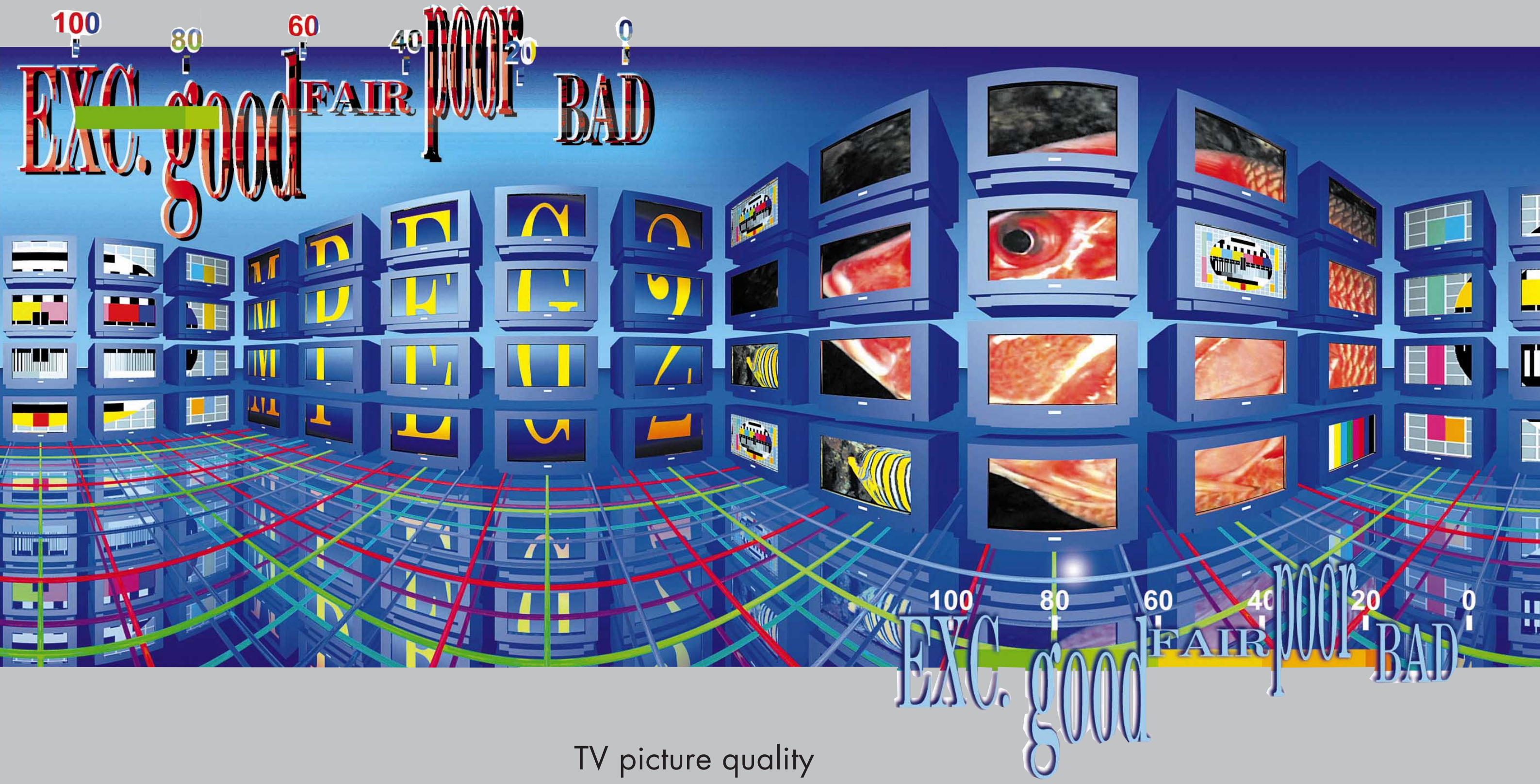
News from Rohde & Schwarz



TV picture quality
Objective measurement method

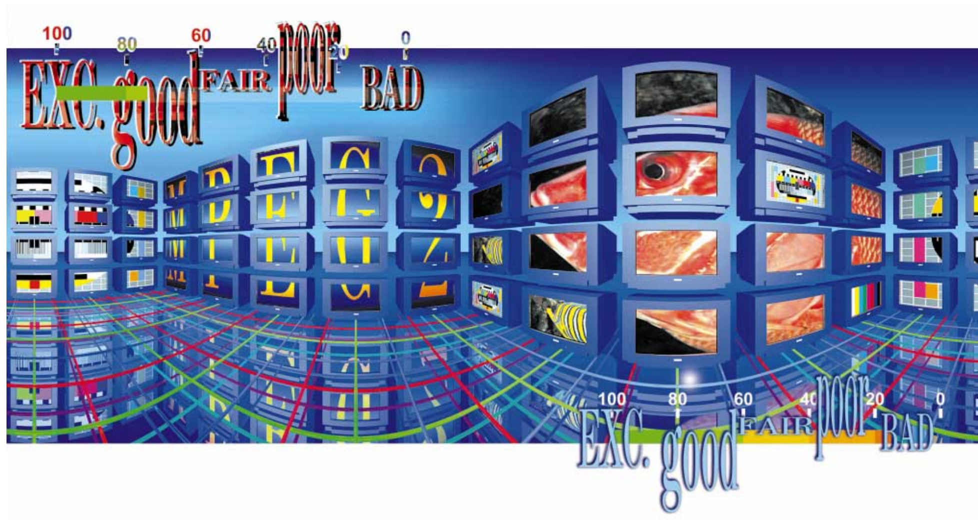
Digital terrestrial video broadcasting
Measurements to DVB-T standard

TETRA mobile radio
Signalling tests

1999/I
161

ROHDE & SCHWARZ

Number 161 1999/I Volume 39



Digital video broadcasting (DVB) requires test methods that evaluate the picture signal itself and also consider perception by the human eye. Rohde & Schwarz together with the technical university of Braunschweig developed a realtime method for objective quality assessment of DCT-coded picture sequences (see final article on page 41). Photo 43 284

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Regular features

The European TETRA standard for professional mobile radio provides excellent transmission quality and frequency economy. To ensure error-free communication, however, the terminal equipment must have unimpaired signalling capability. To test this, Rohde & Schwarz developed TETRA Protocol Test System TS1240 (see page 7).

Imprint

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TV Test Transmitter SFQ Model 20

TV via antenna: digitally fit

TV Test Transmitter SFQ is the solution for testing all digital TV receivers in development, production, quality assurance and service. Its speciality is that it can work as a test transmitter for established standards and adapt very fast to any newly introduced ones. The new SFQ model 20 is suitable for all measurement tasks of terrestrial TV in line with DVB-T standard.

FIG 1 Model 20 of TV Test Transmitter SFQ is specially designed for DVB-T. Photo 45 592/2

The change from analog to digital TV transmission is in full swing. New services like cable (DVB-C) and satellite (DVB-S) are already transmitting in digital. And terrestrial TV, the television of the first hour, is now also going digital. The standard [1] has been adopted, pilot field trials are in progress in many European countries and a nationwide broadcast network is already starting up in Great Britain. The reliability requirements of the new type of transmission and expectations are much higher than for cable and satellite. The purpose of terrestrial TV is providing basic coverage for the public at large. Compared to cable and satellite, the transmitting conditions are much more difficult, being influenced by weather, multipath propagation through landscape features as well as by other electronic radio services. Nevertheless, high-quality reception will be possible not only in buildings but also in the open without a special antenna and with mobile receivers. The present transmission network is being renewed, so transmit frequencies can be used more economically. The solution to all of this is complex coding, highly efficient error correction, OFDM (orthogonal frequency division multiplex) coding and emission via a single-frequency network.

TV Test Transmitter SFQ model 20 (FIG 1) is the right signal source for the whole range of measurement tasks. It provides all necessary signals in excellent quality. For special requirements the user can vary almost any parameter. Errors can be simulated and interference superimposed to mirror real transmission conditions.

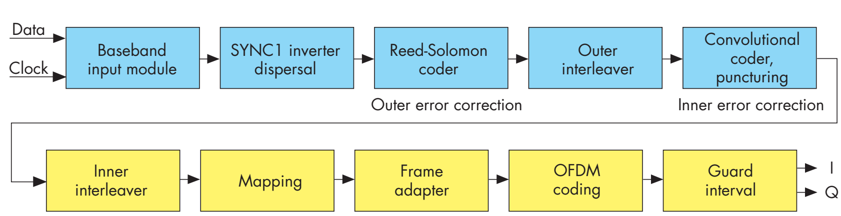

FIG 2 Block diagram of DVB-T coder (blue: modules identical for satellite system)

Function

SFQ generates a **DVB-T signal** fully compatible with ETS 300 744 in all its functions; the following **parameters can be set:**

- bandwidth 6 MHz, 7 MHz and 8 MHz with any intermediate values,
- QPSK, 16QAM or 64QAM modulation,
- code rate 1/2, 2/3, 3/4, 5/6, 7/8,
- guard interval 1/4, 1/8, 1/16, 1/32,
- COFDM with 2k or 8k mode,
- optional hierarchical coding.

The input signal to SFQ is the MPEG2-coded signal. After deriving the synchronizing information, the signal is taken to the scrambler where it is linked to a PRBS sequence for energy dispersal. The following stages are the same as for DVB-S: Reed-Solomon error correction, interleaver, convolutional encoder and puncturing (FIG 2). The rest of signal processing is DVB-T-specific. Due to the more unfavourable conditions of terrestrial propagation the signal is made to pass through further transmission correction stages: an inner bit interleaver (nearest to the antenna) and a symbol interleaver. Mapping is performed according to the selected QPSK, 16QAM or 64QAM coding. After insertion of the pilot and TPS (transmission parameter signalling) carriers in the frame adapter, digital data are changed to the time domain by an inverse fast Fourier transform, to a 1705 (2k) or 6817 (8k) carrier depending on the selected mode. Finally the guard interval is inserted. The further procedure is the same as for DVB-C/S: I/Q modulator, RF converter and lastly the attenuator for setting output level.

Simulation features

Functional tests with ideal signals are necessary but not very helpful for simulating a real situation. Errors and reception problems have to be simulated to define specifications and for functional testing under faulty conditions and at the operation limits. SFQ, designed as a stress generator, offers many features for such purposes. The I/Q modulation enables I and Q to be interchanged, which corresponds to a sideband switchover. The residual carrier can be set, the orthogonality between I and Q (I/Q phase) modified and the amplitude of I and Q (I/Q imbalance) varied.

The modulation can be switched off for all carriers but also for individual carrier groups. The carriers are still available but not modulated. This can be done separately for the data, pilot and TPS carriers. Not just the modulation, the carriers too can be switched off individually or in groups. The coder permits deactivation of operation-specific functions such as scrambler (energy dispersal), Reed-Solomon error correction, convolutional, bit and symbol interleavers. In this way errors can be generated and reproduced individually to investigate whether bit errors have been corrected by the error-control circuit or missing bits correctly replaced by the interleaver function. General transmission problems can be examined in addition to the separately selectable erroneous settings. An internal noise source allows poor receiving conditions to be simulated in a reproducible way. The precise setting of the noise power makes it possible to determine BER characteristics for DVB-T receivers for example.

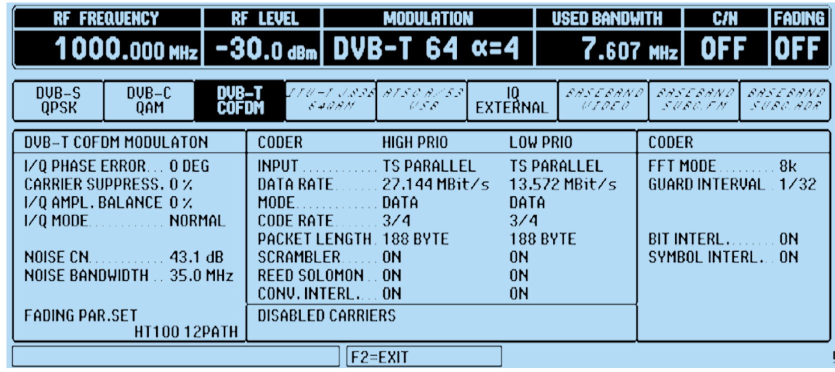

FIG 3 Menu of SFQ: DVB-T status display

The optional fading simulator is a big innovation. It serves for simulating reception by mobile receivers or in an unfavourable environment with a large number of reflections. The different paths of the fading simulator can also be used to simulate a single-frequency network.

Applications

The wide frequency range of SFQ from 0.3 MHz to 3.3 GHz enables tests to be performed beyond frequency limits and at any intermediate frequencies. The large level range from −6 dBm to −99 dBm permits testing of sensitive modules beside providing sufficient level for in-service measurements. At the input interface it is possible to select between SPI (synchronous parallel interface) with LVDS (low-voltage differential signalling) and ASI (asynchronous serial interface). The following internal substitution signals are available: Null TS Packet, PRBS sequence or PRBS packets [2]. Of course, the well-proven features of SFQ model 10 [3] and of DVB-T Modulator SDB-M [4] were retained: user-friendly operation, messages for anomalous settings or operating states, status menu (FIG 3), online help, IEC/IEEE bus and RS-232-C interface as well as firmware updates from a PC. The modular concept, which allows retrofitting for DVB-C/S, is a platform for future standards and coding.

With its flexible DVB-T test signals, TV Test Transmitter SFQ model 20 offers all the features needed in development, acceptance, quality assurance and servicing both for manufacturers of receivers of every kind and for operators of transmitters and receiving installations.

Josef Handl

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Condensed data of TV Test Transmitter SFQ Model 20 for DVB-T

Frequency range	0.3 MHz to 3.3 GHz
Level range	–6 dBm to –99 dBm
Bandwidths	6/7/8 MHz (settable intermediate values)
Inputs for MPEG2	LVDS, ASI (option)
FFT mode	2k and 8k
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
Carrier modification	switchable carrier and modulation
Error simulation	carrier suppression, I/Q imbalance, phase error
Special functions	switchable: scrambler, Reed-Solomon coder, inner interleaver, bit and symbol interleaver
Options	hierarchical coding, noise superimposition, fading simulation, DVB-C and DVB-S

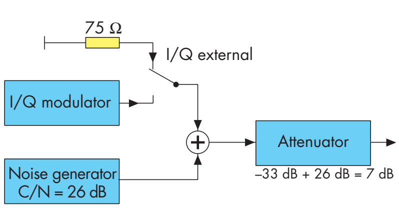
Reader service card 161/01

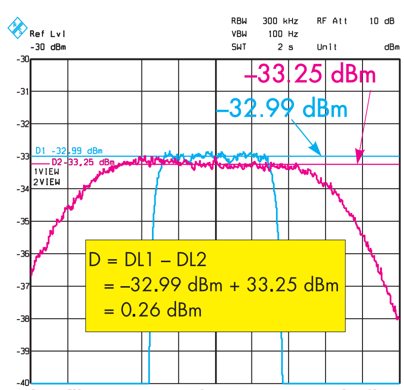
Test hint

Determination of bit error ratio in DVB

The following questions are salient when assessing the quality of a DVB (digital video broadcasting) system: How high is the available margin of a DVB transmission? Up to what C/N ratio can a set-top box still demodulate and decode DVB signals? The answers are obtained through deliberate deterioration of the C/N ratio by superimposing white noise on the DVB signal. Appropriate conversion produces the bit error ratio (BER) as a function of the C/N ratio for QPSK modulation and all QAM modes.

Due to the steepness of the BER versus C/N curve at BER values $<1 \times 10^{-4}$, the C/N ratio must be determined with high absolute accuracy (maximum permissible deviation 0.1 dB). This is ensured by a measurement method using **TV Test Transmitter SFQ** and **Spectrum Analyzer FSE.** SFQ modulates the internally generated PRB sequence in QPSK or QAM. FSE measures the level of the PRBS spectrum





– for example –33 dBm – and marks it with a line at a resolution of 1 dB per division.

After switchover to external I/Q modulation – no signal is applied to these inputs, which are to be terminated with 75 Ω – SFQ no longer outputs a PRBS signal. Then the SFQ noise generator is switched on, which generates a C/N of 26 dB (example) referred to the switched-off PRBS level. To verify whether the noise is exactly 26 dB below the useful signal, the setting of the SFQ attenuator is changed by 26 dB. The two display lines for the useful signal and noise should coincide given a signal level of 33 dB and correction of 26 dB. If not, the difference between the useful signal and the noise signal can be read on Spectrum Analyzer FSE with the aid of a second display line (FIG, center).

The absolute accuracy of this measurement depends solely on the accuracy of the SFQ attenuator. Any overload effects caused by the noise crest factor or the like are excluded through the use of the extremely precise Analyzer FSE. The linearity of the SFQ attenuator is measured to an accuracy of 0.01 dB in acceptance testing and its value is available together with the calibration record. Taking into account the attenuator values, the C/N value can be objectively determined to an accuracy of <0.1 dB, so it is quite adequate for BER measurements in the range 1×10^{-6} to 1×10^{-8}. Because of the simplicity of the measurement, the C/N ratio should be checked prior to every precise BER measurement.

Sigmar Grunwald

Reader service card 161/02 (SFQ) and 161/03 (FSE)

TETRA Protocol Test System TS1240

Type-approval tests of TETRA mobile radios

During the past year, TETRA has been firmly establishing itself to take over from the analog MPT1327 standard in wireless communication. About 25 projects are presently running in Europe and overseas. Any application based on analog systems is a potential market for TETRA. To ensure reliable communication – particularly for police, fire brigades and emergency services – not only RF parameters but also signalling procedures have to be tested in type approval of the transceivers, and this is where TETRA Protocol Test System TS1240 comes in.

The breakthrough has finally been made – that would be the right description for the present status of TETRA (terrestrial trunked radio). Field trials like those in Denmark or the Schengen three-nation field trial have yielded positive results, while others (eg Berlin/Brandenburg police) are still in progress. High speech quality and data transmission at maximized frequency economy are clear advantages over other standards. Technically superior functions such as PDO (packet data optimized – for pure data transmission) or DMO (direct mode operation – direct connection between mobiles without a base station) are waiting to be introduced. On top of this, competition between manufacturers of terminal equipment has meanwhile brought about acceptable prices for mobile and base stations.

To qualify for operation, terminal equipment has to pass the type-approval test to TBR35 (technical basis for regulation), which consists of two parts. In the first part RF parameters are tested with the aid of the Rohde & Schwarz TETRA Simulator TS8940 [1], and in the second part signalling procedures (of the protocol) are checked with TETRA Protocol Test System TS1240 (FIG 1).

