the frequency range from 1.5 to 30 MHz. The six receivers cover the range 10 kHz to 30 MHz. The associated transmitting/receiving antenna is installed on the vessel platform (FIG 2).

Teletype signals from a receiver are routed through a matrix in one of the three MERLIN system processors, high-end terminals for RTTY networks to NATO standard, and then output on a printer or teleprinter. In the other direction, the messages coded by MERLIN are sent via the transmitters. It is also possible to pass on messages received from another vessel via MERLIN.

The system has plenty more to offer. Thanks to an automatic alarm receiving system operating on the international frequency 2.182 kHz, Godetia has an automatic distress signal. PSTN hookup is also possible so that members of the crew can ring home. Vessel-to-vessel communication by means of this system is carried out by three-member teams taking turns every six hours. The communication system proved its reliability during an exercise in the Mediterranean in which Italian, Spanish, English, French and German units participated. Second radio operator Guy Corvelijn confirms: "With this installation, we have a very fast and reliable system. This investment in a communication system that is extremely secure and thus indispensable for navigation is completely justified."

FIG 1 Communication system onboard Belgian vessel Godetia

FIG 2 Antenna system of maritime radio station
Photos: Force Navale

Jean-Paul Hosdain
(Capitaine de Corvette,
Force Navale Zeebruges)

Reader service card 151/23 for further information on maritime radio systems

Photo: Holthaus

CeBIT 96 with extremely satisfied exhibitors

At the world's biggest showgrounds in Hanover, information and communication technology was again the order of the day from 14 through 20 March this year. There were two major differences compared to one year earlier. First of all the show was shortened by one day and did not commence until the Thursday. And secondly the number of visitors dropped from 755,300 to about 600,000. The number of exhibitors on the other hand rose from 6111 to 6507.

The decrease in the number of visitors was planned because, according to the show's organizers, its capacity had more than been reached the year before. The new concept of a "profi CeBIT", accompanied by a drastic increase in entrance prices and consequently one third fewer private visitors than a year earlier, was seen by show committee member Hubert-H. Lange as a "precision landing en route to professionalism". As far as shifting the opening day to a Thursday is concerned, this created enormous scheduling programs for the trade and business press, because there were countless press conferences to be attended in just two days, and so visits to the stands of the exhibitors had to be neglected. The federal information technology association would like the show to run from Monday through Saturday, and we shall have to wait and see how the organizers respond.

Rohde & Schwarz was present as usual in hall 17 with an exhibition area of 192 sqm. The motto this year was "Rohde & Schwarz – Competence in Radiocommunication" (photo above). In relation to the shortness of the show there were more customer contacts, also spread across the weekend. At the focus of interest were mobile radio and EMC engineering, followed by trunked radio. Overall, corporate sales rates the results of CeBIT 96 as very positive, which is in tune with the majority of exhibitors. 89.7% have already announced their intention to attend CeBIT 97. C. Rockrohr

Rohde & Schwarz equips mobile-radio laboratory of Munich Technical University

In a special laboratory of the faculty of communications engineering at Munich Technical University (Prof. J. Hagenauer), a development and test facility is being set up for mobile radio. Rohde & Schwarz, as the world's leading company in the field of digital radiocommunication testing, was awarded an order to equip the laboratory. The facility is being financed by Munich Technical University itself, the Free State of Bavaria, the German government and Rohde & Schwarz. It will enable investigations of the quality of digital radiocommunication when influenced by different kinds of interference, and the possibilities for correction offered by various coding systems. The laboratory will be equipped with several differently configured transmitters with digital modulation, a fading simulator and a number of units for analyzing the spectral width of signals, the impulse response of transmission channels and transmission errors. Beside high-speed digital signal processors, six SUN-Sparc and Ultra workstations will be in use for coding and decoding. There is sufficient capacity in the laboratory for six academic theses to be worked on at the same time. This makes it a highly specialized training facility for engineers in what is the fastest growing field of communications technology. The laboratory will also conduct joint research with industry and network operators. PI

