News from Rohde & Schwarz

Evolution in power measurement
– intelligent sensor technology

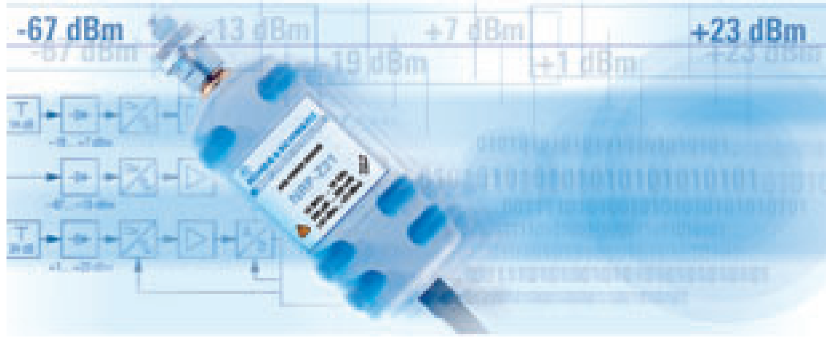
World's first multistandard test set
for MPEG2 and ATM signals

Compact digital direction finder with
high sensitivity and fast measurement

2002/II
174

ROHDE & SCHWARZ

Microwave power meters are only as good as their sensors, which is why they were the focus of development for the new Power Meter Series R&S NRP. The sensors offer a dynamic range of up to 90 dB for modulated signals of any RF bandwidth, plus time gating, high measurement speed and low measurement uncertainty – another step forward in the evolution of power measurement (page 12).



43883

The new Signal Analyzer R&S FSQ has optimum features for analyzing signals on broadband transmission systems as well as multicarrier signals. With an analysis bandwidth of 28 MHz, the instrument is well prepared for future technologies and systems (page 17).

43878/1

The new Microwave Signal Generators R&S SMR50 / SMR60 feature excellent specifications at an attractive price, high reliability, and optional expandability from CW generator to signal source with modulation capability and synthesized sweeper with analog ramp sweep (page 22).

43842/1

MOBILE RADIO

Test systems

Test signals

GENERAL PURPOSE

Power meters

Signal analyzers

Microwave signal generators

Spectrum analyzers

43825/9

The new MPEG2/ATM Test Set R&S DVATM is the world's first unit to process both MPEG2 and ATM signals. It provides interfaces for all applicable layers as well as test signals and analysis functions (page 31).

43783/3

BROADCASTING

Analyzers

TV transmitters

Test transmitters

Refresher topics

RADIOMONITORING

Direction finders

MISCELLANEOUS

Terrestrial digital transmitter networks are currently being set up worldwide, initially with transmitters of the high-power or medium-power class. But there is also a need for low-power transmitters, for example to handle small urban areas and valleys or gaps in coverage. The UHF Transmitter Family R&S SV7000 is a compact and economical solution in such cases (page 36).

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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.

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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 364 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.

There is consequently an enormous test requirement for the GSM 850 and EGPRS innovations. However, no test platform currently on the market consistently supports the new frequency band for GSM 850, i.e. with the same validated hardware. Nor can these systems use the 8PSK modulation format for EGPRS.

An exception is approaching with the new test system family from Rohde & Schwarz. It supports all GSM 850 / 900 / 1800 / 1900 frequency bands in the circuit switched, GPRS and EGPRS connection modes. And it is easily upgraded to a GSM/WCDMA test system.

From development tester to conformance test system

The new modular RF test system family provides for the first time consistent measurements over the entire development cycle of a mobile phone.

The **R&S TS 8955 G** is a modular **development and precompliance RF test solution.** The spectrum starts with test sets with two devices, e.g. a combination of the GSM Protocol Analyzer R&S CRTU-G [1] and Baseband Fading Simulator R&S ABFS [2], or the Universal Radio Communication Tester R&S CMU 200 [3] with the high-end Spectrum Analyzer R&S FSU 8 [4].

Conformance testing to GCF* is the hallmark of mobile phones. The **RF Conformance Test System R&S TS 8950 G** covers all necessary RF measurements. Validation of the R&S TS 8950 G confirms its compliance with the measurement accuracy required in 3GPP specifications and is proof of the quality of the test system.

The test systems of the family are based on the same hardware and software; the R&S TS 8955 G is therefore fully upgradable to an R&S TS 8950 G (FIG 2). This ensures optimum consistency of the measurement results.

This Rohde & Schwarz instrumentation is already in use in development labs all over the world. Besides the equipment mentioned above, the proven Vector Signal Generator R&S SMIQ 03 B [5] and the Microwave Signal Generator R&S SMP 22 are supported.

The high-convenience R&S PASS** software for the entire test system family sets up on these functionalities. A system thus grows with the individual devices, and new functions are fast available. The software allows speedy generation and automation of development tests without time-consuming programming effort.

Possibilities beyond GCF test cases

The systems offer extra and wide-ranging possibilities beyond the official GCF test cases. Under R&S PASS software, all test cases set up on just a few test

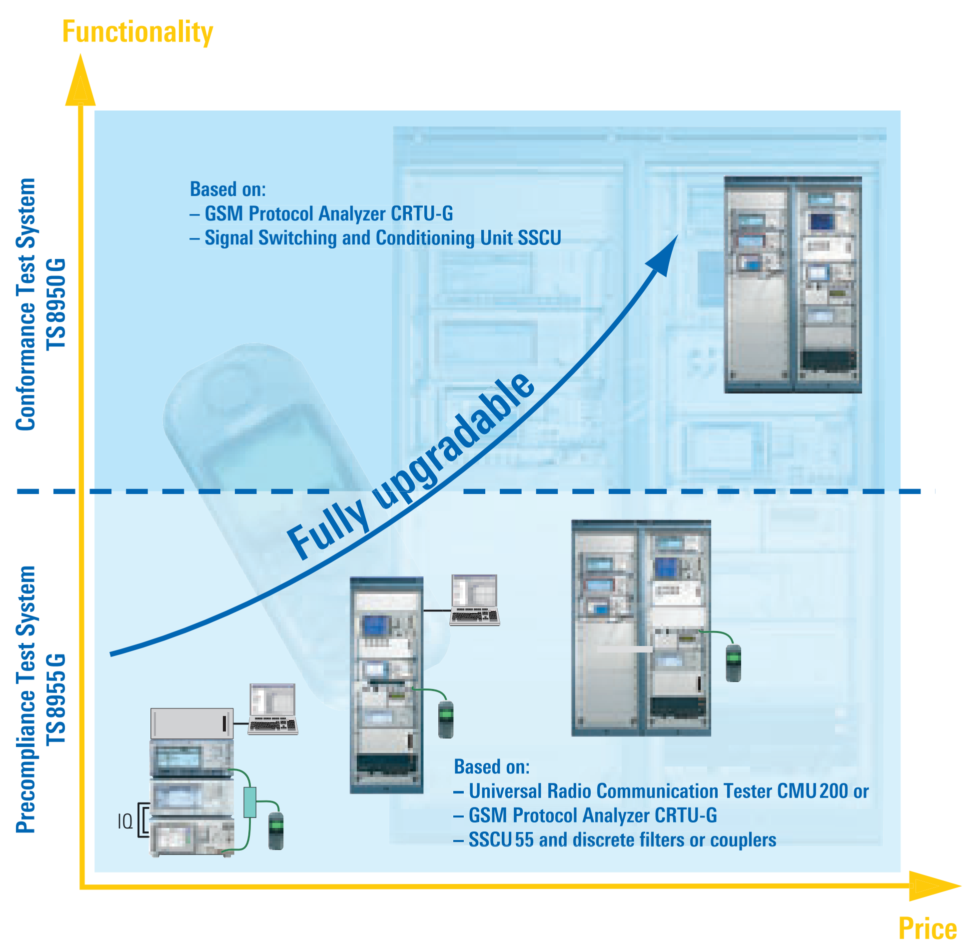


FIG 2 The test system family is based on the same hardware and software; the R&S TS 8955 G is fully upgradable to an R&S TS 8950 G.

* GCF: Global Certification Forum, an initiative of the GSM Association, manufacturers of terminals, test houses and T & M manufacturers for the standardization of mobile telephone test requirements.

** R&S PASS: parametric application software for test systems.

methods (FIG 3). All GSM RF tests for phase 2, GPRS and EDGE in all current and future frequency bands are implemented by only six of them. Receiver tests, for example, are covered by one test method with some 50 parameters. Parameter sets are used to define the test cases, from the levels of useful signals and interference signals through channels and fading settings to the number of measured samples. These parameter sets can be modified, expanded or completely redefined at any time on a user-friendly interface.

That means you can instantly and accurately get to the root of problems occurring during the development of mobile phones. In addition, completely new test cases can be created without any programming effort, e.g. for customer-specific test scenarios (FIG 4).

Automatic path calibration in the R&S TS 8950 G ensures optimum measurement accuracy even in extreme test situations. The complexity of the test sequence thus recedes into the background and the user can fully focus on the actual measurement.

Analysis – online and offline

The user interface of R&S PASS runs as a separate process, independently of the test application. During a test run it is therefore possible to compose the next test sequence for example, analyze earlier test results or define new tests, without interfering with the ongoing test.

With R&S PASS, test results can also be stored outside of the test system in a corporate network. A copy of the analyzer tool allows analysis of results anywhere and at any time (FIG 5).

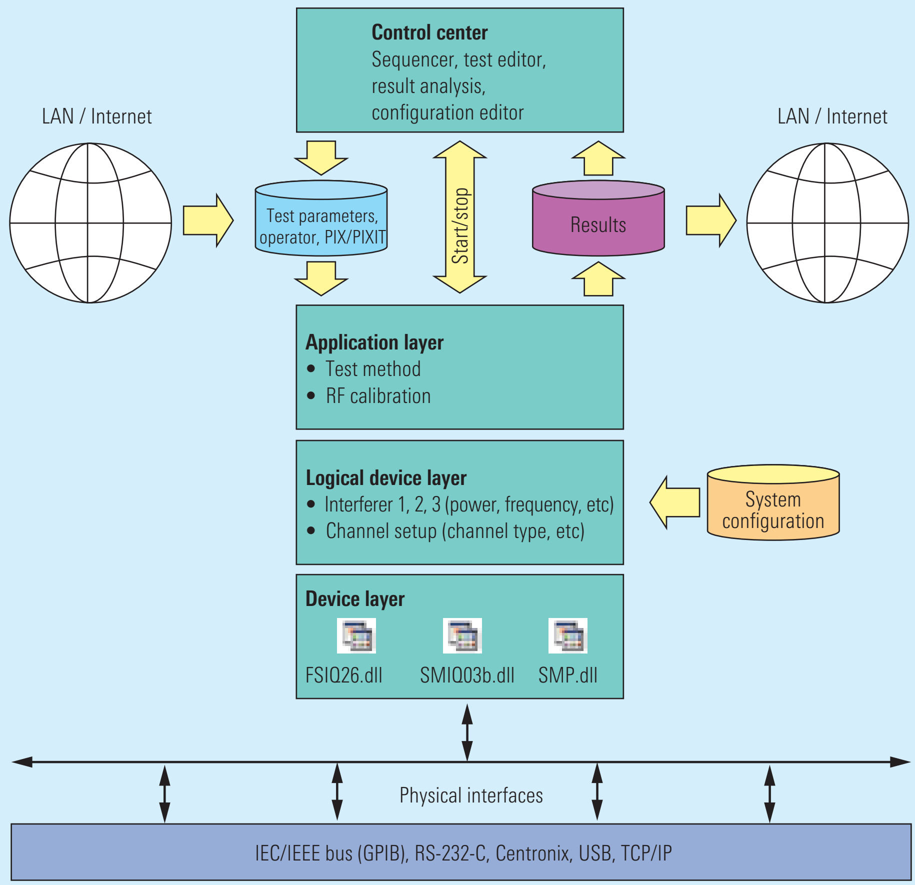


FIG 3 Logical structure of R&S PASS software

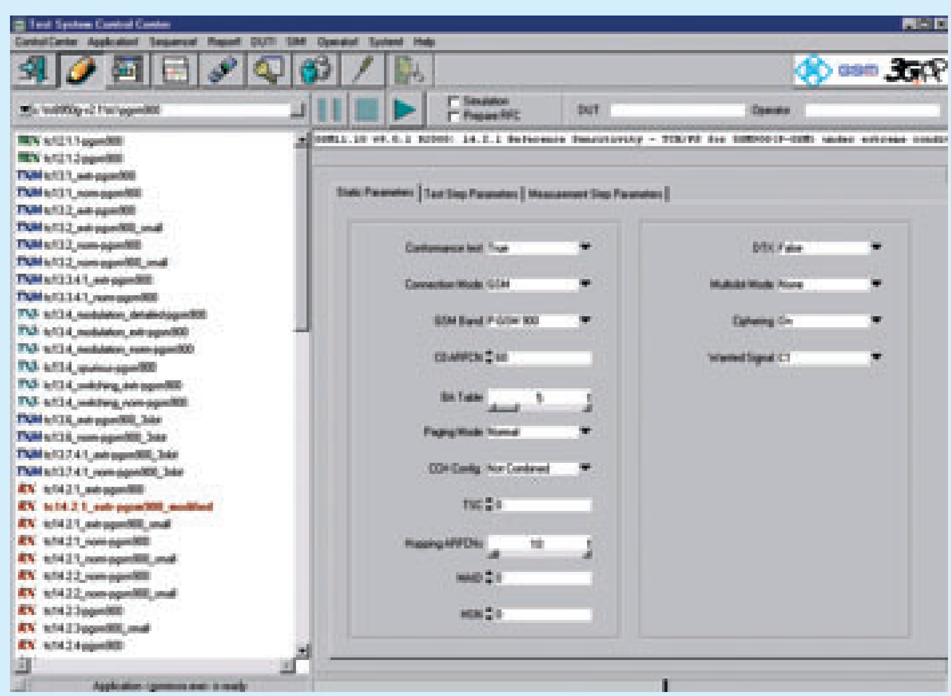


FIG 4 Free access to all test parameters without programming effort

R&S TS 8955 G – a system with many facets

The R&S TS 8955 G system for development and precompliance testing can be configured to customer specifications. Depending on the application, configurations for receiver tests, transmitter tests or both can be created. Together with the customer, Rohde & Schwarz defines the hardware and software for the required test application and thus finds the matching solution. This entry-level configuration is not a one-way street, however, as subsequent upgrading is quite straightforward.

All devices can be logged on and off through the user interface, so configurations can also be modified for the short term. The use of LabWindows CVI™ as a programming environment enables simple integration of customer-specific apparatus, e.g. climatic chambers.

R&S TS 8950 G – oriented on future WCDMA

The fact that the R&S TS 8950 W – an RF test system for WCDMA FDD – is based on the R&S TS 8950 G platform demonstrates the emphasis that Rohde & Schwarz places on modularity and secure solutions for the future. The TS 8950 G and all system variants of the TS 8955 G can be upgraded to WCDMA without exchanging hardware.

Summary

The new test system family from Rohde & Schwarz is a well-rounded solution for the entire development cycle of mobile terminals. The R&S PASS software and the test method concept provide an unprecedented degree of flexibility. They do away with time-consuming programming so that the user can fully focus on the actual measurement application.

The platform concept reduces time to familiarize and offers consistent test results, considerably shortening the development phase for mobile phones.

Alexander Pabst

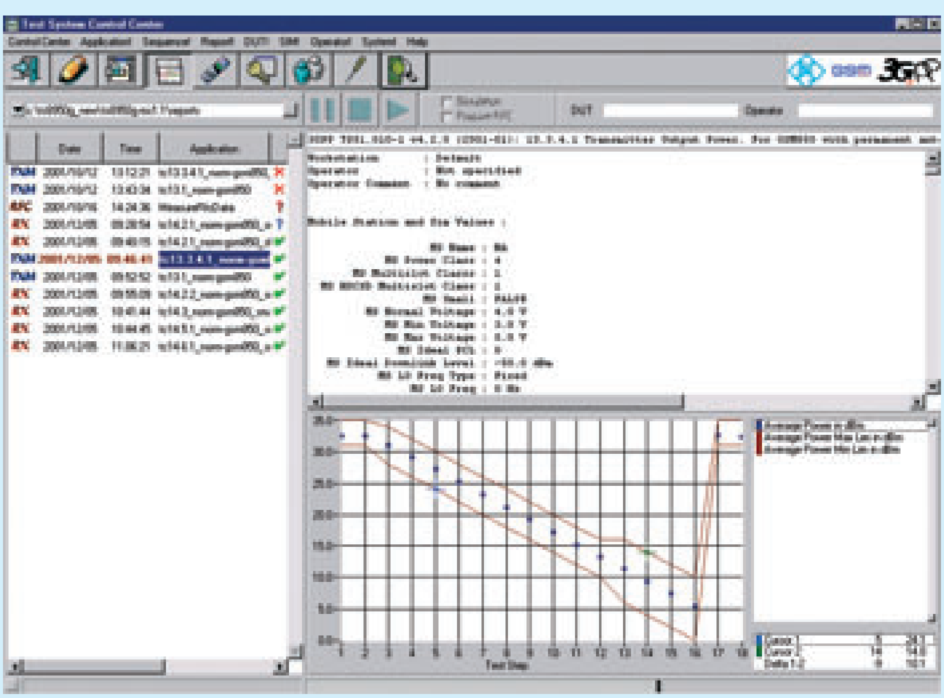
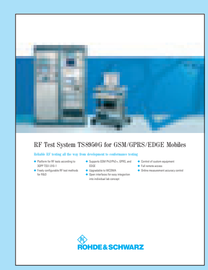


FIG 5 User-friendly evaluation of test results in text and graphics

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



Data sheet TS 8950 G

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[3] Universal Radio Communication Tester CMU 200 – On the fast lane into the mobile radio future. News from Rohde & Schwarz (1999) No. 165, pp 4–7

[4] Spectrum Analyzers FSP / FSU – GSM and EDGE measurements with Application Firmware FS-K5. News from Rohde & Schwarz (2001) No. 170, pp 18–20

[5] Signal Generator SMIQ – Fit for 3G with new options. News from Rohde & Schwarz (2000) No. 166, pp 10–12

FIG 1 The R&S SMIQ03HD opens up new levels of performance in adjacent channel power measurement.

Vector Signal Generator R&S SMIQ03HD

Wide dynamic range for measuring adjacent channel power

WCDMA base station amplifiers must feature excellent spectral purity and low intermodulation distortion to minimize interference in adjacent channels. Measuring these characteristics calls for sources that are able to generate low-noise and low-distortion WCDMA test signals over a wide dynamic range. The R&S SMIQ03HD (FIG 1) is designed especially for this purpose.

Optimal for testing base station amplifiers

High demands are set for adjacent channel leakage ratio (ACLR) in the development and production of base station amplifiers, especially for the upcoming mobile radio generation WCDMA / 3GPP. ACLR is the ratio of the average power measured in the transmission channel to the average power measured in the adjacent channel. Unwanted spurious is mainly caused by third-order intermodulation products in the adjacent channel and fifth-order intermodulation products in the alternate channel.

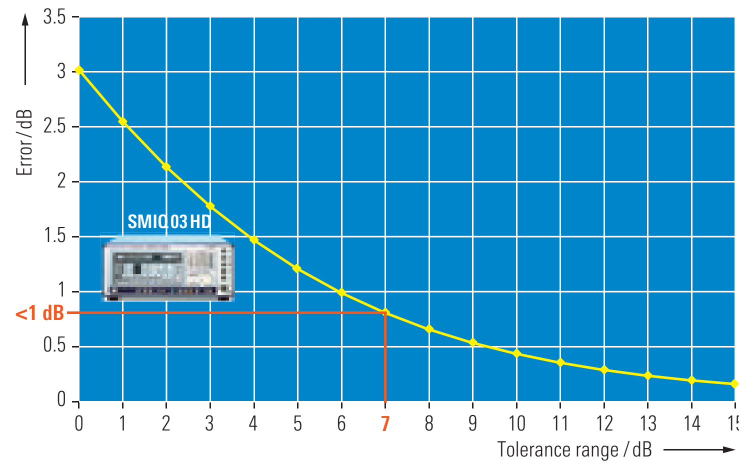
WCDMA specifications [1] stipulate a minimum ACLR of 45 dB in the adjacent channel for amplifier tests. Most producers specify an ACLR of 50 dB for their base stations. To maintain this value in the whole signal chain, the typical ACLR performance of base station components, e.g. amplifiers, must be better by another 10 dB. To provide sufficient margin for measuring these amplifiers, the adjacent channel leakage ratio of the signal generator must exceed this figure by yet another 10 dB. If the ACLR of the signal generator equalled that of the amplifier, an error of approx. 3 dB would result [2]. To keep this error below 1 dB, the ACLR of the generator must be at least 6 dB above that of the amplifier. For an error of <0.5 dB, the ACLR of the signal source must be better by at least 9 dB (FIG 2).

The R&S SMIQ03HD is the ideal partner in this case. Thanks to a newly designed I/Q modulator, the generator produces an outstanding ACLR of typically 70 dB, making it clearly superior to all instruments used before (WCDMA / 3GPP signal: test model 1, 64 DPCHs).

Integrated I/Q filters for highest ACLR

The R&S SMIQ03HD is ideally suited for single-carrier and multicarrier signal applications. Integrated I/Q filters are one of its prime features. They allow spectrally pure multicarrier signals to be generated with an ACLR far above that specified for base stations. Using the optional Arbitrary Waveform Generator ARB SMIQB60 [3], excellent 62 dB (typical) is obtained in the adjacent channel and 64 dB in the alternate channel [4] (FIG 3) for a four-carrier WCDMA signal based on test model 1 with 64 DPCHs. The R&S SMIQ03HD can also be used with the I/Q Modulation Generator R&S AMIQ03 or R&S AMIQ04 to generate signals with a depth of 16 Msamples. The I/Q Simulation Software WinIQSIM™, supplied by Rohde&Schwarz free of charge, offers the user a variety of extra capabilities. Digital signals, e.g. 3GPP multicarrier signals, can be simulated and generated by just a few mouse clicks.

FIG 2 With 70 dB ACLR of the DUT, the error caused by the R&S SMIQ03HD is negligible. The tolerance limit of 7 dB produces an error of <1 dB.



The generator comprises I/Q filters for up to four WCDMA carriers. This ensures a large degree of flexibility for numerous amplifier tests. I/Q filters with bandwidths of 2.5 / 5 / 7.5 and 10 MHz for one to four WCDMA carriers are standard and selectable in the R&S SMIQ03HD. Optimum ACLR values can thus be obtained for each of the four possible multicarrier scenarios.