FIG 1 TETRA Protocol Test System TS1240 tests signalling procedures of TETRA mobiles in development and production. Photo 43 144/2

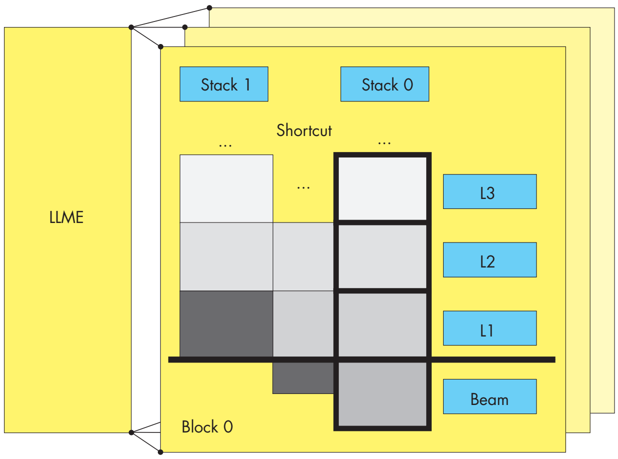


FIG 2
TETRA protocol concept: block, stack, layer (L1, L2, L3) and beam

TETRA status and specifications

Details of **TETRA status** [2]:

Phase 1 (completed in the first half of 1997) defines network and air interface requirements as well as security requirements for PDO and V&D (voice plus data), plus standards and requirements for conformance tests at the air interface and stage one of the supplementary services.

Phase 2 (completed in the second half of 1997) describes the air interface of the DMO and the SDL (specification description language) model, validation and test suites for edition 1 of TBR35, voice codec requirements and testing as well as three security algorithms.

Phase 3 (shortly to be completed) defines the SDL model, validation and test suites for DMO and the SDL model as well as the validation for PDO and the second and third stages of the supplementary services, for the TETRA SIM card, the intersystem interface (ISI) for individual call and mobility management, edition 2 of TBR35, and the PSTN gateway.

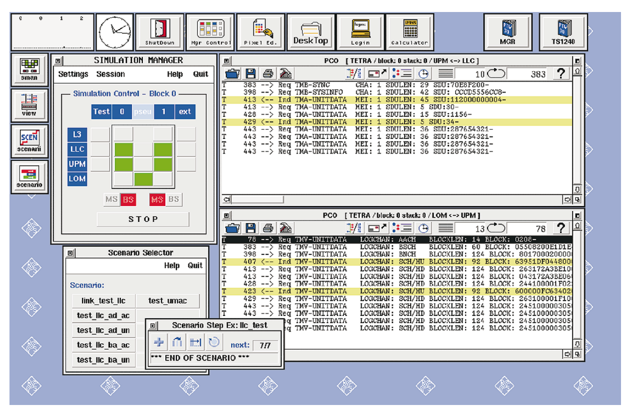
Phase 4 (in progress) defines the completion of the ISI group call and short data service, ISDN gateway, updates of V&D test suites and a test of the V&D and PDO air interfaces.

TETRA operates in the frequency band 380 to 440 MHz; an extension to 900 MHz is planned. Other **features of TETRA** are:

- high spectral efficiency,
- 25 kHz channel spacing with four timeslots per physical channel (TDMA),
- π/4 DQPSK modulation (symbol rate 18 ksym/s),
- voice and data transmission possible,
- simplex, semi-duplex and duplex operation supported,
- encryption (air interface, end-to-end).

Description of protocol tester

TETRA Protocol Test System TS1240 consists of the universal Protocol Test Unit PTW30 and Digital Radiocommunication Tester CMD91. The central unit PTW30 is based on a controller with hardware enhancements, ie a DSP card and an I/Q interface card. Radio-



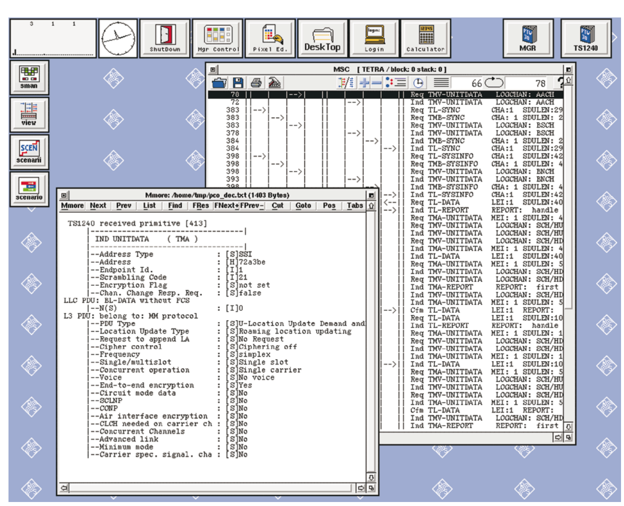


FIG 3
Test System TS1240 offers tools like PCO (top) and MSC for analysis of test results.

communication Tester CMD91 serves as an RF output stage in the transmit and receive directions. Data exchange between PTW30 and CMD91 is in the form of digital I/Q data, while device settings are serially transmitted.

All functions required for the protocol test of TETRA terminal equipment are implemented in the test system software:

Because of the time-critical requirements of the TETRA protocol stack, a **realtime operating system** – LynxOS – is used. This Unix derivative is compatible with Posix and SystemV.

The **TETRA protocol engine** contains all processes, data and interfaces required to control the TETRA protocol stack (FIG 2). One possible operating mode of TS1240 is simulation of a base station for testing a TETRA mobile phone after registration via the air interface. Another operating mode allows the setting up of a direct connection from a higher layer (eg via Ethernet) to an external controller, where a single layer has been started as a DUT (virtual type approval).

A modern **graphical user interface** (GUI) is implemented offering the usual windows. The simulation manager enables selection and setting of the desired simulation mode. PCO (point of control and observation between logical layers) and MSC (message sequence chart representing data transmitted between TS1240 and DUT in decoded form across all layers) are among the means available for result analysis. FIG 3 illustrates the interaction between the modules.

The test cases defined by ETSI (European Telecommunications Standards Institute) are in a language particularly suitable for protocol tests: TTCN (tree and tabular combined notation, in the case of TETRA with ASN.1 notation). This language allows fast and convenient conversion of test cases into executables. This coding is implemented in Test System TS1240 in two steps (FIG 4). First the supplied TTCN compiler translates the code into C language. Secondly, C is translated into executables using system libraries. With the aid of a test case selector, one or more test cases can be conveniently selected and started via the graphical interface, the verdicts being clearly displayed in tabular form. Trace files generated during program run permit detailed analysis down to command level.

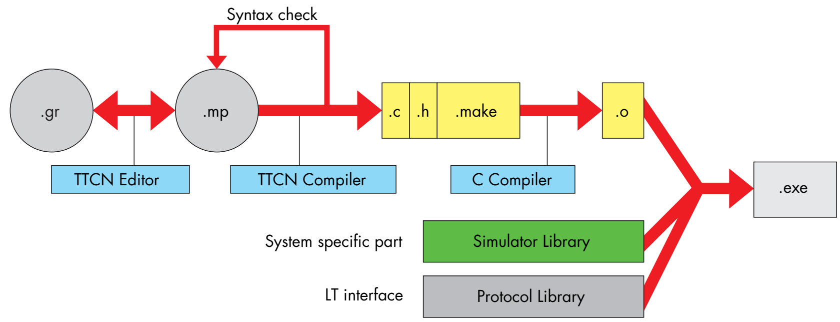


FIG 4 Two-stage implementation of ETSI test cases in TETRA Test System TS1240

Tests not covered by ETSI test cases can be implemented by creating their **own scenario.** For this TS1240 hardware and software are available via function calls (open programming platform). A scenario executor permits the programs to be executed in realtime or line by line.

TETRA Protocol Test System TS1240 is ideal for the development and testing of TETRA signalling procedures and able to translate TTCN test cases published by ETSI into executables. TS1240 features all attributes of a modern protocol tester, following in the steps of a long tradition of Rohde & Schwarz protocol testers for mobile radio standards.

Detlef Willam

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Features of TETRA Protocol Test System TS1240

Implementation to standard of TETRA protocol stack (layer 1 and 2)

TTCN test cases executable to TBR35

All protocol layers implemented per software

TETRA air interface implemented

Open platform concept for programming of scenarios

Graphical user interface

Reader service card 161/04

Digital Radiocommunication Tester CMD80

CDMA, AMPS and IS136 measurements with one unit

The successful Digital Radiocommunication Tester CMD80 has evolved into a multimode mobile radio tester: It now masters D-AMPS according to IS136 along with CDMA and AMPS, making it an indispensable tool in the development, production and service of mobile radio equipment worldwide.

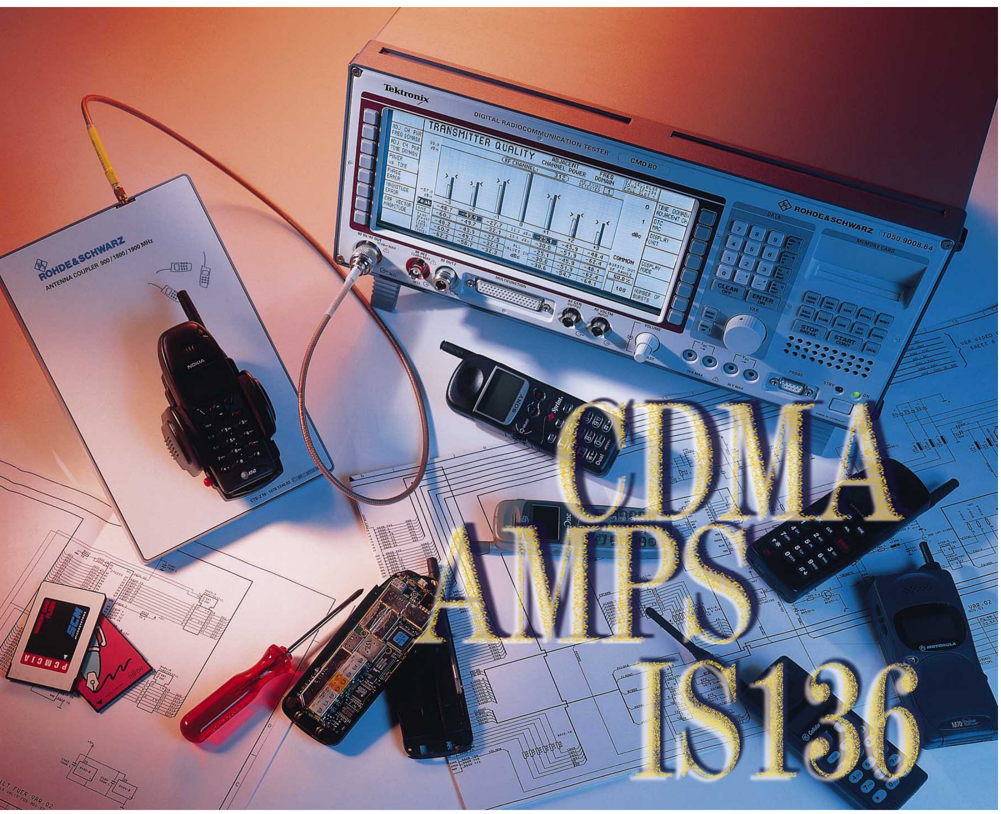

FIG 1 Digital Radiocommunication Tester CMD80, the compact tester for multimode/dual-band mobiles Photo 43 263

In the US, digital networks operating with TDMA (time division multiple access) – D-AMPS – are gaining in importance alongside mobile radio networks based on the analog AMPS (advanced mobile phone system) and the digital CDMA (code division multiple access) standard. In most cases, dual-mode mobile telephones with CDMA/AMPS function (IS95 standard) or D-AMPS/AMPS function (IS136 standard) are offered, often as dual-band phones for the 800 MHz (US cellular) and 1900 MHz (PCS) frequency bands. The consequence of this is that a mobile radio tester is needed that combines all three standards in both frequency bands in a single unit.

Rohde & Schwarz offers such a solution in CMD80 (FIG 1) for full implementation of D-AMPS test technology both with and without signalling. The capability of performing mobile radio measurements according to the three standards with just one instrument is of decisive importance not only in development and service but also, and in particular, in production, where flexible use of mobile radio testers is required. Due to the rapid growth of mobile radio in South America and the Far East, there is huge potential for a multimode/multiband compact tester such as CMD80 in these regions too.

The hardware platform of CMD80 offers a continuous frequency range from 800 to 2200 MHz and the measurements are carried out by means of a digital signal processor. This flexible concept makes it possible to upgrade a CDMA/AMPS dual-mode/dual-band CMD80 [1 to 3] to a multimode/dual-band tester with a minimum of hardware and software, which can be installed straightforward and fast by a service technician.

The various D-AMPS measurements can be performed either as a module test (ie without call setup with the mobile telephone) or with signalling (manual test). Both the US cellular band (800 MHz) and the PCS band (1900 MHz) are covered. The user interface and the IEC/IEEE-bus control comply with the well-proven concept of CDMA and AMPS measurements in CDM80, enabling operation without special knowledge of the different networks.

Measurement standard IS136 defines an external interface to control mobile telephones for testing. This common interface enables checking the different DUT modules without call setup, so the manufacturing process can run at a much faster rate. A bit error rate measurement can even be carried out, ie the receive path of the mobile can also be tested without signalling. The following measurements are possible in the D-AMPS module test with CMD80:

In **transmitter testing** a detailed modulation analysis of the signal received from the mobile station is performed at the power level and frequency defined by the user. The test signal is recorded, synchronized and demodulated. An ideal reference signal, which is compared with the DUT signal, can be generated from these data. The **error vector magnitude** (magnitude of the vectorial error function versus time), the **magnitude error** (amplitude error) and the **phase error** arising during modulation can be derived and represented graphically as a time function versus the emitted burst. These parameters plus **frequency error, origin offset** (carrier crosstalk) and **I/Q imbalance** (measure of unequal gain in the I or Q path of the transmitter modulator) are statistically evaluated and displayed. The **amplitude droop** is also determined to indicate the level difference between the start and the end of a TDMA burst.

What is particularly important for TDMA systems is measurement of **power versus time,** compared to a user-configurable template. Finally, an **adjacent-channel power** measurement (ACP) can be performed. This examines spectral effects due to switching the burst on and off and effects due to modulation, which may disturb transmission in adjacent channels. All six adjacent/alternate channels are evaluated at the same time and represented in a bar diagram (FIG 2). As an alternative, the power curve within an adjacent channel can be examined in the time domain.

For **receiver testing** the mobile station is set to a loopback mode via an external controller by means of a command defined in the D-AMPS standard. CMD80 then sends a test signal at a level that can be set in a wide range, and which contains a suitable, known bit sequence. The mobile telephone can synchronize to this sequence and return it to CMD80 after demodulation. This reflected signal (errorfree transmission on the uplink from the mobile to the base station can be assumed) is demodulated to bit level in CMD80, compared with the known bits of the original signal and the **bit error rate** then calculated. The sensitivity of the mobile station can be determined in this way (FIG 3).

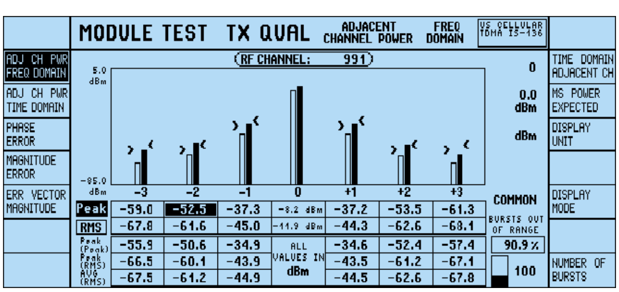

FIG 2
ACP measurement with Digital Radiocommunication Tester CMD80 in D-AMPS module test

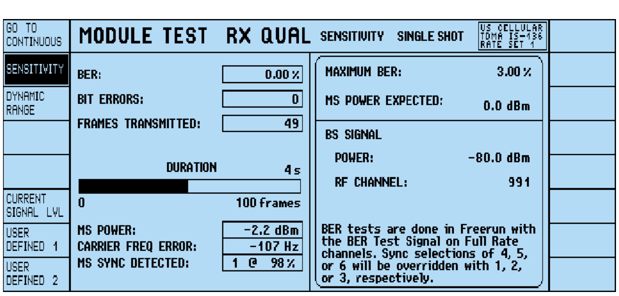

FIG 3
Bit error rate measurement on receive section of mobile with CMD80

The **manual test mode** with call setup to the mobile telephone is used to perform menu-guided operational checks as required in particular in final production testing and in service. In this test mode the mobile first registers in the base station, which is simulated by CMD80. After that a call with **voice loopback** can be set up by CMD80 or the telephone to be tested. The audio data recorded by the mobile's microphone are buffered in CMD80 and reflected to the tested mobile station after a 2 s delay. In this way the speech quality of the DUT can be checked.

A call is set up by CMD80 or the mobile to perform the measurements. In addition to the parameters that can already be examined in the module test, a **time-alignment measurement** is offered in this mode. CMD80 signals to the mobile telephone the time delay, if any, of the mobile's burst signal with respect to the reference clock in the network and measures this time offset. This function is important with TDMA systems for propagation delay compensation in distant base stations. CMD80 can also check **SMS** (short message service) **transfer** to D-AMPS mobile telephones (base station to mobile station). This verifies the capability of a mobile to receive and display user-definable text messages up to a length of 256 bytes.

Another feature of CMD80 is simulation of **mobile assisted handoff** as defined by IS136. When instructed by CMD80, the mobile telephone examines signal quality in different RF channels and reports the results to the base station to support the handoff procedure. **Implicit handoffs** within the standard, ie handoff to another digital traffic channel (a new channel number) or changeover to another timeslot on the same TDMA frequency, can be performed as well as handoffs from and to AMPS. This is decisive for testing multimode mobile telephones.

Based on its new TDMA measurement capability, CMD80 with its high-speed IEC/IEEE-bus operation, clear and uniform operating concept for AMPS, CDMA and D-AMPS and compact design offers a future-oriented approach and thus optimum prerequisites for use in development, service and production.

Thomas Rösner

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Key features of Digital Radiocommunication Tester CMD80

Multimode/dual-band mobile radio tester for production, development, service

High measurement speed, high flexibility, simple operation

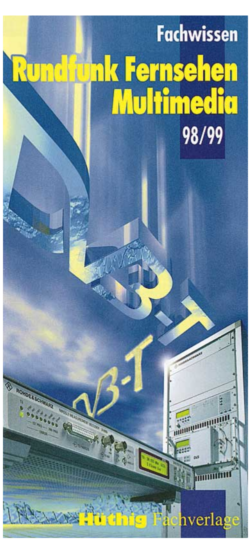
Networks and frequency bands

US cellular (800 MHz)	CDMA(IS95), AMPS/N-AMPS (IS95) D-AMPS/NADC (IS136, IS54)
US PCS (1900 MHz)	CDMA (UB-IS95, J-STD008) D-AMPS/NADC (IS136, IS54)
Japan cellular	CDMA (T53, IS95), N-TACS/J-TACS
China cellular	CDMA (IS95), E-TACS/TACS
Korea PCS (1800 MHz)	CDMA (J-STD008, UB-IS95)

Reader service card 161/05

Reference

Picturesque promotion



For once DVB-T transmitters and modulators and DVB-T test equipment from Rohde & Schwarz have been chosen for a totally different job from their normal one. Utilizing the full stock of photographic skills, they were put on the front page of this brochure to publicize reference books on the topic "Radio, Television, Multimedia" from the German publisher Hüthig Fachverlage of Heidelberg.

At Hüthig specialized qualifications are considered the all-important basis of successful careers as well as of innovation in business, engineering, research and science. Hüthig was set up as a family enterprise in 1925. Today some 70 journals, over 2500 book titles, 120 loose-leaf collections and a growing number of electronic products and services demonstrate the publisher's extraordinary commitment to the transfer of know-how.