5th international EMC trade fair and congress

This three-day event at the Karlsruhe congress center in February 1996 was the biggest trade fair staged to date on electromagnetic compatibility. With 246 exhibitors attending, some 50 more than in 1994, the 4554 registered visitors (approx. 3900 in 1994) were offered a wide view of the market, new products, the latest research results, new or changed standards. Rohde & Schwarz attended sporting a motto of "The Sure Way to CE", ie the EU's conformity mark, and informed the numerous visitors to its stand (photo below) about test equipment to accompany product development, compliance test sets and what Rohde & Schwarz offers in the way of training. Particular interest focused on the compact S-LINE test cell for measuring susceptibility to interference (see also page 7 in this issue). There were PC information terminals on the stand to present a diskette demonstrating Rohde & Schwarz's competence in EMI and EMS solutions, and also giving new customers an overview of CE certification, standards, accredited offices and R&S reference customers. (If you are interested, ask your local R&S representative for the diskette.) As in previous years, Rohde & Schwarz invited visitors to its traditional weisswurst party with beer and pretzels on the second day of the event. This was again very popular, and 350 guests enjoyed the Bavarian specialities while consulting the company's team of EMC experts.

Because of the increased number of exhibitors and visitors, the 6th EMC fair and congress in two years' time is moving to Düsseldorf. Rohde & Schwarz will again be attending.
V. Janssen

Photo: Janssen

Photo: Müller

Rohde & Schwarz faculty prize 1995 in Jena

The faculty prize for excellent scientific achievement at Jena University – donated by Rohde & Schwarz – was awarded at the beginning of the year as part of a colloquium convened by Prof. Wolfgang Richter, the dean of the physico-astronomy faculty. Wolf-Rüdiger Lange, Executive Vice President of Rohde & Schwarz, presented the prize for the best dissertation in 1995 to Dr Andreas Kleinwächter and for the best thesis to Jens Stäbe, Dipl.-Ing. (in the photo from left: Richter, Lange, Kleinwächter, Stäbe).

Whereas Andreas Kleinwächter's subject "Investigation of rotating disks in the general theory of relativity" was expressly theoretical in nature, Jens Stäbe's work "Investigation of the effect of vehicle pitch oscillations on the distribution of dip beams", carried out for automobile producer BMW, is of immediate practical benefit. In awarding the prize for 1995, Rohde & Schwarz continued a five-year tradition. Company co-founder Dr Hermann Schwarz instituted the prize to honour the university that both he and Dr Lothar Rohde attended, and to demonstrate the company's interest in high standards of education for engineers and physicists.

K.-O. Müller

CTD55 – go/nogo tester for GSM, PCN and PCS phones

Beside Go/Nogo tester CTD52 for GSM mobile phones, Rohde & Schwarz is now offering a small, lightweight and low-cost unit – CTD55 – that can test PCN (DCS1800) and PCS (DCS1900) phones in addition (photo above). The tests, with a clear go/nogo result, run automatically, and the user needs no knowledge at all of radiocommunications testing. Optionally CTD55 will allow more in-depth tests that it logs on a connected printer. The functions include call setup and cleardown in both directions, change of power and channel, measurement of power ramping, an echo test and checking of receiver sensitivity.

W. Mittermaier

Reader service card 151/41

RSE success continues

Rohde & Schwarz Engineering and Sales GmbH (RSE) was able to report a 30% leap in orders received, compared to one year earlier, at its third international sales meeting in autumn 1995. In addition to all European representatives, the countries Russia, Turkey, Egypt, Saudi Arabia and the United Arab Emirates attended the annual meeting for the first time, held in Schwangau at the foot of Neuschwanstein Castle to mark the 150th birthday of Bavaria's King Ludwig II. Similarly to King Ludwig in his day, who was very open to innovative engineering, the participants were presented with the latest RSE product lines during their three-day stay. At this meeting too there were trophies for the representatives with the biggest growth and the biggest order book. The highest turnover in Europe was achieved by England, in Germany for the third time by Cologne, and in the Middle East by Saudi Arabia. Cups for the biggest percent growth went to the representatives from Denmark and Russia as well as to the Nuremberg office. To conclude the meeting, as a small thankyou for the good results in the past business year, the group undertook a white-water trip in five dinghies through Imster Gorge. This was mastered with great bravura thanks to the splendid team spirit, most of the participants managing to avoid contact with the 6°C cold water (photo below).

