News from Rohde & Schwarz

TETRA radio systems for secure professional mobile communication

Versatile EMS and EMI measurements for the automobile sector

Fully automatic radiomonitoring system for increasing demands

2003/II
178

ROHDE & SCHWARZ

TETRA, the worldwide digital standard for professional mobile radio, offers excellent speech quality, high data transmission rates and secure, encryptable connections (page 4). The TETRA *ACCESSNET*®-T mobile radio system from Rohde&Schwarz features outstanding characteristics (starting on page 6).

MOBILE RADIO

TETRA radio systems

Test systems

Protocol testers

A new software option combines the R&S CRTU-G and R&S CRTU-W protocol testers to form an expandable and versatile 2G/3G system simulator (page 22).

Radiocommunication testers

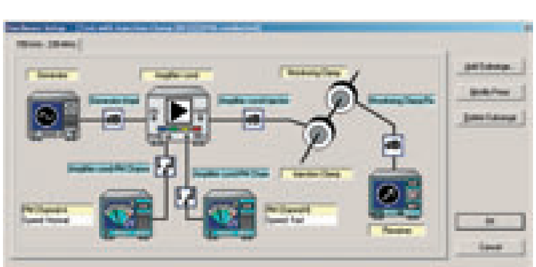
GENERAL PURPOSE

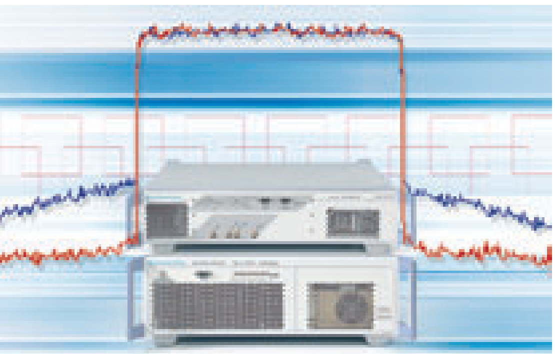
Signal analyzers

EMC/FIELD STRENGTH

Test systems

EMC Measurement Software R&S EMC32-A is a powerful tool that is specially tailored to measurements in the automobile sector in line with ISO 11451/2 and CISPR25 standards as well as to manufacturer-specific measurement procedures (page 36).





Low-power TV Transmitter R&S SV 7002 for DVB-T with 55 W output power (page 48). The Exciter R&S SV 702 (top) can be retrofitted with a new module for automatic precorrection (page 51).

R&S AMMOS® is a universal family of systems for monitoring analog and digital signals in the HF, VHF and UHF frequency ranges (page 56).

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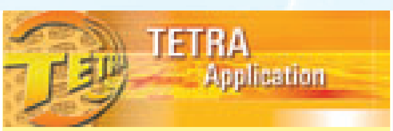
TETRA – the digital standard for professional mobile radio

TETRA, the worldwide digital standard for professional mobile radio, offers excellent speech quality, high data transmission rates and secure, encryptable connections.



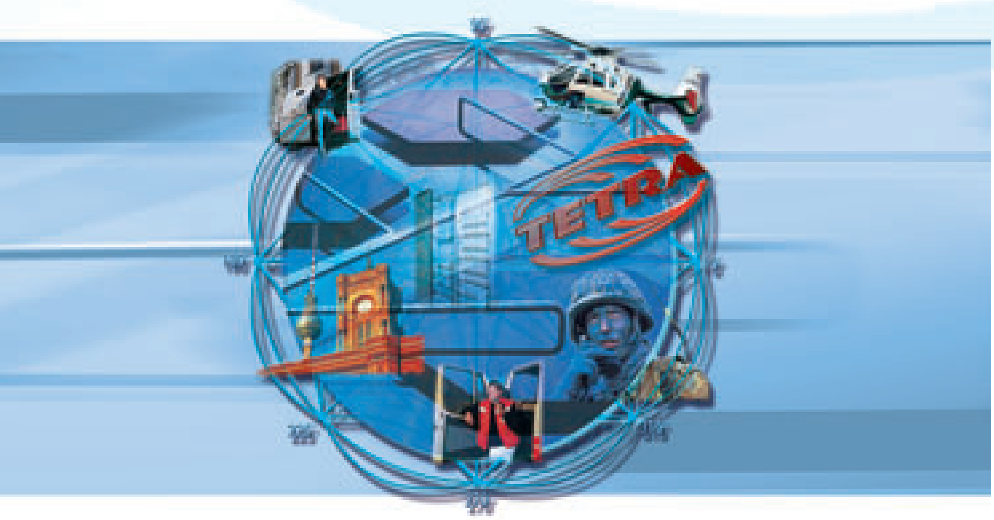
See page 6 for *ACCESSNET*®-T, the digital TETRA mobile radio system from Rohde & Schwarz.

TETRA – an open standard

At the start of the 1990s, the European Telecommunications Standards Institute (ETSI) was commissioned by the EU to create a European standard for professional digital radio. The most important parts of the TETRA standard (terrestrial trunked radio) were adopted at the end of 1995 in national votes.

The influence of users on the development of TETRA can be clearly seen. Government authorities and organizations with security missions in particular have worked together intensely to achieve standardization. Specifically, the compatibility required by the Schengen agreements is not possible without an approved European standard such as TETRA. The sophisticated and thorough voting procedure ensured the standard's high quality and functionality for professional mobile radio users, which cannot be achieved by proprietary technologies. TETRA has meanwhile been introduced on all continents and like GSM is well on the way to becoming a world standard.

NATO in the past released one of its frequency bands – 380 MHz to 400 MHz – and made it available to European NATO countries for use by government authorities and organizations with security missions. The European TETRA standard and the harmonized frequency bands make it possible for the first time to implement a Europe-wide public safety network.



Features of professional mobile radio systems

The most important requirement for mobile radio networks for professional use is availability and security against eavesdropping. Secure physical connections are based on proper technical planning of the network but also on the possibilities offered by the standard. For instance, the handover specified in the TETRA standard ensures that a call can continue smoothly even when moving from one cell to another.

Security against eavesdropping is attained by encryption. For this purpose, the TETRA standard also contains specifications that define the encryption of the air interface and/or end-to-end encryption, for instance.

In emergencies, quick call setup in a public safety network is essential, because every second counts. The call setup time in a TETRA radio cell is therefore ≤300 ms.

Another important feature of professional mobile radio networks, and primarily of public safety networks, are the group-call functions, since the overwhelming majority of communication between users is via group calls. The head of a police or fire-department squad does not inform each squad member individually but passes the information on to everyone involved at the press of a button.

TETRA systems provide radio connections in all conceivable forms. They support voice communications (single, group and announcement call), data transmission (circuit mode data and packet mode data) and short data service using a wide range of data transmission rates and error-protection levels. TETRA employs TDMA (time division multiple access) technology with four integrated communication channels at 25 kHz channel bandwidth.

Harald Haage

TETRA

… world standard with many advantages:

Fast data transmission

TETRA provides 7.2 kbit/s on a communication channel. If necessary, up to four channels can be banded, increasing the data rate to as high as 28.8 kbit/s. Currently work is underway to enhance the standard for even higher transmission rates.

Diverse interfaces

To ensure a standard that is open and used by many manufacturers, TETRA defines the following basic interfaces:
The **air interface** establishes compatibility between terminals of different manufacturers.
The **device interface** guarantees the independent development of mobile radio applications.
The **intersystem interface (ISI)** allows the connection of TETRA networks of different manufacturers.
The **direct mode** ensures secure communication when exiting the covered area, enabling direct radio traffic between mobile radios without the need of a network infrastructure.

Interfaces to wired communication networks are also standardized, leaving only the design of the interfaces within the infrastructure up to the manufacturers. Standardization makes for fair competition, but gives third parties the freedom to implement economical solutions for applications.

Outstanding cost efficiency

The open TETRA standard ensures fair competition. Industry's broad support of TETRA allows users to choose from a large number of companies at reasonable prices.

Secure cooperation

Cooperation between different types of radio networks is becoming more and more important. TETRA networks make it possible to have a large number of connections to external communication networks. For instance, TETRA networks can be connected with public and private telephone networks, different kinds of data networks and also with large command and signalling networks. All these networks can be accessed from mobile radios. Virtual networks within the TETRA radio network ensure that every organization can work independently without requiring its own infrastructure and without having to give up the advantages of a large multifunctional system with efficient resource management.

Open for applications

The open interfaces allow users to create applications or to have them created. A lot can be planned and taken into account in advance except, of course, one thing – a fully turnkey solution for a communication network. The openness of the TETRA standard, however, will help users get closer to their ideals, since it provides room for new applications and enhancements.

ACCESSNET®-T – the digital mobile radio system from Rohde & Schwarz

On board from the start

R&S BICK Mobilfunk, the competence center for mobile radio communication in the Rohde & Schwarz group, collaborated on the ETSI standardization of TETRA – the best insurance that *ACCESSNET*®-T professional mobile radio systems from Rohde & Schwarz conform fully to standard. Since 1995 the company has been a member of the Memorandum of Understanding (MoU), the European association of organizations sharing an interest in the promotion and implementation of TETRA, which comprises more than 80 renowned companies today (information: www.tetramou.com).

ACCESSNET®-T: unlimited scalability

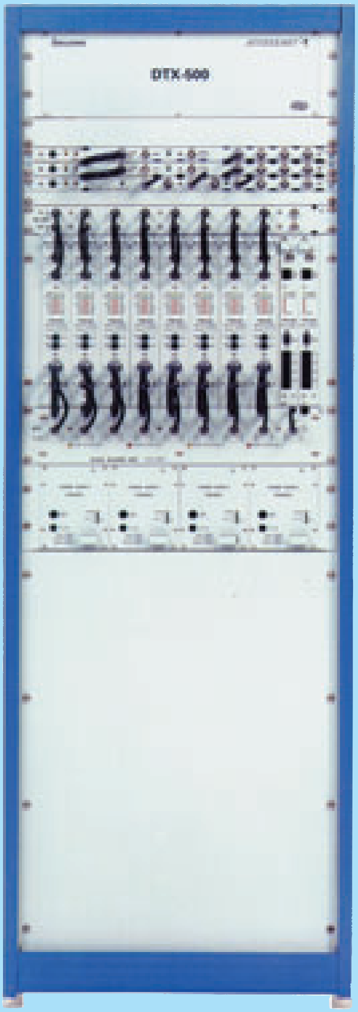
The network structure of the digital mobile radio system *ACCESSNET*®-T is non-hierarchichal and subject to no topological restrictions. The system's suitability for multiprotocol applications allows it to be used as a digital platform for professional mobile radio networks that must meet high availability requirements. The high spectrum efficiency of the standard and the system ensure optimum utilization of the scarce frequency resources.

ACCESSNET®-T is extremely scalable – from a small network at a single company location all the way up to nationwide networks. Mobile radio systems from Rohde & Schwarz can be expanded to suit one's needs, no matter whether more voice capacity is needed or the network has to grow in size. Network nodes can be coupled with each other by means of digital fixed-network connections as well as by microwave link.

***ACCESSNET*®-T is extremely scalable – from a small network at a single company location all the way up to nationwide networks.**

ACCESSNET®-T

… in all sizes from a single source:



From the mini-base station for outdoors (below) to large systems for nationwide networks (right): Rohde & Schwarz offers a comprehensive range of products from a single source.

Any non-Rohde & Schwarz terminal that fulfills the TETRA interoperability profile (TIP) can be operated in an *ACCESSNET®*-T mobile radio system.

TETRA Application

Rohde & Schwarz is one of the leading manufacturers of MPT-1327 and TETRA mobile radio systems for professional users. The company has a 70 % market share of MPT-based systems, setting a standard for both performance and quality. Worldwide more than 250 000 subscribers work with mobile radio systems from Rohde & Schwarz at ministries of the interior, local transit services, airports, train stations and public network operators. This substantiates the efficiency of our single-source, all-in-one solutions:

- Network and project planning
- Exchange equipment
- Base stations
- Network management systems
- Applications
- End-to-end encryption
- Dispatcher systems
- Turnkey installation

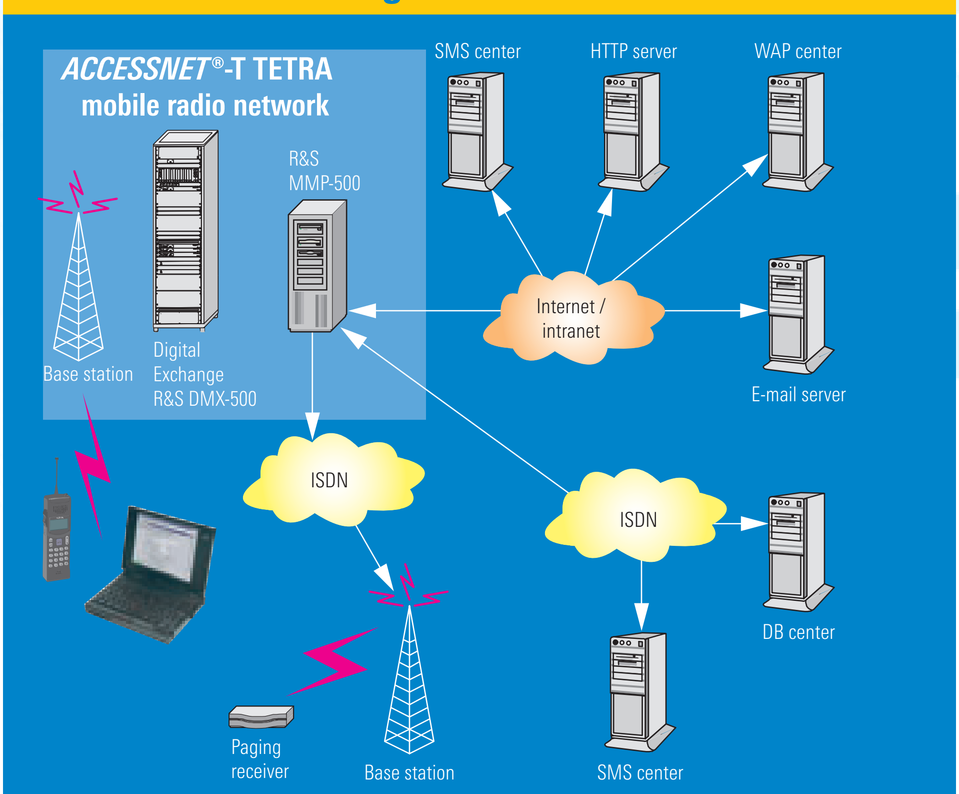
Tried-and-tested and new go well together

Customers appreciate Rohde & Schwarz as a reliable partner, especially when it comes to securing their investments. This is evident in the "soft migration", the Rohde & Schwarz strategy for the transition from MPT-1327 mobile radio systems (including those of other manufacturers) to the modern digital TETRA standard. *ACCESSNET*®-T's multiprotocol capacity makes this possible, as it allows mixed MPT and TETRA user groups to coexist side by side with the use of both technologies and provides a common subset of services.

Fit for all applications

Professional mobile radio systems have to be universally adaptable. After all, they must prove their performance with public network operators and local transit companies, at airports and train stations, for ministries of the interior and in a wide range of other applications. The basic requirement for integrating any kind of application into a TETRA network are standardized interfaces. *ACCESSNET*®-T's superb design provides the ideal conditions for its integration into any user-specific structures.

The bridge into the Internet



The Multi-Messaging Portal R&S MMP-500 connects *ACCESSNET*®-T TETRA mobile radio systems to the Internet and thus to corporate networks as well. This provides mobile subscribers using professional radio with access to information, data applications and messaging services (News from Rohde & Schwarz (2003) No. 177, pp 4–5).

More information, brochures and data sheets at www.rsbick.de (search term: ACCESSNET)

ACCESSNET® -T

… securely encrypted:

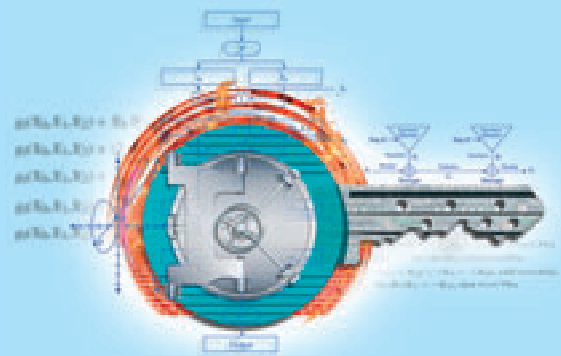
Comprehensive encryption with Rohde & Schwarz

Encryption on the air interface is standard with TETRA. However, this does not cover the entire transmission path from subscriber to subscriber.

For encryption along the entire transmission link, Rohde & Schwarz provides comprehensive solutions for *ACCESSNET*®-T. Rohde & Schwarz SIT GmbH, the Rohde & Schwarz subsidiary that specializes in security in information technology, is Germany's largest supplier of professional encryption methods. It is developing a base system for end-to-end encryption for TETRA radio systems (see box at right).

Examples of the numerous mobile radio networks set up by Rohde & Schwarz on pages 10 to 13.

End-to-end encryption for TETRA from Rohde & Schwarz



The base system for TETRA end-to-end encryption features, for example, full-duplex voice encryption, SDS (short data service) encryption and loadable crypto algorithms.

The base system concept ensures users maximum flexibility:

- The concept's modular design makes it possible to integrate user-specific requirements by cost-efficient adaptation of developments using the base system.
- The concept uses intelligent chipcards (smart cards) of the latest generation as a security module and is therefore largely hardware-independent, for the only thing that terminal equipment manufacturers need to do is adapt the equipment software. Hardware modifications are not necessary for terminals equipped with a SIM card interface, which allows new equipment to be introduced at a favourable price.

Advantages of the smart card solution from Rohde & Schwarz

Flexible and economical

- Complete single-source TETRA network and encryption package from Rohde & Schwarz
- End-to-end encryption independent of the terminal manufacturer
- Loading of user-specific crypto algorithms
- User-specific requirements can be integrated by means of cost-effective adaptation of developments
- Smart cards are easily replaceable and allow battery-saving operation

High degree of confidentiality

- The smart card solution for end-to-end encryption is supported by Germany's Federal Office for Information Security (BSI)
- Compatible with the requirements of the Schengen agreement

Reliable perspective for the future

- The smart card technology is largely standardized (ISO, ETSI)
- The further development of smart card technology provides a safe basis for investment
- Smart cards are a recognized technology in other radio networks

ADONIS – the national *ACCESSNET®*-T security radio network in Austria

In Austria a nationwide, standardized digital mobile radio network for government authorities and relief and rescue organizations is being set up. It fulfills the requirements of the Schengen agreement and allows international cooperation with neighbouring countries. For this purpose, the Austrian ministry of the interior commissioned the Vienna-based company master-talk as the network operator to provide the necessary digital radio services in defined quality.

In summer 2002, Siemens Austria as the general contractor in charge of setting up the network placed the order with R&S BICK Mobilfunk. All necessary material for phase 0, i.e. 90 base stations and 6 exchanges, were delivered at the beginning of February 2003, fulfilling the requirements for on-time implementation of this initial setup phase.

Austrian territory covers an area of 83855 km². ADONIS – Austrian digital operating network for integrated services – ensures nationwide TETRA radio coverage with 1288 base stations, 30 exchanges and several network management centers. Setup of the network will be in a number of phases and completed in the first quarter of 2006.

The ADONIS subscriber groups come from the following domains:

- Federal and state police
- Federal army
- Customs officials
- Judicial organizations
- Rescue services
- Fire departments
- Provincial government offices / disaster control
- Country administration
- Local police

The crucial factor for users of a mobile radio network is not so much the availability of an individual network element but rather the availability of services at a desired time and place. Besides purely technical aspects, the influences of natural phenomena and catastrophes must be taken into account, as well as the possibility of violent external intervention.

To face these dangers and ensure system availability, the *ACCESSNET®*-T network is based on a unique system design. Instead of redundant components, the network employs an intelligent concept called "graceful degradation" that utilizes the existing capacity reserves.

The ADONIS architecture is based on the principle of exchange clusters. A cluster consists of two exchanges at two different locations serving a number of base stations (illustration in box opposite). The base stations are interlinked between the exchanges, so each base station chain is connected to both exchanges. For normal operation, the base stations of a chain can be assigned to an exchange as desired, depending on the traffic volume.

Within a network there are usually areas in which particular demands on system availability are made as well as coverage areas of lesser importance. The system design ensures that important elements within a network can have greater protection than others, providing protection that can be varied within a broad range.

The illustration in the box on the opposite page shows the radio coverage area and its subdivision into clusters selected for ADONIS. The network consists of five clusters with exchanges at ten locations. To compensate for the complete failure of an exchange and provide continued coverage for all base stations, each exchange normally serves only half of the base stations that its capacity allows. The effects of natural phenomena or violent interventions can be efficiently reduced in this way.

Each exchange can operate one application interface and a number of line interfaces. All the line interfaces of a cluster are combined to form an additional network element for connecting to other telecommunications networks (PABX, ISDN). Likewise the combination of all application interfaces of a cluster creates a common TETRA application plat-

ADONIS

… secure with *ACCESSNET®*-T:

form, allowing control centers to be connected, databases to be accessed, communication to be recorded and switching to e-mail and SMS to be implemented via the Multi-Messaging Portal R&S MMP-500.

The ADONIS mobile radio network is monitored by several network management centers which are also connected with exchange clusters following the concept of high system availability.

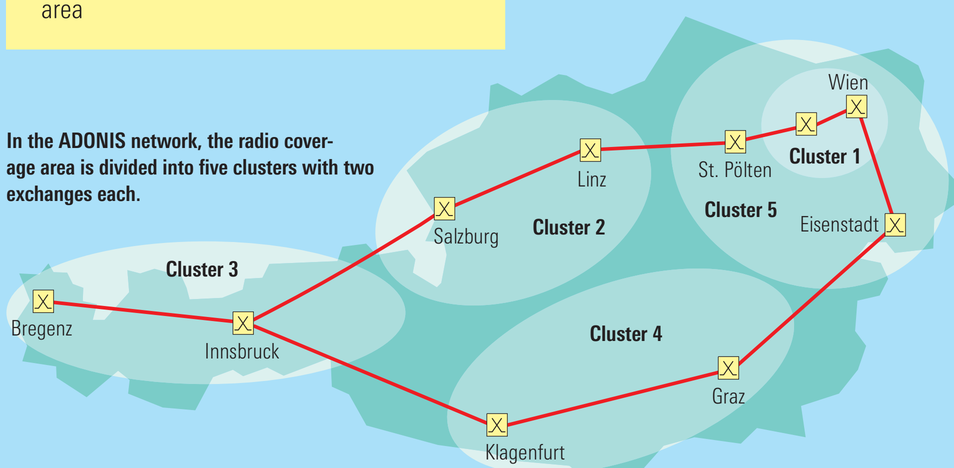
Basically all market-approved and function-certified TETRA terminals can be used in the *ACCESSNET®*-T mobile radio network. The ministry of the interior will select specific devices to be used in ADONIS for the different applications. The devices together with the radio network are subject to continuous monitoring. This helps to ensure the quality of the digital TETRA mobile radio services agreed with the network operator.

In implementing the ADONIS network, the main focus is clearly on mobile communication security. *ACCESSNET®*-T is a TETRA mobile radio network that applies a unique concept to ensure high system availability and stability against all conceivable malfunctions.

Max Zerbst

Progress of the project

- **July 2001**
  Tenders obtained and assessed
- **July 2002**
  Order placed
- **March 2003**
  Phase 0 put into operation; approx. 3% of the area (provincial capitals or a defined district)
- **December 2003**
  Phase 1 put into operation; approx. 35% of the area (provincial capitals or a defined district)
- **December 2004**
  Phase 2 put into operation; approx. 75% of the area
- **December 2005**
  Phase 3 put into operation; approx. 95% of the area



In the ADONIS network, the radio coverage area is divided into five clusters with two exchanges each.

NOAH –
emergency help in a flash via *ACCESSNET*®-T

The modernization of the analog public safety radio network is currently being discussed in Germany. The network is about 30 years old, is no longer state of the art and, above all, does not meet today's safety requirements.

When the topic of public safety radio networks comes up, it is usually about the police security network. But public safety also includes other organizations, such as fire departments, relief organizations, border guard and rescue services. Thus when a digital public safety radio network is set up, the needs of all organizations must be taken into account.

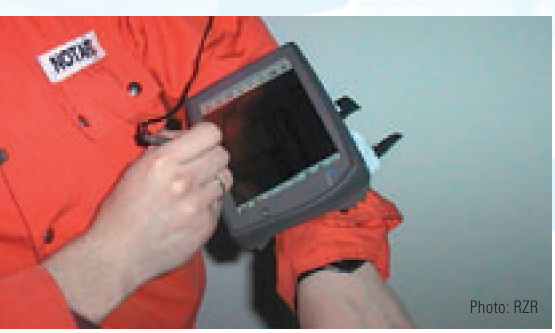


Photo: RZR

Using NOAH *), it was possible to prove just how efficient the digital mobile radio system *ACCESSNET*®-T from Rohde & Schwarz is when it comes to integrating customer-specific solutions. In collaboration with Siemens AG Austria and the Regensburg emergency service center (RZR), the safe and quick data transmission system for emergency medical intervention NOAH developed by RZR was integrated for use with *ACCESSNET*®-T.

The principle of NOAH

Time losses in information transfer are unacceptable, especially when seriously injured accident victims or heart attack patients are involved. Often, however, the methods and procedures used are not ideal, and a large share of the deficits can result from using outdated communication equipment and channels. Another weak point may be the documentation if it is incomplete or imprecise.

To solve these problems, RZR has developed an innovative communications concept. NOAH improves the emergency doctor's communication link to the rescue control center and the casualty departments of hospitals and ensures comprehensive electronic documentation of emergency procedures.

Photo: RZR

This essential component of NOAH, the emergency documentation (emergency medical intervention protocol), meets the requirements of the German Interdisciplinary Association for Intensive and Emergency Medicine (DIVI).

A pocket PC with pen and the NOAH software, which runs under a commercially available Windows® operating system, serves as the input device for NOAH. Data can be transmitted via TETRA terminals with a PEI (peripheral equipment interface) and the TETRA radio network *ACCESSNET*®-T. One TETRA terminal is connected to the serial interface of the pocket PC, and the second terminal is in the rescue control center.

Procedure and communication

Once the alarm has been received, the emergency doctor gets the relevant details from the rescue control center. Within the first three to five minutes after arriving at the scene of the accident, the doctor enters the initial report data (suspected diagnosis, patient's

*) NOAH is a joint project for emergency, organizational and working aid headed by RZR e.V. and subsidized by the European Structural Fund and the State of Bavaria.

characteristics, specialized disciplines required, etc) into the pocket PC and transmits this sensitive personal patient data to the rescue control center, e.g. via the digital TETRA mobile radio network *ACCESSNET*®-T. Entering the data takes no more than 15 seconds, and the control center can immediately suggest a target clinic.

After the emergency doctor has selected the target clinic, the clinic is sent the initial report data and can thus make optimal preparations for looking after the patient. The use of NOAH and the reliable data transmission via the *ACCESSNET*®-T radio network thus gains valuable minutes for the patient.

To be able to transmit data, however, a connection must first be set up. With an approximate call setup time of only about 300 ms, *ACCESSNET*®-T provides the ideal conditions. Transmission within the *ACCESSNET*®-T network runs via a circuit-mode link. A timeslot is used to transmit data at 7.2 kbit/s. With larger amounts of data, the transmission rate can be increased to as high as 28.8 kbit/s by channel banding.

Harald Haage

ACCESSNET®-T

… successful all over the world:

R&S BICK Mobilfunk, the competence center for mobile radio systems in the Rohde & Schwarz group, has many years of experience and has installed systems in numerous countries. A small sampling of the company`s achievements around the globe:

Russia
ACCESSNET®-T mobile radio system for the Russian petroleum supplier SIBNEFT in Nojabr´sk, Sibiria

Latin America
The first TETRA mobile radio system of Latin America for Mexico's state-owned power company Comisión Federal de Electricidad (CFE)

Austria
National security radio network ADONIS (page 10)

Germany
TETRA mobile radio system for the German Armed Forces at Europe's most advanced **combat training center** (News from Rohde & Schwarz (2001) No. 172, pp 8–11)

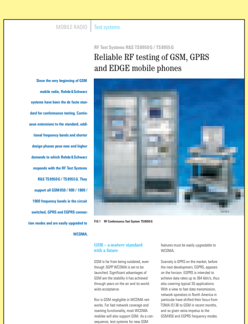
TETRA mobile radio network for police in **Lower Saxony**

WCDMA Test System R&S TS 8950 W

Conformance test system for WCDMA

The WCDMA Test System R&S TS 8950 W expands the Rohde & Schwarz portfolio of RF conformance test systems and provides an all-in-one solution suitable for development tests as well as for the certification of terminal equipment. The new test system for manufacturers and independent test laboratories performs all transmitter, receiver and performance tests according to the 3GPP test specification TS 34.121 fully automatically.

The new test system is based on the Test System R&S TS 8950 G introduced in News from Rohde & Schwarz 174. Both have virtually the same appearance.


MOBILE RADIO | Test systems

RF Test Systems R&S TS 8950 G / TS 8955 G

Reliable RF testing of GSM, GPRS and EDGE mobile phones

Since the very beginning of GSM mobile radio, Rohde & Schwarz systems have been the de facto standard for conformance testing. Continuous extensions to the standard, additional frequency bands and shorter design phases pose new and higher demands to which Rohde & Schwarz responds with the RF Test Systems R&S TS 8950 G / TS 8955 G. They support all GSM 850 / 900 / 1800 / 1900 frequency bands in the circuit switched, GPRS and EGPRS connection modes and are easily upgraded to WCDMA.

FIG 1 RF Conformance Test System TS 8950 G

GSM – a *mature* standard with a future

GSM is far from being outdated, even though 3GPP WCDMA is set to be launched. Significant advantages of GSM are the stability it has achieved through years on the air and its worldwide acceptance.

Nor is GSM negligible in WCDMA networks. For fast network coverage and roaming functionality, most WCDMA mobiles will also support GSM. As a consequence, test systems for new GSM features must be easily upgradable to WCDMA.

Scarcely is GPRS on the market, before the next development, EGPRS, appears on the horizon. EGPRS is intended to achieve data rates up to 384 kbit/s, thus also covering typical 3G applications. With a view to fast data transmission, network operators in North America in particular have shifted their focus from TDMA IS136 to GSM in recent months, and so given extra impetus to the GSM 850 and EGPRS frequency modes.

News from Rohde & Schwarz 4 Number 174 (2002/II)

All tests for certification

The new test system performs not only tests in line with R&TTE (Europe) and FCC (USA) but also all RF tests prescribed by the GCF (Global Certification Forum) for the certification of terminal equipment. A unit will not be approved for use on the market until all these tests have been passed. The test system is based on the hardware and software platform of the well-known GSM Test System R&S TS 8950 G [1], which can also be upgraded to the R&S TS 8950 W. The fully configured Test System R&S TS 8950 G / W makes it possible to test 2G (GSM), 2.5G (GPRS) and 3G mobile phones.

