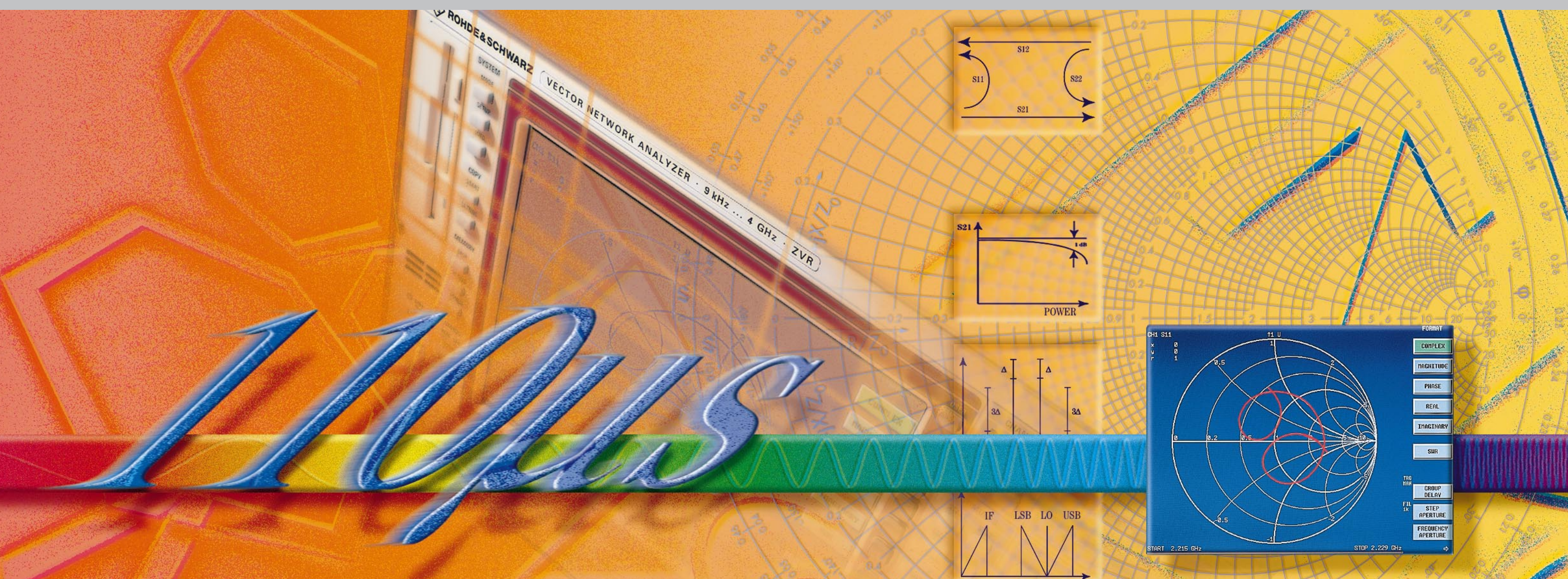
News from Rohde & Schwarz



New test technology
for module production

Digital monitoring direction finders
for HF to UHF

ecoTV: solid-state transmitters set the pace
in terms of economy

150

ROHDE&SCHWARZ

It is with deep sorrow that we say a last farewell to the highly esteemed senior partner and co-founder of our company

Dr. phil. nat. Dr. E. h.
Hermann Schwarz

who passed away on 10 November 1995 at the age of 87.

Executive Board, Company Management,
Employees and Workers' Council of
ROHDE & SCHWARZ GmbH & Co. KG

Dr. Hermann Schwarz, a pioneer of test and communication engineering

"60 years Rohde & Schwarz – 60 years of a life dedicated to Rohde & Schwarz" – this is the heading Dr. Hermann Schwarz chose for an article in "Zeitzeichen", the inhouse magazine for Rohde & Schwarz employees, on the occasion of the company's 60th anniversary. Now, only two years later, this life has ended. Dr. Dr. E. h. Hermann Schwarz passed away in his 88th year on the evening of 10 November 1995.

Born in the old free city of Nördlingen in Swabia in 1908, he was to live through all ten decades of the 20th century, turbulent and history-laden as they were. His youth in his hometown and the holidays he spent on the farms of relatives in the nearby country were the basis for his life-long and deeply felt love of nature, which probably contributed to his decision to study natural sciences following grammar school in Nuremberg. He began his studies of physics, mathematics and geophysics in Heidelberg, continued in Munich - the time he spent here was certainly one factor in his decision to set up business in this city a few years later – and finished in Jena, where he attended lectures by Prof. Esau and Max Wien, met his future friend and partner Lothar Rohde and received his doctorate in 1931. Finding a job was very difficult for young physicists in a time of economic depression, so the two friends stayed on at university for two more years. The contacts to industry they made there, however, encouraged them to set up their own enterprise in Munich in 1933. With the Physico-technical Development Laboratory Dr. Rohde & Dr. Schwarz they laid the foundation for the company Rohde & Schwarz, an international enterprise, which today employs more than 4,000 people and is still independent.

While R&D in the laboratory – with a focus on impedance and dissipation-factor measurements – still made up the bulk of Hermann Schwarz's work in the first few years, he was also from the beginning responsible for organizational and administrative tasks. As both the staff and premises of the enterprise expanded, he had to dedicate more and more of his time to company policy with regard to personnel and management, which on the other hand encouraged his solid talents for business. It had been his idea, for instance, that designs developed by Rohde & Schwarz should not be sold but produced by the company itself. Acquisition of the premises at Tassiloplatz in Munich in 1937 again showed his grasp of future perspectives. As the price for the new premises was almost twice the small company's balance-sheet total of the previous year, this venturesome step was a true entrepreneurial decision which can be seen as the next milestone following the start of the company. The company was now ready for further growth, and at the outbreak of World War II already had 100 employees. For many major firms in the communications sector R&S was the regular supplier of the test equipment they needed for production. As a consequence, R&S soon ran out of space, so the Tassiloplatz building had to be extended and new buildings added. In those years Hermann Schwarz was confronted with difficult decisions such as the city council's plans to relocate the company or the need to find new production sites after air raids had caused damage. These questions were of significance for the very existence of the company and its employees, who by then numbered several hundreds. The partnership of the two owners was also put to many a test but proved to withstand all difficulties.

At that time, true entrepreneurial vision was required to maintain one's power of judgement despite all political and economic problems. The same is true of the time of post-war reconstruction that followed, although it provided a much more gratifying basis. The positive economic trend was reflected in the purposeful yet careful expansion of the new plant on Mühldorfstrasse in Munich. It was at this stage that Hermann Schwarz could explicitly put to use his entrepreneurial flair. The decisions to set up Messgerätebau GmbH in Memmingen, the R&S plant in Cologne, sales offices in various locations and later the production plant in Teisnach in the Bavarian Forest are further milestones that give evidence of Hermann Schwarz's initiative. Another important area was expansion of the group on both the domestic and international market, in particular by building up a large sales network in Europe, Asia and America. This gave him a chance to get to know other countries and peoples and to acquire friends around the world. Just like his employees, they admired him for his charm, honesty and sense of social responsibility, but also for his ability to formulate cogent arguments, for his extraordinary knowledge of history and almost endless supply of quotations.

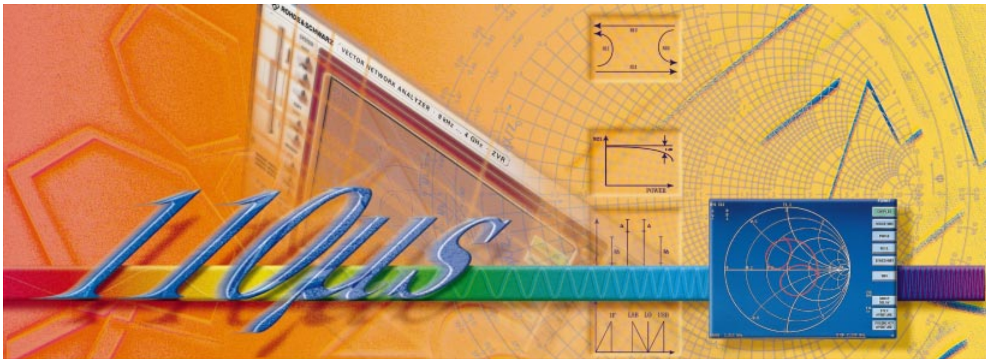
Hermann Schwarz showed again that he was very much aware of his responsibility for the future of the company by making provisions for succession in 1971 in order to be able to cope with any possible course of affairs or risks. After his son Friedrich had completed his education and training with excellent results, Hermann Schwarz appointed him to the Executive Board, allowing himself to reduce his personal involvement in management tasks and hand over responsibility step by step. When he finally gave up Human Resources – his last field of work – he left behind an area of management that had particularly benefited from the extraordinary humanness of his character for decades. The fact that he always demanded very high standards of his own work with people made him fit as a role model. This was something his employees could always feel; he inspired their confidence by having confidence in them. Throughout his life he combined entrepreneurial leadership with humanist values and thus acquired a father-like aura for many in the company. Employees and friends always treasured his fairness, his deep knowledge of human nature, his love of life, his tolerance, his charm, which was visible through an often patriarchal surface, and his exemplary esteem for family ties. These qualities enabled him to make friends not only in his immediate surroundings but also among people he met pursuing his hobbies, namely hunting and fishing, which had evolved from his early love of nature and which he cultivated enthusiastically thus finding recreation from the stress of everyday work.

Understandably, his invaluable contribution to society was officially recognized. As early as 1959 the Technical University of Munich appointed Dr. Schwarz honorary senator. He was also a commercial judge for many years, and in 1971 became honorary consul of the Republic of Iceland. Besides other decorations he was awarded the Bavarian Order of Merit, the Commander's Cross of the Order of Merit of the Federal Republic of Germany, the Medal for Contributions to the Bavarian Economy and the Golden Medal of Honour of the City of Munich. For his exemplary industrial policy he received the Seal of the City of Memmingen in 1984 and became honorary citizen of Teisnach. It was particularly gratifying for Hermann Schwarz to become honorary doctor of his former university in Jena in 1991 after German reunification.

Albert Habermann

Number 150 1996/I Volume 36

In RF measurements, network analysis is the most important task beside spectral analysis and test signal generation. Rohde & Schwarz has launched a complete family of top-grade vector network analyzers, namely entry-level model ZVRL, standard model ZVRE and general-purpose model ZVR – in short, the perfect solution for any requirement and any budget (see article on page 6).



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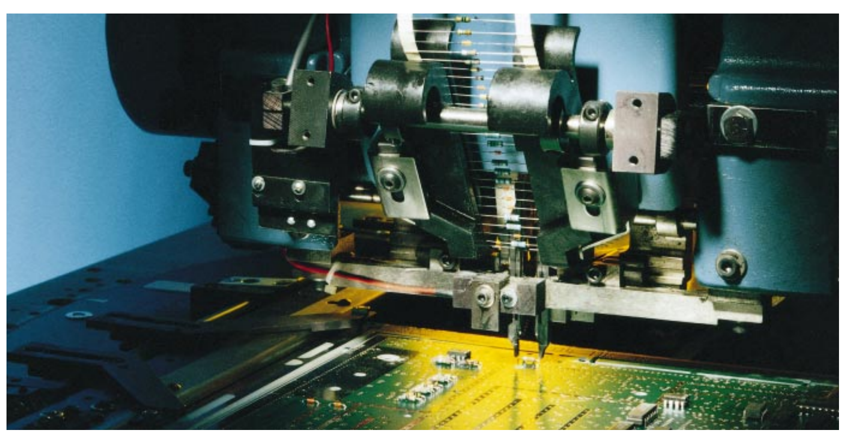

For module testing in production Rohde & Schwarz relies on combining various test methods in a single unit. The wide spectrum of problems from insertion errors through to non-compliance with specifications is now mastered by one test system that applies the most appropriate test method for each situation. What has so far been impossible to detect by affordable electrical measurements can now easily be revealed by optical means such as laser and image processing. The customer's benefits are high error-detection rate, short test setup time and large throughput (see articles on pages 10 and 13).

Imprint

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Vector Network Analyzer Family ZVR

To the heart of the chart

Vector Network Analyzer Family ZVR with its exceptionally high measurement speed gives an entirely new view of aspects of RF circuits which cannot be revealed by conventional analyzers. It has a wide dynamic range thanks to fundamental mixing. An extremely large frequency range is covered by the integrated bridges. Innovative calibration methods such as TOM-X, TNA and AutoCal ensure high measurement accuracy.

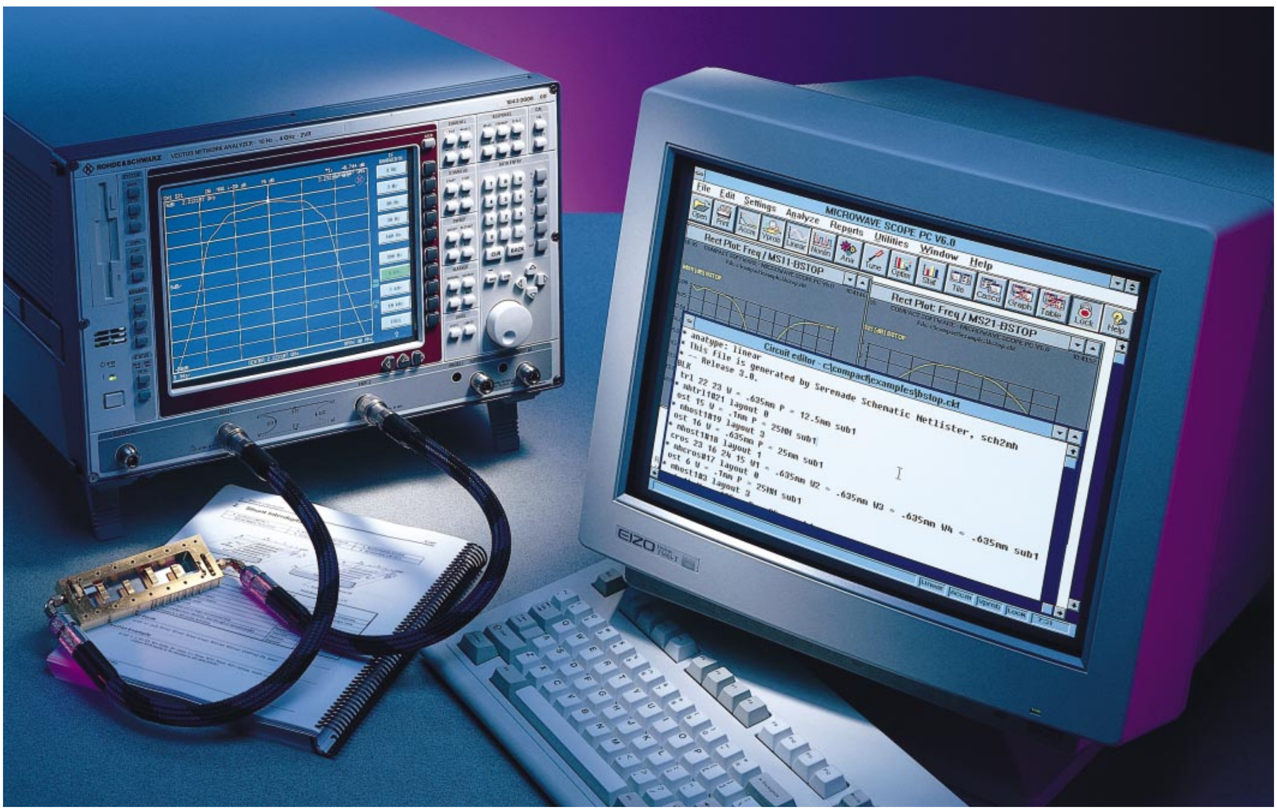

FIG 1 Network analyzers from ZVR family can rapidly and precisely handle different tasks simultaneously – left measuring transfer function of bandpass, right simulation without additional PC.
Photo 42 257

The ZVR family comprises the three models ZVRL, ZVRE and ZVR, each tailored to a different field of application (FIG 1). The common features of all models are their ease of operation, lightning measurement speed and large frequency range that covers 10 Hz, 9 kHz or 300 kHz to 4 GHz depending on the integral test set selected (FIG 2). All models feature an IBM-PC compatible processor core with floppy-disk drive, hard disk, slots for options as well as external interfaces to connect a keyboard, mouse and up to two additional monitors for the analyzer display and the PC screen. This ensures easy analysis of measurement results, their professional documentation and effective networking within the analyzer or with other systems. The effectiveness of all models is further enhanced by accessories and options such as calibration and verification kits, three-port adapters or special firmware packages for frequency-converting and nonlinear measurements.

The entry-level model, **unidirectional Vector Network Analyzer ZVRL,** is for forward transmission and reflection measurements which also provide derived quantities such as input impedance, VSWR or group delay. ZVRL is especially designed for use in production environments and only requires simple calibration methods such as normalization and full oneport calibration. **Bidirectional Network Analyzer ZVRE** is ideal for general-purpose applications, as for instance in research and development labs where forward and reverse s-parameters of twoport devices have to be measured. Unlike ZVRL, it has a test set with two bridges and an electronic switch for quasi-simultaneous measurement of all four s-parameters. This paves the way for the increase in

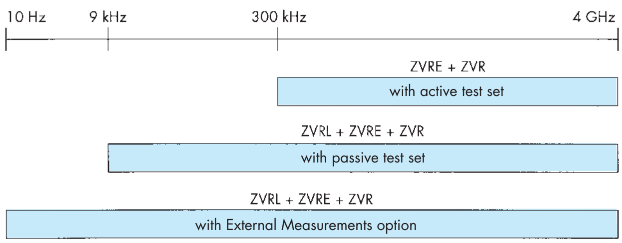

FIG 2
Frequency ranges of ZVR family

measurement accuracy that can be obtained with full twoport system-error calibration [1].

Bidirectional four-channel Network Analyzer ZVR allows the most sophisticated, novel calibration methods to be carried out. Unlike the three-channel ZVRE, it has a second reference channel after the electronic switch so that it is able to carry out a variety of innovative calibration procedures (TOM, TRM, TRL, TNA, TOM-X) [2; 3]. These are characterized by increased convenience and measurement accuracy, mathematically exact elimination of system crosstalk (see Patent on page 51) and are also especially well-suited for in-fixture calibration. The new automatic calibration method AutoCal [4], for which a patent is pending, offers maximum ease of operation and calibration speed. Full twoport calibration of the analyzer takes less than 20 s with just one through connection and without any further manual handling.

The core of all network analyzers of the ZVR family is a fast synthesizer which provides crystal-accurate frequency changes in less than 20 μs. Its amplified output signal is taken to the DUT via the integral, model-specific configurable test set of the analyzer. Its transmission and reflection characteristics are measured by means of a two-stage heterodyne receiver which uses fundamental mixing and are digitally evaluated. The analyzers are equipped with a network of eight microprocessors specially designed to perform the various internal tasks such as unit control, recording of results, data processing, screen graphics and remote control of the unit. Measured values can be converted and displayed in various formats and easily read off the large, bright, high-contrast, colour LCD (FIG 3) without operator fatigue.

Measurement speed

The key feature of a modern analyzer – especially for applications in production – is measurement speed. Quick measurements increase final test throughput and cut costs. Also, fast result acquisition opens up applications which would be impossible for slower analyzers. For example, measurements on GSM amplifiers for mobile-radio applications. Thanks to high measurement speed, a key feature of the ZVR family, it is possible to perform five vector measurements during a GSM pulse of only about 550 μs and so gain completely new insight into the dynamic characteristics of GSM amplifiers (FIG 4).

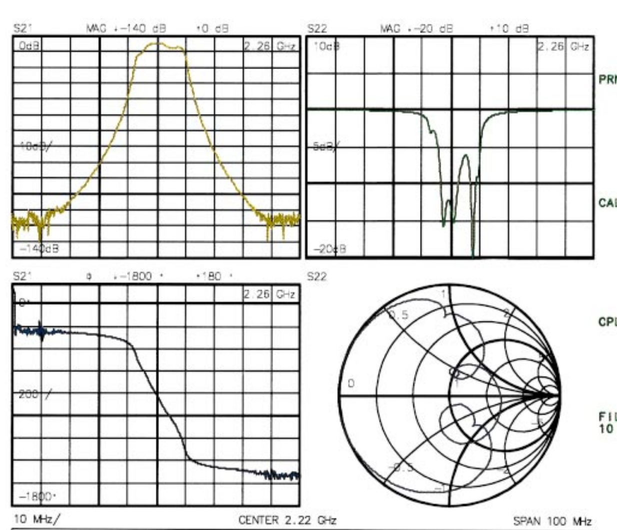

FIG 3
Four-quadrant display of transmission and reflection characteristics of filter with high stop-band attenuation

The time for a complete frequency sweep is determined by the number of testpoints, the IF bandwidth and any averaging used. ZVR analyzers allow any number of testpoints between one and 2001 to be selected. A linear, logarithmic or arbitrarily segmented sweep can be used.

The IF bandwidth can be set in half-decade steps between 1 Hz and 10 kHz and also set to “full” (26.5 kHz). Digital IF filters are used and a certain number of IF signal samples are processed by an internal transputer. With reduced IF bandwidth, the number of samples required increases and so measurement time becomes correspondingly longer for each point. As another transputer processes measurement data in the background while new measured values are being acquired at the next frequency point, this does not affect measurement time, which is 250 μs per point for **normalized measurements** at an IF bandwidth of 10 kHz.

For **full system-error correction,** all four s-parameters must be measured even if only one is to be displayed. Therefore, the electronic switch of bidirectional Analyzers ZVRE and ZVR has to be switched over at each frequency point, the measurement channels in the receiver have to settle to a steady state for a second time, and the measured values for the reverse s-parameters have to be acquired and processed. In this case measurement time per point is approximately 510 µs at a bandwidth of 10 kHz.

If even faster measurements are required, there are two ways of boosting performance: thanks to the full IF bandwidth (26.5 kHz) the measurement time per point is reduced to typically 165 µs for normalized measurements and 310 µs for measurements with full system-error correction. The **fast mode** additionally applies reduced settling times for the generator and the receiver. This cuts measurement time per point to the extremely low value of about 110 µs for normalized measurements, which means exactly five measurements during a GSM pulse of 550 µs. Measurements with full system-error correction require about 235 µs per point in the fast mode while still performing complete forward and reverse measurements and parallel system-error correction calculations. The flyback time after a frequency sweep is approximately 5 ms irrespective of the mode and the number of testpoints.

For very efficient, informative and fast measurements, the characteristics that have been referred to can be combined to give the special mode **segment sweep.** Testpoints can be selected according to the specific characteristics of the DUT. As well as the IF bandwidth, the user can select any level and averaging factor for each sweep segment. In the case of filter measurements, for example, this means that the maximum dynamic range in the stopband, the highest resolution in the passband, the behaviour at stopband poles and filter transmission characteristics at spurious frequencies can be displayed on the screen at maximum speed in one sweep. Production alignments and checks which required cyclic measurements can now be shown on one display. Of course, the segment sweep is simultaneously available in each of the four display channels. Since the four channels can be displayed on the colour LCD with tolerance lines and separate pass/fail information, the display facilities of ZVR analyzers have still further potential for improving the throughput of production testing and increasing test depth without increasing test duration.

The fast acquisition and display of measured values is supported by equally fast data transfer via the **IEC/IEEE bus.** For example, reading out a single marker takes only 15 ms, reading out the complete trace data comprising 401 points takes less than 60 ms. This combination of fast measurement and data transfer offers considerable scope for rationalizing test sequences.

Measurement accuracy

Another point that should be emphasized is the measurement accuracy of ZVR network analyzers which, for a large number of typical applications, is much better than the rather conservative specifications in the data sheet. This can be demonstrated by **verification measurements.** The phase measurement accuracy of reflection measurements, for example, can easily be checked. To do this, a TOM calibration (Through, Open, Match) is carried out on the ZVR network analyzer. Port 1 of ZVR is testport 1 and testport 2 is the end of a 50-cm test cable connected to port 2. The through calibration standard is very easy to implement by simply connecting the cable to port 1. For open and match calibration the standards in Calibration Kit ZV-Z21 are used. After calibration, a female short from Calibration Kit ZCAN [5], which acts as a verification DUT, is connected to the end of the test cable. The special feature of this short is that its short-circuit plane exactly coincides with the reference plane, ie the edge of the outer conductor. Therefore, the phase of the reflection coefficient is expected to be exactly 180° over the entire frequency range. This phase offset of 180° is entered via the offset menu to display the results, ZVR directly indicating its own phase error. As FIG 5 shows, the typical error is less than 0.4°.

A calibrated network analyzer has another important system error which affects the measurement accuracy of both transmission and reflection measurements at twoports, namely **effective load match.** If the load port is not perfectly matched, multiple reflections arise between DUT and analyzer. If there are strong reflections from the DUT, measurement errors may be very large. Measurement uncertainties of this kind must directly be included in the DUT specifications, in particular in the case of bandwidth tests and the assessment of shape factors. Effective load match is easily measured after a TOM calibration by directly connecting the

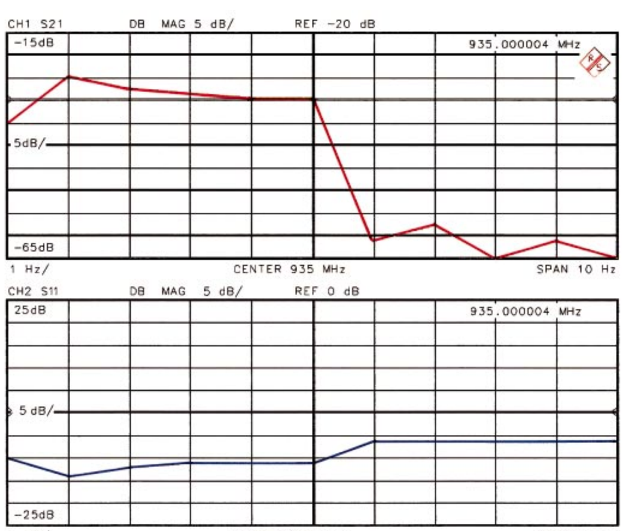

FIG 4 Measurement of transmission (top) and reflection characteristics (bottom) of mobile-radio amplifier during GSM pulse (approx. 550 µs)

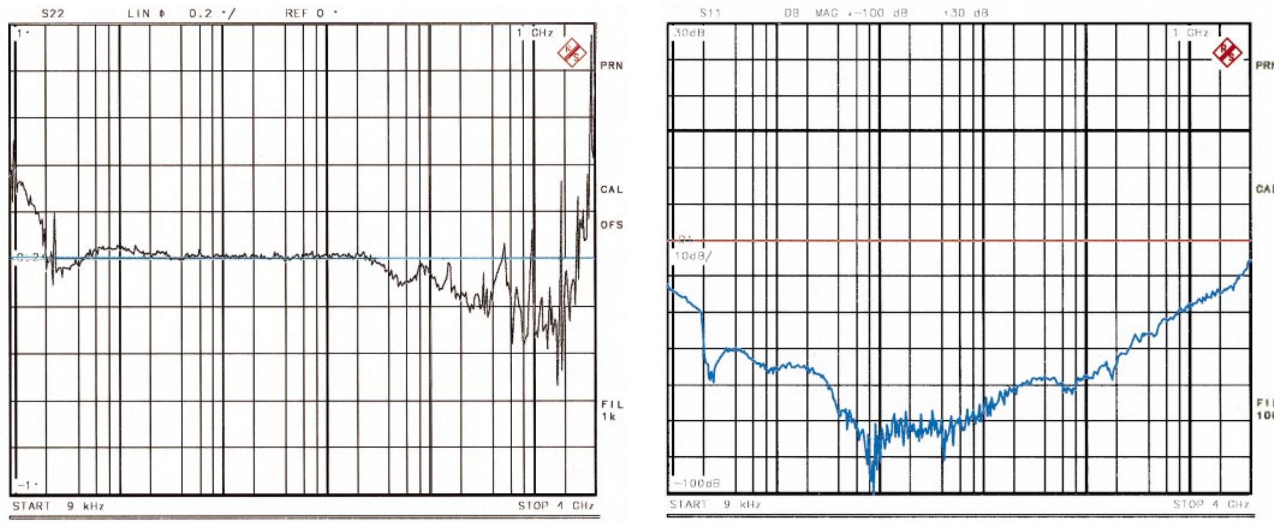

FIG 5 Left: phase errors of short-circuit verification (specification <3° +0.4°/GHz); right: effective load match measured (specification <−30 dB) after system-error correction (TOM)

two testports and displaying the forward reflection into testport 2 as shown on the right in FIG 5. When compared with the specified value of −30 dB, it is evident that the measured effective load match is significantly better (<−50 dB) over a wide frequency range, so that in practice uncertainties caused by multiple reflections between analyzer and DUT can generally be ignored.