The DVB-T components from Rohde & Schwarz, which are already being used in several projects, show the same innovative and future-oriented spirit. A major pilot project was started in the Munich area to test digital video broadcasting via terrestrial networks (DVB-T). The network used for the purpose is a single-frequency network with one transmitter atop Munich's Olympic tower and two others in the suburbs of Freimann and Ismaning. The project is intended to verify the DVB-T system in operation and makes use of Rohde & Schwarz DVB-T transmitters and modulators as well as T&M equipment.

DVB-T components from Rohde & Schwarz play a key role in Europe's first digital terrestrial TV network (in Britain). Rohde & Schwarz was contracted to supply DVB-T TV transmitters of the NV500 family with rms power of up to 4 kW, CODFM Modulators SDB-M, which are fully compatible with ETS300744, and MPEG2 Measurement Decoders DVMD for realtime analysis.

Sö

Digital Radiocommunication Test Set CRTx-DUO

Test platform for HSCSD and multicarrier applications

Mobile radio manufacturers frequently have to perform critical four-channel handover or cell selection/reselection tests during the development of a new model. They also require measurement equipment for testing new data services such as high-speed circuit-switched data (HSCSD) and general packet radio services (GPRS), which make use of more than one active timeslot at a time. CRTx-DUO, a combination of two Radio Test Sets CRTS, CRTP or CRTC, which can be operated as stand-alones again at any time, is a fully fledged four-channel tester ideal for these testing scenarios.

Test specification GSM Rec. 11.10 prescribes all test cases to be performed for the type approval of mobile radios. The vast majority of them are signalling tests and can be performed with two RF channels. The stand-alone testers offered for these applications by Rohde & Schwarz come from the CRTx family of Digital Radiocommunication Test Sets: CRTS (GSM900), CRTP (GSM900 and GSM1800) and CRTC (GSM900, GSM1800 and GSM1900) [1]. They are available with numerous software options covering all specified tests.

The type approval tests supported by the stand-alone units have without exception been accredited by test houses, thus making their use for type approval testing official. One reason why test houses are glad to resort to these Rohde & Schwarz solutions is that in this way they can keep their highly complex TS89xx systems [2] – exclusively supplied by Rohde & Schwarz worldwide – free for elaborate RF tests.

However, more than one channel is required for **cell selection/reselection** and **handover tests** when examining the behaviour of mobile phones under typical conditions. For intercell handover tests, for instance, two network cells each with a C0 carrier (BCCH) and at least one traffic channel (TCH or data) have to be emulated, thus making four channels. New **services like HSCSD and GPRS** require several timeslots simultaneously for correct data transmission. A CRTx can emulate one timeslot per channel. This allows two separate physical channels with one timeslot each or a combined channel of two timeslots to be configured with a CRTx and its two RF channels. CRTx-DUO, a combination of two units, offers four channels and is therefore ideal for this application (FIG 1). For multislot applications, up to three channels can be grouped to form a channel of three timeslots. One possible configuration is a C0 carrier (BCCH) and a traffic channel (uplink and downlink) of three timeslots. This combination also supports frequency hopping of course.

For **multislot layer 1 module tests** it is even possible to emulate a channel of four timeslots, because in this case no C0 carrier is required. A typical example is the bit error rate test that is performed in the initial development stage of data services. This verifies whether the data received in a particular timeslot by the mobile phone are looped back in the correct timeslot.

FIG 1
Multislot channel measurement of GSM mobile with DUO consisting of two Digital Radiocommunication Test Sets CRTC
Photo 43 250

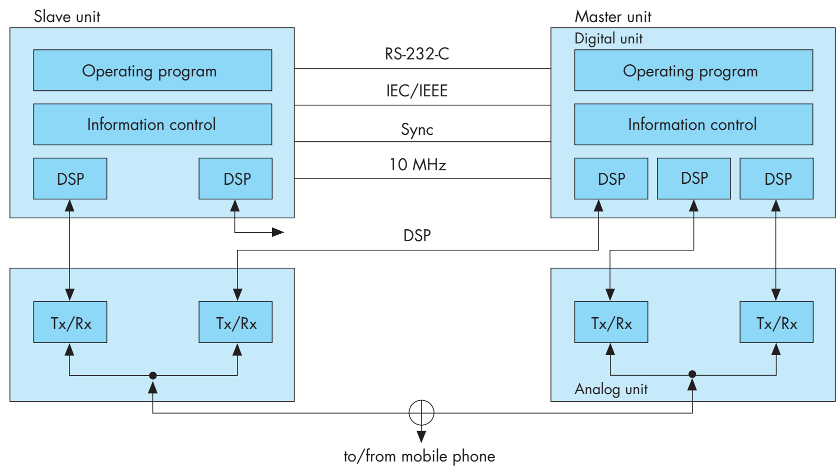


FIG 2 Block diagram of Digital Radiocommunication Test Set DUO with two CRTx

CRTx-DUO may consist of any **combination of CRTx units** (FIG 2). The operating software of the DUO automatically recognizes the models used and addresses them accordingly. The largest number of possibilities is offered by a combination of two CRTC models. This dual setup even supports full multiband handover functions, for instance handover from a GSM900 to a GSM1900 traffic channel. What makes CRTx-DUO particularly attractive for the user is that it can easily be split up into two stand-alones whenever required. Like Type-Approval Test Systems TS89xx, CRTx-DUO is based on CRTx units, so it can be upgraded later to form a complete system. This may become necessary if requirements for RF accuracy are more stringent than those for the signalling tests normally carried out with CRTx-DUO. The DUO is thus an ideal upgrade or downgrade for the Rohde & Schwarz selection of GSM testers.

Operating the DUO is almost the same as operating a single CRTx. Test scenarios written by the user can be programmed on the same, slightly expanded **application platform** that was recently added to the stand-alone tester. This platform is standard for all new applications and test cases for CRTx and TS89xx systems. This means that customers familiar with the individual units will not require extra training. Applications and test cases written for the DUO platform will also run on a TS89xx system without modifications.

Every **test application** or test case consists of a **master program** running on the master digital unit and a **slave program** on the slave digital unit. Both programs can exchange data via a communication link. This also gives the master program full remote control capability for the slave CRTx. The master therefore provides the user interface for the whole system. Normally the slave program only needs to perform the call establishment procedure with assignment to the master traffic channel. This allows it to be used for various tests without modifications, provided it is sufficiently configurable with parameters. A slave program of this kind is included in the master application of the DUO operating software CR02DUO. This means that no programming is required apart from modifying the master program for a new test. The actual programming is therefore very much the same as for a test with a single unit. Besides the functions mentioned above, the master-slave communication link is also capable of transmitting files in both directions. An intercell handover application and a simple program for configuring a C0 carrier channel and a channel of three timeslots are also supplied. They can serve as a basis for the user's own programs. The package also includes a selftest that, together with a mobile phone, verifies the functioning of all essential signalling routines of the DUO. The software for the DUO platform is continuously being added to and updates are quite straightforward.

Peter Ludwig; Frank Körber

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[2] Mellein, H.: Type approval of GSM900/GSM1800 multiband mobiles using System Simulator TS8915. News from Rohde & Schwarz (1998) No. 157, pp 28–29

Condensed data of Digital Radiocommunication Test Set CRTx-DUO

(functions not included in stand-alone CRTx)

RF channels	four fully synchronized channels to GSM Rec. 5.xx, three of which can be grouped to form a channel of three timeslots; the fourth channel emulates the C0 carrier (BCCH)
Test cases	HSCSD, intercell handover, intracell handover, cell selection/reselection
Application	four-channel layer 1 module test

Reader service card 161/06

PC, teletype and radio team up

Even though the combination of radio and teletype (RATT) is generally no longer regarded as a modern means of information exchange, it is often the only available basis for data transmission due to its widespread use. Whether onboard a ship or in an embassy, teletype is still frequently used for sending text messages by radio. Texts are normally written in the internationally defined format ACP-127 (allied communication protocol). For transmission, the individual teletype characters are converted to 5-bit Baudot code. FSK (frequency-shift keying) is used to modulate the radio link. With data transmission rates between 50 and 600 baud, FSK may be comparatively slow but it is very resistant to interference.

The ACP-127 format, which also serves for automatic archiving, addressing, prioritizing and classification, requires the observance of strict formal guidelines and involves a great deal of effort, especially in the preparation of texts and handling of received messages. If large numbers of messages are to be received or transmitted, management tools that support the user are indispensable. A tool of this type is now offered by Rohde & Schwarz in the form of the software product **ACP Message Handling System DS150** (ACP-MHS DS150). It runs under Windows NT and allows data exchange on a radio path between a PC at one end and a teletype unit at the other (FIG 1). With the aid of this program, texts can be generated on a PC, and the teletypewriter at the distant station prints them out on paper or as punched tape. Conversely, conventional teletype messages are intelligible to ACP-MHS stations, which store them as files. The user is thus able to replace the teletypewriter by a PC and the program DS150 without losing teletype as a medium. DS150 also supports the administration and logging of all received and transmitted messages in log books (FIG 2). The program's convenient user interface, the intuitive operating concept and a special mask-oriented editor simplify errorfree generation of teletype messages in line with strict ACP-127 guidelines. Depending on the individual requirements, HF, VHF or UHF radio equipment may be used for transmitting the generated messages.

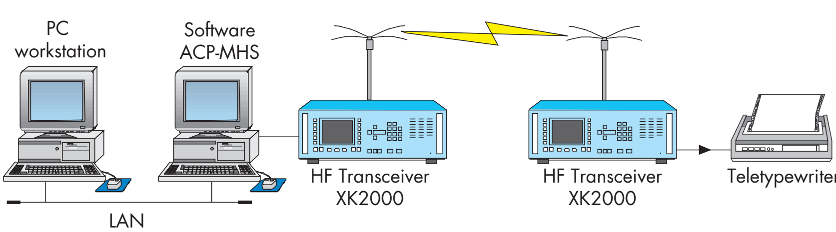

FIG 1 Radio data transmission with teletypewriter and ACP Message Handling System DS150

Besides RATT operation, the software also allows automatic reception of broadcast messages. Messages received in this way are automatically analyzed and placed in receive queues according to priority. The messages can be sorted within the queues according to various criteria such as date time group (DTG) or station serial number (SSN). In contrast to the point-to-point links of RATT operation, no confirmation is issued for broadcast messages.

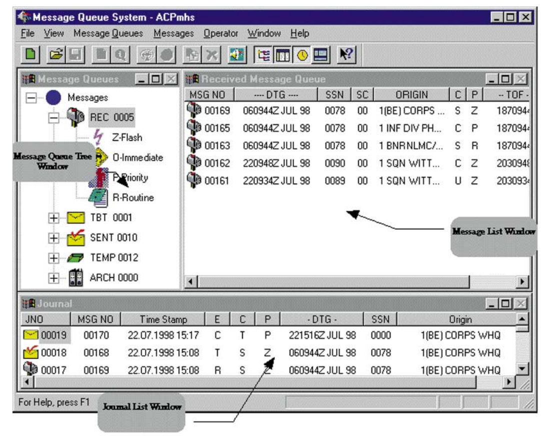

FIG 2 User interface of log book with various sorting criteria

ACP-MHS Software DS150 does away with the restricted interoperability between teletype and other computer-based data services. Combined with the E-mail product PostMan DS100 [1; 2], the software may also be used to attach ACP messages to E-mails for transmission on all types of networks. The other way round, DS150 can forward received E-mail messages to teletype subscribers.

Thomas A. Kneidel; Peter Maurer

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[2] Kneidel, T.: PostMan on tour. News from Rohde & Schwarz (1998) No. 159, p 34

Reader service card 161/07

Fit for the next millennium – W-CDMA signals with Signal Generator SMIQ and Software WinIQSIM

There are two ways of upgrading Signal Generator SMIQ [1] to a source for W-CDMA (wideband code division multiple access) signals. One way involves using Modulation Generator AMIQ [2] to provide the necessary W-CDMA baseband signals for SMIQ. In this case the unit is operated via a convenient menu in Software WinIQSIM [3]. The other way is through W-CDMA option SMIQB43, which is now available and makes SMIQ a stand-alone W-CDMA source. The well-proven options Data Generator SMIQB10 and Modulation Coder SMIQB11 are used to generate the baseband signals.

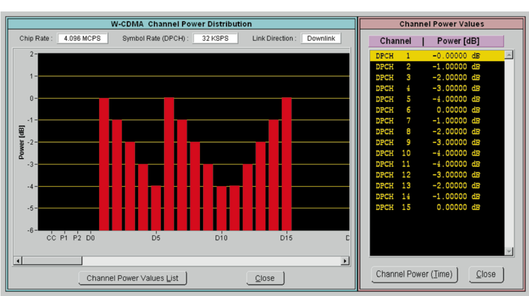

FIG 1 Downlink signal with 15 code channels; code domain power measurement with W-CDMA analyzer

The development of W-CDMA systems is already very advanced, especially in Japan. So both sources support signal generation in line with Japanese specifications, in particular the standard of the Association of Radio Industries and Businesses (ARIB) for a third-generation mobile radio system.

SMIQ has a good track record as an IS95 CDMA signal generator. Equipped with **W-CDMA option SMIQB43** the generator can now deliver **wideband CDMA signals at a keystroke.** Installation of the software is very simple. A new operating menu for W-CDMA is obtained after upgrading SMIQ with new firmware and entering the supplied installation key. It is thus possible to cost-effectively upgrade all SMIQs equipped with the data generator and modulation coder options to a W-CDMA source. Both uplink and downlink signals can be generated, so manufacturers of mobile stations and base stations benefit equally from the new option. Up to 15 code channels can be switched on at the same time (FIG 1). This also applies to an uplink signal, since W-CDMA standards stipulate several active code channels for the mobile station (multicode transmission). An additional uplink mode of SMIQ permits multiplex operation for the I and Q components of the baseband signal as defined by the ARIB standard (FIG 2). SMIQ not only performs the spectral spreading of modulation data with orthogonal codes and long code in line with standards, it also provides the frame structure for the various physical channels such as perch, common control or dedicated physical channel. The data fields of channels can be filled with pseudo-random data sequences to test modules such as amplifiers. Advantageous for the receiver test is that the user can resort to freely programmable data lists to store channel-coded data sequences. All standard symbol rates between 16 ksym/s and 1024 ksym/s are available at a chip rate of 4.096 Mchip/s. There are additional setting possibilities, for example for a time offset of modulation data, for selecting the spreading codes or for assigning a power control symbol. The user thus has a comprehensive set of tools for defining an individual test scenario. All associated SMIQ settings can of course be saved for later use.

The high setting flexibility of W-CDMA option SMIQB43 is particularly important at a stage where the standardization and definition of test specifications are not yet finalized. The large number of possible settings along with excellent signal quality make SMIQ an ideal source for testing W-CDMA modules of every kind. For spectral regrowth measurements on power amplifiers, SMIQ is outstanding with an ACPR of –64 dBc. The quality of the output spectrum can be further improved through the use of ACP option SMIQB46 (adjacent channel power) [4]. With its clean spectrum and vector error of only 1.5 %, SMIQ is a reference source of the highest quality.

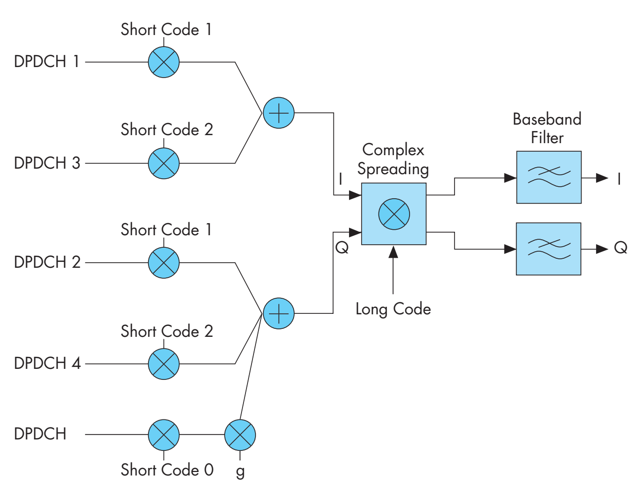

FIG 2 Uplink signal generation to ARIB standard

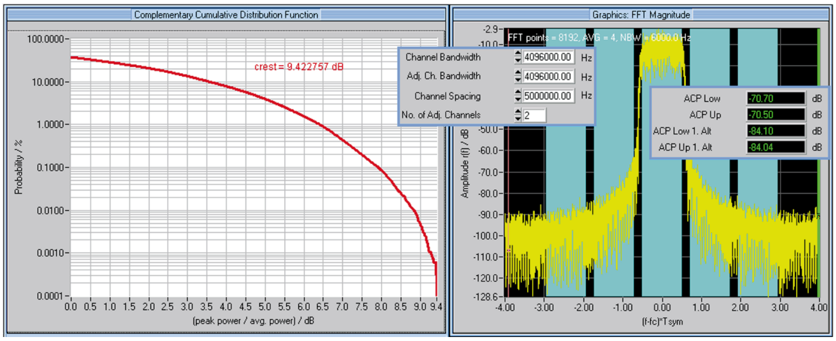

FIG 3 User interface WinIQSIM; left: CCDF of W-CDMA downlink signal with 15 code channels and data offset; right: signal spectrum with ACP measurement

In addition to generation of single-carrier and multicarrier signals and the versatile superimposition of impairments, the user-friendly I/Q Simulation Software WinQSIM offers the possibility of conveniently generating W-CDMA signals. The **combination I/Q modulation source AMIQ plus WinIQSIM and SMIQ** is virtually unsurpassed in terms of flexibility and diversity of functions. With its memory depth of 4 000 000 samples per channel and a sampling rate of up to 100 MHz, AMIQ again fully demonstrates its capabilities.

Chip rates for future extensions of the W-CDMA system are ready implemented (8.192 and 16.384 Mchip/s) in addition to 4.096 Mchip/s. The standard symbol rates of between 16 ksym/s and 1024 ksym/s can be selected depending on chip rate. Of course, WinIQSIM generates the signal components for the various physical channels (1st and 2nd perch, common control and dedicated) in the standard frame structure that is clearly displayed on the user interface. Depending on chip rate up to 512 code channels are available at the same time. The power of the individual code channels, the short code and other parameters such as data, long code offset and power control symbols can be set for each channel. In this way a mixture of signals from several base stations can be configured. This functionality is provided both on the downlink and the uplink and fulfills every requirement in the generation of highly complex signal scenarios.

In addition to a variety of signal-specific functions, WinIQSIM offers some options that are very helpful for generating W-CDMA signals, especially for computation and display of the complementary cumulative distribution function (CCDF). The CCDF indicates the relative probability that the complex samples of the W-CDMA signal will exceed a certain level. Besides the crest factor, this function provides information on the distribution of samples in the I/Q domain, which is an indispensable tool in the development of amplifiers for example (FIG 3 left). The usual graphic modes such as the constellation diagram or signal spectrum for W-CDMA signal analysis are still available. Another new feature is measurement of adjacent-channel power (FIG 3 right). This function permits optimization of baseband filters with respect to adjacent-channel power already at the development stage or for the extension of communication standards. This kind of optimization is indispensable in the face of increasingly densely occupied frequency bands and the scarcity of frequencies. The comprehensive signal generation capabilities of WinIQSIM are rounded off by the context-sensitive online help, which displays detailed information at a mouse click for each window of the user interface. This is especially useful with complex communication standards like W-CDMA.