Configuration and characteristics

The 3GPP standard TS34.121, which describes the conformance tests, divides the tests into transmitter, receiver, performance and radio-resource-management (RRM) tests. The Test System R&S TS 8950 W supports transmitter, receiver and performance tests; for RRM test cases Rohde & Schwarz offers a separate test system.

FIG 1 shows the block diagram of the R&S TS 8950 W. For testing terminal equipment, the test system simulates a WCDMA base station and a number of interference signal sources. The WCDMA base station is simulated by the WCDMA Protocol Tester R&S CRTU-W [2], whose two independent RF channels ensure that even complex test cases such as diversity tests can be performed. The analyzer sets up a connection to the DUT and switches it to the loopback mode, in which all data received from the protocol tester is returned to the test system. The data is then available in the test system for the different measurements. Among other measurements, the Spectrum Analyzer R&S FSU determines the output power and the modulation characteristics.

The system includes a Vector Signal Generator R&S SMIQ 03 B, which generates the WCDMA-modulated interference signal, and by a Microwave Generator R&S SMP 02, which generates the unmodulated interference signal for the blocking and the intermodulation test.

The Baseband Fading Simulator R&S ABFS simulates signal fading that results from multipath propagation and Doppler shift. Like the protocol tester, it is equipped with two channels, so that fading characteristics can be added to two signals independently of each other.

The signal switching and conditioning unit (SSCU) and the advanced signal conditioning unit (ASCU) – two modules containing relays, directional couplers, combiners, amplifiers and several filters – amplify and filter all signals. The SSCU is independent of the standard, whereas the ASCU contains standard-specific components.

The test system is rounded out by a Rubidium frequency standard used as a time reference and a power meter with two probes for path calibration. A system controller controls all test units via diverse interfaces.

Key features of the new test system

- Existing Test Systems R&S TS8950G can be upgraded to a combined GSM/WCDMA Test System R&S TS8950G/W
- High measurement accuracy for conformance test cases and other test cases as well
- Calculation of measurement accuracy for every test case in realtime
- Flexible, convenient user interface
- Generation of user-defined test cases without additional programming
- Wide range of logging and analysis tools

High measurement accuracy

An outstanding feature of the R&S TS8950W is its high measurement accuracy. Through the use of complex mathematical operations and a sophisticated calibration concept based on Rohde&Schwarz's many years of experience in the development of conformance test systems, the measurement uncertainties are well below the maximum permissible limit specified by the 3GPP standard TS34.121. Accuracy is maintained not only in conformance tests but also when the user has changed the tests. This is ensured by a special algorithm that – depending on the actual measurement parameters, such as frequency, level, etc – automatically finds the most favourable path through the SSCU and subsequently calculates the measurement uncertainty for the selected path by taking the instrument settings into account.

GCF test cases and user-specific adaptation

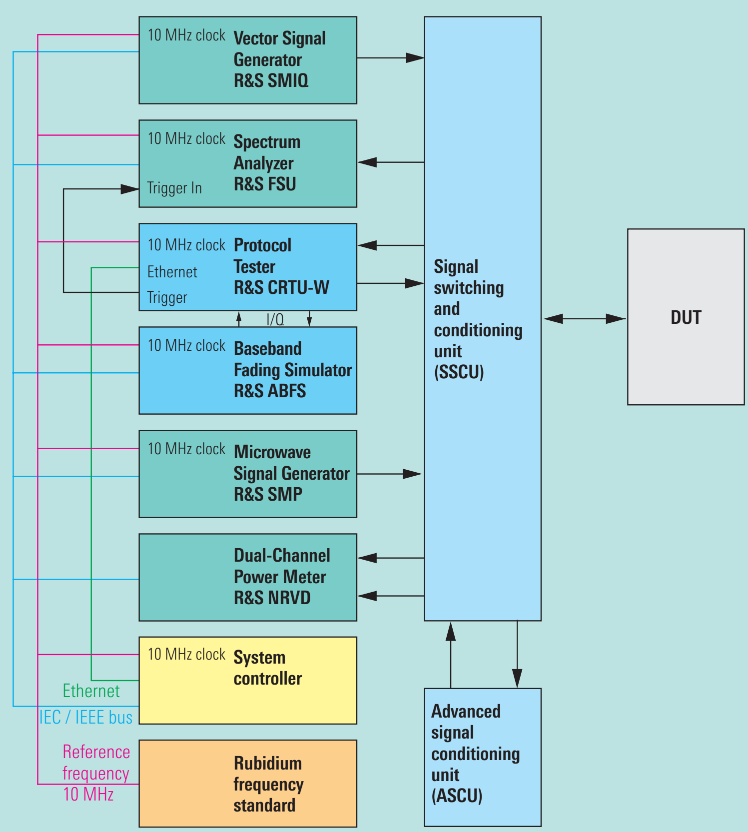
Besides the fully automatic tests according to GCF test specification and requirements, test cases can be adapted and modified to suit the user`s specific needs. Using the PASS software (parametric application software for test systems) from Rohde&Schwarz, all test cases are based on a few test methods. The nearly 40 WCDMA test cases are mapped onto just eight test methods. Receiver tests, for example, are covered by only one test method with some 50 parameters. Test cases are defined by means of parameter sets. Besides the frequency and level of payload and interfering signals, channel configurations, fading profiles or the number of measured samples are available as parameters. FIG 2 shows the parameter list for the Spectrum Emission Mask test case. The parameter sets can be modified, expanded or com-

Cost-efficient modular design

The Test System R&S TS8950W is based on the hardware and software platform of the GSM Test System R&S TS8950G, which has been used in a wide range of applications. The main difference in the hardware of the two systems lies in the different protocol testers and in the ASCUs. By adding a WCDMA protocol tester and one or more ASCUs, a GSM Test System R&S TS8950G can be upgraded to a full-compliance Test System R&S TS8950G/W for 2G (GSM), 2.5G (GPRS) and 3G tests. When fully configured, a test system of this kind supports four GSM bands (850, 900, 1800 and 1900 MHz) and three WCDMA bands (FDD I, FDD II and FDD III).

Of course, it is also possible the other way around: an R&S TS8950W can be expanded into a combined GSM and WCDMA Test System R&S TS8950G/W by adding on a protocol tester and appropriate ASCUs.

FIG 1 Block diagram of the Test System R&S TS8950W.



pletely redefined at any time on a user-friendly interface. In addition to a comprehensive test report, there is also a wide range of logging and analysis tools available for quickly localizing faults on the DUT. Users can thus develop their own test scenarios and perform fast, accurate analyses of problems that may occur during the development of mobile phones.

Analysis – online and offline

The user interface of the PASS software runs as a separate process and is thus independent of the test application. During a test run it is therefore possible to compose the next sequence, analyze earlier results or define new tests without interfering with the ongoing test. FIG 3 shows the result of the Spectrum Emission Mask measurement. The specified limit lines are shown in red, the measurement result in blue. Via the LAN interface, the measurement results can be transferred from the measurement system to the company network, for example. A copy of the analyzer tool then makes it possible to analyze the measurement results on any workstation PC.

Wilfried Tiwald

More information and data sheet at www.rohde-schwarz.com (search term: TS8950W)

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[1] RF Test Systems R&S TS8950G / TS8955G – Reliable RF testing of GSM, GPRS and EDGE mobile phones. News from Rohde&Schwarz (2002) No. 174, pp 4–7

[2] Protocol Tester R&S CRTU-W – Future-proof tool for testing WCDMA terminals. News from Rohde&Schwarz (2002) No. 175, pp 4–7

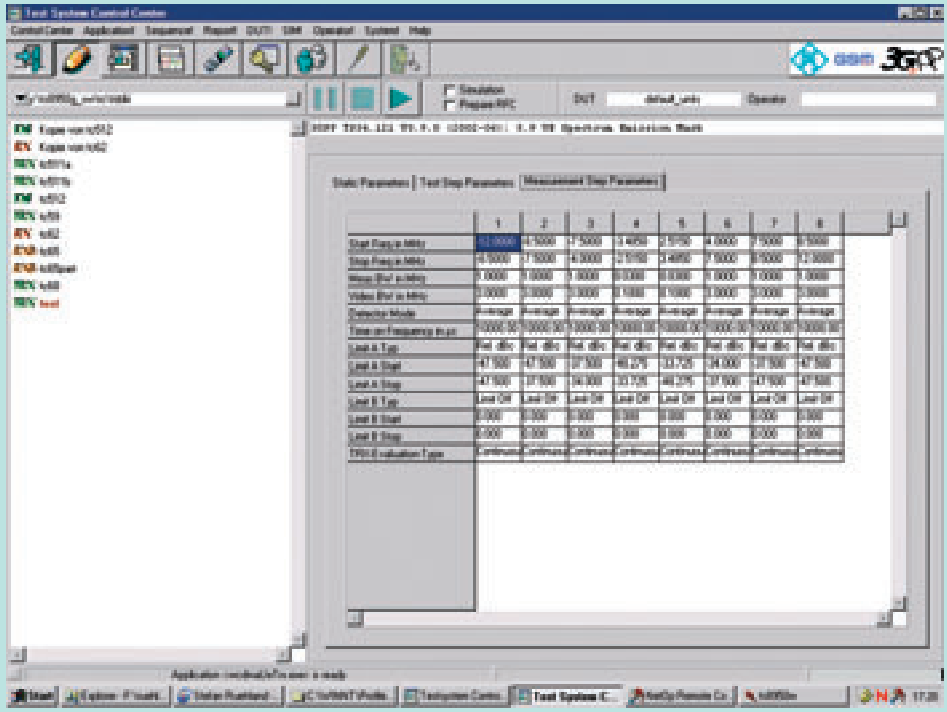

FIG 2 Parameters of the Spectrum Emission Mask test case.

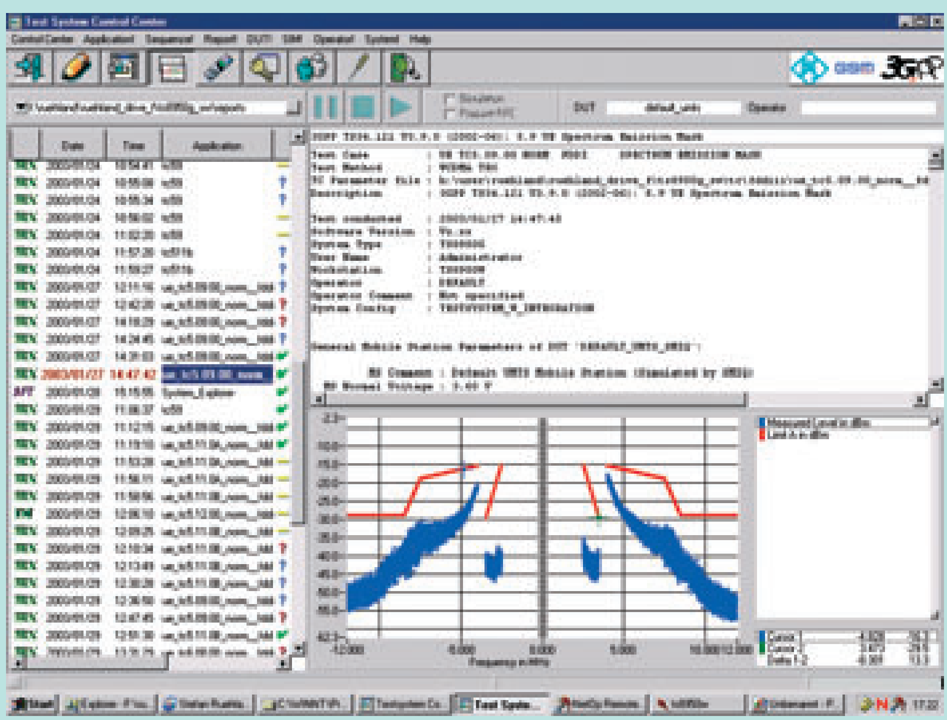

FIG 3 Results of the Spectrum Emission Mask measurement.

Protocol Tester R&S CRTU-G

Test methods and functionalities for location services

Being able to determine the position of a mobile phone opens up a number of interesting applications that fall under the heading of location services (LCS). These services provide mobile phone users with information specific to their current position. Because of these new technical capabilities, network operators and manufacturers of mobile phones are faced with additional test requirements that are fully covered by the GSM Protocol Tester R&S CRTU-G (FIG 1).

FIG 1 The GSM Protocol Tester R&S CRTU-G supports all functions and measurements encountered with location services in mobile radio networks.

New software option for the Protocol Testers R&S CRTU-G/W: see also page 22.

What are location services?

Location services include not only emergency call concepts as defined by the Federal Communications Commission (FCC) but also applications involving the purchase and delivery of goods, public transportation and tourism. For example, using a mobile phone to get answers to questions such as "What can I get here and how do I go about it?" is important not only for consumers but for suppliers of goods and services as well. The situation is similar for public transportation: Determining the right bus and the right bus stop for reaching a destination can be solved elegantly. Adding mobile commerce would also enable users to buy a bus ticket without having to deal directly with the local transportation services. Similar applications are also conceivable in the tourism industry. Information about local sights, hotels, leisure activities, restaurants and much more would be available at the press of a button and could be selectively output on the mobile phone displays of potential customers.

Offering location services requires precise knowledge about where the user is located as well as integrating a positioning mechanism into the mobile phone and the network. The box on the following page presents the various means of determining the position of mobile phones.

LCS require mobile phone positioning –

In phase I of its emergency call concept E911, the FCC defined a method for positioning in which the mobile phone was merely assigned to a base station. Drawing conclusions about positioning accuracy was generally not possible due to the disparate cell sizes, which also meant that positioning was correspondingly imprecise. In phase II, the FCC defined precise requirements for positioning accuracy and established two different methods:

1. Autonomous positioning in the mobile phone

The global positioning system (GPS) offers one means of determining the position of mobile phones. It uses at least 24 satellites that revolve around the earth every 12 hours at an altitude of 20 200 km. Three-dimensional positioning requires the reception of four satellites. The phone must contain a GPS module that receives and analyzes GPS signals. The phone must then send the position data via a signalling channel to the base station for processing.

This method is called **assisted GPS (A-GPS)**; it does not require network support. According to FCC regulations, positioning accuracy must be 50 m for 67% of all calls and 150 m for at least 95% of all calls. The accuracy of this method is very high if a direct connection to the satellites exists. If this is not the case, e.g. in buildings, position data cannot be provided.

2. Network-based positioning

If location services are also to be available in buildings, other methods must be used to determine position, e.g. the analysis of signals sent from the base stations. For **network-based positioning**, the FCC defined a positioning accuracy of 100 m or 300 m. Two possibilities are available for these methods, which use a type of cross direction finding from at least three base stations.

a) Measurement of signal propagation time between mobile phone and each base station

In this method, a mobile phone could immediately return the signals received from three base stations, which could then measure the propagation times. Since the propagation times between the mobile phone and the base stations are proportional to distance, this yields position circles around the three base stations, where the point of intersection is the position of the mobile phone (FIG 2). However, this method is not implementable because each mobile phone requires different process times between the reception and return of a signal and this information is not available to the network, not to mention the extremely high level of frequency resources required.

b) E-OTD method

A far more efficient method is E-OTD (enhanced observed time differences). In this method, the mobile phone measures the reception times of the signals from the base stations and then returns this data to the base stations, where the propagation time differences between the individual signals are determined. These differences yield hyperbolic curves around the known positions of the base stations, and these curves intersect at the point where the mobile phone is located (FIG 3).

Positioning accuracy of the E-OTD-method

The accuracy of the propagation time measurement in the E-OTD method is heavily dependent on the position of the base station and on the quality of the received signal. Under ideal measure-

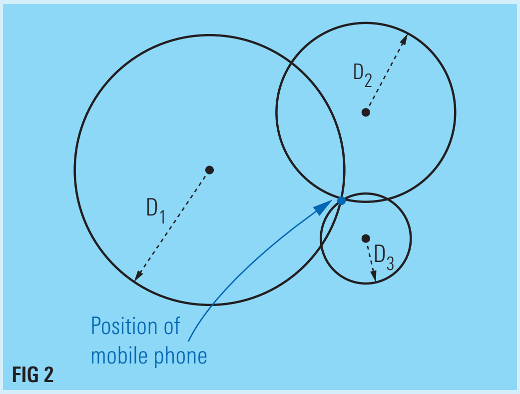

FIG 2

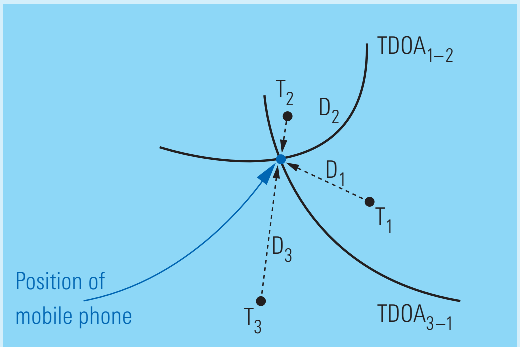

FIG 3

a comparison of two methods

ment conditions, e.g. in the absence of measurement errors, the actual position of the mobile phone in FIG 4 is where the measured hyperboles intersect (shown with broken lines). If the measurement errors are included, the hyperboles expand into corridors whose cross-sectional area forms an ellipse. The ellipse is derived from a three-dimensional Gaussian curve – the probability distribution of the individual measurement values – crossed by one plane. Thus, the measurement results can be said to lie within the ellipse with a probability derived from the probability distribution of the individual measurement values (FIG 5).

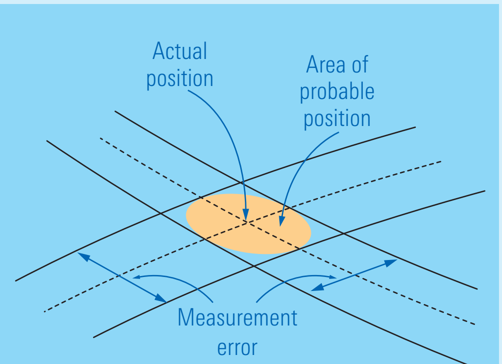

FIG 4

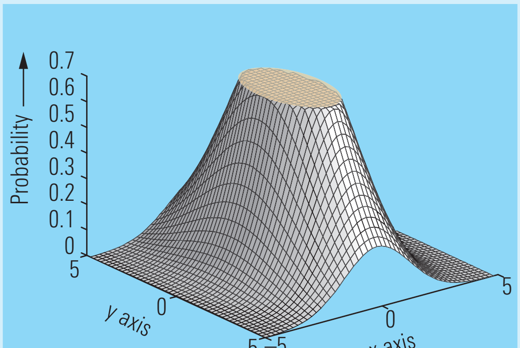

FIG 5

A-GPS or E-OTD?

From the explanation, it is clear that the use of A-GPS limits network operator effort to providing services and applications. The benefits of this method are readily apparent: significantly higher accuracy in positioning and lower upgrade effort. However, GPS is not intended for use in buildings, where it does not yield any results. In this case, E-OTD must be used. This method requires the availability of a network that has been optimized accordingly and the integration of positioning capability. This requires a larger investment in software and hardware. A combined solution will satisfy all requirements but also entails greater effort.

Future development rests heavily on whether navigation capability becomes the focal point or whether the multitude of new services will strike home with users. Manufactures of mobile phones will probably have to acquaint themselves with both technologies, because some network operators are adopting A-GPS and others E-OTD. Since networks with E-OTD will hardly require extra effort to add A-GPS, it can be assumed that these operators will offer a dual system containing both methods.

Protocol Tester R&S CRTU-G: ready for any test

Mobile phone manufacturers and network operators need signalling tests for LCS messages and the ability to measure positioning accuracy. The Protocol Tester R&S CRTU-G [1] covers all these applications. As a standalone instrument, it provides two independent and user-configurable RF channels. However, since most LCS applications require more than two channels, several R&S CRTU-G or R&S CRTU-S units can be cascaded to yield a system for up to eight RF channels. The R&S CRTU-S is designed as an economical alternative for use in multichannel systems. Such systems, which consist of at least one R&S CRTU-G and up to three additional R&S CRTU-G/S units, contain an R&S CRTU-G as a master that controls the remaining cascaded protocol testers as slaves. Each slave provides two additional independent channels. The user benefits from the RF combiners integrated into the protocol testers because these combiners enable cascading without additional RF components.

If the R&S CRTU-G/S is equipped with the option R&S CRTU-B7, it provides a two-channel IQ/IF signal for fading applications by means of the Baseband Fading Simulator R&S ABFS, already calibrated in this combination (FIG 6). The R&S ABFS is controlled by the protocol tester.

Signalling tests with the Protocol Tester R&S CRTU-G

The consistent R&S CRTU-G software concept makes it possible to activate new functions merely by installing software options. Option R&S CRTU-GA01 enables the protocol tester to provide the signalling messages required for the test cases specified in 3GPP TS 51.010, thus supporting both A-GPS and E-OTD.

Users can develop their own test cases or use the test case packages R&S CRTU-GC10 and R&S CRTU-GC11, which represent official 3GPP test cases. R&S CRTU-GC10 and R&S CRTU-GC11 currently provide test cases from sections 70.2, 70.4 and 70.7. The test cases in R&S CRTU-GC10 require only a two-channel system (R&S CRTU-G standalone); for R&S CRTU-GC11, up to five channels are required. Additional signalling test cases are being developed as quickly as possible.

All test cases can be run in any frequency band supported by the protocol tester (850/900/1800/1900 MHz). Operating option R&S CRTU-GA01 in the 850 MHz band requires software option R&S CU-GA85. It makes the protocol tester particularly attractive for the American market, which is the driving force in the LCS segment for the 850 MHz und 1900 MHz frequency bands.

Measurement of positioning accuracy

When positioning accuracy is measured, the outstanding hardware properties of the multichannel systems with several Protocol Testers R&S CRTU-G/S [2] come into their own. To simulate the movement of the mobile telephone, at least one RF signal must be time-shifted while the other two signals remain time-constant. This shifting changes the intersection point in triangulation, which is equivalent to a new position of the mobile phone in the network. The multichannel systems allow the precise time delay of a signal with respect to an internal reference. Even without additional correcting software, an RF channel with a maximum timing error of 50 ns can be generated. When software option R&S CRTU-GA02 is used, the error can be reduced to <5 ns. This applies to GMSK as well as to 8PSK carriers. The Protocol Testers R&S CRTU-G/S can shift the timing of the channels in increments of <5 ns if R&S CRTU-GA02 is used (FIG 7). This makes it possible to comply with the stringent requirements of the 3GPP test specification without any test equipment beyond the R&S CRTU-G/S. The shifting accuracy that can be achieved is <5 ns and is the same with or without R&S CRTU-GA02 (FIG 8).

Most LCS scenarios require two or more RF channels, which is possible with an R&S CRTU-G/S multichannel system. The use of a second channel yields a time offset that is determined by gate propagation times. These time offsets are constant and are noticeable only during the absolute evaluation of propagation time differences in the mobile phone. If an RF signal is time-shifted, the shift can be measured with an error of <5 ns (FIG 9).

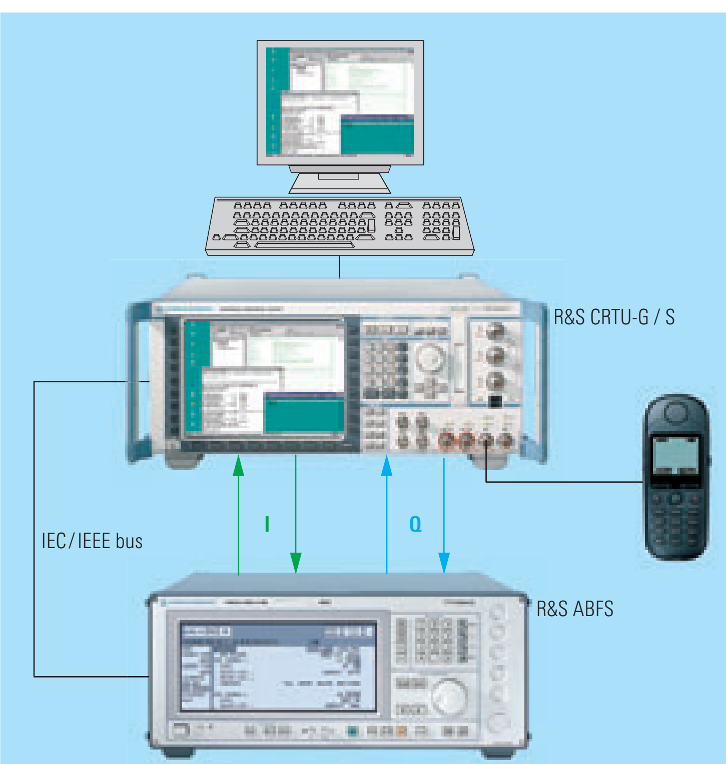

FIG 6 Fading simulation with the R&S ABFS and the R&S CRTU-G/S.

Static or dynamic position measurements

A distinction is made between static and dynamic position measurements. **Static position measurements** involve using a multichannel system to generate a scenario with at least four RF channels, which is the minimum configuration for measuring the position of a mobile phone. Such a system allows one TCH and three BCCHs to be generated. The mobile phone measures the receive times of the individual BCCHs and returns the results on the TCH to the test system. The values measured by the mobile phone can be compared with the real times generated by the test system in order to check the positioning accuracy of the mobile phone. Since the receive times are measured using correlation, the signal quality is highly important.

Implementing signals with fading characteristics as opposed to ideal signals can provide solid information about the quality of the algorithms used. If fading is to be applied to the channels of the multichannel system, one IQ/IF Interface Board R&S CRTU-B7 and one Fading Simulator R&S ABFS must be used with each R&S CRTU-G/S. In all cases, the position must be set exactly.

Dynamic position measurements

require the same configuration as used for static measurements. In contrast, however, the timing of at least one carrier must be varied, which causes the phone to calculate a different geographic position for itself. As a result, the mobile phone can be moved along any definable, reproducible trajectory, and the dynamics of the positioning mechanism in the phone can be analyzed.

Markus Hendeli

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

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[1] GSM Protocol Analyzer R&S CRTU-G – Changing of the guard: after more than 10 years, a new GSM reference system. News from Rohde & Schwarz (2001) No. 171, pp 4–8

[2] GSM Protocol Testers R&S CRTU-G/CRTU-S – Multicell systems with up to four GSM cells. News from Rohde & Schwarz (2002) No. 176, pp 14–16

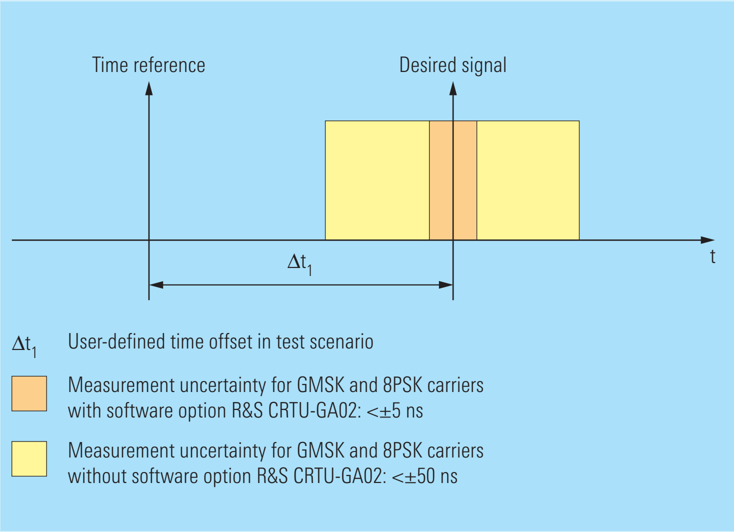

FIG 7 Absolute timing error in the RF channel with and without software option R&S CRTU-GA02.

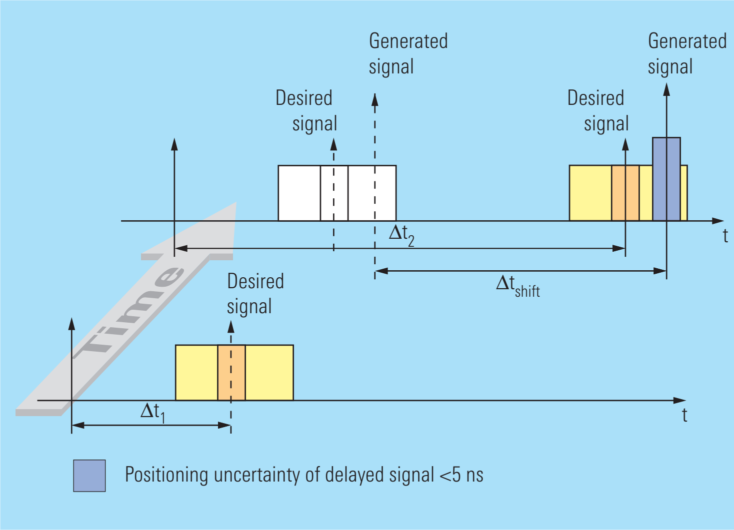

FIG 8 The achievable accuracy when shifting channel timing is the same with or without the use of R&S CRTU-GA02.

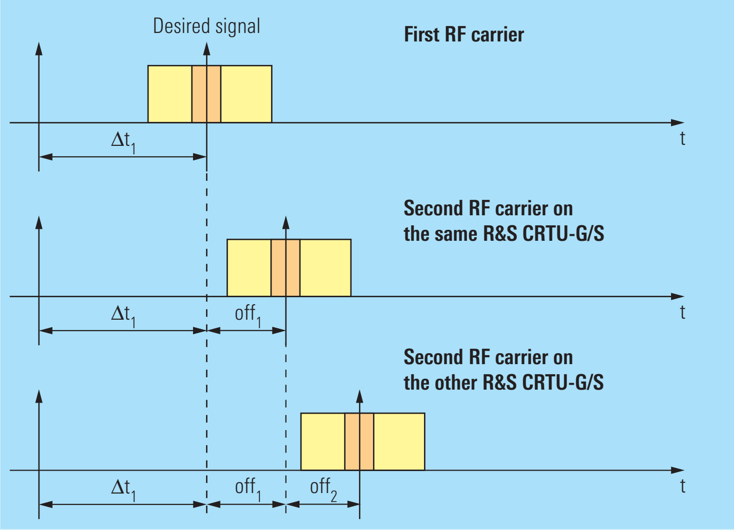

FIG 9 The time offsets caused by gate propagation times are noticeable only during the absolute evaluation of the propagation time differences.

Protocol Tester R&S CRTU-G/-W

2 in 1: Software option for 2G/3G system simulation

The new software option combines the R&S CRTU-G (for GSM/GPRS/EDGE) and R&S CRTU-W (for UMTS/WCDMA-FDD) protocol testers to form an expandable and versatile 2G/3G system simulator (FIG 1).