W. Schmittseifer

Photo: Leonardi

40-kW high-power signal generator from Rohde & Schwarz, a "technical monument"

Karl-Eduard Knaf, president, and Friedmar Kerbe, vice-president of the association for regional and technical history in the Thuringian town of Hermsdorf wrote to us: "As regular readers of your magazine "News from Rohde & Schwarz" and especially after seeing your report "100 years of radiocommunications – Rohde & Schwarz has been shaping it for more than 60 years" we would like to draw your attention to a monument in Hermsdorf: our 40-kW high-power signal generator developed by Rohde & Schwarz and put into operation at HESCHO (Hermsdorf-Schomburg Insulator Company) in 1941. For more detailed information refer to the enclosed brochure."

The following is taken from this brochure: "The association for regional and technical history succeeded in adding the 40-kW high-power signal generator of the ceramics company as a technical monument to the list of protected objects. The signal generator was last operated in 1989 for product testing. One of the aims of the association is to maintain the generator operational and to provide the public at large access to it. The installation was developed by the Munich-based company Rohde & Schwarz and put into operation at HESCHO in July 1941, the result of an interesting technical development accompanied by many personal contacts."

In the chapter "History" a meeting between the senior engineer of HESCHO at that time, Hans Handrek, and Dr Rohde and Dr Schwarz is described. We already mentioned this event in "News from Rohde & Schwarz" about 13 years ago in our jubilee issue on the 50th anniversary of the company (issue 103). We take this opportunity to thank Mr. Knaf and Mr. Kerbe for their letter. All readers who require further information or wish to see the technical monument in Hermsdorf may contact Mr. Knaf or Mr. Kerbe under the following address and phone number:

Verein für Regional- und Technikgeschichte e.V.
Hermsdorf, Industriegelände PF 2153
D-07621 Hermsdorf
☎: (+49 03 66 01) 6 23 72/6 49 08

Digital Radio Analyzer PCSD is adapted by software options either for channel impulse response (CIR) analysis in radio networks or for general interference analysis and C/I analysis; 8-inch colour display (VGA), for external monitors 1024 x 768 pixels; PCMIA interface.
Data sheet PD 757.2150.21 enter 151/24

Digital Radiocommunication Testers CMD50, CMD53 (GSM, PCN/PCS) are equivalent to CMD52 and CMD55 when equipped with options, but are intended for service purposes.
Data sheet PD 757.2209.21 enter 151/25

Vector Signal Analyzer Option FSE-B7 demodulates, analyzes and documents all digital mobile-radio signals with Spectrum Analyzers FSEA and FSEB.
Data sheet PD 757.2167.21 enter 151/26

Antenna Preamplifier ESMI-Z7 (20 MHz to 7 GHz) reduces the noise figure of systems by 8 dB; 50 Ω, VSWR (> 60 MHz): < 1.7; power supply (115 or 230 V) included.
Data sheet PD 757.2215.21 enter 151/27

Calibration System Family TS9000 for measuring instruments is of modular design to allow calibration to various standards and offers fully automatic operation in dialog; complete system configurations are available for specific tasks.
Data sheet PD 757.2309.21 enter 151/28

Spectrum Analyzers FSEA, FSEB, FSEM The data sheet now also covers models FSEM20 (9 kHz to 26.5 GHz) and FSEM30 (20 Hz to 26.5 GHz)
Data sheet PD 757.1519.23 enter 151/29

Digital Monitoring Direction Finders DDF0xM (0.3 to 3000 MHz) feature digital correlative operation according to Watson-Watt; monopulse processing and direction finding of GSM signals; DF error < 1 ° RMS, minimum signal duration HF ≤ 5 ms, VHF/UHF ≤ 500 µs; AC and DC supply; antennas for stationary and mobile use, internal PC with colour LCD available.
Data sheet PD 757.1854.21 enter 151/30

Multichannel Communications System 400U (100 to 163/225 to 400 MHz) is based on the successful Series 400 from R&S, but features enhanced flexibility and serviceability.
Data sheet PD 757.1583.21 enter 151/19