An example illustrating the value of the ZVR analyzers' high measurement accuracy, at low levels in particular, is the quick and reliable search for spurious resonances in filter crystals. Because of the high transmission loss of the specified π-networks for the test adapters, the phase-zero crossings have to be detected at an attenuation of approximately 60 dB. Thanks to the high accuracy and dynamic range of ZVR, this measurement can now also be automated using marker evaluation functions. The ZVR family takes vector network analysis into new applications and meets the development and production requirements of tomorrow.

Dr. Olaf Ostwald; Christian Evers

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Condensed data of Network Analyzer Family ZVR

Frequency range	
with passive test set	9 kHz to 4 GHz
with active test set	300 kHz to 4 GHz
with External Measurements option	10 Hz to 4 GHz
Measurement time	110 µs/point
Dynamic range (with External Measurements option and 10-Hz IF bandwidth)	>130 dB
IF bandwidths	1 Hz to 10 kHz (half-decade steps) and 26.5 kHz (full)
Amplitude uncertainty	<0.05 dB
Phase uncertainty	<0.4°
Calibration methods	TOM, TRM, TRL, TNA, TOSM, TOM-X, AutoCal
Display	26-cm colour LCD
Number of pixels	640 x 480 (SVGA)
Remote control	IEC 625-2 (SCPI 1994.0) or RS-232-C

Reader service card 150/01

LaserVision System LV1

Optical insertion testing combined with classic board test

With LaserVision System LV1 Rohde & Schwarz is extending its spectrum for in-production testing of printed circuits. This system together with the in-circuit test systems from Rohde & Schwarz allows greater test depth to be obtained in insertion testing than with purely electrical test equipment. Visual inspection is thus no longer required. Since electrical and optical tests run in parallel, the total test time per board is reduced – an important aspect in production.

The LaserVision system can operate as a stand-alone although its main application is in extending the classic board testers by concentrating on faults that cannot be detected at all or only with difficulty by electrical means (eg electrolytic capacitors with reversed polarity or incorrectly positioned mechanical components). Through this limitation, LV1 offers a considerably more attractive price than vision and X-ray systems, some of which are three to seven times more expensive. Although such systems can also analyze solder joints, they still mostly require a subsequent in-circuit test.

FIG 1 Combination of Board Test Workstation TSA and LaserVision System LV1 for electrical and optical testing of printed circuits
Photo 41 878

LaserVision System LV1 tests the insertion of printed circuits in production by optical means. It is mainly employed in the production line after the soldering station. It may be appropriate in some cases to test insertion prior to soldering directly after SMD placement. LV1 is highly suitable for testing a large range of lot sizes from sampling for quality control right through to 100% testing in mass production.

Measurement method

The measuring unit of LV1 combines in a single unit optical image processing using two CCD cameras (charge-coupled devices) and a laser triangulation technique for height measurement. The two sensors together with the XY positioning unit are moved over the board to be tested (FIG 1). Prerequisites for reliable results are viewability of the board and reproducible contrast. Suitable image resolution for different component sizes is achieved by means of two separate cameras. Components on the solder side are tested in a second run with the board turned over or from below (in-line feed).

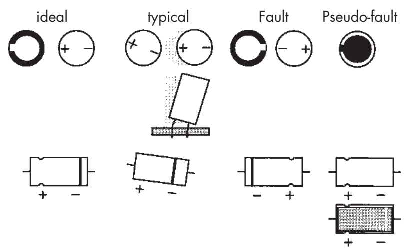

FIG 2 Polarity test of upright and flat mounted electrolytic capacitors

The image-processing section focuses on simple features such as lines, notches, markings and in particular with all feasible spreads as they occur in production: slightly displaced, turned or tilted components (FIG 2). For testing the polarity of electrolytic capacitors for example, the position of the marking or the positive or negative sign is taken as a criterion. The permitted search area and the separation from neighbouring components are defined by positioning and reducing the selected window. Pseudo-faults occur when a component is assessed as incorrect according to optical criteria although electrically it behaves correctly, ie differing colouring or marking of components as a result of changing to a new supplier.

Components with low optical contrast can also be tested with the laser by measuring the relative height with reference to the board. Measurement errors arising from the curvature of the DUT can be compensated through reference measurements (FIG 3). Even the slightest height differences are measurable so that not only missing components but also wrongly polarized ICs can be detected through the absence of a notch indentation. For ICs without a notch the marking line or slanted edge must be examined with the image-processing section.

Detectable insertion faults

The **vision system** of LV1 detects:

- polarity of electrolytic capacitors (flat or upright mounted) or diodes,
- SMD components (depending on contrast),
- parallel circuits (eg electrolytics parallel-connected with ceramic capacitors),
- small RF capacitors, coils, diodes and protective circuits,
- wires, manual modifications,
- displays, LEDs, LCDs,
- switches, jumpers, codings,
- mechanical components and their positions.

The **laser system** checks:

- presence of SMD components,
- presence and orientation of ICs,
- switches, jumpers and mechanical components.

The effect of an undetected insertion fault can be illustrated with the aid of two examples. A wrongly polarized electrolytic capacitor in a power pack explodes when the full voltage is applied in the system test and poses a considerable risk of injury to the operating personnel (typically one in a hundred manually inserted electrolytic capacitors has reversed polarity). A missing overvoltage protection circuit remains undetected in the standard test since the components may not be tested electrically in the majority of cases because of the risk of overloading.

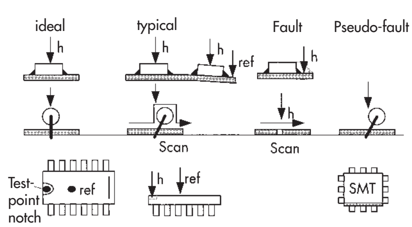

FIG 3 Insertion testing based on height measurement

Operation

The two subsystems of LV1 are controlled and programmed from the same PC. The camera picture and evaluation window are positioned with the mouse (FIG 4). Optical tests are performed according to significant visual features. The rated values can be entered in the respective boxes or learnt from the DUT but can also be evaluated from a CAD system. All settings are made via keys and boxes; no special test language need be learnt. Operation is practically intuitive; programming takes typically two to three minutes per component. To change between the test program and control of LV1 during program generation or debugging, the corresponding window has merely to be clicked. In the test mode, the two measurement tasks run in parallel and are logged together.

Economy

Through the combination of electrical and optical tests the user can generate a reliably running test program in a shorter time and thus obtains a higher rate of fault detection than with purely electrical or optical testing. Using LV1 together with a production test system of families TSA [1; 2] or TSU [3] from Rohde & Schwarz, the overall test time does not increase in spite of the additional tests involved and the greater test depth achieved. The standard electrical test (eg in-circuit test) and the optical tests run in parallel and the results are not combined until the end. Taking a typical board with an in-circuit test time of 15 s, during this time 30 to 50 components can also be tested optically – a sufficient quantity since only a small percentage of the components require the additional optical measurements. If an electrical signal is necessary for the optical measurements (eg driving a LED display), the two types of measurements can be synchronized.

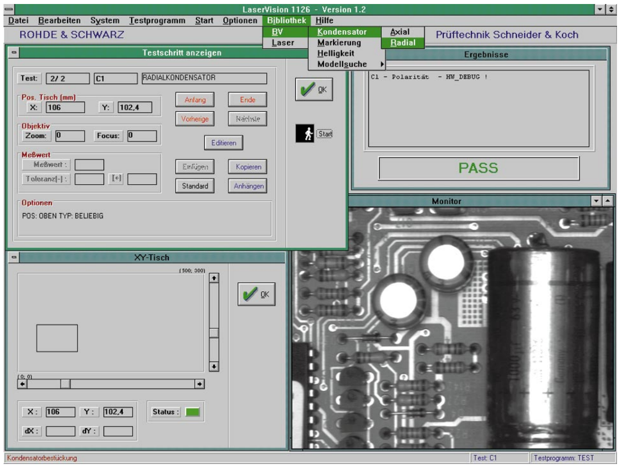

FIG 4
Programming of test on electrolytics using vision unit of LV1

LaserVision System LV1 can replace in many cases an operator carrying out visual inspection of the boards. In contrast to man as operator, no errors arise because of fatigue; for the LaserVision system the monotony of the tests is no problem. However, the operator is superior to the machine in two aspects: he produces no pseudo-faults and can detect modifications adaptively and assess them correctly. The latter cannot be foreseen by the programmer or the image-processing software.

The number of steps in testing is reduced by the combinational test. This yields a benefit for the organization of the test run which is particularly effective for fully automated production lines since each extra test station requires space and additional costs are involved for the stop and associated equipment. The objective is clearly: one tester, one fixture, a single program and test-data acquisition, yet full fault coverage.

Experience

Extensive experience has been gained with the combinational test at a major supplier to one of the largest American computer and instrument manufacturers. Some 15,000 printed circuits (PC mainboards) were tested per month on the combinational tester. The tests revealed mechanical faults for 5% of the boards which in the past remained hidden through electrical testing alone. The fault detection rate is thus substantially higher than that obtained by electrical measurements although only a small number of components is tested optically. The pseudo-fault rate is below 1%, which is considerably better than attainable using manufacturing defects analyzers. Typical faults were wrongly polarized electrolytic capacitors, slanted components or protruding, non-coplanar or displaced connectors produced during soldering so that such boards could not be inserted into their system.

The LaserVision system is therefore a powerful and attractively priced supplement to board testers, with tasks in areas where electrical insertion tests find their limits. The parallel running tests reduce the overall test time for boards and at the same time offer greater test depth.

Dr. Lothar Tschimpke

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Condensed data of LaserVision System LV1

Measurement technique	image evaluation with 2 CCD cameras, laser distance measurement
Board size	max. 520 mm x 330 mm
Test rate	typ. 2 to 3 components/s
Resolution	
Vision system	camera 1 25 µm, camera 2 67 µm
Laser system	typ. 20 µm on component, typ. >0.5 mm on printed card
Option	table without or with shift facility

Reader service card 150/02

Universal Test System TSU

Versatile test platform for production and service of electronic modules

Thanks to its modular structure Test System TSU is a universal test platform for electronic modules and systems. It can be equipped with the complete range of analog and digital measurement devices of the well-known Rohde & Schwarz in-circuit testers and can be expanded by means of VXI-bus instruments. Its applications range from classic production tests to maintenance and repair.

FIG 1 Universal Test System TSU as compact desktop Photo 42 319

The trend towards ever decreasing size and greater performance in electronics also makes itself felt in test technology. With Universal Test System TSU Rohde & Schwarz is now entering the market for portable measuring instruments (FIG 1). Yet there are practically no limits set on the expandability of the system. The core elements of TSU have already proven their worth for some time as employed in functional test assemblies at Rohde & Schwarz Messgerätebau Memmingen, where the broad product line has to be adapted with signals ranging from DC to RF.

Hardware structure

The basic TSU system essentially consists of a module frame with 13 slots and power supply for the measurements and the DUT. Both internal and external expansions are possible at any time. Moreover, the standard basic functions of a test system such as automatic fixture detection, auxiliary voltages for the fixture plug-ins, free interface lines and vacuum control for bed-of-nails fixtures are of course integrated in the basic configuration. A central control module handles communication between the process controller and the modules. Analog signals coming from the DUT or internal modules via an internal analog bus are available at every slot. A special card allows external devices to be connected to the analog bus.

The system is equipped with modules as required by the application and the planned test strategy. Numerous plug-in cards are available for analog and digital functional tests and for analog in-circuit tests. External IEC/IEEE-bus units or even a VXI-bus frame can additionally be integrated. It is also possible to use the modules of Test Workstation Family TSA/TSAS/TSAP [1 to 3] or of the large TSI/TSIC/TSP systems [4] in TSU with the aid of simple interface cards. Customer-specific applications are implemented on a special application module. Depending on the signal requirements, different switch cards can be obtained including relay cards for RF applications up to 4 GHz and cards for high currents (max. 8 A) and high voltages (max. 250/380 V). The signal can be routed via the fixture interface or in the fixture itself. TSU can be operated as a desktop or rackmount depending on the system configuration (FIG 2).

System software

Like with other Rohde & Schwarz test systems, TSU employs Software TSS under Windows NT for use on PCs. Compatibility between all systems of the test family is thus ensured. The programming language is a structured high-level language with easily readable commands for the measurement functions. Various software tools and the convenient user interface enable easy and simple generation of test programs. Analog in-circuit tests are generated automatically from the DUT's board description by the test-program generator. The board description can be taken directly from the CAD system via a software interface or can also be manually entered.

Functional tests can again be obtained manually or simply with the interactive test generator. It is not necessary to have a detailed knowledge of the programming language since programming itself is made by filling in forms from which the program code is generated automatically. Test steps or routines can be tried out straightaway on the hardware, modified and inserted into the test program as required. Measurement data can be represented in diagrams with the integrated trace graphics and logged.

Circuit diagrams and corresponding layouts can be displayed on the screen of the PC to avoid unnecessary time wasted on searching for circuitry or components in diagrams when debugging test programs or repairing DUTs. Search times can be drastically reduced through the use of the integrated search functions. The test program can exchange data in both directions with other Microsoft-compatible products via DDE (dynamic data exchange). Thus, for example, measurement data can be entered directly in Word or Excel forms and logged.

FIG 2 TSU system can be integrated in 19-inch rack for applications requiring lots of add-on units.

Fixture concept

A special feature of the TSU system is its universal cost-effective fixture interface that, besides the contacts for standard applications, can be extended with contacts for signals in the RF range up to 4 GHz and for high currents and voltages. The test system is therefore suitable for the testing of power supplies, power electronics or RF products such as cordless phones. Further benefits are obtained through the use of a fixture system for vacuum and pneumatic drive. Removable fixture plates contain only the DUT-specific nails, all other recurring parts are part of the basic fixture. This, together with novel prefabricated connecting elements, means that 60 % of the costs can be saved in comparison with conventional fixtures.

Use in service and maintenance

Through its modular and flexible configuration as well as handy size and low initial outlay, TSU is ideal for use in service and maintenance. Existing test programs and fixtures can be taken from production provided they have been tested on Rohde & Schwarz test systems in the repair of modules. It is often possible to adopt test programs and fixtures from other test systems by using conversion programs. This results in high cost savings.

Especially for the military sector and the aerospace industry, TSU can be operated with the ATLAS test language widely used in those areas. It is exactly for such applications that the TSU system offers an economically interesting alternative to the often expensive and complex test systems employed up to now.

Test-data storage

In order to have a continuous overview of production quality, incoming test data have to be stored and evaluated. With a view to ISO 9000 and the product liability law, the history of a product from its production to service is of importance. In the long run, high product quality can only be guaranteed through systematic documentation of all work carried out during its life cycle.

Klaus Kundiger;
Dr. Lothar Tschimpke

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Condensed data of Universal Test System TSU

Test methods	analog in-circuit test, analog IC check, analog/digital functional test, emulation test, boundary scan test, LaserVision test
Analog tests	various signal sources and measuring instruments for integration as modules or external units, internal analog bus, instrument multiplexer for external units, signal relays for frequency range DC to 4 GHz, number of pins expandable to 576
Digital test	module for static test (data rate max. 50 kHz) or dynamic test (data rate max. 10 MHz), level range up to ±30 V, number of pins expandable to 256
Computer	standard PC with Windows NT operating system
Software	TSS Windows, interactive test generator, trace graphics, quality management, paperless repair, graphic debugging software, graphic repair station, CAD/CAE link

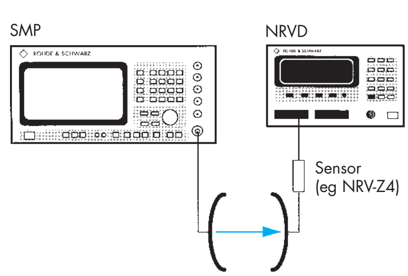
Reader service card 150/03

Installing directional antennas for microwave WLANs

Life without PC networking is hard to imagine in the offices and labs of modern enterprises as it opens up communication facilities for everyone. Up to now most networks have been based on coaxial cables, which are expensive to lay. Thanks to drops in the prices of integrated circuits, wireless local area networks (WLANs) are being seen in a more favourable light because of the economic advantage. It is also obvious that portable computers like notebooks can be networked in this way, but the same also applies to whole buildings and remote factory sites which could have a wireless connection with the main network. This is also a sound approach for countries with an infrastructure that is still being expanded. Short-hop microwave links on the 2.45 GHz ISM frequency are ideal for this purpose. Spread-spectrum methods such as frequency hopping or the direct-sequence spread-spectrum method make it possible to operate several adjacent networks on the same frequency without mutual interference or any risk of eavesdropping.

When such an approach is used, energy is transmitted over a large frequency band (approx. 2 MHz) and the signal cannot be detected with conventional RF measurement devices like power meters or spectrum analyzers. This does not exactly make life easy for someone installing radio-link hops, because the antennas of the transceiver stations have to be aligned spot on. "Eyeballing" may work for short distances, but another more "far-sighted" method has to be found for hop lengths in the km range.

If the transceivers are replaced (as shown in the FIG) by a **Signal Generator SMP** at one end of the microwave link and a **Power Meter NRVD** with sensor (or spectrum analyzer) at the other, antennas are very easy to align. SMP is used



Hop length	Loss
1 km	50.3 dB
2 km	56.3 dB
3 km	59.8 dB
4 km	62.3 dB
5 km	64.3 dB

Path loss between transmitter and receiver at 2.45 GHz, antenna gain 25 dB

to generate a CW signal at the ISM frequency of 2.45 GHz and a level of +20 dBm for instance (all SMP02s and SMP22s can do this). Assuming each antenna has a gain of 25 dB and the hop length is 5 km, a path loss of approx. 64.3 dB (TABLE) is obtained, ie the power meter displays −44.3 dB for optimally aligned antennas.

Wilhelm Kraemer

Reader service card 150/04 for further information on SMP

TV Monitoring and Test Systems TS6100

Video and audio parameters of TV transmitters all under control

High availability is an extremely important factor in the operation of broadcast transmitters. This is why many network operators increasingly make use of automatic monitoring systems enabling them to estimate failure probability at an early stage. System family TS6100 from Rohde & Schwarz offers individual solutions for on-air and off-air monitoring and testing of TV transmitters and CATV systems.

Broadcasters are under an obligation to ensure the transmission and distribution of programs with guaranteed reliability – usually 99.9%, ie no more than nine hours outage per year. The TV monitoring and test systems of the TS6100 family from Rohde & Schwarz (FIG 1) provide the network operator with an economical solution to meet this requirement. **Key features of the system** are:

- modularity,
- use of standard components (hardware and software),
- a variety of configurations ranging from minimal to all-in solutions,
- upgradability,
- remote control and remote polling,
- statistical evaluation of test data.

System family and uses

Within the TS6100 system family, a basic distinction is made between monitoring and measurements. TS6110 and TS6120 are designed for monitoring purposes, whereas TS6130, TS6140 and TS6150 are test systems which can also be configured as monitoring systems (dual solutions). The operator can use these basic systems together with the available options to create an optimal solution to fit the monitoring and measurement tasks required.

FIG 1
TV Test System TS6130 with Video Measurement System VSA, CCVS Generator SFF and Audio Monitoring System AMON
Photo 42 233

Monitoring System TS6110 uses a video PC card for video measurements. This card can be installed in any IBM-compatible computer as the system software runs under Windows 3.1. Since transmitters are known to generate high field strengths, it is advisable to use a well-shielded (against EMI) PC – eg PSM7 from Rohde & Schwarz [1]. TS6110 is a low-cost monitoring system.

Video Measurement System VSA [2] is the core component of **Monitoring System TS6120.** In its minimum configuration the 486/66 processor in the VSA also serves as a system controller. For more complex applications an external controller can be used. Numerous options allow adaptation to specific tasks (FIG 2). In this context the AMON audio option should be particularly mentioned; it enables the user to monitor audio parameters on the air without interrupting the program, as the audio signal itself is used as a test signal. At the same time additional data (eg dynamic RDS data) can be transmitted on the audio line; thus costly data lines are not necessary.

Test System TS6130 was specially designed for on-air measurements during program time. The introduction of solid-state technology has led to a change in the design concept of transmitters. Today single transmitters (sometimes with a passive exciter standby) are used rather than dual transmitters. This means that it is no longer possible to carry out measurements and change settings on standby transmitters, but only on operating transmitters. The basic version of TS6130 consists of Video Measurement System VSA, multistandard CCVS Generator SFF [3] and System Software TS6100/Win. SFF produces a standardized CCVS video signal and allows the generation of

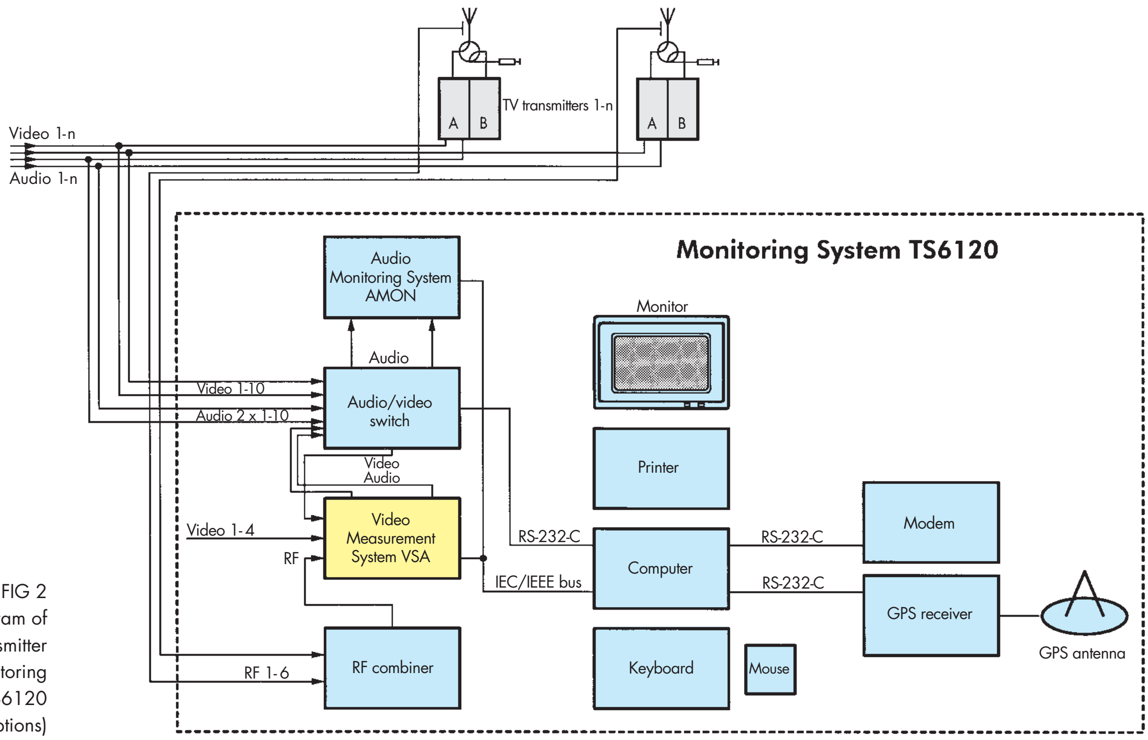


FIG 2 Block diagram of TV transmitter with Monitoring System TS6120 (blue: options)

individual test signals. The most important parameters of baseband, teletext, RF signal (eg vision-carrier phase) and audio signal are measured and evaluated. This enables transmitter alignment to be performed during program emission.

Full-Field Test System TS6140 is based on Spectrum Analyzer FSEA20 [4]. Group delay is measured by a combination of CCVS Generator SFF and Video Analyzer VSA. Further system components are a precision demodulator, a process controller, a switching panel (for RF, IF and AF) and System Software TS6100/Win. The controller and the switching panel form the core of the system. All signals, from RF through IF to AF, are directed to the appropriate inputs and outputs of the instruments depending on the type of measurement carried out, so there is no need for tedious manual switching. This system can be used to check the compliance of transmitters with standard specifications.

TV Network Analyzer SOKF/SWKF [5] is the heart of **Full-Field Test System TS6150.** Similar to TS6140, the TS6150 system is used for testing the transmitter outside program times. The system also incorporates a precision demodulator, a process controller, a switching panel and the system software. Traditionally, tests on TV transmitters are carried out by means of a network analyzer. It can be used to measure amplitude and group-delay frequency response at the video frequency as well as at the IF/RF. Using TV Network Analyzer SOKF, the built-in oscilloscope also serves to evaluate video signals in the time domain. Similar to TS6140, TS6150 can carry out checks on the transmitter for compliance with standard specifications.

Software TS6100/Win

TV Monitoring and Test Systems TS6100 use System Software TS6100/Win (FIG 3) for monitoring and measurements. Statistical evaluation of the data obtained is carried out by the supplied macros, using either MS-Excel or MS-Access. Advantages of Windows 3.1 as a graphic user interface are standardized operation, multitasking and versatility with regard to integration into other programs.

Software TS6100/Win can perform all **monitoring and testing tasks using five different modes:**

- The **automatic mode** is primarily used to monitor and observe selected parameters. This is performed at fixed times of the day and can be continued over several days, weeks, months or even years. If one of the parameters exceeds or falls below a set limit value, an alarm is triggered which, in case of an attended station, is displayed on the screen or otherwise transmitted via modem to a

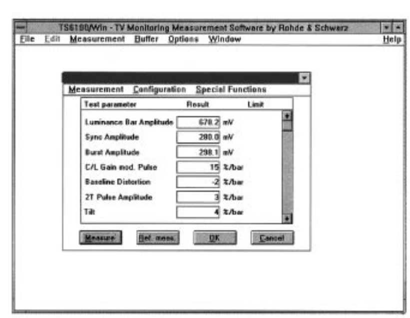


FIG 3 System Software TS6100/Win to run under Windows 3.1

control center. Of course, all data are stored locally and can be retrieved for evaluation at any time.
- The **interactive mode** is used for quickly checking subranges. The automatic mode is in the meantime set on standby.
- The **direct mode** serves to select individual units via virtual user interfaces for fast settings and tests.
- **Run script** is provided to trigger a particular measurement (script). The scripts – a macro language – enable the user to create his own tests. Debug aids and test facilities are contained in the script development environment and facilitate the creation and modification of scripts.
- **Run sequence** serves for the compilation of individual measurements in any combination. In this way individual tests can be grouped together and retrieved as necessary.

Test results are documented by a printer in the form of graphs or tables. The report can be configured according to the user's wishes. With dynamic data exchange (DDE) data can be sent between different Windows programs. The option concept makes the software easy to use and upgradable. Drivers needed for external equipment and additional software options are added to the software kernel. Due to its modular design, the software is extremely flexible. Passwords and a number of access levels safeguard security in the use of the software package. They guarantee that test data are processed by licenced users only and that system configurations are exclusively performed by authorized personnel.

Graphic user interface

In addition to the usual Windows menus File, Edit, Window and Help, TS6100/Win software includes two further menus – Measurement and Options.

The **Measurement menu** serves to operate individual units interactively. A virtual interface is provided for each unit. The automatic tests defined by scripts are started in this menu. The automatic and the interactive test modes are also started here.