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FIG 1 The new software option combines several Protocol Testers R&S CRTU to form a modular 2G/3G system simulator.

Abbreviations

2G / 3G	2nd / 3rd generation of mobile communications
3GPP	3rd Generation Partnership Project
CS	Circuit switched
GERAN	GSM/EDGE radio access network
PCO	Point of control and observation
PLMN	Public land mobile network
PS	Packet switched
RAT	Radio access technology
RR	Radio resource
RRC	Radio resource control
RRM	Radio Resource management
RSSI	Radio signal strength indication
TTCN	Tree and tabular combined notation
UMTS	Universal mobile telecommunications system
USIM	Universal subscriber identity module
UTRAN	UMTS terrestrial radio access network

Clever combination

Rohde & Schwarz now offers a software option for 2G/3G intersystem scenarios, enhancing the functionality of the successful R&S CRTU protocol test platform. This solution is appealing because it does not require a rigid overall system, but instead easily combines existing protocol testers to form a 2G/3G system simulator. After measurements have been completed, the instruments will again be available for the numerous test cases within the specific mobile radio technology.

Networking of UMTS and GSM / GPRS

The UMTS infrastructure for the launch of the commercial network is currently being expanded. However, it will take a few years until this 3G mobile radio standard will provide full coverage. At present, network operators are focusing on equipping densely populated areas and sections along major traffic arteries with 3G network technology. In less densely populated areas, UMTS will become available only gradually. In the meantime, the established GSM/GPRS mobile radio system must close the gaps between the UTMS islands. The integration of the GSM/GPRS infrastructure and the newly added UMTS network components were taken into account in the 3GPP standardization right from the start.

The availability of mobile phones with intersystem function will be decisive in ensuring a smooth start for UMTS and its commercial success. Such mobile phones not only can be used in either of the two mobile radio systems, but also support seamless transition from one network to the other without the call dropping and without the need for a new connection setup. This is the only way to make sure that the subscribers can use the modern services of the network operators smoothly and independently of locations.

Intersystem handover scenarios

The system transitions between UTRAN and GSM/GPRS can be explained in the form of a state diagram. FIG 2 shows the relevant transitions (in red) on the access stratum layers. With regard to CS domain services, e.g. if a connection has been established or is being set up in CELL-DCH, FIG 2 shows the permissible transition from the UTRA RRC connected mode to GSM RR connected mode states and vice versa. The transition is triggered by the original system's transmission of the HANDOVER FROM/TO UTRAN COMMAND. For PS domain services, a transition into the GPRS packet transfer mode is defined only indirectly via the idle mode. Cell selection / reselection involving the cells of both mobile radio systems occurs automatically in the mobile phone in accordance with the criteria defined by the network. Transitions from switched-off to idle mode are not shown; in this case there will be a RAT/PLMN selection based on the USIM settings.

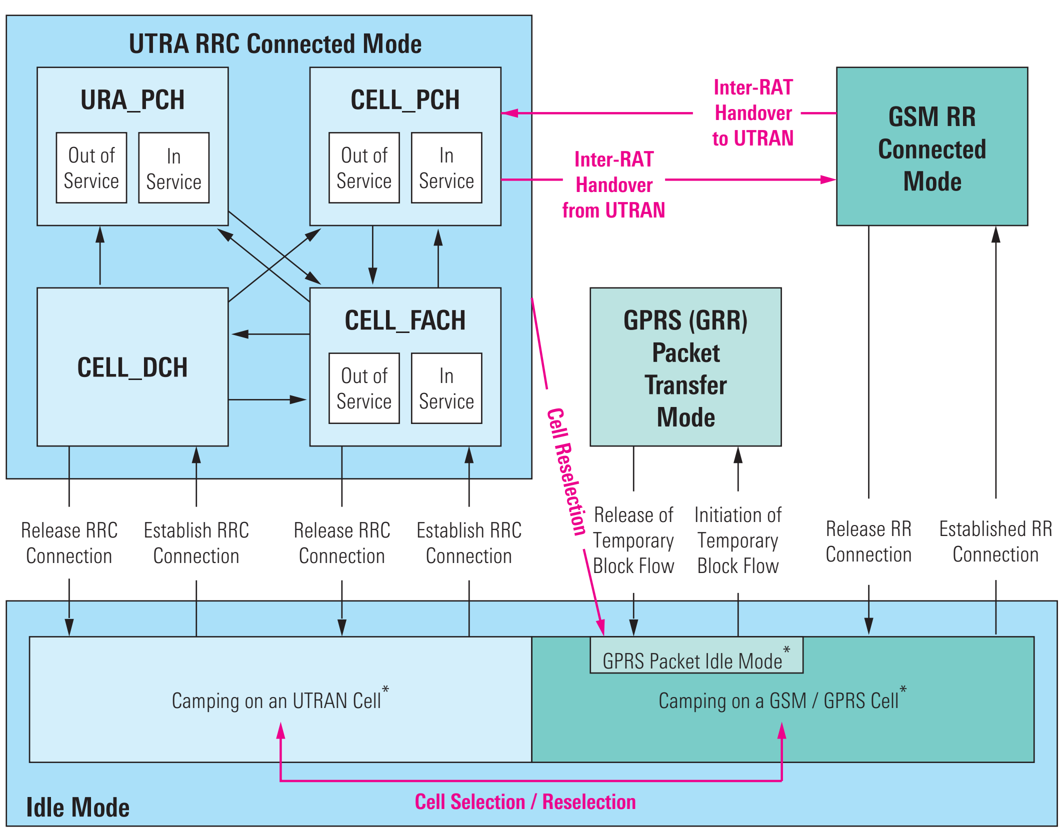
The 3GPP and GERAN standardization bodies have defined protocol tests [2, 3] which are used to check the correct implementation of the state transitions. The test cases specified in the TTCN description language cover both handover and various handover failure scenarios.

The handover processes requiring data rate changes since different data rates are granted to the services in the specific mobile radio network (RAT) are a particular challenge; likewise the fact that UTRAN and GSM/GPRS networks are not synchronized and have different frame lengths.

To be able to perform RSSI measurements on cells of the target system prior to a system change, the UMTS CDMA characteristic requires a specific mode. This mode is referred to as compressed mode and increases the known complexity of the layer 1 procedures and the layer 3 protocol processes at the UMTS end. The Protocol Tester R&S CRTU-W supports this additional functionality on layer 1, thus providing the basis for integrating some of the most important 2G/3G intersystem handover test cases. System changes without preceding inter-RAT measurements are referred to as blind handover. They are more prone to failures during system changes.

FIG 2
Inter-RAT handover and cell selection / reselection are part of the state transitions between the UTRA RRC and the GSM / GPRS states [4].

*** The configuration within idle mode was chosen only for explanation purposes and does not reflect any state of its own.**



2G/3G system simulation using the R&S CRTU

The modular hardware and software architecture of the Protocol Testers R&S CRTU makes it possible to connect the instruments via software to form a 2G/3G system simulator that fulfills virtually all requirements, from simple handover failure tests requiring only one cell of the original RAT up to complex test scenarios requiring several cells on different RAT. The main configuration levels and possible tests are listed below:

A) One R&S CRTU-W
Intersystem handover failure from UTRAN to GSM

B) One R&S CRTU-G
Intersystem handover failure from GSM to UTRAN

C) One R&S CRTU-W/ R&S CRTU-G each
- Intersystem handover from UTRAN to GSM and from GSM to UTRAN (handover and handover failure)
- Idle mode operations (max. two cells on each RAT)
- RRC measurement control & report (max. two cells on each RAT)

D) n × R&S CRTU-W and 1 × R&S CRTU-G and n × R&S CRTU-S (n ≤2)
Same as C (but with more than two cells on each RAT)

The modular design of the R&S CRTU which has proved itself in the setup of a 2G/3G system simulator (FIG 3) is also suitable for similarly complex scenarios such as the RRM test cases (more about this in one of the next issues).

2G/3G software options

Simulation libraries (SimLib) are available for the Protocol Testers R&S CRTU supporting the verified and fully 3GPP-compliant test cases (see box). Rohde & Schwarz will additionally offer proprietary test scripts that assist the user not only in conformance tests but also in the development and integration phase.

To date, the 3GPP test cases specified in the description language TTCN have focused on the circuit switched (CS) domain. In the future, test scenarios involving packet-oriented data transmission are to be expected as well (PS domain). The R&S CRTU is ready to meet this challenge.

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Software options for the 2G/3G intersystem scenario

- **R&S CRTU-GP02** Software expansion "GSM/GPRS Protocol Test Client" for R&S CRTU-PU (external PC)
- **R&S CRTU-WC20** SimLib for "dual-system idle mode operations" test cases in accordance with TS 34.123-3
- **R&S CRTU-WC21** SimLib for "intersystem measurement control & report" test cases in accordance with TS 34.123-3
- **R&S CRTU-WC22** SimLib for "intersystem handover from UTRAN to GSM" test cases in accordance with TS 34.123-3
- **R&S CRTU-WC23** SimLib for "intersystem handover to UTRAN from GSM" test cases in accordance with TS 34.123-3

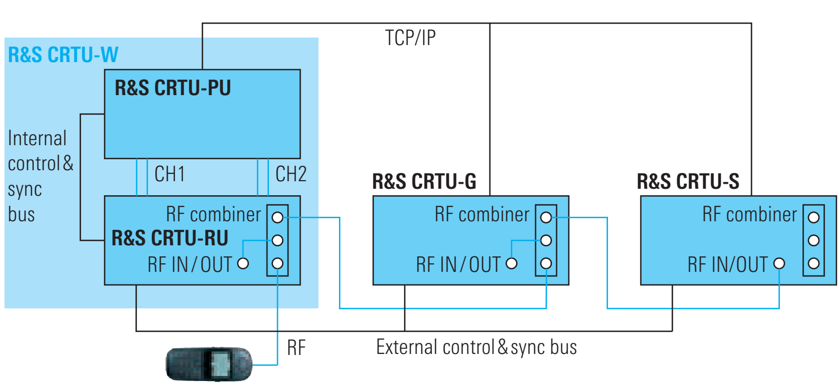


FIG 3 2G/3G system simulator consisting of one each of the R&S CRTU-W, R&S CRTU-G and R&S CRTU-S.

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

REFERENCES
[1] See references on page 21 (multicell systems)
[2] 3GPP TS 34.123: 3GPP Terminals – User Equipment (UE) Protocol Conformance Specification
[3] 3GPP TS 51.010: GSM/EDGE Radio Access Network – Mobile Station (MS) Conformance Specification
[4] 3GPP TS 25.331: 3GPP Radio Access Network – Radio Resource Control (RRC) Protocol Specification

Universal Radio Communication Tester R&S CMU300

Fast transmitter and receiver measurements on WCDMA base stations

43641/2n

FIG 1 The R&S CMU300 is an all-in-one solution for testing WCDMA base stations.

The R&S CMU300 (FIG 1) now provides transmitter and receiver measurements in one instrument, not only for the GSM mobile radio standard but for WCDMA as well. The new option R&S CMU-K75 for measurements on 3GPP base station transmitters complements the existing WCDMA generator for tests on 3GPP base station receivers (option R&S CMU-K76 [1]).

Universal solution for tests on WCDMA base stations

The newly developed transmitter measurements are based on the 3GPP test specification TS25.141 (FDD) and cover all important RF tests in production, development and network support. In implementing the solution, special emphasis was placed on high measurement accuracy and measurement speed.

The new measurements in detail

For the different measurements, the 3GPP test specification TS25.141 [2] prescribes specific test models aimed at simulating a particular channel utilization. The R&S CMU300 supports all these test models. The use of other user-configurable channel tables is also planned.

Basically any desired test models can be selected for all measurements. For example, channel model 1.64, which contains 64 active dedicated channels (DCH), can be used for modulation measurements, although it was primarily designed for spectrum measurements.

Code domain power (CDP)

Precise power control on the uplink and downlink is essential in CDMA systems. The CDP measurement analyzes power distribution across the individual code channels by recording and evaluating one complete WCDMA frame per measurement. The screen is divided into three sections to handle the complex signal structure (FIG 2).

The top section shows the CDP of all codes. Active code channels are highlighted in colour and combined to form a bar whose width depends on the spreading factor.

New features at a glance

- Provision of all uplink reference channels from 12.2 kbit/s to 2048 kbit/s
- Signal generation in realtime with a test data length of up to PRBS 16 for continuous receiver measurements
- Virtually realtime response to changing RF parameters
- Comprehensive and very fast power, modulation and spectrum measurements (CDP: on average only 0.3 s per measurement)
- Convenient and clearly arranged user interface
- Compact tester with GSM / EDGE / GPRS and WCDMA standards in one instrument

In the center section, the CDP of a selected code is displayed versus time. Since the individual code channels may be time-delayed with respect to the frame start, the center diagram contains two time scales. The common pilot channel (CPICH) is used as a reference for the different measurement results because it is not time-delayed (displayed on the first scale). A second scale refers to the selected code channel.

The bottom section displays general modulation parameters as scalar values referring to the selected CPICH slot.

Code domain error power (CDEP)

The CDEP is an analysis of the error signal in the code domain, i.e. the projection of the error power onto the individual code channels. As with the CDP, the screen is divided into three sections (FIG 3). The CDEP is to be measured across a CPICH slot with a defined spreading factor. The display is thus much simpler than for CDP. The top diagram displays the CDEP across all codes in the selected CPICH slot.

In the center diagram, the peak code domain error power (PCDEP) is displayed for all 15 frame slots. Here too, comprehensive means for analysis are available. For example, if the PCDEP is particularly high in one slot, the CDEP over all codes can be viewed by selecting this slot, and thus the code channel with the maximum error can be detected.

Error vector magnitude (EVM)

EVM in the time domain corresponds to CDEP in the code domain. The EVM is the difference between the ideal reference signal and the processed test signal. In contrast to the CDEP, the error is evaluated at the chip level, so that errors are shown in the time domain on the basis of the chip offset from the selected CPICH slot. Analysis is again frame-based; therefore all RMS values of the individual slots are also displayed versus time (FIG 4).

Occupied bandwidth (OBW) and adjacent channel leakage ratio (ACLR)

With the OBW and ACLR measurements, the R&S CMU 300 provides two inband spectrum measurements that are of great importance for assessing WCDMA transmitters (FIG 5). A high dynamic ACLR for even higher requirements will soon be available as an option.

FIG 2 Measurement of code domain power with test model 3.32.

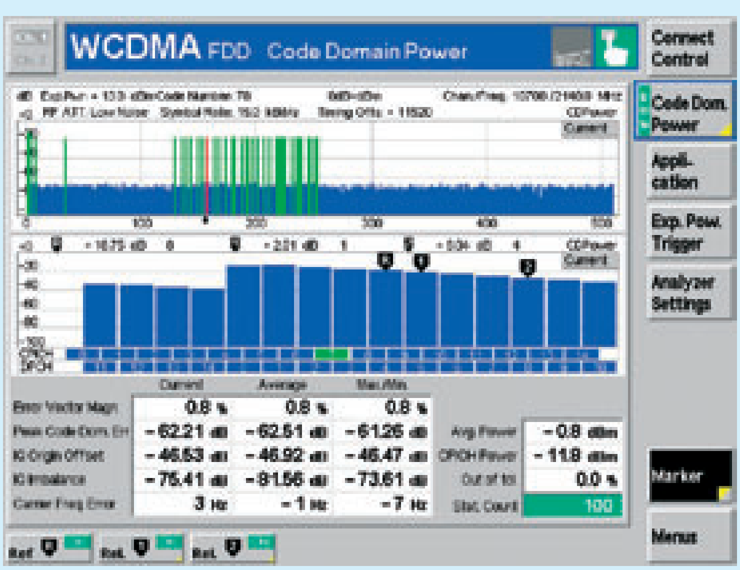
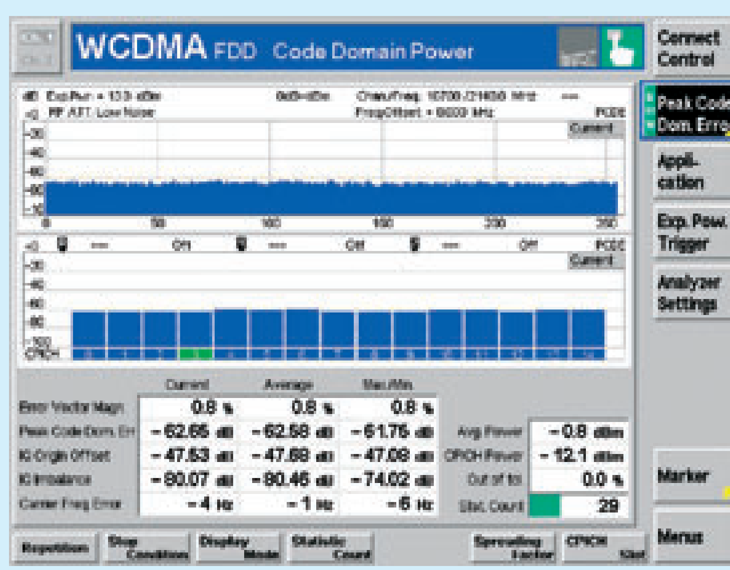


FIG 3 Measurement of code domain error power with test model 3.32.



Option	Designation	Functions
R&S CMU-K75	Software option WCDMA TX test (3GPP/FDD/DL)	Software for transmitter measurements on 3GPP FDD base stations
R&S CMU-U75	Upgrade kit Meas. DSP module for WCDMA	Universal hardware for transmitter measurements on WCDMA base stations
R&S CMU-B76	Hardware option Layer-1 board for WCDMA	Universal hardware for receiver measurements on WCDMA base stations
R&S CMU-K76	Software option WCDMA generator (3GPP/FDD/UL)	Software for receiver measurements on 3GPP base stations
R&S CMU-U76	Upgrade kit Layer-1 board for WCDMA	Contains: WCDMA layer-1 board B76 and power supply SN 250

WCDMA options for the R&S CMU 300.

More information and data sheet at www.rohde-schwarz.com (search term: CMU 300)

Technical information on WCDMA generator

REFERENCES

[1] R&S CMU 300: WCDMA generator for tests on 3GPP base station receivers. News from Rohde&Schwarz (2002) No. 176, pp. 17–20.

[2] 3GPP specifications: www.3gpp.com

Comprehensive high-speed-transmitter measurements

With these measurements, some of which are very complex, the R&S CMU 300 again proves its high measurement speed. For example, the CDP measurement with channel model 3.32 takes only about 0.3 s/frame, even without an additional external frame trigger. Moreover, special IEC/IEEE-bus commands are planned for optimal remote-control performance.

Summary

The newly added transmitter measurements round out the R&S CMU 300 as an all-in-one solution for testing WCDMA base stations. The radio tester is thus able to conduct all important tests on 2G (GSM), 2.5G (EDGE, GPRS, EGPRS) and 3G (WCDMA) base stations.

The development of further features such as the extension of generator functionality by BER/BLER verification (implementation of bit errors) is already underway. With its compact design, easy handling and extremely high measurement speed, the R&S CMU 300 will maintain its role in development, production and network support also in the future. The WCDMA options can be easily added to GSM/EDGE instruments.

Anne Stephan; Rolf Lorenzen

FIG 4 Measurement of error vector magnitude.

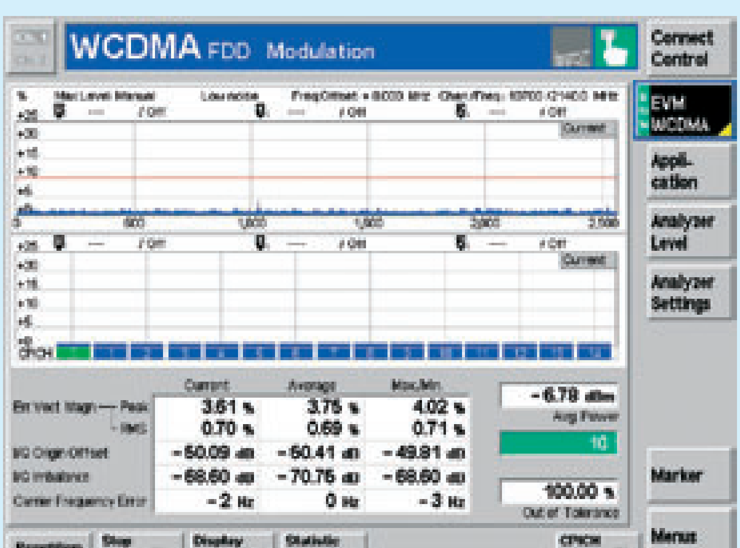
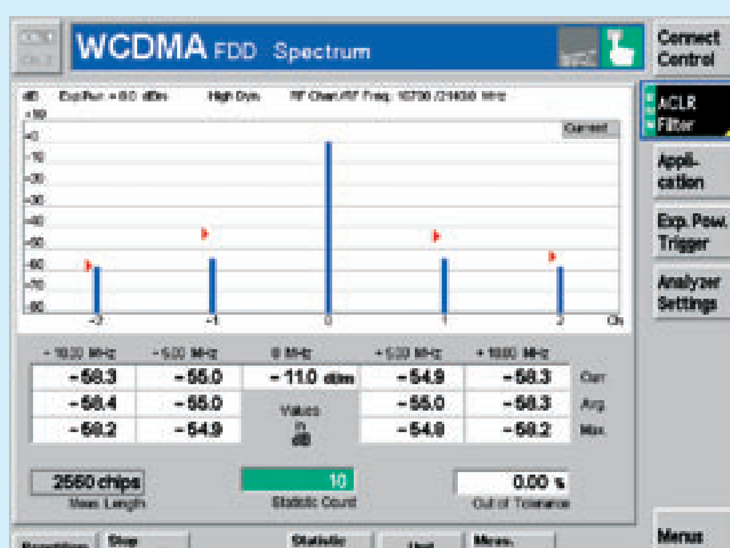


FIG 5 Measurement of adjacent channel leakage ratio.



Universal Radio Communication Tester R&S CMU200

Signalling and measurements on GSM-AMR mobile phones

Everyone is talking about high data rates and innovative data applications. But the development of classic voice transmission is also not at a standstill. The latest innovation in this field is adaptive multirate (AMR), and it is specified across systems for both UMTS and GSM. The R&S CMU200 provides high-quality measurement technology for AMR.

Another article about the R&S CMU200 can be found on page 32.

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

REFERENCES

[1] Universal Radio Communication Tester R&S CMU200 – Audio measurements on mobile phones. News from Rohde&Schwarz (2001) No. 172, pp 18–19

[2] Audio Analyzer R&S UPL – Measuring the acoustic characteristics of 3G mobile phones. News from Rohde&Schwarz (2002) No. 173, pp 15–17

Back to the future with AMR

When the connection in analog transmission gets worse, the voice quality slowly deteriorates. You begin to hear noise and crackling but can still communicate. The situation is different with digital voice transmission: The quality remains at virtually the same level for a long time, suddenly there are interruptions and shortly thereafter nothing but dead silence.

The idea behind adaptive multirate is to adapt the behaviour of digital voice transmission to that of analog transmission in order to maintain the connection for as long as possible. In other words, AMR increases the range of a cell, thereby reducing infrastructure costs.

The principle of digital voice transmission

With digital voice transmission in mobile radio networks, a coder converts the analog voice signal into a digital one. The coder assesses the signal and protects the information content to a greater or lesser degree by inserting additional redundancy bits. This explains why the high voice quality is maintained until shortly before the connection breaks off. Incorrectly transmitted bits are detected by the voice decoder on the basis of the redundancy bits and corrected. The better protection of the important voice information ensures that the good voice quality is maintained for a long time. When the decoder can no longer correct the errors, the voice information completely fails, which is perceived by the users as interruptions in voice transmission.

Reduced voice quality – longer connection

The voice failure can be delayed by increasing the protection against transmission errors. The more redundancy bits are used, the longer errors can be corrected while the connection deteriorates. Additional bits would require a greater transmission bandwidth, which, however, is limited. One possible solution is to reduce the number of information bits by the increase in redundancy bits; Reducing the payload bits, however, results in poorer voice quality, as not all the nuances of voice can be coded any longer. Under good propagation conditions, users do not want to give up good voice quality. Consequently, the voice quality has to be dynamically adapted to the connection quality – and that is exactly what AMR does.

Four voice codecs instead of one

AMR specifies eight full-rate and six half-rate voice codecs of different voice quality. The base station selects up to four different codecs and transmits them to the mobile phone together with instructions as to which voice codec is to be used for which signal quality. While the connection is on, the mobile phone cyclically measures the signal-to-noise ratio and the receive level, determines the RF connection quality on the basis of the results and selects a suitable codec for the downlink. Subsequently it requests the desired voice codec from the base station, which then decides if and under what conditions this codec is used.

The base station measures the connection quality and selects the codec for the opposite direction. The mobile phone must set the codec chosen by the base station and then inform the base station after having made the setting. In order for the base station and mobile phone to select the correct voice codec, data must be exchanged within the voice data packet (inband signalling).

Measurements on AMR voice coders

A mobile radio tester must basically check two things on an AMR mobile phone: the correct selection of the voice codec (inband signalling) and the voice quality. The necessary measurement functions are derived from this information. The mobile radio tester must have at its disposal all AMR voice codecs from which the user can make a selection and define instructions. The mobile radio tester checks the adherence to the instructions in the mobile phone by changing the RF level and evaluating the voice codec requested by the mobile phone. To assess the voice quality, it must be possible to select the actively used voice codec and to set it for the duration of the measurement independently of the mobile phone's request. The mobile radio tester determines the voice quality by means of audio measurements and an AMR-suitable BER measurement.

AMR tests with the R&S CMU200

The option R&S CMU-K45 enhances the Universal Radio Communication Tester R&S CMU200 into an AMR mobile radio tester that provides all required test functions in the accustomed convenient way. All AMR voice codecs can be selected and linked to instructions (FIG 1). In a clearly arranged menu, inband signalling during the call can be set and the mobile phone's response analyzed (FIG 2). The BER measurement automatically adapts to the active AMR voice codec. Together with the options R&S CMU-B52 and R&S CMU-B41, the R&S CMU200 also performs all audio measurements [1, 2].

Rudolf Schindlmeier

FIG 1 The R&S CMU200 provides all specified voice codecs. In the Rate Set Editor, up to four codecs are selected from the eight full-rate and six half-rate voice codecs and linked to user-definable instructions for the switching thresholds between the voice codecs. This rate set is transmitted to the mobile phone during connection setup.

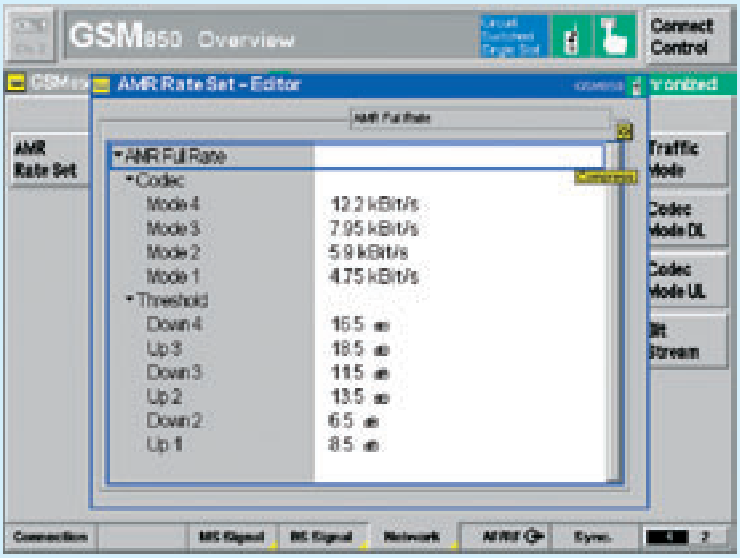
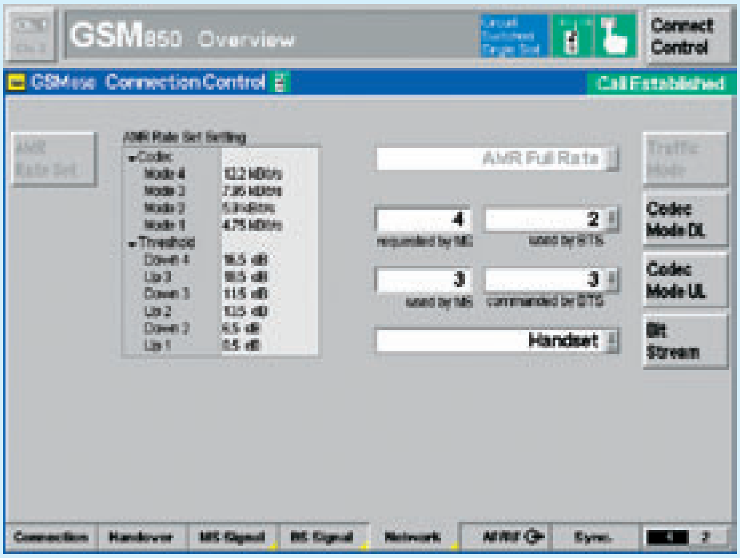


FIG 2 The user at all times has control over which voice codec is to be used in either connection direction. The active voice codec for the downlink is set in the "used by BTS" field, and the one for the uplink is set in the "commanded by BTS" field. The "requested by MS" field always displays the voice codec for the downlink currently requested by the mobile phone. The "used by MS" field shows the voice codec used by the mobile phone on the uplink.



Universal Radio Communication Tester R&S CMU 200

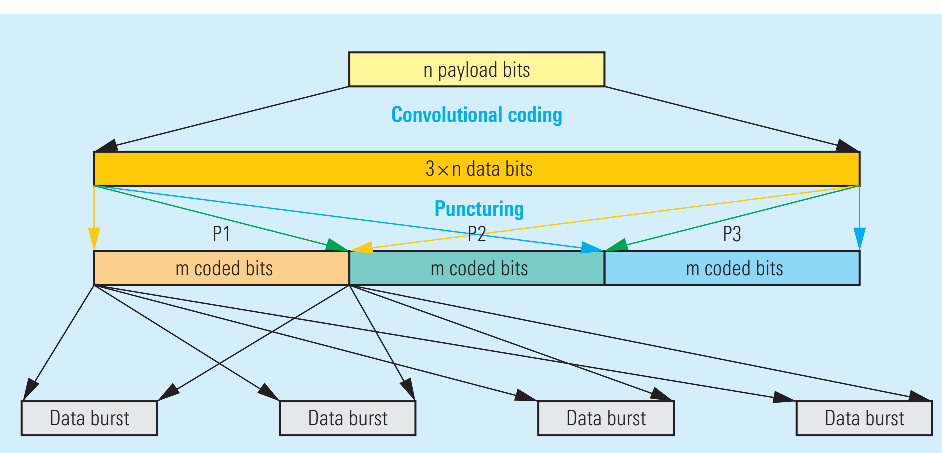
EGPRS signalling with incremental redundancy

With newer and newer innovations, standardization committees have been trying to increase data throughput in mobile radio systems and reduce infrastructure costs. Through the use of a different modulation mode, the data rate of EGPRS is up to three times higher than that of GPRS. An additional increase in data throughput is possible by using incremental redundancy.

