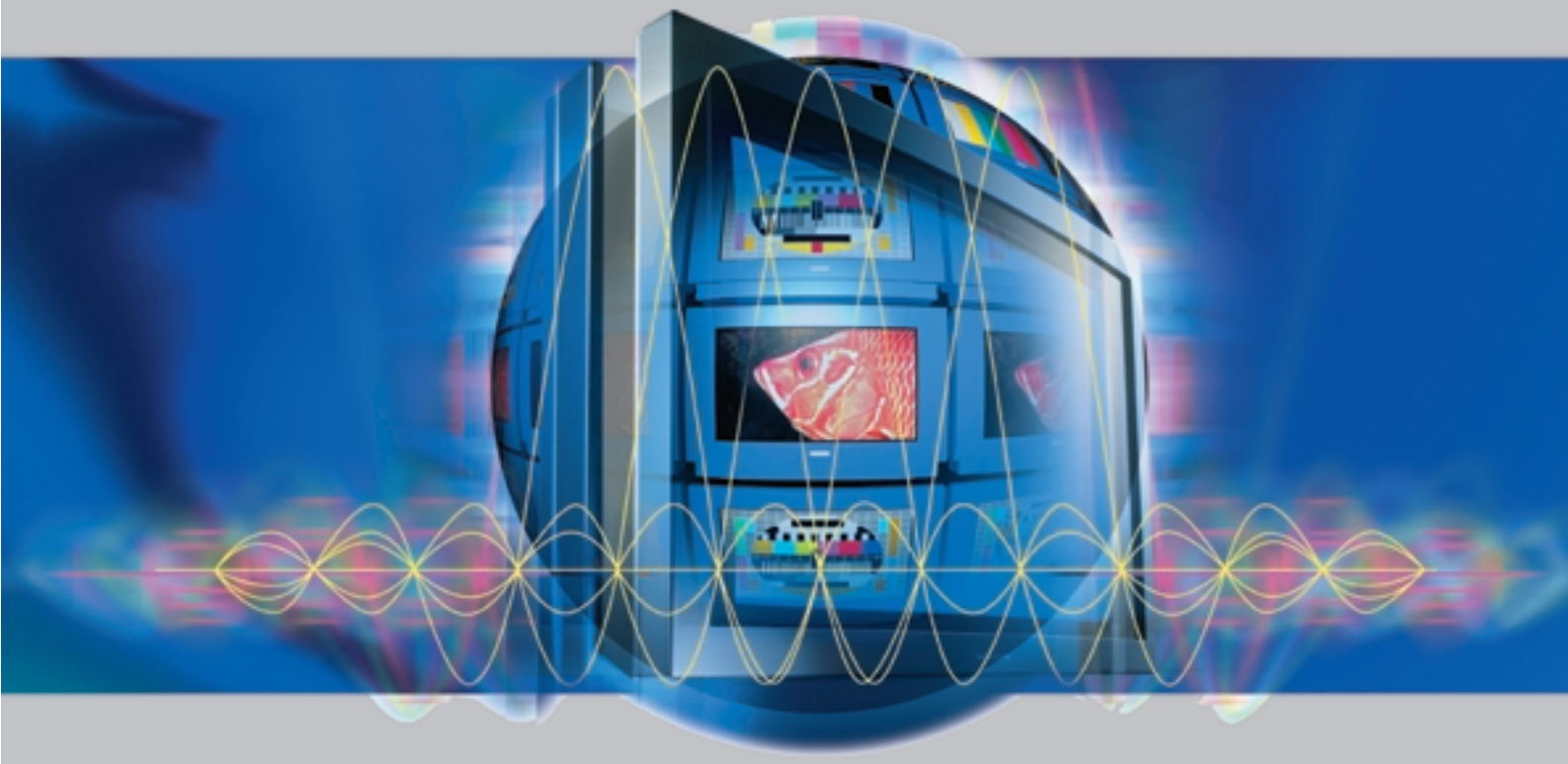
News from Rohde & Schwarz



DVB-T
High-precision test receiver

Monitoring of
DAB and DVB-T transmitter systems

Airborne VHF/UHF transceivers
Secure voice and data transmission

1999/IV
164

ROHDE&SCHWARZ

Number 164 1999/IV Volume 39

With digital video broadcasting (DVB) the last great bastion of analog technology in the field of consumer electronics industry is about to be conquered. Rohde & Schwarz has backed the right "horse" at a very early stage and is now able to offer a comprehensive range of operational and test equipment. For example the new TV Test Receiver EFA-T, the first test receiver allowing realtime measurements on DVB-T signals (page 4). Further articles on digital TV from page 17 onwards

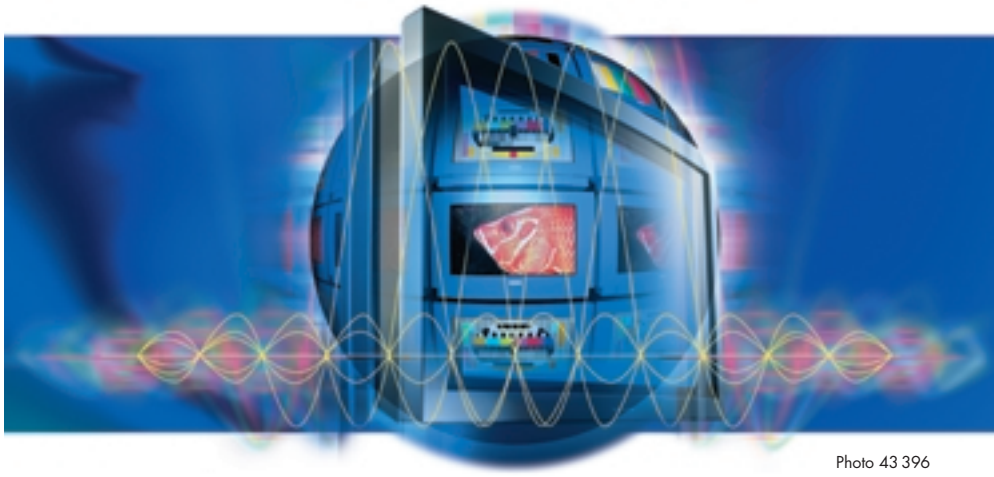


Photo 43 396

Articles

Application notes

Panorama

Regular features

Photo 43 350/5

Many renowned companies of the automobile, consumer electronics and mechanical engineering industry have for years relied on EMC test technology from Rohde & Schwarz: covering everything from small EUTs to wide-body aircraft. Recently Audi AG put its new EMC test center into operation, fully equipped with Rohde & Schwarz technology (page 26)

Imprint

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DVB-T Test Receiver EFA-T

The test reference: now for terrestrial digital TV too

After successful startup of the first European DVB-T network (terrestrial digital video broadcasting) in Britain with currently over 500 000 users, DVB-T is gaining ground in Europe at an ever faster pace. In this context the new DVB-T model of the EFA family of test receivers [1] meets the demand for high-precision reception measurements. Compact in design and featuring comprehensive automatic test functionality, the instrument is ideal in R&D, transmission modulator production and operative monitoring of TV signals.

Photo 43 310/6

FIG 1 DVB-T Test Receiver EFA-T completes the universal EFA test receiver family adding measurements on terrestrial digital TV systems

Universal test receivers for digital TV

Terrestrial digital TV is being introduced in the face of competition from other, likewise digitally modulated TV signals transmitted via satellite and cable. The digital standards reduce the problems encountered with forerunner analog transmission, like limited program variety, degraded signal quality under adverse reception conditions or system-inherent shortcomings. Three major terrestrial digital TV standards have established themselves to date. The ATSC standard adopted in 1996 by the Federal Communications Commission (FCC) is applied in the United States, Canada, Argentina, South Korea and Taiwan. ISDB-T, the Japanese version of the DVB-T standard, is currently only used in Japan, where the first countrywide network is planned for the year 2003.

The most widely used standard, and thus the one apparently progressing at the fastest pace, is the DVB-T standard specified by the European Telecommunications Standards Institute (ETSI) in 1997. It has been adopted in over 19 countries, including the 15 EU member nations, as well as Australia, New Zealand, India and Singapore. Following the British lead, the introduction of digital TV to this standard is now approaching in Spain, Sweden and New Zealand.

In the light of competition from cable and satellite and the high expectations of TV viewers, the requirements made on the reliability and quality of digital signals are extremely high. The EFA test receiver family now comes with a new model – EFA-T – that covers all the measurement tasks to be performed in this scenario.

EFA-T – characteristics

The test receiver, fully compatible in all its functions with ETS 300 744, receives, decodes and analyzes DVB-T signals. All essential parameters for demodulation of the receive signal can be selected automatically or manually:

- Bandwidth 8 MHz, optionally 6 MHz or 7 MHz
- COFDM modulation with 2K or 8K FFT
- QPSK, 16QAM or 64QAM constellation
- Code rate 1/2, 2/3, 3/4, 5/6, 7/8
- Guard interval 1/4, 1/8, 1/16, 1/32
- Hierarchical demodulation α = 1, 2, 4

EFA-T – test reference for DVB-T

The newly developed Test Receiver EFA-T features a multitude of innovative measurement functions right from the basic version, making it a test reference for the systematic detection and analysis of failures and disturbances in the transmission channel (several international patents pending). Apart from total analysis, for example of bit error rate (BER), detailed analyses of freely selectable carrier ranges of the OFDM signal can be performed. These include:

- Constellation diagrams
- Calculation of transmission parameters
- Display of modulation error ratio (MER) as function of frequency
- Presentation of eye aperture as function of frequency

Any failures and disturbances already appear in the display of all carriers of the OFDM signal. They can then be accurately localized by narrowing down the carrier range (see FIGs 3 to 8). A particularly effective method here is presentation of eye aperture as a function of frequency (FIG 5). What it means is that the I and Q values are shown together with the decision thresholds, revealing any transmission errors at a glance and allowing disturbed carriers to be identified.

Investigations have shown that transmission errors (BER) are attributable often to only a few carriers while most carriers are decoded correctly. Detailed analysis is possible by means of constellation diagrams of previously identified single carriers.

EFA-T – operating principle (FIG 2)

First the receive signal is conditioned for the OFDM demodulator. Three slots for filters of 8 MHz (optionally 6 or 7 MHz) bandwidth are available in the receive section for band limiting.

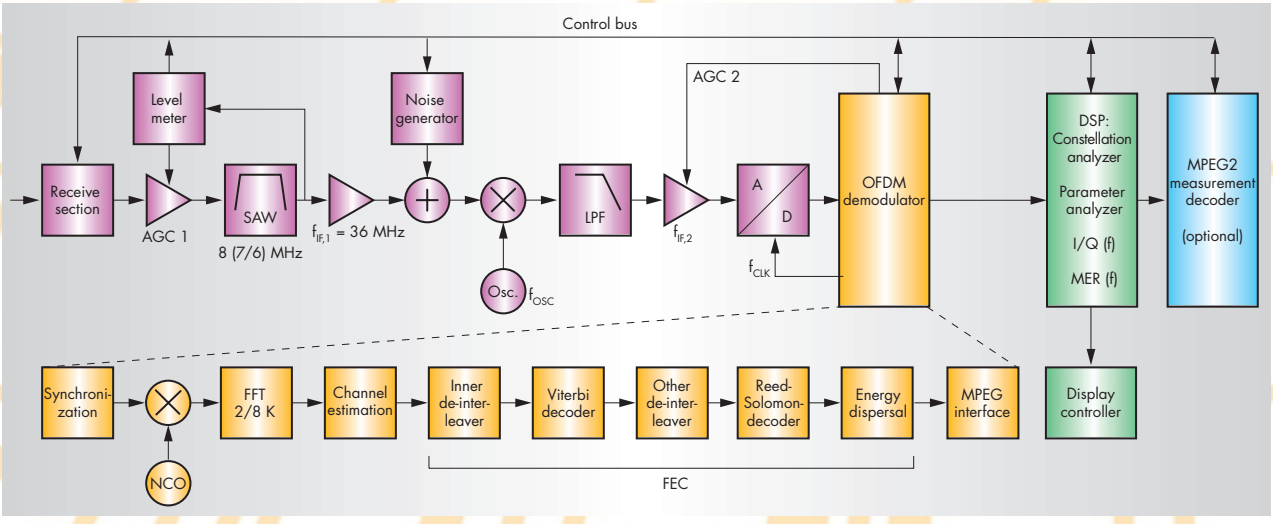
Noise can be superimposed on the receive signal by a built-in noise generator and associated attenuator. The C/N ratio is entered directly thanks to a level meter for both the wanted and noise signal.

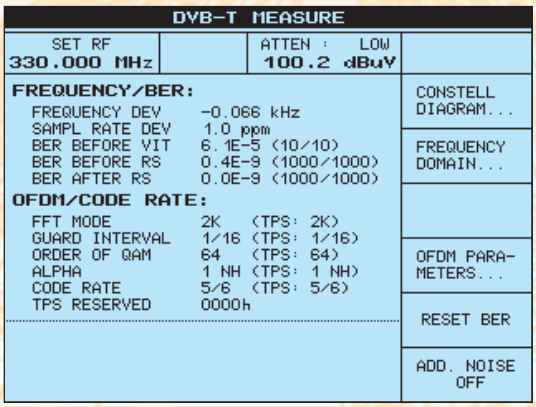
Down-conversion to the second IF is followed by passive analog lowpass filters, the signal then passing to an A/D converter with 12 bit resolution (fixed-frequency sampling without oscillator tracking).

The digitized signal is then applied to the synchronization, digital complex mixer, FFT, channel estimation, error protection and MPEG2 processing stages.

After channel estimation, the I and Q components are coupled out for the constellation diagram and calculation of further transmission parameters and taken to the DSP section. This directly drives the display controller, which results in extremely fast graphical processing of measured results.