The **Options menu** is used for definition of the unit configuration with the interface (eg IEC/IEEE bus, RS-232-C, TTL, AT bus) and the path configuration. Communication configurations can also be selected in this menu. With remote-controlled transmitters it is essential that alarm, fault and query messages are not displayed on the screen but transmitted to a control center, eg via a modem, where the necessary corrections can be taken. Optionally the messages can be stored in a log file. Access levels and passwords are also assigned to the individual users.

System-related services

The presales and aftersales services provided by the supplier are an essential prerequisite for the customer to be able to use a system efficiently. A competent advisory service guarantees that system design is optimally matched to the customer's particular requirements. Comprehensive functional tests, proper commissioning and practice-oriented training make for fast availability of the system without undue delay. In addition to these standard services, Rohde & Schwarz offers longterm support in terms of customized maintenance programs.

Michael Lehmann; Gerhard Strauss

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Condensed data of TV Monitoring and Test Systems TS6100

Frequency range	
TS6110 / 6120 / 6130 / 6150	45 to 860/900 MHz
TS6140	9 kHz to 3.5 GHz
Test modes	automatic, interactive, direct, run script, run sequence
Software	TS6100/Win (under Windows 3.1)
Interfaces	IEC/IEEE bus, RS-232-C, TTL, AT bus

Reader service card 150/05

Spectrum Analyzer FSE with Option FSE-B7

Vector signal analysis – indispensable in digital mobile radio

Spectrum Analyzer FSE not only performs measurements in the spectral domain with high precision and wide dynamic range. Now, with its new vector signal analyzer option, it can also demodulate all signals used in mobile radio, both for analog and digital modulation, and measure their modulation parameters.

FIG 1 Spectrum Analyzer FSE with vector signal analyzer option for measuring digital modulation parameters

With digital modulation methods, not only the spectrum of the transmitted signal is of interest but also its behaviour in the time domain and the quality of the complex modulation. Conventional scalar spectrum analyzers provide measurements in line with standards only for the RF parameters, eg in-channel power, occupied bandwidth, adjacent-channel power or spuria of digitally modulated signals in the frequency domain. However, for measuring power as a function of time, which is required for TDMA transmission methods for example, reference must usually be made to fixed synchronization sequences such as pre- or midambles. Since the time reference is included in the information carried by the signal, the RF signal must be demodulated down to bit level. The bits are used as a trigger reference for representing and measuring the burst. Conventional spectrum analyzers require an external trigger for this measurement, ie the signal must be supplied by the DUT. Therefore only DUTs capable of supplying such a signal can be used, and only qualitative measurements are possible. Scalar spectrum analyzers are completely unsuitable for determining the modulation error of the RF signal. These errors are however specified for all digital radio transmission standards and must therefore be measured.

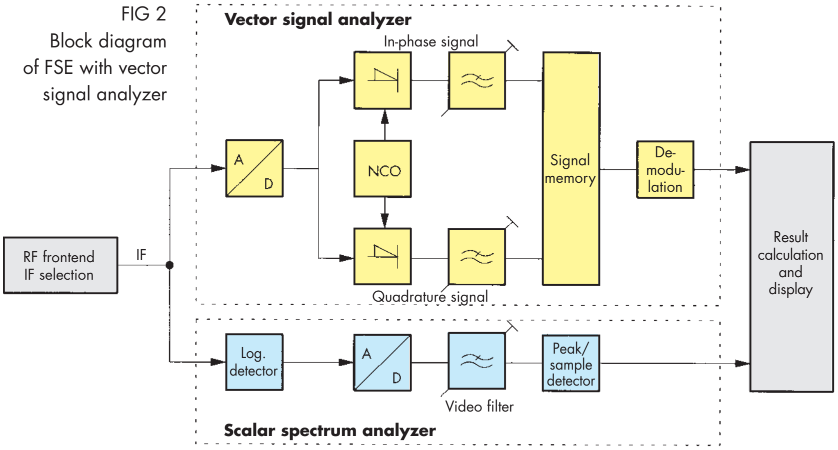

FIG 2 Block diagram of FSE with vector signal analyzer

Spectrum Analyzer FSE [1] with Vector Signal Analyzer Option FSE-B7 is the first instrument to fulfil all the requirements specified in the various standards for measuring the RF parameters of digitally modulated signals. In other words, it meets the stringent requirements made on measurements in the spectral domain with respect to dynamic range, intermodulation characteristics and phase noise. At the same time it supplies the time reference for burst measurements and measures modulation parameters and errors with high accuracy (FIG 1).

These unique capabilities of FSE were achieved by combining a high-grade spectrum analyzer with a vector signal analyzer. After the common RF frontend up to 3.5 GHz or 7 GHz and the IF selection, the IF signal is divided into one path for the scalar spectrum analyzer and another for the vector signal analyzer (FIG 2). In the spectrum analyzer the IF signal is logarithmized and rectified. At the output, the magnitude of the test signal is available; the phase information is lost in the process. The advantage of this method is the wide dynamic range attainable with logarithmic level display as a result of level compression performed by a log amplifier. In the stages following the log amplifier, only the compressed signal is processed. Here FSE attains a dynamic range of 110 dB. In the vector signal analyzer the IF signal is sampled directly by an A/D converter and digitally mixed into the baseband. In this process the real and the imaginary component of the test signal, or its magnitude and phase respectively, are obtained. Thus the complete signal information is available for analysis. Basically the vector signal analyzer could also be used as a spectrum analyzer. However the A/D converter would reduce the dynamic range of the scalar spectrum analyzer. For this reason, FSE with its vector signal analyzer option offers both methods and uses them optimally as required for the measurement in question.

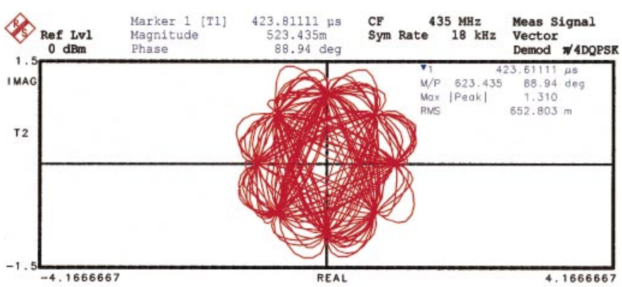

FIG 3
Vector diagram of TETRA signal

Demodulation of signals with analog and digital modulation

With the vector signal analyzer option, FSE can handle all types of modulation commonly used in mobile radio, whether analog methods such as AM or FM or digital modulation such as 2FSK, 4FSK, BPSK, QPSK, DQPSK, offset QPSK, π/4-DQPSK, 8PSK, 16QAM, MSK and GMSK. Ideal signal sources for such tests are the Rohde & Schwarz Signal Generators SME and SMHU58 [2]. In the case of digitally modulated signals, all that has to be done is to enter into FSE the modulation type, symbol rate and receive filter. With this information, FSE demodulates the RF signal down to bit level. The symbol rate is freely selectable up to 1.6 Msymbols per second. As receive filters, Gaussian, cosine and root cosine filters with user-selectable parameters are available. The demodulator of FSE-B7 is synchronized to the frequency and the symbol clock of the test signal and evaluates it in accordance with the modulation type entered.

Thus all RF signals commonly used and standardized in **mobile radio** can be processed:

- GSM, DCS1800 (PCN) or DCS1900 (PCS) worldwide,
- NADC (North American digital cellular),
- Qualcomm CDMA (code division multiple access),
- PHP (personal handy phone, Japan),
- PDC (personal digital cellular, Japan),
- DECT (digital European cordless telephone, Europe, Canada),
- CDPD (cellular digital packed data),
- MOBITEX (mobile data system),
- TETRA (Trans-European trunked radio),
- ERMES (European radio message system),
- CT2/CT3 (cordless telephone),
- APCO25 (Association of Public Safety Communications Officers, Project 25),
- TFTS (terrestrial flight telephone system).

These standards can be directly called by means of softkeys. FSE evaluates signals according to the criteria listed below and displays the **results on the monitor:**

- magnitude and phase, or frequency, as a function of time,
- in-phase and quadrature signals,
- eye and trellis diagrams,
- vector representation in polar diagram,
- constellation diagram,
- table with demodulated bits.

FIG 3 shows a vector representation of a TETRA signal in a polar diagram. TETRA uses π/4-DQPSK modulation at a data rate of 36 kbit/s.

A variety of trigger functions is available for selecting a specific part of the signal. Coarse triggering can be performed free-running, level-dependent or by means of an external signal. The trigger determines the start of reading the measured values into memory. A particular burst can be searched for in the memory. This is especially important for TDMA signals, which transmit information in time slots. It is also possible to synchronize on bit sequences of the signal. Signal display will in this case be related to synchronization sequences in the signal (eg midamble in GSM bursts).

Measurement of modulation errors

Among the most important measurements on digitally modulated signals is the determination of modulation errors. Depending on the type of modulation used, the phase error (modulation with constant amplitude, eg GSM) or the phase and amplitude errors (modulation with amplitude and phase component, eg NADC, TETRA, PHP,

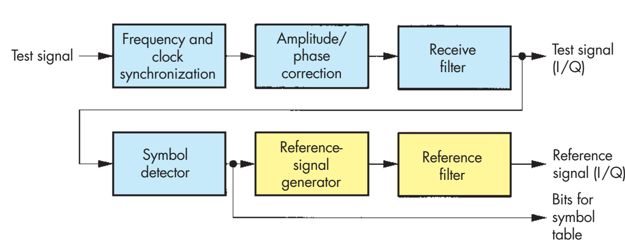

FIG 4
Processing steps in FSE for determining modulation errors

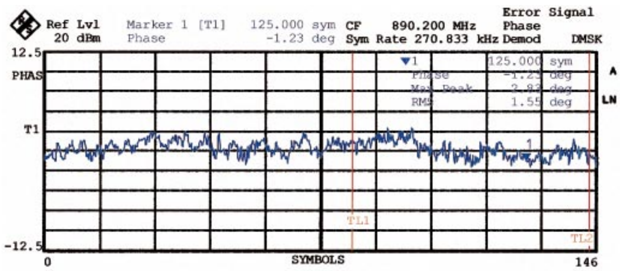

FIG 5
Phase error of GSM burst shown over useful burst range

PDC) are of interest and specified in the relevant standards. For error calculation FSE generates the analog, ideally modulated signal in the baseband (I/Q level) from the demodulated bit stream. FIG 4 shows the processing steps.

For calculation of modulation errors, all parameters of the measured signal and the reference signal are compared. The result can be represented as a trace versus time or symbols, or output numerically as a sum value in an error table. FIG 5 shows the phase error of a GSM burst versus time as an example of a modulation-error measurement.

The error limits of the instrument itself play an important role in modulation-error measurement. In practice the instrument should have an accuracy ten times better than that of the DUT. In the case of GSM for example, a maximum rms phase error of 5° and peak phase error of 20° are allowed. FSE offers excellent values especially with regard to phase noise, so that for GSM phase measurements a residual error of <0.5° (typ. 0.2°) rms and <1.5° peak can be guaranteed. For π/4-DQPSK modulation used by NADC, TETRA or PDC, the error vector magnitude is <0.7% rms and <2% peak. The tolerances permitted by the standards can thus be practically completely allowed for the DUT as no significant part is taken up by the measuring instrument.

Power measurements in time domain

In the case of transmission methods using time multiplexing, each subscriber is assigned a specific time slot in the transmission channel. Timing is defined in the form of tolerance masks, which each transmitter must comply with. A synchronization sequence in the signal (eg the midamble with GSM, DCS1800 or DCS1900) is mostly used as a time reference for the tolerance masks. Accurate measurement of the burst characteristic is therefore possible only by demodulating the signal. Using the vector signal analyzer, FSE exactly determines the time reference by evaluating the demodulated bits and allocating them to the stored samples. With eight samples per symbol, the error limits for the time reference are <6.25% of symbol period without clock synchronization, and <1% of symbol period with clock synchronization.

Measurement speed

FSE not only sets new standards in spectral analysis in terms of dynamic range, precision and measurement speed, but also in modulation analysis. The high measurement speed is based on computing power not common in spectrum analyzers so far. An internal 486 PC is provided for handling the user interface and remote control. Otherwise the PC is free for application programs run on FSE. Measurement speed is not reduced as there is no time-sharing with test runs. Measurements as well as the evaluation and display of results are handled by a network of five transputers. The demodulators and modulation measurements are implemented by means of four digital signal processors coupled to the transputer network. For GSM phase-error calculation for example, the high computing power enables up to five measurements per second.

With its excellent characteristics in spectral and vector signal analysis and its high flexibility, FSE is an ideal development tool. For applications in production, the high measurement speed and configurations in line with standards make FSE a value-for-money one-box solution for all measurements of RF parameters on transmitters.

Josef Wolf

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Condensed data of vector signal analyzer of FSE

Frequency range	100 kHz to 3.5/7 GHz
Demodulators	AM/FM/PM, 2FSK, 4FSK, BPSK, QPSK, DQPSK, O-QPSK, π/4-DQPSK, 8PSK, 16QAM, MSK, GMSK
Symbol rate	max. 1.6 Msymb/s
Receive filters	Gaussian, cosine, root cosine, α/BT = 0.2 to 1
Display modes	magnitude, phase, frequency, eye/trellis diagram, vector diagram, constellation diagram, demodulated bits
Measurements	magnitude error, phase error, frequency error, error vector (magnitude), I/Q offset, I/Q imbalance

Reader service card 150/06

Digital Monitoring Direction Finders DDF0xM

State-of-the-art monitoring direction finding from HF to UHF

The compact, remote-controllable Digital Monitoring Direction Finders DDF0xM are of modular design and operate as correlative interferometers or on the proven Watson-Watt principle. They can easily be integrated into computer-controlled receiving systems, eg for postal radiomonitoring, in the military sector, for police, border guards, customs and coastguard authorities. A wide range of antennas is available for stationary and mobile uses, including wide-aperture systems, which afford high accuracy and sensitivity even under harsh environmental conditions.

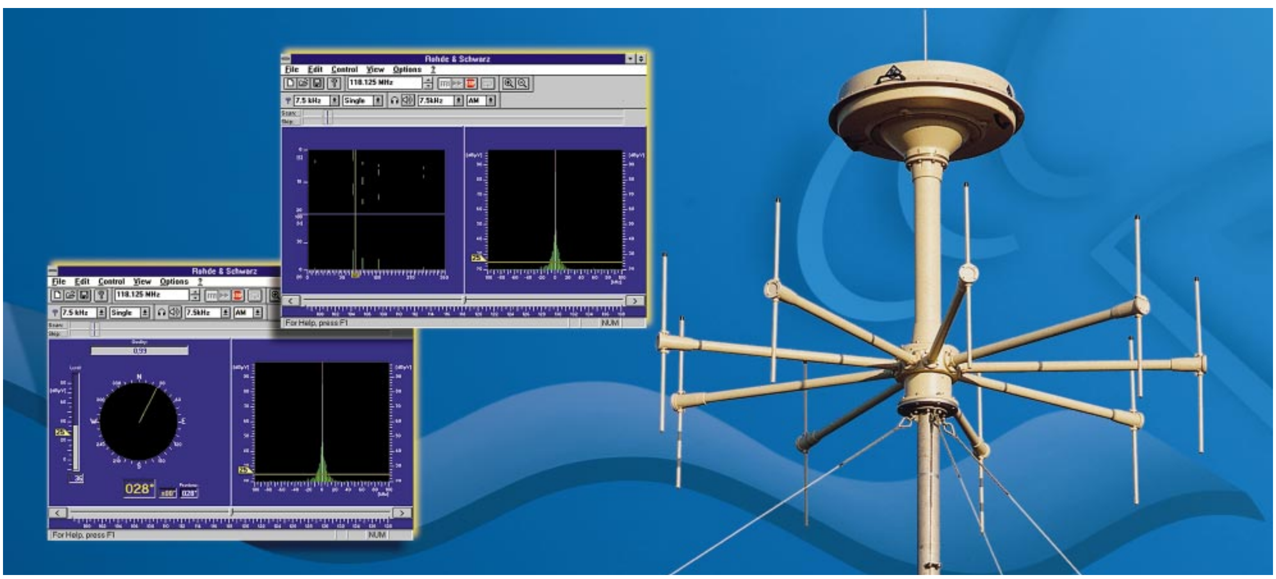


FIG 1 User interface of digital HF-VHF-UHF Monitoring Direction Finder DDF0xM in fixed-frequency mode and VHF-UHF DF antenna

The Rohde & Schwarz doppler Direction Finders PA010 and PA055 and their mobile counterparts PA510 and PA555 have for many years been a great success all over the world. It is in the nature of the doppler principle that the capabilities of these direction finders are limited when it comes to intercepting very short signals as used in frequency hopping, burst and GSM transmissions. For uncomplicated bearings on such signals, Rohde & Schwarz has developed a new generation of direction finders using digital signal processing: DDF0xS for fast scanning [1] and the brand-new DDF0xM mainly for monitoring tasks in the frequency range 0.3 to 3000 MHz (FIG 1). DDF0xM direction finders can also be used for scanning, the probability of intercept being markedly higher than that of conventional direction finders, which can process the signal in only one channel at a time. The direction finders of the DDF family analyze all signals within a frequency window simultaneously with the selected resolution. In the search and scan modes the direction finders behave like several DF units connected in parallel.

The DDF direction finders first determine the complex voltages of the DF antenna and from these calculate the azimuth and, if desired, the elevation. The DF method used can be selected as required to match the task on hand. Besides the classic DF method based on the Watson-Watt principle, these direction finders offer state-of-the-art **correlation methods**, which afford many **advantages** over classic methods:

- extremely high accuracy, sensitivity and flexibility,
- use of wide-aperture, circular-array antennas with a minimum number of radiators (eg circular arrays 1 m in diameter with nine antenna elements covering the wide frequency range 20 to 1300 MHz, or a single array approx. 50 m in diameter for the complete shortwave range),
- high flexibility with respect to antenna geometry,
- in mobile use, very effective reduction of DF errors introduced by platform possible through calibration,
- use of correlation coefficient as criterion for DF quality,
- use as a first step towards high-resolution DF methods.

To measure the complex antenna voltages, DF receivers of one through n paths can be employed. DDF0xM uses a three-path vector voltmeter which is capable of monopulse processing (eg using the Watson-Watt method). The voltmeter is based on VHF-UHF Receiver ESMC [2], which turns the DF unit into a high-quality DF receiver. Wide-aperture DF antennas are

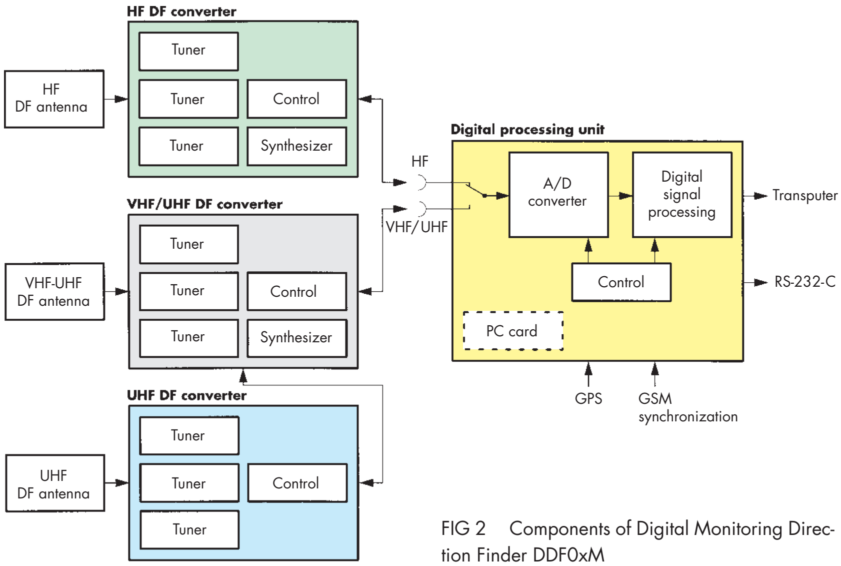


FIG 2 Components of Digital Monitoring Direction Finder DDF0xM

scanned in pairs, resulting in short DF times even for this type of application.

Design and operation

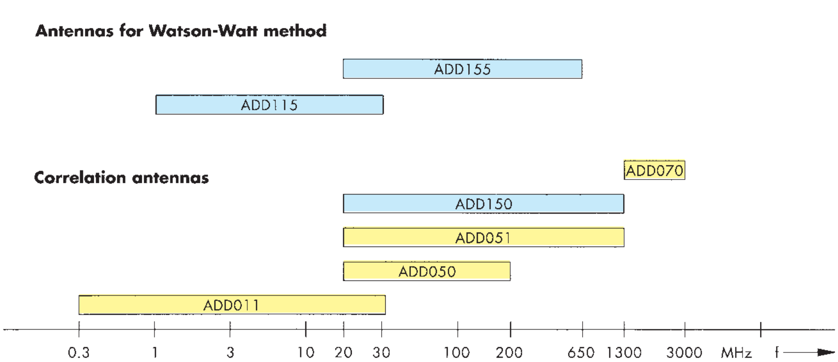
The monitoring direction finders are available in the following **versions:**

- DDF01M for HF (0.3 to 30 MHz),
- DDF05M for VHF/UHF (20 to 1300/3000 MHz),
- DDF06M for HF/VHF/UHF (0.3 to 1300/3000 MHz).

In the three-path receiver frontends the received signal is converted to an IF of 768 kHz (FIG 2). In the digital processing unit the IF is digitized with 16-bit resolution and processed with a real-time bandwidth of 200 kHz (VHF/UHF) or 25 kHz (HF) using fast Fourier transform and polyphase filter banks.

In their basic version, DDF0xM direction finders have no display or control elements on the front panel apart from status-signalling LEDs. The direction finders are operated via an external PC running under the MS Windows NT™ operating system; the DDF operating software is supplied as standard. The digital processing unit is optionally available with a built-in PC and a colour TFT display (approx. 12 cm x 16 cm; 480 x 640 pixels). For this version, special emphasis was placed on the effective suppression of computer-specific EMI, which is of particular importance for direction finders installed in vehicles, as in this case the DF antenna and the DF equipment are usually located close to each other.

FIG 3 Overview of DF Antennas ADD (blue for mobile, yellow for stationary use)



Range of antennas

Two types of DF antenna are available for DDF direction finders (FIG 3):

- compact Antennas ADD115 and ADD155 capable of handling monopulses and designed for maximum DF speed, which together cover the range 1 to 650 MHz (Watson-Watt method),
- correlation DF Antennas ADD011, ADD050, ADD150, ADD051 and ADD070 characterized above all by high DF accuracy and immunity to multipath propagation.

The following **features** are common to all seven antennas:

- large bandwidth,
- integrated lightning protection (ADD150, ADD050 and ADD051 protected as standard against direct strokes),
- wide dynamic range,
- compact design,
- connector for electronic compass.

FIG 4 HF DF Antenna ADD011 (0.3 to 30 MHz, correlation method) Photo 42 342

HF antennas: The compact **ADD115** for the frequency range 1 to 30 MHz, which is only 1.1 m in diameter and accommodated in a radome, is made up of two orthogonally arranged loops and an omnidirectional antenna. Its compact size and lightweight but sturdy construction make this antenna ideal for mobile use. Antenna **ADD011** for 0.3 to 30 MHz (FIG 4) is intended for stationary and transportable use

FIG 5
VHF-UHF DF
Antenna ADD051
(20 to 1300 MHz,
correlation method)
Photo 42 334/1

VHF-UHF antennas: Antenna **ADD150** is designed for universal applications in the frequency range 20 to 1300 MHz. It is accommodated in a radome 1.1 m in diameter and about 0.2 m high. This compact size makes the antenna an ideal choice for applications onboard vehicles, ships and aircraft. The antenna is protected against direct lightning strokes as standard and can thus without any restrictions be mounted on masts and buildings. Antenna **ADD050** offers enhanced accuracy and sensitivity in the frequency range 20 to 200 MHz. This circular-array antenna with a diameter of 3 m is suitable for stationary and transportable applications. DF Antenna **ADD051** (FIG 5) is a combination of ADD050 and ADD150 mounted on a common mast. It covers the complete range of 20 to 1300 MHz with maximum accuracy and sensitivity.

With its short DF times (minimum signal duration ≤500 μs for VHF-UHF, as short as 10 μs with monopulse amplitude processing) and with external synchronization, DDF05M can take bearings even of GSM signals. Since, with the correlation method, not only the azimuth but also the elevation of skywaves is determined in the HF and allows direction finding even of skywaves of high angles of elevation as well as determination of elevation angle, thus enabling fixing of signal sources using the single-station-location (SSL) principle.

UHF antenna: Antenna **ADD070** is available for the frequency range 1300 to 3000 MHz. It is designed as a circular-array antenna with a central reflector and can be mounted on a single mast together with the VHF-UHF antennas.

Operating modes

The most important operating mode of DDF0xM direction finders is the fixed-frequency mode (FFM). In FFM (FIG 6), the direction finder can be matched to the signal characteristic in various ways. As to the display type, a histogram can be selected besides conventional (three-digit) numeric and polar representation with display of the elevation angle and DF quality indication. In addition the spectrum about the receive frequency (±12.5 kHz in the HF range, ±100 kHz in the VHF-UHF range) can be shown in realtime with selectable resolution.

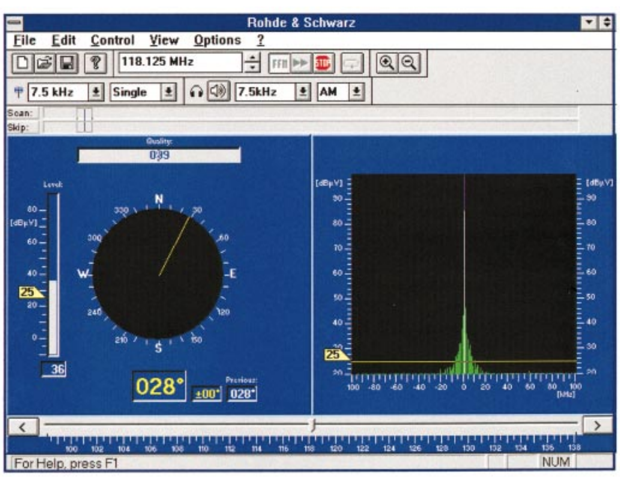


FIG 6 User interface of DDF0xM in fixed-frequency mode

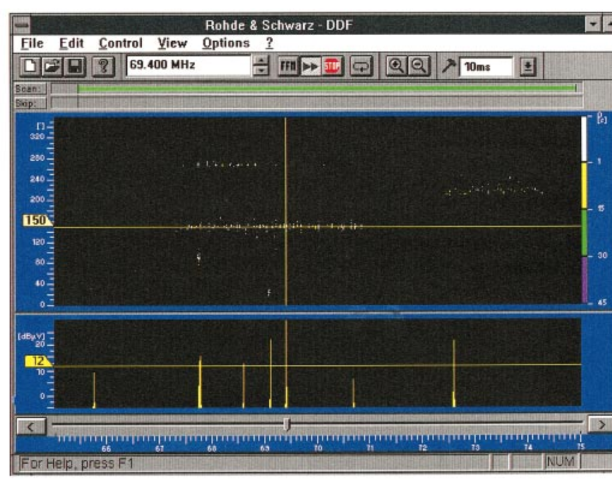


FIG 7 User interface in scan mode

range, DDF01M is equally suitable for single-station location (software option).

Apart from the fixed-frequency mode, DDF0xM direction finders can be operated in the search and scan modes, where the advantages of the large realtime bandwidth used for spectral analysis come into their own. In the scan mode (FIG 7) the direction finders scan a range defined by a start and a stop frequency and with selectable resolution. Only those bearings that are above a preset threshold are indicated, and scanning is not interrupted upon detection of a signal. In the search mode, on the other hand, operation is interrupted for a selectable dwell time when a signal above threshold is detected so that the signal can be examined in more detail. Searching and scanning cannot only be performed over specified frequency ranges but also in individual, stored channels (up to 1000).