Multichannel Communications System 400U (100 to 163/225 to 400 MHz) Information leaflet giving an overview of standard models of this tried and tested modular program.
Info PD 757.1383.21 enter 151/31

Log-Periodic Dipole Antenna HL040 (400 to 3000 MHz) for transmission and reception in mobile and stationary use, linearly polarized broadband field-strength and EMI measurements; 50 Ω, VSWR typ. < 2, gain 5 to 7 dBi; input power max. 50 W (cw).
Data sheet PD 757.1919.21 enter 151/32

Container Location System COLOS, based on GPS, enables three-dimensional positioning of containers with a pinpoint accuracy to within 1 m, thus optimizing container management and transport.
Data sheet PD 757.2180.21 enter 151/10

Spectrum Display EPZ513 The updated data sheet describes the RF panoramic display (max. 650 MHz) when EPZ513 is used together with Compact Receiver ESMC.
Data sheet PD 757.9451.22 enter 151/33

Base station antennas for GSM and PCN networks (860 to 960/1710 to 1889 MHz) are available as omnidirectional and directional antennas with different gain levels, MTBF 40 million hours thanks to completely new stripline technique, electrical and mechanical main-lobe down tilt, easy-to-use snap-in connections.
Info PD 757.1931.21 enter 151/07

TACAN Receiver ETS200 Specifications have been redefined **(R&S Cologne Plant).**
Data sheet PD 757.1754.22 enter 151/34

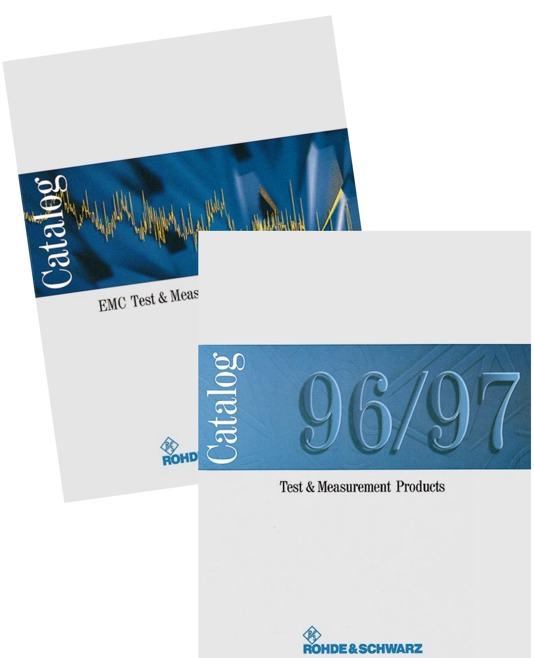
New application notes

C/I EMI analysis in digital radio networks
Appl. 1CMAN26E enter 151/35

Test signals for DAB and DVB
Appl. 1GPAN27E enter 151/36

Frequency hopping for GSM base station tests with Signal Generator SME
Appl. 1GPAN28E enter 151/37

Measurement of clicking noise on audio lines using Audio Analyzer UPD
Appl. 1GPAN31E enter 151/38
Schz



New catalogs

The **Test & Measurement Products Catalog 96/97,** just published in German and English, replaces the Measuring Equipment Catalog 93/94 as well as the New Products Supplement 94/95. On 360 pages this catalog provides a comprehensive overview of Rohde & Schwarz activities in the field of mobile radio, EMC, spectrum and network analysis, signal generators and analyzers, voltage and power measurements as well as general laboratory measurements. In line with business developments at Rohde & Schwarz, the fields of mobile radio, EMC and test systems are given the main emphasis.

The new catalog no longer covers sound and TV broadcasting since a separate catalog is available for this. New additions to the catalog include optical measurements as well as a number of spectrum and network analyzers from Advantest, for whom Rohde & Schwarz is the representative in Europe, Africa, Australia and Brazil. For reasons of sales rights, there is also an English version of the catalog without the Advantest products.

The new Test & Measurement Products Catalog has been completely revised and is a compact reference medium containing all essential information.