EGPRS channel coding

To comprehend incremental redundancy, you have to understand EGPRS channel coding. There are nine different channel coders (MCS-1 to MCS-9) plus their variants, which can be defined by the puncturing scheme. FIG 1 shows the principle of complex EGPRS channel coding in a simplified way. A convolutional coder first spreads the payload data to three times the number of bits, which allows transmission errors to be corrected. Then individual bits are "punched out" according to a defined scheme (puncturing scheme P1, P2 and P3) and the bits are rearranged. Subsequently only the data packet containing puncturing scheme P1 is transmitted in four data bursts. The schemes are selected in such a way that the receiver can reproduce the complete original payload data from each single packet.

FIG 1 Simplified principle of EGPRS channel coding. The payload data is first tripled and then rearranged by punching out bits Thus only some of the bits have to be transmitted but protection against transmission errors is nevertheless maintained.



The principle of incremental redundancy

If an uncorrectable error occurs during the transmission of a data block, the entire block is requested and transmitted again – in the case of GPRS, until it has been received error-free. Information may be transmitted again and again, completely unnecessarily, e.g. if the first transmitted data block contained only a few defective bits.

With EGPRS, the transmitter can alternatively send the data block using puncturing scheme P2. The receiver then puts both received data blocks together and tries to correct the errors. Since it now has considerably more redundancy bits available, the probability that it can decode the block without errors is much higher. If this is still not possible, it will receive the data block with puncturing scheme P3 with the next transmission and can again use all the transmitted bits for decoding it. The receiver thus incrementally requests more and more redundancy bits to analyze the block (FIG 2).

The test method

To test EGPRS signals, it is important that incremental redundancy can be switched on and off as required. If layer 1 is to be tested, it must be off, for otherwise it feigns better receiver quality. If, however, the incremental redundancy performance is to be tested according to test specification 3GPP TS 51.010, the function must be on. In this test, the mobile phone must show a long-term data throughput of at least 20 kbit/s per timeslot.

Incremental redundancy with the R&S CMU200

The Universal Radio Communication Tester R&S CMU200 supports incremental redundancy in the EGPRS tests. Incremental redundancy can be switched on / off as necessary. When the function is off, the desired puncturing scheme can be set (FIG 3). If incremental redundancy is on, the selected puncturing scheme is transmitted first, enabling the tester to check a wide range of transmission combinations. The BLER measurement determines the block error rate and the data throughput separately for each timeslot (FIG 4). Using the BLER measurement of the R&S CMU200, the incremental redundancy performance can be easily tested.

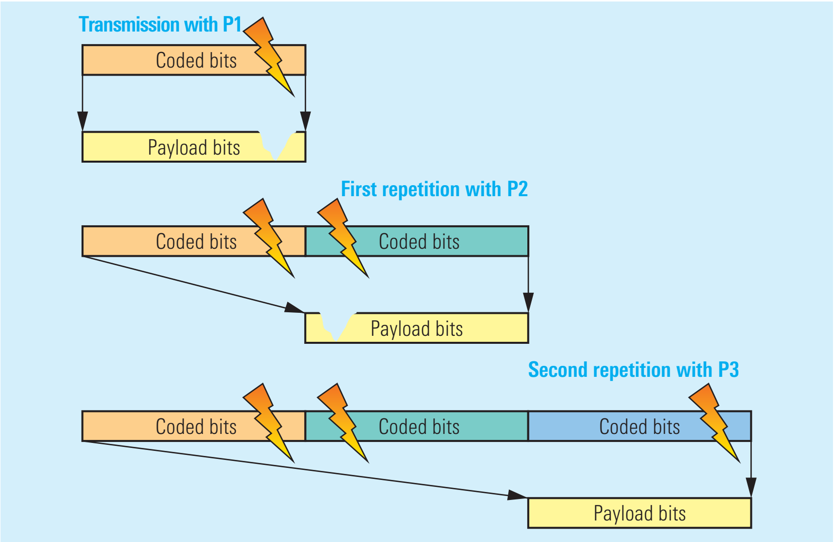


FIG 2 With incremental redundancy, the incorrectly transmitted block is not repeated but the data is transmitted with the next puncturing scheme. Both blocks are then used for error correction. This increases the probability of correcting transmission errors. In the example, all three transmissions are flawed. By combining the three received data blocks, data can, however, be decoded without error.

Summary

The versatile measurement and signalling capabilities of the Universal Radio Communication Tester R&S CMU200 have made the instrument an indispensable tool, especially in EGPRS development. This is a result of the close cooperation between Rohde & Schwarz and the development labs of mobile phone manufacturers.

Rudolf Schindlmeier

FIG 3 In the R&S CMU200, the puncturing scheme to be used can be set for each channel coder. Incremental redundancy can be switched on or off.

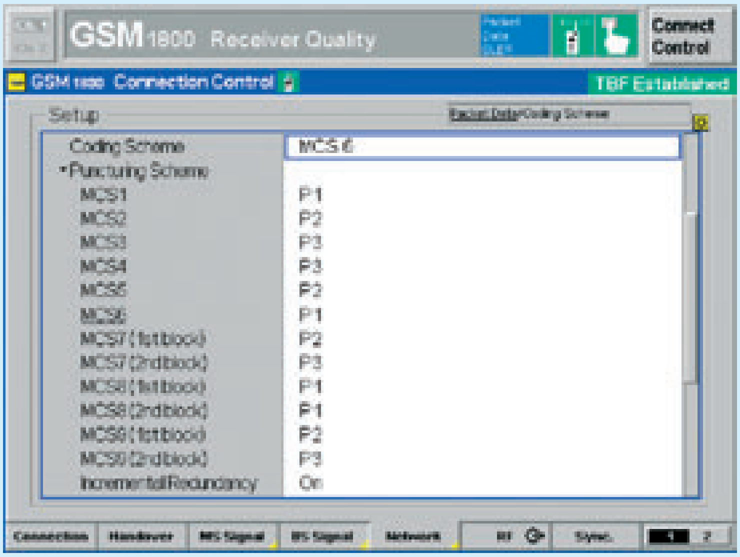


FIG 4 The BLER measurement of the R&S CMU200 evaluates the block error rate and the data throughput separately for each timeslot. This makes the measurement ideal for testing the incremental redundancy performance.

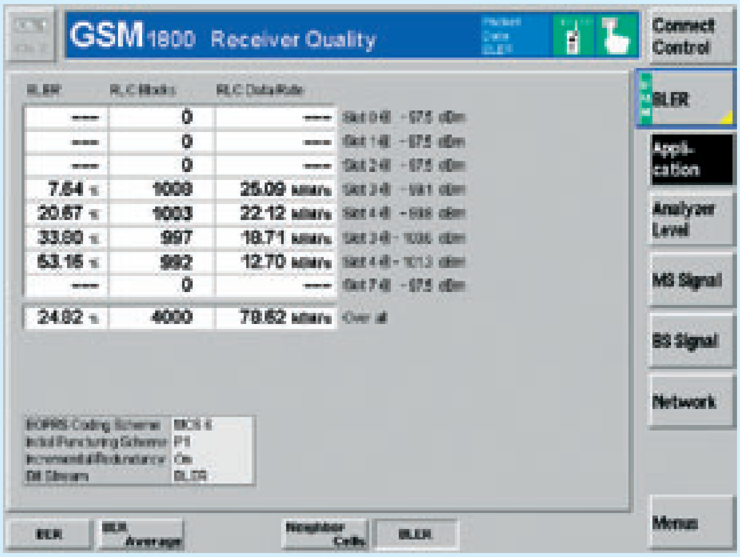


FIG 1 The new R&S FSQ-K70 application software enhances the Signal Analyzer R&S FSQ for high-precision measurements of modulation parameters of digitally modulated signals.

Signal Analyzer R&S FSQ

Application software for precise vector signal analysis

The new R&S FSQ-K70 software package expands the application range of the Signal Analyzer R&S FSQ (FIG 1) for high-precision measurements of the modulation parameters of digitally modulated signals. With its large bandwidth of 28 MHz and user-configurable demodulators for all common modulation modes, the enhanced R&S FSQ is an extremely flexible tool for vector signal analysis.

Low inherent error, precise demodulation

With a wide dynamic range and low phase noise, the Signal Analyzer R&S FSQ [1] converts the RF input signal to the last IF, digitizes it with 14-bit resolution and then converts it to the I/Q baseband. Using a patented method, it corrects the I/Q data stream by taking into account the amplitude and delay distortions of the entire RF receive path, minimizing the path's influence on the measurement signal. It thus ensures a very low inherent error when measuring modulation errors such as the error vector magnitude (EVM), even with transmission methods using high symbol rates. In the case of a 64QAM signal with a 10 MHz symbol rate, for example, the inherent error is only 1% (FIG 2).

Presettings for standard-compliant measurements

R&S FSQ-K70 [2] provides defined default settings for the vector measurement of modulation parameters of common digital radio transmission standards such as WCDMA 3GPP, cdma2000, GSM, EDGE, NADC, PDC, PHS, *Bluetooth*™ and TETRA. After selecting the desired standard from a table, the instrument is configured with the stored setting and instantly permits standard-compliant measurements (FIG 3).

The predefined settings include not only the modulation mode (PSK, MSK, QAM, FSK), filtering (raised cosine, root raised cosine, Gaussian), symbol rate and the specification of the signal ranges to be analyzed, but also the presentation of results.

Frequently needed settings can be defined as a standard and stored under any user-selectable name, allowing the analyzer to switch very quickly between different test scenarios. Complicated manual reconfiguring of the instrument is thus a thing of the past. This possibility is especially advantageous when standards are changed or a new digital standard is issued. Users can make the required modifications or create a new standard immediately on site without having to load new instrument firmware. Needless to say, factory-set standards deleted by mistake can be restored.

Loadable mapping files

The development of new transmission methods often requires symbol constellations that are not yet included in analyzers currently available on the market. With R&S FSQ-K70, this is no longer a problem. The MAPWIZ program – which can be downloaded for free from the Rohde & Schwarz website – allows users for the first time to create their own constellations, transfer them to the measuring instrument and thus respond to new standards at an early stage. The only other software needed is the widely used MATLAB™ simulation program. FIGs 4 and 5 show a constellation created in this way.

Enhanced trigger and measurement capabilities

R&S FSQ-K70 allows triggering to external trigger events, bursts and synchronization patterns contained in the data stream. Triggering can be either to one synchronization pattern at a time or even to several patterns simultaneously. For GSM, this means that the analyzer searches for all training sequences (TSC 0 to TSC 7) and, without knowing the pattern actually transmitted, reliably demodulates the signal. Triggering to burst signals can be very finely parameterized. The analyzer normally determines the level threshold values automatically; as an alternative, they can also be specified manually.

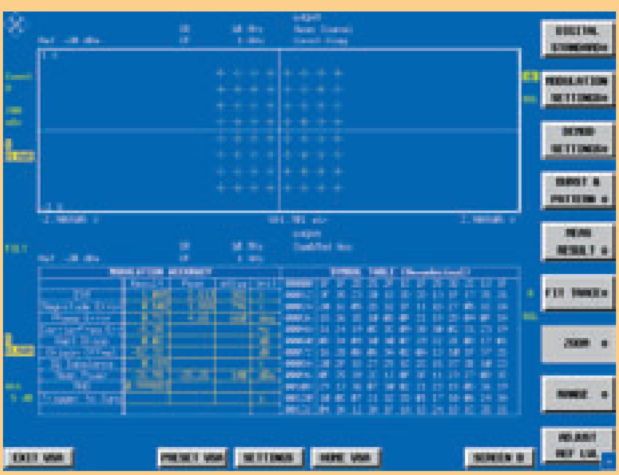


FIG 2 Constellation diagram, numeric result display and decoded symbols of a 64 QAM measurement signal.

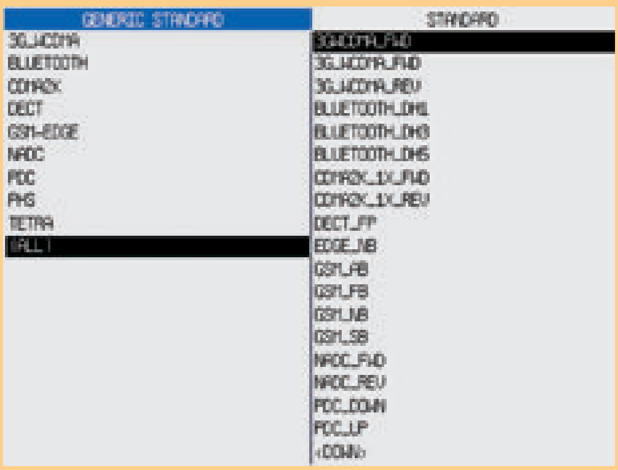


FIG 3 Selecting a standard from a table.

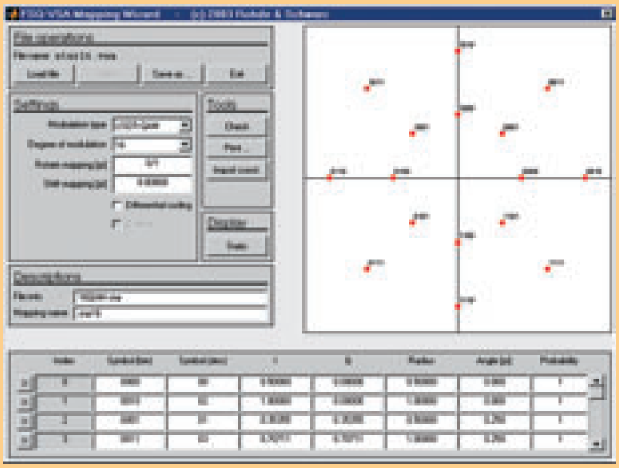


FIG 4 Creating a user-defined constellation.

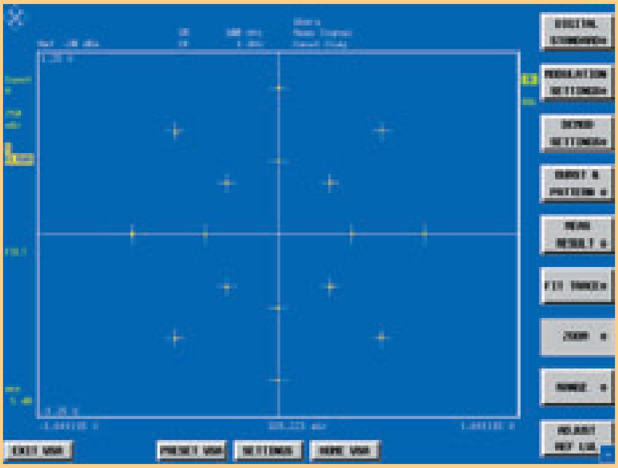


FIG 5 Constellation diagram of a measurement signal with user-specific constellation.

Unique is the easy way of measuring bursts that contain different modulation modes. An IEEE 802.11b burst, for example, contains a BPSK-modulated synchronization component at the beginning, followed by a QPSK-modulated payload component. FIGs 6 and 7 show the constellation diagrams of the components and the amplitude characteristic of the entire burst.

Measurement on filtered and unfiltered signals

The new vector signal analysis software already provides the receive and measurement filters prescribed by the standards for error measurement. In many cases, however, it is necessary to determine the modulation errors for unfiltered signals. It is possible to switch between the analysis of unfiltered and filtered signals at the press of a button. FIG 8 shows the vector diagram of an unfiltered 3π/8-8PSK signal (EDGE).

This function provides completely new analysis capabilities:

- Power measurements on burst signals without switching to the spectrum analyzer mode
- Measurements of nonlinear signal distortions
- Statistical evaluations

Statistical analysis, distribution and standard deviation

Each of the above-mentioned signal or error displays versus time can be switched to a statistical display simply by a keystroke. The statistical distribution of the measurement or error signal allows conclusions to be drawn about the type of modulation error (e.g. noise, sinusoidal interference or signal compression; FIGs 9 and 10). Determining statistical parameters in the measuring instrument makes complicated and time-consuming post-processing of measurement data in an external controller unnecessary.

The result table for modulation accuracy contains numeric results of the most important signal and error parameters (FIG 11). This table can also be easily expanded to include statistical evaluations. The results of the current measurement are listed on the left, while the quadratic and linear average and the standard deviation are listed on the right. In addition, the 95% probability factor ("95:th percentile") is calculated for the EVM measurement parameter.

Nonlinear distortions

An interesting innovation in R&S FSQ-K70, and one that is very useful for the development of amplifiers, is the measurement and display of nonlinear characteristics. From the demodulated bit stream, the software generates the ideal transmit signal with selectable oversampling. The analyzer compares the measurement signal with the ideal transmit signal at all sampling times and subsequently displays the level and phase errors versus the level of the ideal signal. Averaged over many measured values, this yields the display of the AM/AM and AM/φM conversion – key parameters primarily for dimensioning and optimizing power amplifiers. This distortion measurement is not restricted to continuous signals but can also be applied to TDMA signals as are used with EDGE, for example.

FIG 12 shows AM/AM conversion (top) and AM/φM conversion (bottom) for a distorted 16QAM signal (FIG 13).

Maximum measurement speed

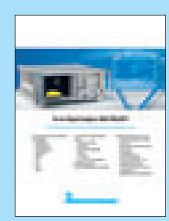
The vector signal analysis in the R&S FSQ is unique in terms of measurement speed and accuracy. The reason is that LSI ASICs are used for signal processing (frequency response correction, clock rate conversion and digital mixing), a powerful floating-point signal processor for demodulation and a Pentium® processor for sequence control, evaluation and display of measurement results.

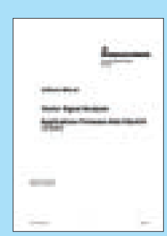
With measurements on GSM or EDGE signals, for example, the R&S FSQ can achieve measurement rates of up to 40 measurements/s. Not only does this allow adjustments to be made without waiting for the measurement result but also makes it possible to perform a series of statistical measurements in very short time. The high measurement speed ensures a high throughput and, together with the low measurement uncertainty, a high yield in production.

Hagen Eckert

More information and data sheets at www.rohde-schwarz.com (search term: FSQ-K70)


Data sheet R&S FSQ


Data sheet R&S FSQ-K70


R&S FSQ-K70 manual

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[1] Signal Analyzers R&S FSQ – Bandwidth and dynamic range for future systems and technologies. News from Rohde&Schwarz (2002) No. 74, pp 17–21
[2] Operating manual for R&S FSQ-K70 (can be downloaded from the Rohde&Schwarz website)

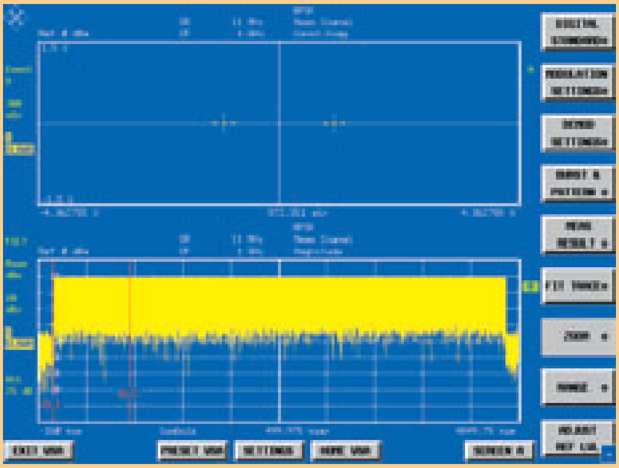


FIG 6
IEEE 802.11b burst; BPSK component.

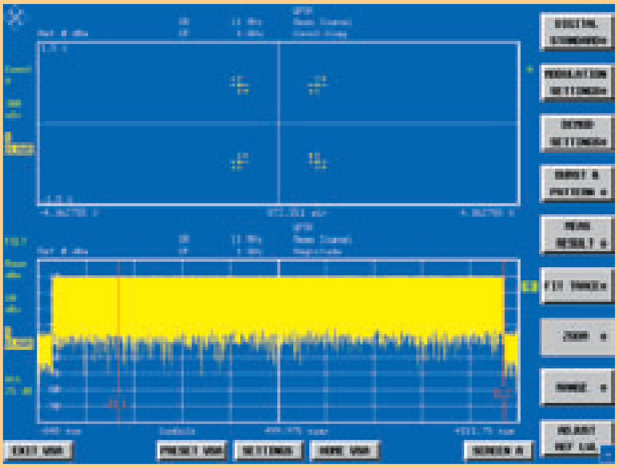


FIG 7
IEEE 802.11b burst; QPSK component.

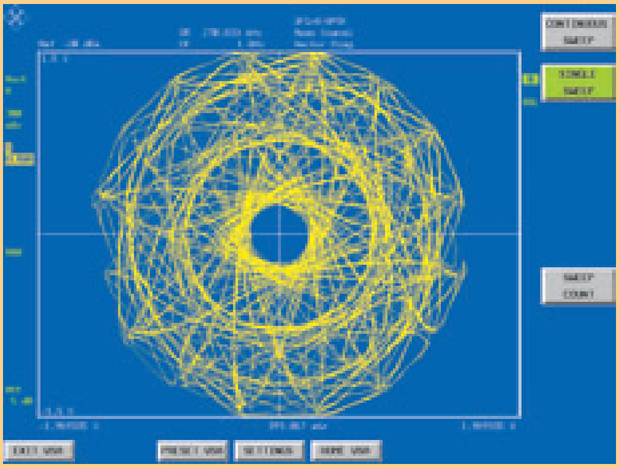


FIG 8
Unfiltered $3\pi/8$-8PSK signal (EDGE).

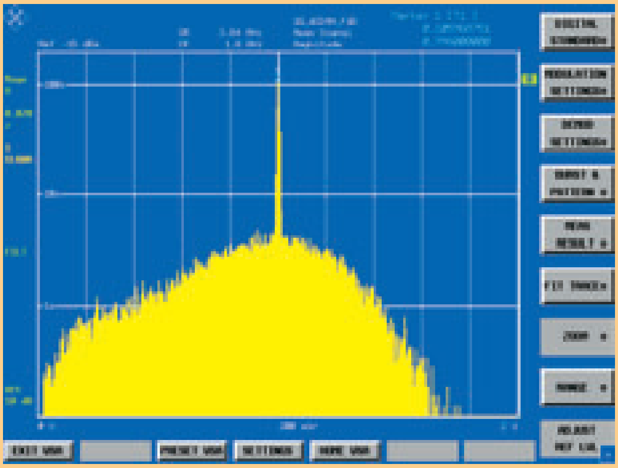


FIG 9
Probability density function (PDF) of a WCDMA measurement signal without superimposed sinusoidal interference.

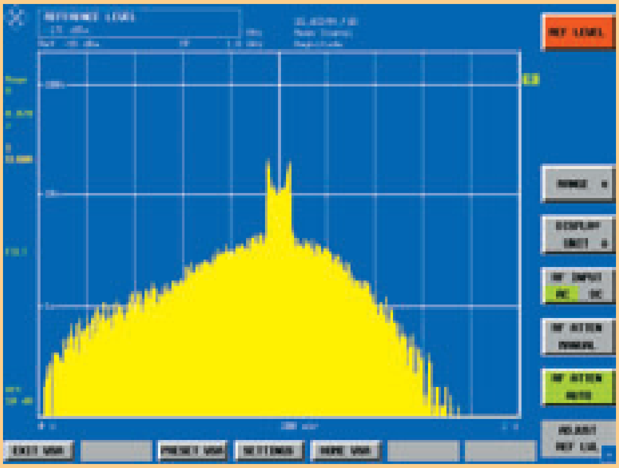


FIG 10
Probability density function (PDF) of a WCDMA measurement signal with superimposed sinusoidal interference.

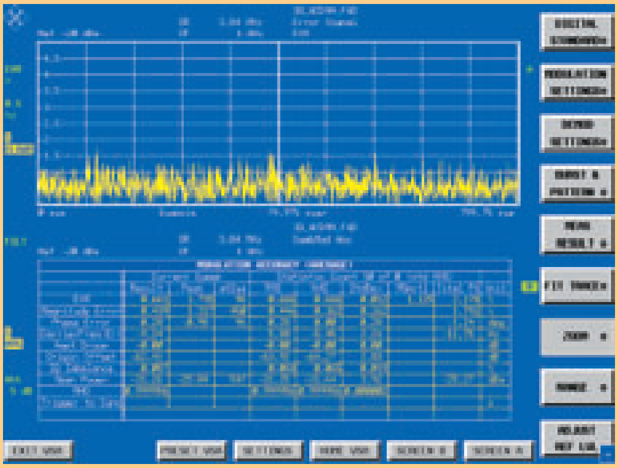


FIG 11
Bottom table: statistical evaluations over several measurements.

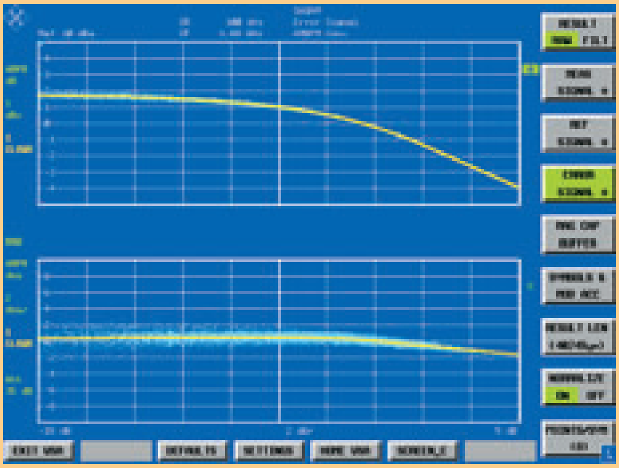


FIG 12
Distortion characteristics of AM/AM and AM/φM conversion. Blue: discrete measurement points; yellow: interpolated conversion curve.

FIG 13
Nonlinear distortions, 16QAM constellation diagram.

EMC Measurement Software R&S EMC32-A

Versatile EMS and EMI measurements for the automobile sector

EMC Measurement Software R&S EMC32-A (automotive) from Rohde & Schwarz is a powerful tool that is specially tailored to measurements in the automobile sector in line with ISO 11451/2 and CISPR 25 standards as well as to manufacturer-specific measurement procedures.

The merging of communications and mobility

With regard to technology, the 1990s featured a significant expansion of useful frequency ranges and the introduction of new modulation modes in wireless communications. At the same time, the percentage of electronic components used in the automobile sector rose steadily. In addition to fixtures such as airbags, ABS systems and traction control, which increase passive safety, it is hard to imagine automobiles without the auxiliary devices that make driving more convenient and enhance communication behind the wheel. In terms of electromagnetic compatibility, the merging of mobility and communications creates new challenges.

Mutual influence of electronic components in the vehicle must be excluded, and radiated disturbances from outside must not impair vehicle safety. For this reason, EMC measurements are performed when the vehicles and their electronic subassemblies (ESAs) are still in the development stage.

For this special field of applications in the automobile sector, Rohde & Schwarz has developed EMC Measurement Software R&S EMC32-A. The new software, which is based on EMC Measurement Software R&S EMC32 [*] launched in 2000, reflects Rohde & Schwarz's 20-plus years of experience in EMC measurements and the company's close cooperation with automobile manufacturers and suppliers.

All-in-one package for the automobile EMC world

R&S EMC32-A supports measurements for determining the immunity to conducted and radiated signals as well as emissions of motor vehicles and ESAs. The intuitive, easy-to-operate user interface allows users to get a quick start (FIG 1).

The software's measurement philosophy is ideal for compliance and batch testing with a high EUT throughput as well as for measurements accompanying development. Hence it can be used for a wide range of applications, from development and QM acceptance tests to production and quality assurance.

Electromagnetic susceptibility – EMS

For EMS measurements, the measurement procedures specified by the international standards ISO 11451 (for motor vehicles) and ISO 11452 (for components) are implemented in the software. The test setups for ISO 11451/2 preinstalled in R&S EMC32-A can be easily adapted to the instruments available in the laboratory interactively or by means of the integrated wizard and appropriate configuration files (FIGs 2 and 3). The online help provides step-by-step instructions from configuring the setup to performing the measurement.

Integrated control algorithms limit the susceptibility level during susceptibility tests, thus protecting the EUT and the test system against overloading.

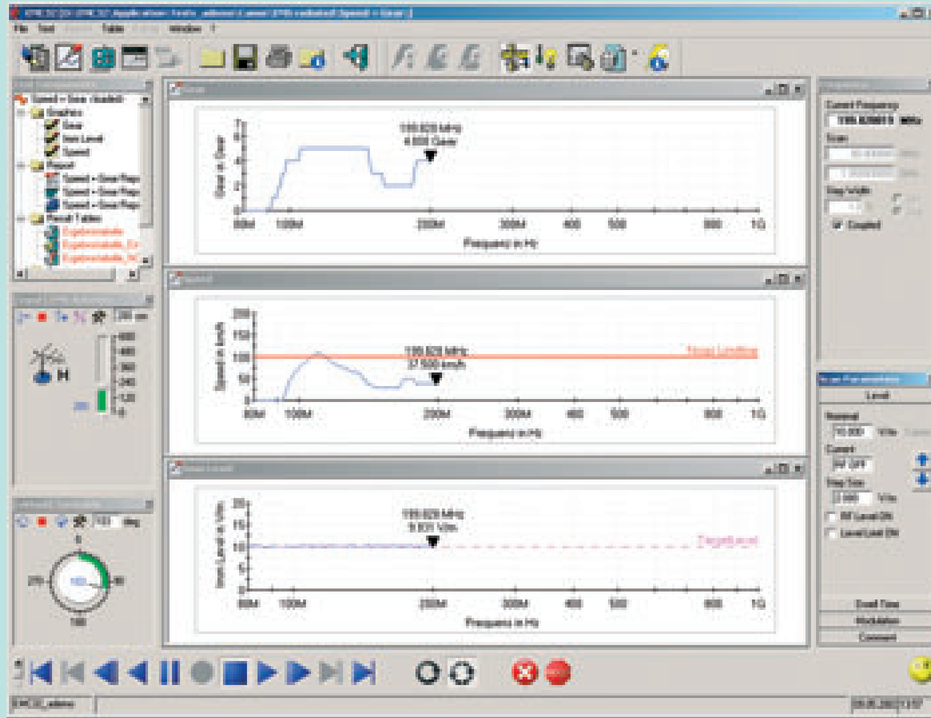


FIG 1 EMC Measurement Software R&S EMC32-A during an EMS test.