WinIQSIM not only generates W-CDMA signals but also signals to standard IS95 (A) in conjunction with the digital standard option AMIQK11. Up to eight complete base stations each with 64 code channels can be simulated on the forward link and 16 mobile stations on the reverse link. The power of channels can be set separately as required. Thanks to its flexibility, the combination WinIQSIM, AMIQ and SMIQ is ready for the future, especially for multicarrier signals and standard proposals such as CDMA2000.

Klaus-Dieter Tiepermann;
Andreas Pauly

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[2] Kernchen, W.; Tiepermann, K.-D.: I/Q Modulation Generator AMIQ – Convenient generation of complex I/Q signals. News from Rohde & Schwarz (1998) No. 159, pp 10–12

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Reader service card 161/08

Secure communication with ComSaveBox

FIG 1
ComSaveBox encrypts any modem link online.
Photo 42 801

Serial links are widely used to transmit information. The data are usually transmitted via modems and public telephone networks. But anyone can access these routes, so there are threats to confidentiality and integrity of data. Data can be intercepted, manipulated or retained, for example, without the sender or recipient noticing. Consequently sensitive data have to be suitably protected against such threats. The most efficient method is the use of cryptography, ie transformation of data so that no conclusions can be drawn about their contents. Furthermore, there are special mechanisms to protect transmitted information against unnoticed manipulation.

ComSaveBox security system

The small ComSaveBox (FIG 1) ensures confidentiality of data during their transfer via the serial interface of a data terminal, a PC for example. All data are automatically encrypted before they are sent out and decrypted when received, thus reliably protecting them against unauthorized access. The FEAL-16X algorithm used for encryption has been analyzed worldwide and is generally recognized. It has a code length of 128 bits and is an impenetrable barrier even for modern methods of cryptoanalysis. The design and development of such systems was based on German and European criteria for IT security. ComSaveBox supports an RS-232-C interface with rates from 9600 to 115 200 baud and the usual standard protocol (8 bits, no parity bit, 1 stop bit). The necessary hardware protocol (DTR/DSR or RTS/CTS) is fully transparent.

The unit can be operated in encrypted and in open transmission mode. In encrypted mode the data sent from the data terminal to ComSaveBox are first encrypted and then forwarded to the data transmission equipment. Data received by the transmission equipment and transferred to ComSaveBox are decrypted and then passed to the data terminal. The code used for encryption and decryption is set by the communication partners prior to data transmission or by remote access through a configuration program. The user can choose between a temporary and a permanent code. A permanent code, which remains stored when ComSaveBox is switched off, is recommended for frequently used links, as for example to a company headquarters, and a temporary code for one-time links. ComSaveBox operates with full transparency in the open mode. Data transmission uses the customary software, eg terminal programs for access to mailboxes and connection to other computers and programs for accessing networks via a modem line (eg asynchronous communication server, NetWare Connect).

Examples of application

File transfer between mailbox and PC

The mailbox of a company stores confidential data, and only authorized persons may access it. Password protection alone is not considered sufficient to prevent unauthorized access. The mailbox is installed on a computer that is fitted with a modem and receives incoming calls. In addition, data should be protected against unauthorized eavesdropping during transmission in the telephone network. To this end, the mailbox computer is fitted with ComSaveBox. All persons who are to have access to the mailbox also have ComSaveBox installed (FIG 2). For mailbox access a code is defined that only authorized persons are informed of. This enables connection to the mailbox and data exchange in encrypted form. Connections in plain text or with the incorrect code are automatically interrupted by ComSaveBox.

Access to Novell network via modem

Company employees are to be able to access the inhouse Novell network from their homes. For this a connect server with a modem and NetWare Connect software are installed. The NetWare password used as the sole means of protection is not regarded as sufficient to prevent unauthorized access. In addition to the password, data are to be protected by encryption during transmission in the telephone network. The connect server is fitted with ComSaveBox. All persons who are to have access to the network will also have ComSaveBox installed at their end and a code is arranged with them. Links with differently set operating modes (eg one ComSaveBox set to "Crypt", the other to "Open") or with an incorrect code are automatically interrupted by ComSaveBox.

Transmission via RS-232-C interface without modem signals

The data collected by a telemetry station are to be transmitted by radio to a central station. The radio equipment has an RS-232-C interface to send digital information, and this is to be encrypted against unauthorized access during transmission. ComSaveBox is inserted into the link between the data collection unit and the radio equipment of the station, and another one is required at the central station. Here the RS-232-C mode is set for the two boxes and also the code for the unit of the telemetry station, ie when a permanent code is to be used, which remains stored even with ComSaveBox switched off. In this case no further configuration of the telemetry unit is required, ie a PC is not needed at the site. With the configured ComSaveBox installed at the telemetry station, an encrypted link can be set up when needed by means of the "Crypt" key on the ComSaveBox at the central station. When the link is no longer required, the encrypted link is cleared down by pressing the "Crypt" key again. Of course, open links are possible any time using the "Open" key.

Use of ISDN modem

Users who frequently have to transmit large amounts of data cost-effectively will recognize the benefits of ISDN. ISDN modems present a number of advantages over plug-in PC cards, so their fields of application are constantly expanding. Installation, identification, available resources (interrupts) and problems with CAPI drivers make the use of plug-in PC cards less desirable. What is more, ISDN modems can easily be taken to another operating site, also in connection with laptops. The transmitted data are to be protected against unauthorized access. ComSaveBox is most suitable for this application, especially with its high communication speed of 115 kbaud. An ISDN modem (eg MicroLink ISDN/TIpro from ELSA) is required for this purpose. ComSaveBox is inserted between the PC and the ISDN modem and initialized (setting of code and mode). If the called station has the same configuration, transmission is possible with a terminal program (eg Telix from ELSA). Transmission rates of up to 115 200 baud can be achieved with two B channels (channel trunking).

Frank Bergmann; Klaus Hesse

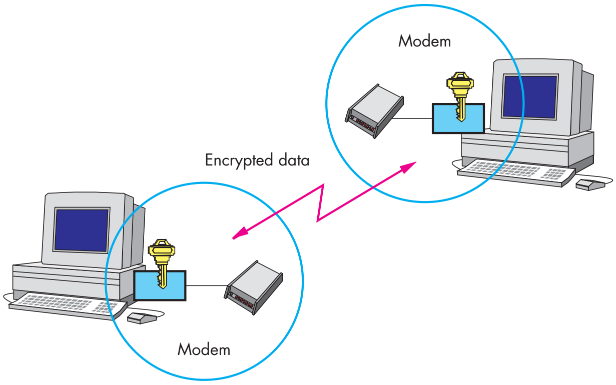

FIG 2
ComSaveBox encryption unit is inserted between data terminal (here PC) and data transmission equipment (here modem).

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Reader service card 161/09

Use of R&S components for Inmarsat-E signal generation at navtec

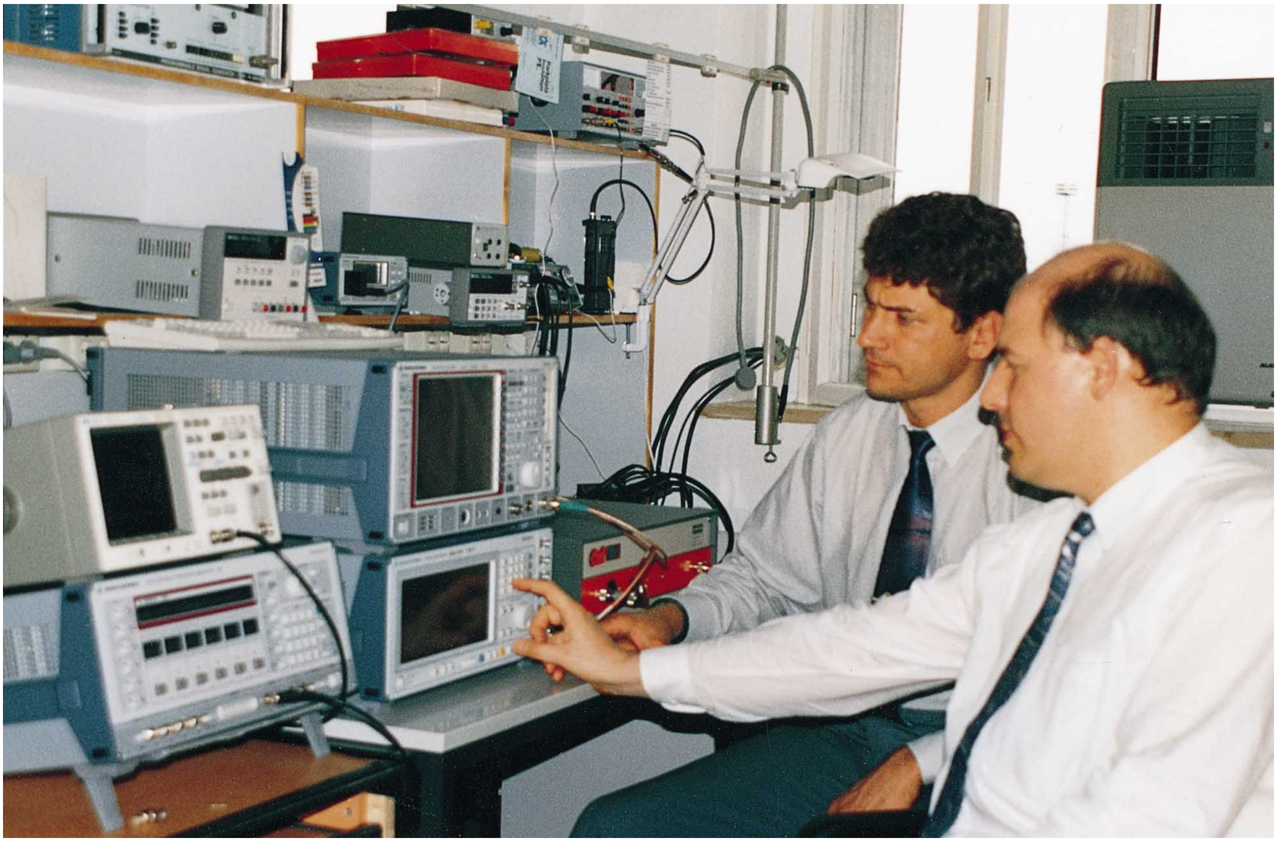
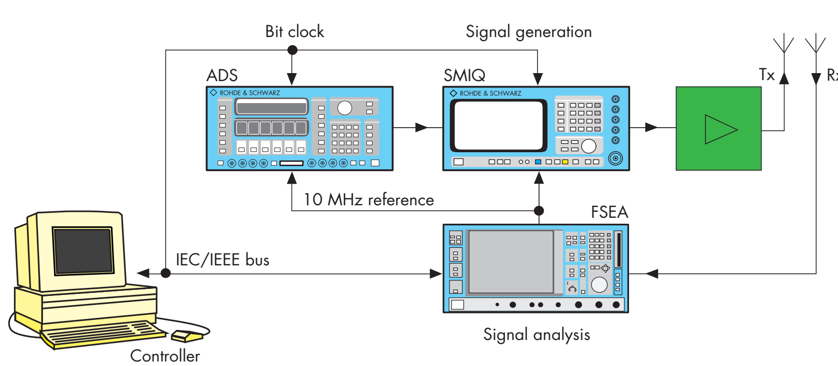


FIG 1 Test setup for generation of Inmarsat-E distress call data at Berlin-based company navtec
Photo: Schäfer

A new worldwide standard for transmitting and evaluating distress calls from ships and aircraft, Inmarsat-E, has established itself in the last few years. It is a system operating in conjunction with the four geostationary Inmarsat satellites. The standard was developed and formulated with the objective of ensuring reliable and unrestricted transmission of distress calls within the shortest possible time and for a large number of users. In contrast to LEO (low earth orbit) satellites, which can be received at a specific position on the earth only for a short time once every one to two hours, geostationary satellites guarantee reception and evaluation without any time restrictions. They also offer more channels, so they can serve a much larger number of users simultaneously.

FIG 2 Block diagram of setup for Inmarsat-E trial emissions with Signal Generator SMIQ, Spectrum Analyzer FSEA and Waveform Generator ADS, all from Rohde & Schwarz



In the past, only two LEO satellites (COSPAS/SARSAT) were available for the reception and evaluation of distress transmitters. The fixed frequency of 121.5 MHz and localization based on measuring the Doppler shift when overflying the vessel in distress resulted in highly inaccurate position data. The situation improved somewhat when a second transmission frequency

(406.025 MHz), a more suitable form of modulation (PSK/TDMA) and transmitter identification were introduced. The numbers of false alarms were high because of the ease of triggering, but distress calls could all be allocated.

Transmission techniques

A major problem of using geostationary instead of LEO satellites is the great distance from the earth (36 000 km). To be able to use battery-powered portable units with low power consumption, the prescribed transmit power had to be reduced. This was only possible through a new approach in the selection of the transmission scheme and the modulation.

The Inmarsat-E system operates with carrier FSK (±120 Hz) and 667 channels (300 Hz spacing) at 1.645 GHz (uplink). The satellite itself has only a 200 kHz wide transponder at 3.619 GHz (downlink). The signal emitted by a distress transmitter consists of a 100-bit telegram prefixed by a 20-bit sync word and suffixed by a 40-bit CRC sum. The telegram contains encoded information on identity, position and nature of distress.

To ensure that the low-power signals (27 to 31 dBm) appear at the ground station receiver with sufficient energy after travelling such a long distance, the energy of successive emissions has to be summed. The telegram is therefore repeated for a duration of five minutes. The receiver knows the exact length of a telegram, so it can easily sum the signal and distinguish it from the noise. Furthermore, the FEC (forward error correction) checksum allows correction of up to five bit errors.

Test system configuration

For its initial trials to determine output power requirements, the correctness of bit pattern generation and antenna functionality, the company navtec computed a test signal offline, which was then generated using reliable components available at the time. Distress call data were simulated for emission via the Inmarsat transponders by a setup consisting of Signal Generator SMIQ, Waveform Generator ADS, Spectrum Analyzer FSEA, a PC with IEC/IEEE-bus card and software HP-VEE (FIGs 1 and 2).

The key component of this setup was Signal Generator SMIQ, whose “list mode” was used to generate the emitted signals. The required data set was computed on a conventional PC and transmitted to SMIQ on an IEC/IEEE bus (FIG 3). Spectrum Analyzer FSEA not only provided the 10 MHz reference frequency but also served for checking the FSK signal at a second antenna. The software for analyzing the FSEA data, also run on the PC, was a slightly modified version of software used in the lab. The final transmission signal was generated by an Amplifier Research output stage. A 0 dB antenna with clockwise circular polarization was used to radiate the signal.

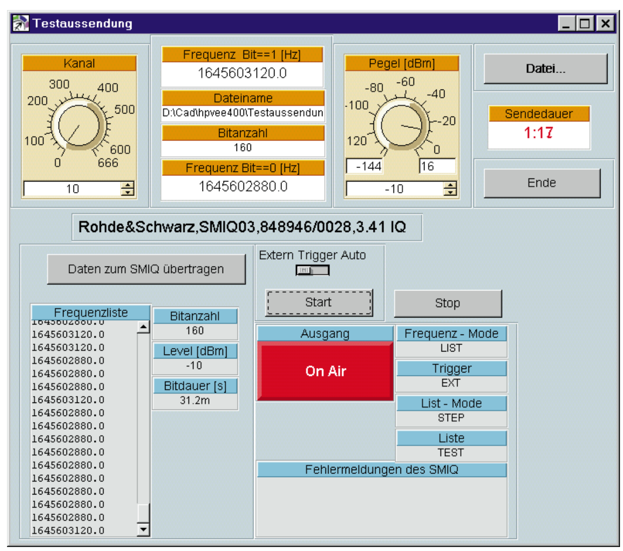


FIG 3 Screen shot of software for programming Signal Generator SMIQ at navtec

SMIQ is ideal in test setups such as these, because it generates signals with high accuracy and can easily be programmed on an IEC/IEEE bus. This makes SMIQ flexible for adaptation to measurement problems that are not covered by built-in standards.

navtec coordinated the trial transmissions with Inmarsat headquarters in London. All receiving land earth stations (LES) in the range of the three visible satellites confirmed reception of the signals down to a transmit power of just 18 dBm.

Dr Anselm Fabig (www.navtec.de)

Use of Measurement Decoder DVMD for quality control by Swiss broadcaster

Broadcasters are increasingly turning to digital technology for better management of resources and the spectrum. When a broadcaster today decides in favour of satellite transmission, this will be in line with **DVB and MPEG2 standards** – at least in Europe. This means that the signal must be conditioned, compressed and multiplexed before it can be modulated and sent to the satellite. At this point the question of measurement and quality arises. Is the signal delivered to the satellite error-free? Analog technology is no longer suitable for this purpose. In analog pictures interference like noise is visible immediately. In the case of signals sent to a satellite at 38 Mbit/s measurement is much more complicated. Digital technology can be deceptive because you suppose everything to be normal when you hear the sound or see the picture. Conventional monitoring is obviously insufficient. To determine whether everything is as it should be in an MPEG2 digital signal, you have to analyze the signal structure and examine the sections in which video and audio information is transported [1].

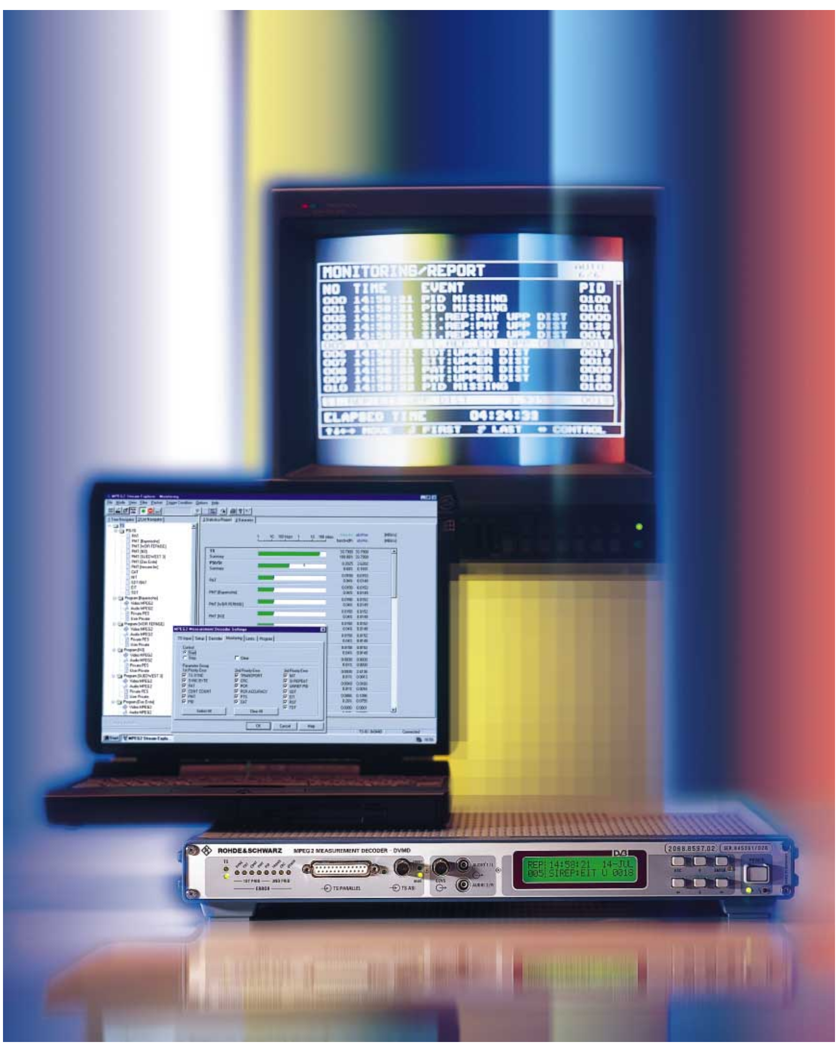


FIG 1 Measurement Decoder DVMD for analysis of MPEG2 transport streams
Photo 43 179/5

Choice of instrument

The MPEG2 standard and its principles are very complex, so it could take months to analyze and check the contents of an MPEG2 stream. The broadcaster, however, must guarantee error-free signals throughout. Furthermore, after installation a DVB transmission system may be operated and monitored by staff who are not necessarily specialized in MPEG2. For these reasons the Swiss broadcaster SRG-SSR decided to use **MPEG2 Measurement Decoder DVMD** [2] as a realtime test instrument (FIG 1). It takes continuous analysis of the signals transferred to the Hot Bird 3 satellite to ensure correct operation of the equipment. This round-the-clock analysis by means of DVMD actually enabled the supplier of the DVB-S system to improve it, since SRG-SSR was the first broadcaster to permanently analyze the signal, and thus equipment errors and instabilities could be detected. No compromise was made: the signal had to conform fully to MPEG2 standard.