Test & Measurement Products Catalog 96/97
PD 756.3501.25 enter 151/39

There is another new publication: the **EMC Test & Measurement Products Catalog.** Since the beginning of this year it has become mandatory for all manufacturers and importers of electrical equipment to ensure the electromagnetic compatibility of their products. On 64 pages the catalog presents the whole range of EMC test and measurement products available from Rohde & Schwarz and gives some EMC background information.

EMC Test & Measurement Products Catalog
PD 757.2350.21 enter 151/40
Kr

Digitally monitored

Edition 6/95 of the defence magazine "armada international", published in Switzerland, looked at modern surveillance direction finding from HF through UHF and highlighted Digital Direction Finder DDF0xM:

The growing spread of time compression and frequency hopping makes it increasingly difficult to intercept an opponent's radiocommunications. Realizing that the necessary search and DF receiver performance exceeds the capabilities of most military surveillance receivers in use, Rohde & Schwarz has developed a new surveillance system working with digital signal processing for fast Fourier transform, linear filtering, etc. One result of this development activity is the recently presented compact DF receivers of the DDF0xM series.

The French magazine "Electronique", no. 54/95, showed a few examples from the wide selection of systems and aids that Rohde & Schwarz offers for measuring emission of and susceptibility to electromagnetic interference.

◁

Where Bavaria is tops

Under this headline "Bayernkurier" presented Rohde & Schwarz of Munich in its edition of 21 October 1995:

One of the outstanding companies in Bavaria is undoubtedly Rohde & Schwarz of Munich, a producer of equipment for radiocommunications, test and measurement, and an enterprise true to the motto "Where Bavaria is tops". There is hardly a TV transmitter or radio station that can manage without its products. In many sectors Rohde & Schwarz is the market leader in Germany, in Europe and even in the world. … At Rohde & Schwarz the manufacturing depth is characteristic. A whole number of pace-setting machine tools and production systems have been designed and built to the company's specifications. "We vouch for each of our services with our good name".

Plain-clothes man

"Highly recommended" was the judgement of a plain-clothes participant in courses on the subject of GSM/PCN at the Rohde & Schwarz training center in Munich. The editor of "Mobilfunk News" in issue 1/96:

The courses last three days, two days for "GSM/PCN – digital mobile telephones" and one day on "GSM/PCN – testing mobile stations". The material is put over in a pleasantly relaxed and interesting way. Whether retailer or design engineer, everyone gets their money's worth. The presenter gives you basic and background knowledge in masterly fashion, and his observations of the scene make you sit up. Even though the price of 1790 and 920 DM may seem high, the participant can be sure straight afterwards that the investment will soon pay off.

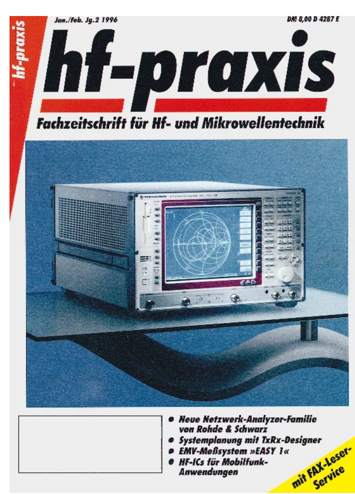
Journey to the heart of the chart

This was the headline chosen in edition 7/96 of "Markt & Technik", the Munich weekly for electronics and information technology, for its report on the presentation of Vector Network Analyzer ZVR at a press conference during the Productronica 95 show:

Rohde & Schwarz is trying to put a new family of test instruments in place on the booming telecommunications market. The ZVR line stands for extremely fast, highly precise and yet user-friendly vector network analysis, one of the company's showpiece activities. … Modular design, Rohde & Schwarz has realized this too, is increasingly important at a time when the unbounded investment of earlier years is giving way to modest restraint and customers have to work with strictly limited budgets.

Top Products of 1995 and The Best in Test

As Top Product of October 1995 the editors of the US magazine "Microwave & RF" chose Digital Radiocommunication Tester CMD80 in edition 12/95, and the jury of "Test & Measurement World", issue 12/95, was also unanimous in placing this Rohde & Schwarz instrument among the Top 11 Test Products.