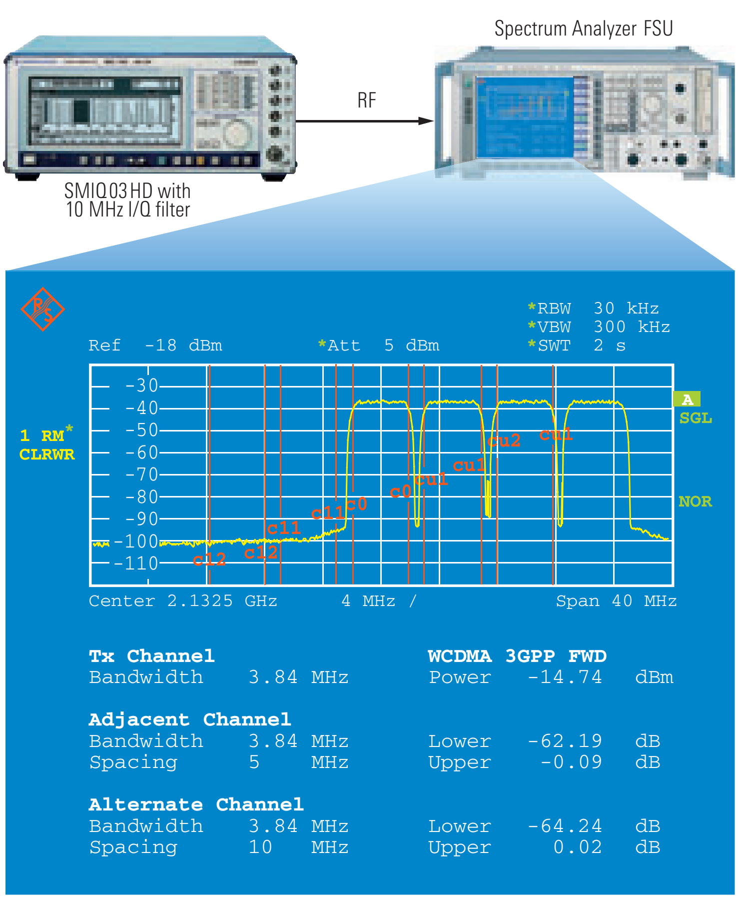


FIG 3 The four-carrier WCDMA signal scenario generated by only one R&S SMIQ03HD yields an ACLR of 62 dB in the adjacent channel.

For record values: High ACLR Option SMIQB57

Not enough that the R&S SMIQ03HD itself features superior signal quality. Signal quality for ACLR performance that no other generator has even come close to can be achieved with the optional Filter SMIQB57, which was especially developed for the WCDMA downlink band (2110 MHz to 2170 MHz). A typical ACLR of 77 dB in the adjacent channel and 82 dB in the alternate channel is an absolute record (FIG 4). In addition, there is the high output level of up to +30 dBm PEP generated by the option in the overrange. The advantages speak for themselves. With this option integrated in the R&S SMIQ03HD, producers of base station components can make substantial cost savings, as no amplifiers or bandpass filters need be connected to the signal generator's RF output. This

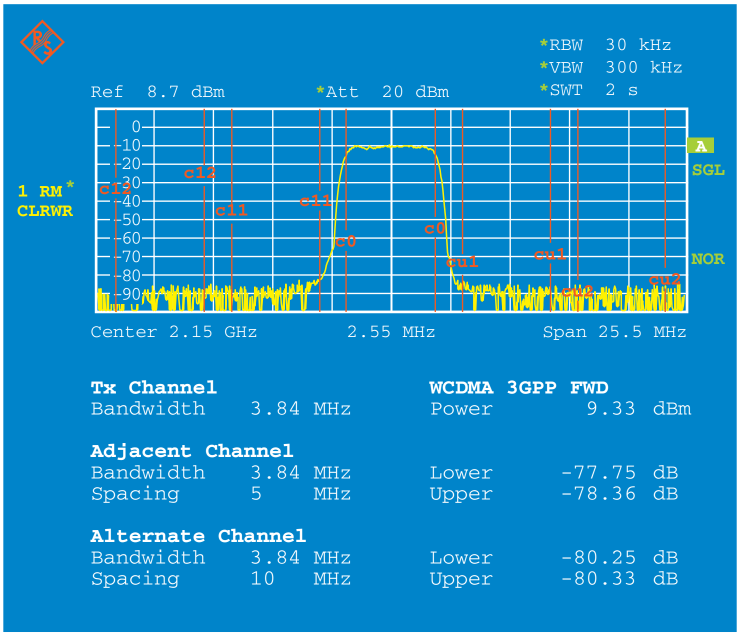


FIG 4 77 dB in the adjacent channel is about 10 dB above the best figures of conventional signal generators.

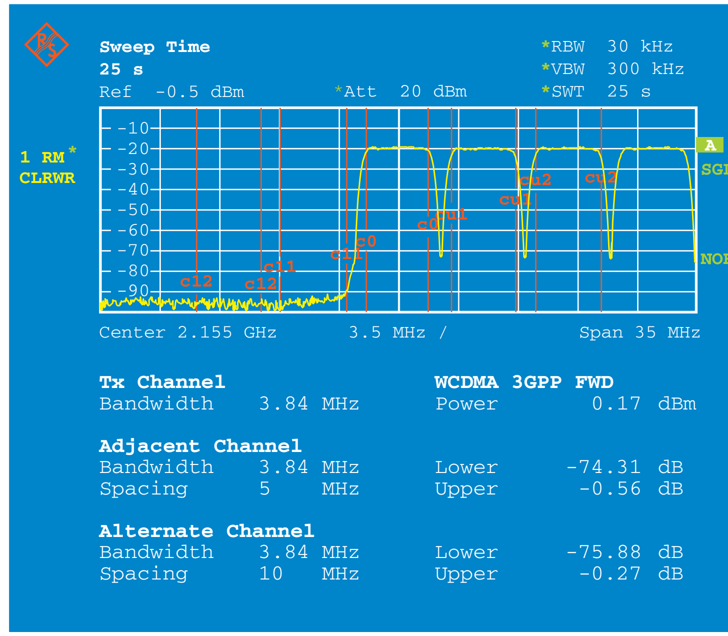


FIG 5 Multicarrier scenarios for exhaustive demands can be created by combining several R&S SMIQ03HD signal generators (each with the SMIQB57 option). In the example above, four generators are used for four carriers.

avoids degradation caused by follow-up driver stages, which make a sizeable contribution to the noise in the output signal.

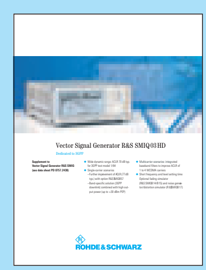
If the user wants to perform measurements with WCDMA multicarrier signals with the maximum spectral purity, up to four generators comprising the SMIQB57 option can be combined. Using one source for each carrier in multicarrier signal generation produces an unrivalled ACLR of typically 74 dB in the adjacent channel (FIG 5) in a four-carrier WCDMA scenario (test model 1 with 64 DPCHs).

Unbeatable in production

Not only in development is the new generator an indispensable high-end tool. High throughput is essential for cost-effective production, so users here can also benefit from the advantages. They will look for extremely fast level and frequency setting times, another strong point of the R&S SMIQ03HD. Setting times of <3 ms for frequency and <2.5 ms for level are noteworthy enough. If the generator is operated in the list mode (<500 µs) or fast restore mode (<800 µs), setting times are even significantly shorter.

Dr Markus Banerjee

More information, data sheets and application notes at www.rohde-schwarz.com (search term: SMIQ)



Data sheet R&S SMIQ03HD

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[1] 3GPP Technical Specification TS25.141 (V3.6.0 – 2001-06) 3rd Generation Partnership Project (3GPP)

[2] 3GPP FDD Base Station Tests with Vector Signal Generator SMIQ. Application note 1GP41 from Rohde&Schwarz

[3] SMIQB60 – Arbitrary Waveform Generator for SMIQ. Application note 1GP45 from Rohde&Schwarz

[4] Generating and Analyzing 3GPP Multicarrier Signals with High Dynamic Range. Application note 1MA48 from Rohde&Schwarz

Fast and efficient – product documentation on CD-ROM

Electronic publications are now a generally accepted standard for technical documentation. Compared to conventional print media, they offer the user a whole number of decisive advantages: faster location of information through integrated search functions and navigation aids as well as more up-to-date information thanks to simpler distribution. Moreover they are easier to deal with thanks to far less volume and weight. The new CD-ROM for the Universal Radiocommunication Testers R&S CMU 200/300 aims to combine all these features.

The functionality of an electronic publication depends on how it is distributed. Pre-recorded sources such as CD-ROMs allow fast access to extensive documents and efficient searching for information. In contrast, the World Wide Web makes up-to-date information available to any number of users and provides means for interaction. CD-ROMs which also include links to the Internet combine the advantages of both.

The CD-ROM for the R&S CMU 200/300 comes with a user interface that can be displayed by all common, Java-compatible standard browsers. A fixed navigation frame permitting direct access to the contents appears on the left. The CD-ROM contains operating and service manuals for the models R&S CMU 200 and R&S CMU 300 as well as for all CMU software options in printable PDF format (Acrobat Reader). Frequently used manuals are also available as onscreen Web help (FIG) and as compiled HTML files (*.chm). The help formats with integrated table of contents simplify fast information finding by an index and full-text search. Texts can be simply copied, e.g. for errorfree transfer of remote-control commands into programs.

The browser-oriented approach provides direct access to the R&S Web site, to look for upcoming events and latest publications, or to contact people at Rohde & Schwarz and send much appreciated feedback.

Silvia Brunold; Dr Martin Jetter

User interface of CD-ROM for R&S CMU with integrated Web help

FIG 1 A powerful team: R&S NRP with 18 GHz Power Sensor R&S NRP-Z21

Microwave power meters are only as good as their sensors, which is why they were the focus of development for the new Power Meter Series R&S NRP. The sensors offer a dynamic range of up to 90 dB for modulated signals of any RF bandwidth, plus time gating, high measurement speed and low measurement uncertainty. Whether used for digital mobile radio, wireless LANs, or classic applications: these sensors set new standards in terms of versatility and accuracy.

Power Meter R&S NRP

Evolution in power measurement – intelligent sensor technology

Intelligent sensors herald a new generation

Digital mobile radio triggered a flood of developments in RF test and measurement engineering, which have also affected power meters. At first, it was the time structure of the test signals that presented new challenges. Today it is the broadband modulation techniques of third-generation mobile radio. And this is only the beginning. Wireless LANs with RF bandwidths of more than 100 MHz are already being discussed.

The problems cannot be solved by conventional sensor designs, especially if you want to keep the greatest advantage of power meters, their high measurement accuracy. For that reason, Rohde & Schwarz again takes an extremely innovative approach with the new generation, comparable to the introduction of intelligent sensors for the URV5 and NRV models in the early 1980s. All the signal processing is relocated into the sensor, which is the key to exploiting the potential of multiple-path sensor technology. The link to the basic unit or any controller is established via the standard USB interface (universal serial bus). The new family of power meters launches with the universal Sensors NRP-Z11 (-Z21) from 10 MHz to 8 (18) GHz and a basic unit of future-oriented design (FIG 1).

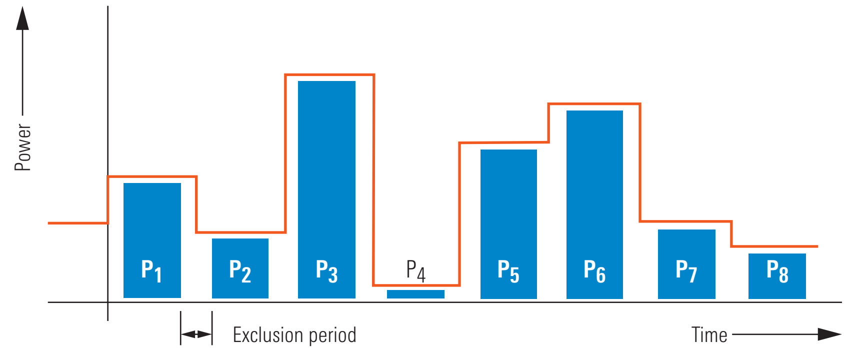


FIG 2 Multislot measurement: for the usual time division methods (e.g. GSM / EDGE, DECT), average power can be measured in all timeslots at the same time.

90 dB dynamic range

If it is true that the popularity of a power sensor grows with its dynamic range, then the NRP-Z11 and NRP-Z21 stand a very good chance of becoming real favourites. For the first time, a range of 90 dB for broadband modulated signals has been achieved, while the lower measurement limit (defined by noise and zero offset) remains a very respectable −67 dBm. And this does not change much if the power is to be measured within a single GSM timeslot (FIG 3). Even for signal-triggered measurement of the mean power of single bursts or the generation of a power/time template, a wider dynamic range is available than with conventional designs.

Signal-synchronized measurements

The NRP-Z11 and NRP-Z21 sensors can measure the average power not only in the classic manner, i.e. continuously without temporal reference to the signal content, but also synchronized with the signal over definable periods of time. Up to 128 intervals (26 when controlled by the basic unit) can be acquired and measured at one go (FIG 2). This allows entire frames of GSM / EDGE signals to be analyzed. Unwanted portions in the transition from one timeslot to the next can be blanked by freely definable exclusion periods at the beginning and end. To measure the power/time template of recurring or non-recurring waveforms (FIG 4), the number of test intervals

Technology ↓	Mode →	**Dynamic range for measuring average power** Bandwidth of test signal 100 MHz/5 MHz/0 (CW)			
		Continuous	**Timeslot** 1 out of 8 (external trigger)	**Burst** duty cycle 1:8 (internal trigger)	**Power vs. time** 256 points (external trigger)
Thermoelectric sensor		50 / 50 / 50 dB	–	–	
Diode	**Sensor in square-law region**	43 / 43 / 50 dB	–	–	
	CW sensor	43 / 43 / 90 dB	–	–	
	Peak sensor	33 / 50 / 80 dB	– / 50 / 57 dB	– / 33 / 37 dB	– / 50 / 57 dB
	Multiple-path sensor	80 / 80 / 80 dB	–	–	
	R&S smart sensor technology	**90 / 90 / 90 dB**	**85 / 85 / 85 dB**	**60 / 60 / 60 dB**	**70 / 70 / 70 dB**

FIG 3 Dynamic range of various sensor technologies as a function of the RF bandwidth of the test signal (peak-to-average ratio always 7 dB).

(points) can be increased to 1024; signal details down to durations of about 10 µs can thus be resolved. Extensive trigger functions, derived from an external source or the test signal, ensure stable conditions.

High system accuracy

The small measurement uncertainty of broadband power meters will continue to be the decisive argument for their use. In practice, the data sheet specifications of about 2% (0.09 dB) for unmodulated, spectrally pure signals of well-matched sources can seldom be achieved. This is due to those error sources that relate to the test signal or external circuitry: harmonics and nonharmonics, modulation, mismatch of the source, and the influence of attenuators and directional couplers connected ahead of the sensor for level matching.

The NRP sensors mark a great step towards resolving these problems. The expression *smart sensor technology* (see opposite page) stands for a whole series of measures intended to give the sensors the behaviour characteristic of thermal sensors. This includes very accurate measurement of average power, regardless of modulation (FIG 5), and high immunity to incorrect weighting of harmonics, spurious and other interference signals. The maximum speed of up to 1500 triggered measurements per second nevertheless equals that of diode sensors (in buffered mode, measurement interval 2 x 100 µs).

The effect of mismatched sources is reduced to the extent technically feasible by the sensors' small SWR (max. 1.13 between 30 MHz and 2.4 GHz), which is largely independent of the power to be measured. Despite this, the value given still results in an uncertainty of ±4% (0.17 dB) on a source with an SWR of 2. This value, which dominates all other errors, can now be reduced to almost zero with the NRP sensors, if the complex reflection coefficient of the source is transmitted to the sensors via the USB data interface. The sensors then correct the matching error, taking into consideration their own impedance mismatch.

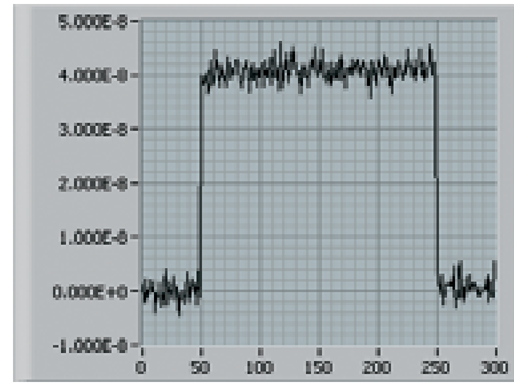


FIG 4 Power/time template of a nonrecurring RF burst for an application in medical electronics, measured with the NRP-Z11 (LabView application without basic unit; readings in W and ms, no averaging).

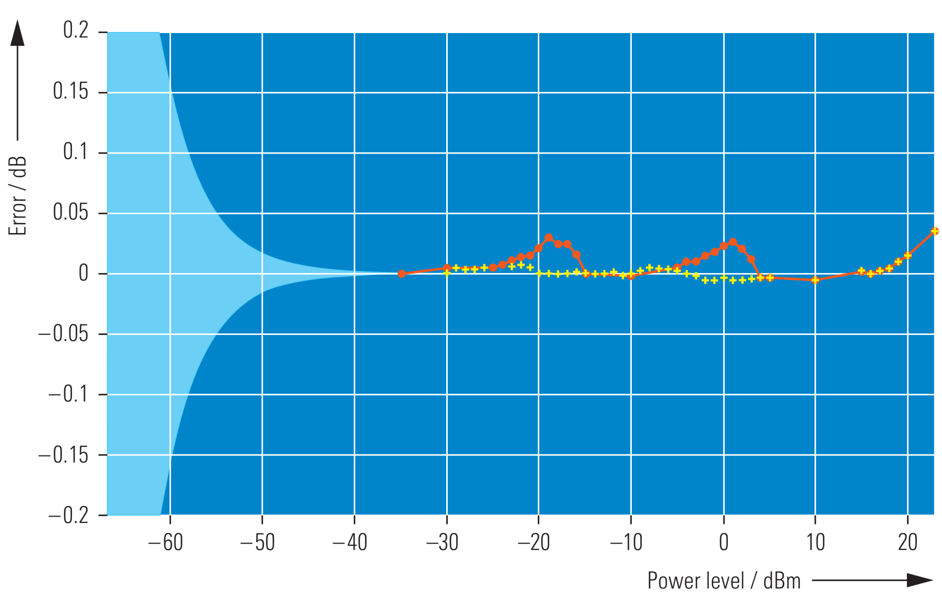


FIG 5 Modulation-related errors of an NRP-Z11 or NRP-Z21 power sensor for a 3GPP test signal (test model 1–64) compared to a CW signal of the same magnitude.
Red: default setting; yellow: transition area between measurement paths shifted by –6 dB;
light blue: uncertainty caused by noise (modulation effect below –30 dBm negligible).

There is a similar problem if the sensor cannot be connected directly to the source, and a level-matching attenuator or connecting cable is necessary. In this case, the interactions between three components must be taken into account – a non-trivial bit of mathematics involving complex numbers. Here, too, the user is offered a straightforward, standardizable solution. With the help of a small software tool that runs on any PC, the complete S-parameter data set of the twoport connected ahead can be loaded into the sensor's memory in the common s2p (Touchstone) format, which every vector network analyzer can provide, and is then taken into account in the measurement. After the source's complex reflection coefficient has been transmitted, a perfectly corrected reading of maximum accuracy is obtained.

Smart sensor technology

The Power Sensors NRP-Z11 and NRP-Z21 from Rohde & Schwarz fuse multiple-path architecture, multiple-diode technology and a simultaneously scanning multichannel measurement system into a unique high-performance concept.

Multiple-path architecture means combining two or three diode detectors to obtain a large dynamic range for modulated signals. This is achieved by operating each one exclusively in the square-law region, and only using the optimally driven detectors for the measurement.

Multiple diodes comprise several zero-bias Schottky diodes connected in series and integrated on one chip. When used in an RF detector, they expand its square-law region, because the measurement voltage is split among several diodes – so that each one is driven less – while at the same time the detected voltages of the individual diodes are added.

The usual, commercially available multiple-path sensors do not come close to exploiting the potential of this technology to the full, either because only two paths or single diodes are used, or because the output signals are processed sequentially with slow integrating A/D converters.

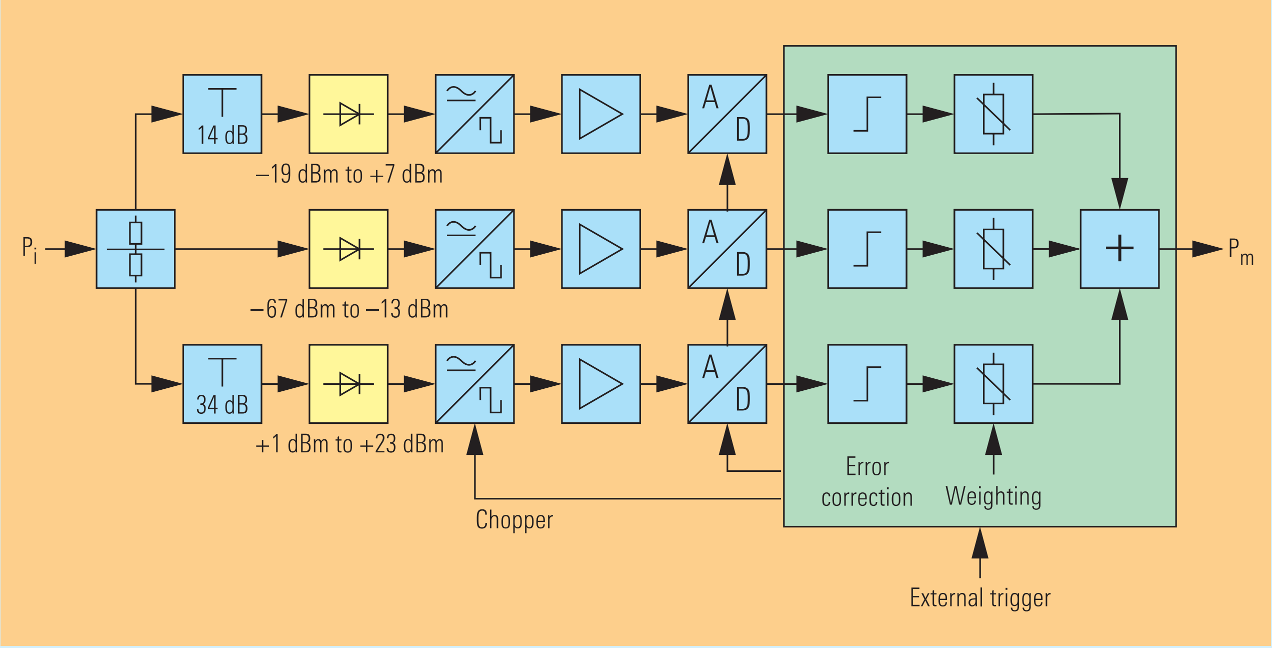
Rohde & Schwarz's multiple-path architecture (patent pending) is characterized by the following features (FIG 6):
- Three signal paths, each fitted with triple diodes
- 6 dB wide overlap ranges, smooth transitions
- Simultaneous scanning and analysis
- Chopper stabilization of the signal paths for repetitive signals

The advantages over conventional technology are obvious: high signal/noise ratio throughout, low modulation effect, negligible delays and discontinuities when switching signal paths, and the ability to perform a time-domain analysis of the test signal within the available video bandwidth.

Thus these sensors not only compete with peak power meters, they are even superior in two respects:
- No restrictions on the RF bandwidth of the test signal
- Larger dynamic range (FIG 2)

So it is already possible today to analyze extremely broadband signals, such as are planned for wireless LANs, or will be created by combining several carriers according to 3GPP.