For an optimum grip on the origin of faults, SRG-SSR decided in favour of a measurement principle that ensures the following **requirements** are met:

- The signal emitted must conform to the standard.
- The signal received from the satellite and passed on to the viewers must be absolutely errorfree (1st and 2nd priority).

FIG 2 shows the implementation, requiring two DVMDs. It ensures that the signals transmitted (output by the main multiplexer) and the signals received are conformal. In case of problems SRG-SSR can quickly deter-

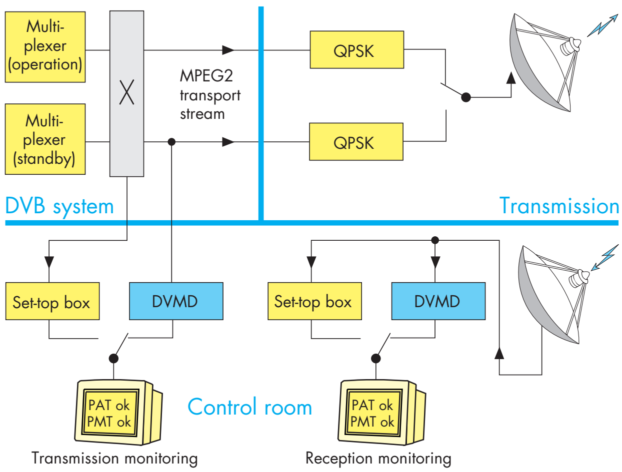


FIG 2
Block diagram of monitoring concept using two MPEG2 Measurement Decoders DVMD

mine whether they are caused by the satellite, by poor reception or by the multiplexer itself, which may transmit signals already errored.

Results after four months

Within the first 24 hours DVMD had signalled numerous errors, and after further investigation two causes for the MPEG2 errors could be tracked down in the DVB systems and eliminated by the supplier through parameter modifications. The causes of sporadic errors were extremely difficult to trace however. In these cases in-depth analyses are required for troubleshooting.

The **error display of DVMD** is clear and convenient. You merely select the parameter in question to find the error details. However, it is necessary to know exactly to what the error (eg Upper Dist) and PID (packet identification) of the errored element refer. For operation the PID number is sufficient since staff have a list of all important PIDs used in the programs. With the aid of DVMD, SRG-SSR detected errors in the broadcast programs. But most set-top boxes received these programs without major problems, except in one case where interruptions were heard. DVMD indicated that the PCRs (program clock references) were out of tolerance (Upper Dist). The PIDs were determined and the programs were found to be really impaired. To detect the origin of the error, a more in-depth analysis was again necessary by the system supplier, who is also responsible for eliminating the problem.

Another major benefit of DVMD is its **decoder.** This makes it easy to determine the components of the service in question. Each component is displayed with its PID, data rate as well as the PID of the entitlement control message (ECM) that scrambles it, which facilitates error detection. DVMD has no decoder for the major conditional access systems, so it cannot be used as a set-top box, since all scrambled programs are invisible, meaning that a set-top box is necessary for monitoring.

Summary

DVMD does a very good job during operation as a detector of errors – or rather anomalies – in the MPEG2 program. In case of anomalies it detects the error and specifies the type and service or component impaired. The operator is thus in a position to assess whether he himself or only the supplier is able to eliminate the error in the system. During operation it is impossible to call in a technician if sporadic errors (duration <1 second) occur. He would have to spend the whole day in front of DVMD to analyze errors of uncertain origin. To keep operating costs reasonable, a technician may only be called in case of a real alarm. At SRG-SSR alarm messages are output by a central system to which DVMD will also be connected and that will signal all errors lasting more than one minute (eg if a teletext PID fails).

SRG-SSR's objective is to ensure that all systems multiplexing its six television programs and the six radio programs of Radio Suisse International can be operated with a minimum of maintenance and repair. In view of the complexity of the systems, this will only be possible with the right working concept, and DVMD is an important part of it.

Damien Corti (SRG-SSR General Management, Engineering & Information Technology)

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[2] 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

Reader service card 161/10

High-power and multicarrier tests with Base-Station Test System TS8510

FIG 1 Test System TS8510 for GSM base stations with high-power extension Photo 43 253

TS8510 was designed by Rohde & Schwarz for manufacturers of GSM mobile-radio base stations and enables complex testing including type approval [1; 2]. Type-approval tests are the prerequisite for setting up new base stations in networks and are performed in compliance with BAPT 222 ZV 6 (Germany) and MPT 1378 (Britain) on the basis of GSM specifications 11.21and 11.23. They also extend to high-power base stations operating with a large number of carriers. It was with a view to the latter base stations that Rohde & Schwarz extended the capabilities of TS8510, especially for transmitter and receiver tests requiring simultaneous activation of all carriers available in a base station at maximum output power as stipulated by GSM specification 11.21.

The basic TS8510 system is designed for maximum input power of 25 W and up to four carriers. The **system with high-power extension** (FIG 1) now offers maximum sum power of 200 W for up to eight carriers (25 W per carrier) or maximum power of 64 W for one carrier. The high-power system extension combines GSM900/1800 or GSM900/1900 and thus covers all GSM bands.

The **extension,** accommodated in a **third rack,** comprises GSM-band-specific notch filters for suppression of the fourth and all further carriers in transmitter and receiver tests, other GSM-band-specific notch filters for suppression of additional carriers in the measurement of intermodulation in the receive band, low-intermodulation attenuators for matching the base-station power to the maximum permissible input power of the basic system, as well as low-intermodulation attenuator cables for defined reduction of maximum power in transmitter tests. These components are activated by operator instructions according to the test case (FIG 2).

The **user interface** of the software allows convenient test configuration, simple determination of test parameters and control of test runs. A power-check test was implemented with the high-power extension, which performs a thermal measurement of RF power on the system interface at the start of each test run, aborts the test run in the presence of impermissible levels and switches off the base station.

The **path compensation** incorporated in the basic TS8510 system, which ensures that the stimuli and measurement accuracy stipulated in GSM documents is adhered to, was extended to match the components contained in the high-power rack. This entails a considerable increase in correction data and greater complexity of correction-data generation and online data correction, so these data were split up according to the test case concerned and a fast

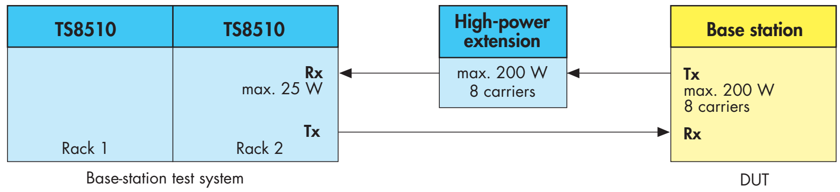

FIG 2 Configuration of Test System TS8510 with high-power extension

storage and loading facility for compensation data was added to the system.

Bearing in mind that base stations are heading for a further increase in the number of carriers and higher carrier power, Test System TS8510 and its high-power extension were designed for flexibility. Thus the A_{bis} interface, base-station configuration and signalling can easily be extended for straightforward adaptation to future requirements.

Volker Wimmer

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Reader service card 161/11

Portable, mobile or stationary radiomonitoring – Rohde & Schwarz has the ideal receiver every time

The selection of radiomonitoring receivers from Rohde & Schwarz satisfies practically all requirements for the detection, localization and display of signals in the frequency range 10 kHz to 3 GHz.

As the successor to the near legendary Receiver EB100, **Miniport Receiver EB200** not only covers the complete frequency range of 10 kHz to 3 GHz but also features important options such as Digi Scan for fast spectrum overview or IF panoramic display for internal IF monitoring up to 1 MHz bandwidth. Computer-aided monitoring is possible with the LAN interface [1]. In addition to stationary and mobile applications, EB200 is designed for **portable use** together with Handheld Directional Antenna HE200. A typical example is the localization of miniature transmitters in rooms, large buildings or on very difficult terrain that even all-wheel-drive DF vehicles cannot penetrate (FIG 1). In conjunction with Antenna HE200 the receiver's range is typically 2 to 3 km. Even without an external power supply but with just a battery pack, a fast overview of the frequency spectrum is obtained in Digi Scan mode.

FIG 1 Miniport Receiver EB200 in use Photo: Dörre

FIG 2
In conjunction with VHF-UHF Direction Finder DDF190 and Spectrum Display EPZ513, Receiver ESMC forms a convenient VHF-UHF monitoring system.
Photo 43 150/6

The differential mode of the Digi Scan option allows localization of miniature transmitters at close range. When the mode is called up, the displayed spectrum is stored as a reference. As you move, the field strength of transmitters at close range varies to a greater extent than that of transmitters located far away. Current spectra are superimposed on the reference spectrum, and any new signals or variations in signal strength are clearly discernible as peaks. The highly sensitive amplifier integrated in the antenna handle can detect even the weakest emissions.

Civil applications of EB200 are the tracking of interference in radiotelephone networks (eg taxi, air traffic control or government communications), coverage measurements in individual cells of a mobile radio network or the detection of spy transmitters (bugs). The frequencies of these bugging devices can be anywhere between a few kHz and GHz, and EB200 is the only receiver that can detect them by determining their frequency and location. It moreover enables military signal search and frequency monitoring.

VHF-UHF Compact Receiver ESMC [2] is by contrast not designed for battery-powered portability but for **mobile and stationary applications** (FIG 2). AC or DC sources (10 to 32 V) can be used to power it. It differs from the lower-cost EB200 in terms of its superior RF characteristics such as sensitivity, linearity and immunity to interference. This is very important for operation on stationary antennas. In the Analog Scan mode (option ESCM-AS), which is an extremely fast frequency scan at a speed of 13 GHz/s with spectrum display, it can also detect frequency-hopping signals. The technical features of ESMC also make it suitable for mobile use in vehicles. In this case the small EB200 can be used as a handoff and monitoring receiver.

As the nucleus of computer-controlled systems for fast and efficient radiomonitoring with special functions for scan replay and statistical evaluations, **VHF-UHF Search Receiver ESMA** [3] is ideal for **purely stationary operation.** Its outstanding features include tracking preselection, an oven-controlled and extremely accurate reference crystal and a high-speed synthesizer with tuning time faster than 150 μs.

Theodor Fokken

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[3] Oberbuchner, E.: Search Receiver ESMA – The ideal frontend for VHF-UHF monitoring systems. News from Rohde & Schwarz (1995) No. 149, pp 7–9

Reader service card 161/12 (EB200), 161/13 (ESMC), 161/14 (ESMA)

New functions added to A_{bis} control software for Radiocommunication Testers CMD54/57

Digital Radiocommunication Testers CMD54/57 [1; 2] are tried and proven instruments for testing base stations (BTS) in production, installation and service. They can control base stations and measure their RF interfaces with the optional A_{bis} interface and A_{bis} control software, CMD assuming essential tasks of the base station controller (BSC). The A_{bis} interface between the BSC and a BTS operates at a data transfer rate of 2.048 Mbit/s or 1.544 Mbit/s. The A_{bis} protocol handles the exchange of data and signalling information between CMD and a BTS.

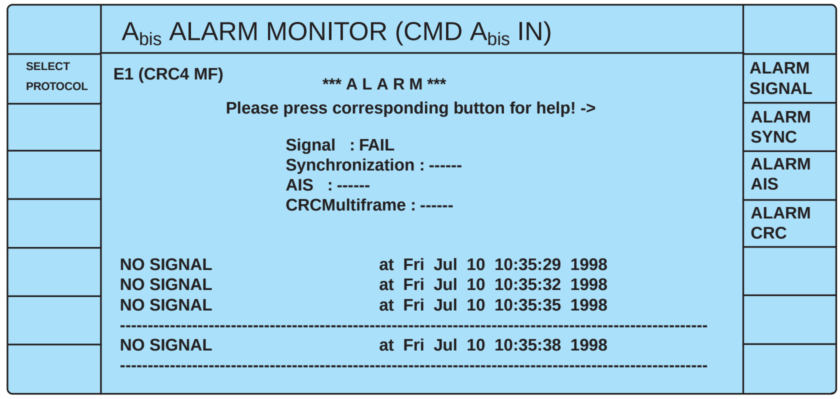

FIG 1 A_{bis} alarm monitor signals faulty connections between Digital Radiocommunication Tester CMD and base station.

The link between CMD and a BTS can be disturbed by numerous errors: for example wrongly connected A_{bis} cables, input level missing or too low, or incorrect setting of the data transfer rate or protocol type and, as a result, no synchronization between the BTS and CMD. To detect these and other faults, Rohde & Schwarz added the **A_{bis} alarm monitor** to the A_{bis} control software (FIG 1), which supervises and displays the status of the A_{bis} interface. The alarms displayed include "No Signal", "No Sync", "Alarm Indication Signal" and "CRC Alarm". An additional help function provides information on the type of fault and, depending on the alarm that appears, its possible causes. No extra analyzer is required for checking the physical properties of the connection.

Standardized test regulations stipulate measurement of major RF characteristics by base station producers and network operators. Numerous **test functions** were added to the A_{bis} control software to simplify these tasks.

- With the mobile originated call (MOC) CMD simulates both the radio equipment and the network for mobile telephone call setup, after which all RF parameters can be measured.
- For use in frequency-hopping applications, a feature was implemented to switch the base station synthesizer to hopping mode.
- An important prerequisite when determining cell coverage is the measurability of all static and dynamic power levels. The setting possibilities for this in the A_{bis} control software were substantially improved.
- Some test regulations (eg GSM 11.21) stipulate activation of BTS transceiver timeslots to a predefined pattern. For this purpose the carrier timeslots are deactivated or operated with maximum static power or dynamic power reduction. CMD subsequently allows tolerance limits to be checked by a "Switching Spectrum" RF measurement.
- The random access channel (RACH) test is used for a functional check of the A_{bis} and RF connections between CMD54/57 and the base station (FIG 2). Here CMD sends an access burst, which is applied to the receiver of the A_{bis} interface via the base station. The A_{bis} control software answers this burst with an immediate assignment message. Proper reception of this by the RF

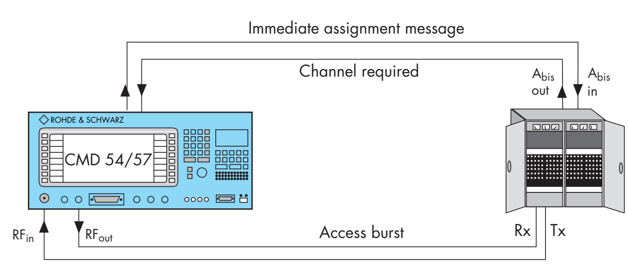

FIG 2
RACH test in line with GSM 11.21

section of CMD means that the uplink and downlink of the A_{bis} and RF connections are correct. If several bursts are sent for this test, evaluation of the frame erasure rate as required by GSM 11.21 provides information on connection quality.

Hubert Kerscher; Karsten Friedrich

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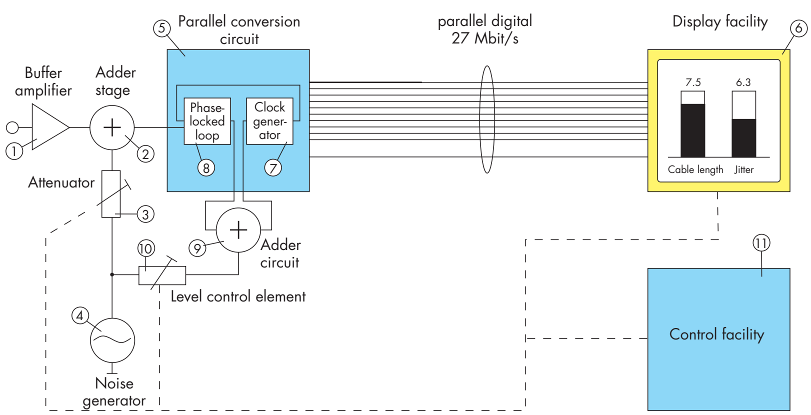
[2] Körber, F.: Testing GSM/PCN/PCS base stations in production, installation and service with CMD54/57. News from Rohde & Schwarz (1996) No. 151, pp 28-30

Reader service card 161/15

Patent

Determination of cable length and/or jitter margin of data transmission paths



In the transmission of serial digital data signals such as video signals it may well be that the data signal received is errorfree although it is strongly disturbed. However, above a certain threshold even a slight increase of interference may cause complete transmission breakdown. The most important types of interference affecting such data signals are linear distortion, which in the main is determined by the length of the cable used for transmission, and jitter caused by the recovery and regeneration of the data clock every time data are received. It is the object of the invention to describe a simple procedure enabling the user to determine the cable length margin and/or jitter margin in a transmission path for serial digital data signals, especially video signals, before disruption of the data signal becomes intolerable; the equipment investment for this procedure is to be as small as possible.

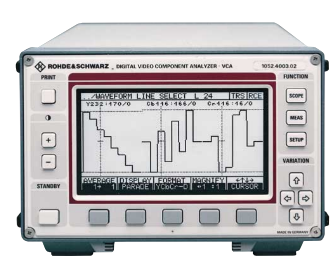
1. Procedure for determination of the cable length margin in the transmission of a serial digital data signal, characterized in that a noise signal of rising level is added to the data signal until an impermissible bit error of the data signal is detected and the cable length margin is determined and indicated from the added noise signal level.

2. Procedure for determination of the jitter margin of a serial digital data signal, especially in combination with a procedure for determination of the cable length margin according to claim 1, characterized in that the data clock of the data signal is recovered and increasingly jittered by a noise signal of rising level until an impermissible bit error of the data signal is detected and the jitter margin is determined and indicated from the noise signal level.