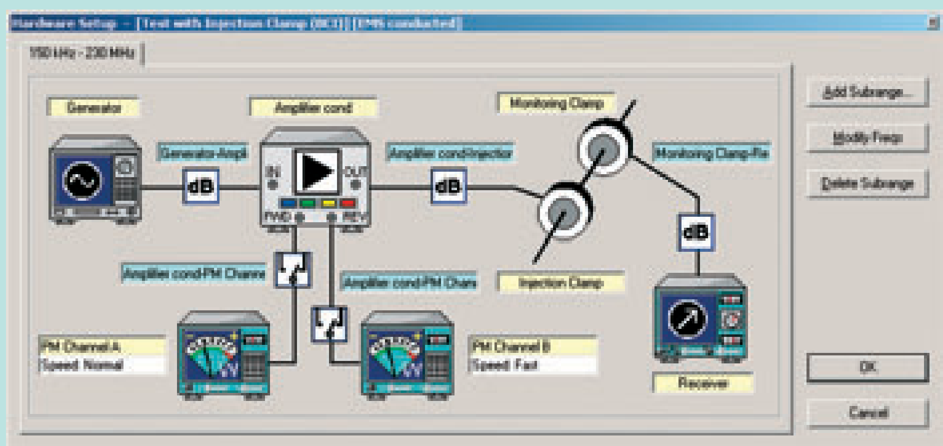


FIG 2 Device configuration for BCI measurements with a spectrum analyzer.

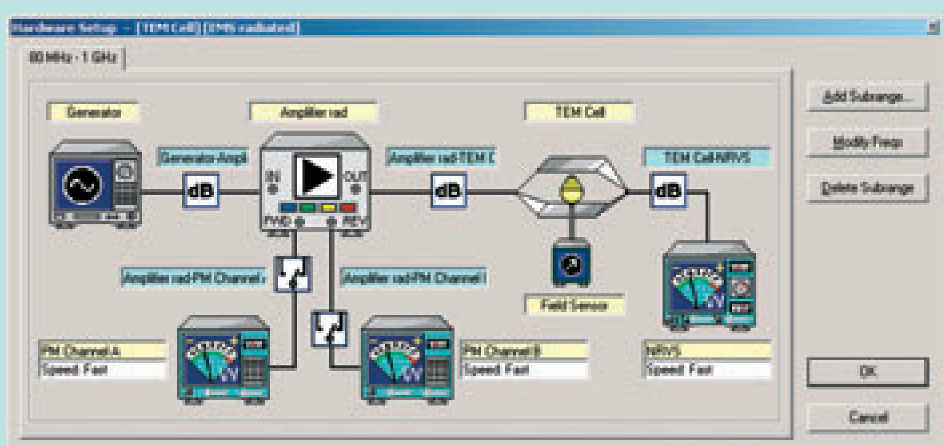


FIG 3 Device configuration for measurements in a TEM cell according to ISO 11452-3.

Stimulation and monitoring of EUT

The most important tasks of EMC measurement software for testing ESAs and vehicles (complete systems) are to generate susceptibility and provide functions for stimulating and monitoring the EUT.

Special features for generating susceptibility parameters

A number of interesting measurement functions for generating susceptibility parameters are implemented in R&S EMC32-A:

- The test specifications for conducted susceptibility BCI (bulk current injection) provide for the measurement of amplifier harmonics and the limiting of the current susceptibility level. For this purpose, the test software allows monitoring of the harmonics by means of a spectrum analyzer or test receiver; this function can also be used for amplifier testing.
- Parallel measurement of the forward and reflected power and the susceptibility level contribute to increasing the measurement speed and EUT throughput.
- The software supports the measurement of TEM cell attenuation specified by ISO 11452-3, which ensures reproducibility of measurement results.
- Additional physical parameters, such as the system impedance of a test setup for BCI tests during operation, can be calculated from the current measurement results by means of user-definable mathematical formulas.

The following **integrated stimulation functions** in R&S EMC32-A allow the EUT to be controlled at defined times in the test sequence:

- Putting the EUT into a defined state (e.g. switching it on or off) when a measurement is started or stopped
- Triggering an action of the EUT at certain frequencies or at each test frequency and using the monitoring functions to check the EUT's response to the influence of the susceptibility parameter
- Resetting the EUT to a defined state after a malfunction has been detected

The software allows **fully automatic monitoring** of the EUT. For this purpose monitoring channels that use defined threshold values or decision windows to provide a Go / NoGo statement as a function of test frequency and the test level. The software displays the test results in a table and/or graph. It also generates a table that only contains frequencies at which an error was detected.

FIG 4 shows the software's extensive interfaces and communication possibilities with the EUT. Communication can be on the basis of physical parameters (voltage, current, frequency, temperature) and by way of acoustic (sound level) or visual (camera) signals. A truly pioneering feature is the monitoring of the EUT via the vehicle's communication bus systems such as CAN, LIN, MOST or FlexRay.

Monitoring with measuring instruments

If communication is via physical parameters, measuring instruments (oscilloscope, TTL converter or voltmeter) are used to monitor the EUT's output signals or apply a defined signal to its inputs.

Monitoring via the CAN bus

In modern vehicles, the ESAs are linked via the CAN (controller area network) communication bus. Monitoring the data traffic on this bus makes it possible to test the functions of the individual components and of the overall system. The Stuttgart-based company Vector Informatik (www.vector-informatik.de) provides a comprehensive software/hardware solution for this purpose. In this case, R&S EMC32-A uses the open interface (COM, DCOM) of the CANoe™ analysis software to send data to a specific device on the CAN bus and to query parameters such as wheel / engine speed or indicator light frequency. The CANoe™ software

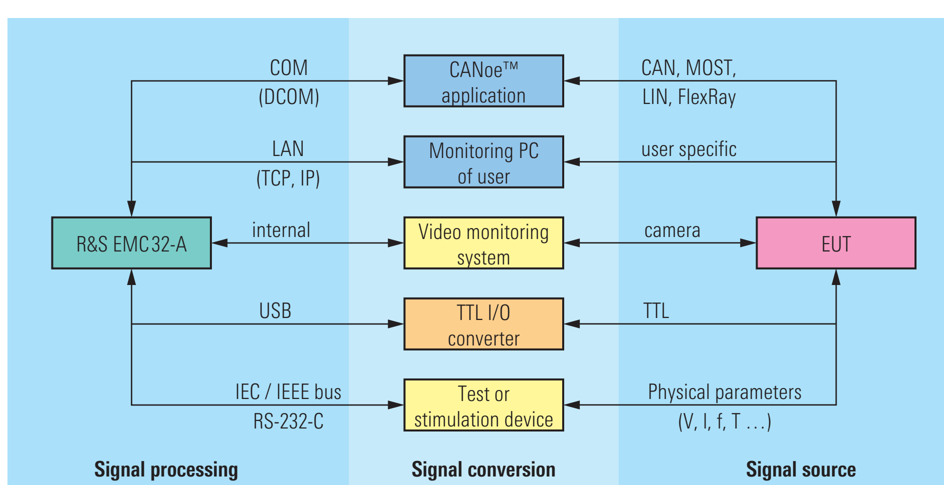


FIG 4 **Monitoring possibilities with EMC Measurement Software R&S EMC32-A.**

can be installed either on the same computer on which R&S EMC32-A is operated or on another computer connected via a local network. FIG 5 shows the configuration for monitoring two parameters of a vehicle with a threshold value for the velocity; FIG 6 shows a list of the available parameters of an ABS control unit. An example of the configuration of a measurement channel is shown in FIG 7.

Automatic determination of immunity threshold

Even in the development phase, it is important to determine the characteristic of the maximum susceptibility as a function of frequency. This measurement can be automated using the extensive monitoring capabilities of R&S EMC32-A. This fully automatic susceptibility measurement outputs two susceptibility level characteristics (hysteresis), which indicate the level at which the EUT's faulty response disappears and the level at which it reoccurs (FIG 8).

EMI measurement according to CISPR 25

R&S EMC32-A already includes the limit lines required for EMI measurements according to CISPR 25. The EMI measurement as specified by the standard produces up to 300000 values per measurement, which are displayed by the software in easy-to-read graphs or tables. Both the zoom functionality and the display of additional graphs allow thorough analysis of details in critical frequency ranges (e.g. LF or VHF range).

R&S EMC32-A also supports monitoring of the EUT for correct functioning in EMI measurements. Particularly supplier companies that use classic temporary-service motors (servomotors, sliding roof, antenna motors) are faced with the ▶

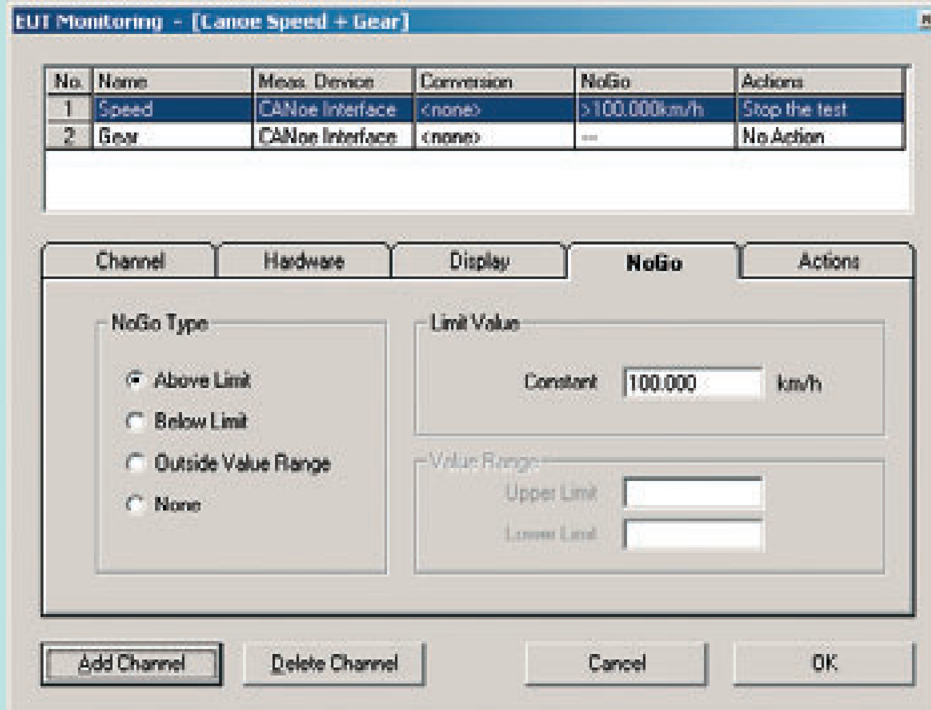


FIG 5 Configuration for monitoring the velocity and gear of a vehicle.

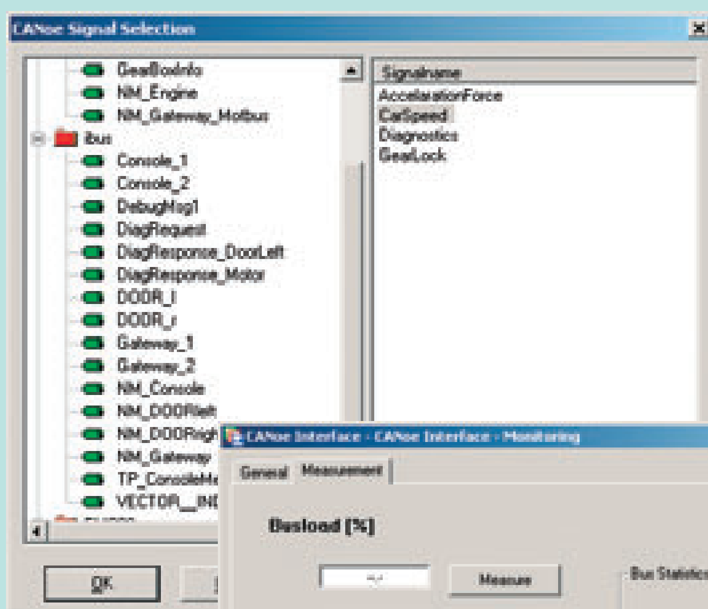


FIG 6
A selection of monitoring signals of an ABS control unit.

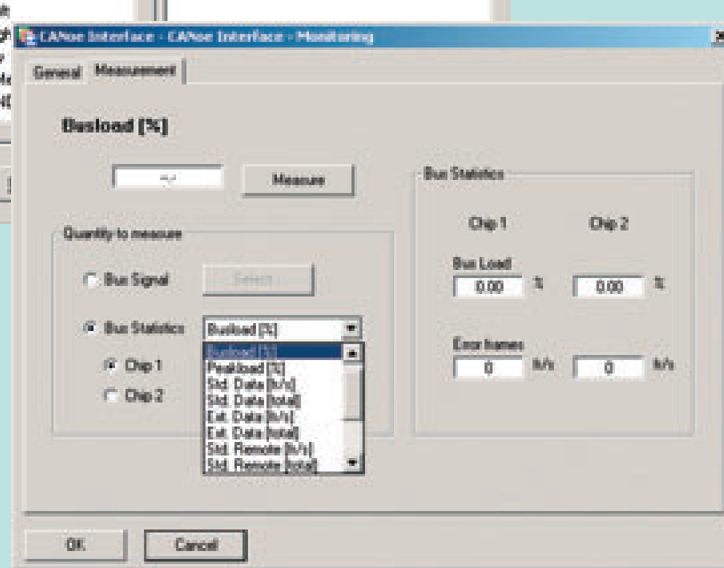


FIG 7
Monitoring of CAN bus statistic values.

challenge during an emission measurement of keeping the EUT running continuously for a length of time that exceeds its duration of operation under real conditions. For this reason, Rohde & Schwarz has taken customer requirements for a flexible monitoring solution during emission measurements into account by introducing R&S EMC32-A.

Comprehensive driver package

A comprehensive driver package, which is standard with R&S EMC32-A, is used for controlling the following equipment classes:

- Signal generators / analyzers
- Power meters
- Field-strength sensors
- Amplifier control units
- Switch units
- Mast and turntable control units

To ensure the use of existing systems or of instruments from other manufacturers, configuration files for the generic drivers supplied with R&S EMC32-A can be downloaded for the following equipment classes from the Rohde & Schwarz website:

- Signal generators
- Power meters
- Amplifier control units
- EUT monitoring equipment

There you will also find an up-to-date overview of all drivers, sorted according to equipment classes, in tabular and graphic form.

Summary

EMC Test Software R&S EMC32-A is an outstanding all-in-one package for EMC measurements in the automobile sector. It features not only comprehensive functionality for stimulating and monitoring automotive components and motor vehicles but also standard-compliant generation of required immunity signals and EMI measurements. With its modular structure, the software can be easily adapted to changes in standards or manufacturer-specific test procedures and allows new measurement instruments to be integrated. It is therefore a future-proof investment.

Robert M. Gratzl; Marcus J. Donhauser

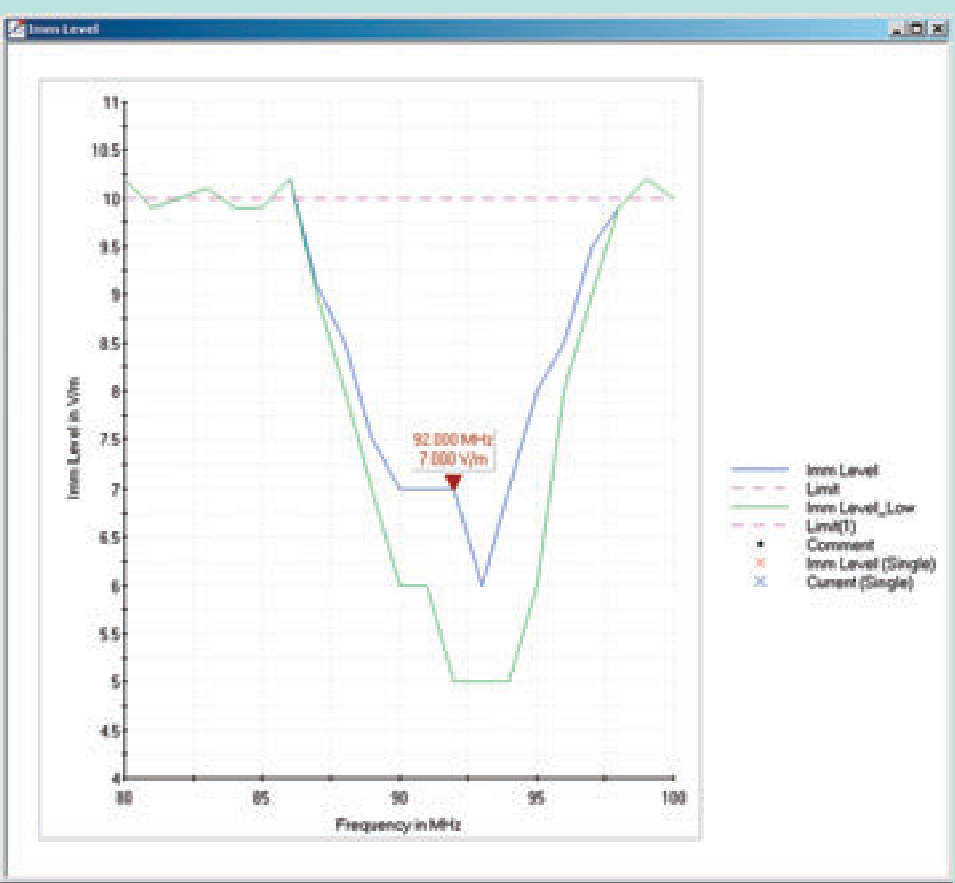


FIG 8
Result of an automatic determination of susceptibility threshold.

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

Data sheet R&S EMC32

REFERENCES
[*] EMC Measurement Software R&S EMC32 – Comprehensive EMI and EMS measurements at a keystroke. News from Rohde & Schwarz (2001) No. 172, pp 27–29

FIG 1 Whether with built-in or external preamplifier, the EMI Test Receivers R&S ESIB represent a superior complete test system, featuring excellent RF and microwave characteristics.

EMI Test Receivers R&S ESIB 26 / R&S ESIB 40

Better system sensitivity through preamplifiers

High attenuation values significantly limit the total sensitivity of a test system in the microwave range. Only the use of a broadband low-noise preamplifier makes it possible to fulfill the high sensitivity requirements defined for measuring radiated emissions (EMI) in compliance with standards.

Measurements in line with standards mean high requirements

The attenuation values and transducer factors of cables and antennas in the microwave range are so high that they considerably limit the sensitivity of a receiving system and thus the dynamic range for measurements. One solution is to use a broadband low-noise preamplifier directly on the antenna or before the receiver input which significantly improves the total sensitivity of a test system. Only then is it possible to fulfill the high requirements placed on the sensitivity and performance of measuring instruments by test standards.

Limit lines and transducer factors for the R&S ESIB ready for download; see page 46.

Specifications for standard-conforming EMI emission measurements in commercial applications above 1 GHz are defined in the basic standard CISPR 16-1 (1999), which also defines requirements for the measurement environment and measuring instrument characteristics up to 18 GHz. Military applications are governed by standards such as the internationally recognized MIL-STD-461 E – and specifically parts RE 102 and RE 103 (RE: radiated emission) – which requires EMI measurements up to 40 GHz.

The EMI Test Receivers R&S ESIB 26 and R&S ESIB 40 (FIG 1) from Rohde & Schwarz offer superb RF characteristics for sensitivity and dynamic range [1]. Equipped with the R&S ESIB-B2 option [2], both have an internal preamplifier (up to 26 GHz or 40 GHz, respectively), which predestines them for measurements in line with the sophisticated MIL standard.

Calculation of noise factor and noise figure

Test systems for radiated emissions are fundamentally a cascade circuit consisting of receiving antenna, preamplifier, connecting cable and EMI test receiver, which in some cases is extended by an internal preamplifier (FIG 2). The total noise factor for this configuration can be calculated by subdividing the components into individual elements such as twoports and determining their separate contribution to the overall result.

The (dimensionless) noise factor F of a twoport is the ratio of its S/N ratio at the input (S_1/N_1) to the S/N ratio at the output (S_2/N_2):

$$F = \frac{S_1/N_1}{S_2/N_2}$$

This yields the noise figure *NF* in dB:

$$NF = 10 \cdot \lg F$$

In addition, the noise factor and gain of twoports are a function of frequency, which means that the individual values for approximate calculations can be determined only for discrete frequency points.

The total noise factor of several twoports connected in series (FIG 3) is obtained by adding together the noise factors of successive twoports while taking into consideration the gain *G* of each preceding port as shown in the following equation:

$$F_{\text{total}} = (F_1 - 1) + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 \cdot G_2} + \cdots + \frac{F_n - 1}{\prod_{i=1}^{n-1} G_i}$$

where F_i = noise factor of a given component
G_i = gain of a given component

Within the equation, the third twoport will thus have a noise factor of F_3 and a gain calculated from the two preceding values, G_1 and G_2.

Because an ideal, noise-free twoport has a noise figure of 0 dB or a noise factor of 1, its contribution to the total noise factor must yield zero. In the equation, this is expressed by:

$$F_z = F - 1$$

Calculation of total noise factor

The following example calculation of the total noise factor is based on the setup shown in FIG 2. Since a preamplifier cannot be placed in front of the receiving antenna, the first possible point of intervention is directly on the antenna output. The low-noise, broadband preamplifier must be dimensioned with respect to overload control in such a manner that it cannot be overdriven by broadband noise signal spectra and that it changes the antenna input parameters as little as possible. As a result, preamplifiers for frequencies up to 18 GHz, 26 GHz or 40 GHz are relatively expensive.

The total noise factor for all four components connected after the antenna is calculated as follows on the basis of their noise factors *F* and gain/attenuation *G*:

$$F_{\text{total}} = (F_1 - 1) + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 \cdot G_2} + \frac{F_4 - 1}{G_1 \cdot G_2 \cdot G_3}$$

The numeric values in the following example calculation – e.g. for 18 GHz – are rounded up or down to obtain simple values that are easy to remember. The corresponding data sheets contain the exact specifications.

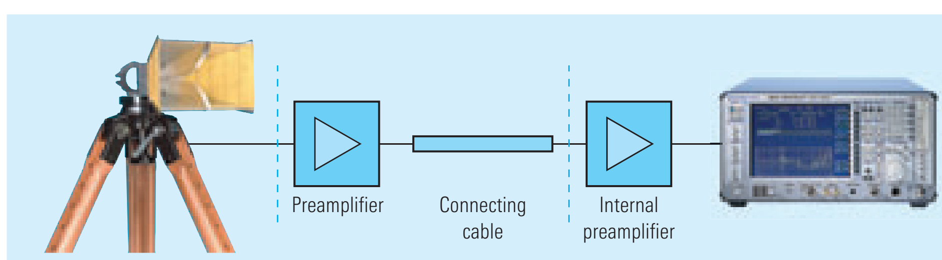


FIG 2 Practical arrangement of twoports in EMI measurements.

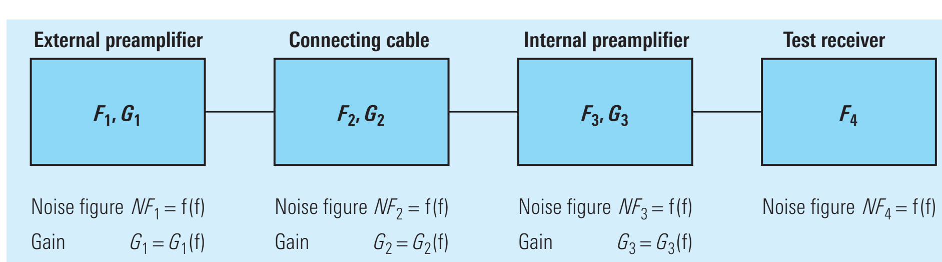


FIG 3 Cascading of several twoports.

Preamplifier
$NF_1 = 3$ dB; $F_1 = 2$;
Gain $g_1 = 30$ dB ($G_1 = 1000$)

Cable RTK081 (FIG 4) at 18 GHz
$NF_2 = 15$ dB; $F_2 = 31.62$;
Attenuation $a_2 = -15$ dB ($G_2 = 0.03162$)

Internal preamplifier
$NF_3 = 10$ dB; $F_3 = 10$;
Gain $g_3 = 20$ dB ($G_3 = 100$)

EMI test receiver
$NF_4 = 20$ dB; $F_4 = 100$

This yields the following:

$$F_{z\,total} = (2-1) + \frac{31.62-1}{1000} + \frac{10-1}{1000 \cdot 0.03162} + \frac{100-1}{1000 \cdot 0.03162 \cdot 100}$$

$$= 1 + 0.03062 + 0.2846 + 0.031309 = 1.3465$$

$$F_{total} = F_{z\,total} + 1 = 2.3465$$

Total noise figure NF_{total} = 3.704 dB

Results from the calculation of the total noise factor

The example calculation shows that the noise of the entire circuit is determined primarily by the preamplifier characteristics. The subsequent components are largely insignificant due to the preamplifier's gain factor. Thus, the amplifier must not be overdimensioned (see also the comments regarding dynamic range on page 46).

The choice of microwave cables is also important. The cables must be chosen with regard to optimum (minimum) length and attenuation. Long cables with high attenuation significantly increase the costs for improved sensitivity with preamplifiers. Investing several hundred to a thousand euros in suitable cables can eliminate the need for better amplifiers, which can cost up to 10 000 euros depending on the frequency range. Cable length can be kept to a minimum in many cases by placing the test equipment located outside the anechoic chamber in a favourable position near the test antenna.

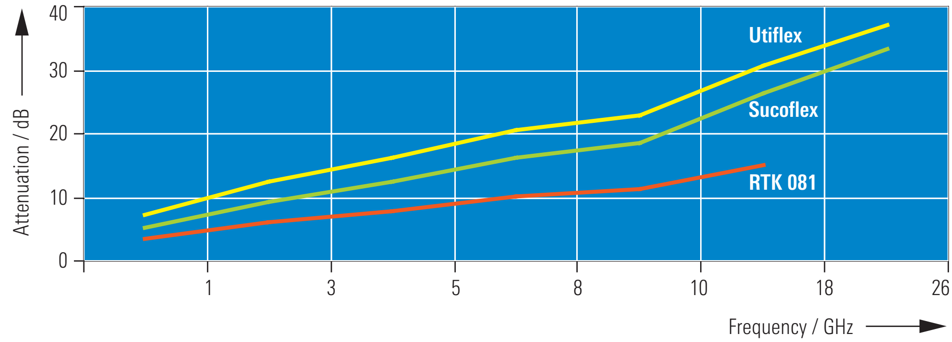


FIG 4 Attenuation of cables with a length of 20 meters.

Which amplifier for the given noise figure?

When the minimum noise figure for the entire test system is in line with the test standards, the required preamplifier gain can also be determined.

In the following example, the total noise figure desired for the test system is 5 dB. A preamplifier with a noise figure of $NF_{preamp} = 3$ dB ($F_{preamp} = 2$) is selected for the specified frequency range. The question is whether an amplifier with 10 dB or 20 dB needs to be selected (G_{preamp} 10 or 100). For example, the subsequent test receiver has a noise figure of $NF_{Rx} = 15$ dB or $F_{Rx} = 31.62$. The following is obtained when these values are used in the simplified equation with a preamplifier preceding the test receiver:

$$F_{z\,total} = (F_{preamp} - 1) + \frac{F_{Rx} - 1}{G_{preamp}}$$

When G_{preamp} = 10:

$$F_{z\,total} = (2-1) + \frac{31.62-1}{10} = 4.062$$

$$F_{total} = F_{z\,total} + 1 = 5.062$$

NF_{total} = 7.04 dB

When G_{preamp} = 100:

$$F_{z\,total} = (2-1) + \frac{31.62-1}{100} = 1.3062$$

$$F_{total} = F_{z\,total} + 1 = 2.3062$$

NF_{total} = 3.62 dB

This shows that a total noise figure of <5 dB can be achieved only with a 20 dB amplifier.

The criteria for using and selecting preamplifiers are thus as follows:

- The 20 dB preamplifier improves sensitivity from 15 dB to 3.6 dB, i.e. the dynamic range increases by 11.4 dB at the lower end but decreases at the upper end. The maximum permissible input level with a 20 dB preamplifier decreases by 20 dB. Thus, the total dynamic range loss is 8.6 dB. **Therefore, do not select more gain than absolutely necessary.**
- **Use an amplifier with suitable linearity**. If broadband signals have high levels and a large occupied bandwidth, a preamplifier can be overdriven. Particular attention should

thus be paid to its linearity, especially when no preselection filters can protect the input stage of the measuring instrument.

- **Attach a preamplifier directly to the antenna** to ensure maximum increase in sensitivity.
- **Use an amplifier with calibrated gain** to minimize the measurement uncertainty of the entire system.

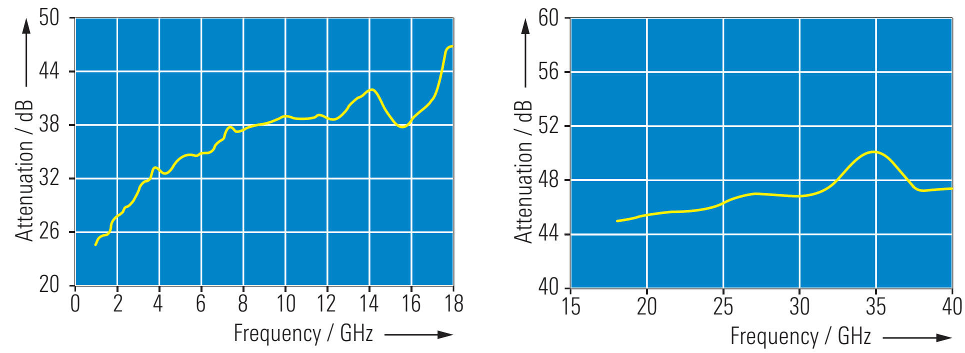


FIG 5 Typical attenna factors for horn attennas.

What is the available dynamic range?

When determining the minimum noise figure required for a complete test system, the dynamic range needs to be considered. For example, if the measurement bandwidth is 1 MHz, the noise floor increases by 60 dB in accordance with 10 log RBW / 1 Hz. Due to the antenna factor, the dynamic range decreases further by approx. 45 dB (at 18 GHz; see FIG 5).

FIG 6 shows this reduction of the dynamic range as a result of a measurement bandwidth of 1 MHz, the use of a preamplifier, allowance for antenna correction values as well as different detector types (peak or average value). The preamplifier reduces the permissible level at the test receiver input by 30 dB, i.e. by its gain. The antenna correction factors represent attenuation values that require higher IF gain, thus increasing the internal noise by the amount of the correction value, e.g. by 45 dB.

Thus, only high-quality test receivers with a basic dynamic range of approx. 100 dB can be used for sophisticated measurements in line with test standards. The Test Receivers R&S ESIB 26 and R&S ESIB 40 feature these prop-

FIG 6 Numerous factors diminish the useful dynamic range.

