ROHDE & SCHWARZ

electronic
measuring instruments and systems 1979

ROHDE&SCHWARZ

This catalog describes the measuring instruments and accessories manufactured by Rohde & Schwarz. For most of the instruments, in particular those up to medium size, the same amount of information is given in this book as in the relevant individual data sheets (which have a larger photo). The company issues more detailed data sheets for measuring instruments of larger size and measuring systems, as well as specialized publications for particular equipment groups.

The documentation is available on request from your nearest R&S office or representative at the address listed at the end of this catalog. A number of enquiry cards are also included for your use. The company's offices and representatives are always available to deal with any questions you may have, and should always be contacted in the first instance when any servicing is required. The experienced engineering staff at the head office in Munich will gladly reply to any technical queries.

Since this catalog has a relatively long validity please ask for confirmation of all data at the time of ordering or when considering a purchase.

new

Identifies the latest developments, i.e. all R&S products newly introduced since the 1978 catalog.

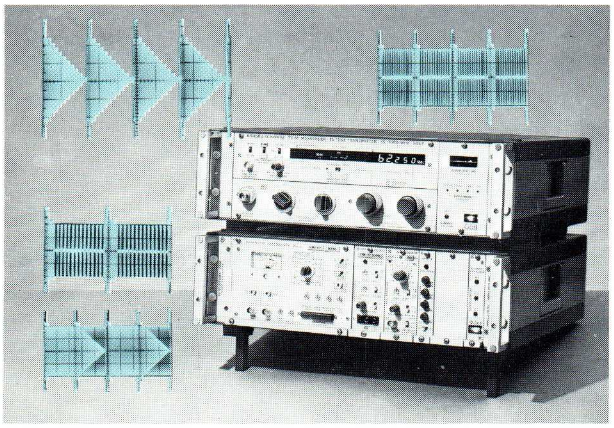
IEC 625 Bus

Identifies equipment having IEC-bus capability, the worldwide standardized interface for use in test systems in line with IEC 625-1 and IEEE 488. For the complete story see section 1.

Explanations of the symbols used in the tables and texts and of the order designations are given on page 267.

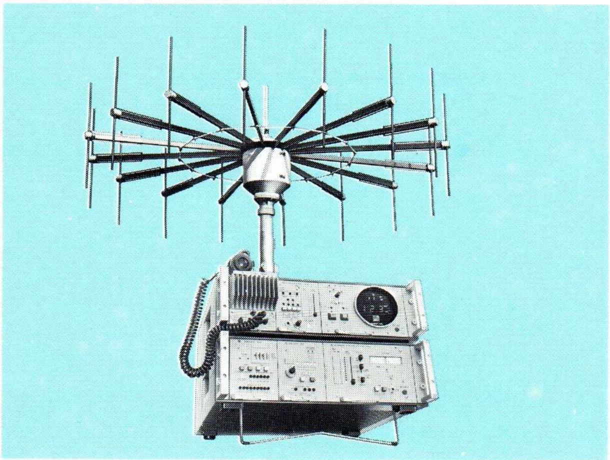
Published by Rohde & Schwarz GmbH & Co. KG, department 5 ZW · Edited by G. Strohbach · English translation by E. Märkl, C. Neumann, D. Picken, U. Renner · Printed in the Federal Republic of Germany · Subject to change without notice

OTHER PRODUCTS



Sound broadcasting and television

R&S measuring instruments and equipment for television and sound broadcasting are presented in a separate 200-page catalog; please use reader service card (at the end of this catalog) if you would like to receive a copy.



Radio equipment

The R&S line of radio equipment for HF, air-traffic control and radiomonitoring is described in various system data sheets and specialized catalogs, which will be sent on request.

Part of the field of **radiomonitoring,** closely related to the measurement domain, is treated in section 8 of this catalog.

contents

See end of catalog for R&S addresses, type listing and idex

R&S INFORMATION

Electronic precision

is the motto under which Rohde & Schwarz has been developing and manufacturing electronic measuring and communications equipment for over forty years. R&S is an independent concern founded in 1933 as a physical and technical development laboratory by physicists Dr. Lothar Rohde and Dr. Hermann Schwarz. Both men are still active in the management of the company. Since 1971 the second generation of owners has been represented by the involvement of Dipl.-Ing. Friedrich Schwarz.

The company has 4500 employees throughout the world and its sales network covers a total of 80 countries. R&S has manufacturing plants in Munich, Memmingen and Teisnach. The company has subsidiary operations in Messgerätebau GmbH and Rohde & Schwarz Vertriebs-GmbH; it also works in close cooperation with other reputable manufacturers such as Tektronix, Inc.

Some R&S milestones are the world's first portable crystal clock (1938), the first VHF broadcast transmitter in Germany (1949), the first automatic IC tester developed in Europe (1967) and the first intelligent RT test assembly with microcomputer and IEC bus (1974). The latest instrument developments are presented in this catalog.

Quality control

The company's style is characterized by dynamism and energy, its products by precision and quality. As the instruments advance in design so too do the circuit techniques used in their realization. R&S develops and manufactures microcircuits in-house and makes use of the latest computer aids for the generation of printed-circuit-board masters. The assembly of the boards is automated.

All stages of development and manufacture of R&S products are performed in close cooperation with the quality assurance department, which reports directly to the R&S management and is responsible for quality planning, reliability, environmental testing, component testing, incoming inspection and, in the production stages, for preproduction control, finish control, assembly control, final acceptance and manufacturing equipment studies. Of course all tests are performed with calibrated instruments and aids.

All these phases – from incoming inspection through in-process control and burn-in to servicing – are watched over by a computer-based fault-acquisition system. The R&S quality assurance system is widely approved by national authorities and civilian services and complies with the most stringent NATO requirements.

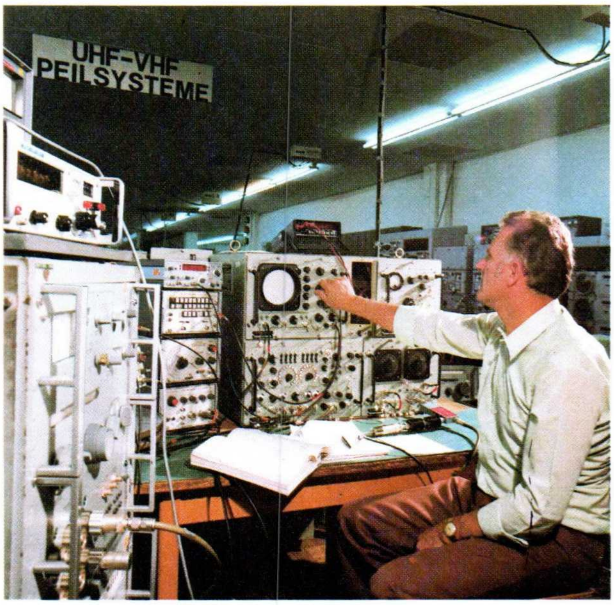
Training

Courses of introduction to new products and on maintenance and repair know-how are run at R&S Munich and at the R&S Service Center Cologne for the staff of the worldwide R&S sales organisation. System initiation and basic technical instruction courses are much appreciated by customers.

Official calibration

The Rohde & Schwarz works in Cologne offer a calibration service. for electronic instruments and systems in their own standards laboratory and in calibration vehicles. The works, which were established in 1960, are the largest industrial service centre for electronic measuring and communication equipment, their main taste being calibration and repair.

In October 1977 the R&S works in Cologne were officially approved as a calibration office of the Federal-German calibration service (DKD) for measuring instruments used in communications. Commercial and industrial enterprises and institutions can have their instruments calibrated and receive an official certificate. The Federal-German standards office (PTB) provides the calibration offices of the DKD with access to national measuring standards and devices and constantly supervises the quality of the work performed by the offices.



Demonstrations

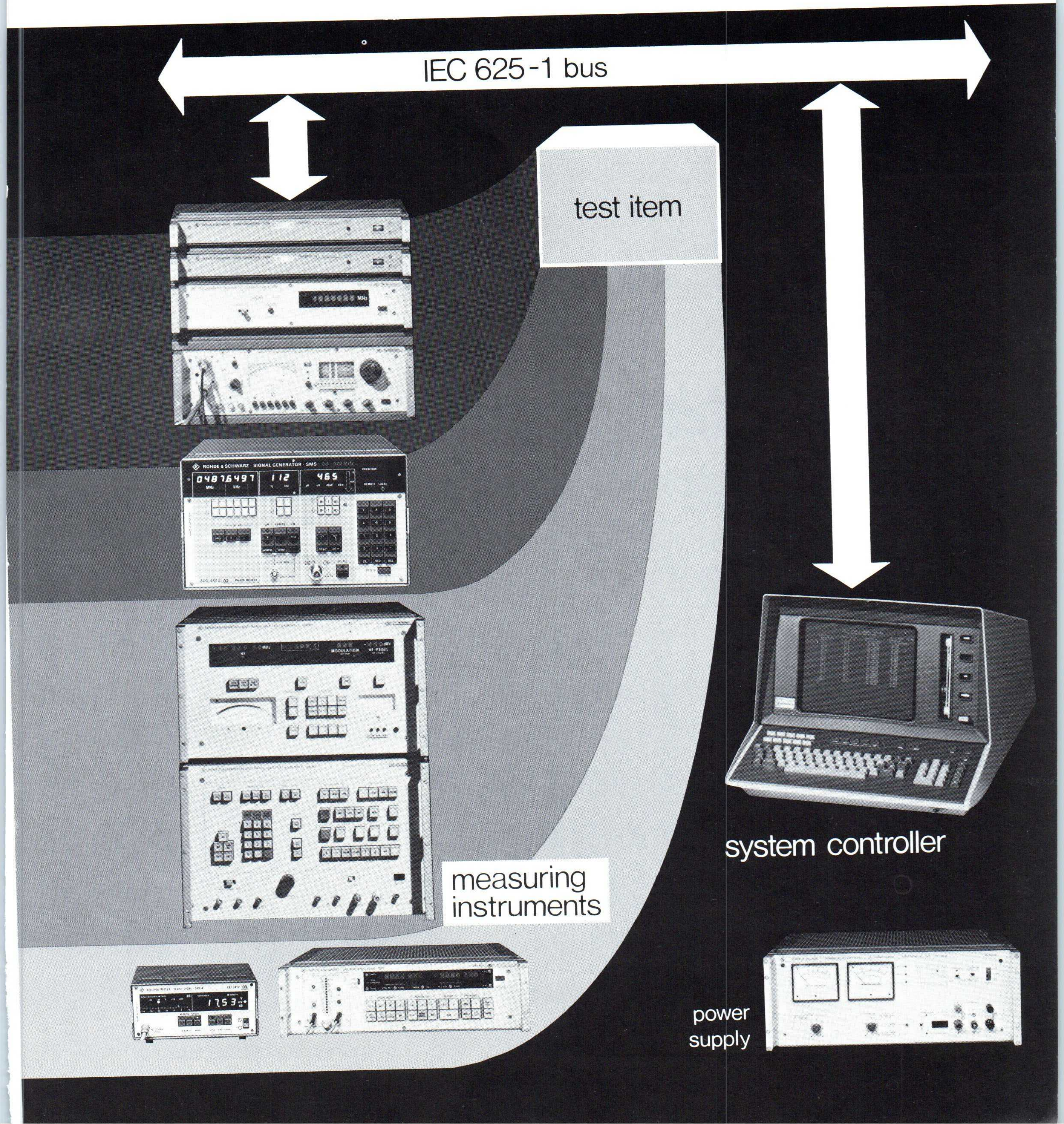
Rohde & Schwarz presents its products every year at nearly fifty fairs and exhibitions all over the world. A spacious demonstration van more over brings the latest developments directly to the door. The visitors' interest generally centres around the automation of measurements and the resulting rationalization.

Four numbers of News from Rohde & Schwarz are issued per year. This technical journal is published in German, English and French – total circulation 45,000 – and is supplied free of charge to qualified readers.

Rohde & Schwarz demonstration van, equipped with precision instruments for automatic AF and RF measurements

The new measuring instrument generation can be controlled via the IEC interface bus and combined to form test assemblies of any required size

automated test systems
the iec bus



1 IEC BUS

The development of favourably priced desktop calculators and intelligent measuring instruments has opened the way – both at the control and the measuring ends – for the implementation of automated measurements on a broad front. The application of automated instrumentation is no longer restricted to a few large-scale users – as it was before for financial reasons – but has become attractive for all users of measuring instruments in development, production and quality control.

The key which permits full use to be made of all the possibilities offered by this new intelligent instrumentation is the IEC bus.

What is the IEC bus?

The IEC bus is a worldwide standardized data bus for use in test systems, permitting measuring instruments from different manufacturers to be combined at will with freely selectable computers without requiring an instrument-compatible interface or special data couplers. The controllers both send commands to the measuring instruments and receive data from them via the IEC bus, which constitutes, so to say, a teletype line between the individual units of a test system, enabling data transfer in either direction.

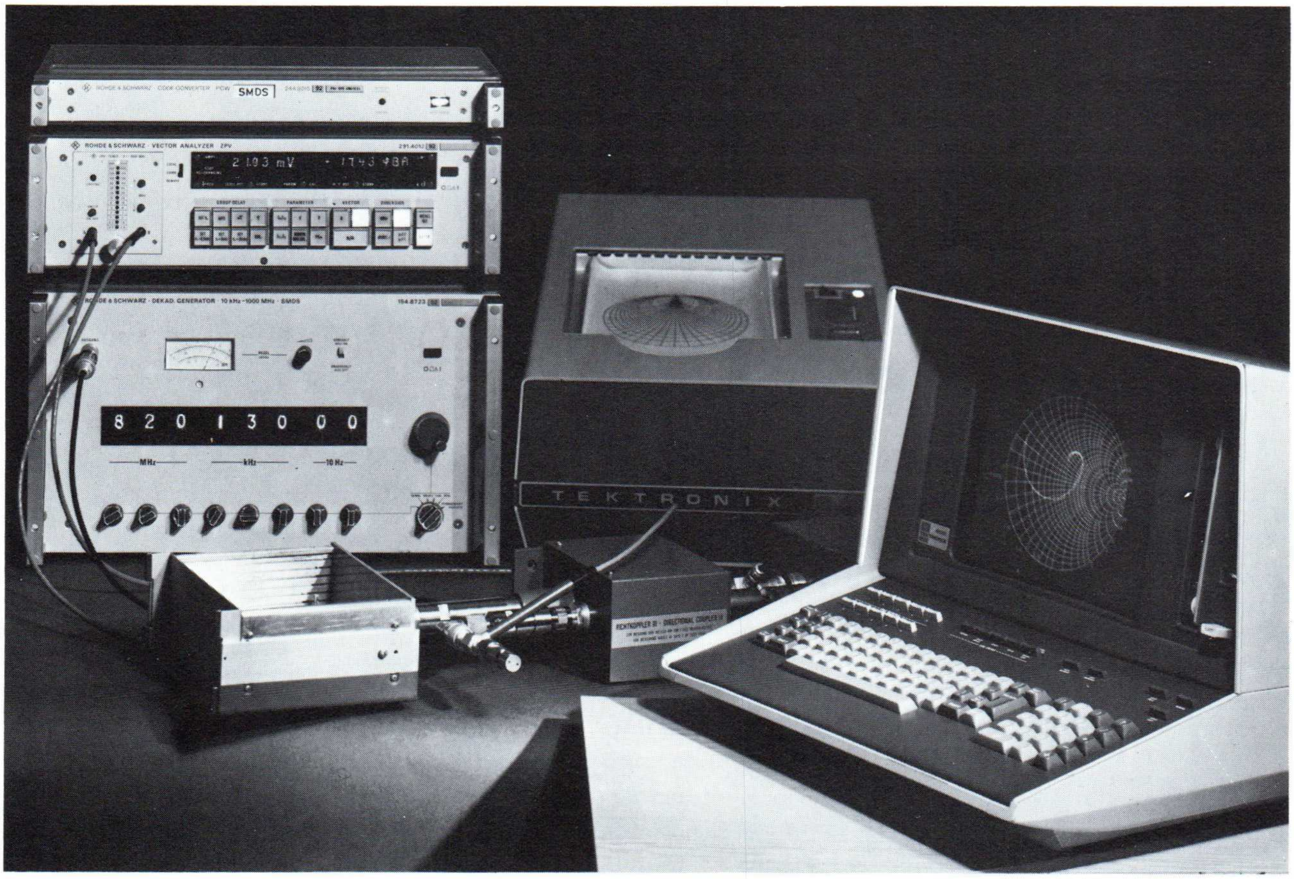
The IEC bus is designed such that combining the instruments into a system requires **no special knowledge** and is achieved by simply linking up the IEC bus connectors of the individual units. All other functions, such as monitoring the usually different data transfer rates of the individual instruments, are performed automatically. The code used for transmitting information via the IEC bus is ASCII, which normally also provides the communication between computers and their peripherals and delivers characters which can be written and read directly.

Desktop calculators featuring a favourable price/performance ratio are ideal for controlling IEC-bus-compatible equipment. In general they are smart enough to meet all usual requirements. Desktop calculators using standard programming languages are of special advantage since changing the computer then presents no problems, their speed being generally sufficient for analog test systems. With increasing speed requirements it is best to use prozessors which R&S offers with IEC-bus connectors.

The IEC bus permits the configuration of automatic test systems which are extremely low-priced and feature high flexibility and reduced space requirements.

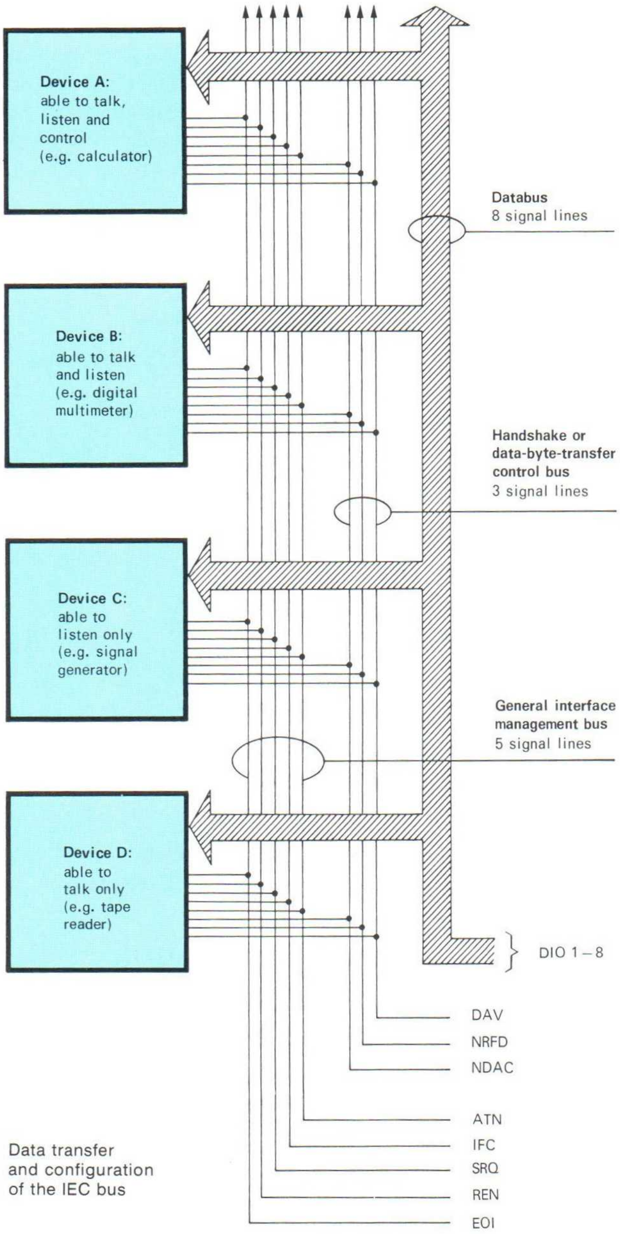
How does the IEC bus function?

The IEC bus consists of three parts: the data lines, the **control lines** for the **timing of what occurs** and the control lines necessary for the **management of the system.**



Application of IEC bus: automatic network analyzer, consisting of Vector Analyzer ZPV, Decade Frequency Generator SMDS, Code Converter PCW and Tektronix calculator 4051 plus hard-copy unit

The actual data transfer is made over eight data lines **DIO** (data input/output) which carry all information and also addresses. The data bus is bidirectional, the data flowing in both directions.



Data transfer and configuration of the IEC bus

As mentioned, the characters are encoded in ASCII, with 7 or 8 bits per character, so that one complete character per clock is transferred over the data bus. The control line **ATN** (attention) serves for identifying whether instrument addresses or data are being transferred.

The other lines for system control are: **IFC** (interface clear) for resetting the system to a defined initial state, **SRQ** (service request) and **EOI** (end or identify) for interrupt control, which enable the instrument to request the attention of the control computer for delivering a test result, and **REN** (remote enable) for putting the measuring devices into programmed operation.

In addition to the manual and remote-control modes which are performed via the REN line, most programmable Rohde & Schwarz instruments feature the combined mode permitting simultaneous programmed and manual operation. This capability considerably facilitates the preparation of test routines and the checking of automated test systems. Thus the computer and the operator are able to work so to speak hand in hand.

The timing of data transfer is controlled via the lines **DAV** (data valid), **NDAC** (not data accepted) and **NRFD** (not ready for data) by the handshake process, that is to say, the slowest device determines the speed of operation. Although this method is not the best from the point of view of speed, it ensures that the user does not have to worry about timing the data transfer. Any combination of IEC-bus-compatible instrumentation can be assembled and automatically adjusts to its own speed of data flow. In general the minimum data flow rate of Rohde & Schwarz instruments is very high, so that normally no noticeable delay of the programming speed is entailed. Since, moreover, in analog measurements the instruments need quite some time to settle to steady state, it can be assumed that even desktop-calculator control does not reduce the physically feasible maximum test speed significantly.

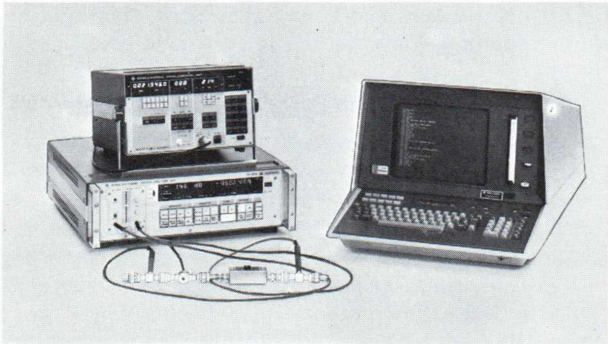
The IEC bus is consequently a self-driving and self-controlling data bus enabling measuring instruments and computers to be put together quite at random.

How is an IEC-bus-compatible test system set up?

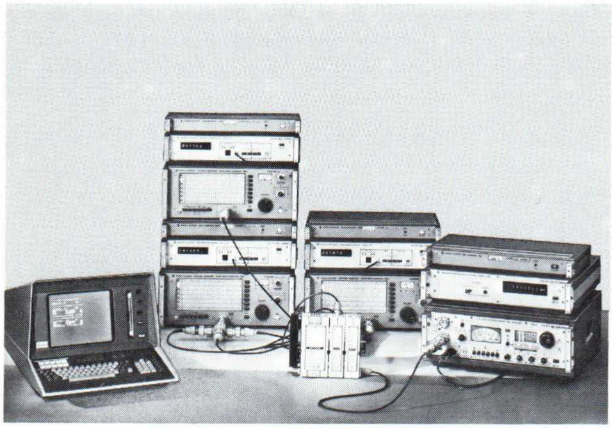
The most important criterion is the **selection** of suitable measuring instruments. Thus the configuration of an IEC-bus-compatible test assembly does not differ from that of a setup consisting of manually operated devices. The measuring instruments are selected for their specific technical characteristics to meet all the requirements involved. Next the necessary interconnection is made. Now the user is able to check in the **manual mode** whether the test assembly complies with his idea. All measuring functions and accuracy specifications are verified.

The step towards **automation** is taken by linking up the IEC-bus connectors located on the rear of the instruments and by connecting them to a desktop calculator. Criteria for selecting this calculator are the programming language, storage capacity, computing speed and operating convenience. The test assembly obtained in this way performs all test routines which are possible in the manual mode in fully automatic operation. Thus in the **first stage** the IEC-bus-compatible test equipment is a configuration of instruments which are operated from a calculator.

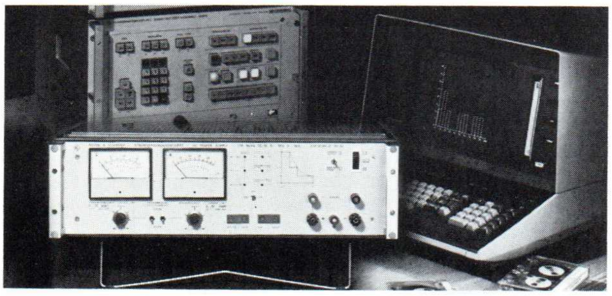
Automatic VHF-UHF test assembly for wanted- and unwanted-signal measurements (MSUP plus Tektronix desktop calculator 4051)



Automatic test assembly for s-parameter measurement (ZPV, SMS and Tektronix desktop calculator 4051)



Automatic test assembly for intermodulation and crossmodulation measurement (3× SMLU plus SMLU-Z and PCW, ESU 2 plus EZK and PCW, Tektronix desktop calculator 4051)



Automatic test assembly for RT equipment and modules (partial view of SMPU, Tektronix desktop calculator 4051); front: programmable Power Supply NGPU 70/10

In the **second stage,** efficient use of the computer capabilities permits optimizing the instrument characteristics. This can be achieved by suitable programs for error correction and self-calibration in accordance with standard curves. In this way, the accuracy can be increased considerably in most cases.

In the **third stage,** measurement evaluation can be expanded from simple test result logging to error statistics, error diagnosis, nominal-to-actual comparison and graphic display.

In practice, the configuration of IEC-bus systems is so easy that the user himself can take care of the assembly. However, Rohde & Schwarz naturally also offers comprehensive system consultancy and assistance for any questions or problems that may arise. Finally, ready-to-use systems are available on request.

For frequent standard applications, the Rohde & Schwarz line includes complete IEC-bus systems with data sheet specifications. The delivery comprises problem-oriented software enabling the user to operate these systems without any extra programming.

Instruments used in IEC-bus systems

The configuration of IEC-bus test systems does not only require **measuring instruments** but also different **system-related devices** to perform control and auxiliary functions. For the measuring instruments see the corresponding sections of this catalog; the system-related devices are described on the following pages.

Measuring instruments

- Test Assembly for Radio Sets SMPU, 10 Hz to 1 GHz
- Vector Analyzer ZPV, 100 kHz to 1 GHz/300 kHz to 2 GHz
- Signal Generator SMS, 0.4 to 520 (1040) MHz
- Millivoltmeter URV 4, 10 kHz to 2 GHz, 700 μV to 1000 V, −50 to +73 dBm
- Programmable VHF-UHF Test Equipment MSUP
- RF Step Attenuator DPSP, 0 to 2700 MHz
- Programmable Voltage Source NGPS
- Programmable Power Supplies NGPU, 175 W and 70 V/max. 10 A;
  350 W and 70 V/max. 20 A
- Temperature Controller PTC
- Digital Thermometer PTM

Adaptable via Code Converter PCW:

- Decade Frequency Generator SMDS, 10 kHz to 1 GHz
- Power Signal Generator SMLU, 25 MHz to 1 GHz
- Precision LF Generator SSN 0.01 Hz to 120 kHz (1.2 MHz)
- Programmable Attenuator Set DPVP, 0 to 1000 MHz
- VHF-UHF Test Receiver ESU 2, 25 to 1000 MHz

System-related devices

- Tektronix Graphic Computing System 4051
- IEC-bus Cable PCK
- AF Relay Matrix PSN
- RF Relay Matrix PSU
- Card Reader PCL
- Code Converter PCW

IEC-bus-compatible measuring instruments for sound- and TV-broadcasting equipment are described in a separate catalog; see note on inside·front cover.

Desktop calculator control

Desktop calculators are excellent for controlling IEC-bus systems. They offer a particularly economic solution for small, decentralized automatic test systems.

Essential advantages of desktop calculators are:

Low price. In addition to the actual computing system, desktop calculators combine in one unit the most important peripherals such as keyboard, magnetic store and display. In this way an especially favourable price/performance ratio is achieved.

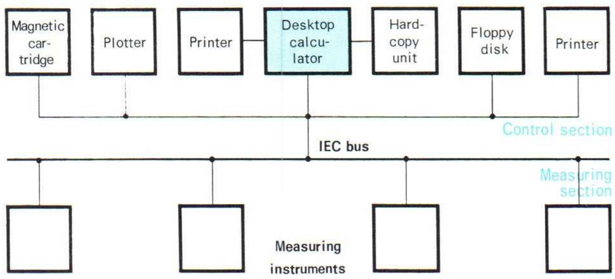
High reliability. Integrating the calculator and the peripherals in one cabinet ensures an extremely high reliability. Putting the system into operation presents no difficulties since no interface problems have to be solved. Modern desktop calculators are fitted with the IEC-bus connector as standard.

Easy operation. Desktop calculators are convenient and easy to operate since their keyboards can be adapted more individually to the specific computing tasks than with the usual standard displays. Program editing in particular is very easy.

Modern desktop calculators feature very high storage capacities and computing speeds which are sufficient for practically all analog testing applications.

Depending on the measurement task, calculators of different capabilities can be used. Calculators with a display screen are to be preferred in any case because of the greater ease of operation. For graphic display, calculators with a storage CRT are mainly used, furnishing graphic documentation via the corresponding hard-copy units.

Rohde & Schwarz automatic test systems are principally controlled from Tektronix desktop calculators. In specific cases programs for other desktop calculators are also available.



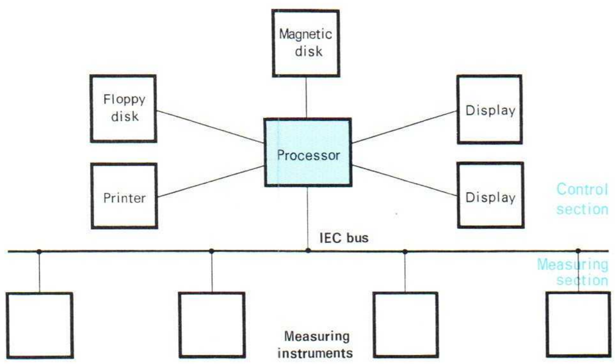
Block diagram of test setup with desktop calculator control

Processor control

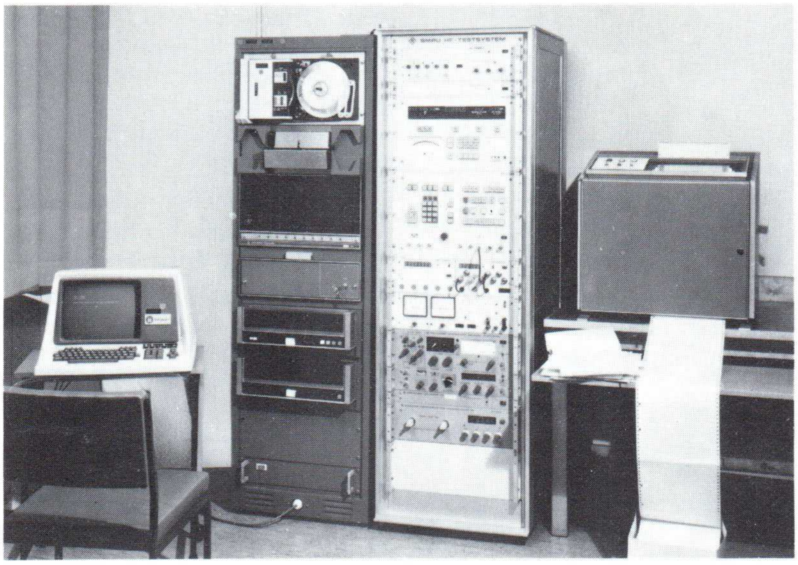
If a higher-capability control computer is required, a processor can be used instead of the desktop calculator for controlling IEC-bus-compatible automatic test systems. Any processor with IEC-bus connector is suitable for this purpose.

The advantages of this configuration are the higher data processing speed and the shorter access time to larger data stores such as the magnetic disk. Thus it is convenient to use processors if, in addition to the actual measurement task, comprehensive data processing is required, for instance selection of test-item-dependent measuring parameters and collection of large amounts of data for statistical evaluation.

For these applications Rohde & Schwarz offers Data General Nova processors as standard. An IEC interface bus and several basic operating systems are available for these processors.



Block diagram of test setup with processor control



RF test system with processor, tape reader and punch, two magnetic-disk units, printer and display

Decentralized computer control

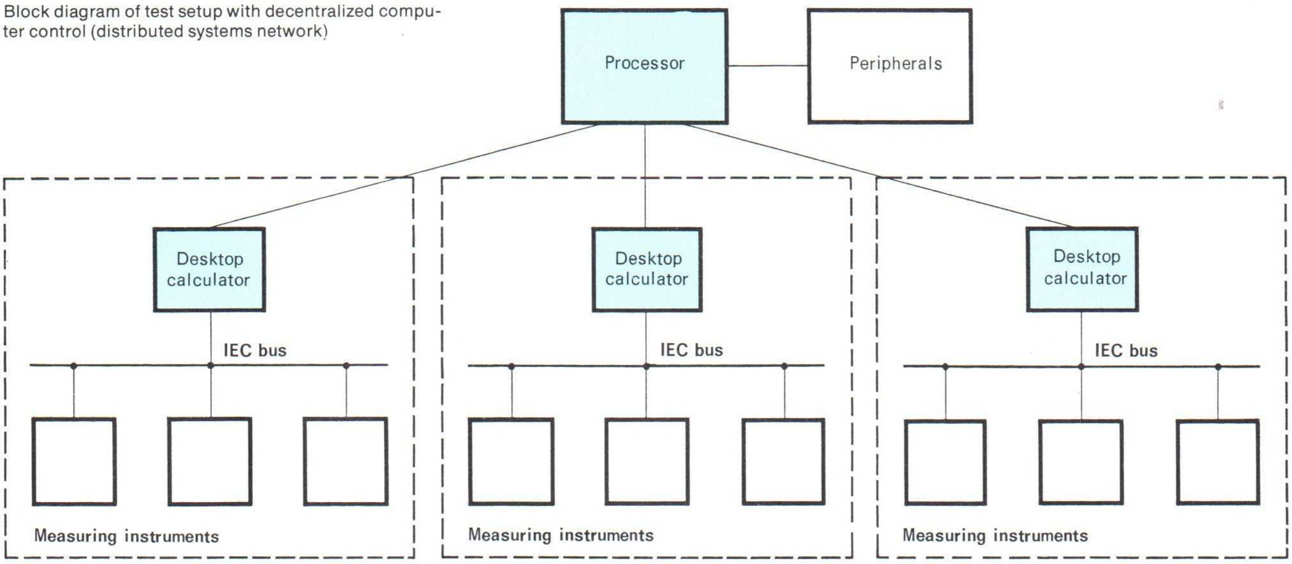
When using several automatic test systems in related applications, it is often best to install a distributed systems network.

In this case, several automatic test systems with desktop calculator control are set up; their measuring capability is fully independent and they are hooked up via normal data lines to a common supervisory computer (processor). However, this processor does not execute any measurements but merely performs housekeeping functions, such as storing and processing the test programs. These programs can be called up from the individual ATSs which also feed their test results to the processor. The supervisory computer then provides for centralized evaluation of all test results collected.

Advantages of this solution are the considerably simpler management and organization as well as the possibility of making rational use of powerful peripherals, such as high-speed printers and bulk stores.

Decentralized computer control is based on desktop calculators featuring the necessary communication capability. The Tektronix Graphic Computing System 4051 is particularly suitable for this purpose. Rohde & Schwarz offers the required operating software for such distributed systems networks.

Block diagram of test setup with decentralized computer control (distributed systems network)



Programming

The programming effort required for an automatic test system is an essential criterion for its economic efficiency. Therefore a complete, technical ATS solution comprises both the realization of the hardware and the corresponding software.

Two different solutions are to be distinguished:

a) for users with higher programming knowledge wishing to make exhaustive use of their ATS capabilities, and

b) for users who have to change their programs very frequently and are not ready to accept a high programming effort.

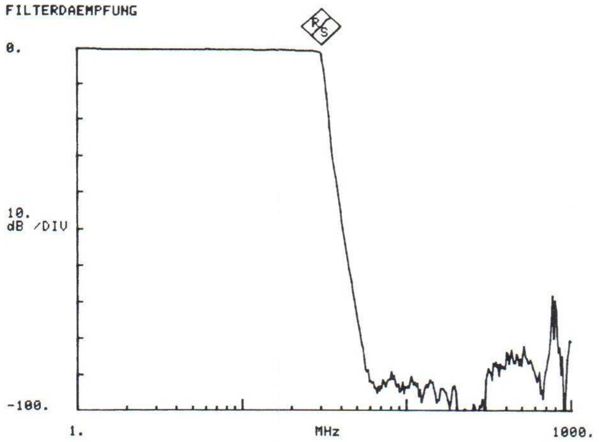
Consequently there are two different modes of programming:

The direct mode using a programming language. The most universal method is to address the instruments directly. Setting and measuring commands are communicated to the instruments in a programming language and combined into test programs using logic functions. The basis is BASIC, the programming language for desktop calculators; it permits IEC-bus-controlled instruments to be directly addressed. With modern R&S measuring instruments of high intelligence it is even possible to enter the settings in ordinary language and to read the test results in the correct mathematical form. This means: instrument intelligence considerably simplifies individual test programs.

Using preprogrammed test routines (basic software). Programming becomes very easy when preprogrammed test routines are used. In this case virtually no programming knowledge is required and the user is able to realize comprehensive test programs within a very short time. For this purpose, Rohde & Schwarz offers **basic software packages** containing ready preprogrammed test routines. These routines are linked in such a way that wrong programming is practically impossible.

Basic software packages are available for instance for all test programs required in RT technology for measuring AM, φM, FM and SSB equipment. Moreover, another software package available for the Tektronix desktop calculator 4051 contains graphics routines which permit complex diagrams, such as the Smith chart, to be represented within a very short time. These software packages have proved themselves in many cases, their number being constantly extended with the appearance of new R&S measuring instruments. It is also of advantage that the packages can be expanded by individual test programs and that no loss in flexibility occurs.

The programming example below to the left shows the procedure executed when measuring an FM stereodecoder with the automatic RF test assembly (SMPU) while the example to the right, relating to the Vector Analyzer ZPV, illustrates the programming effort required for graphic display of complex test parameters.



Measured filter response output by calculator via hard-copy unit

Programming examples

FM stereodecoder measurement using SMPU

```
LIS100,270
100 GOSUB 1                      program start
105 GOSUB 21                     RF generator "on"
110 Y=10.7                       RF centre frequency
120 GOSUB 7
121 GOSUB 25                     FM mode
122 Y=0                          deviation (0)
123 GOSUB 11
124 Y=1                          modulation frequency
125 GOSUB 10
130 Y=0                          RF level (0 dB)
140 GOSUB 9
150 X1=10.55                     RF display width
160 X2=10.8                      start/stop frequency
170 Y1=1.0E-3                    range of output voltage
180 Y2=10
190 X$="MHZ"                     units on X and Y axes
200 Y$="V"
210 T$="ZF-FILTER/DECODER"       heading
220 GOSUB 94                     graphics X lin, Y log
230 X3=1.0E-3                    step width of RF
240 X4=7                         code nos for X and Y axes
250 Y4=41
260 GOSUB 97                     sweep start
270 END
```

Measurement of complex quantities using ZPV

```
100 INIT
110 Y=1
120 GOSUB 1
130 Y=10
140 GOSUB 9
150 Y=900
160 GOSUB 10
170 Y=10
180 GOSUB 11
190 GOSUB 78
200 Y1=-60
210 Y2=0
220 S$="DB"
230 T$="KOPPELDAEMP. RICHTK."
240 GOSUB 90
250 GOSUB 97
260 Y1=-200
270 Y2=400
280 Y$="GR"
290 GOSUB 92
300 GOSUB 98
310 END
```

Example for easy programming with preprogrammed test routines
Code numbers of Basic Software ZPV-K1

1 program start	Y = 1 generator SMPU Y = 2 generator SMLU Y = 3 generator SMDS Y = 4 generator SMS

Input data

	Physical unit
2 test frequency	MHz
3 test level	dBm
6 shift of reference plane	cm
7 relative dielectric constant ε_r	
9 sweep start frequency	MHz
10 sweep stop frequency	MHz
11 sweep step width	MHz
13 number of markers	
14 frequency deviation for group-delay measurement	kHz

Operational settings

17 impedance of test setup 50 Ω
18 impedance of test setup 75 Ω
19 parameter measurement using directional couplers
21 parameter measurement without directional couplers
22 filter on
23 filter off
25 electrical length compensation on
26 electrical length compensation off

Calibration/reference values

27 store magnitude (real component) as reference value
29 store phase (imaginary component), group delay as reference value
30 calibrate parameter
31 calibrate for dynamic group delay measurement

Output of single-shot measurements

33 nominal/actual value comparison, output on display	H1 = upper limit of magnitude (real component) H2 = upper limit of phase (imaginary component) L1 = lower limit of magnitude (real component) L2 = lower limit of phase (imaginary component)
34 nominal/actual value comparison, output on printer	limit input same as under 33

Output of swept-frequency measurements

35 nominal/actual value comparison, output on display	limit input same as under 33
37 nominal/actual value comparison, output on printer	limit input same as under 33

Program execution

39 wait loop 1 s
41 wait loop 0.1 s
42 halt
43 print program

Individual measurements

Vector measurement

		Physical unit
45 voltage measurement channel A	linear	mV, degrees
46 voltage measurement channel A	linear, relative	no dimension, degrees
47 voltage measurement channel A	log	dBm, degrees
49 voltage measurement channel A	log, relative	dB, degrees
50 voltage measurement channel B	linear	mV, degrees
51 voltage measurement channel B	linear, relative	no dimension, degrees
53 voltage measurement channel B	log	dBm, degrees
54 voltage measurement channel B	log, relative	dB, degrees

Vector measurement

		Physical unit
55 voltage ratio measurement, channel B/A	linear	no dimension, degrees
57 voltage ratio measurement, channel B/A	linear, relative	no dimension, degrees
58 voltage ratio measurement, channel B/A	log	dB, degrees
59 voltage ratio measurement, channel B/A	log, relative	dB, degrees

Parameter measurement

62 reflection coefficient measurement	linear by magnitude and phase	no dimension, degrees
63 reflection coefficient measurement	linear with real and imaginary components	no dimension
65 reflection coefficient measurement	log by magnitude and phase	dB, degrees
66 VSWR measurement		no dimension, degrees
67 impedance measurement by magnitude and phase		Ω, degrees
69 impedance measurement in terms of resistance and reactance		Ω
73 admittance measurement by magnitude and phase		mS, degrees
74 admittance measurement in terms of conductance and susceptance		mS
75 transmission factor measurement	linear by magnitude and phase	no dimension, degrees
77 transmission factor measurement	linear with real and imaginary components	no dimension
78 transmission factor measurement	log by magnitude and phase	dB, degrees

Group-delay measurement

82 static group-delay measurement	µs
83 dynamic group-delay measurement	µs

DC voltage measurement

84 voltage measurement at ADC input	V

Graphic display

Charts

85 Smith chart	T$ = "(title, max. 20 characters)"
86 Smith chart + 10 dB	T$ = "(title, max. 20 characters)"
87 Smith chart – 10 dB	T$ = "(title, max. 20 characters)"
88 polar diagram	Y = outer circle T$ = "(title, max. 20 characters)"
89 additional scaling, polar	Y = outer circle
90 cartesian diagram, linear frequency axis	Y1 = minimum vertical axis Y2 = maximum vertical axis S$ = "(unit, max. 3 characters)" T$ = "(title, max. 20 characters)"
91 cartesian diagram, log frequency axis	input same as under 90
92 additional scaling, cartesian	input same as under 90

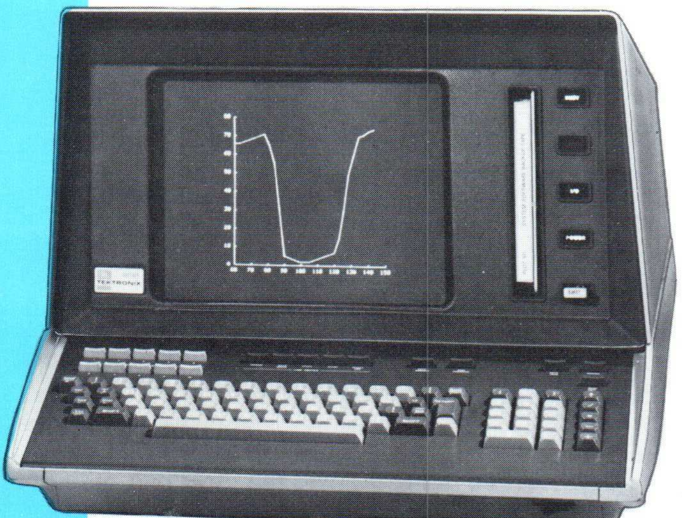
Graphic data output

96 in Smith chart or polar coordinates
97 magnitude (real component) in cartesian coordinates
98 phase (imaginary component, group delay) in cartesian coordinates

Tektronix 4051

Tektronix Graphic Computing System 4051

- Desktop calculator for alphanumeric and graphic display
- Easy-to-handle programming language BASIC
- Flicker-free storage CRT for 2500 characters or 1 million graphic points
- Store capacity 8 kbyte, extendable to max. 32 kbyte



IEC 625 Bus

The IEC-bus controller used most frequently for R&S measuring instruments is the **Tektronix Graphic Computing System 4051**, which permits optimum adaptation to the automation problem to be solved thanks to its stepwise extension capability and the variety of peripherals available. The 4051 is programmed in BASIC and is as easy to use and as powerful as bigger process computers. The large screen permits clear program generation and data display. Data and programs are stored on magnetic tape.

The 4051 basic version has an 8-kbyte store whose capacity is practically all available for program storage and which is sufficient for simple IEC-bus systems. For larger systems and when using basic software or dialog programs 24-kbyte or 32-kbyte stores are required.

The Tektronix Hard Copy Unit 4631, which can be connected directly to the desktop calculator, provides dry copies of the information displayed on the screen. Further peripherals: any printer with V24 interface (via option 10), Digital Plotter 4662, magnetic cartridge unit, additional ROMs for program extension and terminal interface for supervisory computers.

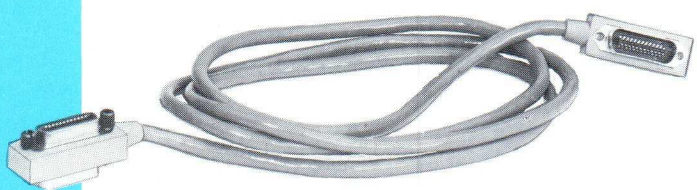
Specifications

Store capacity	basic unit 8 kbyte, extendable to 16 kbyte (option 20), 24 kbyte (option 21) and 32 kbyte (option 22)
Screen	28-cm storage CRT for numeric and graphic display
Magnetic tape store	3M cartridge unit, 256 kbyte, writing/reading speed 76.2 cm/s, searching speed 228.6 cm/s
Programming connector for IEC bus	24-pole Amphenol male, R&S compatible
Programming language	extended BASIC with commands for string functions and graphics
Keyboard	upper and lower case alphanumerics
User-definable keys	10
Dimensions, weight	465 mm × 345 mm × 826 mm, 29.5 kg
Order designations	▶ Tektronix Graphic Computing System 4051
Recommended extras	
Option 1: Terminal Interface	for data transfer according to RS-232-C; input/output 110, 150, 300, 600, 1200, 2400 baud; semi- or full duplex
Option 10: Printer Interface	according to RS-232-C; 110 to 2400 baud
Options 20, 21, 22: Stores	extension to 16, 24, 32 kbyte

PCK

IEC-bus Cable PCK

- Connecting cable of three different lengths for IEC-bus-compatible instruments
- 24-pole male connector with rear socket (piggyback)



IEC 625 Bus

The **Cables PCK** are fitted with 24-pole Amphenol connectors as uniformly used on all R&S instruments. The rear of the connector carries a socket which permits the IEC bus to be connected from one instrument to the other. The cables are screwed with the instrument and with each other, i.e. a perfect mechanical connection is established.

Order designation	▶ IEC-bus Cable PCK
PCK 0.5 m	292.2013.05
PCK 1 m	292.2013.10
PCK 2 m	292.2013.20
PCK 4 m	292.2013.40

PSN

AF Relay Matrix PSN for IEC-bus programming
♦ DC and AF

- Six quick-action reed relays and two power relays
- AF and control applications, high loadability
- Easy to operate, LED indication

IEC 625 Bus

The **AF Relay Matrix PSN** contains eight independent, isolated relays for manual and automatic switchover of control or supply voltages and AF signals for instance in IEC-bus-controlled AF test assemblies, for checkpoint selection and in control engineering. Thus either eight separate switches or max. two 1-out-of-4 switches with the remaining relays as individual switches are available.

Six components are quick-action reed relays featuring high-grade characteristics, while two are power relays which handle currents up to 5 A. All relays are brought out via telephone jacks on the rear panel of the PSN.

Pushbuttons are provided for manual operation with LEDs indicating the switching state. Remote control is performed via the IEC-bus connector. The combined mode permits remote-controlled and manual operation of the relays during program generation and checking.

Specifications

	Relays 1 to 6	Relays 7 and 8
Connectors	telephone jacks on rear panel	
Contact/insulation resistance	60 mΩ/10^9 Ω	20 mΩ/10^9 Ω
Max. power handling capacity	30 VA; 20 W (max. 1 A, 110 V)	1 kVA; 100 W (max. 5 A, 250 V)
Switching time	1 ms	5 ms

General data

Life, nominal temperature range	> 1,000,000 switching actions, +10 to +45 °C
AC supply	115/125/220/235 V ±10%, 47 to 420 Hz (max. 20 VA)
Dimensions, weight	211 mm × 112 mm × 346 mm, 4.0 kg
Order designation	► AF Relay Matrix PSN 290.9210.02
Recommended extra	IEC-bus Cable PCK (see page 13)

PSU

RF Relay Matrix PSU for IEC-bus programming
♦ DC to 6 GHz

- Six independent 50-Ω coaxial relays, low reflection
- RF and pulse applications
- Easy to operate, LED indication

IEC 625 Bus

Six independent, isolated coaxial relays ensure the high flexibility of the **RF Relay Matrix PSU**: six separate coaxial switches or one 1-out-of-4 switch plus three separate switches or two separate 1-out-of-4 switches are possible. The main application is manual and automatic high-precision routing of RF signals in IEC test systems (switching of generators, counters, indicators, attenuators, etc.).

Relays 1 to 3 with 50-Ω N sockets on the front panel of the matrix feature excellent RF characteristics for frequencies up to 6 GHz. Relays 4 to 6 with 50-Ω BNC sockets on the rear panel are suitable for frequencies up to 500 MHz. Pushbuttons are provided for manual operation, with LEDs indicating the switching state. Remote control is performed via the IEC-bus connector; the combined mode is the same as for the PSN.

Specifications

	Relays 1 to 3	Relays 4 to 6
Connectors	50-Ω N female on front panel	50-Ω BNC female on rear panel
Frequency range	DC to 6 GHz	DC to 500 MHz
VSWR	< 1.22 up to 1 GHz	< 1.1 up to 100 MHz
Transmission loss	0.2 dB up to 1 GHz	0.2 dB up to 100 MHz
Crosstalk attenuation	> 80 dB up to 1 GHz	> 40 dB up to 100 MHz
Max. power handling capacity	100 W at 0.1 GHz 50 W at 1 GHz	1 A at 28 V
Switching time	< 20 ms	< 7.5 ms

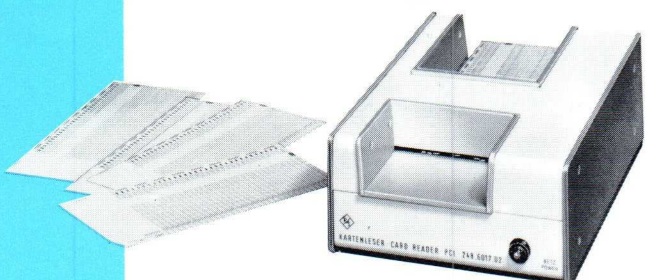
General data

Life, nominal temperature range	> 1,000,000 switching actions, +10 to +45 °C
Power supply	115/125/220/235 V ±10%, 47 to 420 Hz (max. 25 VA)
Dimensions, weight	211 mm × 112 mm × 346 mm, 4.8 kg
Order designation	► RF Relay Matrix PSU 290.8014.02
Recommended extra	IEC-bus Cable PCK (see page 13)

PCL

Card Reader PCL for programming of IEC-bus test systems

- Outputs 8-bit characters
- IEC-bus-compatible
- Control by 8-channel cards with semi-perforated holes (max. 32 characters/card)



IEC 625 Bus

The **Card Reader PCL** is a particularly simple and economical unit for the programmed control of test equipment. The required data and settings are marked on a punched card, each measuring instrument being set accordingly as the card runs through the Card Reader.

The PCL is used to advantage wherever repeated setting of measuring instruments is required. Examples **of applications:** selection of the channel frequency in radiotelephone systems or selective calling frequencies, as well as measurements and alignment in test departments.

The Card Reader can be connected direct to all instruments programmable according to the IEC standard. Connection of several units is possible since the punched card also accommodates the required addresses. For example, the Decade Signal Generator SMDS and Attenuator Set DPVP can be controlled with one punched card.

Test equipment that can only be controlled in BCD, i.e. parallel code, can be adapted to the IEC-bus system by means of the Code Converter PCW. The 8-channel program cards are semi-perforated and the required holes can be made with any pointed object, a special punch not being necessary.

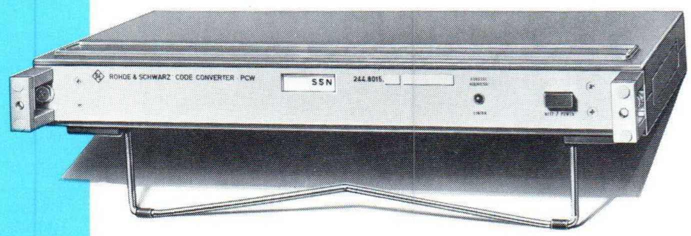
Specifications

Outputs	8 data outputs 1 clock output 1 control line REN 1 control line
Output levels	negative TTL logic (tristate)
Scanning rate	>40 characters/s 1 card/s
AC supply	115/125/220/235 V ±10%, 47 to 440 Hz (12 VA)
Dimensions, weight	162 mm × 84 mm × 264 mm, 2.6 kg
Order designations	► Card Reader PCL 248.6017.02
8-channel cards, set of 500, PCL-Z	248.6598.02

PCW

Code Converter PCW

- Permits IEC-bus programming of parallel-controlled equipment
- Usable for all instruments programmed with TTL levels
- Excellent noise immunity thanks to output buffers



IEC 625 Bus

The **Code Converter PCW** is necessary if instruments designed for parallel remote control are to be programmed via the IEC bus. The PCW receives serial ASCII signals and delivers TTL levels at 44 parallel data outputs. Commands can be output in positive or negative BCD code.

The PCW is addressable; 26 different addresses can be selected. Instructions are allocated to the data outputs by means of an exchangeable code converter board. This permits the PCW to be adapted to individual instruments. Besides ready-wired code converter boards for Rohde & Schwarz standard instruments, a universal board is available which can be coded by the user himself for any particular instrument.

Thus the PCW enables IEC-bus control of all instruments that are programmable with TTL levels in BCD code.

Specifications

Input	7 data lines (ASCII – 7 bits) 6 control lines DAV, NRFD, NDAC, ATN, REN, IFC
Connector	24-pole, Amphenol
Output (50-pole)	8 × 4 bits (TTL level) + 12 × 1 bit
Power supply	115/125/220/235 V ±10%, 47 to 440 Hz (10 VA)
Dimensions, weight	484 mm × 61 mm × 336 mm, 4.5 kg
Order designations	► Code Converter PCW
19" cabinet model	244.8015.92
19" rackmount	244.8015.91
Code Converter Boards for SSN	245.2710.02
SMDS	245.2810.02
DPVP	245.2510.02
SMLU	245.2610.02
ESU 2 (universal use)	291.1113.02
ESU 2 (radiomonitoring applications)	291.1213.02
Test-item control	245.2762.02
Not wired	245.2910.02

PTM

new

IEC 625 Bus

Digital Thermometer PTM
♦ −100 to + 300 °C

- Temperature-measuring device of highest precision with platinum-resistance sensors (Pt 100 according to DIN 43 760) in four-wire circuit
- Measurement of temperature difference between two PTM sensors
- Indication in degrees Celsius (°C) or indication of thermodynamic temperature (K)
- Analog voltage output 0 to 10 V; IEC-bus compatible

Characteristics, functioning

The **Digital Thermometer PTM** is suitable for highest-accuracy temperature measurement from −100 to +300 °C in different media; it has an IEC-bus connector and can thus be used in automatic test systems.

Temperature is measured via exchangeable test sensors (depending on the measurement task), two of which can be connected simultaneously to the two five-pole sockets.

The following three sensor types are available as standard:

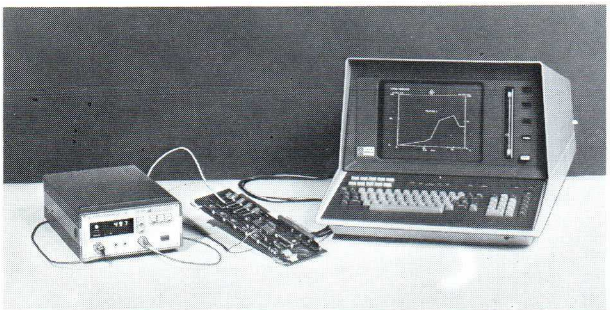
1. **contact sensors** suitable for manual measurements,
2. **adhesive sensors** suitable for sticking to critical temperature points (in the form of wafers 6 mm × 18 mm × 1.5 mm),
3. **immersion sensors** for gases and liquids or for incorporation into solids (dimensions: 4 mm ∅ × 50 mm).

Accuracy. Using these platinum sensors, the maximum error is only 0.2 °C over the entire temperature measurement range. The PTM can be used with one or with two sensing probes (for instance for differential temperature measurement).

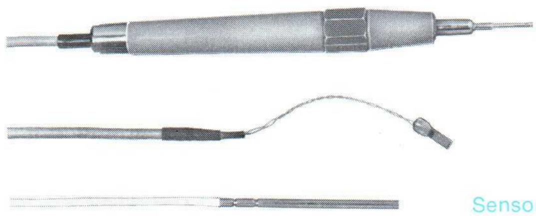
Indication. The PTM displays the temperature (switched when using two sensors) in °C or K. The proportional DC voltage is available at the analog voltage output.

Uses

The PTM finds wide use in the electronic industry and in other fields. Thus the effect of temperature on components or subassemblies when varying the ambient temperature (for instance with the Temperature Controller PTC, see page 17) can be checked automatically via the IEC bus. Trouble shooting in case of temperature effects can also be automated.



Automatic measurement of temperature effect on subassembly



Sensors

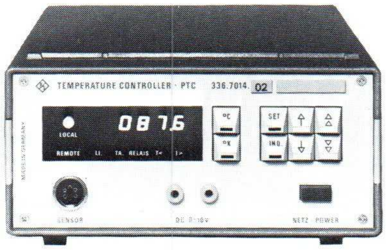
Specifications

Temperature measurement range	−100 to +300 °C
Indication	°C or K (switched when using two sensors), 4 digits, LEDs
Resolution	0.1 °C
Measurement error	< 0.2 °C over entire range (with sensor adjustment) < 0.5 °C from −50 to +60 °C (without sensor adjustment)
Measuring time	depending on type of sensor
Sensor	platinum resistance (Pt 100)
Input	two 5-pole female connectors
Output (analog signal)	0 to 10 V, 2.5 mV/°C, R_{out} = 1 kΩ, telephone jacks
Programming	via IEC-bus connector (IEC 625), 24-pole
Interface functions	T6, TE6 talker functions with sec. address L4 listener function RL1 remote/local DC1 device clear
Time required for data transfer	0.5 to 2 ms
General data	
Nominal temperature range	5 to 45 °C
Storage temperature range	−45 to +70 °C
Power supply	115/125/220/235 V ±10%, 47 to 440 Hz (30 VA)
Dimensions, weight	211 mm × 112 mm × 346 mm, 4 kg
Order designation	► Digital Thermometer PTM 336.8010.02
Accessories supplied	Contact Sensor PTC-Z1, power cord
Recommended extras	
Contact Sensor PTC-Z1 (as 2nd sensor)	336.7914.02
Adhesive Sensor PTC-Z2	336.7937.02
Immersion Sensor PTC-Z3	336.7950.02

Temperature Controller PTC
♦ −100 to +300 °C

- Temperature controller driven via IEC bus; nominal temperature entered in °C or K via keyboard
- Precision measurement using platinum-resistance thermometer in four-wire circuit
- Temperature indication in °C or K; status indication
- 10 A/220 V contactor and control relay incorporated

PTC



new

IEC 625 Bus

Characteristics, functioning

The Temperature Controller PTC is used as a precision measuring and setting device in the range −100 to +300 °C. Thanks to its **IEC-bus connector** it is system-compatible and suitable for use in automatic test system.

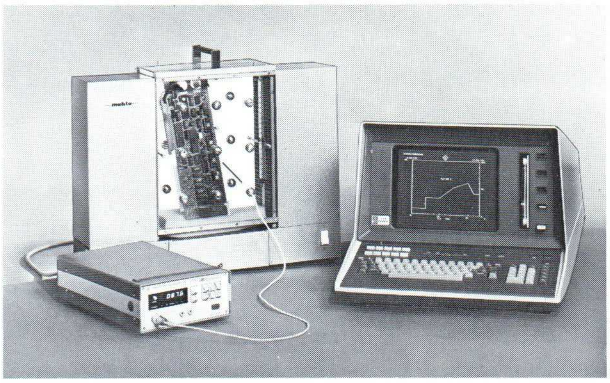
Sensors. The sensor types available for different applications are the same as for the Digital Thermometer PTM (see page 16); the connections for temperature measurement and the procedure itself are also the same.

Temperature control. The temperature picked up with the sensor is compared with the set nominal value. The control signal derived is used for switching a load relay of max. 2200 W switching capacity and a control relay. Linking a calculator, an oven and the PTC permits a programmable temperature control system to be set up.

Accuracy, offset. The platinum sensors used with the PTC ensure a high accuracy. For temperature measurement and nominal-value programming the resolution is 0.2° and the offset ±0.5°. Entry is either in °C or in K.

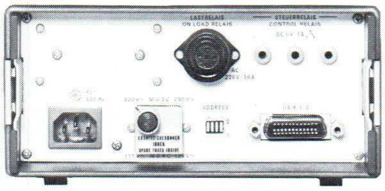
Uses

The programmable Temperature Controller PTC finds a wide range of application, in particular in the development, production and quality control of electronic equipment but also in other fields of industry.



Automatic temperature test on subassemblies using PTC

The programmability of the PTC does not only permit accurate point-by-point determination of the temperature response but also automatic sweeping of complete temperature cycles along with protocolling via the calculator and printer.



Rear view of Temperature Controller PTC

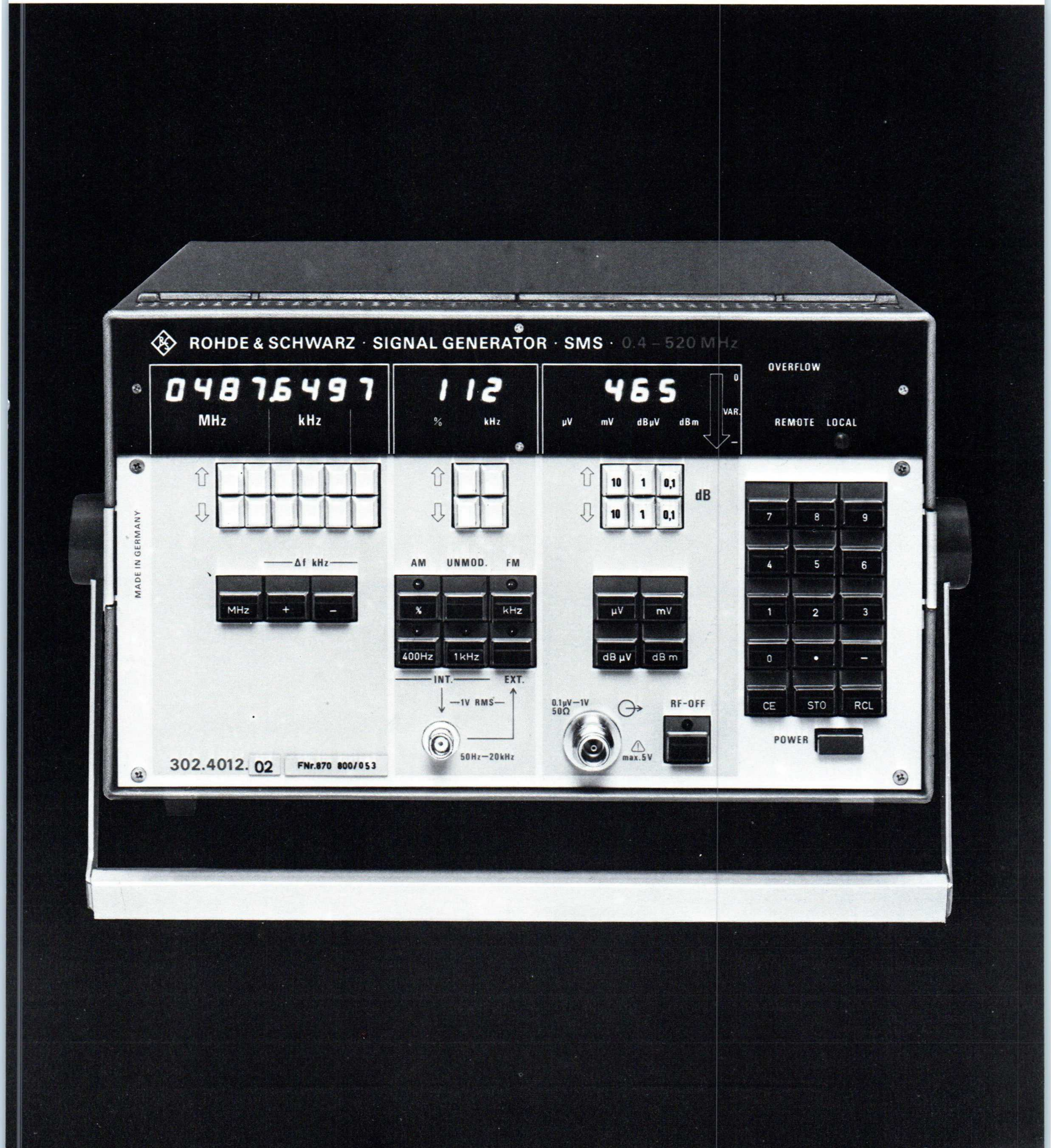
Specifications

Temperature measurement range	−100 to +300 °C
Indication	°C or K (switched when using two sensors)
Resolution	0.1 °C
Measurement error	< 0.2°C over entire range (with sensor adjustment) < 0.5 °C from −50 to +60 °C (without sensor adjustment),
Measuring time	depending on type of sensor
Sensor	platinum resistance (Pt 100)
Rate	30 measurements/s
Input (for sensor)	5-pole female connector
Temperature control range	−100 to +300 °C
Nominal temperature setting	with step buttons, resolution 0.1 °C
Offset	±0.5 °C from nominal, referred to sensor
Switching status indication	lamps for load relay on, measured value > or < nominal value
Outputs	1. load relay 220 V/10 A (output via 4-pole AC supply female connector) 2. control relay (switch) 5 V/100 mA, telephone jacks
Analog signal	0 to 10 V, 2.5 mV/°C R_{out} = 1 kΩ, telephone jacks
Programming	via IEC-bus connector (IEC 625), 24-pole
Interface functions	same as for PTM, page 16
General data	
Nominal temperature range	5 to 45 °C
Storage temperature range	−45 to +70 °C
Power supply	115/125/220/235 V ±10%, 47 to 440 Hz (30 VA)
Dimensions, weight	211 mm × 112 mm × 346 mm, 4 kg
Order designation	► Temperature Controller PTC 336.7014.02
Accessories supplied	Contact Sensor PTC-Z1
Recommended extras	
Contact Sensor PTC-Z1	336.7914.02
Adhesive Sensor PTC-Z2	336.7937.02
Immersion Sensor PTC-Z3	336.7950.02

Signal Generator SMS
for 400 kHz to 1040 MHz,
IEC-bus compatible

2

af and rf signal generators
power signal generators, synthesizers



Rohde & Schwarz offers a complete line of signal generators for the AF to SHF ranges covering 0.01 Hz to 12.5 GHz. The line comprises free-running signal sources of highest spectral purity, solid-state signal generators using phase-lock loops, synthesizers of finest frequency resolution and highest stability as well as generators based on state-of-the-art delay-line circuits for the highest frequencies.

All R&S signal generators feature

- an easy-to-read and fine frequency adjustment,
- an extremely accurate and easy-to-vary output level and
- versatile modulation characteristics.

R&S signal generators have all the characteristics which are required for use in development, production (test department) and servicing over the entire range of low- and high-frequency technology, permitting the performance of the most diversified measurements and simulation of all signals which are necessary for testing components, receivers, circuits, modules and instruments of different types up to the SHF range.

In conjunction with different accessories, the signal generators can be used to create a large variety of general-purpose and user-oriented test assemblies.

For a special introduction to AF and decade signal generators (synthesizers) see pages 26 and 55.

A new operational philosophy has been realized by R&S with its most modern signal generator for receiver testing – the Signal Generator SMS. The ease of operation is evident from the neatly arranged front panel with indicators clearly assigned to the operating controls. This microprocessor-controlled signal generator offers test signals between 400 kHz and 1040 MHz with AM, FM or φM for in-channel testing of any receiver. Thanks to a maximum output level of 1 V into 50 Ω and an attenuator with 0.1 dB resolution the SMS is suitable for all measurements on components and subassemblies. Various options permit a customized configuration, when using, for instance, the IEC-bus interface all SMS parameters can be remotely controlled. The SMS can thus be used in IEC-bus-controlled test assemblies – even in conjunction with Vector Analyzer ZPV.

Signal Generator SMS, a combination of remotely controllable synthesizer and favourably priced signal generator

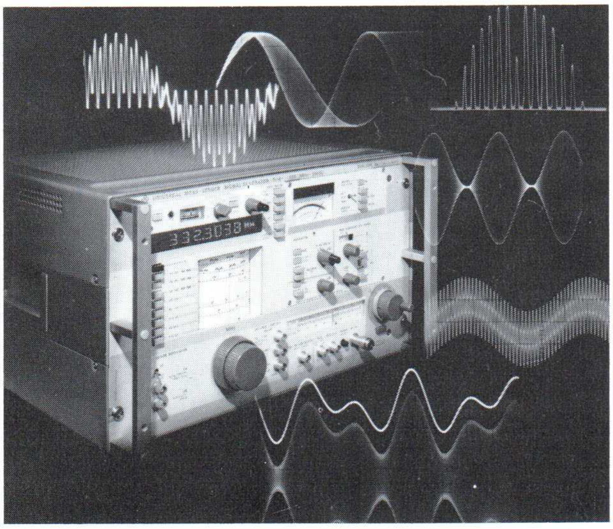
Signal generators for receiver testing from HF to UHF (general-purpose laboratory sources)

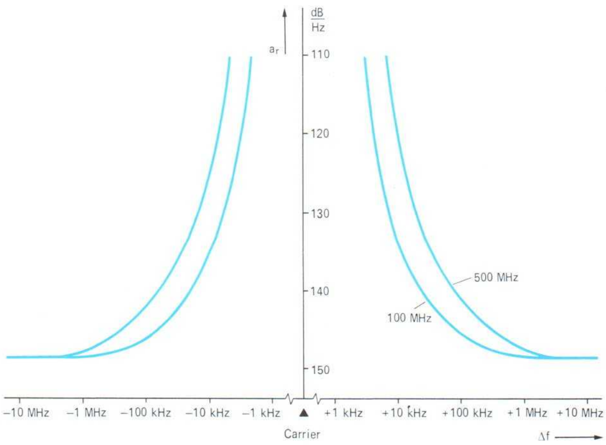
In order to perform their principal function of testing high-quality receivers, signal sources in this group must feature excellent frequency and level resolution, accuracy and setting controls, together with comprehensive modulation characteristics. Thanks to such performance, these signal generators can be used for any type of measurement in the laboratory, test department and servicing shop.

A well-proven universal signal generator from R&S in this category is the Signal Generator SMDU, covering the frequency range from 15 Hz to 1.05 GHz. Most information transmissions fall into this range: broadcasting from LW to VHF, radiotelephony from SW to UHF, air navigation and communication plus important IF bands for transmissions above 1 GHz.

The SMDU carrier frequency is indicated on a seven-digit frequency meter with a resolution of 1 Hz or 10 Hz, which also permits measurement of external signals from 15 Hz to 525 MHz – up to 1 GHz using the frequency range extension. The

Signal Generator SMDU (see page 40)





Signal-to-noise ratio of SMDU carriers 100 MHz and 500 MHz at 1-Hz test bandwidth synchronizer option makes the instrument a synthesized signal generator with a stability of 10^{-8}/month. Thanks to the good control action of the phase-lock loop, the high spectral purity is maintained in addition to the synthesizer stability.

This option permits checking of high-quality receivers which require instruments of outstanding performance for testing characteristics such as the **dynamic adjacent-channel selectivity, desensitization, crossmodulation and intermodulation rejection.** Further advantages are electronic fine tuning and synchronized frequency settings corresponding to the standard channel spacings. When synchronized, any frequency can be adjusted and any common channel spacing covered in steps starting with any frequency.

The level range of the Signal Generator SMDU starts at 0.1 µV EMF – **the sensitivity limit of modern receivers** – and reaches up to 2 V EMF – the **maximum test voltage for components** or the overdrive limit of receivers. The accuracy of the RF output voltage, which is ±0.5 dB typ. over the full level and frequency ranges, corresponds virtually to that of a standard. Any form of modulation (AM, FM or φM) may be applied to the output signal, the harmonic distortion remaining negligible even at large deviations and modulation depths. The universal model 04 of this signal generator family also permits **testing of hifi studio and stereo receivers.**

The SMDU is no conventional signal generator; it is also a substitute for a digital frequency meter (15 Hz to 1.05 GHz), an AF generator and an AF voltmeter. Six different models and five extra options permit an **optimum solution** to be found **for each application** (see overview on page 42).

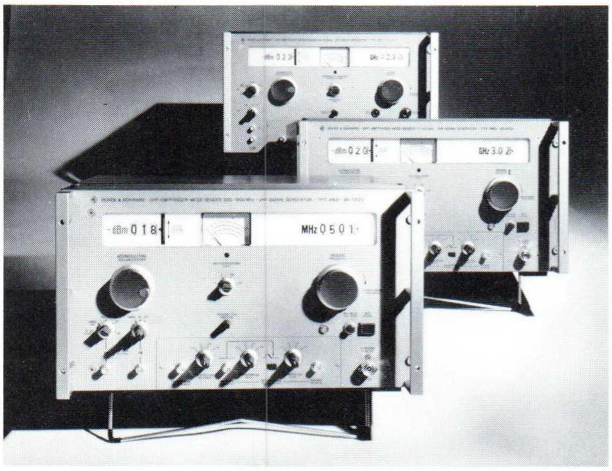
The Adjacent-channel Power Meter NKS completes the RT Test Assemblies SMDU. It measures the adjacent-channel radiation of RT transmitters in compliance with national and international standard specifications.

The Signal Generators SMLH and SMUV, which are especially intended for the shortwave range, deliver signals of high spectral purity in the frequency range 10 kHz to 130 MHz and feature excellent AM and FM characteristics (S/N ratio at 20-kHz spacing from carrier typically 145 dB). With FM the SMUV delivers a stereo-compatible signal with negligible distortion. Options like the 2-W amplifier, synchronization or sweep oscillator permit an optimum configuration of these instruments.

Signal generators for receiver measurements from UHF to SHF

A family of universal signal generators delivering high-stability signals is available for the microwave region. The three instruments SMAI, SMBI, SMCI together span the frequency range from **0.5 to 12.5 GHz.** The output level can be accurately adjusted from −130 dBm to +10 dBm; it can also be electronically levelled.

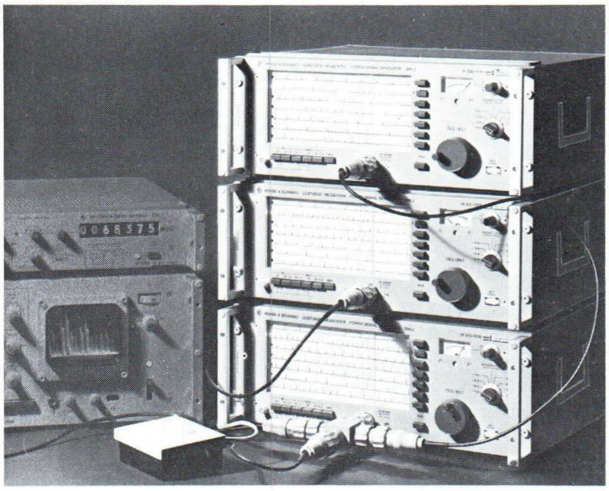
Their outstanding pulse-modulation characteristics make these signal generators well suited for use as **radar test generators and for checking out DME, ATC and TACAN equipment.** Steep edges and carrier suppression by at least 80 dB ensure accurate simulation of radar pulses. FM and AM are also possible.



Signal Generators SMAI, SMBI, SMCI (see page 48)

Power signal generators

From VLF to SHF, R&S power signal generators provide continuous coverage for the range between **10 kHz and 2.7 GHz.**



Power Signal Generator SMLU (see page 50) used in test setup for crossmodulation measurement

Together, the SMLH, SMUV and SMLU cover the range from 10 kHz to 1 GHz, delivering a levelled output power of 2 W (1 W). The SLRD, covering 275 MHz to 2.75 GHz, is a power signal generator for applications which require high levels and stable frequencies; its maximum output level is 35 W. Versatile modulation characteristics (AM, FM, pulse modulation) and **sweep operation** permit universal use for a large variety of measurements.

How to read the tables

The frequency error indicates the limits within which a frequency set on the scale may deviate from its true value, considering all disturbing influences such as AC supply voltage fluctuations (±10%), temperature fluctuations (±15 °C), loading, aging, etc.

Output level. In general, the meters are calibrated in terms of EMF (open-circuit output voltage) and the corresponding values entered in the table. If an impedance is specified beside the voltage, the terminal voltage across the specified load impedance is meant. The lower (minimum) voltage is 1/10 of full-scale deflection with the output attenuator fully in circuit or the lowest readable value. If no calibrated output attenuator is provided, the lower voltage value is specified as "≈ 0".

Frequency range	Designation	Type	Order No. (complete No. see text)	Frequency error	Frequency resolution/ indication	Output level EMF
AF generators						
Sine/triang.: 0.01 Hz to 120 kHz. Square: 0.01 Hz to 1.2 MHz	Precision LF Generator	SSN	204.8014 ...	2×10^{-5} with int. crystal	4-digit display	Sine: 7.75 mV to 6 V Triang.: 1 V_{pp} Square: TTL level
50 Hz to 50 kHz	RC Generator/ Indicator	SUB	100.4120 ...	±3%	1 to 5 (10)%	I ≈ 0 to 3 V sinewave II ≈ 0 to 8 V_{pp} squarewave ↗ 50 to 220 Ω
10 Hz to 1 MHz	RC Oscillator	SRB	100.4094 ...	±1 (2)%	≈1%/mm	I ≈ 0 to 30 V into 600 Ω II 0.1 mV to 10 V
RF generators						
Signal generators for receiver measurements						
0.01 to 40 MHz	AM/FM Signal Generator	SMLH	283.8070.52	(10-MHz crystal: 1×10^{-5}/month)	6-digit display	0.05 µV to 0.5 V (10 V) into 50 Ω
0.01 to 130 MHz	AM/FM Signal Generator	SMUV	301.0120 ...	(10-MHz crystal)	7-digit display	0.05 µV to 0.5 V (10 V) into 50 Ω
30 to 300 MHz	Power Signal Generator	SMLM	100.4413.02	±1%	1×10^{-4}	≈ 0 to 3 V into 60 Ω
30 to 300 MHz	Tunable VHF Amplifier and AM Signal Generator	ASV	100.0976.02	±2%	1 to 3%	≈ 0 to 3 V into 60 Ω
0.4 to 484 MHz	AM/FM Signal Generator	SMDA	100.4559.04	±0.5%	1×10^{-3}/mm fine: 8×10^{-6}/mm	0.1 µV to 1 V EMF (−140 to 0 dBV) 50 Ω
0.14 to 1050 MHz	Signal Generator	SMDU	249.3011 ...	(10-MHz crystal: 1×10^{-8}/month)	7-digit display	0.05 µV to 2 V EMF (−138 to +13 dBm) 50 Ω
0.4 to 520 MHz (1040 MHz)	Signal Generator	SMS	302.4012.02	(crystal; synthesizer)	8-digit display, 100 Hz	0.03 µV to 1 V into 50 Ω (−137 to +13 dBm)
0.5 to 1.8 GHz	UHF Signal Generator	SMAI	100.4594.13	±0.5% ext. freq. sync possible model with ALC	100 kHz/div.	−130 to +10 dBm 50 Ω constant level ±1 (1.75) dB
1.7 to 5.0 GHz	SHF Signal Generator	SMBI	100.4607.13	±0.5% ext. freq. sync possible model with ALC	1 MHz/div.	−130 to +5 dBm 50 Ω constant level ±1 (2) dB
4.8 to 12.5 GHz	SHF Signal Generator	SMCI	100.4613.13	±0.5% ext. freq. sync possible model with ALC	1 MHz/div.	−130 to 0 dBm 50 Ω constant level ±1 (2.5) dB

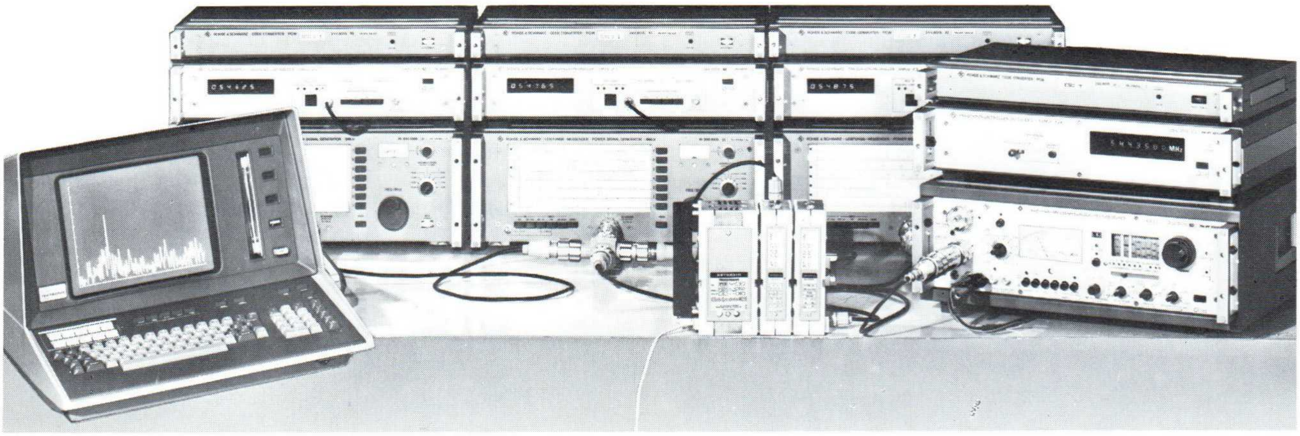
Voltage or power indication error. The values given refer to the non-attenuated voltage shown by the panel meter or, with power signal generators, to the indicated available output power. Abbreviations: of rdg = of reading; of fsd = of full scale deflection.

Output attenuator error. The error of an output attenuator consists of the component contributed by the attenuation setting (in %), a constant attenuation error (in dB) and a constant voltage due to leakage of the attenuator (in µV). The specified values are valid if the attenuator is match-terminated. The tables include only the main error components.

Type of modulation. AM = amplitude modulation with specified modulation depth; FM = frequency modulation with specified frequency deviation; pulse = pulse modulation; φM = phase modulation; SSB = single-sideband AM.

Output attenuator error	Harmonic distortion	Signal-to-noise ratio	Dimensions in mm (W × H × D)	Remarks	Text on page
±1 (2)%	≦0.5% (up to 50 kHz)	> 60 dB	484 × 105 × 336	combinable with 1 to 9999 Hz sequential tone programmer	28
uncalibrated	< 3% typ. 2%	> 90 dB	162 × 238 × 242	built-in selective voltmeter	30
I – II ±0.2 dB	< 0.1 (3)%	> 60 dB	286 × 227 × 226	high output level	31

	Type of modulation	Modulation frequency range internal	external			
±1 dB	AM: 0 to 98% FM: 0 to 50 kHz	1 kHz	30 Hz to 20 kHz	492 × 205 × 514	dig. frequency indication; with option: output power 2 W	32
±1 dB	AM: 0 to 98% FM: 0 to 100 kHz	1 kHz/400 Hz	0 to 100 kHz	492 × 205 × 514	with options: synchron. with 1-kHz steps, sweep oscillator, 2 W output power, suitable for stereo	36
uncalibrated	AM: 0 to 80%	1 kHz (80%)	30 Hz to 200 kHz	470 × 275 × 260		—
uncalibrated	AM: 0 to 95%	1 kHz	30 Hz to 30 kHz	286 × 227 × 226	low-noise selective receiver, frequency meter and power amplifier	38
	AM: 0 to 95% FM: 0 to 75 kHz φM: 0 to 75 kHz	0.3 to 6 kHz + cont. adj.	30 Hz to 10 kHz 30 Hz to 20 kHz 30 Hz to 10 kHz	484 × 239 × 336	high spectral purity of output signal	39
±1 (2) dB	AM: 0 to 98% FM: 0 to 1 MHz φM: preemph. 50/75 µs	15 Hz to 150 kHz	0 to 150 kHz	492 × 296 × 434	six models available: general RF measurements, RT testing, avionics	40
±1 dB	AM: 0 to 90% FM: 50 Hz to 20 kHz φM: 5 rad	1 kHz/400 Hz	50 Hz to 20 kHz	345 × 198 × 370	synthesizer, system-compatible, IEC-bus compatible, extremely low-priced	44
±(0.1 dB ±0.005 dB/ 1-dB step)	pulse: 100% FM: 0 to > 100 kHz AM: 0 to 70%	1 kHz square-wave	up to 200 kHz 1 Hz to 10 MHz 2 Hz to 100 kHz	484 × 283 × 512		48
±(0.1 dB ±0.01 dB/ 1-dB step)	pulse: 100% FM: 0 to > 500 kHz AM: 0 to 70%	1 kHz square-wave	up to 250 kHz 1 Hz to 10 MHz 2 Hz to 100 kHz	484 × 283 × 512	extension of frequency and pulse modulation characteristics using modulation unit	
±(0.1 dB ±0.015 dB/ 1-dB step)	pulse: 100% FM: 0 to > 8 MHz AM: 0 to 70%	1 kHz square-wave	up to 1 MHz 1 Hz to 10 MHz 2 Hz to 100 kHz	484 × 283 × 512		



Automatic RF test assembly for intermodulation and crossmodulation measurements

Continued from pages 22/23

Frequency range	Designation	Type	Order No. (complete No. see text)	Frequency error	Frequency fluctuations	Frequency resolution	Output level Source impedance

Power signal generators for VHF, UHF and SHF

Frequency range	Designation	Type	Order No.	Frequency error	Frequency fluctuations	Frequency resolution	Output level Source impedance
10 kHz to 40 MHz	AM/FM Signal Generator +Option SMLH-B3	SMLH SMUV	283.8070.52 301.0120 ... 284.4210.50	(10-MHz crystal; 1×10^{-5}/month)	200 Hz/5 min	1/10/100 Hz	0.5 to 10 V into 50 Ω
25 to 1000 MHz	Power Signal Generator	SMLU	200.1009.02 200.1009.03	±2% as ... 02, and programmable in BCD for range, freq., level	$< 1 \times 10^{-4}$/10 min	0.2 to 5 MHz/div.	−13 to +33 dBm (2 W) const. level; 50 Ω
0.28 to 2.75 GHz	UHF Power Signal Generator	SLRD	100.4194.02	±2% ext. freq. sync possible	$< 5 \times 10^{-5}$/15 min	5 to 50 MHz/div.	−50 to +45 dBm (P_{max} = 35 W)

Decade signal generators

Frequency range	Designation	Type	Order No.	Smallest increments of lock-tuned frequencies	Error of lock-tuned frequencies	Mean daily drift after 10 days / 100 days of operation	External control
0.01 Hz to 120 kHz (1.2 MHz)	Precision LF Generator	SSN	204.8014 ...	10 µHz			2 MHz (1 MHz)
10 kHz to 1 GHz	Decade Frequency Generator	SMDS	154.8723.52	1 Hz	$< 1 \times 10^{-9}$/°C	$< 5 \times 10^{-8}$/month	10 MHz
50 kHz to 1 GHz	Receiver Test Assembly	SMPU	239.0010.54	10 Hz	$< 2 \times 10^{-9}$/°C	$< 5 \times 10^{-8}$/month	10 MHz

Noise generators

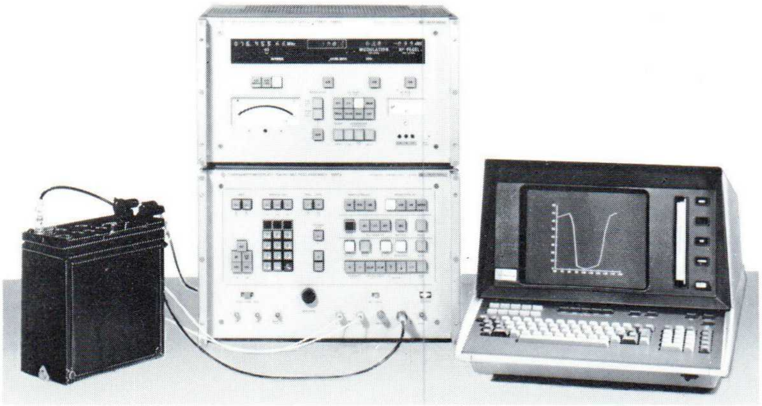
Frequency range	Designation	Type	Order No.	Sub-ranges	Noise power	Source impedance Ω
1 to 1000 MHz	Noise Generator	SKTU	100.4688.50 100.4688.60 100.4688.70	1	0 to 8/15 dB 0 to 9/16 dB 0 to 8/15 dB	50 60 75

RF test assemblies

25 to 1000 MHz	Test assembly for intermodulation and crossmodulation measurements	see page 78
25 to 1000 MHz	Test assembly for RF cables	see page 80
0.14 to 1050 MHz	RT test assembly	see page 64
0.14 to 1050 MHz	Air-navigation test assembly	see page 70
0.05 to 1000 MHz	Automatic RF test assembly	see page 82

signal generators

TABLE **2**



Automatic test assembly for radio sets (SMPU plus Tektronix desktop calculator 4051)

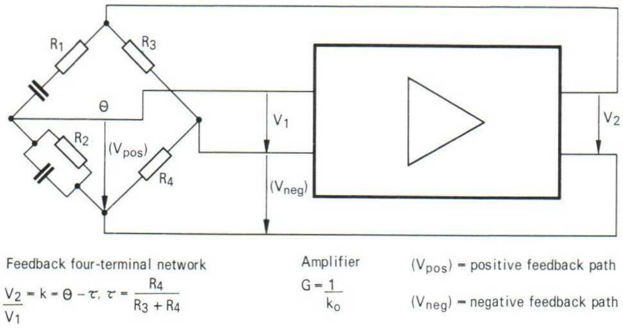
Voltage or power indication error	Output attenuator error	Type of modulation	Modulation frequency range internal	external	Dimensions in mm (W × H × D)	Remarks	Text on page
±1 (2) dB		AM: 0 to 98% FM: 0 to 50 kHz	1 kHz 1 kHz	30 Hz to 20 kHz 30 Hz to 20 kHz	492 × 205 × 514	amplifier complies with IEC recommend.	32
±0.8 dB	±0.12 dB/5 dB	AM: 0 to 90% FM: 1 subrange	1 kHz (70%) —	10 Hz to 8 kHz 0 to 8 kHz	484 × 194 × 436	programming units available; sweeping possible	50
±1.5 (2.5) dB	±(1dB ±0.05 dB/dB)	pulse	1 kHz square-wave	0 to 100 kHz	484 × 328 × 512		54
Output level EMF	**Suppression of spuria**						
7.75 mV to 6 V 50 Ω	> 80 dB	—	—	—	484 × 105 × 336	programming units available	28
2 V max. attenuation up to 15 dB	> 86 dB	AM/FM/SSB	information input 30 MHz ±0.5 MHz (AM up to 500 MHz)		484 × 283 × 509	high spectral purity of output signal	56
0.1 µV to 1 V 50 Ω	> 86 dB	AM: 0 to 99% FM: 0 to 99.9 kHz φM:	0 to 50 kHz 0 to 100 kHz (int. mod. gen. 10 Hz to 99.9 kHz)	same as int.	484 × 605 × 509	programmable via IEC bus	58
					470 × 191 × 261		59
							62 to 89

Signal generators for low frequencies

AF generators are used in many fields of instrumentation. Various designs exist depending on the applications. The most important criteria are frequency accuracy, output level, level accuracy, distortion, switching speed and transient response after frequency changing.

In broadcasting – particularly for hifi – signal generators with low distortion and a relatively high output level are normally required. Frequency accuracy is of secondary importance as nowadays parallel connection of a frequency counter has become common practice.

Signal generators which fulfil these requirements usually make use of a Wien-bridge oscillator.

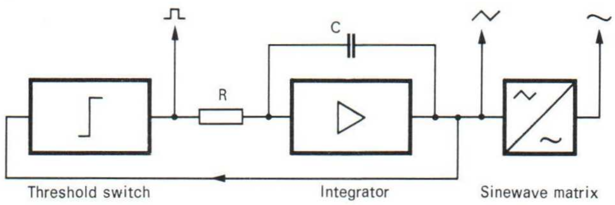


Wien-bridge RC oscillator

The Wien-bridge oscillator is only usable for measurements where manual frequency setting suffices, since it is not suitable for external programming.

Integration method

Generators for programmed measurements, for example function generators, usually employ the following principle.

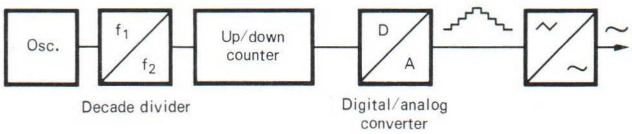


Function generator

A squarewave signal is shaped into a triangle in an integrator. When the triangle reaches a given threshold, the squarewave generator polarity is changed and the process repeated in the opposite sense. A matrix converts the triangular signal into a sinewave.

This type of signal generator can easily be programmed. They do not suffer from overshoot and are therefore ideal for automatic measurements.

The principle is slightly modified for very low frequencies:



Generation of very low frequencies

The triangle is here represented by a staircase, the steps being negligibly small.

Very low frequencies can be produced by this method since the division ratio of the decade divider can be made as high as required.

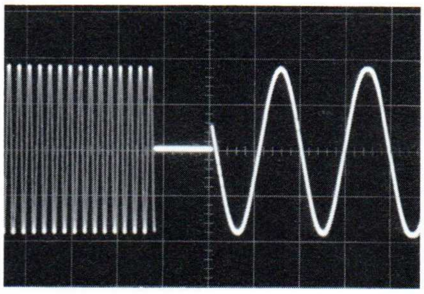
Card-programmed AF test assembly consisting of Precision LF Generator SSN, Code Converter PCW and Card Reader PCL

Frequency accuracy

A drawback of function generators is often poor frequency accuracy. This can be remedied by incorporating a phase lock circuit.

This method provides accurate and quick frequency setting and is employed in the Precision LF Generator SSN.

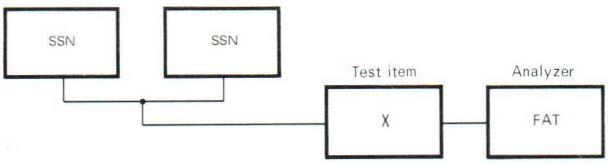
Signal generators with high frequency accuracy, such as the SSN, are used for automatic measurements and in selective calling systems.



Selective calling signal with blanked pause

Difference-frequency method

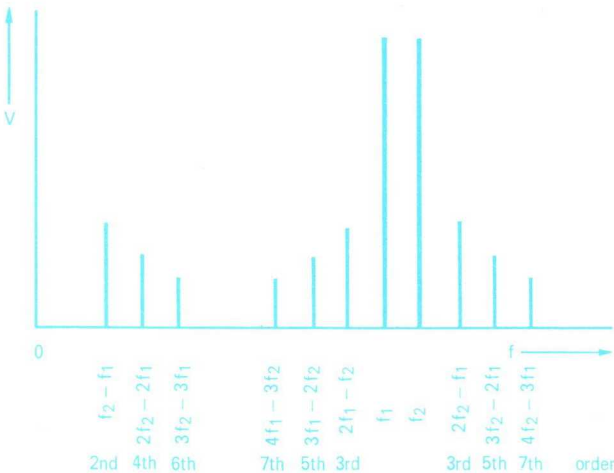
Although distortion measurements can be performed with low-distortion Wien-bridge oscillators, the difference-frequency method is preferable, since the judging of nonlinear distortion depends on the response of the human ear. The pitch and masking effects play an important part, besides the sound pressure. Harmonics are less annoying than non-harmonic difference and sum tones which are perceived more intensely. Similarly, distortion at the upper end of the audible frequency range irritates the listener although the corresponding harmonics are imperceptible. Difference frequency measurements are technically preferable because the inherent distortion of the two signal generators does not affect the result, provided the test frequencies are selected appropriately.



AF distortion measurement by the difference-frequency method

Example: Difference frequency measurement using the Precision LF Generator SSN

Due to its linear output impedance, the SSN is ideal for difference frequency measurements (see below). Distortion occurring in AF modules can be reliably detected. The method has the advantage over conventional distortion measurements that the available dynamic range is much greater when the Wave Analyzer FAT is used. The high frequency stability of the SSN ensures good reproducibility and easy evaluation of the measurements. The test item, e.g. an amplifier, is fed with two signals of different frequencies (f1 and f2) and equal amplitude at a frequency spacing $\triangle f = f1 - f2$. The non-linear characteristic of the test item gives rise to additional frequencies at the output. The 2nd- and 3rd-order difference frequencies are generally used for the measurement, the values being $\triangle f = f1 - f2$ for the former, $f2 + \triangle f = 2f2 - f1$ and $f1 - \triangle f = 2f1 - f2$ for the latter.



Intermodulation spectrum

Higher-order difference frequencies appear as further spectral lines at distances of $\triangle f$.

Second-order intermodulation distortion is

$d_2 = \frac{V_{\triangle f}}{V_{out}\sqrt{2}}$, where $V_{\triangle f}$ is an rms voltage component and V_{out} the rms value of the total voltage at the output.

Third-order intermodulation distortion is:

$$d_3 = \frac{V_{(f1-\triangle f)} + V_{(f2+\triangle f)}}{V_{out}\sqrt{2}}$$

AF test assemblies

Instruments (such as the Precision LF Generator SSN) which are suitable for programmed operation and feature rapid and accurate frequency switchover permit semi- and fully automatic test assemblies to be set up, e.g. for AF distortion measurement using the two-tone method.

SSN

Precision LF Generator SSN
♦ 0.01 Hz to 120 kHz (1.2 MHz)

- Frequency and level programmable
- High frequency and level accuracy
- Outputs for sinusoidal, triangle and squarewave signals

The **SSN** offers extreme accuracy and highest signal quality. It is used to advantage wherever reliable and reproducible measurements are required.

Fields of application

Generation of very accurate low-frequency signals with rapid and accurate frequency selection

Measurements on selective calling equipment; programmed operation in automatic testing systems

Measurement of bandwidth, frequency response, etc., with logarithmic output level adjustment

Investigation of mechanical and biological control processes at low frequencies

Driving of XY recorders (triangle signal) and exact timing (squarewave)

Carrier frequency measurements; physiology; acoustics; difference frequency measurements

Special features

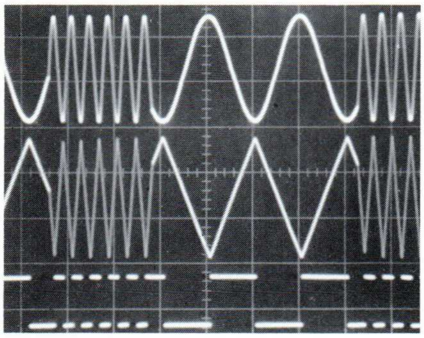
Frequency accuracy. A digital phase lock circuit provides crystal accuracy of the selected frequency. An external standard frequency source can be connected if required.

Level accuracy. A built-in calibrated attenuator permits precise level setting with 0.1-dB resolution.

Ease of operation. The output level can be read simultaneously in V and dB, no conversion being necessary. Full utilization of four frequency decades is possible without range switching thanks to a novel frequency setting concept.

Three output waveforms. Sinusoidal, squarewave and triangle signals are available at parallel floating outputs with a fixed phase relation, see figure below.

Sinusoidal signal (0.01 Hz to 120 kHz). The level can be adjusted logarithmically in steps (in programmed or manual operation), e.g. for the measurement of bandwidth, passband characteristics, frequency response; level blanking is possible in < 10 µs. Level programming in dB; with manual adjustment, the output voltage can be read in V and dB.



Phase relationship of output signals (time scale 5 ms/div.)

Squarewave signal (0.01 Hz to 1.2 MHz). Fixed level; TTL compatible; crystal-controlled periods up to 100 s, suitable for accurate timing.

Triangle signal (0.01 Hz to 120 kHz). Fixed level; time-linear voltage, e.g. for driving XY recorders.

Sinewaves and squarewaves are in phase quadrature, sinusoidal and triangular signals in phase opposition (below 10 Hz pushbutton for instantaneous start at defined starting point).

Frequency and level switching without interference. The use of FET switches and limiting reduces switching interference to a minimum. No overshoot occurs upon frequency switching.

Programming in BCD and ASCII codes. All functions can be remote-controlled in BCD code with the aid of TTL commands. The use of FET switches ensures short switching times and avoids the failures due to wear associated with mechanical relays (digital sweeping is possible). In conjunction with the Code Converter PCW, the SSN can be programmed in ASCII code. This new programming system dispenses with the program control equipment required up to now. When used together with the PCW, the SSN can be controlled directly from the Card Reader PCL (see page 26).

Operation using card reader. When recurrent frequency and level values are required in different sequences, semi-automatic programming substantially simplifies the measurement. The Card Reader PCL is used to control the Precision LF Generator SSN via the Code Converter PCW. Such applications are frequently encountered, say, in production test departments.

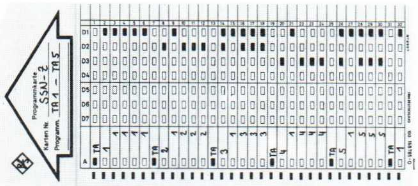
Sweeping. The very short switching times and phase-continuous frequency switching make the SSN suitable for digital sweeping. Very wide frequency variations are possible with absolute linearity. A sweep programmer in BCD code can easily be set up.

Description

The SSN consists of a digital synthesizer, which produces all frequencies in squarewave form, and of a waveform shaper which integrates the squarewave to a triangle signal and shapes the latter into a sinewave by means of a matrix.