Vector Network Analyzer ZVR drew a lot of interest in the press, nationally and internationally. Edition 206 of France's "Electronique International" awarded this top product from Rohde & Schwarz space on its title page. "Elektronik Praxis" (issue 3/96), "hf-praxis" (1-2/96) and "ntz" (2/96) also gave ZVR the pole position on their cover spreads.

Microwave Generator SMP – top-class performance to customer's benefit

FIG 1 Microwave Generator SMP, successful symbiosis of superb microwave technology and ergonomic computer design Photo 42 447

They have been on the market for about two years now – the microwave generators of the SMP family for the frequency range up to 40 GHz. Thanks to their excellent technical characteristics such as high output power, extremely high spectral purity, an intelligent operating concept and, last but not least, an especially attractive purchase price, the generators established themselves in this critical market segment straight away.

The qualities of SMP are reflected by its external design (FIG 1): a large-size LCD display normally provided only on high-grade notebook computers is simply an invitation for you to make an entry. Next you discover that operation is just as easy as it looks: **all settings** can be made **with a few keystrokes.** No need to consult a manual. It is obvious that designers were at work here who knew all about practical operation. All functions have been packed into clear-cut, straightforward menus. Multifunction keys and cryptic special functions are really a thing of the past. And should the user some time or other wish additional information: help texts are available at a keystroke. The benefits for the user are evident. The feeling when working with SMP can best be described by the – slightly modified – slogan of a Bavarian automobile manufacturer: measure with pleasure.

But the merits of SMP are not restricted to its outside. Just take a look at FIG 2, which shows the typical **output power** versus frequency for the various SMP models. Levels of +16 dBm at 27 GHz (SMP03) and +11 dBm at 40 GHz (SMP04) are unparalleled on the market. Not to forget SMP22, which with about +29 dBm at 2 GHz and notable +23 dBm at 20 GHz puts quite a few competitors in their places. The advantages for the customer are obvious here too: the high output power makes all SMP models ideal for use in automatic test systems. "Power killers" such as long connecting cables, waveguide adapters, power dividers or relay matrices become harmless even at 40 GHz. In short, SMP users have got it made. They need no expensive booster amplifiers. The modules shown in FIG 3 guarantee high output power and a wide frequency range.

And yet, what would the user-friendliest and most powerful signal generator be without a high-quality **frequency synthesizer?** SMP users need not worry about this. The state-of-the-art concept of SMP based on direct digital synthesis with a resolution of 0.1 Hz up into the 40-GHz range, excellent frequency stability, fast settling and extremely low SSB phase noise (FIG 4) leaves nothing to be desired.

Naturally, the **modulation characteristics** are every bit as good as the other data offered by generators of the SMP family. For example, AM ranges from DC to 100 kHz. Scan modulation with a wide dynamic range is possible for simulating antenna rotation in radar applications and for similar effects. FM ranges from DC to 5 MHz (typ. 7 MHz) for max. 10 MHz deviation and carrier frequencies up to 20 GHz (or max. 20 MHz deviation for frequencies above 20 GHz). On top of this, SMP is the first microwave generator worldwide to provide phase modulation from DC to 100 kHz. And not to forget pulse modulation, the classic type of modulation performed by microwave genera-