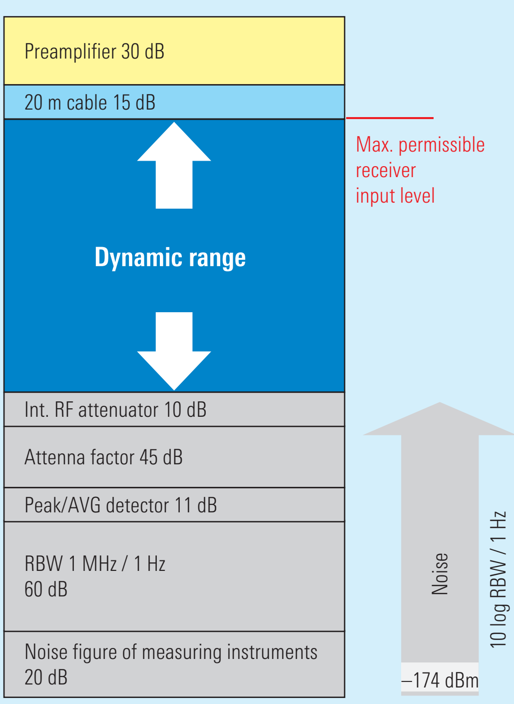
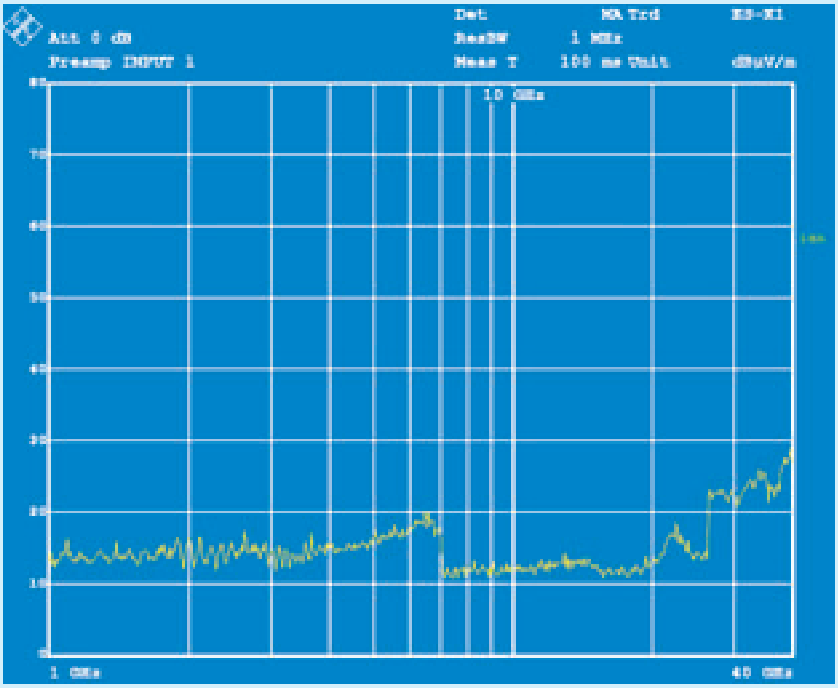


FIG 7 Noise characteristic of the EMI Test Receiver R&S ESIB 40 between 1 GHz and 40 GHz.



erties – large dynamic range and low inherent noise.

These receivers are indispensable because they offer high reproducibility of measured values and the capability to generate reports, which also makes them ideal as reference test instruments in the full compliance class, i.e. for EMC compliance testing to different standards in the certification of electrical and electronic components, instruments and systems in the civil and military area.

FIG 7 shows the typical noise characteristics of the EMI Test Receiver R&S ESIB 40 between 1 GHz and 40 GHz with an activated 20 dB preamplifier, 1 MHz measurement bandwidth and average detector. Including the correction values specified in FIG 5 for the various horn antennas yields the noise curve shown in FIG 8, recorded with a peak detector. The measurement not only meets the MIL-STD-461E RE 102-4 standard when performed with an internal preamplifier but is actually up to 10 dB below the required limit line for maximum permissible emissions. The cable selected determines whether a low-noise preamplifier with corresponding gain must be used.

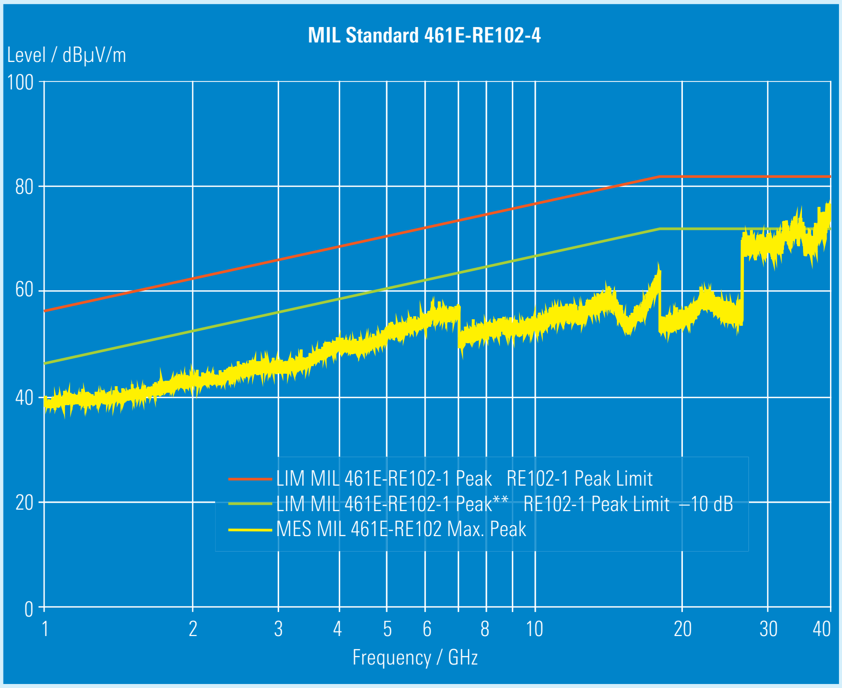
Summary

To meet the strict requirements of the standards for the measurement of radiated emissions up to 40 GHz while taking into account the receiver, connecting cable and antenna, it is necessary to include dimensioning fundamentals such as the determination of noise factor described here. The criteria for cable selection and dimensioning as well as a suitable amplifier are to be determined on the basis of the parameters of the antennas and EMI test receiver that are used.

The EMI Test Receivers R&S ESIB 26 and R&S ESIB 40 with built-in preamplifier option R&S ESIB-B2 up to 26.5 GHz or 40 GHz represent a superior complete test system with excellent RF and microwave specifications. They can be used to successfully perform compliance testing to standard.

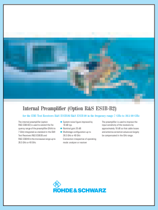
Volker Janssen

FIG 8 Noise curve (peak) at 1 MHz measurement bandwidth and attenna transducer factors.



More information and data sheet at www.rohde-schwarz.com (search term: ESIB-B2)

Data sheet R&S ESIB



Data sheet R&S ESIB-B2

REFERENCES

[1] EMI Test Receivers ESI: EMI professionals through to 40 GHz. News from Rohde & Schwarz (1999) No. 162, pp 7–9

[2] EMI Test Receivers R&S ESIB 26 / R&S ESIB 40: Internal preamplifiers for improved sensitivity above 7 GHz. News from Rohde & Schwarz (2002) No. 173, pp 28–29

EMI Test Receivers R&S ESIB

Limit lines and transducer factors ready for download

The EMI Test Receivers R&S ESIB [*] support generation and storage of virtually any number of limit lines and transducer factors with the aid of an easy-to-use table editor. However, it takes a certain amount of time to edit a large number of tables. For this reason, as a special service the limit lines of the most important EMC standards and the transducer factors of the most common transducers in an R&S ESIB-specific file format can be downloaded from the Rohde & Schwarz website.

Test Receivers R&S ESIB offering high convenience

In EMI measurements, limit lines define values for the spectral characteristic of interference parameters such as voltages, field strengths, currents and powers that must not be exceeded. After a limit line stored in the test receiver has been activated, it is displayed on the screen. The characteristic of the measured values can then be checked either visually or automatically by means of a receiver-internal evaluation routine, to determine whether the limit line (or an adjustable margin to it) has been exceeded, with the line permanently assigned to one of the four traces of the test receiver. In this way, different limit lines can be assigned to the different detectors in the R&S ESIB.

To detect radiated or conducted RF disturbance, a transducer is connected ahead of the test receiver. The transducer converts the disturbance to be measured to a voltage into 50 Ω (receiver input impedance). Most transducers have a frequency-dependent transducer factor. If a typical transducer factor has been stored and activated in the R&S ESIB, the test receiver automatically takes it into account and presents the measured values with correct quantity and unit.

These user-definable limit-value and transducer-factor tables are stored on the internal hard disk of the R&S ESIB; their number is therefore virtually unlimited. As many as 50 values per table are possible.

Which files are ready for downloading?

To reduce the amount of time required to generate the different tables, Rohde & Schwarz provides on its website the limit values of the most important civil and military standards for EMI measurements and the typical transducer factors for common transducers such as antennas, absorbing clamps, probes and coupling networks.

The zip file "lim_tdf.zip" can be downloaded from the Rohde & Schwarz website (just enter the name of the file as the search term). After unpacking this file, the appropriate files in R&S ESIB-specific format can be directly loaded into the instrument.

The file "limitall.lia" provides the limit lines for numerous standards; the two other files, "tdf_all.tfa" and "tdf_all.tsa", contain the typical transducer factors of different transducers (FIGs 1 and 2).

The tables can be easily stored in the R&S ESIB at the press of a button via the RECALL function and the built-in disk drive (path a:\...). After calling the appropriate function <LIMITS> or <SETUP>+<TRANSDUCER>, the tables are available (FIG 3).

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

[*] For references, see page 45.

Transducer	Type designation
Log-Periodic Broadband Antennas	R&S HL023A1, R&S HL025, R&S HL040, R&S HL223
ULTRALOG	R&S HL562
Biconical Antenna	R&S HK116
Rod Antennas	R&S HFH2-Z1, R&S HFH2-Z6
Loop Antenna	R&S HFH2-Z2
Horn Antennas	EMCO 3115, R&S HF906
BiLog Broadband Antennas	CBL6111, CBL6112
Conical Log Spiral Antenna	R&S HUF-Z4
Broadband Dipole	R&S HUF-Z1
Precision Halfwave Dipole Sets	R&S HZ-12, R&S HZ-13
Current Probes	R&S ESH2-Z1, R&S ESV-Z1, R&S EZ-17
Probes	R&S ESH2-Z2, R&S ESH2-Z3
Coupling Networks (CISPR 22)	R&S ENY22, R&S ENY41
Absorbing Clamp	R&S MDS21
Calibrated Magnetic Field Pickup Coil	R&S HZ-10

FIG 1 Transducer factor tables are available for these transducers.

Civil standards	Disturbance
EN55011 (class B/groups 1 and 2)	RFI voltage QP/AV
EN55011 (class B/group 1)	RFI field strength QP
EN55013 (AC supply connection)	RFI voltage QP/AV
EN55013 (AC supply connection)	RFI power QP/AV
EN55014	RFI voltage QP/AV
EN55014	RFI power QP/AV
EN55015	RFI voltage QP/AV
EN55022	RFI voltage QP/AV
EN55022	RFI field strength QP
FCC15 class A	RFI voltage QP/AV
FCC15 class A	RFI field strength QP
FCC15 class B	RFI voltage QP/AV
FCC15 class B	RFI field strength QP
Military standards	
MIL-STD-461E CE101-1 to -4	RFI voltage Pk
MIL-STD-461E CE102-1	RFI voltage Pk
MIL-STD-461E RE101-1 to -2	RFI field strength Pk
MIL-STD-461E RE102-1 to -4	RFI field strength Pk

FIG 2 Civil and military standards for which limit lines are available (QP: quasi-peak; AV: average; Pk: peak).

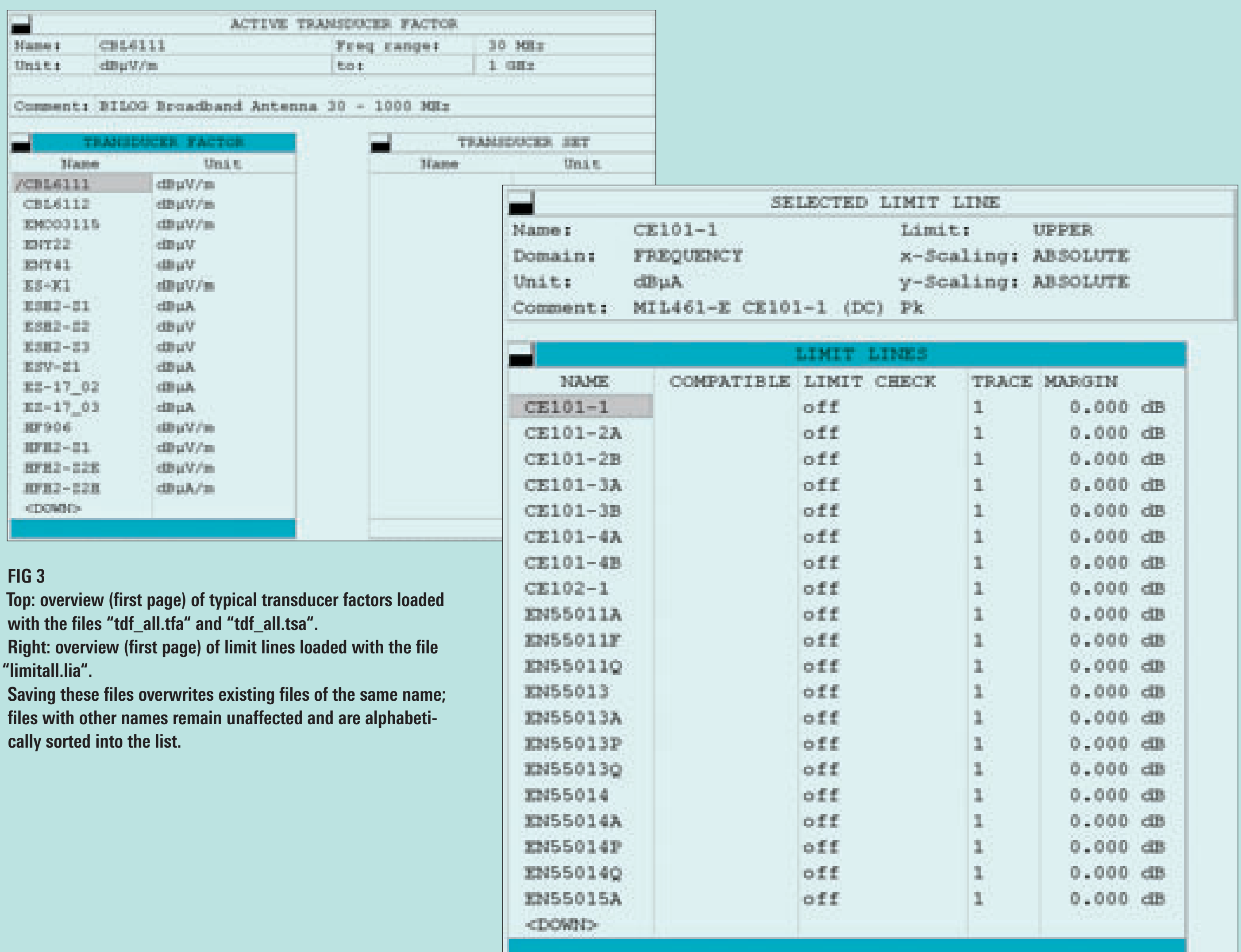


FIG 3
Top: overview (first page) of typical transducer factors loaded with the files "tdf_all.tfa" and "tdf_all.tsa".
Right: overview (first page) of limit lines loaded with the file "limitall.lia".
Saving these files overwrites existing files of the same name; files with other names remain unaffected and are alphabetically sorted into the list.

UHF Transmitter Family R&S SV 7002

DTV low-power transmitters – modular and space-saving

Following the positive market response to the low-power Transmitter Family R&S SV 7000 (50 W to 200 W), Rohde & Schwarz has developed two additional amplifiers for the lower power range and enhanced them with a four-way coupler for higher output power. Together with the new DTV Exciter R&S SV 702 with its integrated central control unit (CCU) and the optional R&S NetCCU as an expanded CCU for standby configurations, the result is a very compact and economical solution for the 5 W to 420 W power range.

FIG 1 The low-power TV Transmitter R&S SV 7002 for DVB-T with 55 W output power. Together with the Exciter R&S SV 702 (top), it provides a compact solution that does not require a transmitter rack.

Flexible and space-saving transmitter design

These new DTV low-power transmitters are used to cover service area gaps, valleys and widely scattered populated areas and are also implemented in data networks with cell structures. This specific application particularly requires that the transmitters be space-saving and very economical.

Flexible concepts and compact transmitters are obtained with the new **DTV Exciter R&S SV 702** [1], which occupies only two height units (HU). Since the exciter comes equipped with a simple CCU, the transmitter without standby does not even require a rack (FIG 1). All operation-relevant interfaces are fully integrated into the units. External components are required only for standby systems or if several amplifiers are combined to boost output power. Two 19" racks with 21 and 42 height units are available for this purpose; a rack with only 12 height units is available for exceptionally compact solutions.

Up to four amplifiers (rather than just two as in the past) can now be combined to boost output power by using a **new four-way coupler**. Thus, 420 W DVB-T power can be implemented in a rack of 21 height units. Being able to set up a large variety of systems and to accommodate several transmitters in a single rack means maximum flexibility. Plus, adding amplifiers with higher output power or extra transmitters to an existing rack takes almost no effort.

The members of the new transmitter family at a glance

The new Transmitter Family R&S SV7002 includes not only the DTV Amplifiers R&S VH610A2/620A2 (also used in the R&S SV7000 family [2]) with DVB-T power of 55 W and 120 W, respectively, but also the two new low-power amplifiers, the 12.5 W R&S VH6010A2 and the 25 W R&S VH6020A2. The new four-way coupler can be used to interconnect up to four amplifiers.

This family of products is rounded out by the new DTV Exciter R&S SV702 with integrated CCU and the optional R&S NetCCU for standby configurations and remote connection.

Various configurations are possible with the new transmitter family:

- Single transmitters
- Transmitters with exciter standby
- Transmitters with passive exciter and output stage standby
- (n+1) standby systems with up to six main transmitters and one standby transmitter

The simple CCU integrated into the Exciter R&S SV702 is sufficient for single transmitters, whereas standby systems also require the new **R&S NetCCU** module with its automatic switchover unit. Like the R&S SV702, the R&S NetCCU is a 19" rackmount of only two height units. If an exciter or the R&S NetCCU fails, operation is maintained by an emergency control circuit redundantly fed by the exciter power supplies.

Transmitter output power is detected either in the exciter or the R&S NetCCU. The amplifiers supply a test voltage obtained in directional couplers at the amplifier outputs.

The exciter can be configured either by means of an external PC with a convenient graphical user interface (GUI) or, if the R&S NetCCU is available, directly from its integrated, high-resolution display.

Two new amplifiers for low transmission power

Two new amplifiers are now available in addition to the existing DTV Amplifiers R&S VH610A2/620A2, which have a DVB-T power of 55 W and 120 W, respectively: the 12.5 W **R&S VH6010A2** and the 25 W **R&S VH6020A2**, which optimally cover the lower power range. All amplifiers are broadband and operate in the 470 MHz to 862 MHz range. The R&S VH6020A2 looks like the R&S VH610A2 from the exterior and is accommodated in a 19" rackmount of three height units. The R&S VH6010A2 is half as wide as a 19" rackmount and takes up only two height units (FIG 3). Thus, two amplifiers take up little space in a rack when installed

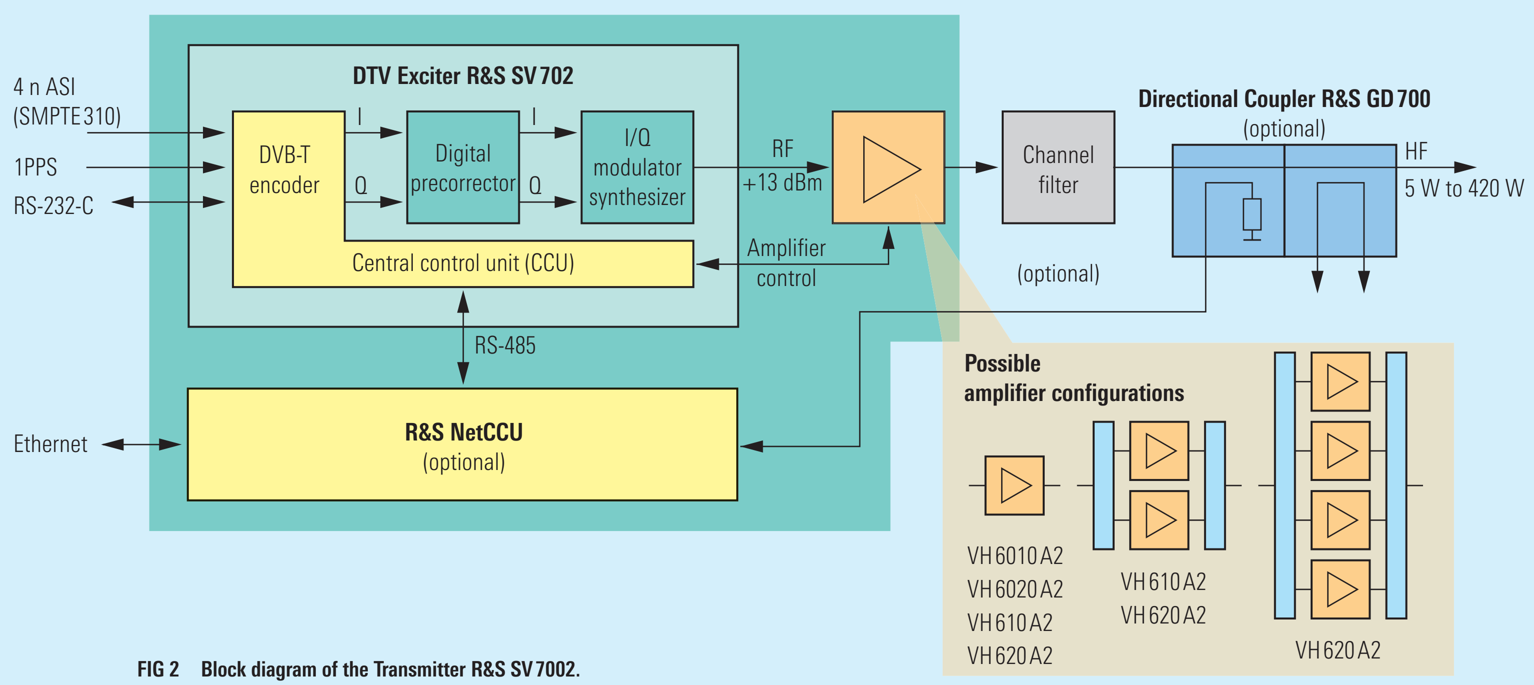


FIG 2 Block diagram of the Transmitter R&S SV7002.

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FIG 3 The DTV Amplifier R&S VH6010A2 (12.5 W) with half the width of a 19" rackmount.

side-by-side by means of an insertion frame. Both the power supply and the complete cooling system are fully integrated into the amplifiers, thus requiring no peripherals. This enables flexible installation in a standard 19" rack or even operation without any rack at all, as shown in FIG 1. Single transmitters merely require an RF connection and a line to the exciter. All amplifiers have identical control interfaces. The driver and output stages are designed using exclusively LDMOS technology, which ensures high basic linearity and stability of the amplifier characteristic for the life of the unit. A built-in protective circuit safeguards the amplifiers against reflection and overheating. Faults are stored in the amplifiers, indicated on the front panel and signalled to the exciter. Optimized heat sinks keep the operating temperature low and thus prolong unit life. The use of new absorbers made from aluminium nitride means that the amplifiers are completely free of beryllium oxide and environmentally friendly.

Optional directional coupler

If an additional test point is needed, the new Directional Coupler R&S GD700 can be inserted into the RF line as an option at the transmitter output before or after the channel filter (FIG 2). The coupler is available as a simple model with only one or, if preferred, two measurement systems. The measurement systems are available with integrated termination or with two outputs for simultaneous measurement of the forward and reflected signal with only one measurement system. The coupling attenuation of the measurement systems can be adapted to the specific application in discrete steps by installing the supplied spacers.

Condensed data of the Transmitter Family R&S SV7002

Frequency range	470 MHz to 862 MHz
RF output power	5 W to 420 W
TV standard	DVB-T ETS 300 744

Remote connection

A simple parallel interface for remote connection is standard in the Exciter R&S SV702. An additional parallel interface is also offered as a hardware option for the R&S NetCCU. The R&S NetLink [3] software option provides a particularly efficient remote connection that uses the Internet (TCP/IP) or SNMP networks to offer the same comprehensive functionality as on the display of the R&S NetCCU.

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More information at www.rohde-schwarz.com (search term: SV7002)

REFERENCES

[1] DTV Exciter R&S SV702: Compact exciter for digital terrestrial TV. News from Rohde & Schwarz (2003), No. 177, pp 40–41
[2] UHF Transmitter Family R&S SV7000: Low-power transmitters for terrestrial digital TV. News from Rohde & Schwarz (2002), No. 174, pp 36–37
[3] R&S NetLink: Enhanced capabilities for management of broadcasting networks. News from Rohde & Schwarz (2003), No. 177, pp 42–43

Automatic and adaptive precorrection of digital TV transmitters

Rohde & Schwarz has developed an automatic precorrection function for digital TV transmitters. Since the digital Exciter R&S SV 700/R&S SV 702 (FIG 1) [*] is modular in design, even transmitter systems already in use can be retrofitted with this module.

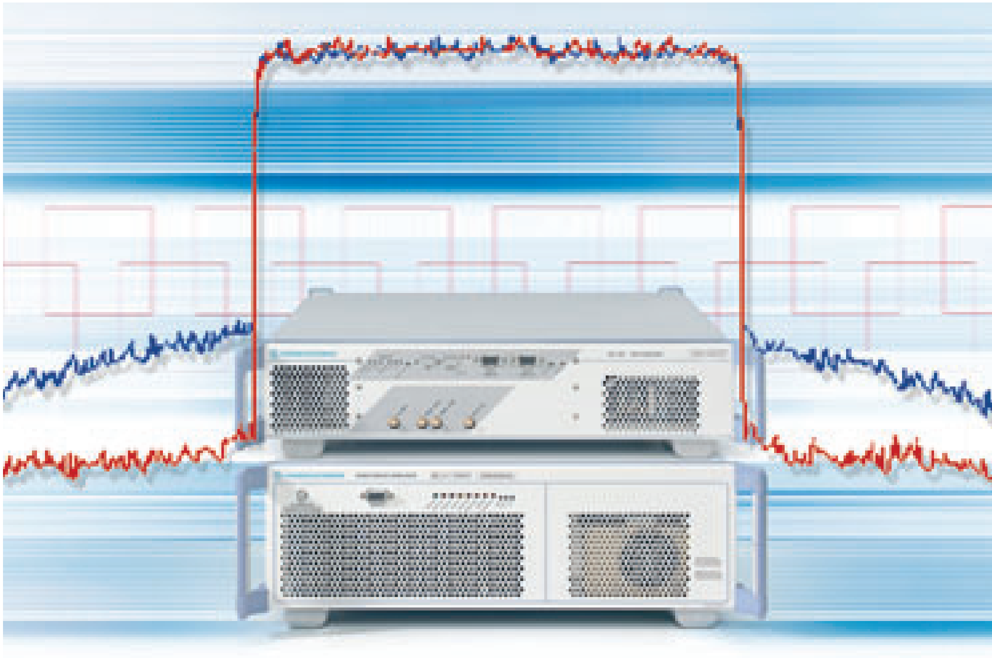

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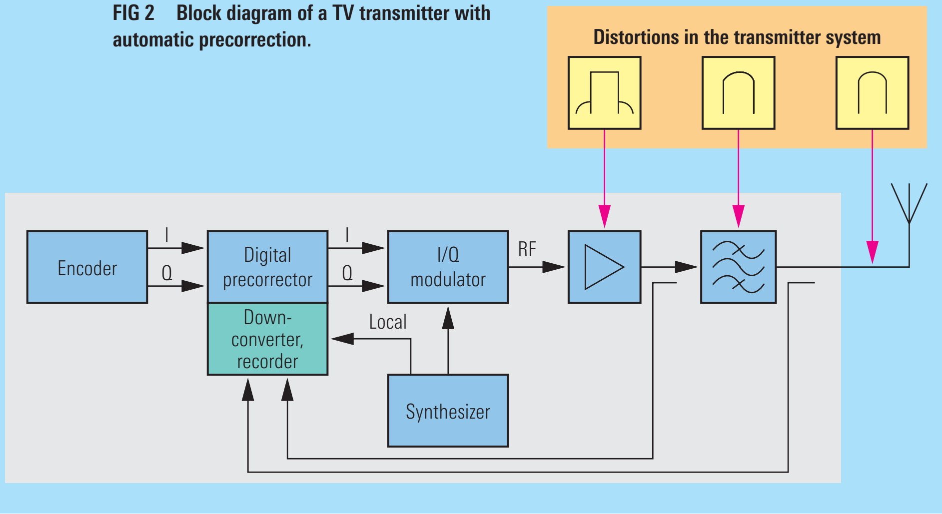
FIG 1 Space-saving digital TV transmitter: The Exciter R&S SV 702 (top) can be retrofitted with the new module for automatic precorrection.

Automatic precorrection for optimum signal quality

An increasing number of TV transmitter systems with digital transmission are being implemented worldwide. While the unambiguous waveform available in analog TV transmitters lends itself to systematic manual precorrection, information on the signal characteristic cannot be obtained in digital systems with commonly used measuring equipment. The sole criterion for manual precorrection is the shoulder distance of the signal spectrum. The new automatic precorrection function from Rohde & Schwarz determines the required parameters from the active signal without requiring much effort and time from the user, thus ensuring optimum signal quality at the transmitter output.

FIG 2 Block diagram of a TV transmitter with automatic precorrection.



Design of a transmitter system with automatic precorrection

FIG 2 shows the basic design of a TV transmitter with automatic precorrection. After the signal is processed in the encoder and precorrector, it is modulated directly to RF in the I/Q modulator. The first test point, which is used to detect nonlinear signal errors, is installed after the amplifier. The channel filter that follows eliminates spurious emissions from the signal, and the signal is then forwarded to the antenna via a second test point. The second test point detects linear signal errors.

Nonlinear and linear distortion

Because of their nonlinear characteristic, power amplifiers produce inband and out-of-band interferences, known as shoulders (see "Distortions in the transmitter system" in FIG 2). These nonlinear distortions are practically constant for the entire lifespan of the solid-state transmitters of the R&S NX6000 / R&S NX7000 families. However, some types of output stages (e.g. with tubes such as the inductive output tube (IOT)) are prone to aging which leads to a change of the distortions. In this case, adjusting the precorrection is recommended.