Selective call signals obtained with the SSN

The switching response of the SSN, being rapid and free from overshoot, is ideal for the generation of selective call signals. Together with the Sequential Tone Programmer SSN-Z1 (featuring frequency and sequential-tone preselection and four-digit display of the call frequency) the SSN constitutes a



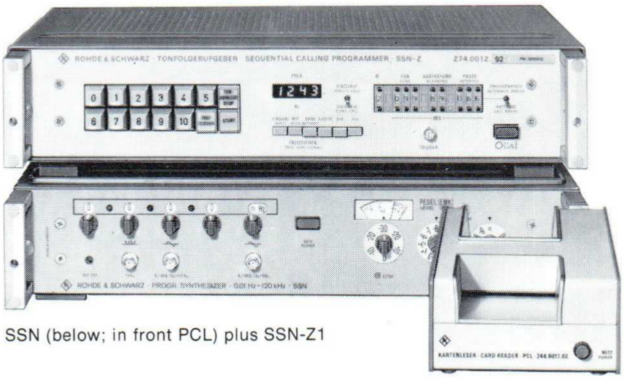
Punched card prepared for frequency entry into the SSN-Z1

Precision Sequential Tone Generator
♦ 1 to 9999 Hz

consisting of

Sequential Tone Programmer SSN-Z1 and Precision LF Generator SSN

- Crystal-controlled sequential-tone signals for three types of selective calls
- Least frequency increments 1 Hz, accuracy 2×10^{-5}
- Frequency programmable (e.g. in ASCII via PCL); digital selection of intervals accurate to 1%



SSN (below; in front PCL) plus SSN-Z1

The **Precision Sequential Tone Generator** produces all common sequential tone call signals and other tone sequences up to 11 tones. The range of application extends from a simple (1 × n) sequential tone call signal such as the Eurosignal – see oscillogram on page 27 – to Rhine radio (2 × 5) and maritime radio (2 × [5 + 4] tones).

The unit can be programmed for single and continuously repeated calls. Single tones can be called up as continuous signals.

The frequency range covers 1 Hz to 9999 Hz in 1-Hz increments. These frequencies are produced by the SSN with a maximum error of 2×10^{-5}. Higher accuracy is obtainable through the use of an external standard frequency.

A freely selectable free-channel signal can be transmitted during call breaks instead of the "level-off" command. During the setting and the execution of the call, LEDs give a four-digit frequency readout. They also show the frequency of single tones that are called up.

Timing of all sequences is possible with selector switches in 1-ms steps with an error < 1%.

Tone duration is 1 to 999 ms, blanking interval 0 to 99 ms; breaks between calls and the intermediate breaks following the fifth signal element in maritime radio can independently be set from 0 to 999 ms. Beginning and end of a single call are identified by time markers at the trigger output.

The Card Reader PCL permits the frequencies of complete sequential tone call signals to be entered quickly and reliably, saving much time in routine measurements.

Specifications of SSN

Frequency	sinusoidal and triangle signals: 0.01 Hz to 120 kHz squarewave: 0.01 Hz to 1.2 MHz
Indication	four digits, least increment 10 µHz
Class of accuracy	2×10^{-5} (with internal crystal)
Reference frequency input	2 MHz, 1 MHz
Reference frequency output	2 MHz
Input/output signal	TTL signal
Signal outputs	shortcircuit proof
Sinusoidal signal	7.75 mV_{rms} to 6 V_{rms} EMF, can be blanked; Z_{out} = 50 Ω
Adjustment	in steps of 10/1/0.1 dB referred to 0.775 V
Indication	in V and dB
Error limits (at 1 kHz)	±1% from −11 to 0 dB ±2% for all other dB values
Frequency-response flatness	≦1% up to 40 kHz ≦2% up to 120 kHz
Suppression of harmonics	> 46 dB from 10 Hz to 50 kHz, 40 dB otherwise
Suppression of spurious signals	> 80 dB
Spurious FM	< −70 dB
Signal-to-noise ratio	> 60 dB
Squarewave	TTL signal
Rise time	< 100 ns
Triangle signal	1 V_{pp} EMF (fixed)
Programming	frequency and level
Parallel:	
Code	BCD, negative
Level	TTL
Response time	< 100 µs (< 10 ms for full accuracy)
IEC bus	with Code Converter PCW
General data	
AC supply	115/125/220/235 V ±10%, 45 VA
Dimensions, weight	484 mm × 105 mm × 336 mm (1 B), 9 kg
Order designations	► Precision LF Generator SSN
19" cabinet model	204.8014.52
19" rackmount	204.8014.51
Recommended extras	
Code Converter PCW (section 1)	
19" cabinet model	244.8015.92
19" rackmount	244.8015.91
Coding board for SSN: PCW-Z	245.2710.02
Card Reader PCL (section 1)	248.6017.02

Specifications of Precision Sequential Tone Generator

Max. number of tones per call	11
Frequency range	1 to 9999 Hz, 1-Hz increments
Timing increment	1 ms ±1%
Tone duration	1 to 999 ms
Blanking interval	0 to 99 ms
Call break	0 to 999 ms
Intermediate break	0 to 999 ms
Types of call	sequential tone selective call (e.g. Eurosignal, Rhine radio, maritime radio) with single/continuous call and breaks, with and without free-channel signal
Frequency readout	4 digits, LEDs
Input	24-pole, for card reader
Outputs	50-pole to SSN BNC socket for trigger
Output signal	see SSN above
AC supply	115/125/220/235 V ±10%, 20 VA
Dimensions, weight of SSN-Z1	492 mm × 116 mm × 392 mm, 5 kg
Order designations (order units separately)	► Sequential Tone Programmer SSN-Z1 274.0012.92 (with 50-way cable) ► Precision LF Generator SSN 204.8014.52
Recommended extras	
Card Reader PCL (page 15)	248.6017.02

SUB

RC Generator/Indicator SUB
♦ 50 Hz to 50 kHz

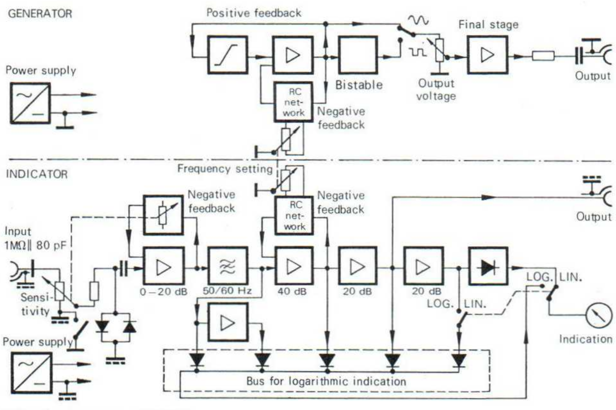
- Ease of operation due to single-knob tuning
- Logarithmic scale range > 80 dB
- Sensitivity: 5 µV full-scale deflection, 1 µV readable

The **SUB** combines a variable-frequency RC oscillator (delivering either a sine- or squarewave signal) with a selective receiver which is tuned to the frequency of the RC oscillator. Thus it is a convenient means for working with impedance bridges, standing-wave detectors and attenuation meters. The logarithmic voltage range covering more than 80 dB permits the bridge balance to be detected without readjusting the gain. The sensitivity can be varied continuously to approx. 50 mV at fsd in linear and to 30 V maximum in logarithmic operation. In addition to the linear and logarithmic scales, the instrument has another two scales calibrated in VSWR and inverse VSWR.

Description. The generator and the indicator feature ganged frequency setting. The selective part of the indicator contains a network and an amplifier identical to those of the frequency-determining section of the generator. A low-noise field-effect transistor is used at the input of the high-impedance preamplifier in the indicator.

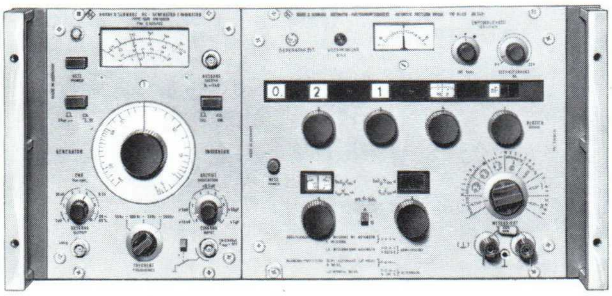
The logarithmic relationship between indication and input voltage over 4 decades is obtained by tapping the stages of the amplifier chain. The tapped signals are then limited and summed as currents on a common bus.

The chassis connections of the generator and indicator can be interrupted by a slide switch.



Block diagram of SUB

The small and handy instrument is accommodated in a 162-mm wide cabinet; however, the SUB (3/8 × 19") can also be mounted in a 19" cabinet (see below) in conjunction with other instruments, e.g. the Automatic Precision Bridge RLCB. For this purpose, the outputs and inputs of the SUB are repeated at the rear.



Combination of SUB with the Automatic Precision Bridge RLCB in a 19" cabinet

Specifications

Frequency range	50 Hz to 50 kHz (3 decades)
Frequency adjustment	continuous, ganged with generator tracking error ≦±3%
Frequency variation caused by AC supply fluctuations of ±10%	≦±1 × 10^{-3}
Generator	
Temperature coefficient of frequency	≦±3 × 10^{-4}/°C
Sinewave output voltage	3 V_{rms} (Z_{out}: 50 to 220 Ω)
Squarewave output voltage	8 V_{pp} EMF
Duty cycle (pulse duration/period)	1:2
Sag or tilt	≦5%
Rise/fall time	≦0.6 µs (10 to 90%)
Coarse EMF calibration	3 to 30 to 300 mV to 30 V
Indicator	
Sensitivity of indication for fsd	
Linear indication	5 µV ±20% at 1 kHz
Logarithmic indication	50 mV at 1 kHz
Deflection due to noise with input shorted	
Typical value at 50 Hz	0.1 µV
1 kHz	0.1 µV
50 kHz	0.7 µV
Attenuation of 2nd harmonic	> 33 dB (up to 10 kHz)
Scale calibration for	lin and log indication, inverse VSWR, VSWR
Input impedance	1 MΩ shunted by 80 pF
General data	
Nominal temperature range	+10 to +35 °C
AC supply	115/125/220/235 V ±10%
Dimensions, weight	162 mm × 238 mm × 242 mm, 3 kg
Order designations	► RC Generator/Indicator SUB
Cabinet model	100.4120.92
19" rackmount	100.4120.91
Recommended extras	
Protective front-panel cover	043.4372.00

SRB

RC Oscillator SRB
♦ 10 Hz to 1 MHz

- Sinewave generator with accurate voltage indication
- Source impedance switchable between 50 and 600 Ω
- Accessory: Balun for the transmission of stereo multiplex signals

SRB with balun

The **SRB** offers all characteristics required for measurements up to 1 MHz in laboratories and servicing concerned with acoustics, ultrasonics and AF engineering. The special circuitry ensures high frequency stability even in the upper of the 5 subranges.

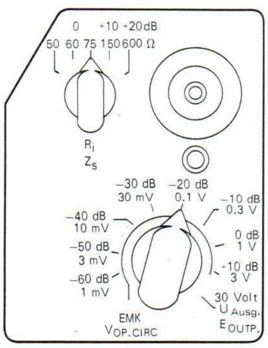
Frequency setting. Each of the five ranges covers one decade between 10 Hz and 1 MHz. In addition, the frequency dial is provided with an inner circle marked with the standard 1/3 octave values according to DIN 45 401. The 1/3 octave scale gives the values log f instead of the frequency in order to convert the logarithmic into a linear relationship and to facilitate series of measurements.

Output level, switch-selected output impedance. The SRB delivers a maximum output power of 1.5 W, the typical distortion being approx. 0.1% for frequencies between 100 Hz and 100 kHz. At medium load, this value is considerably more favourable, see diagram at right.

The output EMF can be switch-selected in 8 steps between 1 mV and 3 V (at 50/60/75 Ω; 600 Ω: 30 V). Fine adjustment between the steps is possible by means of the voltage divider. In position 30 V, the output is taken directly to the voltage divider and delivers max. 30 V.

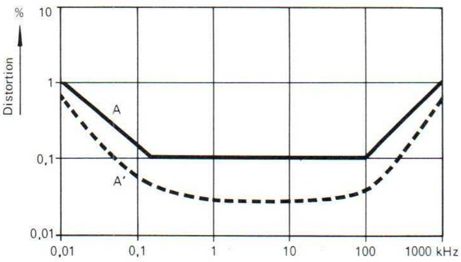
The voltage and level values can be read on the meter calibrated in V and dB.

The output impedance of the SRB can be set to 50 Ω, 60 Ω, 75 Ω, 150 Ω and 600 Ω (not applicable to position 30 V).



Front panel detail of the SRB with controls and output

Distortion at medium load
A guaranteed values
A' typical values



Balun. A balun (see photo above) for 30 Hz to 100 kHz is available for feeding balanced networks or amplifiers which require a push-pull or floating input voltage source. The balun is also used to advantage in test setups for eliminating AC hum pickup. Due to its step-down ratio, the balun has a low impedance (≈ 15 Ω). With the normal load of 600 Ω connected to the secondary, practically the full transformed EMF of the RC Generator SRB is thus available.

Specifications

Frequency range	10 Hz to 1 MHz, in 5 subranges
Frequency accuracy	±1% (at f ≦ 100 Hz: ±2%)
Frequency variation caused by AC supply fluctuations of ±10%	<±3 × 10^{-4} ±0.1 Hz
Maximum output power	1.5 W
Output voltage (free of DC)	adjustable continuously and in steps
direct (Z_{out} ≈20 to 60 Ω)	0 to 30 V, continuously adjustable
via attenuator switch	in 10-dB steps; at Z_{out} 50/60/75 Ω: 1 mV to 3 V 150 Ω: 3 mV to 10 V 600 Ω: 10 mV to 30 V
Indication	calibrated in V and dB
AC supply	115/125/220/235 V ±10%
Dimensions	286 mm × 227 mm × 226 mm

Balun

Input	RF connector 4/13 DIN 47 284 with 25-cm shielded line
Output	knurled terminals 4 mm
Frequency range	30 Hz to 100 kHz
Open-circuit turns ratio	3.16:1 = 10 dB (±0.1 dB)
Impedance	15 Ω (for total winding)
Permissible load impedance	150 Ω up to open circuit
Distortion	<1%

Order designations

SRB	► RC Oscillator SRB 100.4094.02
SRB-Z	► Balun SRB-Z 100.4107.02

SMLH

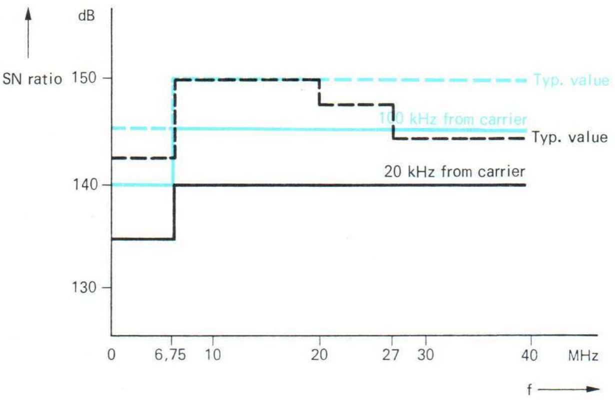
AM/FM Signal Generator SMLH
♦ 10 kHz to 40 MHz

- High frequency stability and spectral purity
- Digital readout with 1-Hz resolution
- Excellent AM and FM characteristics for receiver measurements
- Wide amplitude range with negligible attenuator error

Characteristics, uses

The **SMLH** is the ideal signal generator for all measurements on active and passive components, modules and units to be carried out in the laboratory, servicing and production. It is particularly suitable for receiver measurements from LF to shortwave, e.g. on radio direction finders and shortwave receivers including SSB receivers.

The high spectral purity of the output signals permits all multi-signal measurements, e.g. adjacent-channel selectivity, intermodulation, crossmodulation and blocking. Because of its very high narrowband and broadband signal-to-noise ratios (see diagram) the SMLH is suitable for measurements even on receivers with extreme selectivity.



Signal-to-noise ratio, measured at 1-Hz bandwidth, as a function of carrier frequency and spacing from carrier

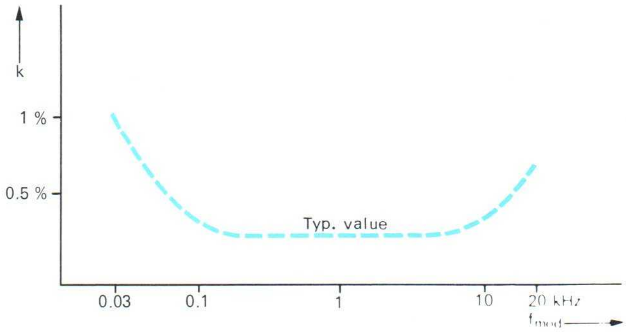
Frequency setting and indication. Pushbuttons for frequency range selection and a tuning knob with coarse/fine drive without stop provide for rapid and reliable frequency setting. The electronic fine adjustment permits a setting accuracy of 1 Hz so that in conjunction with the high frequency stability measurements are also possible on filters with high skirt selectivity or on receivers with narrow channel spacing. The output frequency is read out on a six-digit **frequency** meter – which can also be used for external frequency measurements – with a resolution of max. 1 Hz; the external counter input is high-impedance.

Modulation, sweeping. The AM characteristics of the SMLH are especially designed for testing SSB receivers, the envelope distortion being practically negligible. The FM characteristics enable narrowband sweeping with a maximum deviation of 10 kHz.

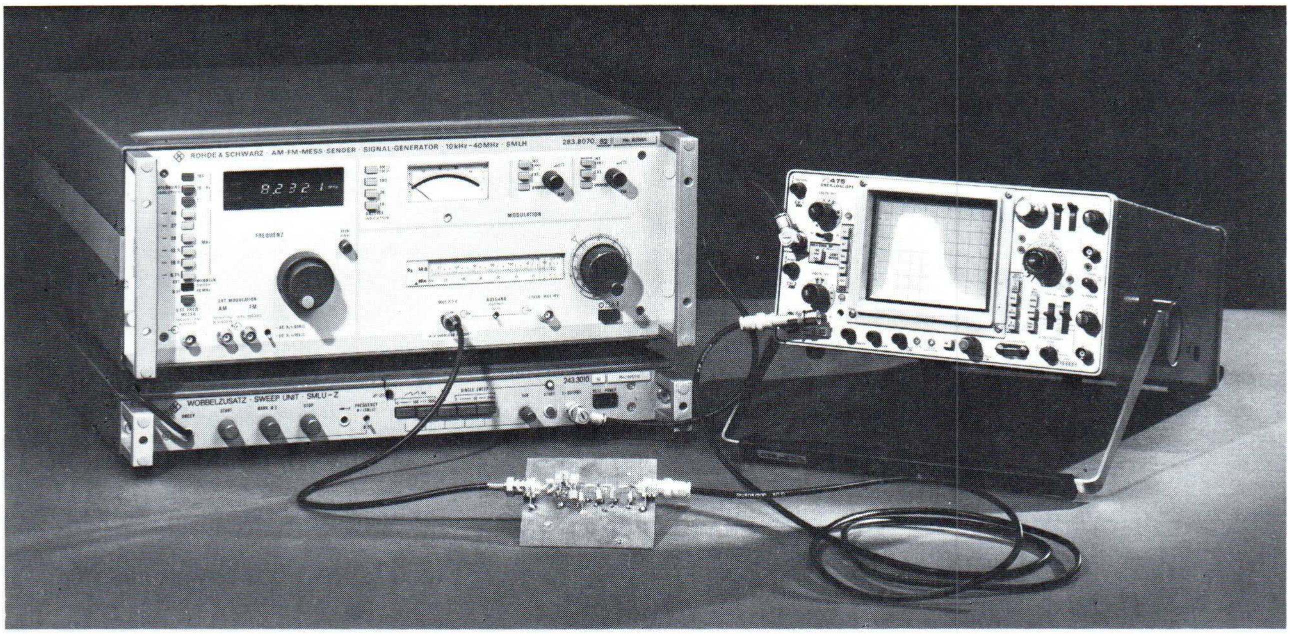
The FM external input can be DC-coupled by means of a switch, permitting the oscillator to be swept from DC to approximately 1 kHz modulation frequency.

Output level. The wide output voltage range (0.05 µV to 0.5 V) together with the RF leakage-free design enable sensitivity measurements to be made on receivers down to levels of 0.1 µV EMF as well as measurements on active components with an EMF of up to 1 V (with 2-W amplifier option up to 10 V into 50 Ω).

Output attenuator. Continuously adjustable, single-knob attenuator for rapid measurement of sensitivity, signal-to-noise ratio and response threshold of squelch and limiting.



Typical values of modulation distortion as a function of modulation frequency at m = 80%



Measurement of a bandpass filter using AM/FM Signal Generator SMLH and Sweep Unit SMLU-Z

Options

A number of options is available for the SMLH which – independent of one another – can be incorporated in the factory or added later following the instructions supplied with them and without requiring any trimming.

Crystal Oscillator SMLH-B2 (counter control). Temperature-compensated crystal oscillator for counter control which improves the accuracy and temperature stability to 5×10^{-8}/month as against the 1×10^{-5}/month of the basic model.

2-W Amplifier SMLH-B3 increases the output power of the SMLH to 2 W (10 V into 50 Ω) with reduced maximum modulation depth: with an output voltage of > 4 V the maximum permissible modulation depth is reduced from 98% ($V_{out} = 4$ V) to 0% ($V_{out} = 10$ V). The equivalent circuit of the power amplifier complies with the IEC recommendations; it consists of a 20-V EMF source with 50-Ω source impedance.

Sweep Oscillator SMLH-B5 permits sweeping between 100 kHz and 40 MHz in two bands which are electronically switched so that the entire frequency range can be continuously swept with a suitable sawtooth generator, e.g. the Sweep Unit SMLU-Z.

Overload Protection SMLH-B7 protects the RF attenuator and the output stage of the SMLH from damage caused by an excessive voltage applied to the RF output.

Sweep Signal Generator SMLH/SMLU-Z

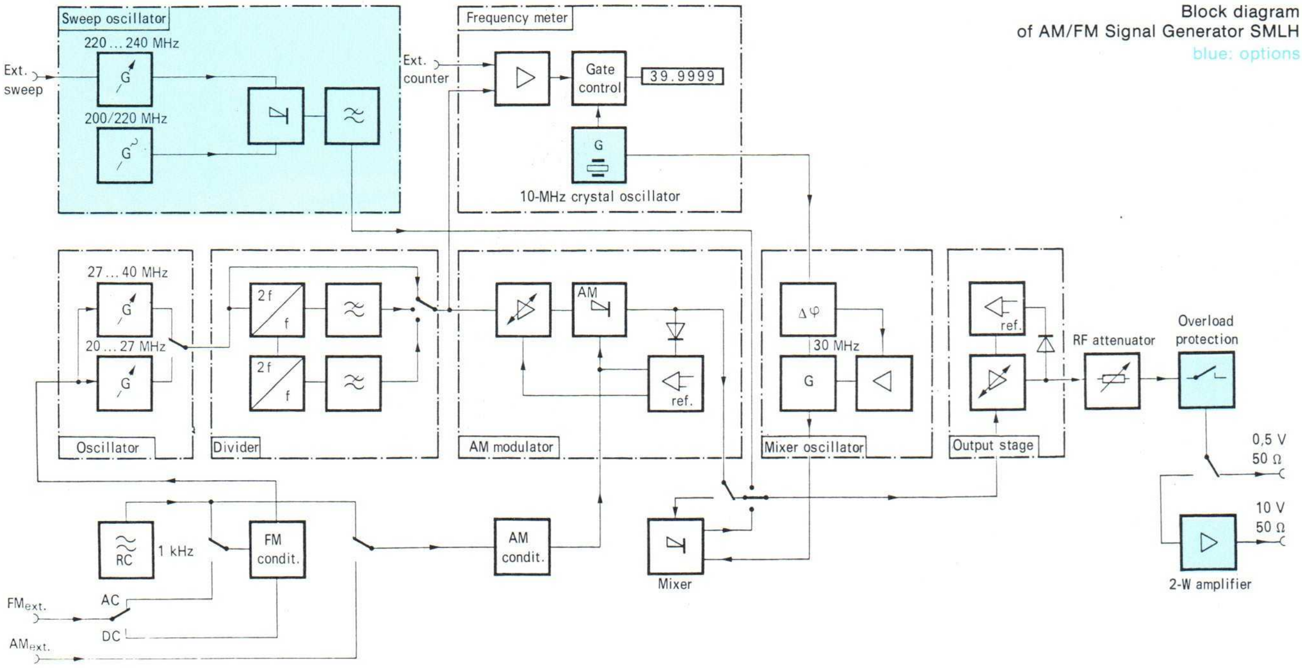
In conjunction with the option SMLH-B5 and the Sweep Unit SMLU-Z (page 53) the SMLH constitutes a broadband sweep generator for sweeping either any desired subrange or the entire frequency range from 0.1 to 40 MHz. The switch-over of the two SMLH subranges is automatically controlled by the sweep unit.

Range selection, markers. The desired sweep range is selected by setting the corresponding start and stop frequencies with two potentiometers. Another potentiometer is used to set a marker within the sweep range, its frequency being read out on the SMLH counter if the sweep time is > 100 ms. The marker is shown as a bright dot on an external display. The start and stop frequencies are indicated on the SMLH counter when the corresponding button is pressed.

The sweep time is adjustable between 10 and 100 ms. Single sweeps of 2 to 200 s or manual tuning between start and stop frequency are also possible.

Test curve display. Any standard oscilloscope with X-Y input as well as ordinary X-Y displays are suitable for showing the measured curves. Operation in conjunction with XY or YT recorders is also possible; the SMLH is provided with outputs for the X-deflection voltage and the marker pulse.

Display driving. The SMLU-Z has an X output and a pulse output for blanking during flyback of the sawtooth.



Block diagram of AM/FM Signal Generator SMLH
blue: options

Description

For the SMLH a design concept has been chosen which utilizes the advantages of various frequency conditioning methods, whilst avoiding their drawbacks. The high frequencies (20 to 40 MHz) are produced directly in two subranges, the low ones (10 kHz to 6.75 MHz) by beating and those in between (6.75 to 20 MHz) by frequency division. The chosen frequencies ensure excellent stability, high narrowband and broadband signal-to-noise ratios as well as high spurious rejection.

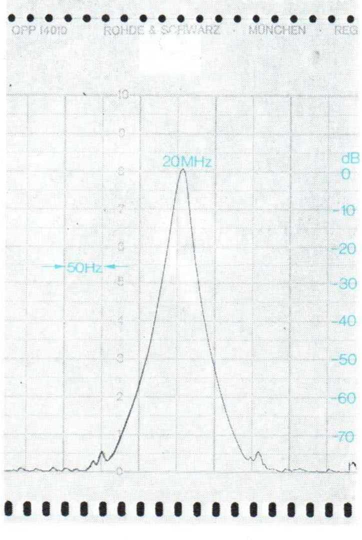
The two continuously tuned oscillators are designed as printed circuits on two ceramic segments, which also bear the stators required for tuning the variable capacitor. Due to the geometrical arrangement of the two oscillator segments only slight retuning of the frequency is required at the subrange limits when switching over the range. If the selected frequency range is exceeded at either end, the counter display blinks.

The modulators have been designed to operate only between 20 and 40 MHz (FM) and 6.75 and 40 MHz (AM), thus providing for the favourable modulation characteristics. The highly degenerative amplitude modulator uses PIN diodes and operates on the principle of current-controlled attenuation. The typical envelope distortion is 0.3% with 80% modulation depth. For the lower carrier frequencies the modulated signal is converted in a low-distortion and low-noise mixer. In this way even low carrier frequencies can be modulated with high frequencies.

The frequency meter with digital readout is made up of a six-decade counter with switch-selectable resolution of 1, 10 or 100 Hz. It measures the signal-generator frequency or the frequency of an external sinewave signal.

The output stage operates with especially low intermodulation distortion. Its output level is sensed and used in the automatic level-control loop. The sensing element – an average-responding rectifier – permits accurate level control (0.5 V into 50 Ω) at all carrier and modulation frequencies.

With the RF output attenuator the output voltage can be continuously adjusted between 0.05 μV and 0.5 V into 50 Ω. The various scales provided on the attenuator permit additional reading of the output level in mV into 50 Ω, in dBμV and dBm and of the output EMF.



Suppression of sidebands near carrier (hum sidebands)

Specifications

SMLH basic model

Frequency range	10 kHz to 40 MHz in 6 subranges
Readout	in 6 digits, resolution 1, 10, 100 Hz
Control crystal	10 MHz, aging 1×10^{-5}/month option SMLH-B2: 5×10^{-8}/month
Frequency meter for ext. test frequencies	10 Hz to 40 MHz, input voltage 100 mV to 3 V
Frequency tuning	
mechanical	coarse/fine drive
electronic	ca. 50 to 150 Hz
Frequency drift	
after 10 min warmup	< 1 kHz/5 min (typ. 200 Hz)
after 2 h warmup	< 200 Hz/5 min (typ. 50 Hz)
RF output	Z_{out} = 50 Ω, BNC socket
Output voltage	0.05 μV to 0.5 V into 50 Ω
Setting	continuous
Error limits	
$V_{out} \leqq 0.2$ V	±1 dB
$V_{out} > 0.2$ V	±2 dB
Frequency response	±0.5 dB (typ. ±0.25 dB)
Spectral purity	
S/N ratio, referred to 1-Hz bandwidth	see diagram on page 32
Suppression of harmonics	> 30 dB, typ. 36 dB
Suppression of spurious signals	> 90 dB at < 20 MHz from carrier
Spurious FM acc. to CCITT	< 3 Hz
Spurious AM acc. to CCITT	< 0.01 %
Suppression of hum sidebands	
50 Hz	> 50 dB
≧ 100 Hz	> 60 dB

Modulation

AM internal	modulation frequency 1 kHz, modulation depth up to 98 % (reduction for V_{out} > 4 V, e.g. with 2-W amplifier option)
external	30 Hz to 20 kHz, voltage requirement 10 mV/%, input impedance 600 Ω
Indicating ranges	10/30/100 %
Error at m = 80 %	±(5% of rdg + 1.5% of fsd)
Envelope distortion	100 Hz to 10 kHz / 30 Hz to 20 kHz
at m = 80 %	< 1 %, typ. 0.3 % / < 2 %, typ. 1 %
Suppression of intermodulation at m = 80 %	> 40 dB, typ. 46 dB (with f_{mod} = 100 Hz to 10 kHz)
FM internal	modulation frequency 1 kHz, frequency deviation up to 50 kHz
external AC	30 Hz to 20 kHz, voltage requirement 10 mV/kHz, input impedance 600 Ω
DC	0 to 1 kHz (max. 10 kHz deviation), voltage requirement 250 mV/kHz, input impedance 10 kΩ
Indicating ranges	10/30/100 kHz deviation
Error	±(5% of rdg + 1.5% of fsd)
FM distortion	< 1 %, typ. 0.5 % (with 10 kHz deviation) < 5 %, typ. 1.5 % (with 50 kHz deviation)
Incidental AM for Δf = 10 kHz, f_{mod} = 1 kHz	< 1 %, typ. 0.2 %

General data

Nominal temperature range	+10 to +45 °C
Shelf temperature range	−40 to +70 °C
Power supply	115/125/220/235 V ±10 %, 47 to 420 Hz (40 to 60 VA)
Dimensions, weight	492 mm × 205 mm × 514 mm, 20 kg
Order designation	► AM/FM Signal Generator SMLH 283.8070.52
SMLH, model 54 (with 2-W amplifier)	283.8070.54

Recommended extras (options) and accessories

Crystal Oscillator SMLH-B2	284.6407.02
2-W Amplifier SMLH-B3	284.4210.50
Sweep Oscillator SMLH-B5	284.5017.02
Overload Protection SMLH-B7	284.6007.50
Sweep Unit SMLU-Z	243.3010.92

SMLH options

Crystal Oscillator SMLH-B2, 10 MHz

Temperature dependence	temperature-compensated
Crystal aging	5×10^{-8}/month
Frequency drift	$< 5 \times 10^{-8}$ ±1 digit at constant ambient temperature
Order designation	► Crystal Oscillator SMLH-B2 284.4010.02

2-W Amplifier SMLH-B3

Frequency range	10 kHz to 40 MHz	
Output voltage	0.5 to 10 V into 50 Ω	
Setting, resolution	same as for basic model	
Error limits	±2 dB, typ. ±1 dB + error of basic unit	
Suppression of harmonics		
with V_{out} between 0.5 and 5 V	> 30 dB, typ. 40 dB	
between 5 and 10 V	> 24 dB, typ. 30 dB	
S/N ratio referred to 1 Hz test bandwidth	20 kHz from carrier	200 kHz from carrier
with V_{out} between 0.5 and 2 V	typ. 135 dB	140 dB
between 2 and 10 V	typ. 140 dB	150 dB
Amplitude modulation depth		
with V_{out} between 0.5 and 4 V	adjustable up to 98 %	
between 4 and 10 V	linear reduction from 98 % at 4 V to 0 % at 10 V	
Envelope distortion at m = 80 %		
$f_{carrier}$ = 30 MHz, V_{out} < 4 V	< 2 %, typ. 1 %	+ error of basic unit
$f_{carrier}$ = 40 MHz, V_{out} < 3 V	< 4 %, typ. 2 %	+ error of basic unit
Indicating error at m = 80 %		
$f_{carrier}$ = 30 MHz, V_{out} < 4 V	< ±10 %	
$f_{carrier}$ = 40 MHz, V_{out} < 3 V	< ±10 %	

Other data same as for basic unit

Order designation	► 2-W Amplifier SMLH-B3 284.4210.50

Sweep Oscillator SMLH-B5

Frequency range/subranges	100 kHz to 20 MHz, 20 to 40 MHz
Required sweep control voltage	0 to +10 V
Spurious FM (f > 1 MHz, test bandwidth 50 Hz to 15 kHz)	< 500 Hz (spurious content of control voltage: < 10 μV)
Frequency-response flatness (1 to 40 MHz)	< ±2.5 dB
Suppression of harmonics (1 to 40 MHz)	> 30 dB, typ. 40 dB
Order designation	► Sweep Oscillator SMLH-B5 284.5017.02

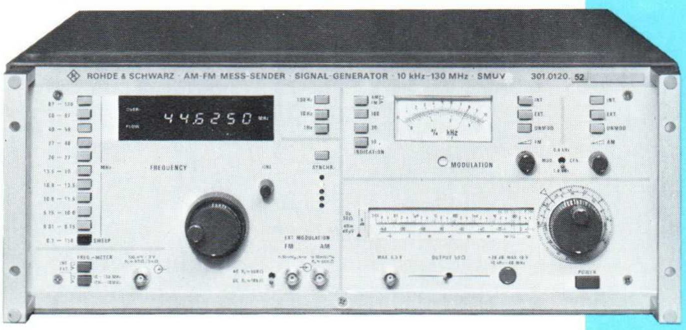
Overload Protection SMLH-B7

Max. permissible power	50 W
Max. permissible voltage	50 V
Order designation	► Overload Protection SMLH-B7 284.6007.50

Sweep Signal Generator SMLH/SMLU-Z

Frequency range	100 kHz to 40 MHz
Sweep width	maximum: entire frequency range
Sweep time	adjustable
sawtooth	10 to 1000 ms
single sweep	2 to 200 s
manual	continuously tunable from 0.1 to 40 MHz
Frequency marker, adjustable	0.5 to 40 MHz
Frequency-response flatness (1 to 40 MHz)	< ±2.5 dB
Blanking pulse	+15 V
Marker pulse	+5 V
Recorder control voltage	max. 20 V/1 A via switch contact
General data of Sweep Unit SMLU-Z	
AC supply	same as for SMLH, power consumption 12 VA
Dimensions, weight	484 mm × 69 mm × 436 mm, 5.4 kg
Order designation	► Sweep Unit SMLU-Z 243.3010.92

SMUV



new

AM/FM Signal Generator SMUV
10 kHz to 130 MHz

- High frequency stability and spectral purity of the output signal
- Frequency counter with 1-Hz resolution
- Wide level range with negligible attenuator error, single range output-level setting
- Low envelope and FM distortion, stereo compatible
- Frequency synchronization with 1-kHz steps (with option)

Characteristics, uses

The AM/FM Signal Generator SMUV, with an even greater performance coverage than the SMLH (pages 32 to 35), is also ideal for use in the laboratory, production and servicing; it mainly differs, however, in the wider frequency range with excellent modulation characteristics for VHF stereo measurements as well as the possibility of sweep operation up to 130 MHz and frequency synchronization with 1-kHz steps (when using an option). The field of application of the SMUV therefore also includes the VHF range.

The high spectral purity and high frequency stability – when using the synchronization option even synthesizer performance – permit measurements even on very narrowband receivers. The high narrowband and broadband S/N ratio enables critical adjacent-channel measurements, whilst the good suppression of spurious signals allows the measurement of intermodulation, crossmodulation and blocking.

Frequency setting, frequency counter. Pushbuttons for the range selection and a tuning knob with coarse/fine drive without stop provide for rapid and reliable frequency setting, the electronic fine tuning permitting an accuracy of 1 Hz. The **frequency counter** reads out the output frequency of the SMUV in seven digits with a selectable resolution of 1, 10 or 100 Hz. External frequencies of 10 Hz to 130 MHz can be measured with the same resolution, the sensitivity being typically 10 mV.

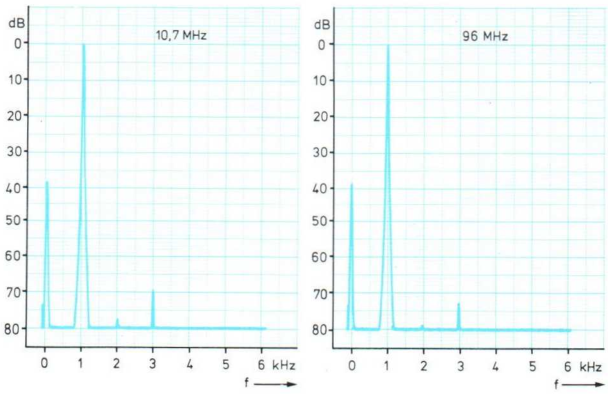
Modulation, sweeping. The very low envelope distortion that is almost independent of carrier and modulation frequency, permits measurements even on high-grade AM receivers. The low intermodulation products with multitone AM are very important when testing SSB receivers.

Frequency modulation is possible down to 10 kHz carrier frequency with large deviation and very little distortion. Thanks to the very low modulation distortion in the VHF and VHF-IF range (see diagram) the SMUV in conjunction with a stereocoder can be used for all measurements, even on first-class stereo receivers.

Narrowband sweeping – e.g. of tuned circuits, IF amplifiers, FM demodulators and filters with high skirt selectivity – is enabled by DC coupling with external FM.

Wideband sweeping. The sweep oscillator option covers the total frequency range from 0.1 to 130 MHz in three subranges which can be electronically switched over with TTL levels so that the entire range can be swept. The Sweep Unit SMLU-Z is tailored to this specific application (see page 33: sweep signal generator SMLH/SMLU-Z; with extended frequency range the same holds true for the SMUV/SMLU-Z).

Output level. The output voltage of the SMUV of 0.05 µV to 0.5 V into 50 Ω is continuously adjustable with a single-range attenuator, thus permitting sensitivity measurements on receivers as well as measurements on components. In conjunction with the 2-W amplifier option the SMUV delivers up to 10 V into 50 Ω in the frequency range 10 kHz to 40 MHz.



Typical FM distortion at 75 kHz deviation,
left: $f_{carrier}$ = 10.7 MHz, right: $f_{carrier}$ = 96 MHz

SMUV models

SMUV basic unit. Options may be retrofitted or incorporated in the factory prior to delivery

SMUV model 55 with options synchronization (SMUV-B9) and temperature-compensated crystal oscillator (SMUV-B1) already incorporated

SMUV model 57 with option 2-W amplifier (SMLH-B3) already incorporated

Options

The options are independent of one another and can be incorporated in the factory or added later to all models, following the mounting instructions supplied with them and without requiring any trimming.

Crystal Oscillator SMUV-B1, temperature-compensated, for counter control, frequency drift 5×10^{-8}/month.

2-W Amplifier SMLH-B3 increases the output power to 2 W (10 V into 50 Ω) in the frequency range 0.01 to 40 MHz.

Sweep Oscillator SMUV-B5, frequency range 0.4 to 130 MHz; see text and page 33.

Overload Protection SMLH-B7 protects the RF attenuator and the output stage from being damaged when excessive RF or DC voltages are applied to the output.

Synchronization SMUV-B9 provides the SMUV with synthesizer stability without affecting the spectral purity. Frequency steps 1 kHz.

Specifications

S MUV basic unit
(unmentioned data are identical with those of SMLH, page 35)

Frequency range	10 kHz to 130 MHz in 10 subranges	
Readout	in 7 digits	
Control crystal	10 MHz, aging 1×10^{-5}/month option SMUV-B1: 5×10^{-8}/month	
Frequency meter for ext. test frequencies	10 Hz to 130 MHz, V_{in} = 30 mV (typ. 10 mV) to 3 V	
Frequency tuning		
mechanical	coarse/fine drive	
electronic	ca. 100 to 500 Hz, depending on range	
Frequency drift	after 10 min	after 2 h
unsynchronized at f ≦ 40 MHz	< 1 kHz/5 min	< 300 Hz/5 min
at f > 40 MHz	< 2 kHz/5 min	< 1 kHz/5 min
synchronized	see option Synchronization SMUV-B9	
RF output	Z_{out} = 50 Ω, BNC socket	
Output voltage	0.05 µV to 0.5 V into 50 Ω	
Setting	continuous	
Error limits	<±1 dB with V_{out} ≦ 0.2 V <±2 dB with V_{out} > 0.2 V	
Frequency-response flatness	<±0.5 dB	
Spectral purity		
S/N ratio, referred to 1 Hz bandwidth	140 (135) dB at 20 kHz from carrier 145 (140) dB at 100 kHz from carrier	
Suppression of harmonics	> 30 dB, typ. 36 dB	
Suppression of spurious signals	> 90 dB at < 15 MHz from carrier	
Spurious FM acc. to CCITT	< 2 Hz, typ. 0.5 Hz	
Modulation		
AM internal	f_{mod}: 400 Hz/1 kHz modulation depth up to 98%, adjustable	
external	30 Hz to 20 kHz voltage requirement 10 mV/% input impedance 600 Ω	
Indicating range	10/30/100%	
Envelope distortion	100 Hz to 10 kHz	30 Hz to 20 kHz
at m = 80%	< 1%, typ. 0.3%	< 2%, typ. 1%
Suppression of intermodulation, m = 80%	> 40 (46) dB from 100 Hz to 10 kHz	
Spurious AM (CCITT/CCIR)	< 0.01%/< 0.03%	
FM internal	f_{mod}: 400 Hz/1 kHz (distortion same as with external FM)	

	f_{mod}	distortion %	(typ.)	= Δf kHz
external AC 0.01 to 40 MHz	30 Hz to 20 kHz	< 1	0.5	≦ 10
40 to 130 MHz	30 Hz to 100 kHz	< 1	0.5	≦ 100
10 to 11.5 MHz	30 Hz to 100 kHz	< 0.1	0.05	≦ 75
		from 87 to 108 MHz:		
external DC 0.01 to 49 MHz	0 to 20 kHz	< 0.15	0.08	≦ 75
40 to 130 MHz	0 to 100 kHz			
10 to 11.5 MHz	0 to 100 kHz			

Input impedance AC/DC	600 Ω/10 kΩ
Voltage requirement	10 mVp/kHz
Frequency deviation	
0.01 to 40 MHz	adjustable up to 50 kHz
40 to 130/10 to 11.5 MHz	adjustable up to 100 kHz
Modulation indicating ranges 10/30/100 kHz	(f_{mod}: 30 Hz to 20 kHz/100 kHz)
Incidental AM (f = 10 kHz, f_{mod} = 1 kHz)	< 1%, typ. 0.2%
Stereo crosstalk attenuation (10 to 11.5; 87 to 108 MHz) 50 Hz/1 kHz/15 kHz	> 40/46/46 dB

SMUV options

Crystal Oscillator SMUV-B1, 10 MHz, temperature-compensated

Crystal aging	5×10^{-8}/month
Frequency drift	5×10^{-8}/10 min after 15 min warmup

2-W Amplifier SMLH-B3

Frequency range	10 kHz to 40 MHz
Output voltage	0.5 to 10 V into 50 Ω

Other data see SMLH-B3 on page 35

Sweep Oscillator SMUV-B5

Frequency ranges	400 kHz to 43.5 MHz 43.5 to 87 MHz 87 to 130 MHz
Range switching	via 36-pole socket on rear panel with TTL levels
Sweep frequency	0 to 100 Hz, control voltage 0 to +10 V
Suppression of harmonics (1 to 130 MHz)	> 30 dB, typ. 40 dB
Spurious FM (1 to 130 MHz)	< 1 kHz
Frequency-response flatness (1 to 130 MHz)	<±1 dB

Overload Protection SMLH-B7

Max. permissible RF power	50 W (max. DC voltage 50 V)

Synchronization SMUV-B9 synchronizes the output frequency with that of the built-in crystal oscillator, disconnectible

Frequency error	error of control crystal +5 Hz
Frequency steps	1 kHz
Max. modulation index	ca. 10 (fmod > 100 Hz, Δf < 10 kHz)

General data

Nominal temperature range	+10 to +45 °C
Shelf temperature range	−40 to +70 °C
Power supply	115/125/220/235 V ±10%, 47 to 420 Hz
Dimensions, weight	492 mm × 205 mm × 514 mm, 22 kg
Order designation	► AM/FM Signal Generator SMUV

(description of various models see above left)

SMUV, basic unit	301.0120.52
SMUV, model 55	301.0120.55
SMUV, model 57	301.0120.57
Accessories supplied	power cable

Recommended extras and accessories

Options:

Crystal Oscillator SMUV-B1 (5×10^{-8})	301.5809.02
2-W Amplifier SMLH-B3	284.4210.50
Sweep Oscillator SMUV-B5, voltage-controlled	301.4802.02
Overload Protection SMLH-B7	284.6007.50
Synchronization SMUV-B9	301.5609.02

Accessory unit:

Sweep Unit SMLU-Z	243.3010.92

ASV

Tunable VHF Amplifier and AM Signal Generator ASV
♦ 30 to 300 MHz

- VHF signal generator
- Voltage, power, buffer and indicating amplifier
- Straight-through receiver
- AM modulator and demodulator
- Frequency converter and harmonic generator

The **ASV** serves as signal generator, receiver and tunable amplifier. It combines ideally these three functions – normally performed by three different instruments – in a single instrument. Its versatility, small size and high quality make the ASV a standard instrument in the VHF range. Moreover, for special measuring problems, the ASV extends the range of application of most of the VHF precision measuring equipment made by R&S.

The output voltage can be adjusted from 30 mV to 3 V into 50 to 60 Ω. Input voltages up to about 10 mV are linearly amplified, higher voltages are limited to an ever increasing degree. The VHF voltage can be modulated from an external source or from an internal 1000-Hz source. A built-in demodulator renders possible the reception of amplitude-modulated VHF signals. The panel meter indicates the VHF output voltage or the percentage modulation.

The ASV is a three-stage signal generator or amplifier whose frequency-determining capacitors and inductors are tuned simultaneously. Thus, the range 30 to 300 MHz can be covered without band switching.

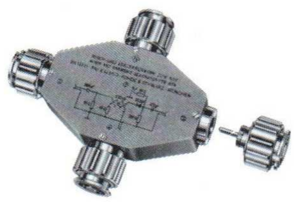
Mixer and Harmonic Generator ASV-Z

The Mixer and Harmonic Generator ASV-Z considerably increases the applications of the ASV, whose range is thus extended beyond the VHF region at both ends. The unit has four connectors which may be used as inputs and outputs.

Applications of the tunable VHF amplifier in conjunction with the mixer and harmonic generator:

Harmonic generator	multiplying ASV output frequencies preferring the lower harmonics giving levelled spectrum
Mixer	for generation of low mixture products for generation of medium mixture products for generation of mixture products in the range of the ASV

Mixer and Harmonic Generator ASV-Z

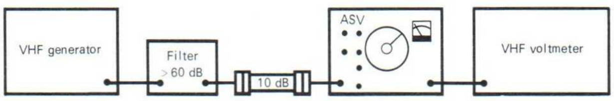


Voltage amplifier. An example is the investigation of the attenuation range of a filter where it is not permissible to apply a high voltage to the filter input. The high gain of the ASV makes measurements possible in the region of maximum stopband attenuation even if an attenuator pad is inserted (see diagram below).

Power amplifier. In conjunction with the ASV, a standard signal generator becomes a power signal generator which can be used for FM within the specified bandwidth of the ASV.

Buffer amplifier. The ASV precludes reactive effects on the test items.

Tunable indicating amplifier. The ASV amplifies and indicates small VHF voltages. Harmonics and spurious voltages are extensively attenuated by excellent far-off selectivity.



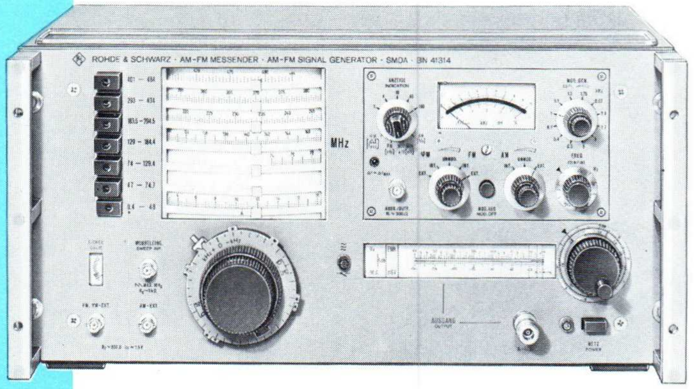
ASV as a voltage amplifier for filter measurement (10-dB attenuator pad used for matching)

Order designations
ASV .... ► Tunable VHF Amplifier and AM Signal Generator ASV 100.0976.02
ASV-Z .... ► Mixer and Harmonic Generator ASV-Z 100.0982.02
For specifications refer to table on page 22.

AM/FM Signal Generator SMDA
♦ 0.4 to 484 MHz

- Pushbutton selection of frequency ranges, Incremental tuning (calibrated in kHz), high frequency stability after short warmup period
- High spectral purity of output signal, low adjacent-channel and far-frequency noise; accurate level setting
- Excellent AM, FM and phase modulation characteristics, accurate modulation indication, tunable modulation source
- Protected against applied RF power

SMDA



LIMITED-AVAILABILITY PRODUCT

The **Signal Generator SMDA** is particularly suitable for the development, testing and servicing of radiotelephone systems used in land mobile stations. In conjunction with the **Power Test Adapter SMDA-Z** the measurements can be carried out very efficiently by simple switchover of the measurement mode (transmitter or receiver measurement).

Signal generator

Entire range from 0.4 to 484 MHz continuously tunable; rapid frequency selection by means of pushbuttons; high spectral purity; low noise; excellent frequency stability after very short warmup time.

The SMDA has excellent modulation characteristics. Amplitude modulation can be adjusted up to 95%, the envelope distortion being 1% (typical value); the residual AM is less than 0.1%. Frequency modulation with a deviation of up to 75 kHz and phase modulation by means of preemphasis (6 dB per octave) are possible. A sweep input permits **sweeping over several channels**, e.g. for filter alignment.

The output voltage is kept constant by ALC. The dynamic range is 140 dB, adjustable from 0.1 µV to 1 V. An automatic overload protection prevents damage to the output from inadvertent RF application.

AF voltmeter. The modulation indicator of the signal generator can be used as an AF millivoltmeter, e.g. for measurement of signal-to-noise ratio, intermodulation and adjacent-channel selectivity without additional equipment. The meter has four subranges: 30/100/300/1000 mV.

Power test adapter

RF power measurement up to 25 W in the range 10 MHz to 550 MHz; three decade ranges on one dial: 0.01 to 0.25/0.1 to 2.5/1 to 25 W; carrier indication with AM.

The measurement mode – transmitter or receiver measurement – is selected with a pushbutton. In receiver measurements the signal generator output is applied without attenuation to the radiotelephone system whereas a 20 dB/25 W attenuator network is inserted between the radiotelephone system and the signal generator in transmitter measurements. The power meter, an attenuator pad for the RF test output and the buffer amplifier for the frequency measurement output are connected simultaneously to the radiotelephone system via passive power dividers. The radiotelephone system is connected to the input of the power test adapter for all measurements on the receiver and transmitter sections. A high-power attenuator of the RBU series can be used to extend the measurement range to 50 or 100 W.

Specifications

AM/FM Signal Generator SMDA

Frequency range	0.4 to 484 MHz
Error limits of frequency	±0.5%
Frequency drift after 3 h of operation at constant ambient temperature	
0.4 to 185 MHz	<±600 Hz/10 min
at other frequencies	$<6\times10^{-6}$/10 min
Output signal	
Output EMF (Z_{out} = 50 Ω)	0.1 µV to 1 V = −140 to 0 dB(V)
Error limits	<±1 dB
Spurious FM (without modulation)	<10 Hz (weighted with CCITT filter for 0.3 to 3 kHz)
S/N ratio for 1-Hz test bandwidth	typ. 130 dB at 20 kHz from carrier
Modulation	external and internal
Modulation frequency range	30 Hz to 10 kHz (AM and FM)
Modulation generator	12 standard frequencies from 0.3 to 6 kHz; cont. 0.27 to 3.4/6 to 6.4 kHz
Amplitude modulation	max. 95% (dist. 1% typ.)
Frequency modulation	max. 75 kHz deviation (dist. <1% for 4 kHz deviation)
Sweeping, max. width	100 to 600 kHz
Sweep frequency	0 to 1 kHz
General data	
AC supply	115/125/220/235 V ±10% (55 VA)
Dimensions, weight	484 mm × 239 mm × 336 mm, 17 kg
Order designation	► AM/FM Signal Generator SMDA 100.4559.04

Power Test Adapter SMDA-Z

Power range	0.25/2.5/25 W (into 50 Ω), can be extended up to 100 W
Error of indication	±(6% of rdg +1.5% of fsd)
Frequency measurement outputs	
a) 10 to 550 MHz Input power 0.1 to 25 W	
Output voltage	300 mV +4 dB/−0 dB
b) RF test output	passive attenuator network
Output voltage	input power minus 26 dB
Order designation	► Power Test Adapter SMDA-Z 244.6012.52

SMDU

Signal Generator SMDU
♦ 15 Hz to 525 (1050) MHz

- Extendable signal generator coming in six different models, two of which permit general RF measurements:
  standard model with simple modulation unit;
  universal model with modulation unit meeting highest requirements and including AF voltmeter
- Extremely high frequency stability and spectral purity, crystal control with option, digital and analog indication
- Easy to operate, rapid frequency selection, single-range output attenuator of highest precision
- Output EMF 0.05 µV to 2 V

Overview models and options on pages 42/43

The **SMDU** family of signal generators permits all measurements on active and passive components, modules and units in laboratories, servicing shops and production plants. These generators are

of precise electrical performance,
economical thanks to available options and
versatile in application.

They comply with all national and international standard specifications for measurements on receivers and RT equipment (including aeronautical communication). Other user-oriented features are:

▷ suitable for stereo operation at carrier and intermediate frequencies (very low modulation distortion even with multiplex signals),

▷ frequency locking with selectable channel spacing (radiotelephony channels) using synchronizer option,

▷ DC coupled FM input for narrowband sweeping.

The **SMDU family** comprises for

general RF measurements, air navigation and communication, RT measurements	Overview on pages 42/43

In addition to these six different models several **options** can easily be added, permitting an optimum, user-oriented system configuration.

Details on the application of the SMDU for air-navigation and RT measurements are included in the description of the corresponding test assembly (see overview on pages 42/43).

Characteristics of SMDU models for general RF measurements

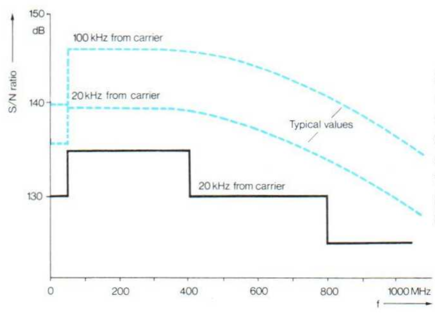
Standard model with AM/FM capability, internal modulation frequency 0.4/1 kHz

Universal model with AM/FM capability meeting highest requirements, internal modulation frequencies 15 Hz to 150 kHz, AF voltmeter with autoranging facility.

They include an RF generator 0.14 to 525 MHz and a frequency meter up to 525 MHz. Any of the options available (see pages 42/43) can be incorporated or added later. For power measurements, the power test adapter or the AM unit (which also measures modulation depth) can be used.

Frequency adjustment by pushbuttons (ranges) and continuous in-between ranges. Frequency indication: coarse on analog scale, fine by seven-digit readout. High frequency stability reached shortly after switching on permits measurements on steep-edged filters and receivers with narrow channel spacing. The SMDU reaches synthesizer stability using the synchronizer without loss in spectral purity of output signal. By means of synchronization, frequency locking is possible at the standard channel spacings. Electronic fine tuning permits the adjustment of intermediate values to an accuracy of a few hertz. Using option SMDU-B3 extends the range up to 1.05 GHz without sacrificing performance. Option SMDU-B5 also permits range extension up to 1.05 GHz, however, with reduced harmonics suppression. When adding any of the two frequency extension options, it is recommendable to order also the option SMDU-B8 (for AM up to 1050 MHz); this option is already incorporated when ordering a new SMDU + frequency extension.

Modulation. The **standard model** features switch-selected modulation frequencies (0.4 kHz and 1 kHz) for AM up to 98% and FM up to 200 kHz deviation. Distortion factor and noise are negligible. Manual selection of indicating ranges. Output voltage of the modulation generator approx. 1 V.



Signal-to-noise ratio as a function of carrier frequency and offset from carrier at 1 Hz test bandwidth; for frequency deviations > 100 kHz 6 dB less

(even better values are obtained with option SMDU-B9)

Modulation (internal and external). For the **universal model**, AM up to 98% and FM with maximum deviation 1000 kHz (also AM + FM) with very low distortion (< 0.15% at 100 kHz deviation). Switch-selected preemphasis of 50 or 75 µs for FM. The typical distortion factor of the modulation generator (15 Hz to 150 kHz) in the AF range is 0.1%. Automatic range selection (can be switched off) and automatic selection of units (kHz, mV, %) for modulation indication. The output voltage of the modulation generator is adjustable between 5 mV and 1 V.

Both SMDU models permit narrowband sweeping via the DC coupled FM input.

RF output signal. Flat frequency response (output levelling) over entire level range and high-accuracy level adjustment. The high output voltage (2 V EMF) can be reduced accurately to as low as 0.05 µV EMF by means of a single-range attenuator with large attenuation range. The carrier can be suppressed without affecting the impedance (pushbutton). The high spectral purity of the output signal permits the SMDU to be used as interfering-signal source in multisignal measurements.

Frequency measurement. The seven-digit frequency meter of the SMDU measures all internally produced and externally applied signals from 15 Hz to 525 MHz with a maximum resolution of 1 Hz or 10 Hz. The option SMDU-B4 extends the range to 1000 MHz for external signals, the resolution then being 10 Hz. The measured frequency is available at a data output in BCD code.

AF voltage measurement. The AF voltmeter of the universal model also measures external AF voltages (average-response rectification) in addition to modulation generator voltages and forms together with the modulation generator an AF level measuring assembly.

Overload protection. The option SMDU-B2 automatically prevents excessive external RF and DC voltages from affecting the output of the SMDU.

Specifications (options included)

Frequency range .... 0.14 to 525 MHz (8 subranges)
with 1.05-GHz frequency range extension .... 0.14 to 1050 MHz (11 subranges)
Indication .... 7-digit readout and analog scale
Control crystal .... 10 MHz (external: TTL)
Aging .... $< 5 \times 10^{-8}$/month
Error limits and resolution of indication:

Frequency	0.14 to 50 MHz	50 to 800 MHz	800 to 1050 MHz
Digital	1 or 10 Hz	10 or 100 Hz	0.1 or 1 kHz
Analog	±5% + 300 kHz	±1%	±1%

Frequency variation (within 10 min measuring time):

	free-running	with synchronizer option: locked	with synchronizer option: + fine tuning
Warmup time	3 h	15 min	15 min
0.14 to 200 MHz	< 1.5 kHz	$< 5 \times 10^{-8}$ + 10 Hz	< 100 Hz
200 to 525 MHz	< 3 kHz		$< 5 \times 10^{-7}$
525 to 1050 MHz	< 6 kHz		

Spacing of locking points (w. synchronizer) .... 12.5/20/25/50/100/150 kHz
Frequency settability

	free-running	with electronic fine tuning	
0.14 to 64 MHz	approx. 100 Hz	< 5/.../< 20 Hz	depending on spacing of locking points
64 to 525 MHz	approx. 100 Hz	< 10/.../< 25 Hz	
525 to 1050 MHz	approx. 150 Hz	< 20/.../< 50 Hz	

Suppression of harmonics (dB) ... 0.14 to 50 MHz: > 26, typ. 30
50 to 525 MHz: > 35, typ. 40
525 to 1050 MHz: > 26, typ. 30

Suppression of spurious responses, if any .... > 90 dB, typ. 100 dB
Incidental AM with f_{mod} = 1 kHz ... < 1%, typ. 0.5% at 100 kHz deviation (for f > 1 MHz)

RF output .... N socket (adaptable); Z_{out} = 50 Ω
Output EMF or power .... 0.05 µV to 2 V EMF/−139 to +13 dBm
Scale calibration (linear) .... V EMF/dBm/dBV/V into 50 Ω
Resolution .... 0.7 mm/dB or 16 mm/dB
Min. output-voltage increment .. 0.25 dB
Attenuator error 0.4 to 525 MHz ... ±1 dB
down to 140 kHz and up to 1050 MHz .... <±2 dB
Carrier suppression .... pushbutton on front panel
VSWR < 0.2 V EMF .... < 525 MHz: < 1.2; > 525 MHz: < 1.4

RF output II (on rear panel) .... N socket (adaptable) ≧20 mV into 50 Ω

Frequency meter (7 digits)

	Resol. (Hz)	Input (ext. max. 10 V)
Int. 15 Hz to 50 MHz	1/10	matched
50 to 800 MHz	10/100	
800 to 1050 MHz	100/1000	
Ext. 15 Hz to 30 MHz	1/10	> 10 mV into 10 kΩ‖20 pF
20 to 1000 MHz	10/100	> 10 (>525 MHz: >30) mV into 50 Ω

Recorder output .... BCD (TTL level)
Modulation .... AM, FM, AM + FM

	Standard model (data apply to both models unless specified separately)	**Universal model**
Mod. Generator	0.4/1 kHz	15 Hz to 150 kHz
Indication	analog and digital; resolution 1 Hz	analog and digital; resolution 1 Hz
Distortion factor	< 0.5%	50 Hz to 53 kHz: <0.2%; other ranges: < 0.5%
V_{out} (Z_{out} = 200 Ω)	approx. 1 V into 600 Ω	5 mV to 1 V into 600 Ω
Indication ranges	—	10/30/ ... /3000 mV
Error limits	—	±(3% of rdg +1.5% of fsd)
Frequency resp.	—	< 2%, typ. 1%

AM .... internal and external
Modulation depth . for V_{out} ≦ 1 V EMF: up to 98%
for V_{out} up to 2 V EMF: decreasing linearly to 30%
Ranges:

$f_{carrier}$ (MHz)	0.14 to 0.45	0.45 to 8	8 to 525
f_{mod} (kHz)	0.03 to 4	0.03 to 10	0.03 to 100

Distortion factor ... 0.45 to 525 MHz: < 1 (2)%; 140 to 450 kHz: < 3% } f_{mod} < 4 kHz, m = 80%
Indicating ranges .. 3/10/30/100%
Error (≦ 1 V EMF) ... 0.45 to 525 MHz: <±3%; 140 to 450 kHz: <±5% } f_{mod} < 4 kHz, m = 80%
V_{in} for ext. AM ..... 20 mV/% (standard model); 15 mV/% (universal model)

	Standard model		Universal model	
FM	internal and external		internal and external	
Frequency deviation				
$f_{carrier}$ (MHz)	< 525	> 525	< 525	> 525
Deviation (kHz)	0 to 100	0 to 200	0 to 500	0 to 1000
			(ranges:	10/100/1000)

f_{mod} .... 15 Hz to 150 kHz if AC-coupled
0 to 150 kHz if DC-coupled
100 Hz to 150 kHz with synchronizer option

	Standard model	Universal model
Distortion factor	< 1%	< 1%; broadcast range: < 0.15%
Crosstalk attenuation with stereo	—	f_{mod} 50 Hz: > 40 dB; 1 kHz: > 46 dB; 15 kHz: > 46 dB
Preemphasis	—	50/75 µs
Ind. ranges (kHz)	3/10/30/100/300	3/10/30/100/300/1000
Error	±(5% of rdg +1.5% of fsd)	
V_{in} for ext. FM	< 50 mV/kHz	△f 100 kHz: < 50 mV/kHz (△f > 100 kHz: < 10 mV)
AF voltmeter	—	15 Hz to 150 kHz; 1 mV to 3 V
Input		> 100 kΩ‖10 pF; BNC
Indicating ranges		10/30/ ... /3000 mV
Error limits 15 Hz to 53 kHz		±(2% of rdg + 1.5% of fsd)
53 to 150 kHz		±(5% of rdg +1.5% of fsd)

Overload protection (option) responds automatically if excessive RF power or DC voltage is applied to the RF output
Max. perm. level ... 50 W, 50 V
Indication .... LED

General data
AC supply .... 115/125/220/235 V ±10%, 90 to 120 VA (depending on model)
Dimensions and weight .... 492 mm × 294 mm × 436 mm, 26 kg

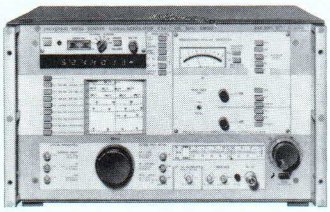
Order designations
▶ Signal Generator SMDU .... 249.3011.02 (standard model)
▶ Signal Generator SMDU .... 249.3011.04 (universal model)

Options (to be ordered separately; characteristics see following page)
▶ SMDU-B1: Synchronizer 249.6340.02
▶ SMDU-B2: Overload Protection 249.7346.02
▶ SMDU-B3: 1.05-GHz Frequency Range Extension 249.9484.02
▶ SMDU-B4: 1-GHz Frequency Meter 250.0012.02
▶ SMDU-B5: 1.05-GHz Frequency Doubler 275.1312.02
▶ SMDU-B8: Amplitude Modulation 525 to 1050 MHz 295.2150.02
▶ SMDU-B9: S/N Ratio Improvement 295.2189.02
Accessories supplied .... 1 power cable

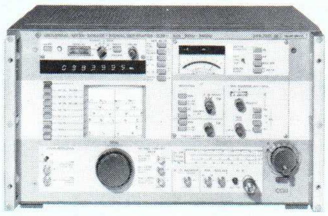
Signal generator family SMDU – models and options

general RF measurements — airnav . . .

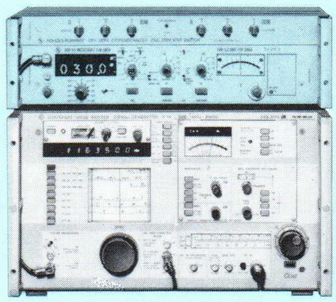
Models*



02



04



08

02: Low-cost signal generator as basic equipment for laboratories or as second source in intermodulation and similar measurements.

04, 08: The ideal test assembly for the laboratory covering wideband measurements and **all receiver tests.** Frequency measurements from 15 Hz to 525 MHz (1 GHz); all AF measurements from 15 Hz to 150 kHz. Specially suited for AF and RF signal generation in hifi and stereo broadcast applications.

All SMDU models (02 to 09) are particularly suited for use as the interfering generator in 2- or 3-source test methods.

08: In combination with the VOR-ILS unit: Air-navigation measurements of highest precision on VOR-ILS receivers and communications receivers.

02: AF generator with two fixed frequencies: 400 and 1000 Hz

04, 08: Broadcast FM quality (stereo compatible −46-dB crosstalk attenuation). AF generator and AF voltmeter for 15 Hz to 150 kHz. Autoranging modulation and voltage indication. FM deviation ±500 kHz.

08: Complete test assembly featuring continuous monitoring of the output values of the VOR-ILS signals and built-in self-check of the most important parameters.

page 40 | 40 | 70

Options ▶

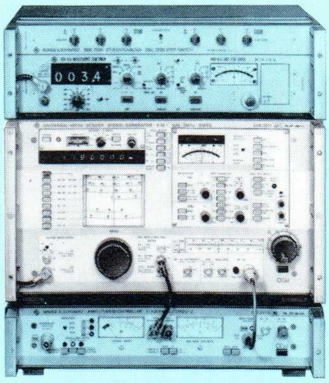
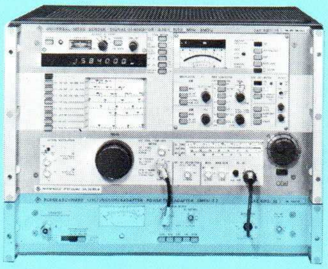
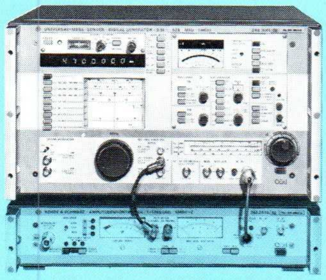
All models of the SMDU can be fitted with the mutually independent options. The options can be ordered together with the signal generator or – with the exception of option -B9 – added later as required.

- Synchronizer SMDU-B1
- Overload Protection SMDU-B2
- 1.05-GHz Frequency Range Extension SMDU-B3
- 1-GHz Frequency Meter SMDU-B4
- 1.05-GHz Frequency Doubler SMDU-B5
- Amplitude Modulation 525 to 1050 MHz SMDU-B8
- S/N Ratio Improvement SMDU-B9

Common features

- Extremely wide frequency range and high frequency stability (5×10^{-8})
- High spectral purity in respect of harmonics, spuria and noise
- Accurate output level (0.05 µV to 2 V EMF) with single-knob setting
- Precise AM, FM and φM modulation characteristics

*) The numerical designation of the different models (02, 04, etc.) refers to the last two digits of the order No.

and aircoms	radiotelephones	
 07	 06 (52) (53) (56)	 09

When used with the AM Unit SMDU-Z1 or the Power Test Adapter SMDU-Z2, these models form complete **AM/FM radiotelephone test sets,** ideally suited for the full range of transmitter and receiver measurements. At the receiver: S/N or SINAD sensitivity, squelch performance, bandwidth, AF distortion and (using a second signal generator to feed the main channel) adjacent-channel selectivity and desensitization. At the transmitter: frequency, power, modulation (FM and, with SMDU-Z1, AM), modulation frequency (e.g. call tone) and modulation distortion. High accuracy in both simple and complex test routines. Time savings when testing multichannel units thanks to semi-automatic deviation meter and channel-to-channel tuning during receiver measurements with SMDU-B1 Synchronizer option.

In combination with VOR-ILS unit: as for SMDU 08 plus measurements on AM/FM transmitters.		Testing of mobile hifi and stereo broadcast receivers with built-in Citizens' Band radio.

External semi-automatic deviation meter for wanted and unwanted modulation (5 Hz to 50 kHz), SINAD meter (6 to 46 dB), CCITT filter, 1-kHz distortion meter (0.5 to 50%), AF generator (30 Hz to 30 kHz and six standard test frequencies), AF rms voltmeter, autoranging. Automatic switching from receiver to transmitter measurements when used with AM Unit SMDU-Z1.

Complete test assembly featuring continuous monitoring of the output values of the VOR-ILS signals and built-in self-check of the most important parameters.	Compact test assemblies with SMDU 06 and option B1 + Z1/30 W: (52) or + Z1/60 W: (53) or + Z2/30 W: (56)	Special FM performance: very low distortion (0.15% at 100 kHz deviation) and good stereo channel separation (46 dB).
70	64	64

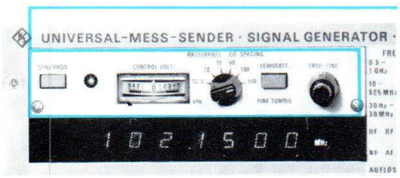
Frequency stability is improved to that of a synthesizer while the high spectral purity of a free-running oscillator is maintained. Operation is greatly simplified by the possibility of synchronized fine tuning and the channel-to-channel jump facility.

The RF output of the SMDU is protected against externally applied power of up to 50 W. This option is fitted as standard in models 06, 07 and 09.

Extends the frequency range of the RF generator to 1.05 GHz without affecting the other characteristics. Digital display of internal frequency up to 1.05 GHz; option SMDU-B4 is not required.

Extends the range of the counter to 1 GHz for external signals (high sensitivity).

SMDU with option SMDU-B1

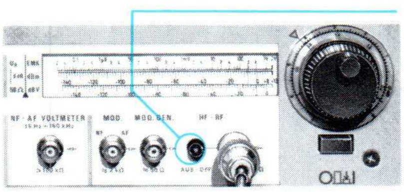


Low-cost option for doubling the RF generator range to 1.05 GHz. Subharmonics and harmonics at least 20 dB below carrier level. Frequency displayed digitally.

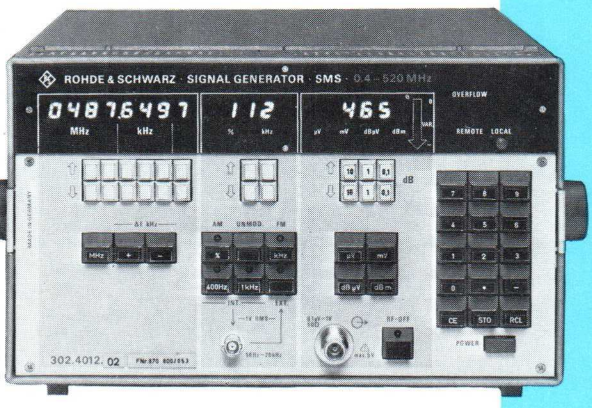
Option B8 permits AM up to 1050 MHz when the frequency range of the SMDU is extended beyond 525 MHz (when ordering a new SMDU, B8 is already incorporated).

Option B9 improves the signal-to-noise ratio, e.g. for measuring the adjacent-channel selectivity far beyond 80 dB.

SMDU with option SMDU-B2



SMS



new

IEC 625 Bus

Signal Generator SMS
♦ 0.4 to 520 (1040) MHz

- Universal, programmable signal generator using synthesizer technology; low-noise instrument with excellent modulation characteristics for AM, FM and phase modulation
- Compact, favourably priced instrument for use in development, production and servicing, customized configuration thanks to various selectable options
- Ease of operation: keyboard entry, digital readout – quasi-continuous variation of frequency, modulation and level
- Wide output voltage range, accurate level setting in dBm, dBμV, μV or mV

Characteristics, uses

With its excellent characteristics the **SMS** meets all the exacting demands that can be made on a universal signal generator of the latest state-of-the-art. The **synthesizer technology** ensures crystal-controlled and stable output frequencies with 100-Hz resolution and negligible spurious modulation. At 20 kHz from the carrier the signal-to-noise ratio is 120 dB (1 Hz test bandwidth).

The compact SMS is easy to carry and also suitable for **mobile use.** Thanks to a number of options, inexpensive adaptation to various applications is possible.

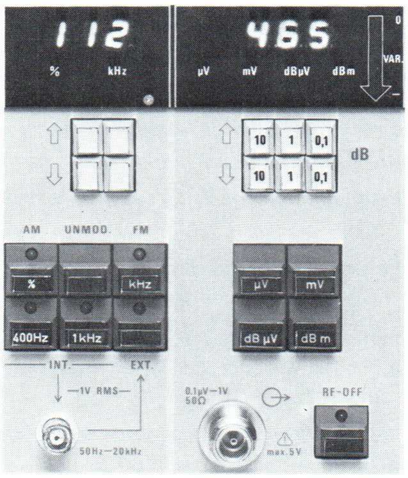
Modulation. The SMS features excellent modulation characteristics. AM up to 90% and FM up to 125 kHz deviation are possible with the aid of the internal modulation generator (400 or 1000 Hz) or with an external signal. The modulation frequency and modulation depth or deviation can be accurately set from the smaller keyboard and are read out in three digits with a resolution of 0.05/1% or 50 Hz/500 Hz/1 kHz, see front panel section below. The distortion is below 1%. External phase modulation is possible between 0 and 5 rad.

Ease of operation. The desired frequency, modulation and RF level are entered from a common keyboard. Range selection or determination of the correct physical unit are not required since the **built-in microprocessor** controls the setting and indication.

Frequency. The wide frequency range from 400 kHz to 520 MHz covers all sound broadcasting ranges from MF up to VHF as well as the frequencies of the most important RT bands and radio services up to UHF. The range can be extended up to 1040 MHz with the aid of the Frequency-range Extension option.

The **entered frequency value** is read out in MHz on the eight-digit display (resolution 100 Hz). Special keys permit variation from the set value towards higher or lower frequencies either in single steps or **continuously** by keeping the key pressed; the changes are automatically carried over to the next decade.

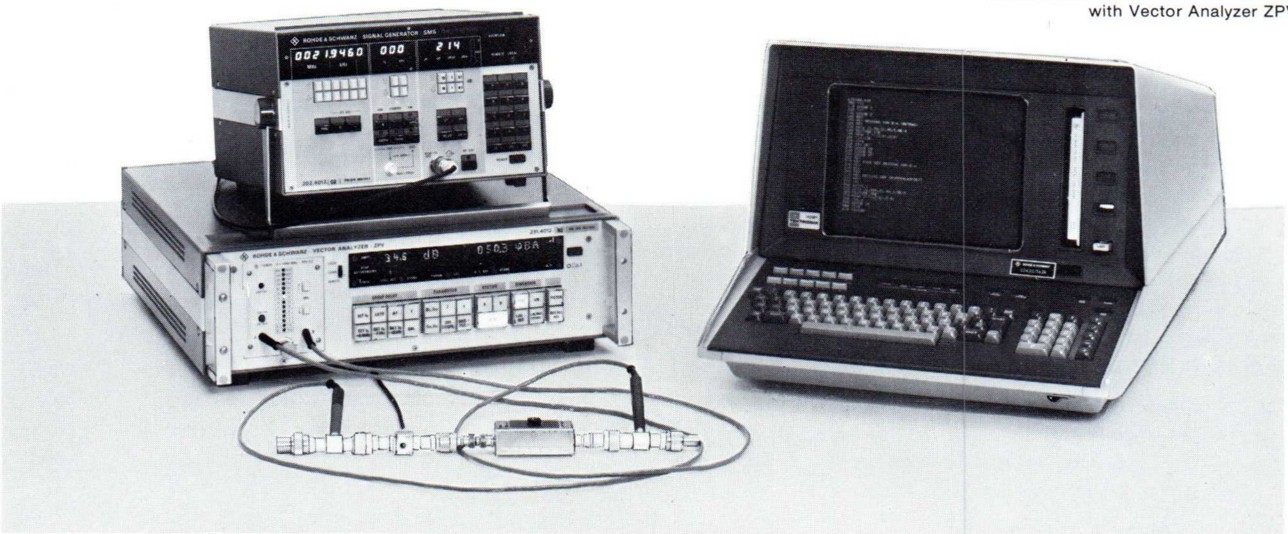
Frequency variations in the form of **channel steps** are easily possible, any step size being selectable by entering the channel spacing in kHz from the keyboard.



Front panel section with setting and indicating sections modulation and output level

SMS

in calculator-controlled test assembly
with Vector Analyzer ZPV



Output level. The maximum output voltage into 50 Ω is 1 V with CW or FM and 0.5 V with AM; it can be accurately set down to 0.03 µV (−137 dBm) from the common keyboard with a resolution of 0.1 dB. If the desired output level is entered in terms of µV, mV, dBµV or dBm, the built-in microprocessor performs the necessary conversion and determines the setting of the output attenuator. An additional **fine attenuator** from 0 to 10 dB without interruption of the RF level has a resolution of 0.1 dB. The adjusted level is read out in four digits on the SMS.

The output voltage of max. 1 V into 50 Ω permits testing of active and passive components and modules, such as transistors, amplifiers, tuners and filters.

The output may be disabled by pressing the button RF-OFF and cut in again without the set values being varied.

Storage. Up to three complete settings (comprising frequency, level, modulation) can be stored and called up at the push of a button.

Remote-controlled operation. All settings of the SMS can also be remotely controlled when the option SMS-B4 (IEC bus) is built in. The signal generator can be combined with all IEC-bus-compatible measuring instruments and calculators so that configuration of any calculator-controlled test systems is possible.

The **short setting times** of typically 40 ms for each function permit series of measurements as are required in quality control, in production or incoming inspection.

Options

A number of options permit flexible, low-cost adaptation of the SMS to various or special requirements. All options listed below can already be included in the SMS prior to delivery or incorporated later; no soldering or trimming is required.

Temperature-controlled Reference Oscillator SMS-B1 improves the frequency stability of the signal generator. By means of temperature control the frequency drift of $<\pm 1 \times 10^{-6}/°C$ is reduced to merely $<\pm 1 \times 10^{-7}$ over the total temperature range from 0 to 50 °C, the aging of the crystal is less than 5×10^{-8}/month.

1.04-GHz Frequency Range Extension SMS-B2 doubles the SMS frequency range (i.e. to 1.04 GHz), the full setting range of the output level being maintained.

Overload Protection SMS-B3 disables the signal generator output as soon as RF power or DC voltage is applied there; e.g. when the push-to-talk button of a connected RT set is inadvertently pressed. Maximum permissible power 30 W.

IEC Bus SMS-B4 permits remote control of all required settings on the SMS from an external control unit. This option provides the SMS with a standard interface in compliance with IEC 625-1 and IEEE 488. The SMS functions as listener with setting times under 40 ms.

Signal Generator SMS

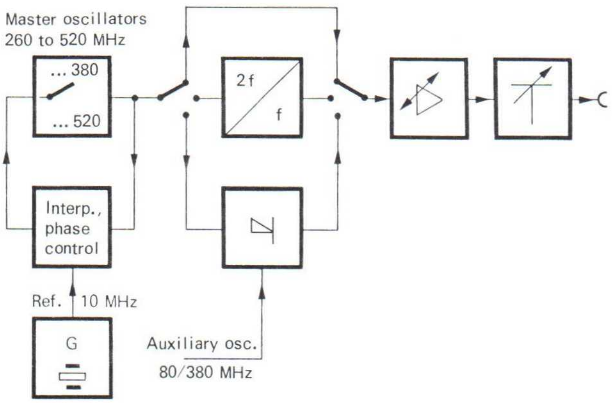
Description

The Signal Generator SMS operates according to the synthesizer principle (frequency synthesis with phase control) with microprocessor-controlled settings.

The frequency processing is based on a crystal-controlled 10-MHz oscillator. The accuracy of the output frequency is therefore the same as that of the oscillator crystal. An external reference frequency can also be applied, e.g. if higher accuracy is required or if several instruments are to be operated from the same frequency standard.

The concept worked out to give the most economical solution uses two master oscillators (260 to 380/380 to 520 MHz),
auxiliary oscillators (80 and 380 MHz)
and only a few interpolation oscillators.

The frequency multiplication follows the same principle in all functional groups: a VCO is phase-locked by a control frequency, the multiplication factor being equal to the division factor in the feedback branch of the PLL.



Functional block diagram of frequency processing circuit in Signal Generator SMS

The **output frequency** from 0.4 to 130 MHz is obtained by mixing with the 380-MHz signal. The frequencies from 130 to 260 MHz are derived by division of the master oscillator frequency. Between 260 and 520 MHz the output frequency of the SMS is that of the master oscillator.

Modulation. AM and levelling are combined in a control circuit, in which the modulation voltage is superimposed on the reference input of the level control. The setting circuit is an integrated PIN-diode modulator.

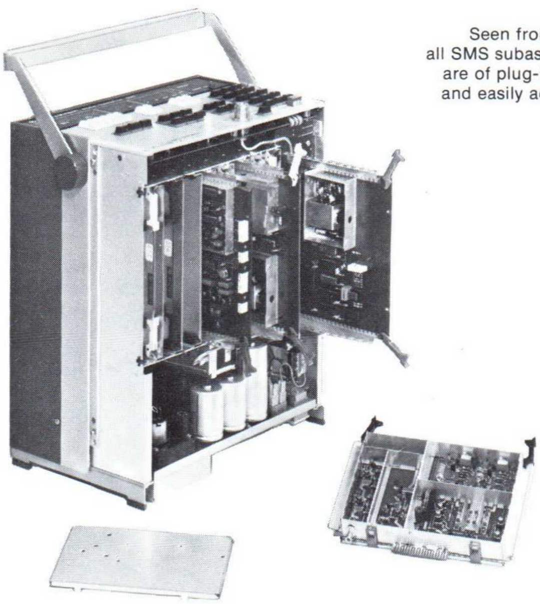
For FM the 80-MHz fixed oscillator frequency is modulated and transferred to the phase-locked loop of the master oscillator by mixing.

In addition to modulation, the level control permits attenuation by 10 dB in 0.1-dB steps.

The switchable **attenuator** (138 dB in 2-dB steps) – especially designed for remote-controlled instruments – has an operational reliability of more than 10 million switching cycles.

A microprocessor interrogates the keyboard, calculates and controls all settings and provides for correct readout on the display.

The microprocessor program also contains a routine for **fault diagnosis**.



Seen from below: all SMS subassemblies are of plug-in design and easily accessible

Specifications

Frequency range	0.4 to 520 MHz, to 1040 MHz with option	
Frequency setting	from keyboard	
Readout	8-digit display	
Resolution	100 Hz	
Error, drift	depending on reference frequency	
Spurious deviation with CW and FM	≦4 Hz (0.3 to 3 kHz with CCITT weighting)	
Suppression of harmonics	≧30 dB	
Suppression of non-harmonic spurious signals	≧60 dB	
Reference oscillator	standard	option SMS-B1
Crystal aging	$<\pm 1 \times 10^{-6}$/ month	$<\pm 5 \times 10^{-8}$/ month
Temperature effect	$<\pm 1 \times 10^{-6}$/°C	$<\pm 1 \times 10^{-7}$ within operating temperature range

Output level with CW/FM	−137 to +13 dBm (0.03 µV to 1 V into 50 Ω)
with AM	−137 to +7 dBm (0.03 µV to 0.5 V into 50 Ω)
Setting	from keyboard
Readout	4-digit display in µV, mV, dBµV or dBm
Resolution	0.1 dB
Fine adjustment	0 to −10 dB with 0.1 dB resolution, without interruption of RF level
Error of output level	≦±1 dB + frequency-response error[1])
Frequency-response flatness	≦±0.5 dB from 8 to 520 MHz ≦±1 dB from 0.4 to 8 MHz
Output	
Output impedance	50 Ω, N female
VSWR	≦1.2 (for level ≦ −3 dBm)[1])

Modulation

AM internal	f_{mod}: 400 Hz or 1 kHz
external from 8 to 520 MHz	f_{mod}: 50 Hz to 20 kHz
from 0.4 to 8 MHz	f_{mod}: 50 Hz to 5 kHz
Modulation depth	0 to 90%
Setting	from keyboard
Readout	3-digit display
Resolution	0.05% from 0 to 9.95%, 1% from 10 to 90%
Error of AM	≦8% of modulation-depth setting[1])
Modulation distortion at m = 80%	≦1.5% with internal modulation[1]) ≦5% with external modulation[1])
Input requirement	1 V_{rms} ±1% into 600 Ω
FM internal	f_{mod}: 400 Hz or 1 kHz
external	f_{mod}: 50 Hz to 20 kHz
Frequency deviation	0 to 125 kHz
Setting	from keyboard
Readout	3-digit display
Resolution	50 Hz from 0 to 9.95 kHz, 500 Hz from 10 to 99.5 kHz, 1 kHz from 100 to 125 kHz
Error of frequency deviation	≦5%
Modulation distortion with 75 kHz deviation	≦1% at f_{mod} = 50 Hz to 2 kHz ≦5% at f_{mod} = 2 to 20 kHz
Input requirement	1 V_{rms} ±1% into 600 Ω
AM +φM (FM)	via second modulation input on rear panel (AM input is DC coupled)
Input requirement: AM	1 V_{rms} for m = 100% } into 600 Ω
φM	1 V_{rms} for 5 rad } into 600 Ω
FM	1 V_{rms} for 100 kHz deviation } into 600 Ω

Data of options

Option: Reference Oscillator SMS-B1 see left column

Option: 1.04-GHz Frequency-range Extension SMS-B2

Frequency range	0.4 to 1040 MHz
In the range 520 to 1040 MHz the following specifications differ from those of the basic unit:	
Resolution of frequency indication	200 Hz
Spurious FM	≦8 Hz (0.3 to 3 kHz with CCITT weighting)
Subharmonics	down ≧20 dB
Error of output level	≦±1 dB + frequency response error[1])
Frequency-response flatness	≦±1 dB
Modulation depth	0 to 60%
Envelope distortion at 60% AM	≦5% at f_{mod} = 50 Hz to 10 kHz[1]) ≦10% at f_{mod} = 10 to 20 kHz[1])

Option: Overload Protection SMS-B3

Response threshold	<1 W RF and <5 V DC
Max. power-handling capacity	30 W

Option: IEC Bus SMS-B4

Interface according to IEE 488 and IEC 625-1 (formerly IEC 66.22) permitting control of all operating modes

Interface functions	AH1	Acceptor handshake
	L1	Listener
	RL1	Remote/Local
	DC1	Device clear
Setting time	40 ms	

General data

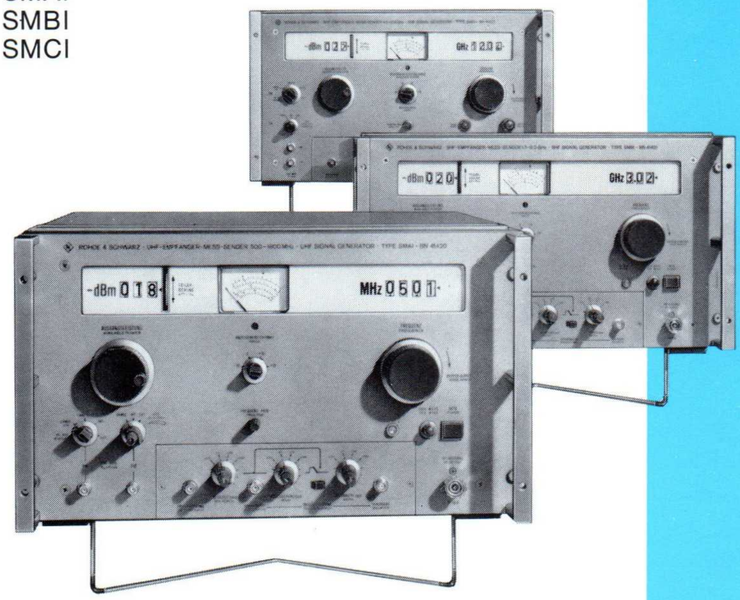
Operating temperature range	+5 to +45 °C
Shelf temperature range	−40 to +70 °C
Power supply	115/125/220/235 V ±10%, 47 to 440 Hz (50 VA)
Dimensions, weight	345 mm × 198 mm × 370 mm, 14.6 kg
Order designation	► Signal Generator SMS 302.4012.02
Accessories supplied	power cord

Recommended extras

Options:	
SMS-B1 Reference Oscillator	302.8918.02
SMS-B2 1.04-GHz Frequency-range Extension	335.0016.02
SMS-B3 Overload Protection	335.0716.02
SMS-B4 IEC Bus	335.0916.02
19" Adapter (4 E, 340 BI)	302.8860.00

[1]) with level fine adjustment at 0 dB.

SMAI
SMBI
SMCI



UHF Signal Generator SMAI
♦ 500 to 1800 MHz

SHF Signal Generator SMBI
♦ 1.7 to 5.0 GHz

SHF Signal Generator SMCI
♦ 4.8 to 12.5 GHz

- Constant output power with all signal generators
- Universal FM and pulse modulation characteristics, AM up to 70%
- Frequency-linear shaft for connection of recorder

Signal generators for UHF and SHF

Types **SMAI, SMBI and SMCI** form a family of modern signal generators which span the entire frequency range from 500 MHz to 12.5 GHz.

The signal generators are suitable for applications such as:

Measurements on receivers:	Measurements on four-terminal networks:
Noise figure	Reflection coefficient
Dynamic range	(using directional coupler
Control characteristics	or impedance-match bridge)
Selectivity	Attenuation constant
Conversion loss	(passband characteristic,
Image rejection	point-by-point or swept)

Uses in radar systems. Sensitivity measurement, simulation of echo pulses for checking the indication. Due to its high modulation quality, the SMAI is particularly well suited for measurements on DME and ATC equipment.

The synchronization facility makes possible measurements requiring extreme frequency stability: on narrowband AM and FM transmission systems, filters with sharp cutoffs, Doppler radar systems.

Variations of output power over the wide frequency range of about 1:3 of each signal generator result inevitably from the different modes of the oscillator valve and from the oscillator coupling system.

Models with ALC

are available for the SMAI, SMBI and SMCI. The ALC also permits amplitude modulation up to 70%. To obtain the full output power, the ALC can be switched off.

The ALC facility leads to new applications.

Attenuation measurement and recording is possible using the signal generators with ALC since the power input to the four-terminal network remains constant and the attenuation characteristic can immediately be seen from the output power.

Operation

Frequency setting with digital indication on roller counters. A friction drive with high gear reduction ensures both rapid tuning and high resolution. A frequency-linear shaft, accessible through the side wall, permits the connection of a recorder or control unit. Attenuation or selectivity curves can thus be plotted automatically.

The frequency stability is sufficient even for narrowband test items. Most stringent requirements – e.g. in the field of microwave spectroscopy – are met when the signal generator is synchronized with the harmonic of a crystal oscillator (second RF output) by means of suitable equipment.

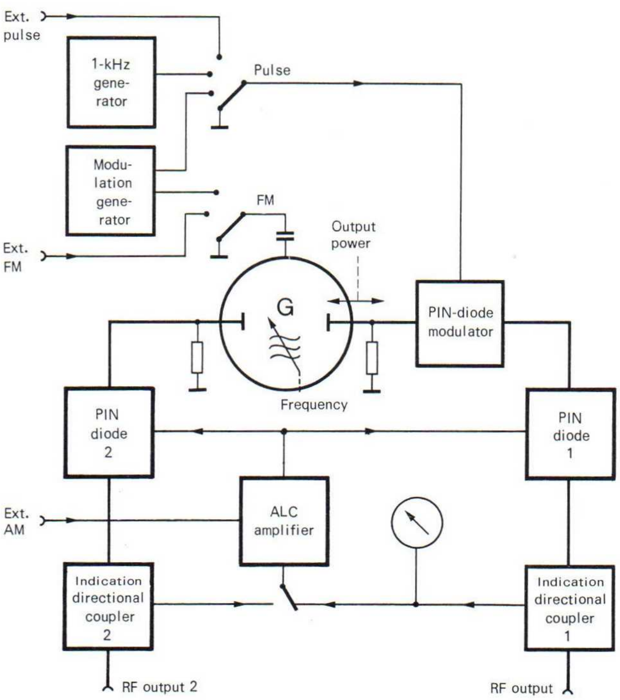
Versatile modulation characteristics are obtained when the plug-in modulation unit (to be ordered separately) or a pulse generator is employed. Simultaneous FM and pulse modulation are possible.

A PIN-diode modulator in the output circuit generates the pulse modulation with a carrier suppression of greater than 80 dB. The signal generator is designed for internal and external pulse modulation. Owing to the built-in modulation amplifier, an input voltage of 2 V is sufficient for full modulation. The signal for internal pulse modulation is delivered either by the built-in 1-kHz generator or by the plugged-in modulation unit. The latter permits adjustment of the repetition frequency, pulse width and delay and can therefore produce all commonly used radar pulses.

External frequency modulation is possible with all versions. If the modulation unit is being used, it delivers a sawtooth voltage with adjustable repetition frequency for internal FM.

The RF energy is coupled out by a piston attenuator. The available output power is indicated by the meter (large values) or can be read from the attenuator (smaller values down to −130 dBm). Constant output level is achieved by two PIN diodes. At the same time, the diodes are for the amplitude modulation of the output signal. Signal generators supplied without ALC **can be modified** to include ALC.

During pulse modulation, an unmodulated signal is available at the second RF output; it can be applied to a frequency meter or used for frequency synchronization in the pulse mode.

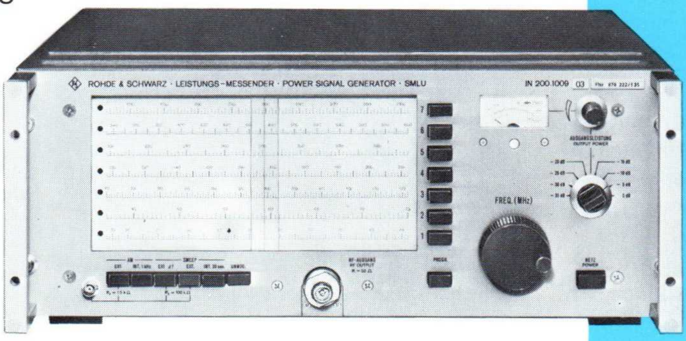


Block diagram of the SMAI with modulation unit

Specifications

	SMAI	SMBI	SMCI
Frequency range	0.5 to 1.8 GHz	1.7 to 5.0 GHz	4.8 to 12.5 GHz
Frequency setting	frequency-linear single-knob tuning in one range		
Frequency indication	on roller counters		
Error limits	±0.5%	±0.5%	±0.5%
Scale resolution	100 kHz/div.	1 MHz/div.	1 MHz/div.
Frequency drift due to change of temperat.	$\leqq 7 \times 10^{-5}$/°C	$\leqq 7 \times 10^{-5}$/°C	$\leqq 4 \times 10^{-5}$/°C
Residual FM	≦1.5 kHz	≦1.5 kHz	$\leqq 1.5 \times 10^{-6}$
Output level	≧+10 dBm (≧+8 dBm)	≧+5 dBm (≧0 dBm)	≧0 dBm
Adjustment range	+10 to −130 dBm	+5 to −130 dBm	0 to −130 dBm
Smallest readable attenuator increment	0.1 dB	0.1 dB	0.1 dB
Residual AM	down ≧60 dB	down ≧ 60 dB	down ≧ 60 dB
Amplitude variation due to ±10% AC supply change	≦0.02 dB	≦0.02 dB	≦0.02 dB
Output impedance	50 Ω	50 Ω	50 Ω
Connector (adaptable)	N female	N female	N female
VSWR	≦2	≦2	≦2
Residual amplitude variation	≦±1 dB (≦±1.75 dB + att. error)	≦±1 dB (≦±2 dB + att. error)	≦±1 dB (≦±2.5 dB + att. error)
Residual AM with ALC	≦1%	≦1%	≦1%
Second RF output	on rear panel for frequency meter or synchronizer		
Output power	≧−15 dBm	≧−20 dBm	≧−15 dBm
Output impedance	50 Ω	50 Ω	50 Ω
Modulation			
Pulse – internal			
Repetition frequency	1000 Hz	1000 Hz	1000 Hz
Pulse width	0.5 ms	0.5 ms	0.5 ms
Rise/fall time	≦100 ns	≦100 ns	≦50 ns
Pulse – external			
Repetition frequency	0 to 200 kHz	0 to 200 kHz	0 to 1 MHz
Pulse width	min. 0.3 μs	min. 0.3 μs	100 ns to 5 ms
Rise/fall time	≦100 ns	≦100 ns	≦50 ns
FM – external	10 Hz to 500 kHz	10 Hz to 500 kHz	1 Hz to 10 MHz
Sensitivity	30 (50) kHz/V Z_{in} = 180 Ω	50 kHz/V Z_{in} = 180 Ω	for max. dev.: 2 V_{pp}
AM – external	10 Hz to 100 kHz, 0 to > 70%	10 Hz to 100 kHz, 0 to > 70%	10 Hz to 100 kHz, 0 to > 70%
With modulation unit			
Pulse – internal			
Repetition time	0.02 to 200 ms	0.02 to 200 ms	0.02 to 200 ms
Pulse width	0.3 to 1000 μs	0.3 to 1000 μs	0.1 to 1000 μs
FM – internal (sawtooth)			
Modulation frequency	50 Hz to 50 kHz	50 Hz to 50 kHz	5 Hz to 50 kHz
Trigger output	pos., delayed 0.1 to 1000 μs	pos., delayed 0.1 to 1000 μs	pos., delayed 0.1 to 1000 μs
Trigger input	negative	negative	negative
Synchronization			
Tuning range	0.25×10^{-3}	0.25×10^{-3}	0.5×10^{-3}
Voltage requirement	max. 20 V	max. 20 V	max. 20 V
General data			
Nominal temperature range	+10 to +35 °C (shelf temperature range: −20 to +75 °C)		
Power supply	115/125/220/235 V ±10%; 47 to 63 Hz		
Dimensions, weight	484 mm × 283 mm × 512 mm, 31 kg		
Order designations	▶ Signal Generator		
	SMAI 100.4594.13	**SMBI** 100.4607.13	**SMCI** 100.4613.03
Modulation Unit	SMAI-E 100.4636.02	SMBI-E 100.4636.02	SMCI-E 100.4636.02
Accessories supplied	1 power cord, 1 shortcircuit N plug		

SMLU



Power Signal Generator SMLU
♦ 25 to 1000 MHz

- Wide frequency range with seven linear subranges
- Maximum output level 33 dBm (2 W) with ALC
- External frequency sweep possible; frequency, range and power programmable

For use as a power sweep generator see page 52

The **Power Signal Generator SMLU** offers the perfect solution to all measurement problems where the output level of conventional signal generators is insufficient. Thanks to its wide frequency range, ALC and sweep facility as well as its extension possibilities to form a system (see page 52), the SMLU is particularly suitable for measurements

on power stages and transistors, frequency multipliers,
of antenna directional patterns and impedances,
of intermodulation and crossmodulation at high levels,
of attenuation, reflection coefficient and transfer impedance of cables.

The Sweep Unit SMLU-Z extends the SMLU to a wideband power sweep generator for 25 to 1000 MHz while the Frequency Controller SMLU-Z3 permits measurement of the SMLU output frequency, synchronization, measurement of the marker frequency during swept-frequency operation and frequency programming (see also page 52).

Characteristics and function

For each frequency subrange, the SMLU has a separate voltage-controlled oscillator, operating at the output frequency. A diode network ensures extremely good linearization of the tuning characteristic.

The provision of ALC and a well-defined 50-Ω output open up a number of new possibilities.

Frequency selection. Pushbutton selection of frequency range, fine adjustment accurate to $\leqq 1 \times 10^{-4}$ on linear scale with 0.2 to 5 MHz resolution. Manual tuning, programming and sweeping possible.

Sweeping. Either single internal sweep of one frequency subrange lasting 20 s – e.g. when using a chart recorder – or external sweep with f_{sw} = 0 to 50 Hz and max. sweep width = 1 subrange. The deflection voltage (sawtooth) of any oscilloscope is suitable as the sweep voltage. Frequency modulation is possible with manual or programmed adjustment of the centre frequency.

For wideband sweeping over any subrange or the total range using the sweep unit see page 52.

Modulation characteristics. In addition to FM (see under "Sweeping"), internal and external amplitude modulation of the SMLU output signal is possible. Amplitude modulation is performed via the ALC amplifier, ensuring a very linear modulation characteristic even at large depths of modulation. Internal AM: 1 kHz, m = 70%. External AM: 10 Hz to 8 kHz, m = 90% (6.5 V_{pp} for 80%).

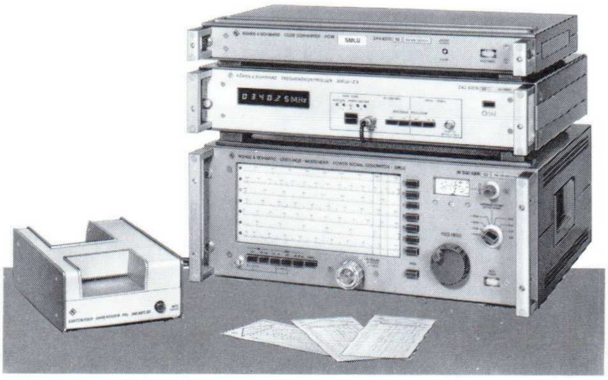
The output power is extracted via a broadband directional coupler and kept constant by means of an ALC amplifier. The output power can be reduced continuously by 10 dB through variation of the reference level and also attenuated in 5-dB steps up to a maximum of 35 dB with a variable attenuator. Panel meter indication of level. An internal protection circuit prevents overloading of the power stages when the signal generator is mismatched.