DDF0xM direction finders can of course be remote-controlled in all functions and over any distance. Functionality depends however on the transmission rate of the data link used. The WinLoc radiolocation program [3] provides a driver that allows integration of DDF0xM direction finders operating in fixed-frequency mode into triangulation systems.

Franz Demmel; Ulrich Unselt;
Dr. Eckhard Schmengler

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Condensed data of Digital Monitoring Direction Finders DDF0xM

	DDF01M	DDF06M / DDF05M
Frequency range	0.3 to 30 MHz	20 to 1300 (3000) MHz
DF method	correlative interferometer, Watson-Watt	
DF error	<1° RMS with ADD011	<1° RMS with ADD051
Sensitivity	typ. 1 μV/m with ADD011	typ. 1 μV/m with ADD051
Operating modes	FFM, scan, search	
Realtime bandwidth	25 kHz	200 kHz
Dynamic range	120 dB	
Minimum signal duration	<5 ms	<500 μs
Demodulation	AM, FM, SSB	
Displays		
FFM	numeric and polar DF value, DF quality, level, elevation, spectrum within realtime bandwidth, DF value versus time (waterfall diagram)	
Scan	levels and DF values versus frequency, frequency versus time (waterfall diagram)	

Reader service card 150/07

Matsushita relays in Audio Analyzer UPD measure the best of audio

"When the sounds of hifi units or amplifiers are measured, relays are often to be found. Like in Audio Analyzer UPD from Rohde & Schwarz,

a compact, general-purpose instrument for determining all audio parameters on analog and digital interfaces. The excellent quality of this instrument with its integrated PC owes much to its digital technology." This praise of our Audio Analyzer UPD appeared in an application report in "newsline" (May 1995) from Matsushita Automation Controls Deutschland GmbH.

Matsushita Automation Controls is a group that operates worldwide. It markets precision components and systems for plant automation, and is an affiliate of Matsushita Electric Works Ltd, Japan, one of the world's biggest electric concerns. The production range includes relays, timers and counters, switches and connectors,

sensors, stored-program controllers and image-processing systems. Sö

Solid-state UHF TV Transmitter NH500

The new reference for TV transmitters: ecoTV

About a year after the presentation of its solid-state TV transmitter for band III, Rohde & Schwarz is launching the solid-state TV Transmitter Family NH500 for band IV/V. Thanks to its modularity, transmitters with output power from 5 to 30 kW can easily be implemented at a favourable price. Any standby concepts as well as different standards are possible.

FIG 1 Solid-state UHF TV Transmitter NH500, the TV transmitter nicknamed ecoTV

The new solid-state UHF TV transmitters of the NH500 series (FIG 1) presented by Rohde & Schwarz at the TV Symposium 95 in Montreux [1] operate, like solid-state VHF Transmitters NM..5 [2], with Exciter SD200. This exciter with all-electronic tuning is designed for PAL, PALplus, NTSC or SECAM colour-television transmission as well as for dual-sound and stereo operation (IRT or NICAM). It directly drives the amplifier modules for vision and sound (FIG 2) without the use of preamplifiers. Very high transmission reliability is guaranteed by the multiple redundancy of all RF power stages and power supplies (many identical plug-in modules), even for operation with only a single transmitter.

The transmitter is nicknamed "ecoTV" as it consumes little power, requires little space and is low on logistics due to identical vision and sound amplifiers. This means savings in operating costs and also in infrastructure. Solid-state Transmitters NH500 have the following **main features:**

- clearly arranged, modular configuration,
- power stages 5/7.5/10/15/20/30 kW,
- no signal degradation on removal of power amplifiers,
- protection facility in each amplifier and power supply,
- patented R&S circuits for power control, phase regulation and characteristic correction,
- exciter with precorrection of nonlinear output-stage characteristics, regulated output power for vision and sound, regulated modulation signals, synthesizer, precision offset, SAW vestigial-sideband filter, sync-pulse regeneration, dual-sound coding and memory with four transmitter basic setups including precorrection,
- split vision/sound amplification,
- broadband amplifiers and power couplers from 470 to 860 MHz,
- bipolar high-power double transistors,
- low junction temperature of output-stage transistors (<120°C/APL = 50%),
- power supply with primary-switched regulators for very high efficiency,
- microprocessor-based transmitter control unit for operation, monitoring and remote control,
- integrated automatic switchover for option "passive exciter standby", "active dual output stage", "passive transmitter standby",
- very low heat dissipation thanks to forced-air cooling,
- high transmitter efficiency,

- optional PAL, PALplus, NTSC or SECAM transmission,
- optional parallel or serial remote interface.

Mechanical design and operation

The interfaced modular design throughout allows virtually all possible transmitter configurations with regard to location and customer standby concepts. The transmitter is divided into two racks. The **exciter rack** accommodates Exciter SD200, a transmitter control unit with display panel and remote interface, vision/sound diplexer and colour-subcarrier trap. The **power-amplifier rack** houses vision and sound amplifiers including power couplers, absorbers, power supply and harmonics filter. This rack can have up to ten plug-ins to provide vision power of 10 kW and sound power of 1.8 kW. For higher power, further racks with amplifier plug-ins are simply added to the transmitter. A monitoring unit integrated in each rack signals operating states to the central control unit.

The **amplifier and power-supply plug-ins** are self-engaging (supply voltage, RF input, RF output, control and monitoring bus) and can be replaced without having to interrupt operation. After releasing a safety catch on the power supply, the supply voltage and thus the RF power of the amplifier plug-in to be removed are blocked – the plug-in can be withdrawn with power switched off. The amplifier and power-supply plug-ins form an air duct. Thus, the amplifier rack merely requires an energy-saving, low-pressure cooling system.

The RF power of the **vision-amplifier and sound-amplifier plug-ins** in the rack is combined by 0° couplers in triplate technology. The associated absorbers mounted on a heatsink are placed direct in the cooling air stream. A diplexer feeds the vision and sound power to the common antenna line. A colour-subcarrier trap for signals with a –4.43 and –8.84 MHz spacing from the vision carrier prevents spurious emission in the lower vestigial sideband. A built-in lightning arrester protects the transmitter output from lightning strokes at the antenna.

The **microprocessor-based transmitter control unit** handles the switch-on sequence, monitoring, display, LED indicators and remote control. The hardware for controlling "passive exciter standby", "active dual output stage" or "passive transmitter standby" is already integrated. To activate any of these, the RF switches with control and RF cables and software are all that is required.

Exciter and 1.5-kW broadband amplifier

Exciter SD200 is used to produce standard RF vision and sound signals, to regenerate sync pulses and to accommodate precorrectors for linear, nonlinear and dynamic errors in the output stage. It is equipped for split or combined amplification and designed for dual-sound operation to IRT and NICAM. Setting of the exciter is fully electronic by software. All parameters such as basic setting of levelling or output-stage-specific precorrections are set from the display unit using the keypad and rollkey and are stored in non-volatile memory. For special conditions, such as operation at reduced power, for repairs or (n+1) standby, four configurations can be defined for level, linearity and group delay for example. The exciter can be set to a new configuration by command.

The **vision and sound amplifiers** are of identical design. The amplifier plug-in is rated for 1.5 kW sync peak power and for 900 W CW or peak sound power (dual-sound operation). It comprises a regulated predriver with integral input-power monitor, level and phase control as well as a class-A driver stage for the drivers of class-AB output-stage transistors. Eight output-stage modules decoupled from each other and for power of 220 W each are combined to obtain nominal power of 1.5 kW (vision) or 900 W (sound). The total gain of the plug-in is approx. 53 dB. The power coupler with integral directional couplers for monitoring is a printed circuit requiring no adjustment. The RF amplifiers operate with standard transistors. At present, transistors from four well-known manufacturers are available and can be used without having to modify layout or adjustment.

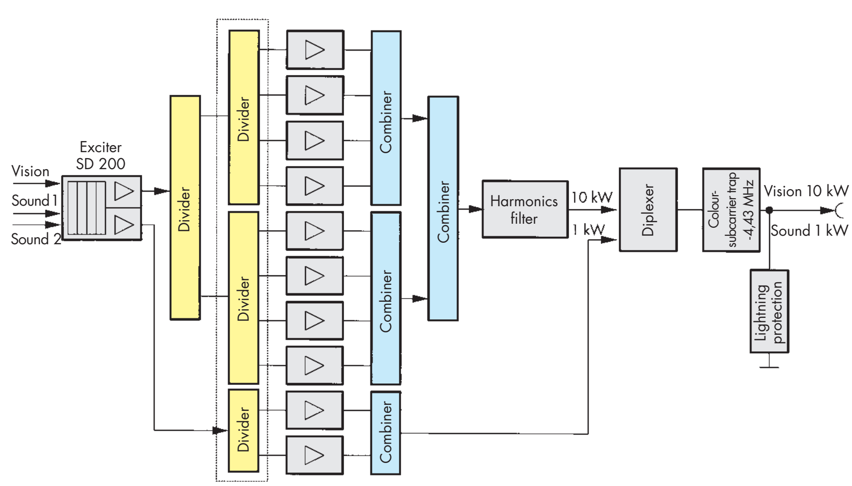

FIG 2 Block diagram of 10-kW TV Transmitter NH510

The amplifier plug-ins are designed to withstand severe conditions such as mismatch at VSWR of 1.5, a permanent all-black picture and inlet air temperature of +45°C. A monitor using the latest SMD technology protects the amplifier against overloading and signals the plug-in operational status to the transmitter control unit. Should a 220-W power module fail, the patented power-regulating circuit prevents the other 220-W power modules from being driven to the full. All modules remain at the same power level and operating point without any change in distortion. The same quality data are thus maintained. LEDs on the plug-in front panel indicate amplifier failures, VSWR >1.5, amplifier overtemperature and out-of-range of the RF level at the amplifier input. Furthermore, the RF output level, the RF phase and the RF threshold of the output power can be set.

Transmitter control unit, monitoring and automatic switchover

The transmitter control unit is the switching center of the transmitter. It ensures the correct switching sequence of the cooling system, power supply and control power. It also monitors air flow, the inlet and outlet temperature and the operating status of the RF power plug-ins, the power supplies and the complete transmitter. A fully integral part is also the automatic switchover for "passive exciter standby", "passive transmitter standby" and "active dual output stage" with the corresponding control fields which are activated by matching front-panel plates and software.

A clearly arranged display panel allows simultaneous indication of three freely selectable operating parameters. Vision, sound-1 and sound-2 power or reflected vision power, reflected sound power, inlet temperature, outlet temperature, absorber power of diplexer, etc are displayed. A current error is displayed in the status line. All basic settings such as power levels, RF thresholds or temperature warning threshold of outgoing air are set using the keypad and rollkey and are stored nonvolatile. Up to 40 transmitter defects with date and time can be stored in a large memory and displayed when required. All relevant messages and commands according to standard specifications are available at the remote interface optionally in parallel (1864-1 relaying) or serial (bitbus/IEC 864-2) form.

Power supply and transmitter cooling

Two amplifier plug-ins are fed from a power-supply plug-in. To ensure high reliability, the power section of the plug-in contains three identical, separate, primary-switched regulators for the collector supply as well as two DC-voltage converters for base-current supply of the RF transistors. Due to the high switching frequency of approx. 100 kHz, size and weight are reduced to a minimum and power-supply efficiency of about 86% is obtained. Built-in monitors protect the power supply against overcurrent, overvoltage and overtemperature.

The heatsinks (optimized by computer simulation) for amplifier and power-supply plug-ins with a very low pressure drop in the air flow allow the use of energy-saving, low-pressure cooling systems. The inlet and outlet air can be routed to the transmitter top or bottom.

Digital signal transmission

The transmitter is ready prepared for future digital TV-signal transmission. Only the vision modulator and monitor of the exciter have to be exchanged for appropriately modified modules. The precorrector for the class-AB output stages can handle COFDM signals (coded orthogonal frequency division multiplex). The power and level monitors in the amplifier are also ready for upgrading.

Hans Seeberger

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Condensed data of solid-state UHF TV Transmitter NH500

Frequency range	470 to 860 MHz
Output power, vision	5/7.5/10/15/20/30 kW
Output power, sound	0.5/0.75/1/1.5/2/3 kW
Output impedance	50 Ω
Standards	B/G, M/N, D/K, I (others on request)
AC supply	3 x 230/400 V, 47 to 63 Hz
RF output	RL68 or RL100, depending on power

Reader service card 150/08

150-W HF Dipole HX002A1

The antenna for reliable shortwave links

Even in the age of optical-fiber and satellite links there is a need for other communication media. Experience gained from critical situations shows that even for very broadband and powerful satellite links bottlenecks in communication can occur. Just as in the past, shortwave can be recommended as an information carrier with many advantages and with it HF Dipole HX002A1 from Rohde & Schwarz.

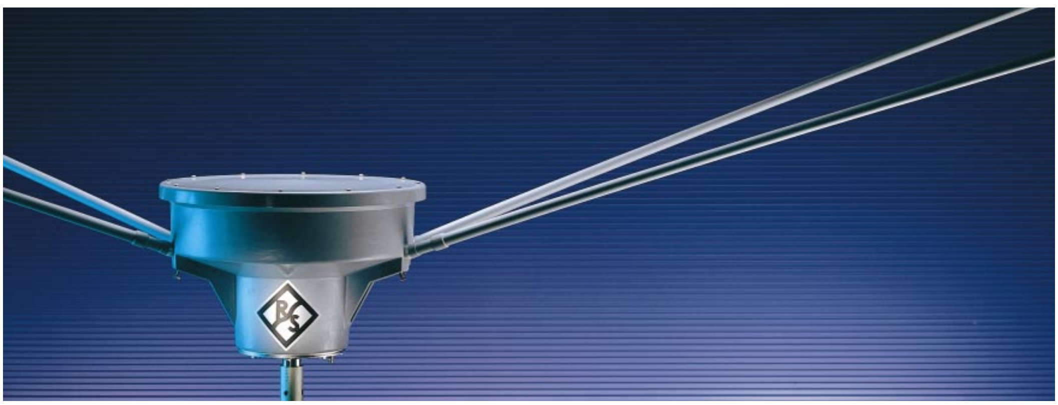


FIG 1
150-W HF Dipole HX002A1
Photo 41 579

Offering independence from infrastructure, providing a free transmission medium and given the big advances made in the development of secure transmission methods, shortwave has, in many cases, become a full-value information medium. The antenna has a major influence on the transmission quality. Any losses at this point of the transmission link cannot be made up for at a later stage. That is why investments in antennas that are state-of-the-art always pay off. Especially in the 100-W class it is very important not to waste any of the effective radiated power by using low-cost antennas. As modern transmission methods often operate with a very large bandwidth, the antenna becomes more and more important for obtaining sufficient signal/noise ratio.

With the newly designed 150-W HF Dipole HX002A1 (FIG 1), Rohde & Schwarz offers a 100-W class model to go with the tried and tested Antenna HX002 for 1 kW [1]. Its main characteristics are problem-free and cost-effective antenna installation, optimum radiation patterns and maximum reliability.

The availability of the communication link is of major importance for any shortwave user. Antennas with optimized performance data such as radiation patterns and gain make a vital contribution to fulfilling this requirement. The radiation pattern has to be matched to the time- and frequency-dependent wave characteristics of the ionosphere and to the orientation and length of the transmission link: steep takeoff angles and low frequencies are required for distances of up to some hundred kilometers whereas flat takeoff angles and higher frequencies are needed for longer distances [2]. Short and medium distances are especially problematic as the low frequencies used do not lend themselves to implementing a compact antenna. That is why rod and loop antennas have been used up to now in many cases. The drawbacks of these antennas compared to HF Dipole HX002A1 are illustrated in FIG 2. Despite the reasonable gain of the rod antenna, the null in the zenith of the radiation pattern prevents high-angle radiation and the socalled skip zone is formed. Loop antennas, on the other hand, may have radiation directed upwards but efficiency and thus gain leave a lot to be desired with regard to the available antenna sizes.

Low-loss dipole antennas arranged horizontally at a sufficient height above ground yield the required radiation patterns and satisfactory gain. Compact antennas of high efficiency that are small in relation to the operating wavelength require low-loss tuning networks, however, to ensure matching with the feeder cable or with the transmitter output impedance. In systems with automatic link setup, for example, these networks have to be tuned fully automatically in a fraction of a second. Broadband solutions in the form of dipoles attenuated with resistors (implemented as loaded dipole, terminated folded dipole, inverted-V, delta antenna, etc) do not yield acceptable gain even with

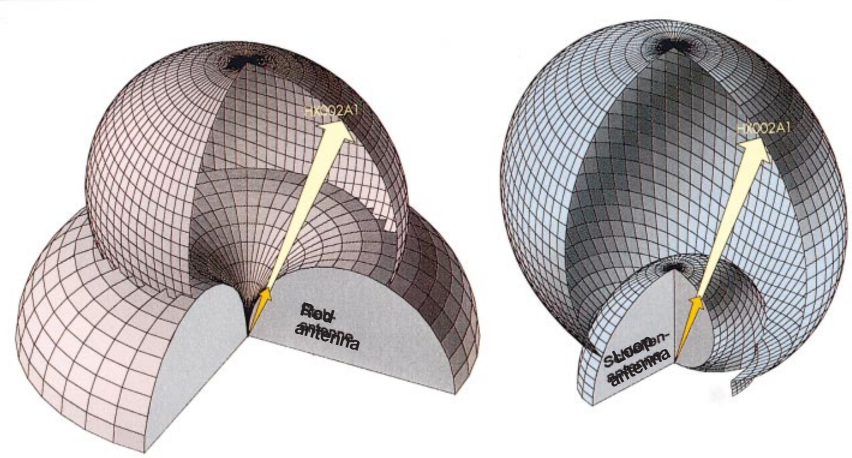


FIG 2 Spatial radiation patterns of rod antenna, loop antenna and HX002A1 at f = 3 MHz. Left: overall HX002A1 pattern compared to that of rod antenna. Right: patterns of loop antenna with side length of 1.4 m and HX002A1. Arrows indicate typical propagation path for medium-range link. Arrow length is measure of field strength generated along this propagation path.

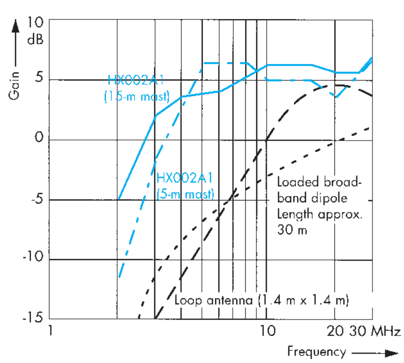


FIG 3 Gain of different shortwave antennas

larger antenna sizes (FIG 3) [3]. Moreover, the required infrastructure such as two masts, additional foundations or tie points on adjacent buildings often nullifies the advantage of a relatively favourably priced antenna.

150-W HF Dipole HX002A1 fully meets all the requirements. Its most important **features** are:

- single mast,
- compact size,
- high gain,
- no control cable,
- setting time < 30 ms.

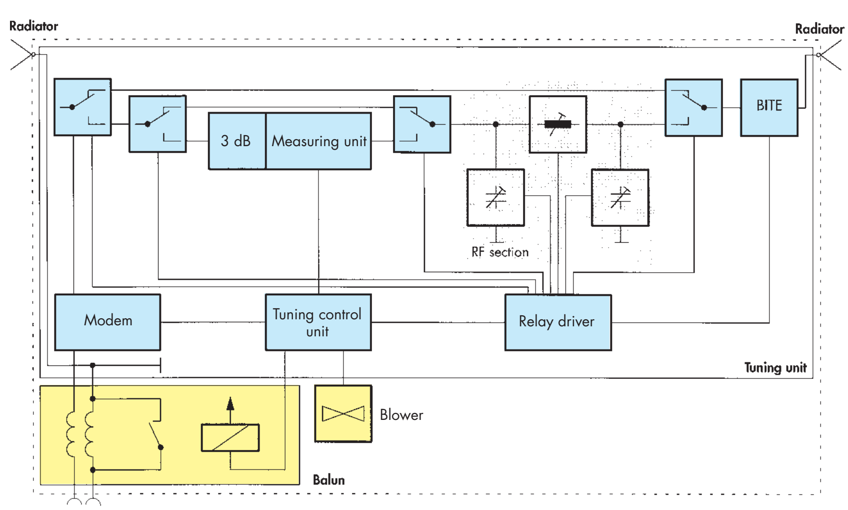
All these excellent features are obtained by integrating the tuning network into the feedpoint of the dipole and by using ultramodern microelectronics. Thanks to its low weight of only 35 kg together with a self-supporting single mast and span of only 10 m, the antenna is ideal for use where the available space is limited as on rooftops in heavily built-up areas. For this application Rohde & Schwarz offers 5-m Mast KM002A1. When the antenna is to be mounted above ground or on very large roof areas, 15-m Mast KM451B2 can be provided.

With a bottom limit frequency of 1.5 MHz the application range of the antenna is greatly extended compared to common high-angle HF radiators: below 2 MHz the antenna is designed to excite mostly groundwaves. Thus the availability of radio links over distances of up to 100 km is further increased due to the fact that these waves propagate above ground independently of the conditions of the ionosphere.

Design

The radiators as well as the automatic tuning unit and balun are part of the compact antenna head of HF Dipole HX002A1 (FIG 4). The tuning elements of the RF section consist of a number of low-loss capacitors and air coils whose values are binary-stepped. The tuning control circuit with its microprocessor core allows rapid and continuous tuning. The typical tuning time at unknown frequencies is 3 s. Tuning settings for up to 1500 frequencies are stored in a nonvolatile learn memory. The time required for repeated tuning is thus drastically reduced to typically 200 ms.

FIG 4 Block diagram of HF Dipole HX002A1



In channel mode the previously learnt tuning settings can be set direct without retuning. In this case the setting time is again reduced to less than 30 ms.

A built-in test equipment (BITE) signals any impermissible operating state to the transceiver connected. Thus the antenna can be protected against overtemperature, overvoltage and overcurrent. The connection to the transceiver or junction unit is noteworthy: the supply voltage, high frequency and control signals are transmitted via a single one-core cable. As no additional control cable is required, setup of the antenna is particularly simple and inexpensive.

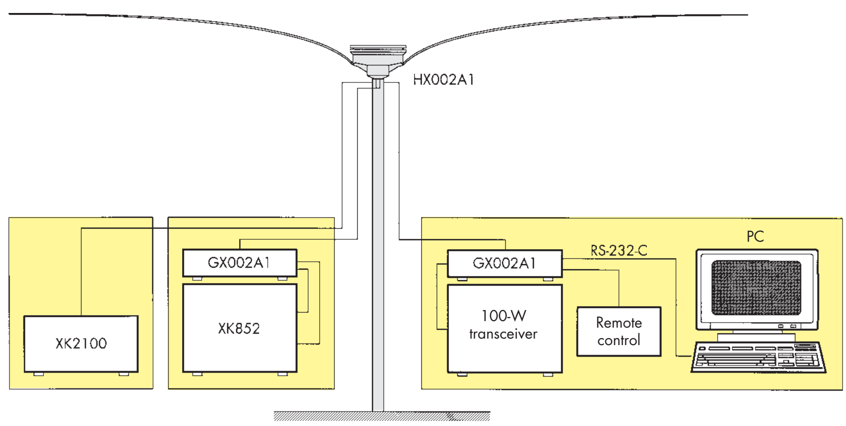


FIG 5 Uses of HF Dipole HX002A1

Use

Antenna HX002A1 can be operated with practically every 100-W shortwave transceiver (FIG 5) and especially easily with Rohde & Schwarz units. Thus the antenna is the ideal complement to HF Transceiver Family XK200 [4] with all its benefits. For setups with XK852, **Junction Unit GX002A1** integrates the antenna into the transceiver operating concept. The antenna need not be operated alone as it is always controlled fully automatically by the transceiver. This also applies to systems using the ALIS processor from Rohde & Schwarz for automatic link setup.

Basically, any 100-W shortwave system can benefit from the advantages of HX002A1. Junction Unit GX002A1 is the link between a non-Rohde & Schwarz 100-W transceiver and the antenna. **Antenna operation** is then limited to three functions:

- triggering of tuning,
- selection of receive mode (narrowband or broadband),
- starting of selftest and display of test results, ie continuous monitoring of key antenna parameters.

These operations can be performed on the junction unit itself, by remote control or from a PC via an RS-232-C interface. Silent tuning and channel call is also possible via this interface. Any inadmissible operating state is signalled to the interfaces so that appropriate actions can be taken to protect the antenna (eg RF switch-off). In this way the antenna can rapidly and easily be integrated into existing shortwave systems.

Franz Demmel; Axel Klein

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Condensed data of 150-W HF Dipole HX002A1

Frequency range	1.5 to 30 MHz
Permissible RF power	150 W PEP, 100 W CW
Required tuning power (for non-R&S transmitters)	50 to 100 W
Input impedance	50 Ω
VSWR	≤ 1.5 (typ. 1.3)
Tuning time	new tuning typ. 3 s, repeat tuning typ. 200 ms, silent tuning ≤ 30 ms
Length of dipole/weight	10.7 m/approx. 35 kg
Junction Unit GX002A1	
Supply	battery 22 to 32 V, AC supply 100/120/220/230 V ±10%
Weight	8.5 kg

Reader service card 150/09

Test signals for digital television

Digital TV is coming in fast. Conventional TV receivers cannot handle digital signals, so new receivers or at least add-on equipment is needed. Development is in full swing at all manufacturers engaged in this field. Among other things, signal generators supplying defined test signals are required. An instrument combination suitable for this task is Arbitrary Waveform Generator ADS [1] and Signal Generator SMHU58 with I/Q modulator [2; 3] (FIG 1).

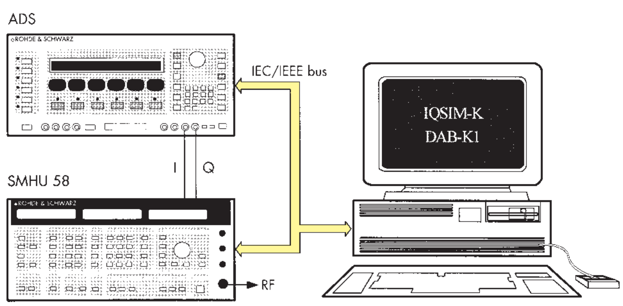

FIG 1
Setup for test-signal generation for digital TV

Transmission paths for DVB

DVB (digital video broadcasting) signals are propagated in three ways: via satellite, on cable networks and via terrestrial transmitters. Since the characteristics of the three methods are so fundamentally different, three different types of modulation standard had to be specified.

Satellite transmission basically functions like transmission on a microwave link. For this, QPSK modulation has been successfully used for a long time. This type of modulation was also chosen for satellite transmission. The attainable data rate depends on the available transponder bandwidth of the satellite and on the desired error protection of digital transmission. The transponder bandwidth of ASTRA 1D, for instance, is 33 MHz and that of succeeding satellites will be extended to more than 50 MHz. To guarantee the highest possible flexibility, a number of data rates ranging from 40 to over 80 Mbit/s have been specified in the standard. The wider the bandwidth, the higher the achievable bit rate. The higher the bit rate, the more programs can be transmitted simultaneously (FIG 2).

When DVB signals are fed into **cable networks,** a problem is encountered: existing networks have a bandwidth of 8 MHz, which cannot easily be changed. The new medium of digital TV therefore has to adapt itself to the given conditions, ie it has to manage with a bandwidth of 8 MHz. With QPSK modulation as used in satellite TV, a data rate of not more than 8 Mbit/s would be possible. However, since transmission on cables is as good as free of disturbance and features an excellent S/N ratio, multi-level modulation may be chosen. In this case 16QAM, 32QAM or even 64QAM modulation can be used, permitting 4, 5 or 6 bits to be transmitted with each modulation step instead of the 2 bits with QPSK. Thus data rates up to 42 Mbit/s can be obtained in an 8-MHz channel (FIG 3).