FIG 6
Sensor architecture in NRP-Z11 and NRP-Z21



Costs per measurement halved

The price of a power meter that meets the requirements of modern communications technology is substantial, and is a sizeable part of the total cost of an RF measurement system. Users consequently often save in the wrong place, and shift the job of power measurement to other, less accurate instruments, or keep the number of test points low. There is no need for such compromises with the NRP sensors, since these can be operated directly on a controller, which is usually available anyway, thus saving the cost of the basic unit. One of the two USB adapters (NRP-Z3 or NRP-Z4) and the software tool kit included as a standard accessory are required for controlling by a PC. The software tool kit comes with both a DLL (dynamic link library) for individualized use of the entire sensor functionality under Windows™, and the *Power Viewer*, a virtual power meter with basic measurement functions for the PC workstation (FIG 7).

Universal basic unit

For those applications requiring a basic unit, the R&S NRP offers everything you expect from a modern power meter – and much more. No other instrument is as small, lightweight and rugged, and the optional battery pack ensures several hours of operation without line power. The NRP has a Windows-style menu interface, a high-resolution graphical display, and is operative in seconds, making it a pleasure to use. Depending on requirements, it can be fitted with one, two or four measurement inputs, an IEC/IEEE bus port being provided as standard. The shortest measurement time, from triggering to readout of the result, is 4 ms; only one modulation period is needed to measure very low-frequency modulated signals.

And evolution continues

The new family will be expanded continuously, starting with the extension of the frequency range. Sensors with upstream power attenuators as well as DC-coupled thermal sensors will be available. Since the influence of the basic unit is nonexistent, the latter will be the most accurate power references commercially available. Display of power versus time and remote control via the USB interface or Ethernet (optional) will round off the functionality of the basic unit.

Thomas Reichel

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

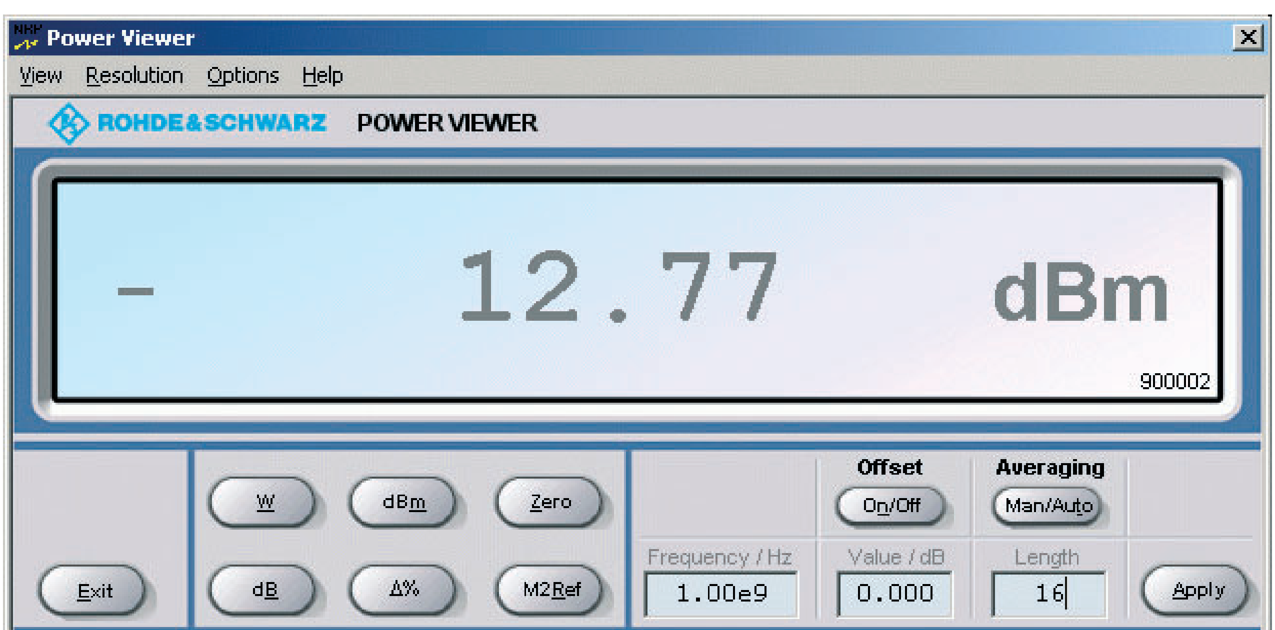


FIG 7 The *Power Viewer* turns any PC (under Windows 98 / 2000 / ME / XP) into a power meter.

Signal Analyzers R&S FSQ

Bandwidth and dynamic range for future systems and technologies

The R&S FSQ is fully in line with the trend towards systems with higher data rates (e.g. wireless LAN) and multicarrier signals. With an analysis bandwidth of 28 MHz, the instrument is well prepared for future technologies and systems, without compromising on dynamic range and easily meeting the demands of all transmission standards. Using only complementary firmware applications, without hardware add-ons, the R&S FSQ is easily expanded into a multistandard or multicarrier analyzer.

FIG 1 The new R&S FSQ comes with optimum features for analyzing broadband transmission systems and multicarrier signals.

Solid advances

Similarly to the spectrum analyzers of the R&S FSE family [1] and the signal analyzers of the R&S FSIQ family [2], Rohde & Schwarz is continuing its successful product policy with the Spectrum Analyzers R&S FSU [3] and the new Signal Analyzers R&S FSQ. The R&S FSQ (FIG 1) is available for three different frequency ranges:

- R&S FSQ 3 — 20 Hz to 3.6 GHz
- R&S FSQ 8 — 20 Hz to 8 GHz
- R&S FSQ 26 — 20 Hz to 26.5 GHz

The analog RF section of the analyzer matches for the most part that of the R&S FSU family in design and characteristics, but with extra capability for vector analysis of signals up to 28 MHz RF bandwidth. Similar to the R&S FSU, the R&S FSQ too features high sensitivity (–155 dBm (1 Hz) at 2 GHz), wide dynamic range (25 dBm TOI at 2 GHz) and low phase noise particularly at large carrier offsets (–160 dBc (1 Hz) at 10 MHz). This creates optimum conditions for signal analysis on broadband transmission systems and multicarrier signals.

Multicarrier signals call for an analyzer with extremely wide dynamic range. Power measurement in unused channels must not be affected by inherent noise, inherent intermodulation or phase noise. All three variables tighten the dynamic range. In the case of 4-carrier signals to 3GPP WCDMA, the wide dynamic range and the low inherent noise of –89 dBm

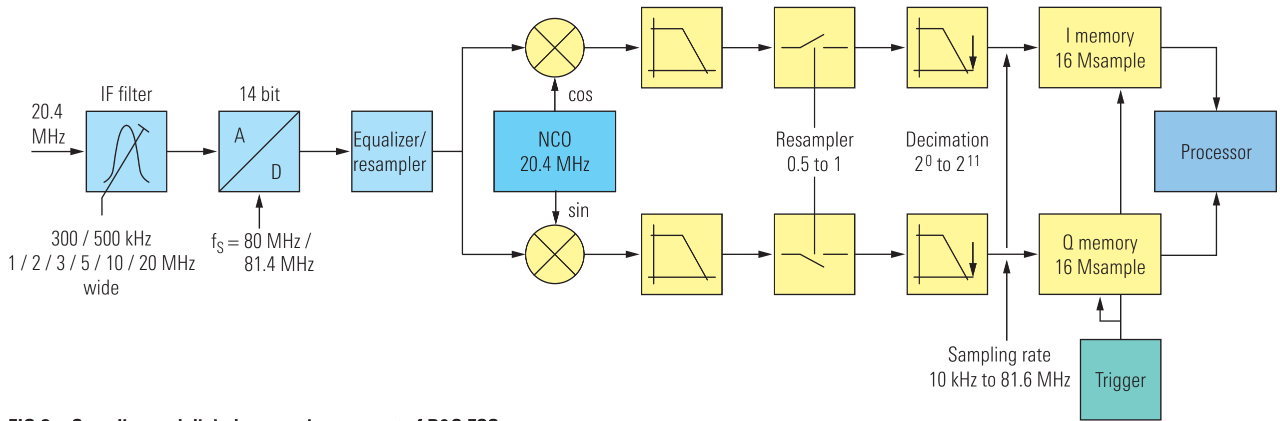


FIG 2 Sampling and digital conversion concept of R&S FSQ

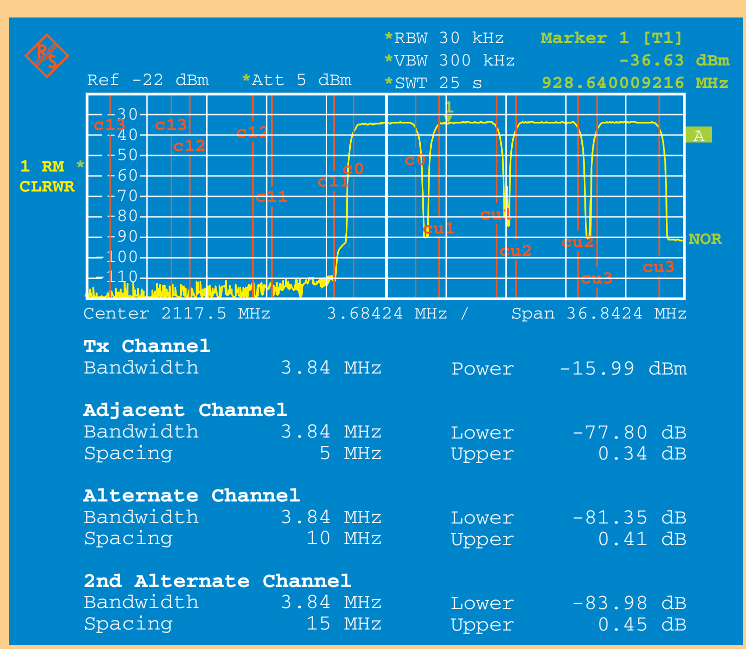
in 4 MHz bandwidth produce a dynamic range of approx. 67 dB in the adjacent channel. The RMS detector and an internal routine for inherent noise compensation allow a boost in dynamic range by as much as 10 dB to approx. 77 dB. With just one WCDMA carrier, level ratios up to 84 dB are possible in the adjacent channel (FIG 3). The R&S FSQ thus achieves the minimum dynamic range of 75 dB in the adjacent channel, which many users require for single carriers, also for WCDMA multicarrier signals.

The wide dynamic range of the analyzer also shows its worth when measuring spurious emissions. The high 1 dB compression point of the input mixer (+13 dBm) requires only a minimum of external filtering for mobile radio transmission systems of both the second and third generation [4]. This does away entirely with the need for tunable notch filters. The selectable number of test points (up to 10 000 per trace) in conjunction with the RMS detector allows power measurements in just one sweep over wide frequency bands. So time-consuming division into several partial sweeps is quite unnecessary. The signal analyzer automatically searches for the maximum levels above a definable threshold, lists them in a table or transfers them to a controller by remote control.

The major difference between the R&S FSQ and FSU families is their signal evaluation. A completely new chip set for conversion to the I/Q baseband was developed that, compared to the R&S FSU, offers significantly higher bandwidth and wider dynamic range, more computing power and greater memory depth.

The R&S FSQ digitizes the 20.4 MHz intermediate frequency for conversion to the I/Q baseband with a sampling rate of up to 81.4 MHz (FIG 2). The resolution of the A/D converter is 14 bits, the equivalent RF bandwidth that can be obtained is 28 MHz. Using a digital resampler in the I/Q baseband, the sampling rate can be optimally adapted to the measurement signal. This resam-

FIG 3 Measurement of adjacent channel power on multicarrier WCDMA signals with noise compensation



pler converts the sampling rate of the A/D converter in realtime and without dynamic loss into almost any sampling rate between 10 kHz and 81.4 MHz. That eliminates the time-consuming signal processing routines often used to match the sampling rate to the symbol rate of digitally modulated signals. Considering the time it takes to record up to 16 million samples for the inphase and quadrature signal, measurement time is obviously reduced quite substantially.

The R&S FSQ equalizes the amplitude and group delay distortions of the analog receive channel also in realtime using a complex, digital compensation filter. For this purpose it uses a reference signal with exactly known frequency response and group delay. At a keystroke, it applies the reference signal to the RF input and calculates an appropriate compensation filter that is cut into the I/Q data stream during measurement. The resulting amplitude frequency response, for example, is < 0.2 dB over at least 66% of the set resolution bandwidth (3 MHz to 50 MHz) or maximally 28 MHz. FIG 4 is an example of the amplitude, phase and group delay distortions measured at 20 MHz resolution bandwidth after correction.

Especially in broadband transmission, both the transmitter and receiver in the system commonly use analog technology for conversion to the baseband. The R&S FSQ can be retrofitted with analog baseband inputs for the analysis of analog I/Q baseband signals.

Sophisticated applications

Scaling and adjustment of multicarrier amplifiers

Output amplifiers for OFDM or CDMA signals and multicarrier amplifiers often take the form of feed-forward amplifiers to increase efficiency if the demands for suppressing adjacent channel power are very high. Amplifier adjustment requires the amplitude and phase information of the transfer function when the service signal is applied. This information can usually be derived from the complex baseband signal. The R&S FSQ measures the data at the amplifier output and outputs them with high bandwidth and dynamic range on the IEC/IEEE-bus or 100BaseT LAN interface. The recording time and sampling rate of the signal can be configured within wide limits.

Analysis of WCDMA signals

The Application Firmware R&S FS-K72 turns the R&S FSQ into a 3GPP signal analyzer for base station signals. It performs all measurements to 3GPP standard and additionally provides valuable data for in-depth analysis of WCDMA signals [5]. Broadband I/Q signal evaluation and the high computing power of the analyzer also enable measurement of multicarrier transmission signals. When, in future, base stations condition several WCDMA RF carriers straight away in the baseband – and possibly

FIG 4 Amplitude, phase and group delay distortion of I/Q data (20 MHz resolution filter)

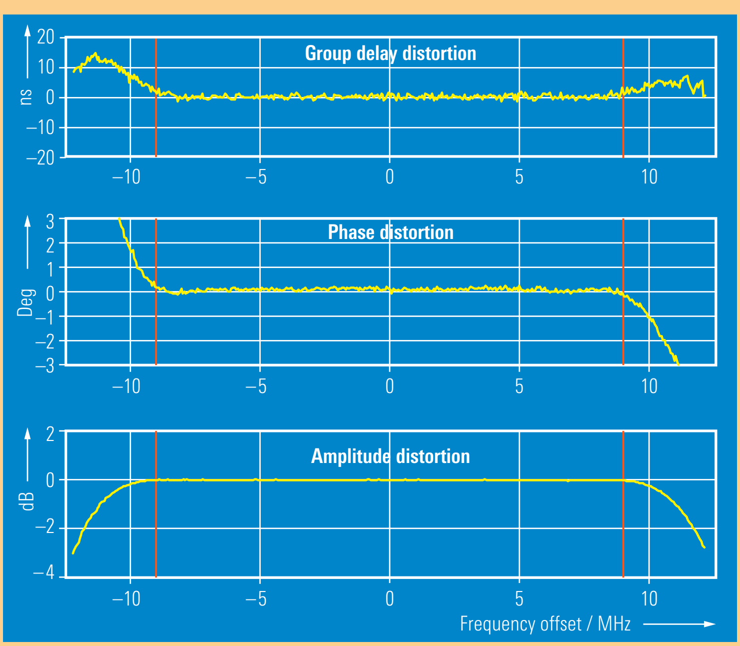
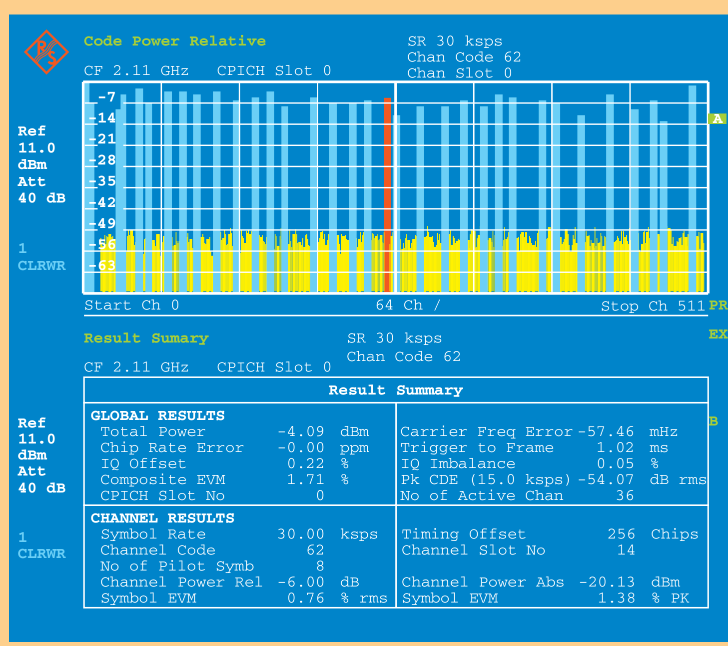


FIG 5 Measurement of WCDMA carrier in code domain



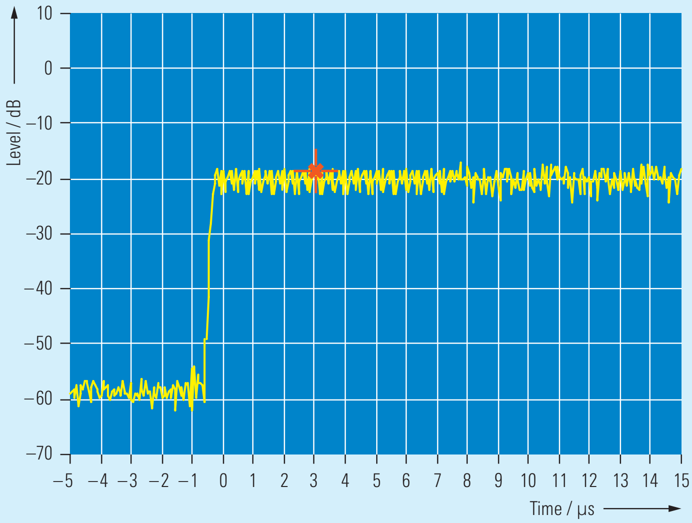


FIG 6 Timing

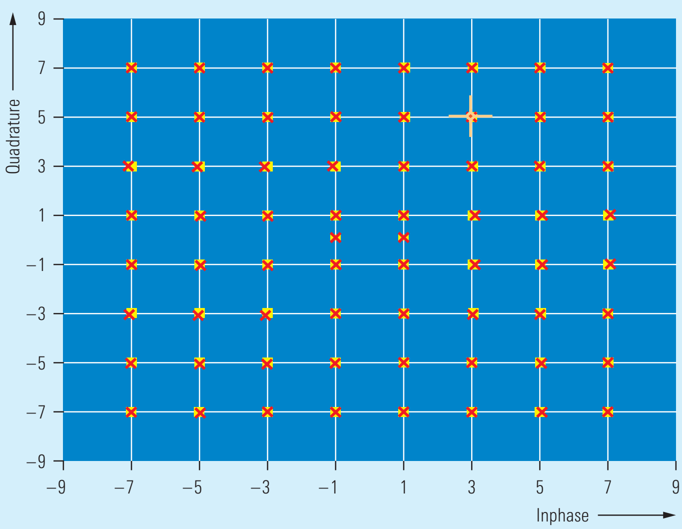


FIG 7 Constellation diagram at transmission rate of 54 Mbit/s (64QAM); red: real signal, yellow: ideal signal

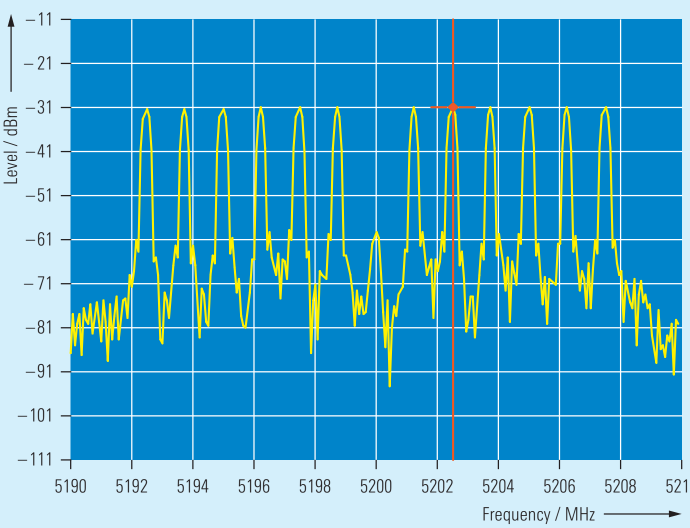


FIG 8 Preamble spectrum

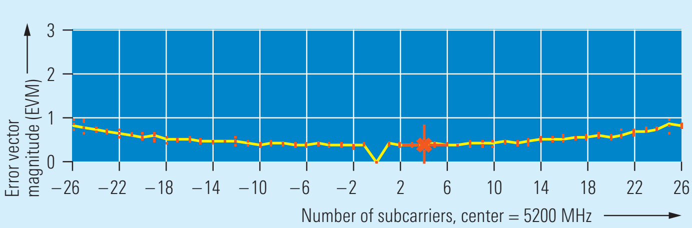


FIG 9 Error vector magnitude of individual OFDM signal carriers

Analysis of WLAN signals to IEEE 802.11a with Signal Analyzer R&S FSQ

Wireless LAN signals to IEEE 802.11a standard are intended for transmission rates of 6 Mbit/s to 54 Mbit/s. Transmission is by OFDM at 20 MHz channel spacing, with 52 carriers spaced at 312.5 kHz. The signal consequently occupies a bandwidth that previous RF spectrum analyzers were unable to process and was therefore the reserve of special-purpose instruments.

Especially for analyzing wireless LAN signals (IEEE 802.11a), the R&S FSQ can load Windows™ software that uses the I/Q data of the RF transmit signal to analyze it. It measures all key parameters of the OFDM signal in the frequency, time and modulation domains for the different transmission rates:

- Spectrum of a selectable section of the RF signal, e.g. preamble
- Amplitude distribution (CCDF) and crest factor
- Transmit spectrum mask
- Frequency error of RF signal and symbol frequency
- I/Q offset and I/Q imbalance
- Constellation diagram (BPSK, QPSK, 16QAM and 64QAM)
- Modulation error (EVM) per OFDM carrier or symbol
- Spectrum flatness
- Bits of payload symbols

FIGs 6 through 9 illustrate some measurements on an IEEE 802.11a signal at a transmission rate of 54 Mbit/s.

even for different kinds of transmission (a mix of 2G and 3G) – analyzers will be faced with new demands that can only be solved by broadband signal processing in the baseband, as is the case with the R&S FSQ. Fitted with the R&S FS-K72 option for example, the analyzer can measure the modulation characteristics of a WCDMA signal in the code domain even in the presence of one or more adjacent carriers. Thanks to its wide dynamic range, it is able to select and analyze a carrier by digital filtering to the exclusion of amplitude or phase distortion (FIG 5).

Both realtime equalization of the RF channel and digital conversion of the sampling rate by hardware to four times the symbol rate of 3.84 MHz significantly contribute to the high measurement speed. The analysis of a complete WCDMA frame thus takes only 1.5 s.

Analysis of WLAN signals
See box on the left.