3. Configuration for determination of the cable length margin and/or jitter margin by means of a procedure according to claim 1 or 2, characterized by a noise generator (4), which is connected via a first level control element (3) to an adder stage (2), whose input is fed with the serial data signal to be measured (V) and whose output is connected to a parallel conversion circuit (5) containing a phase-synchronized clock generator (7) for recovery of the data clock and serving for conversion of the serial data signal to a parallel data signal, the noise generator (4) being connected via a second level control element (10) to an adder circuit (9) integrated into the phase-locked loop (8) of the clock generator (7) of the parallel conversion circuit (5), the parallel output of the parallel conversion circuit (5) being connected to a data signal evaluation and display facility (6), which measures the impermissible bit error, the two level control elements (3, 10) being adjustable via a control facility (11), which is connected to the evaluation and display facility, the setting for the two level control elements (3, 10), which is required until the detection of an impermissible data signal bit error, being displayed as a measure for cable length margin or jitter margin on the display facility in the evaluation and display facility.

Extract from patent specification
DE 44 14574 C2
Patent applied for by Rohde & Schwarz
on 27 April 1994
Issue of patent published on 28 March 1996
Inventors: Harald Ibl; Thomas Hindelang

Used in Digital Video Analyzer VCA



Reader service card 161/16 for further information on VCA

Probability of intercept for frequency hop signals using search receivers (II)

3.3 Receiver in wait mode

Given that the hopper's frequency spacing is known from searching the frequency range, a receiver can be fixed tuned to one of the hop channels. The FH transmitter is then detected when its instantaneous frequency coincides with the set receive frequency. For a hop to be detectable its duration must be $T_h > T_i$. In wait mode (hopper trap) the time required for synthesizer setting and signal processing does not influence probability of intercept, so $T_d = T_i$ applies in this case.

Provided $T_i < T_h$ is valid and the condition described under 2 is met, exactly one detection occurs when the hop frequency and receive frequency coincide. On arrival of a burst the level threshold is exceeded as soon as the detection filter has settled, and at the end of the burst after a corresponding delay the level drops below the threshold again, allowing estimation of the burst duration. In this mode probability of intercept does not depend on hop duration T_h and the arrival time of the burst at the receiving antenna, as is the case with a search receiver in hop mode, so $\bar{n} = 1$ applies. FIG 5b with $M_g = M_{Sc} = 1$ and the equations (5) and (4) are valid for the probability of intercept of a single-channel and a multichannel receiver.

IIf the mean number of valid detection attempts per burst of a sufficiently fast search receiver is $\bar{n} > 1$, the probability of intercept is greater than in wait mode (equation 8). The probability of intercept in search mode may also be less than in wait mode however:

a) When the receiver scan is too slow compared with burst duration $(T_i < T_h < (T_d + T_i))$, in which case the factor $\bar{n} = (T_h - T_i)/T_d$ in (8) is less than 1.

b) If the search receiver is unable to use the a priori information on the hopper frequency range that was assumed for the receiver in wait mode, the receiver may also search in frequency ranges not used by the hopper (FIGs 5a and c). In this case the ratio M_g/M_{Sc} in (8) is less than 1 while in wait mode $M_g = M_{Sc} = 1$ holds.

4 Interception of frequency hoppers: repeated attempts

Up to now we dealt with the probability of intercepting a single hop (burst). If an FH transmitter can be observed for a certain operating time T_t (transmit time of hopper or total on time of receiver), the attempt to hit it can be repeated at N hops with

$$N = T_t \times f_H \qquad (14)$$

if f_H is the hop rate of the transmitter in frequency hops per time increment. (Note: f_H does not equal $1/T_h$ as synthesizer settling has to be considered for the transmitter too.) With each of the N attempts the probability of a hit is P, with $P = P_1$ in (3 to 6) or P_{1h} in (8).

4.1 Binomial distribution

The probability P_N that in N attempts a number Z of exactly k hits occurs is calculated according to the binomial distribution [5]:

$$P_N\,(Z = k) = \binom{N}{k} P^k\,(1 - P)^{N-k}$$

$$\text{with } \binom{N}{k} = \frac{N!}{k!\,(N-k)!} \qquad (15)$$

and the mean value (mean number of hits)

$$\bar{k} = N \times P \qquad (16)$$

Of particular interest are the probabilities derived from (15) that the number Z of hits occurs within a defined interval:

a) The probability of at least one hit in N attempts is

$$P_N\,(Z \geq 1) = 1 - (1 - P)^N \qquad (17)$$

b) The probability of k_1 to k_2 hits in N attempts is

$$P_N\,(k_1 \leq Z \leq k_2)$$

$$= \sum_{l=k_1}^{k_2} \binom{N}{l} P^l (1 - P)^{N-l} \qquad (18)$$

c) The probability of at least k hits in N attempts is

$$P_N\,(Z \geq k) = \sum_{l=k}^{N} \binom{N}{l} P^l (1 - P)^{N-l}$$

$$= 1 - \sum_{l=0}^{k-1} \binom{N}{l} P^l (1 - P)^{N-l} \qquad (19)$$

4.2 Poisson theorem

With a large number of hopper channels M_{FH}, the probability P of intercept for a single hop is often very low, so that even with a large number N of attempts the product $N \times P$ is not a very high number but of the order of 1. In this case the binomial distribution (15) for k of the order of $N \times P$ may be approximated by the Poisson distribution [5]:

$$P_N\,(Z = k) \approx \frac{e^{-NP}(NP)^k}{k!} \qquad (20)$$

A special case should be mentioned: Given a large number of hopper channels M_{FH} and the search range of a single-channel receiver coinciding with the hop range of the transmitter

($M_{Sc} = M_{FH}$, FIG 5d), L complete scans are to be performed [4]. The receiver is to be able to perform on average just one valid detection attempt per frequency hop of the transmitter ($\bar{n}$ = 1). With (5) the detection probability for a single burst is $P = P_1 = 1/M_{FH}$ and the total number of attempts $N = L \times M_{FH}$. With $N \times P = L \times M_{FH} \times (1/M_{FH}) = L$ and using (19) and (20), the probability of at least k hits (FIG 7) is

$$P_N(Z \geq k) = 1 - \sum_{l=0}^{k-1} P_N(Z = l)$$

$$\approx 1 - e^{-L} \sum_{l=0}^{k-1} \frac{L^l}{l!} \qquad (21)$$

According to (21) at least one hit occurs (trace k = 1 in FIG 7) with the probability

$$P_N(Z \geq 1) = 1 - e^{-L} \qquad (22)$$

4.3 DeMoivre-Laplace theorem

If the number N of attempts is sufficiently large that

$$NP(1 - P) >> 1 \qquad (23)$$

is obtained, the binomial distribution (15) can be approximated by a Gaussian distribution [5]:

$$P_N(Z = k) \approx \frac{e^{-(k - NP)^2/2NP(1-P)}}{\sqrt{2\pi NP(1-P)}} \qquad (24)$$

For the total probability (18) the following is obtained:

$$P_N(k_1 \leq Z \leq k_2)$$

$$\approx \frac{1}{2}\left[erf\left(\frac{k_2 - NP}{\sqrt{2NP(1-P)}}\right) - erf\left(\frac{k_1 - NP}{\sqrt{2NP(1-P)}}\right)\right] \qquad (25)$$

where $$erf(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-y^2}\, dy \qquad (26)$$

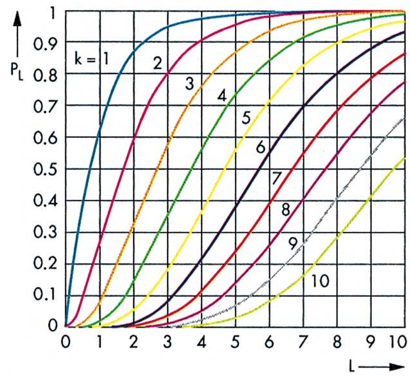


FIG 7 Probability P_L of at least k hits in L scans

Based on (25) with (19), the probability of at least k hits in N attempts is

$$P_N(Z \geq k)$$

$$\approx \frac{1}{2}\left[erf\left(\frac{N - NP}{\sqrt{2NP(1-P)}}\right) - erf\left(\frac{k - NP}{\sqrt{2NP(1-P)}}\right)\right]$$

$$\approx \frac{1}{2}\left[1 - erf\left(\frac{k - NP}{\sqrt{2NP(1-P)}}\right)\right] \qquad (27)$$

The relationship between the number of attempts and receiver scans is shown in the blue BOX.

5 Example

Let us assume that the search range of the receiver and the frequency range of the FH transmitter coincide (FIG 5d) and that the hopper and receiver have 2000 hop positions each ($M_{FH} = M_{Sc}$ = 2000). In this case the probability of intercepting a single burst in a single measurement with a single-channel receiver is $P_1 = 1/M_{FH} = 1/2000$ according to (5).

a) Poisson theorem:
With L = 3 the probability of the hopper being intercepted at least once in three scans is 95% according to curve k = 1

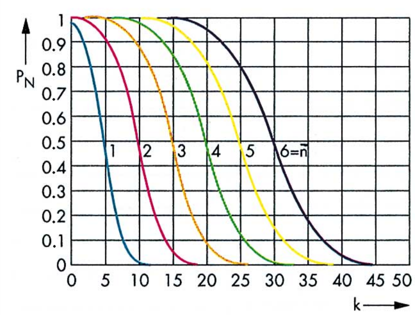


FIG 8 Single-channel receiver: probability P_N of at least k hits in $N = 10^4$ repeated attempts with mean number $\bar{n}$ of valid intercept attempts during one hop interval

Number of repeated attempts during a number of receiver scans

The number N of repeated attempts to detect a transmitter with a random distribution of frequency hops is a decisive parameter for determining probability of intercept (15) to (27). The relationship between N and the number L of receiver scans is as follows:

The dwell time of the receiver at a frequency is assumed to be T_d. For a systematic search through all frequency positions M_{Sc} of a single-channel receiver, the time $T_{Sc,1} = M_{Sc} T_d$ is required for one scan.

With (14) the number N of attempts during L scans is defined as $N_{L,1} = M_{Sc} T_d f_H L$.

In the case of a multichannel receiver with K parallel channels the scan time reduces to

$$T_{Sc,K} = \frac{M_{Sc} T_d}{K}$$

with the result that during L scans only

$$N_{L,K} = \frac{M_{Sc} T_d f_H L}{K}$$

attempts can be made. Seeing as the probability of intercepting a single hop with a multichannel receiver is higher by the factor K than that of a single-channel receiver (3, 8), the mean number $\bar{k}$ of hits is the same for the single-channel and the multichannel receiver for the same number L of scans. The observation time required by the multichannel receiver is shorter by the factor $1/K$.

in FIG 8 or (22), assuming that the receiver performs an average of one valid detection attempt per transmitter hop [4].

b) De Moivre-Laplace theorem:
Let the operating time T_t be sufficiently long that, according to (14), $N = 10^4$ is obtained for the number of repeated attempts. With (16, 8 and 7) the mean number of hits is then

$$\bar{k} = N \times P_{1h} = 10000 \times \bar{n}/2000$$
$$= 5 \times \bar{n}, \text{ where } \bar{n} = (T_h - T_i)/T_d$$

The probability of at least k hits can be approximated using (27). This is shown in FIG 8 for a single-channel receiver and a variable mean number $\bar{n}$ of valid attempts by the receiver during the hop interval T_h (ie with different scan speeds). Trace $\bar{n} = 1$ also applies to a single-channel receiver in wait mode. The same relationship for an eight-channel receiver is plotted in FIG 9. Here the mean number of hits according to (16) with $P = P_{1h}$ (8) is greater by a factor of 8 compared to a single-channel receiver. Trace $\bar{n} = 1$ is also valid for an eight-channel receiver in wait mode. In FIG 10 only one valid detection attempt is assumed per hop interval ($\bar{n} = 1$, $(T_h - T_i)/T_d = 1$ or wait mode) and the effect of an increased number of parallel receiver channels is shown.

For the probabilities of intercept calculated with (27) and shown in FIGs 8 to 10, the effect of a specific measure (parallel channels, faster scan) can easily be estimated with the aid of the mean number of hits according to (16):

The probability traces $P_N(k)$ reach a value of 0.5 when the minimum achievable number of hits is just equal to the mean number of hits ($k = \bar{k}$). With increasing values of $\bar{k}$ the traces consequently shift proportionally to the greater minimum number of hits. Taking a K-channel receiver and substituting (8) in (16), the mean number of hits for the coincidence of search and hop frequency range assumed in FIG 5d is given by

$$\bar{k} = N \times P_{1h} = N \frac{K \bar{n}}{M_{FH}}$$

$$= N \frac{K}{M_{FH}} \left(\frac{T_h - T_i}{T_d} \right) \quad (28)$$

c) Binomial distribution:
If the same relationship as in FIG 10 is to be determined for just a small number of attempts, the binomial distribution must be used without approximations. The diagram shown in FIG 11 is obtained with (19) for only ten repeated attempts. The POI is correspondingly low.

6 Conclusion

Under the conditions described in section 2, the probability of intercept for a single burst (hop) is proportional to the product of the channel number K and the mean number $\bar{n}$ of attempts of a receiver in the hop interval T_h (8, 28). The measures "multichannel receiver" and "fast scan" have the same effect on probability of intercept and are therefore interchangeable. Both measures for increasing probability of intercept require more effort at the receiver end. A search receiver optimized for intercepting sufficiently strong signals works with the largest possible number K of parallel channels and a minimum dwell time T_d, ie the shortest possible times for detection, synthesizer settling and signal processing. Short intercept times call for broadband filters. When the detection time T_i is shortened, probability of intercept is limited by reduced selectivity to narrowband adjacent-channel signals and broadband interfering signals. If the interfering signal is broadband noise, the required field strength increases proportionally to $\sqrt{(1/T_i)}$ for faster detection time T_i. If the FH signal can be observed over a specific operating time, the attempts at detection can be repeated and thus the number of hits increased.

Dr Hans-Christoph Höring

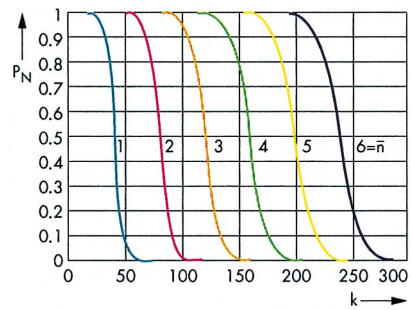


FIG 9 Eight-channel receiver: probability P_N of at least k hits in $N = 10^4$ repeated attempts with mean number $\bar{n}$ of valid intercept attempts during one hop interval

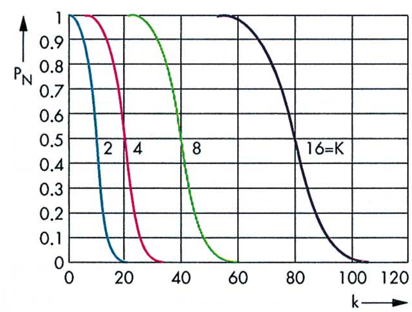


FIG 10 Receiver with K parallel channels, $\bar{n} = 1$: probability P_N of at least k hits in $N = 10^4$ repeated attempts

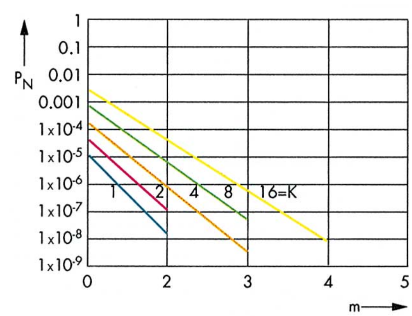


FIG 11 Receiver with K parallel channels, $\bar{n} = 1$: probability P_N of at least m hits in $N = 10$ repeated attempts

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Mobile power measurement with NRT sensor and PC Card Adapter NRT-Z4

The right size for any serviceman's case: PC Card Adapter NRT-Z4 with NRT sensor
Photo 43 233

Directional Power Meter NRT for power and reflection measurements on digital mobile-radio base stations has been a big success in its first two years on the market*. The sensors NRT-Z43 and NRT-Z44 have digital interfaces, which enable them to be used without the basic unit, ie directly at the serial interface of a PC, laptop or notebook. Previously this was made possible by Interface Adapter NRT-Z3 in combination with the graphical Windows user interface NRT-V. What makes the standalone solution so attractive for users working in R&D, production, service and installation is not only the possibility of immediate processing of measured results on a PC but also the favourable price and ease of handling. A minor drawback, especially in mobile applications, was the need to supply the sensor operating voltage via a separate plug-in power adapter.

Thanks to PC Card Adapter NRT-Z4 this is no longer necessary. This adapter is simply inserted into the PC card slot of a laptop or notebook and will then power the sensor as well as transfer data to the PC. Apart from a Type II PC Card socket (PCMCIA specification 2.1), no special requirements are made of the PC. The adapter runs under any Windows operating system (3.x/95/98/NT). The additional power drawn by the sensor is a mere 5 % of the battery capacity and so practically negligible.

Most users will prefer to operate the sensor under the Windows user interface NRT-V supplied with the sensor, which offers the entire functionality of a modern power meter. For logging purposes the measured results can be saved in files together with date and time for further processing by standard office software (eg Excel). For those wishing to integrate the sensor into a measurement system, the Rohde & Schwarz web site provides drivers for LabWindows/CVI, LabVIEW and HP VEE free of charge.

The sensors were designed for frequency and power ranges from 0.2 to 4 GHz/0.003 to 300 W (NRT-Z44) and 0.4 to 4 GHz/0.0007 to 75 W (NRT-Z43), so power measurements are possible on base stations to all customary standards. In the case of CDMA base stations (IS95 and W-CDMA), average power, reflection, peak power (PEP) and amplitude distribution (complementary cumulative distribution function, CCDF) can be measured. The latter two parameters are required for assessing the dynamic performance of CDMA transmitter output stages, which have to handle peak power of about ten times average power with low distortion.

The functionality offered by an NRT sensor connected to a laptop or notebook via PC Card Adapter NRT-Z4 is no less than that of a solution with the basic NRT unit, and holds par with peak power analyzers costing many times more. Another plus is the directional coupler for transmit power measurements, which is ready integrated into the NRT sensor. All in all a complete and inexpensive solution for the needs of today, in other words just plug in and go.

Thomas Reichel

* Reichel, T.: Power Reflection Meter NRT – The next generation in directional power meters. News from Rohde & Schwarz (1997) No. 153, pp 7–9

Reader service card 161/17

CECOM tests products from Rohde & Schwarz

In Ft. Monmouth, New Jersey, Rohde & Schwarz presented its radiocommunication products to the United States Army Communications Electronics Command (CECOM). This took place within the strategic objective to extend and secure the market for Rohde & Schwarz products in the US. The standards set by this central test and procurement authority for defense material (FIG 1) are extremely high: the products selected and purchased there definitely have quality and name.

It is natural that the strategic placement and development of Rohde & Schwarz products should be matched to the requirements of the market. This applies particularly to the line of transmitting and receiving equipment with system components and software modules for strategic radiocommunications, since it has to satisfy stringent national and international standards as well as special operational requirements. In many fields this market is protected by leading American companies. Comparison of procurement procedures adopted in different countries shows that Rohde & Schwarz products are among the leaders, but penetration into the US market with standard products has so far been difficult and marked by little success.

Since December 1996 CECOM has therefore been informed in detail about Rohde & Schwarz products and competence. CECOM found the innovative TCP/IP Software PostMan particularly interesting. During several in-depth talks and product demonstrations in Ft. Monmouth, the department concerned with this specific field had the opportunity to make its own series of tests as of May 1997.