FIG 2 Operating principle of EFA-T





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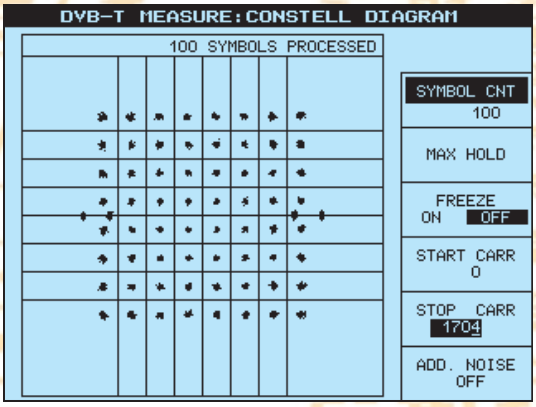

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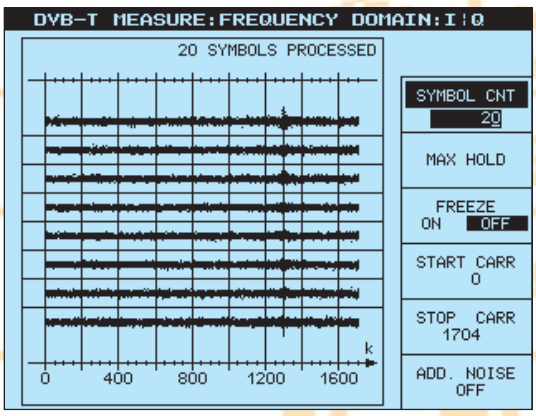

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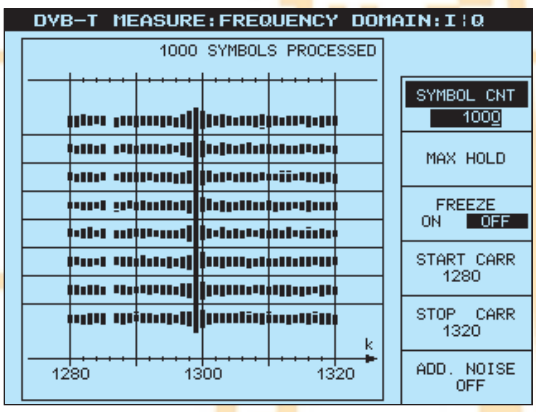

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EFA-T – realtime signal analysis

The powerful digital signal processing of EFA-T provides fast and thorough analysis of the received DVB-T signal. Analysis is performed simultaneously with, but quite independently of, demodulation and decoding. The MPEG transport stream is permanently available for decoding as well as for vision and sound reproduction.

Thanks to this realtime analysis capability, the high number of measured values necessary for the complex calculation and display processes are made available in an extremely short, so far unequalled time for subsequent mathematical/statistical processing. Because of its high-speed data acquisition, Test Receiver EFA-T is an ideal choice not only in R&D but also in production applications, where short measurement cycles are called for.

EFA-T – mobile or stationary

To meet different requirements in the transmission of DVB-T signals, the OFDM demodulator can be optimized for mobile as well as stationary reception simply at a keystroke. The resulting settings mainly affect the speed and channel equalization process as well as internal level control. Reception is thus possible even under highly adverse conditions.

The bandwidths of the main internal phase control circuits can also be configured, for example to analyze noisy signals (eg phase noise) or signals exhibiting particularly strong jitter.

EFA-T – the monitoring receiver

Monitoring receivers permanently monitor the main parameters of broadcast signals directly at the transmitting station. An alarm is triggered if a measured value is outside a predefined test interval. Test Receiver EFA-T is tailored for this application: six parameters with separately selectable alarm thresholds can be chosen for monitoring (FIG 9). Particularly worth emphasizing is BER monitoring at the various stages of reception. This allows emerging problems to be identified at an early stage.

All errors occurring are saved in EFA-T together with the date and time in error reports comprising up to 1000 entries. In addition, EFA-T triggers an acoustic alarm for the operating personnel.

Captions for FIG 3 to 10

FIG 3 Measurement menu: all important data and DVB-T configuration visible at a glance

FIG 4 Constellation diagram, here with simultaneous display of 100 OFDM symbols

FIG 5 Complete analysis of transmission channel showing I/Q as function of frequency. Disturbance at carrier frequency 1300 is clearly discernible

FIG 6 Display of transmission channel (same signal as FIG 5). Disturbed carrier is identified as number 1299

FIG 7 Display of MER as function of frequency (same signal as FIG 5). Here too, disturbance at carrier frequency 1300 is clearly discernible

FIG 8 Constellation diagram for detailed analysis of disturbed carrier (scattered pilot). Diagram shows that it is narrowband interference

FIG 9 Ideal for monitoring tasks: simultaneous monitoring of six key parameters

FIG 10 Parameter calculation for 2K FFT. Here detailed analysis of central carrier (number 852 of transmitted OFDM spectrum)

EFA – the analog and digital family

Although digital TV will constantly gain in importance, analog TV will continue to be used on a very large scale for a long transition period. This is due to the limited available frequency resources and the enormous number of analog TV sets in circulation since colour TV was introduced. So TV signals with analog and digital modulation will coexist in the same frequency band.

This fact is taken into account in the EFA test receiver family. An analog receiver can be fitted with DVB-T option EFA-B10 to yield a combined instrument for measurement of analog and digital terrestrial TV signals. Here the modular and future-oriented concept of the EFA test receiver family again proves its value.

Further options like MPEG2 Decoder EFA-B4 enhance test receiver functionality to produce a compact and universal all-in-one instrument for measuring digital and analog TV signals.

Mathias Leutiger; Christoph Balz

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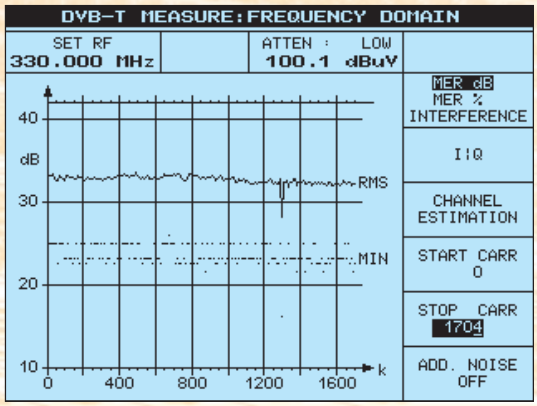

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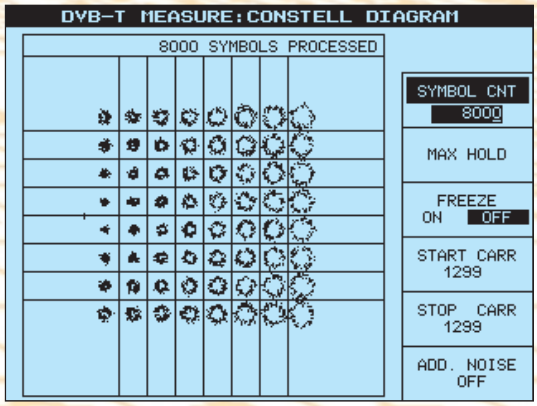

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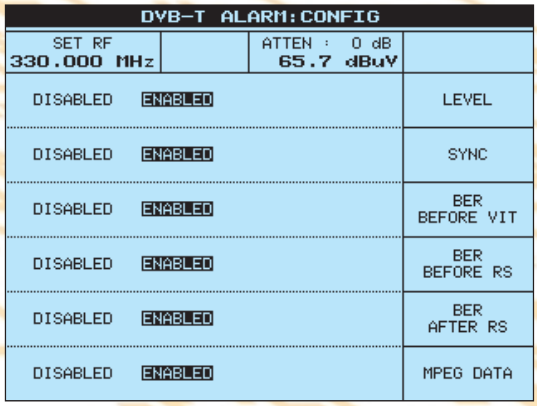

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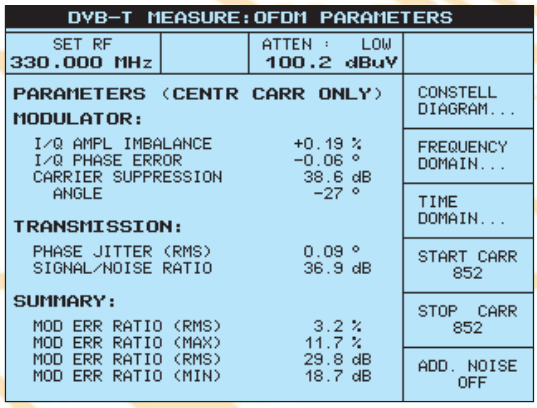

Condensed data of DVB-T Test Receiver EFA-T

Frequency range	45 MHz to 1000 MHz 5 MHz to 1000 MHz with optional RF Preselection (EFA-B3)
Input level range	–47 dBm to +14 dBm –84 dBm to +14 dBm (low-noise) with optional RF Preselection (EFA-B3)
Bandwidth	6/7/8 MHz
FFT mode	2 K and 8 K
Modulation	QPSK, 16QAM, 64QAM
Guard interval	1/4, 1/8, 1/16, 1/32
Inner code rate	1/2, 2/3, 3/4, 5/6, 7/8
BER analysis	before Viterbi, before and after Reed-Solomon
Measurement functions	level, BER, MER, carrier suppression, quadrature error, phase jitter, amplitude imbalance
Graphical displays	constellation diagram, MER (f), I/Q (f), further graphics in preparation (eg spectral analysis)
Output signals	MPEG2-TS: ASI, SPI
Options	MPEG2 Decoder (EFA-B4), RF Preselection (EFA-B3)

Reader service card 164/01

Mobile Air Traffic Control Tower MX400

Out in the wilds – air traffic control in no-man's-land

Mobile Air Traffic Control Tower MX400 (FIG 1) from Rohde & Schwarz was designed for versatility. It is used worldwide wherever reliable air traffic has to be taken up within a minimum of time and the necessary infrastructure is lacking. It has been tried and tested on many occasions under the most adverse conditions and is being used by international customers, among them the peacekeeping forces in Kosovo.

Ready to go – even in no-man's-land

MX400 ensures smooth operation in almost any region of the world. It can stand in for a stationary tower, for instance, if the latter is still under construction or shut down for modification or maintenance. It does not make any difference whether civil or military installations are concerned. Effective thermal insulation of the cabin and a powerful split air-conditioning system provide optimum working conditions for staff and reliable system operation even under the most severe climatic conditions. Since infrastructure at the MATC tower site is mostly insufficient or not available at all, the system works on a separate Diesel generator and uninterruptible power supply.

MX400 is suitable for a whole variety of applications:

- Standby system for main ATC tower
- Visual control room for airfields/ training center
- Semi-permanent system for airfields with seasonal air traffic
- Mobile system for search and rescue operations
- Operations center for air defense

FIG 1 MX400 is set up in a minimum of time and usable at any site thanks to powerful air-conditioning and autonomous power supply

Photo Werk Köln

Modular, customized concept

Trailer and power supply

MX400 is of modular design, configured in close cooperation with the customer and tailored to his needs (FIG 2). It is made up of

- a trailer with integrated hydraulic platform and detachable cabin and
- a separate Diesel generator on a single-axle trailer (FIG 3).

A scissor-lift hydraulic system elevates the cabin to the required operational height of 6.5 m (or to levels in between). The cabin is designed as an independent subsystem meeting all operational requirements of a mobile system (FIG 5) and complies with the standards of ATC authorities and the ICAO (International Civil Aviation Organization).

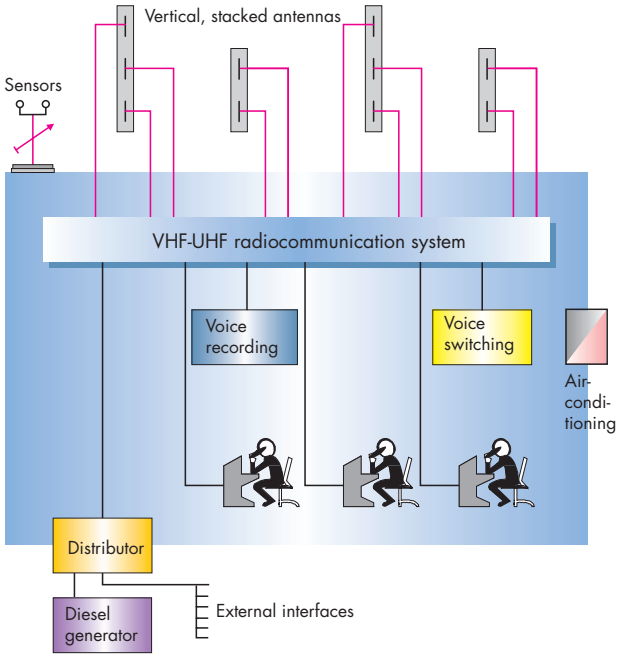

FIG 2
Up to three control positions allow full access to radiocommunication equipment, voice switching system and meteorological data

HF, VHF and UHF radiocommunication

The proven transceivers of the 200/400U series from Rohde&Schwarz are used for communication in the VHF and UHF bands. HF transceivers and a VHF-UHF direction finder are optional. Controllers are integrated for operation of the entire radio equipment.

Global use and highly mobile

MX400 is set up and put into operation in a minimum of time. Two persons will need approximately one hour. The tower is easily transported, so changing the site is just as fast. Cabin dimensions (20" standard size) are in line with DIN and ISO regulations and standards. This simplifies international transportation:

... by land

- The complete system can be attached to a vehicle, eg Unimog, with the generator coupled to the trailer or
- piggybacked on a truck

... by sea

- Transport in a ship as the top container

... and by air

- Transport in a plane, eg Hercules C-130 or Ilyushin (FIG 4)
- or by helicopter

Photo Werk Köln

FIG 3 Trailer and generator: compact and designed for international transportation

FIG 4 Loading MATC in Ilyushin IL-76 transport plane

Photo Werk Köln

Highly selective, automatic filters prevent collocation problems and ensure undisturbed radio operation. Up to four vertical, stacked antennas make setting up of additional antenna masts in the field unnecessary.

Voice switching system

The voice switching system assumes the function of a telephone exchange. It allows access to any transceiver via selection panels.

Voice recording

Using a digital recorder, all calls from the voice switching system can be stored on a hard disk or magneto-optical storage medium that can be extensively accessed via the application software.

Meteorological equipment

Sensors are fixed to an external mast on the roof of the control tower cabin. ATC-relevant data are displayed and evaluated at the control positions.

Diesel generator

The separate generator provides sufficient power for autonomous system operation over several days.

Safety packet

This comprises signal lights, optical observation and signalling equipment, crash alarm, fire extinguishing system, etc.

The system equipment shows: nothing has been forgotten. MATC can assume operation at any site quickly and reliably.