Frequency and output-level programming

Two SMLU models are available (see order designation). With model 02, the level and the frequency range can be remote-controlled. An analog input permits frequency adjustment.

With model 03, parallel programming of the frequency, range and output level is possible in BCD code. The SMLU can also be programmed in serial ASCII code with the aid of the Code Converter PCW (see page 15) and is thus system-compatible. When using the PCW, the SMLU can be programmed by the Card Reader PCL or a punched-tape reader.

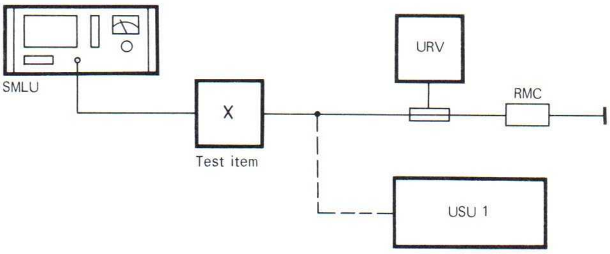
Programmable test assembly with Frequency Controller SMLU-Z3, Code Converter PCW and Card Reader PCL (front left)



Applications of SMLU

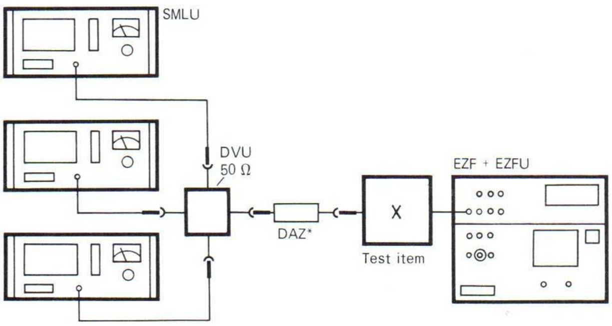
Test setup for transmission measurements

In conjunction with a broadband voltmeter (e.g. the URV 4) a dynamic range of up to 80 dB is obtained. Measurements up to 130 dB are possible using a selective voltmeter, such as the USU 1.



Test setup for intermodulation and crossmodulation measurements

The Power Signal Generator SMLU is ideal for this purpose. Its high output power of 2 W (1 W) ensures good isolation of the three signal generators, minimizing intermodulation and crossmodulation products. The wide frequency range from 25 to 1000 MHz covers all TV bands, permitting easy measurements. Programmability makes for further simplification of the measurement; see photo on page 50.



* Matching pad if required

The three SMLUs are connected via the Four-port Junction Box DVU 4 (201.4018.03). The output impedance is 50 Ω. For measurements on 60-Ω or 75-Ω test items a matching pad (DAZ) can be used.

Matching pad 50 → 60 Ω: 242.1013.02 (attenuation 0.79 dB)

Matching pad 50 → 75 Ω: 242.1513.02 (attenuation 1.76 dB)

Interaction of the three signal generators is precluded by setting the output attenuator of each signal generator to an adequate value. A fine control is provided on the SMLU for fine level adjustment. If the input level at the test item is to be varied, it is best to insert an adjustable attenuator (UHF Attenuator Set DPU 100.8960.50) between the four-port junction box and the matching pad or test item.

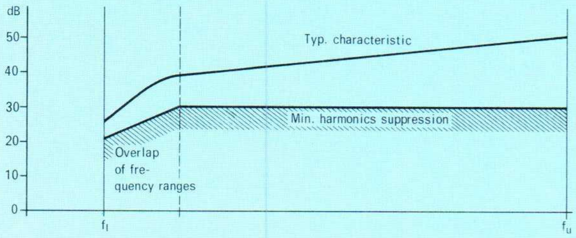
Automatic test setups for

- intermodulation and crossmodulation measurement
- RF cable measurements

see under RF test assemblies on page 60.

Specifications

Frequency range	25 to 1000 MHz
Subranges	25 to 44/42.5 to 74/70.5 to 125/119 to 210/200 to 352/337 to 595/570 to 1000 MHz
Error of frequency indication	≦±2%
Residual FM (10 Hz to 100 kHz test bandwidth)	0.7 to 15 kHz, depending on range
Drift (after 70 minutes of operation)	100×10^{-6}/10 min
Effect of load	230×10^{-6} (between short- and open-circuit)
Frequency synchronization	via 2nd RF output and frequency control input
Output power with ALC	
Frequency subranges	
1 to 6 (25 to 595 MHz)	≧+33 dBm (2 W, 10 V into 50 Ω)
7 (565 to 1000 MHz)	≧+30 dBm (1 W, 7 V into 50 Ω)
With AM: 1 to 6	≧+33 dBm } PEP
7	≧+30 dBm } PEP
Attenuation	
fine	−10 dB (progr. in 0.5-dB steps)
coarse	−35 dB in 5-dB steps
Attenuator error	≦±0.12 dB per 5-dB step
Meter	+22 to +33 dBm (3 to 10 V)
Reflection coefficient	≦15% (VSWR ≦ 1.35)
Connector	Dezifix B, adaptable
Harmonics suppression	range 1: ≧ 30 dB, for all other ranges see diagram



RF output II (rear)	
Output power	30 dB below meter indication
Source impedance; connector	50 Ω; BNC socket
Modulation	
AM internal	modulation frequency 1 kHz, modulation depth 70%
AM external	10 Hz to 8 kHz, max. 90%; V_{in}: 2 to 12 V for 80% modulation
Sweeping	
Internal	single sweep of one frequency subrange within 20 s
External	0 to 50 Hz (sawtooth), max. 1 subrange, input requirement 0 to +10 V
External sweep Δf	FM with centre frequency set by manual or programmed adjustment; 0 to 8 kHz
Output for frequency-proportional voltage	0 to +40 V, on rear
Remote control (programming)	
Logic function of programming inputs	negative logic
	without programming unit / with programming unit
V_{max}	+28 V / DTL/TTL
I_{max}	50 mA / compatible
With programming unit	programming of frequeny range, frequency and output power in BCD code; inputs DTL/TTL compatible, negative logic
General data	
Nominal temperature range	+10 to +40 °C
AC supply	115/125/220/235 V ±10%, 47 to 440 Hz (100 VA)
Dimensions, weight	484 mm × 194 mm × 436 mm, 18.6 kg
Order designations	► Power Signal Generator SMLU
SMLU without programming unit	200.1009.02
with programming unit	200.1009.03
Recommended extras	
Code Converter PCW (section 1)	244.8015.92
Code Converter Board for SMLU	245.2610.02
Card Reader PCL (section 1)	248.6017.02
Sweep Unit SMLU-Z (page 53)	243.3010.92

SMLU alone and with accessory units (blue): Sweep Unit SMLU-Z (centre) and Frequency Controller SMLU-Z3 (back)

SMLU System

The **Power Signal Generator SMLU** – a standard instrument for a variety of measurement tasks in the range 25 to 1000 MHz (see page 50) – is system-compatible and can be adapted with great flexibility to the particular task at hand by simply connecting the accessory units

Sweep Unit SMLU-Z,
Frequency Controller SMLU-Z3

and/or Code Converter PCW (for serial programming, see section 1).

This combination constitutes an extremely wideband sweep generator of high output level which permits very rational and time-saving execution of all broadband measurements.

The following diagram gives an overall picture of the different combinations possible and their outstanding features.

Fixed frequency

- Wide frequency range
- High output power

- Very accurate frequency
- Excellent frequency stability thanks to synchronization
- External frequency measurements
- Frequency and level programmable in ASCII

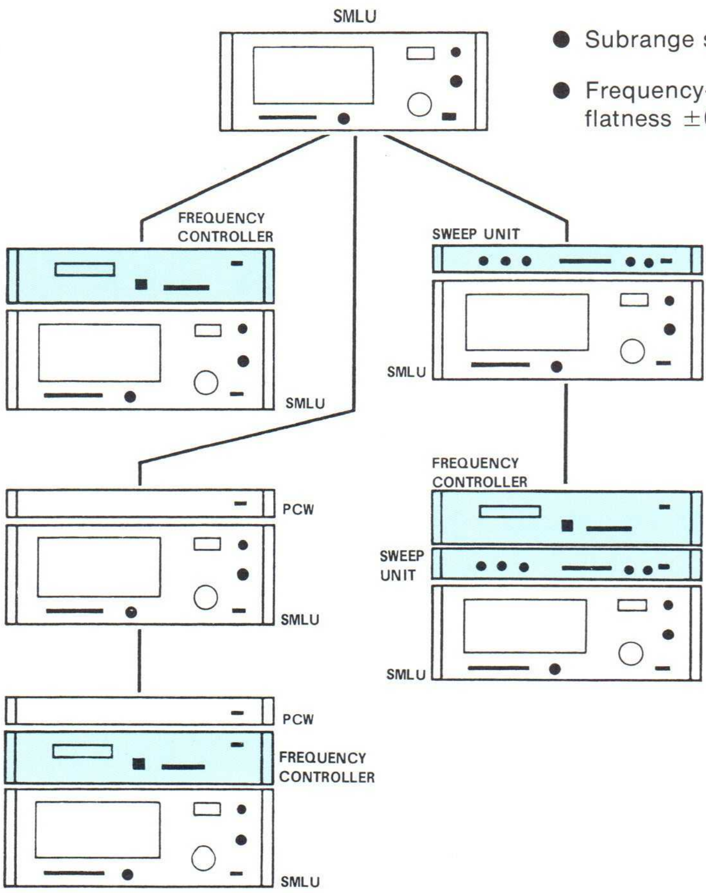
- Frequency programming with high accuracy and stability
- Setting time < 100 ms

Sweep operation

- Subrange sweeping
- Frequency-response flatness ±0.5 dB

- Sweep width 25 to 1000 MHz max.
- Automatic range switchover
- Two continuously adjustable frequency markers

- Accurate measurement of the adjustable marker frequency



SMLU system combinations and their outstanding features

Power Sweep Generator (SMLU + SMLU-Z)

The Power Signal Generator SMLU and the Sweep Unit SMLU-Z constitute a wideband power sweep generator for the range 25 to 1000 MHz.

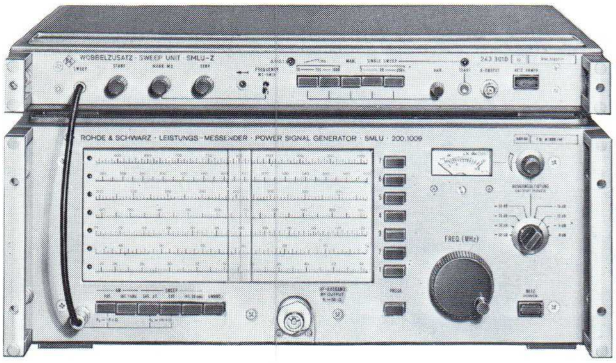
The whole frequency range or any part thereof can be swept through. Switchover between the seven subranges is made automatically by the sweep unit during the sweep process. The start and stop frequencies can be set independently over the whole frequency range. The sweep is logarithmic so that the frequencies at the beginning of the range can be adjusted with the same relative accuracy as those at the end.

The sweep time can be varied over a wide range, enabling optimum conditions for each test item. A lamp signals unsuitable settings.

Single sweep for recorder operation and manual scan are also possible. The necessary contacts for driving the recorder are provided.

Two electronic frequency markers can be shifted independently over the whole frequency range; they appear as bright spots on the display, for instance an oscilloscope. The marker frequency is indicated on the SMLU scale with the reading accuracy of the SMLU or can be measured with an external digital frequency counter. A counter output is provided. The start or stop frequency can also be indicated by pressing a pushbutton.

The measured curve can be represented on a simple oscilloscope or on an inexpensive XY display; the display unit of Polyskop SWOB 3 is particularly suitable for large-scale representation.



SMLU + sweep unit = power sweep generator

Specifications of SMLU + SMLU-Z

Sweepable frequency range	25 to 1000 MHz or any part thereof
Sweep width	max.: total range min.: 0.75 × 10^{-3} of centre frequency
Sweep time, adjustable	10 to 1000 ms, single sweep 2 to 200 s
Output power, stability, harmonics suppression	same as for SMLU, see page 51
Frequency markers	bright spots or marker pulses
Marker output	+5 V_p; BNC socket
X output voltage	0 to +10 V; BNC socket
Blanking output, switch-selected	+15 V_p; BNC socket
Switching contact for recorder control	max. 20 V/1 A
AC supply	115/125/220/235 V ±10%; 47 to 440 Hz (100+12 VA)
Nominal temperature range	+10 to +40 °C
Dimensions, weight (SMLU + SMLU-Z)	484 mm × 260 mm × 436 mm, 24 kg
Order designations (order units separately)	► Power Sweep Generator SMLU + SMLU-Z
SMLU without programming unit	200.1009.02 or
SMLU with programming unit	200.1009.03
Sweep Unit SMLU-Z	243.3010.92

Frequency Controller SMLU-Z3

♦ 10 to 1000 MHz

In addition to the Sweep Unit SMLU-Z another add-on unit to the Power Signal Generator SMLU for 25 to 1000 MHz is available in the Frequency Controller SMLU-Z3.

This unit gives a 6-digit frequency readout in the range of 100 Hz to 1000 MHz and is ideal for the following four tasks:

1. Measuring the SMLU output frequency with a resolution of 1 kHz or 10 kHz.
2. Synchronization, meaning that any frequency adjusted on the SMLU can be maintained with crystal stability by pressing a button.
3. Accurate measurement of the marker frequency in operation with the sweep unit; sweep width is adjustable from 25 to 1000 MHz.
4. Programming the SMLU frequency quickly (< 100 ms) and accurately (10 kHz).

External signal frequencies from 100 Hz to 1000 MHz can also be measured; sensitivity 10 mV, resolution 10 Hz.

The Frequency Controller SMLU-Z3 is driven via the second RF output of the SMLU.

SMLU-Z3

Specifications of SMLU-Z3

Frequency range	10 to 1000 MHz
Indication	6 digits (7-segment LEDs)
Measurement error	±1 digit + error of timebase
Input 1	Z_{in} = 100 kΩ‖30 pF (BNC)
Frequency range	100 Hz to 30 MHz
Resolution	10 Hz or 100 Hz, pushbutton-selected
Input voltage	10 mV to 2 V
Input 2	Z_{in} = 50 Ω (BNC)
Frequency range	10 to 1000 MHz
Resolution	1 kHz or 10 kHz, pushbutton-selected
Input voltage	10 mV to 2 V (AGC)
Internal timebase	10 MHz, aging 1 × 10^{-6}/month
Synchronization with SMLU	
Deviation of centre frequency	±10 kHz
Capture and hold range	≧2%; setting time ≦ 100 (400) ms
Programming	TTL level, negative, BCD
Nominal temperature range	+10 to +40 °C
AC supply	115/125/220/235 V ±10%; 47 to 440 Hz (37 VA)
Dimensions, weight	492 mm × 116 mm × 392 mm, 7 kg
Order designation	► Frequency Controller SMLU-Z3 242.5019.92

SLRD

UHF Power Signal Generator SLRD
♦ 0.28 to 2.75 GHz

- Output power up to 35 W, adjustable down to 1 × 10^{-8} W
- Model suitable for synchronization can be supplied
- External pulse modulation, internal squarewave modulation 1000 Hz

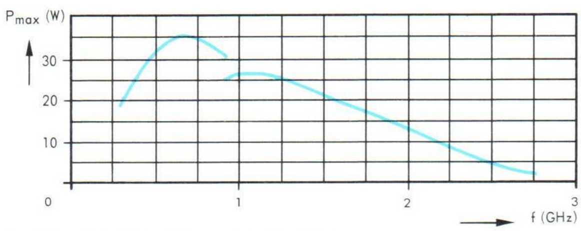
Single-stage power signal generator using a disc-seal triode oscillator and tunable coaxial resonant-line circuits for anode and cathode. Both circuits have separate scales calibrated in MHz. The scale drives can be ganged (single-knob tuning). The whole frequency range is covered in two bands.

Single-knob manual tuning permits accurate adjustment of small frequency increments and rapid tuning through the whole range.

The SLRD model that is suitable for synchronization incorporates two diode tuning units providing signals of crystal accuracy and spectral purity. The tuning units may also be added later.

Modulation characteristics. Internal 1-kHz squarewave modulation of high stability; external pulse modulation possible with rise and fall times of 0.08 to 2 µs and repetition frequencies up to 100 kHz.

The output power can be adjusted from maximum down to −50 dBm in accurate intervals, direct reading being provided by a directional coupler and a meter for levels from +47 to +9 dBm. A piston attenuator calibrated in dB permits the adjustment of low levels.



Typical values of maximum output power

Uses. Measurement of stopband and passband characteristics of filters and other two- and four-terminal networks of high attenuation, feeding of impedance meters (slotted lines, reflectometers), determination of propagation conditions and of attenuation over a radio link.

Specifications

Frequency range	280 to 2750 MHz
Error limits of indication	±2%
Frequency change due to temperature variation	≦7 × 10^{-5}/°C
Harmonics suppression	20 dB typ.
Residual FM	1 to 10 kHz, depending on frequency
Residual AM	≧40 dB down
Synchronization	
Maximum tuning range	1 × 10^{-4} for 280 to 950 MHz 2 × 10^{-5} for 850 to 2750 MHz
Control voltage requirement	±20 V for max. tuning range
Modulation	
Pulse modulation (squarewave), internal	
Modulation depth	100%
Repetition frequency	1 kHz
Rise/fall time	0.08 to 2 µs
Pulse modulation, external	
Repetition frequency	0 to 10/0 to 100 kHz
Pulse width	4 µs to 1 ms
Rise/fall time	0.08 to 2 µs
Voltage requirement	3 V_{pp} into 150 Ω
Output power	
1st RF output (front panel)	Dezifix B, 50 Ω; adaptable
Max. output power	35 W, depending on frequency, see diagram on left
Min. adjustable power	−50 dBm (1 × 10^{-8} W)
Indication for powers	
> +9 dBm	on panel meter
< +9 dBm	on meter and dB scale of piston attenuator
Adjustment range of attenuator	0 to 70 dB
Attenuator error	±(1 dB +0.05 dB/1 dB)
2nd RF output (rear panel)	Dezifix A, 50 Ω; adaptable
Output power	10 µW to 100 mW, depending on frequency; not adjustable
General data	
Nominal temperature range	+10 to +35 °C
AC supply	115/125/220/235 V ±10%, 47 to 63 Hz (175 VA)
Dimensions, weight	484 mm × 328 mm × 512 mm, 38 kg
Order designations	► UHF Power Signal Generator SLRD 100.4194.02 (no synchronization)

Tuning units required for synchronization (on request, the SLRD is supplied with one or two tuning units which can also be added at a later date):

Range 280 to 950 MHz	► Tuning Unit SLRD-Z 100.4207.02
Range 850 to 2750 MHz	► Tuning Unit SLRD-Z 100.4213.02

Decade signal generators, frequency synthesizers

– often summarized by the term frequency synthesizers – are signal generators with an adjustable output frequency derived from a single extremely stable control frequency. They differ basically from variable free-running oscillators in their frequency accuracy, which is several orders better. The digital frequency adjustment, always used with frequency synthesizers, permits an extremely high setting accuracy. For this reason, synthesizers are used instead of free-running oscillators for all precision measurements.

In addition, the digital setting permits remote frequency control. Consequently, automatic systems always use synthesizers for frequency generation.

Compared with free-running oscillators, another advantage of frequency synthesizers is the very low spurious FM.

Automatic receiver test assembly using SMPU

Decade signal generators

These instruments combine the features of the synthesizer with those of a top-quality signal generator. In addition to high frequency stability and setting accuracy, they have an output voltage adjustable from 1 µV up to several volts in well-defined increments. Low RF leakage and negligible pick-up of stray fields are ensured by careful shielding. The output signal can be amplitude- and frequency-modulated. Switch-selected ALC in unmodulated or FM operation facilitates frequency-response measurements.

Instruments from 0 to 1000 MHz are available. This wide frequency range combined with the performance of a general-purpose signal generator opens up a wide field of application in the development, production and maintenance of electronic equipment. Remote frequency selection is possible for all decade signal generators.

Automatic test assemblies for complicated measurements can be built up in conjunction with programmed controllers, remote-controlled attenuators and evaluation units.

Frequency synthesizers

These supply a very stable, variable output frequency. No modulation facility is provided. The output voltage can be varied within about 20 dB. They are used in particular as exciters for selective measurements. Further applications are, for instance, level and impedance measurements which require unmodulated signals.

Frequency generation methods

Two basic methods of frequency generation are predominantly used: **frequency synthesis** using mixers and **frequency analysis** using phase-locked loops. Both methods have advantages and disadvantages. Depending on the application, they are employed separately or in combination.

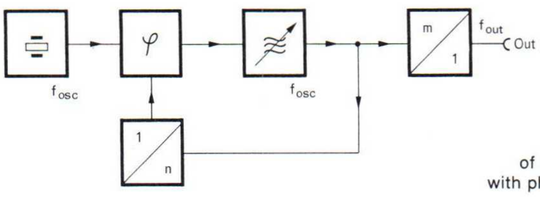
Frequency synthesis

This method consists of mixing and filtering. Selectable harmonics of the highly stable control frequency are filtered out and combined to form the output frequency. Since the frequency scheme can be so calculated that all narrowband filters remain in a steady-state condition the frequencies can be changed very rapidly (selection time 100 µs). 100 dB suppression of spurious signals is obtainable by careful design.

Frequency analysis

This method uses one or more phase-locked oscillators and no filters, thus simplifying the construction. For lower frequencies the extensive use of logic ICs is possible.

Frequency synthesizers using phase-locked oscillators feature simple design and high signal-to-noise ratio. The rather long switchover time may be a disadvantage. The modulation of this type of synthesizer is more complicated. In contrast to the mixing method, SSB modulation is not possible directly.



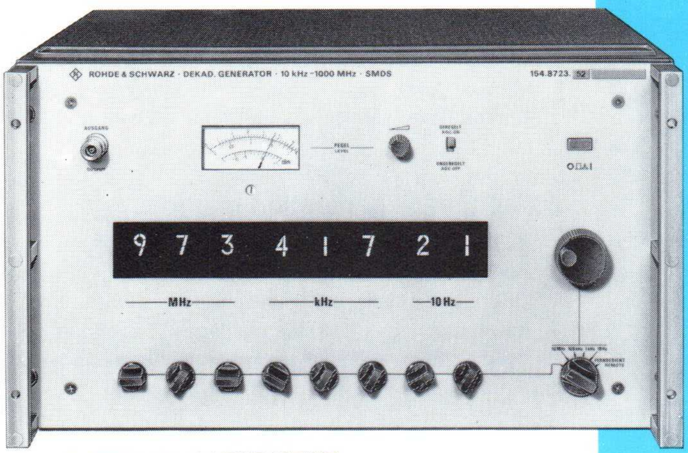
Example of synthesis with phase lock

The oscillator operates at the highest possible frequency. The output signal is obtained by division of the oscillator frequency f_{osc} by the factor m. The oscillator frequency is also divided by the factor n and the quotient compared in a phase detector with the crystal reference frequency. The phase detector controls the oscillator so that its frequency is exactly n times the reference frequency. The output frequency is then

$$f_{out} = \frac{n}{m} \cdot f_{ref}.$$

Thus it is possible to divide the output frequency f_{out} into equal steps by varying n and to select the decade range by varying m.

SMDS



LIMITED-AVAILABILITY PRODUCT

Decade Frequency Generator SMDS
♦ 10 kHz to 1000 MHz

- Digital frequency setting, manual or by remote control
- Smallest frequency increment 10 Hz; quasi-continuous tuning in steps of 10 Hz to 10 MHz
- Suppression of spurious signals > 86 dB (80 dB), high signal-to-noise ratio

The **Decade Signal Generator SMDS** is a universal instrument which is equally suitable for everyday measurements in laboratories and test departments and for use in automatic test assemblies and production testers.

Features

Frequency setting. The output frequency is produced by a combined synthesis and analysis method and can be adjusted manually with 8 decade switches or by remote control in smallest increments of 10 Hz. Quasi-continuous tuning is also possible, by means of a crank-type knob in steps of 10 Hz, 1 kHz, 100 kHz or 10 MHz. Continuous tuning also covers the full frequency range.

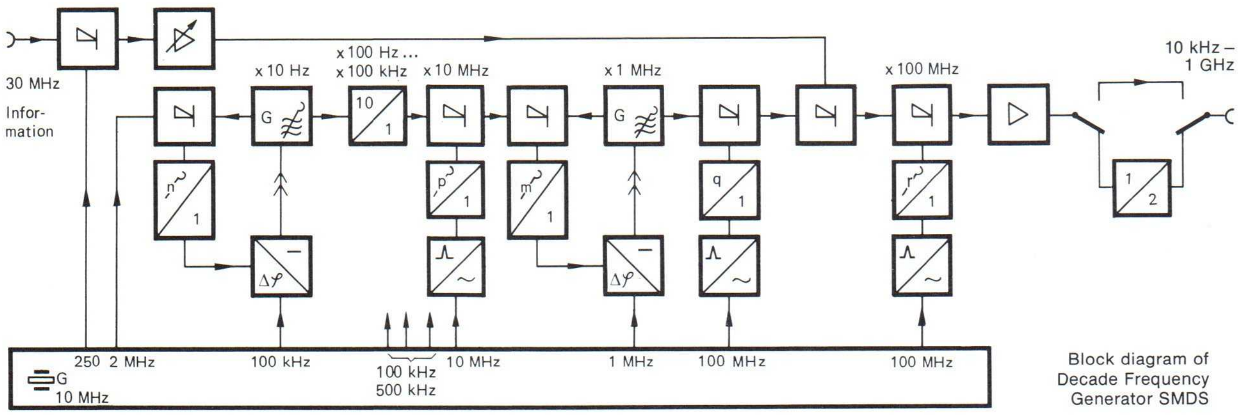
The output frequency is indicated on Nixies for all modes of operation and has the full accuracy of the built-in crystal standard (class of accuracy 10^{-9}) or of the external control frequency, i.e. the loss of accuracy associated with interpolation oscillators is avoided.

For remote control a BCD frequency command is applied to the SMDS. Electronic frequency selection takes place in 20 to 400 μs, depending on the decade, with negligible overshoot. The SMDS is therefore suitable for use in automatic test assemblies and for digital sweeping of highly selective two-terminal and four-terminal networks. When using the Code Converter PCW, the decade frequency generator can be programmed via the IEC bus.

Modulation. The SMDS output signal can be modulated in all conventional modes by applying a modulated subcarrier with 30 MHz centre frequency (bandwidth up to 1 MHz) to the information input.

Output level. The output voltage is indicated on a meter. It can be varied continuously over 15 dB. ALC keeps level variations below 1 dB over the whole frequency range. The ALC can be switched off for amplitude modulation.

Spectral purity. The suppression of spurious signals is > 86 dB up to 500 MHz and > 80 dB above 500 MHz. For the attenuation of noise sidebands see the diagram included in the specifications on the next page; it corresponds to an S/N ratio of > 90 dB up to 500 MHz, even in the vicinity of the carrier, and is at least 84 dB beyond 500 MHz.



Block diagram of Decade Frequency Generator SMDS

Applications of the SMDS

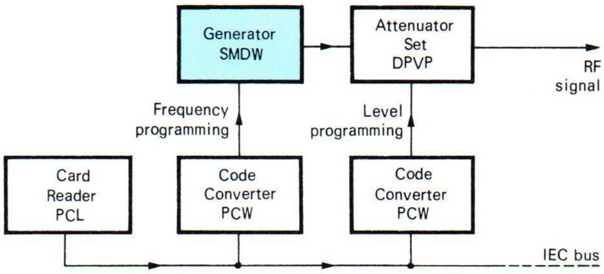
The **SMDS** is a high-grade frequency synthesizer with high spectral purity and S/N ratio. Together with the remote-control capability, these features make it ideal for two main applications:

- Generation of precise signals,
- Use in automatic measuring systems.

High precision signals are required in many fields of technology and engineering, such as microwave spectroscopy, calibration laboratories, checking frequency meters, measurement of filters and crystals, testing narrowband communication equipment, satellite applications and controlling selective receivers.

BCD-programmable frequencies with very short switching times, frequency coverage of 1 GHz in one band, and switch-selected ALC facilitate the use of this frequency synthesizer in automatic and semiautomatic test assemblies. In conjunction with the Code Converter PCW and the Card Reader PLC, which is directly connected to the PCW, the generator may easily be IEC-bus programmed.

The SMDS can also be combined with the Programmable Attenuator Set DPVP, which can be controlled from a Code Converter PCW via the IEC bus: a single punched card is thus sufficient for programming the frequency and level of an RF signal.



Signal generation with the frequency and level programmed by punched card

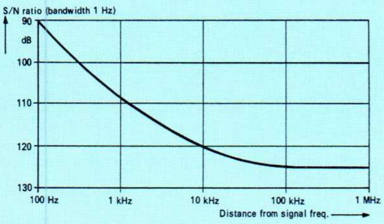
The use of the SMDS together with the card reader is ideal in test setups requiring particular frequencies to be set repeatedly in different sequences. Apart from saving time, this method offers better reliability.

Operation is particularly easy: one of the frequent drawbacks of digital frequency setting is eliminated by the quasi-continuous frequency tuning, which combines the accuracy of digital readout with the flexibility of analog tuning. This makes the SMDS suitable for measurements requiring manual frequency adjustment.

Specifications

Frequency range	10 kHz to 1000 MHz
Frequency setting, digital	8 decade switches resolution: 10 Hz (up to 500 MHz), 20 Hz (500 to 1000 MHz)
quasi-cont.	by knob in selectable steps of 10 Hz, 1 kHz, 100 kHz, 10 MHz
Error limits	same as control frequency
Control frequency	from built-in crystal-controlled master oscillator or externally applied
Frequency drift	
Change due to temperature variation	$< 1 \times 10^{-9}/°C$
Aging (after 100 days)	$< 2 \times 10^{-9}$/day
Output voltage	1 V, ALC
Setting of output voltage	continuous attenuation by 15 dB max.
Frequency response with ALC	< 1 dB (without ALC < 6 dB)
Spectral purity of output signal	
Harmonics	down > 26 dB
Suppression of discrete spurious frequencies	> 86 dB at Δf > 160 Hz from f_{signal} (up to 500 MHz) > 80 dB; at 0.5 to 1.5 f > 70 dB (500 to 1000 MHz)
S/N ratio (1-Hz test bandwidth)	
±100 Hz from signal	> 90 dB (up to 500 MHz; values 6 dB lower above 500 MHz)
±1 kHz from signal	> 105 dB (up to 500 MHz; values 6 dB lower above 500 MHz)
±20 kHz from signal	> 120 dB (up to 500 MHz; values 6 dB lower above 500 MHz)
±200 kHz from signal	> 125 dB (up to 500 MHz; values 6 dB lower above 500 MHz)

S/N ratio: see diagramm on the right

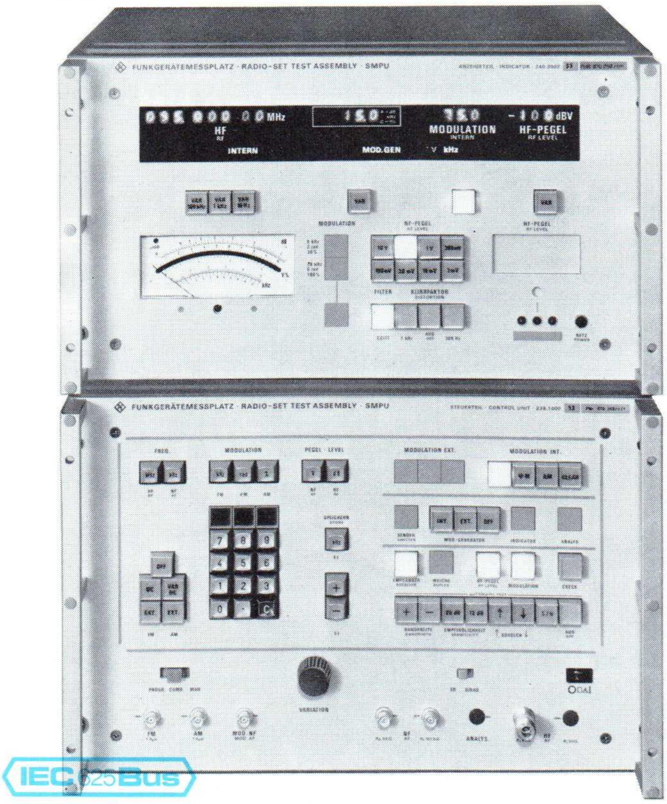


Modulation	via information input with AM, SSB (up to 500 MHz) or FM subcarrier of 30 MHz
Input level	max. 140 mV_{pp}, Z_{in} = 50 Ω
Remote frequency setting	
Code	BCD, negative, TTL signals
when using PCW	IEC bus
Frequency setting time	20 to 400 µs
Outputs	
Generator outputs 10 kHz to 1 GHz	
Front panel	Dezifix A base fitted with N socket
Rear panel	BNC socket
Other rear RF connectors	BNC sockets
Remote-control connector	50-way female connector strip (Amphenol 57-40 500)
General data	
Nominal temperature range	+10 to +45 °C
AC supply	115/125/220/235 V ±10%, 47 to 63 Hz (110 VA)
Dimensions, weight	484 mm × 283 mm × 509 mm, 48 kg
Order designation	► Decade Frequency Generator SMDS
19" cabinet model	154.8723.52

Recommended extras

Programmable Attenuator Set DPVP 214.8017.52
Code Converter PCW 244.8015.92 (with code converter boards 245.2810.02 for SMDS and 245.2510.02 for DPVP)
Card Reader PCL 248.6017.02
Standard Frequency Receiver XKD 100.5678.03 for checking the SMDS crystal frequency
Tektronix Graphic Computing System 4051 for control via IEC bus

SMPU



Decade Signal Generator and Receiver Test Assembly

Decade Signal Generator and Receiver Test Assembly SMPU
♦ 50 kHz to 500 (1000) MHz

- RF generator with programming capability for frequency, level and modulation
- AF voltmeter included in the indicator unit
- High intelligence due to microprocessor
- Excellent modulation characteristics
- Suitable for stereo using an external modulation source

The version of the **Decade Signal Generator SMPU** which is designed as the automatic Receiver Test Assembly includes all instruments required for receiver measurements (in particular broadcast receivers):

> RF generator 50 kHz to 500 MHz (with option: extension to 1 GHz possible) for AM and FM,
> AF level meter for 3 mV to 10 V,
> distortion meter for 0.1 to 99%,
> AF generator and frequency meter.

These instruments are also part of the automatic Test Assembly for Radio Sets SMPU which includes additional units such as an RF power meter and a modulation-depth meter (see page 82).

The Decade Signal Generator SMPU (receiver test assembly) is programmable in accordance with the IEC standard, extension thus being possible for instance by the Tektronix desktop calculator 4051 (see also section 1).

Specifications

RF generator	0.05 to 500 (1000) MHz
Resolution of frequency setting	10 Hz (20 Hz)
Error limits	see crystal
Harmonics	down > 26 dB
Spurious signals	down > 86 dB (80 dB)
S/N ratio referred to 1 Hz bandwidth at ±20 kHz from signal	> 120 dB (114 dB)
Output level (EMF)	0.1 µV to 1 V (−141 to 0 dBV)
Resolution of level setting	1 dB
Error limits	±1 dB
Crystal	
Effect of temperature	$< 2 \times 10^{-9}$/°C
Warmup time of oscillator	max. 15 min
Aging	$< 5 \times 10^{-8}$/month
External control	10 MHz; 0.5 V into 50 Ω
Modulation	
Types	AM, FM and φM
Internal modulation generator	
Frequency range	10 Hz to 99.9 kHz
Distortion	< 1% (up to 20 kHz)
Output voltage	10 mV_{rms} to 7 V_{rms} EMF
Source impedance	50 Ω
Amplitude modulation	
Modes	int. or ext. generator
Modulation depth	0 to 99%, resolution 1%
Frequency range	0 to 50 kHz
Envelope distortion at 90% modulation	≦3%
Level requirement for external AM	1 V (rms)
Frequency modulation	
Modes	int. or ext. generator; AC or DC coupling
Frequency deviation	0 to 99.9 kHz, resolution 100 Hz
Modulation frequency range	20 Hz to 100 kHz (synchronized, AC) 0 to 100 kHz (not synchronized, DC)
Modulation distortion, int.	< 1%
ext.	< 0.1%
Incidental AM up to 20 kHz frequency deviation	< 1%
Level requirement for external FM	1 V (rms)
Phase modulation	
Modes	int. or ext. generator, AC or DC coupling
Phase deviation	0 to 10 rad, resolution 0.1 rad
Modulation frequency range	100 Hz to 6 kHz
AF level measurement (rms-responsive rectification)	
Ranges (in 10-dB steps)	3/10/30/100/300 mV/1/3/10 V
Indication	on meter with dB and V calibration
Error limits	±(3.5% of rdg +1.5% fsd)
Frequency range	50 Hz to 20 kHz without weighting filter, weighting filter according to CCITT
AF frequency meter	
Range	50 Hz to 80 kHz
Sensitivity (min. input level)	1 mV
Maximum input level	10 V
Indication	5 digits, resolution 1 Hz
Distortion measurement	
Test frequency	1 kHz/0.3 kHz
Indication; resolution	3 digits; 0.1%; range 0.1 to 99%
Minimum input level	100 mV
Error limits	±2% ±1 digit
Modes	
Manual control	programming inhibited
Programmed operation	keyboard locked
Combined mode	simultaneous programmed and manual operation with override possibility
Programming and data output	IEC bus
General data	
AC supply	115/125/220/235 V ±10%, 250 VA
Dimensions, Control Unit	484 mm × 328 mm × 509 mm
Indicator	484 mm × 283 mm × 509 mm
Weight (both units)	80 kg
Order designation	► Receiver Test Assembly SMPU 239.0010.54
Recommended extras	
1-GHz Generator Extension SMPU-B1	240.7014.02

Theory of noise measurements

The **noise figure** of four-terminal networks is readily determined with the help of a generator producing white noise in the frequency range concerned. Such generators permit rapid measurements to be made without calculation. The results allow the comparison in sensitivity of different types of receivers or amplifiers.

Definition of noise factor

The **noise factor F** is the ratio of the signal-to-noise power ratio at the input to that at the output of a four-terminal network.

$$F = \frac{S_1/P_1}{S_2/P_2} = \frac{P_2}{G_0 P_1}$$

where

S_1	signal power	at the input
$S_2 = S_1 G_0$		at the output
P_1	noise power	at the input
P_2		at the output

The noise factor is by definition a dimensionless quantity.

$P_1 = kT_0\Delta f$ is the noise power due to the source impedance under the assumption that the temperature of the generator source impedance equals the standard noise temperature T_0. Then

$$F = \frac{P_2}{kT_0\Delta f\, G_0}$$

P_2	output noise power in W
k	Boltzmann's constant in Ws/K
T_0	absolute ambient temperature in kelvins
Δf	effective noise bandwidth in Hz
G_0	power gain
kT_0	4×10^{-21} Ws

The total noise power at the output is referred to the amplified reference power of 1 $kT_0\Delta f$. P_2 is composed of this amplified reference power and the component produced by this noisy four-terminal network. Thus the noise factor can be split up

$$F = \frac{G_0 P_1 + P_2}{G_0 P_1} = 1 + \frac{P_2}{G_0 P_1} = 1 + F_Z$$

where F_Z represents the contribution of the noisy four-terminal network.

The definition of the noise factor is based on the assumption that only the linear transmission range of the four-terminal network is used in the measurement. Non-linearity would seriously alter the noise spectrum and thus lead to measurement errors.

The **noise figure in dB** is obtained as $F_{dB} = 10 \log F$.

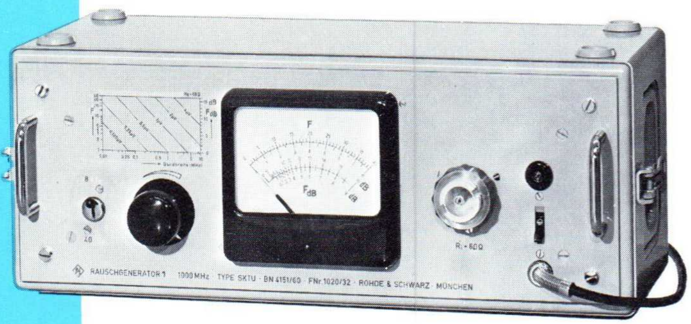
Measurement of noise factor

The definition of the noise factor does not specify the way in which the signal power is generated. It is possible to compare the signal power from a signal generator operating on a discrete frequency with the power of the noise spectrum which, dependent on the passband, appears at the output. To calculate this noise power it is necessary to determine the effective bandwidth. An easier way is to derive the signal power from a noise source. The signal of this noise source is subjected to the same bandwidths which act upon the noise spectrum applied to the input. The effect of bandwidth is thus eliminated. Generators delivering white noise (continuous spectrum with frequency-independent rms value) are therefore used for measurement.

Noise Generator SKTU
♦ 1 to 1000 MHz

- Easy determination of noise figure over a wide frequency range
- Scale calibration in F (dimensionless noise factor) and noise figure f_{dB}

SKTU



The **Noise Generator SKTU** supplies a measurable and adjustable continuous white noise spectrum for the rapid and easy determination of the noise figure of amplifiers or receivers. The noise power is generated using a temperature-limited diode.

The receiver input voltage that gives the signal-to-noise ratio 1 with the measured noise figure and the given receiver bandwidth can be read in microvolts on the nomogram engraved on the left side of the front panel.

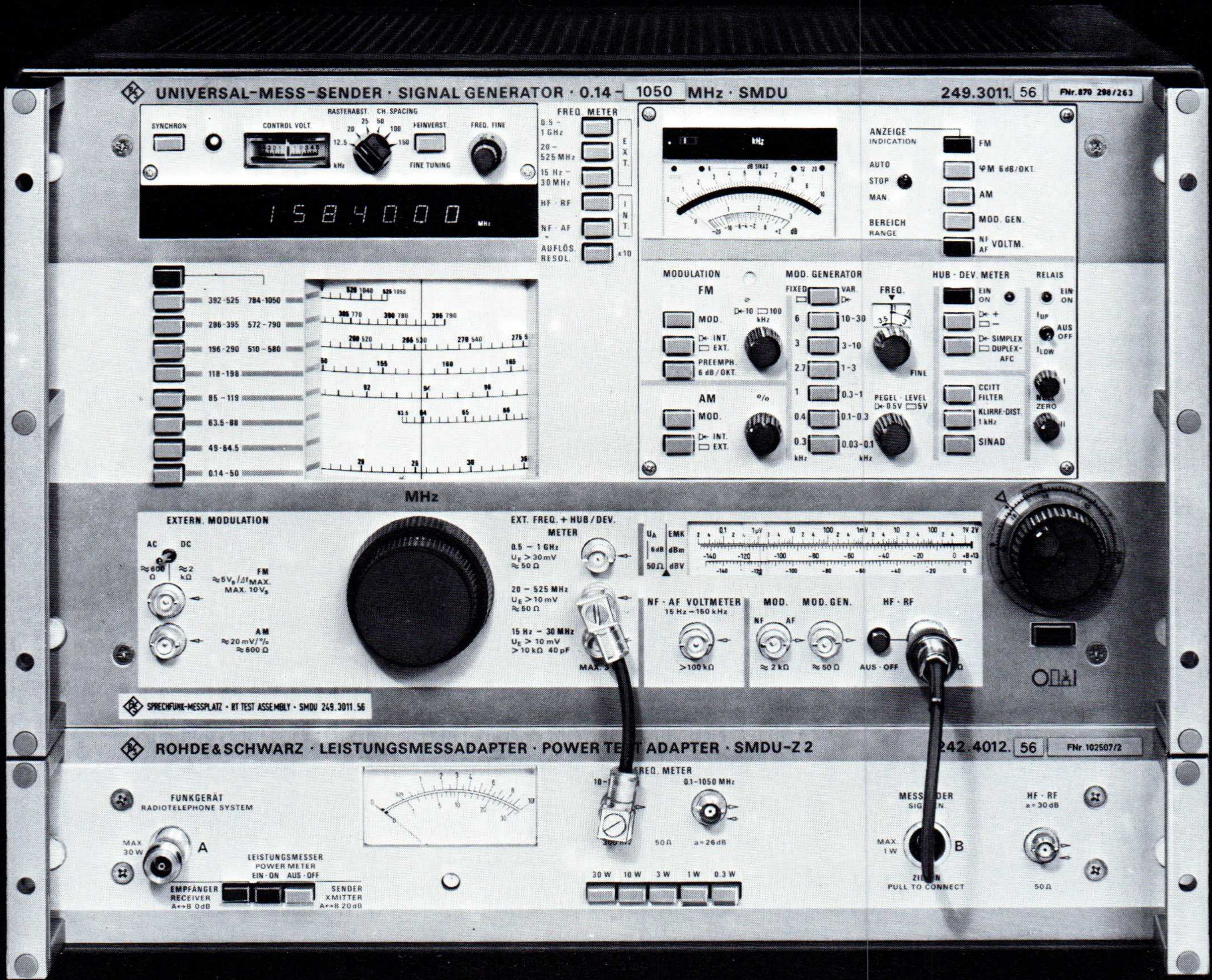
Specifications

Frequency range	1 to 1000 MHz		
Source impedance	50, 60 or 75 Ω, depending on order number		
Noise power	continuously adjustable		
Indicating ranges	50 Ω	60 Ω	75 Ω
Noise factor, 1 to	6.5/33	8/40	6.4/32
Noise figure in dB, 0 to	8/15	9/16	9/15
Error of indication	0.5 (1) dB		
AC supply	115/125/220/235 V		
Dimensions, weight	470 mm × 195 mm × 260 mm, 9 kg		

Order designation	▶ Noise Generator SKTU
50-Ω model	100.4688.50
60-Ω model	100.4688.60
75-Ω model	100.4688.70

Compact
RT test assembly;
details on page 64

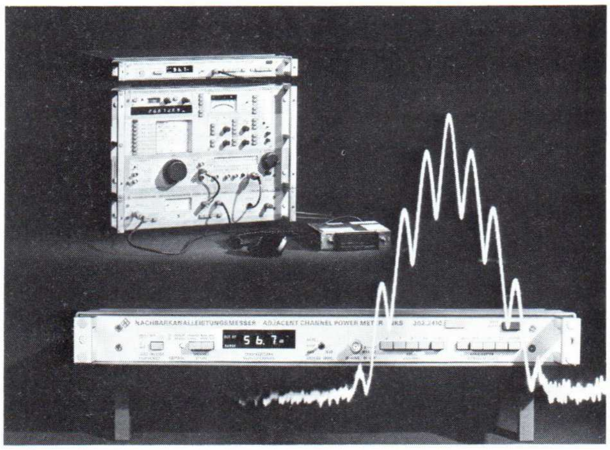
rt test assemblies
automatic af and rf test systems



RT test assemblies

Signal generators play an important role in checking out RT receivers during development, production and servicing. By complementing the signal generator with power, frequency and modulation meters as well as AF test equipment, a test assembly for checking RT transmitters and receivers is obtained.

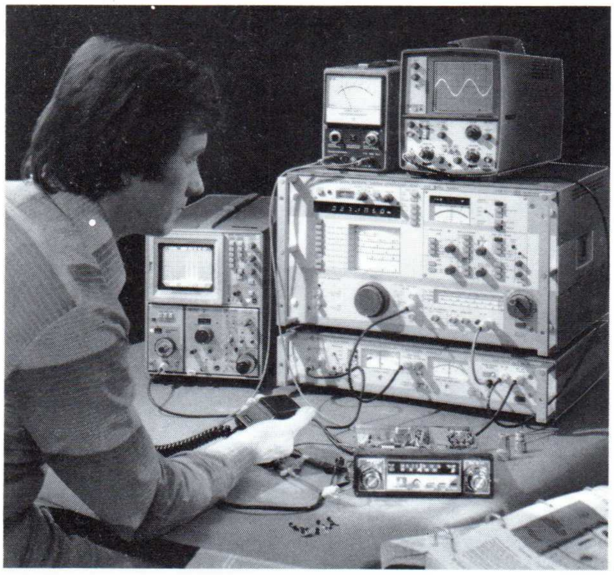
For ten years Rohde & Schwarz has been combining measuring instruments to form RT test assemblies.



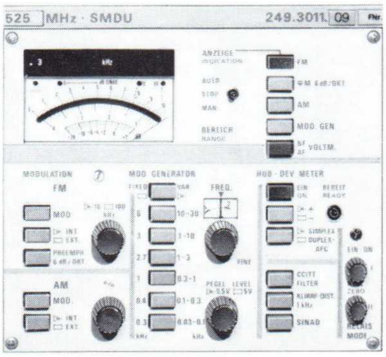
RT Test Assembly SMDU 56 with Adjacent-channel Power Meter NKS

The third and **most modern generation of manually operated test assemblies,** the SMDU models 06, 07 and 09 in conjunction with the AM Unit SMDU-Z1 or the Power Test Adapter SMDU-Z2, features obsolescence-proof design combined with optimum operating convenience. Compact test assemblies with integrated accessories are available under

RT test assembly using SMDU model 09



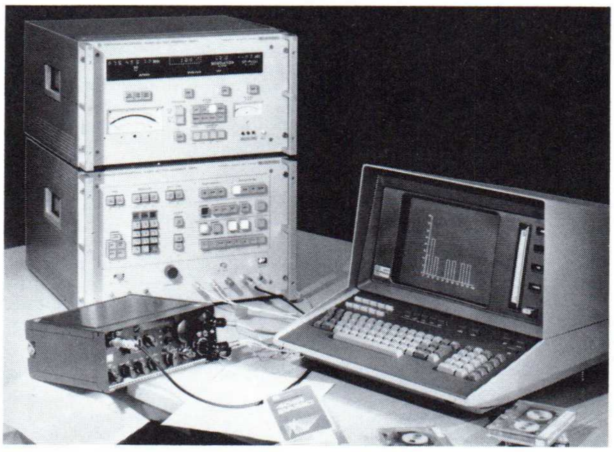
the designations SMDU 52, 53 and 56; see page 69. The SMDU concept meets the requirements of national and international standards, such as CEPT, FTZ, GPO or EIA, with the same ease with which it permits semi-automatic operation of the individual measuring instruments and simultaneous display of the most important test parameters. In the case of channel changeover, the SMDU deviation meter is tuned automatically and, when synchronized, the signal-generator frequency advances by the set channel spacing during tuning. The autoranging facility of the deviation meter, the modulation indication of the distortion meter and the SINAD-ratio meter reduces the measuring time considerably. Depending on the mode, the AM unit automatically switches to transmitter or receiver measurement.



SMDU modulation unit with meter (model 09)

The SMDU options permit custom-tailored optimization of the test assembly. Measurements in the 900-MHz band are also possible and the requirements existing for broadcast receivers combined with CB transceivers are met. RT test assemblies using the SMDU offer today the measuring concept of the eighties.

The Adjacent-channel Power Meter NKS rounds off the line of RT test equipment. In conjunction with the SMDU it measures the adjacent-channel power of RT transmitters in line with national and international standards (CEPT). The NKS tunes automatically to the selected adjacent channel (details on page 77).



Automatic Test Assembly for Radio Sets SMPU (see page 82)

Air-navigation test assemblies

In civil aviation, **VOR/ILS** navigation receivers determine the position and direction of planes. Amplitude-modulated signals in the VHF and UHF ranges are required for testing these receivers. These signals should exhibit a constant group delay between 9 and 11 kHz, very low distortion at 30 and 9960 Hz and a flat frequency response at the modulation frequencies of 90 and 150 Hz.

Models 07 and 08 of the Signal Generator SMDU meet these requirements. In conjunction with the Rohde & Schwarz VOR/ILS unit, these versions constitute a complete test assembly for VOR/ILS receivers of one make. The special advantages of this combination are the continuous monitoring of the modulated RF signals and the built-in self-check of the most important operating parameters. The resulting high reliability is ensured only by this VOR/ILS test assembly. By using this R&S equipment, ATC technicians can have confidence in the measurements they make.

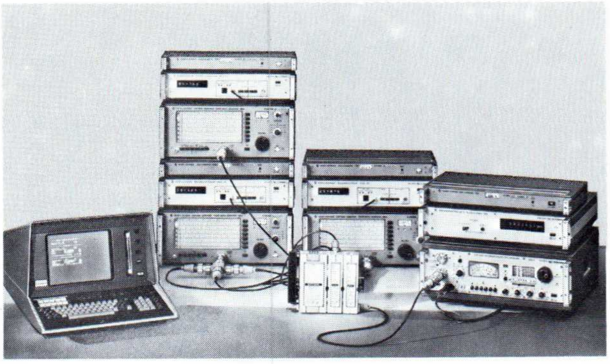
VOR/ILS test assembly (see page 74); back: navigation receiver with test panel

Automatic RF test assemblies

Test assemblies whose routine is controlled from a desktop calculator via the standard IEC bus permit rationalization of RF measurements up to 1000 MHz. Rohde & Schwarz offers two complete test assemblies for different measuring tasks, with which all software for the Tektronix desktop calculator 4051 may also be used.

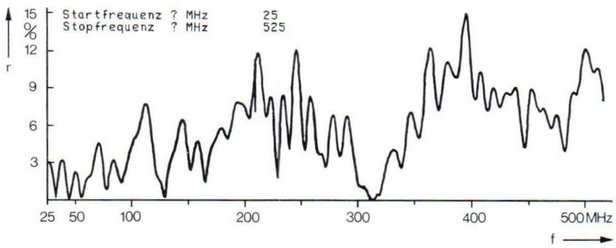
The automatic test assembly for intermodulation and crossmodulation measurements determines nonlinear distortion of antenna and cable-TV amplifiers as well as of semiconductors. Depending on the method used, two or three Power Signal Generators SMLU are included in the test setup.

The programmable VHF-UHF Test Receiver ESU 2 permits selective measurement of interference products. Operator errors are excluded since the whole test sequence is controlled from the calculator. The intermodulation or crossmodulation suppression is printed out directly in dB.



Automatic test assembly for intermodulation and crossmodulation measurements (see page 78)

The test assembly for RF cables automatically measures the average characteristic impedance and attenuation of RF cables in accordance with the specifications of IEC 96-1 or DIN 47 250. It consists of the programmable Power Signal Generator SMLU, an RF voltmeter and an analog/digital converter and can be extended by the Vector Analyzer ZPV. The resonance method is used for measuring. In addition to controlling the test routine, the desktop calculator furnishes the test results, the characteristic impedance being printed out in Ω or the attenuation in dB per 100 m cable length.

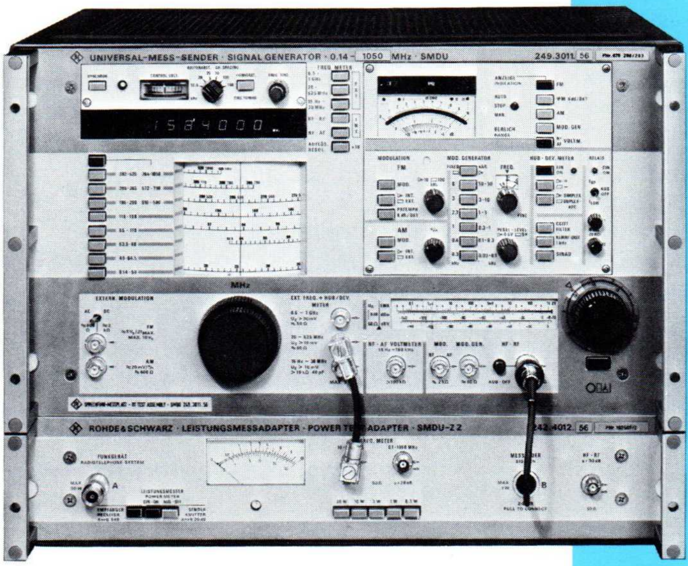


Characteristic impedance of an RF cable, measured with cable test assembly and Vector Analyzer ZPV as a function of frequency

Automatic RF test system

In addition, for production and servicing Rohde & Schwarz offers the **programmable Test Assembly for Radio Sets SMPU** which, in 1974, was the first "intelligent" test setup of this type with a microprocessor to appear on the market. The SMPU can be combined, via its IEC bus, with desktop calculators, such as the Tektronix 4051 (see page 13), to form the heart of a fully automated RF test system for universal use (testing of RT equipment, radio receivers and modules). Comprehensive software is available (page 86).

SMDU



RT Test Assembly SMDU

♦ 0.14 to 525 MHz (1.05 GHz)

- New generation of test assemblies with an extremely favourable price/performance ratio – manual operation with optimized controls for reliable, simple and economic measurements
- System configuration plus options permitting optimum solution of the most diversified measurement tasks
- Synthesizer stability using the synchronizer option, frequency setting accurate to within a few hertz
- Measurement of desensitization beyond 95 dB and adjacent-channel selectivity > 80 dB due to high spectral purity of RF signal
- Testing of hifi and stereo broadcast receivers with built-in Citizens'Band radio

The **RT Test Assembly SMDU** is a test system of highest precision which contains all measuring instruments necessary for standard checkout of RT equipment and meets or even exceeds the requirements of national and international specifications.

This advanced test assembly is based on the same design as its well-proven predecessors – SMDF, SMDM and SMDA – and combines precise measurement techniques with great operating convenience (e.g. automatically tuned deviation meter, channel-to-channel jump facility, autoranging facility). The SMDU test setup complies with the most severe stipulations for RT measurements, which so far have been met only by specialized instruments.

Applications

The comprehensive instrumentation permits a standard solution to be found for all RF measurement tasks. The SMDU test assembly can be used to advantage in laboratories, servicing shops and production plants.

In servicing the great operating convenience of the RT Test Assembly considerably reduces the time required for routine measurements.

For public services and in development laboratories, the high accuracy of the SMDU test assembly permits reliable conclusions in type-approval testing.

In test and production departments, the SMDU can be used to advantage for batch measurements thanks to its semi-automatic operation and the possibility of connecting recording equipment. When determining parameters which are difficult to measure, the RT Test Assembly is superior to any fully automatic test system, especially in regard to spectral purity.

*) SINAD: signal + noise + distortion to noise + distortion.

Configuration

The heart of the RT Test Assembly is the RT version of the SMDU (06, 07 or 09); this basic setup is suitable for all measurements up to 1 GHz.

To obtain a complete test assembly, the following equipment is required:

a) Power Test Adapter SMDU-Z2 or
b) AM Unit SMDU-Z1 (power meter and modulation depth meter); see under specifications.

Thus the following configurations are possible (also available as compact assemblies in common cabinets):

Signal Generator SMDU with

RF generator, 140 kHz to 525 MHz (expandable up to 1.05 GHz), FM and AM, automatic overvoltage protection in the case of accidental transmitter keying
AF generator, 30 Hz to 30 kHz
frequency meter, seven digits, 15 Hz to 525 MHz (1 GHz)
AF voltmeter, 1 mV to 10 V (rms weighting)
distortion meter, 1 to 100% fsd
SINAD*) ration meter, 6 to 46 dB
psophometric weighting filter (in accordance with CCITT)

Power Test Adapter SMDU-Z2 (30 W) with
RF relay switching panel; possibility of connecting analyzer and recording equipment – or

AM Unit SMDU-Z1 (30/60 W) with the same facilities as the power test adapter plus modulation depth meter and automatic mode selection (TX/RX)

Several options, e.g. for frequency range extension or for frequency synchronization, are available and can be readily incorporated if required; see under specifications.

Functions (for receiver and transmitter measurements see page after next)

Signal Generator SMDU

The free-running SMDU oscillator covers the range from 140 kHz to 525 MHz. The oscillator stability is such that any measurement can be started only five minutes after switching on the RT Test Assembly.

The **1.05-GHz Frequency Range Extension and the 1.05-GHz Frequency Doubler options** double the range of the SMDU, its excellent characteristics being maintained. With the doubler, subharmonics are down 20 dB.

The **Synchronizer option** provides for synthesizer stability without affecting the spectral purity of the signal. In addition, this unit permits frequency settings corresponding to the standard channel spacings of the different radio services between 12.5 and 150 kHz as well as continuous fine tuning to any frequency.

The frequency meter for 30 Hz to 525 MHz has a resolution of 1 Hz below 50 MHz and 10 Hz above 50 MHz. An input amplifier provides a sensitivity of 10 mV, thereby making possible measurements of frequency and frequency deviation even with cables of up to about 50 m. The **option SMDU-B4** extends the measurement range up to 1 GHz.

The modulation unit included in the SMDU meets the most stringent requirements so that, for instance in receiver measurements with AM and FM, the inherent distortion is negligible (e.g. model 09: 0.2% for 75 kHz deviation; stereo crosstalk 46 dB)

With the **Amplitude Modulation 525 to 1050 MHz** option, AM is possible in this frequency range with a modulation depth of about 95% and with constant characteristics even if the SMDU is operated with the Frequency Range Extension or the Frequency Doubler option.

The modulation generator delivers six fixed frequencies between 0.3 and 6 kHz or any other modulation frequency which can be set at will between 30 Hz and 30 kHz (the set frequency is indicated on the seven-digit frequency meter, accurate to within 1 Hz). The AF output voltage, which can be continuously adjusted between 1 mV and 5 V, is read from the multimeter which is incorporated in the modulation unit and can be set for mV, kHz or % indication.

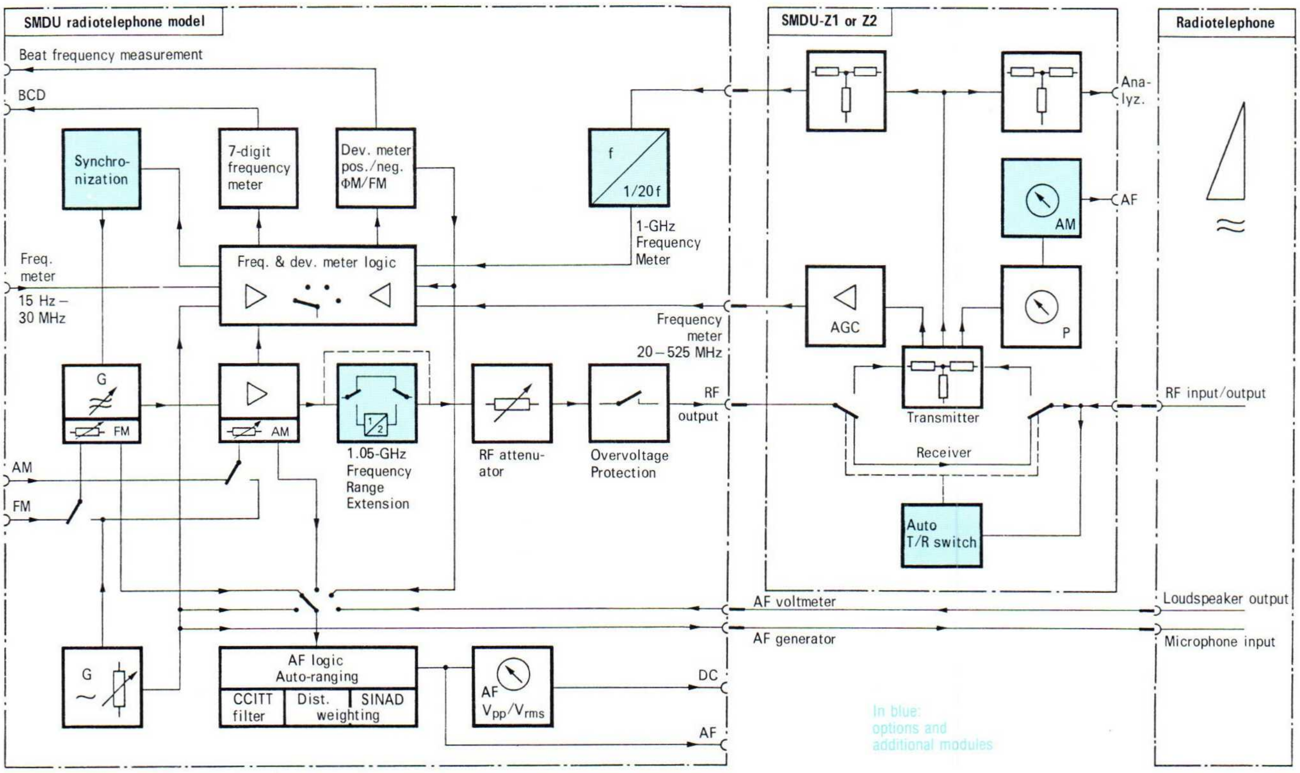
The AF voltmeter (30 Hz to 150 kHz, 1 mV to 10 V), which uses a true rms-responding detector, automatically switches to the correct subrange (out of a total of seven). The bandwidth of the voltmeter can be limited by connecting the psophometric CCITT filter.

The 1-kHz distortion meter (0.5 to 50%) with its autoranging facility can be used in conjunction with the AF voltmeter or the deviation meter. An LED lights up if the test level falls short of the required value.

The SINAD ratio meter (6 to 46 dB) measures the ratio of the total signal to the noise and distortion components. The standard SINAD value (6, 12 or 20 dB) of the corresponding measurement range is marked by LEDs on the scale of the meter.

Continued (deviation meter, power meter) ►

Block diagram of RT Test Assembly SMDU



Functions (continued)

Signal Generator SMDU

The deviation meter measures spurious FM between 10 and 300 Hz (rms weighting) and wanted deviations between 300 Hz and 100 kHz (peak weighting). Separate indication of positive or negative deviation is possible; an LED indicates that the deviation meter is ready for operation (counter-display resolution 1 Hz; the CCITT weighting filter or 1-kHz distortion meter can be connected).

In the simplex mode the deviation meter operates on the receive frequency set on the signal generator whereas it tunes **automatically** to a spacing of between 4.2 and 10 MHz from the latter in the duplex mode.

Thus the deviation meter need not be retuned after channel changeover on multichannel equipment. It is also suitable for measurements on RT equipment in **relay operation.** This saves another deviation meter and a separate tuning operation which would otherwise be required.

SMDU options

SMDU-B1 — **Synchronizer**
Standard equipment in the Radiotelephone Test Assembly, improves the long-term stability to that of a synthesizer. Simplifies operation by channel-stepping facility; electronic fine tuning.

SMDU-B2 — **Overload Protection**
Standard equipment in the Radiotelephone Test Assembly, protects the RF output against externally applied power of up to 50 W.

SMDU-B3 — **1.05-GHz Frequency Range Extension**
Extends the RF-generator range to 1.05 GHz without sacrificing performance characteristics.

SMDU-B4 — **1-GHz Frequency Meter**
Extends the range of the counter to 1 GHz for external signals.

SMDU-B5 — **1.05-GHz Frequency Doubler**
Low-cost option for doubling the frequency range. Subharmonics and harmonics are at least 20 dB below the carrier level.

SMDU-B8 — **Amplitude Modulation 525 to 1050 MHz**
Incorporated in new deliveries of SMDU + Frequency Range Extension; allows amplitude modulation of the carrier up to 1050 MHz.

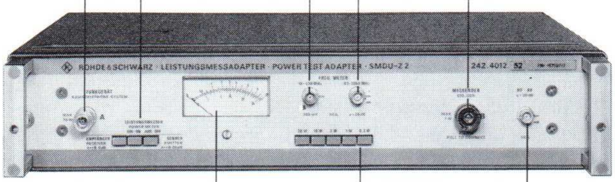
SMDU-B9 — **S/N-ratio Improvement**
Improves the S/N ratio, permitting, for example, adjacent-channel selectivity of more than 80 dB to be measured.

Power Test Adapter and AM Unit

These two instruments, which are both optional, permit connection and adaptation of the RT set to the test assembly and to additional signal generators (if, for instance, the multisignal method is used) or an analyzer. They can also be used for switchover between receiver and transmitter measurements.

Power Test Adapter SMDU-Z2 (1 to 1050 MHz)

The SMDU-Z2 contains a relay switching panel and power attenuators. It distributes the RF signal to the frequency and deviation meters, the power meter and to different test outputs (e.g. for analyzer measurements). Front view see page 61.

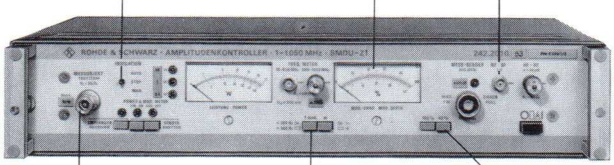


Power Test Adapter SMDU-Z2

AM Unit SMDU-Z1 (1 to 1050 MHz)

Compared with the Power Test Adapter, the more convenient SMDU-Z1 includes an additional modulation depth meter with ranges of 40 and 100%. If powers of ≧ 100 mW are applied, the SMDU-Z1 automatically switches over to transmitter measurement and selects the correct power measurement range.

The AM Unit comes as 30-W and 60-W models.



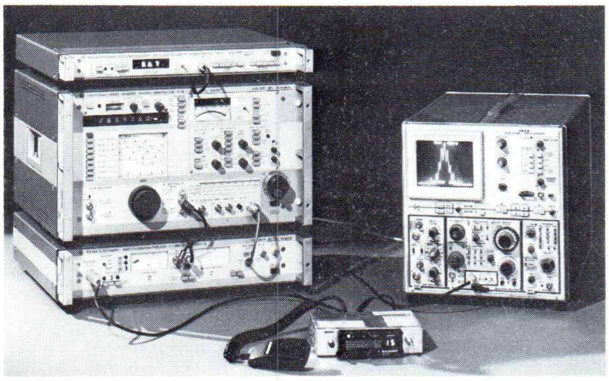
AM Unit SMDU-Z1

Operating convenience and versatility

Setting of the RT Test Assembly for receiver and transmitter measurements requires only very little time:

1. RF: The RF end of the radiotelephone is connected to the Power Test Adapter or AM Unit.
2. AF: a) The mike input is taken to the SMDU modulation generator output and b) the loudspeaker output is connected to the AF voltmeter input.

The measuring instruments are connected via the internal switching panels; thus all measurements can be performed without changing any connections.



Test setup comprising Adjacent-channel Power Meter NKS, Signal Generator SMDU 06 and AM Unit SMDU-Z1

Receiver measurements

After setting the test frequency, modulation type and frequency on the SMDU, the AF voltmeter indicates the voltage at the receiver output or the distortion for a modulation frequency of 1 kHz.

Receiver sensitivity. Convenient measurement is possible using one of the two conventional methods:
S/N ratio of 20 dB
SINAD ratio using the SINAD ratio meter for 6, 12 or 20 dB

Bandwidth. A marker for a 6-dB level difference (EMF and V_{out} cursor lines) on the attenuator simplifies the measurement. Digital display of the cutoff frequencies is provided.

The **squelch threshold** and the limiter action at the AF output of the receiver are determined using the attenuator and the AF voltmeter; the single-range attenuator permits rapid continuous level adjustment without reversal of direction (problem-free determination of hysteresis).

Effects of interfering transmitters, such as intermodulation, adjacent-channel modulation, desensitization or reradiation from closeby receivers, can be measured with great accuracy due to the excellent spectral purity of the generator signal (S/N ratio at 20 kHz > 135 dB/Hz).

Extension of test assembly

The Radiotelephone Test Assembly SMDU incorporates all the instruments required for normal servicing; see also block diagram on page 65.

In practical situations, the investigation of poor radio communications involves further measurements for checking the interference-determining items of the equipment specifications. Consideration must also be given to the possibility that working conditions alone are responsible for disturbed communication. For example, an important parameter such as **adjacent-channel selectivity** can only be measured using a two-source technique. It is therefore advantageous that test assemblies, even when used only for servicing, may be easily extended.

Thanks to the direct connections for a second signal generator and an analyzer, extension of the SMDU Radiotelephone Test Assembly is very straightforward.

Transmitter measurements (brief overview)

Parameter:	Special features:
Frequency tolerance	Immediate indication on frequency meter
Power	Simultaneous indication of power, frequency and deviation
Frequency deviation	Semi-automatic tuning
Deviation limiting	Use of maximum permissible deviation thanks to narrow tolerances
Harmonic distortion	Direct indication at 1 kHz
Calling frequency	Resolution 1 Hz
Modulation depth (using SMDU-Z1)	Power and frequency at the same time
Harmonic distortion	Indication of frequency and distortion
Limiting	With and without weighting
Out-of-band radiation	Direct connection of analyzer
Relay operation	In-service measurement possible without auxiliary oscillators

Adjacent-channel power (new definition)

For assessment of the modulation sidebands or excessive noise components emitted by RT transmitters, the postal authorities have now introduced the definition of adjacent-channel power. Two methods have been specified: a) Analyzer method, b) method with power test receiver.

The **Adjacent-channel Power Meter NKS** from Rohde & Schwarz works on method b); see pages 68 and (details) 77.

Measurement of adjacent-channel power involves nothing more than selection of the desired channel spacing (10, 12.5, 20 or 25 kHz) and the upper or lower adjacent channel. An automatic test program determines the power of the transmitter signal and of the interference and provides digital indication of the ratio of unwanted to carrier signal in dB in compliance with the specifications. The absolute power content of the interfering signal is calculated from the carrier-power indication on the SMDU-Z1 or -Z2 and the ratio shown on the NKS.

Extension of SMDU Test Assembly with Adjacent-channel Power Meter NKS

- Power test receiver for 20 to 950 MHz in line with standard specifications
- Measurement of all RT system characteristics including adjacent-channel power
- Selective measurement of spurious signals

Adjacent-channel Power Meter NKS

Full description on page 77

Due to overcrowding of the RT bands, the postal authorities have introduced the definition of adjacent-channel power to ensure better quality of RT communications.

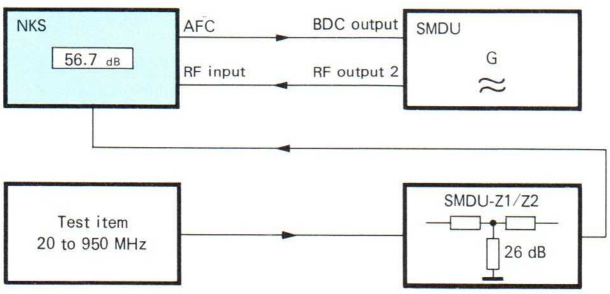
Adjacent-channel power refers to the spectral components present in the adjacent channels of a transmitter; it may be due to ineffective deviation limiting or to modulation distortion in FM transmitters or, with AM, to overmodulation, limiting or harmonic distortion in the event of overdriving.

To extend the SMDU Radiotelephone Test Assembly for the rational and accurate measurement of adjacent-channel power, Rohde & Schwarz offers the

Adjacent-channel Power Meter NKS

The power-test-receiver technique used in the NKS allows the determination of the carrier and adjacent-channel powers by means of an rms-responding rectifier. Thus all signals can be evaluated, the total power in the adjacent channel being measured continuously. The NKS fully complies with the relevant specifications for power test receivers.

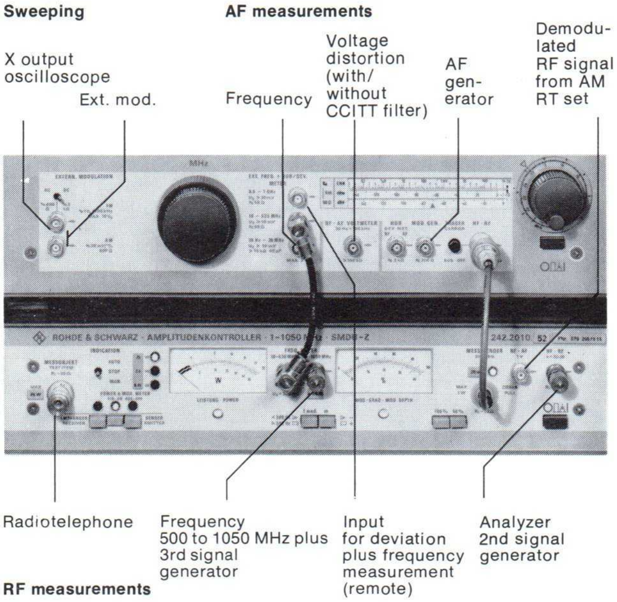
Configuration of test assembly. In conjunction with the SMDU Radiotelephone Test Assembly the Adjacent-channel Power Meter measures the interference in the adjacent channel and indicates the ratio of carrier power to unwanted power in three digits; see block diagram below. Only the desired channel spacing (10/12.5/20/25 kHz) and the upper or lower channel need be selected prior to measurement. Measurement range 0 to 89.9 dB; accuracy ±1 dB.



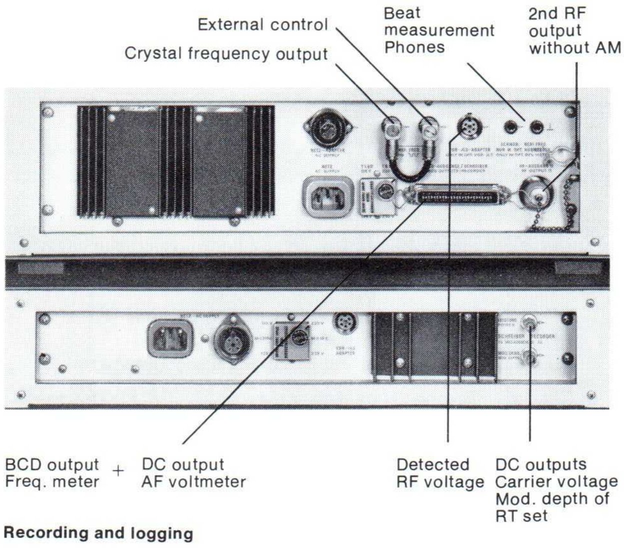
NKS in conjunction with Radiotelephone Test Assembly SMDU

Connectors

SMDU front panel



SMDU rear panel



Specifications

Frequency range	0.14 to 525 MHz; 0.14 to 1050 MHz using SMDU-B3 or B5		
Setting, indication	on drum scale, 7-digit readout (crystal 10 MHz, aging 5 × 10^{-8}/month)		
Scale resolution	up to 50 MHz: 1 or 10 Hz up to 800 MHz: 10 or 100 Hz above 800 MHz: 0.1 or 1 kHz		
Fine tuning using synchronizer option			
Steps corresponding to channel spacing	12.5/20/25/50/100/150 kHz		
Tuning range	20 to 160 kHz		
Frequency instability after warmup			
Free-running oscillator	< 1.5 to < 6 kHz for 0.14 to 1050 MHz		
Using synchronizer	< 5 × 10^{-8} + 10 Hz (for f ≧ 525 MHz)		
Spectral purity			
Spurious frequencies	down > 110 dB (> 90 dB for 0.14 to 50 MHz and 392 to 525 MHz)		
S/N ratio at 20 kHz from carrier, test band 1 Hz	> 135 dB (> 130 dB below 50 and > 125 dB above 525 MHz)		
Spurious AM with FM at f_{mod} = 1 kHz	< 1%, typ. 0.5% with 100 kHz deviation (for f > 1 MHz)		
RF output I	Z_{out} = 50 Ω; N female connector adaptable		
Output EMF and power	0.05 µV to 2 V; −139 to +13 dBm		
Frequency response, attenuator error	up to 500 MHz < ±1 dB up to 1.05 GHz < ±2 dB		
VSWR	< 1.2 (above 525 MHz: < 1.4)		
RF overvoltage protection	automatically disconnects RF outputs		
Max. permissible cond.	50 W or 50 V DC		

AF generator and modulation unit plus measuring instruments

Modulation frequencies			
Fixed	0.3/0.4/1/2.7/3/6 kHz		
Continuous	0.03 to 30 kHz		
Output voltage	1 mV to 5 V into 200 Ω		
Distortion	< 0.5% for 100 Hz to 10 kHz		
Type of modulation (internal and external)	AM	FM	φM
Modulation range	0 to 98%	0 to 100 kHz	0 to 100 rad
Modulation distortion	< 1.5% 80%	< 1% f_{max} 20 kHz	< 1% f_{max} 6 kHz
Measurement ranges	10/30/100%	1/3/10/30/100 kHz	1/3/10/30/100 rad
Characteristics of model 09			
Modulation distortion	< 0.2% at 75 kHz deviation in the FM broadcast ranges		
Stereo crosstalk attenuation	> 40 dB at 50 Hz > 46 dB at 1 kHz and 15 kHz		
Frequency meter/with option	15 Hz to 30 MHz	20 to 525 MHz	0.5 to 1 GHz
Sensitivity	10 mV	10 mV	30 mV
Resolution	1/10 Hz	10/100 Hz	10/100 Hz
Deviation meter	for positive and negative frequency and phase deviation		
Measurement ranges	10 to 300 Hz (rms weighting) 300 Hz to 100 kHz (peak weighting)		
Symmetry error	< ±1.5%		
AF voltmeter	1 mV to 10 V, 15 Hz to 30 kHz		
Error limits	±(3% of rdg +1.5% of fsd)		
Detector/weighting filter	rms-responding/CCITT		
Distortion meter	0.5 to 30% (50%), 1 kHz		
Voltage/deviation range	50 mV to 3 V/700 Hz to 40 kHz		
Error limits	±(10% of rdg +1.5% of fsd) +0.3%		
SINAD ratio meter	6 to 46 dB, 50 mV to 3 V		
Error limits	±(10% of rdg +1.5% of fsd) plus inherent noise 0.3% (=50 dB)		
CCITT filter	complying with CEPT specifications, usable with deviation meter and AF voltmeter		

Power Test Adapter	**SMDU-Z2**	
AM Unit		**SMDU-Z1**
TX/RX switchover	manual	automatic above 0.1 W
Frequency range	1 to 1050 MHz	1 to 1050 MHz
Power measurement range	50 mW to 30 W	50 mW to 30 W or 100 mW to 60 W
Modulation depth meter	—	0 to 40/0 to 100%
RF output	for analyzer connection and multisignal measurements; attenuation input/output 30 dB (VSWR 1.2)	

High-power attenuator

Attenuation RX/TX measurement	
with SMDU-Z1/30 W and SMDU-Z2	0 + 0.6 dB/20 ±1.3 dB
with SMDU-Z1/60 W	0 + 0.6 dB/26 ±1.3 dB

RF connector (analyzer, multisignal measurement)

Input/output attenuation/VSWR	30 ±0.8 dB/1.3

Adjacent-channel Power Meter (details on page 77)

Frequeny range	20 to 950 MHz	
Input voltage range		
RF input	0.1 to 2 V	
LO input	50 to 200 mV	
Adj.-channel power measurement	Channel spacing	Bandwidth
	10 kHz	8.5 kHz
	12.5 kHz	8.5 kHz
	20 kHz	14 kHz
	25 kHz	16 kHz
Measurement range (signal/interference power)	0 to 89.9 dB	
Weighting	rms value	
Error limits	±1 dB	
Indication	3 digits	

General data

Nominal temperature range	+10 to +45 °C
Shelf temperature range	−40 to +70 °C
AC supply	115/125/220/235 V ±10%, 47 to 420 Hz (100 to 120 VA depending on configuration)
Dimensions and weight of complete test assy	484 mm × 401 mm × 436 mm, 37 kg
Order designation	► RT Test Assembly SMDU

Single instruments for combination as test assembly

	Order No.
Signal Generator SMDU	
Radiotelephone model	249.3011.06 **or**
Radiotelephone model stereo-compatible	249.3011.09 **or**
Radiotelephone-navigation model	249.3011.07
Power Test Adapter	
SMDU-Z2	242.4012.52 **or**
AM Unit	
SMDU-Z1/30 W	242.2010.52 **or**
SMDU-Z1/60 W	242.2010.53

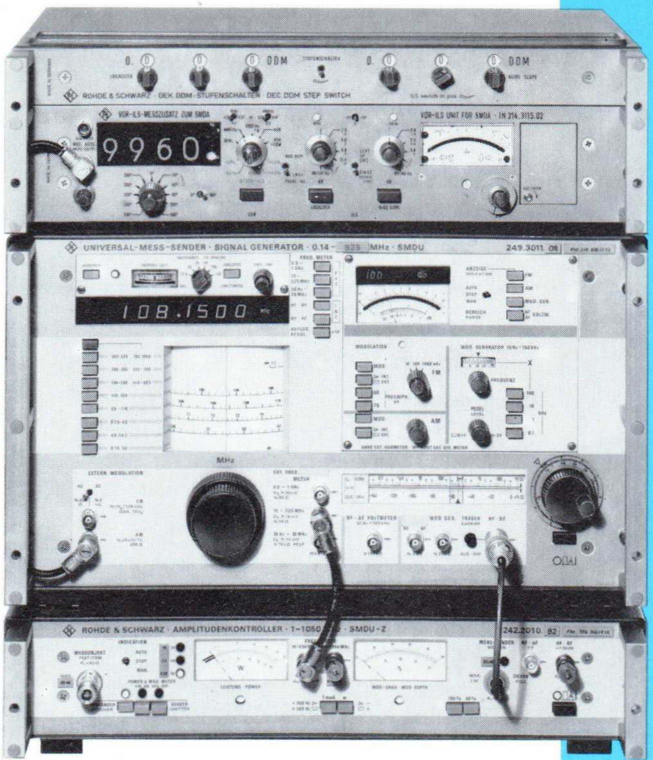
Compact test assemblies based on Signal Generator SMDU 06

SMDU 52 with SMDU-B1 option and AM Unit SMDU-Z1/30 W	249.3011.52
SMDU 53 with SMDU-Z1/60 W instead of /30 W	249.3011.53
SMDU 56 with Power Test Adapter SMDU-Z2 instead of SMDU-Z1	249.3011.56
Accessories supplied	power cable, 1 BNC-BNC connecting cable (for SMDU-Z1, -Z2)

Recommended extras

Adjacent-channel Power Meter NKS	302.2410.02
Options (description on page 66)	
SMDU-B1: Synchronizer (standard equipment in test assembly)	249.6340.02
SMDU-B3: 1.05-GHz Frequency Range Extension	249.9484.02
SMDU-B4: 1-GHz Frequency Meter	250.0012.02
SMDU-B5: 1.05-GHz Frequency Doubler	275.1312.02
SMDU-B8: Amplitude Modulation 525 to 1050 MHz	295.2150.02
SMDU-B9: S/N Ratio Improvement	295.2189.02

VOR/ILS Test Assembly



Test Assembly for Airborne VOR/ILS and Communication Equipment
♦ 0.14 to 1050 MHz

Complete test system from a single manufacturer; guaranteed data for system as a whole:

- Signal Generator SMDU in several models, with spuria-free and low-noise output, featuring excellent modulation characteristics
- VOR/ILS Unit with modulation generator, phase, modulation-depth and DDM meter as well as self-check for VOR/ILS output signals
- AM Unit with output-power meter, modulation-depth meter and automatic T/R switchover

Variants and options optimally combinable for all applications

The test assembly can be used for the development, production and servicing of airborne communication and VOR/ILS*) air-navigation equipment. It offers highest reliability due to the built-in self-testing facility and thanks to the available instruments for absolute measurement of the VOR zero phase and modulation depth (see pages 75/76). Thus it enables the user to strictly observe the relevant test specifications for VOR/ILS and communication equipment (e.g. ARINC 578 and 579).

The system concept allows the user to check the measurement accuracy in a simple way, which can normally be done only by the manufacturer, and thus meets the requirement of all institutions responsible for the safety of air traffic.

Moreover, the test assembly features a very favourable price/performance ratio since it is part of a modular system within the general measuring-instrument line.

The **basic equipment**, consisting of
Signal Generator SMDU (page 40),
VOR/ILS Unit and
AM Unit,

can be varied with respect to the signal generator used (see ordering data). The SMDU navigation model (08) is preferred for the VOR/ILS Test Assembly whereas the SMDU radiotelephone & navigation model (07) contains in addition all measuring instruments required for FM RT equipment, permitting, for instance, determination of deviation, distortion and SINAD ratio.

Several **options** are available; they can be incorporated in the signal generators upon delivery or added later without any adjustment.

Synchronizer SMDU-B1. This module improves the SMDU frequency stability to that of a synthesizer while maintaining its high spectral purity. Operation is greatly simplified thanks to the channel-to-channel jump facility at the spacings 50, 100 and 150 kHz used by VOR/ILS services and to synchronized fine tuning with extremely high resolution.

1.05-GHz Frequency Range Extension SMDU-B3. This doubles the frequency range of the SMDU while maintaining its excellent characteristics.

1-GHz Frequency Meter SMDU-B4. This module is required for frequency measurements above 525 MHz. The overall range of the seven-digit frequency meter is then 15 Hz to 1 GHz with a resolution of 10 Hz at 1 GHz.

Overload Protection SMDU-B2. This module protects the RF attenuator and the output stage against inadvertent application of RF or DC voltages. This option is fitted as standard in the radiotelephone & navigation model.

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*) VOR: VHF Omnidirectional Range. A radio-navigation method employing phase comparison of two 30-Hz signals.

ILS: Instrument Landing System (blind approach) with azimuth and glide-path links, providing a line of intersection between two directional lobes at a 90-Hz and a 150-Hz amplitude-modulated carrier frequency.

The VOR/ILS Unit, which produces all signals required for VOR/ILS measurements and checks those provided by the signal generator, is available with and without decade DDM step switch. In conjunction with this switch, an extremely fine adjustment of all DDM values in steps of 0.001 is possible, permitting precise linearity measurements on ILS systems (category III).

Another variation is possible using the AM Unit which measures power and modulation depth and permits automatic switchover between transmitter and receiver measurements. If only FM RT equipment is to be checked out, the simpler and less expensive Power Test Adapter SMDU-Z2 can be used.

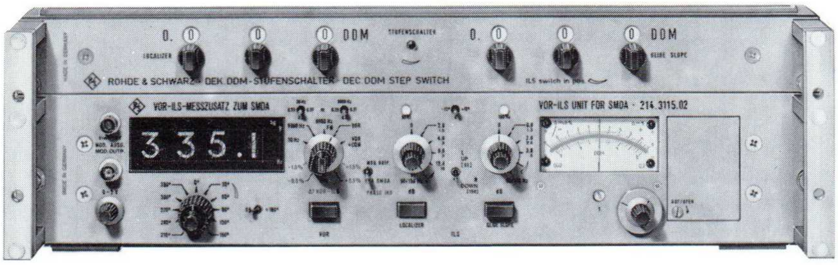
Characteristics of the test assembly for navigation measurements and modulation

- Suitable for all VOR and ILS test programs according to RTCA and ARINC
- VOR phase adjustable in steps and continuously from 0 to 360°
- Phase-angle indication in four digits and by indicator lamp with an accuracy of 0.05°
- DDM values separately adjustable for localizer and glide slope in standard steps of 0.001 DDM and continuously
- Expanded range for measurements around zero DDM; discrimination 0.001/scale division
- Modulation signal generation for measurements on marker receivers, radiotelephone systems and AF sections of VOR/ILS receivers (with signal tracing)
- Self-testing facility for the modulation characteristics, for modulation generator and monitor

Modes, modulation signals, indications

Mode	Signal	Simult. check M: meter C: counter	Light signal (range)	Signal modification *) "On" signalled by flashing lamps
VOR	30 Hz (variable phase)	M: % dev. from 30 % mod.	Δ mod. 5 %	*) 30 Hz with freq. variation by ±0.5 % and ±1.5 % steps *) ±25 % amplitude variation of 30-Hz and 9960-Hz components Ext. AM (0 to 10 kHz, up to 80 %) of mod. 9960-Hz subcarrier (interference simulation DVOR) Ext. AM (0 to 10 kHz, up to 80 %) for complete VOR signal Addition of external interference signals Fine modulation-depth adjustment
	9960 Hz (CW)	M: % dev. from 30 % mod. C: frequency	Δ mod. 5 % Hz	
	9960 Hz freq. mod. with 30 Hz (480 Hz deviation)	M: % dev. of freq. dev.	± dev. 5 %	
	VOR signal Phase setting: 30° steps and continuous; 180° switch	C: phase of signal	bg. φ	
	VOR sig. + communication sig. 1020 Hz	C: phase of signal	bg. φ	
ILS Localizer	90 Hz, 150 Hz } for left/right	M: % dev. from 20 % mod.	Δ mod. 5 %	*) 90 Hz and 150 Hz with freq. variation by ±0.5 % and ±1.5 % steps *) Phase relation of components switchable: −12/0/+12° (referred to 30 Hz) One component cut off (90 Hz or 150 Hz) Left/right switching (in localizer mode) Up/down switching (in glide slope mode) Addition of external interference signals Fine modulation-depth adjustment
	In steps: Points / DDM / dB 0 / 0 / 0	M: DDM	DDM 0.02	
	1.5 / 0.0465 / 2.0 3 / 0.093 / 4.0 5 / 0.155 / 6.57 10 / 0.310 / 12.39 Cont. 0 to 12.9 / 0 to 04	M: DDM	DDM 0.2	
	With Decade DDM Step Switch: in steps of 0.001 from 0.000 to 0.400 DDM	M: DDM	DDM 0.2	
ILS Glide slope	90 Hz, 150 Hz } for up/down	M: % dev. from 40 % mod.	Δ mod. 5 %	
	In steps: Points / DDM / dB 0 / 0	M: DDM	DDM 0.02	
	1.3 / 0.0455 / 0.99 2.6 / 0.091 / 1.97 5 / 0.175 / 3.76 Cont. 0 to 22.8 / 0 to 0.8	M: DDM	DDM 0.2	
	With Decade DDM Step Switch: in steps of 0.001 from 0.000 to 0.800 DDM	M: DDM	DDM 0.2	
Marker signal/ communication	All modulation frequencies continuously adjustable	Indication on modulation unit of signal generator		

Test Assembly for Airborne VOR/ILS and Communication Equipment (cont'd from page 71)



VOR/ILS Unit with
Decade DDM Step Switch

Measurements on air-navigation receivers

For testing VOR/ILS receivers, the RF carrier of the Signal Generator SMDU is amplitude-modulated with the signals which have been processed in the VOR/ILS Unit.

VOR signals

Two 30-Hz signals of mutually variable phase are produced in the generator section of the VOR/ILS Unit – reference signal (30 Hz) frequency-modulated upon 9960-Hz carrier.

Possibilities of setting the phase: 30° steps, continuously variable by > 30° and phase reversal (180°). The phase shift of the AF signals demodulated from the RF carrier is indicated by four numerical indicator tubes providing for a resolution of 0.03°. Controls are provided for adjusting the generation and output of the individual components allowing simultaneous measurement of the modulation depth, its variation or that of the components of the VOR signal as well as percentage variation of the modulation frequencies according to the requirements of standard specifications. Built-in modulators and adder inputs are provided for the simulation of interference.

ILS signals

The 90-Hz and 150-Hz ILS signals are derived in rigid phase relation from a 1800-Hz squarewave signal (see block diagram showing signal processing) by the action of a frequency divider and a wave converter.

The various depths of modulation are automatically set by switching the modes of operation between "localizer" or "glide slope". Standard DDM values can be set in each mode, intermediate values in position "continuous"

The Decade DDM Step Switch permits accurate adjustment of DDM values in steps of 0.001, the sum of the modulation depths of the signals remaining constant.

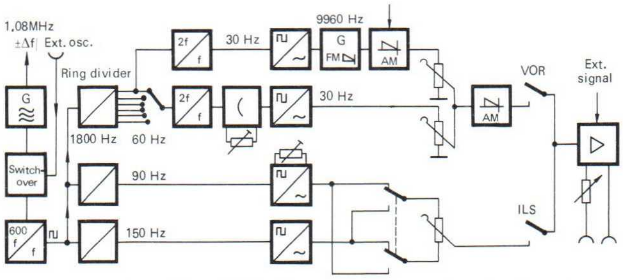
Separate controls are provided for blanking the individual components, for phase shift and changing the components in compliance with the requirements of the standard specifications.

According to the mode of operation selected, a meter displays either the modulation depth △mod. (0.2% per scale division, 5% fsd), the DDM zero (0.001 per scale division, 0.02 fsd) or the DDM values adjusted (0.01 per scale division, 0.2 fsd) of the demodulated RF signal.

The VOR/ILS Unit is equipped with a self-testing facility for checking its essential subassemblies.

Modulation signal processing

All modulation signals are derived from an oscillator which can be varied by ±0.5% and ±1.5%. The VOR signals (30-Hz reference and 30-Hz variable-phase) and the ILS signals of 90 Hz and 150 Hz are provided by separate frequency dividers.



Generator section of the VOR/ILS Unit; processing of modulation signals

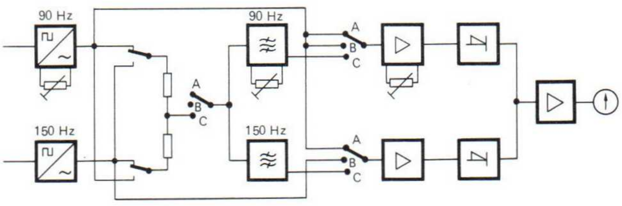
After conversion from squarewave to sinewave shape, the 30-Hz reference signal modulates the frequency of a 9960-Hz oscillator, while the variable signal is added to the reference signal after the squarewave-to-sinewave conversion.

The digitally processed 90-Hz and 150-Hz signals are also taken through a squarewave/sinewave converter and are added in a resistive network after the DDM divider. An output amplifier provides the appropriate signal level for the SMDU, the other AF output (continuous) is for general AF measurements.

Self-testing facility of the VOR/ILS Unit

By means of the built-in self-testing facility, the VOR/ILS Unit can be adjusted exactly to the rectified voltage of the signal generator (SMDU) and the measuring systems as well as their error limits checked.

The VOR phase meter is checked by connecting it to a point of zero reference phase in the generator section and adjusted, if required. The free-running 1.08-MHz signal can be compared with a 1.08-MHz crystal-oscillator frequency and subsequently adjusted.



Self-testing facility of the VOR/ILS Unit (ILS section)

The ILS signals can be adjusted as follows. In switch position A, the same signal is applied to both measuring channels to ensure identical gain setting. In position B, the 90-Hz and the 150-Hz signals are separately applied to the measuring channels and their amplitudes adjusted with respect to each other (to DDM zero). In position C, the insertion loss in the measuring paths can be checked and the differences compensated for.

Specifications

Frequency range	0.14 to 525 MHz; 0.14 to 1050 MHz using option SMDU-B3
Setting, indication	on drum scale, 7-digit readout (crystal 10 MHz, aging 5×10^{-8}/month)
Scale resolution	up to 50 MHz: 1 or 10 Hz; up to 800 MHz: 10 or 100 Hz; above 800 MHz: 0.1 or 1 kHz
Fine tuning using synchronizer option	
Steps corresponding to channel spacing	12.5/20/25/50/100/150 kHz
Tuning range	20 to 160 kHz
Frequency instability after warmup	
Free-running oscillator	< 1.5 to < 6 kHz for 0.14 to 1050 MHz
Using synchronizer	$<5\times10^{-8}$(+10 Hz for f ≧ 525 MHz)
Spectral purity	
Spurious frequencies	down > 110 dB (> 90 dB for 0.14 to 50 MHz and 392 to 525 MHz)
S/N ratio at 20 kHz from carrier, test band 1 Hz	> 135 dB (> 130 dB below 50, > 125 dB above 525 MHz)
Spurious AM	down > 80 dB
RF output I	Z_{out} = 50 Ω; N female connector, adaptable
Output EMF and power	0.05 µV to 2 V = −139 to +13 dBm
Frequency response, attenuator error	up to 500 MHz < ±1 dB; up to 1.05 GHz < ±2 dB
VSWR	< 1.2 (above 525 MHz: < 1.4)
RF overvoltage protection	automatically disconnects RF output
Max. permissible power	50 W (or 50 V DC)
RF output II (rear panel)	> 20 mV into 50 Ω (without AM)

Frequency meter/		
with option	15 Hz to 525 MHz /	0.5 to 1 GHz
Sensitivity	10 mV	30 mV
Resolution	1 Hz (10 Hz, above 20 MHz: 10 /100 Hz)	10 Hz (100 Hz)

Specifications for

	Navigation model	Radiotelephone navigation model
AF generator/modulation unit/measuring instruments		
Modulation frequencies	15 Hz to 150 kHz, continuous	0.3/0.4/1/2.7/3/6 kHz; 0.03 to 30 kHz cont.
Output voltage	5 mV to 1 V into 600 Ω	1 mV to 5 V into 200 Ω
Distortion	< 0.2 (0.5)%	< 0.5% (0.1 to 10 kHz)
Voltmeter ranges	10 mV to 3 V	10 mV to 10 V
Error limits	±(2% of rdg + 1.5% of fsd)	±(2% of rdg + 1.5% of fsd)
Rectifier response/weighting filter	average	rms/CCITT
Deviation meter, distortion meter, SINAD ratio meter, CCITT filter	see RT Test Assembly on page 69	

VOR/ILS modulation
VOR/ILS Unit

VOR modulation signal, consisting of:

30-Hz signal	
Fixed-frequency error limits	$\pm3\times10^{-4}$
Incremental tuning	±0.5% and ±1.5%
Distortion	< 0.5%
Phase shift between the 30-Hz signals	
in steps of	30°
continuously between steps	>30°
9960-Hz auxiliary carrier	
Frequency accuracy	$\pm2\times10^{-3}$
Frequency deviation	480 Hz
Distortion	< 1%
1020-Hz communication signal	
Frequency accuracy	±1.5%
Distortion	< 0.5%

ILS modulation signals

90-Hz and 150-Hz signals	
Frequency accuracy	$\pm3\times10^{-4}$
Incremental tuning	±0.5% and ±1.5%
Distortion	< 0.5%
Deviation of signal amplitudes at DDM 0	$<5\times10^{-4}$

Indicator section (measurement of demodulated generator signal)

VOR signals:	
Digital phase readout	four digits
Resolution	0.02°
Error	< 0.05°
Modulation-depth indication	for 30 Hz and 9960 Hz
Range	nominal value ±5%
Error	< 1%
Frequency-deviation indication	
Range	±5% (from nominal value)
Error	< 1%
ILS signals:	
Modulation-depth indication	for 90 Hz and 150 Hz
Range	nominal value ±5%
Error	< 0.5%
Analog indication of DDM values	
Ranges	0.02 and 0.2
Error	< 4% from DDM value + 2% of fsd
Resolution of indication per scale division (1.2 mm)	0.001 for zero DDM; 0.01 for remaining DDM values

VOR/ILS Unit with Decade DDM Step Switch

Sum of individual depths of modulation	constant
Error of steps	0.1%
Error of DDM steps via Signal Generator SMDU	
up to 0.175 DDM	< (2% of DDM value + 0.0005)
up to 0.310 DDM	< 3% of DDM value
for max. DDM value	approx. 5% of DDM value

Power measurement	SMDU-Z1	SMDU-Z1
Measurement ranges	0.05 to 0.3/1/3/10/30 W	0.1 to 0.6/2/6/20/60 W

Modulation measurement

Measurement ranges	0 to 40/100%	0 to 40/100%
Input power	0.1 to 30 W	0.2 to 60 W

General data

Nominal temperature range	+10 to +45 °C
Shelf temperature range	−40 to +70 °C
AC supply	115/125/220/235 V ±10% (130 to 160 VA)
Dimensions, weight	484 mm × 283 mm × 436 mm, 25 kg
Vibration test	in accordance with VDE 0411

Order designations for VOR/ILS Test Assemblies (please order units separately) ▶ Order No.