General applications
For general applications in the lab or in production, the R&S FSQ – like the R&S FSU – provides a wide variety of functions that simplify measurements or help to avoid errors:
- Two independent measurement settings quickly selectable at a keystroke
- Split-screen display with independent measurement settings in both windows
- Four markers or delta markers
- Markers for measuring noise power density
- Markers for measuring oscillator phase noise
- Automatic intermodulation measurement for determining the third-order intercept point
- Frequency counter with 0.1 Hz resolution for a 50 ms measurement period
- Power measurement in the time domain (mean, RMS and peak power)
- Measurement of amplitude distribution (CCDF) and crest factor
- Measurement of occupied bandwidth
- User-definable limit lines (absolute or relative) with selectable margin and pass/fail indication
- Consideration of correction factors (transducers) in level measurement
- Fast measurement of levels with user-definable frequency lists in remote control mode
- Control of external generators for measuring transfer functions (option FSP-B10)

High measurement speed

The R&S FSU already set new standards for spectrum analyzers in terms of measurement speed. The R&S FSQ improves on this again with more powerful signal processing hardware and an even faster main processor. In remote control mode for example, it sends up to 50 measurement traces per second to the controller for a 10 MHz span. At zero span, the number of traces is 75.

Compatible with R&S FSE, FSP and FSU

The R&S FSQ family adds to the measurement functionality offered by Rohde & Schwarz spectrum analyzers. Compatibility plays a special role, in particular for remote control. User investment in test programs is not lost when changing to the R&S FSQ, which is to a large extent command-compatible with the Rohde & Schwarz instruments FSE, FSIQ, FSP [6] and FSU, if they contain the particular function.

Josef Wolf

Condensed data of R&S FSQ

Frequency range	20 Hz to 3.6/8/26.5 GHz
Amplitude measurement range	–155 dBm to 30 dBm
Amplitude display range	1 dB, 10 dB to 200 dB in 10 dB steps, linear
Level measurement uncertainty	0.3 dB up to 3.6 GHz
Resolution bandwidths	1 Hz to 30 kHz FFT filter, in steps of 1/2/3/5, 10 Hz to 20 MHz in steps of 1/2/3/5 and 50 MHz, channel filter (100 Hz to 5 MHz)
Detectors	max. peak, min. peak, auto peak, sample, average, RMS, quasi-peak
Display	21 cm (8.4" colour TFT LCD, SVGA resolution)
Remote control	IEC 625-2 (SCPI 1997.0), RS-232-C, 100BaseT LAN

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

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[1] Spectrum Analyzer FSEM/FSEK – Fast spectrum analysis now through to 40 GHz. News from Rohde & Schwarz (1996) No. 152, pp 7–9
[2] Signal Analyzer FSIQ – Ready for all measurements on 3GPP base station transmitters. News from Rohde & Schwarz (2001) No. 170, pp 15–17
[3] FSU 26: see p 25 in this issue
[4] Application note 1EF45, Spurious Emission Measurement on 3GPP Base Station Transmitters
[5] Data sheet WCDMA 3GPP Application Firmware R&S FS-K72
[6] Spectrum Analyzer FSP – Medium class aspiring to high end. News from Rohde & Schwarz (2000) No. 166, pp 4–7

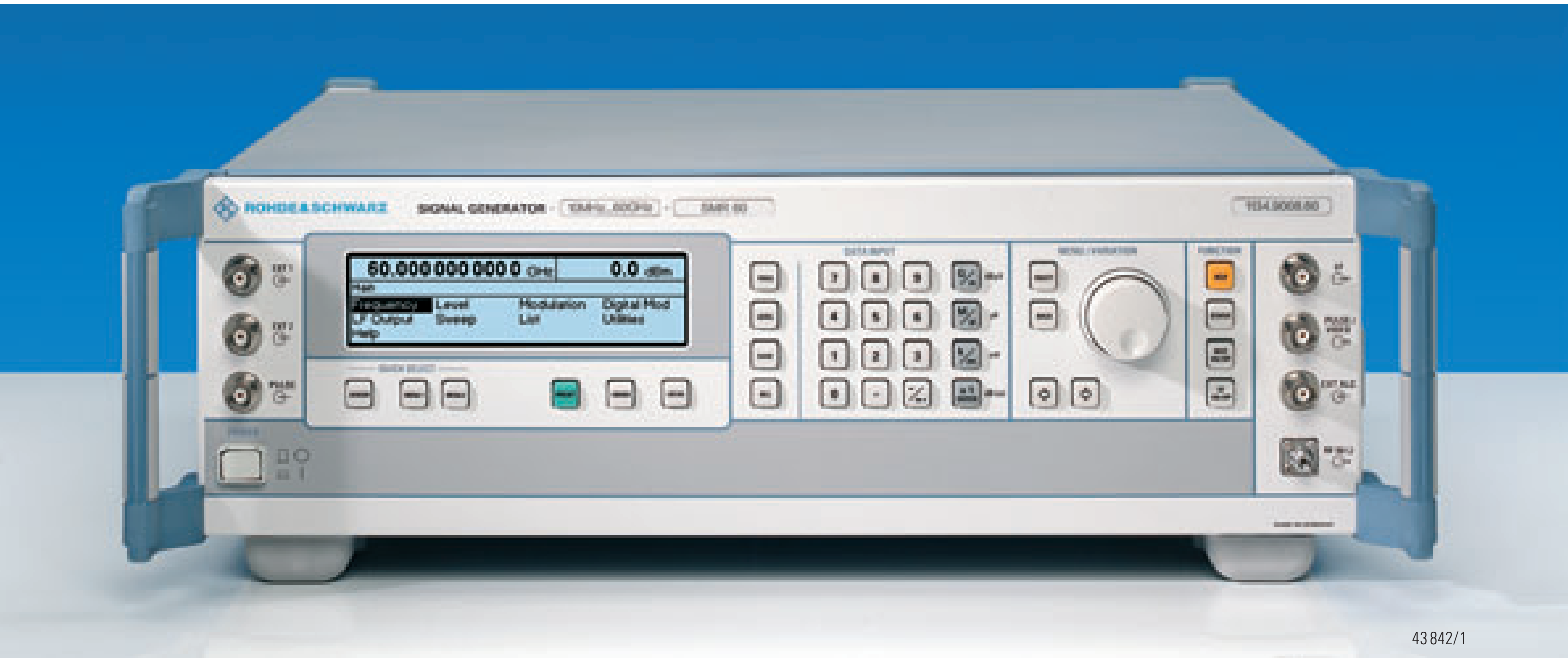

FIG 1 Microwave Signal Generator R&S SMR60

Microwave Signal Generators R&S SMR50 / SMR60

Allrounders up to 60 GHz

The new Microwave Signal Generators R&S SMR50 / SMR60 come with convincing features: excellent specifications at an attractive price, high reliability, optional expandability from CW generator to signal source with modulation capability and synthesized sweeper with analog ramp sweep.

Extensive functionality

Two new models, R&S SMR50 and R&S SMR60 (FIG 1), have been added to the tried and tested Microwave Signal Generator Family SMR [*]. Both have a lower cutoff frequency of 1 GHz and cover the range to 50 GHz (R&S SMR50) and 60 GHz (R&S SMR60). The lower cutoff frequency can optionally be extended down to 10 MHz. Owing to an advanced frequency synthesis concept with a fractional-N divider, both generators exhibit excellent single-sideband phase noise (FIG 2) and high spurious suppression. High-grade filters in the RF output produce optimum suppression of harmonics and subharmonics.

The higher the working frequencies in microwave test setups, the more important is high output level of the signal source used, because attenuation in virtually all passive components of the setup increases with frequency. FIG 3 shows the typical curve of the maximally available output level of an R&S SMR50 or R&S SMR60 versus frequency when fitted with the optional RF attenuator. With the aid of this option, the lowest output level setting is –110 dBm, which is often required for measurements on receivers. Without the option, the lowest level that can be set is –20 dBm. In this case, however, the maximally available output power at 60 GHz is up to 4 dB higher (up to 3 dB at 50 GHz). A stable output level is ensured in any case by precise level control with corrected frequency response.

Like all other SMR models, the basic R&S SMR 50 and R&S SMR 60 feature a powerful **digital step sweep** and an interface to connect an R&S FSP or R&S FSU spectrum analyzer. This allows exact synchronization of the frequency sweeps of the SMR and the spectrum analyzer. The instruments form a tracking system for scalar network analysis that satisfies all requirements for sweep speed and dynamic range. FIG 4 shows the basic setup for determining the transmission (magnitude of S_{21}) of a twoport. A combination of SMR and FSP or FSU also allows measurements on frequency-converting twoports such as mixers, frequency multipliers or dividers, since the frequency sweep settings of both instruments can be offset. The instrument combination is easily and exclusively operated from the spectrum analyzer.

Pulse modulation is still the most important mode in the microwave range. So the basic R&S SMR 50 and R&S SMR 60 models come equipped with a **high-grade pulse modulator** for all the measurements usually required on radar equipment.

Flexible optioning

An additional **pulse generator** produces single and double pulses. The pulse generator can work automatically, be externally triggered or operated in external gate mode.

The optional AM/FM/Scan Modulator SMR-B5 expands the R&S SMR 50 and R&S SMR 60 into **signal generators with modulation capabilities**. Scan modulation (logarithmic AM) is mainly used to simulate a rotating radar antenna. In addition to the modulation circuitry, the option is equipped with a high-grade LF generator with a range from 0.1 Hz to 10 MHz. Sources fitted

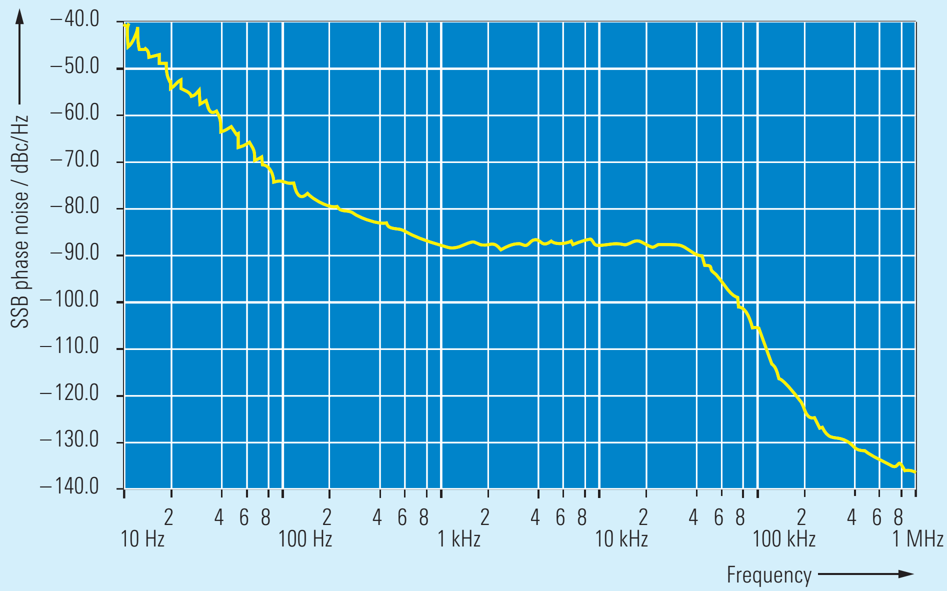

FIG 2 Single-sideband phase noise at 10 GHz

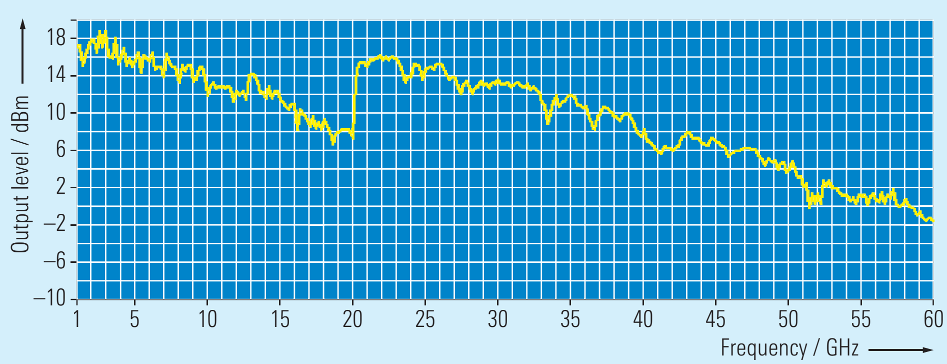

FIG 3 Typical maximum output level versus frequency (with optional RF attenuator)

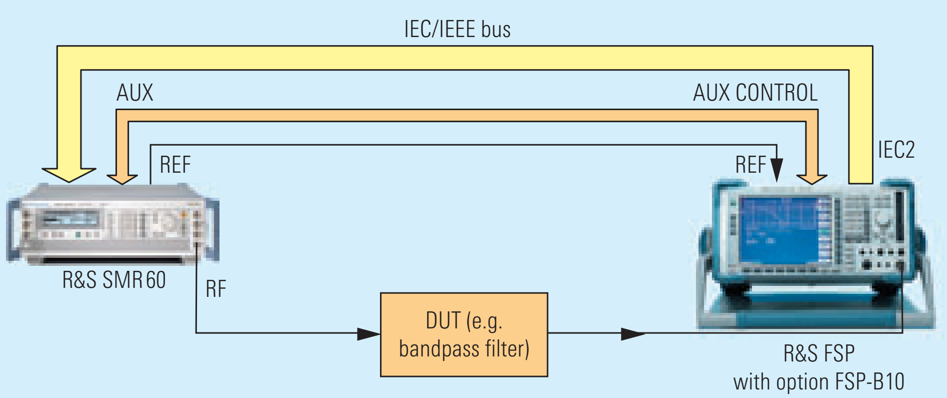

FIG 4 Transmission measurement with R&S SMR 60 and Spectrum Analyzer R&S FSP

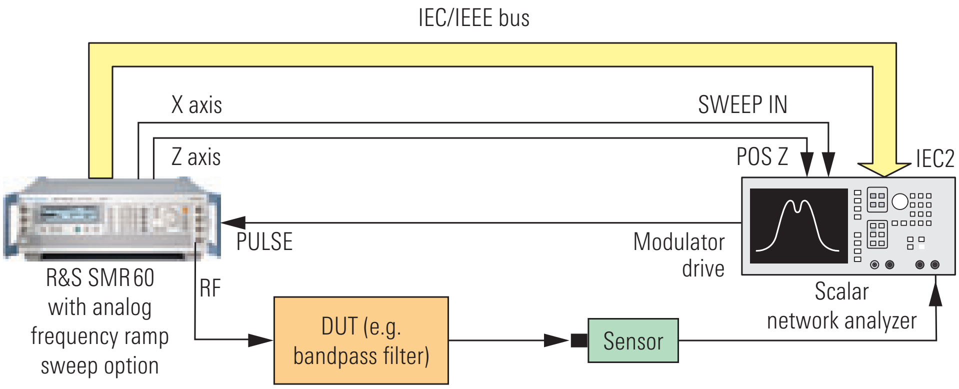

FIG 5 Transmission measurement with R&S SMR60 and scalar network analyzer

with this option can produce signals from 0.1 Hz right through to 60 GHz.

The **analog ramp sweep option** adds a function to the microwave generators of the R&S SMR family which corresponds to the analog frequency sweep of traditional sweep generators. In this way, ten complete sweeps per second are easily achieved, which is a necessity for operation with conventional scalar network analyzers. Large use is made of such network analyzers with diode sensors in the upper microwave region because they are a low-cost alternative to vector network analyzers or systems with tracking receivers. Due to the broadband nature of diode sensors however, strict requirements are made for harmonic, subharmonic and spurious suppression of the synthesized sweepers that are used in order to limit measurement error. The R&S SMR50, R&S SMR60 and all other members of the SMR family optimally fulfil these requirements.

FIG 5 shows a setup for transmission measurement (S_{21}) on a twoport. While the generator in the R&S SMR / spectrum analyzer combination in FIG 4 is controlled by the analyzer, here it is the other way round. All major parameters such as start and stop frequency, frequency markers, sweep time and RF level are now set on the signal source, which – after each new setting – first of all sends both the start and the stop frequency to the scalar network analyzer, which then displays the values. In a next step, the generator controls the entire sweep. The analyzer concentrates on measurement and display. Scalar network analyzers can usually be operated in DC or AC mode. Maximum sensitivity in DC mode is limited to approx. –55 dBm, depending on the sensor used, while in AC mode it may be better by 3 dB to 4 dB. FIG 5 shows the AC mode. Operation in DC mode can dispense with the connecting line between the PULSE input of the generator and the modulator drive output of the scalar network analyzer.

Wilhelm Kraemer

Condensed data of R&S SMR50 / SMR60

Frequency range R&S SMR50 / SMR60	10 MHz to 50 GHz / 10 MHz to 60 GHz
Resolution	1 kHz (0.1 Hz with option SMR-B3)
Harmonics	
≤0.03 GHz / >0.03 GHz to 20 GHz / >20 GHz	<–50 dBc / <–55 dBc / <–40 dBc
Subharmonics ≤20 GHz / >20 GHz	<–65 dBc / <–30 dBc
Spurious	
≤20 GHz / >20 GHz to 40 GHz / >40 GHz	<–60 dBc / <–54 dBc / <–52 dBc
SSB phase noise	
(at 10 GHz, 10 kHz from carrier)	<–83 dBc
Level R&S SMR50 (at 50 GHz)	>+3 dBm (without option SMR-B18)
R&S SMR60 (at 60 GHz)	>0 dBm (without option SMR-B18)
AM / FM / scan AM	with option SMR-B5
Pulse modulation on/off ratio	>80 dB
Minimum pulse width	25 ns (ALC off) / 500 ns (ALC on)
LF generator (option SMR-B5)	0.1 Hz to 10 MHz, sinewave, rectangular
Pulse generator (option SMR-B14)	100 ns to 85 s
Digital frequency sweep/level sweep	10 ms/1 ms to 5 s per step
Analog frequency ramp sweep (option SMR-B4)	10 ms to 100 s

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

REFERENCES

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

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FIG 1 **New to the analyzer family – microwave Spectrum Analyzer R&S FSU 26**

Spectrum Analyzer R&S FSU 26

Excellent dynamic range up to 26 GHz plus low measurement uncertainty

This new analyzer (FIG 1) is an addition to the R&S FSU family. Excellent dynamic range and sensitivity plus unique measurement functionality such as fast ACP in the time domain or channel filters are now also available for microwave applications. New functions that can be retrofitted to the analyzer family as firmware updates mean additional upgrading and improved dynamic range for ACP measurements.

High-end features up into the microwave range

The Spectrum Analyzer R&S FSU 26 is based on the proven 3 GHz and 8 GHz models of the FSU family and offers the same high-grade characteristics as well as identical operation and measurement functions [1]. Fundamental mixing in the entire frequency range up to 26 GHz ensures very high sensitivity to the highest input frequency (FIG 2). The R&S FSU 26 thus meets a major prerequisite for wide dynamic range and allows measurement of very small signals (e.g. harmonics and nonharmonics) with sufficient S/N ratio and consequently low measurement uncertainty.

Measurement uncertainty in the upper microwave range is to a large extent determined by the frequency response of the YIG filter. In this case, the patented frequency response correction ensures a figure of <2 dB to 22 GHz and <2.5 dB to 26 GHz without the peaking usually required.

Often just as important are repeatability and stability of measured results, especially in production. These depend not only on frequency response but, and in large part, on the stability of the local oscillators and the YIG filter. With its synchronous sweep and internal calibration of the tuning characteristic of the YIG filter, the R&S FSU 26 sets standards here too.

Major applications for the R&S FSU 26 are measurements on radio relay, satellite link or radar systems. Large resolution bandwidths up to 50 MHz and special trigger functions such as IF POWER, selectable TRIGGER OFFSET including pretrigger and GATED TRIGGER support measurements on pulsed signals as used in radar. With integrated routines and a standard RMS detector, the R&S FSU 26 is fast and simple to operate when performing highly accurate power and channel power measurements as well as C/N_0 and C/N measurements, which are typical of radio relay or satellite links.

Another important application is the measurement of spurious emissions of wireless mobile communication systems up to 12.75 GHz. The analyzer is optimized for such measurements on base stations to GSM standard. Here it demonstrates an excellent signal-to-phase-noise ratio of as much as –160 dBc/Hz at relatively large carrier offsets of 10 MHz and a high 1 dB compression point of +13 dBm. This does away with the need for elaborate test setups with tunable, band-specific – and expensive – notch filters. Combined with the application firmware packages for GSM (FS-K5) and 3GPP/FDD (FS-K72), the R&S FSU 26 is the optimum analyzer for base station tests, including spurious emission measurement up to 12.75 GHz.

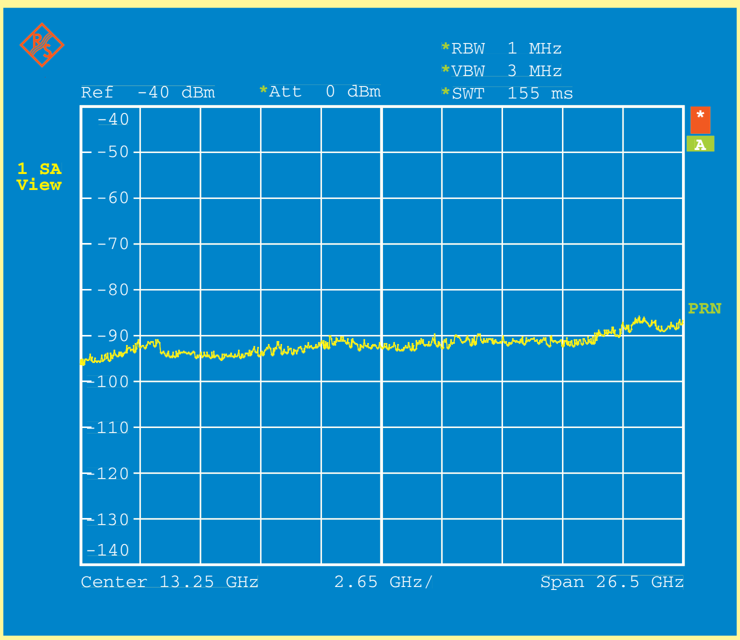


FIG 2
Inherent noise of R&S FSU 26 over its entire frequency range, measured with 1 MHz bandwidth

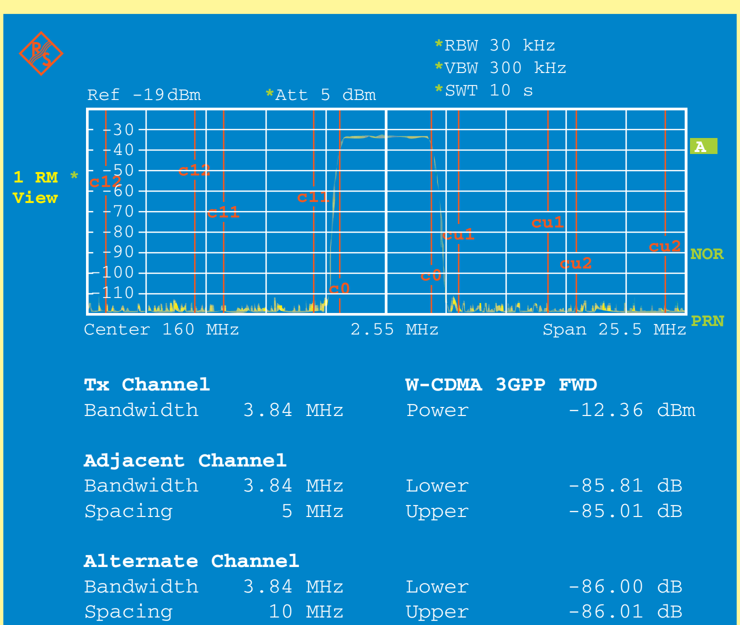


FIG 3
Using noise correction, the R&S FSU achieves 84 dB dynamic range in the 3GPP ACLR measurement. However, this wide dynamic range can only be verified by a bandpass-filtered transmit signal.