Technical support from Munich together with local backup made it possible for CECOM communication specialists, planners and purchasers to learn more about the merits of the global communication products from Rohde & Schwarz. The radio systems were tested extensively and their operability examined. In conclusion to the tests, a comparative test lasting several days of Rohde & Schwarz and rival products took place in New Jersey and in Washington, DC, in December 1997. Link response, data throughput and handling in an operational scenario over distances of up to 200 miles were the decisive usability and evaluation criteria. The shortwave transmission system from Rohde & Schwarz with HF Transceiver XK2000 and TCP/IP Software PostMan proved its excellence and is certainly going to find new potential users in the US.

Besides E-mail on shortwave, the transfer of TCP/IP packets to VHF and UHF radio links was also tested. The VHF and UHF radio links were connected via a router to a LAN controlled by System Processor MERLIN. This combination went towards proving that TCP/IP packets could also be transmitted transparently on shortwaves (FIG 2). This is particularly important for applications in which the coverage of VHF-UHF radio transmission is not sufficient and shortwave has to be

FIG 1 CECOM headquarters in Ft. Monmouth, NJ (USA) – central procurement organization for US army Photo: Müller

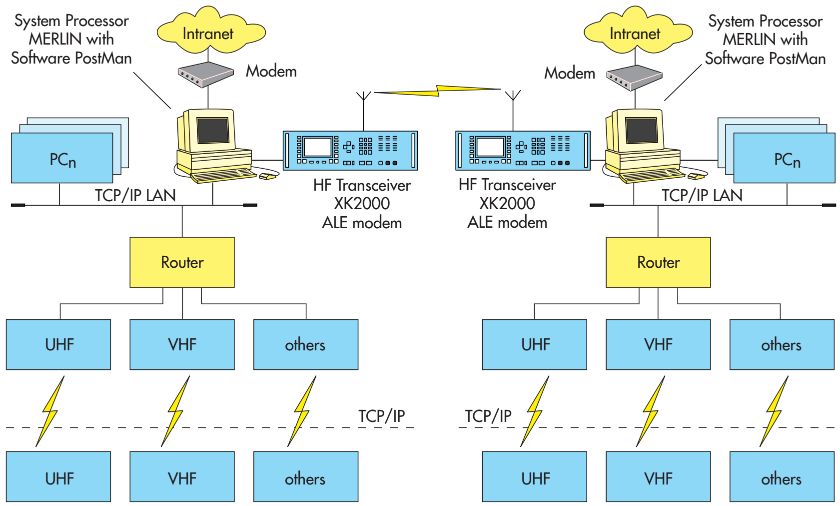

FIG 2 TCP/IP interface permits unlimited integration of software product PostMan in existing communication systems.

employed to increase range. Further tests checked transparent access to an Intranet application via shortwave. For this purpose a commercial browser was simply configured so that it could access the set TCP/IP address via HF radio on the typical Intranet applications frequently deployed in military systems.

Peter Maurer; Gerd Müller

Reader service card 161/18 for more information on PostMan

Simulation of channel noise and nonlinear amplifier distortion with Signal Generator SMIQ

A state-of-the-art signal generator should not only be capable of delivering ideal signals with diverse types of modulation but also of simulating signal impairments of the kind encountered in practice. The impairments can originate from nonlinear transmitter stages, interference on the radio link or noisy receiver input stages.

With its **optional noise generator and distortion simulator** (SMIQB17), Vector Signal Generator SMIQ [1] can superimpose a noise signal and create nonlinear distortion of the modulation signal. The noise signal bandwidth can be set between 10 kHz and 10 MHz and has Gaussian amplitude distribution (additive white Gaussian noise, AWGN). The S/N ratio can be set with high resolution between −5.0 and +30.0 dB. The distortion is predefined by two characteristics,

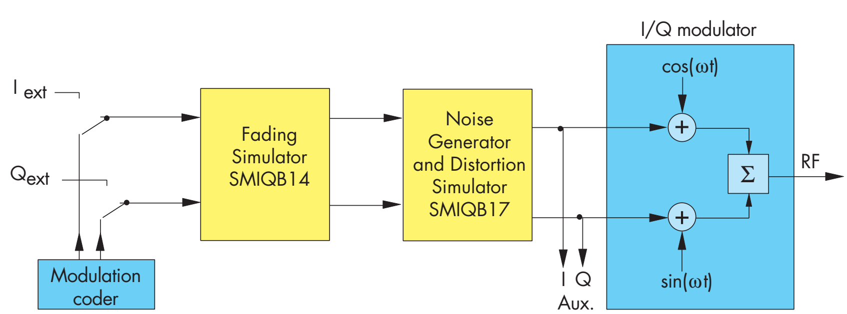

FIG 1 Setup for complete simulation of radio channel with Vector Signal Generator SMIQ and options SMIQB17 and SMIQB14 (yellow)

AM/AM and AM/PM, since an amplifier will usually distort both amplitude and phase.

The signal processing of option SMIQB17 is digital, so high precision and reproducibility are obtained. This is important for the S/N ratio, for example, since receivers can react to very small noise level changes. Noise and distortion can be combined with signal degradation by using the **fading simulator option** (SMIQB14) [2] and thus a radio channel can be completely simulated (FIG 1).

DUT via a directional coupler. The test method is described in detail in [3].

Another application is the compensation of nonlinear amplifier distortion by pre-equalization, a method of increasing importance through the use of digital signal processing. The powerful testing tool SMIQB17 is available to the engineer for the development of such methods. The freely programmable characteristics enable him to test pre-equalization on an amplifier before implementation of the signal processing.

fier to be equalized. This means that the inverse function should be activated for the AM/AM characteristic and the negated function for the AM/PM characteristic. Inversion can be activated and deactivated in the menu.

Also worth mentioning is an application in which the noise generator and distortion simulator option simulates a noisy satellite signal distorted by a transmitter output stage, an application important for WorldSpace satellite sound broadcasting [4].

Thomas Ehrhardt

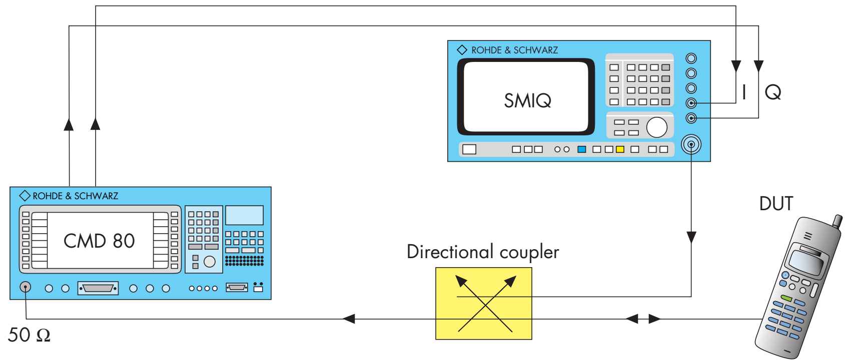

FIG 2 Setup for measuring frame error rate on CDMA mobile radios

One application example is the simulation of a CDMA radio channel. To measure the frame error rate (FER) of a CDMA mobile radio under conditions of fading in line with section 9.3.4 of IS98, an AWGN signal simulating external interference such as adjacent cells has to be superimposed on the useful signal (FIG 2). Digital Radiocommunication Tester CMD80 acts as the base station and performs the FER measurement in loopback mode. The modulated transmit data of CMD80 are fed to SMIQ as a baseband signal (I and Q). SMIQ applies the signal to the fading simulator, superimposes the noise and converts it to the RF domain, the RF signal then being routed to the

There are two possibilities of entering the AM/AM and AM/PM characteristics:

1. Entry of points on an IEC/IEEE bus (up to 30); these are subjected to cubic spline interpolation so that internal resolution of 2000 values is obtained.
2. Entry of polynomial coefficients in the menu; 2000 points are calculated from four coefficients for amplitude distortion and four for phase distortion using the polynomial equation.

If the polynomials correspond to the characteristics of the tested amplifier, these should be inverted for the ampli-

REFERENCES

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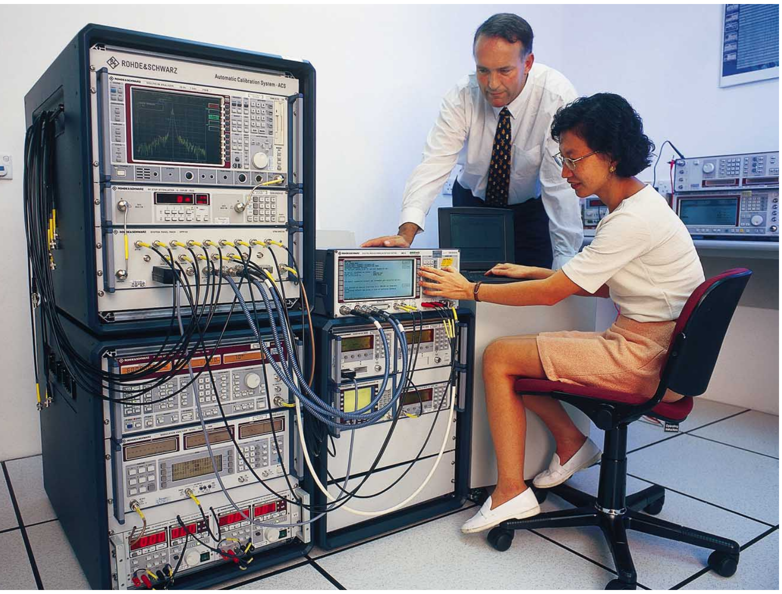
[2] Lüttich, F.: Signal Generator SMIQ + SMIQB14 – Fading simulator and signal generator in one unit. News from Rohde & Schwarz (1997) No. 155, pp 9–11

[3] Rohde & Schwarz: Application Note 1MA05_2D

[4] Kernchen, W.: Vector Signal Generator SMIQ02W/SMIQ03W – Test signals for digital WorldSpace satellite sound broadcasting. News from Rohde & Schwarz (1998) No. 160, pp 79

Reader service card 161/19

ACS100 test systems for calibration of R&S test and measurement equipment worldwide



Automatic Calibration System ACS100 at Rohde & Schwarz Support Centre Asia in Singapore
Photo 43 237/2

Rohde & Schwarz produces and markets T&M equipment and systems of the highest quality and accuracy. Naturally, top-class equipment too needs to undergo regular tests for compliance with the accuracy specified in its data sheet. Speed of calibration is particularly important for equipment used on production lines, because ongoing production must not be impeded. For this reason, **calibration** has to fulfill the following **requirements:**

- maximum accuracy,
- high speed,
- logging of measurement results,
- on-site calibration,
- comparable and uniform quality worldwide,
- compliance with ISO guide 25.

These challenging demands are met by the universal **Automatic Calibration System ACS100** (FIG) developed by Rohde & Schwarz. This calibration system is unique of its kind and has now been installed at all major Rohde & Schwarz service centers around the world, from Singapore to Brazil, where it contributes to the highly accurate control of measuring equipment used on production lines and in labs. The system consists of a number of instruments mounted in transportable, vibration-proof racks, which are remote-controlled from a computer on an IEC/IEEE-bus interface. The nucleus of the system is its software, which is specially generated for each device to be tested and performs the entire calibration process automatically, including the printout of test reports. The basic version is for calibration of signal generators and both analog and digital radio test sets. An extension allows the automatic calibration of spectrum analyzers and test receivers.

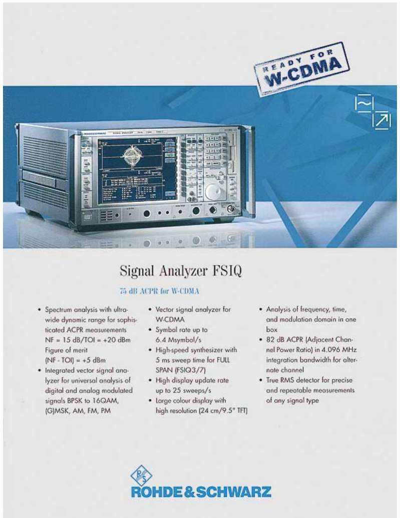
ACS100 is designed for **mobility,** so it can easily be transported to the customer and used on site. Valuable time is thus no longer wasted in transporting the devices to be calibrated back and forth, and flexible use of the calibration system at night and on weekends reduces the downtime of a production line to next to zero. ACS100 is used worldwide, so equipment data and measurement results from all continents can be compared for the benefit of service and repair.

Another feature of this system is its **ease of operation.** Convenient software informs the operator in detail about proper connection of the DUTs and any further interaction. A wide variety of electrical parameters are measured and recorded almost fully automatically at a keystroke, so the system can be operated by any operator having undergone brief familiarization, without requiring the presence of specialists. Furthermore, a support team is permanently available to ensure optimal utilization of the system.

The ACS100 system is in compliance with **ISO guide 25** and therefore allows fast and straightforward calibration to ISO 9000. Another advantage is that the system is largely modular and can easily be extended and matched to future requirements. From the beginning the support team attached great importance to maintaining close contact with the users so that it could respond quickly to customers' wishes and suggestions for optimizing the system. This is an indispensable contribution to providing excellent calibration for Rohde & Schwarz T&M equipment, which in turn leads to greater customer satisfaction.

Hans-Joachim Mann; Gerhard Keßler

Reader service card 161/20



Signal Analyzer FSIQ (20 Hz to 3.5/7/26.5 GHz, resolution 0.01 Hz) With 75 dB ACPR dynamic range, the three models are intended for W-CDMA as well as universal analysis of digital and analog modulated signals; 5 ms sweep time for full span (models 3 and 7), resolution bandwidth 1 Hz to 10 MHz in 1/2/3/5 steps, 5-section resolution filter with high selectivity, FFT filter 1 Hz to 1 kHz, displayed noise floor typ. −150 dBm in 10 Hz bandwidth, total measurement uncertainty <1 dB up to 2.2 GHz, <1.5 dB up to 7 GHz; 24 cm/9.5" TFT display.

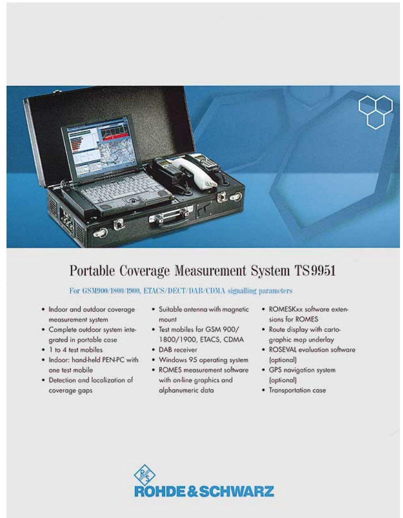
Data sheet PD 757.4160.21 enter 161/21

Noise Generator and Distortion Simulator SMIQ-B17 (RF bandwidth >14 MHz) delivers signals with amplitude and phase distortion for testing receivers.

Data sheet PD 757.4547.21 enter 161/19

MPEG2 Measurement Decoder DVMD is now able to check limit values of null packets and offers optional alarm lines and also a new parallel interface.

Data sheet PD 757.2744.22 enter 161/10



Spectrum Analyzers FSE Models 21 and 31 of FSEM and FSEK are newcomers in the data sheet as well as the optional External Mixer FSE-B21 in both of them.

Data sheet PD 757.1519.26 enter 161/22

DVB-T Modulator SDB-M Numerous modifications of the design concept made it necessary to revise the complete data sheet.

Data sheet PD 757.3634.22 enter 161/23

TV Test Transmitter SFQ Model 10 can now be matched to every application.

Data sheet PD 757.3334.23 enter 161/24

Remote Control & Monitoring System Series 200 RCMS for ATC can be custom-tailored by Rohde & Schwarz. The systems produce, for example, maps, channel overviews and single- or multi-channel displays.

Data sheet PD 757.4218.21 enter 161/25

Portable Coverage Measurement System TS9951 performs measurements to GSM900/1800/1900, ETACS, DECT, DAB and CDMA (IS95, J-STD-008).

Info PD 757.2109.22 enter 161/26

BMS Cover Family TS6200 detects coverage gaps in broadcasting networks (go/nogo and detailed measurements) during mobile and stationary field-strength measurements.

Flyer PD 757.3828.21 enter 161/27

Evaluation Software TS9954 Roseval can be matched to most digital networks for field-strength analysis of measurement results from TS99.. systems.

Data sheet PD 757.4082.21 enter 161/28

HF Dipole HX002M1 (1.5 MHz to 30 MHz, 150 W PEP) The compact version of HX002 is adapted to the complexity of shipboard operation.

Data sheet PD 757.4101.21 enter 161/29

Schz

Test and Measurement Products 1999/2000

The new Rohde & Schwarz catalog is now available in German and English. For the first time it comes with a hard cover and colour illustrations and also includes a CD-ROM with the contents of the catalog. On 432 pages you will find Rohde & Schwarz solutions for mobile radio, EMC and general-purpose measurements together with test equipment for sound and television broadcasting, as well as turnkey test and measurement systems from Rohde & Schwarz. The CD-ROM accompanying the catalog can also be ordered separately.

Catalog CD-ROM PD 757.4560.51
enter 161/30

Kr

50 years of Rohde & Schwarz transmitter design

Left: Europe's first VHF FM sound broadcast transmitter dated 1949; below: most recent VHF FM Transmitter SR610E1 with 10 kW output power and menu-guided operation as well as remote control on various interfaces (see News from Rohde & Schwarz 159 (1998), pp 18–19)

50 years of VHF FM sound broadcast transmitters from Rohde & Schwarz

On 28 February 1949 Rohde & Schwarz delivered Europe's first VHF FM sound broadcast transmitter to Bayerischer Rundfunk in Munich.

There were no home FM receivers at that time, so Rohde & Schwarz designed and built a range of them. Bayerischer Rundfunk presented these receivers to politicians and other VIPs to convince them of the excellent sound quality and reliability of the new broadcasting medium. Orders then followed from the military broadcasters AFN and BFN as well as from other German and foreign broadcasting corporations. This "booster" was successful: VHF FM sound broadcasting became widely accepted.

In the decades that followed Rohde & Schwarz developed many generations of very different FM transmitters for all power classes, moving with the advances in technology and meeting newly emerging requirements. Among the milestones were the introduction of stereo transmission in 1963 as well as unattended operation of large transmitter stations thanks to automation, standby concepts and remote monitoring.

Today the company offers a complete range of transmitters from low power up to high power of 20 kW. The latest generation of solid-state transmitters for digital audio broadcasting (DAB) marks a new era for Rohde & Schwarz in the history of terrestrial broadcasting.

Friedrich Steinhoff

First TETRA project in Germany

Rohde & Schwarz BICK Mobilfunk and Dornier recently signed a contract for the first TETRA project in Germany. It covers a digital *ACCESSNET®*-T trunked radio system for voice and data communication including 42 TETRA RF carriers, distributed among seven sites, as well as special terminal equipment for up to 2500 subscribers. The system will be installed at a training area of the German armed forces. Factory acceptance is planned for October 1999, and in spring 2000 the system is to be installed and put into operation at the training area.

"We won this contract because of our expert competence as an internationally successful manufacturer of trunking systems, the special technical features of our *ACCESSNET®*-T trunked radio system in terms of application orientation and connectivity, as well as the conviction that TETRA is the future-proof technology for professional mobile radio in the next two decades", commented Heinz Bick, Managing Director of R&S BICK Mobilfunk, on the signing of the contract.