Signal Generator SMDU	
Navigation model	249.3011.08
Radiotelephone & navigation model	249.3011.07
VOR/ILS Unit	
with Decade DDM Step Switch	214.3115.10
without Decade DDM Step Switch	214.3115.02
AM Unit SMDU-Z1/30 W	242.2010.52
SMDU-Z1/60 W	242.2010.53

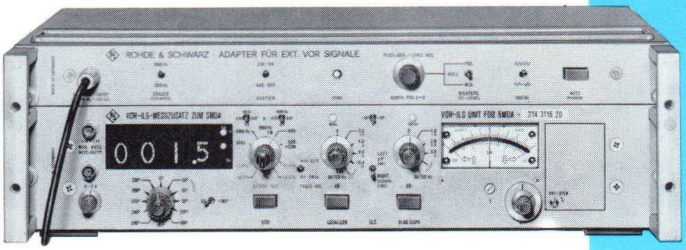
Options

SMDU-B1: Synchronizer	249.6340.02
SMDU-B2: Overload Protection	249.7346.02
SMDU-B3: 1.05-GHz Frequency Range Extension	249.9484.02
SMDU-B4: 1-GHz Frequency Meter	250.0012.02
SMDU-B5: 1.05-GHz Frequency Doubler	275.1312.02

Recommended accessories

Signal Generator SMDU, standard version	249.3011.02 (for two-signal measurements)
VOR Zero-phase Meter POR	242.0017.92 (data on page 75)
Precision AM Meter AMA	211.4010.52 (data on page 76)
Test Assembly for VOR Systems	214.3115.20 (data on page 74)

VOR Test Assembly



Test Assembly for VOR Systems

- Digital VOR phase indication with 0.05° resolution
- Selective frequency counter for 30-Hz, 9960-Hz and 1020-Hz signals
- Modulation depth meter for demodulated VOR signals
- Deviation meter for 9960-Hz subcarrier

Measuring capabilities

▷ Signal component measurement in VOR and DVOR ground stations during operation

▷ Measurements on monitors and checking of the alarm thresholds of the signal components and the keyable 1020-Hz identification signal

▷ Error location and signal tracing in AF subassemblies, converters and resolvers

▷ Checking and calibration of ramp testers

▷ Measurements on monitoring dipoles (detected signal)

Uses

The Test Assembly for VOR Systems is suitable for all measurements on VOR ground stations and the associated monitors. The built-in phase meter permits measurement of VOR signals and signal tracing in VOR receivers. The VOR signal components can be derived separately or combined from the signal generator section of the VOR/ILS Unit for measurements on AF subassemblies.

To perform all measurements necessary on VOR/ILS navigation and communication receivers, the Signal Generator SMDU and the Power Test Adapter SMDU-Z2 or the AM Unit SMDU-Z1 can be added to the Test Assembly for VOR Systems (see page 43).

Description

For **frequency and phase measurements** synchronization with the external 30-Hz VOR signal is provided, ensuring that the period of the clock frequency always corresponds exactly to 1/100 degree, independent of any fluctuations of the 30-Hz signals.

If the DC voltage component of the input signal is proportional to the detected RF voltage, departures of ±5% from the **nominal modulation depth** can be measured. Additional positive or negative DC voltage components can be compensated for in the test assembly. For measurements on VOR monitors, the 1020-Hz identification signal produced in the test assembly can be keyed at a repetition rate of 200 ms.

Specifications

Test input	BNC female connector
Voltage requirement without rectified voltage	0.24 to 2.4 V_{pp} VOR AF signal
Permissible DC component	±0.2 to ±2 V
Input impedance	100 kΩ
Permissible frequency variation of the 30-Hz component of the input signal	±2%
Phase meter	
Indication	4-digit readout plus signal lamp for 0.05° resolution
Error of indication	<0.1°
Indication of synchronization	by LED
Indication of modulation depth and frequency deviation (9960 Hz ±Δf)	on moving-coil meter with standard value at scale centre
Indicating range	±5% departure from standard value (m = 30%; frequency deviation = 480 Hz)
Error of indication for VOR signal components in AM measurements	depending on demodulation characteristic of rectifier used
Error of frequency deviation indication	< ±1%
Indication of frequency error of 30-Hz signal	4-digit readout
Resolution	1×10^{-4}
Gate time	0.01 s
Frequency indication 9960 and 1020 Hz	4-digit readout
Subcarrier	9960 Hz ±500 Hz
Identifying signal	1020 Hz ±150 Hz
Resolution	1 Hz
Gate time	1 s
VOR signal with identifying signal	
Identifying signal	can be keyed
Pulse repetition frequency	5 Hz
Pulse duration	100 ms

For more details on the VOR signal generator and the test assembly for airborne VOR/ILS and communication equipment see page 70, but

Amplitude variation of the 30-Hz and 9960-Hz components, switch-controlled	±15%, alarm thresholds for VOR ground stations according to Annex 10

General data

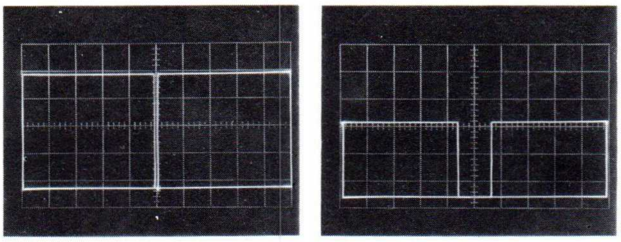
Nominal temperature range	+10 to +45 °C
Shelf temperature range	−45 to +70 °C
Power supply	115/125/220/235 V ±10% (47 to 440 Hz), 45 VA
Dimensions, weight	484 mm × 150 mm × 336 mm, 12 kg
Order designation	▶ Test Assembly for VOR Systems 214.3115.20
Accessories supplied	AF connecting cable 214.5718.00 (for connection of modulation output to AM input of SMDU) power cable 025.2365.00
Recommended extras	Signal Generator SMDU (page 43) VOR Zero-phase Meter POR 242.0017.92 (page 75)

POR

VOR Zero-phase Meter POR

- Resolution 0.01° in the most sensitive range
- Accuracy can be checked directly with an oscilloscope
- Deviation checking facility (display of modulation index)

The **POR** is a maintenance-free, high-sensitivity instrument for measuring the phase difference (up to 10°) between the variable and reference-phase components of a VOR signal and for checking the deviation of the VOR subcarrier. The VOR signal consists of the sum of a 30-Hz signal (variable component) and a 9960-Hz subcarrier which is frequency-modulated with a 30-Hz signal (reference component); the standard deviation of the subcarrier is 480 Hz corresponding to a modulation index of 16.



Output at test socket 2.
Left: correctly functioning instrument, the gap in the oscillogram is narrow; right: with a phase error of 0.017° in the 9960-Hz branch, the width of the gap in the oscillogram is 10% of the entire display width.

Uses

The precision zero-phase meter is suitable for use in the calibration laboratories of

- ▷ airline companies
- ▷ ATC authorities
- ▷ manufacturers of VOR transmitting and receiving equipment
- ▷ maintenance companies.

The zero-phase condition of VOR signals from sources such as VOR generators, ramp testers and VOR ground equipment can be measured with great accuracy. In addition, the POR is suitable for tracing signals in the subassemblies of VOR transmitting and receiving equipment. The phase of the test signal can be shifted +30° for checking the sense of phase rotation of resolvers and VOR generators.

In the deviation mode, the deviation of the VOR subcarrier is measured and the associated modulation index indicated.

The instrument is outstanding in its ease of operation: it is only necessary to perform a minimum setting with the input signal.

Self-testing

Two test sockets (test voltages) on the rear panel permit checking of the accuracy of the instrument using an oscilloscope.

Test socket 1 permits checking the effectiveness of the phase compensation section in the 30-Hz branch.

Test socket 2 enables display of the test voltage on an oscilloscope, the resolution being such that the highest possible resulting error is less than 0.01°; see oscillograms above.

Specifications

Phase indication		
Ranges	0.3°/1°/10°	
Resolution in 0.3° range	0.01°	
Amplitude controls		
coarse	ten-turn helipot	
fine	potentiometer	
Error of the zero phase in the 0.3° range	< 0.02°	
Indication error (phase measurement)		
0.3° range	< 10% of rdg ±1.5% of fsd	plus zero error
1° and 10° ranges	< 5% of rdg ±1.5% of fsd	plus zero error
Deviation indication		
Indication range	modulation index 0 to 20	
Indication of standard modulation index	mark at m = 16	
Indication error		
for m = 16, f = 30 Hz ±1% in the temp. range +20 to +30 °C	≦ 1%	
otherwise for f = 30 Hz ±1%	< 5% of rdg ±1.5% of fsd	
Test input	BNC female connector	
Level requirement	200 to 700 mV	
Input impedance	> 10 kΩ	
Maximum permissible DC component	5 V	
General data		
Nominal temperature range	+10 to +45 °C	
Shelf temperature range	−45 to +70 °C	
AC supply	115/125/220/235 V ±10% (47 to 440 Hz); 9 VA	
Dimensions, weight	484 mm × 105 mm × 336 mm, 8 kg	
Order designation	► VOR Zero-phase Meter POR 242.0017.92	
Recommended extras	1 RF connecting cable 100.6945.10 (for test input, BNC male connectors, 1 m long)	

AMA

Precision AM Meter AMA
♦ 50 to 350 MHz/0 to 100%

- Precise modulation-depth measurement for testing and calibration of navigation and measuring equipment
- Selective measurement of modulation-frequency fundamental with switch-selected bandpass filter
- Easy checking of inherent accuracy by means of simple instruments

The **Precision AM Meter AMA** performs modulation-depth measurements of highest precision, such as required for the calibration of communications, navigation and measuring equipment. Its own accuracy can be checked rapidly with the aid of relatively simple instruments, e.g. a digital voltmeter and AF generator. For the measurement, the AMA requires only a stable subcarrier, e.g. from a signal generator such as SMDA, SMDU or SMDS.

Uses

The Precision AM Meter finds **application** with

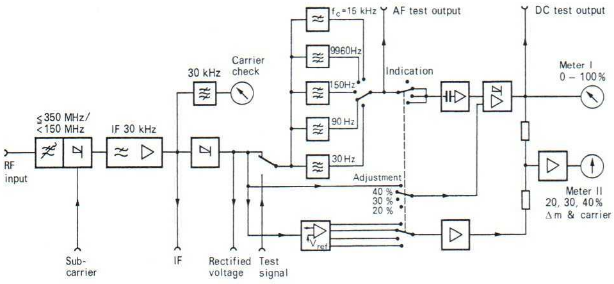
▷ calibration laboratories of airlines,

▷ ATC authorities,

▷ manufacturers of ILS and VOR transmitting/receiving equipment.

Wideband and selective measurement of modulation depth. Apart from wideband measurements at modulation frequencies up to 12 kHz, the AMA permits selective measurements at 30, 90, 150 and 9960 Hz, taking into account only the fundamental of the modulation frequency, as do the aeronautical receivers. Switch-selected bandpass filters with excellent stability of the transmission coefficient make it possible to determine modulation depth selectively even if several signal components are present, as in ILS and VOR systems. Interruptions in operation are thereby avoided and modulation depth is always measured correctly.

Indication, resolution. The unit has two panel meters, one indicating modulation depth from 0 to 100% and the other the deviation from the nominal depth of either 20, 30 or 40%.



Block diagram of Precision AM Meter AMA

With a measurement range of only ±2% very high resolution is here obtained. This analog indication enables the user to adjust equipment rapidly for nominal modulation.

Self-checking

The AMA has a DC output delivering a (rectified) voltage which is strictly proportional to the modulation depth. Relating to this the voltage present at the AF or DC test output, it is possible to calculate the modulation depth and to compare it with the indicated value, taking into account the transmission coefficient (which can also be checked). Further outputs make available typical voltages for performance checking so that any faults are reliably detected.

Specifications

Carrier frequency range	50 to 350 MHz	
Input requirement	5 to 10 mV	
Subcarrier (from signal generator)	test frequency ±30 kHz	
Voltage requirement	0.5 to 1.5 V into 50 Ω	
Modulation frequency range	10 Hz to 12 kHz	
Switch-selected bandpass filters	30, 90, 150, 9960 Hz	
Measurement range		
Meter I	0 to 100%	
Meter II		
Nominal modulation m	20, 30, 40% (mid-scale)	
Indication range Δm	±2%	
Error limits of indication		
Measurement range 0 to 98%	±(1% of rdg + 1.5% of fsd) for sinusoidal modulation with bandpass filters	
	30, 90, 150 Hz	9960 Hz
Measurement range		
18 to 22%	±0.1% m	±0.2% m
28 to 32%	±0.15% m	±0.3% m
38 to 42%	±0.2% m	±0.4% m
Ext. measurement with DVM and bandpass filter		
Mod. depth 18 to 42%	±0.25% of rdg	
Mod. depth 15 to 80%	±0.5% of rdg	
Permissible modulation distortion	10% (with bandpass)	
Permissible deviation of modulation frequency	±0.5% when measuring with bandpass	

General data

Nominal temperature range	+15 to +35 °C
Shelf temperature range	−40 to +70 °C
Power supply	115/125/220/235 V ±10%, 44 to 440 Hz (10 VA)
Dimensions, weight	484 mm × 105 mm × 336 mm, 7.5 kg

Order designation	▶ Precision AM Meter AMA 211.4010.52

Recommended signal sources for subcarrier

AM/FM Signal Generator SMDA	100.4559.04
Universal Signal Generator SMDU	249.3011.02
Signal Generator SMS	302.4012.02
Decade Frequency Generator SMDS	154.8723.52

Adjacent-channel Power Meter NKS
♦ 20 to 950 MHz

- Power test receiver complying with standard specifications
- Extends the SMDU RT Test Assemblies for the measurement of all RT system characteristics including adjacent-channel power
- Measurement of spurious signals and interference due to transients

NKS

new

The **Adjacent-channel Power Meter NKS** is used in conjunction with the SMDU RT Test Assembly to measure and evaluate all unwanted (power) spectral components of an RT transmitter in the adjacent channel.

The power-test-receiver technique used in the NKS determines the adjacent-channel power by means of an rms rectifier. This permits the total power to be measured and evaluated continuously and irrespective of the type of modulation. The NKS complies with all standard specifications for power test receivers.

Configuration of test assembly. Combined with the SMDU RT Test Assembly according to the block diagram on page 68, the Adjacent-channel Power Meter measures the interference in the adjacent channel and indicates the ratio of carrier power to unwanted power in dB in three digits.

Measurement of adjacent-channel power involves nothing more than selection of the desired channel spacing (10/12.5/20 or 25 kHz) and the upper or lower adjacent channel. An automatic test program provides digital indication of the ratio of carrier to unwanted signal. The absolute power of the interfering signal is calculated from the power indication on the SMDU-Z1 or -Z2 and the ratio shown on the NKS.

Another use of the NKS is the selective measurement of spurious signals. In the mode "store carrier" the level of the carrier is memorized. If the oscillator of the SMDU is then tuned to the frequency of the spurious signal, the ratio of carrier to unwanted signal is indicated in dB. The test assembly thus does the work of an analyzer with a dynamic range of 80 to 90 dB.

Measurement of adjacent-channel interference due to transients – until now performed only roughly with an analyzer – is now possible with the NKS. Thanks to the precise performance of the memory circuit of the NKS, such interference can now be measured accurately.

Description

The NKS converts the signal of the test item to an IF of 455 kHz ± channel spacing. The Signal Generator SMDU, with its high spectral purity, is used as an auxiliary oscillator. A control voltage, which permits automatic tuning of the frequency of the SMDU over a range of about 600 kHz, is derived from the IF of the NKS by a pulse discriminator.

For selection of the adjacent-channel power of a radio set, high-grade 455-kHz ceramic bandpass filters are used, ensuring the required carrier suppression and covering the bandwidths specified for the various channel spacings. In conjunction with the SMDU, the IF is adjusted via the control loop so that the adjacent channel being investigated is within the passband of the associated filter.

Specifications

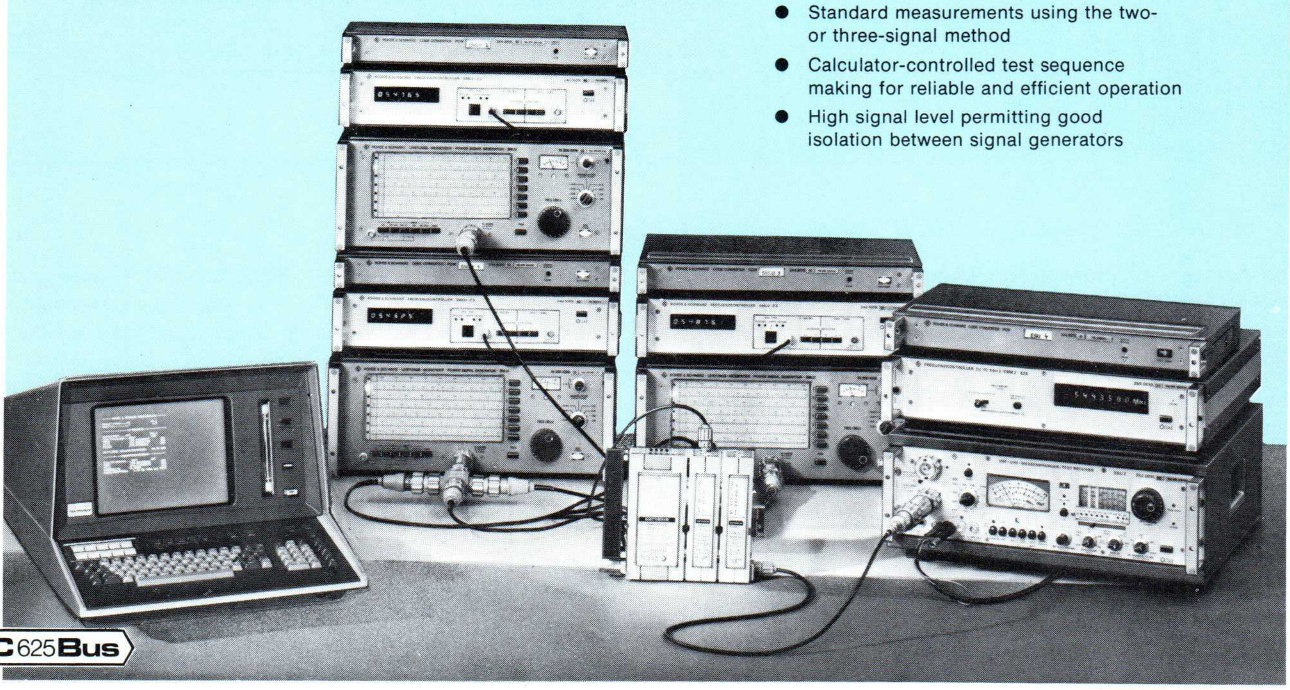
Frequency range	20 to 950 MHz
RF input	Z_{in} ≈50 Ω, BNC female connector
Input voltage range	0.1 to 2 V (max. permissible 5 V)
Input power range	
via SMDU-Z1 52 and Z2	0.1 to 30 W
via SMDU-Z1 53	0.2 to 60 W
LO input (rear)	Z_{in} ≈ 50 Ω, BNC female connector
Input voltage range	0.05 to 0.2 V matched to SMDU
IF output	BNC female connector (rear)
Frequency/output voltage	455 kHz/0.2 V into 50 Ω
Adjacent-channel power measurement	complies with CEPT and FTZ specifications
	channel spacing: 10 kHz – bandwidth 8.5 kHz; 12.5 kHz – 8.5 kHz; 20 kHz – 14 kHz; 25 kHz – 16 kHz
Selectable spacing from useful channel	±1 and ±2 channels
Indication	carrier-to-unwanted-power ratio in three digits
Measurement range	0 to 89.9 dB in 10-dB steps, error limits ±0.5 dB
Weighting	rms value (crest factor 10)
Indication error	±1 dB
Storage times	
Carrier frequency, normal operation	automatic resetting after 2 min
storage operation	±1 dB deviation after 15 min ±1 kHz deviation after 15 min
Measurement of transient behaviour	start delayed by 10 (±2) ms, duration 1 s
General data	
Nominal temperature range	+10 to +45 °C
Shelf temperature range	−40 to +70 °C
Power supply	115/125/220/235 V ±10%, 47 to 420 Hz (15 VA)
Dimensions, weight	492 mm × 78 mm × 434 mm, 5 kg
Order designation	▶ Adjacent-channel Power Meter NKS 302.2410.02

Accessories supplied
Connecting cables: LO input/SMDU RF output II
AFC/BCD outputs of SMDU
RF input/Frequency Meter SMDU-Z
Power cable

IM/CM Test Assembly

Automatic Test Assembly for Intermodulation and Crossmodulation Measurements
♦ 25 to 1000 MHz

- Standard measurements using the two- or three-signal method
- Calculator-controlled test sequence making for reliable and efficient operation
- High signal level permitting good isolation between signal generators



IEC 625 Bus

Definitions and test procedures for RF distortion

When processing and transmitting RF signals, intermodulation and crossmodulation products occur due to the nonlinearity in the characteristics of active and passive components. This distortion is defined as follows:

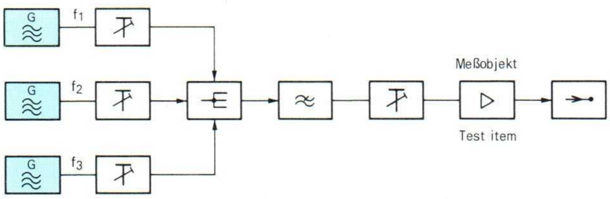
Intermodulation. If an input signal consists of several fundamental frequencies (e.g. picture carrier f_p, sound carrier f_s, colour subcarrier f_{sc}), unwanted combination frequencies are produced in the transmission channel ($f_{unwanted} = f_p + f_s - f_{sc}$) causing a moiré effect in the television picture.

Crossmodulation. Crossmodulation is the modulation of the useful signal by an unwanted transmitter signal.

Test procedures. The procedures for measuring the receiver characteristics with respect to these two types of unwanted modulation are practically identical and they are laid down in standard specifications, such as DIN 45 004 (test procedures for antenna amplifiers), VDE 0855, or IEC and ZVEI recommendations.

These standards and the relevant specifications require measurements using the **three-signal method** in which a composite input signal is produced by interconnecting three signal generators in CW operation.

In the alternative **two-signal method** the combination frequencies produced are outside of the TV channel so that this test method is suitable only for evaluating broadband amplifiers.



Principle of test setup for intermodulation and crossmodulation measurements using the three-signal method

The above-mentioned measurements require numerous, complicated operations and are time-consuming and expensive in the manual mode. If, however, modern calculator control is used, these tests can be performed in a few seconds and a hard-copy test report obtained.

Automatic test assembly

This automatic test assembly is used for standard measurements of intermodulation (DIN 45 004, method K) and crossmodulation (method B) suppression to 75 dB using the three-signal method. In addition, intermodulation measurements according to the two-signal method and gain and frequency-response measurements are possible.

Applications. The calculator-controlled RF test assembly permits saving of costs wherever frequent measurements of nonlinear distortion are to be performed on test items, such as

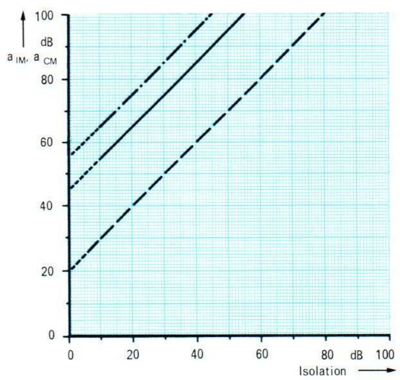
- ▷ channel amplifiers for centralized antenna systems
- ▷ wideband amplifiers for cable networks and CATV
- ▷ semiconductors and modules for amplifiers.

In addition to intermodulation measurements, other tasks can be easily solved using the appropriate instrument configuration, e.g. during the production of RF cables, filters, tuners or antennas.

Ease of measurement due to basic software – versatility. An automatic test assembly has a very wide range of application. The basic software – permitting control of the instruments integrated into the test system – is designed such that it can be used as the foundation for specific test programs. Thus, using the appropriate instruments, individual requirements can be met with a minimum of programming.

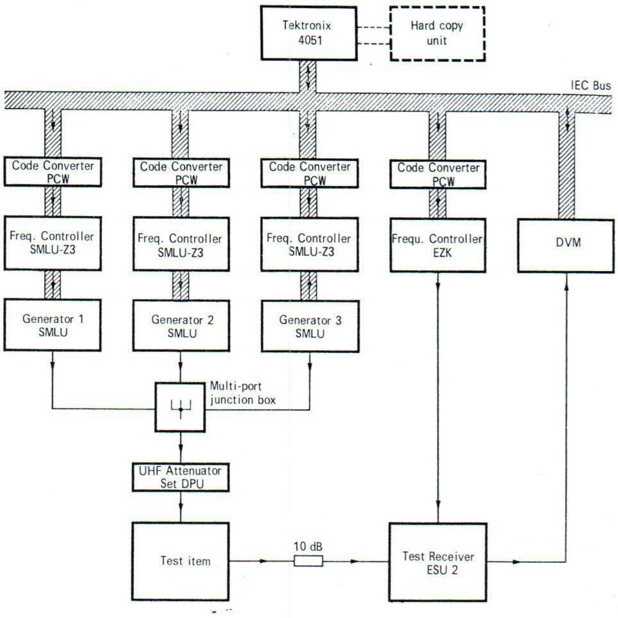
To measure for instance intermodulation, it is sufficient to enter the channel frequency and the desired output level. The calculator takes care of the rest in a few seconds: calculating and setting the correct frequency spacings and level ratios, setting the required output level, measuring the intermodulation product and calculating its relation to the sync peak.

Configuration – function. The nucleus of the test assembly for intermodulation and crossmodulation measurements is three or two (depending on the method used) Power Signal Generators SMLU covering the wide frequency range of 25 to 1000 MHz. The high output power level of up to 2 W permits a high degree of isolation between the generators so that their outputs do not interact. For residual intermodulation products down 80 dB, the level applied to the test item is still 115 dB(μV) (see diagram below). No external filters are required due to the good harmonics suppression of the SMLU of 40 dB.



Intermodulation and crossmodulation suppression a_{IM} and a_{CM} of SMLU as a function of isolation; **solid line:** three-signal IM suppression referred to sync peak; **dashed line:** two-signal IM suppression referred to carrier; **chain-dotted line:** CM suppression

A Frequency Controller SMLU-Z3, which is driven from the Tektronix 4051 desktop calculator, is used for programmed frequency setting of each signal generator. The Code Converters PCW establish the connection to the IEC bus and permit level programming. The selective VHF-UHF Test Receiver ESU 2 measures and indicates the unwanted products. Its frequency as well as the sensitivity switchover are programmed by the calculator via the Frequency Controller EZK and an additional PCW. The DVM converts the ESU 2 output DC voltage, which is proportional to the measured value, and applies the digital result to the calculator.



Block diagram of the Automatic RF Test Assembly for intermodulation and crossmodulation measurement

Specifications

(for specifications of the individual instruments see the corresponding type in the catalog)

Frequency range	25 to 1000 MHz
Frequency error	
with free-running SMLU	≦ ±2%
Frequency Controller SMLU-Z3	±10 kHz
Frequency resolution with SMLU-Z3	1 kHz or 10 kHz
SMLU output level	up to 595 MHz: +33 dBm (2 W) 10 V into 50 Ω
	up to 1000 MHz: +30 dBm (1 W) 7.07 V into 50 Ω
Attenuation of output power	
Signal Generator SMLU	coarse: 35 dB in 5-dB steps fine: 10 dB
UHF Attenuator Set DPU	0 to 140 dB in 1-dB steps; error ±0.05 to 1 dB
Measurement range of VHF-UHF Test Receiver ESU 2	−10 to +120 dB(μV)
Measurement error	≦±1 dB for V_{in} ≧ 1 μV
Frequency instability using Frequency Controller EZK	< 100 Hz
Frequency indication	7 digits
Program length using	
Tektronix 4051 calculator	12 kbyte
Basic software	2 kbyte
Storage capacity of magnetic-tape cartridge	256 kbyte
Print format	72 characters/line
Graphic display	19 cm × 14 cm

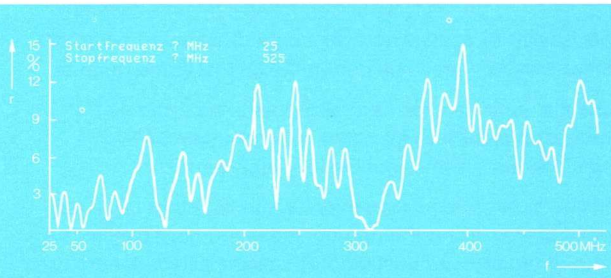
Order designations (order units separately)

Quantity	Designation	▶ Order No.
3 (2)	Power Signal Generator	SMLU 200.1009.03
3 (2)	Frequency Controller	SMLU-Z3 .. 242.5019.92
4 (3)	Code Converter	PCW 244.8015.92
3 (2)	Coding Board for SMLU	PCW-Z 245.2610.02
1	Coding Board for EZK	PCW-Z 291.1113.02
1	VHF-UHF Test Receiver	ESU 2 ..... 252.0010.55
1	Frequency Controller	EZK 255.0010.02
1	UHF Attenuator Set	DPU 100.8960.50
1	Four-Port Junction Box	DVU 4 ..... 201.4018.02
	Three-Port Junction Box	DVU 3 ..... 100.5203.50
5	Cable for IEC Bus (24-core)	PCK ...... see page 13
1	Desktop Calculator Tektronix	4051 (with options 04, 01, 100)
1	Digital Voltmeter	PM 2441 with IEC Bus Interface PM 9284, please order direct from Philips
1	Cable for IEC Bus (24/25-core)	SMPU-Z8 .. 216.0188.02
1	Cartridge (software) and System Description	SMLU-K2 .. 240.9800.02

CABLE Test Assembly

Automatic Test Assembly for RF Cables
♦ 25 to 1000 MHz

- Cable measurements in accordance with specifications of IEC 96-1 or DIN 47 250
- Automatic calculation of results from measured values
- Calculator-controlled test sequence, excluding operator errors



IEC 625 Bus

Definitions and test procedures for cable characteristics

For distortion-free signal transmission RF cables should exhibit certain characteristics whose determination is specified in IEC recommendation 96-1 and, with almost the same wording, in standard DIN 47 250. The following RF parameters are to be measured:

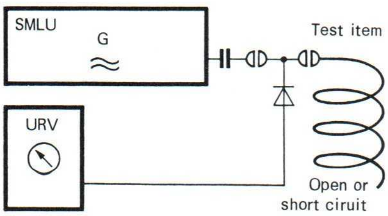
1. mean characteristic impedance
2. uniformity of impedance
3. attenuation.

All these measurements can be performed automatically using this test assembly. If the screening efficiency is also to be determined automatically, a programmable test receiver (e.g. ESU 2) has to be added to the setup. Since, however, this measurement is required only for type approval of braided cables, it depends on the individual case whether automatic determination is of advantage.

For determination of the mean characteristic impedance a cable of suitable length, with its free end open or shorted, is loosely coupled to a generator. The value is found from the frequency spacing of the resonance maxima determined by a frequency response measurement and the total cable capacitance.

For measuring the uniformity of impedance a reflectometer is used: the frequency is varied in steps or continuously and the reflection factor plotted as a frequency function on the connected display unit or recorder; see diagram. This measurement is used for locating frequency-dependent reflection which is caused by periodic imperfections distributed over the full cable length.

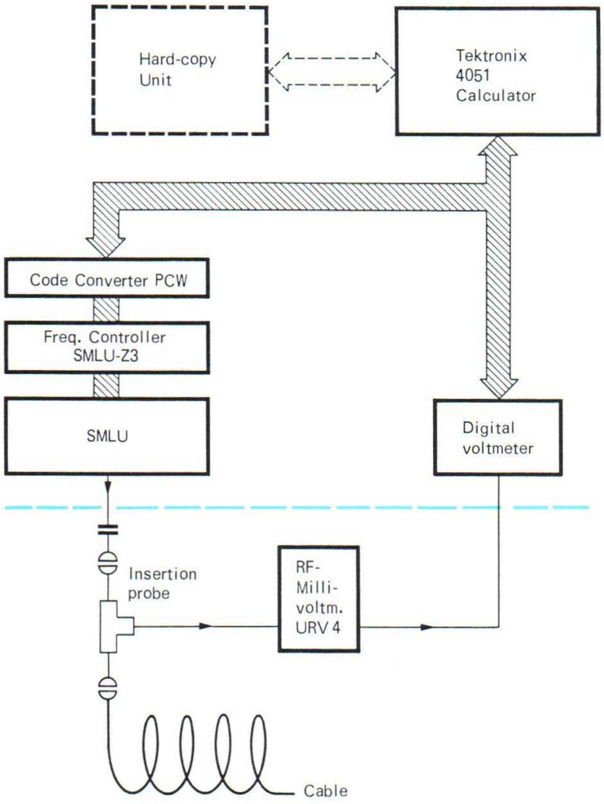
The attenuation can be determined by a two-port method – preferably for cables of higher attenuation – or from the width of the resonance peak. The resonance method is used to advantage for extremely low-loss cables or for lines whose far end is not accessible for a two-port measurement. The required test assembly corresponds to that for determining the mean characteristic impedance.



Test setup for cable resonance-frequency measurement

Automatic test assembly for RF cables

Control of the test sequence from a desktop calculator replaces the time-consuming manual checkout, permitting an advantageous combination of automatic measurement and calculation of results. It prevents wrong results due to operator or arithmetic errors and furnishes a neat, reproducible test report.

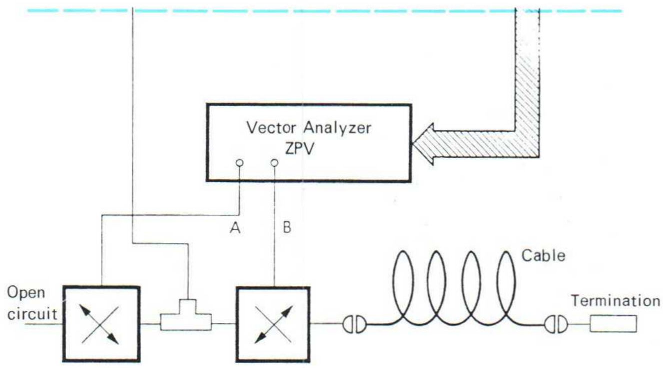


Block diagram of test assembly for RF cables

It contains a display which also permits graphic computing and uses the BASIC language. Thus program preparation and modification is very easy (see section 1).

The Vector Analyzer ZPV is used for measuring the reflection coefficient for evaluation of the uniformity of the characteristic impedance. The reflection coefficient is represented as a function of frequency on a display or recorder; frequency variation is in steps or continuous.

Extension of test assembly for RF cables by Vector Analyzer ZPV (e.g. for measuring impedance uniformity)



Versatility of application thanks to basic software

The basic programs required for driving the connected measuring instruments have been provided such that they also permit other measuring problems to be solved. The fundamental principle in determining cable characteristics is a frequency response measurement, thus programs for related tasks can be readily established in a similar way. The basic routines required for later extension of the test assembly by R&S instruments are already available so that a variety of different automatic measurements is possible over the entire frequency range up to 1000 MHz.

Configuration and function

The RF generator included in the automatic test assembly is the Power Signal Generator SMLU, which is particularly suitable for general use thanks to its wide frequency range (25 to 1000 MHz) and high output level (2 W). A frequency controller, which is driven from the desktop calculator, is used for programmed setting of the SMLU output frequency. For cable measurements, the high output power permits use of a wideband and thus easily operated meter. The RF Millivoltmeter URV 4 measures the resonance voltage at the cable end. The proportional output voltage of the millivoltmeter is applied via a digital voltmeter (A/D converter) to the calculator.

Control of the instruments and entry of the measured values into the calculator are carried out by way of the international-standard IEC bus, which enables ready interconnection of all measuring instruments fitted with this interface. The desktop calculator 4051 from Tektronix is available for controlling the test sequence.

Specifications

(for specs of individual instruments see corresponding type in catalog)

Frequency range	25 to 1000 MHz
Frequency resolution	10 kHz or 1 kHz
Frequency error	10 kHz or 1 kHz + timebase error
SMLU output level	up to 595 MHz: +33 dBm (2 W) up to 1000 MHz: +30 dBm (1 W)
Attenuation measurement range	39.5 dB in 0.5-dB steps
Meas. range of RF millivoltmeter	0.7 mV to 10 V
Measurement error	1.5% of rdg + freq.-resp. error (average: 1%; max. 15%)
Characteristic-impedance measurement	
Measurement error	±0.2% + error of capac. meas.
Attenuation measurement	
Measurement error	±0.2 dB
Control using Tektronix 4051 calculator	
Program length	12 kbyte
Basic software	2 kbyte
Print format	72 characters/line
Graphic display	19 cm × 14 cm

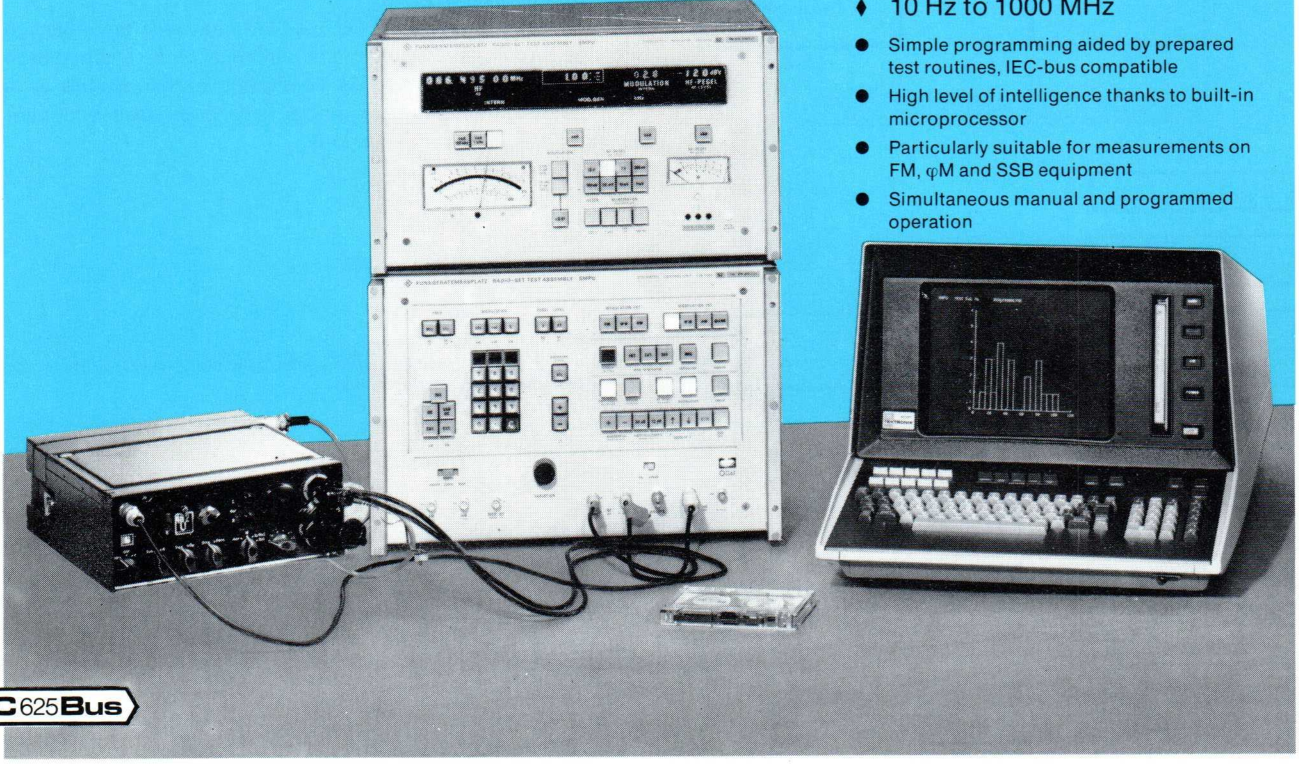
▶ **Order designations** of individual instruments

Control units, interface	
Tektronix Graphic Computing System 4051	
Cartridge (software) and System Description SMLU-K2	240.9800.02
Code Converter PCW	244.8015.92
Cable PCK for IEC Bus, 24-core	292.2013.10 (1 m long) 292.2013.20 (2 m long)
Signal generators	
Power Signal Generator SMLU	200.1009.03
Frequency Controller SMLU-Z3	242.5019.92
Coding Board for SMLU, PCW-Z	245.2610.02
Indicators	
Vector Analyzer ZPV	291.4012.92
Tuner ZPV-E2	292.0010.02
IEC-bus option ZPV-B1	292.3610.02
s-parameter option ZPV-B2	292.3810.02
Insertion Adapter ZPV-Z1 (2 req'd)	292.2713.50
Feed Unit ZPV-Z2	292.2913.50
Directional Coupler ZPV-Z3 (2 req'd)	292.3110.50
RF Millivoltmeter URV 4	292.5012.02
Digital voltmeter, e.g. Philips PM 2441 or Fluke 8500A	please order direct from supplier

SMPU

Automatic RF Test System SMPU
♦ 10 Hz to 1000 MHz

- Simple programming aided by prepared test routines, IEC-bus compatible
- High level of intelligence thanks to built-in microprocessor
- Particularly suitable for measurements on FM, φM and SSB equipment
- Simultaneous manual and programmed operation



The SMPU is the nucleus of a **fully automatic** general-purpose **RF test system.**

The system is ideal for testing transmitting/receiving equipment as well as RF and AF **modules** and components.

Basic configuration

The SMPU, which basically consists of the indicator (top, centre) and the control unit (bottom), includes the following measuring instruments, especially suitable for testing radiocommunication equipment:

synthesizer, 50 kHz to 500 (1000) MHz,
AF generator, 10 Hz to 100 kHz,
modulator for AM/FM/φM,
attenuator set up to 141 dB,
automatic frequency and phase deviation meter,
modulation depth meter (option),
RF frequency counter, 40 kHz to 500 (1000) MHz,
AF frequency counter, 50 Hz to 80 kHz,
AF level meter, 3 mV to 10 V,
distortion meter,
RF power meter up to 50 W,
CCITT weighting filter,
DC voltmeter (option).

These instruments are controlled by the built-in microprocessor, ensuring ease of operation, elimination of user errors and a high degree of automation even without the use of an external calculator.
For extension to a fully automatic system see page 84.

Characteristics, functioning

The SMPU finds application in development, production, quality control and servicing. Operation and programming are greatly facilitated by the built-in microprocessor. Every individual instrument can be addressed directly and therefore also be used separately.

The simplified operation becomes particularly evident when characteristics which cannot be measured directly have to be deduced from a number of individual readings by arithmetic operations. For this purpose, the SMPU stores complete test routines complying with CEPT specifications. Thus fully automatic measurement of, for instance, receiver sensitivity, receiver bandwidth, S/N ratio and squelch response is possible. By simply pressing the appropriate pushbutton the program is engaged and the final result is made available on a digital readout. The SMPU enables automation of the majority of standard test methods used for radiotelephone equipment.

Basic software packages containing programmed test routines are available for the expanded fully automatic test assembly (combination with desktop calculator; see page 84 ff.).

Data entry. All settings are digitally entered by means of pushbuttons and can be varied in analog form by a knob. In addition, the carrier frequency is adjustable in steps of any size corresponding, for instance, to the channel spacing. The SMPU displays the set data on a digital readout.

Mode selection. The different modes of operation of the SMPU are pushbutton-selected. These mode selectors are combined such that erroneous settings are corrected automatically. In general, only one button has to be pressed for each measurement. This applies in particular to automatic routines, which start after pressing the corresponding program button and run through until the test result is displayed.

Programming. All data and settings of the SMPU are programmed in ASCII in accordance with the IEC standard. When a command is executed, the corresponding button lights up on the SMPU.

In addition to the conventional modes MAN. and PROGR., a third mode, COMB., can be selected on the SMPU. In this case, programming and manual operation are possible at the same time. Thus, for instance, the channel frequency can first be programmed and then, for the actual measurement, be varied by hand or adjusted in steps corresponding to the channel spacings.

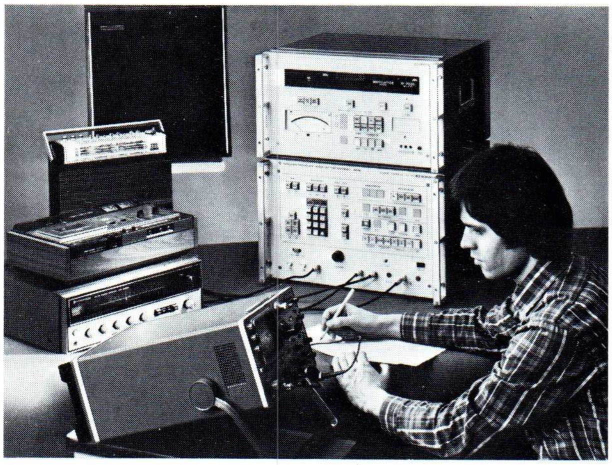
Self-testing facility. The RF and AF output frequency, AF output level and AF distortion as well as frequency modulation of the SMPU can be checked with the aid of a built-in testing facility.

Semi-automatic operation

The Card Reader PCL and the desktop calculator can be connected directly.

When a program card punched with the desired settings is inserted into the reader, the corresponding measurements are triggered, permitting reliable operation of the SMPU by unskilled staff.

A special advantage of the SMPU is that it can be programmed and manually operated at the same time. This enables proper coordination of the card-reader or computer control and the operator's decision.



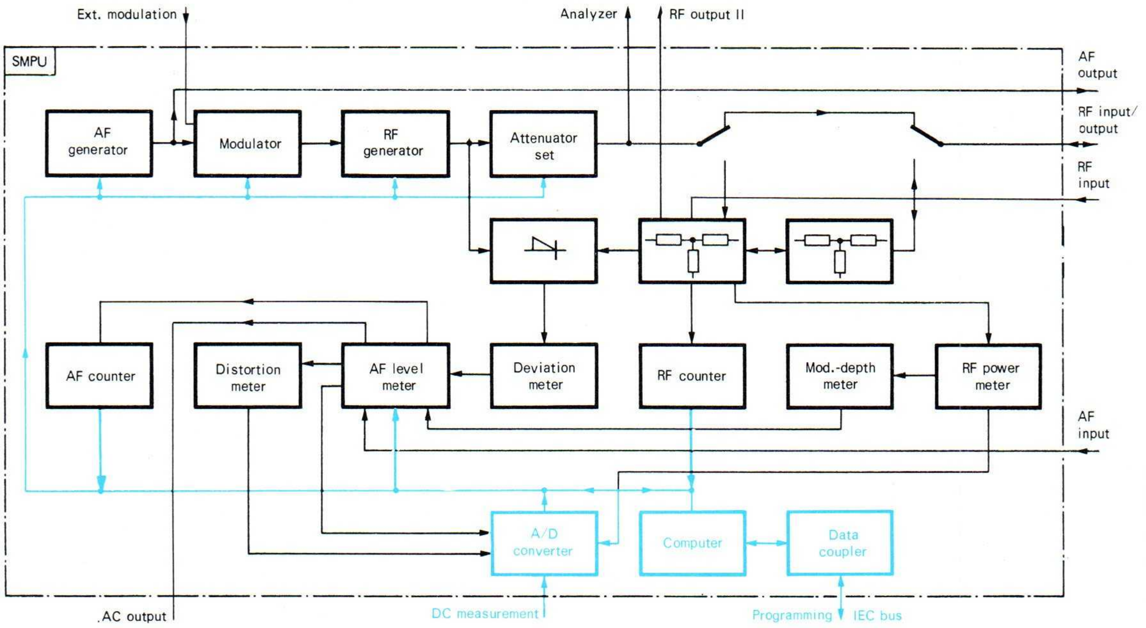
SMPU Receiver Test Assembly used for measuring a stereo receiving system

Receiver Test Assembly

For receiver measurements alone a special SMPU version is available. This Receiver Test Assembly does not contain the instruments for transmitter measurements (RF power meter, modulation meter, RF frequency counter, overload protection, analyzer output). For details see page 58.

The Receiver Test Assembly is particularly suitable for measurements on broadcast receivers but can also be used as a general-purpose RF signal generator.

Programming. The SMPU is fitted with an IEC-bus-compatible programming connector via which all SMPU functions can be remote-controlled and the measured values are made available. In this way, the SMPU can be directly connected to all IEC-bus-compatible control and measuring instruments (see section 1).



Simplified diagram of RT Test Assembly (black: basic configuration) **with extensions (blue)**

SMPU extension
to a fully automatic RF test assembly

If the SMPU is augmented by a computer, a fully automatic system, including data logging, for practically all RF measurements, is obtained.

The use of the IEC bus makes it possible to control the RF Test System by means of any IEC-bus compatible desktop calculator or microcomputer. Rohde & Schwarz recommend the 4051 Computing System from Tektronix (section 1) with **graphic capability**, which uses the worldwide accepted BASIC programming language.

In addition, the range of application of the RF Test System can be extended as desired by using other measuring instruments which are IEC-bus compatible; see diagram below and example on page 85. For instance, the Precision LF Generator SSN for producing crystal-controlled modulation frequencies and the Decade Frequency Generator SMDS or other BCD-programmable synthesizers for two-generator measurements can be connected via the Code Converter PCW. This combination can also be controlled from the Card Reader PCL, a desktop calculator or a minicomputer.

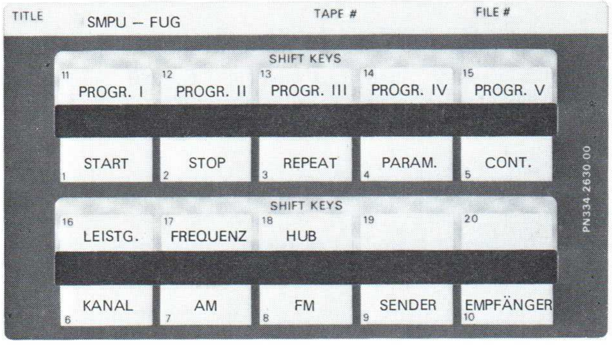
System control

The SMPU system is normally controlled by the Tektronix desktop computing system 4051. It can be programmed in three basically different ways:

1. Direct programming in **BASIC** language
2. Program prepared via **code numbers** with the aid of the basic software
3. Use of **dialog programs**.

The computer has an IEC-bus connection and can be connected directly to the measuring instruments. It is available with different storage capacities. The 8 k version is sufficient for simple test programs without using the basic software. Use of the basic software SMPU-K1, -K6 or -K7 requires a 24 k or 32 k store. The international BASIC language is used for programming.

Besides this it is possible to assign a group of computer keys to any particular functions. Special functions, such as repetition of measurement, single step, parameter predetermination, etc. and the selection of the test program can thus be initiated by pressing a button.

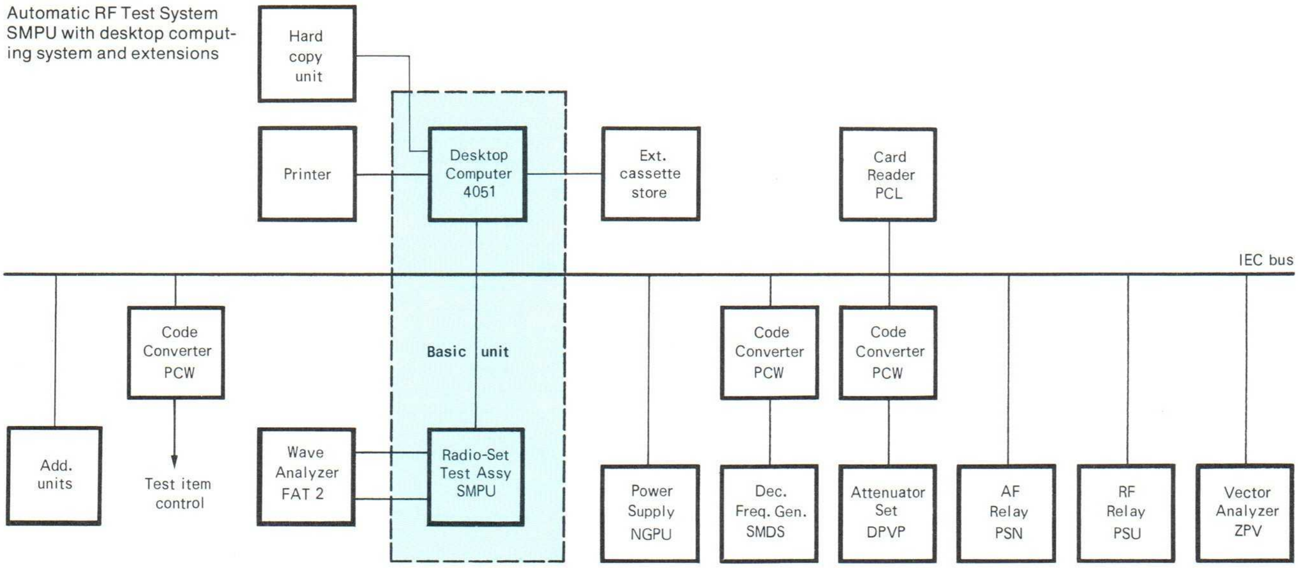


Overlay for the keyboard of the desktop computing system 4051

An overlay for the keyboard (photo above) is used to label the buttons clearly.

The **printer interface** (computing system option 10) permits any printer with V24 interface to be connected. The Tektronix **Hard-copy Unit 4631** provides direct copies of the screen display. Its use is recommended whenever a graphic plot is desired in addition to the printed data.

Automatic RF Test System SMPU with desktop computing system and extensions



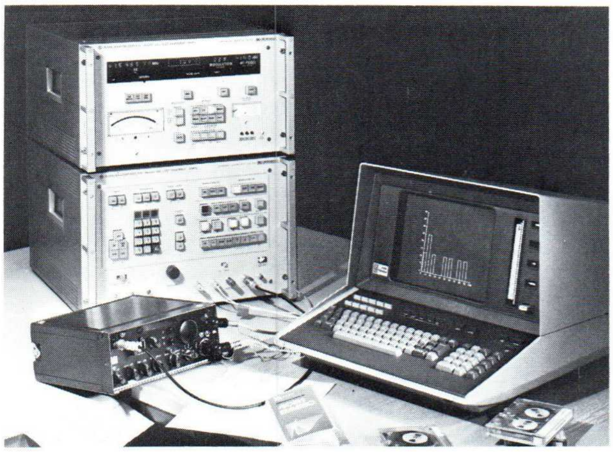
Applications

The way an SMPU system is put to use depends on the application.

In the field of servicing, the SMPU performs the initial and final inspections. Before beginning the repair work, the service man obtains a full picture of the defective item by an overall check of the equipment or module concerned. When the work is finished, another full check shows its result and possible effects on other characteristics. The satisfactory execution of the repair is documented by data logging. This is helpful in case of any later complaints.

Short test programs are available for goods-out wards inspection in production testing. Conceived for an optimum time-performance relationship, they are limited to checking the nominal characteristics and perhaps preparation of error statistics.

In the PC-board test department, the SMPU system not only measures the module characteristics; it may substantially reduce the testing time for each board since a dialog-mode error diagnosis is possible with the aid of test points on the boards and suitable test programs.



SMPU with desktop computer control and magnetic-tape cassettes (standard version for RT set servicing)

More measurements can be made on each test item when the SMPU system is used in quality control. The high measurement rate allows complete and objective testing of all items, which would be impossible with manual measurements.

Example: SMPU with Vector Analyzer ZPV

Measurement of reflection coefficient, matching and transmission factor

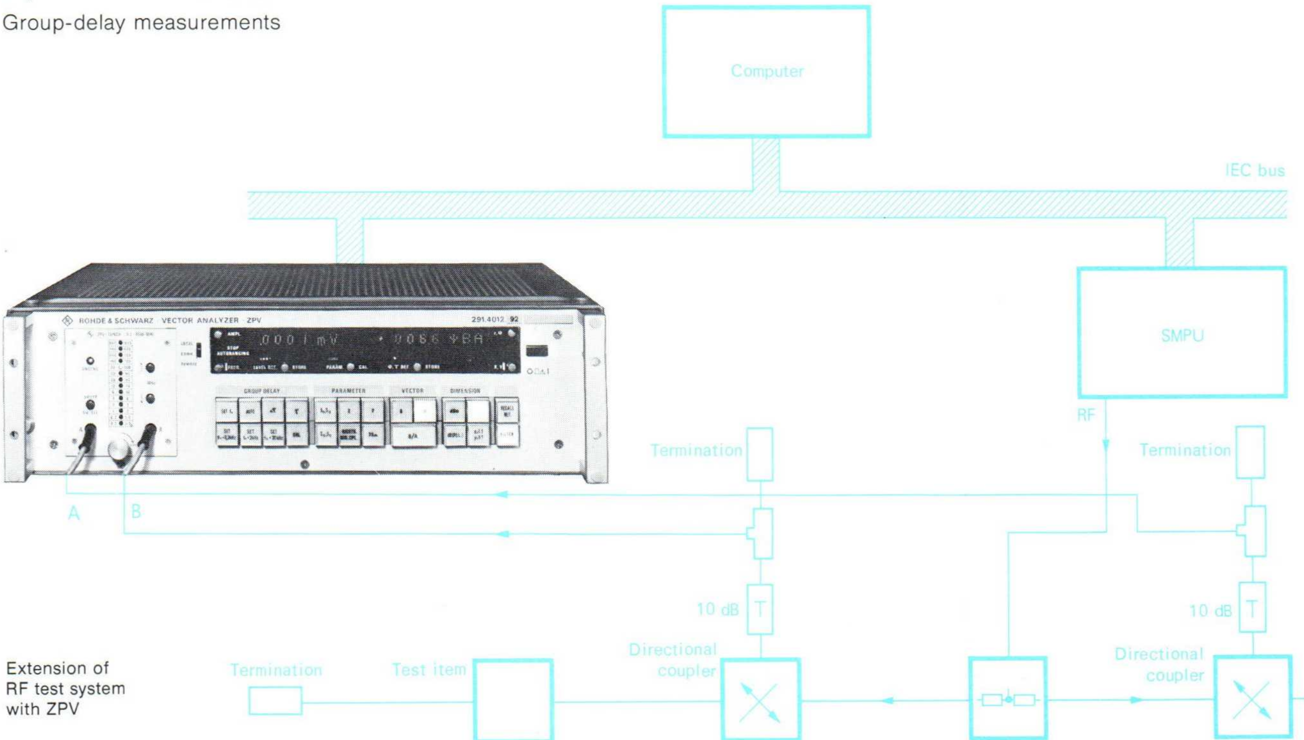
Measurement of phase response

Measurements on control loops

Selective voltage measurement with high sensitivity

Impedance measurements

Group-delay measurements



Extension of RF test system with ZPV

SMPU basic software

The purpose of software

Computer-controlled, automatic test systems facilitate the rapid and accurate execution of measurement sequences without any setting errors. Before operating such a system, however, it is necessary to prepare a test program, or **software,** which will cause the system to execute all the necessary settings and measurements. The preparation of such a program generally calls for pertinent knowledge and experience on the part of the programmer and requires a long time.

The use of basic software, made available by Rohde & Schwarz in the form of magnetic tape cartridges, brings many advantages. The basic software is a collection of ready-to-use test routines for the control of the test system from the Tektronix Computing System 4051.

Each test routine contains all the steps necessary for the execution of the measurement: setting the measuring instrument, input and output of data, changing of settings on the test item, computation of final results from several measured values. Output routines display the result on the screen of the calculator or generate a printout on a printer connected to the computer. The results are also compared with preset nominal values and an indication given if the tolerance limits are exceeded.

The user can, of course, extend the basic software by the addition of special routines. This permits non-standard problems to be solved.

Programming – no prior experience needed

Programming using the basic software involves nothing more than preparation of a user program in which the required test routines are called up with **code numbers.** In this way even complex measurement procedures can be programmed in a very short time.

The rationalizing effect is made obvious by way of an example. Routine 61 implements the measurement of an AF voltage between 1 mV and 10 V. The program needed without using the basic software is shown below:

```
2000 REM"MESSUNG NF-PEGEL"
2010 PRINT @15:"OX"
2020 INPUT @15:Y
2030 Z=INT(Y*0.1)
2040 B=Y-10*Z+32
2050 IF Z>1000 THEN 3000
2060 IF Z<250 THEN 3100
2070 Z=Z*1.0E-3*SQR(10↑(B-31))
2080 IMAGE FD.3D
2090 PRINT USING 2080:Z
2100 GO TO 2010
2110 END
3000 B=B+1
3010 Z$=CHR(B)
3020 PRINT @15:Z$
3030 FOR I=1 TO 100
3040 NEXT I
3050 GO TO 2010
3100 B=B-1
3110 GO TO 3010
```

Using basic software the statement GOSUB 61 suffices for the execution of the program shown opposite

Three different versions of the basic software

are available to the user of the SMPU:

SMPU-K1	for measurements on receivers and RT transceivers using AM, FM or φM
SMPU-K6	for measurements on AM and SSB (A3J) receivers and transceivers
SMPU-K7	for AF and RF tests (including swept-parameter measurements) on components and subassemblies.

SMPU-K1 Basic software for Tektronix 4051 Computing System

Measurements on: RT transceivers and receivers for AM, FM, φM

The basic software SMPU-K1 consists of test routines specially tailored to measurements on radiotelephones and receivers working with amplitude, frequency and phase modulation.

Test assembly configuration

The computer-controlled, automatic AM/FM test assembly can be operated in various configurations. The smallest system consists of the Automatic Radiotelephone Test Assembly SMPU in combination with the desktop Computing System 4051. This permits the most important measurements, such as modulation characteristics, receiver sensitivity, bandwidth and transmitter power to be carried out. Extended forms of the test assembly include the AF Wave Analyzer FAT 2, the Programmable Attenuator DPVP, an AF-DC Relay Matrix PSN and an RF Relay Matrix PSU. This configuration performs further measurements on the transmitter such as harmonics and spurious suppression plus adjacent-channel power. It is also possible to display the spectrum of the emission. The addition of the Programmable Power Supply NGPU permits programmed setting of the supply voltage and measurement of the power consumption of the test object.

An extract from the code number list is given below to show the rationalizing effect obtained through the basic software. The total list comprises about 100 test routines; only those for transmitter measurements are listed in detail:

		Code no.*
Test assembly configuration		92
Input data		1 to 17
Operating modes		19 to 27
Test-item control		31 to 33
Receiver measurements		41 to 60
Transmitter measurements		
RF power	W	68
RF frequency	MHz	69
Calling frequency	kHz	70
Positive modulation	kHz/rad/%	71
Positive call modulation	kHz/rad/%	72
Negative modulation	kHz/rad/%	73
Negative call modulation	kHz/rad/%	74
Spurious modulation (broadband)	Hz/mrad/‰	75
Spurious modulation (narrowband)	Hz/mrad/‰	76
Harmonic distortion at 1 kHz	%	77
Harmonic distortion at 300 Hz	%	78
Frequency response	dB	79
Wideband S/N ratio	dB	80
Weighted S/N ratio	dB	81
Modulation sensitivity	V	82
Analyzer measurements		35 to 40
Selective-calling measurements		24 to 30
AF measurements		61 to 67
Program control		83 to 91
Output of measured values		94 to 98

* For complete code number list see data sheet 240 651.

new

SMPU-K6

Basic software for Tektronix 4051 Computing System
Measurements on: AM and SSB transceivers and receivers

The basic software SMPU-K6 consists of test routines prepared specially for measurements on receivers and radiotelephones working with amplitude or single-sideband modulation.

Test assembly configuration

Several configurations are possible for this test assembly also. The smallest system consists of the SMPU with the 4051 desktop Computing System and the AF Wave Analyzer FAT 2. This allows all **receiver and transmitter measurements with single-tone modulation** to be carried out.

Adding the Precision LF Generator SSN, the Programmable Attenuator DPVP and the Relay Matrix PSU permits fully automatic measurements on transmitters with **two-tone modulation**.

Programmed setting of the supply voltage and measurement of the current drawn by the test item can be made by including the Programmable Power Supply NGPU in the test assembly.

Extract from the code number list for basic software SMPU-K6. The grouping for test assembly configuration, input data, etc. is similar to that of SMPU-K1 (page 86).

Operating modes		Code no.
Transmitter test		19
Receiver test		20
AM		21
Unmodulated		23
SSB/USB		29
SSB/LSB		30
AM external		26
Set control line		31
Clear control line		32
Control line 1 to 8		
Channel selection BCD		33
Receiver measurements		
Convert dBV to µV	dBV	41
SINAD sensitivity	kHz	43
SSB passband centre shift		46
Upper 6-dB point (relative)	kHz	47
Lower 6-dB point (relative)	kHz	48
Upper squelch limit	dBV	50
Lower squelch limit	dBV	51
AF frequency response	dB	52
S/N ratio	dB	53
SINAD ratio	dB	54
Image-frequency rejection	dB	55
IF rejection	dB	57
Interference immunity	dB	42
Y = interference frequency (MHz)		

new

SMPU-K7

Basic software for Tektronix 4051 Computing System
Measurements: AF and RF testing, module tests

The basic software SMPU-K7 makes the most of the measurement versatility offered by the individual instruments contained in the SMPU. It is ideal for module testing and for use in development, manufacturing and quality control. Complete programs for sweep measurements and graphic presentations can be prepared within minutes with the aid of graphic routines.

Test assembly configuration

The SMPU (page 82) together with the 4051 Computing System can form the minimum configuration for use with this basic software. Each of the matched instruments in the SMPU can be addressed individually by the SMPU-K7 routines. The following instruments can be operated merely by entering code numbers:

50-kHz-to-1000-MHz synthesizer with AM, FM and φM
0.3-mV-to-10-V AF millivoltmeter
50-Hz-to-1-GHz frequency counter
100-mW-to-50-W RF power meter
AM,FM and φM modulation meter.

Further IEC-bus-compatible measuring instruments can be added to the test assembly and the required control routines written into the space provided in the basic software SMPU-K7.

Extract from the code number list for basic software SMPU-K7; only the routines for graphic presentation are listed in detail (for complete code number list see data sheet 240 651).

	Code no.
RF generator input data	7 to 14
Operating modes	21 to 34
AF generator input data	15/17
Operating modes	35/37
AF voltmeter	41 to 45
Modulation meter	46 to 53
Distortion meter	54/55
RF counter	58/65
RF power meter	61
DC voltmeter	62/63
Nominal/actual comparison	67 to 74
Program control	1 to 6
Graphics	
Y1, Y2 = min./max. vertical	
X1, X2 = min./max. horizontal	
T$ = text	
X$, Y$ = unit on X/Y axis	
Diagram X/Y, lin/lin	92
Diagram X/Y, log/lin	93
Diagram X/Y, lin/log	94
Diagram X/Y, log/log	95
Additional vertical scaling	96
Sweep start	97
X1, X2 = starting/final value	
X3 = step size	
X4 = code number of independent variable (X axis)	
Y4 = code number of dependent variable (Y axis)	
Freely programmable test and setting routines	
Free space for routines prepared by user	75 to 90

Automatic RF Test System SMPU

Specifications

RF generator	0.05 to 500 MHz (1000 MHz)
Resolution of frequency setting	10 Hz (20 Hz)
Error limits	see crystal
Harmonics	down > 26 dB
Spurious signals	down > 86 dB (80 dB)
S/N ratio referred to 1 Hz bandwidth at ±20 kHz from signal	typ. 120 dB (114 dB between 500 and 1000 MHz)
Output level	0.05 µV to 0.5 V into 50 Ω
Source impedance	50 Ω, VSWR < 1.2 (for V < 0.1 V into 50 Ω)
Resolution of level setting	1 dB (0.1 dB with electronic control, switching time 42 ms)
Error limits	±1 dB (0.2 to 500 MHz), ±2 dB (at 1000 MHz)
Connection:	
Output 1 (on front panel)	N female connector
Output 2 (on rear panel)	BNC female connector

Crystal

Instability due to temperature effect	$<2\times10^{-9}/°C$
Warmup time of oscillator	max. 15 min
Aging	$<5\times10^{-8}$/month
External control	10 MHz; 0.5 V into 50 Ω

Modulation

Types	AM, FM, φM

Internal modulation generator

Frequency range	10 Hz to 99.9 kHz
Resolution of frequency setting	three decades
Error limits of frequency setting	±2% (10 Hz to 20 kHz), ±4% (20 to 99.9 kHz)
Distortion	< 1% (up to 20 kHz)
Output voltage	10 mV_{rms} to 7 V_{rms} EMF
Source impedance	50 Ω
Resolution of AF level setting	10 mV
Error limits of level setting	±2% ±1 mV (0 to 20 kHz)

Amplitude modulation (50 kHz to 500 MHz)

Modes	int. or ext. generator
Modulation depth	0 to 99%, resolution 1%
Frequency range	0 to 50 kHz
Envelope distortion at 90% modulation	≦3%
Level requirement for external AM	1 V_{rms}

Frequency modulation

Modes	int. or ext. generator; AC or DC coupling
Frequency deviation	0 to 99.9 kHz, resolution 100 Hz
Error limits of deviation setting	±4% ±10 Hz (f_{mod} = 1 kHz)
Flatness of frequency response	±3% (0 to 20 kHz), ±6% (20 to 100 kHz)
Modulation frequency range	20 Hz to 100 kHz (synchronized, AC) 0 to 100 kHz (not synchronized, DC)
Mod. distortion, int.	< 1%
ext.	< 0.1%
Incidental AM up to 20 kHz frequency deviation	< 1%
Level requirement for external FM	1 V_{rms}

Phase modulation

Modes	int. or ext. generator, AC or DC coupling
Phase deviation	0 to 10 rad, resolution 0.1 rad
Modulation frequency range	300 Hz to 6 kHz

RF overload protection	switches automatically to transmitter measurement when RF power is applied; P_{max} 50 W

Frequency measurement

RF frequency meter	
Range	40 kHz to 500 MHz (1000 MHz)
Sensitivity (minimum input level)	10 mV at f < 300 MHz 50 mV at f > 300 MHz
Maximum input level	3 V; at power test input 0.1 to 25 (50) W
Indication	8 digits, resolution 10 Hz
AF frequency meter	
Range	50 Hz to 80 kHz
Sensitivity (min. input level)	1 mV
Maximum input level	10 V
Indication	5 digits, resolution 1 Hz

Frequency deviation measurement (positive and negative deviation can be measured separately)

Frequency range	1 to 500 (1000) MHz (autom. tuning)
Sensitivity (minimum input level)	50 mV at f < 300 MHz 100 mV at f > 300 MHz
Maximum input level	3 V; range of power input 0.1 to 25 (50) W
Deviation ranges	5/20 kHz (useful deviation, peak value) 50/200 Hz (residual FM, rms value)
Modulation frequency range	50 Hz to 9 kHz without weighting filter, weighting filter according to CCITT
Indication, error limits	on mirror-scale meter; ±(1.5% of rdg + 1.5% of fs)
AF output level	1 V at fs

Phase deviation measurement

Phase deviation ranges	2/5 (useful deviation, peak value) 0.02/0.05 (residual φM, rms value)
Modulation frequency range	300 Hz to 6 kHz
Deterioration of frequency-response flatness	±2%

Modulation depth measurement (option)

Frequency range	1 to 1000 MHz
Ranges	0.3/30/100%
Error limits	±(3% of rdg ± 1.5% of fs) for power levels > 100 mW
AF output level	1 V at fs

AF level measurement (rms-responsive rectification)

Ranges (in 10-dB steps)	3/10/30/100/300 mV/1/3/10 V
Input impedance	10 kΩ
Indication	on meter with dB and V calibration
Error limits	±(3.5% of rdg + 1.5% of fs)
Frequency range	50 Hz to 20 kHz without weighting filter, weighting filter according to CCITT
Voltage at output MOD. AF	1 V_{rms} at fs

Power measurement

Ranges	0.25/2.5/25 W (0.5/5/50 W int. selectable)
Error limits	±(6% of rdg ±1.5% of fs)
Frequency range	1 to 1000 MHz

Distortion measurement

Test frequency	0.3 kHz/1 kHz
Indication; resolution	3 digits; 0.1%; range 0.1 to 99%
Minimum input level	100 mV
Error limits	±2% ±1 digit

DC voltage measurement (digital data output only; measurement time approx. 1 ms)

Measurement range	0 to 100 mV (0 to 5 V; internal range switching by changing soldered connections)
Resolution	0.1 mV (5 mV)
Error limits	±1% ±1 digit
Connector	BNC female, floating
Maximum common-mode voltage to chassis	±9 V

Digital voltmeter (option; data output only via digital output; measurement time approx. 1 ms)

Ranges	0.1/0.3/1/3/10/30/100 V
Input impedance	10 MΩ
Resolution	0.1% of fs
Error limits	±(0.3% of rdg + 0.3% of fs)

Analyzer output	0 to 1000 MHz, BNC female connector
Attenuation with respect to power input	26 ±1 dB (+ 3 dB at 50 W)
VSWR	< 1.2

Modes

Manual control	programming inhibited
Programmed operation	keyboard locked
Combined mode	simultaneous programmed and manual operation with override possibility

Programming and data output

Code	IEC-bus compatible (IEEE 488)
Transfer time	2 to 50 µs per character
Output time	approx. 250 µs per character

Resolution of data variation (knob or program command)

Frequency, RF	10 Hz/1 kHz/100 kHz
AF	3 digits
Level, RF	1 dB
AF	10 mV
Modulation depth	1%
Frequency deviation	100 Hz, phase deviation 0.1 rad

Fixed programs of SMPU

(fully automatic program sequence, pushbutton-selected)

Bandwidth – upper limit	measurement of frequency difference between upper 6-dB point and nominal frequency, taken at 10-dB noise attenuation
Measurement time	< 12 s
Indication, resolution	3 digits, 100 Hz
Bandwidth – lower limit	measurement as above, at lower 6-dB point
Sensitivity – 20 dB	input level measurement for 20-dB S/N ratio or SINAD ratio (switch-selected)
Measurement time	< 8 s
Indication, resolution	3 digits, 1 dBV
Sensitivity – 12 dB	input level measurement for 12-dB S/N ratio or SINAD ratio (switch-selected); measurement and indication as for 20 dB
Lower squelch response level	RF input level at which the squelch switches the AF off
Measurement time	< 10 s
Indication, resolution	3 digits, 0.1 dB
Upper squelch response level	RF input level at which the squelch switches the AF on
Measurement time	< 15 s
Indication, resolution	3 digits, 0.1 dB
S/N ratio	or SINAD ratio with previously set input level
Measurement time	< 0.5 s
Indication, resolution	3 digits, 0.1 to 0.4 dB

General data of SMPU

Nominal temperature range	+10 to +45 °C
Shelf temperature range	−20 to +70 °C
AC supply	115/125/220/235 V ±10%, 47 to 60 Hz (250 VA)
Overall dimensions (W × H × D)	Control unit: 484 mm × 328 mm × 509 mm Indicator: 484 mm × 283 mm × 509 mm
Weight	80 kg

Order designations (order items separately)

Test assembly .... ▶ Automatic RT Test Assembly SMPU

	Order no.
SMPU (50 kHz to 500 MHz)	239.0010.52
SMPU Receiver Test Assembly	239.0010.54
Option Modulation Depth Meter SMPU-Z1	240.0326.02
Option Navigation SMPU-Z3	240.6018.50
Option 1-GHz Generator Extension SMPU-B1	240.7014.02
Option 1-GHz Indicating Ranger Extension SMPU-B2	240.8010.02
Option Digital Voltmeter SMPU-B3	292.7015.02

For **accessories supplied** see below

Control equipment

Tektronix 4051 Computing System (with display)
- with 24-k memory capacity: option 21
- with 32-k memory capacity: option 22
- with printer control: option 10

Card reader PCL (for data input to SMPU)	248.6017.02
IEC-bus cable, 24-way PCK (1-m)	292.2013.10
PCK (2-m)	292.2013.20

Basic software for control with 4051 Computing System

SMPU-K1 (AM, FM, φM)	240.6518.02
SMPU-K6 (AM, SSB)	240.7215.02
SMPU-K7 (AF/RF testing)	240.7315.02

Dialog program

SMPU-K2, German	240.6618.02
SMPU-K3, English	240.6718.02
SMPU-K4, dialog copy	240.6818.02

Printer, Texas Instruments 755 RO
Hard-copy Unit Tektronix 4631, for plotting screen display

Accessories supplied

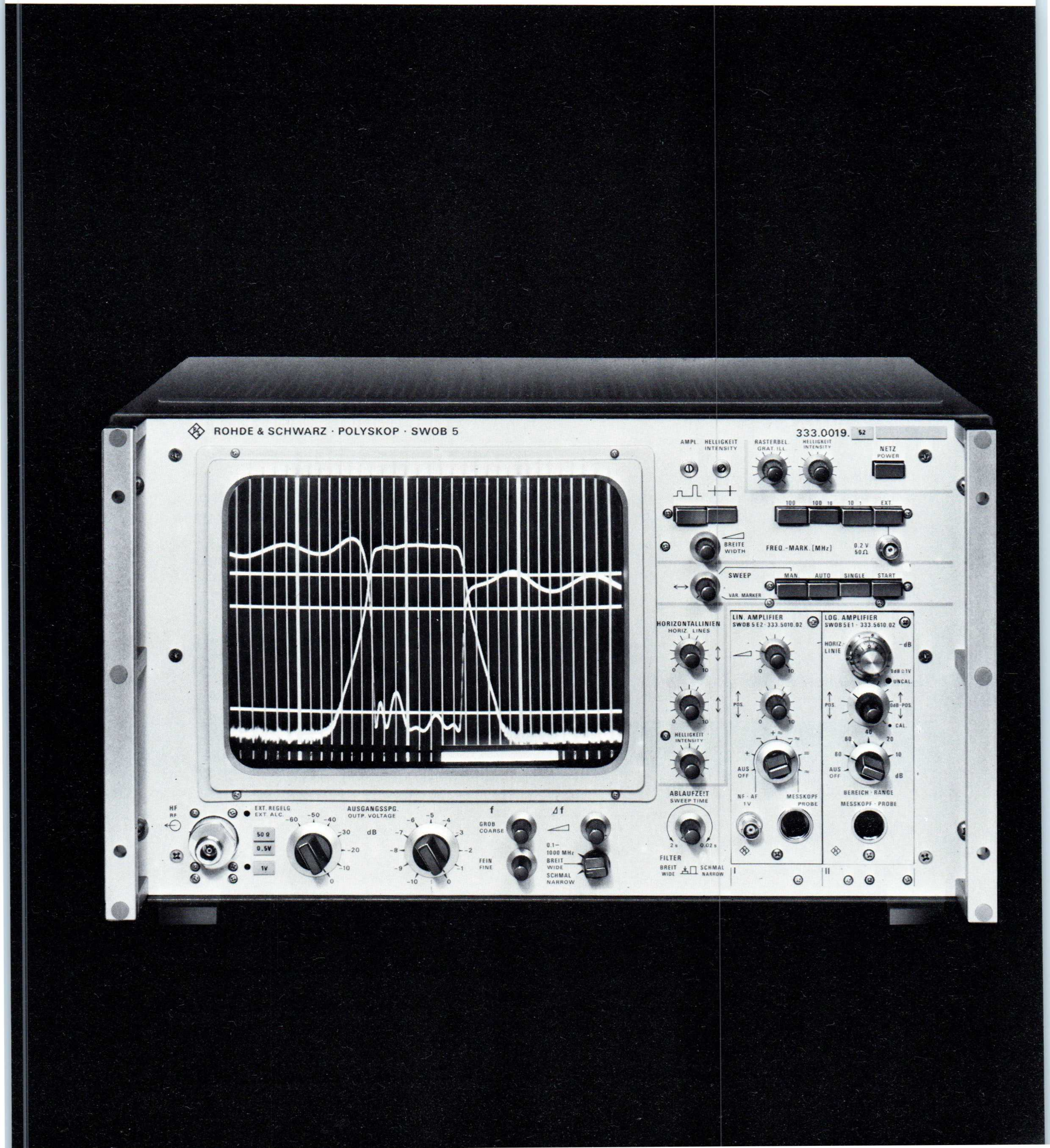
4 RF patch cords	239.0055.00	} for rear connections
1 RF cable	239.0084.00	
1 power cord	025.2365.00	
1 lamp extractor	239.4444.00	
1 male multipoint connector	018.6075.00	} for connection of external instruments
1 connector shell	018.6052.00	
1 50-Ω termination (BNC)	244.7677.00	for analyzer output
1 cable	239.9081.00	} for internal switch-over 25/50 W
1 cable	239.9098.00	

Extension measurement equipment

RF Relay Matrix PSU	290.8014.02	
AF Relay Matrix PSN	290.9210.02	
Code Converter PCW (for adaptation to IEC bus)	244.8015.92	+ PCW coding board
coding board for test-item control		245.2762.02
universal coding board (blank)		245.2910.02
Precision LF Generator SSN	204.8014.52	245.2710.02
Programmable Attenuator Set DPVP	214.8017.52	245.2510.02
Decade Signal Generator SMDW	103.9968.52	245.2810.02
Decade Frequency Generator SMDS	154.8723.52	245.2810.02
Wave Analyzer FAT 2: 5 to 500 MHz	100.8690.33 or	
0.2 to 200 MHz	100.8690.35	
Power Supply NGPU (70 V, 10 A)	192.0049.92	
Power Supply NGPU (70 V, 20 A)	192.0055.92	
VHF-UHF Test Receiver ESU 2	252.0010.55	291.1113.02
Vector Analyzer ZPV	292.4012.92	
Tuner ZPV-E2, 0.1 to 1000 MHz	292.0010.02	
Millivoltmeter URV 4	292.5012.03	

Sweep tester
Polyskop SWOB 5;
details on page 104

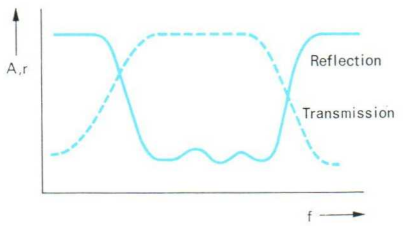
sweep testers
network analyzers



Rational measurements using sweep testers

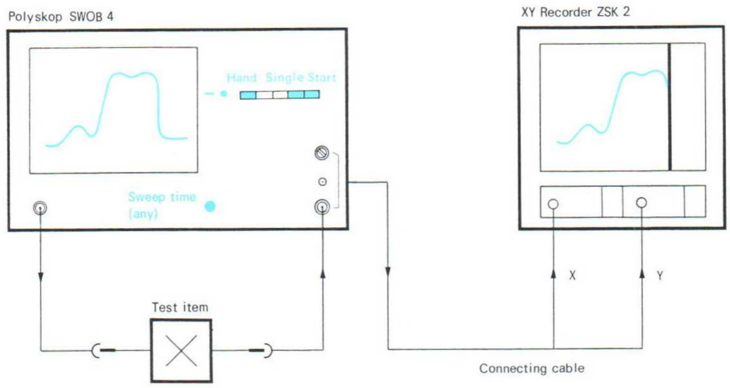
The increasing complexity of electronic circuits requires more accurate measurement results over ever wider frequency ranges. Swept-frequency measurements are a satisfactory solution which can also be applied to rationalized test methods. At present this is probably the most important and largest field of RF measuring technology.

The **advantages** are obvious: automatic curve display considerably reduces the measuring time, i.e. no variation of the characteristic occurs during the test procedure; as against point-by-point measurement, rapid variations of the measured values (dips) are evident. Moreover, the effects of interventions, such as alignment work, are discernible simultaneously and immediately even for several parameters over the entire range of interest.



Simultaneous display of two parameters

Even if computer-controlled point-by-point measurement is increasingly offered as an alternative, this technique cannot be used for a rapid overview or for continuous display of the variations occurring during alignment. However, with swept-frequency measurements, even the advantage of protocolling need not be sacrificed; see the setup below using Polyskop SWOB 4.



Logging of test results in single sweep (sweep time about 30 s) using XY Recorder ZSK 2

Compact sweep assemblies combining the sweep generator, display and marker generator in one unit permit particularly economic and easy-to-use test setup configurations. This holds for all instruments of the Polyskop series described here; see also page after next under configuration of sweep testers.

In addition to the compact test assemblies described on the following pages and to the swept-frequency test equipment listed in the table, the Rohde & Schwarz line offers a number of signal generators and measuring instruments for various applications which include or can be equipped with a swept-frequency capability, for example

Signal Generator	SMDU	0.14 to 1000 MHz	page 40
Vector Analyzer	ZPV	0.1 to 2000 MHz	page 110

Sweep generators and sweep assemblies (overview)

Frequency Range	Designation	Type	Order No. (complete No. see text)	Subranges	Sweep width	Sweep frequency Sweep time	Output EMF
0.1 to 40 MHz	Sweep Generator	SMLH/ SMLU-Z	283.8070 ...	2 (1)	entire range	10 ms to 1 s 2 to 200 s	1 V (10 V) −133 to +33 dBm
0.1 to 130 MHz	Sweep Generator	SMUV/ SMLU-Z	301.0120 ...	3 (1)	entire range	10 ms to 1 s 2 to 200 s	1 V (10 V) −133 to +33 dBm
25 to 1000 MHz	Power Sweep Generator	SMLU/ SMLU-Z	200.1009 ...	7 (1)	entire range	10 ms to 1 s 2 to 200 s	10 (7) V into 50 Ω −13 to +33 dBm
0.02 to 1250 MHz	Polyskop	SWOB 3	104.5050 ...	10	0.05 to 100% of subrange	20 ms to 10 s and manual control sawtooth	300 µV to 1 V
0.1 to 1000 MHz	Polyskop	SWOB 4	289.0013 ...	1	wide/narrow 5 to 1000 MHz 0.15 to 30 MHz	20 ms to 2 s and manual control sawtooth	300 µV to 1 V
0.1 to 1000 MHz	Polyskop	SWOB 5	333.0019 ...	1	wide/narrow 5 to 1000 MHz 0.3 to 50 MHz	20 ms to 2 s and manual control sawtooth	300 µV to 1 (2) V

Applications of RF swept-frequency measurements

Division into different application groups gives a better overview of the wide field in which swept-frequency measurements can be used to advantage. Essentially there are three groups which are determined by the tasks to be solved and the parameters to be measured:

- measurement on two- and four-terminal networks to determine the reflection and transmission characteristics by magnitude
- measurement on two- and four-terminal networks to determine the reflection and transmission characteristics by magnitude and phase (network analyzers)
- measurement or examination of generator signals with the aid of scanning receivers (spectrum analyzers)

The following text deals only with sweep assemblies used for the first group of measurements (for the second group see page 110 ff. and for the third group section 7). The first group is divided into wideband and narrowband swept-frequency measurements.

Wideband swept-frequency measurements

In wideband swept-frequency measurements a large bandwidth, high spectral purity (harmonics and spuria), excellent amplitude stability, a low output reflection factor and a precise output-voltage divider are of primary importance for the generator. The possibility of switching over different preprogrammable generator settings, such as sweep width and frequency, at the push of a button is a desirable feature for use of the equipment in production and quality control.

For the display, a high sensitivity and wide dynamic range, flat frequency response, simultaneous display of several curves and the largest possible screen – in particular for use in production – are required. If the advantages of swept-frequency measurements are to be fully used, it is essential to have clear, easy-to-discern frequency markers permitting satisfactory reading even on steep and noisy filter edges; moreover, when examining mixer configurations and tuners, suppression of an unwanted signal occurring at the test-item output due to the mixer should be possible during the return sweep.

The present, advanced state of thin-film and thick-film technology permits the construction of amplifiers featuring an almost flat amplitude-frequency response and good input and output matching over very wide ranges. Only modern sweep testers meeting the above requirements enable measurements on these modules.

Narrowband swept-frequency measurements

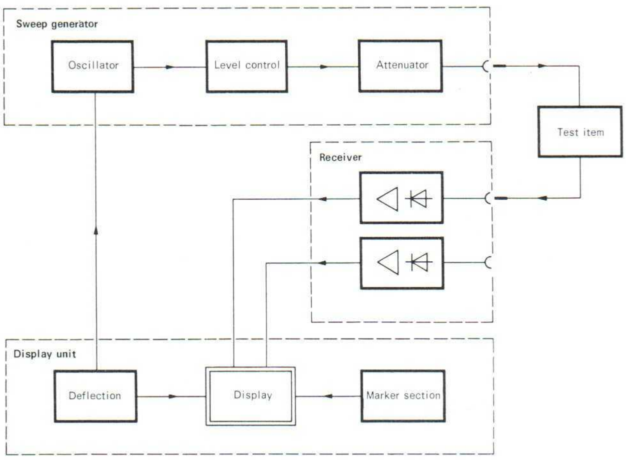
In narrowband swept-frequency measurements, in particular the spectral purity of the generator close to the carrier should be very high since the test items are mainly sharp-cutoff filters, especially crystal filters. To cover the high stopband attenuation of such filters, a wide dynamic range is required for the indicator, necessitating highly selective tracking receivers.

Assembly for	Voltage required for full picture height RF	Frequency-response flatness in swept operation	Internal frequency markers	Size in mm (W × H × D)	Text on page
50 Ω	(0 to +10 V)	<±2.5 dB	adjustable over entire range	492 × 290 × 514	33
50 Ω	(0 to +10 V)	<±1 dB	adjustable over entire range	492 × 290 × 514	36
50 Ω		≦ ± 0.8 dB	adjustable over entire range	484 × 260 × 436	53
50 Ω 60 Ω 75 Ω	50 mV lin + log 5 mV to 5 V	EMF: ≦ 0.3 dB in subrange V_{out}: ≦ 0.5 dB in subrange ≦ 1 dB (0.1 to 1000 MHz)	1/10/100 MHz	484 × 372 × 425	96
50 Ω 60 Ω 75 Ω	<25 mV	V_{out}: <±0.5 dB	1/10/100 MHz	484 × 328 × 436	102
50 Ω 60 Ω 75 Ω		V_{out}: <±0.5 dB	1/10/100 MHz	484 × 328 × 436	104

Configuration of sweep testers

Sweep testers determining by magnitude the quantity to be measured are used everywhere, however, especially in production and test departments since there normally only the magnitude of reflection coefficients and transmission factors is of interest. When aligning to minimum or optimum values, complex evaluation is also not required in most cases, but a convenient and easy-to-use test setup is essential.

The simplest type of sweep tester comprises a sweep generator, a diode detector and, as the display unit, an oscilloscope whose horizontal deflection is driven from the generator. Compact sweepers are available for frequencies up to 1 GHz, the sweep generator, indicator and display section being combined in one set.



Block diagram of sweep generator test assembly, e.g. SWOB 4

Such a compact sweeper has the following advantages: ease of operation since setting the sweep separately on the generator and on the display is not necessary and interconnections between the individual units are not required; high indication sensitivity since special amplifiers matched to the measuring head are used permitting also logarithmic display; display sections matched to the special requirements of sweeping and enabling several test curves, reference lines and frequency markers (vertical-line markers) to be inserted simultaneously.

Extension of sweep testers

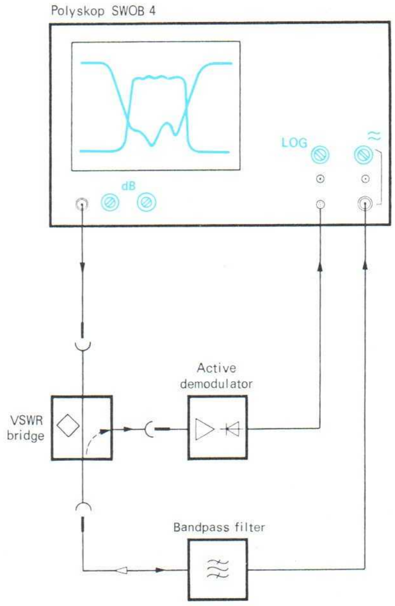
Accessories are required to make full use of the swept-frequency measurement capability. Directional couplers or VSWR bridges are available for measuring standing-wave ratios or reflection. While a directional coupler is not to be recommended for wideband measurements since it has a frequency-dependent coupling attenuation, the VSWR bridge with its flat frequency response is especially suitable for this purpose.

If the voltage curves at the input and output of a test item are to be observed simultaneously or the input voltage applied to the test item is to be displayed along with the reflection coefficient, insertion heads are required. These units consist of a certain length of coaxial line, the voltage being measured across the inner conductor.

Another possibility of extending a compact sweep tester is to use an active demodulator which considerably increases the measuring sensitivity. Demodulators of this type consist of a wideband preamplifier with low input reflection and an extremely flat frequency response plus a detector circuit at the amplifier output.

Wideband sweep tester

As has been mentioned above, the main application of sweep testers which measure quantities by magnitude is the display of the amplitude response and of the VSWR or return loss as a function of frequency. The test setup used in the example below consists of a compact Rohde & Schwarz sweeper – SWOB 4 (frequency range 0.1 to 1000 MHz), a VSWR bridge and an active demodulator. The test item is a bandpass filter.



Wideband sweep tester 0.1 to 1000 MHz

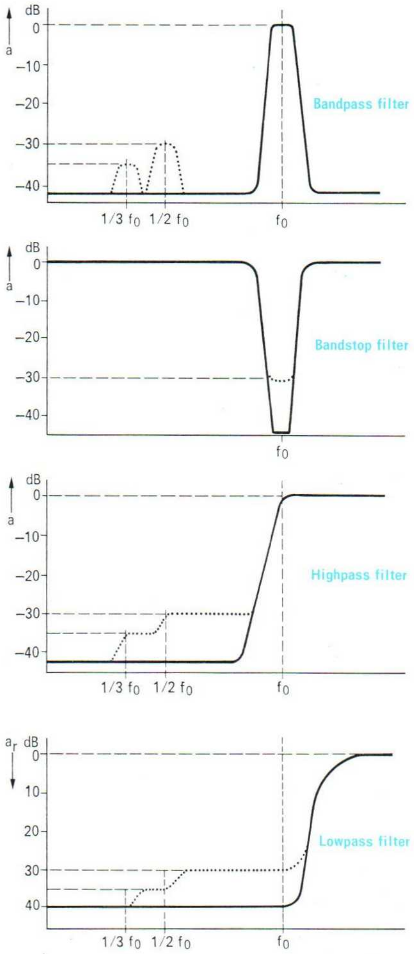
The sweep generator voltage is applied to the VSWR bridge. The item under test is connected to the test output of the bridge, the test-item output being taken directly to the RF input of the sweep generator so that measurement of the voltage after the test item is possible with the correct termination. The voltage reflected at the filter input is measured via the bridge output with the aid of the Active Demodulator SWOB 4-Z.

Since the VSWR bridge has an attenuation of 6 dB between the test voltage input and the test item connector, a filter attenuation of 42 dB can still be displayed with a generator output of 0.5 V and a display input sensitivity of 2 mV.

Measurement error in wideband sweeping

caused by harmonics and spuria

Wideband detectors are almost exclusively used in sweep testers which measure quantities by magnitude; for this reason errors may occur especially when measuring filters if the suppression of harmonics and spuria in the sweep signal is lower than the stopband attenuation or return loss to be measured; see the following examples:



Bandpass filter. When reaching an integral submultiple of the passband frequency, the corresponding harmonics are allowed to pass through the filter and are evaluated. Below the passband, apparent attenuation dips are produced. The difference between the peak attenuation of these dips and the true passband attenuation of the filter corresponds to the suppression of the related harmonic.

Bandstop filter. When passing through the stopband, all harmonics are evaluated simultaneously since they fall into the passband. This simulates too low a stopband attenuation. The maximum measurable stopband attenuation corresponds to the harmonics suppression at the stop frequency.

Highpass filter. While the fundamental passes through the stopband, the harmonics consecutively fall into the passband and are evaluated. A stepped stopband attenuation is displayed decreasing in accordance with the harmonics present; the difference between each point on the step curve and the amplitude in the passband corresponds to the suppression of the related harmonic.

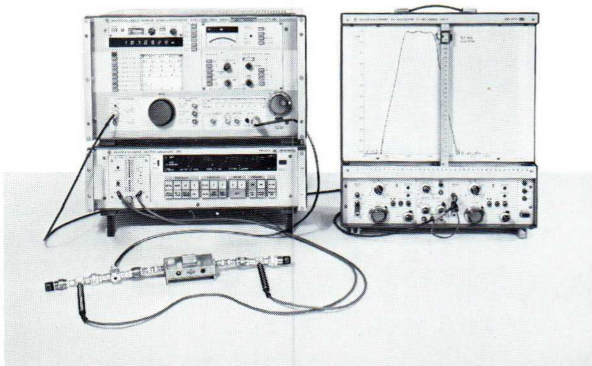
Lowpass filter. Here errors may occur when measuring the return loss. While the test frequency sweeps through the passband of the filter where little reflection occurs (high return loss), the associated harmonics fall into the stopband, are heavily reflected and simulate a rising, staircase-like reflection characteristic.

Measurement errors of the above-mentioned type can be neglected to a large extent with test setups of the Polyskop series since spurious frequencies are down > 60 dB and a harmonics suppression of typ. 40 dB is maintained. Other advantages of these sweep test assemblies are the size of the screen (16 cm × 22 cm), the display of vertical frequency markers covering the full screen height and the possibility of inserting three different horizontal lines at any position of the screen. In this way all details of the display can be easily recognized and evaluated.

Narrowband sweep tester

The photo below shows an example of a narrowband sweep tester consisting of the following instruments: Signal Generator SMDU (0.14 to 1050 MHz) as narrowband sweep generator, Vector Analyzer ZPV (0.1 to 1000 MHz) as selective tracking receiver and XY Recorder ZSK 2 as output unit. The test item is a crystal filter with a very steep cutoff and a high stopband attenuation. This test setup permits logarithmic measurements over a dynamic range of more than 100 dB. The low spurious FM of the signal generator of only a few hertz enables even extremely steep filter edges to be represented satisfactorily. The recorder delivers the sweep voltage for the signal generator while the vector analyzer synchronizes automatically to the test frequency. The greatest possible sweep width is determined by the signal generator and is between 1 and 2 MHz depending on the frequency range. The error sources which exist with wideband sweeping do not occur since the measurement is selective and no harmonics of the test signal fall into the sweep band due to the relatively small frequency variation with respect to the absolute frequency (for frequencies > 1 MHz).

Narrowband sweeper for 140 kHz to 1 GHz



Polyskop SWOB 3: Sweep Generator Assembly of modular design

Display Unit ▶

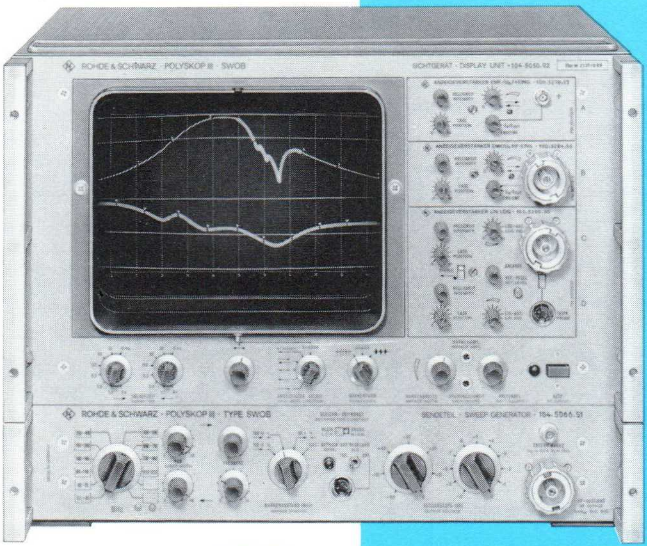
Simultaneous display of four measurements

Forward and return sweep times separately adjustable

No-parallax electronic superimposition of reference lines for frequency and level display

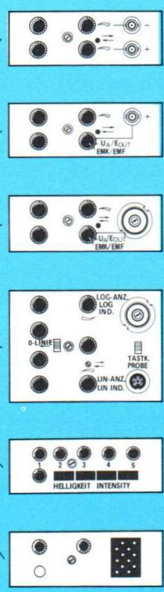
Sweep Generator ▶

12 frequency subranges
Centre frequency adjustable at will
Marker spectrum 1/10/100 MHz



LIMITED-AVAILABILITY PRODUCT

Plug-ins



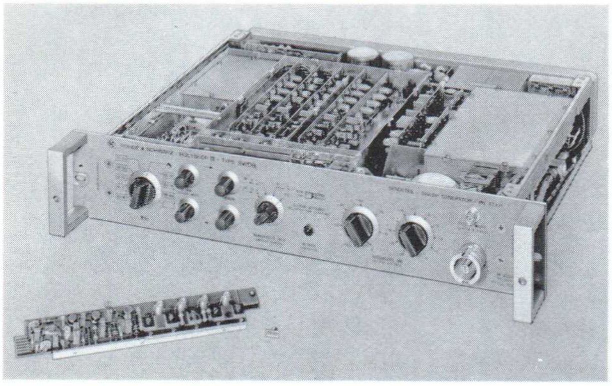
Polyskop SWOB 3 ♦ 20 kHz to 1250 MHz

- Versatile modular instrument for four-channel frequency-response display
- Forward and return sweeps can be displayed separately, at the same height or vertically offset
- 1 V maximum EMF, with ALC; 70-dB output attenuator; with Frequency-marker Unit: three shiftable brightup markers are produced, readout of the marker frequency being possible on a counter

Polyskop SWOB 3 is a fully transistorized sweep generator assembly for measurements on two-pole and two-port networks; tailored to the customer's requirements due to modular design:

- Display Unit (basic unit)
- Sweep Generator with oscillator for range I, 0.1 to 45 MHz
- Wideband Sweep Generator with oscillators for 1 to 300/460 to 860 MHz
- sweep oscillator cards for use in the Sweep Generator as required
- amplifier modules and other plug-ins

A great variety of accessory instruments such as the Impedance-match Bridge (p. 99) for return-loss measurements and the Video Demodulator (p. 101) for measurements on TV equipment are available for special applications.

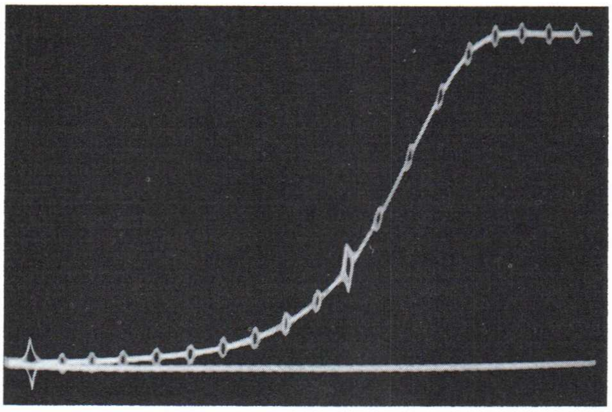


Sweep Generator of SWOB 3 with plug-in sweep oscillator card

Sweep Generator (19″ rackmount)

The frequency range from 20 kHz to 1250 MHz is covered by 10 sweep oscillators which are designed as plug-in cards (see lower photo). Sweep oscillator I for 0.1 to 45 MHz is supplied with the Sweep Generator, other sweep oscillator cards for standard and special ranges can be ordered as required. Up to 12 cards can be accommodated in the Sweep Generator.

Besides the use of the plug-in oscillator cards and the oscillators for special ranges – e.g. for entire TV bands – listed on page 101, the instrument is laid out to accept oscillator cards for other subranges.