Firmware version 1.42 now with new functions

An important measurement within the 3GPP standard is adjacent channel power or ACP (referred to as adjacent channel leakage ratio or ACLR in 3G specifications). The requirements for measuring multicarrier amplifiers or D/A converters, for example, far exceed the standard specifications and often also the capabilities of much of today's T&M equipment. Wider dynamic range for ACP measurement in this case means simplified test setups and above all considerably reduced measurement uncertainty.

The new noise correction function expands the dynamic range of the R&S FSU for ACP measurements from 77 dB to as much as 84 dB (FIG 3). The advantage is that an ACLR value of 74 dB with an additional error of only <0.5 dB – caused by the instrument's inaccuracy – can be exactly determined. In this procedure, the RMS detector precisely identifies the instrument's inherent noise and, in a second step, compensates it.

If the mixer level is optimally set, test limits are determined equally by inherent noise and spectral regrowth due to intermodulation. Pure noise correction would, at best, yield an improvement by only 3 dB. RF attenuation is consequently increased automatically by 5 dB, reducing the spectral regrowth share by 15 dB and allowing inherent noise compensation to produce a 7 dB improvement.

Other new functions make for easier and faster spurious emission measurement. An increase in the number of trace points up to 10001 allows the R&S FSU to perform measurements in one sweep at a 20-fold larger span with the RMS detector and the same resolution bandwidths [2]. The PEAK LIST marker function then searches for all peaks within a selectable frequency band (maximally 100) and above a set limit line, reading out the result in the form of a table.

Also available are transducer factors for correcting the frequency-dependent insertion loss of test setups or antenna frequency response.

The firmware update can be obtained direct from the Rohde & Schwarz website.

Herbert Schmitt

Condensed data of R&S FSU 26

Frequency range	20 Hz to 26.5 GHz
Displayed average noise level 2 / 26 GHz	–146 dBm / –138 dBm (measured at 10 Hz bandwidth)
Resolution bandwidths	10 Hz to 50 MHz in steps of 1/2/3/5, 1 Hz to 30 kHz by FFT filters, channel filter 100 Hz to 5 MHz
Total amplitude measurement uncertainty	<0.3 dB up to 3.6 GHz, <3 dB up to 26 GHz

More information, data sheet and application note at www.rohde-schwarz.com (search terms: FSU or 1EF45)

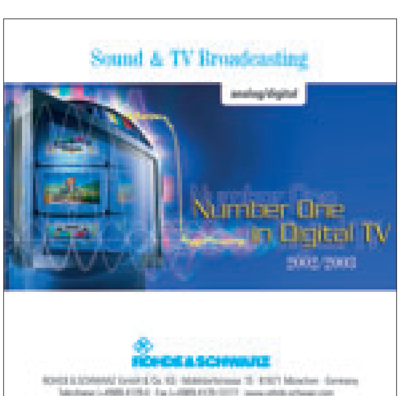
Data sheet R&S FSU

Application note 1EF45

REFERENCES

[1] Spectrum Analyzer FSU – Best RF performance – third generation of high-end analyzers. News from Rohde & Schwarz (2001) No. 171, pp 20–25
[2] Application note 1EF45 (Rohde & Schwarz website)

CD-ROM TIP | Sound & TV Broadcasting Catalog



R&S sound and TV broadcasting product range on CD-ROM

The new CD-ROM catalog "Sound & TV Broadcasting 2002/2003" is now available. The main focus is on digital TV (DVB) – Rohde & Schwarz presenting a complete product portfolio from generation through transmission to analysis of digital broadcast signals. The CD also includes data sheets, giving the user a clear picture of the entire range of TV and video technology available from Rohde & Schwarz.

You can order the CD-ROM catalog (quote PD 0757.4618.53) free of charge from any Rohde & Schwarz office.

Gerhard Krätschmer

Spectrum Analyzers R3172 / R3182 from Advantest

Analyzing broadband FMCW signals at a keystroke

FIG 1 Spectrum Analyzer R3182 from Advantest (9 kHz to 40 GHz)

FMCW signals have become popular for distance measurements in recent years in addition to classic pulsed radar signals. For this special and new measurement application, Advantest has developed an FM demodulation option for its Spectrum Analyzers R3172 and R3182 (FIG 1), allowing demodulation of FMCW signals and examination of deviation and linearity.

A new measuring application – FMCW signals

Classic distance measurement is based on time-delayed reception of pulsed signals. The distance is determined from the time it takes the pulse to travel between the transmitter and receiver via a reflecting object.

In contrast to this, FMCW (frequency-modulated continuous wave) signals are applied continuously, but the carrier frequency is broadband modulated in linear ramps. The distance to the reflecting object can be determined from the different frequencies of the transmit and receive signal (see box on page 30). This method of measuring distance and speed is often used in the far radar range with a carrier frequency between 76 GHz and 77 GHz, for instance by the automobile industry for ACC (adaptive cruise control) or in the military sector.

With this new method, the distance resolution depends on the frequency deviation of the radar signal, analogous to pulsed radar signals where it is a function of bandwidth. The carrier is therefore broadband modulated, the typical modulation deviation being maximally 250 MHz.

The two microwave Analyzers R3172 and R3182 from Advantest are able to demodulate signals with a peak-to-peak frequency deviation of up to 500 MHz and display them as frequency versus time. The ramp structure and deviation can be analyzed at a keystroke. This attractive new solution means that all major signal parameters can be characterized conveniently and within a minimum of time.

A high-speed IEC/IEEE bus further enhances the time to measure, which is of particular advantage in a production environment.

External mixers up to 110 GHz

External mixers are required for measurements between 76 GHz and 77 GHz to extend the analyzer frequency ranges. Advantest has developed two-diode mixers with low conversion loss especially for the R3172 / R3182 analyzers. These mean a considerable improvement in measurement sensitivity compared to conventional single-diode mixers. To simplify entering frequency-dependent conversion loss parameters on the analyzer, the values are supplied on a diskette ready to read in. The analyzers also come with a software preselector to suppress image frequencies. This allows unambiguous identification of the input signal.

Measuring linearity and deviation

Deviation and linearity are key parameters for defining ramp characteristics. Immediately after signal demodulation, the analyzer shows a menu for deviation and linearity measurement. For deviation, the software automatically sets two markers. They show the spacing between the positive/negative peak and the carrier frequency, the mean deviation and the repetition frequency (FIG 2).

The linearity of the frequency ramp is decisive for measurement accuracy and ▶

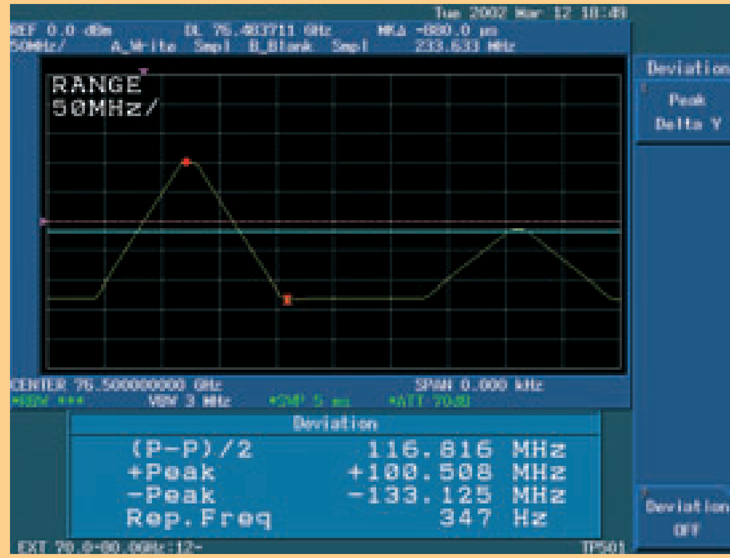


FIG 2
Measuring deviation of FMCW radar signal

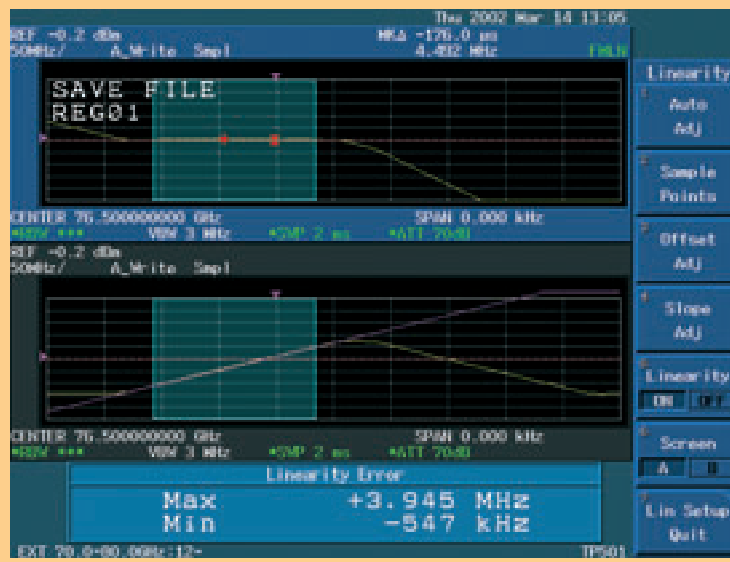


FIG 3
Linearity measurement with window and reference line on vertical scale of 50 MHz/div

FIG 4
Higher resolution of linearity error display by reducing vertical scale to 500 kHz/div

FMCW in detail

The carrier signal of the radar sensor is frequency-modulated in linear ramps (FIG 5). The sensor receives and transmits simultaneously. The difference frequency Δf between the transmitted and received signal (e.g. between two vehicles) is proportional to the time difference of the two signals and is generated in the sensor by mixing. The time difference of the two signals is in turn proportional to the distance between the transmitter and the reflecting object. The distance between two objects can thus be determined with high accuracy from the difference frequency Δf, the resolution depending on the bandwidth (deviation) of the ramp signal [*].

The Doppler shift – a frequency shift between two objects moving in relation to each other – is used in addition to determine the relative speed of the reflecting object, e.g. the vehicle ahead. So the FMCW radar determines distance and speed independently of each other.

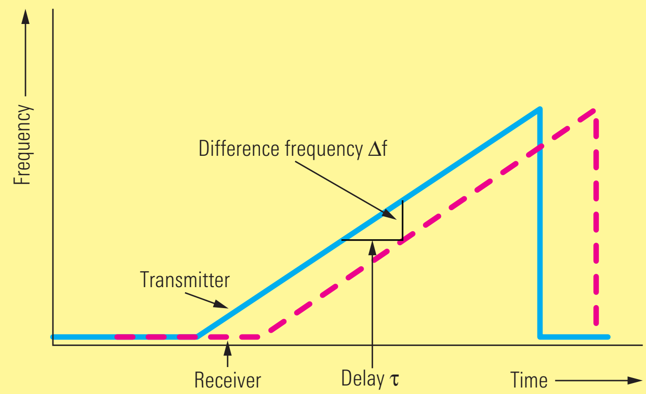


FIG 5 Signal pattern in FMCW radar

therefore is a major parameter of FMCW radar signals. For linearity measurements, a window and a straight reference line can be displayed on the particular segment. The maximum and minimum difference frequency between the signal section and the reference line is then measured with the aid of two markers (FIG 3). This is a convenient way for the user to determine the linearity error of the ramp signal. Reducing the vertical scaling increases the accuracy of the linearity display (FIG 4). The typical linearity error of the analyzers for FM demodulation is as low as 0.2% of the scaling, which ensures accurate measurement results.

With option .29 (50 µs sweep time in time domain) even FMCW signals with a short ramp period can be displayed.

Summary

The integrated FM demodulator of the Advantest Spectrum Analyzers R3172 / R3182 allows you to analyze the deviation and linearity characteristics of broadband FMCW radar signals at a simple keystroke. This saves a lot of time, particularly in production, because to date measuring the linearity required time-consuming evaluation of discrete frequencies.

The new external mixers ensure high sensitivity in the frequency bands up to 110 GHz, where you find the radar frequencies used for ACC in the automobile industry and for military applications. Advantest is thus able to offer an attractively priced and all-in-one solution for analyzing FMCW radar signals.

Patricio Dueñas

More information and data sheet at www.rohde-schwarz.com (search term: R3172 or R3182)

Data sheet for Spectrum Analyzers R3172 and R3182

REFERENCE
[*] Olbrich, H., Winter, K., Lucas, B., Beez, T., Mayer, H.: Design and Development Process of Present ACC Systems. Robert Bosch GmbH

MPEG2 / ATM Test Set R&S DVATM

Measurements on MPEG2 and ATM signals – across all layers

The use of new transmission routes for MPEG2 calls for innovative and intelligent T&M concepts in the field of broadcasting and for telecommunication network operators. The new Test Set R&S DVATM (FIG 1) provides interfaces for all layers involved as well as test signals and analysis functions. It is the world´s first unit to process both MPEG2 and ATM signals.


43825/6

FIG 1 R&S DVATM – a multistandard measurement tool with interfaces for all layers

Major abbreviations	
AAL	ATM adaptation layer
ATM	Asynchronous transfer mode
CIAT	Cell inter arrival time
CDV	Cell delay variation
CTD	Cell transfer delay
DS3	Digital signal 3: 44.736 Mbit/s (USA)
E3	Electrical interface signal 3: 34.368 Mbit/s (Europe)
NMOC	Network management operation center
OAM	Operation, administration and management
PDH	Plesiochronous digital hierarchy
PLCP	Physical layer convergence protocol
SDH	Synchronous digital hierarchy
SDI	Serial digital interface
SONET	Synchronous optical network
VCI	Virtual channel identifier
VPI	Virtual path identifier

Ensuring broadcast transmission quality

Digitization of the broadcast world produced MPEG2, a method using compression that is gaining more and more acceptance in the broadcasting sector. The services of telecommunication network operators are increasingly being used to transmit and route signals in realtime and in the appropriate quality. This means the fusing of two completely different worlds.

When broadcast content is transmitted in telecommunication networks, the signals must pass unimpaired through very different network structures and elements and at varying levels of network usage [1].

Operators and providers of telecommunication networks with broadcasting applications, on their part, are faced with the task of guaranteeing the contractual transmission quality. To date, testing this quality when providing an installation and monitoring it during transmission called for a host of different T&M devices.

The new all-in-one solution from Rohde&Schwarz, the MPEG2/ATM Test Set R&S DVATM, simplifies this task considerably. Designed in particular for users who transmit MPEG2 signals over ATM networks, it is the first unit worldwide to process both MPEG2 and ATM signals. ▶

No layer left out

The Test Set R&S DVATM is a multistandard instrument that, thanks to a variety of integrated interfaces, allows the user to measure signals at any point of the transmission route, analyze them and feed in test signals (FIG 2).

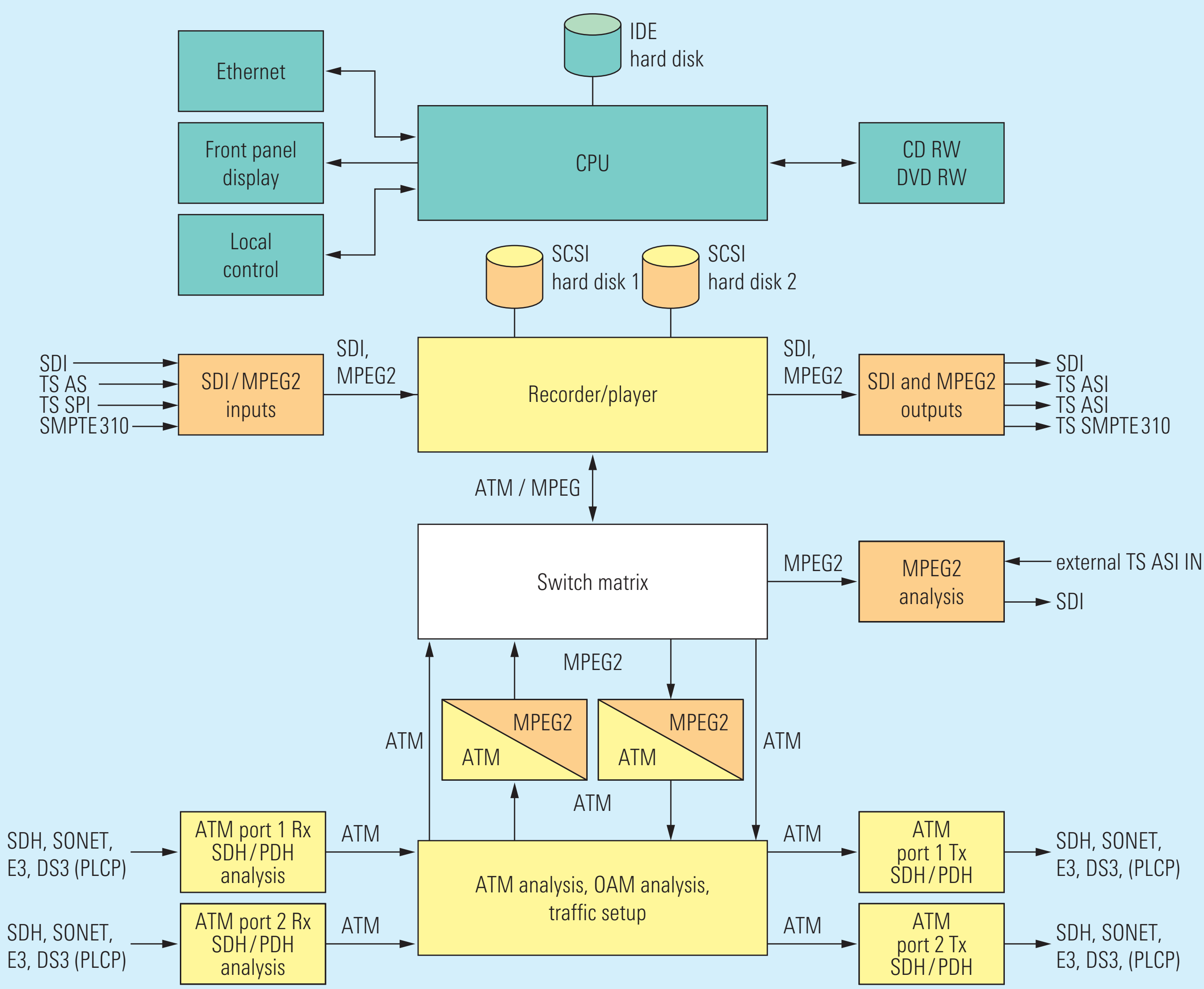
The test set supports fast and target-oriented identification of defective network elements. It analyzes and clearly displays the impact on the transmitted broadcast signals. Its universal concept allows analysis from the application layer (MPEG2) through ATM to the physical transport layer with SDH and PDH. It provides the user with all layers required for this task and specifically analyzes a connection in a defined transmission channel (VPI / VCI).

For this purpose, two ATM ports that can be used independently of each other are provided at the network end. The two interfaces can be software-configured to provide up to six different standards.

The analysis function of the ATM ports recognizes alarms and defects in all standards – SDH, SONET, E3-(PLCP), DS3-(PLCP) – and displays them as events, error lists or graphically.

The network statistics report of the new test set is a scan function for the ATM ports to identify and list active ATM connections and their specific parameters. This gives the user a fast and clear overview of assignments and activities within the network, enabling him to select connections simply and surely for analysis.

FIG 2 Block diagram of R&S DVATM



An ATM statistics function that analyzes the entire ATM port with all active connections provides information on the status of arriving cells. Other important connection parameters are delay (CIAT, CTD) and jitter (point-to-point and point-to-two-point measurements – CDV) of the transmitted ATM cells. The user can additionally monitor compliance with contractual parameters by a policing function.

The OAM fault management function on the F4 and F5 OAM layer allows monitoring of OAM activities and detection of end-to-end and segment alarms. This function can optionally be expanded to OAM performance management.

Extensive measurements on the different ATM adaptation layers (AAL1, AAL1 with FEC and AAL5) enable you to draw conclusions about the working of this level. This is of special interest for the transmission of MPEG2 transport streams. The MPEG2 transport stream packed in ATM cells can also be applied to an internal MPEG2 decoder/analyzer.

MPEG2 analysis is based on the recommendations of the ETSI standard ETR101290. Here the transport stream is examined and evaluated for first, second and third order priority errors. A new variant of the Stream Explorer software [2] produces the display, fitted with new functionality to measure the overall jitter of MPEG2 transport streams.

The R&S DVATM integrates versatile recorder and player tools. A data stream can be selected from an SDI, MPEG2 or ATM signal set for testing network elements, and SDI, MPEG2 or ATM signals can be recorded. These are available afterwards for more accurate evaluation. The recorder functionality also features an automatic trigger that is actuated by errors in the different layers.

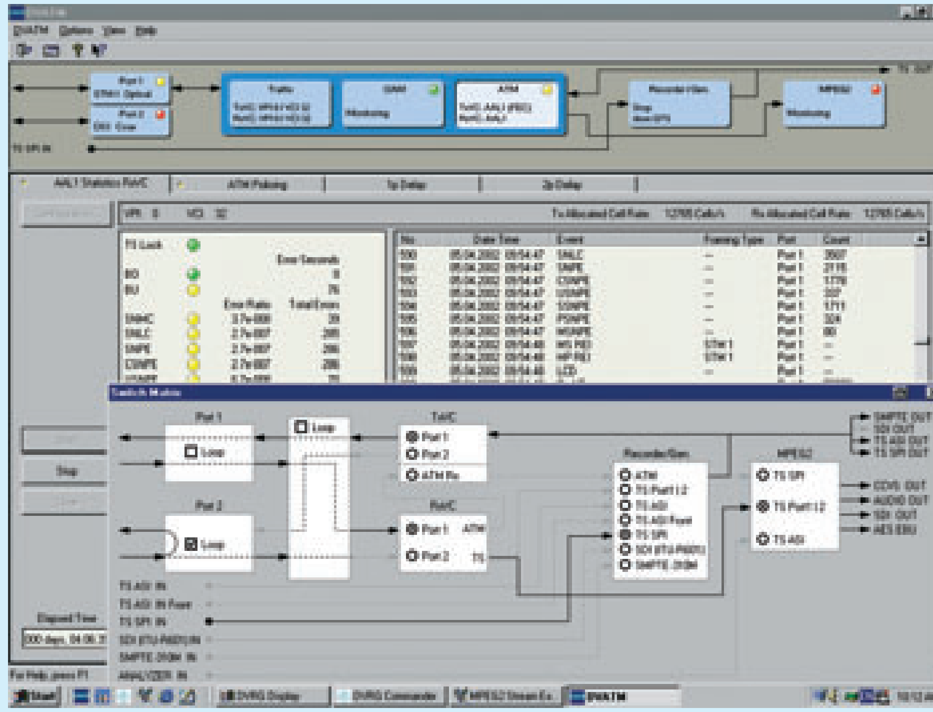


FIG 3 User interface of R&S DVATM with navigation window, measurement window with AAL1 (FEC) and switch matrix for device configuration (front)

Self-explanatory operation

Based on the Windows™ Embedded NT operating system, the test set presents the user with a PC-like screen. The self-explanatory and clearly structured user interface simplifies handling of this complex allrounder. The window is divided in two. At the top you always see a superordinate navigation window showing all important information about the configuration and measurement states. Below is the currently active software. In this way the user has complete control of all settings of the test set at all times (FIG 3).