The channel filter after the amplifier eliminates interferences outside the channel used. The steep filter edges produce linear distortions (amplitude frequency response and group delay) in the passband and at the channel boundaries. These errors can also change as a result of a change in the filter characterisitic due to environmental influences. Adaptive adjusting of the linear precorrection may thus be necessary to ensure high signal quality for the transmitter system.

Linear distortions that are not detected by the automatic control function and therefore require additional manual compensation can occur in RF antenna feeders or in other inserted components such as channel combiners.

Precorrector design

The new precorrector can compensate for these distortions and supports both automatic and adaptive precorrection. The digital design makes the preset characteristics stable and reproducible at any time. Since the module is mechanically compatible with the conventional precorrector, exciters already in use can also be retrofitted without any problem.

FIG 3 shows the design of the new automatic precorrector. The digital baseband signal first passes through the linear frequency response precorrector. This precorrector corrects all linear distortions that occur in and after the channel filter by using an efficient digital finite impulse response (FIR) filter. It is followed by the nonlinear precorrector, which corrects instantaneous amplitude and phase distortions that occur in the output stage.

The signal returned from the test points is made available at the RF input of the precorrector via a selection switch, where it is demodulated, digitized and recorded together with the undistorted baseband signal. The digital signal processor (DSP) calculates the signal distortions from the recorded signal curves, derives the characteristics and sets them. Memory swap areas allow a new characteristic to be activated without switching off the output signal or the precorrection.

Operating modes and control of the precorrector

The precorrector supports the manual, automatic and adaptive operating modes. All three are separately available for linear and nonlinear precorrection. They are set and controlled via a convenient PC user interface with graphical display of the linear and nonlinear characteristics (FIG 4).

In the manual mode, the characteristics are entered via the graphical user interface and sent to the precorrector. In the automatic mode, adjustment is started at the press of a button. The automatic control function first performs a measurement. The settings are then calculated and loaded in the precorrector.

In the adaptive mode, signal quality is continuously checked at the output. Tolerances for the characteristics can be set via the graphical user interface. If tolerances are exceeded, the correction characteristics are adjusted without transmission being interrupted. The display shows the automatically or adaptively activated characteristics. These modes also provide manual means for setting linear distortions not detected by the automatic control function.

Condensed data for automatic precorrection

Frequency ranges	170 MHz to 240 MHz 470 MHz to 860 MHz
TV standards	DVB-T ETS 300 744 ATSC / 8VSB
Frequency response precorrection	±2 dB
Group delay precorrection	500 ns (optionally 1.5 µs)
Nonlinear precorrection	3 dB amplitude 45° phase
Operating modes	Manual, automatic, adaptive

Applications

Automatic precorrection offers substantial advantages for operating digital TV transmitter systems. When transmitters are placed into service or undergo maintenance, the optimum operating state can be set quickly and reliably by pressing a button. Thus, switching to a different transmission frequency or changing the output power, both of which require an adjustment in precorrection, can be performed in a matter of minutes.

A typical application for **adaptive precorrection** is ATSC transmitters, which are operated in the adjacent channel of an analog TV transmitter. This involves the use of extremely steep channel combiners or sharp-tuned filters, which cause group delay differences of greater than 1.5 µs in the useful channel. In addition, environmental influences can alter the characteristic of these components. Since the ATSC signal is very sensitive to group delay errors of only a few nanoseconds, the continuous monitoring and correction provided by adaptive precorrection ensures optimum signal quality.

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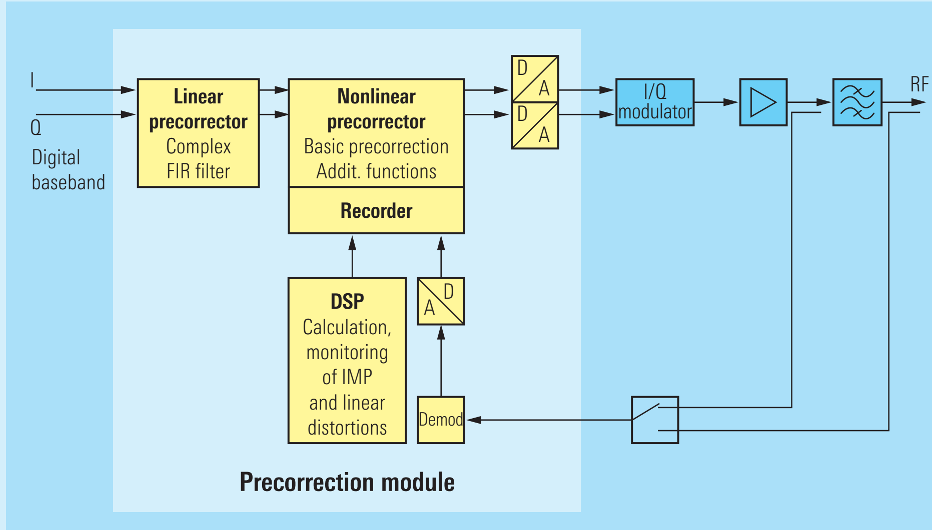
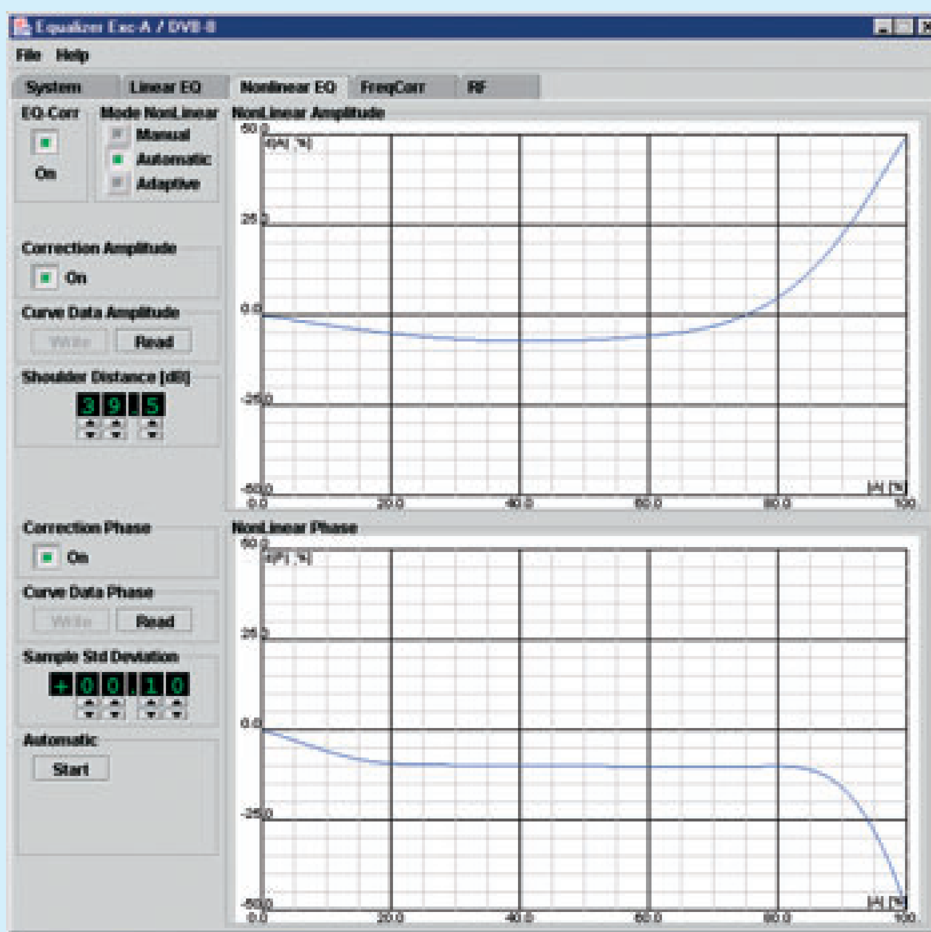


FIG 3 Block diagram of the precorrection module.

FIG 4 Convenient user interface for nonlinear precorrection.



More information on Rohde & Schwarz transmitters at www.rohde-schwarz.com

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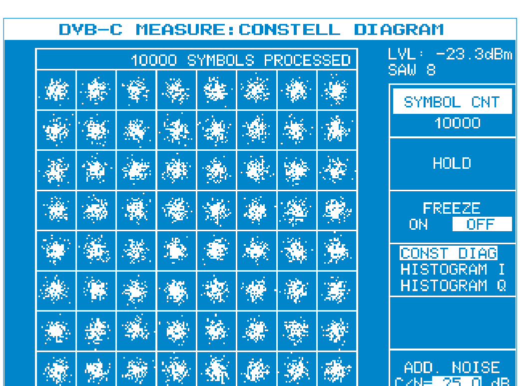
[*] DTV Exciter R&S SV 702 – Compact exciter for digital terrestrial TV. News from Rohde & Schwarz (2003) No. 177, pp 40–41

The right way to measure:

SNR and MER of digitally modulated signals with additive noise

This test tip describes for different digital TV transmission standards the correlation between the superimposed noise in the channel (carrier-to-noise ratio, or C/N) and the maximum measurable signal-to-noise ratio (SNR) in the test receiver. Furthermore, it portrays software that automatically determines the bit error ratio (BER) as a function of C/N.

FIG 1
Deviation of the measured values from the ideal position due to noise (C/N = 25 dB) – here shown for 64QAM, measured with the TV Test Receiver R&S EFA.



Calculating the SNR

The transmission of digitally modulated signals can be accompanied by manifold types of interference that has to be analyzed and quantified – for example, with the high-end TV Test Receiver R&S EFA from Rohde & Schwarz. Sometimes special cases such as the influence of additive white Gaussian noise are also of interest to users. The noise fed to the transmission channel (described by the ratio of the carrier power C to the noise power N in the transmission channel) results in a deviation of the measured values from the ideal position in the constellation diagram (FIG 1). In extreme cases this can cause bit errors. Unlike C/N, the SNR is determined on the basis of the I/Q data and is thus a baseband quantity. By mathematically eliminating other causes of interference such as phase noise, carrier suppression, etc (reduction method), appropriate test algorithms make it possible to determine the noise components on the basis of the constellation data. The ratio between the rms value of the payload data and the reduced effective error is referred to as SNR and usually given in dB. The modulation error ratio (MER) is obtained by establishing the relationship between the rms value of the payload data and the effective error without reduction. The MER value in dB is thus always lower (worse) than the SNR value. Another common measurand is the error vector magnitude (EVM): It is determined by the ratio of the cumulative error to the peak value of the payload data, and is specified in %.

Correlation between C/N and SNR

The ratio of the carrier to the noise in the channel (C/N) is determined from the noise power density N_0 of the channel and the noise bandwidth B. With single-carrier signals, the symbol rate (with VSB methods, half the symbol rate) is usually used as the noise bandwidth; in the case of OFDM signals, the bandwidth of the transmission channel (e.g. 8 MHz) is normally used. By applying the reduction method, the noise components remain unchanged. The noise in the transmission channel (C/N) thus has an immediate effect on the SNR. However, the following special features have to be taken into account:

Single-carrier modulation without pilot (QAM, e.g. DVB-C / -S, J.83/B)

Filtering the receive signal in the root raised cosine filter (Nyquist filter) at the receiver end gives the useful signal a different shape than the noise. This also changes the ratio of both components to each other (FIG 2).

Modulation with pilot (e.g. DVB-T)

If a pilot (subcarrier) exists, it is included in the total power but is not part of the useful signal components. This also leads to a change of the attainable SNR with the specified C/N and should be taken into account when making calculations (FIG 2).

Single-carrier modulation with pilot (e.g. ATSC)

Both effects are to be taken into account.

Modulation and TV standard	Noise bandwidth B_N	SNR_{max} / dB = C/N / dB + k
QAM (DVB-C, r = 0.15)	B_N = symbol rate (R&S EFA mod. 60/63)	k = –0.1660 dB
QAM (DVB-C, r = 0.15)	B_N = channel bandwidth (R&S EFA mod. 20/23)	k = –0.1660 dB + 10 × log (chan. bandw. / symbol rate)
QAM (J.83/B, r = 0.12)	B_N = symbol rate (R&S EFA mod. 70/73)	k = –0.1323 dB
QAM (J.83/B, r = 0.18)	B_N = symbol rate (R&S EFA mod. 70/73)	k = –0.2000 dB
OFDM (DVB-T, with pilot)	B_N = channel bandwidth = 8 or 7 or 6 MHz (R&S EFA mod. 40/43)	k = –0.1169 dB
8VSB (ATSC, with pilot, r = 0.115)	B_N = symbol rate/2 (R&S EFA mod. 50/53)	k = –0.4387 dB

Modulation and TV standard	Noise bandwidth B_N	SNR_{max} / dB = C/N / dB + k
QAM (J.83/B, r = 0.12)	B_N = symbol rate	k = –0.1323 dB
QAM (DVB-C, r = 0.15)	B_N = symbol rate	k = –0.1660 dB
QAM (J.83/B, r = 0.18)	B_N = symbol rate	k = –0.2000 dB
QPSK (DVB-S, r = 0.35)	B_N = symbol rate	k = –0.3977 dB
OFDM (DVB-T, with pilot)	B_N = useful bandwidth	k = –0.3345 dB
8VSB (ATSC, with pilot, r = 0.115)	B_N = symbol rate/2	k = – 0.4387 dB

FIG 2 Left: maximum measurable SNR (baseband noise) as a function of C/N (noise in transmission channel) taking into account the modulation parameters. Noise source is the TV Test Receiver R&S EFA. With a specific C/N, the actually obtainable SNR/MER cannot exceed the specified maximum values, which thus represent the theoretical upper limit. In practice, quantization effects, receiver noise and rounding effects in signal processing always result in SNR and MER values that are below the specified limits.
Right: Like the table on the left, but here the noise source is the TV Test Transmitter R&S SFQ.

The BER graphs described in the relevant technical literature usually use the SNR as a parameter, not the C/N.

Software for displaying BER as a function of C/N

For fully automatic measurement of the bit error ratio (BER) as a function of the channel noise (C/N), Rohde & Schwarz has developed software that makes it easy to control the TV Test Receiver R&S EFA from a PC. The software outputs the BER values at different points (before or after error correction) and graphically displays them (FIG 3). The noise generator in the R&S EFA is used to set the C/N value. All conversions between C/N and SNR described in the table in FIG 2 are performed automatically by the software and displayed in the form of a double scale (C/N and SNR or S/N) if desired. The measurement time is automatically adapted as a function of the measured BER. The software, which is called **EFA Noise-Diagram**, can be downloaded from the Rohde & Schwarz website free of charge.

Christoph Balz

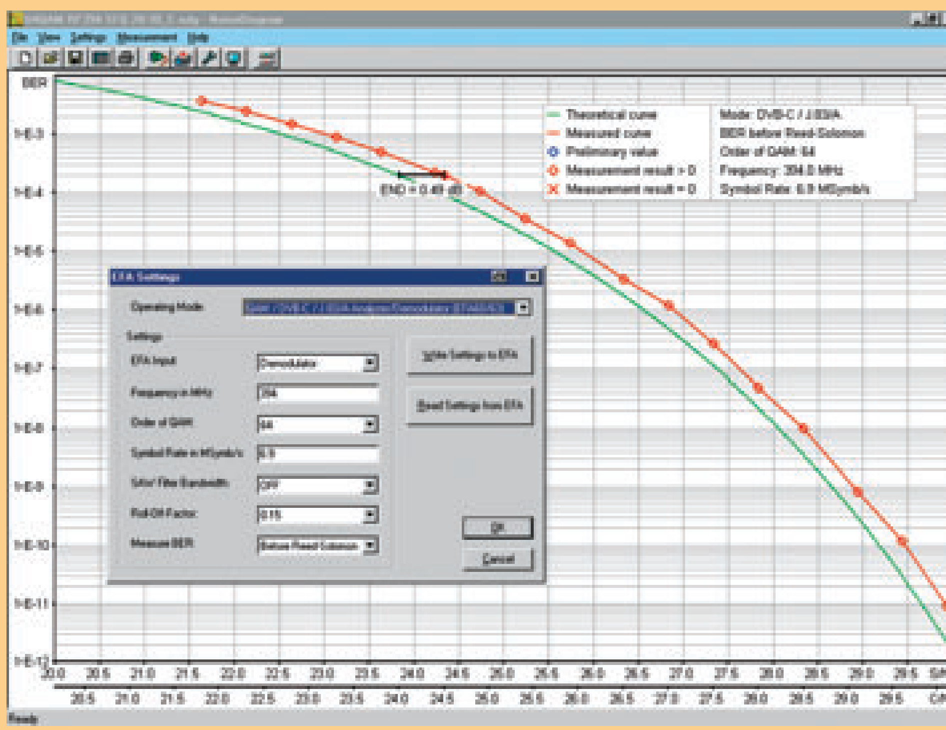


FIG 3 Measurement of the bit error ratio BER as a function of the channel C/N, with conversion to the obtainable SNR values (second scale, S/N; see also the left-hand table in FIG 2). The noise is generated by the noise generator in the TV Test Receiver R&S EFA. The display is for DVB-C. Green: the theoretically obtainable curve; red: the curve actually measured. The END (equivalent noise degradation) is determined automatically from the measured values.

FIG 1 Example of an R&S AMMOS® base system for the HF range with two sensor groups for processing up to 16 digital data transfers simultaneously.

Automatic Modular Monitoring System R&S AMMOS®

Seeing clearly through the thicket of signals

R&S AMMOS® (automatic modular monitoring of signals) is a universal family of systems from Rohde & Schwarz for monitoring analog and digital signals in the HF, VHF and UHF frequency ranges. The base system presented here (FIG 1) is designed for narrowband signal processing in the HF range from 10 kHz to 30 MHz.

R&S AMMOS® – meets any challenge

A primary task in monitoring a communication scenario is to monitor analog and digital HF, VHF and UHF radiocommunications. Depending on the application, a radiomonitoring system must fulfill extremely different requirements.

A new VHF/UHF receiver for R&S AMMOS® is described on pages 61 to 63.

Some tasks require "large-scale" stationary radiomonitoring systems, where the focus is on unrestricted scalability and expandability. These systems are usually equipped with a large number of receivers and many operator workstations with parallel use of the available sensors from the common pool. They are designed to carry out the "production" – to log decoded, digital radio signals as readable text – and the analysis of signals and transmission modes, in most cases automatically. With such requirements, the systems predominantly feature highly automated processes that are monitored by operating personnel.

Other tasks, such as quickly recording and processing radiocommunications and identifying the corresponding radio stations on the basis of the collected data, call for small, compact systems. These systems should be designed for mobile use, be modular in structure, provide all system functions at just a few workstations, and allow fast response to detected changes in the situation picture.

The tasks could hardly be more divergent, yet R&S AMMOS®, with its fully modular design with regard to sensor devices and software, is ideal for such purposes and delivers outstanding performance for virtually all possible applications.

The architecture of R&S AMMOS®

A 19" VXI mainframe (FIG 2) serves as the carrier for the sensor devices. It accommodates the VXI modules such as the VXI Monitoring Receiver R&S EM010 [*] or the DSP Board R&S GX400DP (FIG 3). Depending on the requirement, the modules can be flexibly combined according to their function and quantity. For example, a compact mainframe populated with eight VXI Monitoring Receivers R&S EM010 and two DSP Boards R&S GX400DP – a sensor group – can process up to eight digital data transfers simultaneously.

The sensor group is equipped with a CORBA interface (common object request broker architecture), via which it is addressable using a modern interface definition derived from object-oriented software development. The inter- ▶

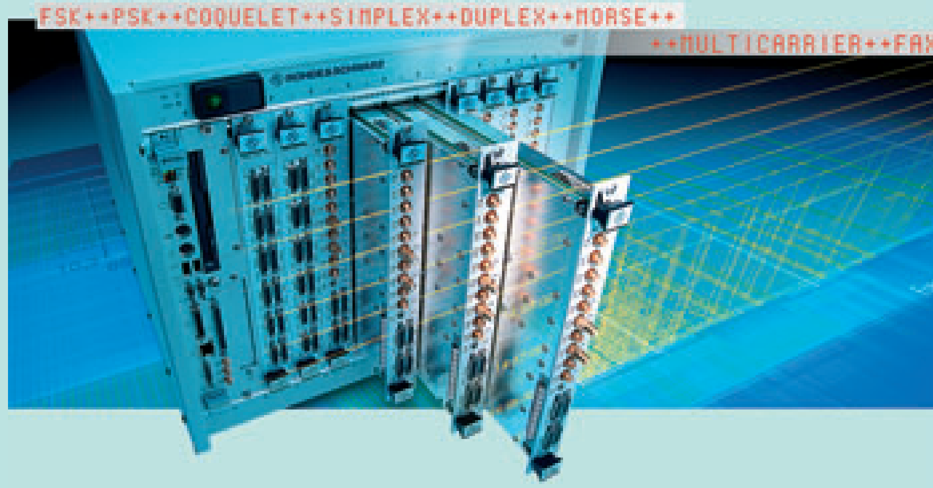


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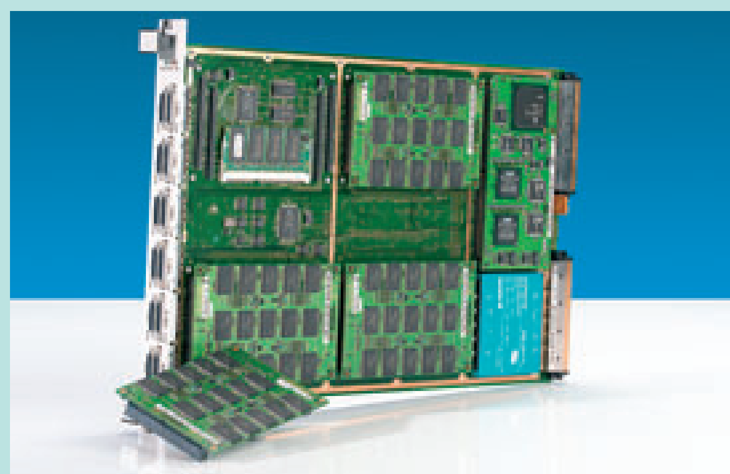
FIG 2 Populated with eight VXI Monitoring Receivers R&S EM010 and two DSP Boards R&S GX400DP, the R&S AMMOS® Sensor Group R&S GX400NB for HF can process up to eight digital data transfers simultaneously.

FIG 3 The DSP Board R&S GX400DP is equipped with two powerful digital signal processors.



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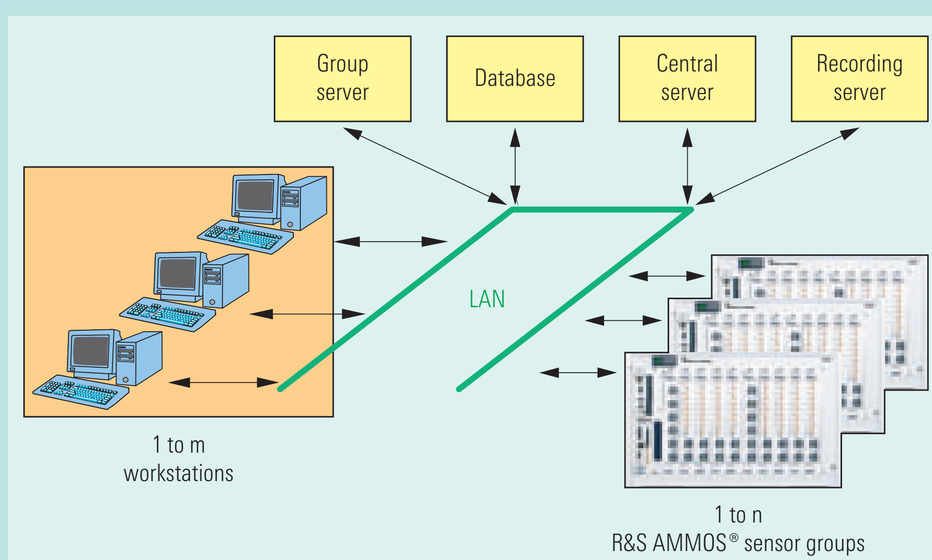


FIG 4 An Ethernet LAN serves as the central means of communication in R&S AMMOS®.

face transmits not only control and digital data signals but also digital audio signals, so that an Ethernet connection between sensor groups at one end and the workstations, servers, signal recording machines, etc, at the other end suffices for data exchange (FIG 4). Thus, R&S AMMOS® is designed for operation via a wide area network (WAN), e.g. via a satellite link.

The IPC concept of R&S AMMOS®

An interception processing channel (IPC) in R&S AMMOS® combines a number of devices (e.g. receivers, demodulators, decoders) that were previously controlled separately, thereby forming a unit. It is able to function automatically in accordance with the preparameterization by the operator.

Each sensor group provides a number of IPCs that can be controlled both automatically by the system and manually by an operator. An IPC is configured dynamically on request using the available resources in the sensor pool and is then "specialized" for efficiently performing the task at hand (FIGs 5 to 7).

Each IPC is presented to the operator on a graphical user interface ideally adapted to the data/information to be displayed (see examples in FIGs 8 and 9).

Automation of productive operation

In productive operation, the IPCs can respond to a change in the signal or in the mode used by parameterization with known characteristics of the signals to be monitored (e.g. when the modulation mode or the coding changes) and can automatically adjust themselves (FIG 10).

Recording and replaying signals

All IPCs have a signal buffer in which the last 60 seconds of the signal being recorded are digitally stored (digital IF with 20 kHz bandwidth). The operator can start recording the digitized IF data stream at any time for later processing or analysis. The data is taken from the signal buffer and recorded with a lead time of up to 60 seconds.

To replay the digital IF data, it is fed directly to the VXI Monitoring Receiver R&S EM010 via the VXI bus. Feeding the data to the IPC input ensures that the same functions and processing capacities are available to the operator both online (with signals from the antenna) and offline (with signals from the recording).

FIG 11 shows a table indicating which data types can be recorded with the R&S AMMOS® base system and stored on the workstation hard disk.

Multichannel operation

Multiple IPCs can be used simultaneously at a workstation. The control processes, which are usually automated, can be deactivated at any time, allowing the operator to manually control the IPC whenever desired.

IPC type	Application
Tuner	Detection of speech transmission (acoustic). Application of the R&S EM010 scan functions for monitoring a frequency range.
Data (digital communication)	Detection of digital radiocommunications. Demodulation and decoding of the signal.
Morse	Similar to data-type IPC but specially for Morse signals (Morse radio).
Classification	Classification of signal parameters of "unknown" signals (modulation mode, coding method).
Decoder development	A decoder-development environment from Rohde & Schwarz enables users to add new decoders to the library in the sensor group by themselves. This IPC type is designed for testing decoders during the development phase; it can be used in the same way as a data-type IPC.

FIG 5 The IPC types for R&S AMMOS®.

ASK 2
FSK 2 / 4 / 8
MSK
PSK 2 / 4 / 8
Multitone (2 to 64 tones)
Multichannel (MPSK2 / 4 / 8, MFSK2; up to 24 channels)

FIG 6 The modulation modes in R&S AMMOS®.

7-bit ASCII 1 or 2 stop even / odd parity
8-bit ASCII 1 or 2 stop even / odd parity
ARQ-E3 4 Ch / 8 Ch
ARQ-E 4 Ch / 5 Ch / 8 Ch
ARQ-N
ARQ-S 4 Ch / 5 Ch / 6 Ch
AUTOSPEC
BAUDOT 1.0 / 1.5 / 2.0 stop bit
COQUELET-8 / -13 / -80
FEC-A, FEC-S
G-TOR
PACTOR 1 version 1-7 (HAM, ICRC, UNHCR, IFRC)
PICCOLO MK 6 / MK 12
POL-ARQ
SITOR-A / -B
SPREAD 11 / 21 / 51
SWED-ARQ (short, middle, long)

FIG 7 The standard decoding methods in R&S AMMOS®.

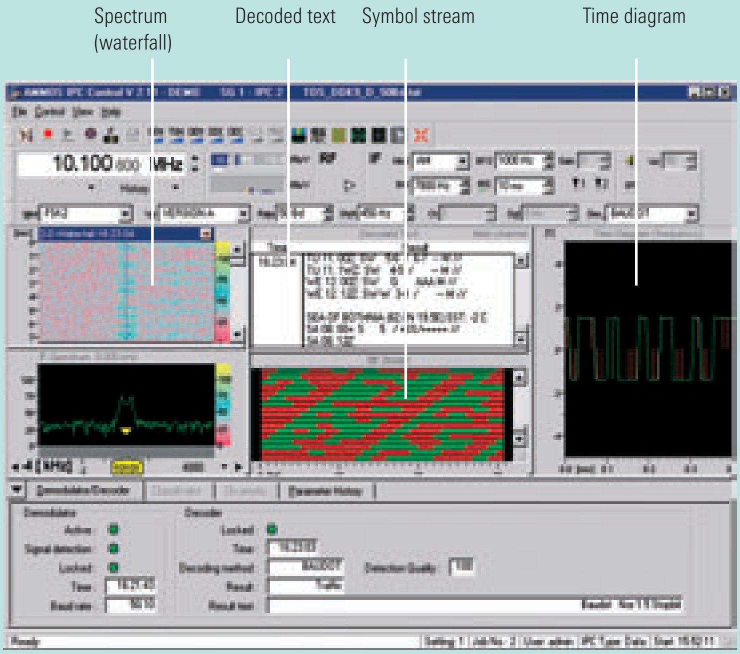


FIG 8 A data-type IPC demodulates and decodes a Baudot meteorological radio signal (productive operation).

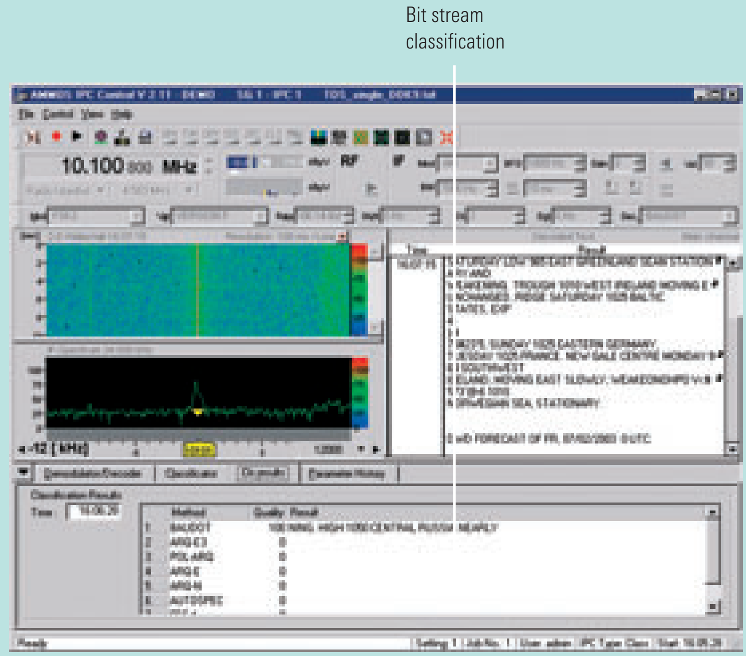


FIG 9 A classification-type IPC classifies the parameters of the demodulator and the coding method (Baudot in this example). The IPC subsequently switches to productive operation.