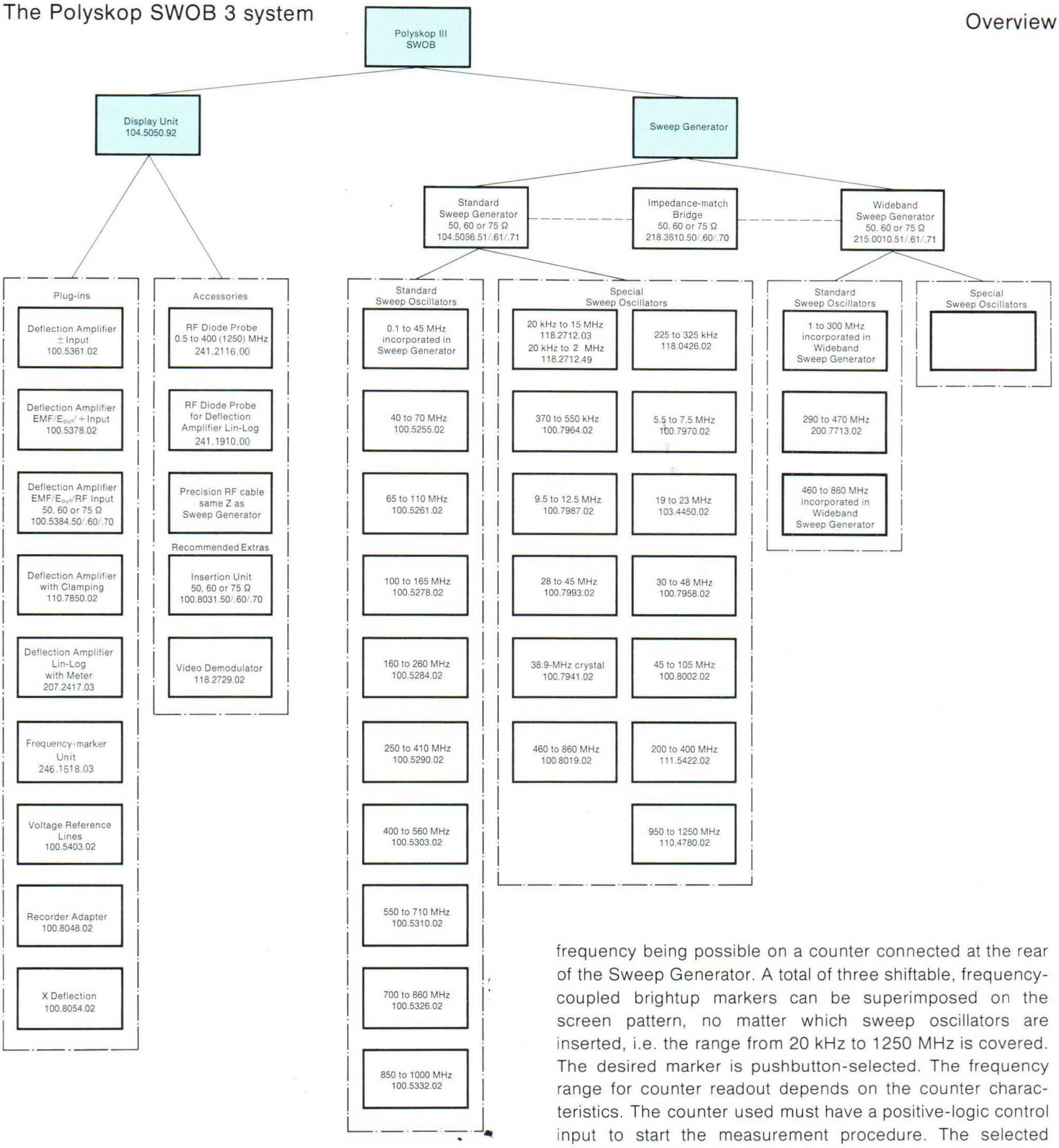


Frequency response curve of a highpass filter with beat markers (large 10 MHz, small 1 MHz) and zero-reference line (RF blanking)

The centre frequency and the forward sweep can be set at will within the subrange. The required control voltage (sawtooth) is derived from the Display Unit. The set sweep width can be also scanned manually.

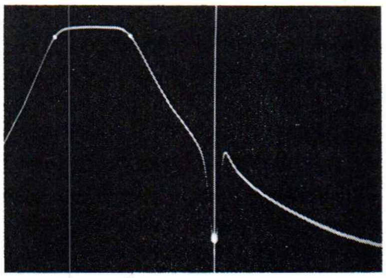
The Polyskop SWOB 3 system

Overview



The marker section produces crystal-controlled frequencies from which frequency spectra with a spacing of 100, 10 and 1 MHz are derived and superimposed on the swept oscillator frequency. The spectra are available in three switch-selected scales and can be readily distinguished according to the marker size and brightness (see page 96). The voltage requirement of the external marker input is about 200 mV for markers between 0.1 and 1000 MHz.

Exact determination of frequencies on the passband curve of narrowband test items raises problems since the marker spacing cannot be reduced at will. Here the **Frequency-marker Unit** offers an elegant solution: the built-in sweep oscillator can be stopped briefly during the sweep to produce brightup markers on the screen, digital readout of the marker frequency being possible on a counter connected at the rear of the Sweep Generator. A total of three shiftable, frequency-coupled brightup markers can be superimposed on the screen pattern, no matter which sweep oscillators are inserted, i.e. the range from 20 kHz to 1250 MHz is covered. The desired marker is pushbutton-selected. The frequency range for counter readout depends on the counter characteristics. The counter used must have a positive-logic control input to start the measurement procedure. The selected marker can be displayed in the form of a vertical line or a pulse.

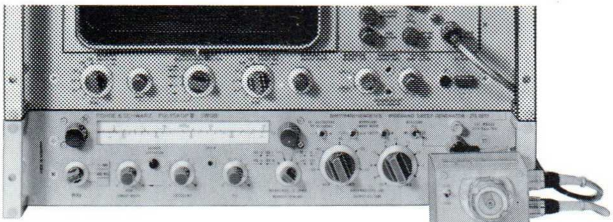


Screen display with three superimposed brightup markers; the marker frequencies can be measured successively or individually at the counter output (in the photo the third marker is identified by a vertical line).

Wideband Sweep Generator (19″ rackmount)

Instead of the Sweep Generator described on page 96 a Wideband Sweep Generator (photo below) for the switch-selected ranges of 1 to 300/460 to 860 MHz can be used in conjunction with the Display Unit. An additional range can be provided by inserting any sweep oscillator card up to 860 MHz. The Wideband Sweep Generator is substantially similar in design to the standard Sweep Generator (page 96) and has been provided especially for measurements on **cable TV and antenna systems.**

The forward sweep width is set for wideband sweeping by selecting a start and a stop frequency on a scale or for narrowband sweeping by adjusting the centre frequency and a symmetrical sweep width. The return sweep width (sweep magnification) can be selected independently within the forward sweep limits in wideband operation; with narrowband sweeping, the forward and return sweeps have the same width. Switch position CW permits point-by-point measurements to be performed with manual frequency setting within the selected range. In this mode the spurious FM of the output frequency is at a minimum.



Section of SWOB 3, showing Wideband Sweep Generator and Impedance-match Bridge (in front)

Display Unit (basic unit in 19″ cabinet)

The Display Unit operates on the principle of vertical scanning. **Simultaneous display of four measurements** is possible on the 21 cm × 16 cm picture tube. Forward sweep and flyback can be adjusted separately in steps between 15 ms and 3 s (up to 60 s after internal modification). The sweep time of 30 s required for recording is automatically selected in conjunction with the Recorder Adapter.

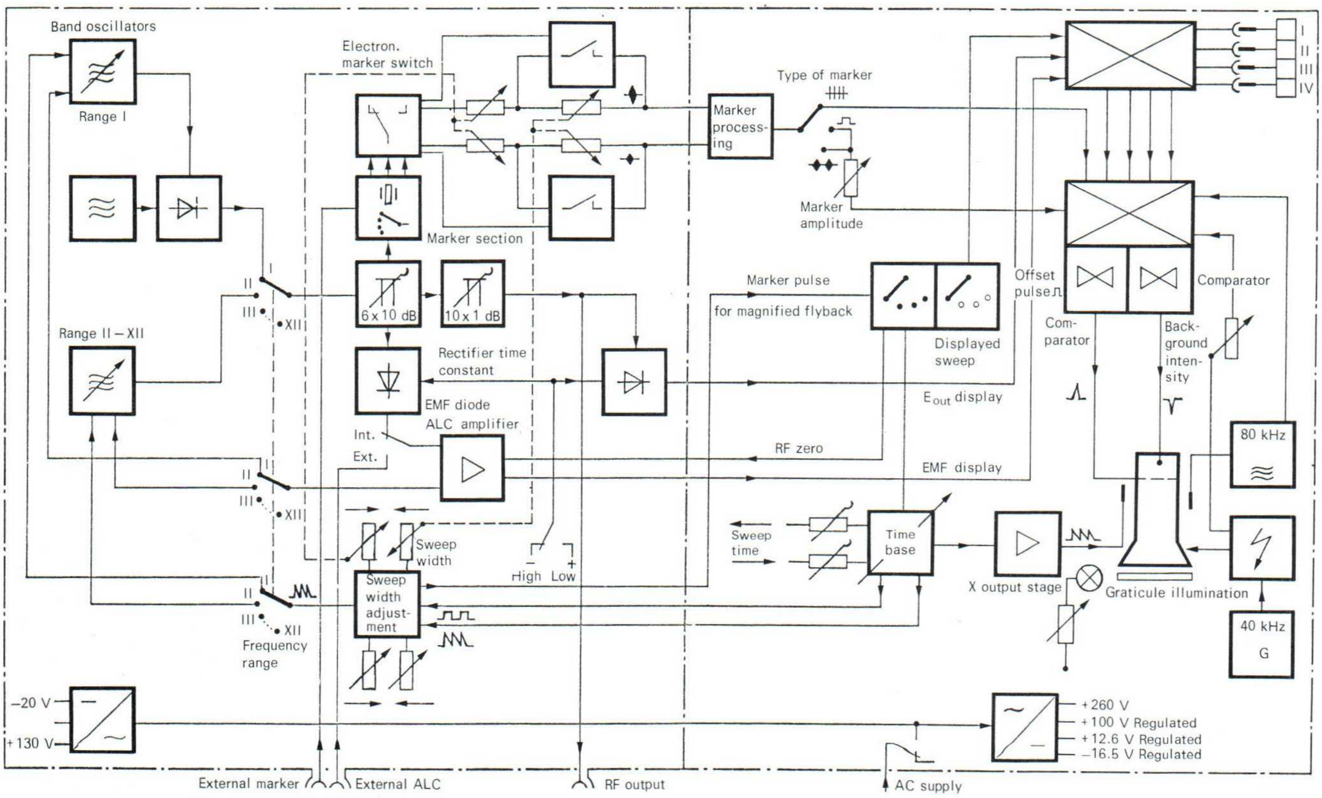
The return sweep can be displayed separately, together with the forward sweep at the same height or vertically offset. Moreover, any portion of the forward sweep can be **magnified during flyback.** This portion is made brighter in the forward sweep curve.

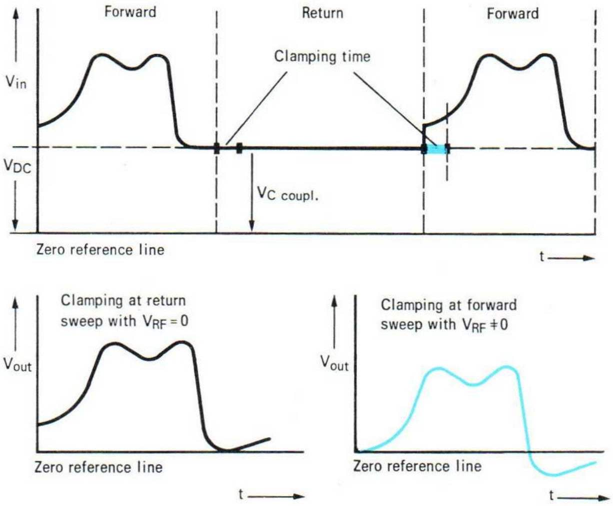
A front-panel knob permits the horizontal deflection and thus the frequency of the sweep oscillator to be **manually swept over the selected range.** The Display Unit furthermore contains the controls for frequency-marker width and height, type of marker, background intensity of display and graticule illumination.

A zero reference line can be displayed during the return sweep by **RF blanking.** The reference line is required when Deflection Amplifiers with Clamping are used (for possible errors with level clamping see next page); otherwise it provides easy reference.

Beat, pulse or vertical-line markers can be superimposed on the curve after suitable processing of the frequency markers from the Sweep Generator. Determination of the marker centre is easiest with the beat markers.

Block diagram of SWOB 3; left: Sweep Generator (the Wideband Sweep Generator is essentially of the same design), right: Display Unit





Clamping of the input signal is possible at the return sweep and the forward sweep. Bottom left: clamping at the return sweep with $V_{RF} = 0$; bottom right: error occurring with clamping at the forward sweep since $V_{RF} \neq 0$ must not be reduced to zero by the clamping

No-parallax electronic superimposition of horizontal **reference lines** is possible for level calibration (see Voltage Reference Lines Plug-in).

Four compartments are provided on the front panel to the right of the picture tube for accommodation of **exchangeable sub-units** which are used for separate control of the four display channels and amplification of the displayed quantities.

A **synchronization output** at the rear of the Display Unit makes available the X deflection sawtooth and the forward-return squarewave for the control and synchronization of other instruments.

Specifications

(General data and order designations on page after next)

Sweep Generator, Wideband Sweep Generator

Frequency range
- Sweep Generator .... 0.02 to 1250 MHz in 12 ranges, see order numbers
- Wideband Sweep Generator .... 1 to 860 MHz in 3 ranges, see order numbers

Sweep width, forward
- Sweep Generator .... 0.05 to 100% } of range
- Wideband Sweep Generator .... 1 to 100% } of range

Sweep width, return
- Sweep Generator .... 0.2 to 100% } of forward sweep width
- Wideband Sweep Generator .... 1 to 100% } of forward sweep width

F1 ± Δf (narrowband sweeping) with Wideband Sweep Generator . 0.2 to 6% of range (forward and return sweep widths equal)

CW (no sweep) with Wideband Sweep Generator ..... frequency adjustable within the range

Detail magnification .... by reducing the return sweep width

RF blanking during return sweep .. switch-selected for display of zero reference line

Spurious FM
- Sweep Generator .... ranges I to III: ≦ ±5 kHz; ranges IV to X: ≦ ±8 kHz
- Wideband Sweep Generator .... range I: ≦ ±7 kHz } in CW mode; range II: typ. < 25 kHz } in CW mode
- Special ranges .... ≦±10^{-4} referred to max. sweep width

Sweep linearity at max. sweep width
- Sweep Generator .... ranges I to III: < 1:1.5; ranges IV to X: < 1:2.5
- Wideband Sweep Generator .... range I: < 1:1.5; range II: < 1:3
- Special/wideband ranges ...... typ. 1:2/typ. 1:3

Output level (EMF)
- 50-Ω model .... 0.8 V
- 60-Ω model .... 1.0 V
- 75-Ω model .... 0.8 V (Wideb. Sw. Gen. 0.7 V)

Frequency response with max. sweep width and match-termination .... ≦0.5 dB (≦ 0.05 dB/MHz); ≦1 dB at 0.1 to 1000 MHz

ALC .... int./ext. switch-selected
- ALC input .... 3-pole flange connector

Output attenuator .... 6 × 10 dB, 10 × 1 dB

Attenuator error: 1-dB steps ..... ≦±0.2 dB (total ≦ ±0.5 dB)
- 10-dB steps ..... ≦±0.1 dB (total ≦ ±0.3 dB)

Suppression of harmonics
- Sweep Generator .... ≧20 dB at 0.1 to < 0.5 MHz; ≧34 dB at 0.5 to < 1 MHz; ≧40 dB at 1 to 1000 MHz; typ. 40 dB at > 1000 MHz
- Wideband Sweep Generator .... ≧20 dB at 1 to 5 MHz; > 36 (typ. 40) dB at > 5 to 300 MHz; ≧26 dB at 460 to 500 MHz; ≧34 dB at 500 to 860 MHz

RF connector .... Dezifix B; 50, 60 or 75 Ω

Frequency markers .... internal/external switch-selected

Frequency range int./ext.
- Sweep Generator .... 1 to 1250 MHz/0.1 to 1250 MHz
- Wideband Sweep Generator .... 1 to 860 MHz/1 to 860 MHz

Error of built-in crystal .... < 1 × 10^{-4}

$V_{in\ rms}$ for ext. markers .... 0.2 to 0.5 V (frequency-dependent)

Marker input .... BNC female connector

Selectable marker spacings (int.):

Switch position		Marker spacing in MHz Forward		Return	
		Amplitude or intensity			
		Large	Small	Large	Small
100 10→ ←		100	10	100	10
100 10→	10 1 ←	100	10	10	1
10 1→ ←		10	1	10	1
Ext. → ←		—	ext.	—	ext.

Weight: Sweep Generator .... 12 kg } 19″ rackmounts
- Wideband Sweep Generator .... 15 kg } 19″ rackmounts

Impedance-match Bridge for sweep generators (recommended extra)

Frequency range .... 0.1 to 400 MHz

Output voltage (switch-selected) .... 6 dB/26 dB below max. sweep generator output voltage

Return loss indication range ..... > 40 dB up to 300 MHz } with ideal Z_o; > 37 dB up to 400 MHz } with ideal Z_o

Measurement error .... ≦±0.8 dB

Display Unit (basic unit)

Useful display area .... 21 cm × 16 cm

Phosphor .... blue (prim.), yellow-green (sec.)

Persistence .... 0.1 to 1 s for 90% drop

Sweep time (separate adjustment of forward and return sweeps)
- Forward .... 15 ms to 3 s } manual sweeping also possible
- Return .... 15 ms to 3 s } manual sweeping also possible
- F1 ± Δf (Wideband Sweep Gen.) 15 to 150 ms (forward and return sweeps equal)

Sweep direction (forward sweep) . . . frequency increasing from left to right

Sweep display, switch-selected . . . forward only/return only/forward and return/forward and return with vertical offset/return blanked/manual

Horizontal markers .... pulse, line or beat markers; amplitude (intensity) adjustable; for f see table above

Vertical markers .... max. 5 level reference lines (see Voltage Reference Lines Plug-in page 100)

Sync output .... 5-pole flange connector
- Signals .... X sawtooth/forward-return squarewave/ +12.6 V/ −16 V

Weight .... 30 kg (with cabinet for sweep generator)

RF Diode Probe 241.2116.00 (supplied with Display Unit)

Frequency range .... 0.5 to 400 MHz; approx. measurement: 0.1 to 1250 MHz

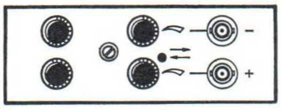
Input impedance .... ≧30 kΩ‖2 to 3 pF (at 50 MHz)

Permissible input voltage .... $V_{rms} < 5$ V; $V_{DC} < 100$ V

Input requirement .... ≧50 mV for full picture height

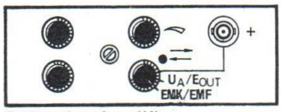
Plug-ins for Polyskop SWOB 3

The plug-ins listed below can be inserted in the empty spaces provided on the front panel for connection to the measurement channels of the Polyskop. Each plug-in has gain, intensity and vertical-position controls besides front-panel test sockets.



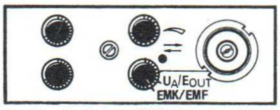
Deflection Amplifier ± Input

Deflection Amplifier ± Input with high-impedance differential amplifier input. Gain continuously and independently adjustable for both inputs up to 10 mV for full display height. RF indication using diode probe of Display Unit. Spurious voltages picked up in screened cables can be compensated for by connecting the screen to the second input.



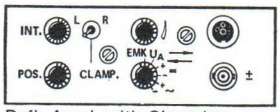
Deflection Amplifier EMF / V_{out} / + Input

Defl. Amplifier EMF/V_{out}/+ Input. In addition to a high-impedance positive DC voltage input, this plug-in also offers the selection of V_{out} or the EMF of the Sweep Generator instead of the test signal. Single gain control for all three signals (max. 10 mV at the test input for full display height).



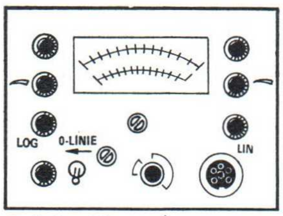
Deflection Ampflifier EMF / V_{out} / RF Input

Defl. Amplifier EMF/V_{out}/RF Input for direct RF measurement via internal low-reflection broadband demodulator (up to 1250 MHz) with coaxial input and match-termination (other data as for ± input plug-in).



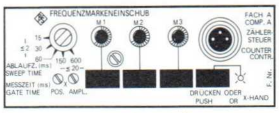
Defl. Ampl. with Clamping

Deflection Amplifier with Clamping for measuring demodulated voltages even if constant DC potentials up to 1000 times higher are superimposed. The start of either the forward or the return sweep can be clamped to the constant component (reference level). Other facilities: connector for RF probes of lin/log plug-ins, internal connectors for V_{out} and EMF; input can be switched to DC-coupled mode with reversible polarity.



Defl. Amplifier Lin/Log w. Meter

Deflection Amplifier Lin/Log with Meter for absolute level measurements on a lin or log scale at any points of the display, independent of the sweep. The frequency at which the amplitude is measured is identified on the screen. Probe input only.

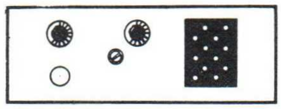


Frequency-marker Unit

Frequency-marker Unit for exact measurement of passband characteristics of narrowband test items. This plug-in permits a total of three shiftable, frequency-coupled brightup markers to be superimposed on the screen pattern; the marker frequency can be displayed on a counter connected on the rear of the Sweep Generator. The desired marker is pushbutton-selected and can be displayed in the form of a vertical line or a pulse.

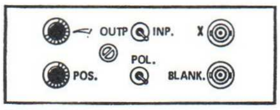
Voltage Ref. Lines Plug-in

Voltage Reference Lines Plug-in for the display of a vertical scale consisting of a max. of five independently selectable and shiftable horizontal lines; calibration in dB using the Sweep Generator output attenuator.



Recorder Adapter

Recorder Adapter for the control of an XY recorder or camera. The sweep period of 30 s is automatically selected with the start of recorder tracking. The recording mode is determined by the position of the mode switch on the Display Unit.



X-Deflection Amplifier

X-Deflection Plug-in makes an adjustable X-deflection voltage available, e.g. for the control of external sweep generators, or is used to apply an external deflection voltage. An input for blanking is provided.

Specifications of the Plug-ins

(Order numbers on next page)

Deflection Amplifier ± Input

Test inputs	2 BNC sockets (+/−) usable as a differential input
Max. input voltage	±10 V } one terminal
Input impedance	500 kΩ ±20% } to chassis
Deflection factor	≦0.6 mV/cm continuously adjustable
Vertical displacement between forward and return sweeps	up to 100% display height, continuously adjustable

Deflection Amplifier EMF/V_{out}/ + Input

Test input	+ input (BNC)/V_{out}/EMF, switch-selected
Max. input voltage	+ 10 V
Input impedance	500 kΩ ±20%
Deflection factor and vertical displacement as above	
EMF and V_{out} indication	continuously adjustable
V_{out} level with max. sensitivity	≦50 mV for full display height

Deflection Amplifier EMF/V_{out}/ RF Input

Test input	RF input (Dezifix B)/V_{out}/EMF, switch-selected
RF indication	via internal detector
Detector input circuit	unbalanced, earthed; 50/60/75 Ω
VSWR	≦1.1 up to 1000 MHz
Max. input voltage and power	5 V (no DC), 0.5 W
Sensitivity	≦50 mV for full display height
Rectification characteristic	non-linear for $V_{in\,rms}$ < 350 mV (approx. square-law)

Deflection Amplifier with Clamping

Test inputs	selection of EMF/V_{out}, DC/AC coupling, +/− signal
Connectors	BNC and 5-pole flange connector
Total permissible input voltage	±150 V with AC coupling ±10 V with DC coupling
Max. permissible superimposed DC component with AC coupling	< V_{test} × 1000 for full display height
Deflection factor	≦0.5 V/cm
Clamping (switch-selected)	at start of forward or return sweep

Other data as for Deflection Amplifier EMF/V_{out}/ + Input

Deflection Amplifier Lin/Log with Meter

RF indication	lin and log on screen and lin or log on meter simultaneously
Display ranges	lin: 20 dB, log: 60 (typ. 70) dB
Meter ranges lin	2 mV to 0.05/0.15/0.5/1.5/5 V
log	−50 to 0/ + 20 dB
Test input	5-pole flange connector
RF probe 111.1091.00 (supplied with the plug-in)	Z_{in} = 30 kΩ‖2.5 pF (at 50 MHz)
Probe tips	0/20/40 dB
Frequency range	0.1/3/1 to 500 MHz
$V_{in\,rms}$	0.002 to 5/0.02 to 50/0.2 to 500 V

Frequency-marker Unit

Sweep times	15, 30, 60, 150, 600 ms
Resolution of marker display	0.1% of max. sweep range
Frequency readout on counter	via rear connector on Sweep Generator; TTL level

Voltage Reference Lines Plug-in

Number of reference lines	5 (4 can be switched on independently)
Vertical positioning	continuously over full display height, separately for each line
Intensity of lines	continuously adjustable, one control for all lines

Recorder Adapter

Y output	0 to +5 V, 20 kΩ
X output	0 to +6 V, 1.5 kΩ
Zero adjustment	together with recorder
Sweep control	by pushbutton (automatic selection of 30 s sweep period)
Stylus control	with make contact (max. 28 V/0.5 A/10 W)
Connector	12-pole female

X Deflection Plug-in

X signal output	
Output voltage V_{out} (adjustable)	+10 to −14 V, Z_{out} ≦ 10 Ω
Positioning of V_{out}	±(8 V ±10%) symmetrically about 0
X signal input	
Input voltage V_{in} (adjustable)	≧1 V (+ or −), Z_{in} ≧ 70 kΩ
Permissible superimposed DC	≦±0.5 V_{in}
Blanking	open circuit or −2 to −15 V: bright; 0 to +12 V: dark
Connectors	BNC female

Video Sweep Oscillator

Frequency range	20 kHz to 15 MHz (standard version) 20 kHz to 2 MHz (modified version)
Output EMF (rms)	1 V ±5%
Frequency-response flatness of EMF and of output voltage with match-termination	≦0.2 dB
Spurious sweep width	< 1.5 kHz (standard version) < 200 Hz (modified version)
Sweep lin. (max. sweep width)	< 1:1.5
Harmonics suppression	> 40 dB

Extras

Video Demodulator

RF input	75 Ω; BNC male connector
Return loss	> 34 dB
Permissible input voltage (V_{rms})	> 5 V
Superimposed AC and DC	< 6 V (rms)
Frequency range	10/100 kHz to 50 MHz, switch-selected
Connector on Deflection Amplifier	5-pole flange connector

RF Insertion Unit

Frequency range	0.1 to 1250 MHz
Characteristic impedance	50/60/75 Ω; VSWR ≦ 1.1 (< 1 GHz)
Permissible input voltage	< 5 V_{rms} (superimposed DC < 100 V)

General data

Nominal temperature range	+10 to +35 °C
Components	solid-state
Picture tube	M 28-12 GM
Power supply	115/125/220/235 V +10/−15%, 47 to 63 Hz (190 VA)
Dimensions, weight (Display Unit + Sweep Gen.)	484 mm × 372 mm × 436 mm, 42 kg

Order designations

▶ Order numbers

Display Unit (basic unit) with 19″ cabinet for one Sweep Generator (without plug-ins)	104.5050.92
Sweep Generator (plug-in with osc. I: 0.1 to 45 MHz)	
50-Ω model	104.5066.51
60-Ω model	104.5066.61
75-Ω model	104.5066.71
Wideband Sweep Generator (plug-in with osc. I: 1 to 300 MHz and II: 460 to 860 MHz)	
50-Ω model	215.0010.51
60-Ω model	215.0010.61
75-Ω model	215.0010.71
Combination Display Unit plus Wideband Sweep Generator 1 to 860 MHz	
50-Ω model	104.5050.52
60-Ω model	104.5050.62
75-Ω model	104.5050.72

Sweep Oscillators SWOB 3-Z (standard)

Sweep Generator		
I	0.1 to 45 MHz	incorporated in Sweep Generator
II	40 to 70 MHz	100.5255.02
III	65 to 110 MHz	100.5261.02
IV	100 to 165 MHz	100.5278.02
V	160 to 260 MHz	100.5284.02
VI	250 to 410 MHz	100.5290.02
VII	400 to 560 MHz	100.5303.02
VIII	550 to 710 MHz	100.5310.02
IX	700 to 860 MHz	100.5326.02
X	850 to 1000 MHz	100.5332.02
Wideband Sweep Generator		
I	1 to 300 MHz	} incorporated in Wideband Sweep Generator
II	460 to 860 MHz	}
III	290 to 470 MHz	200.7713.02

Special Sweep Oscillators SWOB 3-Z

20 kHz to 15 MHz (video sweep oscillator)	118.2712.03
20 kHz to 2 MHz (video, modif.)	118.2712.49
225 to 325 kHz	118.0426.02
370 to 550 kHz	100.7964.02
5.5 to 7.5 MHz (OIRT sound)	100.7970.02
9.5 to 12.5 MHz	100.7987.02
19 to 23 MHz	103.4450.02
28 to 45 MHz	100.7993.02
30 to 48 MHz	100.7958.02
38.9 MHz (crystal oscillator)	100.7941.02
45 to 105 MHz (wideband sweep oscillator)	100.8002.02
200 to 400 MHz	111.5422.02
460 to 860 MHz (wideband sweep oscillator)	100.8019.02
950 to 1250 MHz	110.4780.02

Plug-ins SWOB 3-E

Deflection Amplifier ± Input	100.5361.02
Deflection Amplifier EMF/V_{out}/ + Input	100.5378.02
Deflection Amplifier EMF/V_{out}/RF Input	
50-Ω model	100.5384.50
60-Ω model	100.5384.60
75-Ω model	100.5384.70
Deflection Amplifier with Clamping	110.7850.02
Deflection Amplifier Lin/Log with Meter	207.2417.03
Frequency-marker Unit	246.1518.03
Voltage Reference Lines Plug-in	100.5403.02
Recorder Adapter	100.8048.02
X Deflection Plug-in	100.8054.02

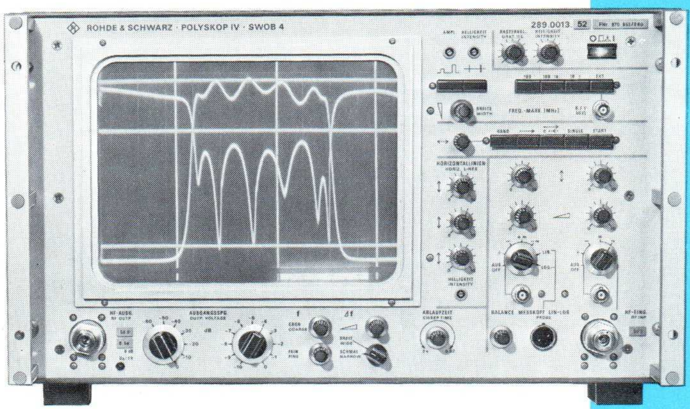
Accessories supplied

1 RF Probe 241.2116.00 (page 99)
1 graticule (built-in) and 1 filter (exchangeable)
1 RF precision cable (50 cm) 126.1992.00 (50 Ω), 126.2001.00 (60 Ω) or 126.2018.00 (75 Ω) for Sweep Generator
1 RF Probe 111.1091.00 (page 101) for Deflection Amplifier Lin/Log

Recommended extras SWOB 3-Z

Impedance-match Bridge 218.3610.50 (50 Ω), 218.3610.60 (60 Ω) or 218.3610.70 (75 Ω); page 99
Video Demodulator 118.2729.02 (page 101)
RF Insertion Unit 100.8031.50 (50 Ω), 100.8031.60 (60 Ω) or 100.8031.70 (75 Ω); page 101
Directional Coupler ZPW for 167 to 430 MHz: 110.1746.60 (60 Ω) or 110.1746.70 (75 Ω); for 380 to 1000 MHz: 110.1752.50 (50 Ω), 110.1752.60 (60 Ω) or 110.1752.70 (75 Ω)
Cabinet 110.7409.00 (for use of Display Unit alone)
Camera attachment (please order from Steinheil-Lear-Siegler Vertriebs-GmbH, D-8045 Ismaning)

SWOB 4



Polyskop SWOB 4
♦ 0.1 to 1000 MHz

- Compact sweep tester for dual-channel display
- Sweep width continuously adjustable from ≈ 150 kHz to 1000 MHz
- Precise electronic frequency and level markers
- Logarithmic deflection amplifier

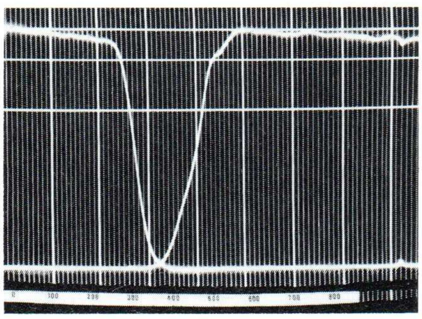
Characteristics and uses

Polyskop SWOB 4 combines in a compact unit a sweep generator with 70-dB attenuator, display unit with logarithmic amplifier and large-size screen, frequency marker generator and adjustable level reference lines.

The SWOB 4 permits two quantities to be displayed simultaneously as functions of frequency. Many characteristics such as gain, attenuation or linearity can thereby be measured.

The technical concept of this member of the proven Polyskop family is based on long years of experience in this field. Like Polyskop SWOB 3, SWOB 4 is also ideal for use in laboratories, test and production departments, especially where ease of operation is required together with large-screen and broadband display for long series of measurements.

Application on page 94



Broadband measurement over > 800 MHz on a VHF-UHF filter for TV bands III and IV/V

Description

Frequency range, sweep width. The SWOB 4 frequency range, 100 kHz to 1000 MHz, can be swept in one band with maximum sweep width setting. Wide or narrow sweep can be switch-selected. In the NARROW position the maximum width is about 30 MHz, minimum < 150 kHz.

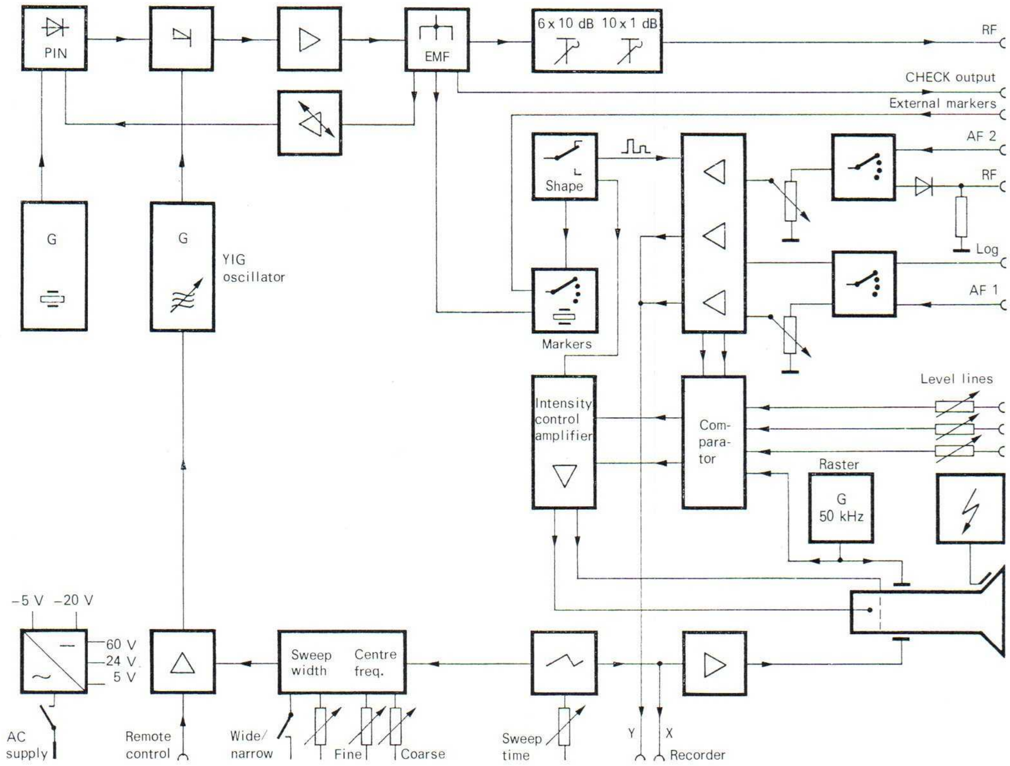
The frequency axis is linear in time and the sweep can be adjusted continuously from 20 ms to 2 s. In the SINGLE mode the sweep time is automatically extended to 30 s when a recorder is connected.

Frequency markers. Pulse or vertical-line markers provide a scale on the frequency axis with the decades identified by higher intensity; see illustration on the left. A bright bar at the lower edge of the screen marks the adjusted sweep range on a scale.

Display. The incorporated deflection amplifiers can be switched for positive and negative test voltages. The deflection factor is at least 0.5 mV/cm. DC voltages up to 50 V can be eliminated by clamping. When an RF signal of 25 mV is applied, the internal demodulator, which is match-terminated, gives a deflection voltage sufficient for full display height.

Sweep control. The modes manual, forward, forward with zero reference in the return sweep, and SINGLE can be selected by a switch. The SINGLE mode is also used for recorder operation.

Connectors for remote control and external instruments. The rear panel accommodates remote-control input, trigger input, RF check output, recorder output for AF 1 and a test socket to which supply voltages, display signal (squarewave) and sweep voltage (sawtooth) are applied.



Block diagram of Polyskop SWOB 4

Specifications

Frequency range . . . . 0.1 to 1000 MHz (in one band; only centre frequency and sweep width need be adjusted)

Sweep width	max.	min.
WIDE	≈1000 MHz	≈5 MHz
NARROW	≈25 MHz	≈0.15 MHz

Spurious sweep width (NARROW) . . . . ≦5 kHz, typ. 3 kHz
Sweep linearity . . . . better than 1:1.01
Indication linearity . . . . better than 1:1.1
Centre frequency . . . . freely adjustable: coarse–fine

Output EMF into	50 Ω:	60 Ω:	75 Ω:
(N female connector; 60 Ω: Dezifix B; adaptable)	1 V	1 V	0.7 V

(can be increased by 6 dB in the range 0.5 to 300 MHz by rear switch)

Frequency-response flatness (V_{out} with match-termination) . . . . <1 dB (typ. 0.5 dB) for 0.1 to 1000 MHz; <0.15 dB for 10 MHz sweep
Output level setting . . . . attenuator 0 to 70 dB, 1-dB steps
Attenuator error up to 1000 MHz . . . . . fine ≦ ±0.2 dB; coarse ≦ ±0.5 dB

Harmonic suppression
0.1 to 1 MHz . . . . ≧30 dB
>1 to 1000 MHz . . . . ≧36 dB (typ. 40 dB)
Suppression of non-harmonic spurious signals . . . . . ≧40 dB
Frequency markers,
internal . . . . 100; 100/10; 10/1 MHz
external . . . . V_{in} ≈ 0.2 V; 1 to 1000 MHz
Marker display . . . . pulse or vertical-line markers

Frequency sweep:

Sweep mode, display			
——→	——→ / 0 ←——	HAND	SINGLE
Forward only (rising f)	Forward/return with zero ref.	Manual	Triggered by button, return blanked
Sweep time Forward 0.02 to 2 s Return 20 ms, fixed	Forward 0.02 to 2 s Return 0.02 to 2 s	— —	Forward 0.02 to 2 s Return 0.02 to 2 s (≈ 30 s with recorder adapter cable)

Triggering . . . . in SINGLE mode, trigger level +5 V

Useful display area . . . . 21 cm × 16 cm, screen type GM

AF input . . . . 2 BNC female connectors
Deflection coefficient . . . . 0.2 mV/cm
Max. input voltage . . . . ±50 V
Overload capacity . . . . >20 dB referred to full display height
Selection of test signal to be displayed . . . . rotary switch
AF 1 . . . . OFF/ + / − /+ ≈ / − ≈ /Lin/Log
AF 2 . . . . OFF/ + / − /RF − /RF ≈
Clamping of test signal . . . . in switch position ≈, RF is blanked during return and AF clamped to 0
Superimposed DC . . . . ±50 V max.
Display range . . . . 20 dB (linear)

RF input . . . . N female connector, 60 Ω: Dezifix B (adaptable), match-terminated, VSWR ≦ 1.1 (up to 1000 MHz)
Input voltage, rms
Minimum for full display height . . . . . 25 mV
Maximum permissible . . . . 5 V

Reference lines . . . . three; separate adjustment of vertical position; common adjustment of intensity

General data
Nominal temperature range . . +5 to +40 °C
Shelf temperature range . . . . −25 to +60 °C
Power supply . . . . 110/125/220/235 V ±10% (180 VA)
Dimensions, weight . . . . . . 484 mm × 328 mm × 436 mm, 25 kg

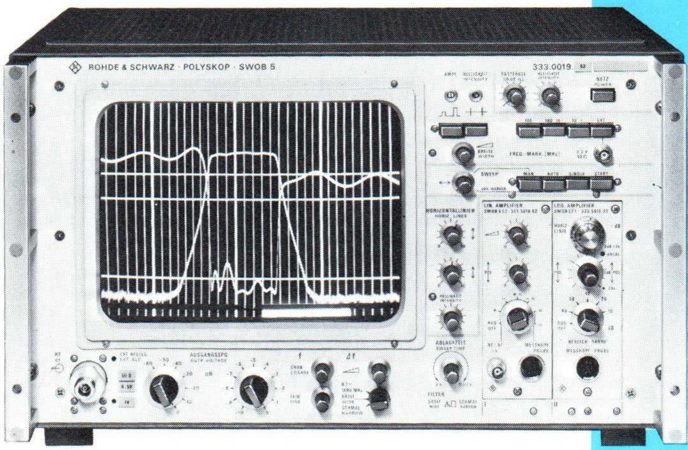
Order designations	▶ Polyskop SWOB 4
50-Ω model	289.0013.52
60-Ω model	289.0013.62
75-Ω model	289.0013.72

Accessories supplied . . . . . . power cable

Recommended extras	**50 Ω:**	**60 Ω:**	**75 Ω:**
RF Insertion Unit SWOB 4-Z	289.6711.00	154.8369.00	289.6763.00
Precision Cable (freq. resp.)	100.7670.10	126.2001.00	100.7687.00
Active Demodulator SWOB 4-Z	289.5773.52	—	289.5773.72
VSWR Bridge	912.7003.00	—	912.7303.00

Lin/Log Demod. Probe SWOB 3-Z	241.1910.00	(0.1 to 500 MHz)
Demodulator Probe SWOB 3-Z	241.2116.03	(0.5 to 400 MHz)
Recorder Adapter Cable	289.5450.02	(sweep time switchover)
Overvoltage Protection	289.6511.52	(for RF input or output)

SWOB 5



new

Polyskop SWOB 5
♦ 0.1 to 1000 MHz

- Compact sweep tester for single-channel or dual-channel display with linear or logarithmic amplification (variable configuration)
- Wide dynamic range (75 dB) through low inherent noise and high output voltage
- Calibrated level line with logarithmic amplification plus two independently shiftable level lines
- Pulse or vertical-line frequency markers with crystal accuracy

Characteristics and uses

Polyskop SWOB 5, like SWOB 4, combines in a compact unit all the measuring facilities needed in an up-to-date sweep tester:

sweep generator with an output EMF of 1 V (+6 dB if required), with output attenuator covering 70 dB;

display section with linear or logarithmic amplifiers, with a dynamic range of 76 dB; large-size screen, marker generator, calibrated level marker and additional horizontal reference lines.

The display section, unlike that of the SWOB 4, can be equipped with different amplifiers, see next page.

SWOB 5 is ideal for use in laboratories, test and production departments and wherever ease of operation is required together with large-screen display, high dynamic range and accurate results for either one-off tests or long series of measurements.

As the sweep width of SWOB 5 covers the whole frequency range, the frequency response of very wideband test items can be easily displayed within and even outside their service ranges.

Although wideband frequency-response and matching measurements are the most frequent applications, the very small spurious FM and high frequency stability also permit narrowband test items to be measured.

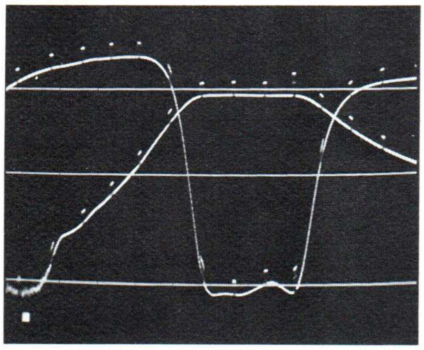
The extension possibilities and test examples given on pages 94 and 95 apply without restriction also for SWOB 5.

Description

The Sweep Generator delivers the swept RF in one band from 0.1 to 1000 MHz. Three modes can be switch-selected for sweep width:

0.1 to 1000 MHz
wide (max. 1000 MHz, min. 5 MHz)
narrow (max. 50 MHz, min. 0.3 MHz).

The output voltage of 0.5 V into 50 Ω (or 1 V into 50 Ω by switchover on the rear) ensures an excellent dynamic range for the whole instrument. Even with the doubled output voltage the frequency response is guaranteed in the range from 5 to 300 MHz (flatness typically ±0.25 dB, plus 0.2 dB with voltage doubling).



Reflection-coefficient and attenuation curves of 25-MHz bandpass filter with pulse frequency markers

The low spurious FM of typically 3 kHz allows a sharp display of steep filter slopes. Good harmonic suppression is also important when filters are to be checked without measurement errors (refer to page 95); the typical value for SWOB 5 is 40 dB.

The Display Section consists of two units:

measuring head and
deflection amplifier.

Terminating probes and insertion units with different characteristic impedance and high-impedance probes are available for use as **measuring head.**

The **deflection amplifiers** are in the form of plug-in units, permitting optimum adaptation of the set to different measurement tasks and to the customer's requirements for price and performance. The following amplifier combinations are possible for linear and/or logarithmic display.

1. One linear amplifier
   (low-priced single-channel version)
2. Two linear amplifiers
3. One linear and one logarithmic amplifier
4. Two logarithmic amplifiers
   (high comfort for most exacting requirements).

The **linear amplifier** amplifies the detected voltage from the measuring head for display. It may be used wherever a display range of 20 to 30 dB and a deflection factor of about 2 mV/cm are adequate.

The **logarithmic amplifier** has, in conjunction with a terminating probe or insertion unit, a noise limit of typically 170 µV, corresponding to a **dynamic range** of 70 dB with a sweep-generator output voltage of 0.5 V (even 76 dB is obtainable if the maximum output voltage of the sweep generator is changed to 1 V with the rear switch).

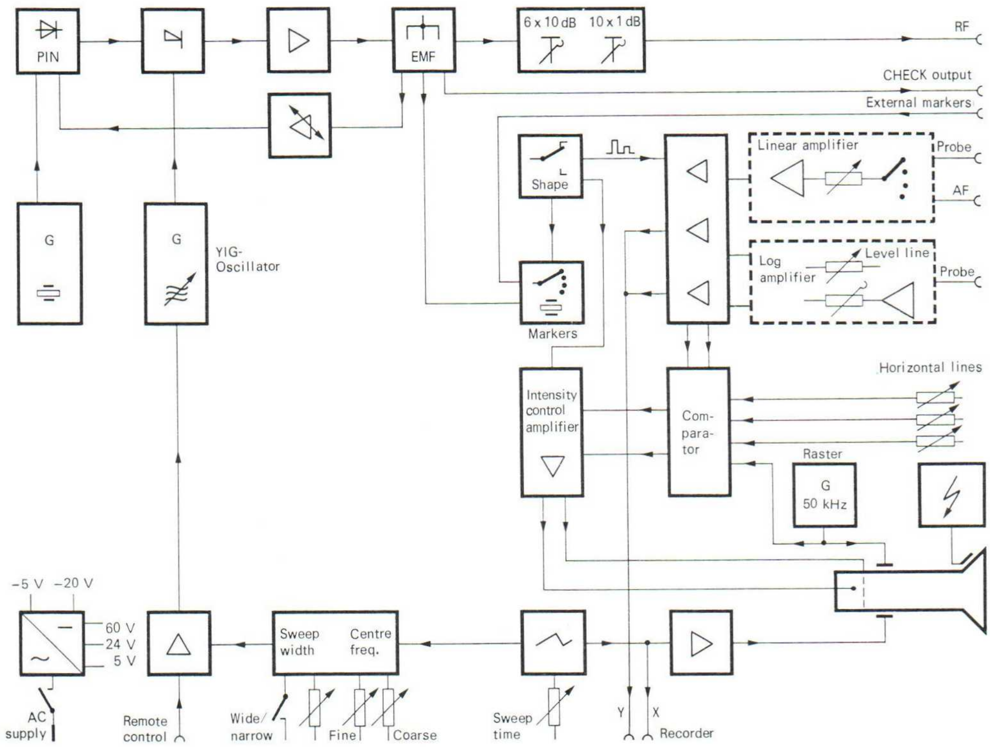
Use of the **Active Demodulator SWOB5Z4** gives a limit sensitivity of 20 µV. With a permissible driving level of 50 mV for the Active Demodulator, the dynamic range is then about 70 dB.

Magnification. The display range on the screen can be switched to 80/60/40/20 or 10 dB and shifted by more than 80 dB with the aid of a potentiometer. Any part of the display can thus be spread.

A shiftable **calibrated horizontal line** facilitates accurate level measurement. A ten-turn helical potentiometer permits vertical shifting with 0.1 dB resolution. The zero position can be varied with a control knob, the detent position of which corresponds to a reference level of 1 V. A lamp lights when the knob is not in this calibrated position. A filter can be switched into circuit for the observation of very small signals on the screen.

Compensation of spurious signals. Spurious signals such as may arise, for example, from the oscillator voltage of a tuner and which may limit the useful dynamic range are measured by both the linear and logarithmic amplifiers during the return sweep – while the RF is blanked – and compensated for.

Display. See next page.



Block diagram of Polyskop SWOB 5

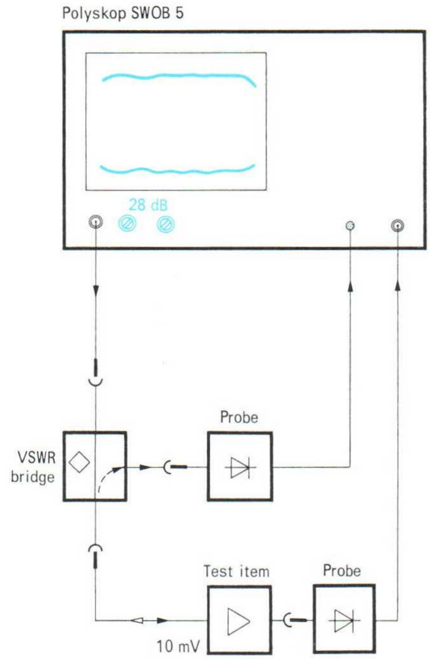
Polyskop SWOB 5, continued

The display of the results is obtained on a long-persistence screen. The screen size of 21 cm × 16 cm enables unstrained working. Four level lines (configuration with two amplifiers) and crystal-controlled vertical-line markers (or pulse markers) yield a coordinate grid of excellent clarity. A bright bar at the lower edge of the screen indicates the selected sweep range and helps to avoid reading errors.

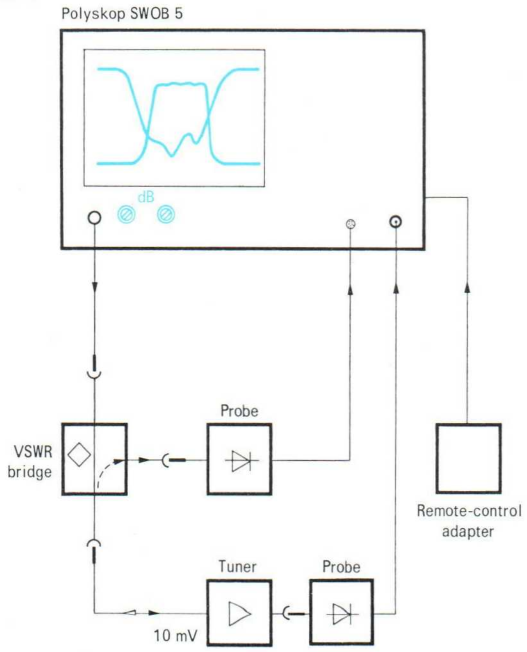
A recorder output with pen-lift contact and the possibility of triggering a counter connected at the rear by means of a manually adjustable brightup marker complete the outstanding measuring capabilities of SWOB 5.

Examples

Task. Measurement of amplitude/frequency response and matching on active broadband test items, such as cable-TV and antenna amplifiers.



Task. Measurement of amplitude/frequency response and matching on TV tuners using automatic sweep-width adjustment.



Specifications

Frequency range	0.1 to 1000 MHz (in one band; only centre frequency and sweep width need be adjusted)	
Sweep width	max.	min.
WIDE	≈1000 MHz	≈5 MHz
NARROW	≈ 50 MHz	≈0.3 MHz
Spurious FM (NARROW)	≦5 kHz, typ. 3 kHz	
Sweep linearity	1:1.01	
Indication linearity	better than 1:1.1	
Sweep adjustment	Δf and centre frequency (coarse-fine)	
external	via remote-control input	
Scale error of range indication	±4% of fs	
Remote control	via 7-pole female connector on rear	
Centre-frequency adjustment	5 to 8 V	
Sweep-width adjustment (ext. potentiometer ≈ 5 kΩ)	0 Ω for f_{min}, R_{max} for f_{max}	
Sweep time	0 to 5 V for 2 to 0.02 s	
RF monitoring output	50 mV into 50 Ω, BNC female connector on rear	
Output EMF	50 Ω	75 Ω
	1 V ± 5%	0.7 V ± 5%
	(can be increased by 6 dB by rear switch)	
Connector	N female	
Frequency-response flatness of output voltage with match-termination	< ±0.5 dB (typ. ±0.25 dB) for 0.1 to 1000 MHz, < 0.15 dB for 10 MHz sweep	
with 6-dB increase	± 0.2 dB in addition (5 to 300 MHz, otherwise ≈ 1 dB)	
Output attenuator	0 to 70 dB in 1-dB steps	
Error coarse (10-dB steps)	≦±0.5 dB	
fine (1-dB steps)	≦±0.2 dB	
Harmonic suppression		
0.1 to 1 MHz	≧30 dB	
> 1 to 1000 MHz	≧36 dB (typ. 40 dB)	
Suppression of non-harmonic spurious signals	≧40 dB	
Frequency sweep		
AUTO	forward/return with RF blanked during return	
MAN	manual sweep adjustment	
SINGLE	triggered by button, recorder operation	
Sweep time: AUTO	forward: 0.02 to 2 s, continuously adjustable; return: 0.01 to 0.3 s	
SINGLE	≈0.02 to 2 s, continuously adjustable	
Triggering	in SINGLE mode	
Ext. trigger level	≈ +5 V (at rear input)	
Frequency markers internal	100 MHz; 100/10 MHz; 10/1 MHz; error $< \pm 1 \times 10^{-4}$	
external	1 to 1000 MHz, ≈ 0.2 V (50 Ω)	
Marker type	impulse and vertical-line markers	
Orientation along frequency axis (internal)	marker amplitude or brightness modulated to highlight the decades	
Brightup marker	by MAN adjustment in AUTO mode	
Trigger signal for counter	TTL H during unblanked period (> 10 ms), BNC input	

Level lines	two; separate adjustment of vertical position; common adjustment of intensity
Useful display area	21 cm × 16 cm; screen type M 28-12 GM
Recorder output	±2.5 V for max. X deflection 2.5 V for max. Y deflection $R_{out} \approx 5$ kΩ
Connector	6-pole female (1 channel) or BNC female (2 channels)
External X deflection	±1 V (triangular) for full display width
Connector	7-pole female on rear

Amplifier plug-ins

Logarithmic amplifier

Measurement range (full display height)	10/20/40/60/80 dB
Noise level (with Demodulator SWOB5Z1 or RF insertion unit SWOB5Z3)	typ. 170 µV (with filter)
Max. test voltage	1 V
Level line, calibrated in dB	
Reference level	shiftable by 10 dB; detent position calibrated at 1 V = 0 dB
Adjustment range	0 to < −80 dB, resolution 0.1 dB
Zero adjustment range	> 80 dB (error 1 dB, typ.)
Lowpass filter	switch-selected, indicated
3-dB point	60 Hz
Connector for measuring head	7-pole female

Linear amplifier

Inputs	**AF**	**Meas. head**
Input impedance	500 kΩ	500 kΩ
Connector	BNC female	7-pole female
Input selector positions	+ / − / + ≈ / − ≈	= / ≈ (compensation for spurious RF signals in test item)
Deflection coefficient	0.2 mV/cm	–
Voltage required for full display height with max. sensitivity	< 3 mV	< 15 mV (in conjunction with SWOB5Z1 or SWOB5Z3)
Max. permissible input voltage	10 V (= or ≈)	5 V (≈) or 10 V (=)

Measuring heads

Demodulator SWOB5Z1 (with built-in termination)

Impedance	50 or 75 Ω depending on model, connector: N female, VSWR < 1.1
Frequency range	0.1 to 1000 MHz
Frequency-response flatness	< ±0.5 dB, typ. 0.25 dB (0.4 to 1000 MHz)
Max. test voltage	1 V
Max. permissible input voltage	5 V (≈) or 10 V (=)
Connection to lin/log amplifier	via cable (1 m) and 7-pole male connector

RF Insertion Unit SWOB5Z3

Impedance	50/75 Ω depending on model
Connector	N male
VSWR	< 1.1 (75 Ω: 1.2)
Frequency range	0.1 to 1000 MHz
Frequency-response flatness	< ±0.5 dB, typ. 0.25 dB (0.4 to 1000 MHz)
Max. test voltage	1 V
Max. permissible input voltage	5 V (≈) or 10 V (=)
Connection to lin/log amplifier	via cable (1 m) and 7-pole male connector

Log. Probe SWOB5Z2

Impedance (depending on frequency and attenuator)	> 3 kΩ to > 20 MΩ‖0.5 to 2.5 pF
at 50 MHz and 0 dB	30 kΩ‖2.5 pF
Frequency range	0.1/5/1 to 500 MHz (rough indication up to 1000 MHz)
Attenuation of probe tips	0/20/40 dB
Input voltage range	2 mV to 1 V/20 mV to 10 V/ 0.2 to 100 V (rms)
Input circuit	unbalanced, earthed

Demodulator SWOB 3-Z (probe with BNC male connector)

Frequency range	0.5 to 400 MHz (rough indication up to 1000 MHz)
Input impedance	
at 50 MHz	≧30 kΩ‖2 to 3 pF
at 200 MHz	≧10 kΩ

Input voltage	min. 50 mV for full display height, max. permissible 5 V RF, superimposed DC up to 100 V
Output signal	+ DC ≧ 5 mV into > 500 kΩ for 50 mV_{rms} (0.5 to 400 MHz)

Active Demodulator (50 or 75 Ω depending on model)

Input voltage range	20 µV to 50 mV
Frequency-response flatness	≦ ±1.5 dB for 5 to 1000 MHz
Input VSWR	≦1.2

Recommended extras

VSWR Bridge (50 or 75 Ω depending on model)

Frequency range	10 to 1000 MHz
Directivity	≧40 dB

Overvoltage Protection (for RF input or output)

Impedance	50 Ω
Response threshold	4 V DC or RF
Switching time	≦3 ms

Extensions

(mounting with electrical connections via irreversible connectors of basic unit)

External control

Switchover	int./ext. via slide switch; lamp lights in ext. mode
Input	7-pole female connector for Insertion Unit SWOB5Z3
Voltage adjustment	0.1 to 0.5 V, continuous

Slow sweep

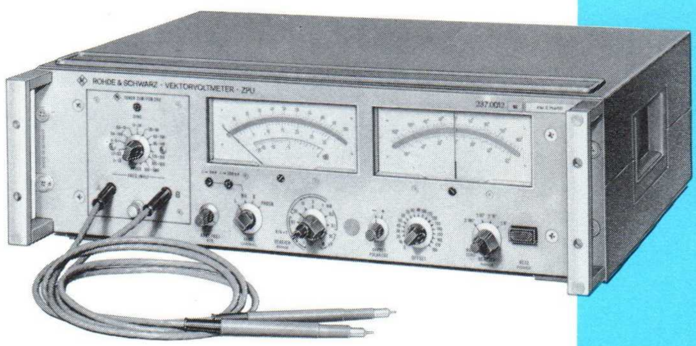
X voltage	±2.5 V for max. deflection
Y voltage	1 V for max. deflection
Sweep time	0.02 to 2 s; ≈ 30 s with recorder cable plugged in
Connectors	6-pole female (1 channel) BNC female (2 channels)

General data

Nominal temperature range	+5 to +40 °C
Shelf temperature range	−25 to +60 °C
Power supply	110/125/220/235 V ±10%, 47 to 63 Hz (180 VA)
Dimensions, weight	484 mm × 328 mm × 436 mm, 25 kg

Order designation	▶ Polyskop SWOB 5
SWOB 5, without amplifier plug-ins:	
50-Ω model	333.0019.52
75-Ω model	333.0019.72
Amplifier plug-ins:	
Log. Amplifier SWOB5E1	333.5610.02
Lin. Amplifier SWOB5E2	333.5010.02
Measuring heads:	
Demodulator SWOB5Z1	
50-Ω model	333.7513.52
75-Ω model	333.7513.72
RF Insertion Unit SWOB5Z3	
50-Ω model	333.8010.52
75-Ω model	333.8010.72
Log. Probe SWOB5Z2	333.9016.02
Demodulator Probe SWOB 3-Z	241.2116.00
Active Demodulator SWOB5Z4	
50-Ω model	333.8510.52
75-Ω model	333.8510.72
Accessories supplied	power cable
Recommended extras (for data see above)	
VSWR Bridge SWOB4-Z	
50-Ω model	912.7003.00
75-Ω model	912.7303.00
Overvoltage Protection	333.9316.52
Recorder Adapter Cable SWOB4-Z	289.5450.02
RF cable, 1 m long	100.7687.00
Extensions:	
External Control SWOB5B1	333.6700.02
Slow Sweep SWOB5B2	333.9516.02

ZPU



Vector Voltmeter ZPU
♦ 0.1 to 1000 MHz

- Voltage magnitude measurement in two channels and phase difference measurement between the two channels
- Two test channels, automatic frequency tuning
- Indication of phase difference from 0 to ±180°; measurement of voltage ratios and s-parameters; phase-response measurements, e.g. in control loops and feedback systems

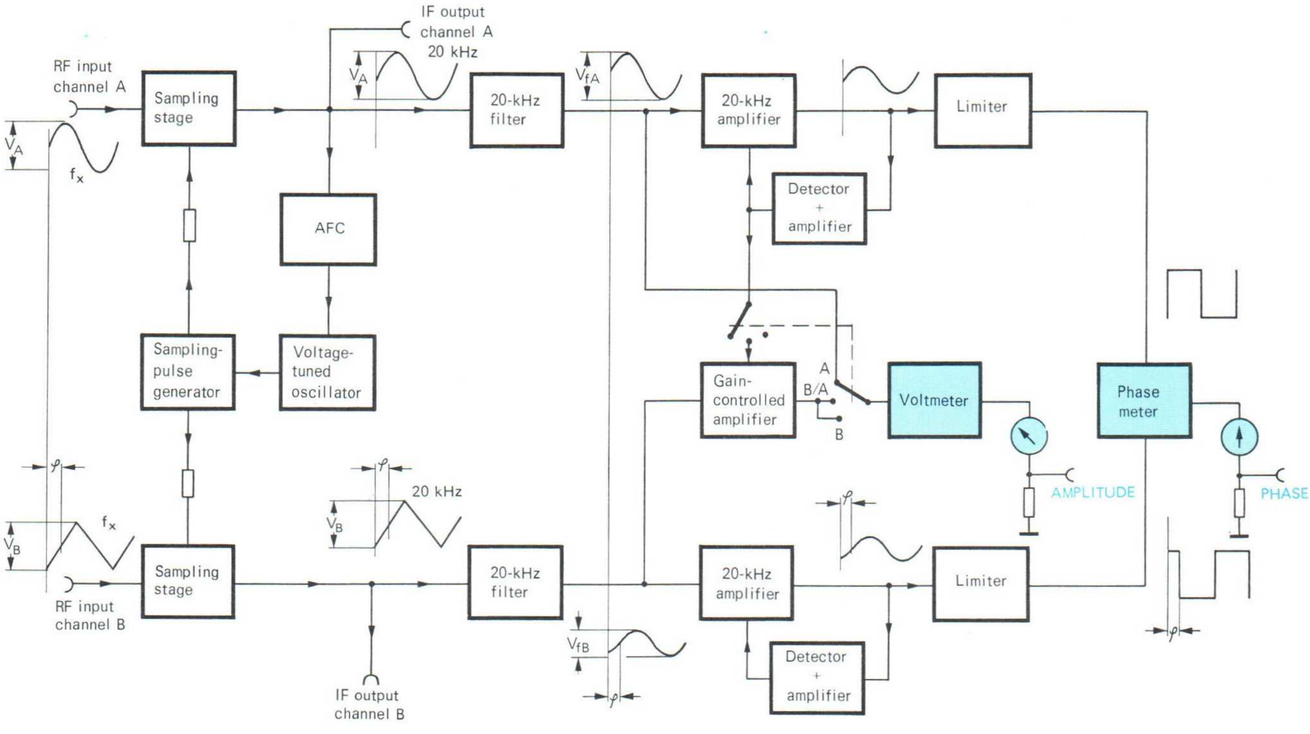
The **Vector Voltmeter ZPU** has two channels (A, B) and measures voltages with respect to magnitude and phase with automatic tuning. It also permits ratio measurements and – together with directional couplers – the measurement of s-parameters. The frequency range extends from 0.1 to 1000 MHz in 14 subranges.

Amplitude range. Channel A is for reference voltages from 300 µV to 1 V, channel B for test voltages from 2 µV to 1 V. A plug-on divider supplied with the set extends the measurement ranges by a factor of 100. The reference and test voltages are applied to the ZPU via low-capacitance probes (with or without plug-on divider) which are fixed to the unit and can also be plugged into the insertion adapters furnished with the ZPU. Voltage indication, switch-selected for channel A or B, is obtained on a mirror-scale meter in conjunction with a 10-dB range switch.

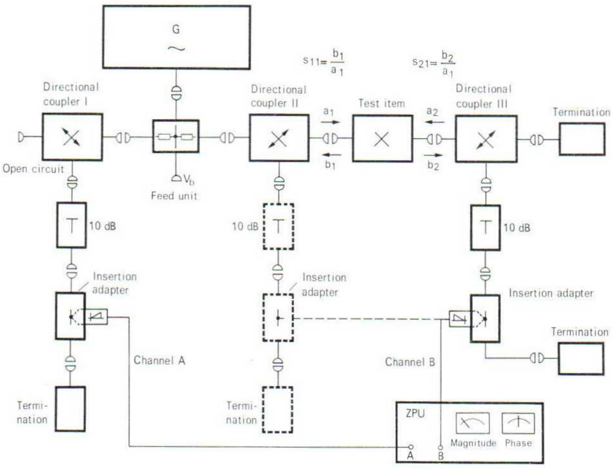
Phase indication is given on another meter (with zero-centre scale and end-scale ranges of ±6°, ±18°, ±60° and ±180°). Resolution is ±0.1°.

Ratio measurement. In position B/A of the mode selector the Vector Voltmeter also measures voltage ratios. The input voltage range for channel A (denominator) is 3 to 300 mV. If a voltage outside this range is applied, the corresponding lamp lights to show that V_A is too high or too low, meaning that a correct measurement is not possible. The measurement ranges above the inherent noise of the ZPU usable as a function of the denominator voltage A are listed in the table under "Specifications" for the lowest, medium and highest range of A. The magnitude of B/A is indicated on the meter for voltage indication and the phase simultaneously on the phase meter.

Block diagram of Vector Voltmeter ZPU



s-parameter measurement. With its ratio measurement capability the Vector Voltmeter ZPU can also be used to measure s-parameters. This requires an assembly of three directional couplers for 1 to 1000 MHz with standard characteristic impedance; see the diagram below and recommended extras (details on page 244). For the measurement the ZPU probes are plugged into the insertion adapters. These are match-terminated on one side whereas the other – a reflection-free test input – is connected to the directional couplers.



Basic diagram of test setup using three directional couplers (RI to RIII) and ZPU as ratio meter for s-parameter measurements

The directional coupler R II measures the signal ahead of and R III after the test item, R I being used to eliminate frequency dependence by comparison. The generator voltage V_b is applied via the feed unit (furnished with the set). The directivity of the couplers is 45 dB.

Measurement without directional couplers:

The variety of accessories permits the parameters s_{11} and s_{22} to be measured without directional couplers. The additional measurement error is less than 1% from 0.1 to 100 MHz and less than 3% from 100 to 300 MHz.

Information outputs. 20-kHz IF signals are available at two BNC connectors at the rear. Two DC outputs – one for magnitude and one for phase indication – are also provided.

Remote control. All manual settings made on the ZPU can also be performed by remote control. The indication can be switched to channel A, B or B/A by applying a +20-V voltage; see specifications. The 14 frequency subranges are switched by means of 24 contacts (to be shorted to chassis), the voltage ranges by applying +20 V. The required DC voltages are available at multipoint connectors at the rear.

A wide range of accessories including plug-on dividers, insertion adapters, etc. copes with all measurement and matching problems. Using BNC adapters, for example, the ZPU can be connected to any BNC socket.

Specifications

Frequency range	0.1 to 1000 MHz
Subranges	0.1 to 0.3/0.3 to 1/1 to 1.9/ 1.7 to 3.3/3 to 6/5.4 to 10.6/ 9.5 to 19/17 to 34/30 to 60/ 53 to 100/95 to 188/170 to 336/ 300 to 590/530 to 1000 MHz
Frequency tuning	automatic within subranges; subrange selection manual or remote-controlled
Frequency tracking (also with swept signals)	tracking speed 30 MHz/s
Input impedance	100 kΩ shunted by 2 pF; 10 MΩ shunted by 2 pF with 100:1 divider
Max. input voltage	3 V AC; ±50 V DC
Crosstalk attenuation	≧100 dB at 0.1 to 500 MHz ≧80 dB up to 1000 MHz
Bandwidth of indication channels	1 kHz; 2 Hz in ranges 10 µV/30 µV
Voltage indication	minimum input voltage for channel A: ≦ 0.4 mV
Voltage ranges	Channel A: 1 mV to 1 V in 10-dB steps; Channel B: 10 µV to 1 V in 10-dB steps
Extension	by a factor of 100 with plug-on divider
Error of voltage indication (frequency response; measured with probe and insertion adapter)	< 2% at 0.3 to 100 MHz < 6% at 100 to 500 MHz < 15% at 500 to 1000 MHz
Indication of ratio B/A	voltage range for denominator quantity A: 3 to 300 mV

Usable ratio ranges as a function of denominator A in the lower, medium and upper voltage ranges

A = mV			B/A ranges	
200 to 300	20 to 30	3 to 4	1	to 3
			0.3	to 1
			0.1	to 0.3
			0.03	to 0.1
			0.01	to 0.03
			0.003	to 0.01
			0.001	to 0.003
			0.0003	to 0.001
			0.0001	to 0.0003
			0.00003	to 0.0001
			0.00001	to 0.00003

Adjustment range of denominator A	≈3 dB
Error of ratio indication	< ±3%
Non-linearity	< 2% of fs
Recorder output	0 to +1 V DC proportional to meter reading; Z = 1 kΩ; BNC
Phase indication	0 to ±180°/±60°/±18°/±6° for fs
Resolution	±0.1°
Offset	±180° in 10° steps
Error with fixed frequency and 2×100 mV at probe tips	< 1% +1°
Frequency effect	< ±1°/< ±5°/< ±8° up to 100 MHz/500 MHz/1 GHz
Effect of amplitude variations	< 1°/20 dB
Recorder output	0 to ±0.5 V proportional to phase indication; Z = 1 kΩ; BNC
Remote control capability	frequency range, mode, measurement range
Frequency range	14 subranges from 0.1 to 1000 MHz, selected by contact to chassis
Modes	channel A, channel B, B/A, selected with +20 V DC, code 1, 2 or 3 out of 7
General data	
Nominal temperature range	+18 to +30 °C
Shelf temperature range	−40 to +75 °C
Power supply	115/125/220/235 V ±10%, 47 to 400 Hz (40 VA)
Dimensions, weight	484 mm × 150 mm × 436 mm, 13 kg
Order designation	► Vector Voltmeter ZPU 237.0012.12

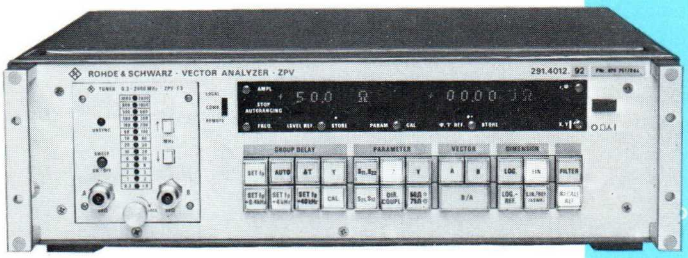
Accessories supplied

2 insertion adapters, 1 feed unit,
2 BNC/ ... adapters, 2 100:1 plug-on dividers,
3 chassis terminals, 1 case for accessories, 1 probe tip,
2 isolators, 1 Smith chart, power cable, spare cap

Recommended extras

Directional Coupler, 45 dB (N connectors) ZPV-Z3 292.3110.50
Precision Termination RNA, 50 Ω (N connector) 272.4510.50
Termination RNB, 50 Ω (N connector) 272.4910.50
Attenuators DNF, 50 Ω (N connectors), 10/20/30 dB: 272.4210.50/ 272.4310.50/272.4410.50
VSWR Bridge SWOB 4-Z, 50 Ω (N male/female connectors) 912.7003.50

ZPV



IEC 625 Bus

Vector Analyzer ZPV
♦ 100 kHz to 2 GHz

- Digital vector voltmeter
- Direct reading of s-parameters as well as y- and z-parameters
- Reflection and impedance measurement with directional couplers, VSWR bridge or T junction
- Autoranging feature
- Group-delay measurement
- IEC-bus compatible

Characteristics and uses

The **Vector Analyzer ZPV** implements a novel technique for the measurement of complex quantities. Its functional principle is that of a dual-channel vector voltmeter measuring amplitude and phase. As in conventional vector voltmeters, the frequency is synchronized in the reference channel, so that a selective measurement is performed at one frequency.

Combined with a **microprocessor**, the ZPV decisively simplifies all complex measurement procedures. All functions are fully automated and the required value is read out directly on the display. Thus the ZPV outdoes conventional analog vector voltmeters in operating convenience and display possibilities. Its typical applications are control engineering, crystal, antenna and amplifier measurements, etc.

The basic version of the ZPV is equipped for **voltage measurements by magnitude and phase.** Two expanded versions provide in addition for automated measurement of **two-port parameters** and of **group delay.**

Using different tuners (see next page) and the appropriate measuring facilities (directional couplers, etc., see recommended extras on page 117) the Vector Analyzer can be fitted to meet the user's specific requirements with respect to frequency range and test method.

Display possibilities. The two digital readouts of the ZPV indicate both components of the measured complex quantity. The display can be in cartesian or polar coordinates, linear, logarithmic, absolute or relative.

Autoranging. Range selection is fully automatic due to the built-in microprocessor so that the measured value can be read off directly after selecting the mode and physical unit. For swept-frequency operation and special display modes the amplitude and frequency autoranging facilities can be disconnected.

Automatically tuned filter. The ZPV incorporates an automatically tuned filter which provides for stable indication of noise-corrupted test signals. The microprocessor analyzes the stability of the signal and determines the time constant required for fluctuation-free display of the result.

Calibration at the push of a button. For complex measurements a reference plane has to be defined. This is done in the ZPV at the push of button, determining phase zero, magnitude = unity and reference characteristic impedance. These values are stored in the built-in microprocessor and maintained even when changing the test mode so that new calibration is required only if the test setup is modified.

Swept-frequency operation, recorder outputs. Control voltages monitored by the microprocessor ensure that high-precision signals are always available at the X and Y outputs. Transient response of the synchronization stage due to sampling is suppressed. Consequently the Vector Analyzer ZPV can also be used in swept-frequency operation; however, the sweep rate of the ZPV, which is slow compared with sweeper display units, has to be considered. The test results obtained in swept-frequency checkouts can be plotted on a recorder or displayed on a storage oscilloscope up to a dynamic range of 110 dB. For narrowband sweeping, for instance in crystal testing, additional special outputs are available.

System compatibility. With the IEC-bus Option ZPV-B1 the ZPV becomes fully programmable. The IEC bus permits both setting of all modes on the instrument and outputting of all test results. Various methods of data transfer ensure optimum data transmission speed. In addition to the separate output of real and imaginary components or magnitude and phase, the complete complex quantity can be transmitted as one data word. The readout is either dependent on the measurement time or independent of time so that optimum use of the measurement speed is made. Manually selected modes can be output via the IEC bus. Basic Software ZPV-K1 and ZPV-K2 facilitate programming of automatic measurements with the desktop Tektronix Graphic Computing System 4051, permitting whole program sections to be called up by means of code numbers (see page 114).

Vector measurement

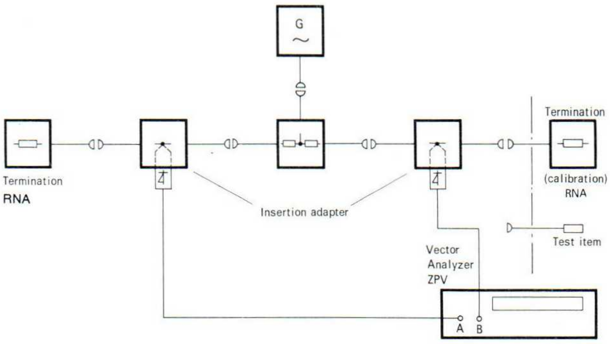
In the basic ZPV version the voltages in channels A and B are measured and indicated in absolute mV or dBm values and relative to any presettable reference value in dB. Simultaneously the phase difference between channels A and B is indicated. The voltage ratio between the two channels can be indicated linearly and logarithmically – both in absolute or relative values – or with its real and imaginary components.

Two-port measurement

When using the s-parameter Option ZPV-B2, the s-parameters, impedance and admittance values can be read out on the digital ZPV display either in cartesian or in polar coordinates. Impedance and admittance are indicated both in absolute values and normalized to the characteristic impedance, the reference being either 50 or 75 Ω. The ZPV permits impedance calculation for test setups using directional couplers and bridges or based on the voltage measurement method. The type used is entered with the aid of a pushbutton.

The **s-parameters** are read out linearly or logarithmically. Direct indication of the VSWR is also possible. The reference plane is defined at the push of a button, the reference phase and amplitude being automatically stored in the ZPV.

For two-ports in the range < 100 MHz the voltage measurement method can be used (see figure below) whereas use of an impedance-match bridge or directional couplers is to be preferred at higher frequencies (> 100 MHz) because of the increased accuracy.



Two-port measurement based on the voltage method

Group-delay measurement

The Group-delay Option ZPV-B3 enables the ZPV to measure group delay with high resolution (typ. 1 ns). The ZPV is combined for this purpose with an FSK generator. From the phase variation resulting from the frequency shift, the equipment calculates the group delay and gives a direct readout in nanoseconds. An automatic calibration routine calibrates the frequency shift of the signal generator.

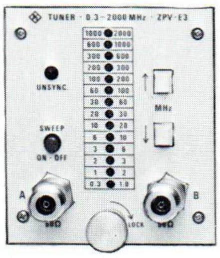
Description (modes)

The ZPV is of modular construction; the tuner is therefore exchangeable.

Tuner ZPV-E2. The ZPV-E2 covers the frequency range of 100 kHz to 1 GHz (typ. 1.2 GHz). Its two associated probes permit voltages to be measured with high impedance. Insertion units are combined with the probes for measurements in coaxial systems. Directional couplers can also be connected through the insertion units.

Tuner ZPV-E2

Tuner ZPV-E3. The ZPV-E3, in conjunction with the basic unit ZPV, permits vector measurements, two-port measurements and group-delay measurements in coaxial systems over a wide range of frequency and signal level. It is thus possible to take full advantage of the measuring and processing capabilities offered by the ZPV and its options (see page 110). The frequency coverage of 300 kHz to 2000 MHz is twice that of the tuner with probes, ZPV-E2, and thereby considerably extends the range of possible applications of the basic unit.

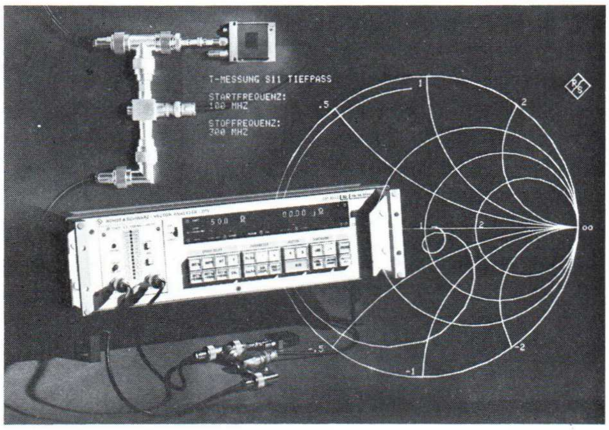


Tuner ZPV-E3
(larger scale than Tuner ZPV-E2)

new

The input impedance of the test inputs, which are fitted with female N connectors, is 50 Ω. This permits **simple and straightforward test setups** since the test circuits used can be connected directly to the ZPV-E3. There is no need for the insertion unit and associated termination required with the ZPV-E2.

Vector Analyzer ZPV, continued



Vector Analyzer ZPV fitted with Tuner ZPV-E3 used for filter measurement according to T-junction method

Description of ZPV Tuners

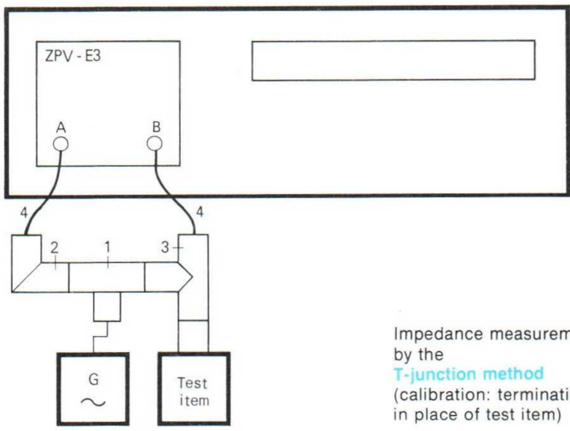
The ZPV Tuners convert the input signals of the channels A and B with the aid of two sampling mixer stages over a wide frequency range to an intermediate frequency of 20 kHz, the fundamental of the input signals being retained with amplitude and phase fidelity. The shape of the curve is also more or less retained unless the spectral components of the input signals exceed 1000 or 2000 MHz. The IF signals are available at the outputs of the basic unit. Only the fundamental is used for signal evaluation. The tuner covers 14 frequency subranges. The required subrange is selected either manually or automatically under the control of the basic unit. Tuning to the fundamental of the input signal of channel A takes place automatically within the subranges. Channel B is then tuned to the same receive frequency.

Measuring methods

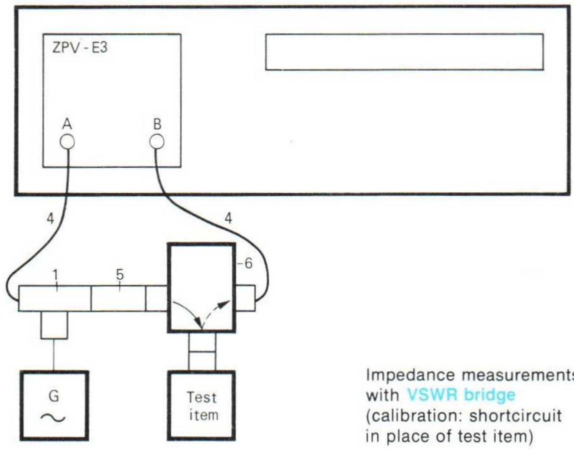
new Reflection-coefficient and impedance measurements can be made with directional couplers or VSWR bridges (figure in the middle) or by the simple T-junction method (top), a new measuring method that greatly simplifies the test setup and, as a result, drastically cuts down its costs. After entry of the type of desired test setup at the push of a button on the basic unit the parameter of interest can be determined using the calculating power of the internal microprocessor and is read out digitally. While the entire frequency range of the Tuner ZPV-E3 is utilized with this T-junction method, directional couplers or impedance-match bridges restrict the frequency range according to their particular characteristics. The last figure shows how simple it is to carry out transmission-factor measurements.

Legend

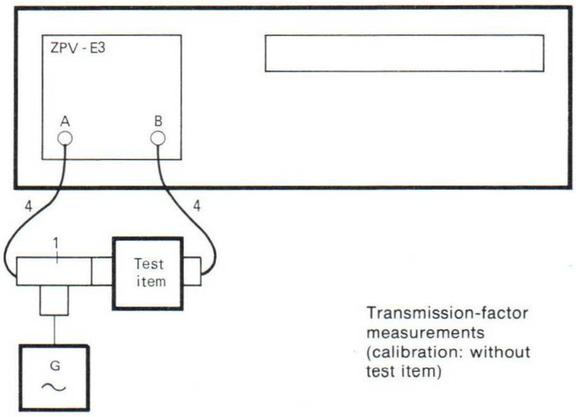
1 = Feed-in	4 = Pair of measuring cables
2 = Angle piece	5 = Two-way plug
3 = T junction	6 = Impedance-match bridge



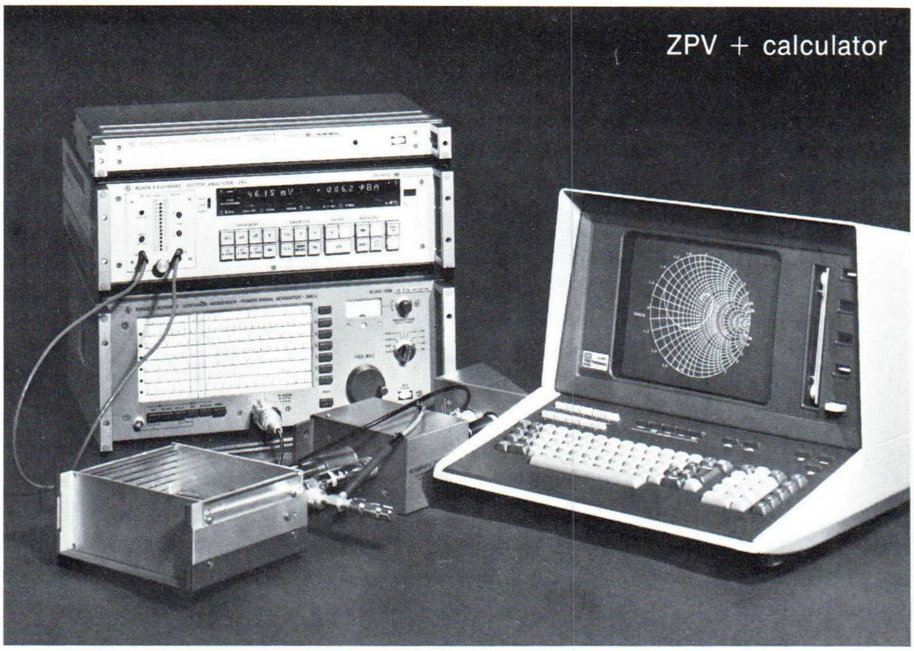
Impedance measurement by the T-junction method (calibration: termination in place of test item)



Impedance measurements with VSWR bridge (calibration: shortcircuit in place of test item)



Transmission-factor measurements (calibration: without test item)



Calculator-controlled Network Analyzer

♦ 100 kHz to 1000 (2000) MHz

- Fully automated measurement of all two-port parameters
- Graphic screen display
- High measurement rate
- Expandable with IEC-bus-compatible equipment

System configuration, characteristics

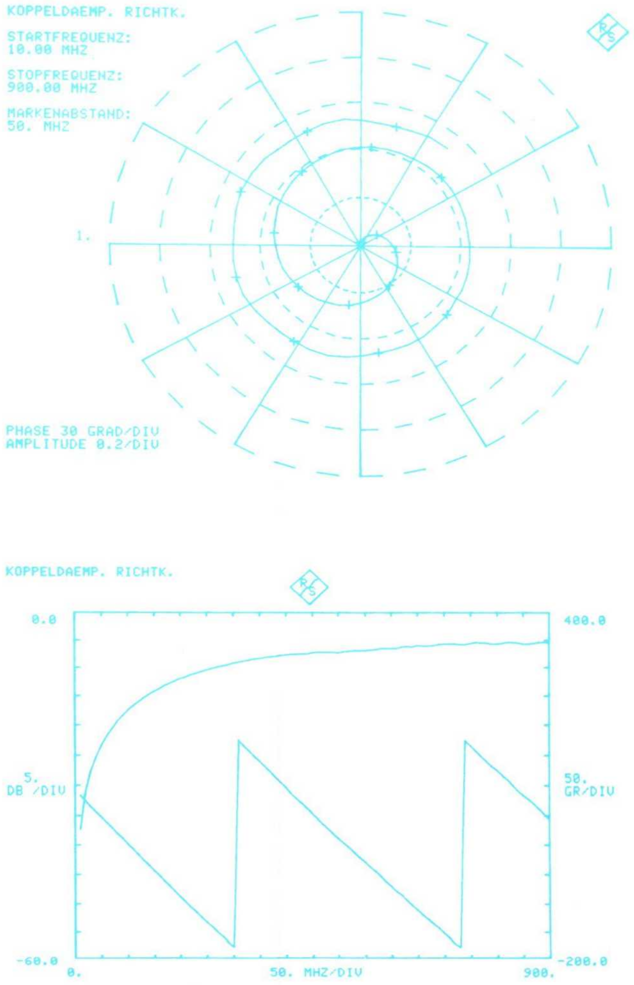
When combining the Vector Analyzer ZPV with a programmable frequency generator and a calculator, a fully automatic network analyzer system is obtained.

Calculator. For controlling the ZPV, the Tektronix Graphic Computing System 4051 is ideal; this desktop calculator gives a direct graphic display of the measured values.

Generator. Various Rohde & Schwarz generators are suitable for use with the ZPV. For somewhat less stringent frequency-accuracy requirements, the Power Signal Generator SMLU can be used in the range from 25 MHz to 1 GHz. The Decade Frequency Generator SMDS and the Signal Generator SMS permit precision measurements in the ZPV range up to 1 GHz. Both the normal and the receiver test versions of the Test Assembly for Radio Sets SMPU can also be used to form an automatic network analyzer.

Software. For this combination of instruments, Rohde & Schwarz offers easy-to-handle basic software so that a minimum of time is required to get acquainted with the application of the network analyzer. The preprogrammed measurement and display modes can be called up with code numbers (see page 114). Graphic display in particular shows the efficiency of the basic software: the curves plotted can be made available directly as hardcopy documentation (for examples of programming and graphic display see to the right).

The resulting automatic network analyzer system (see figure above) is superior in many respects to the calculator-controlled systems used hitherto: the high intelligence of the ZPV makes operation and programming simple and easy to understand. The test speed, in particular for impedance and admittance measurements, is very high since computing and control are performed to a large extent in the ZPV at optimum speed. Only a minimum of data and control commands has to be transferred between the calculator and the peripherals.



Coupling attenuation of a directional coupler represented in polar coordinates (top) and in cartesian coordinates (bottom); output on hardcopy unit (heavily reduced scale)

Calculator-controlled Network Analyzer ZPV

Measurement capabilities, operation

The system fully automates all measurements that are possible with the ZPV, i.e. depending on the ZPV version:

voltage measurements by magnitude and phase,
s-parameter, impedance and admittance measurements,
group-delay measurements.

Comprehensive basic software facilitates not only the operation of the analyzer system but also programming. The user need not learn any programming language. Ready-made test routines can be called up by means of code numbers.

Basic software

The Basic Software ZPV-K1 permits both easy programming of point-by-point measurements as they are required for final inspection and graphic display of continuous frequency-dependent curves (for two examples of such curves output on the hardcopy unit see preceding page). There are different possibilities of outputting the test result: numerical display on the screen or by a printer and graphic display on the screen or output on a hardcopy unit. Comparing of nominal and actual values is also possible. For the table compiling the setting commands see below and for an extract of the list of code numbers associated with the Basic Software see righthand column, top.

Setting commands

Control characters	Setting
AR..	amplitude range
FR..	frequency range
GØ	tendency indication OFF
G1	tendency indication ON
HZ.....	frequency value
KØ	recorder output OFF
K1	recorder output ON
PO....	phase offset
SH	high measurement speed
SL	low measurement speed
TE	external triggering
TI	internal triggering
TR	reference value (10 ASCII characters)
TS	device status word (10 ASCII characters)

Calculator-controlled network analyzer assembly comprising Vector Analyzer ZPV, Power Signal Generator SMLU and hard-coby unit

Extract of code number list for Basic Software ZPV-K1

As an example only the input data and the graphics output are listed in detail (for complete list see data sheet 292 401).

Program start Y = 1 generator SMPU
Y = 2 generator SMLU
Y = 3 generator SMDS
Y = 4 generator SMS

Input data	Physical unit	Code No.
Test frequency	MHz	2
Test level	dBm	3
Shift of reference plane	cm	6
Relative dielectric constant		7
Sweep start frequency	MHz	9
Sweep stop frequency	MHz	10
Sweep step width	MHz	11
Number of markers		13
Frequency deviation for group-delay measurement	kHz	14
Operational settings		17 to 26
Calibration/reference values		27 to 31
Output of single-shot measurements		33, 34
Output of swept-frequency measurements		35, 37
Program execution		39 to 43
Individual measurements		
Vector measurement		45 to 59
Parameter measurement		62 to 78
Group-delay measurement		82, 83
DC voltage measurement		84
Graphic display		
Diagrams		85 to 92
Graphic data output		
Smith chart or polar coordinates		96
Magnitude (real component) in cartesian coordinates		97
Phase (imaginary component, group delay) in cartesian coordinates		98

Example of programming for Tektronix Graphic Computing System 4051 using the Basic Software ZPV-K1

```
100 INIT
110 Y=1
120 GOSUB 1
130 Y=10
140 GOSUB 9
150 Y=900
160 GOSUB 10
170 Y=10
180 GOSUB 11
190 GOSUB 78
200 Y1=-60
210 Y2=0
220 S$="DB"
230 T$="KOPPELDAEMP. RICHTK."
240 GOSUB 90
250 GOSUB 97
260 Y1=-200
270 Y2=400
280 Y$="GR"
290 GOSUB 92
300 GOSUB 98
310 END
```

Specifications

ZPV basic unit with options

Display of measured quantities

Vector measurement

P Polar-coordinate representation

Magnitude of voltage (channel A or B)

Lin indication	3 digits with floating decimal point, max. resolution 1 µV
Log indication (absolute) in dBm (0 dBm corresponding to 1 mW into 50 Ω)	4 digits, resolution 0.1 dB
Log indication (relative) in dB	4 digits, resolution 0.1 dB (for values < 1 dB: 0.01 dB)
Indication of reference value for relative voltage measurements in dBm	4 digits, resolution 0.1 dB

Magnitude of ratio

Lin indication	3 digits with floating decimal point, max. resolution 0.001
Log indication	4 digits, resolution 0.1 dB

Phase

Readout in degrees	4 digits, resolution 0.1°
Range	−180 to +180°
Indication of phase reference value in degrees	4 digits, resolution 0.1°

C Cartesian-coordinate representation

Lin indication	3 digits with floating decimal point, max. resolution 0.001
Calibration of reference phase and level	automatic by pushbutton

s-parameter measurement (option ZPV-B2)

Test method	for frequencies < 100 MHz: direct voltage measurement for frequencies > 100 MHz: use of directional coupler or VSWR bridge
Calibration of reference phase and level	automatic by pushbutton
Characteristic impedance	50 Ω/75 Ω, switch-selected

P Polar-coordinate representation

Lin indication of magnitude	3 digits with floating decimal point, max. resolution 0.001
Log indication of magnitude	4 digits, resolution 0.1 dB
Indication of phase in degrees	4 digits, resolution 0.1°
VSWR	4 digits with floating decimal point

C Cartesian-coordinate representation

Lin indication	3 digits with floating decimal point, max. resolution 0.001

Impedance or admittance measurement (option ZPV-B2)

Characteristic impedance	50 Ω/75 Ω, switch-selected

P Polar-coordinate representation

Absolute indication of magnitude in Ω or mS	3 digits with floating decimal point, max. resolution 0.1 Ω or 0.1 mS
Normalized indication of magnitude	4 digits, resolution 0.01
Indication of phase in degrees	4 digits, resolution 0.1°

C Cartesian-coordinate representation

Normalized indication	3 digits with floating decimal point, max. resolution 0.01
Absolute indication in Ω or mS	3 digits with floating decimal point, max. resolution 0.1 Ω or 0.1 mS

Group-delay measurement (option ZPV-B3)

Indication	3 digits with floating decimal point, max. resolution 1 ns
Frequency shift	0.4/4/40 kHz, switch-selected
Measured quantities	group delay and group-delay variation
Modes	single-shot and continuous measurement

Programming (option ZPV-B1)

System	IEC 625-1 (IEEE 488)
Connector	24-way Amphenol

Interface functions

T6, TE6	talker capability with secondary address, series polling and automatic unaddressing
L4	listener capability with automatic unaddressing
SR1	service request (switch-selected)
DC1	device clear
DT1	device trigger

Timing (typical values)

Time required for addressing	1 µs
Time required for data transfer	0.5 to 2 ms
Period between reception of talker address and output of first data word	0.5 ms
Max. data output time/character	0.5 ms
Code	ISO 7-bit
Figure representation	decimal
Delimiters	16 different characters can be set (factory setting:CR)

Test outputs

X and Y outputs for recorder

Output-voltage range	0 to +1.25 V DC
Output impedance	1 kΩ
Connector	BNC

r and φ output for narrowband sweeping

Output voltage range r	0 to 1 V DC
Output voltage range φ	−0.5 to +0.5 V
Output impedance	1 kΩ
Test bandwidth	1 kHz (15 Hz for ≦ 100 µV in channel B)
Connector	BNC

IF outputs for channels A and B

Output frequency	20 kHz
Output level	AC input level on probe
Output impedance	1 kΩ
Connector	BNC

DC voltage test input

Input voltage range	0 to +10 V, resolution 2.5 mV
Input impedance	> 100 kΩ
Connector	BNC

For specifications of ZPV plus Tuners -E2 and -E3 see next page

General data (basic unit)

Nominal temperature range	+10 to +45 °C
Shelf temperature range	−40 to +75 °C
Power supply	115/125/220/235 V ±10%, 47 to 420 Hz (90 VA)
Overall dimensions (W × H × D)	492 mm × 161 mm × 514 mm
Weight (including options and Tuner ZPV-E2)	16 kg

For **order designations** see page 117

Specifications

ZPV plus Tuner ZPV-E2

(accuracy data applicable for set with frequency autoranging facility disabled)

Basic characteristics

Frequency range .... 0.1 to 1000 MHz
Subranges (14) .... 0.1 to 0.3 to 1 to 2 to 3 to 6 to 10 to 20 to 30 to 60 to 100 to 200 to 300 to 600 to 1000 MHz
Subrange overlap .... >10%
Range setting .... automatic or manual
Tuning within subrange .... automatic
Hold range .... 0.2 to 0.4 MHz at f < 1 MHz; 1 to 3 MHz at f = 1 to 1000 MHz
Maximum sweep rate for tracking within hold range ..... 0.3 to 3 MHz/s for f < 1 MHz; 3 to 30 MHz/s for f = 1 to 1000 MHz
Input impedance of probes .... 60 kΩ‖2 pF
with 100:1 divider .... 6 MΩ‖2 pF
Maximum input voltage .... 3 V AC, ±50 V DC
Crosstalk attenuation referred to signals at probe tips .... ≧100 dB at f = 0.1 to 500 MHz; ≧80 dB at f = 500 to 1000 MHz

Sensitivity and input level

	Frequency range	Sensitivity	Input level
Channel A	0.1 to 1 MHz	1200 µV (400 µV typical)	max. 0.3 V
	1 to 1000 MHz	400 µV (150 µV typical)	max. 1 V
Channel B	0.1 to 1 MHz	3 µV (1 µV typical)	max. 0.3 V
	1 to 1000 MHz	3 µV (1 µV typical)	max. 1 V

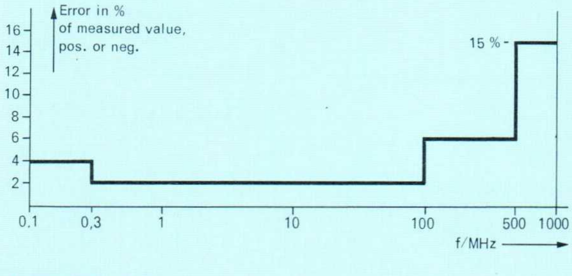
Additional error with 100:1 divider .... ±6% at f = 1 to 200 MHz

Display of measured quantities

Vector measurement[1])

P Polar-coordinate representation

Magnitude of voltage (channel A or B)



Magnitude of ratio

Measurement range .... −90 to +70 dB within the permissible input levels
Indication error at fixed frequency[2])
with calibration button (linearity) .... ± 1.5% (at f > 500 MHz only if V_{in} < 0.3 V)
without calibration button (difference between A and B) .... ±3% at f = 0.1 to 100 MHz; ±6% at f = 100 to 1000 MHz

Phase

Measurement range .... −180 to +180°
Linearity error .... < 0.5° at fixed frequency and 2×100 mV at probe tips
Effect of frequency variation (reference frequency 10 MHz) .... < ±3° at f = 0.1 to 0.3 MHz; < ±1° at f = 0.3 to 100 MHz; < ±4° up to f = 500 MHz; < ±6° up to f = 1000 MHz
Effect of level variation[2]) .... < 0.05°/dB; < 3° over entire range

C Cartesian-coordinate representation

Measurement range .... −90 to +70 dB within the permissible input levels
Error of polar-to-cartesian conversion .... < 0.1%

s-parameter measurement

Measurement ranges and errors .. see vector measurement of magnitude of ratio and phase; errors and ranges of directional couplers must be taken into account
Reflection measurement range with Directional Coupler ZPV-Z3 ...... −45 to +10 dB

Impedance or admittance measurement

Measurement error .... see vector measurement of magnitude of ratio and phase
Range of impedance measurement with Directional Coupler ZPV-Z3 .. approx. 5 to 500 Ω in 50-Ω systems or approx. 7.5 to 750 Ω in 75-Ω systems

Group-delay measurement[1])

Frequency shift 40 kHz
Range .... 1 to 10,000 ns, resolution 1 ns
Measurement error (for V_{in} > 30 mV) < ±3% ±3 ns (from 1 MHz)
(V_{in} = voltage in channels A and B)

Frequency shift 4 kHz
Range .... 10 ns to 100 µs, resolution 10 ns
Measurement error (for V_{in} > 30 mV) < ±3% ±30 ns (from 1 MHz)

Frequency shift 400 Hz
Range .... 100 ns to 1 ms, resolution 100 ns
Measurement error (for V_{in} > 30 mV) < ±3% ±300 ns (from 1 MHz)

Timing
Time required for
synchronization .... < 20 ms
complex vector or s-parameter measurement (synchronization time not included) .... 30 ms for levels > 100 µV; 80 ms for levels < 100 µV
complex impedance measurement (synchronization time not included) .... 50 ms for levels > 100 µV; 100 ms for levels < 100 µV
automatic group-delay measurement (synchronization time not included) .... 150 ms for levels > 30 mV (without filter); 400 ms for levels > 30 mV (with filter)

General data

Nominal temperature range ...... +18 to +30 °C
Operating temperature range ..... +10 to +45 °C

ZPV plus Tuner ZPV-E3

Basic characteristics

Frequency range .... 0.3 to 2000 MHz
Subranges (14) .... 0.3 to 1 to 2 to 3 to 6 to 10 to 20 to 30 to 60 to 100 to 200 to 300 to 600 to 1000 to 2000 MHz
Subrange overlap .... > 10%
Range setting .... automatic or by hand
Tuning within subrange .... automatic
Hold range .... 0.2 to 0.4 MHz at f < 1 MHz; 1 to 3 MHz at f = 1 to 2000 MHz
Maximum sweep speed within hold range .... 0.3 to 3 MHz/s at f < 1 MHz; 3 to 30 MHz/s at f = 1 to 2000 MHz

Input impedance .... 50 Ω
VSWR .... < 1.2 (up to 1.5 GHz), < 1.9 (up to 2 GHz)
Max. input voltage .... 5 V_{rms}, max. ±15 V
Suppression of crosstalk referred to signals at probe tips .... ≧100 dB at f = 0.3 to 500 MHz; ≧80 dB at f = 500 to 1000 MHz; ≧70 dB at f = 1000 to 2000 MHz

Sensitivity and input level

	Frequency range	Sensitivity	Input level
Channel A	0.3 to 1 MHz	1200 µV (400 µV typ.)	0.3 V max.
	1 to 2000 MHz	1 mV (300 µV typ.)	1 V max.
Channel B	0.3 to 1 MHz	5 µV (1 µV typ.)	0.3 V max.
	1 to 2000 MHz	5 µV (1 µV typ.)	1 V max.