Michael Fraebel

Reader service card 164/02

Photo 40 738/3

FIG 5
Control tower cabin with three ATC workstations

Photo 41 960

FIG 6
VHF-UHF transceivers from Rohde & Schwarz used for radiocommunication

Optical Network Analyzer Q7750 and Optical Chirpform Test Set Q7606

Unique measuring instruments for wavelength division multiplex

The enormous amount of data distributed today around the globe is mostly transmitted via fiber-optic cables, submarine cables featuring largely in this [1]. An efficient way of increasing the data rate in fiber-optic cable networks is to transmit several optical wavelengths using the wavelength division multiplex method. ADVANTEST, a cooperating partner of Rohde & Schwarz for many years, has launched two completely new and unique instruments on the world market for measurements on active and passive components in this application.

Photo: Photodisk

Before: one fiber, one wavelength

The developers of the first fiberglass transmission links knew that their bandwidth resources were immensely greater than those of copper cables. But many years of intensive research were required before this potential could be adequately utilized.

Until about three years ago, information in fiber-optic cables was transmitted to relatively wideband receivers almost exclusively with a single wavelength. More than ten years ago already, engineers achieved data rates of 2.5 Gbit/s with this method in the laboratory, shortly after 10 Gbit/s and more. Since these transmission rates are now far too low for

Photo 43 308

FIG 1
Users familiar with RF network analysis will immediately feel at ease with Optical Network Analyzer Q7750: only the enter key labelled "THz" may seem unusual at first

handling international information exchange, eg on the Internet, new ways were sought of making full use of the bandwidth capacity of glass fibers.

Now: one fiber, many wavelengths

Since a data rate increase at the transmitter end can presently only be achieved with considerable technical outlay, the use of several multiplexed optical wavelengths is an efficient alternative. It is possible, for instance, to transmit 20 Gbit/s using eight of the presently favourably priced 2.5 Gbit channels on a single fiber with the aid of WDM (wavelength division multiplex). With greater channel density of up to 128 x 10 Gbit/s, laboratories are about to achieve transmission rates in the terabit range (DWDM = dense wavelength division multiplex).

In the high-frequency range the step into multiplexing was taken decades ago. With optical transmissions this was not possible for a long time since, until a few years ago, really stable transmitters were not available. In the beginning, the developers made do with two widely spaced wavelengths, but this proved to be unsuitable for long-haul transmissions. All modern WDM and DWDM systems operate in the region of 1550 nm with a channel spacing of often only 100 GHz (0.8 nm) and soon even 50 GHz (0.4 nm).

Compared to the standards used in radiocommunication, this spacing strikes one as being very wide. The situation is completely different in the case of optical transmissions. Here extremely stable lasers and highly selective wavelength demultiplexers are required, which also makes high demands on measuring instruments.

ADVANTEST took up the challenge and extended its range of measuring instruments accordingly, presenting two new instruments that are absolutely unique on the world market.

Unrivalled instruments for measurements on active and passive components

Optical Network Analyzer Q7750 (FIG 1) is designed for characterizing passive elements, eg optical wavelength splitters, which split up the WDM signal into single channels before it can be detected by a receiver.

Anyone familiar with RF network analysis will quickly feel at ease with this instrument. Only the enter key labelled "THz" (1 THz = 1000 GHz) indicates that Q7750 measures in the region of infrared light. It simultaneously measures reflection and transmission characteristics, the display being switchable between amplitude, optical group delay and chromatic dispersion. Revolutionary are not only the type and scope of result recording but also the short measurement time of only several seconds depending on instrument settings.

Optical Chirp Test Set Q7606 (FIG 2) is used for characterizing active com-

FIG 2 Optical Chirp Test Set Q7606 measures wavelength stability during level transition with unrivalled time-domain and spectral resolution

Photo 43 307

ponents, ie laser generators and modulators. It measures wavelength stability during level transitions with unrivalled resolution in the time domain and spectrum. Q7606 works by the principle of an optical heterodyning receiver and its 20 MHz frequency resolution in the spectral range is higher by several powers of tens than that of an optical spectrum analyzer. This instrument opens up completely new potential in the fairly young field of optical phase modulation, unrivalled by any other product on the market. FIG 3 shows amplitude (blue) and optical frequency modulation (chirp) characteristics for comparison.

By offering these new measuring instruments, Rohde & Schwarz will contribute its share to reducing the time for measuring important parameters of WDM components in development, production and quality assurance. Users will be able to advance the development of even more powerful transmission components for the information society of the future.

Peter Wollmann

Condensed data of Q7750

Wavelength	1530 nm to 1600 nm
Channels	S11 and S21 (optical)
Measurement functions	amplitude, group delay, chromatic dispersion
Wavelength error	±0.025 nm
Sweep range	0.1 nm to 70 nm
Dynamic range	transmission: 35 dB (typ. 40 dB) reflection: 33 dB (typ. 38 dB)
Group delay	0.1 ps to 25 ns
Chromatic dispersion	0.01 ps/nm to 1 µs/nm

Condensed data of Q7606

Wavelength	1510 nm to 1590 nm (Q7606B) 1530 nm to 1580 nm (Q7606A)
Power range	–20 dBm to +10 dBm (Q7606B) –10 dBm to +10 dBm (Q7606A)
Free spectral range	150 GHz ±15 GHz
Demodulation bandwidth	100 Hz to 50 GHz
Resolution of resolution bandwidth	20 MHz pp
Insertion loss	10 dB (Q7606B only)

Reader service card 164/03

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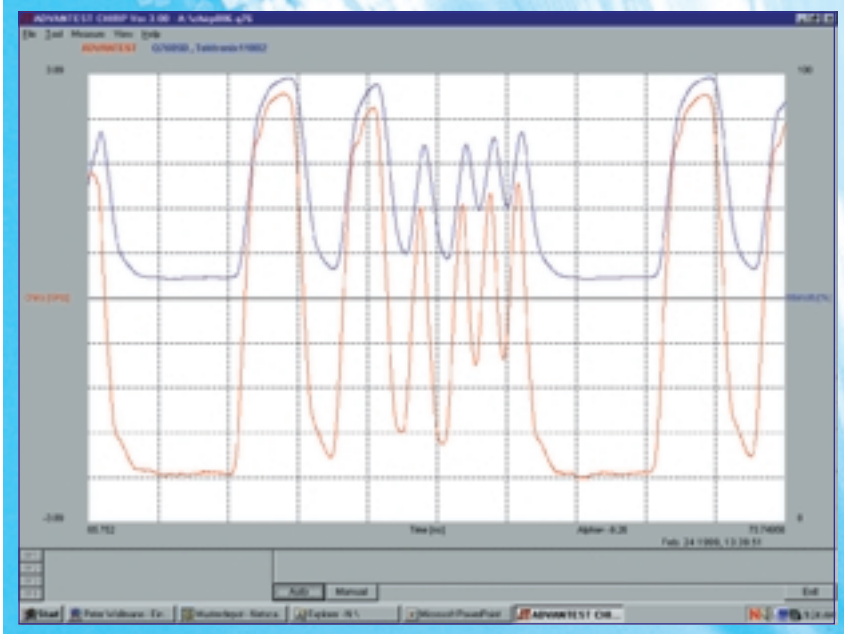
FIG 3
Amplitude (blue) and optical frequency modulation (red)



Communication System Panel TS-CSP

Clear layout instead of cable jungle – flexible wiring of test systems

Automatic test systems for functional tests and final testing of electronic products require a large variety of DUT fixtures, stimulus signals, etc. Soon there is a tangle of connecting cables and it gets even worse if something has to be changed. Communication System Panel TS-CSP with its switch matrix modules is the solution to this problem. It was specially designed for use in production test systems and establishes any kind of connection between DUT and measuring instruments efficiently and cost-effectively. Convenient software makes it easy for the user to have everything under control and to make changes quickly and error-free.

Efficient and versatile for modern production environments

Instead of a chaotic tangle of cables as can often be found between DUT fixture, measuring instruments, relay boxes or data acquisition cards and power supplies, Communication System Panel TS-CSP (FIG1) provides a cost-effective alternative that is especially appreciated in modern production environments. All DUT signals are distributed via switch matrix modules that can be conveniently interconnected via software as required.

In a conventional configuration several signal sources and measuring instruments are often connected with a multitude of cables via various plug-in adapters or with the aid of expensive pylon connections. Not so with TS-CSP. The panel significantly cuts time and costs incurred in the configuration, maintenance and modification of test systems. Signals are combined in groups and then distributed in the

FIG 1
Communication System Panel TS-CSP – switching center for test systems (here in conjunction with Digital Radiocommunication Tester CMD 65 for testing mobile phones)

There are many applications ...

Communication System Panel TS-CSP is ideal for use in:

- Functional test systems for telecommunication products such as mobile phones, cordless terminal equipment and associated base stations
- Production testers for products from automation, sensor technology and telemetry sectors
- Automotive test systems
- EMC/EMI test systems as RF switch matrix
- Lab test sets

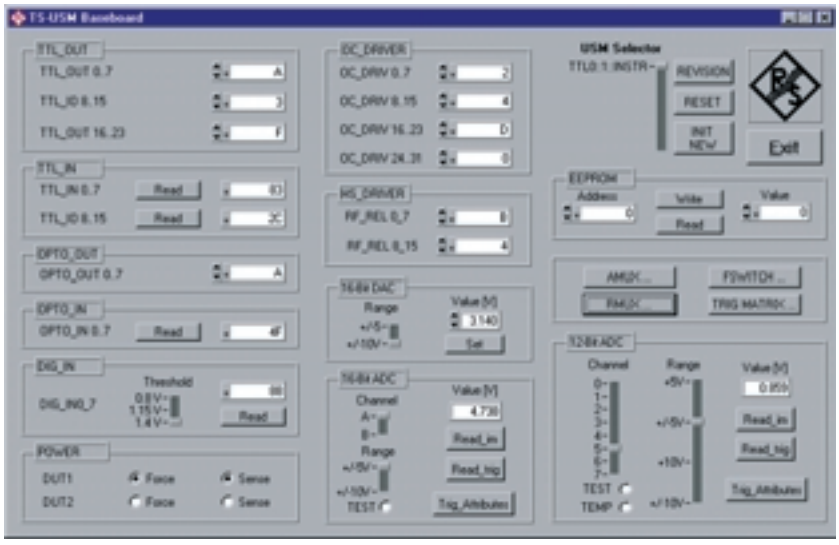


FIG 2 User interface for interactive access to all device functions

TS-CSP. The optimization of the panel for use in production systems and the integrated switching technique result in an extremely favourable price/performance ratio per test channel.

Compact integration of basic functions into modular concept

Two types of cabinets are available to accommodate either two or five switch matrix modules. This means that efficient solutions can be implemented even for small production test systems. The following switch matrix modules are available:

- **TS-USM**
  Universal Switch Matrix: offering multi I/O functionality
- **TS-RFM**
  RF Switch Matrix: for RF signal switching
- **TS-USMF**
  Universal Switch Matrix Fixture: rugged fixture interface for use in production tests

Two different RF Switch Matrix Modules TS-RFM with four or twelve relays are available for efficient RF signal distribution. The required number of RF testpoints with signals in the frequency range from DC to 12 GHz can be set on the measuring devices under software control.

What is more, node potentials, operating voltages and audio signals that have to be checked as part of functional tests can also be switched automatically via the Universal Switch Matrix TS-USM.

Measurement functions for analog voltages as well as digital signal acquisition are already implemented in TS-USM. A programmable voltage source for analog output levels and digital output ports for DUT stimula-

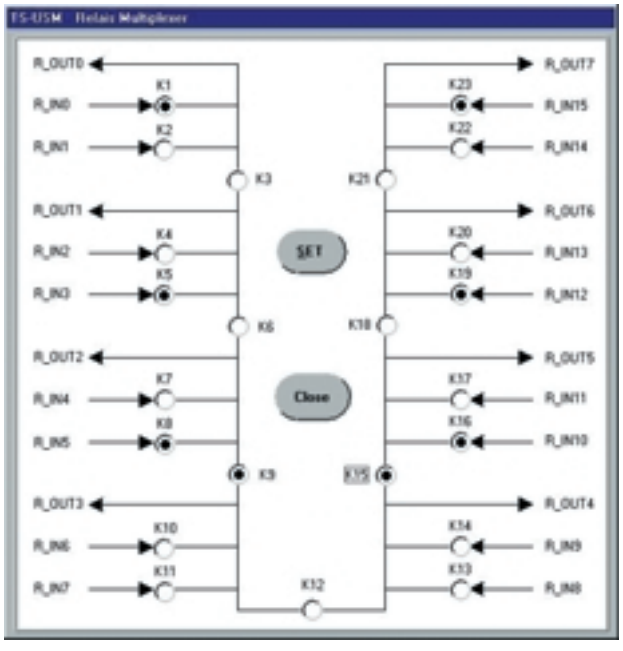


FIG 3
Clear layout instead of cable jungle: neat graphical user interface for switch matrix relays

tion are also integrated. DUT powering from an external supply unit is switched by power relays in TS-USM.

To control the switch matrix modules an IEC/IEEE bus interface is provided as standard. A high-speed TTL interface is optionally available in the form of PC Card Interface PS-B11.

Simultaneous testing through cascading

Simultaneous testing of several DUTs is made possible by flexible scaling and the large number of channels provided by TS-CSP. Fitted with a remote-control interface, TS-USM can be used as a baseboard for cascading further switch matrix modules. In this way high-performance systems can then be configured to contain, for instance, the complete signal switching of a functional tester for mobile phones that is able to simultaneously test a panel of four PCBs.

Straightforward cabling for complex test systems

The DUT fixture can be connected directly, ie mechanically docked, to Universal Switch Matrix TS-USM with the aid of two 160-pin connectors.

Often, however, the DUT fixture is located remotely in an automated contacting station within a production line. In this case the Universal Switch Matrix Fixture TS-USMF can be used to connect the DUT fixture to the TS-CSP panel. The test and supply signal lines are combined in DUT-specific groups and rearranged so that they can be adapted with the aid of lockable edge connectors. This significantly cuts the time required to service and maintain the tester and adapt the DUT fixture. The RF cable connections to the measuring instruments are made via N connectors. SMA connectors, preferred for test fixtures, are provided to take the signals from the DUT to RF Switch Matrix TS-RFM.

Comprehensive software support ensured

Rohde&Schwarz provides comprehensive driver support for C programming language under LabWindows/CVI. The driver software conforms to the international VISA (virtual instrument standard architecture) standard drawn up to provide standardized software modules for more efficient test program generation. TS-CSP of course features the hardware and software selftest functions that are required for use in production environments.