A switch matrix is available for intuitive, sure and fast configuration of the internal test setup and measurement functions. In a block diagram, it gives an overview of the inputs and outputs used and of the interconnection of test set modules.

In longterm measurements, an error report at the ATM and MPEG2 end records error events, indicating time, duration and type of error. An additional graphical presentation of measured values at the ATM level ensures a quick overview.

Quick infos, activated by the mouse pointer, immediately output abbreviations used in SDH, PDH and ATM in full length. This keeps the user informed on abbreviations from the telecommunication world.

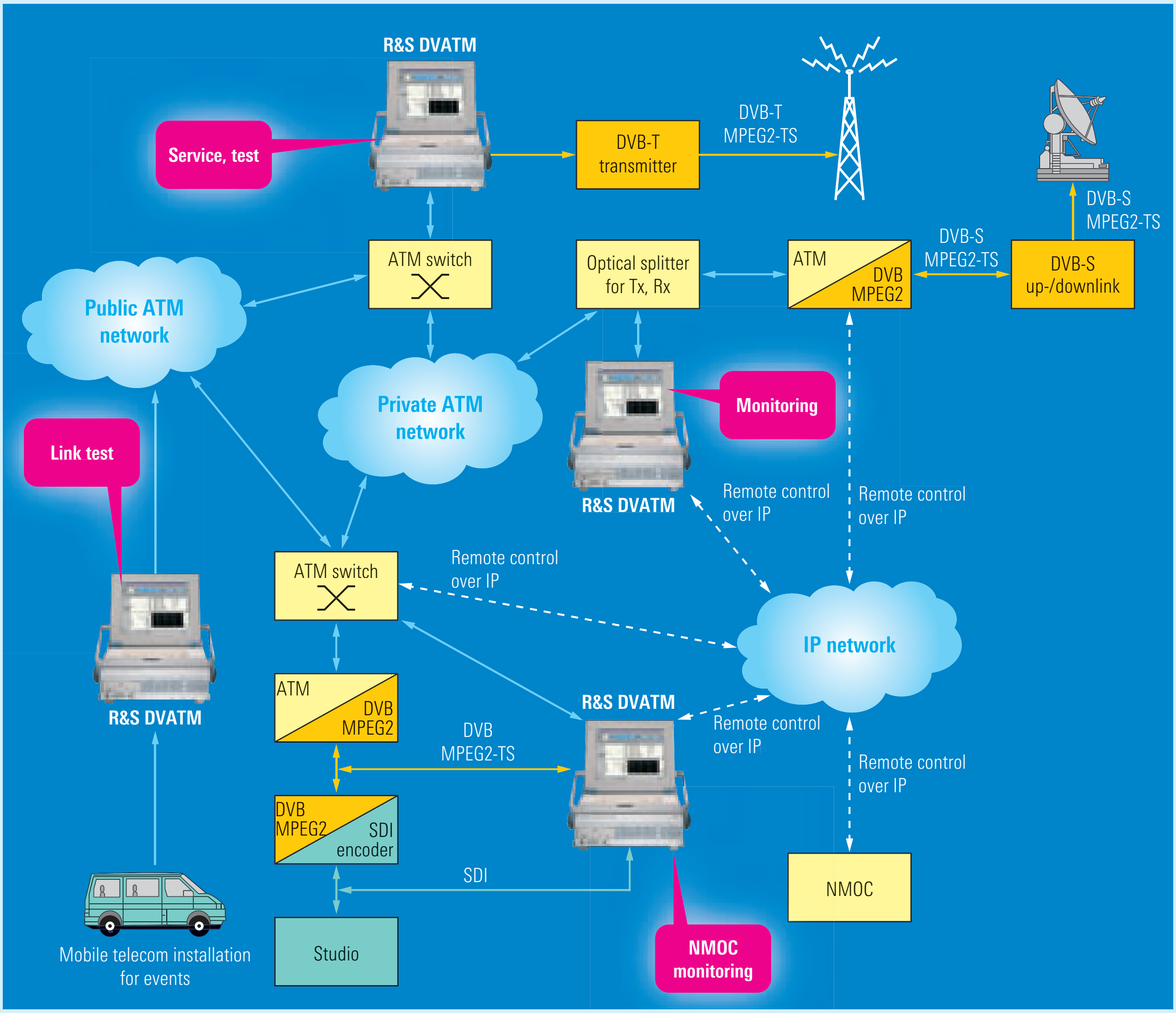
Thanks to the PC-based platform, the loading of new data streams for the generator from CD or an Ethernet connection is just as easy as the recording, archiving and copying of such data. The DVD read and CD RW drive is used for this purpose. It also serves for loading new software components or firmware updates to expand the test set's functionality.

Applications for the MPEG2/ATM Test Set R&S DVATM

One application is the installation and startup of transmission routes, network elements, MPEG2/ATM adapters and SDI encoders (FIG 4). The R&S DVATM allows bench testing of the entire equipment plus transmission simulation prior to installation. All required settings can be made in advance. This cuts installation and commissioning costs and saves unnecessary field trials on equipment already in place. Testing transmission routes prior to use allows early identification of possible connection problems. This ensures subsequent errorfree transmission, in which the test set can also be used to monitor quality.

In monitoring mode, the R&S DVATM can log and record data streams of the layers. Used in a network management operation center, the test set can monitor connections under remote control. The user interface of the test set can be exported to any PC over IP networks. In the event of problems, specific path sections can thus be tested and analyzed from a remote location.

FIG 4 Examples of R&S DVATM application versatility



Summary – a multifunctional allrounder

The R&S DVATM is a multifunctional MPEG2 and ATM test set. It is intended for all measurement applications in which MPEG2 signals are transported over ATM telecommunication interfaces. For all these applications it offers the necessary tools from the MPEG2 and telecommunication world (FIG 5), providing the required interfaces for all layers involved as well as test signals and analytical functions.

The R&S DVATM is the first unit worldwide that is able to process both MPEG2 and ATM signals. The user interface is designed in the style commonly found in sound and TV broadcasting. It gives the user a clear overview of the complex relations and operations at all times.

The test set can be fitted with various options matching specific measurement requirements. Functional units that can be used independently of each other are another asset. Several simultaneous measurements can be performed on very different signals, layers and interfaces.

The user benefits from an allrounder that is a cost-effective and compact, portable measurement solution in the field of broadcast signal transmission over telecommunication networks with ATM.

Ralph Kirchhoff

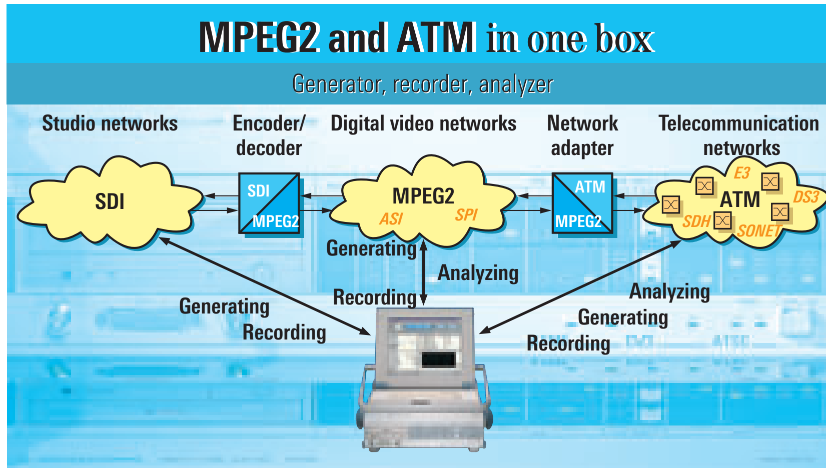


FIG 5 Measurement at any point of transmission route with R&S DVATM

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

REFERENCES

[1] MPEG2 over ATM – the state of the art. News from Rohde & Schwarz (2002) No. 173, pp 46–47

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

Condensed data of R&S DVATM

Player/recorder	SDI, MPEG2, ATM
Analysis	MPEG2 (ETR 290), ATM (CBR, AAL1, AAL1 with FEC, AAL5, delay measurements, F4/F5 OAM fault and performance management) ATM interfaces (SDH/SONET, E3, DS3, E3-PLCP, DS3-PLCP)
Interfaces	SDI (in/out) MPEG2 (ASI, SPI, SMPTE-310, audio in/out) SDH/SONETI (multimode, single mode with SC connectors, electrically with RJ45) DS3/E3 with/without PLCP (BNC connector 75 Ω)

UHF Transmitter Family R&S SV 7000

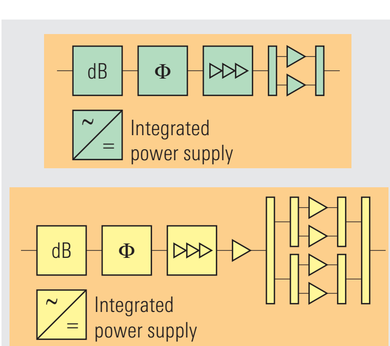
Low-power transmitters for terrestrial digital TV

Terrestrial digital transmitter networks are currently being set up worldwide, initially with transmitters of the high-power or medium-power class. But there is also a need for low-power transmitters, for example to cover small urban areas and valleys or for closing coverage gaps. The UHF Transmitter Family R&S SV 7000 is a compact and economical solution in such cases.


43783/1

FIG 1
Air-cooled, low-power TV Transmitter R&S SV 7000 for DVB-T, configured for 2 x 210 W and with NetLink option

FIG 2
Schematic of UHF Power Amplifier R&S VH 610 A2 (top) and R&S VH 620 A2



Compact and modular system

The low-power Transmitters R&S SV 7000 are mainly used to cover small urban areas and valleys and to close gaps in coverage. The innovative Exciter R&S SV 700 [1] for the transmitters of the NV 7000 (1 kW to 50 kW) and NV 7001 (200 W to 800 W) families is also used in these low-power transmitters [2; 3]. This ensures a uniform operating concept for transmitters of all power classes. Transmitters can be implemented in line with the DVB-T standard ETS 300 744 and the American ATSC standard. Especially compact and space-saving solutions are obtained when several transmitters are integrated in a single rack.

The R&S SV 7000 transmitter family is a building block system. Two racks of different size and four transmitter kits with output powers between 55 W and 210 W for DVB-T and 70 W to 230 W for ATSC are available, maximally two amplifiers per transmitter being com-

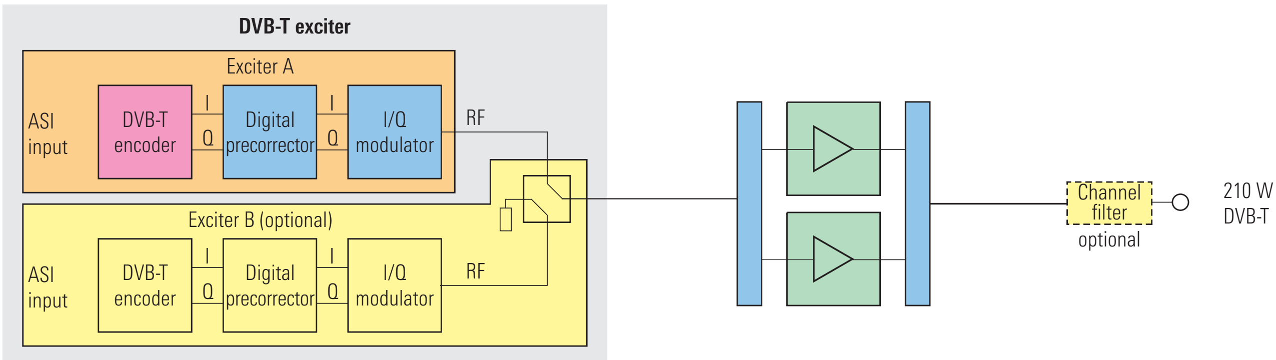


FIG 3 Schematic of Transmitter R&S SV 7000

bined to boost power (FIG 3). Different configurations are possible: as a single transmitter, transmitter with exciter standby, transmitter with passive transmitter standby or as a system in (n+1) standby configuration with up to six operative transmitters and one standby. In the case of exciter standby, the central control unit (CCU) is driven by an additional power supply. A bypass circuit is also provided for the CCU so that the latter can be replaced without interrupting operation in the event of failure.

The large variety of systems and the possibility of housing several transmitters in a single rack mean maximum flexibility. Two single transmitters with a total DVB-T output power of 210 W (FIG 1) can be accommodated in a rack of 21 height units, up to four single transmitters in a rack of 42 height units. Subsequent integration of amplifiers or transmitters into an existing rack takes little effort particularly because the modules of a specific transmitter (amplifier, coupler, absorber, cables) come as ready and complete kits. The power combiners and absorber resistors (dummy loads) required for combining the amplifiers as well as the rack controller are accommodated in the back of the rack for easy access.

Power amplifiers

Two different power amplifiers are available. The UHF Amplifier R&S VH 610 A2 produces power of 55 W for DVB-T or 70 W for ATSC, the R&S VH 620 A2 120 W for DVB-T or 130 W for ATSC (FIG 2). Both are broadband to operate in the 470 MHz to 862 MHz band and are accommodated in 19-inch rackmounts of only three height units. From the outside, the only difference is the depth. The concept is very similar to that of high-power and medium-power amplifiers. The power supply and the whole cooling system are integrated in the amplifier. The output stage transistors in advanced LDMOS technology as well as the preamplifier module are the same and the interfaces are almost identical to those of the higher power amplifiers. This means considerable advantages in terms of spare parts logistics and service, and the same test equipment can be used. A built-in protection facility guards the amplifier against reflection and overheating. Faults are indicated on the front panel and signalled to the exciter. The output power is circuit-controlled and can be set from the exciter by a DC voltage. A monitored fan with high airflow in conjunction with an optimized heat sink ensures low junction temperature and thus long life of the power transistors.

Remote control

For remote control, an RS-232-C interface is integrated as standard in the exciter for connecting a modem, a parallel interface can be optionally integrated, and the NetLink [4] option is available as an efficient, future-oriented medium. There is sufficient space in the racks for the 19-inch NetLink plug-in of only one height unit (FIG 1).

Bernhard Kaehs

More information at www.rohde-schwarz.com (search term: SV 7000)

REFERENCES

[1] Exciter R&S SV 700 – Digital TV standard ATSC for Transmitter Family R&S Nx 700 x. News from Rohde & Schwarz (2001) No. 172, pp 40–41

[2] Liquid-cooled TV transmitters for terrestrial digital TV. News from Rohde & Schwarz (1999) No. 165, pp 11–13

[3] Medium-power transmitter for terrestrial digital and analog TV. News from Rohde & Schwarz (2001) No. 171, pp 39–41

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

TV Test Transmitter R&S SFQ

New coder for DVB-S/-DSNG and DVB-C standards

With a new coder, the TV Test Transmitter R&S SFQ (FIG 1) now supports the satellite standard DVB-S/-DSNG (digital satellite news gathering), which meets the growing demand for more transmission capacity. The coder also matches the DVB-S and DVB-C standards. It stands for a considerably extended symbol rate range and enhanced quality. The future-proofness of the universal R&S SFQ modulation platform and the versatile capabilities of the new coder are not at least due to high-efficiency Turbo coding.

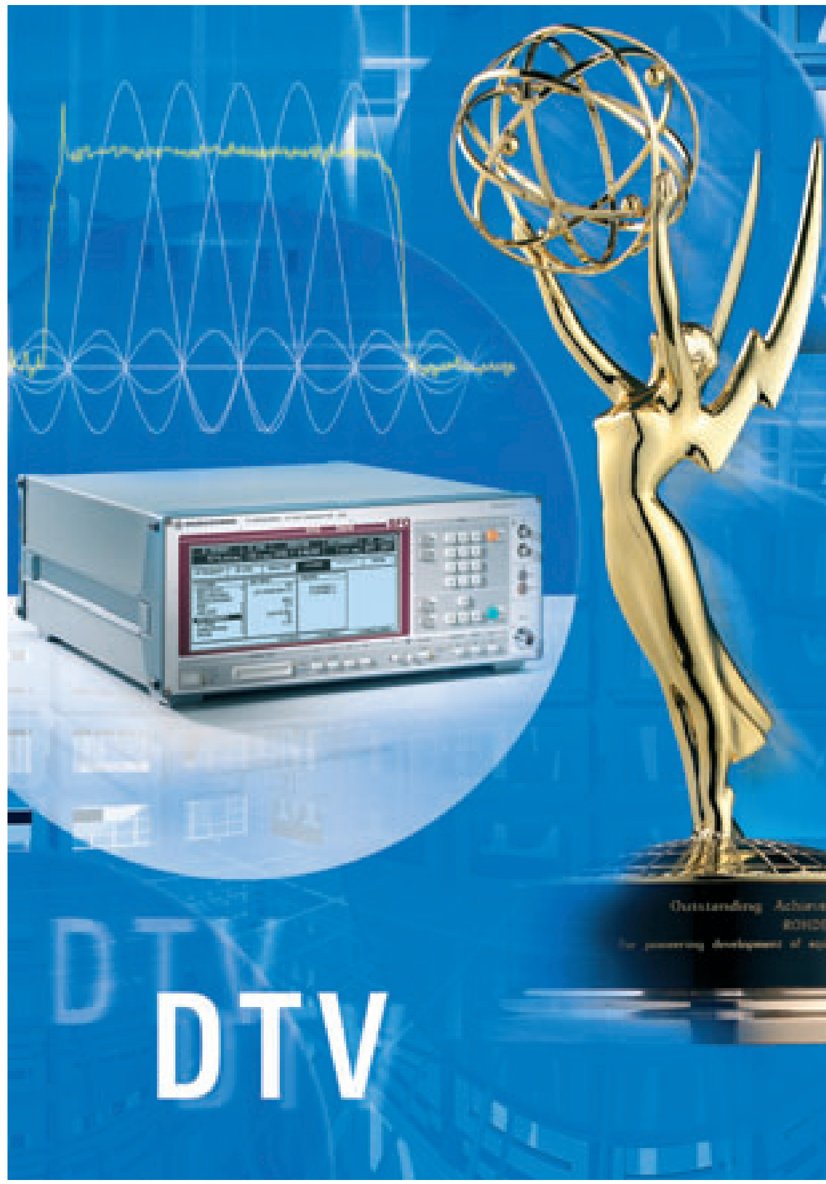


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FIG 1 The National Academy of Television Arts and Sciences awarded Rohde & Schwarz an EMMY for the TV Test Transmitter R&S SFQ. The signal source was commended for its unique capabilities and contribution to the further development of digital television.

R&S SFQ offers all major standards

Satellite transmission to DVB

The R&S SFQ supports satellite transmission to DVB-S (EN 300 421) and DVB-DSNG (EN 301 210) standards. All code rates are user-selectable. The digital modulation formats QPSK, 8PSK and 16QAM can be chosen. QPSK corresponds to the DVB-S format.

Enormous range of symbol rates

When it comes to DVB-S, the new coder bursts the previous bounds. All symbol rates between 0.1 and 80 Msymb/s can be set without any restrictions to the input data rate, so all transponder bandwidths can be covered. In tuner production, this will allow testing and specifying components to well beyond the required operating range.

DVB cable transmissions

Like the previous coder, the new coder is in line with the DVB-C standard (EN 300 429). 16 / 32 / 64 / 128 and 256QAM modulation can be selected. And like the satellite standard, the range of symbol rates was extended at both ends to produce 0.1 through 8 Msymb/s.

Satellite transmission with Turbo coding

What makes Turbo coding/decoding attractive is the fact that the bit error rate (BER) versus C/N ratio comes very close to the Shannon limit (coding gain, FIG 2) [1]. Given a stable transponder bandwidth, the gain produced by Turbo coding can be used for a higher net data rate, or the same net data rate can be transmitted with smaller parabolic antennas or lower output power.

Turbo methods for digital TV broadcasting are not yet finally specified and fully standardized. But by advance implementation of a proprietary Turbo method (France Telecom / ST Microelectronics), Rohde & Schwarz was able to prove that the R&S SFQ with its programmable logic ICs (FPGAs) can be rapidly adapted to market requirements.

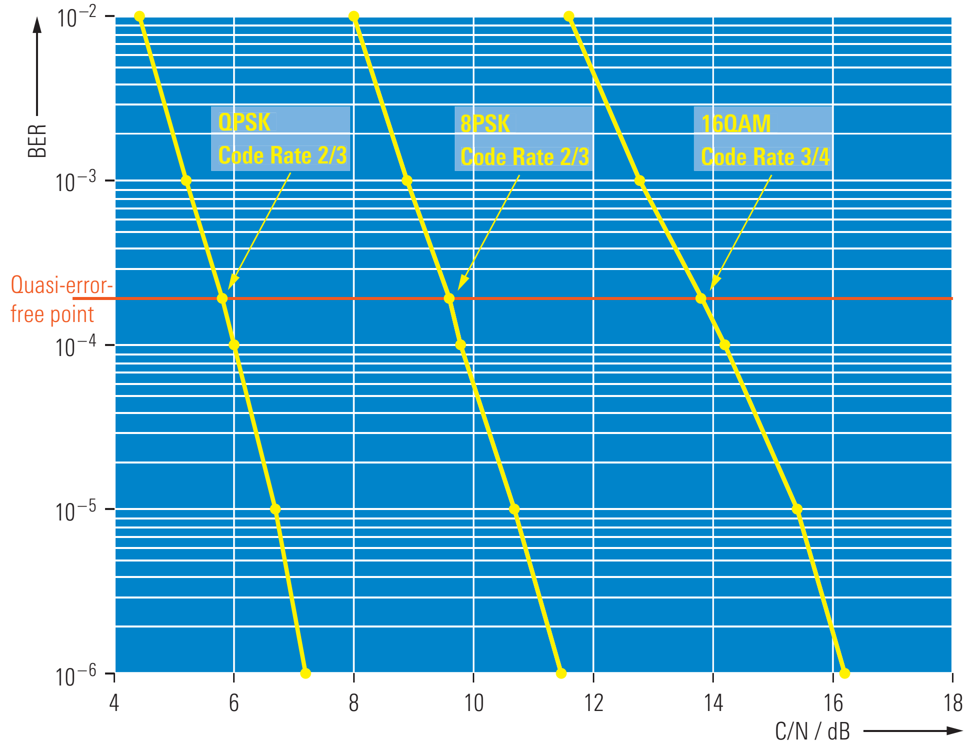


FIG 2 **BER versus C/N ratio in DVB-S and DVB-DSNG (rate 27.5 Msymb/s)**

Turbo coding – close to Shannon channel capacity

The use of Turbo codes allows what is currently the most powerful decoding method, also known as iterative decoding. Turbo codes result in a gain that increases transmission capacity to within a few tenths of a decibel of the channel capacity defined by Shannon. This method is based on two key innovations: parallel recursive convolutional coding and iterative decoding.