Display of measured quantities

Vector measurement

P Polar-coordinate representation

Magnitude of voltage (channel A or B)

Error of voltage measurement (absolute) at a constant input level of 100 mV
up to f = 100 MHz .... +0.2/−0.2 dB
up to f = 500 MHz .... +0.5/−0.5 dB
up to f = 1500 MHz .... +1.2/−1.2 dB
up to f = 2000 MHz .... +1.2/−2.3 dB

[1]) Measured in 50-Ω system or with isolator.
[2]) For additional measurement error due to crosstalk see crosstalk attenuation (lefthand column).

Magnitude of ratio

Ratio measurement range	−90 to +70 dB within permissible input level
Indicating error at fixed frequency[3]) with calibration button (linearity)	± 1.5% (at f > 1000 MHz only if V_{in} < 0.3 V)
without calibration button (difference between A and B)	±3% at f = 0.3 to 500 MHz ±6% at f = 500 to 1500 MHz ±12% at f = 1500 to 2000 MHz

Phase

Phase measurement range	−180 to +180°
Nonlinearity	< 0.5° at fixed frequency and 100 mV at both test inputs
Frequency response (reference frequency: 10 MHz)	< ±1° at f = 0.3 to 100 MHz < ±4° up to f = 500 MHz < ±6° up to f = 1500 MHz < ±12° up to f = 2000 MHz
Amplitude response[3])	< 0.05°/dB referred to 100 mV at both test inputs < 3° over entire level range

© Cartesian-coordinate representation

Measurement range	−90 to +70 dB within permissible input level range
Error of conversion from polar-coordinate to cartesian-coordinate representation	< 0.1%

s-parameter measurement

Measurement ranges and measurement errors	see vector measurement magnitude of ratio and phase; in addition, errors and measurement limits of the test setup used must be taken into account
Measurement ranges of reflection-coefficient measurement	−45 to +10 dB

Impedance or admittance measurement

Measurement error	see s-parameter measurement
Measurement range for impedance measurements with Directional Couplers ZPV-Z3 or VSWR Bridge ZRB	≈5 to 500 Ω in 50-Ω systems or ≈7.5 to 750 Ω in 75-Ω systems
with T junction	≈2.5 to 250 Ω

Group-delay measurement, Timing, General data } same as for ZPV-E2, see preceding page

Automatic Network Analyzer

Frequency range	0.1 to 1000 (2000) MHz 10 to 1000 MHz when using directional couplers
Resolution up to 500 MHz	10 Hz
up to 1000 MHz	20 Hz
Measurement capabilities	voltage lin or log, vectors in polar or cartesian coordinates; s parameters; impedance/admittance; group delay
Dynamic range	−90 to +70 dB
Minimum input level	3 µV
Display	digital and graphic
Time required for display of complete locus	10 to 20 s (about 50 measuring points)
for complex measurement	200 ms for levels > 100 µV
Programming	IEC bus (IEC 625-1, IEEE 488)

[3]) Additional measurement error due to crosstalk, see suppression of crosstalk (see page 116, lefthand column).

Order designations

Vector Analyzer ZPV

Basic unit without tuner and without options	► Vector Analyzer ZPV 291.4012.92
Accessories supplied	power cable
Tuner 100 kHz to 1 GHz, without options	► Tuner ZPV-E2 292.0010.02
Accessories supplied	2 BNC adapters 3 ground terminals 2 insulators 1 100:1 divider 1 probe tip 1 accessory case
Tuner 300 kHz to 2 GHz, without options	► Tuner ZPV-E3 301.7018.02
Options for IEC-bus programming	► IEC-bus Option ZPV-B1 292.3610.02 (including 2 m IEC-bus cable)
s-parameter measurement	► s-parameter Option ZPV-B2 292.3810.02
group-delay measurement	► Group-delay Option ZPV-B3 292.3910.02 (including calibration cable for 50 ns)

Recommended extras

Insertion Adapter ZPV-Z1 (at least two units required; N female/male connectors)	292.2713.50
Feed Unit ZPV-Z2, 50 Ω (connectors: generator – BNC, others – N female)	292.2913.50
Directional Coupler ZPV-Z3, 45 dB, 50 Ω (at least two units required, N male connector for RF input, N female connector for test output and item)	292.3110.50
Precision Termination RNA	272.4510.50
Termination RNB	172.4910.50
Attenuator DNF (10/20 dB)	272.4210.50/272.4310.50
Shortcircuit N male connector, 50 Ω	017.8080.00
VSWR Bridge SWOB4-Z (50/75 Ω)	912.7003.00/912.7303.00

Additional equipment

Signal Generators: SMLH, SMUV (pages 32 to 37), SMLU (page 50), SMS (page 44), SMDU 02 or 04 (page 40), SMPU (page 82)

Equipment and accessories for extending the ZPV to a fully automatic network analyzer

Controllers

Tektronix Graphic Computing System 4051

with 24-k store:	option 21
with 32-k store:	option 22
with printer interface:	option 10
Card Reader PCL	248.6017.02
Cables for IEC bus, 0.5 to 4 m	see page 13

Basic Software for control by 4051

ZPV-K1, including manual	292.2113.02

Printer, for example

Facit 4555 or Texas Instruments 755 RO
Hard Copy Unit (for graphic copies): Tektronix 4631

Signal generators and test assemblies

Decade Signal Generator SMDS	154.8723.52
Code Converter PCW	244.8015.92
Coding Board PCW-Z	245.2810.02
Signal Generator SMS	302.4012.02
Power Signal Generator SMLU	200.1009.03
Frequency Controller SMLU-Z3	242.5019.92
Code Converter PCW	244.8015.92
Coding Board PCW-Z	245.2610.02
Automatic Receiver Test Assembly SMPU	239.0010.54

Additional measuring facilities

Programmable Attenuator Set DPVP	214.8017.52
Coding Board PCW-Z	245.2510.02
RF Relay Matrix PSU	290.8014.02

Caesium Frequency Standard XSC
with Digital Clock CADM;
details on page 122

5

standard-frequency and standard-time systems

The new R&S line of standard-frequency and standard-time modules

The new generation of R&S modular standard-frequency and standard-time units allows economical, personalized standard-frequency and standard-time systems to be made up (overview on page 124).

The individual modules are compact functional blocks that can be combined into systems exactly in line with technical requirements. This flexibility permits adaptation to the user's needs and, moreover, fitting of additional modules if different technical needs arise at a later date.

Electrical characteristics

All modules are designed for supply with 22 to 32 V DC. Connection to all conventionally used AC supply voltages is possible by means of the Power Supply XSRM-Z laid out for a maximum permanent output current of 1.6 A. The XSRM-Z contains a 0.8-Ah NiCd cell battery for buffer operation, which feeds the units connected (e.g. the XSRM for a maximum of one hour) in case of an AC supply failure. The buffer circuit is also effective when modules are fed direct from an airborne 28 V DC supply.

When a Rubidium Frequency Standard XSRM and other modules are connected simultaneously, the XSRM automatically has priority during its warmup phase (about 20 minutes) of higher current drain, meaning that the other modules connected are not fed via the associated connectors during this period.

Once the warmup phase is completed, the current consumption of the XSRM drops to about 0.65 A, so that 0.95 A is available to feed other modules. Only one XSRM can be operated at a time from one power supply. The standby power supply of the Caesium Frequency Standard XSC functions in a similar way, offering 0.55 A for feeding other modules only after a warmup period of about 20 minutes. Here again a NiCd cell battery ensures continuity of operation in case of an AC supply failure.

Connecting cables. Two-pole connecting cables, both ends equipped with LEMO connectors, are used to convey the supply voltage from the Power Supply XSRM-Z or the Caesium Frequency Standard XSC to the modules.

Two-pole cables with one LEMO connector and one banana plug are provided for feeding the modules from an external battery. One such cable is supplied with each module. RF and control signals are transmitted via coaxial cables with BNC male connectors.

Typical current drain after heating at 24 V DC and 20 °C ambient temperature:

XSRM	0.65 A	XSRM-Z3	0.18 A
XSC	1.05 A	XSRM-Z	0.09A
XSD 2	0.20 A	(freq. conv.)	
XKE 2	0.40 A	CADM w/o	0.25 A
		with LED display	0.30 A

Construction, functional blocks

The modules are compact units with a front-panel width of
- 50 mm (XSRM-Z, XSRM-Z3) or
- 100 mm (XSRM, XSD 2, XKE 2, CADM, Power Supply XSRM-Z)

and a height of 133 mm, in line with DIN and ANSI recommendations.

Individual modules can be combined into stable functional setups (see also page 124 for possible combinations) in the following ways:

For 19″ racks, 19″ cabinets, DIN racks
A 19″ frame (237.6840.02), which may be inserted in 19″ racks or 19″ cabinets (237.7317.02) or mounted in DIN racks with the aid of adapters, accommodates any modules of 50 and 100 mm width up to an overall width of 400 mm.

The standard frame has two 50-mm and two 100-mm wide blank panels screwed to both its front and rear sides, leaving space for 100 mm module width.

Smaller module groups of 250 mm maximum width may be incorporated into a smaller cabinet of 5/8 of 19″ width with a fixed frame (237.6040.02). Blank panels of 100 mm and 50 mm for both the front and rear sides are included in the delivery.

The Caesium Frequency Standard XSC is always incorporated in a special 19″ frame and delivered with a cabinet. Instead of the blank panel a module of 100 mm width (or two of 50 mm) can be inserted.

Frequency standards

Frequency standards are the heart of many test and communications sets, governing their frequency accuracy. Supplying at least one signal with a very stable period which is not affected by environmental conditions and which is always an integer fraction of a second, frequency standards are also time standards.

There exist primary and secondary standards as for mechanical measurements.

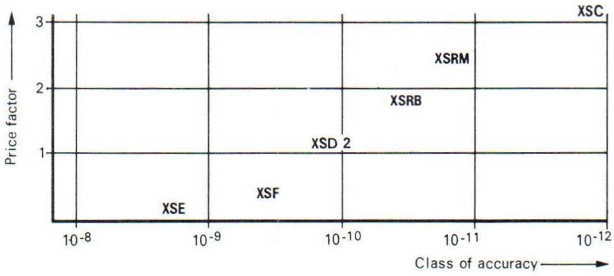
Primary frequency standards produce the output frequency with a caesium beam atomic clock as defined by the 13th general conference on weights and measures of October, 1967. Such units are used for scientific purposes, for navigation and for calibration tasks.

Secondary frequency standards are used to a much greater extent, particularly in electronic measurements and communications engineering. Their accuracy and stability, though inferior, still amply fulfil the practical requirements. Moreover, with the aid of commercially available equipment (frequency controllers, standard frequency receivers and phase recorders: XKE 2, XKD, XKP) the secondary standards can be corrected at any time by radio – automatically, if necessary – against primary standards. The advantages of simpler design make up for the reduced accuracy of the secondary standards: high reliability and relatively low purchasing and operating costs. Primary standard frequency emissions can be received all over the world.

Class of accuracy. A secondary frequency standard is characterized by the aging of its oscillator. This is the monotonic frequency drift which is independent of environmental influences. Aging decreases with the operating time, but as the rate of aging varies from specimen to specimen no precise prediction can be made. Limits are therefore specified for guaranteed maximum aging, which, however, are not normally reached in practice. All Rohde & Schwarz frequency standards are so designed that the frequency error due to external effects is of the same order as the guaranteed daily aging. This value determines the class of accuracy, which is typical of the quality of the standard.

Instrument models. Rohde & Schwarz makes frequency standards of different classes of accuracy to meet most diversified requirements. The sets also differ in other features, such as possibility of automatic frequency correction (XSD 2), built-in standby battery, higher or lower setting accuracy of the frequency trimmer. A suitable frequency standard can thus be selected for every application.

The frequency standards of the higher classes of accuracy (XSC, XSRM and XSD 2) are designed for continuous operation because aging decreases with the operating time. Shortness of warmup time is less important than low power consumption to save the built-in or external battery. In contrast, the oscillator modules XSRB, XSE and XSF have a particularly short warmup time, small dimensions and low weight.



Relation between price and accuracy of frequency standards

Overview

Output frequencies	Designation	Type	Order No.	Mean daily drift after 10 days of operation	Output voltage EMF	Source impedance Ω	Text on page
Frequency standards							Module system: 124
5 MHz	Caesium Frequency Standard	XSC	299.4011.02	$\pm 5 \times 10^{-12}$ for the whole tube life	2 V	50	122
5 MHz	Rubidium Frequency Standard	XSRM	238.4011.02	$< 2 \times 10^{-11}$/month	1 V	50/100	126
5 MHz	Crystal Oscillator	XSD 2	283.6010.02	$< 2 \times 10^{-10}$/day	1 V	50/100	127
Oscillator modules							
5 MHz	Rubidium Oscillator	XSRB	216.0213.03	$< 5 \times 10^{-11}$/month	1 V	50	132
1 to 10 MHz	Crystal Oscillator	XSE	100.7641 ... (complete No. see text)	$< 3 \times 10^{-9}$/day	0.5 V	500	134
5 MHz	Crystal Oscillator	XSF	100.5578.02	$< 5 \times 10^{-10}$/day	0.5V	500	134

XSC

Caesium Frequency Standard XSC
♦ 5 MHz

- Error limits $\pm 1 \times 10^{-11}$
- Modular design
- Standby power supply
- Small dimensions

While secondary frequency standards, such as the Rubidium Frequency Standard XSRM and the Rubidium Oscillator XSRB (which are dealt with later), require recalibration in spite of their high frequency stability, this is not necessary for primary frequency standards.

The Caesium Frequency Standard XSC is a primary frequency standard whose frequency is basically determined by the beam tube principle so that it requires no recalibration during its whole life.

Caesium Frequency Standard XSC and Digital Clock CADM

Characteristics and uses

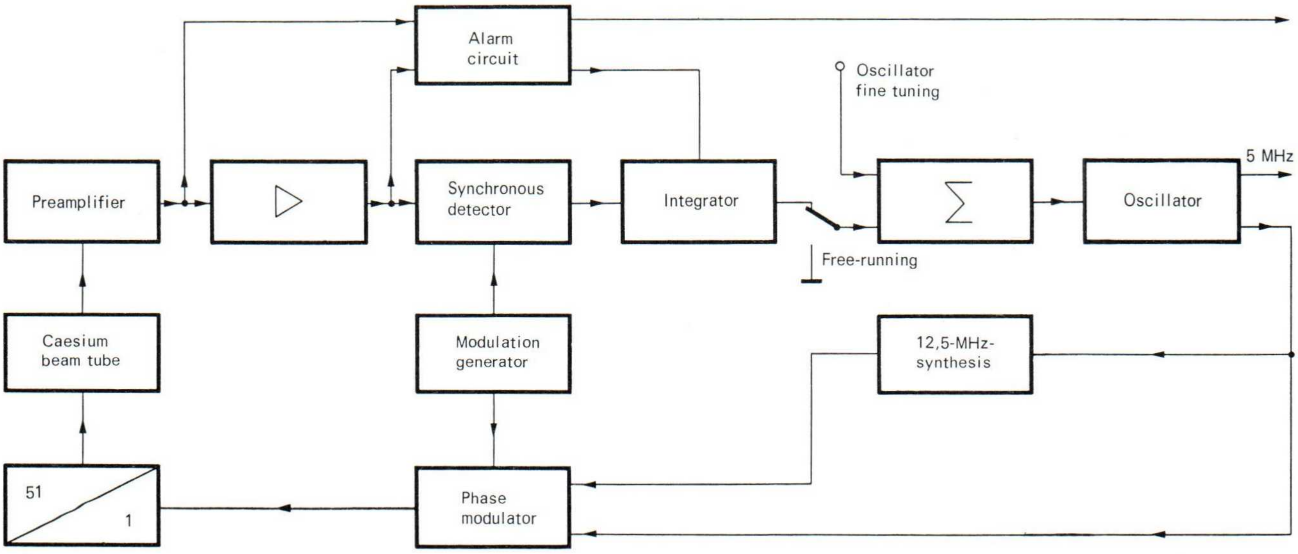
The XSC is ideal for all applications in which frequency recalibration is not feasible, e.g. in mobile use, or where it is impossible to receive a standard reference frequency.

The Caesium Frequency Standard XSC features the most modern design, small dimensions and low power consumption. In the case of AC supply failures, a standby power supply automatically takes over and is recharged when the AC supply voltage is present again.

Extension units

For extending the XSC, the R&S standard frequency module line is available (see page 124). In addition to the standard frequency of 5 MHz, the Frequency Converter XSRM-Z delivers the output signals of 0.1 MHz, 1 MHz and 10 MHz.

Block diagram of Caesium Frequency Standard XSC

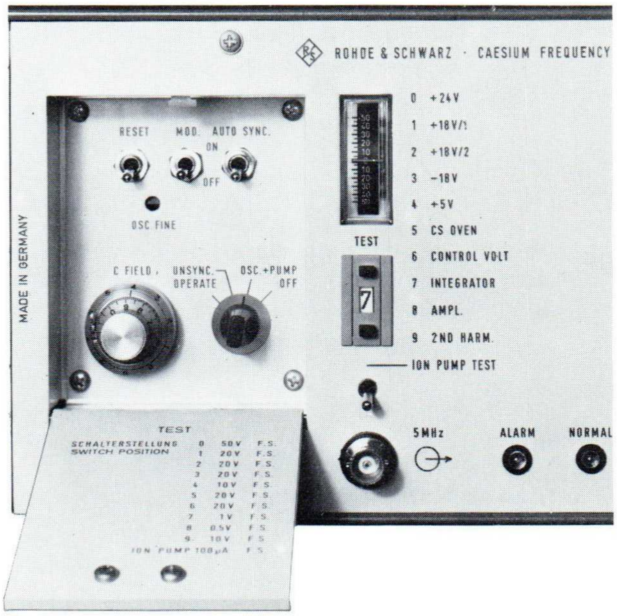


The Phase Comparator XSRM-Z3 permits ready phase comparison between the Caesium Frequency Standard XSC and external test items at the frequencies 1/2/3 to 10 MHz.

In conjunction with the Digital Clock CADM, the XSC constitutes a clock of absolute accuracy which can be used for control purposes and as a mobile time reference.

Operation

The XSC is extremely easy and convenient to operate. A number of its functions can be readily checked with the aid of a front-panel switch. The frequency-determining elements are protected by a flap to prevent unauthorized access to the instrument settings.



Front panel of Caesium Frequency Standard XSC

Description

The Caesium Frequency Standard XSC uses a hyperfine level transition in the caesium-133 atom as a reference to keep a 5-MHz crystal oscillator in phase lock. The caesium beam tube used is an ultramodern development meeting highest requirements with respect to reliability, long life and other essential characteristics. The 5-MHz crystal oscillator features extremely low noise and aging.

Specifications

Output frequency	5 MHz, with option XSRM-Z: 0.1/1/5/10 MHz
Output EMF	2 V_{rms}
Output impedance	50 Ω
Connectors	BNC female on front and rear panels
Harmonics suppression	> 40 dB
S/N ratio for bandwidth 1 Hz	85 dB
10 Hz	125 dB
100 Hz	140 dB
1 kHz	140 dB
Frequency accuracy	
Error at 0 to 50 °C	$\pm 1 \times 10^{-11}$
Reproducibility	$\pm 5 \times 10^{-12}$
Longterm stability (referred to tube life)	$\pm 5 \times 10^{-12}$
Shortterm stability for t = 1 s	3×10^{-11}
10 s	1×10^{-11}
100 s	3×10^{-12}
100,000 s	3×10^{-13}
Crystal aging	$< 1 \times 10^{-10}$/day
Frequency correction	
Coarse	4×10^{-7}
Fine	1×10^{-7}
General data	
Operating temperature range	0 to +50 °C
Shelf temperature range	−20 to +50 °C
Humidity	max. 95% (for operating temperature range)
Power supply	
AC supply	115/230 V ±20%, 47 to 420 Hz (70 VA)
External battery	22 to 28 V, max. 40 W; backup time (standby) 0.5 h
Dimensions, weight (XSC alone)	492 mm × 161 mm × 514 mm, 23 kg
Order designation	► Caesium Frequency Standard XSC 299.4011.02

Accessories supplied

1 two-core connecting cable (for external battery)
1 RF connecting cable (0.5 m, BNC)
1 connecting cable (0.1 m, for standby power supply)
1 power cable

Options (see page 130)

Frequency Converter XSRM-Z	238.0616.02
Phase Comparator XSRM-Z3	278.9314.02
Digital Clock CADM	289.6014.02

STANDARD FREQUENCY MODULES

Standard frequency module system

The Rubidium Frequency Standard XSRM and the Crystal Oscillator XSD 2 (if required in conjunction with the Standard Frequency Receiver XKE 2) are the basic units of a modular system which can be extended in steps by a power supply, frequency converter and phase comparator and also augmented for time indication and clock control with highest accuracy.

Available standard cabinets for housing the modules:

Cabinet

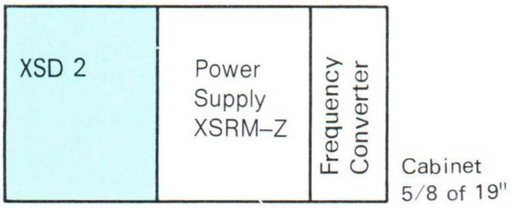
a) 5/8 of 19", with frame and blank panels ► Order No. 237.6040.02

b) 19'', without frame ► Order No. 237.7317.02
(required frame must be ordered separ.)

Frame

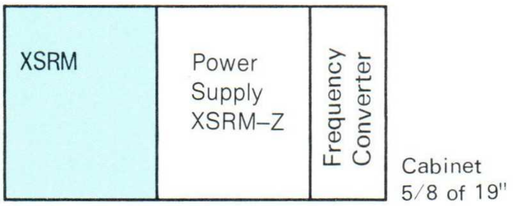
with blank panels, for insertion into 19" racks and 19" cabinets ► Order No. 237.6840.02

1



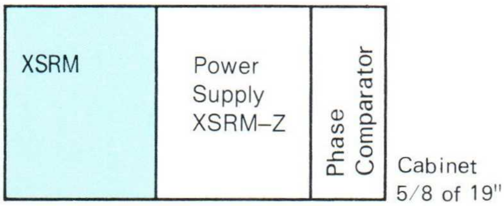
Low-priced precision crystal standard, also for mobile use; longterm drift: 10^{-9}/month

2



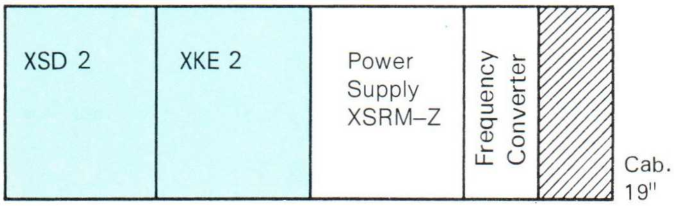
Atomic frequency standard, also for mobile use; longterm drift: 10^{-11}/month

3



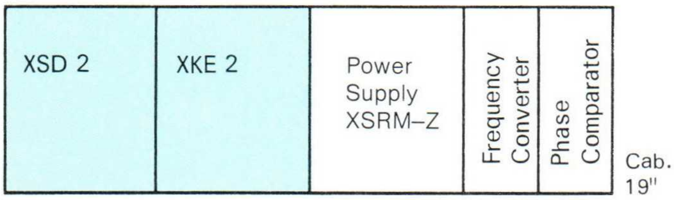
Test assembly for crystal oscillator recalibration, also for mobile use; longterm drift: 10^{-11}/month

4



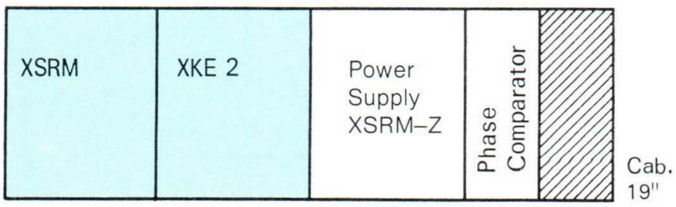
Controlled crystal standard, for stationary use only; longterm drift: 10^{-10} without limit

5



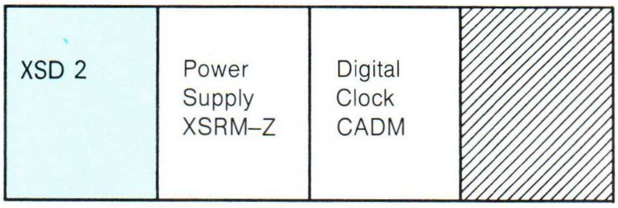
Test assembly for crystal oscillator recalibration; with controlled crystal standard for stationary use only; longterm drift: 10^{-10} without limit

6



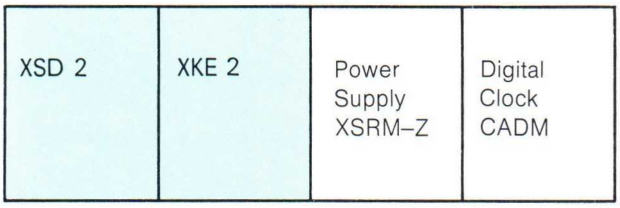
Controlled atomic frequency standard, for stationary use only; longterm drift: 10^{-11} without limit; using phase comparator: test assembly for crystal oscillator recalibration

Standard-frequency/standard-time module system

7


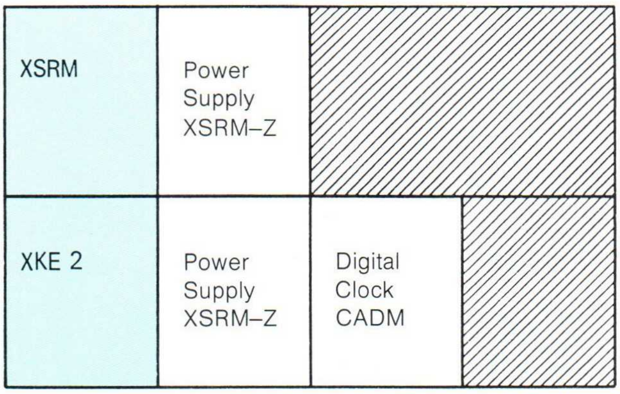
Cab. 19″

Free-running crystal clock, particularly low-priced and suitable for mobile use

8


Cab. 19″

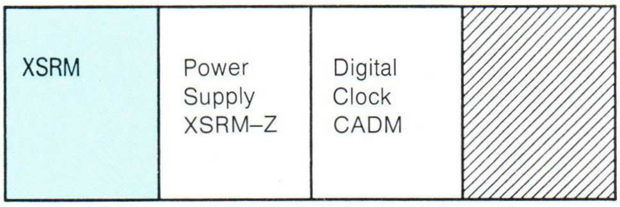
Controlled crystal clock, normal version for stationary use

9


Cab. 19″

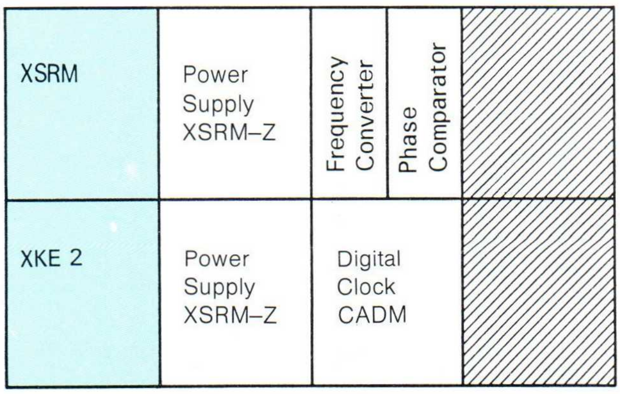
Cab. 19″

Controlled atomic clock, maximum possible accuracy; no recalibration required; for stationary use only

10


Cab. 19″

Free-running atomic clock, maximum accuracy; for mobile use; suitable as mobile time reference

11


Cab. 19″

Cab. 19″

Controlled atomic frequency and time standard, basic equipment for institutes and laboratories requiring precise frequency and time signals

XSRM

Rubidium Frequency Standard XSRM ♦ 5 MHz

- Longterm drift $< 2\times10^{-11}$/month
- High spectral purity of output signal (signal-to-noise ratio ≧ 125 dB)
- High reliability and long life

The design of this compact **Rubidium Frequency Standard** is based on R&S's more than 30 years of experience in building standard-frequency equipment. Up-to-date technology has been employed, resulting in a very small and favourably priced instrument. In addition to the excellent technical performance, high reliability is of great importance, particularly for controlling TV transmitters.

The XSRM is the basic unit of a modular system and can be expanded by a standby power pack (see power supply) and a plug-in frequency converter which delivers several coherent frequencies. These 19″ subunits form a modular system and can be combined according to the requirements (see page 124).

Output frequency, accuracy. The XSRM delivers a 5-MHz sinusoidal output voltage (1 V EMF) of extremely high spectral purity (S/N ratio ≧ 125 dB). The frequency drift due to aging is less than 2×10^{-11}/month. In conjunction with the Frequency Converter XSRM-Z frequencies of 10 MHz, 5 MHz, 1 MHz and 100 kHz can be generated.

Description

The XSRM makes use of one of the atomic resonances of Rb 87, an isotope of the alkali metal rubidium. The Rubidium Frequency Standard operates on the gas-filled cavity-resonator principle with optical excitation and optical scanning. A precision crystal oscillator is continuously controlled, compensating for the drift due to aging.

Power supply. The basic unit is for DC voltage. The built-in stabilizer handles voltages varying from 22 to 32 V.

The optional power pack enables operation from the AC supply. Should the AC supply fail, a built-in battery automatically takes over and is recharged upon return of the AC power (see page 130).

Applications

Due to its excellent characteristics, the XSRM opens up a variety of applications, such as

- ▷ control of standard-frequency and standard-time systems
- ▷ mobile and fixed radio navigation systems
- ▷ satellite communications and time multiplex systems
- ▷ geodesy, research in natural resources
- ▷ single-sideband transmission at very high frequencies
- ▷ control of TV transmitters with precision offset
- ▷ colour TV – central control of studio sync generators
- ▷ radar systems, signal encoders
- ▷ calibration of synthesizers and counters.

With its high shortterm stability, the XSRM is suitable for buffer operation of caesium standards, which feature even higher frequency accuracy but worse shortterm stability.

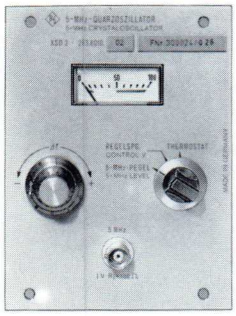
Specifications

Output frequency	5 MHz (sinusoidal)
Output EMF	$1\ V_{rms} \pm 10\%$ $Z_{out} = 50\ \Omega \pm 10\%$ (rear socket) $Z_{out} = 500\ \Omega \pm 10\%$ (front-panel socket)
Harmonic distortion	≦3%
S/N ratio (at ≧ 100 Hz from carrier)	≧125 dB (1-Hz bandwidth)
Suppression of non-harmonic spurious frequencies	≧120 dB
Frequency accuracy	
Longterm error	$\leqq 2\times10^{-11}$/month
Shortterm error (standard deviation)	$\leqq 5\times10^{-11}$ with $\tau = 1$ s
Effect of ambient temperature	$\leqq 2\times10^{-12}$/°C
Effect of supply voltage	$\leqq 2\times10^{-11}$/10%
Frequency correction	by varying the resonator magnetic field
Range of adjustment	2×10^{-9} (mech. with potentiometer, el. via control input)
Setting accuracy	$\leqq 5\times10^{-12}$
Nominal conditions	
Nominal temperature	−20 to +45 °C
Shelf temperature	−40 to +70 °C
Warmup time for $\Delta f/f < 10^{-9}$	approx. 35 min
General data	
Power supply	22 to 32 V (DC)
Current drain	max. 1.8 A during heating approx. 0.7 A after heating at 24 V and +25 °C
Dimensions, weight	100 mm × 132 mm × 342 mm, 3.7 kg
Order designation	▶ Rubidium Frequency Standard XSRM 238.4011.02
Recommended extra modules	see pages 124 and 130.

Crystal Oscillator XSD 2
♦ 5 MHz

- Class of accuracy 10^{-10}
- High spectral purity of output signal
- Input for frequency-correction voltage

XSD 2



The **Crystal Oscillator XSD 2** is a particularly low-priced frequency source of the R&S standard-frequency module line. It features small drift due to aging, high shortterm stability and is very little affected by temperature variations.

The XSD 2 can be **combined** at random **with all other units** of the modular system (see pages 124/125).

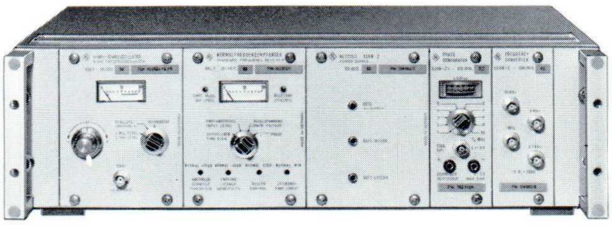
When used with the Power Supply XSRM-Z (see page 130) the Crystal Oscillator has a backup time of more than 6 hours.

Output frequency, accuracy. The Crystal Oscillator delivers a 5-MHz sinusoidal signal of high spectral purity directly at two outputs (output EMF 1 V). The frequency drift due to aging is less than 2×10^{-10}/day.

For different frequencies, the XSD 2 can be used in conjunction with the Frequency Converter XSRM-Z (see page 130) so that signals of 10 MHz, 5 MHz, 1 MHz and 100 kHz are available in phase lock.

Frequency correction. The frequency of XSD 2 can be corrected with the aid of a calibrated potentiometer and via a control-voltage input, for instance with the Standard Frequency Receiver XKE 2.

Power supply. The XSD 2 uses 24 V DC, however, the built-in regulator handles supply fluctuations between 22 and 32 V without affecting the accuracy.



XSD 2 used in a setup for calibration laboratories

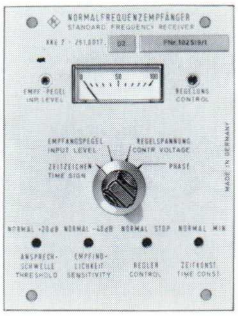
Example of application

The combination of XSD 2 plus XKE 2 is a particularly low-priced setup for producing precise frequencies for use in calibration laboratories – although, if the accuracy requirements are more stringent, the combination of the Rubidium Frequency Standard XSRM and the XKE 2 is to be preferred.

Specifications

Output frequency	5 MHz
Output EMF	1 V_{rms} ±10% Z_{out} = 50 Ω ±10% (rear socket) Z_{out} = 100 Ω ±10% (front-panel socket)
Harmonic distortion	≦3%
S/N ratio (at ≧ 100 Hz from carrier), 1-Hz test bandwidth	> 130 dB
Connectors	BNC female
Frequency accuracy	
Longterm drift	
after 5 days of cont. operation	$< 5 \times 10^{-10}$/day
after 30 days of cont. operation	$< 2 \times 10^{-10}$/day
Shortterm drift (standard variation)	$< 1 \times 10^{-11}$ for $\tau = 1$ s
Effect of ambient temperature	$< 5 \times 10^{-11}$/°C
Effect of supply voltage variations	$< 1 \times 10^{-11}$/10%
Effect of load (opencircuit/50 Ω)	$< 1 \times 10^{-10}$
Frequency correction	mechanical and electronic
with ten-turn potentiometer on front panel	2×10^{-7}
by external DC voltage 0 to ±10 V	$\pm 4 \times 10^{-8}$
Nominal conditions	
Nominal temperature range	−20 to +50 °C
Shelf temperature range	−40 to +70 °C
Warmup time for $\Delta f/f \leqq 10^{-8}$	1.5 h (referred to error after 60 min)
General data	
Power supply	22 to 32 V DC
Current drain	max. 300 mA
Power consumption	< 1 W (after warmup)
Dimensions, weight	100 mm × 132 mm × 342 mm, 2,5 kg
Order designation	► Crystal Oscillator XSD 2 283.6010.02
Recommended extra modules	see pages 124 and 130

XKE 2



Standard Frequency Receiver XKE 2

♦ 10 kHz to 200 kHz

- Recalibration of crystal and atomic frequency standards
- Selectable receive frequencies (plug-in boards)
- High sensitivity and excellent protection against interference thanks to preselection
- Time-signal output

The **XKE 2** is a universal standard frequency receiver which permits control of crystal and atomic frequency standards. It is available for all frequencies in the range 10 to 200 kHz.

Characteristics and uses

The receiver includes a preselection circuit, featuring thus excellent characteristics with respect to sensitivity and protection against interference. In addition, the Standard Frequency Receiver XKE 2 uses ALC so that high reliability is ensured even under adverse conditions of reception.

The combination of the Standard Frequency Receiver XKE 2 and the Crystal Oscillator XSD 2 (see page 127) replaces the time-proven setup XKE/XSD and is a particularly low-priced solution to the problem of producing precise standard frequencies.

The accuracy is increased when using the combination XKE 2/XSRM (Rubidium Frequency Standard, see page 126). Thanks to the higher inherent stability of the XSRM, a considerably longer control time constant can be selected, enabling improved averaging of the frequency variations of the received signal caused by propagation fluctuations.

The frequency accuracy of the XKE 2/XSRM combination corresponds to an unlimited longterm drift of 1×10^{-11}. The receiver is designed for a control time constant which can be extended up to 60 days.

Description

The XKE 2 features outstanding reliability since, for instance for frequency correction, electronic components are used exclusively. The Standard Frequency Receiver comes as a subunit for a 19″ chassis and can be combined with all other modules of the R&S standard-frequency system.

The XKE 2 is equipped with a time-signal output so that when receiving time-signal-modulated standard-frequency transmitters the corresponding time information is simultaneously available.

Specifications

Receive frequency f_1	standard version: 60/75/77.5 kHz; internally selectable; other frequencies possible in the range 10 to 200 kHz
Input voltage of receive frequency f_1	1 µV to 10 mV, switchable to 100 µV to 1 V
Input impedance	50 Ω ±20%
Controlled frequency f_2	1/2/5/10 MHz
Input voltage of controlled frequency f_2	200 mV to 2 V
Input impedance	> 500 Ω
Capture range for controlled frequency f_2	$\frac{\Delta f}{f} = > 1 \times 10^{-7}$
Control time constant	8 time-constant factors internally selectable: 1/32/64/128/256/512/1024/2048 × 6.25 × 10^{-7} (s/V); for accelerated control it is possible to switch to the smallest factor externally
Control inputs	
Time-constant switching	TTL level or switch; logic 0 = smallest control time constant
Control stop	TTL level or switch; logic 0 = control stop
Receiver-sensitivity switching	TTL level or switch; logic 0 = 40-dB attenuation
Outputs	
Control voltage	0 to +10 V, max. 5 mA; short-circuit-proof
Phase difference	0 to +10 V, max. 5 mA; short-circuit-proof 0 to 100 µs phase difference
Received-signal level	0 to +10 V, max. 5 mA; short-circuit-proof; approximated logarithmic indication ≈ 4 decades
Time signal	TTL level
Fault signal	TTL level
1-MHz standard frequency	200-ns pulse, 1 V_{pp}, Z_{out} = 50 Ω; phase-locked to receive frequency
General data	
Phase error as function of ambient temperature	< 1 µs/10 °C
Nominal temperature range	0 to +50 °C
Shelf temperature range	−40 to +70 °C
Power supply	22 to 32 V DC
Current drain	max. 400 mA
Dimensions, weight	100 mm × 132 mm × 390 mm, 2.5 kg
Order designations	► Standard Frequency Receiver XKE 2 291.0017.02
Filter XKE 2-B1 for 60, 75 and 77.5 kHz	299.3015.02

Accessories supplied

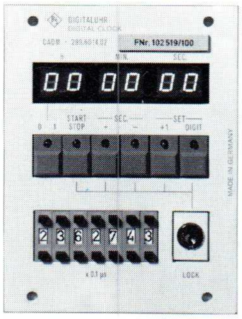
1 two-core connecting cable (for external battery)
2 RF connecting cables (BNC)
1 connecting cable (for control voltage)
1 two-core connecting cable (for standby power supply)

Recommended extra	Ferrite Antenna XKE 2-Z1 299.3515.50

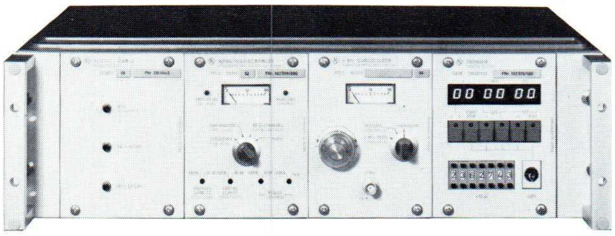
Digital Clock CADM
♦ Days/hours/minutes/seconds

- Excellent protection against interference
- Phase adjustment with a resolution of 0.1 µs
- Readout disconnectible
- Seconds control output
- Synchronization input

CADM



The **Digital Clock CADM** is an extension of the R&S standard-frequency module line permitting standard-time systems to be set up. It can be combined with the Crystal Oscillator XSD 2, the Rubidium Frequency Standard XSRM and the Caesium Frequency Standard XSC.



Precision time system including CADM, XSD 2 and XKE 2

Characteristics and uses

The CADM features interference rejection which meets the most stringent requirements so that even in the case of heavy ambient disturbance, for instance in mobile use, no time error occurs.

In conjunction with atomic frequency standards the CADM is a high-quality precision clock complying with the strictest specifications stipulated for time standards. It can be used in time-signal systems, for master clock control, for scientific purposes and as a mobile time standard.

Description

The time is read out in seconds, minutes, hours and days on the CADM front panel and the corresponding information made available in BCD code on the rear panel. The Digital Clock can be advanced and set back with the aid of pushbuttons.

An automatic monitoring circuit indicates interruptions of operation, covering even momentary disturbance.

A seconds output is available for time control.

The clock includes a digitally adjustable phase shifter with a resolution of 0.1 µs so that the time can be set with high precision. The CADM can be started automatically via a synchronization input and a key switch prevents unauthorized access to the instrument settings.

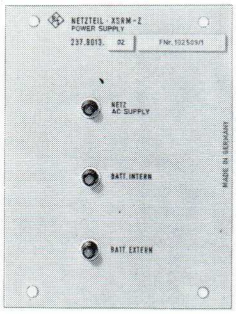
The CADM is part of the R&S standard module line. It can be powered from the Power Supply XSRM-Z.

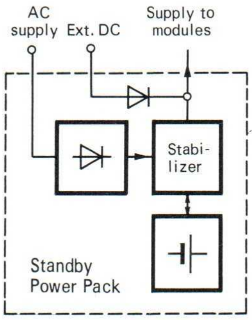
Specifications

Readout	6 digits, disconnectible
Time information displayed	days, hours, minutes, seconds (leap years considered automatically)
Control	
Input frequency	5 MHz/10 MHz
Input sensitivity	200 mV_{rms}
Max. input voltage	5 V_{rms}
Input impedance	> 500 Ω
Connector	BNC female
Synchronization input	BNC female connector
Input signal	TTL level
Synchronization error	< 2 µs
Outputs	
Seconds clock 1	
Pulse duration	20 µs
Rise time	< 20 ns
Output EMF	2 to 20 V (adjustable)
Connector	BNC female
Phase	adjustable by means of phase shifter
Seconds clock 2	data same as for seconds clock 1, however, phase not adjustable
Time information	
Output	days, hours, minutes, seconds
Code	BCD, negative
Level	TTL
Connector	37-way, Cannon female
Performance monitoring	interruptions of operation indicated and stored automatically
General data	
Power supply	22 to 32 V DC
Current drain	0.2 A
Dimensions, weight	100 mm × 132 mm × 342 mm, 1.5 kg
Order designation	► Digital Clock CADM 299.6014.02

Additional units of standard-frequency module system (overview see pages 124 and 125)

Power Supply XSRM-Z





The Power Supply XSRM-Z contains a maintenance-free NiCd cell battery which feeds the instruments connected (e.g. XSRM or XSD 2) for one to six hours in the case of AC supply failure. The XSRM-Z delivers a peak current of 1.6 A.

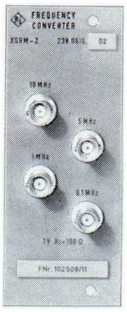
During AC supply operation, the battery is automatically charged. Switchover from AC-supply to battery operation is also automatic.

The self-heating effect is only slight since high efficiency is obtained by a control circuit making use of the angle of current flow. The XSRM-Z can also be fed from an external battery. Three front-panel lamps indicate the mode of operation (AC supply/internal battery/external battery). The internal-battery lamp starts flashing if the charge falls below a threshold level.

Specifications of Power Supply XSRM-Z

Input voltage	230/115 V_{rms} ±20% (47 to 400 Hz)
Power consumption	max. 70 VA
Input for external battery (input voltage)	24 to 28 V
DC output	
Voltage during AC supply operation	23 V, regulated
Voltage during battery operation	22 to 30 V
Max. output current	1.6 A
Useful capacity	0.8 Ah
Mean backup time (e.g. with XSRM), battery operation at 25 °C	1 h
Nominal temperature range	−20 to +45 °C
Shelf temperature range	−20 to +50 °C
Dimensions, weight	100 mm × 132 mm × 342 mm, 5.2 kg
Order designation	► Power Supply XSRM-Z 237.8013.02

Frequency Converter XSRM-Z



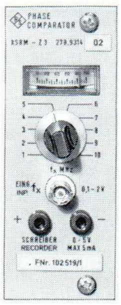
The Frequency Converter XSRM-Z is driven with the 5-MHz signal delivered by the XSRM, XSC or XSD 2. Each of the frequencies – 10 MHz, 5 MHz, 1 MHz and 0.1 MHz – is available at two parallel outputs on the front and rear panels. All signals are sinusoidal and phase-locked to the input signal.

The Frequency Converter can be powered from the Power Supply XSRM-Z.

Specifications of Frequency Converter XSRM-Z

Input	
Frequency	5 MHz
Permissible range of input voltage	0.2 to 2 V_{rms}
Input impedance	≧500 Ω
Connector	BNC female
Outputs	
Frequencies	0.1 MHz, 1 MHz, 5 MHz, 10 MHz
Output voltage	1 V_{rms}, sinewave
Harmonic distortion	< 3%
Output impedance	
Outputs on front panel	100 Ω ±10% (BNC sockets)
Outputs on rear panel	50 Ω ±10% (BNC sockets)
Supply voltage	22 to 32 V DC
Power consumption	2 W
Nominal temperature range	−20 to +45 °C
Shelf temperature range	−20 to +60 °C
Dimensions, weight	50 mm × 132 mm × 342 mm, 1 kg
Order designation	► Frequency Converter XSRM-Z 238.0616.02

Phase Comparator XSRM-Z3



The Phase Comparator XSRM-Z3 is used for checking and recalibrating control frequencies, derived for instance from crystal oscillators in counters and synthesizers.

Any 5-MHz source of appropriate accuracy (e.g. XSRM, XSD 2) can be used as the reference. Frequency differences between 1×10^{-6} to 1×10^{-9} can be determined directly on the panel meter. The recorder output permits considerably smaller errors to be logged or frequency and phase deviations to be recorded over a longer period of time.

Any test item with a frequency of 1 MHz or an integer multiple thereof (up to 10 MHz) can be measured. A rotary switch on the front panel permits the Phase Comparator to be set to the corresponding input frequency.

Specifications of Phase Comparator XSRM-Z3

Input frequency f_{st}	5 MHz
Input voltage range	0.1 to 2 V_{rms}
Input frequency f_x	1/to/10 MHz
Input voltage range	0.1 to 2 V
Indication of phase difference	0 to 1 µs (= 0 to 360°)
Recorder output	0 to 5 V (= 0 to 1 µs)
General data	
Nominal temperature range	−20 to +45 °C
Shelf temperature range	−40 to +70 °C
Supply voltage	22 to 32 V DC
Current drain	180 mA
Dimensions, weight	50 mm × 132 mm × 342 mm, 0.9 kg
Order designation	► Phase Comparator XSRM-Z3 278.9314.02

Standard Frequency Receiver XKD
♦- 200 kHz

XKD

- Received frequency: 200-kHz standard frequency
- Accurate indication even for non-sinusoidal input voltages
- Recorder output for phase and frequency deviation
- Frequency evaluation accurate to 1×10^{-8} on panel meter; higher accuracy obtainable using a recorder

The Standard Frequency Receiver XKD permits rapid and simple monitoring of frequency standards. The following frequencies can be compared and measured: 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 MHz as well as 100 kHz. The unit receives the high-stability 200-kHz Droitwich standard frequency and indicates the phase difference in comparison with the frequency to be checked. The speed and the direction of the phase variation permit the magnitude and the sense of the frequency error to be determined.

The XKD is especially suitable for calibrating crystal oscillators in counters and synthesizers.

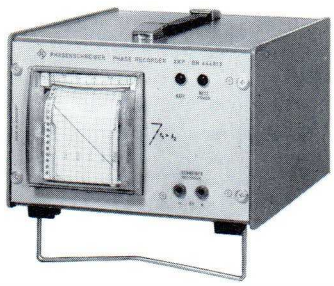
Frequency errors down to about 10^{-8} can be observed directly on the panel meter. A recorder should be used if higher accuracy is required.

Specifications

Comparison frequencies	100 kHz and 1 to 10 MHz in 1-MHz steps compared to standard radio frequency 200 kHz or its subharmonics down to 10 kHz
Required input voltage V	
200-kHz input I (60 Ω)	$\geqq 2\ \mu V_{rms}$
input II (3 kΩ)	$\geqq 10\ \mu V_{rms}$
Input f_x (500 Ω)	$\geqq 0.1\ V_{rms}$ (sine), $\geqq 0.2$ V (pulse)
Recorder outputs (parallel connection)	Output I, front panel Output II, rear panel; $Z_s < 10\ \Omega$, output EMF 1 V/µs
AC supply	110/220 V ±20%
Dimensions, weight	109 mm × 238 mm × 277 mm, 3 kg
Order designation	► Standard Frequency Receiver XKD 100.5678.03

Phase Recorder XKP for standard frequency comparison

XKP



- Frequency and phase recording at 50 Hz to 5 MHz
- Linear indication (sawtooth) 0 to 360°
- Frequency evaluation over one hour to within $\pm 2 \times 10^{-12}$

A simple method of determining the difference between two almost identical frequencies is to measure the mutual phase deviation within a set time interval. The Phase Recorder XKP serves this purpose.

The test result is recorded in the form of a slowly running sawtooth voltage with constant amplitude (corresponding to 360° phase difference). The instantaneous value of this voltage corresponds to the phase difference between the frequencies being compared. The voltage variation within a set time interval is a measure of the frequency difference.

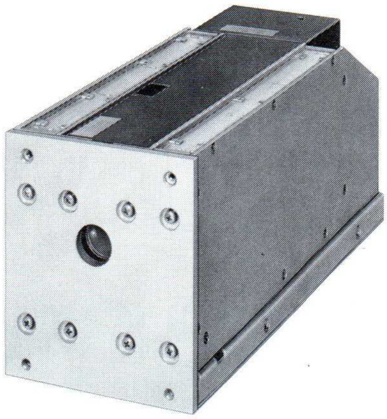
The main application of the XKP is the monitoring of standard-frequency and standard-time systems. Due to its wide frequency range, it is suitable for determining the relative frequency error of atomic frequency standards (accuracy 10^{-12} to 10^{-13}) and for measuring at lower frequencies down to the AC supply frequency.

The set is AC-supply and/or battery operated, the battery taking over only on AC supply failure. The XKP comes as a 19″ subunit or as a cabinet model (216 mm × 154 mm × 284 mm). Two Phase Recorders can be accommodated in a 19″ rackmount.

Specifications

Frequency range	50 Hz to 5 MHz
Input voltage	0.3 to 10 V_{rms}
Input impedance at	
50 Hz to 1 kHz	> 60 Ω
1 kHz to 5 MHz	> 1 kΩ
Input connectors	2, BNC female, floating (on rear panel)
Indication	wax-paper dot recorder
Output voltage	0 to 5 V, linear for 0 to 360° phase difference
Zero drift	$< 2 \times 10^{-5}$ of fsd/°C
Operating temperature range	−10 to +50 °C
Power supply	
AC supply	115/125/220/235 V +10/−15%, 50 Hz (6 VA)
Battery	11 to 16 V, 320 mA, switchable to 21 to 32 V, 400 mA (not to be charged from the instrument)
Dimensions and weight	
Cabinet model	216 mm × 154 mm × 284 mm, 6 kg
Subunit (1/2 of 19″)	208 mm × 133 mm × 284 mm
Order designations	► Phase Recorder XKP
Cabinet model	100.5655.92
Subunit	100.5655.91
Accessories supplied	1 power cable, 1 graticule

XSRB



Rubidium Oscillator XSRB
♦ 5 MHz

- Low-cost building block – compact and lightweight
- Rapid warmup, wide working-temperature range
- High precision and stability: longterm drift ≦ 5×10^{-11}/month

The **Rubidium Oscillator XSRB**, which features similar electric characteristics to the Rubidium Frequency Standard XSRM (see page 126) is available for incorporation into instruments and systems. This competitively priced module has been designed as a compact circuit component to be used by other manufacturers in their own equipment.

Characteristics and uses

The XSRB is suitable for inclusion in all mobile and stationary instruments and systems calling for an extremely precise frequency reference as a control or monitoring signal.

Output signal. The output of the XSRB is a sinusoidal signal at 5 MHz. The EMF is 1 V and the signal-to-noise ratio is better than 130 dB. Thorough screening ensures that the effects of external magnetic fields are kept to a minimum. Two auxiliary outputs allow the use of an external meter for continuous monitoring of the oscillator or for checking that the control voltage remains within the permissible range. A frequency-correction input is also provided so that the oscillator frequency can be trimmed by comparison with an even more precise signal such as a standard-frequency broadcast. If the oscillator fails, an alarm signal is given at a separate output.

Frequency precision. The XSRB is over a hundred times more accurate than conventional crystal oscillators – thereby guaranteeing an adequate safety margin. The frequency drift of the XSRB due to aging is less than 5×10^{-11} per month. The unit can therefore replace precision crystal oscillators – a substitution which can also be justified on economic grounds particularly since the longterm stability and precision of the output signal eliminate the need for costly readjustments.

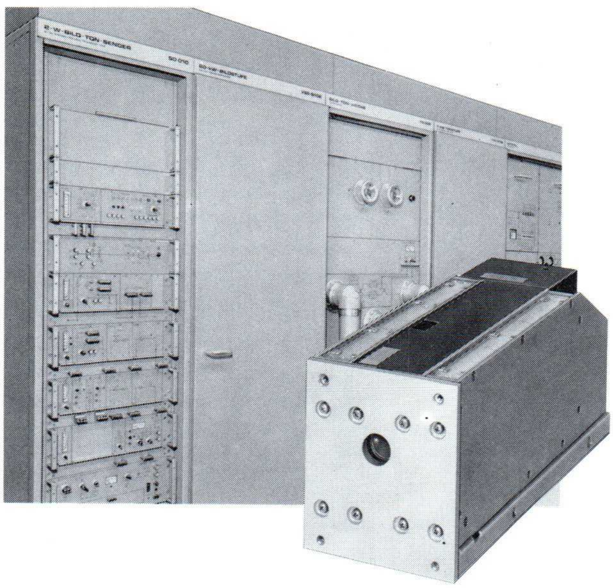
Applications. High-stability signals (standard frequencies) are called for in communications and navigation systems; typical examples are

precision offset operation of TV transmitters,
control of standard-frequency systems,
SSB transmission at very high frequencies,
satellite radio and geodesy,
extraterrestrial communications.

Other applications are found in microwave spectroscopy. More generally, the XSRB is ideal for controlling precision counters, synthesizers and crystal oscillators.

Description

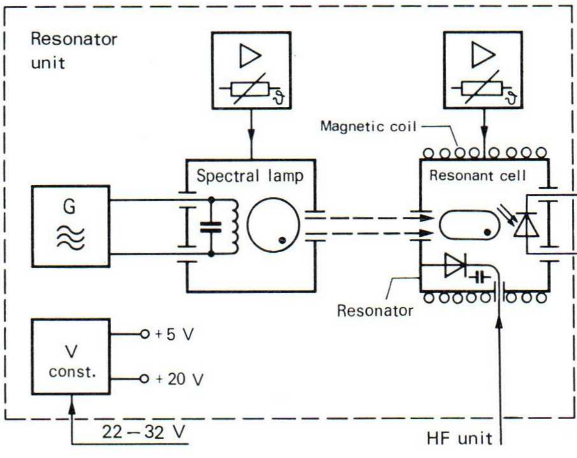
The standard frequency source in the XSRB is a resonant mode of atoms of rubidium 87, an isotope of the alkali metal rubidium. By means of a spectral lamp and a resonant cell a control signal is developed and used to compensate for the aging of a crystal oscillator.



A typical application of the XSRB: precision-offset operation of a TV transmitter

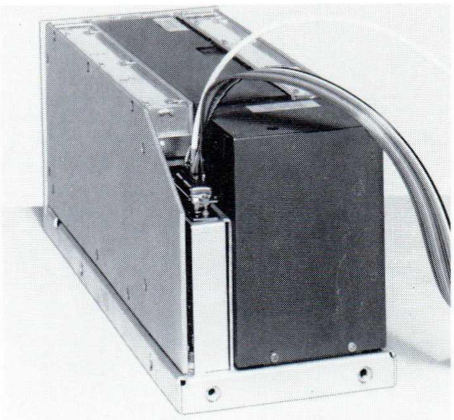
Subassemblies. The XSRB consists of four subassemblies:

1. Resonator unit with spectral lamp, resonant cell and their respective ovens; this unit is electrically and magnetically screened (see block diagram)
2. HF unit (frequency division and comparison)
3. LF unit (control signal processing)
4. Crystal oscillator unit with oven



Resonator unit

Installation. The front of the XSRB serves as both mounting plate and heatsink. The temperature measured on this plate should never be outside the range −25 to +60 °C, which is also the admissible ambient temperature range.



Input / output connector of XSRB

Power requirements. The oscillator is designed for operation from a DC supply voltage. This may vary within the range 22 to 32 V thanks to the action of the built-in stabilizer. Operation from any standard battery supply of the appropriate voltage is therefore feasible.

The XSRB is extremely easy to service. The spectral lamp can be changed very rapidly.

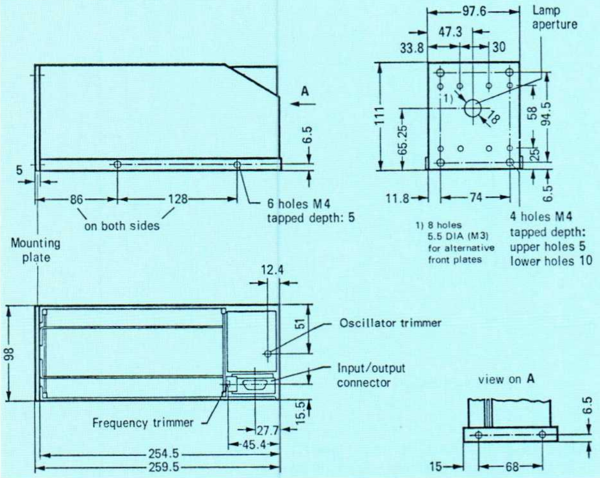
Specifications

Output frequency	5 MHz
Output EMF (sinusoidal)	1 V ±10%; Z_{out} = 50 Ω
Connector	Cannon male connector strip DAM-11 W 1 P
Distortion	≦3%
Signal-to-noise ratio (≧ 100 Hz from output frequency)	≧130 dB (1-Hz measurement bandwidth)
Suppression of non-harmonic frequencies	≧120 dB
Frequency errors	
Longterm drift	$\leqq 2\times10^{-11}$ per month
Shortterm (1 s) instability (standard deviation)	$\leqq 2\times10^{-11}$
Effect of ambient temperature	$\leqq 4\times10^{-10}$ across the specified temperature range
Effect of operating voltage	$\leqq 2\times10^{-11}/10\%$
Effect of external magnetic field	$\leqq 4\times10^{-13}/\frac{A}{m}$
Effect of atmospheric pressure	$\leqq 5\times10^{-13}$/mbar for altitudes between 0 and 10,000 m
Frequency correction	
Adjustment range	
using potentiometer	2×10^{-9}
Setting uncertainty	$\leqq 5\times10^{-12}$
using external control input	1×10^{-9}
Control voltage range	0 to +10 V DC
General data	
Alarm signal output	changeover contact
Nominal temperature range (temperature of mounting plate)	−25 to +60 °C
Shelf temperature range	−40 to +70 °C
Warmup time for frequency error less than 1×10^{-9}	approx. 10 min. at +25 °C
Supply voltage requirement (negative earth)	22 to 32 V DC
Current drain	
during warmup	2.2 A max.
during normal operation	approx. 0.7 A at 24 V and +25 °C
Dimensions	see drawing below
Weight	3.3 kg
Order designation	► Rubidium Oscillator XSRB 216.0213.03

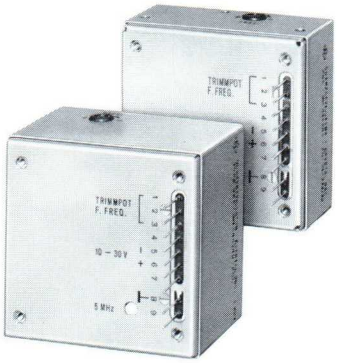
Accessories supplied: tool for changing spectral lamp, 1 female connector strip with mating male connector.

The spectral lamp and the resonant cell carry a 3-year guarantee.

Dimensions in mm



XSE / XSF



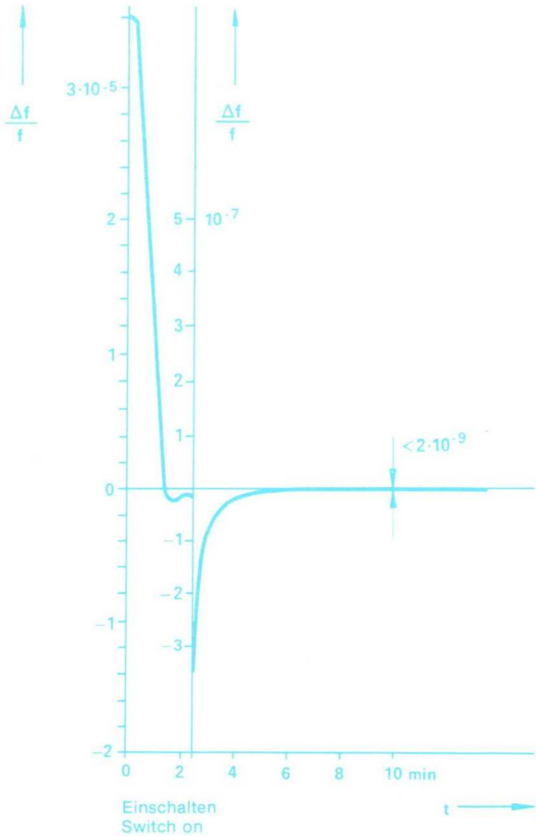
Crystal Oscillator XSE ♦ 1 to 10 MHz
Crystal Oscillator XSF ♦ 5 MHz

- Class of accuracy 10^{-9} for XSE, 10^{-10} for XSF
- Extremely short warmup period
- Operating range 10 to 30 V, 2.5 W; −40 to +65 °C

Plug-in Crystal Oscillators XSE (top) for 1 to 10 MHz and XSF for 5 MHz; shown on larger scale than usual.

The Crystal Oscillators XSE and XSF are suitable for incorporation into high-quality frequency counters, standard frequency generators and decade exciters.

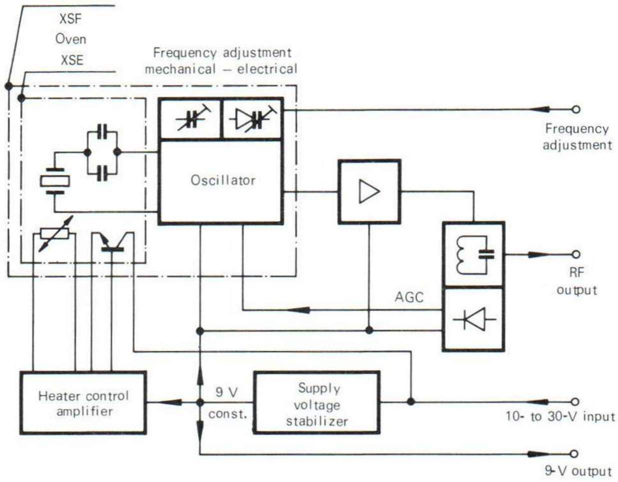
The main differences between the two types are in the class of accuracy, warmup time (see table) and available output frequency. The **XSF** is designed for 5 MHz whereas the **XSE** is available for 1, 5 or 10 MHz; other frequencies between 1 and 10 MHz on request.



Warmup response of XSE using 5-MHz crystal (3rd harmonic) referred to values obtained after 60 minutes of operation

Common specifications and construction

The unusually wide ranges of temperature and operating voltages permit use of the crystal oscillators under extreme ambient conditions with negligible effect on frequency accuracy.



Block diagram of Crystal Oscillators XSE and XSF

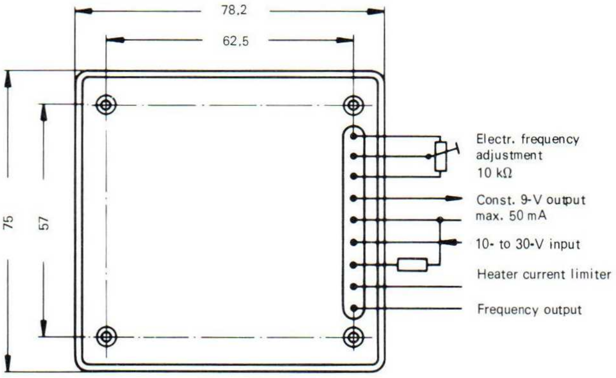
The crystal frequency can be adjusted with a trimmer (coarse) and varactor (fine). An external potentiometer must be connected to drive the varactor. The required stabilized reference voltage is available from the crystal oscillator.

Both modules (XSE and XSF) are equipped with an oven. In the XSE, only the crystal and the frequency-determining components are kept at a constant temperature while in the XSF the oscillator circuit is also accommodated in the oven.

Rapid warmup of the oven is possible by connecting a wire link between two solder tags. If a suitable resistor is inserted instead of the link, any heater current below maximum can be selected to suit the capacity of the available power supply. High ripple voltage being permissible for warmup, the operating voltage need not be stabilized in many cases.

The sudden change from maximum heater current to normal operating current can be utilized for the delayed connection of further loads via relays.

The XSE and XSF have identical contact arrangements. They are such that the modules can be connected directly to a printed circuit board.



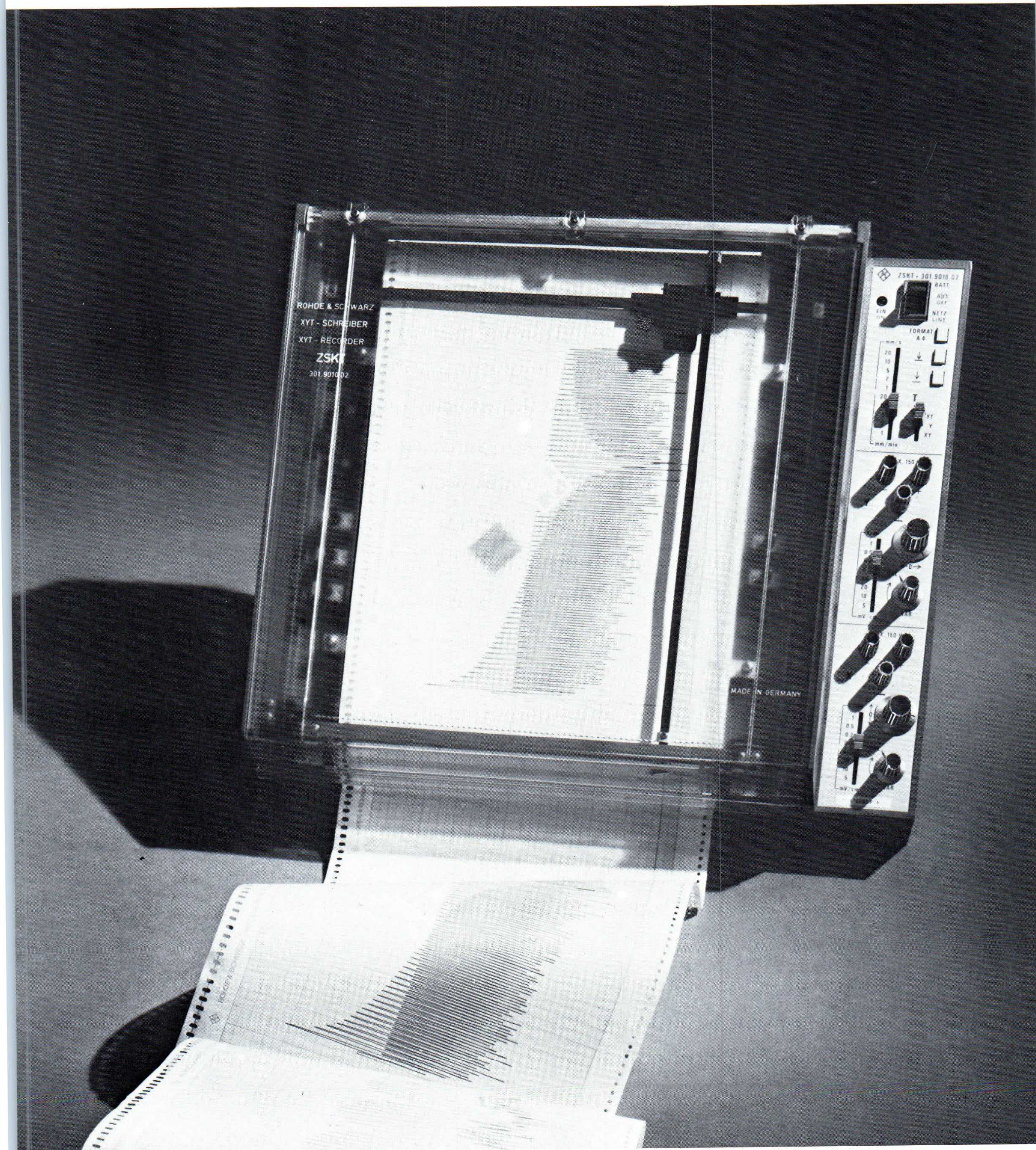
Contact arrangement of Crystal Oscillators XSE and XSF

Specifications of XSE and XSF

	Type and output frequency		
	XSE 1 to 5 MHz	**XSE** 5 to 10 MHz	**XSF** 5 MHz
Frequency			
Freq. error with ambient temp. of 25 °C and rapid warmup			
after 1.5 min	$<1\times10^{-6}$	$<1\times10^{-6}$	
after 4 min	$<1\times10^{-7}$	$<1\times10^{-7}$	
after 7 (5) min	$<1\times10^{-8}$	$(<1\times10^{-8})$	$<1\times10^{-6}$
after 30 min			$<1\times10^{-8}$
Aging after 30 days of continuous operation	$<3\times10^{-9}$/d	$<2\times10^{-9}$/d	$<2\times10^{-10}$/d
Output EMF	>0.5 V		>0.5 V
Output impedance	500 Ω		500 Ω
S/N ratio (referred to 1-Hz bandwidth)	>110 dB	>120 dB	>120 dB
Nominal operating voltage	10 to 30 V		10 to 30 V
Heater current (adjustable)	0.17 to 0.6 A		0.4 to 0.8 A
Average current requirement at +22 °C ambient temperature and			
$V_s = 12$ V	160 mA		175 mA
$V_s = 24$ V	80 mA		100 mA
Warmup time at 30 V, I_{max}, +22 °C amb. temperature	1 min		3 min
General data			
Operating temperature range	−40 to +65 °C		−40 to +65 °C
Shelf temperature range	−50 to +80 °C		−50 to +80 °C
Weight	200 g		300 g
► **Order Nos.**			
1 MHz output frequency	100.7641.02		
5 MHz output frequency	100.7641.05		100.5578.02
10 MHz output frequency	100.7641.10		
PAL colour subcarrier	100.7641.04		

XYT Recorder ZSKT,
universal two-axis recorder;
details on page 158

broadband voltmeters · recorders power meters and reflectometers



Electronic voltmeters

Rohde & Schwarz makes voltmeters of high sensitivity and for applications up to very high frequencies. In addition to the indicator section these instruments comprise **electronic circuitry** such as broadband and selective amplifiers, mixers, oscillators, logarithmation circuits and rectifiers.

All models presented in this catalog are electronic voltmeters; they are tabulated in two main groups, each possessing its particular common features:

1. DC and broadband voltmeters
2. Selective voltmeters (section 7)

Following the general description of voltmeter features, the characteristics typical of each group are briefly outlined.

Characteristics of voltmeters

Basic differences

Type of voltmeter	Indicates (of input voltage)
DC voltmeter	DC component
Broadband voltmeter	rectified AC component within frequency range
Selective voltmeter	rectified component from frequency spectrum

Meter rectifiers

An AC voltage must be rectified for measurement. Three types of rectification are distinguished according to the weighting of the waveform: rms response, average response and peak response.

RMS-responsive rectification. The rms value (V_{rms}) of an AC voltage is the positive square root of the mean value, evaluated over a period of time, of the square of the AC voltage. With the Microvoltmeter UVM, the Video Noise Meter UPSF and the Psophometers UPGS and UPGR, Rohde & Schwarz presents instruments equipped with a new type of rms-responsive rectifier which permits the true rms value of the test voltage (e. g. of pulse, noise or interfering voltages) to be directly measured. The RF-DC Millivoltmeters URV and URV 3 measure the rms value of RF voltages in their three (two) most sensitive ranges.

Average-responsive rectification. The rectified average value (V_{av}) is the average of the magnitude of the AC voltage over a period of time. Voltmeters with average-responsive rectification indicate the rms value of a sinewave voltage. The approximate rms value of the fundamental wave is measured in the presence of weak harmonic components or in the case of noise voltages (Millivoltmeter UVN).

Peak-responsive rectification. The Microvoltmeter UVM permits the peak-to-peak value (V_{pp}) of the test voltage to be directly measured. The Psophometer UPGR contains a peak-responsive rectifier with defined rise and fall time constants for weighted noise measurements (quasi-peak-responsive rectifier); it indicates $V_p/\sqrt{2}$, i.e. the rms value for sinewaves.

For sinewave voltages: $V_{pp} = 2\,V_p = 2\sqrt{2}\,V_{rms} = \pi V_{av}$.

The ratio V_p/V_{rms} is called peak factor, V_{rms}/V_{av} is the form factor.

Input impedances

In electronic **voltmeters with amplifier input** the input impedance is generally well defined and can be represented by a resistance and a lossy capacitance in parallel. **Broadband voltmeters** normally have an input impedance of about 1 MΩ shunted by 25 to 45 pF. This amounts to ≈ 50 Ω at 100 MHz. The parallel capacitance of any connected coaxial cable (30 to 100 pF) renders the input impedance still lower. Improvement of the input conditions is possible using a **voltage divider probe**.

Diode probes include a capacitively coupled half-wave rectifier. Their input capacitance of ≈ 2 pF can be reduced to about 0.5 pF by plug-in dividers, but this involves a loss in sensitivity. Diode probes permit measurements with high impedance at frequencies up to 1 GHz.

Noise voltages, reference potential

The voltage of a test point to common return (chassis, earth) is to be determined in most measurements.

If both the test voltage source and the voltmeter are earthed through the earth conductor of the AC supply, noise pickup may result in the test circuit. This can often be remedied by plugging the source and the voltmeter into a twin wall socket.

Measurements using a broadband voltmeter are invalidated by noise voltages. The erroneous result is not immediately recognized unless the test voltage can be reduced to 0.

Noise pickup does not occur in a voltmeter with floating input, required for measurements between two test points which both have a voltage to earth.

Measurements on balanced audio-frequency transmission systems call for instruments with balanced test input and high common-mode rejection (126 dB at 50 Hz).

A noise voltage may also originate in the input stages of the voltmeter and affect the result, especially in the most sensitive ranges. For example, a noise voltage of about 15µV whose spectrum lies mainly below 10 kHz is produced in the amplifier input of a voltmeter with 1 MΩ||30 pF. This noise component is negligible if the voltage source has a low impedance (e.g. 50 Ω).

DC and broadband voltmeters

DC voltmeters

The test signal (test voltage) passes through a DC amplifier of selectable gain and is applied to the meter.

A chopper amplifier first changes the test voltage into an AC voltage, which is amplified and then rectified in a synchronous rectifier. The chopper amplifier is outstanding for its low zero drift and is therefore used in DC voltmeters of very high sensitivity (UIG, URV).

Broadband voltmeters with rectifier input

A rectifier which covers a wide voltage range changes the unknown AC voltage into a DC voltage. This DC voltage is processed in the basic unit and indicated. The broadband coverage of this voltmeter type depends on the mechanical design of the meter rectifier and on the RF characteristics of the rectifier diodes.

A probe (if necessary, with plug-in divider) incorporating a capacitively coupled half-wave rectifier is used for measurements on open circuits. It features high input impedance and very low input capacitance. The voltage indication depends on the type of chassis connection and on the source impedance of the test voltage source.

Measurements in coaxial circuits are carried out with the aid of coaxial RF insertion heads. They incorporate a diode detector inserted in the inner conductor or connected via a piston attenuator and permit broadband voltage measurements to be made up to 2 GHz with low reflection. With match-termination, the indicated voltage equals the voltage of the forward wave. The voltage indication with mismatch lies between twice the voltage of the forward wave and 0.

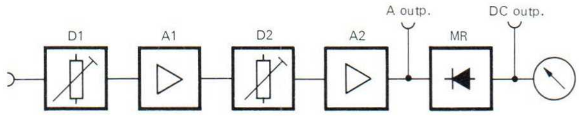
Broadband voltmeters with rectifier input measure the rms value of small test voltages up to 30 mV and the peak or peak-to-peak value (URV family) of voltages above 1 V. The meter reads the rms value of a sinewave in the entire measurement range.

The probes and insertion units of the millivoltmeters of the URV family have, in addition to the detector circuit for the RF voltage to be measured, a comparison detector of similar design to which the comparison voltage produced by a control loop in the basic unit is applied. The control loop provides for a voltage-proportional meter scale throughout the measurement range.

The measuring heads can be freely interchanged; the accuracy depends only on the degree of matching of the characteristics of the two diodes used in each measuring head for the measurement and comparison circuits. Any measuring head combined with any basic unit therefore complies with the data-sheet specifications.

Broadband voltmeters with amplifier input

Sensitive broadband (amplifier) voltmeters are normally designed according to the following principle:



Simplified diagram of an amplifier voltmeter

The high-impedance input divider D1 covers two or three steps and prevents overloading of the amplifier A1. This is followed by the low-impedance main divider D2 (10-dB steps). Both dividers together with the amplifiers A1 and A2 form a broadband amplifier which can also be used as a preamplifier (via amplifier output A outp.) for insensitive meters or recorders. The design of the final stage of the main amplifier depends on whether low-impedance or high-impedance driving of the meter rectifier MR and which type of rectification is used. The DC voltage output (DC outp.) permits the connection of a recorder or digital voltmeter.

Broadband voltmeters with balanced amplifier input

The input section of the Psophometers UPGS and UPGR consists of a balanced attenuator and a balanced amplifier which are accommodated in a shielding can and isolated from the rest of the circuitry by a broadband transformer and a transformer-coupled power supply. A high-impedance balanced input (100 kΩ) with very high common-mode rejection (126 dB at 50 Hz) is thereby realized.

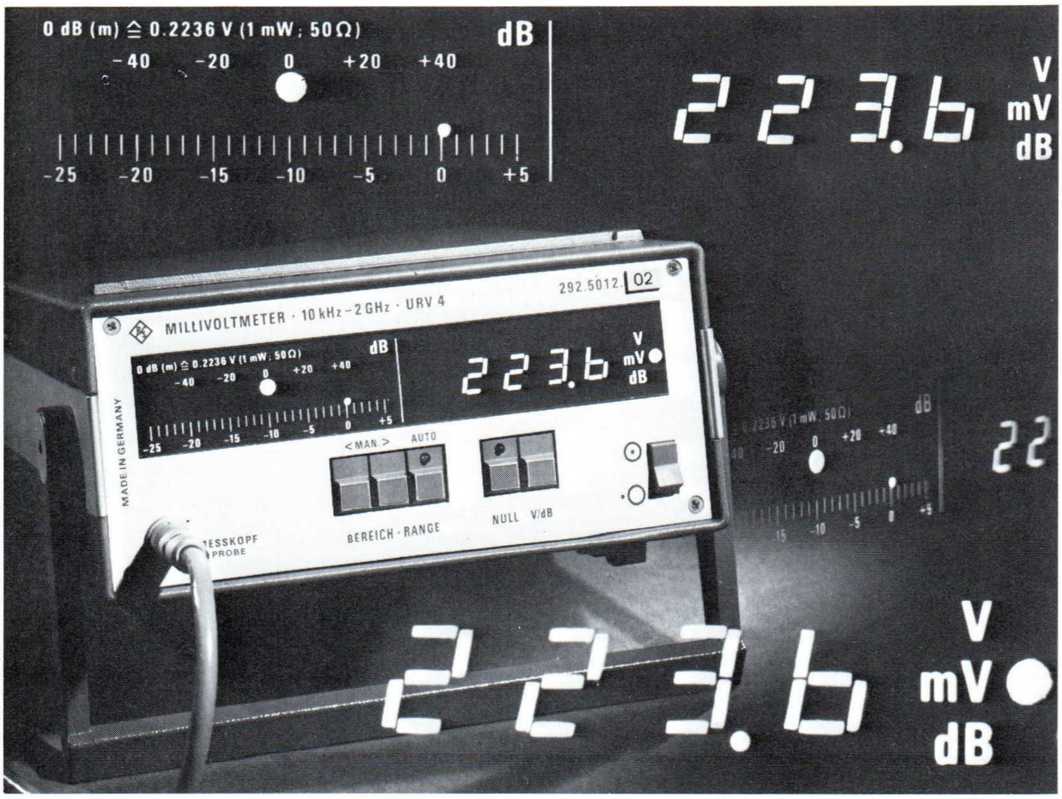
Weighted measurement of noise level

DIN, CCIR and CCITT specify weighted measurements for determining the noise levels in telephone and electroacoustic broadband transmission systems.

Simulation of the subjective noise effect is achieved with a psophometric weighting filter and the dynamic behaviour of the meter rectifier and movement.

The Psophometers UPGS and UPGR permit noise voltage to be measured in compliance with the latest international standard recommendations.

Frequency range	Designation	Type	Order No.	Voltage range	Sub-ranges	Fsd of lowest subrange	Error of voltage indication of fsd	Frequency response of voltage indication, dB
DC voltage	DC Microvoltmeter	UIG	203.5111.02	0.2 µV to 320 V (30 kV) 1 pA to 320 mA	16	10 µV 10 pA	±1.5%	—
15 Hz to 20 kHz	Psophometer	UPGS	248.0019.02	1 µV to 350 V −120 to +53 dB	14	10 µV	±2%	—
15 Hz to 100 kHz	Psophometer	UPGR	248.1915.02	1 µV to 350 V −110 to +53 dB	14	10 µV	±2%	—
10 Hz to 1 MHz	AF Millivoltmeter	UVN	100.0160.02	0.1 mV to 300 V −80 to +52 dB	12	1 mV	±2%	±0.17
10 Hz to 15 MHz	Microvoltmeter	UVM	110.2994.02	I 10 µV to 33 V II 100 µV to 330 V	I 12 II 12	I 100 µV II 1 mV	see p. 147	
I DC voltage II 1 kHz to 1.6 GHz	RF-DC Millivoltmeter	URV	216.3612.02	I 50 µV to 1050 V II 0.5 mV to 10.5 V (1050 V)	I 12 II 8	I 3 mV II 3 mV	see p. 148	II ±0.16
10 kHz to 2 GHz	Millivoltmeter	URV 3	302.9014.02	0.7 mV to 1050 V	8	3 mV	2% (inherent error)	
10 kHz to 2 GHz	Millivoltmeter	URV 4	292.5012.02	0.7 mV to 1000 V	automatic		1% of rdg	



Error of input attenuator dB	Rectification (type of weighting)	Input resistance or impedance at sockets balanced	unbalanced	Permissible voltage to earth	Amplifier output max. gain	Dimensions in mm (W × H × D)	Text on page
—	—	—	↗10/50 MΩ ↗1 Ω/1 kΩ/1 MΩ floating	500 V	100 dB	162 × 238 × 302	142
—	rms	600 Ω/ 10 kΩ/100 kΩ	1 MΩ	500 V	80 dB	210 × 184 × 263	143
—	peak rms	600 Ω/ 10 kΩ/100 kΩ	1 MΩ	500 V	70 dB	210 × 184 × 263	144
±0.1	average	—	1 MΩ; 30 pF	500 V	60 dB	162 × 238 × 241	146
—	I rms, peak factor = 10 II peak-peak	—	1 MΩ; 40 pF		66 dB	162 × 238 × 302	147
—	I – II peak rms	—	I 10 M Ω‖10 pF II probe or insertion unit	500 V	50 dB	162 × 238 × 275	148
—	peak rms	—	probe or insertion unit		— recorder output	240 × 109 × 217	150
—	peak rms	—	probe or insertion unit		— recorder output	240 × 109 × 217	152

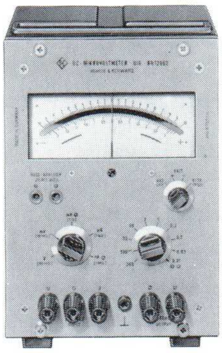
How to read the tables

Voltage range. Initial values correspond either to 10% of the final value in the lowest subrange or to the smallest discernible value.

The **error of voltage indication** is divided as follows:

1. The **errors of the voltage indication** caused by the meter, the rectifier and any circuit elements for the meter indication are specified in per cent of full-scale deflection (fsd).
2. The **frequency response of the voltage indication** refers to the frequency response of the entire instrument.
3. The **attenuator error** includes the error caused by the extension of the voltage range. The error is composed of a component of the attenuation setting expressed in per cent and of a constant attenuation error expressed in dB. These values apply for match termination.

UIG



DC Microvoltmeter UIG

♦ 0.2 µV to 320 V
(up to 30 kV with probe)
1 pA to 320 mA

- High sensitivity; floating circuitry
- Amplifier output −50 to +100 dB
- Independent of AC supply, battery sufficient for 10,000 operating hours

The **DC Microvoltmeter UIG** is a very accurate and sensitive measuring instrument with an amplifier output. The MOSFETs in the chopper and the precision design of the amplifiers keep the power consumption so low that one battery is sufficient for 10,000 operating hours. The time of operation is dependent on the storage life of the six single cells (battery voltage is checked on meter). Since the circuit is isolated from the cabinet, the UIG can be operated off earth.

Measurement ranges and input resistances. DC-voltage and DC-current ranges are set by means of two switches, one for numerical values and the other for units. The full-scale value is determined by the positions of the two switches.

Switch 2, numerical values:		0.01/0.03/0.1/0.3/1/3/10/30/100/300
Switch 1, units:	mV/V	(R_{in} = 10/50 MΩ)
	nA/µA/mA	(R_{in} = 1 MΩ/1 kΩ/1 Ω)

Switch 1 in position mV: the amplifier is directly connected to the voltage-test terminal; ranges 10 µV to 300 mV with **10-MΩ input resistance.** Position V: a 60-dB attenuator is connected ahead; range 10 mV to 300 V with **50-MΩ input resistance.** In the positions nA, µA and mA, the amplifier is shunted by the resistances 1 MΩ, 1 kΩ and 1 Ω and connected to the current-test terminals.

Reading. The measured value is indicated on a meter having a mirror scale of 105°; class of accuracy 0.5. Since the zero is in the middle of the scale, no polarity reversal is required. The electrical zero need only be adjusted in the most sensitive ranges.

Accuracy. In the temperature range +10 to +35 °C the error is below 2.5% in all ranges, at room temperature 1.5% (without noise and drift). Typical values of voltage and current drifts: 50 nV/°C and 1 pA/°C; typical values of noise: 0.3 μV_{pp} and 0.8 pA_{pp}.

Amplifier output. Open-circuit voltage 1 V at full-scale deflection. Gain adjustable in 10-dB steps from −50 to +100 dB, error limit 0.5%.

Examples of application

Compared with a classical voltmeter, the UIG offers a far higher sensitivity and complete off-earth operation at an input resistance of 50 MΩ in the range 1 mV to 320 V. The following examples are only some of the applications possible with the UIG.

Measurement of low resistances such as contact resistances, winding and printed-circuit conductor resistances (measured with the aid of a power source). Measurement range with a test current of 1 A: 1 µΩ to 320 mΩ; with 1 mA: 1 mΩ to 320 Ω; direct resistance readings.

Insulation-resistance measurements (by means of current measurement). Resistance up to 10 TΩ can be measured with a test voltage of 10 V.

Bridge measurements. Null detection and error measurements according to the deflection method can be carried out. With a bridge supply voltage of 10 V, a resolution of 0.2 × 10^{-6} can be achieved.

Measurement of rectified diode voltages. An RF voltage of 0.7 mV produces a rectified voltage of approximately 10 µV on an ideal diode. This corresponds to full-scale deflection in the most sensitive range of the UIG.

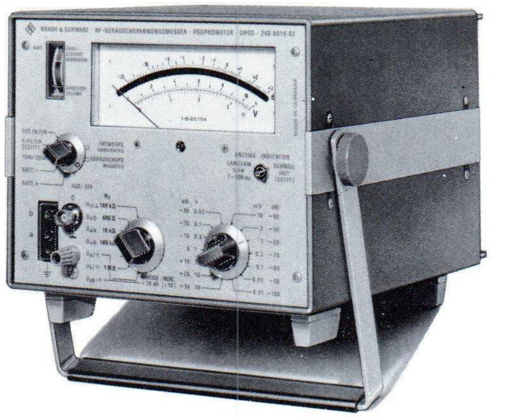
Semiconductor measurements, e.g. pinch-off voltage and gate current of field-effect transistors, offset voltage and offset current of operational amplifiers.

Use as input adapter, e.g. in conjunction with digital multimeters, whose sensitivity is improved by two orders of magnitude (resolution 1 µV), or with any low-sensitivity DC recorder.

Specifications

Measurement ranges and input resistances	see text on the left
Minimum readable voltage	0.2 µV
Maximum readable voltage	320 V
Minimum readable current	< 1 pA
Maximum readable current	320 mA
Error limit	1.5%
Maximum values at test input	
Voltage, position V	500 V
position mV	300 V, short-time
Current, position mA	1 A } response threshold of fuse
position µA	10 mA } response threshold of fuse
position nA	5 mA (300 V, short-time)
Insulation resistance between common and earth	> 10^{10} Ω
Amplifier output	1 V; R_{out} = 1 kΩ
Power supply	6 single cells IEC-R 20
Dimensions, weight	162 mm × 238 mm × 302 mm, 4 kg
Order designation	► DC Microvoltmeter UIG 203.5111.02
Accessories supplied	1 set of batteries 1.5 V/IEC-R 20
Recommended extra	30-kV DC Probe (UGWD-Z) 100.8519.02

UPGS



Psophometers UPGS

♦ 15 Hz to 20 kHz, −120 to +53 dB, 1 µV to 350 V

- Psophometer for commercial telephone circuits complying with CCITT Recommendations and featuring high sensitivity
- High-impedance balanced and unbalanced inputs
- True rms-responding detector with switch-selected time constant
- Error limits ±2%

The **Psophometer UPGS** complies with CCITT Recommendations and is used for

wideband level and voltage measurements in the AF range from 15 Hz to 20 kHz, and for

measuring weighted and unweighted noise voltages and levels in telephone transmission channels.

The UPGS has a high-impedance balanced input with excellent common-mode rejection. It can be switched for balanced measurements with 600 Ω, 10 kΩ or 100 kΩ input impedance, high-impedance measurement of the voltage to earth of the a-and b-wires, direct measurements of common-mode voltage and – via an isolated BNC female connector – floating measurement of AF voltages.

For weighted measurements the built-in telephone weighting filter can be switched in or external filters can be connected for special applications. The Octave Filter PBO or the Third-octave Filter PBT, for example, permits a rough spectrum analysis of the test signal.

Due to the use of a true rms-responding detector, the indication is independent of the frequency and phase relations of the individual components even if voltages comprising a number of different frequencies are applied. Small superimposed noise voltages cause only small measuring errors since the indicated value is derived from the sum of the mean squares of test voltage and noise voltage.

When the instrument is driven to full-scale deflection, the peak factor should not be higher than 5. If only 1/xth of the scale length is used, a peak factor of 5x is permissible. Combined overdrive indication for the amplifier and rms-responding detector prevents erroneous measurements.

Outputs. DC output: A voltage proportional to the rms value of the measured voltage is available for connection of a recorder or digital voltmeter. AC output: The UPGS is used as a balanced preamplifier for oscilloscopes, etc. Headphones output.

The UPGS can be powered from batteries, permitting floating operation and mobile use of the Psophometer.

Specifications

Frequency range
for wideband unweighted measurements .... 15 Hz to 20 kHz
for weighted measurements ...... CCITT telephone weighting filter

Test inputs, ranges, noise

Switch pos.	Input circuit u = unbalanced b = balanced	Z_{in}	Voltage range		Level range		Inherent noise	
			total	subrange	total	subrange	weighted	unweighted
1	u, common mode	1 MΩ [1]	10 µV – 350 V	as below, x 10	−100 to +53 dB	as below, +20 dB	30 µV	150 µV
2	u, V_b to earth	1 MΩ					30 µV	150 µV
3	u, V_a to earth	1 MΩ					30 µV	150 µV
4 [2]	b, high impedance	100 kΩ	1 µV – 35 V	10/30/100/300 µV/1/3/10/30/100/300 mV/1/3/10/30 V	−120 to +33 dB	−100/−90/ to −10/0/+10/ to +30 dB	3 µV	15 µV
5	b, high impedance	10 kΩ					1 µV	8 µV
6	b, low impedance	600 Ω					0.6 µV	5 µV
7	u, floating	100 kΩ					0.6 µV	5 µV

Connectors, balanced input ...... shielded two-pole socket
unbalanced input .... isolated BNC socket

Meter detector .... true rms-responding detector
Max. permissible peak factor ..... 5 (at fsd)
Detector time constant
in FAST position .... approx. 30 ms (for psophometric measurements)
in SLOW position .... approx. 500 ms

Indication .... moving-coil meter with mirror scale
Ranges .... −20 to +3 dB for level
0 to 11/0 to 3.5 for voltage

Overdrive capacity ahead of filter .. 100 times or 40 dB (for sinewave voltages ref. to fsd at 800 Hz)
at rms-responding detector .... 3.54 times or 11 dB, overdrive ind.

Error limits of ind. with sinewave voltages, t_{amb} +15 to +30 °C
Freq. response in % of rdg +1% of fsd

Switch positions 1 to 3	1/to/30 mV	0.1/to/300 V
30 Hz to 5 kHz	±2	±1
15 to 30 Hz/5 to 20 kHz	±4	±2
Switch positions 4 to 7	10/to/100 µV	300 µV/to/30 V
30 Hz to 10 kHz	±2	±1
15 to 30 Hz/10 to 20 kHz	±4	±2

Additional error of detector ...... ±3% (for peak factor 3 to 5)

Outputs
DC voltage output .... 1 V, Z_{out} = 1 kΩ, knurled terminals
AC voltage output .... 100 mV, Z_{out} = 600 Ω, isol. BNC female connector, max. gain 80 dB
Phones output .... 60 mV to 1.2 V (adjustable), Z_{out} = 600 Ω, max. gain 108 dB

Connection of external filter ...... 2 isol. BNC female connectors, 600 Ω

Compensation of passband attenuation .... 0 to 3 dB

General data
Power supply .... 6 single cells, 1.5 V
current drain approx. 2 mA
battery life: 3000 hrs

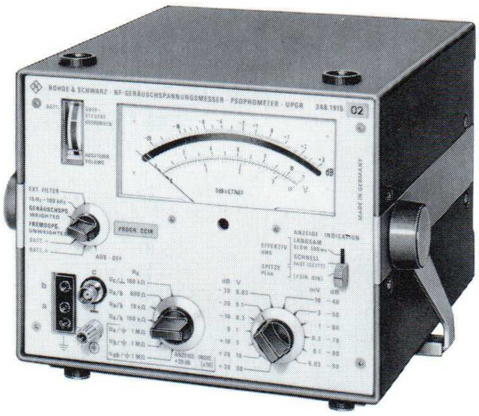
Dimensions, weight
(without batteries) .... 210 mm × 184 mm × 263 mm, 4 kg

Order designation .... ▶ Psophometer
UPGS for battery operation 248.0019.02
UPGS for
AC supply operation 248.0019.03

Recommended extras: Octave Filter PBO 201.5520.02
Third-octave Filter PBT 235.3014.02

[1]) Differential input impedance for direct measurement of unbalanced voltage component: 10 kΩ.
[2]) Typical values.

UPGR



Psophometer UPGR

♦ 15 Hz to 100 kHz
−110 to +53 dB
3 µV to 350 V

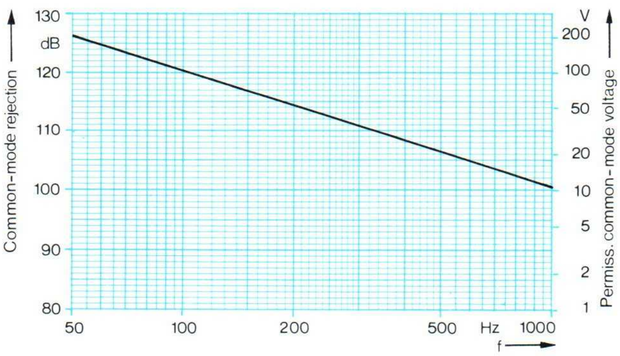
- Psophometer complying with CCIR (DIN 45 405 and CCITT by means of accessory filter)
- Psophometer complying with CCITT (using telephone weighting filter)
- High-impedance balanced and unbalanced inputs
- Peak-responding detector complying with CCIR and DIN and true rms-responding detector with switch-selected time constant complying with CCITT

Combined with its two options the **Psophometer UPGR** complies with the relevant recommendations of CCIR, CCITT and DIN 45 405. It is used for

wideband level and voltage measurements in the AF range from 15 Hz to 100 kHz, and for

measurement of weighted and unweighted noise voltages and levels in electroacoustic broadband and telephone transmission systems.

The UPGR has a high-impedance balanced input with excellent common-mode rejection (diagram below). It can be switched for balanced measurements with 600 Ω, 10 kΩ and 100 kΩ input impedance, high-impedance measurement of the voltage to earth of the a- and b-wires, direct measurement of common-mode voltage and – via an isolated BNC female connector – floating measurement of AF voltages.



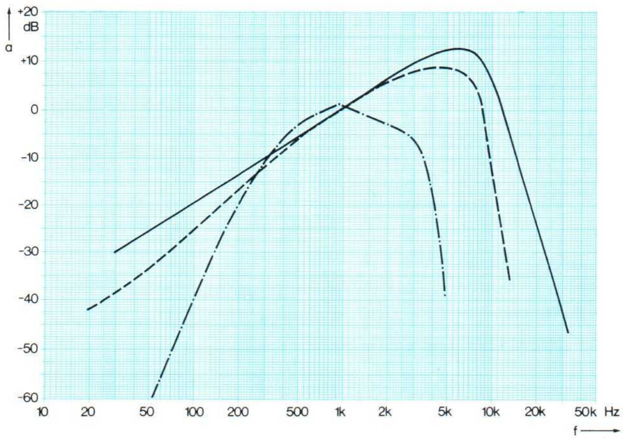
Common-mode rejection and common-mode voltage of UPGR versus frequency

Weighted noise measurements can be performed with the following filters:

broadcast weighting filter in line with CCIR (inbuilt)

broadcast weighting filter UPGR-Z2 in line with old standards of CCITT and DIN (option; can be readily substituted for the CCIR filter)

telephone weighting filter UPGR-Z1 in line with CCITT (option; can be attached and connected at the rear of the set).



Standard characteristics of psophometric filters

Full line: program weighting filter complying with CCIR Rec. 468 (future DIN standard)
Dashed line: program weighting filter complying with DIN 45 405 and CCITT Rec. P. 53 B (old)
Chain-dotted line: telephone weighting filter complying with CCITT Rec. P. 53 A

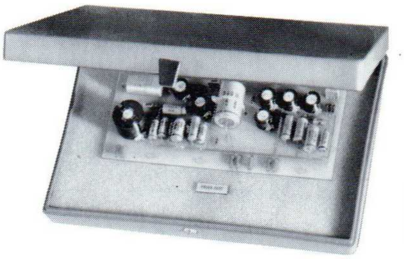
The following unweighted measurements can be made with the UPGR:

Unweighted noise measurements in the range 31.5 Hz to 16 kHz via the inbuilt CCIR filter

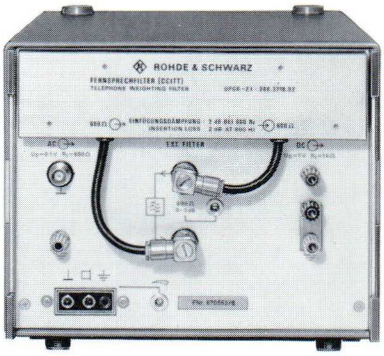
Unweighted noise measurements in the range 31.5 Hz to 20 kHz in line with DIN via the filter UPGR-Z2 (see above)

Accurate voltage and level measurements in the wideband range of 15 Hz to 100 kHz, e.g. in stereo channels and on control and pilot tones.

External filters can be connected at the rear for special measurement tasks. In conjunction with the Octave Filter PBO or Third-octave Filter PBT, for example, a rough spectral analysis of the test signal is possible. The Telephone Weighting Filter UPGR-Z1 can also be connected here.



Filter UPGR-Z2 (option) in accessory case (broadcast weighting filter for old standard)

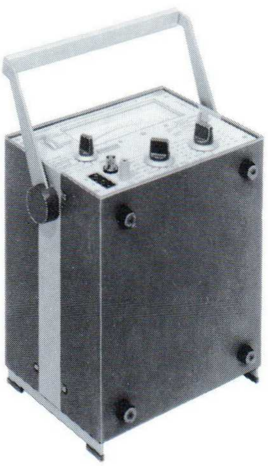


Rear of UPGR with Telephone Weighting Filter UPGR-Z1 attached

For indication of the test results, the meter of the UPGR can be switched for peak reading according to DIN and CCIR or rms reading according to CCITT. When the instrument is driven to full-scale deflection, the peak factor should not be higher than 10 in rms measurements corresponding to an overdrive capacity of 17 dB relative to sinewave voltages. In the case of peak-responsive measurements the overdrive capacity is 20 dB; this is of special importance for weighting short individual pulses. A combined overdrive indication for the amplifier and the rms-responding detector prevents erroneous measurements.

Outputs. DC output: A voltage proportional to the rms or peak value is available for connection of a recorder or digital voltmeter. AC output: The UPGR can be used as a balanced preamplifier for oscilloscopes, etc. Headphones output.

The UPGR can be powered from batteries (permitting floating operation and mobile use) or from the AC supply.