Based on this driver software, an operating program is available for the communication system panel (FIG 2) that allows the user to control the panel simply by mouse clicks. This reduces familiarization time to a minimum. As the relay matrix modules too can be controlled from the graphical user interface (FIG 3), the test engineer can put fixture wiring into operation and test it interactively.

Erwin Böhler; Daniel Seemann

Condensed data of TS-CSP, TS-USM, TS-RFM

TS-CSP	Slots	2 or 5 (cabinet height of 2 HU or 4 HU)
	Remote-control interface	IEC/IEEE bus or direct TTL with PS-B11
TS-USM	Digital inputs/outputs	40
	Optocouplers	8 inputs, 8 outputs, 5 V/24 V
	Open-collector drivers	16
	A/D converter	8 channels/12 bits, 2 channels/16 bits
	D/A converter	1 channel, 16 bits, ±5 V/±10 V
	AF matrix	analog switch, relay matrix single relays, power relays
TS-RFM	TS-RFM1	12 RF relays, DC to 12 GHz
	TS-RFM3	4 RF relays, DC to 12 GHz

Reader service card 164/04

Monitoring DAB and DVB-T transmitter systems

Measurements made easy: firm grip on complex problems

To identify transmitters, handle interference and verify compliance with stipulated conditions for authorization, the monitoring services of licensing authorities must be capable of measuring the technical parameters of transmitter systems off air. Rohde & Schwarz offers an extensive range of monitoring and measuring equipment for this purpose (FIG 1).

Photo 43 172/2

FIG 1 Rohde & Schwarz offers an extensive range of stationary and mobile monitoring and measuring equipment for the latest methods of digital transmission

Complete product line for complex measurement tasks

Modern DAB and DVB-T systems use complex modes of digital transmission, the measurement and identification of which require special instruments and methods. All major technical parameters of such systems can be measured with **Spectrum Monitoring System ARGUS-IT** (formerly SMSI) [1] together with Spectrum Analyzer FSE, Signal Analyzer FSIQ or EMI Test Receiver ESI plus Measurement Software ArgusMon (FIG 2). Some typical measurements are described below.

Evaluation of interference on digital transmission links additionally requires measurements of coverage and bit error rate. Here too, Rohde & Schwarz is able to offer a wide selection of coverage measurement systems [2].

FIG 2
Dialog window of EMI Test Receiver ESI in DAB/DVB-T measurements with Measurement Software ArgusMon

Typical tasks of monitoring services

Receive level

The strength of the receive level must be known to assess quality and propagation conditions. And it is also the basis for coverage measurements. Unlike with analog signals, the type of detector used plays an important role in transmissions with digital contents. Depending on the modulation of the individual carriers, the level of a DAB/DVB-T signal has different peak, average and rms values. Whereas the peak value of the main carrier (or the sum of the carriers with COFDM) represents the maximum of the rms values collected during the measurement time, the time-averaged rms value corresponds to the power of an unmodulated CW carrier of the same level. Both values can be varied by suitably influencing (coding) the transmitted information. For example, if you ensure that practically no 64QAM values simultaneously have 0° or 180° phase and maximum amplitude, the result is a signal with a very large margin between peak and rms, whereas in simple frequency shift key-

ing without any amplitude modification the two values will be the same.

For adequate reception quality, the total energy applied to the receiver, ie the rms value, is decisive. If the digital transmission system is the source of interference however, the peak value is the key factor, since this determines the extent of interference especially on analog receivers. So monitoring services must be capable of measuring both peak and rms values. The difference between the two is called the crest factor and specified in dB. It is a characteristic feature of every kind of digital transmission, and for DAB/DVB-T it is typically between 10 dB and 13 dB. To avoid impairment of other radio services by high peak loads and to make effective use of available transmitter power, it is necessary to keep this value as low as possible, for example by appropriate coding of the data stream.

Digital transmission systems take up a lot of bandwidth, so broader IF filters than for analog radio services are usually needed to measure level accurately. Assuming that the transmitted energy is uniformly distributed across the used channel (as with DAB and DVB-T), the entire level can also be measured with narrower filters and converted to the actual bandwidth. The ArgusMon software sets the analyzer to a filter bandwidth of 1 MHz for this measurement. Conversion to entire level is done automatically using the occupied bandwidth measured narrowband.

Occupied bandwidth

This is an important criterion for identifying radio services since their channel spacings are known. And measuring the occupied bandwidth of digital systems is especially important because they often tend to produce considerable spurious emissions due to the types of modulation used, and these unduly expand the actual occupied bandwidth. Basically bandwidth is measured by the same principles as for analog signals. The decisive parameter in most cases is the 99% bandwidth, ie the bandwidth into which 99% of the total emitted energy falls. The DAB/DVB-T signal is scanned for this purpose using a 1 kHz test filter. Calculation of the 99% bandwidth is then made by graphical integration of the recorded RF spectrum. Two markers are set on the cutoff frequencies for a plausibility check by the user.

Frequency

The frequency of DAB/DVB-T signals cannot be measured like with analog signals because of the special nature of the modulation. Measurement Software ArgusMon calculates the frequency using the two marker frequencies of the bandwidth measurement and displays it.

Vestigial sideband characteristic

Measuring the characteristic of vestigial sideband emissions is of particular importance with DAB/DVB-T transmitters.

Due to the almost rectangular form of the RF spectrum of DAB/DVB-T transmitters, practically the full transmitting energy is present directly at the boundary to channels of adjacent radio services – unlike with all other systems. The specified transmitter mask, defining spectral characteristic versus frequency, has very steep edges at the channel boundaries to prevent undue impairment of other radio services by vestigial sideband emissions. Compliance with these masks is especially difficult in the case of DAB/DVB-T transmitters since the type of signal involved, with its large number of adjacent carriers, is susceptible to the formation of intermodulation products. Reducing vestigial sideband emissions to an acceptable level can in most cases be achieved only by considerable technical effort at the transmitter end. Monitoring services as well as the operators of such transmitters must therefore be able to measure the characteristic of sideband emissions. The currently valid transmitter masks for DAB and DVB-T (FIG 3/4) stipulate

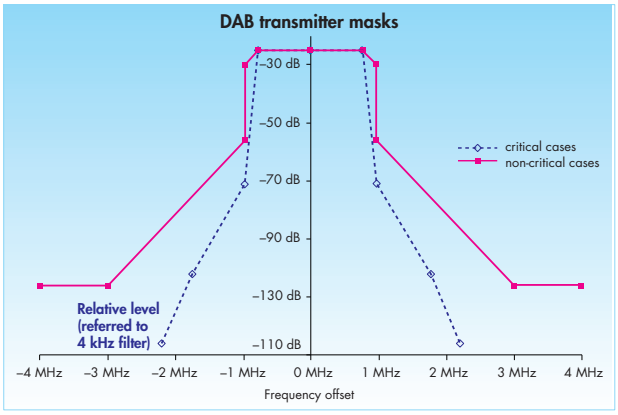


FIG 3
DAB transmitter masks according to Wiesbaden agreement

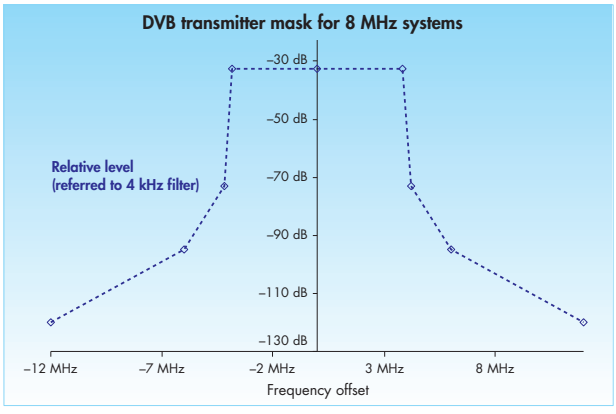


FIG 4
DVB transmitter mask according to Chester agreement 1997

level reductions down to –126 dB (referred to entire level and 4 kHz measurement bandwidth).
From FIG 3 it can be seen that the spectral characteristic of a DAB transmitter would have to be recorded with a dynamic range of at least 110 dB to verify compliance with the critical mask. This is not possible with currently available test receivers or analyzers alone. The limits of measurement techniques also show for DVB-T. In the presence of a multicarrier signal, test receivers too are susceptible to intermodulation, so the maximum used level must not exceed about 50 dBµV for this measurement (provided that a measurement filter with 4 kHz bandwidth is available). With this useful level, emissions of –27 dBµV would have to be measured accurately at a frequency offset of 12 MHz from the DVB-T center.

To measure the vestigial sideband characteristic of DAB and DVB-T transmitters, the signal is fed through a notch filter, which rejects the used channel as effectively as possible while letting the adjacent channel pass. In this way the test receiver is protected against overloading by the strong used signal while maintaining its full sensitivity in the range of interest of vestigial sideband emissions. The notch filter must be tunable. The attenuation along the frequency band to be represented must be added to the measured signal to obtain the true, unfiltered signal. The tracking generator of the analyzer is needed to accurately determine the filter response curve. FIG 5 illustrates the test setup. The example in the box right demonstrates how easy such measurements can be.

Summary

The combination of Spectrum Monitoring System ARGUS-IT with instruments FSE, FSIQ or ESI makes it very easy to carry out all the above measurements on DAB/DVB-T signals required for interference handling and evaluation of the RF signal characteristic.

Jörg Pfitzner

Measurements made easy with ArgusMon software

Vestigial sideband emissions of DVB transmitter above used channel (FIG 6)

First the notch filter is manually tuned so that the passband begins at the cutoff frequency to be represented (depending on the edge to be measured). A tunable highpass or lowpass filter or a bandpass filter may also be used.

The only values you have to enter in the ArgusMon software are those for the frequency band to be displayed (682 MHz to 692 MHz). The program automatically takes the other values like center frequency (680 MHz) and bandwidth (7.61 MHz) from the results of measurement in the used channel.

Once the measurement is started, everything else is automatic. First the filter response curve, then the level characteristic of the filtered signal are measured across the band of interest, and the values of the two curves are added. The result is a graphical presentation of the true – ie unfiltered – signal characteristic. The relevant limit line normalized to the level is inserted into the diagram so that you see at a glance whether or not the transmitter complies with the stipulated mask.

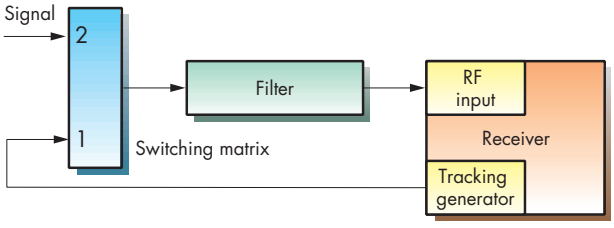


FIG 5
Block diagram of setup for measuring DAB/DVB vestigial sideband emissions

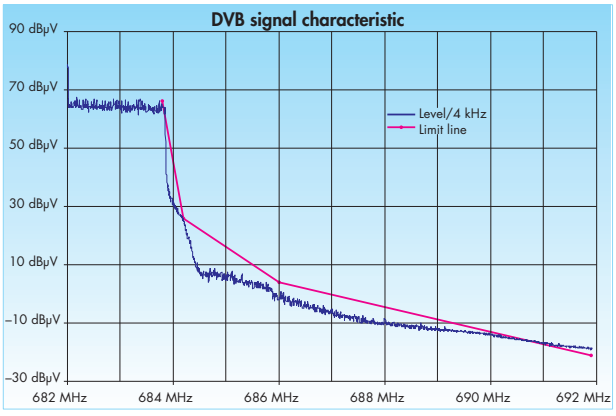


FIG 6
Result of vestigial sideband measurement with wide dynamic range

REFERENCES

[1] Wolf D. Seidl: Spectrum monitoring the ITU way. News from Rohde & Schwarz (1997) No. 153, pp 26–27

[2] Michael Lehmann; Dr Manfred Schukat: Coverage measurement and monitoring systems for DAB-T and DVB-T. News from Rohde & Schwarz (1999) No. 162, pp 22–24

Reader service card 164/05

MPEG2 measurement generators and decoders

Let's go west: ATSC ready for takeoff

A special standard complying with national requirements is used in the US for terrestrial broadcasting of digital TV signals: ATSC (Advanced Television Systems Committee). Same as the European DVB standard, ATSC is based on MPEG2 coding but it differs in some essential features. Several countries in South America and Asia are about to adopt this standard. So Rohde & Schwarz has integrated the ATSC standard in all its measuring instruments concerned.

Photo 42 499/3

FIG 1
MPEG2 Measurement Generator DVG and MPEG2 Measurement Decoder DVMD with optional software now also support the North American ATSC standard

For the last three years Rohde & Schwarz has been accompanying the worldwide introduction of digital TV with its "dream team" made up of MPEG2 Measurement Generator DVG, MPEG2 Measurement Decoder DVMD [1] and the optional software packages Stream Combiner™ and Stream Explorer™ [2]. The instruments are now multistandard units and support the North American ATSC standard which differs from the European standard in some essential features:

- High-resolution formats (480, 720, 1080 lines)
- Progressive scanning (60 Hz)
- 6-channel Dolby surround AC-3-coded audio
- Other tables
- Data-compressed table contents

MPEG2 Measurement Generator DVG is a versatile transport stream signal source especially suited for continuous operation. It is able to provide a comprehensive range of test patterns (bounce, sweep, colorbars, etc), test tones (CCITT.033) and moving picture sequences in a seamless loop. This makes it an ideal instrument for production testing of set-top boxes and for testing modulators and transmission links. The generator has been revised and upgraded and the following enhancements have been added:

- ATSC sequences with HDTV video and audio elementary streams (Dolby AC-3)
- Faster hardware
- Larger memory
- Expansion of SPI and ASI interfaces to 208 bytes/packet

With the aid of the optional software **Stream Combiner™ DVG-B1**, other external elementary streams can also be integrated and multiplexed to a continuous seamless transport stream for DVG (FIG 2). This function was enhanced particularly for the use of Dolby AC-3-coded audio and 4:2:2 or HDTV video sequences of up to 25 Mbit/s. An ATSC setup ensures that the program paradigm is adhered to and that all required ATSC tables and descriptors are added. The comprehensive editor enables modification of ATSC tables (STT, MGT, TVCT, CVCT, RRT, EIT, ETT, PIT) and their extension by other descriptors. The editor also uses Huffman coding for information in plain text within the tables. Also new is the possibility of including com-

prehensive or non-standardized tables and descriptors from files.