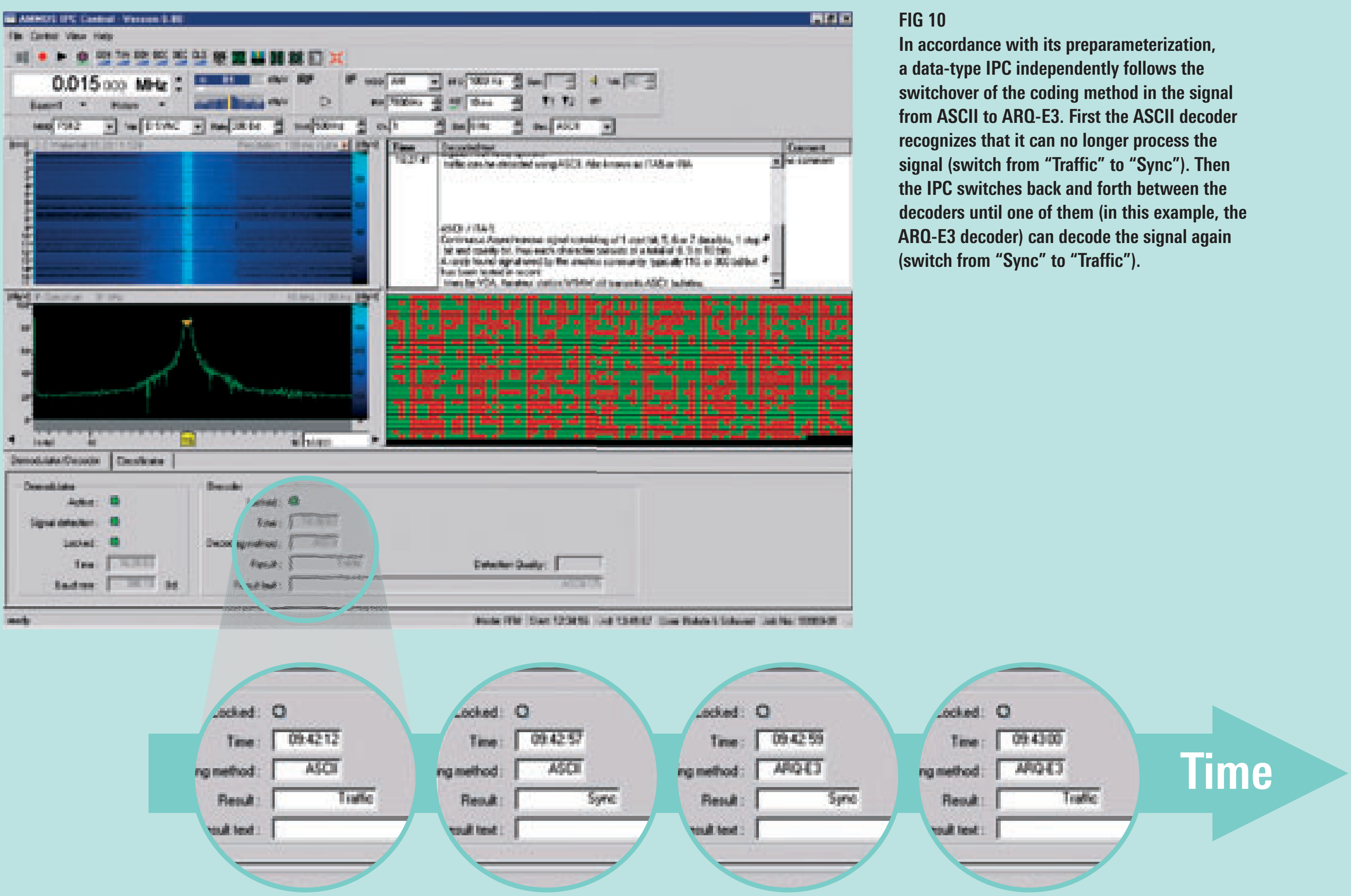


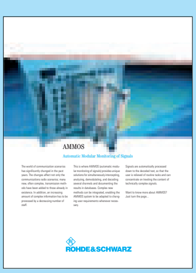
FIG 10
In accordance with its preparameterization, a data-type IPC independently follows the switchover of the coding method in the signal from ASCII to ARQ-E3. First the ASCII decoder recognizes that it can no longer process the signal (switch from "Traffic" to "Sync"). Then the IPC switches back and forth between the decoders until one of them (in this example, the ARQ-E3 decoder) can decode the signal again (switch from "Sync" to "Traffic").

The future development of R&S AMMOS®

The R&S AMMOS® base system presented here is part of a flexible overall solution for multichannel search, monitoring and production systems. In the future, this solution will also incorporate wideband and narrowband signal processing in the frequency range 300 Hz to 3.6 GHz, including direction/location-finding information. It will thus also make it possible to detect LPI (low probability of intercept) signals such as burst signals or hoppers.

Jürgen Modlich

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



Datenblatt R&S AMMOS

REFERENCES

[*] HF Receiver EM010 – Digital, VXI-based HF receiver with broadband IF output. News from Rohde & Schwarz (2000) No. 168, pp 25–26

Data type	Task
Digitized intermediate frequency with 20 kHz bandwidth (branched off at the digital IF output of the VXI Monitoring Receiver R&S EM010)	Replay of a recorded signal for offline processing with an IPC.
Symbol stream (branched off at the demodulator output)	Analysis of the bit stream with special programs developed for this in order to obtain more information about the mode used (demodulation, decoding) in the case of unknown signals.
Decoded text	Readable message content. Can also be encrypted (decryption outside of R&S AMMOS®).
Technical parameters Measurement results of the classification (modulation mode recognition, bit stream classification)	Evaluation of the measured signal parameters, e.g. to allow correct parameterization of an IPC for monitoring the signal.
Recording of frequency occupancy information using the **scan functions** of the tuner-type IPC	Compiling of frequency occupancy statistics (display, which frequencies and how often and/or how long they were used; see FIG 12).
Reports	Summary of different data for later evaluation (e.g. current instrument settings and results obtained with it) in HTML format, including a screenshot of the IPC visualization.

FIG 11 Data types that can be detected with an R&S AMMOS® base system and stored on the hard disk of a workstation.

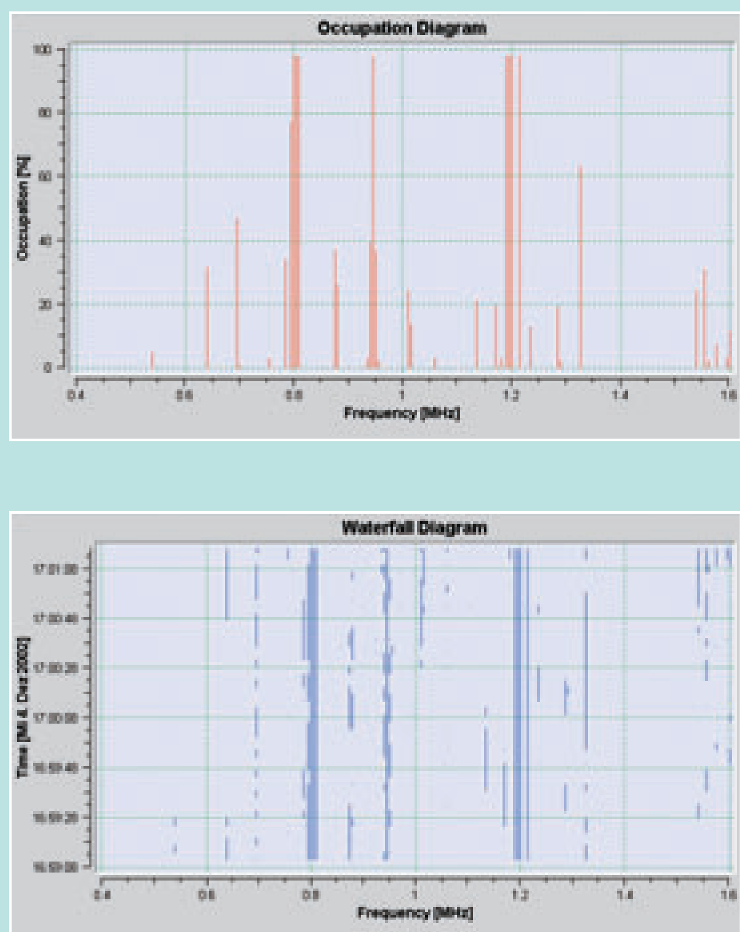


FIG 12 Display of the statistical frequency occupancy (top) and the time occupancy (waterfall diagram, bottom) within a monitored time period. It can be clearly seen that two transmitters are continuously active at 0.8 MHz and 1.2 MHz (radio stations Bayern 1 at 801 kHz and Voice of America at 1197 kHz).

VHF/UHF Receiver R&S EM 050

Digital VXI-based receiver for 20 MHz to 3.6 GHz

The new VHF/UHF Receiver R&S EM 050 (FIGs 1 and 2) is another vital component in the state-of-the art VXI receiver and analyzer family from Rohde & Schwarz, opening up the 20 MHz to 3600 MHz frequency range. It combines outstanding RF characteristics with the powerful signal processing of state-of-the-art technology.

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FIG 1 Digital R&S EM 050 monitoring receiver in VXI technology.

New addition to tried-and-tested technology

For well over two years now, the VXI HF Receiver R&S EM 010 [*] has proven a success on the market for the 300 Hz to 30 MHz frequency range. Its attractive characteristics coupled with easy system integration quickly sparked user interest in receivers designed for higher frequency ranges. Building on this success, the VHF/UHF Receiver R&S EM 050 was developed to VXI standard (VXI: VME bus extension for instrumentation; VME: versa modular eurocard IEEE 1014); it is based on years of Rohde & Schwarz production expertise in the area of professional radiomonitoring receivers.

Wide dynamic range – high sensitivity

With the R&S EM 050, great importance was placed on excellent large-signal characteristics and high sensitivity – two features that are crucial if numerous powerful transmitters "challenge" the receiver, or if weak signals in critical scenarios require unambiguous identification. The user quickly finds the correct settings for successful radiomonitoring even in a signal environment prone to interference. Furthermore, optimum receive conditions are ensured by matching preselection ranges with tracking or fixed bandpass filters.

Powerful digital signal processing

All intermediate frequencies are processed in powerful signal processors and field programmable gate arrays (FPGA). This technology allows the implementation of functions that are indispensable in modern radiomonitoring. The new receiver includes numerous filters, different evaluation methods for level measurements, matching time constants and a multitude of standard demodulators, to name just the most important features. Another advantage of this technology is the availability of signals or signal contents in digital form on different interfaces, which is a crucial aspect in system integration. One of the receiver's special features is its front panel data port (FPDP) interface which has been designed for maximum data rates. Moreover, signal processing provides sufficient leeway for future expansions.

Narrowband – wideband

Up to now, different applications required different receivers. The R&S EM050, however, is capable of processing both narrowband and wideband transmissions without any performance loss. Its digital IF filters with bandwidths between 150 Hz and 2 MHz plus numerous internal demodulators allow the receiver to handle a multitude of signals; if it is connected to external DSP boards via the appropriate interfaces, it can also process complex signals. This combination opens up the full scope of analysis and demodulation of digital signals.

Yet this is by no means all that the R&S EM050 can do. Transmission methods such as used with bandspread signals (DSSS: direct sequence spread spectrum), frequency-varying emissions (FH: frequency hopping) or pulsed signals require even wider bandwidths.

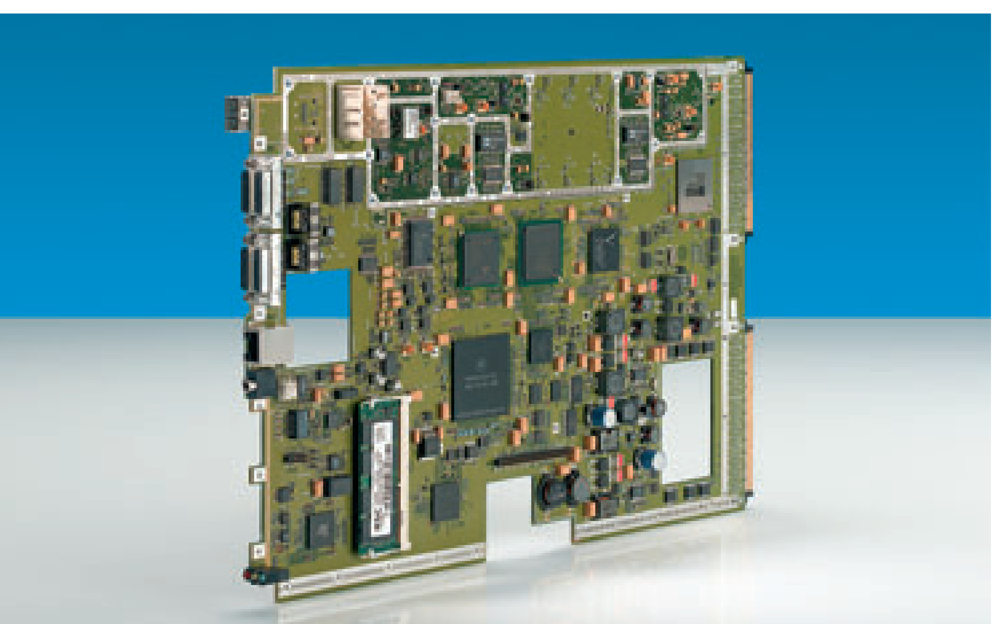

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FIG 2 State-of-the art DSPs and FPGAs on a multilayer with 10 layers ensure extremely powerful signal processing in the R&S EM050. The rear is for the VXI bus only; everything else can be accessed from the front panel.

Together with a wideband DSP board that is connected to the wideband IF output of the receiver, the latter can reliably detect such signals and make them accessible for further processing. But optimum signal analysis is not much use if the signals are not detected. Such tasks require high scan rates, which are no problem with the wideband combination of receiver and DSP board since scan rates in the two-digit GHz range can be easily achieved, depending on the settings made.

Large systems – small systems

The R&S EM050 is designed for multichannel receive and analysis systems that are used in state-of-the-art radiomonitoring, for example in the powerful R&S AMMOS® monitoring system from Rohde&Schwarz (page 56). Its automatic, parameterized processes allow users to handle the enormous data flow and to detect and analyze signals of interest without incurring any loss. R&S AMMOS® of course fully controls the R&S EM050. The modular design of the system enables the user to start on a small scale and expand the system step by step; there are no limits to performance.

The new receiver offers decisive advantages, and not only in larger systems, but also in smaller-sized units, because the diverse hardware and software combinations that are feasible allow optimum adaptation to the tasks at hand. Simply combining a receiver with different DSP boards from Rohde&Schwarz and the associated software opens up an unprecedented variety of functions in radiomonitoring. This flexibility yields even more advantages because the user gets everything from a single source plus the guarantee that everything fits together.

The user can, of course, personally integrate the R&S EM050 into a monitoring system. The necessary interfaces and commands are detailed in the manual.

Versatile applications

Whether the R&S EM050 is integrated into large or small systems, it can handle a multitude of further applications in addition to the ones already mentioned, for example:

- Buffer memory for wideband signals
- Signal-specific detection
- Visualization of wideband spectra
- Monitoring of wideband frequency occupancy
- Statistics on frequency / level / time
- Replaying and reprocessing of recorded wideband signals

Summary

The R&S EM050 is a powerful receiver that will superbly accomplish the tasks at hand for many years to come. Since internal signal processing can be adjusted via software, the R&S EM050 is also ideal for handling future signal scenarios.

Christian Gottlob

Main characteristics of the R&S EM050

Operating modes

- Fixed frequency
- Memory scan
- Frequency scan
- Fast RF spectrum
- Replay (IF)
- Wideband
- Test

Data output

- Baseband signals (I and Q) in digital form; 10 MHz maximum bandwidth
- IF analog
  f = 405.4 MHz, B_{max} = 50 MHz
  f = 21.4 MHz, B = 10 MHz
- Video digital
- Video analog, B = DC to ½ IF bandwidth
- DAT recorder, AES3 format
- Audio digital
- Audio analog (600 Ω and headphones)

Demodulation modes in fixed frequency operating mode
AM, FM, CW, LSB, USB, ISB, PULSE, IQ

IF bandwidth is settable between 150 Hz and 2 MHz in 21 steps.

Squelch is settable from –30 dBµV to 130 dBµV in 1 dB steps.

Gain control is selectable: either automatic (AGC) or manual (MGC) gain control.

In **memory scan** mode, all relevant parameters can be set for each channel:

- Memory
- Frequency
- Demodulation mode
- Bandwidth
- Preamplifier / attenuator
- Squelch

In **replay mode**, recorded IF data can be fed via the data interface for post-processing.

In **test mode**, a comprehensive selftest is performed, either as a short or as a long test.

Condensed data of the R&S EM050

Frequency range	20 MHz to 3600 MHz
Second-order intercept point	typ. 55 dBm
Third-order intercept point	≥17 dBm (20 MHz to 300 MHz) ≥20 dBm (300 MHz to 3600 MHz)
Noise figure	≤12 dB (f <2000 MHz) ≤15 dB (2000 MHz to 3000 MHz)
Digital IF filters	21 filters, 150 Hz to 2 MHz

More information at www.rohde-schwarz.com (search term: AMMOS)

REFERENCES

[*] HF Receiver R&S EM010: Digital VXI-based HF receiver with broadband IF output. News from Rohde & Schwarz (2000) No. 168, pp 25–26

T&M trends in broadband communication

The introduction of digital TV means that engineers will have to become familiar with new test parameters and the T&M instruments that support them. This article provides an overview of current trends in broadband communication T&M based on today's measuring equipment.

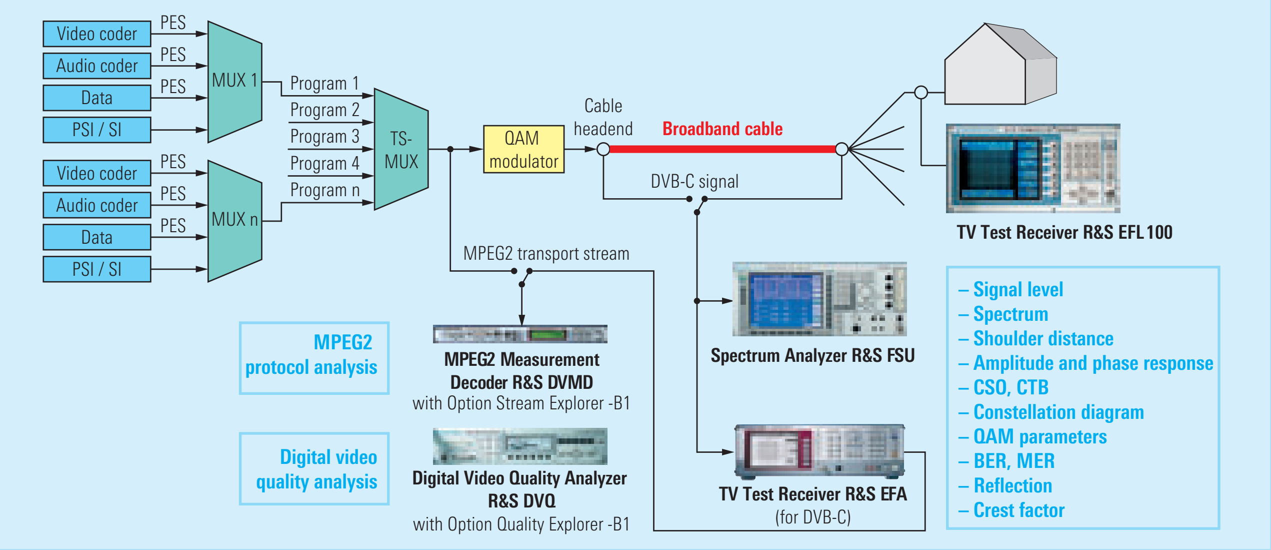
The leap from analog to digital TV (DVB) will force engineers to become familiar with completely new types of signals. Existing signal parameters are either no longer relevant or are now defined differently, with new ones being added. With analog TV, the focus was almost exclusively on the transmission signal itself, but now engineers must also deal with the signal's contents, the MPEG2 transport streams. This must be done in various ways with regard to quality and measuring depth, depending on where the measurement is performed within the signal chain. This article uses the DVB-C signal chain as an example (FIG 1).

Packetized elementary streams (PES) for video, audio and data, together with various tables, are combined by a multiplexer (MUX) according to the MPEG2 and DVB standards to form a transport stream. A number of transport streams can be merged in a transport stream multiplexer (TS-MUX) to form an MPEG2 transport stream, which contains several programs. This transport stream is fed to a modulator, and the signal that is modulated according to DVB-C is then distributed via a cable headend.

Having providers supply the correct programs in the agreed quality before the programs are fed to the broadband communication network via the cable headend is of great interest for network operators in particular. This requires the use of test instruments that have a wider dynamic range than the components to be measured in order to ensure sufficient safety margins.

Rohde & Schwarz supplies the MPEG2 Measurement Decoder R&S DVMD for measuring and analyzing the content. If measurement is performed after the modulator, the DVB-C signal must first be demodulated, of course. The TV Test Receiver R&S EFA is ideal for this.

FIG 1 Signal chain in digital transmission via broadband cable (DVB-C).



The MPEG2 measurement decoder can output error messages sorted by priority according to TR 101 290. It is also possible to analyze/measure the contents and repetition rates of tables. The content test can even go so far as to examine the quality of the current MPEG2 video data compression in realtime using the Digital Video Quality Analyzer R&S DVQ.

The parameters of the signal to be transmitted gain significance after the modulator (QAM in this case). The most important ones are the modulation error ratio (MER), bit error ratio (BER) and level. These parameters are very well suited for long-term monitoring of the complete system (FIG 2), e.g. using the TV Test Receiver R&S EFA. By observing trends over a long period of time, errors in the making can be detected early on, long before they result in visible and/or audible interference or even costly failures.

In the subsequent part of the signal chain, test parameters that characterize the transmission medium (copper or fiber-optic cables) and the interference affecting it must be recorded. Among these are the signal-to-noise ratio, signal level, CSO (composite second order) and CTB (composite triple beat). The parameters CSO and CTB describe intermodulation which can occur in the cable if, for example, all channels are being used. In addition, reflections can be recorded and splicing measured in order to locate defective spots in the transmission medium itself. A series of small specialized handheld test instruments is available for this purpose.

The network layer 4 area – after the house interconnection point – calls for TV test receivers such as the new R&S EFL100, which are useful to service technicians when configuring and maintaining signal distribution systems (FIG 3). The demands made on such receivers are rather low – in contrast to test instruments used at cable headends, which must show maximum precision. Nevertheless, the test receiver must be good enough to ensure that minimum requirements (signal level, MER) are met. The TV Test Receiver R&S EFL100 is designed for analog and digital TV signals and can thus handle the mixed operation that is customary in the cable today. The unit will be described in detail in the next issue of News from Rohde & Schwarz.

Where are these trends leading? Continuing digitization and miniaturization will produce increasingly compact test instruments. A wide range of different measurement functions – today still spread over a number of instruments – will be integrated into one or just a few test instruments, as is already the case with the new TV Test Receiver R&S EFL 100. The trend toward higher transmission capacities will place greater demands on engineers and T & M alike. Two recognizable code words for this trend are HDTV (high definition TV) and QAM 1024. Rohde & Schwarz will continue to support all those involved in this rapid development, providing them with leading-edge technology and know-how.

Werner Dürport

FIG 2 History of level and MER.

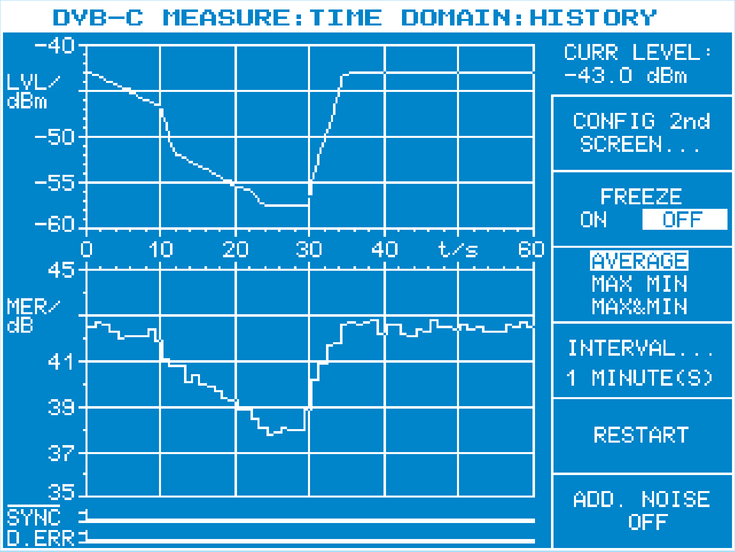


FIG 3 The TV Test Receiver R&S EFL 100.

Software radios for the Brazilian armed forces

Rohde & Schwarz has received a multimillion-euro order from the Brazilian armed forces to supply tactical HF/VHF radios.

The order includes both vehicle and manpack versions of the R&S M3TR family. The software radios feature multiband (different frequency bands), multimode (different radio modes) and multirole (different applications) functionality. The order, which is scheduled for implementation in 2004, is an important success for Rohde & Schwarz and will further fortify its strong position on the global market.

The order contains not only the Rohde & Schwarz radios themselves but also the entire integrated logistics support (ILS) for the program. This includes the training of all personnel involved, the complete documentation in the national language, local technical support and project management.

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Large-scale order: analog high-power TV transmitters for Indonesia

The Indonesian TV network operator PT. Duta Visual Nusantara – TV7 has contracted Rohde & Schwarz to supply, install and commission a number of 10 kW and 20 kW TV transmitters of the R&S NH 7000 series.

Within the last two years, Rohde & Schwarz has delivered numerous TV transmitters and thus become the leader on the Indonesian TV transmitter market. Besides the public broadcasters, Indonesia has several private TV network operators that are expanding their transmitter networks. In addition, digital TV is to be introduced in Indonesia as from 2005. Owing to this potential, Indonesia is one of the world's most important TV transmitter markets for Rohde & Schwarz. In anticipation of the future growth of this market, Rohde & Schwarz established the subsidiary "PT. Rohde & Schwarz Indonesia", which offers complete installation and commissioning services as well as customer training and optimum 24-hour on-site support. This includes maintenance free of charge during the warranty period. The currently ordered transmitters will also be installed and commissioned by the local subsidiary.

Expansion of digital TETRA mobile radio network in Lower Saxony

The regional administration of Lüneburg has commissioned R&S BICK Mobilfunk, a subsidiary of Rohde & Schwarz, to expand the digital TETRA mobile radio network in the district of Lüchow-Dannenberg.

The *ACCESSNET*®-T radio system was put into service a year ago and is used by the police for security-related operations, in particular for safeguarding the Gorleben interim nuclear waste storage site. Additional TETRA base stations considerably expand radio coverage to ensure full, tap-proof protection of the road transport of nuclear waste containers.

The order placed by the administration of Lüneburg comprised the planning of the network, including radio coverage, delivery, installation and putting into operation of the other TETRA base stations. The area now covered spans the entire Lüchow-Dannenberg-Gorleben interim storage site region. In cooperation with the specialists of the police office for technology and procurement in Lower Saxony, the new R&S DTX-500 base stations were connected to the existing R&S DSS-500 local exchange unit. Prior to the last nuclear waste transport (end of 2002), the expanded TETRA mobile radio network was put into operation. During the road transport of the containers in Lower Saxony, a digital TETRA speech and data radio network, in this case *ACCESSNET*®-T, was thus employed for the first time for tap-proof communication among the police.

Rohde & Schwarz at NAB 2003 in Las Vegas

At this year's NAB trade show for broadcasting, held from 5 to 10 April 2003 in Las Vegas, Rohde & Schwarz presented innovative technology and solutions. The focus was on new sound and TV broadcast transmitters and T & M solutions. With its R&S EFL 100, for example, Rohde & Schwarz presented a TV test receiver in the lower price segment for the first time.

The R&S EFL 100 was specially developed for measurements required in the installation and maintenance of antenna and signal distribution systems. The design and operating concept of the instrument are optimized for mobile use. Moreover, the R&S EFL100 has multistandard capability. Both analog and digital TV signals can be received and measured.

Encryption unit now approved for NATO

The ISDN Encryption Unit ELCRODAT 6-2S developed by Rohde & Schwarz SIT, having received approval for all national levels of classified information from the German Information Security Agency (BSI), has now been approved for all NATO grades of classified information as well.

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As a result of the certification, governments, public authorities or the military in all NATO countries can now use the encryption system. The ELCRODAT 6-2S was developed on behalf of the BSI especially for tap-proof transmission of information in the ISDN network.

Protecting ISDN systems against manipulation or eavesdropping is increasingly becoming standard practice at companies and public authorities. Yet if the flow of information is subject to a certain level of secrecy, as is the case with governmental agencies, embassies or the military, the use of encryption units that are specially approved for this purpose and ensure comprehensive security is required. The ELCRODAT 6-2S from Rohde & Schwarz SIT is an ISDN encryption unit for all national levels of classified information up to "TOP SECRET".

The ELCRODAT 6-2S encrypts all voice, fax, video and data communication for the basic rate access (S_0 interface) in the Euro-ISDN network. It can be used for all ISDN basic services and even over satellite links. An extremely secure combination of different methods is used for encryption. The key used is always regenerated, does not leave the system and is immediately deleted after the transmission. This procedure ensures maximum security. The physical setup of the unit complies with the most exacting demands, i.e. it includes data, procedure, access and transmission security and provides effective protection against espionage.

New Managing Director at Rohde & Schwarz in the United Kingdom

Frank Mackel (39) became the new Managing Director of Rohde & Schwarz UK Ltd. on 1 January 2003. He is responsible for the company's sales and service activities in the United Kingdom and Ireland. His predecessor, Campbell Morrow, will remain active as chairman of the board.

The United Kingdom is one of the biggest markets in Europe for Rohde & Schwarz. Frank Mackel has held a number of sales positions at the company since 1987. Among other assignments, he was responsible for developing the EMC T&M business field at Rohde & Schwarz UK. In the past seven years, he directed the sales offices of Rohde & Schwarz Vertriebs GmbH in Hamburg and later also in Berlin.

"Opportunities to further expand existing market share are currently opening up for Rohde & Schwarz in all fields of activities in the United Kingdom and Ireland", stated Frank Mackel. "To promote this, we will invest even more in our sales and service activities. We can thus ensure that our customers will benefit from our product innovations and the experience of our staff in the United Kingdom and Ireland."

Visit us on Internet at www.rohde-schwarz.com

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