When the UPGR is operated in this position an additional error of 1% of fsd is to be taken into account

Specifications

Frequency range, wideband ...... 15 Hz to 100 kHz
3-dB cutoff frequencies .... 3 Hz/300 kHz
Weighted/unweighted measurements .... psophometric/flat filter in line with CCIR
psophometric filter (DIN/CCITT) and flat filter (DIN) as options
telephone weighting filter (CCITT) as option

Test inputs, measurement ranges

Switch position	Input circuit u = unbalanced b = balanced	Z_{in}	Voltage range		Level range	
			total	subrange	total	subrange
1	u, common mode	1 MΩ	30 µV – 350V	as below, x 10	–90 to +53 dB	as below, +20 dB
2	u, V_b to earth	1 MΩ				
3	u, V_a to earth	1 MΩ				
4	b, high impedance	100 kΩ	3 µV – 35 V	30/100 300 µV/ 1/3/10/30/ 100/300 mV/ 1/3/10/30 V	–110 to +33 dB	–90/.../–10/ 0/+10/+30 dB
5	b, high impedance	10 kΩ				
6	b, low impedance	600 Ω				
7	u, floating	100 kΩ				

For rough indication only .... 10 µV/–100 dB
Connectors, bal. input .... shielded two-pole female
unbal. input .... isolated BNC female
Input protection .... electronic circuit and fuse

Rms-responding detector .... max. peak factor = 10 (at fsd)
Detector time constant
FAST .... 30 ms for psophom. meas.
SLOW .... 500 ms

Peak-responding detector .... overdrive capacity 20 dB
Charge/discharge time constant .. 1 ms/250 ms

Indication .... moving-coil meter, mirror scale
Indication ranges .... –20 to +3 dB for level
0 to 11/0 to 3.5 V for voltage

Overdrive capacity ahead of filter .. 100 times or 40 dB (with sinewave referred to fsd at 1 kHz)
Overdrive indication .... red range of check meter

Error limits of indication with sinewave voltages and rms-responding detection; 15 Hz to 100 kHz, t_{amb} = +15 to +30 °C
Frequency-response error in % of rdg +1% of fsd

Switch positions 1 to 3	3/to/30 mV	0.1/to/300 V
15 to 30 Hz	±3	±2
30 Hz to 5 kHz	±2	±1
5 to 20 kHz	±5	±2
20 to 100 kHz	0/–30	±3
Below 3 mV well-defined measurement is not possible (inherent noise)		
Switch positions 4 to 7	30 and 100 µV	300 µV/to/30 V
15 to 30 Hz	±3	±2
30 Hz to 20 kHz	±2	±1
20 to 100 kHz	±4	±3

Indicator range 10 µV .... typically same as for 30-µV range
Additional error of detector ...... ±3% (with peak factor between 3 and 5)
Peak-responding detector .... in line with CCIR and DIN
Effect of operating position ...... add. error of ±1% if differing from a normal one

Inherent noise (depending on operating mode)

Switch position	1 to 3	4	5	6 and 7
Max. value in µV, rms	180	19	12	8
peak	300	30	17	10

Outputs
DC .... 1 V, 1 kΩ, knurled terminals
AC .... 100 mV, 600 Ω, isolated BNC, 70 dB max. gain
Phones (15 Hz to 20 kHz) .... max. 0 dB, adj.; 600 Ω

Connection of external filter ...... 2 isol. BNC female connectors, 600 Ω
Compensation of passband attenuation .... 0 to 3 dB

General data
Power supply battery .... 6 single cells 1.5 V; ≈ 3 mA approx. 2000 hours per set
AC supply .... 100 to 260 V, 47 to 420 Hz (1 VA)
Dimensions .... 210 mm × 181 mm × 281 mm
Weight w/o batt./w. power supply .... 4.2 kg/4.8 kg

Order designation .... ▶ Psophometer
UPGR for battery operation ...... 248.1915.02 (incl. battery)
UPGR for AC supply operation 248.1915.03

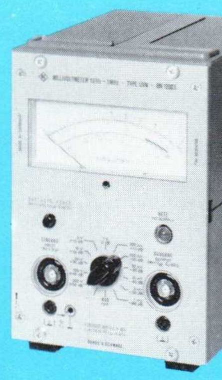
Recommended extras
Telephone Weighting Filter UPGR-Z1 (CCITT) 248.3718.02
Broadcast Weighting Filter UPGR-Z2 (CCITT/DIN) 248.3601.02
19" rack adapter 085.5548.00 (for two UPGR units)
Blank panel for rack adapter: 085.5677.00 (if only one UPGR is incorp.)
Third-octave Filter PBT 235.3014.02
Octave Filter PBO 201.5520.02

UVN

Millivoltmeter UVN

♦ 10 Hz to 1 MHz
0.1 mV to 300 V

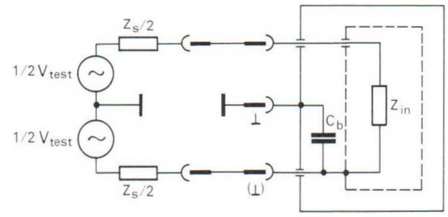
Z_{in} = 1 MΩ shunted by 30 pF
unbalanced,
floating



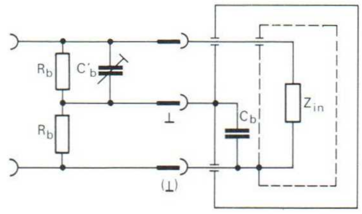
- Sensitive broadband voltmeter with average-responsive rectifier and amplifier output
- Common-mode rejection up to 120 dB
- Operation from AC supply or built-in battery

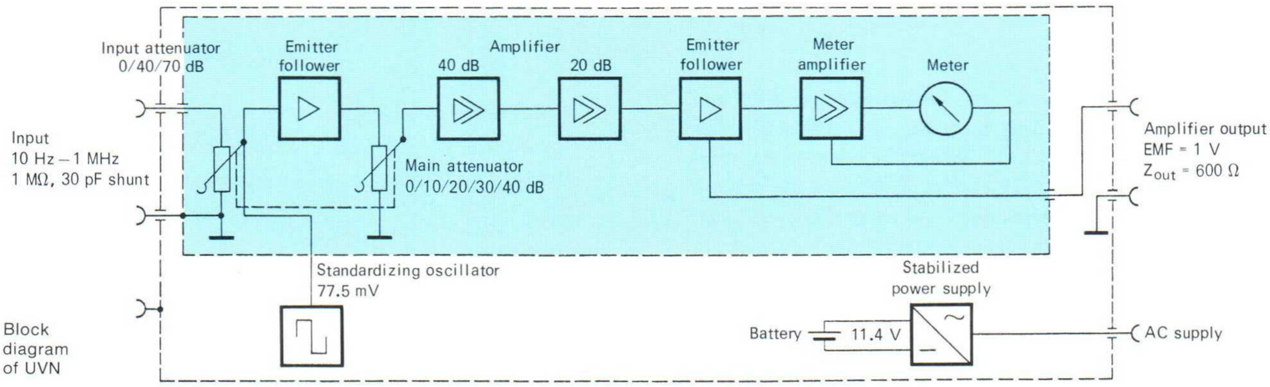
The UVN can readily be used for balanced level measurements in the audio-frequency range. The error liable to occur with no balancing is negligible with $Z_s < 1$ kΩ.

Direct measurement of a balanced AC voltage



Balanced input by adding external components





Block diagram of UVN

The **Millivoltmeter UVN** measures and amplifies voltages in the frequency range of 10 Hz to 1 MHz. It is noteworthy for its floating circuit. The circuit shielding is isolated from the voltmeter cabinet. The capacitance C_b between common and chassis is about 500 pF.

Voltmeter characteristics. Earthed and floating voltages (levels from −80 to +52 dB above 0.775 V) can be measured virtually without circuit loading, with a common-mode rejection of up to 120 dB. The indication is obtained in rms values on a sinewave with a maximum error of ±2% of fsd referred to 1 kHz.

Amplifier characteristics. The amplifier output of the UVN is also floating, the source impedance is 600 Ω. With 60 dB gain, 1 V EMF (±2%) is available at fsd. Frequency response is ±0.2 dB referred to 1 kHz. Distortion is less than 0.4% up to 50 kHz, less than 3% up to 1 MHz.

Thanks to these characteristics the UVN can be used, for example, as a preamplifier for oscilloscopes.

AC supply and battery operation are possible; the built-in Ni-Cd battery has a capacity of 30 hours and is charged during AC supply operation.

Specifications

Frequency range	10 Hz to 1 MHz
Measurement subranges	1/3/10/30/100/300 mV/ 1/3/10/30/100/300 V fsd
Rectification	average-responsive
Scale calibration	in rms values with sinusoidal signal
Deflection due to noise	≦50 μV in 1-mV range
Temperature response of gain	
in the range +23 to +45 °C	+0.5%/°C
in the range +23 to −15 °C	+1%/°C
Input impedance	1 MΩ, 30-pF shunt, unbalanced, floating
Maximum permissible total voltage at input	600 V (DC voltage and peak AC voltage)
Insulation resistance between common and chassis	> 100 MΩ, C = 400 pF
Common-mode rejection at 10 to 100 Hz	≧120 dB
Amplifier output	Z_s = 600 Ω, EMF at 1 kHz: 1 V (corresponding to 60 dB gain)
Connectors (input and output)	BNC female
Power supply	115/125/220/235 V +10/−15%
Battery operation	30 hours with fully charged battery
Dimensions, weight	162 mm × 238 mm × 241 mm, 3.5 kg
Order designation	► AF Millivoltmeter UVN 100.0160.02
Recommended extras	2 RF connecting cables 100.6945.10 2 adapters 408.4509.00 (BNC male – 4/13 female)

- Sensitive broadband voltmeter for laboratory, test and service departments
- Precise waveform weighting: rms values up to a peak factor of 10, peak-to-peak values up to a peak factor of 100
- Error limit 1%, built-in lowpass filter, input impedance 1 MΩ shunted by 40 pF
- AC output, max. gain 66 dB
  DC output, short settling time

UVM

Microvoltmeter UVM
♦ 10 Hz to 15 MHz

V_{rms}: 10 µV to 33 V
V_{pp}: 100 µV to 330 V

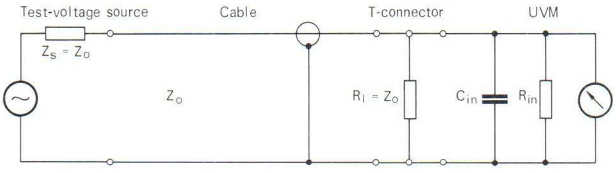
AC and DC outputs

The **Microvoltmeter UVM** measures AC voltages of any waveform in the frequency range from 10 Hz to 15 MHz. It indicates the **rms value** from 10 µV to 33 V and the peak-to-peak value from 100 µV to 330 V, each in 12 subranges, depending on the rectification mode selected. Thanks to its high sensitivity, large bandwidth and precise waveform weighting the UVM is ideal for measuring noise voltages, distorted sinewaves and pulse signals as well as frequency responses.

The UVM may also be used as a laboratory amplifier/**indicator**, the lower and upper 3-dB cutoff frequencies being 2 Hz and 25 MHz, respectively. A DC voltage proportional to V_{rms} or V_{pp} is available at the DC output for connection of a recorder or digital voltmeter.

The power can be determined by measuring the voltage across the load. It is possible to measure power levels from 0.1 pW to 1.8 W into 600 Ω and levels from 1 pW to 18 W into 60 Ω (see test circuit below).

Normally, the test-voltage source is connected to the high-impedance input via a coaxial cable. The connecting cable should be match-terminated at least at one end to counteract any voltage-transformation effect introduced by the cable and input capacitances. For precise **frequency-response measurements,** it is recommended that a BNC T-connector be plugged directly into the input of the UVM. A termination should then be connected to the second port of the T-connector, and the test voltage be applied to the third port using a cable (see test circuit below). For measurements on **high-impedance sources** ($Z_S \gg 50$ Ω), use of a 10:1 attenuator probe with an input impedance of 10 MΩ shunted by 7 to 10 pF is recommended.



Test circuit for high relative accuracy up to 15 MHz

When measuring pulses with steep edges it is important that the input be matched since the test result may be affected by phase distortions in **peak-to-peak value measurements.**

In rms-responding measurements, phase distortions are of no significance. The peak factor of the test voltage should not exceed 10 at full-scale deflection. If only 1/X of the meter scale is utilized, the maximum permissible peak factor is 10 × X (with 50%: 10 × 2 = 20).

A switch-selected **lowpass filter** (LP) with 1 MHz cutoff frequency (3 dB) reduces inherent noise. – Operation from AC supply.

Specifications

Frequency range	10 Hz to 15 MHz
with lowpass filter	10 Hz to 100 kHz
Voltage and level ranges	
rms response (V_{rms})	10 µV to 33 V; −100 to +32.5 dB (0 dB = 0.7746 V)
peak-to-peak response (V_{pp})	100 µV to 330 V; −80 to +52.5 dB
Subranges (fsd)	0.1/0.3/1/3/10/30/300 mV or V −80/to/+30 dB in 10-dB steps
Permissible input voltage	max. 600 V
Indication error at fsd with sinusoidal voltages	see table; temperature range +18 to +26 °C

V_{rms} ranges	0.1 mV	0.3 to 3 mV	10 mV to 10 V	30 V
10 to 20 Hz, LP on/off	2%	2%	2%	2%
20 Hz to 100 kHz, LP on/off	2%	1%	1%	1%
100 kHz to 2 MHz, without LP	3%	2%	1%	1%
2 to 10 MHz, without LP	5%	3%	2%	3%
10 to 15 MHz, without LP	7%	5%	3%	5%

Amplifier output	75 Ω, short-circuit proof, V_{rms} = 0.2 V, V_{pp} = 2 V, open-circuit voltage gain −44 to +66 dB
DC output	1 kΩ, 1 V at fsd
General data	
Nominal temperature range	+10 to +35 °C
Power supply	115/125/220/235 V ±10%, 47 to 63 Hz (16 VA)
Dimensions, weight	162 mm × 238 mm × 302 mm, 5 kg (3/8 of 19″ unit)
Order designation	► Microvoltmeter UVM 110.2994.02
Recommended extras	BNC T-connector 017.6588.00; Termination RMF (BNC): 100.2927.50 (50 Ω), ... 60 (60 Ω), ... 70 (75 Ω)

URV

RF-DC Millivoltmeter URV
♦ DC, 10 kHz to 2 GHz

- High sensitivity for DC and AC, lowest subrange 3 mV fsd
- Basic error 2.5% for RF measurement, 1% for DC measurement
- Two probe inputs facilitate two-port measurements
- RF voltage measurement in coaxial systems up to 350 V
- Battery operation: floating system

Two instrument versions for level measurement in dB and in dBm

The **RF-DC Millivoltmeter URV** belongs to the time-proven URV series which is continuously being adapted to the state of the art.

The instrument features high sensitivity and accuracy, and a comprehensive range of accessories, such as probes, attenuators, insertion heads and adapters, make it suitable for many applications.

The URV comes in two versions:

with V and dB scales (0 dB = 0.7746 V; 1 mW into 600 Ω)
with V and dBm scales (0 dBm = 0.2236 V; 1 mW into 50 Ω)

all other data being identical.

Applications

Measurements on resonant circuits in oscillators, narrow-band amplifiers and filters, the extremely low loading causing only slight damping and detuning.

RF voltage measurements on broadband amplifiers. The slight load capacitance produces no phase shift, say, in feed-back amplifiers.

Measurements on the outputs of low-power transmitters up to 200 W or of power stages.

Maximum, minimum, nominal-value adjustment of voltages. Measurement of the 3-dB points as a function of frequency.

Frequency-response measurements on two-port networks (gain, attenuation) are readily carried out with the URV, one probe being connected to the input and one to the output of the test item with switch selection on the URV.

Characteristics

Measurement ranges and input impedances.
Measurements are possible direct at the DC input (4 mm knurled terminals) from 50 µV to 1050 V into 10 MΩ, and up to 30 kV into 1 GΩ using the high-voltage probe.

Two equivalent inputs (three-pole sockets) permit the simultaneous connection of two measuring heads for AC or RF measurements. They can be switch-selected on the instrument.

Combined with its various options (see specifications) the URV offers the following capabilities:

Use of

Probe alone (0.2 mV to 10.5 V, C_{in} = 2.5 pF)

Probe + 20-dB divider (up to 100 V, C_{in} = 1 pF)
+ 40-dB divider (up to 1000 V, C_{in} = 0.5 pF)
+ 75-Ω adapter (makes up a termination for 75-Ω coaxial systems; 0.1 to 200 MHz, max. 2 W)
+ coaxial BNC insertion adapter (with or without divider; for example up to 350 V with 40-dB divider)

Coaxial insertion heads with low reflection coefficients

10-V insertion head (200 µV to 10.5 V, 50 Ω: 10 kHz to 2 GHz; 60, 75 Ω: up to 1.6 GHz)
100-V insertion head (2 mV to 105 V, 1 MHz to 2 GHz with 50 Ω and 60 Ω)

Coaxial insertion heads and 75-Ω adapters are available for different connector systems; see specifications.

Accuracy

The measuring heads are instrument-compatible; combined with any URV basic unit each probe and insertion head complies with the specified error limits without any adjustment.

At room temperature the error limits of the URV are 0.5% of rdg +0.5% of fsd for DC voltage measurements, 1.5% of fsd plus frequency response of probe and insertion unit for AC measurements; see table below.

Frequency response error in % of reading

Probe	Range	10 kHz – 100 kHz	100 kHz – 300 kHz	300 kHz – 1 MHz	1 MHz – 2 MHz	2 MHz – 100 MHz	100 MHz – 200 MHz	200 MHz – 500 MHz	500 MHz – 1 GHz	1 GHz – 1.6 GHz	1.6 GHz – 2 GHz
10-V insertion unit 50 Ω	0.1 – 10 V	% of rdg 1					2	5	7	15	
	0.2 – 100 mV	2					3	7	10	15	
10-V insertion unit 60 Ω/75 Ω	0.1 – 10 V	1					2	5	7	15	
	0.2 – 100 mV	2					3	7	10	15	
100-V insertion unit 50 Ω/60 Ω	1 – 100 V				1		2	5	7	15	
	2 – 1000 mV				2		3	7	10	15	
RF probe*	0.1 – 10 V		2	1			3	6	10		
	0.2 – 100 mV		3				5	10	15		
with 20-dB divider	1 – 100 V					6	8	12			
	2 – 1000 mV					8	10	15			
with 40-dB divider	10 – 1000 V				6		8	12			
	0.02 – 10 V				8		10	15			
with 75-Ω adapter	0.1 – 10 V		2	1			3				
	0.2 – 100 mV		3				5				

*) Probe alone or with 20-dB or 40-dB divider in BNC adapter (50-Ω coaxial system).

Reflection coefficients

Probe	Z_0	10 kHz – 100 MHz	100 MHz – 200 MHz	200 MHz – 500 MHz	500 MHz – 1 GHz	1 GHz – 1.6 GHz	1.6 GHz – 2 GHz
10-V insertion unit	50 Ω	Reflection coefficient in % 1		2	5	10	15
	60 Ω	2		3	10	15	
	75 Ω	3		5	15	20	
100-V insertion unit	50/60 Ω	1				2	
75-Ω adapter	75 Ω	1	3				

Indication, weighting

The URV has a 105° mirror scale which indicates the rms value for sinusoidal voltages. With non-sinusoidal voltages, the true rms value is indicated independently of the waveform in the ranges up to 30 mV (3 V with divider). For voltages of 1 V and higher, the test circuit operates as a full-wave peak-responding detector for all measuring heads.

Functional description

The RF probe and the insertion unit both have two similarly designed detector circuits, one for the RF voltage to be measured and the other for the comparison voltage generated in the instrument. The difference of the two detected voltages is taken via an attenuator to a chopper amplifier followed by a filter and a control loop. The squarewave thus processed is converted to a sinewave and according to the measurement range drives the comparison detector circuit. Since matched diode pairs with identical characteristics are used in the detector circuits, the indicated voltage is proportional to the amplitude of a sinusoidal test voltage.

Specifications

DC voltage range .... 50 µV to 1050 V
Subranges .... 3/10/30/100/300 mV/ 1/3/10/30/100/300/1000 V

AC voltage range .... 0.2 mV to 10.5 (1050) V
Level, URV with dB scale .... −70 to +22.5 (62.5) dB
URV with dBm scale .... −60 to +33 (73) dBm
Subranges .... 3/10/30/100/300 mV/ 1/3/10 V
−50/to/+20 dB or −40/to/+30 dBm

With
Probe/10-V insertion unit .... 0.2 mV to 10.5 V
Probe + divider
20 dB/100-V insertion unit .... 2 mV to 105 V
40 dB .... 20 mV to 1050 V

Frequency range
RF probe .... 100 kHz to 1 GHz (as indicator 2 GHz)
with 20-dB divider .... 2 to 500 MHz
with 40-dB divider .... 1 to 500 MHz
with 75-Ω adapter .... 100 kHz to 200 MHz (as indicator 500 MHz)
10-V insertion unit, 50 Ω .... 10 kHz to 2 GHz (3 GHz)
60, 75 Ω .... 10 kHz to 1.6 GHz (3 GHz)
100-V insertion unit, 50, 60 Ω .... 1 MHz to 2 GHz (3 GHz)

Input impedance
DC input .... 10 MΩ shunted by 10 pF
Probe .... > 80 kΩ (up to 10 MHz), C_{in} = 2.5 pF
with 20-dB divider .... > 1 MΩ (up to 20 MHz), C_{in} = 1 pF
with 40-dB divider .... > 10 MΩ (up to 20 MHz), C_{in} = 0.5 pF
Insertion units .... 50 Ω, 60 Ω, 75 Ω, acc. to order; reflection coefficient up to 200 MHz: 1 (3)%; see also table on left

Loading capacity	Max. values for V_{DC}	V_{rms} (sinewave)
DC input	1200 V	800 V
Probe	400 V	15 V
with 20-dB divider	1000 V	150 V
with 40-dB divider (100 MHz)	1000 V	1050 V
with 40-dB divider (500 MHz)	1000 V	210 V
10-V insertion unit	50 V	15 V
100-V insertion unit	1000 V	150 V
75-Ω adapter (up to 200 MHz)	12 V	12 V
Common line ref. to chassis	500 V	—

Error limits	V_{DC}	V_{rms} (sinewave)
at t_{amb} = +20 to +25 °C	0.5% of rdg +0.5% of fsd	1.5% of fsd
at t_{amb} = +15 to +30 °C	0.5% of rdg 1% of fsd	2% of fsd
plus frequency response error	see table in text under accuracy	
VSWR of insertion unit	see table on left	

DC output
Open-circuit voltage .... 1 V for indication of 10 or 3.16
Source impedance .... 1 kΩ
Settling time .... 500 ms

General data
Nominal temperature range .... +10 to +40 °C
Operating temperature range .... −20 to +60 °C (w/o meas. head)
Shelf temperature range .... −25 to +75 °C (w/o meas. head and batt.)
Operating and shelf temperature range for measuring heads .... 0 to +45 °C
Dimensions, weight .... 162 mm × 238 mm × 275 mm, 4 kg

Order designations .... ► RF-DC Millivoltmeter URV
URV with V and dB scales 216.3612.02
URV with V and dBm scales 216.3612.03

Accessories supplied
1 battery set
1 RF Probe URV-Z1 incl. earth cable with clip, earth sleeve, hook tip, solder tip, 20-dB and 40-dB dividers

Recommended extras
BNC Adapter URV-Z incl. matching sleeve 241.1110.02
75-Ω Adapter URV-Z3 incl. adapters UNI-9 socket to BNC and other systems 243.9118.70
Accessory case for probe, 75-Ω/ BNC adapter and small parts 219.5900.02
30-kV DC probe 100.8519.02
RF Probe URV-Z1 .... 243.8811.02

RF Insertion Units	URV-Z2 10 V	URV-Z4 100 V
50 Ω, Dezifix B	288.8010.54	283.7716.54
N male/female	288.8010.55	283.7716.55
7/16 male/female	288.8010.56	—
60 Ω, Dezifix B	288.8010.64	283.7716.64
6/16 male/female	288.8010.66	—
75 Ω, Dezifix B	288.8010.74	—

URV 3

new

Millivoltmeter URV 3
♦ 10 kHz to 2 GHz
0.7 mV to 1050 V

- Handy RF millivoltmeter for mobile and stationary use
- High-impedance voltage measurement with RF probe and dividers; voltage and level measurement using insertion units with defined characteristic impedance of 50 or 75 Ω
- Basic error 2%
- Universal powering system – battery, accumulator, power supply unit or external source

The **Millivoltmeter URV 3**, the latest analog unit of the URV family, is a highly sensitive and accurate voltage and level meter for the frequency range from 10 kHz to 2 GHz (up to 3 GHz if used only as an indicator).

A broad range of accessories, such as probe, dividers, insertion units and adapters, and battery operation capability permit versatile mobile and stationary use of the voltmeter.

Applications

RF voltage measurement. High-impedance measurements with RF probe in broadband amplifiers, on resonant circuits of oscillators, narrowband amplifiers and filters; measurements with impedance-matched RF insertion unit at the outputs of transmitters and other coaxial systems. True rms-value measurement possible up to 3 V and peak-value measurement from 1 V RF voltage.

Adjustment to maximum, minimum or nominal value. Determination of the 3-dB points as a function of frequency.

Gain or attenuation measurement on passive or active four-terminal networks as a function of frequency (frequency response).

Level measurement in dBm referred to 0 dBm = 1 mW into Z = 50 Ω (0.2236 V), correction of level indication (according to relation $10 \lg \frac{Z}{50}$): +1.76 dB at Z = 75 Ω.

Characteristics

The URV 3 affords extremely constant indication and zero setting as well as easy reading of the measured values. Low capacitive and resistive loading by the RF probe minimize measuring errors introduced by detuning of resonant circuits, damping and unwanted phase shifts in feedback networks, etc. Mismatching is negligible thanks to the low reflection coefficient of the RF insertion units.

Measuring principle, measuring heads. In accordance with the well-proven control method used by the URV instruments (see page 149 under functional description), the RF voltage is converted into a proportional DC voltage of high linearity so that the accuracy is exclusively determined by the matching of the characteristics of the diodes incorporated in the measuring head. This makes the **measuring heads freely interchangeable** within the URV family without degrading the error limits.

The RF probe is supplied with the URV 3, the other accessories are recommended extras.

Connections and measuring possibilities:

Measurement using

probe alone (700 µV to 10.5 V, C_{in} = 2.5 pF)

probe
+ 20-dB divider (up to 105 V, C_{in} = 1 pF)
+ 40-dB divider (up to 1050 V, C_{in} = 0.5 pF)
+ coaxial BNC adapter (with or without divider; with 40-dB divider for instance up to 350 V)
+ 75-Ω adapter (RF voltage measurement in 75-Ω coaxial systems, 100 kHz to 500 MHz)

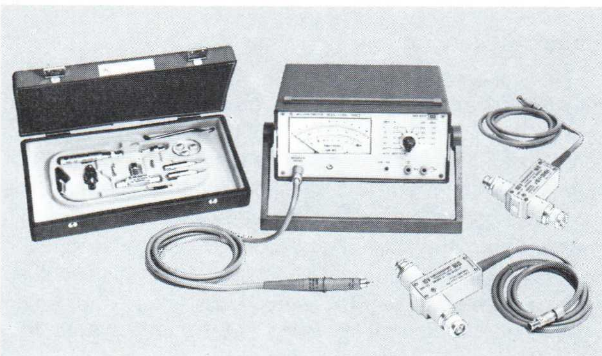
coaxial insertion units at low reflection coefficients

10-V insertion unit (700 µV to 10.5 V, 50 Ω: 10 kHz to 2 GHz, 75 Ω: 10 kHz to 1.6 GHz)

100-V insertion unit (7 mV to 105 V, 1 MHz to 2 GHz, 50 Ω)

Appropriately terminated, the 100-V insertion unit is suitable for measurements on power stages up to 200 W.

URV 3 with measuring heads and insertion units plus case accommodating small parts



Input impedance of RF probe. The input impedance of the RF probe is given by the input capacitance C_{in} (see to the right) and the parallel input resistance R_p, which is dependent on the test voltage (100 kΩ to 1 MΩ between 1 mV and 10 V) and, above 3 MHz, also on the frequency.

Indication, waveform weighting. The RF voltage and level are indicated on a precision moving-coil meter on separate scales in eight subranges which can be manually selected. The level indication in dBm is valid for 50-Ω coaxial systems but can also be used to advantage for relative measurements in case of an undefined source impedance.

Rms-value measurement. The URV 3 measures and reads the rms value in the three most sensitive measurement ranges. At voltages above 1 V, it measures the peak-to-peak value (V_{pp}) but reads out the value $V_{pp}/2\sqrt{2}$ corresponding to the rms value for sinusoidal voltages.

Accuracy. The operational error consists of the basic error plus the frequency-response error. At room temperature the basic error is 2%; for the frequency-response error see the table below.

Frequency response error in % of reading

Measuring head	Range	10 kHz to 100 kHz	100 kHz to 300 kHz	300 kHz to 1 MHz	1 MHz to 2 MHz	2 MHz to 200 MHz	200 MHz to 500 MHz	500 MHz to 1 GHz	1 GHz to 1.6 GHz	1.6 GHz to 2 GHz
10-V insertion unit 50 Ω	0.1 to 10 V	% of rdg 1					2	5	7	15
	0.7 to 100 mV	2					3	7	10	15
10-V insertion unit 75 Ω	0.1 to 10 V	1					2	5	7	15
	0.7 to 100 mV	2					3	7	10	15
100-V insertion unit 50 Ω	1 to 100 V				1		2	5	7	15
	7 to 1000 mV				2		3	7	10	15
RF probe *)	0.1 to 10 V		2	1			3	7	18	
	0.7 to 100 mV		3				5	10	15	
with 20-dB divider	1 to 100 V					11	13	16		
	7 to 1000 mV					13	15	20		
with 40-dB divider	10 to 1000 V				6		8	12		
	0.07 to 10 V				8		10	15		
with 75-Ω adapter	0.1 to 10 V		2	1			3	10		
	0.7 to 100 mV		3				5	12		

*) Probe alone or with 20-dB or 40-dB divider in BNC adapter (50-Ω coaxial system).

Reflection coefficients

Measuring head	Z_0	10 kHz to 100 MHz	100 MHz to 200 MHz	200 MHz to 500 MHz	500 MHz to 1 GHz	1 GHz to 1.6 GHz	1.6 GHz to 2 GHz
10-V insertion unit	50 Ω	Reflection coefficient in % 1		2	5	10	15
	75 Ω	3		5	15	20	
100-V insertion unit	50 Ω	1				2	
75-Ω adapter	75 Ω	1.5	3	10			

Specifications

Instrument

Test input
Parameters measured . . . voltage (V, mV)/level (dBm)
Frequency range . . . 10 kHz to 2 GHz
Voltage range . . . 700 µV to 1050 V (with dividers)
Subranges . . . 3/10/30/100 mV/0.3/1/3/10 V
Level range . . . −50 to +73 dBm
Subranges . . . −40/−30/−20/−10/0/+10/+20/+30 dBm
Level reference . . . 0 dBm corresponding to 1 mW into 50 Ω (0.2236 V)
Range of indication . . . 300 to 700 µV or −57 to −50 dBm

Connection of measuring head . . . three-pole socket (for URV measuring heads)

Recorder output (shortcircuit-proof)
Output voltage . . . 1 V at final value 10, 3.3 V at final value 3.3, 10 V at final value 10 in range 10 V
Output impedance . . . 1 kΩ
Polarity . . . positive, referred to ground
Connectors . . . two 4-mm sockets
Setting time . . . approx. 100 ms for test voltages > 10 mV (increasing with decreasing test voltages)

RF measuring heads . . . RF probe with 20-dB and 40-dB dividers as well as BNC adapter and 75-Ω adapter; 10-V insertion unit (50, 75 Ω); 100-V insertion unit (50 Ω)

Input impedance of RF probe . . . R_p > 80 kΩ (up to 10 MHz), C_{in} = 2.5 pF
with 20-dB divider . . . R_p > 1 MΩ (up to 20 MHz), C_{in} = 1 pF
with 40-dB divider . . . R_p > 10 MΩ (up to 20 MHz), C_{in} = 0.5 pF

Voltage rating

	V DC	V_{rms} (sinewave)	V_s
RF probe	400 V	15 V	22 V
with 20-dB divider	1000 V	150 V	220 V
with 40-dB divider up to 100 MHz	1000 V	1050 V	1500 V
up to 500 MHz	1000 V	210 V	1500 V
10-V insertion unit	50 V	15 V	22 V
100-V insertion unit	1000 V	150 V	220 V
75-Ω adapter (P_{max} = 2 W)	12 V	12 V	17 V

Frequency ranges
RF probe . . . 100 kHz to 1 GHz (up to 2 GHz if only used as indicator)
with 20-dB/40-dB divider . . . 2 to 500 MHz/1 to 500 MHz
10-V insertion unit, 50 Ω . . . 10 kHz to 2 GHz (up to 3 GHz if only used as indicator)
10-V insertion unit, 75 Ω . . . 10 kHz to 1.6 GHz
100-V insertion unit, 50 Ω . . . 1 MHz to 2 GHz
75-Ω adapter . . . 100 kHz to 500 MHz

Voltage ranges (level ranges Z = 50 Ω)
RF probe, 10-V insertion unit . . . 700 µV to 10.5 V/−50 to +33 dBm
RF probe with 20-dB divider, 100-V insertion unit . . . 7 mV to 105 V/−30 to +53 dBm
RF probe with 40-dB divider . . . 70 mV to 1050 V/−10 to +73 dBm

Error limits (sinewave voltages)

Operational error = basic error + frequency response error
Basic error at t_{amb} +20 to +25 °C . 2% of fsd
t_{amb} +15 to +30 °C . 2.5% of fsd
t_{amb} +5 to +40 °C . . 2.5% of fsd +2% of rdg
Frequency-response error . . . see diagram to the left

General data

		Measuring heads
Nominal temperature range	+5 to +40 °C	
Operating temperature range	−20 to +60 °C	0 to +45 °C
Shelf temperature range	−25 to +75 °C	−15 to +60 °C

Power supply . . . battery compartment for operation with: 4 single cells 1.5 V, R-20, DIN 40 866 and IEC, lead-acid accumulator or AC-supply unit; external source 5 to 8 V/35 mA
Service life
Battery (alkali-manganese cells) . . . approx. 200 h
Lead-acid accumulator . . . approx. 70 h
Overall dimensions, weight . . . 240 mm × 109 mm × 217 mm, 2.5 kg (with batteries)
Order designation . . . ► Millivoltmeter URV 3 302.9014.02

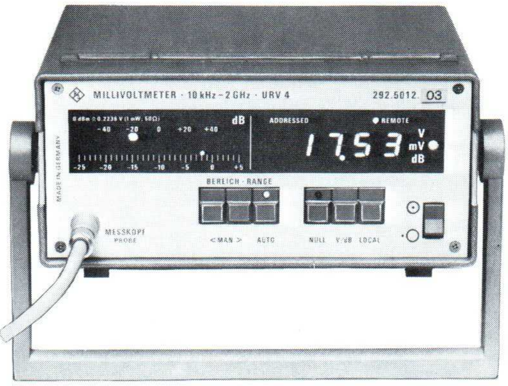
Accessories supplied
RF Probe URV-Z7 . . . comprising earth cable with clip, earth sleeve, earth strip, hook tip, solder tip, case
4 batteries, R-20, IEC

Recommended extras
Accessories URV-Z6 . . . 292.5364.02 comprising 20-dB divider, 40-dB divider, BNC adapter URV-Z for RF probe, including reducing sleeve for dividers
75-Ω Adapter URV-Z3 . . . 243.9118.70 comprising adapters from UNI-9 socket to 2.5/6 connector, to 1.6/5.6 connector, to BNC connector

RF insertion units	50 Ω N connectors	50 Ω Dezifix B	75 Ω Dezifix B
10-V Insertion Unit URV-Z2	288.8010.55	288.8010.54	288.8010.74
100-V Insertion Unit URV-Z4	283.7716.55	—	—

Power Supply (6 V) EGT-Z (220/115 V, 50/60 Hz) with connecting cable for buffer operation and charging . . . 201.5414.00
Lead-acid Storage Battery (6 V) EGT-Z . . . 201.5437.00

URV 4



new

IEC 625 Bus

Millivoltmeter URV 4

♦ 10 kHz to 2 GHz
700 μV to 1000 V/−50 to +73 dBm

- Digital readout of voltage and level, resolution 1 μV and 0.01 dB
- Additional analog level indication for trimming (rapid tendency indication), resolution 0.5 dB
- RF voltage measurement in coaxial systems up to 350 V
- Programming and data output possible through IEC bus

The **URV 4** – the first digital meter of the URV series – is a highly sensitive and accurate **millivoltmeter** measuring RF voltages and levels from 10 kHz to 2 GHz, up to 3 GHz if only used as indicator. Both high-impedance measurements using the probe of low capacitive loading and voltage measurements in any coaxial system (up to 350 V) or systems of standard characteristic impedance (50 and 75 Ω) are possible. To this end a comprehensive range of accessories such as probes and measuring heads is available.

System compatibility. The URV 4 is available with and without IEC-bus connector, the characteristics remaining the same. In addition to the conventional applications (see also URV and URV 3), the instrument fitted with the IEC-bus connector is especially suitable for use in automatic test assemblies and systems.

The digital display gives a readout of the voltage or the level. Its high resolution and accuracy (4000 steps for measuring voltage; 10,000 steps without autoranging) is optimally matched to the overall accuracy of the measuring head and the meter. The measurement ranges can also be pushbutton-selected after switching off the autoranging. The levels are indicated directly in dB relative to 1 mW into 50 Ω in all subranges. When the unknown signal falls out of the selected subrange, the display of the URV 4 flashes.

Additional analog indication. To facilitate trimming (tendency indication) and for coarse measurements an additional **analog indication** is provided on the URV 4 in the form of a row of LEDs. The coverage is 30 dB in steps of 1 dB. Since two LEDs light inbetween steps, level differences of 0.5 dB are discernible. The reference value for the analog scale can be taken from the five additional range indications.

Automatic zeroing. The URV 4 features **automatic zeroing** for voltage measurements in the most sensitive measurement range. It sets the electrical zero at the press of a button doing away with the tedious and error-prone zero setting by means of a zero adjustment potentiometer. Zero correction is not required in the higher measuring ranges.

A level-proportional DC voltage (100 mV/dB) is available at the recorder output provided on the rear panel of the URV 4. Thus with the aid of automatic ranging continuous recording is possible over a dynamic range of 83 dB.

The URV 4 can be powered from the AC supply or an **external battery** (automatic switchover depending on available AC supply voltage).

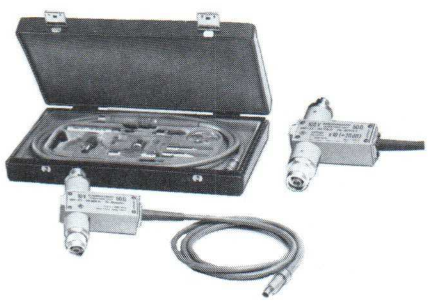
Measuring heads (probes, insertion units, adapters)

The measuring heads are freely interchangeable – also with those of the predecessor type URV. The RF probe is supplied with the URV 4, the other extras are recommended for use with the set.

RF probe alone:	300 μV to 10 V 100 kHz to 1 GHz (indicator up to 2 GHz)
+20-dB divider:	3 mV to 100 V 2 to 500 MHz
+40-dB divider:	30 mV to 1000 V 1 to 500 MHz
+BNC adapter (with or without divider):	measurement in any coaxial system up to 350 V (probe +40 dB)
+75-Ω adapter:	300 μV to 10 V 100 kHz to 500 MHz
10-V insertion unit; 50, 60 or 75 Ω:	300 μV to 10 V 10 kHz to 2 GHz (50 Ω)
100-V insertion unit; 50 or 60 Ω: (for powers up to 200 W)	3 mV to 100 V 1 MHz to 2 GHz

Input impedance of RF probe. The input impedance of the RF probe is given by the input impedance C_{in} (see to the right) and the parallel input resistance R_p, which is dependent on the test voltage (100 kΩ to 1 MΩ between 1 mV and 1 V) and, above 3 MHz, also on the frequency.

Case containing accessories and recommended extras



Waveform weighting. The URV 4 measures and reads out the rms value in the two most sensitive measurement ranges. At voltages above 1 V, it measures the peak-to-peak value (V_{pp}), but reads out the value $V_{pp}/2\sqrt{2}$ corresponding to the rms value for sinusoidal voltages. The following table gives test voltage (100 kΩ to 1 MΩ between 1 mV and 10 V) and, with a weighting error of 2 and 5% (blue for peak-value measurement).

Probe +	10-V insertion unit	20-dB divider + 100-V insertion unit	40-dB divider
Error	2 / 5%	2 / 5%	2 / 5%
V_{meas}	crest factor	crest factor	crest factor
3 mV	10/13		
10 mV	3/ 4		
30 mV	1.7/ 2	10/13	
100 mV		3/ 4	
300 mV		1.7/ 2	10/13
1 V	2.8/5.6		3/ 4
3 V	8.5/17		1.7/ 2
10 V	28/ 56	2.8/5.6	
30 V		8.5/ 17	
100 V		28/ 56	2.8/5.6
300 V			8.5/ 17
1000 V			28/ 56

Accuracy. The operational error consists of the basic error plus the frequency-response error; see the corresponding tables.

Basic error in the indicating range 300 to 4000 or – 20 to +5 dBm on the analog scale

	Voltage measurement *)		Level measurement *)		
	4 mV to 10 V	0.7 to 4 mV	-35 to +33 dBm	-45 to -35 dBm	-50 to -45 dBm
+20 to +25 °C	1 % of rdg + 3 digits	1 % of rdg + 30 digits	0.2 dB	0.4 dB	0.6 dB
+15 to +30 °C	2 % of rdg + 3 digits	2 % of rdg + 40 digits	0.3 dB	0.6 dB	0.8 dB
+ 5 to +40 °C	3 % of rdg + 5 digits	5 % of rdg + 50 digits	0.5 dB	1 dB	1.2 dB

*) Used only as indicator at voltages <0.7 mV or levels <–50 dBm.

Frequency-response error (reflection coefficients as for URV, page 149)

Measuring head	Range	10 kHz	100 kHz	300 kHz	1 MHz	2 MHz	100 MHz	200 MHz	500 MHz	1 GHz	1.6 GHz – 2 GHz
10-V insertion unit 50 Ω	0.1 to 10 V	% of rdg 1					2	5	7	15	
	0.7 to 100 mV	2					3	7	10	15	
10-V insertion unit 75 Ω	0.1 to 10 V	1					2	5	7	15	
	0.7 to 100 mV	2					3	7	10	15	
100-V insertion unit 50 Ω	1 to 100 V				1		2	5	7·	15	
	7 to 1000 mV				2		3	7	10	15	
RF probe *)	0.1 to 10 V		2	1			3	7	18		
	0.7 to 100 mV		3				5	10	15		
with 20-dB divider	1 to 100 V					11	13	16			
	7 to 1000 mV					13	15	20			
with 40-dB divider	10 to 1000 V				6		8	12			
	0.07 to 10 V				8		10	15			
with 75-Ω adapter	0.1 to 10 V		2	1			3	10			
	0.7 to 100 mV		3				5	12			

*) Probe alone or with 20-dB or 40-dB divider in BNC adapter (50-Ω coaxial system).

Specifications

Instrument

Test input
Parameters measured .... voltage/level (dBm)
Frequency range .... 10 kHz to 2 GHz
Voltage range .... 700 µV to 1000 V
Subranges .... 4/40/400 mV/4/10 V

Level range .... –50 to +73 dBm
Subranges .... –40/–20/0/+20/+40 dB
Level reference .... 0 dBm corresponding to 0.2236 V (1 mW into 50 Ω)
Range of indication .... 300 to 700 µV
Range setting .... autoranging; pushbuttons for manual setting to next higher/lower subrange

Auto zeroing .... electronic zeroing by pushbutton control for measuring RF voltages < 4 mV

Readout of measured value
Range indication, analog .... 5 LEDs for subranges
digital .... decimal point and physical unit (mV/V/dB)
Digital display
Voltage .... 4 digits (4000 steps, 10,000 steps without autoranging), resolution 1 µV)
Level .... 4 digits plus polarity sign, resolution 0.01 dB
Analog level indication .... row of 31 LEDs
Indicating range .... –25 to +5 dB, step size 1 dB, resolution 0.5 dB

Recorder output .... 1 kΩ, shortcircuit-proof
Output voltage .... positive or negative level-proportional DC voltage, 0 V at 0 dBm (223.6 mV), 100 mV per dB input level variation
Dynamic range .... 83 dB

IEC-bus connector (version 03) ... interface in accordance with IEC 625-1 for controlling the operating modes
Interface functions .... SH1, AH1, T1, L2, SR1, RL1, PP ∅, DC1, DT ∅, C ∅
Setting time .... level-dependent, up to 30 measurements/s

Connection of measuring head ... three-pole female connector (for URV measuring head)

RF measuring heads .... RF probe with 20-dB and 40-dB dividers as well as BNC adapter and 75-Ω adapter
10-V insertion unit (50, 60, 75 Ω)
100-V insertion unit (50, 60 Ω)

Input impedance of RF probe ..... R_p > 80 kΩ (up to 10 MHz), C_{in} = 2.5 pF
with 20-dB divider .... R_p > 1 MΩ (up to 20 MHz), C_{in} = 1 pF
with 40-dB divider .... R_p > 10 MΩ (up to 20 MHz), C_{in} = 0.5 pF

Voltage rating	V DC	V_{rms} (sinewave)	V_p
RF probe	400 V	15 V	22 V
with 20-dB divider	1000 V	150	220 V
with 40-dB divier			
up to 100 MHz	1000 V	1050 V	1500 V
up to 500 MHz	1000 V	210 V	1500 V
10-V insertion unit	50 V	15 V	22 V
100-V insertion unit	1000 V	150 V	220 V
75-Ω adapter (P_{max} = 2 W)	12 V	12 V	17 V

Frequency ranges
RF probe .... 100 kHz to 1 GHz (2 GHz)
with 20-dB/40-dB divider ...... 2 to 500 MHz/1 to 500 MHz
10-V insertion unit 50 Ω .... 10 kHz to 2 GHz (indicator: 3 GHz)
10-V insertion unit 75 Ω .... 10 kHz to 1.6 GHz
100-V insertion unit 50 Ω .... 1 MHz to 2 GHz
75-Ω adapter .... 100 kHz to 500 MHz

Voltage ranges (level ranges)
RF probe, 10-V insertion unit ..... 700 µV to 10 V/–50 to +33 dBm
RF probe with 20-dB divider, 100-V insertion unit .... 7 mV to 100 V/–30 to +53 dBm
RF probe with 40-dB divider ...... 70 mV to 1000 V/–10 to +73 dBm

Error limits .... see lefthand column under accuracy

General data
Nominal temperature range ...... +5 to +40 °C
Operating temperature range ..... –20 to +60 °C (measuring head: 0 to +45 °C)
Shelf temperature range .... –25 to +75 °C (measuring head: –15 to +60 °C)
Power supply, AC supply .... 115/220 V ±10%, 47 to 440 Hz (4 VA, version 03: 6 VA)
ext. battery .... 11 to 28 V, 300 (450) mA at 12 V
Dimensions, weight .... 240 mm × 109 mm × 217 mm, 2.6 kg (2.9 kg)

Order designation .... ► Millivoltmeter URV 4
URV 4 without IEC-bus connector 292.5012.02
with IEC-bus connector 292.5012.03

Accessories supplied
RF Probe URV-Z7 with earth cable and clip, earth sleeve, earth strip, hook tip, solder tip and case
Connector for battery; power cable

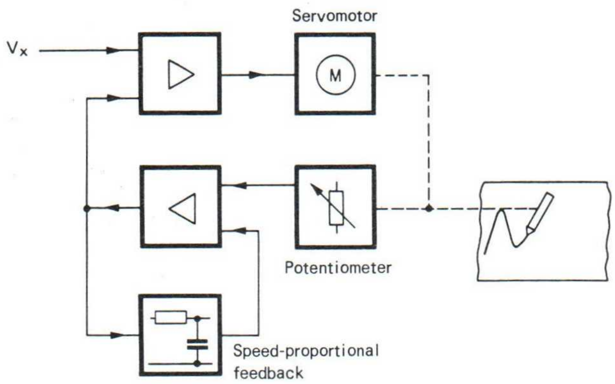
Recommended extras
Accessories URV-Z6, 75-Ω adapter and RF insertion units as for URV 3 on page 151

Introduction

A quantity recorded as a function of time or of another variable can be readily interpreted and precisely evaluated.

Principle of potentiometer-type recorders

The self-balancing potentiometer principle is illustrated in the following diagram:

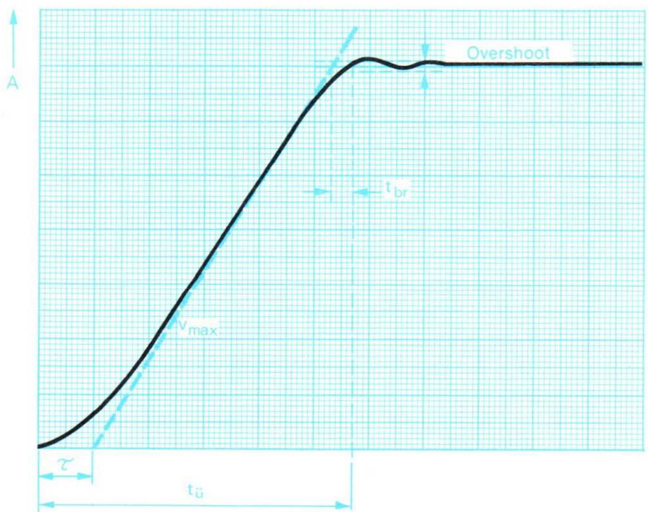


Simplified diagram of potentiometer-type recorder

The input voltage V_X is compared with the output voltage of the balance potentiometer, which is fed from a reference voltage source. If there is a difference, the motor acts on the potentiometer and thereby on the stylus until balance is restored. The speed-proportional feedback affords optimal damping of the system.

Dynamic behaviour of the potentiometer-type recorder

Whether a quickly varying quantity is represented faithfully depends on the dynamic characteristics of the recorder. The step function is most commonly used to test a recorder for maximum writing speed, time constant of recording system and overshoot or damping. The typical step function is shown below:



Step function of a recorder and definition of terms

The servomotor has reached its final speed v_{max} after about 3τ. The asymptote to the slewing function with the slope v_{max} intersects with the time axis at the point τ.

The braking force of the servomotor is greater than the starting force, since the polarity is reversed at full rpm; therefore an optimally damped system has a shorter braking time than starting time, typically about 0.5 τ.

The settling time is the sum of starting time τ, running time at constant speed v_{max} and braking time $t_{br} \approx 0.5\ \tau$ (see diagram). For a step of amplitude A the settling time is obtained as

$$t_S \approx 1.5\,\tau + \frac{A}{v_{max}}$$

The time constant of the servosystem can also be determined from the starting acceleration "a" which is specified by many manufacturers and the final speed v_{max}.

$$\tau = \frac{v_{max}}{a}$$

Here it is to be noted that "a" is the starting acceleration from standstill and not equal to the maximum acceleration a_{max} during braking, which is in practice about 1.5 a to 1.8 a.

Recall of important notions

Linearity. The departure of indication from linear response is stated in percent of the calibrated width of the chart as a function of the input level.

Reproducibility (hysteresis, deadband). Coincidence obtained with repeated plotting of the same pairs of values or time functions. (Hysteresis or deadband designate the departure occuring with repeated plotting of the same value, referred to the higher or lower values; the departure is stated in percent of the calibrated width of the chart.)

Maximum writing speed v_{max}. Final speed of the recording carriage produced by the servomotor in response to a step function on one coordinate axis.

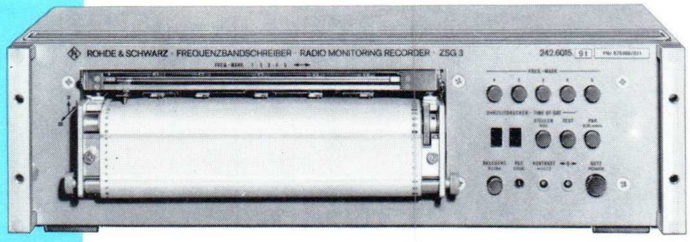
Time constant τ. Characteristic quantity of the servo system, indicating the time required by the recording carriage to reach 63% of the maximum writing speed.

Settling time t_S. Time the stylus takes with a step function from the start until it reaches the full amplitude to within ±1 mm without exceeding this tolerance again.

ZSG 3

Radiomonitoring Recorder ZSG 3

- Electro-sensitive recording of radio signals with automatic time-of-day printout
- Five individually selected frequency markers
- Visible and audible end-of-paper signals



Characteristics and uses

The **Radiomonitoring Recorder ZSG 3** records the radio signals picked up within a selected frequency band by a receiving system, thus constituting a valuable supplement for radiomonitoring stations.

The signals are traced on electro-sensitive paper in the form of horizontal lines. The sawtooth voltage which tunes the receiver is used to control the stylus over a chart width of 200 mm. The deflection of the recording electrode is thus a measure of the instantaneous reception frequency. The recorded trace length depends upon the adjusted threshold, the receiver bandwidth and the field strength. Recording by means of the voltage-controlled electrode is only effected during the forward sweep. A constant paper feed gives an accurate time scale, which is 30 s or 60 s/line when the ZSG 3 is used in conjunction with the Radiomonitoring/Recording System MFBR.

Orientation and evaluation are facilitated by additionally recording up to five frequency markers. The ZSG 3 records every full hour on the righthand margin in seven-segment figures.

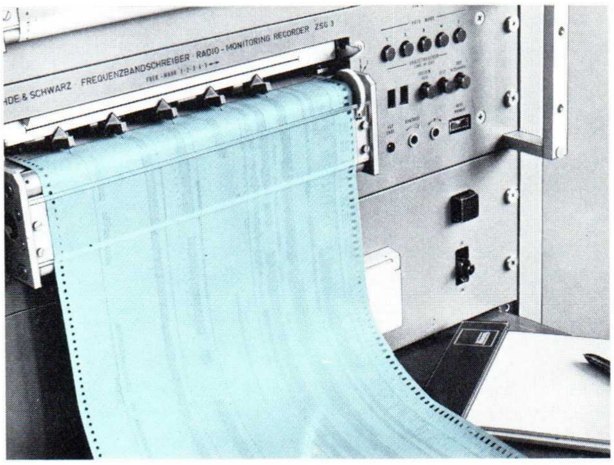
Excellent dynamic and static characteristics, such as high controlling torque, good linearity and reproducibility, make the ZSG 3 a versatile unit for radio-signal recording.

Description

The Radiomonitoring Recorder ZSG 3 operates on the principle of the self-balancing potentiometer. The input V_X must be a sawtooth voltage which also tunes the receiver of the radiomonitoring/recording system. Recording is electro-sensitive, producing a black trace at the point where the recording electrode touches the paper when the electrode voltage is applied. This so-called Z control is accomplished by the processed signal of the receiver output.

An additional recording device, controlled by the paper feed and the hour pulse derived from a clock system, records every **full hour** on the righthand margin by way of seven-segment figures.

Recording with paper chart flowing out



Specifications

Recording principle	voltage-controlled recording head
Recording voltage	$< 42\ V_{rms}$
Intensitiy control	by potentiometer on front panel
Recording paper	electro-sensitive, blank paper
Size of paper roll	width 230 mm, diameter 50 mm, length 20 m
Paper feed	by stepping motor, forward only
Advance	0.41 mm/step
Free running	by pushbutton (approx. 5 mm/s)
Paper-advance control	by return pulse of sawtooth (TTL)
Paper output	flowing out or rolled up
End-of-paper signal	pilot lamp and buzzer
Time-of-day recording	by 7-segment digits (1 to 24) on righthand margin
Control	by hour pulse from a clock system (TTL or contact)
Time setting at beginning of recording	by pushbutton and 7-segment readout on front panel
Frequency markers	by 5 manually adjustable electrodes, individually selected by pushbuttons
Z control	digital or analog
Digital	with TTL signal
Analog (adj. threshold)	0 to +10 V, R_{in} = 250 kΩ
Output	TTL signal

Servo circuit

Deflection factor	0.5 V/cm (+10 V for 20 cm)
Input	differential input, floating; R_{in} = 40 kΩ
Non-linearity	±0.1% of fsd (±0.2 mm)
Calibrated chart width	200 mm
Overflow	2 mm to the right and to the left
Position of zero	left, setting range ±2 cm
Maximum recording speed	20 cm/s

General data

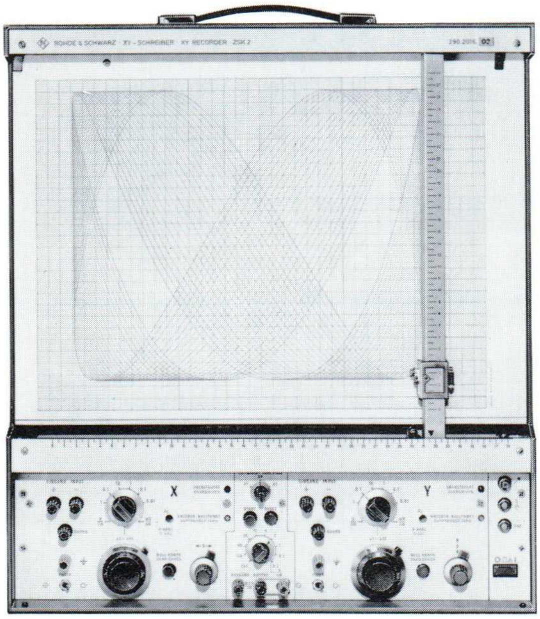
Connectors	36-pole female at the rear
Nominal temperature range	+10 to +35 °C
AC supply	115/125/220/235 V ±10%, 100 VA (3 A)
Dimensions	484 mm × 150 mm × 436 mm
Weight, cabinet included	12.6 kg
not included	11.6 kg

Order designations	▶ Radiomonitoring Recorder ZSG 3
19″ cabinet model	242.6015.92
19″ rackmount	242.6015.91

Accessories supplied

1 power cord 025.2365.00; 3 rolls of recording paper 084.1761.00; 10 electrode wires 242.7786.00; 2 frequency-marker electrodes 242.7863.00

ZSK 2

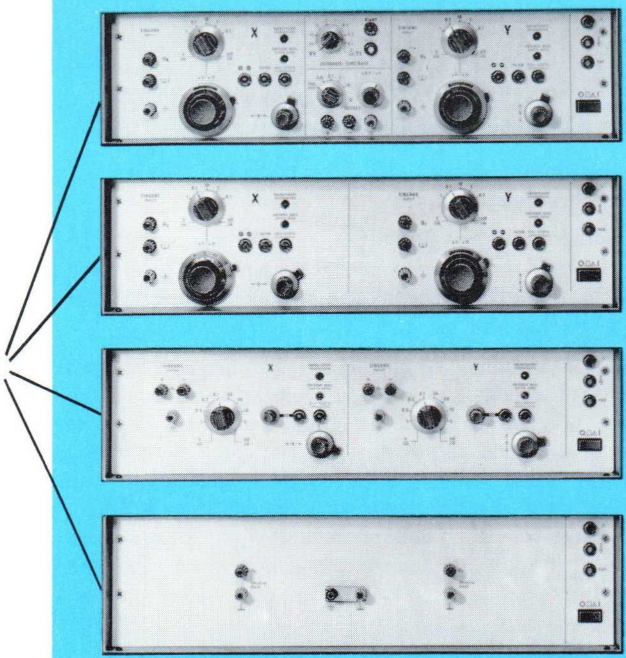


- Floating inputs up to 500 V DC
- Common-mode rejection up to 200 dB
- Writing speed > 110 cm/s on both axes
- Timebase; recording times up to 76 minutes

XY Recorder System ZSK 2

♦ 10 µV/cm to 11 V/cm

- Choise of five models; the right recorder for each application area
- Electrostatic paper holddown and electronic writing-width limiting for DIN A3 and DIN A4 sizes



Type family, characteristics, uses

The ZSK-2 family is a range of high-quality XY and YT recorders featuring high writing speed, precision and reliability.

Models of the ZSK-2 recorder system

The ZSK-2 type family offers a user-oriented selection of five models. They differ mainly in the characteristics of the input section; see data on next page.

List of models:

02 Universal model
04 Standard model
06 Lab model with timebase
08 Lab model
10 System model (without operating controls and adjustments)

The wide deflection-factor range of 10 µV/cm to 11 V/cm, the timebase generator and an internal DC voltage source for offset compensation (depending on model) offer a great variety of applications.

The electrostatic paper holddown grips charts of DIN A3 size (297 mm × 420 mm) or smaller. Switch-selected limiting of the writing range to DIN A3 or DIN A4 ensures that the stylus remains within the selected useful area. Overdriving is indicated.

Plotting with ballpoint or fibre pen in four or five selectable colours; see recommended extras.

The input amplifier of models 02, 06 and 08 is floating and isolated from chassis for both the X and Y axes. Therefore the connection of test signals that are referred to different common points for the X and Y axes does not cause any problem.

A timebase generator incorporated in models 02 and 06 permits plotting of quantities varying in time. Model 06 includes in addition an isolated DC voltage source for **offset compensation** in the range 1 mV to 10 V.

Remote control is possible for lowering/lifting the recording stylus, forward and return sweep of the timebase and zero offset.

Outputs. The connections for remote control and the outputs for the deflection-proportional voltage and the timebase generator are combined in a multiway connector at the rear of the set.

Description

The ZSK 2 operates on the principle of the self-balancing potentiometer. This affords excellent linearity and accuracy. The potentiometer circuit is isolated from the test circuit by buffer amplifiers.

Model 02 is designed as a differential amplifier with guard and has extremely high common-mode rejection.

Model 04 has differential amplifiers for the X and Y axes which are taken to chassis potential.

No adjustment are provided on the system model 10; suitable transducers are used for matching to the measurement problem.

The ZSK 2 can be mounted in 19" racks by means of adapter bars.

Specifications

Specifications of input section	Universal model 02	Standard model 04	Lab model with timebase 06	Lab model 08	System model 10
Deflection factor	10 μV/cm to 11 V/cm	5 mV/cm to 3 V/cm	100 μV/cm to 11 V/cm	100 μV/cm to 11 V/cm	100 mV/cm
Steps	6	8	5	5	—
Continuous adjustment	cal. × 1 to × 11	× 1 to × 3	cal. × 1 to × 11	cal. × 1 to × 11	—
Error	0.2% ±0.5 div.	0.3%	0.2% ±2.5 div.	0.2% ±0.5 div.	0.2%
Input circuit	floating diff. ampl., guard; X, Y isol. from chassis	diff. ampl. for X and Y	floating ampl., X, Y isol. from chassis	floating ampl., X, Y isol. from chassis	dir. input, common chassis for X & Y
Input impedance	10 MΩ (1 MΩ)	1 MΩ	1 MΩ	1 MΩ	20 kΩ
Max. input voltage	500 V (≦ 1 V/cm) 150 V	100 V	100 V (≦ 1 V/cm) 400 V	100 V (≦ 1 V/cm) 400 V	20 V
Max. common-mode voltage	500 V	100 V	200 V	200 V	—
Common-mode rejection DC	> 160 dB	> 60 dB	> 160 dB	> 160 dB	—
50 Hz AC	> 140 to > 80 dB (depending on range)	> 60 dB	> 110 to > 60 dB (depending on range)	> 110 to > 60 dB (depending on range)	
Zero offset	±1 full scale	±1 full scale	±1 full scale	±1 full scale	—
Timebase generator	X, Y: 0.2 to 120 s/cm	—	X: 0.1 to 20 s/cm	—	—
Steps	9	—	8	—	—
Output	0.1 V/cm	—	0.1 V/cm	—	—
Offset voltage source	—	—	1 mV to 10 V	—	—
Steps	—	—	8	—	—
Continuous adjustment	—	—	× 0.1 to × 1	—	—
Max. voltage to chassis	—	—	200 V	—	—
Temperature coefficient	—	—	$\leqq 5 \times 10^{-5}/°C$	—	—

System specifications

Calibrated chart area	280 mm × 380 mm (DIN A3)
Electronic limiting	a) 280 mm × 180 mm (DIN A4) b) 380 mm × 280 mm (DIN A3) switch-selected
Paper holddown	electrostatic
Stylus	ballpoint pen or fibre pen (see extras)
Lowering of stylus	by pushbutton or ext. control
Max. writing speed	> 110 cm/s on X and Y axes
Mechanical time constant of servosystem	25 ms
Max. settling time for fsd	
on X axis	400 ms
on Y axis	310 ms
Overshoot	≦1 mm
Linearity	0.1% of fsd
Reproducibility	±0.05% of fsd
DC voltage output	retransmitting potentiometer, < 1 Ω, short-circuit proof
Zero setting, ext.	0.1 V/cm, max. 10 V
Ratio recording	by external reference voltage
Rated value of nominal voltage	1.000 V
Operating voltage range	0.5 to 1.5 V ($V_{in\,max}$: 50 V)
Input impedance	1 MΩ

General data

Nominal temperature range	+5 to +40 °C
Operating temperature range	−10 to +45 °C
Shelf temperature range	−20 to +70 °C
Power supply	115/125/220/235 V +10/−15%, 47 to 420 Hz (50 to 150 VA, depending on recording mode)
Dimensions	440 mm × 490 mm × 160 mm

Order designations ► XY Recorder ZSK 2

02 Universal Model	290.2016.02
04 Standard Model	290.2016.04
06 Lab Model with timebase	290.2016.06
08 Lab Model	290.2016.08
10 System Model	290.2016.10

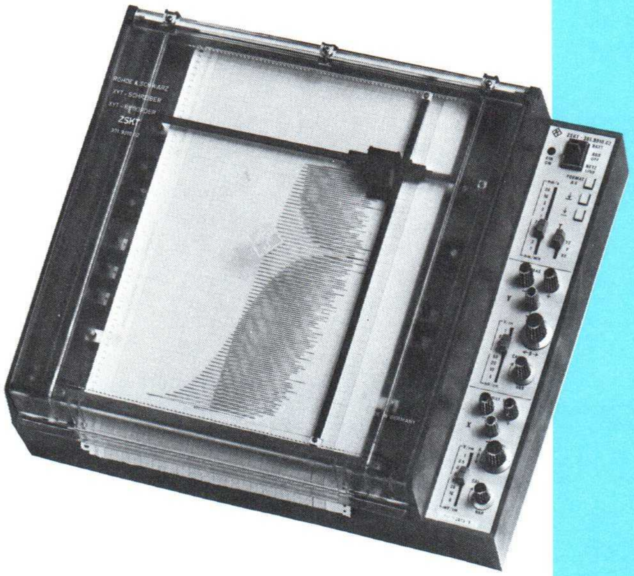
Accessories supplied

1 set of ballpoint pens (four colours, 10 pens)
2 shorting links 19 mm
2 shorting links 25 mm
1 pad of paper, calibrated in mm, DIN A3
power cable, service kit, dust cover

Recommended extras

Fibre-pen kit (holder + pen set)	247.7690.02
Set of fibre pens (2 × black, 1 × red, 1 × green, 1 × blue)	247.7855.00
Fibre-pen packets	
black (5 pens)	247.7755.00
red (5 pens)	247.7790.00
blue (5 pens)	247.7778.00
yellow (5 pens)	247.7810.00
green (5 pens)	247.7832.00
Transport cover	290.2100.00
36-pole male connector	247.7055.00
19" rack adapter (2 required)	290.2097.00

ZSKT



new

XYT Recorder ZSKT
♦ 5 mV/cm to 3 V/cm

- XY and YT recording
- Excellent dynamic characteristics
- DIN-A4-format paper advance in XY operation
- Differential-amplifier inputs for X and Y signals
- Remote-controllable functions: paper feed, DIN-A4-format advance and pen lift

Characteristics and uses

The ZSKT is an extremely fast and accurate two-axis recorder with outstanding dynamic characteristics. It permits XY and YT recording and can be battery-powered and remotely controlled.

With these and many other features the ZSKT can be universally used, for example for mobile operation, for acoustic applications thanks to its high writing speed, or for automatic recording thanks to DIN-A4-format paper advance in the XY mode.

The dynamic characteristics of the recorder are virtually the same on both axes because of the identical construction. Events changing simultaneously in both directions at a fast rate can therefore be recorded practically free of distortion.

With a maximum writing speed of more than 120 cm/s and a maximum acceleration of more than 6 g, the ZSKT sets new standards in its price category. Nonlinearity and reproducibility error (hysteresis) are less than 0.2% referred to the calibrated writing width. Overshoot is very small at ±1 mm.

The useful writing area of ZSKT is 180 mm × 240 mm in XY operation. YT recording is possible with 180 mm width for more than 250 hours without interruption using the minimum chart speed of 1 mm/min and a paper roll that is 15 m long. For details on paper advance and recording see under description.

Remote control is possible for pen lift, paper advance in YT operation, DIN-A4-format advance in XY operation and start/stop. The stepping motor for paper advance can be controlled via a separate input, any paper speed up to 20 mm/s being adjustable. The remote-control capability makes the ZSKT ideal for use in automatic measuring systems.

Description

Operating principle. The ZSKT operates on the principle of a self-balancing potentiometer. A new design of the recording system makes do with reduced driving forces. The lower current drain makes battery operation possible.

Input amplifiers. Differential amplifiers are used in the input stage, which makes connecting the signal sources very easy. The common-mode voltage may be as high as 100 V (common-mode rejection 60 dB).

Deflection sensitivity. The deflection factor can be set in eight calibrated steps from 5 mV/cm to 1 V/cm. Uncalibrated variation is also possible giving scale factors of ×1 to ×3, i.e. to a maximum of 3 V/cm.

Zero. The zero can be shifted over the whole writing width and suppressed by up to one full writing width; setting by means of ten-turn potentiometer.

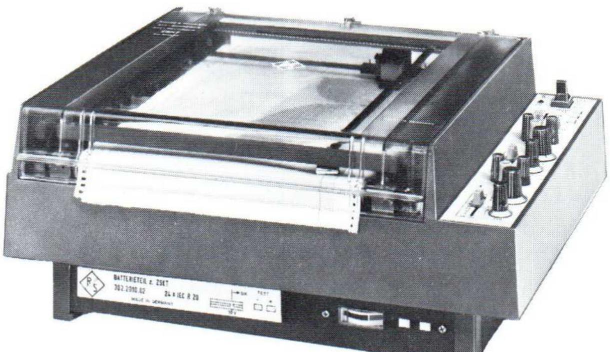
Electronic writing-area limiting prevents the recording system from bouncing against a mechanical stop when the input amplifier is overdriven. This reduces wear of the mechanical parts, considerably enhancing the life expectancy and reliability of the recorder.

Recording. Fibre-tipped pens – available in different colours – are used for recording. The pen snaps into the penholder clip. The recording is made on paper rolls at least 15 m long and preprinted with a millimeter grid, or on individual sheets. Different modes of paper feed are used in XY operation and YT operation:

XY operation. At the push of a button the paper is advanced by 300 mm. The advance is controlled by a stepping motor so that the pen shifts to a horizontal grid line at a distance of exactly 300 mm.

YT operation. The X input amplifier is cut off. Instead of X deflection the paper is advanced by the stepping motor. True YT recording is thus possible without time limitation. The paper speed can be set in ten steps from 20 mm/s to 1 mm/min.

Power supply. The ZSKT is normally powered from the local AC supply, but it can also be used with external DC-voltage sources (2 × 12 to 20 V) or batteries; see photo below. The operating time with battery supply is at least 20 hours and even longer if the dynamic characteristics of the recorder are not fully utilized.



XYT Recorder ZSKT
on top of battery pack

Mechanical design. The case of the ZSKT is a one-piece fibreglass-reinforced moulding. The writing area with the driving mechanism is protected by a transparent cover. When the cover is opened the servomotors are switched off.

The **battery pack** can be fastened with two screws to the base of the recorder. Recorder and battery pack thus form a unit that is easy to transport and can be used anywhere.

A **rack adapter** available as an extra permits ready mounting of the ZSKT in a standard 19" rack.

Specifications

Recording system

Writing area in XY operation	180 mm × 240 mm
Writing width in YT operation	180 mm
Recording paper	rolls, width 220 mm or individual DIN-A4-format sheets
Recording pen	fibre-tipped pens
Max. writing speed	not less than 120 cm/s in both directions
Acceleration	> 60 m/s²
Mechanical time constant of servosystem	≈20 ms
6-dB cutoff frequency for ±1 cm deflection	≈15 Hz
Settling time for full-scale deflection in Y direction	≈150 ms
in X direction	≈180 ms
Nonlinearity	0.2%
Reproducibility	0.2%
Overshoot	±1 mm
Pen control	by pushbutton or remote

XY inputs

Test inputs	3 knurled terminals for X and Y directions, designated +/−/⊥
Input circuits	differential amplifiers for X and Y deflection
Deflection factor, calibrated	5 mV/cm to 1 V/cm in 8 steps, max. error 0.2%
uncalibrated	×1 to ×3
Input impedance	1 MΩ
Zero setting	±1 writing width, using ten-turn potentiometer
Common-mode rejection	> 60 dB
Max. permissible common-mode voltage	100 V (between input and ⊥)

Paper feed

Drive	stepping motor
Start/stop	by pushbutton or remote control, switch-selected
Paper advance	
XY operation	DIN-A4-format advance (exactly 300 mm) or smaller steps, max. duration of advance 15 s
YT operation	switch-selected speeds 1, 2, 5, 10, 20 mm/s 1, 2, 5, 10, 20 mm/min

General data

Nominal temperature range	+5 to +40 °C
Operating temperature range	−10 to +45 °C
Shelf temperature range	−20 to +70 °C
Power supply	AC supply, battery or external 2 × 12 V DC source
AC supply	115/220 V ± 10%, 47 to 63 Hz (10 VA)
Battery	from battery pack (with indicator), 24 single cells IEC R-20; 20 hours of operation using battery pack with alkali-manganese cells
Dimensions, weight	380 mm × 110 mm × 320 mm, 5 kg
with battery pack	380 mm × 150 mm × 320 mm, 7.5 kg

Order designation	▶ XYT Recorder ZSKT 301.9010.02
Accessories supplied	1 roll recording chart 1 set of fibre-tipped pens power cable

Recommended extras

Battery Pack ZSKT-Z2	302.2010.02
Recording chart (roll of 15 m)	301.9291.00
Fibre-tipped pens (sets of 4 pens)	
red	301.9456.00
blue	301.9479.00
green	301.9491.00
black	301.9433.00
Set of fibre-tipped pens (one of each of above colours)	301.9510.00
19" rack adapter	302.1813.02

Power measurement at high frequencies

Active power is defined in electrical engineering as the product of the magnitudes of current and voltage, taking account of the phase angle between them:

$$P_{active} = |\underline{V}_{rms}| \, |\underline{I}_{rms}| \cos\varphi .$$

This applies, of course, also for RF power.

The frequency range in which a power measurement according to this formula is practicable extends from a few Hz to about 10 kHz. A dynamometer inserted into the current and voltage paths accomplishes the multiplication with correct phase.

At higher frequencies the dynamometer can no longer be used to measure power. Two completely different methods are employed here represented by the output power meter (absorption type) and the directional power meter, which also differ in their fields of application.

Power meters and reflectometers

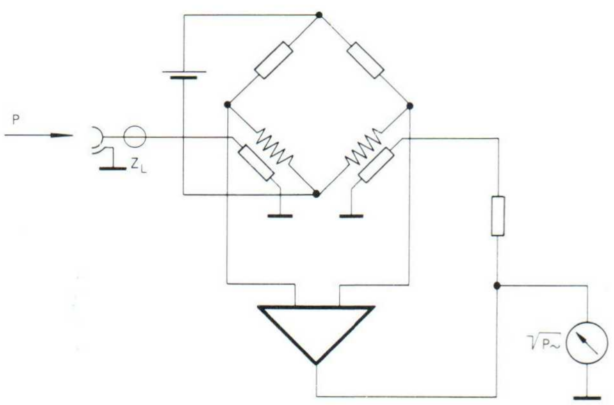
Output power meters

Output power meters practically have a resistive input impedance, the standard values being 50, 60 or 75 Ω (Z_0). They thus reflect only a small portion of the incident wave energy while the major part is converted into heat. The power indication of the output power meter is derived from the measurement of the heat produced (calorimeter).

The Microwave Power Meter NRS (page 165) operates according to this principle.

The power consumed in a matched probe is converted into heat and unbalances a very sensitive bridge. The power of a standard resistor required to compensate for the unbalance is a measure of the power applied to the probe.

The principle of the output power meter is shown in the following diagram.



Power measurement using temperature-dependent resistors in a bridge circuit

Directional power meters

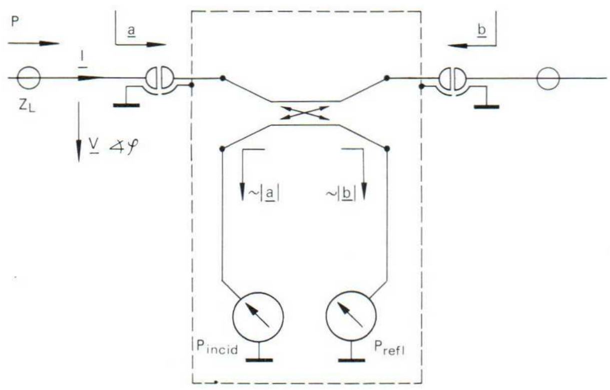
Directional power meters are inserted into a transmission line and measure the incident and reflected powers according to a directional-coupler principle. Transmitter output power and antenna or load matching can be checked simultaneously with this type of power meter.

The reflection coefficient is obtained as

$$|\underline{r}| = \sqrt{\frac{P_{refl}}{P_{incid}}}$$

and

$$VSWR = \frac{1 + \sqrt{P_{refl}/P_{incid}}}{1 - \sqrt{P_{refl}/P_{incid}}}$$



Power measurement using directional coupler

Instruments operating on this principle are the Power Meters NAU and NAUS.

Overview

Several instruments with different power and frequency ranges are available for use in the frequency range of 1 to 1000 MHz; see table on next page.

Type NAN with its power range extending up to 1.2 kW is suitable for power measurement and matching indication in the **shortwave range.**

With a power range of 30 W NAUS 3 is ideal for **measurements on radiotelephone equipment** between 25 and 1000 MHz. All frequency bands and power classes of the radio sets are covered without exchanging any measuring heads or inserts. The AM Unit SMDU-Z1 and the Power Test Adapter SMDU-Z2 are destined for use in radiotelephone and air navigation test assemblies, but can also operate on their own.

For **higher power applications,** e.g. measurement on transmitter systems, NAUS 4 (25 to 1000 MHz, 110 W) and NAU (25 to 500 MHz, 1000 W) are available.

Adjacent-channel **interference components** of radio equipment are measured and weighted by the **Adjacent-channel Power Meter NKS** in conjunction with the RT Test Assembly SMDU. The NKS is therefore described in section 3 page 77 among the test assemblies.

Frequency range	Designation	Type	Order No.*	Power range	Sub-ranges	Error of fsd	Indication of small refl. components	Text on page
1.5 to 30 MHz	HF Wattmeter & Matching Indicator	NAN	100.2727 ...	0 to 1.2 kW	4	±8% incl. freq. resp.	—	161
25 to 500 MHz	UHF Wattmeter & Matching Indicator	NAU	100.2810 ...	2 to 1000 W	4	±3% ±2% of reading at 23 °C	2 to 1000 W (4 ranges)	164
25 to 525 MHz 25 to 1000 MHz 25 to 1000 MHz	Directional Power Meter	NAUS NAUS 3 NAUS 4	200.8010.64 288.8610 ... 289.9010 ...	20 mW to 30 W 20 mW to 30 W 50 mW to 110 W	5 5 5	page 163	20 mW to 34 W 20 mW to 34 W 50 mW to 110 W	162
1 to 1050 MHz	AM Unit	SMDU-Z1	242.2010 ...	50 mW to 30 W 0.1 to 60 W	5 5	±(8% of rdg +1.5% of fsd)	—	70
1 to 1050 MHz	Power Test Adapter	SMDU-Z2	242.4012.52	50 mW to 30 W	5	± (8% of rdg +1.5% of fsd)	—	70
0 to 15 GHz	Microwave Power Meter + Probe	NRS	100.2433.92 100.2440 ...	0.1 to 330 mW[1]	5	±1.5 (2.3)%	—	165

*** If seven-figure designation is given, see text for complete (nine-figure) order No.**

[1]) The measurement range can be extended with high-power attenuators (section 11).

NAN

HF Wattmeter & Matching Indicator NAN
♦ 1.5 to 30 MHz

- Reflection-coefficient range of 0 to 100%
- Power range up to 1200 W, direkt reflection indication with 20 W incident power

The HF Wattmeter affords direct power and reflection-coefficient reading in the shortwave range. The instrument is suitable for measuring the power of HF transmitters and for matching aerials, therapeutic equipment and other loads.

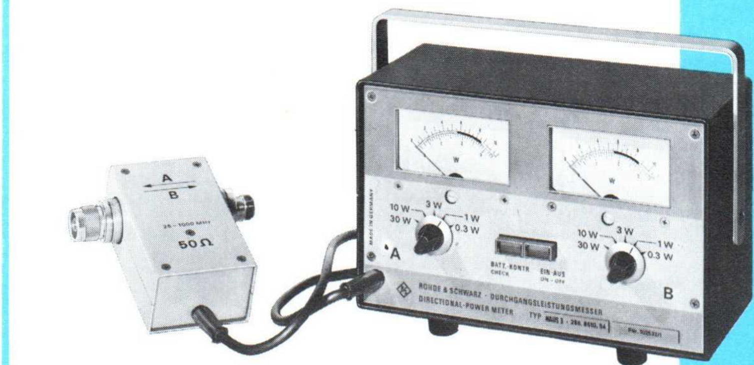
The NAN consists of a measuring head and an indicator. The measuring head is connected into the transmission line. It accommodates two directional couplers and is connected to the indicator section with a cable. The indication of incident or reflected power as well as reflection can be switch-selected.

The measuring-head connector is an RF female connector 4/13, DIN 47 284, that can be adapted to many other connector systems.

Specifications

Frequency range	1.5 to 30 MHz
Four subranges for incident and reflected power (fsd)	36/120/360/1200 W
Reflection-coefficient range	0 to 100%
Minimum incident power required for direct reflection-coefficient reading	20 W
Maximum power	1200 W
Characteristic impedance	50 Ω
Reflection due to the coupling systems	< 2%
Error limits of indication incl. frequency response error	±8% of fsd (with temperature correction curve)
Dimensions	measuring head: 76 mm × 76 mm × 100 mm indicator: 130 mm × 180 mm × 105 mm
Order designation	► HF Wattmeter & Matching Indicator NAN 100.2727.50

NAUS

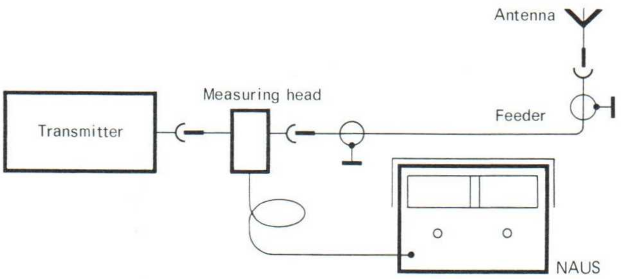


Directional Power Meter
NAUS ♦ 25 to 525 MHz/30 W
NAUS 3 ♦ 25 to 1000 MHz/30 W
NAUS 4 ♦ 25 to 1000 MHz/110 W

- For servicing radio sets and systems
- Separate measuring head – forward direction arbitrary
- Simultaneous indication of incident (forward) and reflected power – independent range setting
- Lowest power reading 20 mW (NAUS 4: 50 mW); average indication, high accuracy

The **Directional Power Meters NAUS** are handy, easy to operate and designed for in situ servicing of radiotelephone equipment, radio installations (up to 110 W with NAUS 4) and walkie-talkies of low output. Owing to their wide frequency and power ranges the NAUS power meters can be used over the entire radiotelephone bands for the output levels of most types of radiotelephone equipment.

The power meters of the NAUS series are equal in presentation and similar in design; they differ mainly in their frequency ranges and power handling capacities, see above. The instruments consist of an indicator (case with carrying handle, see photos) and a separate measuring head, which can be connected in either direction. The incident and the reflected power are indicated on separate meters so that – also due to the wide continuous frequency range – operating errors are precluded.



Power measurement on antenna feeder using NAUS

Measurement ranges. The power range of all NAUS power meters is divided into five subranges; it extends from 20 mW to 34 W or from 50 mW to 110 W depending on the model; fsd is obtained with 0.3 W or 1 W in the most sensitive range. The range of the 30-W models can be extended to 68 W by inserting a High-power Attenuator RBU (3 dB, see section 11).

Indication and accuracy. The instruments deliver correct results under all conditions: the indication is highly stable and insensitive to temperature fluctuations. Since the rectifier diodes are very lightly driven, both meter scales are linearly calibrated and the indications can be easily read. True average indication is also given of non-sinusoidal signals (modulated transmitter). The negligible internal losses do not impair the measurements. With the model for 25 to 525 MHz measurements are also possible above 525 MHz (up to 1000 MHz) with reduced accuracy.

Input and output. The measuring head is available in the following versions depending on the order number:

NAUS	60 Ω	Dezifix B, adaptable
NAUS 3	50 Ω	Dezifix B or N female/male, all adaptable
NAUS 4	50 Ω	N female/male, adaptable

Suitable screw-in assemblies for conversion to other connector systems (e.g. UHF or BNC): please enquire.

Since the two measuring channels are alike, the forward direction is arbitrary.

Design and power supply. The measuring head of the NAUS consists of a directional coupler. The input power is fed through to the load with almost no attenuation (electrical length of line 140 mm). The secondary line is matched at both ends. Voltages proportional to the incident and reflected power are coupled into this line and rectified. An RC section is used to compensate for the frequency response of the coupler. The rectified signal voltages are fed via the connecting cable to the instrument which includes shielded chopper amplifiers, and are then displayed separately.

The power supply uses five 1.5-V batteries (R20, acc. to DIN or IEC). These can be easily replaced after removing the cabinet cover (voltage check by pressing a pushbutton on the lefthand meter). Owing to the very low current drain, a set of commercially available, leakproof batteries has a lifetime of almost one year with continuous operation (> 7000 operating hours).

Directional Power Meter NAUS 4 (50 mW to 110 W)

A diagram (right) for determining the VSWR as a function of the incident and reflected power is provided on the rear of the instrument.

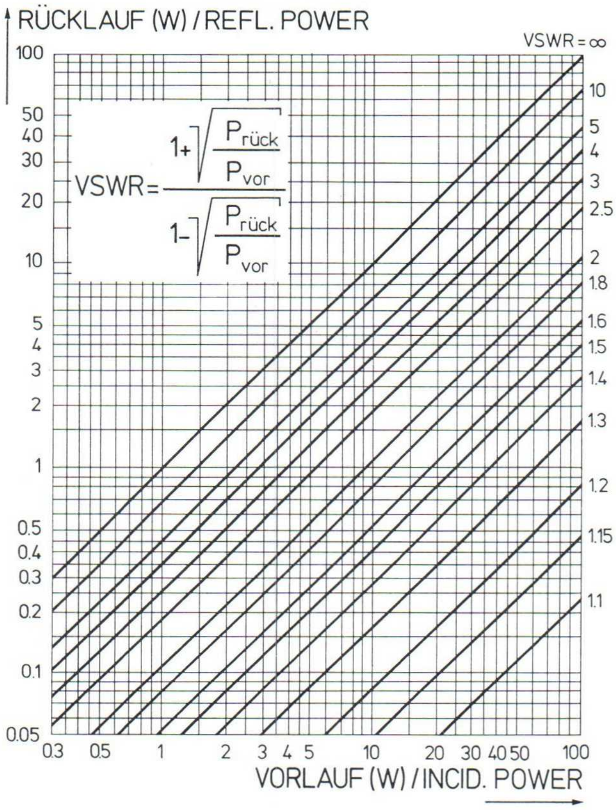


Diagram for rapid assessment of VSWR from incident and reflected power (provided on the rear panel of each instrument)

Measurement of incident and reflected power on antenna feeder of police car using directional power meter

Specifications

Frequency range NAUS .... 25 to 525 MHz (1000 MHz, see text)
NAUS 3 and 4 ... 25 to 1000 MHz

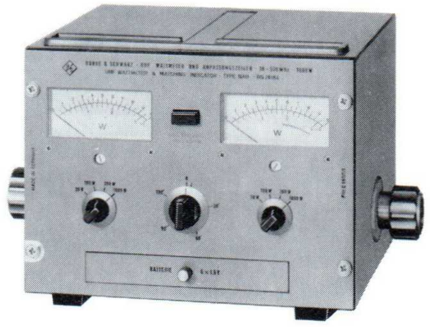
	NAUS NAUS 3	NAUS 4
Permissible incident and reflected power	35 W	110 W
Indication ranges	0.34/1.1/3.4/11/34 W	1.1/3.4/11/34/110 W
Lowest power reading	20 mW	50 mW
Indication error	≦3% of rdg ±2% of fsd	≦3% of rdg ±2% of fsd
Effect of temperature	≦0.25%/°C	≦0.25%/°C
Directivity		
at and above 30 MHz	≧30 dB	≧30 dB
up to 30 MHz	≧26 dB	≧26 dB
Characteristic impedance	NAUS: 60 Ω NAUS 3: 50 Ω	50 Ω
VSWR	≦1.03	≦1.03
Transmission loss		
up to 300 MHz	≦0.1 dB	0.08 dB
up to 525 MHz	≦0.25 dB	0.15 dB
up to 1000 MHz	≦0.75 dB	0.35 dB
Electrical length of transmission channel	140 mm	140 mm

General data (all models)

Nominal temperature range	−20 to +55 °C
Shelf temperature range	−25 to +70 °C
Power supply	5 single cells 1.5 V, R 20 IEC
Battery life	> 7000 hours
Dimensions indicator	230 mm × 150 mm × 130 mm
measuring head 50 Ω	125 mm × 105 mm × 45 mm
60 Ω	125 mm × 105 mm × 62 mm
Weight	4 kg

Order designations	► Directional Power Meter
NAUS (60 Ω)	200.8010.64
NAUS 3 (50 Ω), Dezifix B	288.8610.54
N connector	288.8610.55
NAUS 4 (50 Ω), N connector	289.9010.55

NAU



UHF Wattmeter and Matching Indicator NAU
♦ 25 to 500 MHz

- Power range 2 to 1000 W
- Average indication with all waveforms
- Reflection-free measurement (VSWR < 1.02)

Inserted into the transmission line, the **UHF Wattmeter NAU** indicates the incident and the reflected power simultaneously on separate meters.

Power range. 2 to 1000 W in the subranges 2 to 31.6/5 to 100/20 to 316/50 to 1000 W.

The range is selected separately for incident and for reflected power by means of rotary switches on the front panel. No plug-in elements need be changed or connected to different terminals.

Indication and accuracy. Linear scale calibration of both meters provides very good reading accuracy. The meter diodes, driven with a very low level, operate in the squarelaw section of the characteristic. True average reading is obtained even with non-sinusoidal inputs (modulated transmitters).

The test input and output are adaptable Dezifix B connectors on the side panels. The set can be operated in either direction, the two meter circuits being identical.

Circuit design and power supply. The Directional Power Meter NAU contains a symmetrical directional coupler. The power is fed to the load via one arm of the directional coupler almost without loss. The other arm is match-terminated at each end with a detector mount. A temperature-stabilized chopper amplifier equipped with field-effect transistors is provided for each meter. The transistors are driven from a pulse generator. The chopper stage is followed by feedback amplifiers. A second feedback path through the whole amplifier in the DC circuit ensures high stability. Here the RF diodes are temperature-compensated. The power is supplied by six 1.5-V dry cells; the operating voltage is stabilized. Operating and battery voltage checks can be carried out by pressing a button; the lefthand meter then shows the stabilized rated voltage and the righthand meter the battery voltage (useful battery life about 400 hours).

Timer. Before the NAU is switched on, a timer is set for a maximum period of two hours, after which time it automatically switches off the power supply.

Examples of application. Power measurements on modulated or unmodulated transmitters; reflection measurements for matching loads to transmission lines and transmitters (a diagram is supplied with each instrument for rapid and easy determination of the VSWR as a function of incident and reflected power).

Other examples are the impedance matching of amplifiers (input/output in one operational process) and gain measurements on power transistors at high frequencies.

Specifications

Frequency range	25 to 500 MHz
Incident and reflected power ranges (on two separate meters)	2 to 31.6/5 to 100/20 to 316/50 to 1000 W
Scale calibration	average values, linear scale
Response time	1 s
Indication error in range 50 to 500 MHz	±2% of rdg ±3% of fsd
Effect of frequency in the range 25 to 50 MHz	−2% per 5 MHz from 50 MHz downwards
VSWR	< 1.02
Maximum power	1100 W
Test terminals	two Dezifix B with precision compression nut, adaptable
Characteristic impedance	50 Ω or 60 Ω, acc. to order No.
Electrical length of primary arm	300 mm
Operation direction	either
Timer for operation	up to two hours
Power supply	6 dry batteries, 1.5 V, IEC R 6
Current drain	2 mA
Dimensions, weight	290 mm × 175 mm × 245 mm (incl. 32 mm projection of connectors), 5.5 kg
Order designations	► UHF Wattmeter and Matching Indicator NAU
50-Ω model	100.2810.50
60-Ω model	100.2810.60
Accessories supplied	2 covers for connectors, 1 battery pack (built-in)

NRS

Microwave Power Meter NRS

♦ 0.1 to 330 mW

- Wide frequency range 0 to 15 GHz
- Exchangeable probes for 50 Ω, 60 Ω and 75 Ω
- Automatic zero adjustment

The **NRS** makes high-accuracy power measurements on test items to be terminated with 50 Ω, 60 Ω or 75 Ω (coaxial lines). Its wide frequency range ensures a large field of application, especially in the RF range.

Power range. The power range of 0.1 to 330 mW is divided into five subranges 3/10/30/100/300 mW, corresponding to 5-dB steps. Continuous **range extension up to 60 kW** is possible by means of attenuators of high power-handling capacity or load resistors with an output for an accurately known insertion loss (see section 11).

Indication and accuracy. Only active power is measured and indicated. AC signals of any waveform, even very short pulses, are correctly measured. As the NRS has a flat frequency response from DC to 15 GHz it also provides a true power indication of frequency spectra. The error limits are ±2% of the reading of the mW scale. The accuracy can be greatly improved through the use of an external indicator. The rear output of the NRS delivers a DC voltage V_0 which equals to within ±0.2% the original rms voltage V_S of the source. The power is calculated from the voltage V_0 read on a digital voltmeter

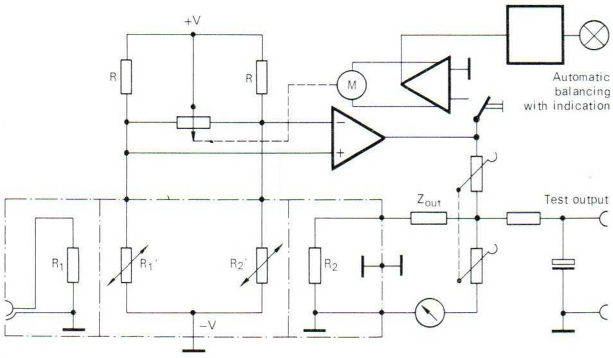
$$P = \frac{1}{Z_0}\left(\frac{V_0}{2}\right)^2 = \frac{V_0^2}{4Z_0}$$

The error of power measurement is in this case < ±0.4% of reading.

The response time of the NRS is short relative to other calorimetric power meters. It is less than 10 s for 100% ±2% of the reading for powers > 1 mW.

Connection (probe). The unknown power is picked up by a probe. Probes for the NRS are available with 50, 60 and 75 Ω input impedance (to be ordered separately). They can be used with any basic unit and are interchangeable. The probes are equipped with coaxial connectors which can readily be adapted to the Dezifix A or Dezifix B system (screw-in assembly supplied with the probe).

Test output. A test output for the connection of a DC recorder or analog/digital converter is provided at the rear of the NRS. (For output voltage see "Indication and accuracy"; Z_{out} = 2 kΩ ±10%.) Moreover, the NRS has an input for triggering the automatic balancing facility, which makes it suitable for incorporation into automatic test assemblies.



Simplified diagram of Power Meter NRS

Specifications

Basic unit

Power ranges (fsd)	3/10/30/100/300 mW
Calibration	in mW and dBm
Indication error	≦±1.5% at fsd ≦±2.3% at 31.6% of fsd
Frequency range	0 to 15 GHz max. } depending on probe
Input impedance	50 Ω, 60 Ω, 75 Ω } depending on probe
Recorder output	Z_{out} = 2 kΩ, V_{out} proportional to RF input voltage
Temperature effect	≦±0.03%/°C
Response time for powers ≧1 mW	≦10 s

Probes	**50 Ω** 0 to 15 GHz	**50 Ω** 0 to 12.5 GHz	**60 Ω** 0 to 4.8 GHz	**75 Ω** 0 to 1 GHz
Reflection coefficient				
0 to 4.5 GHz	< 1% +2%/GHz for all types			
up to 11 GHz	< 10%	< 10%	—	—
above	< 20%	< 20%	—	—
Connector	Dezifix A[1]	Dezifix A[1]	Dezifix B	Dezifix B
Dimensions, weight	484 mm × 150 mm × 336 mm, 12 kg			

Order designations

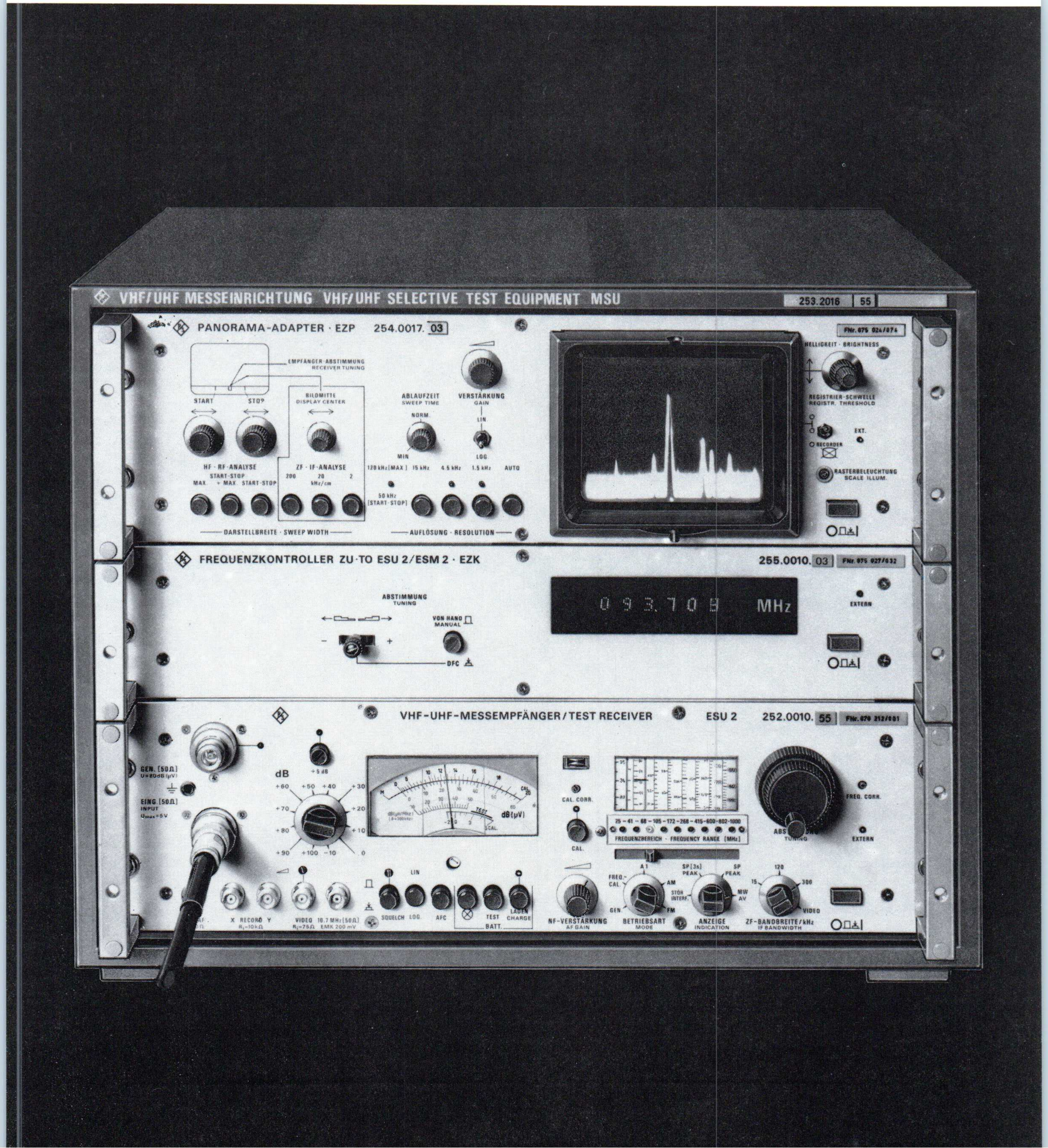
Basic unit	► Microwave Power Meter NRS 100.2433.92
Probes 50 Ω, 0 to 15 GHz	► Probe for NRS, 100.2440.50
50 Ω, 0 to 12.5 GHz	► Probe for NRS, 100.2440.05
60 Ω, 0 to 4.8 GHz	► Probe for NRS, 100.2440.60
75 Ω, 0 to 1 GHz	► Probe for NRS, 100.2440.70
Accessories supplied	
for basic unit	power cable, connecting cable (2 m, basic unit – probe)
for 50-Ω probe	1 adapter from Dezifix A to B

[1]) Adapter from Dezifix A to B is delivered with the probe.

VHF-UHF Selective Test Equipment MSU,
a programmable test assembly
for field-strength and voltage measurements;
details on page 176

7

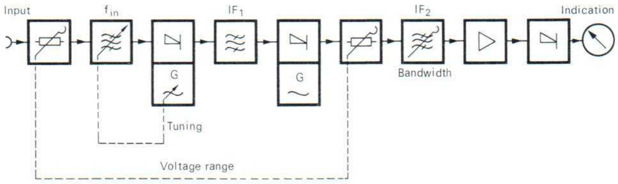
test receivers · field-strength meters wave analyzers · modulation meters



Selective voltmeters

Apart from a few exceptions, selective voltmeters operate on the **heterodyne principle**: The test voltage V_{in} of frequency f_{in} is fed to a frequency changer (mixer and oscillator) where it is converted without amplitude distortion into a fixed IF suitable for further processing. This method allows fixed-tuned filters to be used for the IF, permitting in turn very good selectivity to be obtained for the voltmeter. The shape of the selectivity characteristic is independent of the test frequency. The attenuator used for voltage-range selection can also be designed for the fixed IF and therefore be made very accurate without elaborate circuitry. A suitable IF permits the required amplifiers, demodulators and stabilizing circuits to be realized with minimum design effort.

The limited overdriving capacity and the ambiguity*) of the frequency changer require special precautions in the **heterodyne voltmeter**. The maximum level for linear conversion is between 10 and 100 mV. To reduce higher input voltages, attenuators must be provided. The ambiguity of the frequency changer can be overcome by selective circuits preceding the frequency changer or by a suitable IF. To obtain the required selectivity in sets for high input frequencies, a **second conversion** to a much lower intermediate frequency is necessary. The main filters and main amplifiers operate at this second IF. The basic design of a selective voltmeter is shown in the following diagram.



Simplified diagram of a double-heterodyne selective voltmeter

*) Ambiguity: In addition to the test frequency, other frequencies may produce the intermediate frequency by forming sums or differences with the oscillator frequency or its harmonics.