MPEG2 Measurement Decoder DVMD serves for monitoring DVB-conformal transport streams at nodes in transmission links and distribution centers. It monitors the transport stream for errors to ETR 290 (DVB Measurement Guidelines), eg data rates used, whether all time stamps are correct and whether all necessary tables are included at the specified repetition rates. This monitoring task can now also be performed on ATSC transport streams.

The software package **Stream Explorer™ DVMD-B1** available as an option for DVMD is now ATSC-compatible too. In addition to performing MPEG2-specific measurements it determines the data rate of ATSC elementary streams and tables and offers an ATSC table interpreter with Huffman decoding for compressed information texts. Thus the complete table content of ATSC transport streams can be detected, displayed and easily monitored (FIG 3).

All products mentioned come from now on as multistandard models, ie DVG and DVMD as well as Stream Combiner™ and Stream Explorer™ comply with the European DVB and the North American ATSC standard. Older instruments can be upgraded.

Thanks to these new characteristics, customers in North America will be well-equipped for ensuring the reliability of digital TV. The instruments will also support European manufacturers producing for the North American market and enable them to guarantee the required high quality of their products in development and production.

Harald Weigold

Reader service card 164/06 for information on DVG, DVMD and optional software

REFERENCES

[1] Fischbacher, M.; Weigold, H.: MPEG2 Generator DVG and MPEG2 Measurement Decoder DVMD – Test equipment for digital TV in line with MPEG2. News from Rohde & Schwarz (1996) No. 152, pp 20 – 23

[2] Fischbacher, M.; Rohde, W.: PC software for MPEG2 dream team DVG/DVMD. News from Rohde & Schwarz (1997) No. 154, p 29

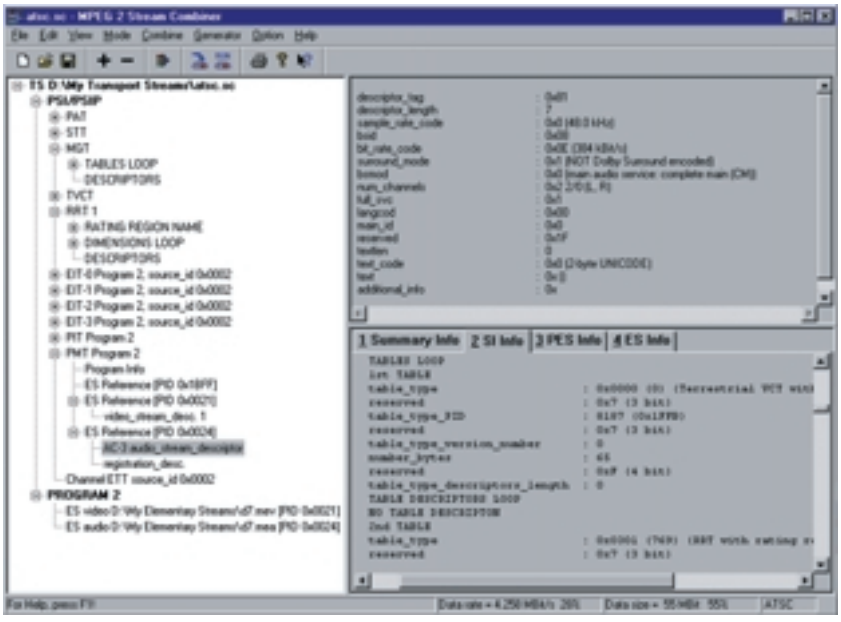


FIG 2 Configuring an ATSC transport stream for MPEG2 Measurement Generator DVG with Stream Combiner™ software

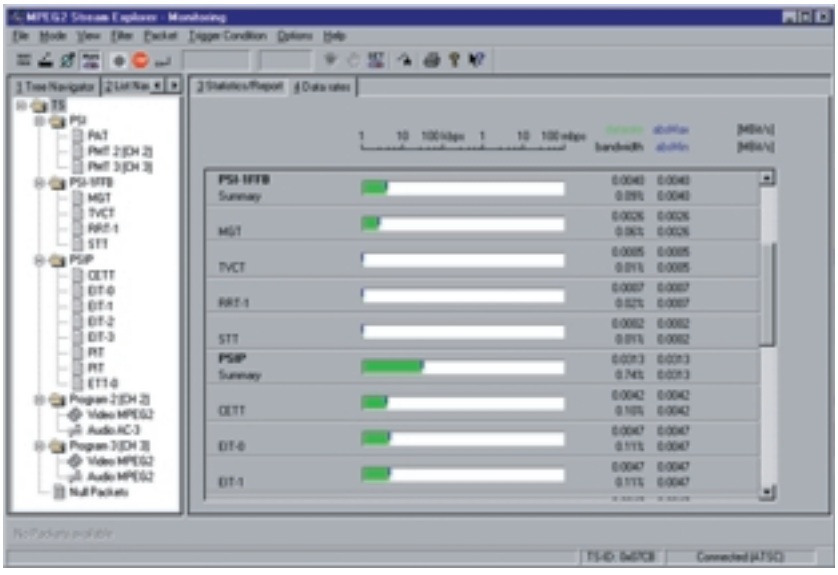


FIG 3 Data rate monitoring of ATSC tables (PSIP) with MPEG2 Measurement Decoder DVMD and Stream Explorer™ software

TV Test Receiver EFA

A precision instrument that also analyzes arbitrary QAM signals

Quadrature amplitude modulation (QAM) is increasingly gaining in importance in modern communication and transmission systems, offering, as it does, particularly high spectrum efficiency and reliability in digital data transmission. This applies to wired and wireless links alike.

TV Test Receiver EFA from Rohde & Schwarz, the test reference for analog and digital TV signals, analyzes and displays even arbitrary QAM signals with high precision without special synchronization sequences.

Photo 43 310/5

FIG 1 The EFA instrument family is a versatile, high-performance TV test receiver and demodulator platform that can be optimally configured for any application, whether digital or analog

Analysis of arbitrary QAM signals with EFA

Digital TV Test Receiver EFA (see also page 4 in this issue and [1]) is ideal not only for DVB-C measurements but also for the analysis of arbitrary QAM signals (model 20 or 23) since it can be optimally configured for the purpose. No special sync words are required for signal synchronization, display of the constellation diagram, parameter calculations or spectrum and echo measurements. However, correct synchronization to the input signal essentially depends on the data used for modulation, especially if these are repetitive data sequences.

What to observe in modulation using PRBS sequences

PRBS (pseudo-random binary sequences) are frequently used to generate QAM signals. The advantage of such signals is their seemingly random distribution, which in the case of QAM leads to uniform occupation of all decision fields. Various standard sequences with bit lengths of 2^9-1, $2^{15}-1$ and $2^{23}-1$ are used. The sequence 2^9-1 is not suitable however, especially in conjunction with higher-order QAM (eg 256QAM), and for the following reasons:

1. If a standard sequence is used, the data sequence is cyclically repeated. At the end of a sequence, the next one starts immediately, ie the signal is periodic. The output signal of the QAM modulator therefore has a discrete spectrum. With a very short PRBS, as with 2^9-1, the discrete lines of the spectrum are spaced far apart, so synchronization to the input signal is not possible.

2. With 256QAM, 8 bits are combined to form a symbol. With a short PRBS, only a few different bit combinations are possible. If the 2^9-1 (= 511 bits) sequence is cyclically repeated, the symbols repeat after as few as eight sequences. So, with 256 different decision fields (in the case of 256QAM), only about two symbols per decision field are possible before the sequence repeats. Random distribution results in some decision fields carrying no symbols at all while others carry four and more.

Settings on QAM modulator SMIQ with option SMIQ-B10 (after preset)

Frequency:
- Frequency: 36.000 MHz

Level:
- Amplitude: – 7dBm

Digital Modulation:
- State: ON
- Modulation:
  - Type: 256QAM – 8b/symb
- Symbol Rate: 5 000 000 symb/s

Digital Modulation:
- Source:
  - Source: PRBS
  - PRBS Length: 2^{15}–1
- Filter:
  - Filter Type: SQR COS
  - Filter Parameter: 0.15
- Coding: Phase Diff.

Settings on TV Test Receiver EFA (after preset)

Mode:
- QAM Analyzer/Demod

Input: IF (36 MHz)

Status:
- Order of QAM: 256
- SAW Filter Bandwidth: OFF
- Symbol Rate:
  - Symbol Rate Value: 5 MSPS

Special Function:
- Min BER Integr.: BER EXT
- MPEG Data Output:
  - Par. MPEG Data PLL: ON
- IQ Inversion: Normal

FIG 2 Settings required on Signal Generator SMIQ for synchronizing arbitrary 256QAM signal with TV Test Receiver EFA

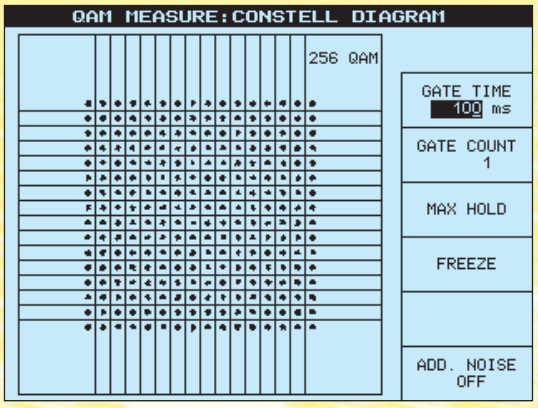


FIG 3 (top right)
Constellation diagram for 256QAM

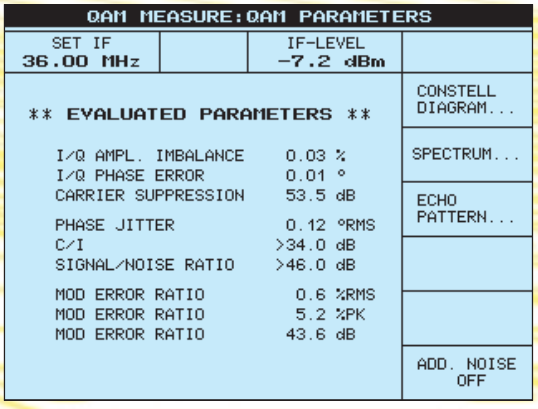


FIG 4 (bottom right)
Parameters calculated for 256QAM

However, to synchronize the QAM signal correctly, it is necessary that all decision fields be occupied with an equally frequent number of symbols.

Both of these problems are of a basic, ie physical nature, and therefore apply to all measurements of QAM signals irrespective of the measuring instrument used.

How to do it

In our example, Signal Generator SMIQ [2] from Rohde & Schwarz with option SMIQ-B10 supplies the QAM signal, which is then evaluated by TV Test Receiver EFA. FIG 2 shows the QAM modulator settings required for correct transmission of a QAM signal and for analysis by the test receiver. SMIQ internally generates I/Q signals for any standard required and supplies the modulated signal at its RF output.

The above settings are selected so that all physical and technical requirements necessary for synchronizing all QAM signals up to 256QAM (FIG 3 and 4) are met.

Summary

TV Test Receiver EFA is an ideal choice for the analysis and evaluation of arbitrary QAM signals, even for signals containing no synchronization information at all. To ensure correct transmission of such signals, only a few physical relationships have to be taken into account, for example the length of the random sequence in repetitive data sequences. Differential coding must also be selected on the generator. Excellent results can be achieved in this way even for relatively short sequences, for example PRBS 2^{15}–1.

Christoph Balz

Reader service card 164/07

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[1] Christoph Balz; Ernst Polz; Walter Fischer: TV Test Receiver Family EFA – Top fit for digital television. News from Rohde & Schwarz (1996) No. 152, pp 17–19

[2] Johann Klier: Signal Generator SMIQ – High-quality digital modulation up to 3.3 GHz. News from Rohde & Schwarz (1997) No. 154, pp 4–6

Miniport Receiver EB 200

Hard times for eavesdroppers

The optional DIGI-Scan allows Miniport Receiver EB 200 – the portable all-in solution for radiolocation [1] – to cover a wide RF spectrum from 10 kHz through 3 GHz. This gives the user a variety of applications, including the detection and localization of spy transmitters (FIG 1).

Photo 43 408/1

FIG 1
Thanks to its low weight, powerful directional antennas and high sensitivity, Miniport Receiver EB 200 is perfectly suited for numerous applications, eg for detecting spy transmitters

Industrial espionage causes serious damage

Professional eavesdroppers use sophisticated electronic techniques to get hold of the information they want. The effort seems to pay off, seeing as how information and communication are factors of strategic importance nowadays. The high-tech industry is a particularly promising target. In Germany alone, the losses caused by industrial espionage are estimated at several billion marks per year.

Miniature transmitters have long been popular devices for finding out, acoustically, about what other people are doing. Today it is no problem, not even for amateurs, to come by the equipment required. Socalled spy shops offer their products openly on the Internet – miniature transmitters for eavesdropping on rooms and telephones, directional microphones and miniaturized cameras concealed in cigarette packs and pens.

Swatting small bugs fast: EB 200 with DIGI-Scan

With EB 200 on their tail, bugging devices have no chance of hiding. RF Spectrum DIGI-Scan, an option for EB 200, provides the user with an overview of the current frequency spectrum within seconds. It detects any interferer and also hopping frequencies in a shot and then pinpoints them with the aid of its handheld directional antenna.

An electronic "tracker dog" – easy to handle

The exact localization of miniature transmitters starts with determination of the frequency on which they are operating. This is done by calling up the DIGI-Scan option on EB 200 and allowing the receiver to scan the selected frequency range (FIG 2). Localization of miniature transmitters at close range is made possible by the differential mode of DIGI-Scan (FIG 3). After calling up this mode, the current spectrum is stored as a reference. New spectra are superimposed on the reference spectrum, and any newly appearing signals or variations in signal strength are clearly discernible as peaks. Once the frequency of the spy transmitter is determined in the DIGI-Scan mode, the remainder is simple and fast: set EB200 to the frequency (FIG 4), call up the TONE

mode in the display menu and set the level of the determined frequency approximately to the center of the bar shown on the level display. For localizing emission sources with the handheld antenna, the user only has to observe the level display or the loudness of the tone. The maximum level or the loudest tone will guide him straight towards the transmitter.

EB 200 is the only portable minireceiver combining spectrum display and level/tone search in a single unit.