PI

DVB-T pilot project in single-frequency transmitter network in Munich region

A pilot project has been started in the Munich region to test digital video broadcasting (DVB) via terrestrial transmitter networks (DVB-T). The participants in this field trial, supported by the Bavarian ministry of economics, transport and technology, are Rohde & Schwarz, Bayerische Medien Technik, Bayerischer Rundfunk, the Institute for

Radio Engineering and Deutsche Telekom. The project went on the air on the occasion of the Bavarian media congress.

To implement the project, a single-frequency network was set up in the Munich region with transmitters located on Munich's Olympic tower, in Freimann and Ismaning. Rohde & Schwarz supplied not only the DVB-T transmitters and modulators but also the measurement equipment for testing the DVB-T system.

Terrestrial DVB is a simple and flexible alternative to TV broadcasting via cable or satellite. DVB-T enables simultaneous transmission of four programs in one analog TV channel. The essential benefit of broadcasting in single-frequency networks is the economy, ie sparse frequency resources can be utilized much more efficiently. In addition, less transmitting power is required and reception is improved through multipath propagation.

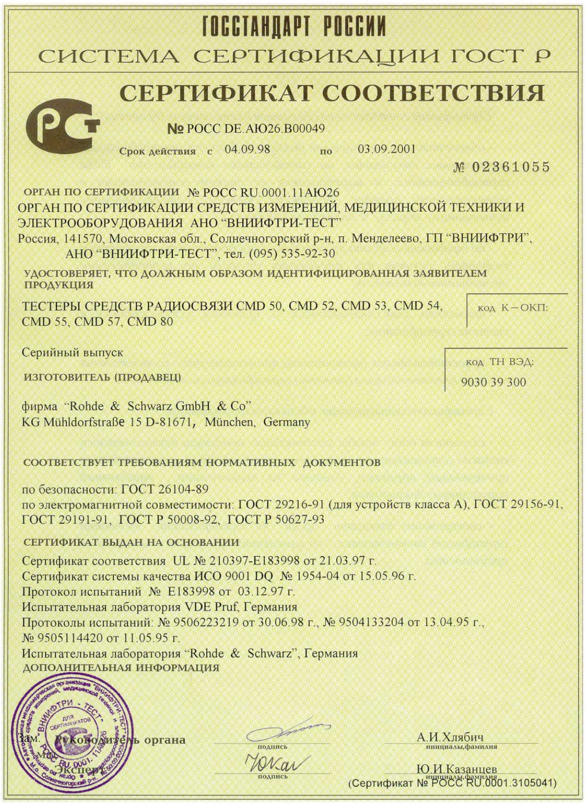
PI

Chair at Tongji University, Shanghai

Tongji University of Shanghai is one of the oldest and most renowned universities in the People's Republic of China. Its history goes back to 1907, when a German doctor founded a medical school following the model in his home country. For decades medicine and engineering sciences have been lectured in German. And at Tongji the German language and the links to the German scientific community still play a more important role than at any other university in China. An aspect deserving special mention is the excellent German language training the Chinese students receive. Therefore it is no wonder that the lady president of the university speaks fluent German. Ms Wu Qidi proved her impressive mastery of German during her short visit to Rohde & Schwarz headquarters (photo), arranged by Prof. Elmar Schrüfer of the chair of electrical measurement engineering at the Munich Technical University. Ms Wu Qidi holds a degree in electrical engineering and studied for several years in Switzerland. The aim of the visit was to get to know Rohde & Schwarz and to discuss the possibilities of future cooperation at university level, especially in the field of electrical engineering/telecommunications.

In the meantime Rohde & Schwarz has decided to endow a chair at Tongji University to document its long-term engagement in China. The company needs well trained Chinese engineers who, beside their qualifications and knowledge of German, are also familiar with German practices and technical standards. In this way Rohde & Schwarz is reinforcing its commitment to China and the Asian market.

Johannes Beckmann



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СЕРТИФИКАТ СООТВЕТСТВИЯ

№ РОСС DE.АЮ26.В00049

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ГОСУДАРСТВЕННЫЙ
КОМИТЕТ РОССИЙСКОЙ ФЕДЕРАЦИИ
ДАРТИЗАЦИИ, МЕТРОЛОГИИ И СЕРТИФИКАЦИИ
(ГОССТАНДАРТ РОССИИ)

ЕРТИФИКАТ

утверждении типа средств измерений

ERN APPROVAL CERTIFICATE
MEASURING INSTRUMENTS

5.002.A № 5449

Действителен до « 01 » октября 2003 г.

тестеров средств радиосвязи

, CMD 54, CMD 55, CMD 57, CMD 80

z GmbH & Co.", Германия

В.В.Таболин

Rohde & Schwarz radiocommunication testers certified for Russian market

Rohde & Schwarz Austria succeeded in obtaining certification of all major radiocommunication test equipment from Rohde & Schwarz for the Russian market. On the basis of this the test equipment is entered in a state register listing all certified instruments from Russia and abroad. The register is a list of preferences that must be adhered to by Russian users when they intend to purchase equipment.

Heinz Heger

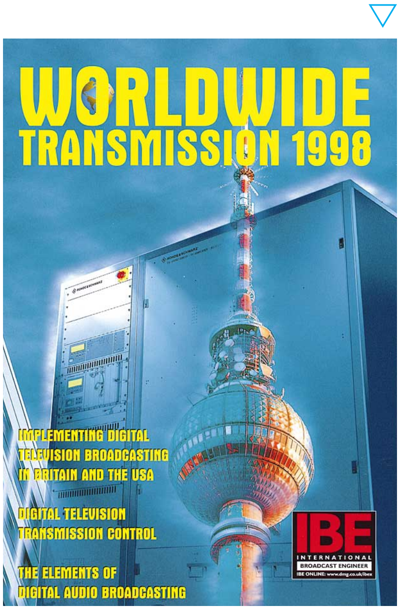
In a masterpiece of a photo, Rohde & Schwarz's EMI Test Receiver ESCS30 took the title spread of the August/98 issue of the magazine "EMV-ESD". This high-speed receiver with standard conformity allround is actually a fusion of three instruments: RF plus IF plus time domain analyzer.

Allrounders for GSM and DECT phones

The September/98 issue of the Swiss technology magazine "Polyskop" referred to Digital Radio Testers CTS60 and CTS65 as multitalents when it comes to servicing GSM and DECT mobile phones:

In Digital Radio Tester CTS65 Rohde & Schwarz is now offering a compact and low-price, multimode service tester for GSM mobiles as well as cordless phones to DECT standard. You can choose CTS60 for the DECT application alone.

On the cover of its special Worldwide Transmission 1998 issue, the "International Broadcast Engineer" shed the right light on solid-state UHF DVB-T Transmitter NV500, another major addition to Rohde & Schwarz's selection of transmission and test equipment for terrestrial digital video broadcasting.



Electronic sleuth

The reputed magazines "Communications International" (10/98) and "Microwave Journal" (7/98) presented Digital Direction Finder DDF0xS for high-speed scanning of crowded communication scenarios:

Wireless communication is increasingly being spread across frequencies or compressed in time. To monitor these signals you need systems that can detect and locate emissions, simultaneously if possible, within a wide frequency band. Digital Direction Finders DDF0xS from Rohde & Schwarz, designed for extremely fast scanning based on fast Fourier transform, go a very long way towards satisfying these requirements, no matter how dense the signal scenario. They are especially suitable for intercepting and locating broadband and short-term signals between 0.5 and 1300 MHz.

Mobile communication systems based on I/Q modulation have increased significantly in recent years. The title of edition 9/98 of the electronic designer's magazine "elektronik industrie" highlighted this trend and a Rohde & Schwarz contribution on the subject, looking at the applications and benefits of I/Q Modulation Generator AMIQ.

Quo vadis T&M?

This was the theme of the 8/98 edition of "Elektronik Journal", which asked specialists of leading firms for their opinion:

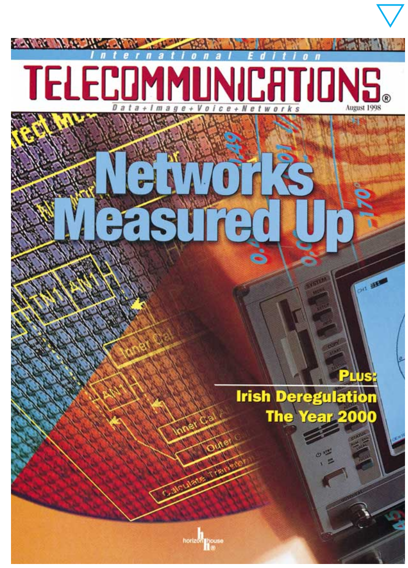
Rohde & Schwarz emphasizes the importance of cooperation deals: "To enable us to serve global markets, we entered into alliances very early on with partners in the USA (Tektronix) and Japan (Advantest)", explained Roland Steffen and David Picken of the Test & Measurement Division. Asked about the challenges of the future, the answer from Rohde & Schwarz was quite clear: "2001 is going to be the year of test & measurement technology for third-generation mobile radio".

Rohde & Schwarz the ideal partner for mobile production

This was the rating awarded by the trade journal "Funkspiegel" in its 2/98 edition, accompanied by a rundown of all the necessary test procedures and test steps:

Being the market leader in test equipment for digital mobile radio, Rohde & Schwarz's range features solutions for all the tests spoken of and for all accepted mobile radio standards. Also available are complete system solutions for the production of mobile radios and cordless phones.

The international edition of "Telecommunications" (8/98) took a look at network measurements and came to the conclusion that the use of new technologies and constantly increasing demands for quality in the offered services leave providers no choice but to have their networks measured. So it was no coincidence that Rohde & Schwarz's Vector Network Analyzer ZVC figured big on the title page.



Picture quality measurements for digital TV

At last a way of measuring the quality of television! There is surely no viewer who would not appreciate it. But to allay great hopes – or even fears – it is not the quality of the contents of TV programs that is meant. This will remain the subjective judgement of the viewer. Here quality means the quality of the picture itself, the requirements and methods of measuring it, the associated problems and newly emerging solutions.

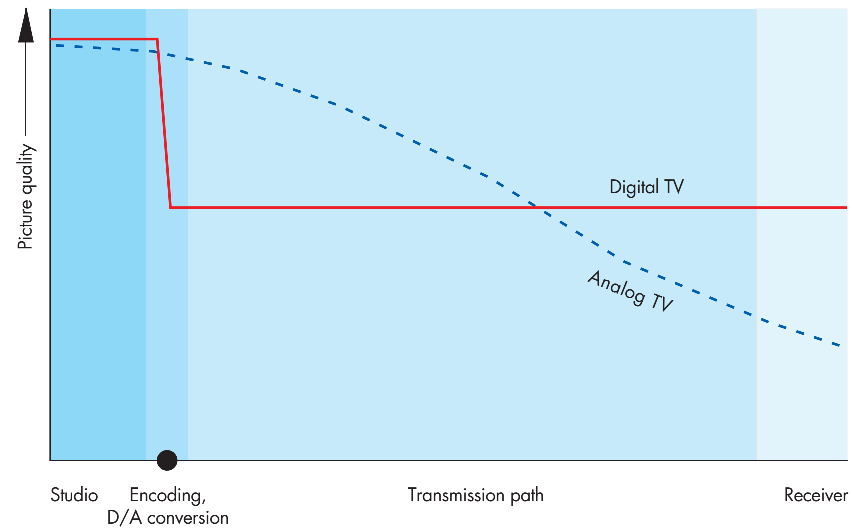


FIG 1 Degradation of picture quality along transmission path in analog and digital TV

New requirements through digitization

Colour television is now in its thirties and the technique is more or less perfect. Why then think about picture quality? The answer is to be found in the transition from the analog TV set to the multimedia home platform. This means that TV terminals are going to allow the viewer to receive innumerable TV programs and work with interactive data services [1]. The basis of all this is digital video broadcasting or DVB [2].

This change greatly affects the picture quality. In analog television, quality is determined by the length and quality of the transmission path. The possible degradations are familiar enough: noise, reflections and blurred pictures. The poorer the transmission path, the poorer the displayed picture. Not so with digital TV. Here the picture quality is essentially determined at the beginning of the transmission link through encoding and multiplexing several programs in a transmission channel (transport stream). Given errorfree transmission of the data signal, the picture quality remains unchanged over the entire path (FIG 1).

Quality problems caused by encoding

Encoding is performed in line with the MPEG2 standard, which enables better utilization of transmission paths by drastically reducing the data rate of the digitized picture. The 270 Mbit/s source signal is converted in several steps to a signal of 5 Mbit/s or even less. Data compression of course affects the video picture. The art of encoding is to make the changes to the data stream so that they remain undetected by the human eye. This is more and more difficult to achieve with decreasing output rate. The picture content itself also has an effect. The finer and more irregular the structures, the more difficult encoding becomes. The MPEG2 standard only describes the tools for data compression and the syntax of the transmission signal. Outlay and quality of the implementation of a video encoder are left to the manufacturers. The achievable picture quality is therefore not only determined by the data rate and the source picture but also by the type of encoder used.

The changes caused in the picture by encoding differ completely from those encountered in analog transmission. The most clearly visible effect is blocking (FIG 2). The reason for this is that to perform data compression the picture is divided into DCT (discrete cosine transform) blocks of 8 x 8 pixels, ie it is converted from the time to the frequency domain. As a result all the measurement techniques used so successfully for many years in analog TV for determining the picture quality have become redundant.

Subjective quality measurements to ITU

How do you distinguish a good encoder from a less good one? How do you determine the minimum acceptable data rate? And finally, how can you monitor picture quality during transmission? These requirements call for a test method that evaluates the picture signal itself and takes into account the perception capabilities of the human eye. The best way would be to include the viewer in the process. There is no accounting for tastes however, so the results obtained this way could only be subjective. For comparison and reproduction of results, the ITU (International Telecommunication Union) specified several test methods [3].

FIG 2 Clearly visible blocking effects on digitally coded TV picture and – by comparison – picture without blocking with quality values to SSCQE (subjective) and DVQL (objective)

Two methods are used among others. With the DSCQS (double stimulus continuous quality scale) method the test sequence to be judged and the original (eg before processing) are presented to the test person. A quality mark on a continuous scale is assigned to the two sequences, each of which is about 10 s long, and the difference is further evaluated. The employed scale of 0 to 100 covers the quality levels excellent / good / fair / poor / bad as specified by ITU and all values in between (FIG 3). This method permits even very slight quality differences to be resolved.

With the second method, called SSCQE (single stimulus continuous quality evaluation), only the sequence to be assessed is displayed. During the presentation the test person moves a slider on a scale from 0 to 100 according to his/her subjective impression of picture quality. This value is sampled at a frequency of 2 Hz, thus yielding two quality values per second. The method can be used when no original sequence is available as a reference and thus corresponds better to the real-life situation of the TV viewer who cannot see the picture recorded in the studio.

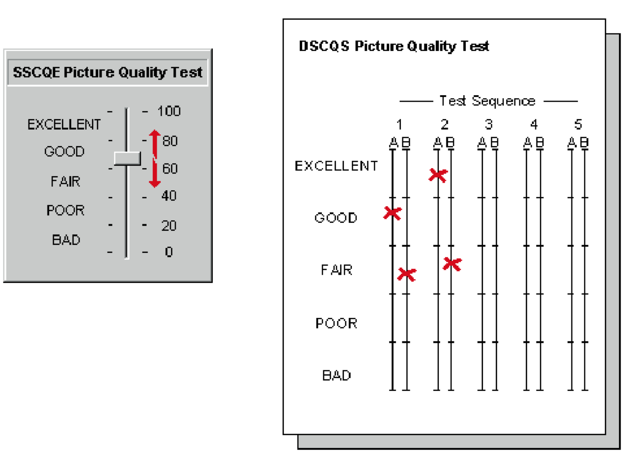


FIG 3 Quality scale for comparative (DSCQS) and absolute (SSCQE) assessment of picture sequences

Both methods take into account the subjective perception of the human eye. It was found, for instance, that quality degradation in fast-motion pictures or pictures showing very many details is not perceived to the same degree as in slow-motion pictures or pictures containing few details only (masking effect caused by high level of activity in time and content).

New objective test method from Rohde & Schwarz

To obtain reproducible results from subjective tests, long test sequences have to be performed, which are very time-consuming. This may be acceptable for basic investigations but not for the quality assessment required during program transmission. For this reason Rohde & Schwarz started up the "picture quality analysis" development project. The aim of the project was the development of a method for realtime, objective quality assessment of DCT-coded picture sequences without needing a reference signal.

As in other developments in the past, the Institute for Communications Technology of Braunschweig Technical University was brought in to collaborate. The worldwide successful MPEG2 Generator DVG and Measurement Decoder DVMD are the result of such cooperation in previous projects [4]. In the present project the institute headed by Prof. Ulrich Reimers has developed the desired method, which is based on picture data analysis. The result of the analysis, the DVQL-W (digital video quality level – weighted), corresponds to the subjective quality value obtained by the SSCQE method on a scale from 0 to 100. It also takes into account the above-mentioned masking effect of human perception. The correlation between the objective quality values (DVQL-W) obtained with the new method and the subjective quality assessments (to SSCQE) performed as a trial is better than 90% (FIG 4).

The new method was presented to an astonished expert audience during lectures given at the annual meeting of the FKTG in Erfurt in May 1998 and at the IBC show in Amsterdam in September of the same year [5]. The topic is also receiving a great deal of attention in national and international technical publications [6; 7]. The demand is great, so Rohde & Schwarz is working intensively on getting an instrument onto the market that uses this method among others for the quality assessment of DCT-coded picture sequences in realtime and without a reference signal.

Alexander Wörner; Harald Ibl

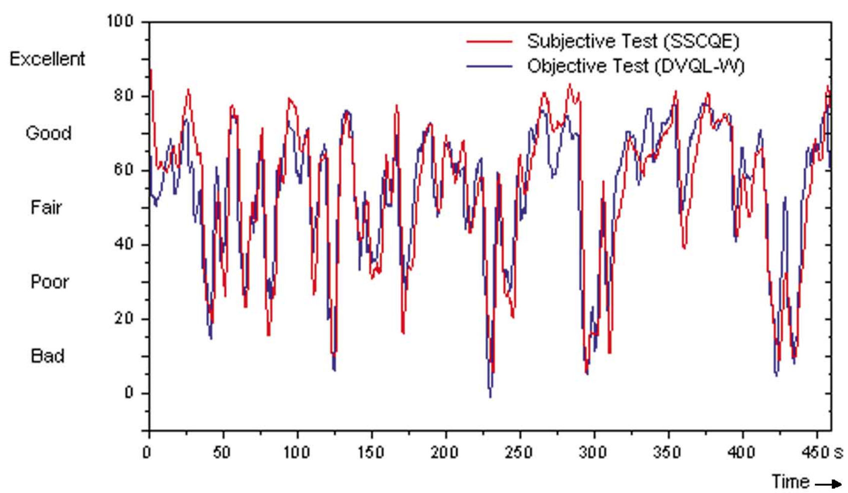


FIG 4 Comparison of objective test results (DVQL-W) and subjective quality assessments (SSCQE) for 480 s sample sequence

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