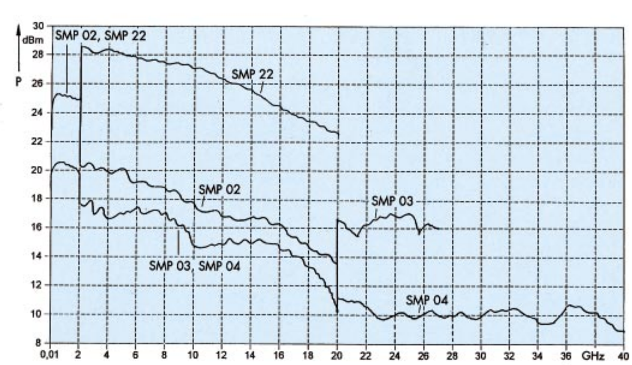


FIG 2 Typical maximum output power of Microwave Generators SMP

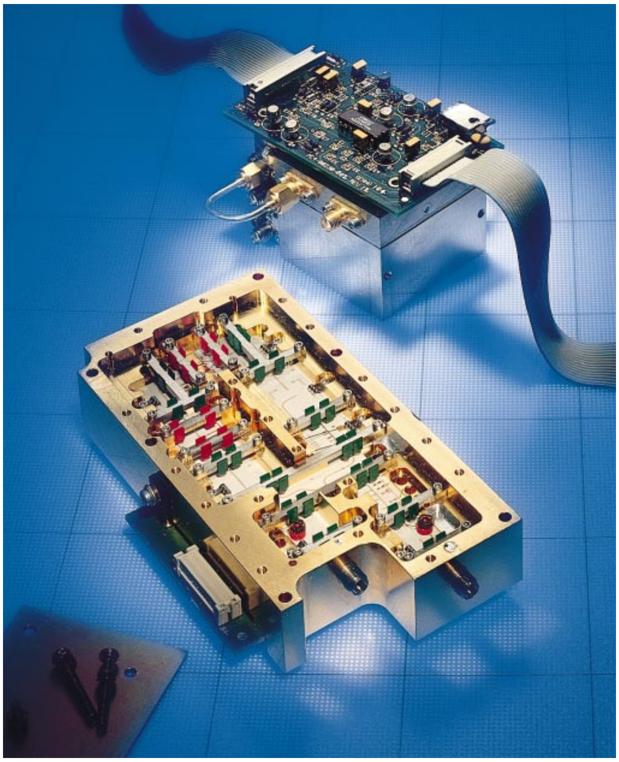


FIG 3 The YFO (YIG filter oscillator), the core of SMP (background), features space-tested technology for high output power, extremely high spectral purity and reliability. In the 40-GHz frequency doubler (front), patented thin-film technology does the trick: output power that sets new standards worldwide. Photo 42 444

tors, where SMP features rise and fall times typically shorter than 5ns, pulse widths below 10 ns and an on/off ratio better than 80 dB.

One problem frequently encountered in microwave measurements is that signal sources and EUTs have to be connected to one another via cables that are long compared with the wavelength, which means high attenuation as well as high frequency response. So it is difficult to feed the EUT with defined RF power. The signal generators of the SMP family offer four functions to solve this problem:

1. **User correction** to obtain a user-selectable frequency-response characteristic of the RF level. Correction values can be entered manually or via the IEC/IEEE bus. With an external power meter (NRVS or NRVD) connected, SMP determines correction values automatically at a keystroke.
2. **Memory sequence,** programmable sequence with complete instrument setups.
3. **List mode,** programmable sequence with up to 2003 frequency and level pairs.
4. **External level control** using external level meter.

At this point the inclined reader may be wondering if so much high tech is affordable. Well, the SMP family was designed not only for excellent technical performance but for **high economy and future-proofness** too. The result is an instrument the user can tailor to his requirements by choosing from a wide range of options the components he really needs. Should a subsequent extension or adaptation be necessary to handle new measurement tasks – no problem, SMP can easily be retrofitted as required. Built-in diagnostic functions and computer-aided measurement functions ensure fast and uncomplicated servicing. Calibration is required every three years at the earliest. The unit need not be opened for calibration, nor do any mechanical adjustments have to be made.

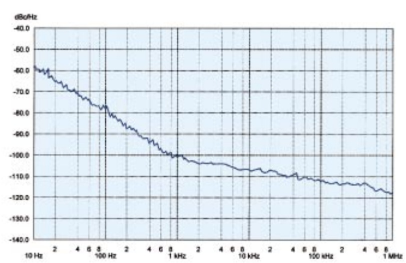


FIG 4 SSB phase noise of Microwave Generators SMP at 10 GHz

Which member of the SMP family is the right one for you? Take your choice from the versions listed in the blue box.

Wilhelm Kraemer

Model	Frequency range	Output power
SMP02	10 MHz/2 to 20 GHz	>+11.5 dBm
SMP22	10 MHz/2 to 20 GHz	>+20 dBm
SMP03	10 MHz/2 to 27 GHz	>+13 dBm
SMP04	10 MHz/2 to 40 GHz	>+10 dBm

Reader service card 151/42

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