Theodor Fokken

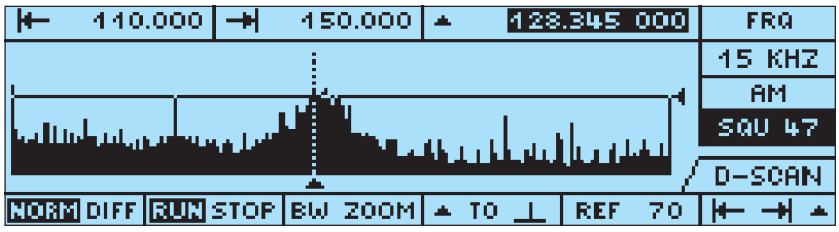

FIG 2 EB 200 in normal DIGI-Scan mode

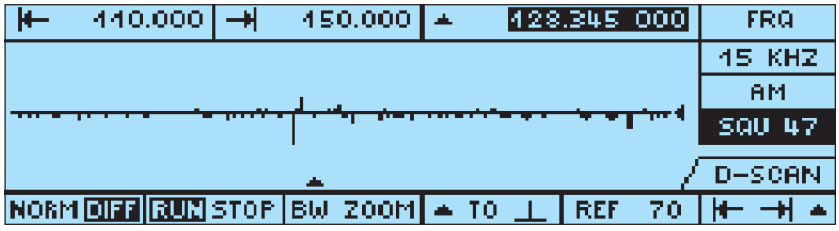

FIG 3 EB 200 in differential DIGI-Scan mode

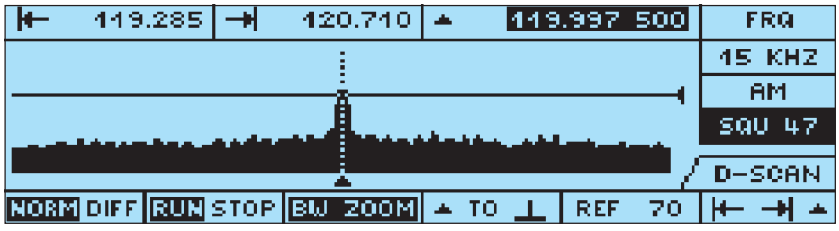

FIG 4 EB 200 in DIGI-Scan mode with high IF resolution for frequency tuning

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[1] Günther Klenner: Miniport Receiver EB 200 and Handheld Directional Antenna HE 200 – Radiolocation from 10 kHz to 3 GHz with portable equipment. News from Rohde & Schwarz (1997) No. 156, pp 4–6

Reader service card 164/08

Correction

In the test hint "Conversion of C/N or SNR to E_b/N_0 in DVB" in issue No. 163, "C" rather than "S" was incorrectly used in some equations. The correct equations are printed on the right. Please overlook our mistake.

$$S/N = E_b/N_0 + 10 \times \lg\frac{188}{204} + 10 \times \lg(m) + 10 \times \lg(P) - 10 \times \lg\left(1 - \frac{\alpha}{4}\right) \text{ dB}$$

Equation 1

$$E_b/N_0 = S/N - 10 \times \lg\frac{188}{204} - 10 \times \lg(m) - 10 \times \lg(P) + 10 \times \lg\left(1 - \frac{\alpha}{4}\right) \text{ dB}$$

Equation 2

For measurements in the **QAM demodulator,** $\sqrt{\cos}$ roll-off filtering has to be taken into account.

$$E_b/N_0 = S/N - 10 \times \lg\frac{188}{204} - 10 \times \lg(m) + 10 \times \lg\left(1 - \frac{\alpha}{4}\right) \text{ dB}$$

For measurements in the **satellite demodulator** with QPSK, the equation for determining the BER as a function of E_b/N_0 after Viterbi FEC is as follows:

$$E_b/N_0 = S/N - 10 \times \lg\frac{188}{204} - 10 \times \lg(m) - 10 \times \lg(P) + 10 \times \lg\left(1 - \frac{\alpha}{4}\right) \text{ dB}$$

EMC test centers of any size – precise, fully automatic and universal

Decades of experience and an allround product range have made Rohde & Schwarz a market leader in the field of EMC test technology and EMC test centers. A large number of renowned companies of the automobile, consumer electronics and mechanical engineering industry have for many years relied on its EMC technology, covering everything from small EUTs to wide-body aircraft. Recently Audi put its new EMC test center into operation, fully equipped with Rohde & Schwarz technology. This article gives an example of the EMC test center concept that has already proven itself at other well-known companies.

Photo: 43 350/1

State-of-the-art test technology for high-tech vehicles

The EMC test center of Audi AG in Ingoldstadt comprises a large and a small anechoic chamber and several shielded and unshielded operating areas. Audi thus has all the required facilities within its premises to test in detail the electromagnetic compatibility of its vehicles and supplied parts. The center can test to all relevant regulations such as EU directive 95/54, ISO 11451/11452, DIN/VDE 40839 and CISPR 12 standards as well as in-house regulations.

The efficient and reliable test systems can be flexibly deployed for both in-development measurements and approval testing. The outstanding features of the systems are:

- Powerful software for short preparation and test times and thus for high throughput
- Precise units and system components ensuring reproducible test results

FIG 1 Measurements are performed automatically in the large anechoic chamber, so the operator can fully concentrate on EUT response

- High accuracy through automatic correction of frequency-response errors
- Reliable and fully automatic systems allowing the user to fully concentrate on the equipment under test
- Fully automatic monitoring and result logging of the equipment under test

EMS Software EMS-K1: What's new in version 1.20?

- Analysis mode:
  - Combination of automatic and manual scan, with free selection of frequency steps, variation of modulation parameters and change of antenna polarization and turntable position
  - Display of system parameters in test window
  - Reduction of test times by simultaneous measurement of forward and reflected power with two power meters
- EUT monitoring: interface for new EUT Monitoring Software EMON-K1

EUT Monitoring Software EMON-K1: new ways for EUT monitoring

- Synchronous monitoring (complete measurement at each test frequency) or asynchronous operation (free-running measurement) in combination with EMS Software EMS-K1
- Representation of measurement data in expressive graphical or tabular form
- Convenient reporting
- Storage of all setups and test results in ASCII and WMF format for further processing
- Monitoring and stimulus channels
- Device drivers can be created by user
- Graphical user interface and context-sensitive help

Complete vehicle testing in large anechoic chamber

Even if a high degree of reliability of the individual components is attained as a result of EMC testing during development, a final test of the assembled vehicle is indispensable. Once built-in, components might show a quite different behaviour than in the TEM cell or stripline.

For this reason the anechoic chamber of 25 m x 20 m x 10 m with chassis dynamometer (FIG 1) serves for testing vehicles as a whole. The test system simulates the electromagnetic fields occurring in the open in the frequency range from 6 MHz to 3 GHz.

High-precision EMC test technology from Rohde & Schwarz

At the beginning of the signal chain, **Signal Generator SME03** generates an RF signal that can be modulated and level-controlled. This signal is taken to power amplifiers via a remotely controlled relay matrix. The amplifiers supply RF output power of up to 10 kW, which yields field strength of up to 200 V/m. **Four isotropic field sensors** transmit the magnitude of the field strength measured at the site of the equipment under test via fiber-optic cables.

The three **log-periodic antennas** used in vehicle measurements were designed for high field strength and high test volume. A remotely controlled antenna installed on the rear wall of the chamber covers the range from 3 MHz to 30 MHz. The two other antennas (30 MHz to 220 MHz) and (220 MHz to 1 GHz) are mounted on a railed carriage. A horn antenna is used above 1 GHz.

Measurement of forward and reflected power is implemented by **two Millivoltmeters URV5**. The settling time at each frequency point can be largely reduced by using two power meters that are supported by optimized software.

EMS Software EMS-K1 of the field-strength controller (see box) controls the test routine and supports all common methods of electric field generation:

- Electric field levelling with closed control loop (EUT and field sensor are at the same location)
- Substitution method (currently the most widespread method; the actual measurement is preceded by a reference measurement in the empty chamber)
- Theoretical method (the required power is evaluated by means of a formula or from antenna gain available in tabular form)

Due to the high field strength, nobody is allowed to remain in the anechoic chamber, so the **EUT monitoring system** performs stimulation and monitoring of the equipment under test via fiber-optic cables. The system is controlled by a separate PC that runs with the newly developed **EUT Monitoring Software EMON-K1** (see box). It controls the system and provides information about the EUT functions, which is then sent to the field-strength controller.

A **video system** with three fixed cameras provides an overview of the anechoic chamber and, with the aid of two mobile cameras, enables the user to check the instruments in the vehicle. The current values of frequency and field strength are then shown in the pictures of the mobile cameras.

An **intercom** with several stations simplifies preparation of the vehicle to undergo testing and maintenance of the chassis dynamometer and amplifiers.

Large-scale projects in good hands

The whole project was implemented within 12 months. With such tight schedules, nothing can be left to chance. Audi fully relied on Rohde & Schwarz's long experience in the implementation of EMC systems.

In addition to the design and supply of EMC test technology Rohde & Schwarz was also responsible for planning and performing the complete installation of the ground-floor laboratory. Based on the standard specifications and the scope of deliveries and services required, Rohde & Schwarz harmonized all details with the customer from the very beginning. A comprehensive interface catalog was worked out and agreed upon with the site supervisory staff and the supplier of the shielded enclosures. The systems were installed on schedule and handed over to the operators after suitable training.

Reinhard Göster

Reader service card 164/09 for more information on EMC test systems

Photo 43 350/7

FIG 2 A look into the control room: precise EMC technology from Rohde & Schwarz ensures reproducible test results

Regular features

Rohde & Schwarz Web site in new look and more comprehensive than ever

Rohde & Schwarz is now present on the Internet with a totally new look. The new Web pages contain comprehensive information on all product lines as well as background information on new technologies. What is more, a lot of in-depth information material such as data sheets, catalogs, application notes, technical brochures and the in-house journal "News from Rohde & Schwarz" as well as driver software are available for downloading.

In the design of the new Web site, fast and user-friendly handling was given top priority. Instructions are mostly in plain text and graphics are optimized in size to considerably reduce download times. Dynamic navigation and clear-cut layout make handling very easy. The desired topics are quickly found thanks to full-text search.

All current Rohde & Schwarz products can be called up on the Internet complete with photo, description and most of them even with their data sheet. The Web pages also contain an overview of services and seminars, news, events, general information about Rohde & Schwarz as well as a separate press section.

The new Web pages can be found on the Internet at http://www.rsd.de. For optimum viewing, Web browsers of version 4 and higher and activated Java script are recommended.

Christian Hess

3G test scenario in research and development

Third-generation mobile radio – universal test concepts pave the way

The world of mobile radiocommunication is undergoing dramatic changes as far as technology, services and type approval test regulations are concerned: the third mobile radio generation (3G) is on its way (FIG 1). Pioneering measurement technology has to come up with solutions for increasingly complex test requirements at an early stage and should be instrumental in launching the new generation on the road to success. Rohde & Schwarz, the world's market leader in the field of mobile radio test technology, takes up this enormous challenge with a flexible and future-oriented test concept.

Photo 43 360

FIG 1
While today's mobile phones are mostly used for voice communication, those of the third generation (3G) will open up the entire multimedia spectrum

2G – 2.5G – 3G: mobile radiocommunication moves on unabated

The introduction of high-speed data services (HSCSD) and packet-oriented transmission methods (GPRS) for the second mobile radio generation (2G) is currently the first step towards new applications using high data rates (2.5G technology). Test platforms from Rohde & Schwarz are well prepared for this transition [1], [2].

At the same time the next mobile radio generation based on W-CDMA (3G) is on its way. Its standardization is making rapid progress within the framework of the international 3GPP (3rd generation partnership project) body. Signal generators and analyzers from Rohde & Schwarz have set standards in this field from the very beginning [3], [4], [5]. There is also a growing demand for more complex test systems as 3G activities progress beyond the research stage and turn into ambitious development projects. Requirements go far beyond mere RF measurements at the air interface or signalling tests at layers 1 to 3. Testing overlaid applications at a higher protocol level (> layer 3) is gaining in importance.

FIG 2 gives an overview of the emerging scenario. While today's mobile phones are mostly used as terminals for voice communication, mobiles of the third generation will open up the entire multimedia spectrum from voice telephony through video applications to data services based on the Internet protocol (IP) and integrated by the wireless application protocol (WAP). It is conceivable that dedicated terminals like personal digital assistants (PDA) will provide access to the different services, so that a mobile acts like a mobile switching station. Transmission in the local area between the terminal and the mobile station will be based on standards optimized for this

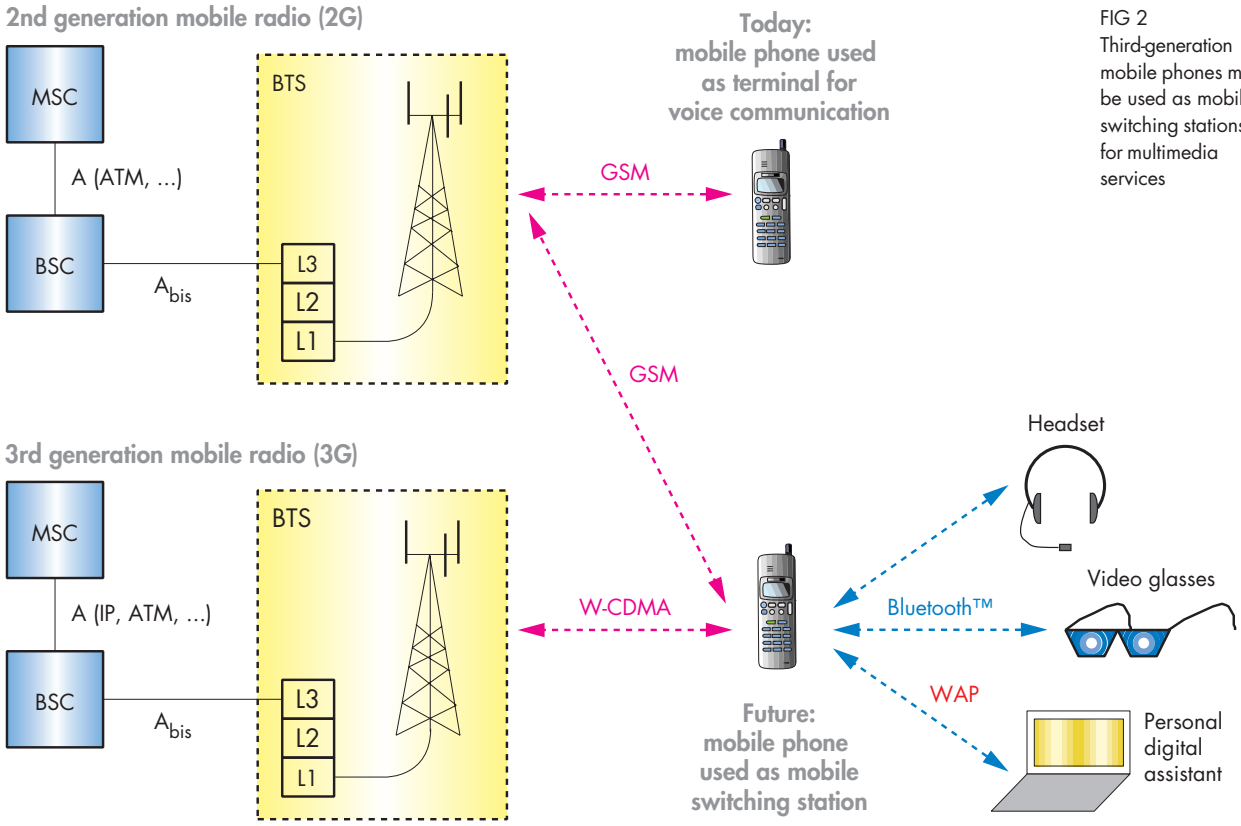

FIG 2
Third-generation mobile phones may be used as mobile switching stations for multimedia services

purpose, like Bluetooth™, whereas mobile-to-network linkup will be via W-CDMA or GSM.