When digital TV signals are propagated via **terrestrial TV transmitters,** a combination of the problems involved with terrestrial DAB (digital audio broadcasting) and cable TV is encountered. Multipath reception occurs as with DAB and, in addition, the available frequencies are organized in 7- or 8-MHz channels. At present the modulation modes of the two systems are being combined: COFDM with 64QAM for the individual carriers (FIG 4). As in this case the signal bandwidth may be wider than with DAB, the number of carriers can be increased. Up to 6785 carriers spaced approx. 1.1 kHz are being considered at present. Thus the data rate of about 42 Mbit/s obtained in the cable network can be achieved in an 8-MHz channel or 7/8 of it (35 Mbit/s) in a 7-MHz channel.

Different signals – one solution

No matter how very different the modulation modes used for digital TV are, practically all of them can be generated with the combination SMHU58 + ADS [4]. This is made possible thanks to the flexibility of the arbitrary waveform generator. Computation of these signals is very complicated however. Here, software packages IQSIM-K and

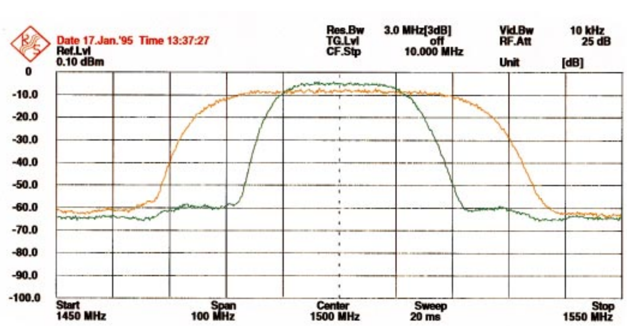

FIG 2
Spectra of DVB signals via satellite

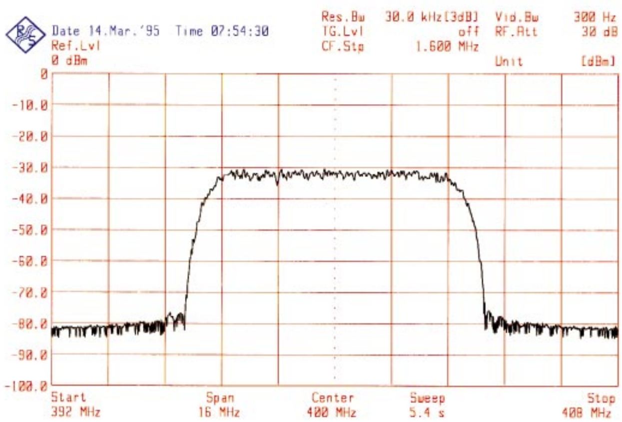

FIG 3 DVB signal for cable network

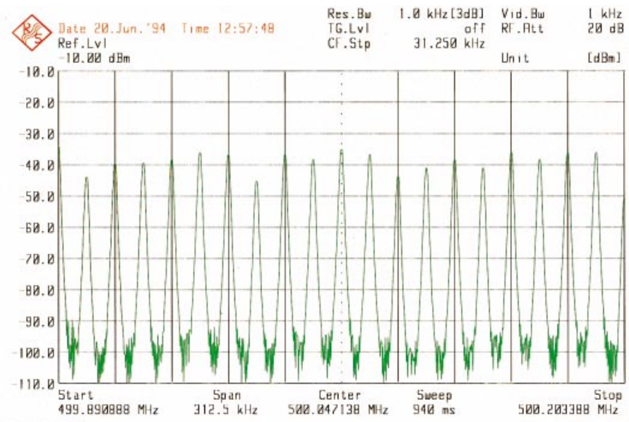

FIG 4 Detail of spectrum of terrestrial DVB signal (COFDM with 64QAM)

DAB-K1 provide the necessary support [5; 6]. Depending on whether a signal with only one modulated carrier is used as in satellite or cable TV, or a COFDM signal with a large number of carriers, the signals are calculated by means of IQSIM-K or DAB-K1.

Software IQSIM-K is able to handle virtually any type of modulation for transmitting data on a single carrier: FSK, PSK and, of course, QPSK and 16/32/64QAM, which are of particular interest here. Selectable signal filtering according to the $\sqrt{\cos}$ rolloff as stipulated by the DVB standard is also provided and may be adapted to modifications of the standard or expansions. The capability of impressing interference onto the normally very clean modulation signal may be of particular interest for development labs, eg the superposition of noise for BER measurements or the generation of modulation errors as may be caused by non-ideal I/Q modulators of transmitters. Thanks to versatile analyzing capabilities like spectrum display of the modulated signal, eye pattern, vector display or display of I/Q signals, modulated signals can be simulated already on a PC. After transfer to ADS, they are available for modulating SMHU58.

COFDM signals for terrestrial digital TV require completely different computation and handling. **Software DAB-K1** was therefore developed for these signals. The number of carriers to be generated can be set between two and 8190, the carrier spacing is freely selectable. Phase and amplitude of the individual carriers can be read in from a data file. Such a file is used, for instance, to generate a DVB signal for terrestrial digital TV transmission. The 12-bit amplitude resolution of ADS is also sufficient for future 256QAM modulation of the carriers. From the predefined phase and amplitude values, the program calculates a signal waveform whose spectrum after I/Q modulation shows exactly the predefined values. Of course, interference can also be generated with DAB-K1. For simulating fading effects, for instance, a certain number of carriers can be suppressed or a random amplitude or phase error be impressed. A special problem area with these signals is amplitude peaks of brief duration, whose clipping can be simulated.

For simulating a sequence of COFDM symbols as transmitted in sound and TV programs, several symbols are computed consecutively and stored in ADS. Up to 25 different symbols (or altogether 64k data words) can be saved. The symbols are then organized in a sequence in which the same symbol may occur several times. With DAB-K1, random symbol sequences can also be generated. The sequence is transferred to ADS and the individual symbols are called up one after the other. The spectrum of a signal generated in this way fully corresponds to that obtained with music or video modulation.

For generating the broadband signals required for satellite TV, Arbitrary Waveform Generator AWG2021 from Tektronix is available. The characteristics of this generator are very similar to those of ADS and, like ADS, it can be combined with SMHU58, Software IQSIM-K and Software DAB-K1.

Albert Winter

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Reader service card 150/10

BER measurements with Base-Station Test System TS8510

FIG 1 Test System TS8510 for GSM/PCN base stations Photo 41 749

Test System TS8510 was designed for type-approval tests on GSM and PCN base stations [1]. The tests are described in GSM specifications 11.21 and 11.23 (GSM spec. 11.21 contains RF and link-management tests, GSM spec. 11.23 signalling tests). Digital Radiocommunication Test Set CRTP04 [2] is the main component of the system. As a signalling unit, it is responsible for setting up calls with the base station and its two signal sources simulate the traffic channel and a GMSK-modulated spurious signal. After call set-up, CRTP04 measures the power ramp, phase error and bit error rate. CRTP04 also acts as a system controller. The other components of the system are a spectrum analyzer, a fading simulator, two signal generators for the generation of interfering signals, an RF switching matrix, a power meter for path compensation and a protocol tester.

Receiver measurements play a critical role in the development and approval of base stations as the quality of the receiver is the main factor that determines the quality of a base station. With analog networks the quality of a receiver is determined by measuring the signal/noise ratio or total harmonic distortion of the demodulated wanted signal; with digital networks, on the other hand, the bit error rate before D/A conversion is measured. This poses a difficulty in GSM and PCN networks, because only bits that represent the wanted signal are used for measuring the bit error rate. GSM networks transmit 456 bits in a 20-ms frame but only 260 bits represent the wanted signal. 182 of the 260 wanted signal bits use redundancy for error control, only 78 bits are transmitted without error protection. The other 196 bits are used to detect and correct errors. In GSM parlance one refers to class I bits (protected bits) and class II bits (unprotected bits). Within class I, a distinction is made between class Ia bits and class Ib bits. In addition to convolutional coding for all class I bits, class Ia bits are also protected by three parity bits. The receiver uses the parity bits to determine the quality of the data and in the case of an irrecoverable error among the class Ia bits rejects the entire frame. The receiver replaces the rejected frame by an interpolated expectancy value.

According to the GSM specification, the following **bit-error-rate measurements** are to be performed **in the traffic channel:**

bit error ratio (BER)

$\mathbf{BER = b_f / b_o}$

b_f being the number of errored bits and b_o the total number of bits,

frame erasure ratio (FER)

$\mathbf{FER = f_{bfi} / f_o}$

f_{bfi} being the number of rejected frames and f_o the total number of frames,

residual bit error ratio (RBER)

$\mathbf{RBER = b_{fok} / b_{ok}}$

b_{fok} being the number of errored bits in frames that have not been designated as errored and b_{ok} the total number of bits in good frames.

Besides BER measurements in the traffic channel, the GSM specification also defines **BER measurements in signalling channels.** These measurements are performed by comparing bits in or after the receiver. It is assumed in the specification that base stations are equipped with special test interfaces; these interfaces, however, are usually provided by different manufacturers and are, therefore, not suitable for a universal test system. If these tests are carried out on the A_{bis} interface, special test interfaces are not necessary. One should be aware of the fact, however, that at this interface bit errors have already been corrected. In order to obtain meaningful test results, error correction at the base station needs to be switched off, as otherwise only unprotected class II bits are available for measuring bit error rate.

In **BER measurements as performed by Test System TS8510,** the data stream received by the base station is fed to the base-station transmitter and then back to the test system. Loopback takes place either at the A_{bis} interface or in the receiver unit still before error correction (FIG 2), if such is allowed by the base station. In the latter case one has to differentiate between two loopback modes: in one mode data are looped back without bad frame detection, in the other the bits of a rejected frame are set to zero and sent to the test system via the base-station transmitter. CRTP04 determines BER, FER and RBER. This arrangement also allows BER measurements in signalling channels, provided the base station has a suitable loopback. Before each BER test, the signal path leading from the A_{bis} interface via the base-station transmitter to the CRTP04 receiver is tested to ensure that all data on this signal path are transmitted without bit errors.

GSM specifications stipulate several bit-error-rate measurements on base stations. The **Static Layer 1 Receiver Functions** test is for measuring bit error rate under "ideal" conditions. For this test the level of the signal generated by CRTP04 is around –80 dBm. The base station operating in loopback mode sends the received signal back to CRTP04 for evaluation. The bit error rate must not exceed 0.0001%. The level of the wanted signal is increased step by step up to –15 dBm. A bit error rate of up to 0.001% is permitted. The last step is to loop back the signal through the fading simulator, the maximum bit error rate now being 3%.

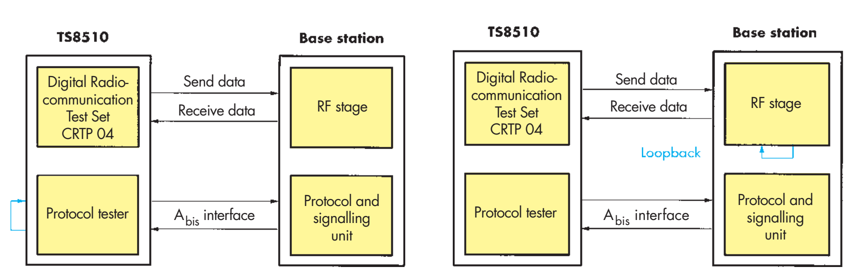

FIG 2 Loopback modes for BER measurements: at A_{bis} interface (left) or in base station (right)

If only the wanted signal is available for the Static Layer 1 Receiver Functions test of a base station, one or more interfering signals are added to the wanted signal for further tests. For the **Static Reference Sensitivity** test CRTP04 generates a wanted signal with a level of –104 dBm. In the adjacent time slots of the wanted signal, two interfering signals whose levels are 50 dB higher are generated by RF Generator SME03. The RBER of class II bits must not exceed 2%.

Reception conditions are even stricter for the **Multipath Reference Sensitivity Conditions** test. In this test the wanted signal is degraded by the fading simulator. The bit error rate is measured by CRTP04 using the fading profiles Typical Urban 50 km/h, Rural Area 250 km/h and Hilly Terrain 100 km/h. The maximum permissible RBER of class II bits is between 7% for rural area and 9% for hilly terrain.

The **Reference Interference Level** test case measures a receiver's immunity to EMI with the wanted signal and interfering signal at the same frequency. The level of the interfering signal generated by the RF generator is 9 dB lower than that of the wanted signal generated by CRTP04. The test is repeated with the interfering signal being generated at the wanted signal's frequency +200 kHz and its level 9 dB higher. In a further test, the interfering signal's offset is 400 kHz and its level 41 dB higher than that of the wanted signal.

The **Blocking** test case (FIG 3) is very demanding both for the device under test and the test system. The wanted signal generated by CRTP04 has a level of –101 dBm. The blocking signal is generated by the microwave generator of TS8510. With frequencies between 100 kHz and 12.75 GHz the

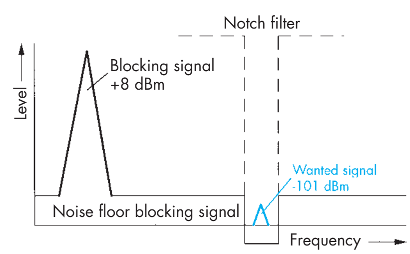

FIG 3 Blocking test with Base-Station Test System TS8510

level is +8 dBm. This test requires a signal with a particularly good S/N ratio. The measurement bandwidth of the base-station receiver is 200 kHz. At an input bandwidth of 200 kHz, the noise power per 1 Hz is
10 log (200 kHz/1 Hz) = 53 dB.
The required S/N ratio is obtained as follows: 8 dB – (–101 dBm) + 53 dB + 10 dB (margin) = 172 dBc.
This extremely high S/N ratio is achieved by a notch filter incorporated in TS8510.

The **Intermodulation Characteristics** test case verifies the linearity of the base-station receiver. The composite signal is made up of a wanted signal of –104 dBm and two interfering signals of –43 dBm. The intermodulation products of the interfering signals are superimposed on the wanted signal. The RBER of the class II bits measured by this test must not exceed 2%.

The signals used for all receiver tests must have accurately defined levels. This is ensured by a complex **RF switching matrix.** It filters, mixes, amplifies or attenuates the signals. Two RF test probes are incorporated at crucial points of the switching matrix to minimize frequency dependence. One channel is used to monitor transmission levels, the other to monitor receive levels. These test probes determine reference values to automatically compensate for level errors that occur when the tests are being run.

Michael Manert; Wilfried Tiwald

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Reader service card 150/11

Loudspeaker measurements with Audio Analyzer UPD

Development and production of top-quality loudspeakers and enclosures are impossible without a fast and reliable audio tester that generates all necessary signals (noise, sinewave, burst) and measures the response of electrical and acoustic components. Loudspeaker measurements using Audio Analyzer UPD from Rohde & Schwarz [1] are supported by an application program which can be loaded and started directly under the UPD software (FIG 1), provided UPD is fitted with option UPD-K1 [2]. This means that all UPD functions can be called in the usual way even when the application is running. This program adds special **tests and computing routines for loudspeaker measurements** to existing UPD functions:

- measurement of impedance and derived parameters to IEC 268, part 5,
- sound-pressure measurement (frequency range, efficiency and angle of radiation),
- phase response and group delay,
- harmonic-distortion measurements,
- polarity measurements.

The program is equally well suited for use in development labs or production environments, for instance by defining

FIG 1 Audio Analyzer UPD for loudspeaker measurements in sound studios

Photo 41 751/7

the characteristics of a reference loudspeaker and the tolerances (go/nogo test).

Impedance and sound pressure can be measured in different ways, with measuring time or precision optimized as appropriate. The test setup must include a power amplifier and a precision test microphone (except for impedance measurements).

After the application program has been started, the entire **operation** is by softkeys that resemble UPD controls or via keyboard entries in dialog mode. Every softkey operation can be memorized and repeated (macros) so that measurements can be combined in any number of ways – real help with production testing for instance. By pressing a softkey the user can temporarily switch over to UPD operating software to scale and label graphics for instance, and then return to the application program.

For **impedance measurements** the impedance versus frequency characteristic is recorded and all relevant impedance values and parameters such as a loudspeaker's Q and equivalent volume are calculated (FIG 2). Since UPD is equipped with a DC generator and DC test function, resistance can be measured without using any additional equipment. Resonance impedance, resonance frequency and tuning frequency are derived from the impedance characteristic. Q and equivalent volume are calculated to IEC 268, part 5. UPD graphics functions provide the absolute impedance minimum and maximum.

The **sound pressure versus frequency characteristic** (FIG 3) can be used to evaluate loudspeaker sound quality, shows whether the crossover networks are dimensioned correctly and also detects if the polarity of any speaker unit has been reversed. Measuring the sound pressure at a fixed frequency yields the maximum sound pressure (at rated power) and the sensitivity (at 1 W). Sensitivity is required in turn as a reference for the 0-dB line of the transfer function and the 0-dB point for determining the radiation angle.

There is an automatic routine for setting output power. Depending on nominal loudspeaker impedance, this routine adjusts the generator level until the output power is obtained.

The measurement can be performed in three different ways:

1. FFT analysis of a special pseudo-random noise signal; preferred application: fast measurement of the entire frequency range, eg in production testing.

2. Frequency sweep with sine signals; preferred application: measurements under free-field conditions (eg in an anechoic chamber) and near-field measurements, ie wherever sound reflections do not occur or can be neglected.

3. Frequency sweep with burst signals; preferred application: far-field measurements (even in non-anechoic chambers). The burst generator included as standard in UPD is used for a specially programmed sweep which measures only the first period of the sound wave.

With both sweep measurements, the lower and the upper frequency range can be measured separately at different microphone distances, and the near-field and far-field curves can be combined at a transition frequency selected numerically or graphically.

Linear frequency sweeping is recommended for **phase-linearity measurements.** The phase between loudspeaker input and output sound wave is measured. A linear phase response (ideal case) is a straight line. To obtain a continuous phase response without jumps of 360°, the sweep points measured by UPD from 0° to 360° are processed by the application software. However, the measured phase difference between two adjacent sweep points may not exceed 180°. The application software automatically ensures that this condition is met by calculating an appropriate frequency increment on the basis of the microphone distance that has been entered.

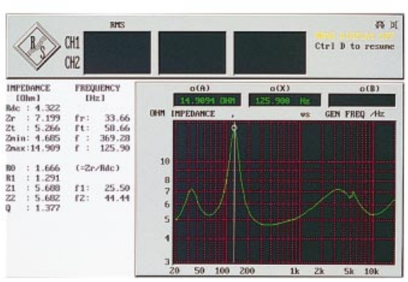

FIG 2 Impedance characteristic with test report (resonance frequency and impedance, resistance, Q, etc)

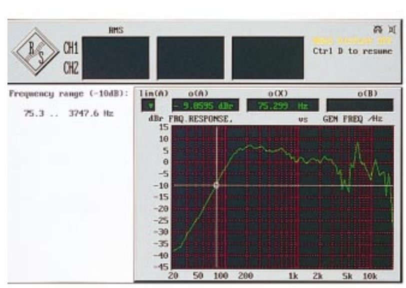

FIG 3 Frequency response and calculated frequency range of loudspeaker (to IEC 268, part 5)

To make linearity errors easier to see on the screen, the phase response can also be displayed as linearity deviation or group delay. If a reference DUT is used to compare the measured phase at a fixed frequency, any reverse polarity condition can be detected (reference and DUT are 180° out of phase). As the microphone distance for the reference and the DUT must be the same to within a certain degree of accuracy, this method of checking polarity is best for low frequencies.

The following types of **total harmonic distortion** can be measured and displayed: THD total, THD d2, THD d3 and THD+N. It is possible to display both the distortion at a fixed frequency and the distortion frequency response as a bargraph (set of single measurements), as a curve representing the frequency response or as a frequency spectrum of the harmonics (FFT).

Martin Schlechter

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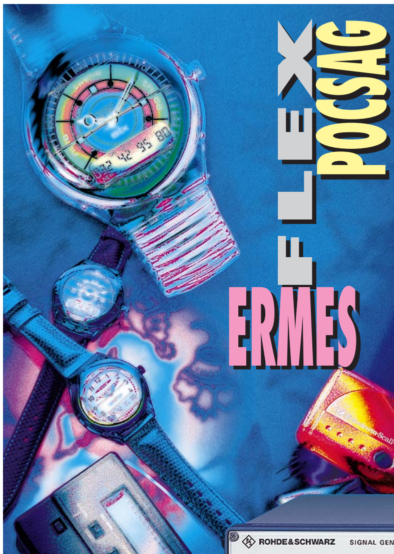
Reader service card 150/12

Signal Generator SME for tests on ERMES, FLEX and POCSAG pagers



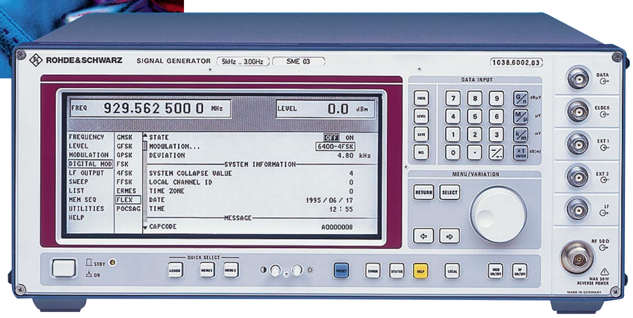


FIG 1 Signal Generator SME, expert for all pager systems

More and more new systems are establishing themselves not only in digital mobile radio but also on the pager market. Examples are ERMES [1] (European Radio Message System) and FLEX [2], which are used in addition to POCSAG [3] (Post Office Code Standardization Advisory Group) set up in 1979 and known in Germany under the name of Cityruf [4]. Common to these systems is unidirectional communication from the transmitter to the pager, which does not acknowledge the receipt of a message. Of course all pagers must be tested in development, production and service. For this Rohde & Schwarz offers Signal Generator SME (FIG 1), which is able to supply the required signalling for each of the above systems.

An essential test that has to be performed irrespective of the system used is **sensitivity** measurement. Here the quality standards are determined by system specifications and the quality aimed at by manufacturers. For example, an ERMES pager fulfils the standard sensitivity requirements if it correctly recognizes eight of ten calls received at a field strength of 25 dBV/m (80% call reliability). Fluctuations in production tolerances make it necessary for manufacturers to provide a safety margin, ie produce pagers with sensitivity higher than stipulated so as to reliably fulfil standard requirements.

Another test is concerned with the recovery of **synchronization.** This is the capability of a pager of restoring the required synchronization with the transmitted signal after a brief interruption of reception. In accordance with FTZ guideline 171TR1 (Cityruf) (FTZ = Research and Technology Center of German Telekom), the pager is sent test modulation with the level reduced by 40 dB relative to the signal level for a specific time (FIG 2). The pager must still be able to receive calls without losing synchronization with the transmitted signal.

Signal Generator SME provides the appropriate signals for both tests without any additional external equipment. Convenient operating menus assist the user in generating a message to the pager. SME requires just a minimum of information to generate the complete data protocol, eg the pager address or message contents and further network-specific information.

Differences between pager systems

Each of the three systems transmits tone-only, numeric and alphanumeric messages. But the systems still differ considerably from one another (see blue box).

POCSAG, which originates from Great Britain, is a widely used system. In Germany it is used for Cityruf, Scall and others. Since POCSAG pagers operate at a fixed frequency, the radio networks employ the time-slot method: transmitters change frequency in a cycle of up to two minutes so that different frequencies are used in adjacent transmitter zones. Within a zone, transmitters operate on a common frequency. Depending on the country, frequencies between 450 and 470 MHz are used. The transmission protocol is of a comparatively simple structure. The transmission of messages is not bound to a fixed time pattern. A transmission can be started any time, so the pager must listen all the time if it is not to miss a call. The words of a message are protected by checksums. To compensate for interference lasting longer than a message word, a message can be repeated up to three times.

FLEX was developed by Motorola from 1993 onwards. Compared with POCSAG, particular emphasis was placed on more efficient utilization of channels, enhanced transmission reliability and low energy consumption by the pager. It is possible to use POCSAG transmitters in the FLEX system with only minor modifications. The two systems can even be combined to operate in time multiplex. FLEX uses FSK with two or four states, resulting

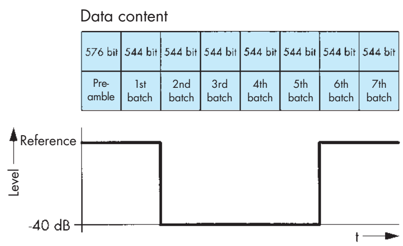


FIG 2 Signal for testing recovery of synchronization with Cityruf in compliance with FTZ guideline 171TR1

in a data rate of up to 6400 bit/s. To increase transmission reliability, the messages (with checksums) are interleaved: the first bits of all words are sent first, then the second bits, and so on. Interference of reception extending over several dozens of bits is thus distributed to all words of a message and corrected by means of the checksums.

FLEX transmissions are rigidly coupled to the time of day. A new cycle is started every full hour. Messages for individual addresses are sent at defined times within a cycle. This means that a pager, once synchronized, needs to be ready for reception only for a fraction of the cycle without any messages being missed and can thus save battery power. Moreover, date and time of day and also binary data transparent to the receiver can be transmitted with FLEX. In conjunction with a computer, this would enable FLEX to receive current stock-market prices for example.

ERMES, unlike POCSAG, does not use time slots but frequency-division multiplex. The ERMES standard defines 16 channels and 16 classes of receiver. As with FLEX, transmitters operate within a fixed time pattern coupled to the time of day. Messages are transmitted in a time window of 750 ms for each class of receiver, then changeover is made to the next class. Each channel starts with a different class of receiver, so in case of a fully featured transmitter system a pager can receive messages for its class at any time by changing channel every 750 ms. This system makes greater demands on the receivers but enables flexible expansion of the network from one up to 16 transmitters per zone, with all pagers profiting from the additional transmitters provided. Like in FLEX, the bits of the message words are interleaved in the ERMES system to improve transmission reliability.

One signal generator for all pager systems

Signal Generator SME supplies tone-only, numeric and alphanumeric messages for each of the three paging systems. As to alphanumeric messages, SME provides memory capacity for three predefined and three user-definable message texts. Switchover can be made between filler data and messages on a keystroke or by an external trigger. SME offers the following **special features** for each system:

POCSAG
- Bit rates of 512, 1200, 2400 bit/s,
- FSK and FFSK modulation,
- selectable frequency deviation,
- selectable time-slot duration.

FLEX
- Setting of all important network and system information,
- all types of message available, including special numeric, secure and binary messages,
- on request, automatic adaptation of transmission parameters with change of CAPCODE,
- all three bit rates (1600, 3200 and 6400 bit/s) and both modulation types (2FSK and 4FSK) selectable,
- simulation of time slots with data from other transmission systems,
- emergency resynchronization,
- allowance for cycle number during transmission, ie signal in line with standard over one hour.

ERMES
- Setting of all important network and system information,
- deliberate corruption of bits of message words,
- free selection of receiver class to which message is sent.

With the above features, Signal Generator SME is an unrivalled signal source for all pager systems. The flexible instrument concept allows convenient and cost-effective integration of a wide variety of data protocols used in today's pager systems plus support for future systems.

Mathias Leutiger; Daniel Schröder

Pager system	POCSAG (Cityruf)	FLEX	ERMES
Transmit frequency	3 frequencies, 465.970 to 466.230 MHz	Not definded	16 channels, 169.4125 to 169.8125 MHz
Modulation	FSK with 2 states	FSK with 2 or 4 states	FSK with 4 states
Data rate	512 to 2400 bit/s	1600 to 6400 bit/s	6250 bit/s
Number of addresses	2^{21} per frequency	Approx. 10^9 per network operator	2^{22} per network operator
Area of use	Europe	USA, Asia	Europe (being built up)
Options required in Signal Generator SME	DM Coder SME-B11, Memory Extension SME-B12, POCSAG Option SME-B42	DM Coder SME-B11, Memory Extension SME-B12, FLEX Option SME-B41	DM Coder SME-B11, Memory Extension SME-B12

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[3] British Post Office: A Standard Code for Radiopaging (POCSAG), 1979

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Reader service card 150/13 for further information on SME

Interference analysis in digital mobile-radio networks

Co-channel and adjacent-channel interference is the major source of disturbance in digital mobile-radio networks to GSM standard. Various measures can be taken to eliminate this type of interference once it is localized. Rohde & Schwarz offers the right test and measurement product for this purpose. **Interference Analysis System PCSD-K1/K11** combines sensitive RF measurement circuits with high-performance processors and algorithms to detect and analyze

- co-channel interference,
- adjacent-channel interference,
- reflection,
- noise power,
- narrowband interference,
- power density spectra,
- power in the broadcast control channel (BCCH).