Principle of Turbo coding

Parallel recursive convolutional coders consist of two or more feedback encoders for block or convolutional codes (FIG 3). The top branch transmits the uncoded information and forms the systematic path x. An information block is fed to the first encoder C1 and coded (output y1). The original data block is written to an interleaver, whose output is the input for the second encoder C2 with output y2.

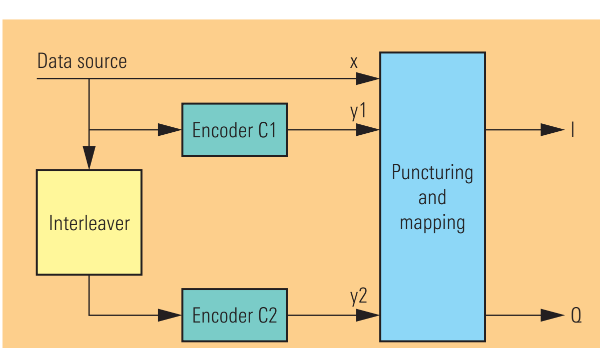


FIG 3 **Structure of Turbo coder**

The right interleaver algorithm plays a big part in overall code performance. Pseudo-random block interleavers are used here, i.e. the information is writ-

Possible scenario for introducing Turbo code in digital television

Both the use of high-order modulation (8PSK, 16QAM) and Turbo coding create a major problem for satellite operators, because the new methods are not compatible with household set-top boxes. Necessary re-investment would considerably hinder acceptance of the new system.

So a procedure permitting gradual conversion to the new system would be desirable. With the backward-compatible mode [2] a solution is in view. Here the transport stream to be transmitted is split into a high-priority component (compatible with DVB-S) and a (non-compatible) low-priority component (FIG 5). The high-priority branch performs DVB-S channel coding, the non-compatible component is Turbo-coded.

The 2-bit output symbols from the DVB-S branch (QPSK) are combined with a 1-bit symbol from the Turbo branch in the mapper and then transmitted with 8PSK modulation.

The two constellation points of 8PSK modulation in the quadrant are now as close to each other as possible (FIG 4), so a conventional satellite receiver interprets them as a single point and therefore only decodes the high-priority branch. A modern set-top box is nevertheless able to demodulate 8PSK and produce the complete information. The latest set-top boxes can also decode entirely Turbo-coded 8PSK modulation. During a transitional period, the backward-compatible mode can be used. As soon as newer set-top boxes are being used by all viewers, a switchover can be made to pure 8PSK/Turbo coding and the full performance of the system utilized.

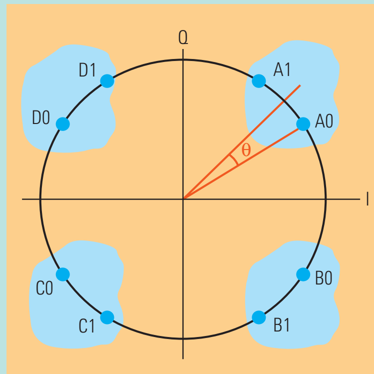


FIG 4 Constellation in backward-compatible mode [2]

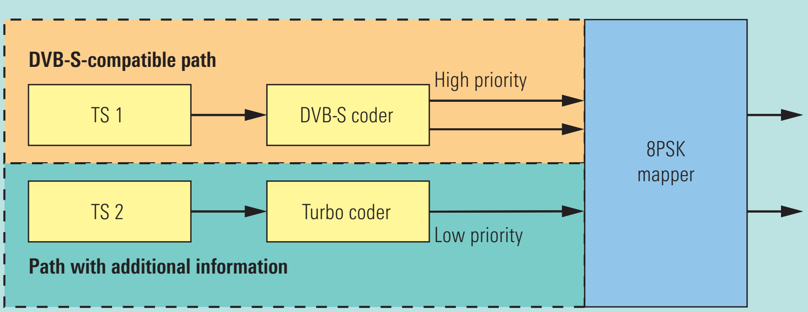


FIG 5 Backward-compatible mode

ten in line by line but read out in a quasi-random sequence. Separate decoding probabilities can thus be determined for each path by the decoders in the receiver.

The interleaver also ensures that the set of code words generated by the encoders is of favourable weight. That reduces the probability of the decoder determining incorrect code words.

The original data block in the systematic path x and the outputs from the encoders y1 and y2 are multiplexed, punctured and transmitted in the traffic channel.

Principle of Turbo decoding

Turbo decoding is an iterative method involving several soft-in-soft-out decoders. Part of the soft output is forwarded to the next decoding stage after each iteration step. Splitting the decoding into a number of iterative operations considerably increases the coding gain and at the same time reduces decoder complexity.

Flexible adaptation by options

The coder hardware only need be purchased once. Further transmission standards can subsequently be activated by buying a software option and entering an enable code, without opening the unit (FIG 6).

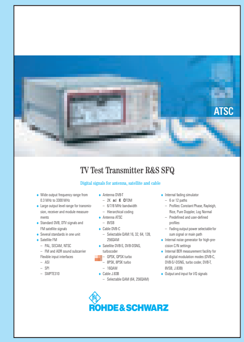
Option -B23 or -B24 must be installed first to operate the Satellite Turbo -B25 software option (enable code).

Günter Huber; Franz-Josef Zimmermann

Major innovations in the new coder for the R&S SFQ

- **Satellite modulation enhanced by 8PSK and 16QAM**
- **Expanded range of symbol rates**
  DVB-S: 0.1 to 80 Msymb/s
  DVB-C: 0.1 to 8 Msymb/s
- **Minimum setting time, i.e. fast settling**
  A VCO (voltage-controlled oscillator) is tuned with the aid of a DDS (direct digital synthesis) chip in a fast loop. Fine tuning is performed by controlling the fill state of the FIFO. This ensures fast settling of the module even in the case of considerable symbol rate variations. This is a decisive factor particularly in production, as fast switching operations shorten the time to test and thus reduce costs.
- **Linking of the symbol rate to the internal reference frequency**
  The symbol rate of internal signals is a function of the SFQ's internal reference frequency. The latter can also be coupled with an external reference frequency.
- **Optimized pulse filtering**
  More taps are available in the FIR (finite impulse response) filter for pulse filtering (root raised cosine rolloff) than in the coder previously used. Thus the rolloff could be better approximated and the shoulder attenuation improved at the same time. This eliminates effects of the transmit filter on the eye aperture, which can be quite noticeable when measuring the BER for 256QAM in the range 1×10^{-9} (ahead of the Reed-Solomon decoder).
- **Minimal symbol jitter**
  Thanks to the new oscillator concept, internal clock quality was substantially improved, which results in low phase jitter.

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



REFERENCES
[1] Berrou, C., Glavieux, A., Thitimajshima, P.: Near Shannon limit error-correcting coding and decoding: Turbo codes. Proc. IEEE International Conference on Communication (ICC), pp 1064–1070, Geneva, May 1993
[2] Morello, A., Mignone, V., Rai-CRIT: Backward compatible solutions for DVB-S2. DVB Technical Module, TM2638, February 2002

Option	Firmware	Hardware
R&S SFQ-B21	DVB-C	incl. coder hardware
R&S SFQ-B22	DVB-C	none
R&S SFQ-B23	DVB-S, DVB-DSNG	incl. coder hardware
R&S SFQ-B24	DVB-S, DVB-DSNG	none
R&S SFQ-B25	Satellite Turbo	none

FIG 6 Available options

Continued from No. 172

Measurements on MPEG2 and DVB-T signals (5)

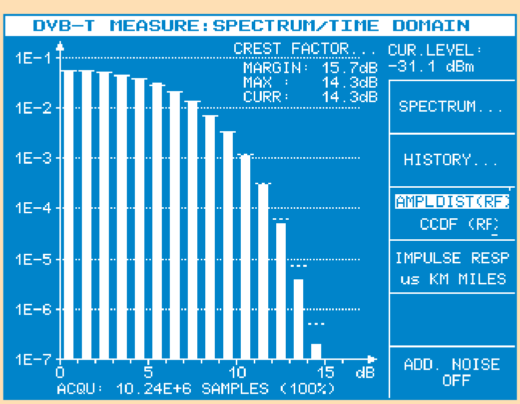
Part 4 of this refresher topic dealt with defining and measuring the crest factor of a DVB-T signal and power measurements on DVB-T transmitters. This fifth and last part looks at measurements and parameters for evaluating DVB-T transmission quality.

Bit error ratio (BER)

BER is one of the chief figures of merit in digital video broadcasting. In DVB-T, BER is measured at three points after demodulation:

- As raw bit error ratio before any error correction (i.e. before inner FEC), generally referred to as "BER before Viterbi"
- After the first error correction (i.e. after outer FEC) as "BER after Viterbi" or "BER before Reed-Solomon"
- After the second error correction (i.e. outer FEC) as "BER after Reed-Solomon"

The TV Test Receiver R&S EFA measures BER during normal operation and displays all three values in the MEASURE menu. To speed up display, you first select a number of data blocks for evaluation, each block comprising 10^7 bits. Although BER calculated from these few blocks is usually displayed with low resolution, e.g. 0.0 E–5, the result is already conclusive and available immediately. The test receiver then performs sliding BER calculation until the result is obtained with final accuracy. In the example shown in FIG 34, measurement before Viterbi starts with 10 data blocks (red arrow). These 10×10^7 bits have already been processed, and the result is 2.0 E–4. For BER before RS, sliding cal-



To refresh your memory: part 4 (No. 172) focussed on crest factor measurement with the TV Test Receiver R&S EFA.

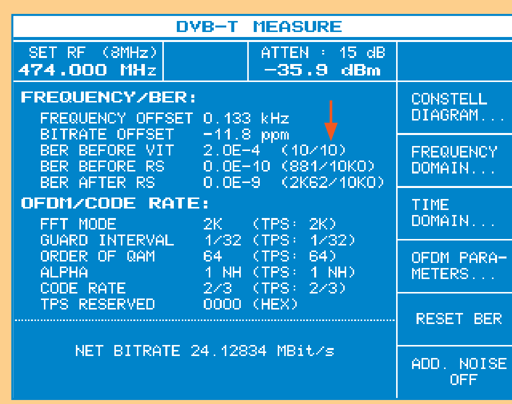


FIG 34 MEASURE menu of TV Test Receiver R&S EFA with frequency offset, data rate offset and OFDM/code rate parameters

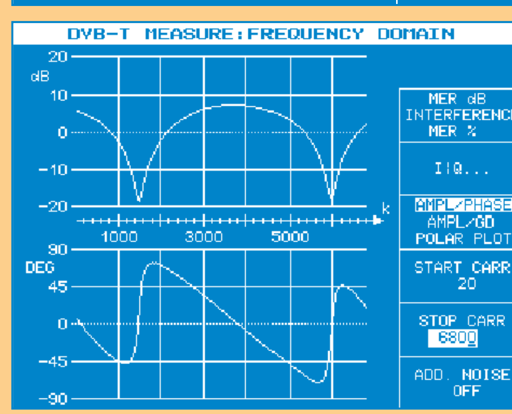


FIG 35 Linear distortion (amplitude and phase) due to fading in transmission channel (with carrier number k plotted along abscissa)

culation is active. Here, a total of 10 000 blocks has to be checked, of which 881 have been processed so far.

This example shows the efficiency of Viterbi forward error correction: at a code rate of 2/3, it corrects BER of 2.0 E–4 to 0.0 E–10 before RS FEC. This value is very close to the quasi-error free (QEF) point obtained after RS FEC.

Frequency offset and data rate offset

The status line of the MEASURE menu shows you the input level, the manually set channel center frequency and the channel bandwidth. The center frequency of the input signal is compared with the set frequency and the difference indicated under FREQUENCY OFFSET.

DVB-T data rates are defined for each modulation mode (QPSK, 16QAM or 64QAM), guard interval and puncturing rate. Deviations from this affect the DVB-T spectrum. So the deviation from the specified data rate is measured and indicated in ppm under BITRATE OFFSET (FIG 34).

Display of DVB-T modulator settings

The broadcaster must know the exact setting of a DVB-T transmitter at any time. These settings are automatically found by the TV Test Receiver R&S EFA or manually entered and displayed. In addition, the settings transmitted over the TPS carriers are listed in the MEASURE menu (FIG 34, TPS values in brackets). In the AUTO or TPS mode of COFDM, the test receiver automatically tracks any change in DVB-T configuration data.

Measurements in frequency domain

Channel amplitude and phase response

The nominal amplitude and phase values of the scattered pilots of the COFDM symbol are stored in the TV test receiver and compared with the actual values of the pilots received to determine the channel transfer function. Based on this function, the amplitude and phase response or group delay of the DVB-T transmitter's RF output is to be measured, including all filters between transmitter output and antenna (FIG 35).

Frequency response calculation with FFT

Calculating channel frequency response by FFT (fast Fourier transform) produces much higher resolution of level deviations than complex comparison of pilots. Although FFT is not a full equivalent to ▶

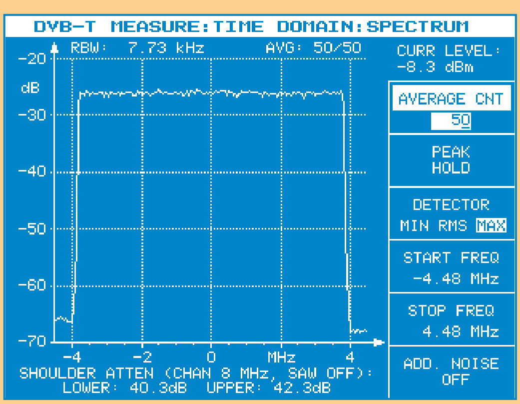


FIG 36
Spectrum of a DVB-T channel

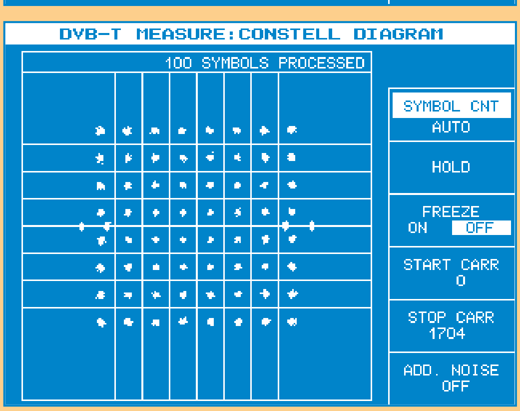


FIG 37
Constellation diagram for 64QAM (2k mode)

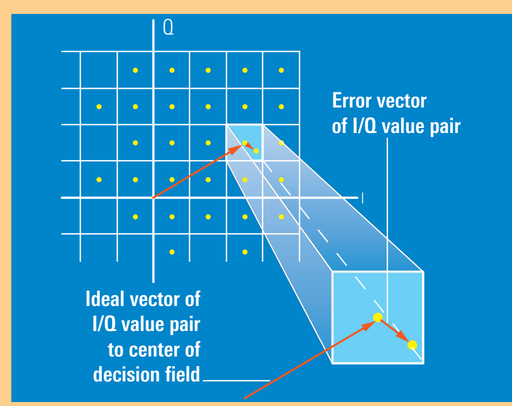


FIG 38
Definition of MER parameter

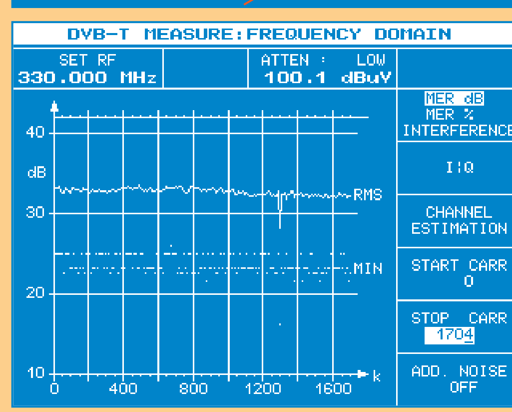


FIG 39
MER versus k carriers with narrowband interference

spectrum analyzer measurements, it is adequate for analyzing the spectrum of a transmission channel and for determining out-of-band components to TR 101 290 (FIG 36).

Constellation diagram

The TV test receiver maps each DVB-T carrier to its baseband by an FFT. All I/Q value pairs thus obtained are projected into the decision fields for QPSK, 16QAM or 64QAM, so producing a constellation diagram (FIG 37).

The I/Q values of all carriers between START CARR and STOP CARR are included; the pilot and TPS carriers are plotted along the I axis. The TPS carriers show the mean power within the constellation diagram, whereas the pilot carriers appear with power higher by a factor of 16/9 (= 1.777).

MER measurement

MER (modulation error ratio) summarizes all errors indicated by a constellation diagram. The definition of this parameter is illustrated by FIG 38.

For each I/Q pair of a constellation diagram there is just one theoretical target point precisely in the center of each decision field. But this target is hardly ever hit. This is due to the effect of quantization in A/D conversion involving a limited number of bits, rounding errors, D/A conversion in the modulator, phase jitter of the converter clock and superimposed noise in transmission. From this an error vector can be formed that combines all these effects. MER is calculated from the sum of the squares of ideal vectors and that of the error vectors.

The TV Test Receiver R&S EFA not only calculates MER but also presents it as a function of frequency, i.e. MER is shown for each carrier of a COFDM channel, which is much more conclusive. Errors affecting just a few carriers of a COFDM symbol can immediately be located in this way.

This is illustrated by FIG 39, which shows a pronounced MER dip in the carrier region about k = 1300 (k = index of COFDM carrier). To determine the disturbed carrier, the start carrier is selected a little below 1300 (e.g. k = 1280) and the stop carrier a little above (e.g. k = 1320) in this menu or the I/Q menu. The disturbed carrier can thus be exactly identified; in this case it is k = 1299 (FIG 40).

Initially therefore, DVB-T transmitter monitoring uses the MER parameter (in addition to BER). After BER, MER is the primary parameter in a DVB transmission system, providing information on transmission quality at a glance.

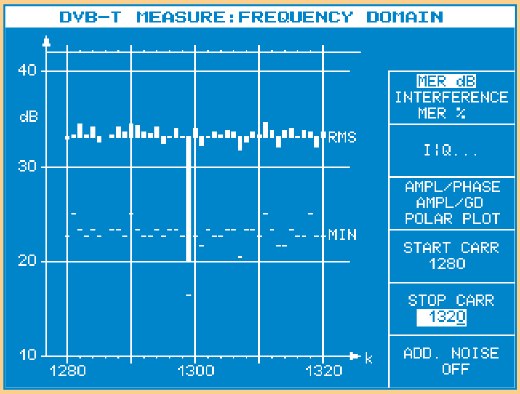


FIG 40 Zoomed MER of 2k COFDM signal; interference is on carrier 1299

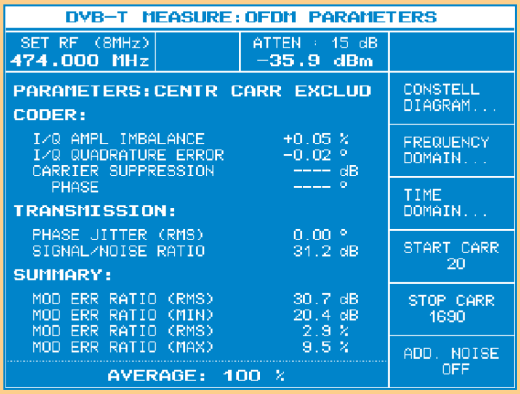


FIG 41 Measurement of OFDM parameters without central carrier

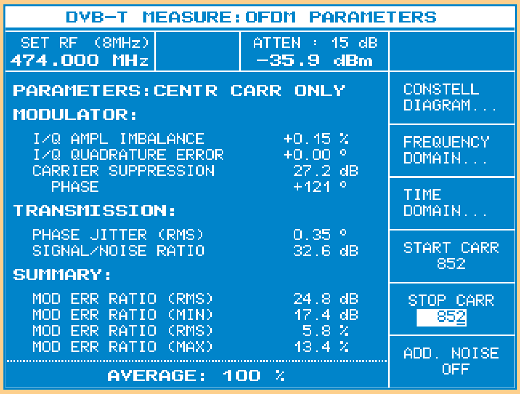


FIG 42 Measurement of OFDM parameters in 2k mode (on central carrier only)

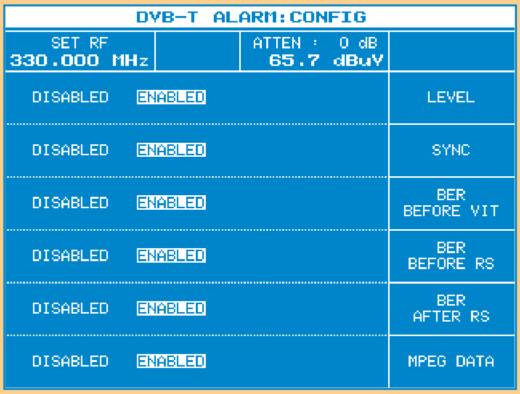


FIG 43 Alarm configuration menu

I/Q parameter measurement in OFDM signals

Like in DVB-C (cable) and DVB-S (satellite) broadcasting systems, a distinction is made in DVB-T between errors originating from the modulator and errors caused during transmission. The parameters I/Q AMPL IMBALANCE, I/Q QUADRATURE ERROR, CARRIER SUPPRESSION and PHASE (residual carrier) are typical performance parameters of the exciter, whereas during transmission noise-like disturbance like PHASE JITTER and SIGNAL/NOISE RATIO degrades the useful signal. MER is again obtained as a sum parameter and displayed under different designations (FIG 41).

Residual carrier measurement

In residual carrier measurement, some special features have to be taken into account. Defined as a very narrowband interferer, the residual carrier has an effect only on the central carrier and so can only be measured in the region of this carrier.

In 2k mode, the central carrier is a scattered pilot inserted in every fourth symbol (FIG 42). In 8k mode, the central carrier is assigned a continual pilot.

Despite these restrictions, the TV test receiver measures the residual carrier with high accuracy using a patented computation standard. Only the central carrier (852 for 2k or 3408 for 8k) is selected in 2k or 8k mode. The residual carrier in DVB-T is referred to the signal power of a single OFDM carrier in accordance with TR 101 290. DVB-C and DVB-S, on the other hand, refer it to the mean power of the overall spectrum. For this reason, the logarithmic ratio obtained for the residual carrier in DVB-T is much smaller than for DVB-C or DVB-S at the same absolute residual carrier level. In 2k mode, the difference will be D = 10 x log (1705) = 32.3 dB, in 8k mode D = 10 x log (6817) = 38.3 dB.

Example: In DVB-C, residual carrier suppression is typically >60 dB. In 8k mode in DVB-T, values will scarcely exceed 60 dB – 38.3 dB = 21.7 dB.