At the network end, too, it is becoming obvious that IP-transparent structures are about to experience a breakthrough. Protocol tests will gain enormously in importance in a scenario of this kind with its large number of multimode handover processes and the growing orientation towards data applications.

Early elimination of errors in product design

The principle test objective in research and development is to minimize design costs and time to market while maximizing product quality. This means that faults during the product development process must be eliminated at the earliest possible stage. This process can be divided into four phases of increasing complexity, for which different test requirements can be identified (FIG 3).

During the **research phase** the main emphasis is initially on the investigation of RF parameters and coding algorithms under varying conditions like interference and fading. Realtime signal processing is not required at this stage as finite signal sequences are sufficient. The largest saving potential is in the **module test phase**. For example previously, when the air interface was the only access medium, signalling software could not be thoroughly tested until after complete inte-

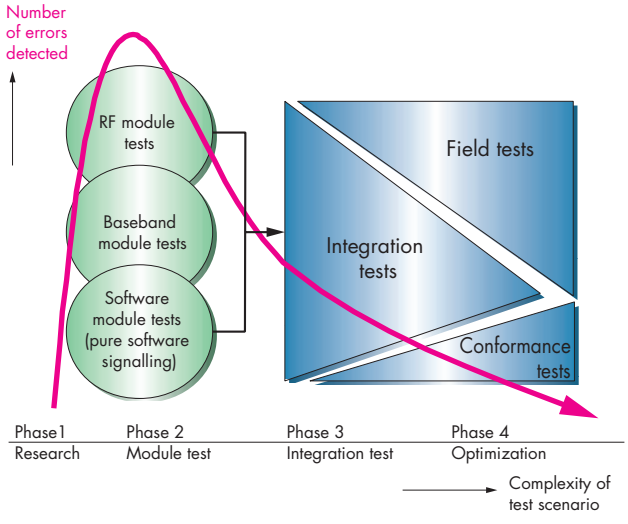

FIG 3
Modern test methods should eliminate faults in the product design process at the earliest possible stage

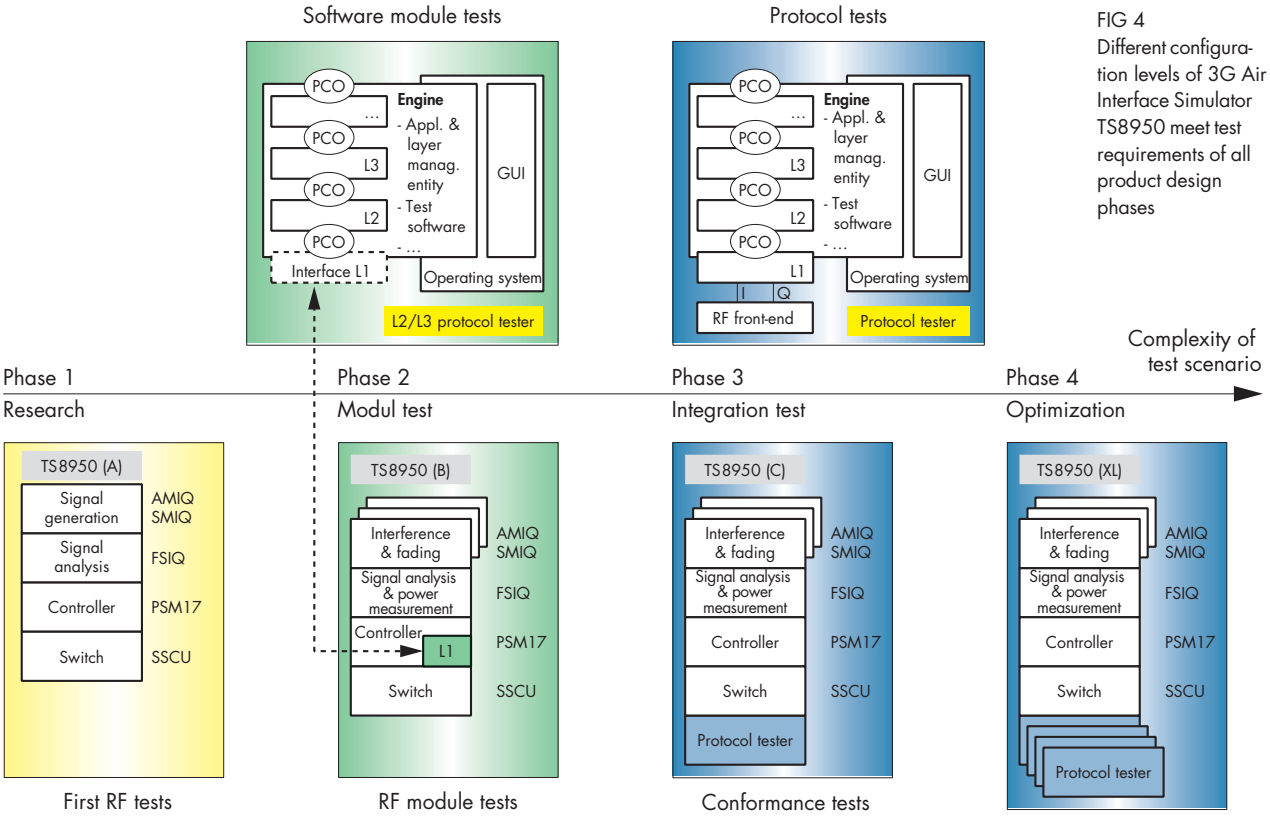

FIG 4
Different configuration levels of 3G Air Interface Simulator TS8950 meet test requirements of all product design phases

gration of the device under test (DUT). But future test equipment should enable independent analysis of RF, baseband and software modules developed in parallel. Testing via the air interface in the **integration phase** can then concentrate on errors that arise from module interworking. In the final **optimization phase**, complex conformance tests and real or simulated field tests are then carried out to improve product characteristics.

Universal test concept covering each product design phase

Rohde&Schwarz satisfies the different requirements of the four phases with an extremely flexible test concept. The basis of this is a modular, upgradeable 3G Air Interface Simulator TS8950 with integrated components for protocol tests (FIG 4). Instead of rigid test cases, this highly advanced test system provides individually parameterized test methods that can be combined to form any desired test scenario. Thanks to this strategy, TS8950 is not only able to respond flexibly to the still changing specifications resulting from 3GPP standardization but also supports manufacturer- and network-specific test sequences.

As a consequence of the R&TTE directive of the European Commission, taking effect on 1 January 2000, mandatory type-approval tests will be replaced by binding manufacturers' declarations of compliance, so this flexible test concept will gain enormously in importance. This approach also ensures compliance even with the stringent requirements of operators like the Japanese NTT DoCoMo, which will be putting the first 3G network into operation at the beginning of 2001.

The next issue of News from Rohde&Schwarz will contain more details of the TS8950 test system.

Holger Jauch

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Reader service card 164/10 for more information about 3G solutions

Airborne VHF/UHF Transceivers Series 6000

Software radios – top in secure data and voice transmission

The new series 6000 VHF/UHF airborne transceivers are of extremely compact size and low weight and offer multifunctional applications for highly protected and reliable data and voice communication. The software radios are able to handle all important EPMs (electronic protection measures) and thanks to P³I (preplanned product improvement) technology they keep pace with future development requirements. The new generation was presented to an expert public at the largest European air show, the Aerosalon in Le Bourget near Paris.

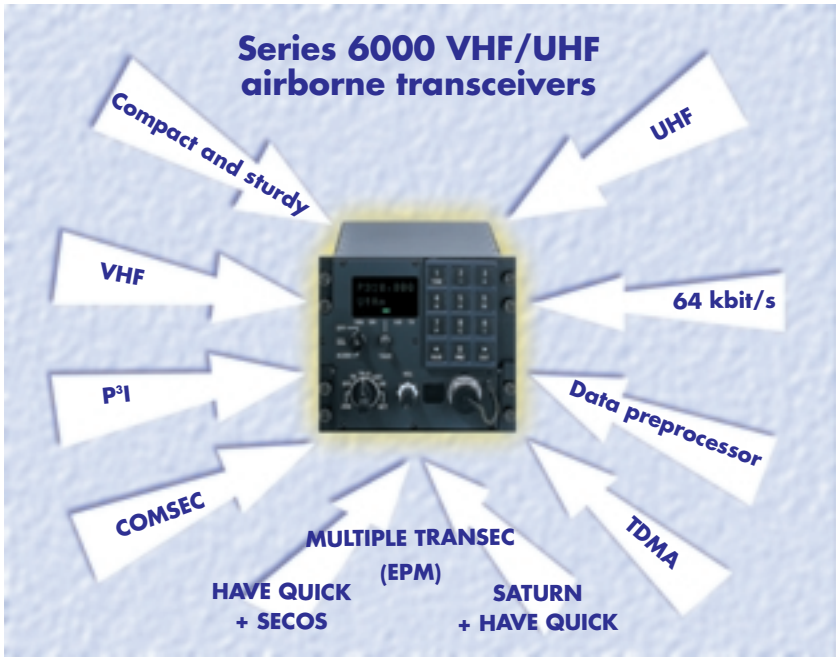

FIG 1 New Series 6000 software radios (here cockpit version) convince through flexibility and universal use

Software-defined functions

The Series 6000 airborne transceivers are the first generation of software radios featuring among others outstanding flexibility. Functions are mainly software-determined. The transceivers can keep pace with technical evolution by way of upgrades. The open instrument architecture makes them open-ended for future needs (FIG 1).

Combined EPMs

Series 6000 transceivers support state-of-the-art and extremely fast SATURN frequency hopping and, for reasons of compatibility, also the earlier, HAVE QUICK I/II. As a worldwide unique feature, they use SECOS frequency hopping developed by Rohde & Schwarz, enabling countries with special security requirements to directly influence the COMSEC (voice and data security) and TRANSEC (frequency hopping) functions.

Rohde & Schwarz implemented a combination of all these EPMs in the Series 6000 compact multiband software radios and prepared them for future upgrades through the use of P³I.

A particular benefit of this solution is that in combination with Series 400 U ground-to-air stations and tactical ground transmitters from Rohde & Schwarz, this new generation of airborne transceivers makes up an all-round and extremely flexible air-to-ground EPM communication system.

New equipment or retrofit for numerous platforms

Rohde & Schwarz airborne transceivers provide reliable services to armed forces throughout the world on numerous airborne platforms including the Eurofighter TYPHOON and the helicopters TIGER and NH90.

The units of Series 6000 are suitable for outfitting new flying platforms. They are also ideal for F³ (form, fit, function) retrofitting projects and direct connection to existing AN/ARC-164 radio equipment with or without adapters.

FIG 3
Series 6000 airborne transceivers adaptable to future requirements by means of software and with their modular design ensuring fast and economical maintenance

FIG 2
VHF/UHF transceiver in version for remote control

Series 6000 special features

- VHF/UHF 108 MHz to 400 MHz
  – 10 W AM, 15 W FM,
  – 30 MHz to 88 MHz optional
- Full F³ retrofitting for AN/ARC types like ARC-164
- Installation in cockpit or avionic bay
- EPM techniques HAVE QUICK I/II, SECOS, SATURN
- Modular design, surface-mount technology
- High reliability
- BIT (built-in test) at module level with high error detection probability
- Information data rate up to 64 kbit/s
- Weight <4 kg

Version overview

Series 6000 comprises **VHF/UHF transceivers** for

- Local and remote control (FIG 2)
- Cockpit installation with MIL bus
- Avionic bay with MIL bus
- **Control units** with/without MIL bus

Recommended extras

- Special-to-type test equipment (STTE)
- Key Distribution Device KDD-3700
- Communication Management and Handling Software (CMHS)

Modular design and minimum maintenance

The individual modules of the VHF/UHF transceivers have defined interfaces. They can be replaced without any adjustment or alignment, ensuring fast and economical maintenance (FIG 3).

Other benefits are

- Excellent accessibility
- Standardized components
- Minimum number of tools required
- Minimum-scheduled maintenance

Series 6000 with worldwide top technology is expected to become a great success on the international market. Large orders for modernization of avionic transceiver equipment have already been placed by two countries, confirming the significance of the name Rohde & Schwarz on the market for ECM-resistant air-to-ground communication systems.

Ekkehardt Claussen

Reader service card 164/11

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Digital Radiocommunication Testers CMD
Models for measurements to GSM and DECT as well as the latest CMD65 model plus all options available are covered by the new data sheet with comprehensively revised specifications.

Data sheet PD 757.2596.22 enter 164/12

BMS Coverage Measurement System TS6200
Due to the comprehensive description of the system and individual units, the data sheet became a publication comprising eight pages. An extra sheet on DAB-T and DVB-T measurements is inserted.

Data sheet PD 757.3828.22 enter 164/13

▽

DVG & Stream Combiner™ for ATSC and **DVMD & Stream Explorer™ for ATSC**
The software for Measurement Generator DVG and Measurement Decoder DVMD also enables analysis and representation of TV signals to DVB and ATSC standards.