With co-channel and adjacent-channel interference the network-specific interferer is identified and classified as permanent or traffic-dependent interference depending on the type of channel. All interference measurements refer to the downlink, ie the link from the base station to the mobile phone.

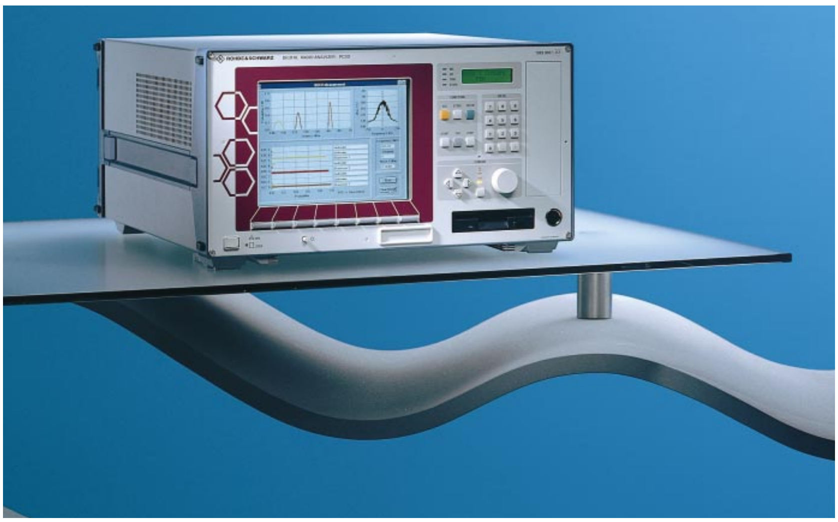

FIG 1 Digital Radio Analyzer PCSD as core of Interference Analysis System PCSD-K1/K11
Photo 42 147

The downlink measurement has priority since base stations are generally less susceptible to interference and can change frequency if interference becomes too strong.

Hardware components of interference analysis system

Options allow the interference analysis system to be configured for various applications. The basic version comprises Digital Radio Analyzer PCSD (FIG 1), which includes a complete PC, a three-channel 12-bit A/D converter board and a board with the proven i860 vector processor. The RF section consists of Test Receiver ESVD, which features the low phase noise required for interference measurements. This basic version enables the full range of interference measurements in stationary applications. For mobile use the basic version can be extended by a GPS receiver.

Measurement procedure

A measurement with the interference analysis system is equivalent to the identification of one or more bicycle lamps amidst 100 car headlights as seen with the naked eye within 0.5 s from a distance of 200 km. This comparison applies to the determination of the nominal power and the identification of the BCC (base-station colour code) of a base station often several cells away, which may cause interference in another mobile-radio cell due to its channel occupancy. The nominal power is the power of the radio waves of the base-station BCCH at the site of measurement and forms the basis of the interference measurements (FIG 2). In the above scenario, the car headlights are the occupied traffic or signalling channels which use the same frequency and belong to the examined or an adjacent base station as well as other interference which complicates analysis of network-specific interferers.

In **stationary measurements** (software option PCSD-K1) up to 640,000 samples of the IF signal are taken for nominal-power measurement and BCC identification and analyzed within a few seconds by means of special signal-processing methods and specially developed algorithms for pattern recognition. Pattern recognition can detect several BCCHs on one channel with power ratios up to 40 dB. A probability analysis of the BCCs allows detected BCCHs to be allocated to one or sometimes several base stations. Using optimized null-space projection the nominal power of potentially interfering base stations is determined with a sensitivity of –135 dBm.

In **mobile measurements** (software option PCSD-K11) one to three interferers can be tracked simultaneously depending on the system configuration. A high-resolution stationary measurement is always carried out before a mobile measurement to select the interferer and ensure synchronization. The BCCH power of the interfering base stations is determined continuously throughout the entire test route. The GPS receiver provides the system all the time with site and motion information. The mobile measurement does away with any ambiguity in interferer identification, which occurs rarely in stationary measurements if BCCH and BCC are identical, since it uses site-related signal-delay comparison.

The possibility of power measurement on and identification of BCCH carriers opens up the following **concept for measuring co-channel and adjacent-channel interference.** From a frequency-occupancy table containing the base-station data of an investigated region, the system automatically selects at the site all frequencies at which BCCHs are sent by certain base stations. Due to their channel occupancy such base stations can give rise to co-channel or adjacent-channel interference in at least one channel of the carrier station and in addition lie within a predefined maximum distance. The nominal power and its source are determined by stationary or mobile measurements on the selected frequencies.

For identifying the interference, a distinction is made between whether a measured BCCH or another traffic channel has caused the interference. If the BCCH itself is the interferer, the **interference is permanent** since BCCHs continuously emit a constant power level. In the case of co-channel interference the interference power is equivalent to the measured nominal power, whereas with adjacent-channel interference it corresponds to that part of the nominal power that results from the transmitter GSM spectrum and the input filter of the mobile phone.

However, if a traffic channel has caused the interference, the **interference is traffic-dependent** since RF power is emitted on traffic channels only if there is really information to be transmitted. Time and power distribution of traffic-dependent interference furthermore depend on network parameters such as frequency hopping (FH), power control (PC) and discontinuous data transfer (DTX). The ratio between co-channel and adjacent-channel interference corresponds to that of BCCHs. For the sake of clarity, normalized traffic-dependent interference is displayed which is referred to the BCCH transmit power in the allocated traffic channel. Without power control this interference differs from permanent interference only in that it occurs less frequently. Measures such as FH and DTX reduce the probability of transmission impairments caused by traffic-dependent interference.

Advantages of the measurement concept:

- The measurement is carried out without manipulations on the network and independently of the network parameters PC, FH and DTX.
- The measurement is not related to traffic-dependent interference the occurrence of which would otherwise have to be waited for. The normalized measurement allows traffic-dependent interference to be determined and eliminated.
- The measured data enable adequate evaluation of new channel allocations as well as detection of free channels.

Eliminating interference

The most simple method for eliminating interference is changing the channel allocation or switching the channel off. For frequency economy, however, it is better and also common practice to use sector antennas and to adapt the tilt of the antenna. The analysis system can check the antenna setting by means of a stationary measurement. The high dynamic range and sensitivity of the system are particularly advantageous for this application since a measurement margin of more than 20 dB is available. Another interesting way of avoiding an area with lots of interference is by manipulating the handover parameters of a base station. Depending on its distance from the mobile phone, the base station decides whether to hand over the call to another station or not.

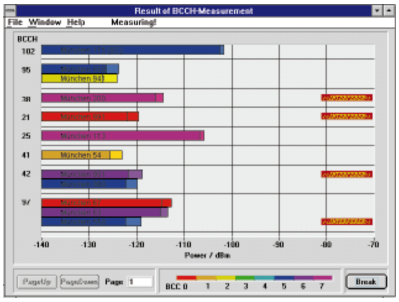

FIG 2 Interference power measurement and BCC identification of interfering base stations take place in automatically selected BCCHs. Signals of different interfering base stations can be isolated for each channel.

Network optimization

The interference analysis system is also suitable for optimizing and extending a low-interference network. There are two possible ways of doing this. The first one allocates another radio channel to the specific base station. This channel should cause minimum interference in other cells and should not be subject to interference. Before the channel is used, it is entered into the regional frequency-occupancy table for the test system. An evaluation of the nominal powers measured will immediately inform the user about all the potential interferers for this channel. The second method is based on comprehensive frequency planning. The system determines the nominal power of all base stations throughout the entire region across cell boundaries. The measurements are performed in the operating network and provide the latest coverage data for the planning software of the network operator. This software evaluates the results to optimize the network.

Operation and results

The system features an MS Windows user interface. In addition to detailed definition of all test parameters, the system provides easy-to-use **preprogrammable measurement routines:**

- nominal power measurement on all channels,
- detailed interference measurements for a specific base station.

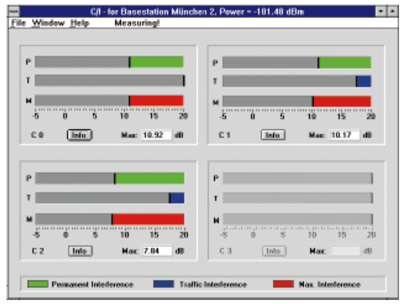

FIG 3 C/I ratio of used base-station channels (green = permanent, blue = traffic-dependent, red = summary). The info button gives access to a list of all measured interference sources of the channel in question.

Such standard measurements are selected via a single menu item. Should additional test parameters be required, they can be entered in the appropriate windows. During the measurement the user can switch from one window to another. Interference is displayed in three windows which show permanent, traffic-dependent and summary interference. Clicking the info button will show all interference according to type and source (FIG 3). The results can be evaluated by means of the measurement system or any PC without any hardware extension.

Otmar Wanierke

Reader service card 150/14

Longterm monitoring of digital serial video signal using Digital Video Component Analyzer VCA

In digital TV studios, pictures are passed among the various items of studio equipment in the form of data bits. Digital transmission is quite different to analog transmission: if analog transmission errors occur, the degradation in picture quality is proportional to the number of errors. With digital transmission, however, there is no perceptible reduction in picture quality until a certain bit error rate is reached. Only when this rate is exceeded – just one or two extra errors may be sufficient – does the quality suddenly drop. As a worst-case scenario, there may be a loss of sync and the picture disappears completely. This is where test technology comes into its own as it can provide a way of continuously monitoring the quality of digital serial video transmissions. Digital Video Component

FIG 1 VCA and PC performing digital serial video-signal monitoring round the clock Photo 42 331

Analyzer VCA, developed by Rohde & Schwarz, fully meets these requirements as it monitors the video signal in time windows of approx. 10 seconds [1; 2].

Longterm, continuous monitoring is also required for errors that occur only rarely. When, say, a film is copied from one tape deck to another, the copy must be error-free. Visual inspection would also take a considerable number of man hours (eg 2 to 10 h). This difficulty can be overcome by integrating VCA into a test and monitoring system specifically designed for this purpose. **VCA remote monitoring, a Windows application** supports digital video-signal monitoring around the clock thanks to the VCA measurement functions TRS (timing reference signal) and RCE (reserved code error) used to check the sync frame of the digital video signal. This measurement cannot find every bit error but it can be performed on live signals, ie on moving pictures. As an alternative the application provides a CRC (cyclic redundancy check) monitoring function for digital stills to detect sporadic bit errors in the active picture area.

The **hardware requirement** is a PC with the MS Windows operating system and a VCA with a remote-control option (FIG 1). The values measured by VCA are read by the VCA remote monitoring program via the serial RS-232-C interface and processed so that the total number of errors is shown on the history display (FIG 2). Moreover, the individual errors are listed on the error-rate display and the measured values are stored in a file with a predefined name.

The **File menu** contains a number of useful functions to process measurements. Previous result protocols can be displayed again and checked with the cursor using the "Load old result" function. The functions "Create ASCII error list" and "Create ASCII dataset" transform the result protocols into different ASCII tables so that the measured values can be analyzed by a database program (eg MS Excel) to provide statistics or a better overview. If you really want each and every error time stamped and documented, use "Create ASCII error list". This gives a clear overview of that part of the measurement which is of interest.

If transients of long duration are involved, it is often a good idea to increase the measurement time. VCA uses intervals between 2 and 10 s depending on the number of fields to be measured. This time window can be increased to 1 to 60 min. with "Create ASCII dataset". This creates a table which can be graphically processed later using a database program. It is then possible to display the transient response (of special interest when developing studio equipment) in a way that is easy to understand.

FIG 2 Evaluation of longterm measurement with error cluster at 10.50 h. Cursor function makes it easy to find times when errors occurred.

In the **Measure menu,** the measurement functions (TRS, RCE or CRC) are started by selecting the measurement or by clicking the appropriate icon. The user is then asked for the size of the measurement window, the video-signal standard (525 or 625 lines) and the file name. The measurement is stopped by clicking the stop icon. A stopped measurement can be continued by pressing the Cont icon (continue measuring). The halt time is marked red and can be taken into account at any later stage of analysis.

The serial interface of the PC is configured in the **Interface menu.** The PC configuration and the VCA configuration must be the same. If not, the PC and the VCA will not be able to communicate and an error message will be output.

The **cursor functions** make it easy to find measured bit errors rapidly. Three cursor functions are available: go one pixel to the right or left on the screen, scroll one page to the right or left and place cursor on the next error before or after the current time. With the latter function the whole measurement is automatically checked for errors. This is especially important for longterm measurements in which only a few errors have occurred.

Martin Flach

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[2] Osterloh, G.: Analysis of digital transport layer with Video Analyzer VCA. News from Rohde & Schwarz (1995) No. 149, pp 40 – 41

Reader service card 150/15 for further information on VCA

Measuring all TV RF and video parameters for the first time in a compact unit

FIG 1
Video Measurement System VSA supports special test requirements of TV transmitters and cable systems with the aid of built-in test-receiver option (configuration menu of test receiver displayed)
Photo 42 329/2

Different measuring instruments such as TV test receivers, TV oscilloscopes, video monitors and video analyzers are required for quality assurance and reliable monitoring of TV cable networks and terrestrial transmission equipment. If monitoring is to be carried out by means of an automatic system, a process controller is required for controlling these units. For the user this means high investment costs and space requirements which are not always available in mobile applications. With **Video Measurement System VSA,** which integrates all the measuring units mentioned including a process controller in a single unit (see News No. 147), Rohde & Schwarz now offers, together with **Test Receiver Option VSA-B10** (FIG 1), an ideal compact unit for standards B/G, D/K and I. The option not only saves space but also does away with the complete cabling which is otherwise required. Thanks to its excellent performance data and the great number of system interfaces as well as the measurement and controller functions of the basic unit, all standard applications as well as customer-specific solutions can easily be implemented. Unattended CATV system monitoring, remote polling of measurement results, automatic activation of standby equipment during a transmitter breakdown or uses in laboratory and service environments, quality assurance and production monitoring of TV consumer units are all possible with this powerful team of VSA with its option VSA-B10.

The **main features** of the **TV test receiver** are:

- frequency range from 47 to 862 MHz,
- 50- or 75-Ω input,
- IF input and IF output,
- video and audio outputs,
- large dynamic range (40 to 120 dBμV),
- low-noise and low-distortion mode,
- low-noise preamplifier can be added to improve noise figure of receiver,
- video S/N ratio (weighted at 66 dBμV) >56 dB,
- intercarrier ratio (weighted) >46 dB,
- channel and frequency search,
- synthesizer with low phase noise and high frequency resolution (1 Hz),
- digital frequency control,
- manual and automatic gain control,
- integrated zero clamping for defining vision modulation depth,
- selectable synchronous detector mode with sampled or continuous phase control as well as selectable time constants,
- sound demodulation according to IRT dual-sound carrier method,
- linear distortion of video frequency response <0.5 dB (luminance/chrominance error <±20 ns),
- video group-delay correction of receiver and sound deemphasis can be switched off,
- sound monitoring via loudspeaker of basic unit,
- built-in microprocessor for receiver control.

The microprocessor which controls the complete range of receiver functions collects continuously all the relevant RF data of the input signal. These data are then available as **additional measurement parameters** in the VSA measurement list and are also part of the VSA test report. The following parameters are measured:

- vision carrier power and frequency,
- vision/sound power and frequency ratios,
- FM deviation of sound carrier and pilot tone,
- pilot-tone frequency and coding,
- modulation depth of vision carrier (residual carrier),
- vision-carrier phase modulation.

The important measurements of vision-carrier phase modulation and residual carrier required for **TV transmitter alignment** are performed in VSA by means of a single measurement (FIG 2). The external cabling that used to be required as well as corresponding interface problems now belong to the past thanks to the compact unit VSA with integrated Test Receiver VSA-B10.

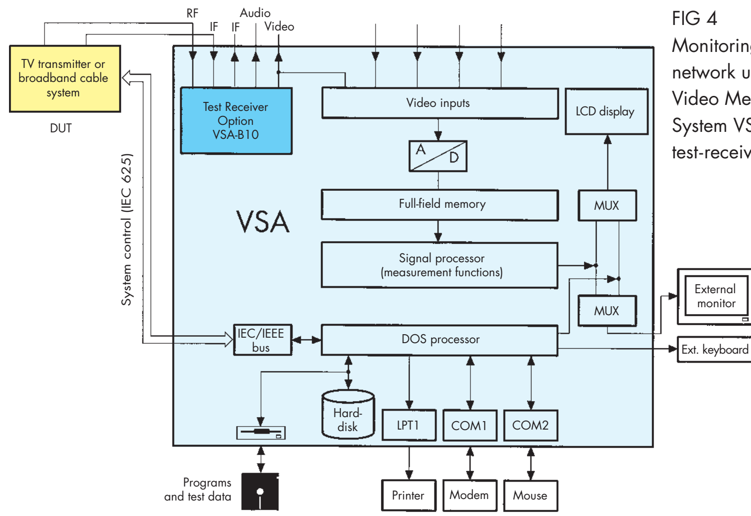


FIG 4 Monitoring cable network using Video Measurement System VSA with test-receiver option

All VSAs are equipped as standard for later **installation of the test receiver.** The test receiver can be installed direct by the user or through a Rohde & Schwarz service center. No modification of the basic unit or system software is required. The built-in test-receiver option is detected when VSA is powered up. The corresponding control menus are then automatically available.

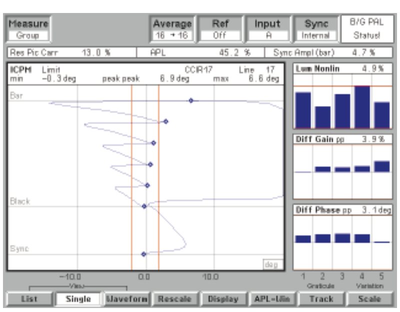


FIG 2 Measurement of modulation-dependent phase modulation of vision carrier

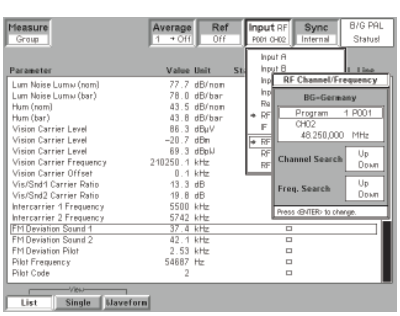


FIG 3 Display with RF parameters and control menu of test receiver

Manual **operation** of the test receiver is completely integrated into the simple VSA menu system. Operation of the test receiver is very comfortable thanks to its three pop-up menus.

The required receive channel is set in the **Set RF Channel/Freq menu** (FIG 3). This can be done by selecting a channel or program number from the stored channel table or by direct entry of the receive frequency. A continuous, automatic frequency search with settable threshold is provided for detecting unknown transmitters. If only the transmitters of the stored channel table are to be considered, fast channel search can be used. For practical use it is of great advantage to set the receive channel with the monitor picture displayed. If the monitor picture is suitably set in the background, the measurement data of the scrolled receive channels can be read direct without any switchover between menus. The parameters of the test receiver, eg volume, sound channel, search threshold are set in the **Set RF/IF Config menu.** The **Set RF Channel Definition menu** is used to define the channel table used. The user can change freely the frequency, program names and channel designations of each of the maximum 150 receive frequencies of a table. Almost any number of channel tables can be saved on or recalled from a diskette or the built-in harddisk. All the functions of manual operation can also be remote-controlled.

With the test receiver integrated into Video Measurement System VSA, a complete TV measuring and monitoring system including all receive, analysis, control and logging functions can for the first time be implemented in a single compact unit (FIG 4). The excellent receive performance data together with the versatile measurement functions make VSA the ideal all-in system for TV-transmitter and CATV applications.

Richard Finkenzeller; Ernst Polz

Reader service card 150/16 for further information on VSA

Radiocommunication system helps Italian customs authorities in coastal monitoring

FIG 1 Patrol boat of customs authorities and communication system from Rohde & Schwarz

With a length of more than 5000 km, in part difficult to access, rocky and jagged, the coastline around Italy is anything but simple to monitor and control. Italian customs authorities have the task of monitoring their coastline borders with different classes of patrol boats (FIG 1) to prevent smuggling and illegal immigration. With the radar equipment used it is possible to monitor vessel movements and individual objects at close range. With a large number of rapidly moving objects, however, patrol boats soon reach their limits. The **Tactical Data Link System** developed by Rohde & Schwarz is a real help in such a situation. The radar displays of the patrol boats are collected in a control center and the overall long-range radar display derived from the individual displays is then sent back to the boats. A message-handling system integrated into the transmission link transmits messages to the single boats, coordinates their actions and allows efficient action to be taken.

The **main components of the communication system** are an external radio system (HF and VHF/UHF), internal communication unit, central control and message-handling system. 400-W Transceiver XK855 with integrated FSK modem, ALIS processor [1] and fast HF modem is used as the HF transmit/receive station. The VHF/UHF radio system consists of Transceiver XT452 with external 2.4-kbit data modem and two VHF units provided by the user. The approved and tested DICS (Digital Internal Communications System) serves for internal communication. The core of the radio system is the MERLIN system processor [2]. It controls the radio equipment, sets the DICS, acts as the link between the radar and the position controller, generates and processes messages and also controls data flow.

The **operative and communicative procedure** is as follows:
Several patrol boats form a task group which is interconnected by a star-shaped radio network on HF and VHF (FIG 2). The Net Control Ship (NCS) is the network manager, which controls data exchange with the other participating units (PUs). As a rule, a task group consists of about five participating units monitoring a specific area of the sea. Every PU can assume the function of the NCS. To keep the time required for a complete network cycle to a minimum, the total number of participating units should not be more than 15.

Error-free, interference-resistant transmission of radar data and short operative messages is at the top of priorities. Transmission of messages according to ACP127 comes next in importance. **Three types of data link** are available:
- VHF RSX.25 data link (RSX.25 = R&S adaptation of wired X.25 protocol to the HF radio channel),
- HF RSX.25 data link,
- HF ALIS long-range data link.

The red circles in FIG 2 indicate the radar range of the individual PUs. The dark green circle around the NCS defines the communication area covered by VHF (line of sight). The light green circle represents the area covered by HF. Operations in the two circles take place simultaneously. All PUs of the VHF circle also participate in the HF circle. If a PU exceeds the VHF range of the NCS, data exchange is automatically performed in the HF circle.

In a **polling method** the NCS queries the radar information of the individual PUs and then retransmits the overall NCS radar display to the PUs. While data exchange between the units is usually transmitted by means of an RSX.25 data protocol at both HF and VHF/UHF, the frequencies from PU to PU can be quite different. Moreover, data are protected using an FEC method and transmitted in packages according to RSX.25 at 2.7 kbit/s. After the completion of a cycle, all the boats of a task group have the overall position display. If an object to be monitored is in the detection range of the PU which is farthest offshore and if this object moves rapidly towards the coast, it can be intercepted by the PUs cruising near the coastline. The actions to be taken are coordinated by the NCS and passed on by the message-handling system. Data exchange (radar and messages) with other NCS, the coastal stations and headquarters in Rome is usually managed in ALIS long-range mode because of the distance. The ALIS processor allows automatic link setup, automatic frequency change with adaptive reaction in case of channel disturbances and restores the connection if a PU is no longer in contact.

The **communication procedure** can be explained by way of the **HF super cycle.** Apart from the long-range ALIS mode, the structure of the VHF super cycle is identical with the HF super cycle.

1st step (login/logout of PUs); mainly performed if there is a change in the number of network participating units.

2nd step (single poll); exchange of radar data in RSX.25 mode with all PUs (top priority). This radar cycle to all PUs is run several times. The number of polling sequences is fixed in the configuration setup of the NCS operator. Error-free data transfer is guaranteed thanks to FEC protection, the RSX.25 protocol with 2.7-kbit burst transmission and multiple transmissions.

3rd step (RSX.25 Association Group); transmission of message-handling data in RSX.25 mode (2nd priority).

4th step (ALIS login/logout); applies if the number of participants in long-range ALIS mode is changed.

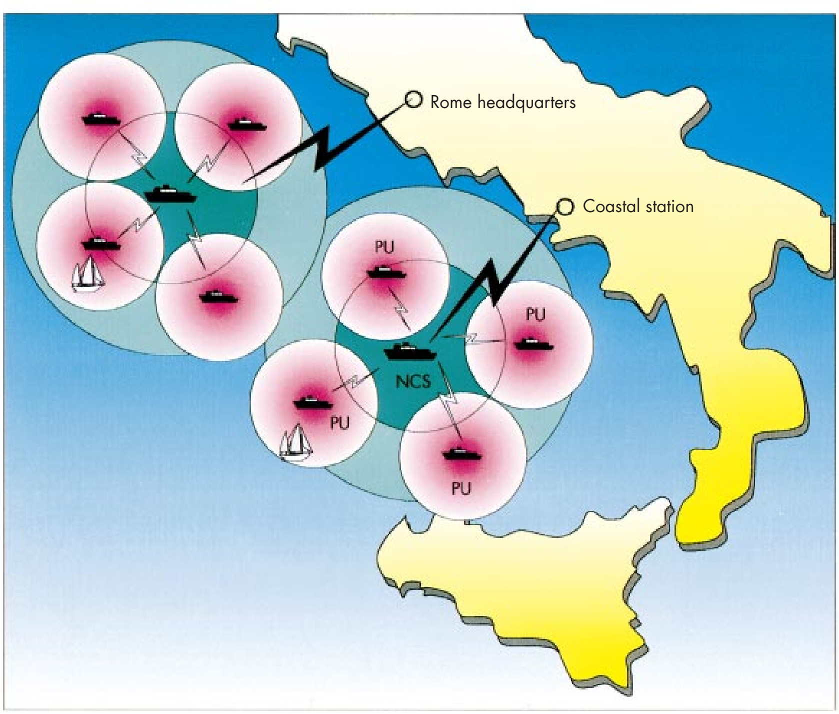
5th step (ALIS Association Group); the data (radar and messages) are transmitted to other NCS, the regional control center and to the Rome headquarters in long-range ALIS mode.

6th step (ALIS passive free slot); this step serves for the registration of new PUs.

A later stage will also allow the transmission of **video or infrared stills** so that the PUs pursuing a suspect vessel have photographic proof to intercept the right target. The video cameras on the patrol boats will be networked with the MERLIN system processor. The digitized and compressed stills (approx. 40 to 80 kbit) according to the required resolution will be processed as a file in the message-handling system. Helicopters and airplanes can also be equipped with the data-link method. These “flying PUs” will close the gaps between the different task groups, extend the radar range and allow more long-range actions.

Manfred Jungherz; Peter Maurer

FIG 2 Communication scenario



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Reader service card 150/17

Digital modulation and mobile radio (I)

When speech is transmitted using digital mobile radio, it is first of all digitized and then source- and channel-coded. On the one hand, this ensures that the data stream from the source coders has a considerably lower bit rate than the original data signal and, on the other, channel coding provides additional error control for transmissions via the radio channel. The channel-coded data stream is a sequence of bursts which are transmitted using a combined FDM/TDM method. The modulation techniques used must be tailored to the radio channel. Our new refresher topic describes how the information to be transmitted is modulated onto an RF carrier and recovered in the receiver with special reference to GSM networks. Due to the nature of the topic, the fundamental relationships will be expressed mathematically using complex numbers where necessary.