Alarm report

Measurement results are not only displayed at the transmitter site but can also be remotely queried via an RS-232-C interface and IEC625 / IEEE488 bus. Monitoring by single queries is very time-consuming however, as there is a large quantity of measured data to be handled. Remote monitoring with the TV Test Receiver R&S EFA greatly simplifies this procedure. All it takes is activation of the ALARM menu (FIG 43). After selecting the parameters in the ALARM CONFIGURATION menu, you set

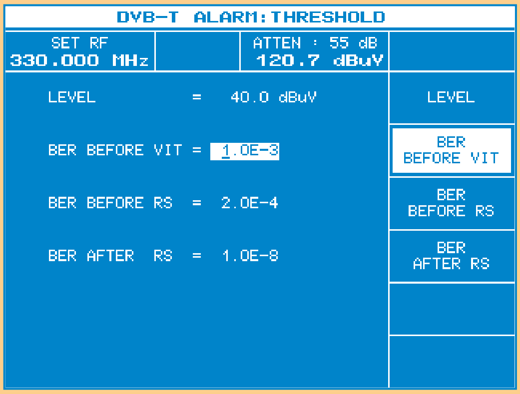


FIG 44
Setting of alarm thresholds

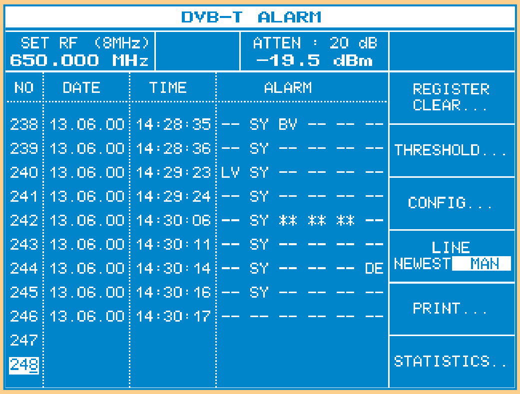


FIG 45
Alarm list

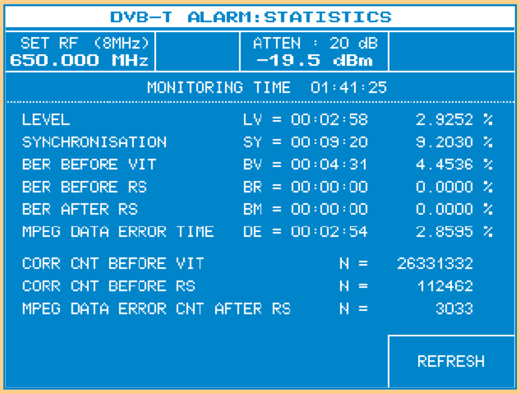


FIG 46
Statistical evaluation of error periods

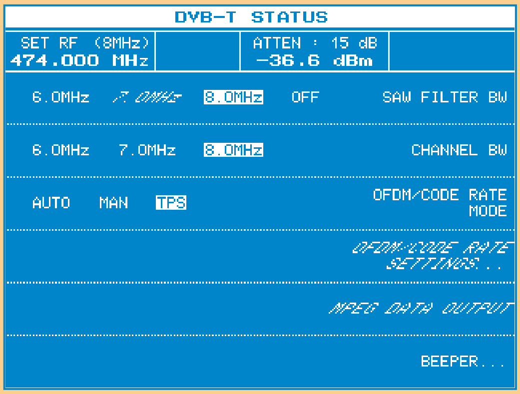


FIG 47
Status menu

the alarm thresholds (FIG 44). Non-correctable data and synchronization failure are absolute events, so they are not assigned a threshold.

The activated alarms are combined to a sum signal brought out at a rear connector of the test receiver. In the event of a sum alarm, the single alarms can be queried via the remote control interfaces.

Pressing the ALARM hardkey produces the alarm list on the display (FIG 45). The list may comprise up to 1000 lines in which each event is entered with its number, date, time and the parameter triggering the alarm. It may sometimes be necessary, for statistical purposes, to know the duration of individual errors and their percentage of overall monitoring time. This information appears in the STATISTICS menu item (FIG 46).

Measurements in VHF bands I and III

The European standard EN 300 744 currently only specifies DVB-T for the UHF band and 8 MHz channels. In notes, reference is made to 7 MHz channels, which are defined for VHF bands I and III and, in Australia, also used in band IV/V.

The TV Test Receiver R&S EFA carries out selective measurements in the 7 MHz bandwidth and also in the 6 MHz bandwidth by means of two options: 7 MHz SAW Filter EFA-B12 and 6 MHz SAW Filter EFA-B11, which can be fitted in addition to the optional 8 MHz IF SAW Filter EFA-B13. One of these optional filters has to be ordered together with the TV Test Receiver R&S EFA. The selected bandwidth is displayed in the STATUS menu (FIG 47).

Measurements in DVB-T single-frequency networks

The guard interval allows for all signals reflected or directly received from other transmitters during DVB-T reception in a single-frequency network (SFN). The path delay of such signals must not exceed the duration of the guard interval. Depending on the selected setting, the test receiver calculates the path delay in µs or the path length in kilometers or miles.

FIG 48 shows that leading echoes are possible in a DVB-T network, for example when signals are received from a low-power gap-filler station located closer than a high-power transmitter. In this case the delay is –10 µs; the gap filler is about 3 km closer than the main transmitter, which is at 0 µs. At 25 µs there is a trailing echo, which may result from reflection over a path of about 7.5 km.

The echo profile shown in FIG 48 is valid for a DVB-T network with 8 MHz channel bandwidth and a guard interval longer than 28 µs. This measurement also allows determination of the distance in kilometers between the transmitters of an SFN, provided there is a line of sight between the transmitting and receiving antennas. The distance between transmitters in an SFN, as determined by the guard interval and the FFT mode, must not exceed the values specified in the table shown in FIG 49.

Sigmar Grunwald

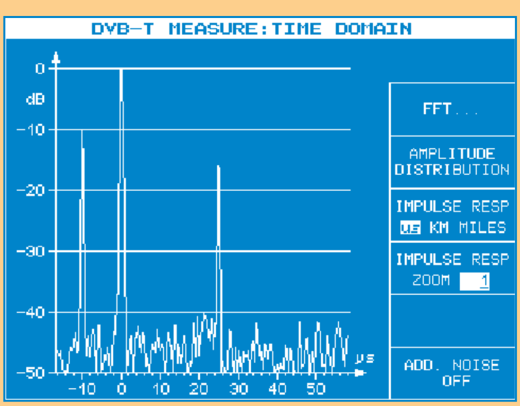
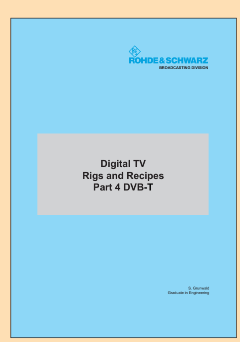


FIG 48 Typical echo diagram

	Distance between transmitters (km)			
FFT	τ = 1/4	τ = 1/8	τ = 1/16	τ = 1/32
2k	16.8	8.4	4.2	2.1
8k	67.2	33.6	16.8	8.4

FIG 49 Maximum permissible distance between transmitters in a single-frequency network

More information at www.rohde-schwarz.com



The full version of this refresher topic of about 70 pages can be found on the Rohde & Schwarz website (search term: 7BM_ADD01)

Digital Direction Finder R&S DDF 195

New digital direction finder for 0.5 MHz to 3000 MHz

43 799/4

FIG 1 Core of new digital direction finder: DF Processor R&S EBD 195

The new Digital Direction Finder R&S DDF 195 is the successor to the proven DDF 190 [1; 2].

Improving the proven

The basic principle of the DDF 190 is on the whole maintained in the R&S DDF 195. Consequently the new direction finder is also a single-channel system comprising one or several DF antennas and a DF Processor R&S EBD 195 (FIG 1). The single-channel configuration calls for only one – in many cases ready available – receiver with an unregulated IF of 10.7 MHz or 21.4 MHz. The Monitoring Receivers ESMB, EB 200 and ESMC from Rohde & Schwarz are particularly suitable for this role since their interfaces do away with the need for separate range settings on the DF processor.

In addition to the use of ready available receivers, the concept of the single-channel Direction Finder R&S DDF 195 offers a number of advantages:

- Extremely compact and flexible system solutions
- Only one RF cable and one control cable required
- High accuracy of bearings through integrated calibration routines

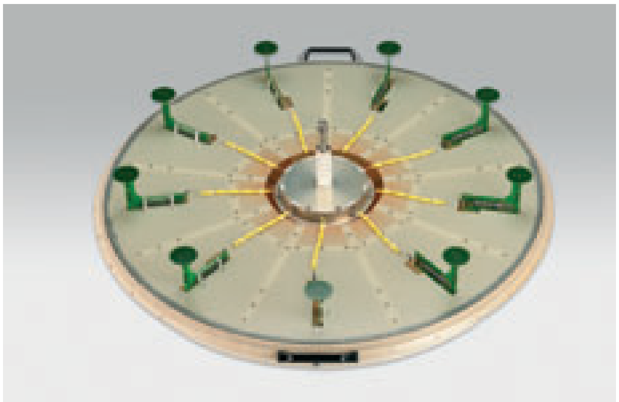


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FIG 2 VHF-UHF DF Antenna R&S ADD 195 (top of radome removed)

The direction finder operates in the VHF and UHF range on the correlative interferometer principle. In the shortwave range, similar to the Watson-Watt method, a bearing is obtained from the

Single-channel interferometer DF principle

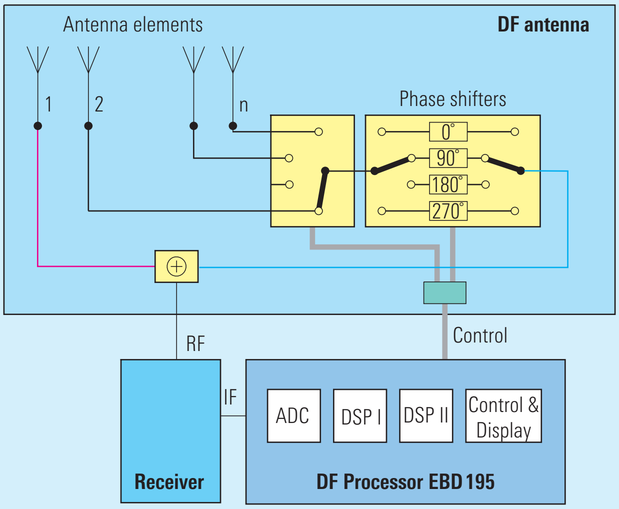
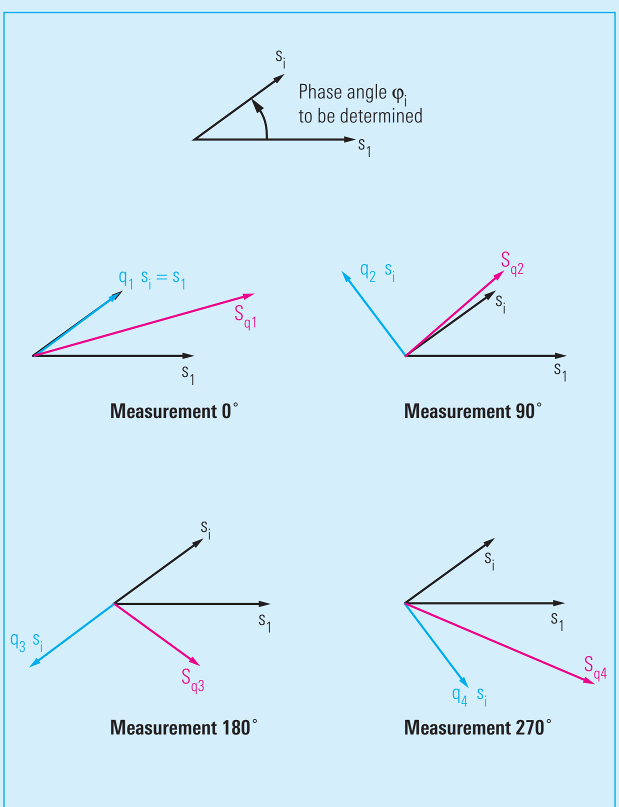


FIG 3 Principle of single-channel correlative interferometer



$$\varphi_i = -\arctan \frac{|S_{q2}|^2 - |S_{q4}|^2}{|S_{q1}|^2 - |S_{q3}|^2}$$

FIG 4 Mathematical principle of single-channel phase measurement

The principle of single-channel direction finding, patented by Rohde & Schwarz, is a multiplex method permitting the carrier phase between two signals to be measured independently of the modulation phase (FIG 3). This is a prerequisite for direction finding on the interferometer principle, for which at least two coherently operating channels were required in conventional systems.

The basic principle is to add the vectors of the two signals between which the phase is to be measured with a shift of 0°, 90°, 180° and 270°, and to calculate the unknown phase shift from the measured amplitudes of the sum signal (FIG 4). These steps are repeated for each phase angle to be determined – i.e. eight times for the Antennas R&S ADD 195 and R&S ADD 071 – and a bearing is calculated from these values.

The bearing is calculated in the same way as in multichannel systems: the set of measured phases is compared to those phases that would be created by a plane wave arriving from the direction α_r. The direction α_r is varied through 360° and the bearing α is obtained when the measured phases match best.

Single-channel phase measurement of course takes longer than in a multichannel system because of the switching steps required. It should also be noted that the switching operations during direction finding may degrade the useful modulation. To avoid this, the R&S DDF 195 can be switched between DF, listening and measurement modes.

Basically, the number of evaluation channels is no criterion for the quality of a direction finder. A single-channel system, tailored to its purpose, is easily the match of if not superior to a multichannel system.

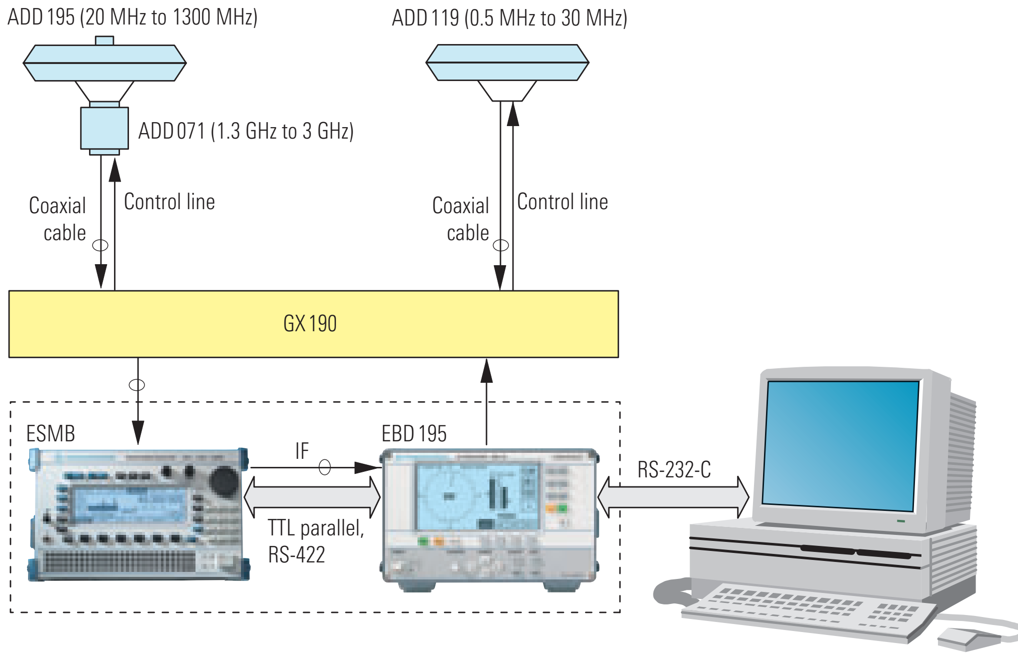


FIG 5 R&S DDF 195 in semimobile DF system covering 0.5 MHz through 3000 MHz

signals of the DF Antenna R&S ADD 119 with its figure-of-eight characteristics. The choice of the correlative interferometer principle for the V/UHF range is an essential prerequisite for creating extremely broadband antennas. The whole frequency range from 0.5 MHz through 3000 MHz is thus covered by only three antennas that can be flexibly combined into a system (FIG 5).

If more than one DF antenna is used (e.g. ADD 195 and ADD 119), the DF processor requires a Connection Board R&S GX 190 to switch between them. This GX 190 also distributes control signals to the antennas. Three receiving or test antennas can be connected to the GX 190 in addition to the three DF antennas and switched to the receiver input for monitoring.

New features of Digital Direction Finder R&S DDF 195

Improved sensitivity

The new DF Antenna R&S ADD 195 (FIG 2) improves sensitivity in the 20 MHz to 100 MHz range by about 10 dB compared to the R&S DDF 190. This was achieved without changing the antenna size, simply by rearranging the antenna elements and splitting into additional subranges that are internally selected.

The HF DF Antenna ADD 119 and the UHF DF Antenna ADD 071 continue to be used without any modifications.

Reduced DF times

To meet the need for bearings of increasingly short-duration signals, a new SDS mode is implemented that can easily detect and process signals of only 10 ms duration.

Direct Q filter adjustment

The Q filter with a selectable minimum DF quality has proven to be a useful tool for the operator. To date, setting required a number of menu steps. The figure for minimum DF quality can now be varied directly by a pair of keys on the front panel of the DF Processor R&S EBD 195.

Improved selftest

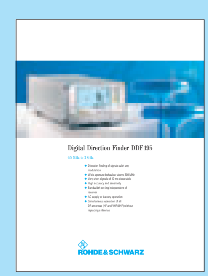
The capability of the DF processor in the R&S DDF 195 to identify defective antenna elements is substantially improved.

Remote control and system integration

The R&S DDF 195 can of course also be remote-controlled, e.g. by a suitably modified version of the DDF 190 control software. But the two tried and tested software packages ARGUS and RAMON have also been adapted to the new functionality of the R&S DDF 195.

Franz Demmel; Ulrich Unselt

More information and data sheet at www.rohde-schwarz.com (search term: DDF 195)



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[1] VHF-UHF Direction Finder DDF 190 – Digital direction finding from 20 to 3000 MHz to ITU guidelines. News from Rohde & Schwarz (1996) No. 152, pp 30–32
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German Chancellor Gerhard Schröder called in on Rohde & Schwarz at the ILA.

International Aerospace Exhibition and Conferences in Berlin

The International Aerospace Exhibition and Conferences ILA was held in Berlin from 6 through 12 May 2002. More than 330 aricraft being showcased, 1000 exhibitors from over 40 countries and 85000 trade visitors notched up a new attendance record.

"Safe and Secure Radiocomms" was the theme on the Rohde & Schwarz stand. Besides the multiband, multimode and multirole software radio families M3AR (airborne) and M3SR (surface), the ELCRODAT 4-2 und ELCRODAT 6-2 crypto products from Rohde & Schwarz's subsidiary SIT GmbH were on show. Secure communication solutions were also obviously appreciated by German Chancellor Gerhard Schröder during his visit to the Rohde & Schwarz stand.

Rohde & Schwarz supplies first TETRA mobile radio system in Latin America

Rohde & Schwarz BICK Mobilfunk supplied a TETRA *ACCESSNET*®-T mobile radio system to Mexico's state power utility Comisión Federal de Electricidad (CFE). The system, which went into operation in April 2002, is the first TETRA radio network in Latin America.

The system is intended for internal communication between CFE service and maintenance staff. Decisive points in its favour were flexible scaling and interoperability. When required, CFE can expand the network at any time using the existing components. In addition, interoperability enables straightforward use of various terminals from other certified TETRA suppliers.

The system uses two TETRA carriers in the 800 MHz frequency band and provides seven traffic channels. Rohde & Schwarz BICK Mobilfunk plans to set up further TETRA systems in this region in the course of the year.

INET and Rohde & Schwarz conclude sales agreement

The American company INET and Rohde & Schwarz have concluded a sales agreement. Under the terms, Rohde & Schwarz will market Spectra multiprotocol test solutions from INET in Germany, the major applications of which are signalling tests on telecommunication systems. A special focus of Spectra is load generation. These products will enable Rohde & Schwarz to expand its product portfolio for the development and test labs of system producers and network operators.

Australia's armed forces favour T&M equipment from Rohde & Schwarz

The Australian Rohde & Schwarz subsidiary has been named a preferred supplier of electronic T&M equipment by the Australian Defence Force (ADF). Over the past 20 years, the company has supplied the Australian forces with a host of equipment: more than 200 communication testers, some 150 signal generators and over 70 power meters have been added to the ADF's inventory. Years of good experience with the products plus full calibration, repair and training support contributed to the nomination of Rohde & Schwarz.

System for statewide EMF monitoring

Rohde & Schwarz supplied a system to the Bavarian Environmental Protection Agency that allows precise measurement of electromagnetic fields (EMFs) in the environment, emitted by mobile radio or power installations for example. This marks the start of statewide EMF monitoring in Bavaria, which is to determine the current situation and track the development of the environmental burden on the state's populace. The system was officially handed over to Bavaria's Minister of the Environment, Dr Werner Schnappauf, and the President of the Bavarian Environmental Protection Agency, Christoph Himmighoffen, on 24 April 2002.

The mobile system consists of a test receiver working with a special antenna configuration (omnidirectional antennas covering 20 MHz through 3 GHz). Emissions are detected, evaluated and automatically compared to limits by software. Both the level of the environmental burden and compliance with set limits can be exactly determined in this way. The Environmental Protection Agency will collect and analyze data from 400 statistically selected test points in Bavaria in the course of this year. This blanket detection of the real environmental load produced by electromagnetic fields is a worldwide first, creating a new environmental indicator that makes it possible to better assess the current situation, track trends and counteract them.

Bavaria's Minister of the Environment, Dr Werner Schnappauf (2nd from right), at the handover of the new monitoring system

Advanced software radios to protect the rain forest

The Brazilian Air Force awarded Rohde & Schwarz a contract for an initial 152 M3AR airborne transceivers, with an option for more. The advanced software radios will be used onboard 76 aircraft of the type EMB-314 Super Tucano/ALX from Embraer, which will be deployed as from 2003 within the SIVAM (Sistema de Vigiláncia da Amazónia) project for the protection of the Brazilian rain forest.

The new Super Tucano/ALX will reconnoiter the Amazon rain forest.

Brazil launched SIVAM a few years back, intended to protect the Amazon forest against destruction by fire and unauthorized clearing and to keep a watch on smuggling and guerilla activities. The project involves the installation of ground and air control stations with a total value of about $ 3 billion. It also involves setting up an aircraft fleet to be operated by the Brazilian Air Force. Rohde & Schwarz won the contract to supply the radiocommunication equipment for the Embraer ALX propeller aircraft, and the first M3AR software radios will be delivered this year. Decisive factors in favour of Rohde & Schwarz were the modular software concept and the capability for jam-resistant and protected voice and data transmission.

Digital TV network in Taiwan set up by Rohde & Schwarz

A new DVB-T television network using Rohde & Schwarz transmitter technology has gone on the air in Taiwan. At short notice the company supplied three liquid-cooled TV transmitters for the country's first digital TV network. The crucial factors in favour of Rohde & Schwarz were its many years of experience as a worldwide market leader in DVB-T transmitter technology, fast availability and the range of possibilities for remote control of the transmitters. Another 30 to 40 transmitters will eventually be added to create a nationwide single-frequency network. By the end of 2003, Taiwan's five TV broadcasters plan to have 10 to 15 channels operating.

Stefan Böttinger

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ROHDE & SCHWARZ

ROHDE & SCHWARZ GmbH & Co. KG · Mühldorfstrasse 15 · 81671 München, Germany · P.O.B. 80 14 69 · 81614 München
Support Center: Tel. (+49) 18 05 12 42 42 · E-Mail: customersupport@rohde-schwarz.com · Fax (+49 89) 41 29-137 77