Data sheet
DVG: PD 757.4730.21 enter 164/14
DVMD: PD 757.4747.21 enter 164/15

TV Test Receiver Family EFA (5 MHz to 1000 MHz) has been extended by test receiver and test demodulator for standard M/N, DVB-C test demodulator as well as options for video bandwidth switching, residual picture carrier measurement, pilot deviation measurement and 6 MHz SAW filter (DVB-C).

Data sheet PD 757.2421.22 enter 164/16

Voltage Sensors URV5-Z (9 kHz to 3 GHz; 200 µV to 1000 V; 1 nW to 200 W) Models URV5-Z2 and URV5-Z4 with extended frequency range (including models with 5 m cables) are now also included and the overview of power sensors was supplemented by models NRV-Z15/-Z32/-Z33/-Z55.

Data sheet PD 756.9816.22 enter 164/17

Spectrum Monitoring Software ARGUS (10 kHz to 40 GHz) offers all features required for monitoring, measurement, registration and statistical evaluation of signals in individual stations as well as in nationwide networks in combination with comprehensive frequency management functions.

Info PD 757.4818.21 enter 164/18

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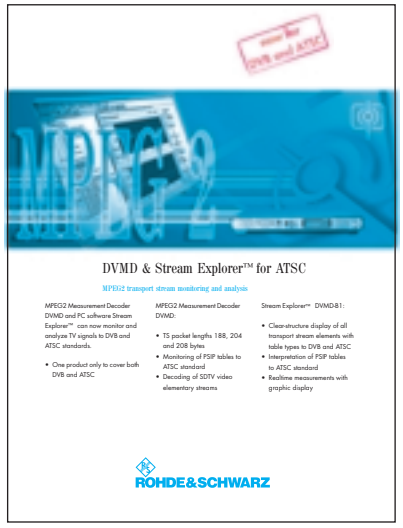


150 kHz Highpass EZ-25 (up to 30 MHz) enables conducted emission measurements (to EN 50065 part I) in the presence of longwave mains disturbance signals for any CISPR test receiver; pulse energy capability 50 mWs.

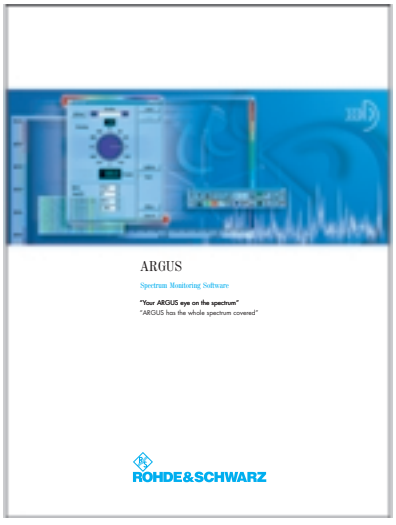
Data sheet PD 757.4976.21 enter 164/19

R&S Teisnach is **system supplier for mechanical and electrical components**, offering mechanical precision for the world market in ISO quality and according to NATO specifications.

Info PD 757.4624.21 enter 164/20

TV Test Transmitter SFQ (300 kHz to 3.3 GHz) Newly included in the data sheet are SFQ models 20 for DVB-T (7/8/9 MHz bandwidths) and 30 for ATSC (8VSB/16VSB) as well as the options for fading simulation (up to 6 or 12 paths) and ATSC coder.

Data sheet PD 757.3334.24 enter 164/21



New application notes

Bit Error Rate Measurements with AMIQ and WinIQSIM
Appl. 1GP36_0E enter 164/22

Acoustic Measurements on GSM Mobile Phones with Audio Analyzer UPL and Digital Radiocommunication Tester CMD
Appl. 1GA39_0E enter 164/23

GPIB-Bus Device Finder
Appl. 1MA17_2E enter 164/24

Frequency Response Measurements
Appl. 1MA09_2E enter 164/25

Schz

Photo 43 122/1

Sensitive testing with Universal Test System TSU

In its June edition the journal "Elektronik Praxis" reported on use of the TSU test platform from Rohde & Schwarz for production testing of ABS modules.

With a view to this highly sensitive aspect of electronic control equipment in motor cars, TSU was fitted with Automotive Production Test System APTS and the analog measurement subsystem AMV. The article describes how ABS module tests are performed and presents the benefits of APTS and AMV.

Big performance in a small package

Under this heading the German "Elektronik Journal" described the new Microwave Signal Generator SMR from Rohde & Schwarz in its May edition.

"Small, lightweight and reliable and at the same time easy to operate and inexpensive to buy and maintain: these are the major requirements stated by most users when asked about modern microwave generators. The designers at Rohde & Schwarz were well aware of this when starting work on their new series, and the result was the new SMR family."

Photo 43 264/3

A treat for radio pros

A "treat" is what "Radio Scanner" magazine called Miniport Receiver EB 200 in its February edition.

"For radio pros demanding maximum standards that cannot even be satisfied by the performance of a high-quality radio scanner, Rohde & Schwarz of Munich has provided another treat: Miniport Receiver EB 200, a monitoring receiver for professional applications."

Failure-proof broadcasting from Pic du Midi thanks to Rohde & Schwarz

In its March edition "Radio World", which has a worldwide circulation, dedicated an article to the installation of Rohde & Schwarz transmitters for TDF (Télédiffusion de France) on top of the Pic du Midi d´Ossau, 180 km from Toulouse in France.

The article focuses on the difficult conditions of installing the three 2.5 kW FM transmitters at the site and on their functionality. "The new equipment is completely of solid-state design, which guarantees continuous operation even in the event of a module or power failure."

Photo 43 077/3

"Picture quality in digital TV" was the central issue in edition 112 of the journal "TV Amateur".

As the front page clearly shows, solutions from Rohde & Schwarz were at the center of attention. It displays two test patterns used by Video Quality Analyzer DVQ to measure both subjective and objective picture quality. The article in the journal described in great detail the testing technique as well as the Rohde & Schwarz equipment used.

TV transmitters for first DVB-T network in Norway

Rohde & Schwarz received an order for five high-power DVB-T transmitters from the Norwegian network operator Norkring. With four 5 kW Transmitters NV6500 and one 2.5 kW Transmitter NV2500, Norway's first DVB-T network is to be installed. According to Norkring, the reason for ordering the new liquid-cooled transmitters from Rohde & Schwarz was the compact design, the advanced amplifier technology and the company's know-how in the DVB-T field. Installation of the DVB-T network – starting at sites in Oslo, Bergen and Gulen – marks the country's first step into the digital terrestrial TV era. The project is also the first order for the new family of liquid-cooled TV transmitters from Rohde & Schwarz, which are at present the most compact worldwide and require the least floor space. Efficiency is also considerably increased thanks to state-of-the-art LDMOS transistor technology. Further reasons for placing the order with Rohde & Schwarz were the company's many years of experience in the modulation and processing of DVB-T signals and the possibility of remote-controlling the TV transmitters.

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IT security department of Bosch Telecom taken over by Rohde & Schwarz

SIT, Gesellschaft für Systeme der Informationstechnik mbH, a subsidiary of Rohde & Schwarz, has taken over the security in information technology operations of Bosch Telecom GmbH, Stuttgart, as of 1 July 1999. Rohde & Schwarz has been successfully active in the field of IT security, data protection and encryption for quite some time. This know-how is not only used to advantage in new products for IT security but also in the radiocommunication systems from Rohde & Schwarz. The purpose of this acquisition is to accentuate the design of solutions for secure and reliable utilization of information and communication technology.

Radiocommunication equipment for Eurofighter Typhoon

Rohde & Schwarz was selected as the supplier of the radio equipment for the Eurofighter Typhoon, Europe's most advanced combat aircraft, which is now going into series production. For the first batch comprising 147 aircraft Rohde & Schwarz won an order for 317 transceivers. The VHF/UHF equipment provides clear and encrypted transmission and reception of voice signals. In the coming ten years a total of 620 Typhoon aircraft will be built for Germany, Britain, Italy and Spain and equipped with the VHF/UHF transceivers from Rohde & Schwarz. Other countries have shown an interest in buying Typhoon aircraft as well.

The VHF/UHF transceivers were specially developed for the Typhoon: they are built by four companies from the countries involved in the project as agreed by their governments, with Rohde & Schwarz being the leader of the consortium. With the participation in this project Rohde & Schwarz – which also provides radiocommunication equipment for the new TIGER helicopter – strengthens its position as a leading supplier of sophisticated radiocommunication technology.

Rohde & Schwarz takes over REMA Leo Haag setting up its own subsidiary in Spain

On 1 July 1999 Rohde & Schwarz took over REMA Leo Haag, the company's Spanish representative for many years, which will now become Rohde & Schwarz España. REMA Leo Haag has been marketing Rohde & Schwarz products since the late 30s and is today one of Spain's leading electronics suppliers. The takeover enables Rohde & Schwarz to strengthen its position on the European market and to show direct presence on the important Spanish growth market.

Stefan Böttinger

Rohde & Schwarz faculty award 1999

As in recent years, the Day of the Faculty of Electrical Engineering and Information Technology held at the Technical University in Munich again formed a fitting background for the Rohde & Schwarz faculty award ceremony. COO Hans Wagner presented the award this time round to Dr.-Ing. Christian Legl (photo).

In his thesis, Dr Legl investigated field-programmable gate arrays (FPGAs) and developed a highly efficient technique for their logical synthesis, which received a lot of attention in specialist circles. In his speech, Hans Wagner underlined the importance of Dr Legl's contribution especially for companies like Rohde & Schwarz, where FPGAs are used as economical solutions for medium-batch applications.

The world's first portable crystal clock returns home to Rohde & Schwarz museum

In 1972, when the Olympic Games were held in Munich (summer) and Sapporo (winter), the two cities decided to twin. As a result Sapporo organized an exhibition of representative products from the city of Munich. The mayor of Munich invited important companies of his city to participate, and Rohde & Schwarz offered – as a historical milestone in measurement technology – its crystal clock developed in 1936.

The world's first portable crystal clock returns home from Sapporo to Munich. Dr Matthias Ludwig, Rohde & Schwarz, expresses his gratitude to the director general of economic affairs of the city of Sapporo, Noboru Takahashi (center)

The instrument was the world's first portable crystal clock and reference signal generator. The crystal clock was accurate to 0.004 seconds per day, and the reference signal generator to 1×10^{-7} per day between 1 kHz and 100 kHz. Because of its extremely high accuracy, it was widely used around the world as a time standard. For Rohde & Schwarz, and in particular for Dr Schwarz, one of the two founders of the company, the instrument meant a great deal, as it was by far the most popular product during the starting years of the company.

The clock, which had since been displayed in the Access Sapporo, the new event hall, together with other products of the city of Munich, has now been returned. It will in future be exhibited again in the Measuring Instruments Museum of Rohde & Schwarz.

Akihiko Yoshimura
ADVANTEST

How random is chance?

Most people have thought about chance and predictability at some time or other. The famous tile that drops from the roof just as someone is passing below is a typical starting point for such reflections. Chance refers to events that can hardly or not at all be predicted like the drawing of numbers at a roulette table.

Investigation and utilization of chance or random events have always had their place in science and technology. Probability theory and mathematical statistics are concerned with measurements of random events. The following examples should illustrate the benefits of the specific use of random events.

What are random numbers good for?

The use of random numbers goes far beyond the world of gambling. In mathematics, for example, random events are employed for optimization techniques or for calculating complicated integrals. With the aid of the Monte Carlo method for instance – the name itself tells you that chance is an important factor – the area of complicated geometric forms can be determined with high accuracy. You place a rectangle around the area to be calculated and a great number of points are 'thrown' randomly into the rectangle. Then you count the points within the area to be calculated. The product of the share of the counted points and the area of the rectangle gives you an approximate value for the area of interest. With this method, the accuracy of the result depends on the number and the randomness of the points.

Randomly generated parameters are often used as input to simulate complex systems on a computer. The advantage is that the simulation is "impartial" and that system analysis is not falsified by "preferential" parameters. The same applies to tests involving randomly generated interferences or to random sampling when testing product quality.

IT security is another area of application for random numbers. In this rapidly growing business field, professional solutions are offered by SIT Gesellschaft für Systeme der Informationstechnik mbH, a subsidiary of Rohde & Schwarz. Through the use of bit sequences that cannot be predicted, techniques have been established that are now indispensable:

- Encryption methods use secret keys and other parameters produced by a random generator to make them unpredictable for non-authorized persons. For instance, SIT products offer solutions both in hardware and software that generate random bit sequences for encryption parameters (keys and initialization values).
- With the digital signature it is similar. If a potential attacker knows the rule for generating keys, he has a better chance of cracking the code and forging signatures.
- With socalled challenge response protocols used for authentication, a potential attacker can adapt to it and prepare for the correct response if some challenges occur very frequently.
- Random bit sequences used for stream ciphers or frequency hopping are normally not directly generated in a random way but derived indirectly from a randomly generated secret key. But these derived sequences must show statistical characteristics similar to those of randomly generated bit sequences. In particular, the sequence bits should not be predictable without knowledge of the secret key.

How are random numbers generated?

Random numbers used for the mentioned applications can be generated in a variety of ways apart from throwing dice or tossing a coin.

Many programming languages contain a function for generating random numbers. Numerals with statistical characteristics similar to those of random figures are generated from the system clock of the computer and from entered parameters. These values are mostly sufficient for simulation programs and Monte Carlo calculations, but unpredictability and other crypto requirements are only met to a limited extent. One reason for this is that a year has "only" about 31.5 million seconds and such a number is quickly checked through on a modern PC.

An interesting method is used by the e-mail encryption software PGP (pretty good privacy): the user is asked to strike any sequence of keys on the keyboard for generating a random parameter. After the character sequence has been processed in a complicated conversion process, the criterion of unpredictability should be met.

Other solutions have to be found however if a great number of random parameters is needed and/or the encryption keys should be generated independently of the persons involved. Effective and secure generation of random numbers is also very important when implementing the laws regarding electronic signatures.

Various physical phenomena may be used as a basis in generators producing random bit sequences. One example is the noise characteristics of Zener diodes. By processing these noise signals, bit sequences can be generated that are unpredictable and have "ideal" statistical characteristics.

The next issue will look at statistical criteria for assessing the quality of randomly generated bit sequences.

Dr Ralph Wernsdorf

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