Rohde & Schwarz has special expertise in the field of digital mobile radio. We are involved in an extensive range of activities from consultation on various technical committees, in particular the earlier Groupe Spécial Mobile, which gave its name to the European GSM network, through the development of a complete range of test equipment and systems to the provision of a wide range of system simulators. Rohde & Schwarz also organizes training courses ranging from the practical to the theoretical which are specially tailored to the needs of network operators and system users. This was the starting point for this refresher topic.

1 Modulating signals and RF carriers

Initially the information to be transmitted is in the form of a sequence a(n) comprising elements from the set $a \in \{0; 1\}$. The modulator converts this sequence of logical ones and zeros into a sequence of analog signals which are suitable for transmission. The conversion of this sequence into voltages in the baseband is referred to as baseband modulation and the conversion of these baseband signals into RF signals is termed RF carrier modulation. In general a block of k bits from the sequence a(n) can be represented by one of the $M = 2^k$ possible states of the baseband signal. For example a "block" comprising one bit can be represented by one of two voltages, 0 or 5 V, or by one of two RF frequencies, $f + \Delta f$ or $f - \Delta f$. A block comprising two bits (a dibit) can be represented by one of four voltages or by one of four frequencies and so on. The states of the baseband signal and the RF signal can be expressed in an even more general form as signals $u_i(t)$ and $s_i(t)$ respectively. These signals do not necessarily have to remain constant over the duration of a bit. This means that digital modulation is simply the process of selecting one of the $M = 2^k$ possible baseband or RF signals and assigning this signal to a block of k bits. This procedure is referred to as M-ary modulation (FIG 1).

1.1 Baseband modulation

An NRZ signal (non return to zero) is a signal that remains at a constant, non-zero value over the duration of a bit T_{bit}. The opposite is an RZ signal (return to zero) which only has a non-zero value for a fraction of T_{bit}, for example $T_{bit}/2$, and goes to 0 for the rest of the time. Either signal can be unipolar or bipolar. If they are unipolar, one of the two logical symbols is represented by a finite (positive or negative) voltage, the other by 0 V. Bipolar signals represent the two logical symbols by voltages with opposite polarities.

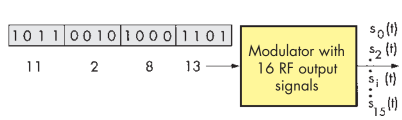


FIG 1 M-ary modulation (here M = 16)

The sequence a(n) is mapped digitally onto the baseband signals. First of all, the sequence a(n) is replaced by a sequence of weighted Dirac delta functions $a(n) \cdot \delta(nT) \in \{0;1\}$. To produce a unipolar NRZ signal, this sequence is fed into an interpolation filter with the transfer function:

$$H(f) = \frac{\sin \pi f T}{\pi f T} = si(\pi f T) \qquad (1a)$$

or with the impulse response

$$h(t) = \begin{cases} \frac{1}{T} & \text{for } -\frac{T_{bit}}{2} \le t \le \frac{T_{bit}}{2} \quad (\sin x/x \text{ lowpass filter}) \\ 0 & \text{elsewhere} \end{cases} \qquad (1b)$$

To generate a bipolar signal, −0.5 is added before filtering and the sum signal $[(a(n) - 0.5) \cdot \delta(nT)] \in \{-0.5; +0.5\}$ is multiplied by 2. D/A conversion (FIG 2) is then performed after digital filtering. However, the NRZ signals generated in this way are not bandlimited and, theoretically, would give rise to an infinitely wide RF spectrum after carrier modulation. The sin x/x lowpass filter is, therefore, replaced by a lowpass that provides more effective bandlimiting (eg with a cos rolloff or Gaussian transfer function). After D/A conversion the sampling frequency from the digital section still has to be removed from the modulating signal by means of an analog lowpass.

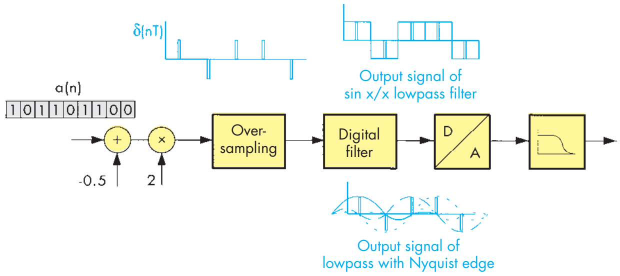


FIG 2
Generating
baseband signals

1.2 Description of RF signal

The expression

$$s(t) = \sqrt{2E_{bit}/T_{bit}} \cdot a(t) \cdot \cos[2\pi f_c(t)\,t+\varphi(t)] \quad (2)$$

represents the RF signal as a real function, where E_{bit} is the energy transmitted per bit. Consequently $\sqrt{2E_{bit}/T_{bit}}$ is the voltage drop across a 1-Ω resistor. The term a(t) gives the amplitude as a function of time, $f_c(t)$ the carrier frequency as a function of time and φ(t) the instantaneous phase. To simplify the notation, the expression $\sqrt{2E_{bit}/T_{bit}} \cdot a(t)$ is often replaced by A(t) or, if a(t) is constant, by A; s(t) is also referred to as the bandpass signal provided its bandwidth is small in comparison with the carrier frequency f_c.

The RF signal can also be described in terms of its I and Q components (in-phase and quadrature). They are:

$$s_I(t) = A(t) \cdot \cos[\varphi(t)] \cdot \cos(2\pi f_c t)$$

and

$$s_Q(t) = A(t) \cdot \sin[\varphi(t)] \cdot [-\sin(2\pi f_c t)] \quad (3)$$

with

$$s(t) = A(t) \cdot \cos[2\pi f_c t + \varphi(t)] = s_I(t) + s_Q(t).$$

This type of representation, which is of course also valid for unmodulated RF signals, makes it a lot easier to understand modulator operation.

The amplitudes of the two modulated I/Q components are functions of time even when A(t) = A = const. or a(t) = 1, in other words even when the RF signal has a constant envelope as is the case for networks using modulation techniques based on the GSM standard (GSM stands for Groupe Spécial Mobile or Global System for Mobile Communications). They can also be thought of as double-sideband amplitude-modulated RF signals with suppressed carrier. The modulating signals are functions such as cos[φ(t)] and −sin[φ(t)] for example.

To determine the degree to which the signal is distorted as it passes through the communication channel, all that needs to be known is how the communication channel affects the envelope of these two components. Introducing the complex envelope of the complex signal:

$$\underline{s}(t) = A \cdot e^{j\varphi(t)} \cdot e^{j2\pi f_c t}, \quad (4)$$

which is related to the real RF signal by

$$s(t) = \mathrm{Re}[A \cdot e^{j\varphi(t)} \cdot e^{j2\pi f_c t}] \quad (5)$$

is a good way of doing this.

The complex envelope, which is also referred to as the equivalent baseband signal, then has the form:

$$\underline{u}(t) = \sqrt{2E_{bit}/T_{bit}} \cdot e^{j\varphi(t)} = A \cdot \cos[\varphi(t)] + jA \cdot \sin[\varphi(t)]. \quad (6)$$

The similarity between the complex envelopes and the I/Q representation of the real signal is striking.

To be continued. Peter Hatzold

Feedback

Mail from South Africa

Hugo Schmitt of Faure in South Africa who collects old radio equipment, receivers and valves sent us the opposite photograph. He writes: "I enclose a picture of some old Rohde & Schwarz equipment which I am sure you will recognize. The VHF relay receiver (editor: front middle, type ESB, market launch 1951) was taken out of service by the South African Broadcasting Company, as they are converting to stereo transistor equipment. These old sets (I have three) have been in continuous use for 30 years and still work perfectly!".

Software SME-K1 for programming the data generator of Signal Generator SME

The strong points of SME come into play especially when RF signals with different types of digital modulation are to be generated [1]. SME is capable of GMSK, $\pi/4$-DQPSK, GFSK, FSK, 4FSK and FFSK modulation and is thus suitable for testing practically any type of mobile-radio network. Pseudo-random bit sequences or user-specific data can be used as modulation data. To store the data in SME, the DM coder option with 8192-bit memory depth is available [2; 3]. When the DM memory extension option is used in addition, storage capacity is increased to nearly 8 Mbits (precisely 8,388,480 bits).

In addition to the modulation data, information on the level attenuation required in some mobile-radio networks and on the burst mode is stored. While the SME operating menu includes an editor for entering data into the DM coder, it is in most cases more convenient to use a PC, which is the only viable alternative for handling the masses of data generated by the memory extension option.

Programming on a PC is greatly facilitated by Software SME-K1. It allows convenient generation and compilation of data sequences for a wide variety of tasks. The software is organized in three menus (file, edit, transfer) and offers functions for file handling, editing and transfer of data from and to SME. The software can be operated via a keyboard or mouse. Hotkeys are provided for fast activation of the main functions.

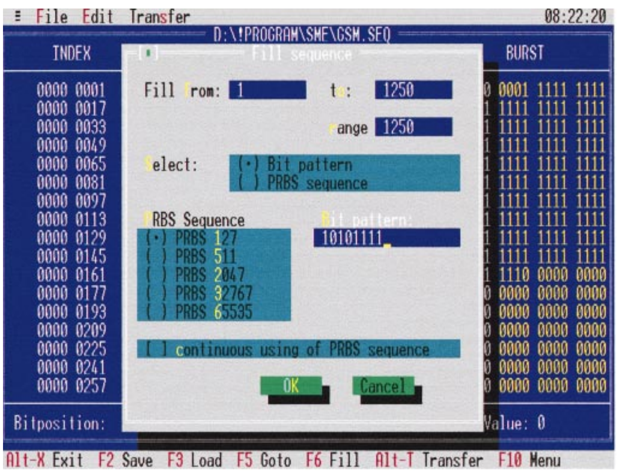


FIG 1 Window with Fill editing function

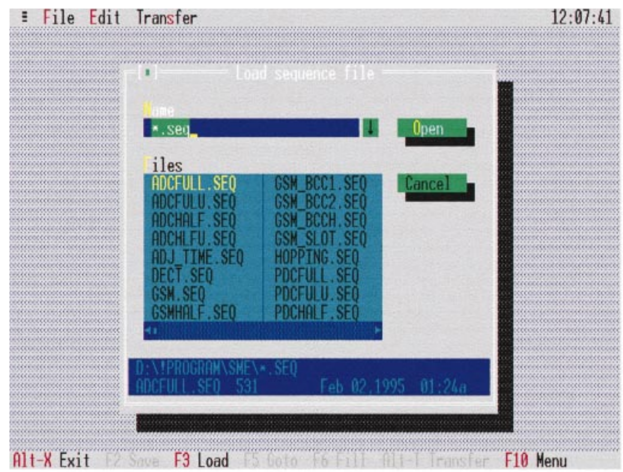


FIG 2 Display of standard signal sequences supplied with SME-K1

Here are details of the three menus:

The **file handling menu** contains all functions required for the generation of new data sequences, their storage in and call from the PC. The PC offers virtually unlimited memory capacity for a diverse variety of data sequences.

The **editing functions** are structured in three areas (Data, Level Att and Burst) that can be edited separately. Data are entered by overwriting the default values with 0 or 1. Various additional functions are provided for enhanced ease of operation. The Fill function, for example, allows a predefined area to be overwritten with a user-defined pattern of up to eight bits or with a pseudo-random bit sequence (PRBS), which repeats after 127, 511, 2047, 32,735 or 65,535 bits (FIG 1). A special function – Continuous Use of PRBS – makes it possible to insert defined bit sequences into the PRBS without the sequence being started from the beginning. GSM bit-error-rate measurements, for example, require long PRBS sequences, whose contents are distributed to many consecutive time slots. Apart from the PRBS data, each time slot must contain tail bits and training sequences. The Continuous Use of PRBS function allows the PRBS to be continued with no break after these synchronization bits have been entered. With the Insert, Append and Delete functions, the length of the data sequence can be varied subsequently. Insert, Append and Delete act on each of the three data areas, so that Data, Level Att and Burst always have the same length. The Rotate function makes it possible to adapt the burst data to different signal delays in SME.

The **transfer menu** contains the Transfer and Receive functions. The Transfer function starts data transfer to SME. The Receive function loads data from SME to the PC. It is thus possible to save the entire data contents of SME if new data are to be stored in SME temporarily.

Standard signal sequences for the most important communication systems, eg GSM, DECT, ADC and PDC, are supplied with the software (FIG 2).

Hardware requirements: Software SME-K1 runs under the MS-DOS operating system and makes very little demands on the PC. SME-K1 requires no more than 450 Kbytes of RAM. Since data transfer to SME is via the IEC/IEEE bus (FIG 3), an IEC/IEEE-bus interface (PAT-B1 or compatible) must be provided and driver GPIB.COM installed.

Albert Winter

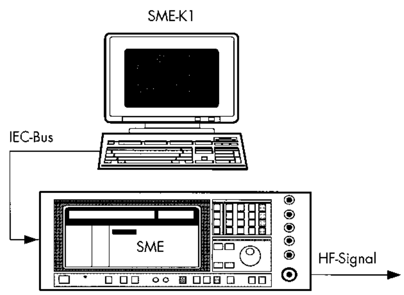


FIG 3 PC with Software SME-K1 and Signal Generator SME

REFERENCES

[1] Lüttich, F.; Klier, J.: Signal Generator SME – The specialist for digital communications. News from Rohde & Schwarz (1993) No. 141, pp 4–7

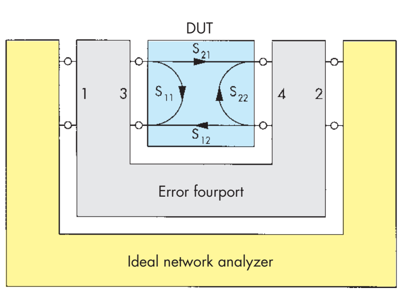
[2] Application Note 1GPAN08: SME with option DM coder, hints for using the data generator

[3] Application Note 1GPAN14: Simulation of BCCH channel of GSM/PCN base station with Signal Generator SME

Reader service card 150/18

Calibration method for network analyzers

The TOM-X* calibration method is a further development of the TOM calibration technique. Unlike conventional calibration methods, TOM-X is based upon a mathematically exact model that describes all possible cross couplings between the four receive channels. As a consequence, this method allows these cross couplings to be eliminated analytically. The error model shown in the figure below is used as a basis (full model). An error fourport is inserted between the DUT and the twoport network analyzer, eg ZVR. It represents the non-ideal characteristics of the system and describes all possible cross couplings. The scattering matrix of the error fourport has 4 x 4 = 16 complex elements, one of which can be eliminated by normalization. The remaining 15 unknown terms have to be determined for each frequency point by vector calibration measurements.



The TOM-X calibration method is highly effective, but is extremely involved. Unlike other calibration methods, two oneport standards have to be connected simultaneously to the two test ports of the network analyzer. The term "double oneport standards" is therefore often used in this context. A total of five twoport calibration measurements are required: direct through-connection of the two test ports, matched load at both ports, matched load at port 1 and simultaneous open-circuit of port 2, both test ports open-circuited, and port 1 open-circuited with simultaneous matched load at port 2.

After calibration the system-error correction facility calculates a mathematically exact correction that eliminates crosstalk in a highly effective way and so increases the overall dynamic range of the system. TOM-X is the only twoport calibration method which is able to correct DUT-dependent crosstalk. This is why it is called TOM-X, X referring to crosstalk. The reduction of crosstalk achieved by TOM-X makes exact measurements possible – even at signal levels lower than system crosstalk. This feature is particularly useful for on-wafer measurements where crosstalk of about 40 dB may arise between the test probes.

* Heuermann, H.; Prof. Dr.-Ing. Schiek, B.: Results of Network Analyzer Measurements with Leakage Errors Corrected with the TMS-15-Term Procedure. IEEE MTT-S International Microwave Symposium, San Diego (1994) pp 1361–1364

German patent DE 43 32 273 A1
Date of application by Rohde & Schwarz 23 September 1993
Date of publication 16 June 1994
Inventors:
Prof. Dr.-Ing. Burkhard Schiek;
Holger Heuermann

Used in vector network analyzers from ZVR family

Reader service card 150/01 for further information on ZVR

Remarks on the future of radiocommunications

On the occasion of the 100th anniversary of radiocommunications, Rohde & Schwarz invited many guests to celebrate this event in Munich (see also our Newsgram on page 58 in this issue). Hans Wagner, President and COO of Rohde & Schwarz gave an outlook on the second century of radiocommunications (FIG). Here is an extract from his speech. This follows straight on from the editorial in NEWS 149, describing the contribution of Rohde & Schwarz to the history of radiocommunications until the present day.

The future of radiocommunications, in particular the future of terrestrial radio, appeared to be without any great prospects in the eighties. Apart from classic mobile applications (such as in cars, airplanes and ships) which could not be mastered otherwise, the future seemed to belong to the optical fiber beside the copper cable. But then a development was initiated, starting out from data technology and data transmission, which introduced revolutionary changes for all other fields of information technology and communications: the linking together of information processing and transmission by means of optimized and standardized coding methods. It was known that the transmission channel could only be used optimally if the digital or – if only available in analog form first – digitized information were prepared beforehand to allow optimum matching to the transmission channel. Suddenly solutions became feasible that could only be dreamt of over the years: practically error-free, undisturbed transmission of information was possible via the most difficult and susceptible channel, namely the radio link with all its disturbing effects.

Hans Wagner, President and COO of Rohde & Schwarz, made the final speech when the 100th anniversary of radiocommunications was celebrated at Rohde & Schwarz

It was with digital technology that mobile radio was to be tackled, all available techniques such as source coding, time multiplexing, band spreading being made use of. Ultramodern modulation methods were employed and the standard (GSM) that was quickly accepted worldwide was born. Development which first was started with the mobile phone now continues with the cordless digital phone and the wireless cable or wireless local loop.

At the same time development of redundancy-reducing methods in particular for vision and sound transmission is surging ahead. Methods making use of human physiological, acoustical and optical perception (key word MUSICAM for sound broadcasting) coupled with modern multi-carrier modulation have paved the way to digital audio broadcasting (DAB) and digital video broadcasting (DVB), which are becoming of interest worldwide and are already in use in pilot networks (see articles on page 58).

With the exception of broadcasting, radio used to be the technology for authorities and for amateur operators. Even the costly analog carphone was a privilege for only a few. Today, for example, the cordless phone is on its way to becoming an inexpensive consumer article worldwide. This was not made possible by digitization alone. It was only by microprocessor technology that the dream of high-performance consumer articles came true. Many hundreds of thousands of transistor functions are united on just a few square millimeters. A precondition for units to become favourably priced is the production of large quantities. This is only possible by worldwide standardization of the basic systems. For GSM this approach was successful. For DAB and DVB it is likely to succeed.

There are thus two technological driving forces – ie digitization with coding and high integration of the products to be implemented – that have offered and will continue to offer new prospects to radiocommunications. The most important impetus, however, is the liberalization and deregulation that have been initiated worldwide. It was only through competition (now also in the field of radiotelephony) that the number of subscribers sharply increased because of interesting new services as well as falling charges and that the use of integrated circuits led to favourable prices. After mobile radio, this competition is going for broadcasting and will change it. Just think of interactive services. Multimedia services which are now implementable first have to be separated from one another and allocated to generic terms such as broadcasting or individual communication.

The use of wireless communication via electromagnetic waves will be more and more versatile in future. Digital technology made radio an equal partner with optical fiber and copper cable for a variety of applications. Radio systems except those with high transmitting power in the kW range or higher are physically mobile and quickly set up. That is why they are preferred to wire and glass.

Due to the future and practically exclusive use of digital transmission within the field of radiocommunications, technical developments will, even more strongly than today, concentrate on software and especially coding and signalling. The generation of high RF power will become more and more unimportant compared to intelligent, adaptive methods of managing transmission power, as already used with GSM, or compared to methods and concepts that use low transmission power in the first place. As a result of the fast growing use of radio technology, electromagnetic compatibility and its optimization will become more and more important, especially in those applications reserved for wire and optical fiber (eg last mile, wireless LAN or local loop).

In this case also the national frequency allocation and frequency management organizations will more than ever before be required to deal with the problems of avoiding or eliminating mutual interference and of supporting the desired competition of the network and service providers as best as possible. The impelling use of highly integrated circuits in the radio equipment of the future calls for stable, reliable and close cooperation with chip manufacturers and for access to software required for modelling, simulation and testing of equipment.

In the long run only radio applications based on internationally used standards and methods will survive. Any constraints in the use of radiocommunications will exclusively lie in the limited resource frequency including its physical limitations as far as propagation and compatibility are concerned. Apart from a few exceptions (security, military) frequency allocation will be shifted towards commercial and public use according to the law of supply and demand.

As almost unlimited, complex applications are possible in the radio channel thanks to digital technology, radiocommunications will in many cases become an integral part of hybrid systems. All this calls for real international cooperation within industry, among network operators and service providers but also between each of the three groups in order to be at the front with the competitors. On the threshold of the second century of radiocommunications Rohde & Schwarz has attuned to the situation and will face the challenges of future radio systems and international partnerships with all its energy.

Hans Wagner

Multimode Radiocommunication Tester CMD for GSM, PCN, PCS and DECT mobiles

With its CMD family, Rohde & Schwarz provides testers for mobiles used in all internationally significant types of digital, cellular mobile-radio networks. All the units have the same look and a similar design. Differences only occur when certain test facilities and operating procedures have to be optimized for a specific network.

FIG 1
Multimode radio-communication tester CMD for mobiles to GSM, PCN, PCS and DECT standards
Photo 42 198

A single CMD (FIG 1) now encompasses both GSM/PCN/PCS and DECT test technologies and so even more benefit can be derived from synergies and standardized production and service measurements – in particular for the dual-mode mobiles of the future. The desired additional measurement functions are provided by means of options which ensure maximum flexibility and adaptability to future requirements. Upgrading is no longer a problem and units that are already in use can be converted at minimum cost.

The option concept and the signalling units for both GSM/PCN/PCS and DECT have major advantages for dual-mode mobiles in particular as these mobiles support DECT and GSM or similar standards. The signalling units are optimized to obtain the best measurement speed for the network in question. As there are two signalling units, there is no need to load different operating software for different systems and this speeds up the process. This is highly advantageous in manufacturing environments because speeding up a test procedure by even a few seconds may make the difference between mobile production being economical or not.

CMD52 for GSM, CMD55 for GSM/PCN/PCS [1; 2] and DECT Tester CMD60 [3] can be converted into a multimode radiocommunication tester (TABLE). CMD55 with DECT option, for example, is nothing other than a combination of CMD55 and CMD60 (FIG 2). Implementing multimode capability by combining two units does not involve any trade-offs. Every single measurement facility, the excellent data of the basic units as well as manual and remote control together with the high measurement speed remain exactly the same.

Michael Vohrer

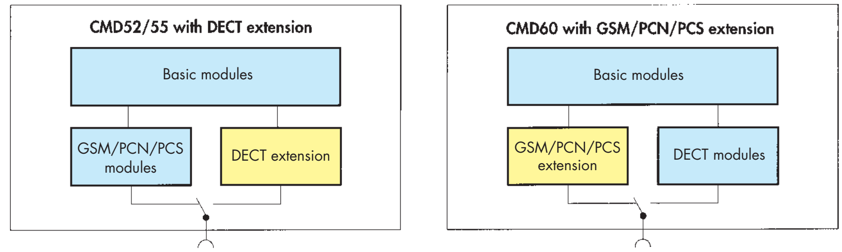


FIG 2 Concept of multimode facility for Digital Radiocommunication Tester CMD maintains high measurement quality, ease of measurement and measurement speed with separate functional units including signalling.

	GSM	PCN (DCS1800)	PCS (DCS1900)	DECT
CMD52	●	o	o	o
CMD55	●	●	o	o
CMD60	o	o	o	●

TABLE: CMD models for GSM, PCN, PCS and DECT with multimode options (● = as standard, o = optional)

REFERENCES

[1] Mittermaier, W.; Holzmann, G.: Digital Radiocommunication Tester CMD55 – GSM and PCN tester in one compact unit. News from Rohde & Schwarz (1994) No. 145, pp 18 – 20

[2] Vohrer, M.: Advanced test technology for GSM/PCN mobile phones with CMD52/55. News from Rohde & Schwarz (1994) No. 145, pp 48 – 49

[3] Mauncksch, T.: Digital Radiocommunication Tester CMD60 – A favourably priced compact test set for series production of DECT mobiles. News from Rohde & Schwarz (1995) No. 149, pp 13 – 15

Reader service card 150/19

Low-cost Service Radiocommunication Testers CMD50/53 for GSM/PCN/PCS mobiles

The digital radiocommunication testers of the CMD family for GSM, PCN (DCS1800) and PCS (DCS1900) have gained remarkable market acceptance thanks to their universality, high measurement accuracy and high measurement speed and are used by almost every manufacturer of mobile phones. Rohde & Schwarz has now added another two members, both ideal for service applications and attractively priced, to the family: CMD50 for GSM and CMD53 for GSM, PCN and optionally PCS (FIG).

The new models are based on their counterparts CMD52 and CMD55 [1 to 3] but are stripped of those test facilities that are not relevant to service applications. Thus CMD50/53 has an RS-232-C remote interface instead of a high-speed IEC/IEEE-bus interface. The multifunction connector for accessing the I/Q signals of the internal CMD modulators and demodulators, which are only of relevance for production and development, is solely for CMD52/55. The high-level RF output on CMD52/55 as well as the RF input/output and highly sensitive second RF input for special module production tests are available as options for CMD50/53. This ensures that testing mobiles of the future which may have an integrated antenna and no RF connector will not be a problem. A DC ammeter/voltmeter with GSM-specific test curve is also available as an option.

All other facilities, technical data and operation are identical for the four units. As a result, joint operation and replacement are straightforward and, if CMD52/55 is used for production testing and CMD50/53 for service work, one can be absolutely certain that the instruments' responses are identical and results are 100% consistent. Automatic, internal sequencing programs, eg for production, can also be used for service testing. The blue box gives a clear overview of all the available options and accessories for Digital Radiocommunication Tester CMD50/53.

With CMD50/53 a manufacturer of mobiles not only has an attractive, cost-effective solution for service applications but can also enjoy the advantages of the coherent test philosophy that provides almost identical test technology from module testing and final production testing with CMD52/55 through to maintenance and service with CMD50/53.

Michael Vohrer

GSM, PCN and PCS mobile Radiocommunication Tester CMD53 for service and maintenance at a favourable price Photo 42 288

Options

CMD-B1	OCXO Reference Oscillator
CMD-B3	Multi-Reference Frequency Inputs/Outputs
CMD-B4	Phase/Frequency Error, Power Ramping and BER Measurement
CMD-B41	AF Measurement Unit with Frequency Counter
CMD-B42	Power Ramping Measurement with High Dynamic Range
CMD-B43	GSM-Spectrum Measurements
CMD-B62	Memory Card Interface (CMD-B6 also required)
CMD-B19	PCS Extension (for CMD53)
CMD-B20	DC Ammeter/Voltmeter
CMD-B30	High-Level RF Output, Sensitive RF Input

Accessories

CMD-Z1	Formatted Memory Card
CTD-Z10	Antenna Coupler with Shielded Chamber

Software

CMD-K43	Narrowband Spectrum Analysis

REFERENCES

[1] Mittermaier, W.; Holzmann, G.: Digital Radiocommunication Tester CMD55 – GSM and PCN tester in one compact unit. News from Rohde & Schwarz (1994) No. 145, pp 18–20

[2] Vohrer, M.: Advanced test technology for GSM/PCN mobile phones with CMD52/55. News from Rohde & Schwarz (1994) No. 145, pp 48–49

[3] Mittermaier, W.: Module test with Digital Radiocommunication Tester CMD52/55. News from Rohde & Schwarz (1995) No. 149, pp 36–37

Reader service card 150/20

CMD compact tester R4860 tests telephones of Japanese mobile-radio network PDC

Digital Radiocommunication Tester R4860, compact tester based on CMD units, for transmitter and receiver tests on mobile phones of Japanese network PDC Photo 42 333/1

Together with its Japanese partner Advantest, Rohde & Schwarz, a world leader in test technology for mobile radio, has developed a tester for the Japanese digital mobile-radio network PDC (personal digital cellular). **Digital Radiocommunication Tester R4860** (FIG) is based on the successful **CMD family** (see pages 53 and 54 in this issue). Mobile phones for the digital network currently being introduced in Japan are tested during service, maintenance and production. The **key parameters of the PDC network** are:

Frequency range

MS → BS	940 to 956 MHz and 1429 to 1453 MHz
BS → MS	810 to 826 MHz and 1477 to 1501 MHz
Power	4 power stages up to 3 W
Channel spacing	50 kHz (interleaved channel spacing 25 Hz)
TDMA	2 out of 6 timeslots, frame length 40 ms
Modulation	π/4-DQPSK

Production and service tests on mobiles are essential for picking up manufacturing faults and detecting defects caused by wear and tear during operation. These defects are mainly detected by testing the RF interface. The signalling software in the mobile station is not involved. Via a control interface, the radiocommunication tester sets the mobile phone to a state in which the tests can be performed.

Transmitter tests in R4860:

a) frequency accuracy of carrier,
b) occupied bandwidth,
c) transmit power, power ramping,
d) leakage power between time slots,
e) modulation,
f) adjacent-channel power, spurious emissions,
g) bit rate error.

Receiver test:

h) sensitivity (BER).

Tests a, b, c, e, g and h ensure that the user has a high-quality communication link; b, d and f ensure that a large number of subscribers can use the network without causing mutual interference.

Manual operation of the tester is supported by a large high-contrast LCD display, softkeys and user prompts. No prior knowledge of PDC is required to operate the unit. The parameters are preset to standard values in the configuration menu just like the pass/fail limits. Thus the test routine for the mobile station is very easy and simple to perform. A useful contribution in this regard is the automatic display of key results. This ease of operation is a great help when equipment is being serviced.

All the single tests and test results are also available at the **remote interface** (IEEE 488). High measurement speed, especially via the IEC/IEEE bus, predestine R4860 for final testing on the production line.

Thomas Maucksch

Reader service card 150/21

Gas chromatography for monitoring production processes in chemical industry

It is essential to monitor every subprocess of a manufacturing process. This is why the composition and quality of end and intermediate products also have to be monitored. High-speed multi-component analyzers are used to ensure that modern production processes are highly efficient. In this respect, minimizing operating costs is just as important as simple and rapid integration into the production environment.

The gas chromatograph is a typical multi-component analyzer. It is able to separate complex gas mixtures and analyze their components. The method makes use of the different solubility of substances in a mobile and a stationary phase. In the stationary phase, the gas mixture is transported through a coated separation column by a carrier gas. Different components take different times to pass along the column and so they become separated. Finally a detector records the time sequence of the gas components.

As part of a new product range, Rohde & Schwarz Cologne has developed a modern process gas chromatograph (PGC), Micro PGC 400 (FIG), for use in tough industrial environments. The core of this unit is a miniaturized gas chromatograph whose components are micro-machined from silicon. This extremely high-precision technique has been borrowed from micro-chip production. The use of micro components – such as valves – guarantees a long operating life and extra short analysis times. The use of a miniaturized injector and detector makes the Micro PGC 400 between ten and 20 times faster than conventional GC systems. The separation capability is also excellent of course.

For example, the Micro PGC 400 can analyze 33 refinery gases in less than three minutes, injection and analysis taking place simultaneously on four channels. Conventional systems would take about 20 minutes under the same conditions. The Micro PGC can therefore now be used for applications that were previously unsuitable for gas chromatographs because they were too slow.

Process gas chromatograph Micro PGC 400 for analyzing 33 refinery gases

Extremely short cycle times and long operating life are obtained by using appropriate backflush precut columns to vent with switching. This multi-component analyzer fully meets industry's growing demand for easier operation, more user-friendly design, lower operating costs and greater flexibility. Thanks to a variety of options – such as a range of injectors, backflushing, explosion-proof measures, sampling systems, alarm functions – together with application planning, Rohde & Schwarz has a turnkey system which can be tailored to the needs of the customer.

Dr. Andreas Waßerburger

Reader service card 150/22

100 years of radiocommunications – good reason for R&S to celebrate

This jubilee (the subject of the title and editorial in the last issue of News) was an opportunity for Rohde & Schwarz to put on a big show to celebrate achievements to date and look to the future of radiocommunications together with some 200 guests from international politics, telecoms and industry. On the evening of 11 October 1995 the arriving guests were ushered into a large marquee, set up on the company's premises in Munich, for a variety program "The world of radiocommunications". The climax was the appearance of direct descendants of radio pioneers Popov and Marconi: Nadejda Mishkinis from Moscow and Capt. Vittorio Marconi from Colombia (shown in the photo between R&S executives Friedrich Schwarz and Hans Wagner).

Next day Friedrich Schwarz opened the event by welcoming the guests. He underscored the special role of the private and independent concern Rohde & Schwarz on the market and the way it had adapted to the new challenges of a digital world. Gerhard O. Pfeffermann, state secretary from the German PTT ministry, outlined in his address the worldwide opportunities and consequences of telecommunications deregulation and liberalization. Director Theodor Irmer brought words of greeting from the International Telecommunications Union (ITU) and praised Rohde & Schwarz's commitment to the radiocommunications sector. Prof. Les W. Barclay and the former director of ITU Radiocommunications, Richard C. Kirby, reviewed the milestones in the hundred-year history of radiocommunications with the assistance of impressive, original recordings and documents.

The guests were also shown something of the major areas in which Rohde & Schwarz operates through practical examples and demonstrations of hardware and software. For the evening there was an invitation to an official reception in Munich's Residence. Following a tour of the treasure vault, the antiquary and the gallery of ancestral portraits, Bavaria's state minister of economics, Dr. Otto Wiesheu, welcomed the guests and expressed his pleasure at the fact that so many prominent persons from all over the world had followed Rohde & Schwarz's invitation to Munich to see technology from Bavaria. In a concluding address, COO Hans Wagner presented his thoughts on the – digital – future of radiocommunications as a partner of equal rank to copper cable and optical fiber (extract on page 52 in this issue). All this technology was rounded off by a cosy Bavarian evening in the alps to the accompaniment of traditional music. HW/ro

DAB live in Peking

Coinciding with the start of the DAB pilot project in Bavaria in October 1995 (see following report), an international broadcasting symposium was staged in China with focus on DAB (digital audio broadcasting). A Rohde & Schwarz team travelled to Peking to attend the important event. The company's capabilities in the sector were demonstrated through lectures and a live broadcast of the DAB program of Bayerischer Rundfunk (BR) via satellite to Peking and onto the Rohde & Schwarz exhibition stand.

On the morning after the official DAB start, following the early-morning news, the third channel of BR broadcast an item on DAB in Chinese and transmitted it to Peking at the same time, where many visitors to the Rohde & Schwarz stand were surprised by the program live from Germany in their native language and CD quality. With the support of German Telekom there was also a video conference via satellite between Peking and Munich (the photo shows the participants at the German end). The guests in Peking were He Dong Cai, vice-minister of the ministry of radio, film and TV, who sponsored the symposium, Cheng Xiaoning, president of the academy of broadcasting science, and Wu Yingjian of the state science and technology commission. In Munich minister of state Erwin Huber, in his welcoming address to the Chinese vice-minister, looked forward to the introduction of DAB in China too with the support of Bavarian industry. He Dong Cai was very impressed by the live broadcast from Munich to Peking, thanking everyone involved and announcing the start of a DAB pilot project in southern China next year. J. Beckmann

Start of DAB project in Bavaria

On the occasion of the media conference in Munich in October 1995, the go-ahead was given for the world's biggest DAB network, the pilot project in Bavaria. The Bavarian state center for new media invited some 800 guests to the event on the Praterinsel in Munich, including German PTT minister Dr. Wolfgang Bötsch and minister of state Erwin Huber. Rohde & Schwarz, as general contractor for the engineering of the DAB transmitter stations, played a large part in organizing the evening. An R&S aerial photo of the Wendelstein station was the eye-catcher right in the foyer. The digital signals broadcast in the Munich region were illustrated by a laser projection.

The official start was then triggered by minister of state Huber at the push of a button during a live relay from the Praterinsel into the "Bayern-Rundschau" news, following which a special program "Brisant" was broadcast from the event by Bayerischer Rundfunk (BR). This included various features on the subject of DAB plus interviews with ministers Bötsch and Huber, the director of BR, Prof. Dr. Albert Scharf, and the president of the Bavarian state center for new media, Prof. Dr. Wolf-Dieter Ring.

To the applause of the guests, Rohde & Schwarz presented a DAB birthday cake to mark the end of the official part. The 250-kilo work of art (measuring 1.4 x 1.2 m) was shaped like a map of Bavaria. Coloured icing marked the propagation areas of the digital broadcast signals, and the transmitter stations were modelled in chocolate. Rohde & Schwarz COO Hans Wagner presented the knife to ministers Bötsch and Huber for cutting the cake (in the photo from left: minister of state Erwin Huber, Hans Wagner and Prof. Dr. Wolf-Dieter Ring). The cake went down well, so well in fact that there was nothing left of it. N. Julien

Radiocommunication testers CMS for Australian army

The Australian army has ordered 154 Radiocommunication Service Monitors CMS53 from Rohde & Schwarz (Australia) Pty Ltd. The photo shows in the foreground brigadier Grahame Hellyer, AM, general director of materials, and Andrew Bean, managing director of Rohde & Schwarz in Australia, at the signing of the contract. These test sets will replace a large number of different instruments currently used for the repair and maintenance of field-communication and other electronic equipment in the frequency range 1 Hz to 1 GHz. CMS53 is practically a complete, portable multi-purpose maintenance workstation that can be powered on DC or AC.

In this contract, which Rohde & Schwarz won in the face of tough competition from other well-known names in test engineering, the Australian army once more showed its trust in R&S technology. In the 1980s it purchased 300 Signal Generators SMS and 90 Radiocommunication Testers CMT. Radiocommunication Service Monitor CMS53 is tailored exactly to the special needs of the army. Here, for the first time, a CMS was fitted with an RF millivoltmeter. Strict requirements for operating environment had to be satisfied, and at the same time the range of transmitter and receiver tests was expanded. G. Higgs

Microelectronics at R&S – showing the way in environment-friendly fabrication

The microelectronics center of competence in Munich produces thinfilm substrates for microwave modules. Through continuous follow-on development of the techniques and technologies, these high-tech components from Rohde & Schwarz are able to satisfy the highest demands. Among the latest examples of the modern fabrication is the development of a layer system qualified to MIL standard 883, and the introduction of statistical process control. Rohde & Schwarz is also exemplary in the treatment of its own waste water, having invested in a new detoxication plant. Together with the manufacturer and thanks to the commitment of the building department of the city of Munich, a fully automatic, biological plant was created in which the "hunger" of the anaerobic biomass for the effluent components to be detoxicated is made use of (photo). The operating costs and the effort that goes into occupational safety are small because, in contrast to conventional methods, hardly any extra detoxicating chemicals are needed. And, last but not least, the enriched precious metals can be recovered from the perished biomass. R. Frodl

CDG forum in Seattle

At the beginning of October 1995 the first forum of the CDG (CDMA Development Group), initiated by the companies U.S. West and Qualcomm, was staged in Seattle in the US state Washington. The aim of the event, at the foot of the Space Needle (photo), was to gain an overall view of currently available testing means for CDMA (code-division multiple access) with the aid of leading instrument producers. 250 participants were able to gather information about the capabilities of mapping systems, evaluation tools, test instruments and systems through the numerous lectures and demonstrations. The forum was of special significance for Rohde & Schwarz because it offered an opportunity of presenting Digital Radiocommunication Tester CMD80 for CDMA to a broad public. CMD80 is a joint development between Rohde & Schwarz and Tektronix (more about the unit in News 149, p 47). Two teams – one in Munich, the other in Beaverton, Oregon – designed this, the world's first compact CDMA test set, in less than 18 months on the basis of the CMD family. M. Scholla

ENDIEL 95 in Lisbon

ENDIEL 95, Portugal's biggest industrial show with some 200 exhibitors, held the stage for five days in the capital Lisbon in the summer of last year. As part of the show there was also a European EMC seminar, supported and organized by ICP (Instituto das Comunicacoes de Portugal). This seminar lent ENDIEL 95 international importance. The lecture by Manfred Stecher (EMC expert at Rohde & Schwarz and member of the CISPR committee) on "Field-strength measurement in the presence of ambient noise" met with great interest. Together with its Portuguese representative Telerus S.A., Rohde & Schwarz presented a number of new products. In addition to the very latest in EMC test engineering, examples of modern GSM test instrumentation were shown. One exhibit that attracted a lot of attention was the CTD52, a go/nogo tester for GSM mobile phones. The most prominent visitor to the Rohde & Schwarz stand was the Portuguese minister for industry and energy, Luis Fernando Mira Amaral (second from left in the photo, talking to Rodrigo Leitão, managing director of Telerus). B. Mohacsy

Information in print

Vector Network Analyzers ZVR (for all measurements and new calibration methods such as TOM-X), **ZVRE** (for magnitude and phase of all s-parameters) and **ZVRL** (for magnitude and phase of s_{11} and s_{21}) are extremely sensitive and have a refresh rate of over 25 frames/s; 9 kHz (10 Hz with option) to 4 GHz, resolution 10 µHz, dynamic range (with option) >130 dB, reference channel (ZVR: 2), calibration time <20 s, automatic two-port calibration; numerous options (eg computer function).
Data sheet PD 757.1802.21 enter 150/01

Digital Radiocommunication Tester CMD60 (DECT) performs fast RF tests to CTR06 (upgradable for GSM, DCS1800 and DCS1900); RS-232-C interface, AF tests and IEC/IEEE-bus interface with options.
Data sheet PD 757.1731.21 enter 150/23

Digital Radiocommunication Tester CMD80 is a compact tester for CDMA mobile stations (IS 95) including power supplies; RS-232-C interface (IEC/IEEE bus as option).
Data sheet PD 757.1825.21 enter 150/24

Digital Radiocommunication Test Sets CRTP02, CRTC02; the data sheet now includes CRTC02 for mobile stations to GSM, DCS1800 and DCS1900.
Data sheet PD 757.0058.22 enter 150/25

EMI Test Receiver ESPC (150 kHz to 1 GHz, optional range extensions to 9 kHz and 2.05 GHz) for interference weighting to CISPR16-1 (10 Hz PRF) and measurements to commercial EMI standards; powered from internal (option) or external battery.
Data sheet PD 757.2009.21 enter 150/26

Microwave Signal Generator SMP (0.01/2 to 40 GHz); the revised data sheet now also features models 03 (27 GHz) and 04 (40 GHz).
Data sheet PD 757.0935.21 enter 150/04

Universal Shielding Chamber CTD-Z10 with Antenna Coupler for Mobile Radio (900-MHz band) for interference-free testing on all cellular networks; attenuation >50 dB.
Data sheet PD 757.1960.21 enter 150/27

EMI Software ESxS-K1 for receiver family ESS/ESHS/ESVS is user-friendly and operates under Windows 3.1 (80836 or higher).
Data sheet PD 757.1848.21 enter 150/28

Sound and TV Broadcasting System STARS (87.5 to 108/470 to 860 MHz) for use in inaccessible areas and under harsh climatic conditions converts satellite signals to terrestrial frequencies (transmit power of 10 W for TV and 20 W for VHF); power supply 1200 VA.
Data sheet PD 757.1948.21 enter 150/29

VHF-UHF Search Receiver ESMA (20 to 1300 MHz) is the perfect central unit for fast (5 GHz/s) and precise radiomonitoring; high sensitivity, tracking preselection, large dynamic range, measures frequency offset and short-duration signals, optional data analysis, can be powered both from AC line and battery.
Data sheet PD 757.1719.21 enter 150/30

Solutions for Coverage Measurements. This brochure gives an overview of the coverage measurement systems of the TS9950 family for planning, optimization and maintenance of digital radio networks.
Info PD 757.1925.21 enter 150/31

Listen. Locate. Analyze. This brochure deals with radiomonitoring and radiolocation and shows why Rohde & Schwarz is the ideal partner for system solutions.
Info PD 757.1954.21 enter 150/32

Encoder Test Sequence DVTS (JPEG, MPEG). This module contains static and moving picture elements for encoder quality assessment.
Info PD 757.1790.21 enter 150/33

Documentation – mediator between man and technology. The **R & S Cologne Plant** guarantees that its documentation complies with legal provisions and enhances user safety.
Info PD 757.2015.11 enter 150/34

New application notes

Automatic measurements on tape recorders using Audio Analyzer UPD
Appl 1GPAN19E enter 150/35

IEC/IEEE-bus control of Audio Analyzer UPD
Appl 1GPAN22E enter 150/36

Measurements of dual-tone multifrequency dialling signals with Audio Analyzer UPD
Appl 1GPAN23E enter 150/37

Measurements on tuners using Audio Analyzer UPD and Signal Generator SMT
Appl 1GPAN24E enter 150/38

Base-station adjacent timeslot rejection measurement with CMD and SME
Appl 1GPAN26E enter 150/39

Schz

Booktalk

Der deutsche Rundfunk
Faszination einer technischen Entwicklung

by Siegfried Hermann, Wolf Kahle and Joachim Kniestedt. Published 1994 by R. v. Decker's Verlag, G. Schenck, Heidelberg. ISBN 3-7685-2394-2, 288 pages, more than 200 illustrations (six of them from Rohde & Schwarz), available in bookshops, price DM 65 (only in German).

This book was produced in cooperation with German Telekom and shows that its predecessor, the PTT, laid the foundation for the technical development of broadcasting. Joachim Kniestedt, familiar as an author of numerous articles on the technology and history of sound and TV broadcasting, reports on the beginning of broadcasting and its development up to 1989 in West Germany. In the chapter "The ultra-short-wave for broadcasting – the wave of joy" there is mention of the achievements of Rohde & Schwarz in this field.

Dr. Siegfried Hermann, a scientific assistant in broadcasting in East Germany up to the time of reunification, reports on the development of broadcasting there after 1945. Joachim Kniestedt returns to talk of broadcasting in a unified Germany and international regulations governing the use of broadcast frequencies. Dr. Wolf Kahle, who long worked for the state broadcaster in Weimar, for Berliner Rundfunk and the German PTT, explains the broadcast studio engineering of the German PTT.

The book is interesting for both specialists and those with a general interest in broadcasting.

Signal Generator SME appeared all of four times on the cover of »Mercado Electronica« 23/95, published in Argentina. In the same issue there was an article by Rohde & Schwarz on the new IEC/IEEE-bus command language SCPI for remotely controlling instruments, making the work of the user very much simpler.

At the right time

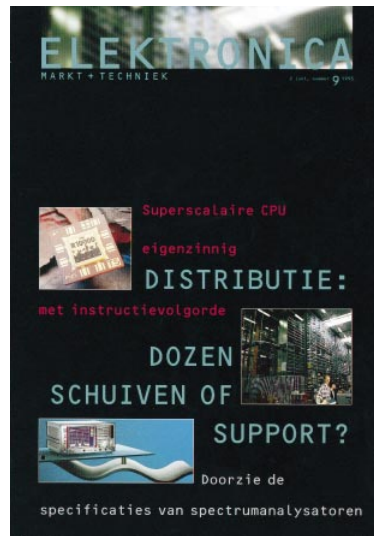
Andreas Schümchen of »Medien-Bulletin« spoke in issue 8/95 to Franz Dosch, executive vice president of the sound and TV broadcasting division at Rohde & Schwarz, about the challenges facing broadcasters:

DAB is a long due innovation in sound broadcasting. It is a European development and investment, and so we are committed to implement it in Europe… From the source coding in the studio through satellite up-links and down-links to terrestrial transmitting components, we offer everything needed to create a complete, synchronized broadcasting network. On the subject of DBV (digital television): …We have already implemented a pilot project in Switzerland, the combination of a PAL transmitter with a DVB transmitter that broadcasts terrestrially and can be switched by telephone modem to analog PAL or DVB. The Swiss PTT is using this project to investigate coverage quality. All our analog TV transmitters are already designed today so that they can go digital without any modification.

Online measurement for the environment

The magazine »CHEManager« 9/95 reported on the ENVITEC 95 show:

Rohde & Schwarz presented a new online metering method for combustion aerosols. Using the CT-500 immission meter, PAH particles can be detected so that PAH emissions can be traced, localized and quantified like immissions, and load ratios and components can be judged reliably.



Spectrum Analyzer FSE from Rohde & Schwarz is used to being a cover star, like on the Dutch magazine »Elektronica« 9/95.

Modern receiver for EMC

In »EMC Journal« 3/95 Wolf Schreyer, product manager for signal analysis and EMC T&M products at Rohde & Schwarz, gave a summary of the situation shortly before the entering into force of the German EMC act on 1 January 1996, presenting at the same time the concept of Rohde & Schwarz's Precertification Test Receiver ESPC:

The development of electronic products is much too costly nowadays to leave the final result, even in part, to chance. This naturally also applies to the interference emitted by such products, which, once the transition period expires on 1 January 1996, will be subject once and for all to the German EMC act (EMVG) and is due to become a headache for many manufacturers, mainly medium-sized businesses. Now that awareness of the need for such emission measurements has woken from its long sleep, test engineering has adapted to the situation. ESPC sticks out among the mass of precompliance receivers, and to emphasize the fact it has been dubbed a precertification test receiver. The risk of unsatisfactory or even unusable test results is much smaller, an encouraging factor for those who are not familiar with all the tricks and ruses of interference measurement.

Quality for the future

On the subject of ISO 9000 at Rohde & Schwarz, editor Paul Kho interviewed the director of the central quality department, Manfred Fleischmann, for »Konstruktionspraxis« 8/95:

Rohde & Schwarz got its ISO 9001 certificate in 1992. That was just the beginning of further improvement of quality within the company. Not just so that the following audits could be surmounted, but above all for an internal quality policy that will ensure lasting satisfaction of all customers.

Multifunctional communication

The new Accessnet® digital exchange from R&S Bick Mobilfunk was a subject for the communications magazine »NET« 8-9/95:

Wireless business and administrative communication will now be even more flexible on the Accessnet® radiocommunication system. A new digital exchange allows simultaneous operation of analog and digital trunked-radio channels. A network operator can therefore continue to use his existing Accessnet infrastructure and flexibly integrate a modern digital system step by step.

»praktiker«, an Austrian magazine for multimedia and electronics, showed the Inmarsat-M radiophone SP1600 from Rohde & Schwarz on the cover of its July/August 1995 issue and devoted an article to the purpose and use of this modern radio system.

Rohde & Schwarz system support – there's system to our service

FIG 1 The support hotline provides the user of Rohde & Schwarz test systems with competent assistance.

"This is the Rohde & Schwarz test system support hotline." These words spoken by a friendly voice welcome callers of the hotline of our system support (+49 89-41 29-36 07) day and night. All customers who have opted for a Rohde & Schwarz test system and longterm support of their system by means of a service agreement can resort to this hotline (FIG 1).

For our customers, test systems are valuable capital goods which allow them to be successful in their respective markets. When buying a test system the question of when the capital invested will have paid off is crucial. This question is closely linked to the availability of the system. Only high operational availability can ensure fast **amortization.**

The **choice of the test system** is of course of vital importance in this context. Rohde & Schwarz test systems combine the advantages of Rohde & Schwarz measuring equipment as well as the latest achievements in hardware and software with the know-how and experience gained by the company over many decades. The decision in favour of a Rohde & Schwarz test system is a decision for quality and reliability throughout the entire lifetime of the system.

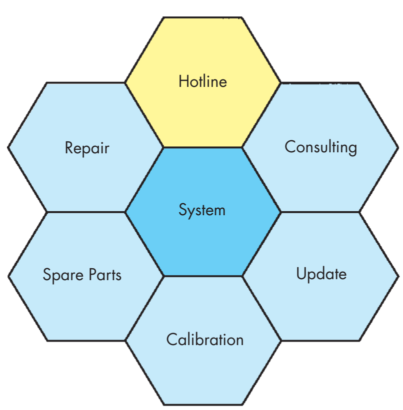


FIG 2 After-sales support

Another important aspect when choosing the system supplier is the question of how high system availability in demanding everyday use and thus the **value of the investment made** can be maintained over the period of amortization and during the entire life cycle of the system. Rohde & Schwarz offers a wide range of customized service agreements to guarantee system support under any conditions. According to the Rohde & Schwarz system philosophy, the high demand placed on competence does not stop with system development but is maintained during the operational life of the systems in terms of servicing (FIG 2).

Hotline support, continuous updating of system software, fast replacement and repair of equipment and modules should faults arise are essential pre-

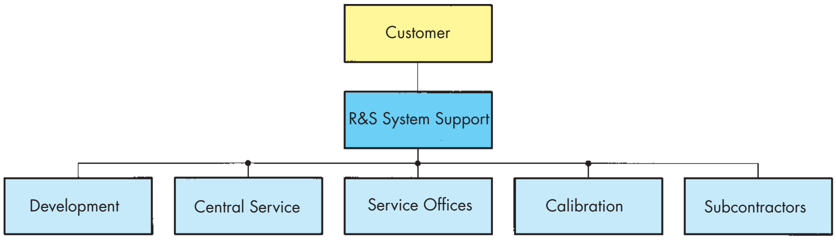


FIG 3 The customer can get in touch with a central partner at Rohde & Schwarz.

requisites for high system availability. Rohde & Schwarz offers integrated solutions comprising both system hardware and software. All problems the customer might encounter during the operation of the system will be handled by a **central partner** who is in close contact with all relevant Rohde & Schwarz departments (FIG 3).

The **service concept** is of modular structure and consists of unit blocks providing a whole series of service products and options for hardware and software. Thus the customer will be able to adapt the service to his specific systems and needs:

Period	Services available
Warranty period	Rohde & Schwarz system warranty (part of regular system service)
	Enhanced warranty service
	Option: express support
	Option: extended service time
	On-site startup service
	Calibration service
After-warranty period	After-warranty service
	Option: express support
	Option: extended service time
	Option: guaranteed availability
	Calibration service

The **enhanced warranty service** supplements the standard warranty services of Rohde & Schwarz to satisfy already during the warranty period the high demands placed on system availability and offers a service time of eight hours and a defined response time:

- database-supported information system with direct customer access,
- hotline service,
- access to a pool of spare modules,
- on-site repair, if required,
- escalation procedure.

The **after-warranty service** is to ensure that the high system availability already achieved by the enhanced warranty service will be maintained after expiry of the warranty. It contains all the unit blocks of the enhanced warranty service plus the following:

- repair of faults,
- supply of software updates.

The **on-site startup service** gives the customer the on-site support of an experienced system engineer during the critical phase of starting up the system. The system engineer provides application support and assists the customer in all matters relating to system handling and service which are usually encountered during the startup period of a complex system. This support assures smooth transition to efficient use of the system:

- support in system handling and operation,
- application support.

The **calibration service** is for checking the specified parameters of the system at regular intervals and correcting them if necessary. It comprises the following services:

- calibration at specified intervals in line with ISO 9001/EN 21001,
- traceability of calibration to national or international standards,
- calibration reports and certificates,
- on-site calibration possible.

The **express support** is the ideal supplement both to the enhanced warranty service and the after-warranty service. It ensures that any downtimes of the system will be kept to a minimum and provides the following services:

- hotline service with a response time of 24 hours,
- extended equipment pool with express dispatch,
- express repair,
- quick on-site support by local service engineer.

The **extended service time** option is for customers whose working day lasts longer than eight hours. We can extend the service time for their systems up to 16 hours per day.

The **guaranteed availability** option in conjunction with the calibration service and the express support will assure the customer extremely high system availability after expiry of the warranty.

All these services are based on the competence and experience of the Rohde & Schwarz system support staff, who look upon themselves as partners of the customers and whose chief objective is customer satisfaction. Perhaps we can soon welcome you with the words: "This is the Rohde & Schwarz test system support hotline…".

Werner Baumgärtel

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