Frequency range	Designation	Type	Order No. (complete No.: see text)	Voltage range	Subranges	Fsd of lowest subrange	Error of voltage indication
50 Hz to 50 kHz	RC Generator/ Indicator	SUB	100.4120.92	1 µV to 30 V	—	≈ 5 µV	—
0.1 to 30 MHz	Field-strength Meter	HFH	100.1014.02	0.1 µV to 0.1 V	10 (+1)	1 µV	lin: ±1 dB
10 kHz to 60 MHz	Selective Microvoltmeter	USH 1	205.3616 ...	0.3 µV to 3 V	14	1 µV	lin: ±0.5 dB log: ±1 dB
25 to 300 MHz	VHF Field-strength Meter and Test Receiver	HFV	203.6018 ...	1 µV to 0.1 V	9	10 µV	±2 dB
30 to 300 MHz	Tunable VHF Amplifier	ASV	100.0976.02	0.5 to 10 mV	2	≈ 2.5 mV	—
30 to 1000 MHz	Selective Microvoltmeter	USU 1	110.4722 ...	≈3 µV to 3 V	12	10 µV	±0.3 dB
25 to 1000 MHz	VHF-UHF Test Receiver	ESU 2	252.0010 ...	−10 to +120 dB(µV)	11	10 dB(µV)	≦ ±1 dB
25 to 1000 MHz	VHF-UHF Selective Test Equipment	MSU	253.2016.55	−10 to +120 dB(µV)	11	10 dB(µV)	≦±1 dB
1 to 13 GHz	Test Receiver	USU 3	111.5439 ...	12 µV to 40 mV	standard attenuator in IF section	≦60 µV	±0.3 dB

test receivers

In a test receiver the pass frequency of the filters preceding the first frequency changer tracks with the frequency-change oscillator which determines the test frequency. This **tracking preselection** is necessary at the present state of the art of frequency changers if the test receiver is used to measure pulse spectra at frequencies above 100 kHz (interference measurements in line with CISPR, VDE); on the other hand, it adds to the versatility of test receiver applications, for example, for measuring harmonic spectra. The passband attenuation of tracking preselection being not generally constant over the tuning range, test receivers include level standardizing oscillators making calibration possible at any frequency. The standardizing oscillator may be a pulse generator yielding a constant spectrum in the relevant frequency range or a sinewave generator of constant level whose frequency tracks the receiver tuning. In modern instruments (e.g. ESU 2) the calibration is automated.

Selective microvoltmeters (e.g. USU 1) are simpler in design: here the oscillator frequency and the 1st intermediate frequency are higher than the maximum input frequency.

The required preselection can in this case be realized by a fixed-tuned lowpass filter. Voltmeters based on this principle need only be calibrated at one frequency provided the attenuation of the first frequency changer is frequency-independent. The use of a lowpass filter input involves exacting demands for the linearity of the input amplifier and mixer. With inadequate linearity, the presence of several frequency components in the input frequency range may lead to measurement errors.

Frequency response dB	Error of std. attenuator dB	Noise voltage µV	Input impedance	Intermediate frequency MHz 1st IF	2nd IF	3rd IF	IF band width kHz	Image frequency rejection	Dimensions in mm (W × H × D)	Text on page
—	—	0.1 to 0.5	1 MΩ; < 80 pF	—	—	—	(2/5/15%)	—	163 × 238 × 275	30
calib. possible at any frequency	±0.3	0.03	60 Ω	0.062 0.46 1.65	— 0.062 0.062		0.2/1/8	> 50 dB	430 × 350 × 400	181
±0.2 (0.3)	±0.2	0.25	50/60/75/ 150 Ω	83.08	5.9	0.08	20/5/1/ 0.2	≧ 80 dB	484 × 194 × 509	170
calib. possible at any frequency	±0.5	< 0.7	50 Ω	400	10.7		120	> 80 dB	326 × 96 × 290	182
—	—	1 to 3.4	≈ 50 to 60 Ω	—			(≈ 1%)	—	286 × 227 × 226	38
±1 (+1/−2)	±0.5	< 2 (4)	50 Ω	1560	160	21.4	MHz: 0.2/2	> 80 dB	484 × 194 × 509	172
calib. possible at any frequency	—	≦ −13 dB(µV)	50/60/75 Ω	199.3/ 339.3	10.7	0.45	15/120/300	> 70 dB	492 × 195 × 556	174
calib. possible at any frequency	—	≦ −13 dB(µV)	50 Ω	199.3/ 339.3	10.7	0.45	15/120/300	> 70 dB	520 × 400 × 535	178
—	±0.5	< 4	50 Ω	500	146	21.4	MHz: 0.2/2	0	484 × 194 × 509	173

USH 1

Selective Microvoltmeter USH 1

- 10 kHz to 60 MHz
  0.3 µV to 3 V

- Absolute and relative voltage measurements with spread linear and with logarithmic indication within the dynamic range of 80 dB
- Switch-selected automatic tuning circuit suitable for narrowband sweeping
- Switch-selected input impedance and bandwidth

The **Selective Microvoltmeter USH 1** is a system-compatible instrument of high sensitivity which permits point-by-point and swept-frequency selective measurements. It features high frequency setting and reading accuracy.

Principle of operation. Heterodyne receiver with broadband input, high first IF and triple frequency conversion.

Frequency setting continuous or crystal-controlled in the range 10 kHz to 60 MHz. Indication on an approximately linear scale with a resolution of 100 kHz/scale division. In addition any frequency can be lock-tuned by means of a 1-MHz spectrum which is shiftable by −0.1 to 0 to 1.1 MHz (resolution of linear scale 2 kHz/scale division).

The USH 1 also provides for switch-selected phase lock (at 1 kHz or 10 kHz) of the synchronizing oscillator and interpolation between the spectrum points in the range −300 to 0 to 1100 Hz (resolution 20 Hz/scale division).

Automatic tuning circuit. An APC circuit with a holding range of ±100 kHz eliminates any frequency errors without offset (the meter indicates the frequency error). In point-by-point measurements the APC circuit is a **tuning aid.**

In narrowband measurements the opened APC circuit is controlled by a sawtooth derived from the display unit or the oscilloscope (narrowband analysis). The switch-selected sweep width of ±100 kHz/±10 kHz can be accurately adjusted on a ten-turn helical potentiometer. In sideband analysis (see below) a built-in generator produces a △f-dependent signal in the range −100 to 0 to 100 kHz for modulation of the transmitter.

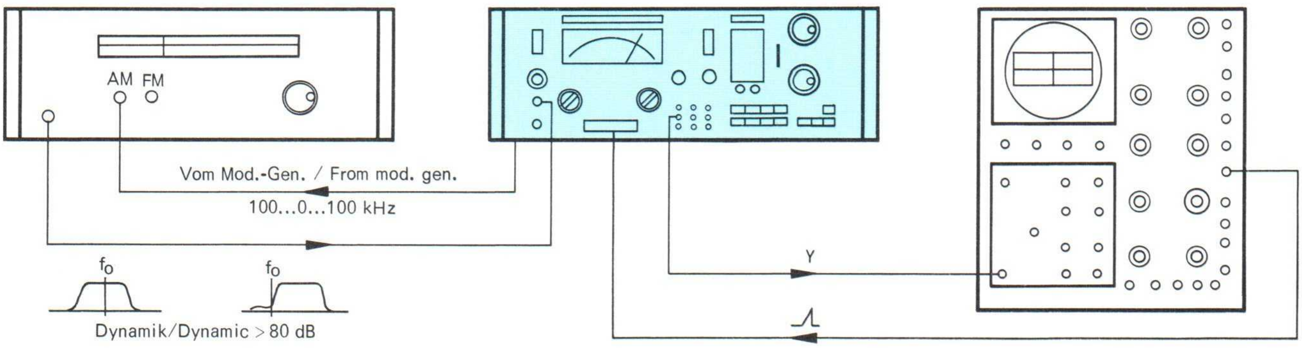
The bandwidths of the third IF can be switch-selected:
20/5/1/0.2 kHz or 20/1/0.2 kHz/30 Hz

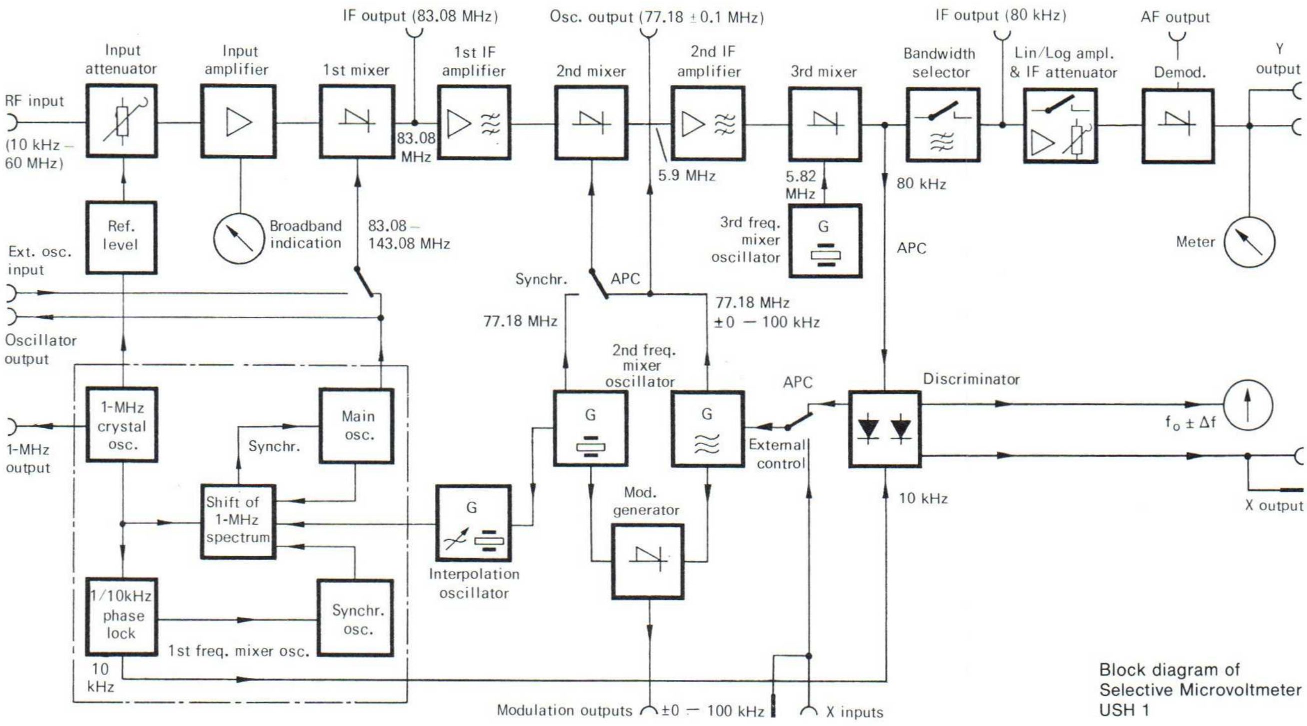
At the bandwidth of 200 Hz, the noise voltage is ≦ 0.3 µV; the rejection at three times the bandwidth from the centre frequency is ≧ 60 dB (≧ 50 dB at 30 and 200 Hz bandwidth).

The input impedance can be switch-selected between 50, 60, 75 or 150 Ω to ensure adaptation to the test item. The switch has a vacant position which can be connected to any impedance < 150 Ω. Measurement with superimposed DC voltage is possible up to ±3 V.

The voltage measurement range is selected with the input (+10/to/−40 dB) and IF (0/to/−80 dB) attenuators if linear indication is wanted, and only with the input attenuator if logarithmic indication is preferred. The range is indicated by luminous figures.

Sideband analysis using the USH 1





Block diagram of Selective Microvoltmeter USH 1

Indication

Reading in V and dB (calibrated) on moving-coil meter of class 1. Switch-selected average- or peak-responsive rectification and spread linear indication.

Broadband drive-level indication (input sum voltage) on edgewise meter with two-colour (low-noise/low-distortion) scale.

Calibration of frequency scales and absolute-value indication of meter (calibration level 0 dB ±≦ 0.1 dB) by built-in 1-MHz standardizing oscillator. For relative measurements the level is adjustable to 0 dB. Frequency calibration is also possible with external frequencies.

Inputs and outputs

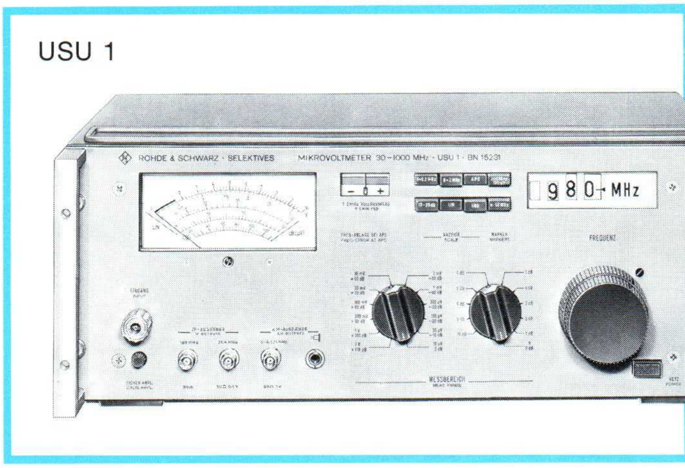
1. Input and output for first frequency changer, 83 to 143 MHz, Z_{in} (for 100 to 300 mV) or Z_{out} (for 10 to 30 mV): 50 Ω; Output for second frequency changer 77.18 (±0.1) MHz, 30 mV, Z_{out} = 50 Ω
2. X input, control voltage V_{pp} for maximum deviation: 1 to 200 V into 100 kΩ (polarity switch-selected) or 10 V into 7 kΩ (system input)
3. IF output, 83.0866 MHz, bandwidth ±100 kHz, 5 to 20 mV, Z_{out} = 50 Ω
4. IF output, 80 kHz (bandwidths see page 170), 1 V EMF, Z_{out} ≧ 1 kΩ
5. Modulation output (for SB measurement), −100 to 0 to 100 kHz, 0.775 V, Z_{out} = 75 Ω
6. Reference-frequency output, 1 MHz $\pm 1 \times 10^{-7}$, 0.5 V EMF into 75 Ω
7. X outputs: 0 to −10 V, Z_{out} = 12 kΩ
8. Y output, 0 to +1 V EMF, Z_{out} < 100 Ω
9. AF output, 0 to +1 V EMF, Z_{out} = 33 Ω (1 µF)
10. Remote-control inputs, switchover to first external oscillator, APC/analysis and bandwidth selection (max. +6.5 V/100 mA ext.)

Specifications

Frequency setting	
Receive-frequency range (f_{rec})	10 kHz to 60 MHz
Setting error of f_{rec} with main oscillator	
without phase lock	≦±150 kHz
with phase lock	±2 kHz
with phase lock and incremental lock tuning of synchronizing oscillator	≦±100 Hz
Frequency error of main oscillator	
without phase lock	≦50 kHz within 12 h
with phase lock	≦1 kHz within 12 h
with phase lock and incremental lock tuning of synchronizing oscillator	≦10 Hz
Voltage measurement	
Type of measurement and indication	absolute/relative measurement, lin (spread) or log indication, average or peak-responsive ind. (rms calib.)
Measurement range	0.3 µV to 3 V/−130 to +12 dB
Subranges with lin ind.	1 µV/to/3 V (1/3/10 steps)
with log indication	80-dB dynamic range 0 dB for 10 mV/to/3 V
Frequency response (referred to 1 MHz)	≦±0.2 dB from 10 kHz to 30 MHz ≦±0.3 dB from 30 to 60 MHz
Reading error of meter	
"Lin": 0 to 10/0 to 3	< ±1.5% of fsd (V scale)
+2 to 0 to −10 to −20 dB	−0.2/< ±0.5/< ±1 dB
"Log"	≦±1 dB (absolute)
Indication of input sum voltage	
Low-noise mode	measurement taking into account the permissible overdriving
Low-distortion mode	measurement with harmonic ratio not exceeding the specified limits (see below)
Signal input	DC coupled
VSWR	≦1.1 for Z_{in} = 150 Ω ≦1.05 for Z_{in} = 50/60/75 Ω
IF rejection	≧60 dB for first IF ≧80 dB for 2nd and 3rd IFs
Overdrive capacity	
for $f_1 - f_2$ < 100 kHz	≧10 dB } for indication error
for $f_1 - f_2$ ≧ 100 kHz	≧15 dB } of 0.5 dB
Harmonic ratio (acc. to DIN)	≧50 dB for f_{rec} ≦ 1 MHz, typ. 70 dB for f_{rec} > 1 MHz
General data	
AC supply	115/125/220/235 V +10/−15%, 47 to 63 Hz (55 VA)
Dimensions, weight	
19" cabinet model	484 mm × 194 mm × 509 mm, 27 kg
19" rackmount	483 mm × 177 mm × 498 mm, 25 kg

Order designations	▶ Selective Microvoltmeter USH 1	
	19" cabinet model	**19" rackmount**
Bandwidth 20/5/1/0.2 kHz	205.3616.04	205.3616.03
20/1/0.2 kHz/30 Hz	205.3616.06	—

USU 1



Selective Microvoltmeter USU 1
♦ 30 to 1000 MHz

- Voltage range of approx. 3 µV to 3 V
- Automatic tuning with capture range of ±1 MHz
- Switch-selected bandwidth 0.2 or 2 MHz

The **USU 1** is a highly sensitive selective voltmeter covering a wide frequency range.

Frequency setting by single-knob tuning, the whole range being covered by 3 turns; in addition incremental tuning 1:100. Digital frequency indication on a counter dial. Calibration is possible at 50-MHz intervals by means of a built-in calibration oscillator.

Automatic tuning. The 3rd oscillator is tuned such that the receiver tracks input frequency variations up to ±2 MHz (lock-in range) and the frequency error is indicated. Capture effective at $V_{in} \geqq 6$ µV.

Bandwidth. The filter for the 3rd IF (21.4 MHz) can be switched for 200 kHz or 2 MHz bandwidth; the noise deflection is < 2 µV or < 4 µV, respectively.

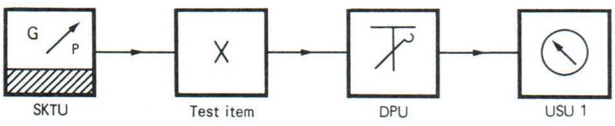
Voltage range. 10 µV to 3 V for fsd. Sensitivity in linear operation selectable in 10-dB and 1-dB steps by calibrated attenuators. In logarithmic operation voltages from 10 µV to 3 V are indicated on a scale.

Voltage indication approximately linear, calibrated in V, dB(µV). **Calibration** at 200 MHz by built-in 100-µV standardizing oscillator.

Outputs (see "Specifications"). The IF outputs can be used for connecting accessory equipment, such as a panoramic adapter for spectrum analysis of the input signal.

Example of application

The USU 1 can be used for measuring the noise figure of transistors with the following test setup:



The Noise Generator SKTU (see page 59) delivers a continuous spectrum from 1 to 1000 MHz, its power being continuously adjustable from 0 to 16 dB. The noise figure of 1 to 40 is indicated in two ranges. The UHF Attenuator Set DPU (see section 11) permits the power derived from the test item to be divided by two and the Selective Microvoltmeter USU 1 is used as a power indicator.

When slightly modifying the noise generator and using a programmable attenuator set, a semi-automatic test setup is obtained in conjunction with the USU 1, permitting noise figure checks on RF transistor batches at the producer's or user's.

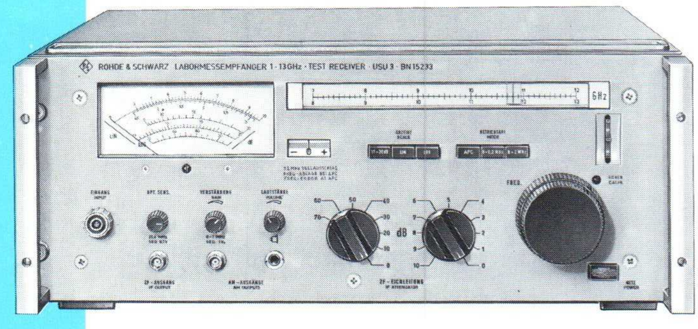
Specifications

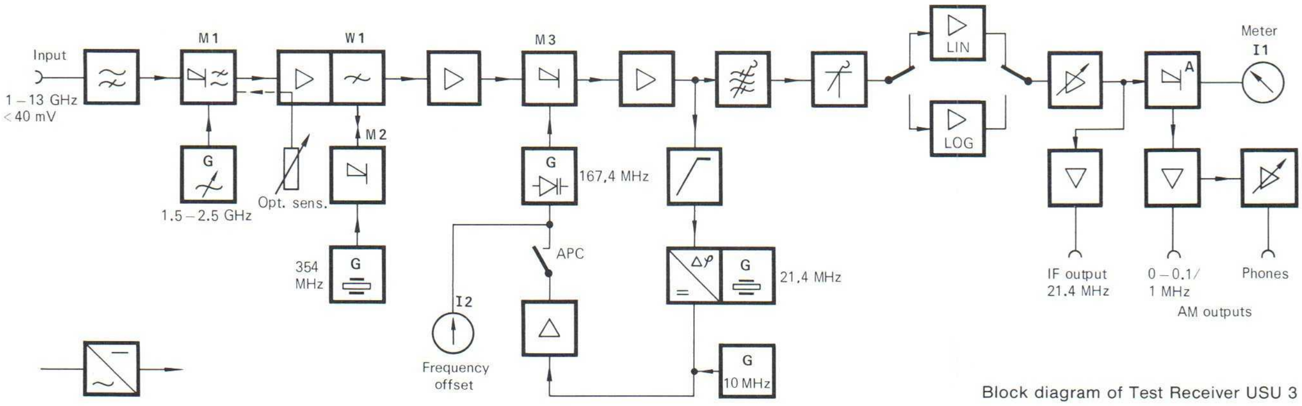
Principle	superhet with wideband input
Frequency range	30 to 1000 MHz, continuous tuning without range switching
Frequency indication	on counter dial; error limits 1%, referred to first local oscillator 1590 to 2560 MHz; calibration with internal spectrum at 50-MHz intervals
Automatic tuning	phase control loop, can be switched off
Capture/lock-in range	≧±1 MHz/≧ ±2 MHz
Input voltage requirement	≧6 µV
Voltage indication	pointer-type meter, calibrated in absolute values: V, dB (µV); the range 17 to 20 dB can be spread over the whole scale length
Frequency response	< ±1 dB (above 800 MHz: +1/−2 dB)
Attenuator	in 10-dB and 1-dB steps
Noise figure	approx. 20 dB at B = 0.2 MHz approx. 16 dB at B = 2.0 MHz
Noise deflection with 0.2 MHz bandwidth	< 2 µV
IF rejection	> 80 dB for IF 1 and 2 > 100 dB for IF 3
Input	50 Ω, unbalanced, earthed, connector: Dezifix A, adaptable
Outputs	
IF output, 160 MHz	B = 25 MHz, Z_{out} = 50 Ω, BNC
IF output, 21.4 MHz	B = 0.2 or 2 MHz, Z_{out} = 50 Ω, BNC
AM output	0 to 0.1/1 MHz, Z_{out} = 50 Ω, BNC
Headphone output	100 Hz to 20 kHz, Z_{out} = 50 Ω (2.2 µF)
Dimensions, weight	484 mm × 194 mm × 509 mm, 25 kg
Order designations	► Selective Microvoltmeter USU 1
19" cabinet model	110.4722.02
19" rackmount	110.4722.51

Test Receiver USU 3
♦ 1 to 13 GHz

- Voltage measurements from approx. 12 (60) µV to 40 mV
- Logarithmic scale for rough measurements
- Linearized easy-to-read frequency scale

USU 3





Block diagram of Test Receiver USU 3

The **Test Receiver USU 3** is a sensitive relative-voltage meter featuring wide frequency and dynamic ranges. It uses triple conversion of the input frequency (mixers M1 to M3) and a first IF below the input frequency range.

Frequency setting by single-knob tuning; coverage of five subranges by three turns (additionally, incremental tuning with 1:100 reduction). Separate scale for first local-oscillator frequency. An external oscillator may be used for calibration at 50-MHz intervals. Harmonic mixing is used above 3 GHz.

Automatic tuning facility. By adjusting the third local oscillator the receiver is brought to track with input frequency variations up to ±2 MHz (lock-in range) and to indicate the frequency offset of the input signal. Capture sensitivity: V_{in} = 10 to 60 µV, depending on test frequency.

Bandwidths. The filter for the 3rd IF (21.4 MHz) can be switched between 200 kHz and 2 MHz.

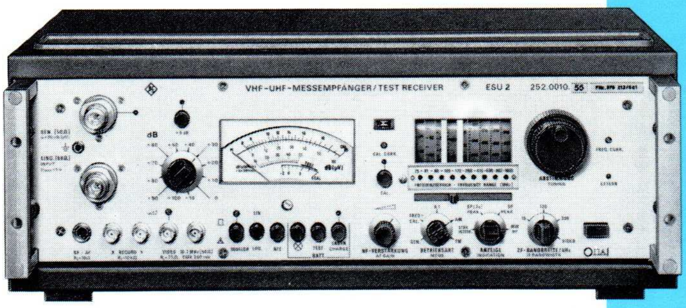
Voltage range approx. 12 (60) µV to 40 mV = −85 (−70) to −15 dBm. Sensitivity setting continuously variable by approximately 5 dB and in steps of 7 × 10 dB and 10 × 1 dB by means of calibrated attenuator. Error of 10-dB steps = ±0.1 dB, of 1-dB steps = ±0.05 dB (total error of calibrated attenuator < +0.5 dB).

Voltage indication approximately linear; 70 dB logarithmic scale. Sensitivity, especially at higher frequencies, substantially improved by means of adjustable operating point of first mixer.

Specifications

Principle	superhet with wideband input, relative-voltage meter
Frequency range	1 to 13 GHz
Frequency indication	5 selectable double scales for f_{in}, 1 scale for fundamental frequency of first local oscillator
Subranges in GHz	1 to 2/2 to 3/2.5 to 4.5/3.5 to 5.5/ 4 to 7/5 to 8/5.5 to 9.5/6.5 to 10.5/ 7 to 12/8 to 13
Error limits	< 1%, calibration at 50-MHz intervals possible
Automatic tuning	phase control loop, can be switched off
Capture/lock-in range	≧±1 MHz/≧ ±2 MHz
Minimum input level	typical: 5 dB below fsd at full sensitivity
Voltage indication	pointer-type meter, calibrated in relative values; the range 17 to 20 dB can be spread over the whole scale length
Sensitivity adjustment	with IF attenuator in 10-dB and 1-dB steps, continuous by approx. 4 dB through gain variation
Noise figure	approx. 20 dB at B = 0.2 MHz approx. 16 dB at B = 2.0 MHz
IF rejection	> 90 dB for IF 2 and 3 ≧45 dB for IF 1
Input	50 Ω, unbalanced, earthed, connector: Dezifix A, adaptable
Outputs	
IF output, 21.4 MHz	B = 0.2 or 2 MHz, Z_{out} = 50 Ω, BNC
AM output	0 to 0.1/1 MHz, Z_{out} = 50 Ω, BNC
Headphone output	100 Hz to 20 kHz, Z_{out} = 120 Ω (22 µF)
Dimensions, weight	484 mm × 194 mm × 509 mm, 22 kg
Order designations	► Test Receiver USU 3
19" cabinet model	111.5439.52
19" rackmount	111.5439.51

ESU 2



VHF-UHF Test Receiver ESU 2

♦ 25 to 1000 MHz
−10 to +120 dB(μV)

- Manually and remotely controllable test receiver for field-strength measurements, CISPR and MIL interference measurements, selective voltage measurements in laboratories and test departments, and for radiomonitoring
- Error ≦ ±1 dB – automatic voltage calibration
- Indication modes: average, peak, VDE and CISPR weighting

The **VHF-UHF Test Receiver ESU 2** is designed for the measurement and demodulation of AM and FM signals, and for the measurement of TV, pulse-modulated and interference signals.

It finds application as a

self-contained test receiver,

a system component combined, for example, with a frequency controller and a panoramic adapter (see below) or with punched-card or calculator control (see page 178);

Field-Strength Meter HFU 2 (together with appropriate antennas, mast and tripod; see page 184).

Test receiver applications

Test and development laboratories. Versatile selective voltmeter, offering many ways of evaluating each input; measurement of RF current from −30 to +100 dB(μA) using current probe for 25 to 300 MHz, see recommended extras.

The reference voltage output of the ESU 2 permits field-strength calibration and measurements on two-ports with an overall range (attenuation, gain) of 130 dB; swept measurements over frequency subranges are possible using the Panoramic Adapter EZP for display.

Television measurements. The peak-responding indication permits direct measurement of the sync-peak rms vision-carrier level independently of the picture content. Using the average-value indication, the sound carrier and the noise level can be measured to obtain the signal-to-noise ratio. The two direct-coupled AM-demodulator outputs are particularly useful for measuring hum- and crossmodulation on the pilot carriers in cable TV networks.

Interference measurements. The ESU 2 incorporates a weighting filter as required for radio interference measurement according to the procedures laid down in VDE 0875 and by CISPR. Interference field-strength measurements can be made with the help of antennas. Radio noise power measurements are also possible using the Absorbing Clamp MDS-21. Wideband interference can be measured according to MIL standards (electromagnetic compatibility measurements) on a separate calibrated scale. Measurements of single pulses or pulse trains with low repetition rates are possible thanks to a peak response with a hold time of 3 s.

Auxiliary instruments for diversified applications

Frequency Controller EZK displays the reception frequency with a resolution of 1 kHz. With digital frequency control (DFC) the set frequency is held to within 100 Hz, meaning that the ESU 2 is always ready for operation even when handling intermittent signals. The DFC mode permits manual frequency variation with three speeds and digital frequency setting via a BCD input.

Panoramic Adapter EZP displays the spectrum of the received signal with different resolution bandwidths. The sweep width can either be set to cover up to a full receiver subrange (RF analysis) or up to ±1 MHz from the receive frequency (IF analysis). The receiver plus adapter forms an analyzer with tuned preselection in the subrange for the RF analysis mode.

A radiomonitoring recorder, e.g. ZSG 3, can be connected at outputs provided on the EZP to produce a hard-copy record of band occupancy.

Battery Unit. This mounts on the rear panel and renders the receiver independent of an AC supply (3.5-h operation per recharge), for example, in field-strength measurements.

Programmability. All settings of ESU 2 can be programmed via two rear-panel inputs, including frequency selection if the Frequency Controller EZK is used. It is also possible to use both manual and programmed operation simultaneously, as well as to connect several ESU 2s for master-slave operation.

Description (see block diagram)

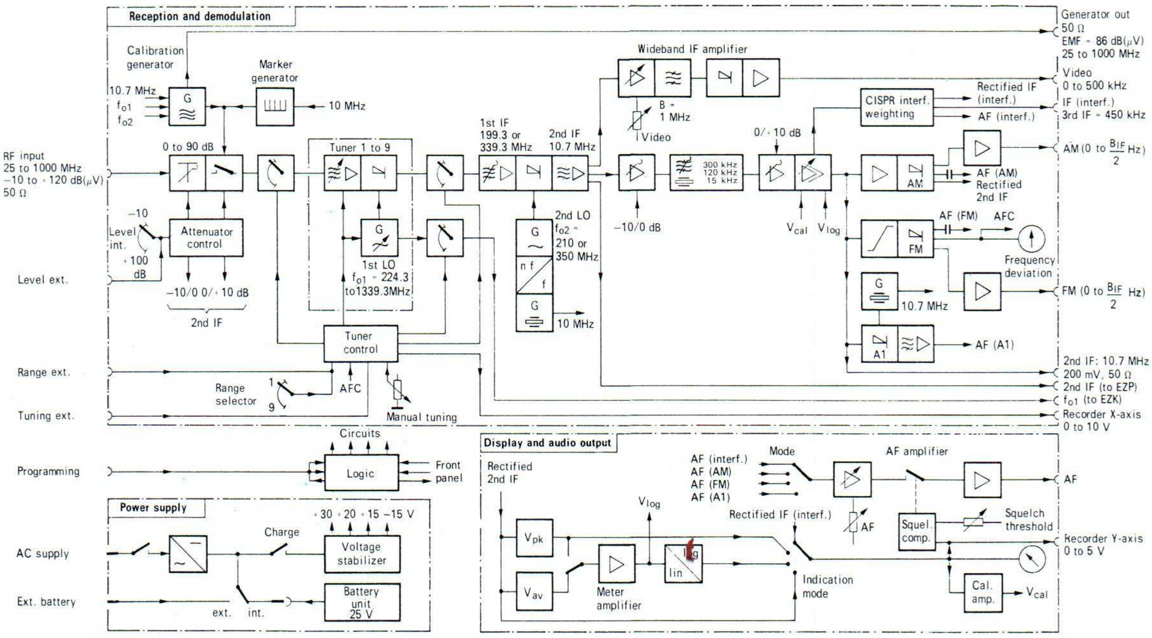
Double superheterodyne receiver with range-dependent 1st IF; 2nd IF = 10.7 MHz; tuned preselection; voltage-controlled frequency tuning in nine overlapping subranges.

Sensitivity, level switching. Noise figure is typically 8 dB up to 400 MHz and 10 dB up to 1000 MHz. The received signals and the signals for frequency and voltage calibration are applied to the level switch, whose attenuation can be varied in 10-dB steps. The calibration generator produces a signal at the receiver centre frequency, which is used to adjust the overall gain for voltage calibration (measurement error ≦ ±1 dB).

The tuner control conveys the RF input signal and internal or external tuning voltages to one of the nine subrange tuners and switches the 1st oscillator and 1st IF to output lines.

10.7-MHz IF signal, bandwidths. The information contained in the 2nd IF of 10.7 MHz is processed along three different paths:

1. Wideband IF amplifier with a bandwidth of about 1 MHz; the signal is then AM demodulated and made available at the video output 0 to 500 kHz.
2. 2nd-IF output for IF or RF analysis by means of the Panoramic Adapter.



Block diagram of VHF-UHF Test Receiver ESU 2

3. Principal IF amplifier with filter section, gain control and demodulation stages; crystal filters are used for 15 and 120 kHz bandwidth, ceramic filters for 300 kHz.

Signal demodulation, outputs. ESU 2 has demodulators and outputs for AM and FM signals (A1, A3 and F3) and a CISPR interference-weighting filter with an associated IF output (450 kHz). The display and audio section contains a switch-selected squelch and connections for loudspeaker, phones and recorder.

Specifications

Frequency range	(20)* 25 to 1000 MHz
Subranges	24 to 42 MHz; 40 to 70 MHz; 67 to 110 MHz; 100 to 175 MHz; 170 to 270 MHz; 265 to 420 MHz; 410 to 605 MHz; 595 to 805 MHz; 800 to 1005 MHz
Frequency setting	range selection: slide switch tuning: coarse/fine drive for drum dial (2 m long)
Resolution	100 kHz/mm (1 MHz/mm)
Setting error	< ±(1 × 10^{-3} f_{in} + 100 kHz) (after calib.)
AFC	switch-selected
RF input	Z_{in} = 50 Ω, N female connector, adaptable
VSWR	< 1.15 (< 2)
Noise figure (typical)	8 dB up to 400 MHz, 10 dB up to 1000 MHz
Suppression of spurious responses within RF passband	
Level switch at −10 dB	> 70 dB referred to 0.3 µV
≧ 0 dB	> 70 dB referred to 1 µV
Image-frequency rejection	> 70 dB
IF rejection	> 80 dB
Intermediate frequencies	
1st IF	199.3 MHz for subranges 1, 2 and 6; 339.3 MHz for other subranges
2nd IF/6-dB bandwidths	10.7 MHz/15/120/300 kHz
3rd IF	450 kHz (6-dB bandwidth 120 kHz)
Measurement range	−10 to +120 dB(µV) for linear average-value indication; 10-dB steps
Measurement error (after calibration)	≦±1 dB for V_{in} ≧ 1 µV
Indicated noise (15 kHz bandwidth)	≦−13 dB(µV), typical −16 dB(µV)
Indication	analog, illuminated scale
Indication range	
Lin	20 dB
Log	60 dB; 40 dB log peak value in dB (µV/MHz) at 300 kHz bandwidth
For interference measurement	7 dB

* A model with slightly restricted specifications is available for 20 to 1000 MHz.

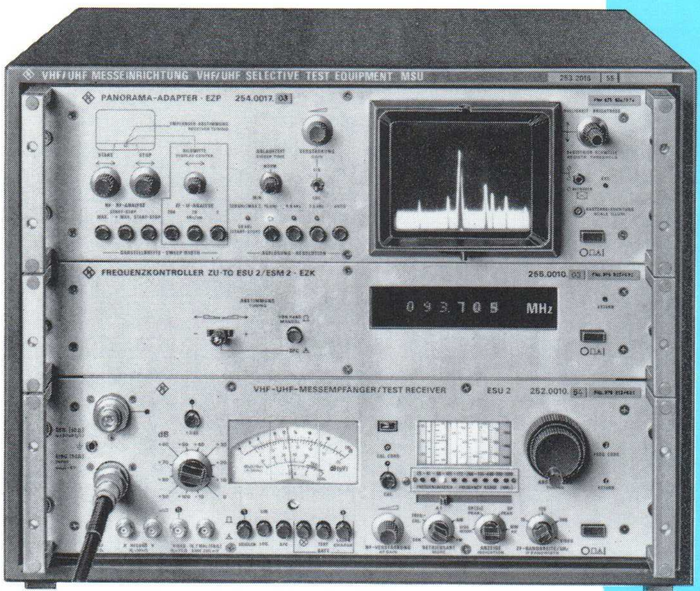
Indication modes	average value, lin and log; peak value, lin and log and lin with 3 s hold time; weighted according to VDE 0876 and CISPR Publ. 2 and 4
Types of demodulation	AM and FM (A1, A3 and F3)
Outputs	
Reference voltage	EMF = 86 dB(µV); Z_s = 50 Ω; N female connector, adaptable
10.7-MHz IF	EMF ≈ 200 mV; 50 Ω; BNC
450-kHz IF	EMF ≈ 15 mV (unmod.); 120 kHz bandwidth; 50 Ω; BNC
AF	≦1.2 W (adjustable) into 8 to 16 Ω; JK-34 jack
Squelch	switch-selected, threshold adjustable
Video 0 to 500 kHz	EMF = 2 V, adjustable over 70 dB; 75 Ω; BNC
Demodulator outputs	
AM	EMF ≈ 1 V; 75 Ω; BNC
FM	EMF ≈ ±1 V for △f = ±125 kHz; 75 Ω; BNC
Recorder outputs	BNC
X for frequency	0 to 10 V; 10 kΩ
Y for signal level	0 to 5 V proportional to meter reading; 10 kΩ
Connectors for Panoramic Adapter EZP, Frequency Controller EZK and for remote control	multiway female connector strips
General data	
Nominal temperature range	0 to +40 °C
Shelf temperature range	−25 to +70 °C
AC supply	115/125/220/235 V +10/−15% (65 VA)
Battery operation	
with battery unit (cabinet model only)	holds 20 NiCd cells IEC KR 33/61, approx. 3.5 hours operating time
from external battery	21 to 28 V, negative earth
Charging	internal charger; charging time for battery unit 14 hours; charging current for external battery 400 mA
Dimensions, weight	
Cabinet model (with battery unit empty)	492 mm × 195 mm × 556 mm; 27 kg
19″ rackmount	483 mm × 133 mm × 507 mm; 22 kg

Order designations	▶ VHF-UHF Test Receiver ESU 2	
19″ cabinet model (N female)*	252.0010.55	
19″ rackmount (N female)*	252.0010.54	
ESU 2, special models	19″ cabinet model	19″ rackmount
60-Ω model (Dezifix B)*	252.0010.62	252.0010.61
75-Ω model (Dezifix B)*	252.0010.72	252.0010.71
Model for frequency range 20 to 1000 MHz	252.0010.59	252.0010.58

Recommended extras	
RF Clamp-on Current Probe ESU-Z, 25 to 300 MHz	100.1137.02
RF Cable for connection to ESU 2	204.1090.02
Absorbing Clamp MDS-21	194.0100.50
BNC female/N male adapter (for Current Probe and MDS-21)	118.2812.00
Headphones	110.2959.00
For cabinet model only: NiCd cells RS 4 (20 required) Order No. for 1 cell	252.6001.00

* On convertible base

MSU



VHF-UHF Selective Test Equipment MSU

♦ 25 to 1000 MHz
−10 to +120 dB(μV)

- Programmable test assembly for field-strength measurements (with calibrated antennas), CISPR and MIL interference measurements, selective voltage measurements in laboratories and test departments, for radio reconnaissance and radiomonitoring
- Digital display of receiver frequency with 100-Hz resolution
- Analog voltage indication (average, peak and CISPR weighting)
- Spectral display – RF and IF analysis with high resolution

Automatic test assembly (Programmable VHF-UHF Test Equipment MSUP with Tektronix 4051 desktop computer) on page 179

The **VHF-UHF Selective Test Equipment MSU** is designed for the measurement and demodulation of AM and FM signals, and for the measurement of TV, pulse-modulated and interference signals. It is composed of the following instruments:

VHF-UHF Test Receiver ESU 2	(see page 174)
Frequency Controller EZK	(see section 8)
Panoramic Adapter EZP	(see section 8)

Great ease of operation of the equipment makes for precise and rational measurements: internal reference for automatic voltage calibration, seven-digit display of receiver frequency, high sensitivity (typical noise figure 8 dB up to 400 MHz, 10 dB up to 1000 MHz), wide dynamic range and good image-frequency and IF rejection (precluding measurement ambiguities), panoramic display covering up to an ESU 2 subrange, recorder outputs, TTL logic for remote control and connection facilities for slave equipment.

Frequency setting and accuracy. The reception range of 25 to 1000 MHz is covered in nine subranges selected by a slide switch. Frequency can be adjusted continuously by a coarse/fine drive on the ESU 2 drum dial, no change of the direction of rotation being necessary at the range end (resolution 100 kHz to 1 MHz/mm). The Frequency Controller displays the set frequency in seven digits with 1 kHz resolution. Switch-selected AFC and an A1 demodulator further facilitate the tuning procedure.

With digital frequency control (DFC) of the EZK, the set frequency remains locked to the crystal frequency (resolution of display 100 Hz). Quasi-continuous frequency variation in three speeds is simultaneously possible by means of a Kellog switch. Digital setting of the receiver frequency is also possible in BCD code through the EZK.

Sensitivity, voltage calibration, display. As the noise figure is typically 10 dB up to 1000 MHz, voltages of 0.3 μV can be measured with the smallest bandwidth. Voltage calibration of the Test Receiver is possible within one second by the press of a button. The input and calibration signals pass through a level switch with motor-controlled 10-dB steps, extending the linear indication range of 20 dB (Test Receiver) to a measurement range covering −10 to +120 dB(μV), and correspondingly the logarithmic ranges of 60 dB (Test Receiver) and 70 dB (Panoramic Adapter). Display modes: average, peak, VDE and CISPR weighting.

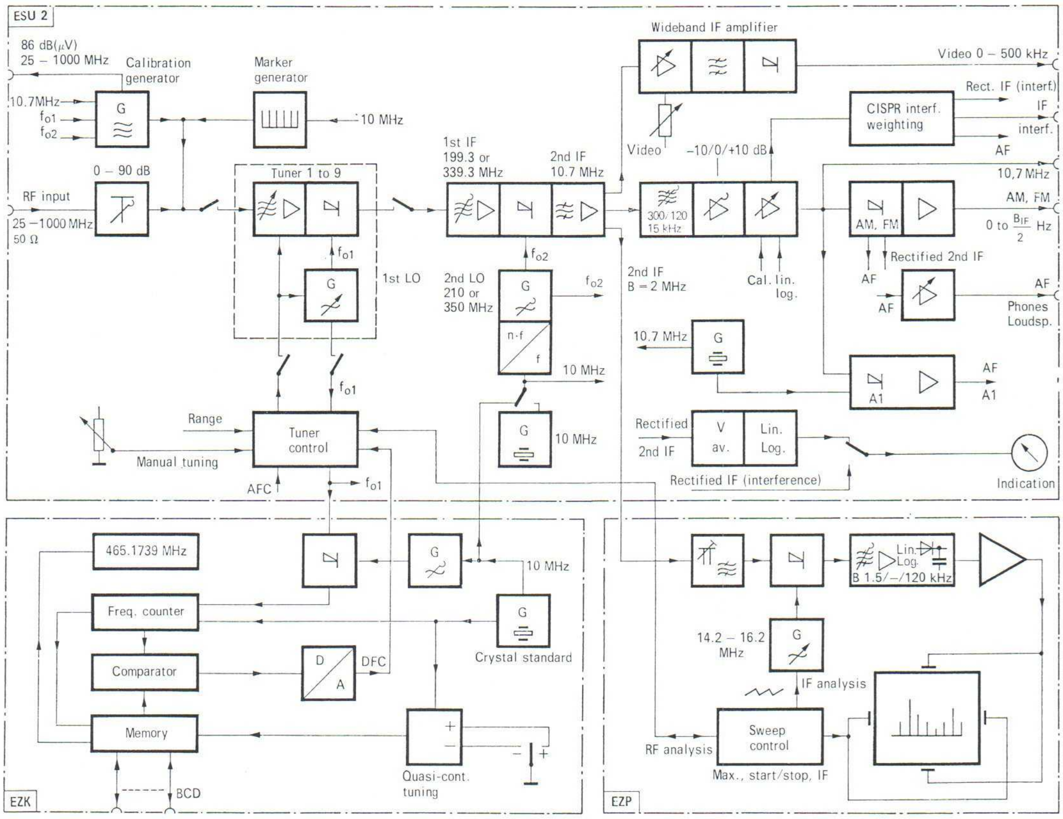
Bandwidths. The bandwidths are fixed for the IF wideband amplifier (1 MHz) and the Panoramic Adapter (2 MHz) and can be switch-selected (300, 120 or 15 kHz) for the 10.7-MHz signal via the 2nd-IF amplifier as required for further evaluation.

Panoramic display. The EZP displays the spectrum of the RF input signal across a maximum of an ESU 2 subrange. Band occupancy, level, frequency (spacing) and modulation can thereby be assessed. The tuning of the Test Receiver is facilitated by a position marker produced in the EZP.

The following display modes and widths are possible:

a) RF analysis covering full subrange (max. 200 MHz with ESU 2). Start/stop markers can be set to display any detail thereof either alone or together with the subrange in a two-line representation.

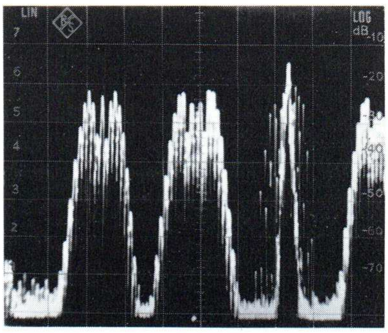
b) IF analysis with a maximum display width of 2 MHz and automatic optimization of sweep time or resolution bandwidth.



Block diagram of VHF-UHF Selective Test Equipment MSU

Demodulation, outputs. The Test Receiver is designed for AM, FM and pulse modulation and has a video output for 0 to 500 kHz. The audio section delivers the demodulated and amplified signal to the loudspeaker or phones output. It contains a switch-selected squelch. The various outputs (IF, demodulator, AF and recorder outputs) afford great versatility.

Operation, programming, slave equipment. All functions of the receiver front-panel controls can be remotely controlled via rear connectors. Frequency setting is programmable in BCD code. It is also possible to use both manual and programmed operation simultaneously. Slave units ESU 2 + EZK can be connected to the Test Equipment.



IF analysis: Modulation spectrum of one occupied and three free public-land-mobile-service channels; display width 200 kHz, resolution 1.5 kHz

Specifications of Selective Test Equipment MSU

(Specifications of units: ESU 2 p. 174, EZK/EZP section 8)

Frequency range	25 to 1000 MHz, 9 subranges
Frequency setting	a) continuous with subrange slide switch and coarse/fine drive; drum dial 2 m in length, resolution 100 kHz in lowest subrange
	b) quasi-continuous on EZK in three speeds with digital display; steps and resolution 100 Hz
	c) external in BCD, setting time typ. 0.5 s including automatic range selection
Frequency display	6 digits with manual tuning (ESU 2); 7 digits with tuning through EZK
Noise figure up to 400 MHz	8 dB (typ.)
up to 1000 MHz	10 dB (typ.)
RF input	50 Ω, N female connector, adaptable
Suppression of spurious responses within RF passband with level switch at –10/≧0 dB	> 70 dB referred to 0.3/1 μV
Image-frequency rejection	> 70 dB
IF rejection	> 80 dB
2nd IF	10.7 MHz
6-dB bandwidth	15/120/300 kHz
3rd IF	450 kHz } only for CISPR interference measurements
6-dB bandwidth	120 kHz }
Measurement range	–10 to +120 dB(μV) for linear average-value indication; 10-dB steps
Measurement error	≦±1 dB for inputs ≧ 1 μV
Voltage indication lin	20 dB
log	60 dB, 40 dB log peak value for MIL measurement of wideband interference in dB (μV/MHz)
log	7 dB for CISPR interference measurement
Indication modes	average value, lin and log; peak value, lin and log, weighted according to VDE 0876 and CISPR Publ. 2 and 4
Demodulation	AM and FM (A1, A3 and F3)
Panoramic display wideband (subrange) display	max. 1 subrange with 120 kHz resolution or any detail with 50 kHz resolution
Narrowband display (IF analysis)	20 kHz to 2 MHz display width with resolution bandwidths 1.5/4.5/15 kHz
Level display	> 70 dB log or 20 dB lin
Screen size	10 cm × 8 cm (calibrated graticule 10 dB/cm)
Nominal temperature range	0 to +40 °C
AC supply	115/125/220/235 V +10/–15%, 47 to 420 Hz (140 VA)
Dimensions, weight	520 mm × 400 mm × 535 mm, 60 kg
Order designation (complete system)	▶ VHF-UHF Selective Test Equipment MSU 253.2016.55
MSU without RF analysis	253.2216.99
Accessories supplied	power cable, 2 connecting cables, battery cable for connection to ESU 2

ESU 2 punched-card controlled

VHF-UHF Test Equipment with punched-card controlled ESU 2

♦ 25 to 1000 MHz/−10 to +120 dB(µV)

- Combines advantages of automated and manual operation
- Semi-perforated cards for simple manual programming
- Read-in time per setting including calibration (one card) of about 1.5 s
- Control to IEC standard

The remote-control inputs of ESU 2 are designed to permit external control of all or any of the functions of the set. Remaining functions are operated manually on the ESU 2 front panel. This partly programmed operation relieves the operator from routine work and leaves him more time for the measurement proper. A typical example are radiomonitoring tasks, requiring a multitude of frequencies from various services with different types of modulation and spectral widths to be set before the corresponding antenna voltage or field strength can be measured and the modulation aurally monitored. **Punched-card control of the ESU 2** here substantially simplifies the operator's task.

Function, programming

A punched card, which can be prepared within a few minutes without the use of costly aids and without programming knowledge, stores

receiver frequency (100 Hz resolution),
IF bandwidth (15, 120 or 300 kHz),
display mode (average value, peak value, weighted according to CISPR),
operating mode (FM, AM or A1) and
automatic receiver calibration command.

Assisted by the Frequency Controller EZK and the Code Converter PCW, the Card Reader PCL sets these data on the receiver within 1.5 s.

Measurement and evaluation involving the setting of the level switch, selection of linear or logarithmic scale, reading of measured value, adjusting the AF gain for the connected loudspeaker or headset and further signal evaluation with the aid of additional units connected to the output are performed by the operator. The receiver frequency can still be quasi-continuously or manually adjusted for individual test signal observation. In addition to automatic calibration, manual calibration is also possible.

Uses

This system concept of Rohde & Schwarz offers simplified operation at reasonable cost, above all for radiomonitoring purposes. Quite often semi-automation is preferable to fully automatic testing not only for reasons of economy but on technical grounds. In addition to the time saved in the preparation of the measurement the operator need no longer attend to routine duties, thereby considerably cutting down operational errors. This is of particular advantage when making periodic checks of fixed radio services using various types of modulation.

For field-strength measurements the VHF-UHF Field-strength Meter HFU 2 (consisting of ESU 2, two broadband antennas, mast and tripod) is used instead of the ESU 2; see page 184.

The punched-card controlled ESU 2 also saves considerable time when carrying out interference measurements **according to CISPR** or any measurements in the laboratory and test department where the same frequency settings are required time and again.

Evaluation is facilitated by the Panoramic Adapter EZP, which permits IF analyses (sweep width up to 2 MHz) and RF analyses over subranges of the ESU 2.

Specifications of Test Equipment

For **specifications of individual units** see

Test Receiver	page 174
Frequency Controller	section 8
Code Converter/Card Reader	section 1

Order designations of individual units

VHF-UHF Test Receiver ESU 2 (standard version)	252.0010.55
Frequency Controller EZK	255.0010.02
Code Converter PCW	244.8015.92
Coding Board PCW-Z (radiomonitoring) including patch cord.	291.1213.02
Card Reader PCL	248.6017.02
8-track Punched Cards PCL-Z (set of 500 pcs.)	248.6598.02

Recommended extras and modifications

Panoramic Adapter EZP	254.0017.02
VHF-UHF Field-strength Meter HFU 2 (in place of separate unit ESU 2)	253.0013.55

Automatic Test Equipment
♦ 25 to 1000 MHz/−10 to +120 dB(μV)

consisting of

Programmable VHF-UHF Test Equipment MSUP and Tektronix 4051 Computing System

- Dialog programs available for various applications
- Control complying with IEC standards; therefore simple extension with further measuring instruments

The **Programmable VHF-UHF Test Equipment MSUP** is composed of the VHF-UHF Selective Test Equipment MSU described on page 176 and the IEC-bus Adapter ESU 2-Z4. It constitutes a compact IEC-bus-compatible test system for selective measurements of voltage and two-port parameters. In conjunction with clamp-on RF current probes and calibrated antennas current and field-strength measurements are possible. A frequency counter can be inserted into the IEC-bus Adapter for remote frequency measurement with the MSUP (photo on right, top; not supplied). The loudspeaker incorporated in the ESU 2-Z4 facilitates aural monitoring of the modulation content for radiomonitoring and acoustic assessment of radio interference measured according to CISPR and VDE 0875. A button on the ESU 2-Z4 permits rapid transition to manual operation.

Control, characteristics. The MSUP Test Equipment is controlled by the Tektronix 4051 desktop computing system with storage CRT for numerical and graphic display. The screen also facilitates preparation and correction of programs.

The **software** available with the test assembly consists of a basic program containing complete control, self-check, test and calculating routines, with which the user can compile individual programs without difficulties, and of **prepared dialog programs** for various applications.

The **advantage of computer control** lies in
- shorter test time,
- automatic preparation of test reports which are easy to interpret,
- elimination of operating errors.

The dialog programs are written so that even untrained operators may use the system.

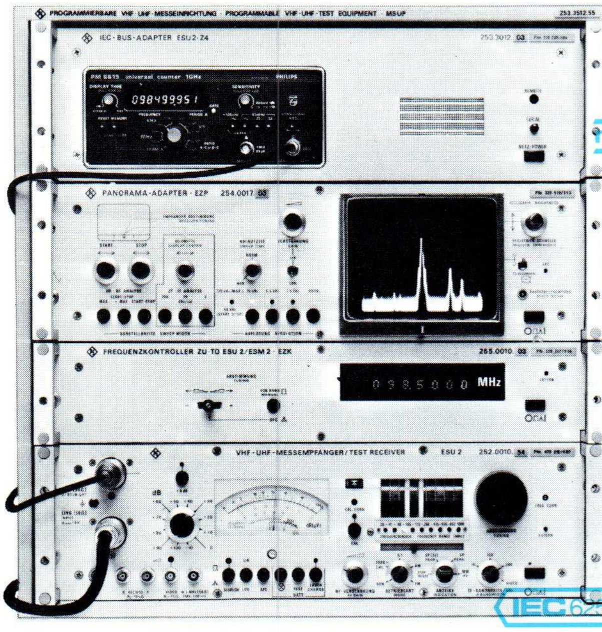
Uses

The system is intended for all situations where a great number of measurements must be carried out, logged and evaluated with constant high accuracy and reliability. This especially applies to measurements of spectral characteristics of useful and unwanted signals.

A search program for radiomonitoring is used to measure within a specified frequency range the input voltages exceeding a certain strength. With the aid of an IEC-bus-compatible frequency counter in the ESU 2-Z4, the respective frequencies are determined. Another dialog program permits level and frequency measurements for radiomonitoring on fixed frequencies which are stored in the calculator.

When measuring e-m interference according to MIL specifications and VG regulations the test system permits separate detection of sinewave and wideband interference sources.

Calculator-controlled ESU 2



new

IEC 625 Bus

In the case of radio-interference measurements according to CISPR and VDE 0875 this test system is the first to offer the possibility of automatically recording the test results over a large dynamic range.

When measuring the harmonics of a signal or the absolute value of the transfer constant of **two-port networks** the possibility to obtain derived quantities (voltage ratios) by processing measured values (voltages) offered by the computing system is profitably used; during field-strength measurements the computing system automatically considers the (frequency-dependent) antenna factor (k).

Specifications of MSUP

Frequency range	25 to 1000 MHz

(For data of individual instruments see in this catalog: ESU 2: p. 174, EZK and EZP: pp. 196, 197)

VHF input	N female connector
IEC-bus connector	24-way, female (Amphenol)
Working temperature range	0 to +40 °C
AC supply	115/125/220/235 V (180 VA)
Dimensions, weight	520 mm × 534 mm × 635 mm, 70 kg
Order designation	► Programmable VHF-UHF Test Equipment MSUP 253.3512.55

Recommended extras

Desktop Computing System	Tektronix 4051
with 24k memory	option 21
with 32k memory	option 22
Magnetic-tape cassettes (5 pcs.)	Tektronix 119-0680-01
Software ESU 2-K1 (German)	253.2516.02
ESU 2-K2 (English)	263.2616.02
IEC-bus Cable PCK	292.2013.20
Frequency Counter	Philips PM 6615/04 with PM 9676

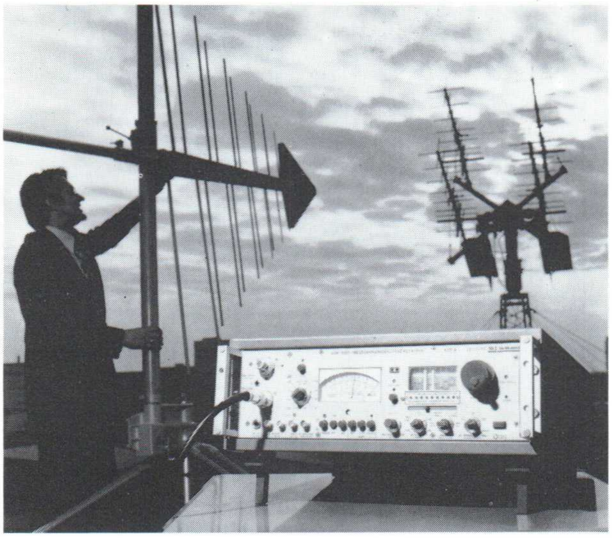
IEC-bus Adapter as individual unit

IEC-bus connector	24-way, female
Connectors for ESU 2 and EZK	three 50-way, female
Working temperature range	0 to +50 °C
AC supply	115/125/220/235 V (30 VA)
Dimensions, weight	
19″ cabinet model (design 80)	492 mm × 161 mm × 514 mm, 11 kg
19″ rackmount	483 mm × 133 mm × 506 mm, 10 kg
Order designation	► IEC-bus Adapter ESU 2-Z4
19″ cabinet model	253.3012.02
19″ rackmount	253.3012.03

Field-strength meters and receivers

Magnetic field strength (A/m) and electric field strength (V/m) are measured in practice in V/m or µV/m or in dB(µV/m). The electric and magnetic fields are related according to $E = HZ_0$, where $Z_0 = \sqrt{\mu_0/\varepsilon_0} = 120\pi\Omega$ is the field characteristic impedance of free space.

The measurement of electric or magnetic field strength is reduced to a voltage or power measurement by means of a calibrated antenna. The calibrated test receivers[1]) employed here can also be used for other measuring and monitoring purposes.



VHF-UHF Field-strength Meter HFU 2 for propagation measurements, measurement of radiation patterns and interference field strength

[1]) Special-purpose receivers (HF, VHF and UHF ATC, VHF and TV relay reception) are described in separate data sheets.

The antennas used at frequencies below 30 MHz are broadband. The dimensions are small compared to the wavelength. The electric field strength is measured with rod antennas of constant length and the magnetic component with loop antennas. To improve the accuracy, the loop antennas are included in the calibration of the field-strength meter. At higher frequencies (above 25 MHz) tuned antennas with broadband characteristics (dipoles or log-periodic antennas) are used. Probes of small dimensions are suitable for determining field configurations.

The test receivers are selective heterodyne receivers with switch-selected bandwidth. The built-in standardizing oscillator allows a voltage calibration of the receiver at any frequency. Switch-selected attenuators in the IF section and at the receiver input extend the meter range, which is calibrated in dB. Linear indication covering 20 dB or logarithmic indication over 40 or 60 dB can be switch-selected. Test receivers meet stringent requirements in regard to far-off selectivity, rejection of spurious responses and stray fields. In addition to a recorder output, AF and IF outputs are provided for the connection of interpreting equipment, such as analyzers, panoramic units or oscilloscopes.

In conjunction with a radio interference indicator, **interference field measurements** complying with VDE 0876 or CISPR recommendations can be carried out.

The Absorbing Clamp **MDS** (see page 185) in conjunction with a radio-interference measuring receiver permits radio interference power issued from the power cable of an interference source to be measured in the frequency range 30 to 300 (1000) MHz according to VDE 0875.

The **monitoring receivers** (section 8) need not provide for accurate measurement of input voltage or power. The switchable attenuators and the standardizing oscillator are omitted. On the other hand, the monitoring receivers feature high setting accuracy for the reception frequency and excellent stabilization of the AF output voltage at different input levels. Adequate selectivity and heavy rejection of spurious responses and intermodulation preclude errors in observation. IF and AF outputs allow the connection of accessories for the evaluation of the received signal.

Frequency range	Designation	Type	Order No.	Voltage range	Field-strength range	Antennas	See also page
0.1 to 30 MHz	Field-strength Meter Clamp-on RF Current Probe	HFH —	100.1014.02 100.1050.02	0 to 120 dB (0.1 µV) (0.1 µV to 0.1 V) 0.1 µA to 0.1 A	0 to 120 dB (µV/m) (1 µV/m to 1 V/m) —	3 loop antennas 1 rod antenna —	181
25 to 300 MHz	VHF Field-strength Meter	HFV	203.6018.02	0 to 100 dB (µV) (1 µV to 0.1 V)	3 to 121 dB (µV/m)	< 60 MHz sh. dipole > 60 MHz tun. dipole	182
25 to 1000 MHz	VHF-UHF Field-strength Meter	HFU 2	253.0013.55	−10 to +120 dB (µV)	−7.5 to +143 dB (µV/m)	broadband dipole log-periodic antenna	184

Field-strength Meter HFH
♦ 0.1 to 30 MHz

- Uses: propagation measurements, radio monitoring, testing of shieldings, selective measurement of very small voltages
- Wide measurement range (120 dB), accuracy complying with CCIR recommendations
- Switch-selected peak- and average-value modes;
  IF bandwidths 100 Hz/500 Hz/4 kHz

HFH

The **Field-strength Meter HFH** measures the field strength of distant transmitters, the radiation field of antennas and the radio-interference field of electric appliances and systems. It can also be used as a monitoring receiver and, without the antennas, as a tunable microvoltmeter. Accessory equipment permits the observation and recording of field strength as a function of time, and also of the occupation of frequency bands by stations and of the power distribution in the frequency band of a transmitter.

The HFH is especially suitable for measuring wave propagation, for radio monitoring, determining the radiation pattern and efficiency of antennas, testing shieldings and measuring very small voltages in the laboratory.

Included in the delivery are one test receiver, three (rotatable) loop antennas, one rod antenna with counterpoise, one inductive and one capacitive probe, one carrying case which can also be used as a table, and cables. The broadband Loop Antenna 100.1037.02 can be supplied extra for operation at a distance from the receiver, making it suitable for mobile radio monitoring.

Characteristics. Division of the frequency range into ten subranges and a built-in standardizing oscillator (500-kHz calibration points) ensure good and reliable setting accuracy of the receiver. The meter can be operated with AFC in the frequency ranges above 0.8 MHz. An external frequency synthesizer can be used in lieu of the local oscillator for recordings over a long period of time. A switch permits any of three IF bandwidths to be selected.

The Field-strength Meter HFH gives direct reading of the field strength in dB(μV/m) or the voltage in dB(0.1 μV). Indication range: linear 20 dB, logarithmic 40/60 dB; total measurement range: 0 to 120 dB(μV/m) or 0 to 120 dB(1 μV). The indication is switchable from average value to peak value (slide back). Bandwidth is also switch-selected. BFO; input for external oscillator; outputs for 1st and 2nd IF; headphones and loudspeaker outputs; output for recorder.

Clamp-on RF Current Probe for the HFH. In combination with the RF Current Probe, the HFH permits measurements of currents in the frequency range from 0.1 to 30 MHz.

The Clamp-on RF Current Probe serves as current transformer and surrounds the live conductor during measurement (dia. < 13.5 mm).

Specifications

Field-strength Meter HFH

Frequency range	0.1 to 30 MHz, 10 subranges
Scale discrimination	0.4 to 19 kHz/mm
Measurement range (10-dB steps)	0 to 100 dB
Field-strength measurement	0 to 120 dB(μV/m)
Selective voltage measurement	0 to 120 dB(0.1 μV)
Meter ranges	lin 0 to 20 dB log 0 to 40/60 dB
Type of indication, switch-selected	average or peak value
Error of indication	
Field-strength measurement	
using loop antenna	< ±1.5 dB
using rod antenna	< ±2 dB
Voltage measurement	< ±1 dB
Input impedance	60 Ω
IF bandwidth (3 dB)	±100/500/4000 Hz
Outputs	
IF I	460 kHz or 1.65 MHz, depending on frequency range selected
IF II	62 kHz
Recorder output	−3 V ±10% at fsd on meter
Headphones	Z_i = 4 kΩ
Loudspeaker	Z_i = 15 Ω
Inputs	a) external control voltage, max. −3.5 V b) external oscillator: 60 Ω, approx. 0.5 V
Beat-frequency oscillator	800 Hz, switch-selected
Power supply	AC: 115/125/220/235 V +10/−15% Battery: 12 V ±10% (6 A)
Dimensions, weight	430 mm × 358 mm × 440 mm, 45 kg
Order designation	▶ Field-strength Meter HFH 100.1014.02
Accessories supplied	1 carrying case for accessories, can be used as table
Recommended extras	Loop Antenna HFH-Z 0.1 to 30 MHz, 100.1037.02, Clamp-on RF Current Probe 100.1050.02

Clamp-on RF Current Probe HFH-Z

Frequency range	0.1 to 30 MHz
Measurement range with HFH	0.1 μA to 0.1 A
Measurement error	< ±1.5 dB
Order designation	▶ Clamp-on RF Current Probe HFH-Z 100.1050.02

HFV

VHF Field-strength Meter and Test Receiver HFV

♦ 25 to 300 MHz

- Frequency range covered in one band
- Measurement range 0 to 100 dB(μV); indication range log 60 dB, lin 20 dB; peak- and average-value modes
- Interference measurement according to VDE and CISPR (with Pulse Weighting Unit)

The selective instrument HFV for 25 to 300 MHz is available in three models to suit different applications (models 02/03, 04, 05; see ordering information):

Field-strength meter	with rotatable and tiltable dipole, with optional Pulse Weighting Unit
Test receiver	for selective measurements, especially in cable TV systems, with dipole, 75 Ω input
Test receiver	for radiomonitoring and selective laboratory measurements, 50 Ω input, IF bandwidth 36 kHz, squelch

The main characteristics such as frequency range, voltage range, demodulation, etc. are the same for the three models, only the application-oriented data for bandwidth, input impedance and interference weighting and the equipment configuration differ.

The VHF Field-strength Meter HFV (models 02 and 03) with dipole antenna is used for measurements of radio-signal propagation and of interfering fields existing in the particular service area. Its high performance makes it also suitable for laboratory use as a selective microvoltmeter for absolute and relative measurements. Input impedance 50 Ω.

HFV with dipole antenna

A dipole which may be tilted and rotated, with a coaxial feeder, is used as **antenna** for field-strength measurements. It operates as a shortened dipole between 25 and 60 MHz and as a tunable halfwave dipole from 60 to 300 MHz. Field strength is determined from the indicated voltage with the aid of an antenna-factor curve.

The **test receiver** – a heterodyne receiver with high IF – is tunable through the whole range without band switching. Adequate faroff selectivity is ensured by the selective input and by a bandpass filter. A crystal filter with a 6-dB bandwidth of 120 kHz (36 kHz for model 05) is provided in the second IF stage. A substantially low-distortion reproduction of FM broadcasts is thus also possible. A built-in pulse generator supplies pulses of 100 Hz repetition frequency with constant amplitude up to 300 MHz, permitting voltage calibration at any frequency.

Measurement ranges and signal evaluation. The instrument indicates the average and peak values of the IF signal over a linear range of 20 dB or a logarithmic range of 60 dB. With the 8 × 10 dB attenuator, the linear indication covers an overall range of 100 dB. Average-value indication is used to measure AM and FM signals. Peak-value measurement allows, for example, the sync-peak rms value of the picture carrier in TV signals to be indicated independent of the picture information. Furthermore, signals from pulse-modulated transmitters and interfering signals can be measured. The 10.7-MHz IF output allows observation on an oscilloscope. The AF and recorder outputs provide more possibilities for the evaluation of AM and FM signals.

Pulse Weighting Unit. The Field-strength Meter is available with or without Pulse Weighting Unit. In conjunction with this accessory, the HFV presents the overdriving capacity required according to VDE 0876 and CISPR Publ. 2 and complies with the tolerances admitted for bandwidth and weighting (attenuation adjustable in 5-dB steps). Weighted **measurements of interference field strength** and – with the Absorbing Clamp MDS (see page 185) – **measurements of radio interference power** complying with VDE 0875 are possible.

RF current measurements from 0.1 μA to 0.1 A can be carried out in conjunction with the Clamp-on RF Current Probe at frequencies from 25 to 300 MHz.

Test receiver for cable-TV systems

The portable VHF Test Receiver HFV (model 04) with input impedance of 75 Ω is suitable for all selective measurements, in particular in **cable-TV systems.** It can measure throughout the VHF range.

High resistance to overdriving of the RF input stages. Suppression of intermodulation by more than 70 dB in conjunction with the preselection enables measurements in cable-TV systems with all carriers present; the IF bandwidth of 120 kHz provides good selectivity in FM channels.

Switched modes of indication. The instrument's meter can be switched for peak or average indication of the measured signal voltage. With peak response the rms of the picture carrier of TV signals can be measured at sync peak independently of the picture content. The average response plus high sensitivity simplify noise measurements, the measured values being corrected to the system bandwidth (e.g. addition of 15.2 dB for 4 MHz).

Use with dipole antenna. The dipole antenna that is supplied with the instrument enables radiation measurements on cable-TV systems, the good linearity of the HFV preventing errors caused by intermodulation and the average response errors resulting from pulsed interference.

Accessories for evaluation. By connecting suitable instruments for frequency analysis to the IF output (2nd IF 10.7 MHz) it's possible to evaluate intermodulation and cross-modulation products in a channel. The video output, with its 10-dB overscale linearity, can be used for oscilloscope analysis of hum modulation.

Test receiver for radiomonitoring. HFV model 05 is used for reception of AM and FM signals. With an IF bandwidth of 36 kHz it is particularly suitable for operation in particular channels. Logarithmic indication over 60 dB, a switch-selected squelch and AFC are ideal features for radiomonitoring. A built-in calibration oscillator together with linear indication facilitates the accurate measurement of received signals. A halfwave dipole is supplied with the set for accurate determination of field strength.

Laboratory use (applies to all models). In the laboratory the HFV is suitable as a selective microvoltmeter. The circuitry is designed to ensure good suppression of spuriae and intermodulation. RF currents can be measured with the aid of the RF Current Probe ESU-Z (see recommended extras).

The **power supply** of the HFV is either from a local AC supply or from the built-in battery (about 7 hours of operation, charging time about 14 hours).

Specifications

Frequency range ... 25 to 300 MHz
Setting error (temperature range +10 to +30 °C) ... $< \pm 5\times10^{-3}\times f_{in} \pm 500$ kHz
Scale resolution ... 300 kHz/mm
AFC ... switch-selected

Antenna
25 to 60 MHz ... shortened halfwave dipole
60 to 300 MHz ... tuned halfwave dipole

Input impedance
Models 02, 03 ... 50 Ω
04 ... 75 Ω
05 ... 50 Ω
VSWR
Level switch position < 20 dB ... 2 (typical)
≧ 20 dB ... < 1.25

IF/bandwidths/interference rejection
1st IF ... 400 MHz
2nd IF ... 10.7 MHz
6-dB bandwidth models 02, 03 ... 120 kHz ±10%
04 ... 120 kHz ±10%
05 ... 36 kHz ±2 kHz
IF rejection ... > 80 dB
Image rejection ... > 80 dB
RF leakage with battery op. ... indication < 3 µV
Oscillator reradiation at RF input with match-termination ... < 30 µV

Measurement range, indication
Measurement range, linear
Voltage ... 0 to 100 dB(µV)
Field strength, minimum 50-Ω model 3 to 23 dB(µV/m)
75-Ω model 1.5 to 22 dB(µV/m)
maximum 50-Ω model 103 to 123 dB(µV/m)
75-Ω model 101.5 to 122 dB(µV/m)
Measurement range, logarithmic ... 0 to 130 dB(µV)
Measurement error
Voltage measurement ... < ±2 dB
Field-strength measurement ... < ±4 dB
Indication ... average/peak, switch-selected
Range lin. ... 20 dB
log. ... 60 dB

Demodulation ... AM/FM, switch-selected
Squelch ... only in model 05, switch-selected

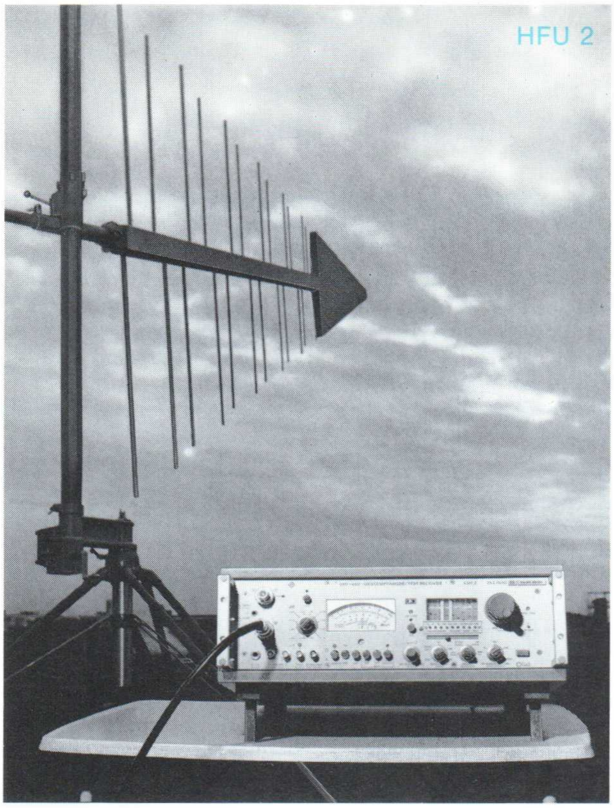
Outputs
IF ... 10.7 MHz, Z_{out} = 50 Ω
Video (only models 04, 05) ... 0 to 16 kHz, Z_{out} = 100 kΩ
Phones ... Z_{out} = 15 Ω
Loudspeaker ... built-in, switch-selected

General data
Power supply AC supply ... 110/115/125/220/235 V +10/−15%, 47 to 63 Hz (10 VA)
Battery ... 10 NiCd cells RS 1.8 (IEC KR 26/50)
Charging ... built-in charging circuit, charging time 14 hrs
Dimensions
without leather case ... 367 mm × 113 mm × 270 mm
with leather case ... 428 mm × 135 mm × 294 mm
Weight (with antenna, battery, leather case) ... 9.5 kg

Order designations
Field-strength Meter ... ▶ VHF Field-strength Meter HFV
without Pulse-weighting Unit ... 203.6018.02
with Pulse-weighting Unit ... 203.6018.03
Test Receiver ... ▶ VHF Test Receiver HFV
for CATV measurements ... 203.6018.04
for radiomonitoring ... 203.6018.05
Accessories supplied ... dipole antenna, tape measure, antenna-factor curve, leather case, power cable

Recommended extras ... Headphones HFV-Z 204.0220.00
DEAC cell 020.3805.00 (10 required)
Clamp-on RF Current Probe ESU-Z 100.1137.02
Cable for current probe 204.1090.02
Probe HFV-Z 204.1010.02

VHF-UHF FIELD-STRENGTH METERS



VHF-UHF Field-strength Meter HFU 2
♦ 25 to 1000 MHz

- Test assembly for measurements of propagation characteristics and coverage, antenna patterns and radio interference with CISPR and VDE weighting
- Two broadband antennas covering the whole frequency range
- Programmable field-strength measurement; wide range: −7.5 (+13) to +122.5 (143) dB(μV/m); generator output for field calibration

The **VHF-UHF Field-strength Meter HFU 2** is equally suitable for signal- and interfering-field-strength measurements and for radio monitoring (radio reconnaissance). It consists of

VHF-UHF Test Receiver ESU 2 (see page 174),
two broadband antennas,
antenna mast and accessories.

The Test Receiver ESU 2 (for description see page 174) constituting the heart of the system, allows automatic calibration of its voltage indication at any frequency within one second.

It performs

measurement and demodulation of AM and FM signals,
measurement of sync-peak effective carrier power of TV signals with negative modulation,
measurement of pulse-modulated signals.

The ESU 2 has three switch-selected IF bandwidths (15/120/300 kHz) and the following connection facilities for signal evaluation:

three IF outputs (one for the Panoramic Adapter EZP),
DC-coupled demodulator outputs for AM and FM,
AF output for loudspeaker or phones,
frequency and level outputs for recorders.

The meter has a linear range of 20 dB and a logarithmic range of 60 dB. Logarithmic indication is particularly suitable for long-term recording of heavily fluctuating fields.

Antennas. Dipole of constant length for frequencies from 25 to 80 MHz; the antenna input impedance is compensated over this range. Above 80 MHz: log-periodic broadband antenna with 6.5 dB gain over the full range. A smaller log-periodic antenna for 450 to 2500 MHz and with similar characteristics is additionally available.

The antenna height on the mast can be adjusted from 1 to 3.6 m; the azimuth and polarization plane are freely adjustable; the elevation angle can be varied by ±30° from the horizontal plane.

Field-strength measurement. Field strength in dB(μV/m) is obtained by adding the antenna factor k and the measured voltage in dB. Programmed field-strength measurement is also possible with the HFU 2.

Antenna patterns. The standard voltage of 80 dB(μV) across 50 Ω which is available at an ESU 2 output replaces a signal generator in the measurement of antenna patterns.

Interference field measurement. The HFU 2 is a standard instrument for radio interference measurements in line with W.-German specifications (VDE) and international recommendations (CISPR). A weighting filter for measuring pulse interference according to standards is incorporated in the receiver.

Accessory units, such as Frequency Controller, Panoramic Adapter and Recorder extend the range of applications; see under ESU 2, page 174.

Specifications

Frequency range	25 to 1000 MHz/20 to 1000 MHz[1])
Measurement range	
Lower limit	−7.5 to +13 dB(μV/m) } frequency-dependent
Upper limit	+122.5 to +143 dB (μV/m) } frequency-dependent
Measurement error	< ±3 dB including antenna
Test receiver	VHF-UHF Test Receiver ESU 2 (p. 175)
Frequency range	25 to 1000 MHz in 9 subranges
Antenna input	50 Ω; N female connector, adaptable
Measurement range	−10 to +120 dB (μV)
Measurement error	≦±1 dB
Antennas	
Broadband dipole 25 to 80 MHz	
Connector	50 Ω; N female connector, adaptable
VSWR	<2
Antenna factor k	7.5 to 14 dB (frequency-dependent)
Dimensions, weight	length 3 m, knocked down 0.8 m, 2.5 kg
Log-periodic broadband antenna HL 023 for 80 to 1300 MHz	
Connector	50 Ω; N female connector, adaptable
VSWR	< 2 (up to 1000 MHz)
Antenna factor k	2.5 to 23 dB in range 80 to 1000 MHz, frequency-dependent
Dimensions, weight	length 1.7 m, width 2 m, knocked down 1.7 m × 0.5 m, 6 kg
Antenna mast (epoxy glass)	
Adjustment ranges	
Antenna height	1 to 3.6 m
Polarization	any
Azimuth	any
Elevation	±30°
Dimensions, weight	length 1.65 m (knocked down); 20 kg (incl. accessories)
Tripod	length 0.9 m, dia. 0.22 m (knocked down), 9 kg
Order designation	► VHF-UHF Field-strength Meter HFU 2 253.0013.55
Special model 20 to 1000 MHz	HFU 2 253.0713.99

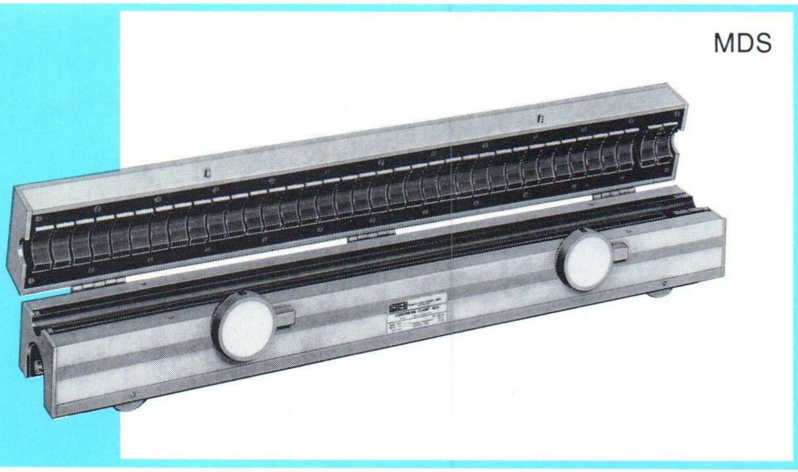
System breakdown (delivery of individual items also possible)

VHF-UHF Test Receiver ESU 2 with power and battery cables and Battery Unit	see p. 174
Broadband Dipole HFU 2-Z1, 25 to 80 MHz	253.0113.55
Log-per. Broadband Antenna HL 023, 80 to 1300 MHz	465.8716.55
Tripod HFU-Z	100.1114.02
Mast with swivel arm and antenna bracket, HFU-Z	100.1120.02
RF Connecting Cable HFU 2-Z3, 5 m long	252.0103.55
Headphones	110.2959.00

[1]) A model with slightly restricted specifications is available for 20 to 1000 MHz.

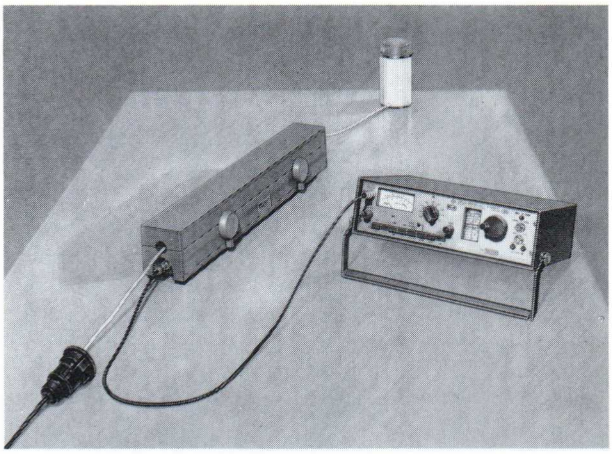
Absorbing Clamps
MDS-20 MDS-21
♦ 30 to 300 MHz ♦ 30 to 1000 MHz

- Direct measurement of RF interference power on power cords and connecting cables of electrical appliances
- Meter reading in dB(μV) on interference measuring receiver corresponds to RF interference power in dB(pW)



Measurement of interference power in the VHF range

For perfect reception of radio and television signals, interference from electrical appliances must be kept within certain limits. The amount of interference from an interference source is expressed in terms of voltage, power, current or field strength. On account of direct radiation, the interference in the metric-wave range has up to now been defined as the field strength prevailing at a certain distance. The reliability of this rather inconvenient measurement depends on numerous parameters. The development*) of an absorbing clamp offers a considerably simplified measuring method.



Test setup consisting of VHF Field-strength Meter HFV and Absorbing Clamp MDS-20 for the measurement of interference power

The **Absorbing Clamps** MDS-20 and MDS-21 in conjunction with an interference measuring receiver according to CISPR, Publ. 2, e.g. HFV, permit the interference to be measured directly as the noise power introduced by the interference source in the power cord. Measurements with the MDS Absorbing Clamps are easier and more reliable than field-strength measurements. Moreover, the Absorbing Clamp is insensitive to external radiation.

Operating principle and functioning. Interference is mainly radiated from the power cord of the interference source. For this reason, a ferrite absorber is provided inside the MDS Absorbing Clamp, which encircles the power cord and acts as a resistance to the RF interference power. A calibrated interference measuring receiver, connected to the input, measures the RF current flowing through the absorber via a current converter. Because, with this arrangement, there is no matching between the interference source, the power cable and the absorber, the Absorbing Clamp must be slid along the power cord to adjust for maximum interference power. By suitable design of the absorber and choice of the conversion ratio of the current converter, the reading obtained on the calibrated interference-measuring receiver in dB(μV) corresponds to a power indication in dB(pW).

Construction. The units consist of a plastic case of two parts hinged together, each containing a set of ferrite ring halves. These are fixed in plastic spring holders, thus forming a duct for the power cord of the interfering appliance. Eccentric catches provide the required contact pressure. Rollers are provided to facilitate moving the Absorbing Clamp when searching for interference maxima.

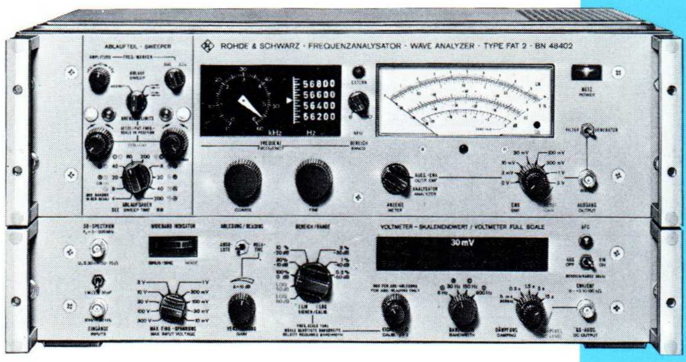
MDS-21 version up to 1000 MHz. In comparison to the MDS-20, this unit has an additional shield and makes use of a correction curve. As a result, radio-interference measurements up to 1000 MHz are possible on lines and cables.

Specifications

Diameter of appliance power cable	up to 20 mm	
Dimensions, weight	610 mm × 115 mm × 80 mm, 6.3 kg	
Order designations	► Absorbing Clamp	
	50 Ω	60 Ω
MDS-20 (30 to 300 MHz)	203.4421.50	203.4421.60
MDS-21 (30 to 1000 MHz)	194.0100.50	—
Accessories supplied	1 coaxial cable (MDS → interference receiver), 5 m long, with BNC male connectors for 50 Ω and 1 × BNC, 1 × Dezifix B for 60 Ω; 1 calibration curve	

*) after Meyer de Stadelhofen (Switzerland)

FAT 2



Wave Analyzer FAT 2
♦ 10 Hz to 60 kHz

- 10 sweep speeds within any frequency limits
- Dynamic range of 80 dB; two accurate logarithmic scales
- Sideband measurements up to 500 MHz by additional mixing

The **Wave Analyzer FAT 2** is used for the measurement of distortion and mixer products, noise investigations, measurement of frequencies, voltages or frequency response and for all kinds of spectral measurement problems (SSB measurements, two-tone modulation, measurement of harmonics and non-harmonic spurious components).

FAT 2 is ideal for measuring AC supply harmonics according to DIN EN 50 006/VDE 0838, as it can be connected direct to the power line or the unit under test if the relevant protective measures are taken. For a 50-Hz AC supply, for example, harmonics up to n = 40 (i.e. 2000 Hz) can be measured with 6 Hz test bandwidth.

Two logarithmic voltage ranges. Logarithmic representation saves time and is, moreover, necessary for the display of a spectrum. FAT 2 has been provided with two logarithmic ranges.

Tracking generator for frequency-response measurements and for use of analyzer as a tunable filter. A tracking generator for selective frequency-response measurements forms part of the standard equipment of heterodyne-type wave analyzers. The tracking generator of FAT 2 comprises a step attenuator, potentiometer and output voltmeter and together with the display section constitutes a complete test assembly for selective frequency-response measurements with absolute or relative readings.

Perfect recording. The analyzer, sweeper and recorder form a functional unit which permits accurate recording of spectrograms and frequency curves.

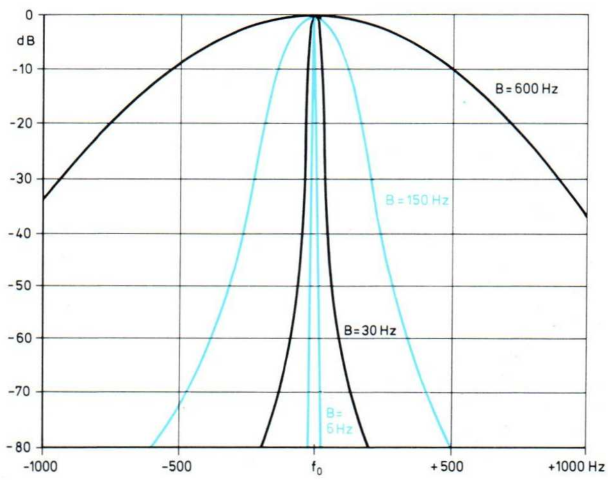
Special features of FAT 2

Two inputs extending the field of application. FAT 2 is provided with a second input, which is taken to an additional mixer operating up to 500 MHz and permitting the conversion of narrow frequency bands down to the input range of the analyzer. Sideband analyses are thus possible with highest resolution.

Dynamic range of 80 dB. Harmonics and modulation products can be measured down to 0.01%.

Rapid and accurate frequency setting. The frequency is selected rapidly and reliably. A coarse and a fine scale offer simple readings with high resolution. The high scale accuracy can be checked in 1-kHz increments by a crystal-controlled calibration spectrum.

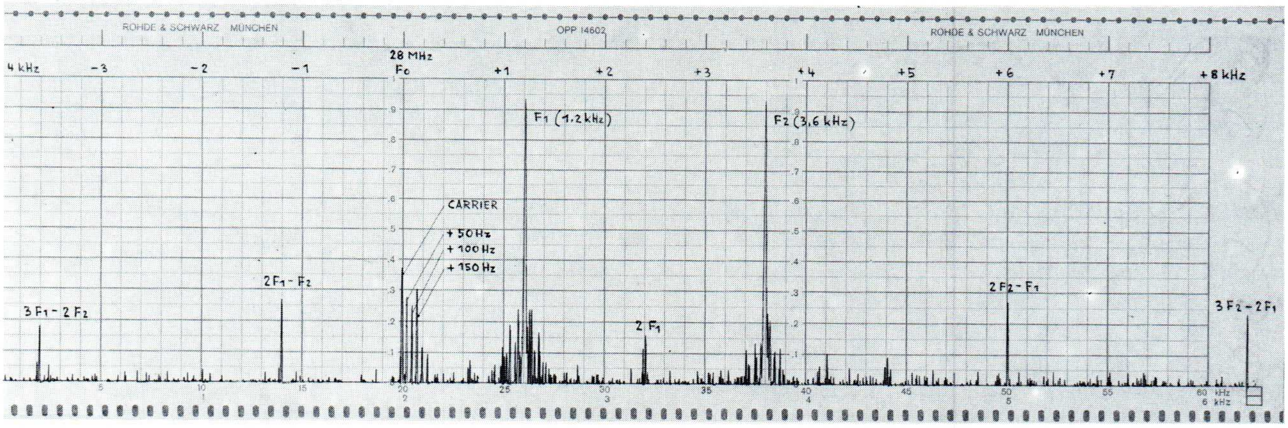
Staggered bandwidths. FAT 2 contains four bandpass filters between 6 Hz and 600 Hz, see diagram on the right. A bandwidth of less than 6 Hz does not seem useful in view of the transient response of the filter, as sweep time increases as the square of 1/B and would become impracticable.



Selectable bandwidths of FAT 2

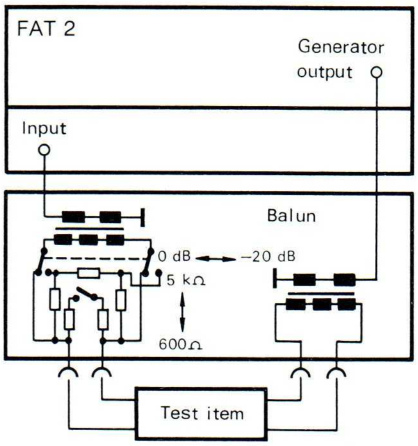
Example of application

Sideband analysis up to 500 MHz. Sideband analyses are primarily used for evaluating transmitters. This involves the measurement of the components obtained from useful and spurious modulation and, in addition, the spectral components lying outside the transmitting channel, such as the vestigial sideband and the residual carrier in single-sideband operation. The distortions within the channel are determined by measuring the intermodulation products. The sideband analysis using the Wave Analyzer FAT 2 offers an extremely high frequency resolution.



Two-tone modulation of SSB shortwave transmitter. The spectrogram shows the suppression of carrier and single sideband, distortion products, hum and noise modulation as well as basic noise. The recording was made with FAT 2.

Balun for FAT 2. The analyzer can be supplied with a balun for measurements on balanced test items, comprising an output balun and an input balun. The balanced input with switch-selected input impedance is provided with a balanced input attenuator. It permits distortion measurements even at high voltages.



Simplified diagram of balun

Specifications of Balun

Output balun (from tracking generator of FAT 2)

Turns ratio	1:1
Output impedance	600 Ω
Frequency response	≦1% from 10 Hz to 60 kHz
Common-mode rejection	> 80 dB (up to 20 kHz)

Input balun (to test input of FAT 2)

Turns ratio	1:1 (without input attenuator)
Input impedance	600 Ω or 5 kΩ, switch-selected
Balanced input attenuator	20 dB (can be switched off)
Frequency response	≦1% from 10 Hz to 20 kHz (at 60 kHz: ±1.5 dB)
Common-mode rejection	> 80 dB at 1 kHz; > 60 dB at 10 kHz
Distortion at 20 Hz	
without input attenuator	< 0.1% at 5 V
with 20-dB input attenuator	< 0.1% at 50 V
Max. permissible DC voltage	250 V

General data

Dimensions, weight	484 mm × 105 mm × 436 mm, 6.2 kg
Order designation	► Balun FAT-Z 218.9018.02

Specifications

Frequency range; resolution I	10 Hz to 6 kHz; 5 Hz/div.
II	10 Hz to 60 kHz; 50 Hz/div.
Error limits of indication	±(0.3% +5 Hz)
Calibration spectrum	1-kHz spacings
Bandwidths (3 dB)	6/30/150/600 Hz ±10%
AFC, hold-in range (2%)	>±18 Hz (B = 6 Hz) >±120 Hz (B = 30 Hz)
Input I	1 MΩ‖30 pF
Scale range lin (fsd)	30 µV to 300 V (15 subranges)
log (can be shifted)	50/80 dB (1 µV to 300 V)
Dynamic range	80 dB
Hum	> 80 dB
Distortion / S/N ratio	> 86 dB/ > 90 dB
Input II	additional mixer for SB analysis 0.2 to 200/5 to 500 MHz, display range ±30 kHz
Outputs	
DC output	0 to +3 V, adjustable
Damping	5 ms/0.3/1.5/5/15 s
IF output (80 kHz)	1 V/10 kΩ
Tracking generator	
Output for filtered input signal	0.1 mV to 3 V from 600 Ω; 10-dB attenuator and fine adjustment; EMF indication
Sweeper	
Sweep time for full range	adjustable: 4/8/20/40/80/200 s 8/20/40/200 min
Frequency limits (start/stop)	adjustable
Frequency markers (2 scales)	±1 V, continuously adjustable
X output	0 to −8 V
Recorder output	for connection of recorder
General data	
Nominal temperature range	+10 to +35 °C
AC supply	115/125/220/235 V ±10%, 50 or 60 Hz (internal changeover); 55 VA
Dimensions, weight	484 mm × 239 mm × 436 mm, 29 kg
Order designation	► Wave Analyzer FAT 2
FAT 2 int. mixer up to 500 MHz	100.8690.33
int. mixer up to 200 MHz	100.8690.35
Recommended extra	Balun FAT-Z (see left)

AMA

Precision AM Meter AMA
♦ 50 to 350 MHz/0 to 100%

- Precise modulation-depth measurement for testing and calibration of navigation and measuring equipment
- Selective measurement of modulation-frequency fundamental with switch-selected bandpass filter
- Easy checking of inherent accuracy by means of simple instruments

The **Precision AM Meter AMA** performs modulation-depth measurements of highest precision, such as required for the calibration of communications, navigation and measuring equipment. Its own accuracy (see section 3) can be checked rapidly with the aid of relatively simple instruments, e.g. a digital voltmeter and AF generator. For the measurement, the AMA requires only a stable subcarrier, e.g. from a signal generator such as SMDU, SMDS or SMS.

The Precision AM Meter finds application with
calibration laboratories of airlines,
ATC authorities,
manufacturers of ILS and VOR transmitting/receiving equipment.

Wideband and selective measurement of modulation depth. Apart from wideband measurements at modulation frequencies up to 12 kHz, the AMA permits selective measurements at 30, 90, 150 and 9960 Hz (even if several signal components are present).

Indication. The AMA has two panel meters, meter I indicating modulation depths from 0 to 100% and meter II the deviation from the nominal depth of 20, 30 or 40%. With a measurement range of only ±2%, meter II permits rapid adjustment for nominal modulation depth at an extremely high resolution.

Specifications
(see also page 76)

Carrier frequency range	50 to 350 MHz
Input requirement	5 to 10 mV
Subcarrier (from signal generator)	test frequency ±30 kHz
Voltage requirement	0.5 to 1.5 V into 50 Ω
Modulation frequency range	10 Hz to 12 kHz
Switch-selected passband filters	30, 90, 150, 9960 Hz
Measurement range	
Meter I	0 to 100%
Meter II	
Nominal modulation m	20, 30, 40% (mid-scale)
Indication range Δm	±2%
Error limits of meter I	±(1% of rdg +1.5% of fsd)
Meter II at 30/90/150 Hz	±0.1 to 0.2% } with bandpass filter
at 9960 Hz	±0.2 to 0.4% } with bandpass filter
Ext. measurement (DVM)	
Range 10 to 98%	±1.5% of rdg for pure sinewave modulation
Range 18 to 42%	±0.25% of rdg with bandpass filter
AC supply	115/125/220/235 V ±10%, 44 to 440 Hz (10 VA)
Dimensions, weight	484 mm × 105 mm × 336 mm, 7.5 kg
Order designation	► Precision AM Meter AMA 211.4010.52

Recommended signal sources for subcarrier

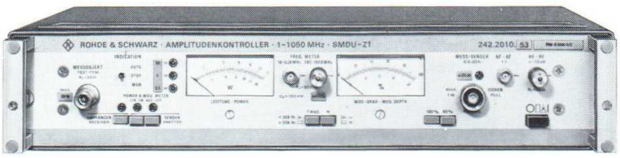
AM/FM Signal Generator SMDA	100.4559.04
Universal Signal Generator SMDU	249.3011.02
Decade Frequency Generator SMDS	154.8723.52
Signal Generator SMS	302.4012.02

AM Unit SMDU-Z1
♦ 1 to 1050 MHz/0 to 100%

- Simultaneous modulation-depth and power measurement
- RF outputs for connection of analyzer, oscilloscope, frequency meter, etc.
- Recorder outputs for modulation depth and power; AF output

The **AM Unit SMDU-Z1** permits simultaneous measurement of modulation depth in the ranges 40% and 100% as well as of RF power up to 30 W or 60 W (depending on the version) in five automatically selected ranges on all transmitters and power stages.

Integrated into the RT test assembly (see section 3), it is used for adapting the RT equipment to the test setup, to additional signal generators and evaluation units; switchover between transmitter and receiver measurements is automatic.



Specifications

Mod. depth measurement ranges	0 to 40/100%
Error limits	±(4% of rdg +1.5% of fsd)
Input power	0.1 to 30/0.2 to 60 W, depending on version
Modulation frequency range	25 Hz to 10 kHz
Power measurement ranges	0.05 to 0.3/1/3/10/30 W or 0.1 to 0.6/2/6/20/60 W
AC supply	115/125/220/235 V ±10%, 47 to 440 Hz (6 VA)
Dimensions, weight	492 mm × 118 mm × 434 mm, 8.5 kg
Order designations	► AM Unit SMDU-Z1
30-W version	242.2010.52
60-W version	242.2010.53

FMV

Frequency Deviation Meter FMV
♦ 20 to 300 (600) MHz

- Frequency deviation measurements (0 to 150 kHz) at modulation frequencies between 30 Hz and 75 kHz
- Indication of relative centre-frequency error of the transmitter up to ±100 kHz
- Internal deemphasis, switch-selected

The **FMV** is a high-grade test demodulator used for monitoring FM transmitters. The modulation-frequency measurement range between 30 Hz and 75 kHz also permits low-distortion demodulation of **stereo-modulated signals.** The instrument gives direct reading of the frequency deviation, of the amplitude modulation depth up to 30 (60)% for transmitters modulated by 30 to 15,000 Hz, and of relative centre-frequency errors up to ±100 kHz. Direct measurement with transmitter frequencies from 20 to 300 MHz; when using harmonics measurement possible up to and above 600 MHz. Stereo signals can be measured via a separate output in conjunction with the Standard Stereodecoder MSDC 2 (in separate catalog on VHF-sound and television broadcasting) or other instruments.

Specifications

Frequency range	20 to 300 MHz (up to 600 MHz with harmonics)
Frequency scale error	< ±1%
Input impedance	60 Ω
RF input voltage	10 to 25 mV (40 to 100 mV for AM)
Deviation indication	0 to 10/30/60/150 kHz
Modulation-depth indication	0 to 10/30/60%
Test output	Z_s < 30 (< 150) Ω, floating
Switch-selected deemphasis	50 µs
Multiplex output	unbal., earthed Z_s = 100 Ω
AC supply	115/125/220/235 V ±10%
Dimensions, weight	540 mm × 233 mm × 378 mm, 27 kg
Order designation	▶ Frequency Deviation Meter FMV 100.5932.02

FTZ

Direct-reading Distortion Meter FTZ
♦ 0.2 to 30%

- Frequencies: 40 Hz/1/5/15 kHz
- Direct reading – no bridge balancing required
- Connection facility for phones or oscilloscope

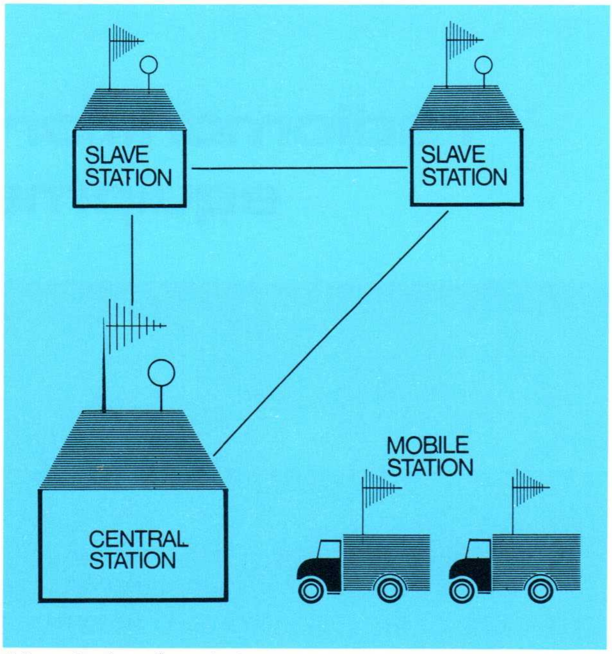
Distortion factors can be quickly and conveniently measured with the **Direct-reading Distortion Meter FTZ.** Measurements can be taken at 40, 1000, 5000, and 15,000 Hz and the results read directly from a meter. Measurement range 0.2 to 1/3/10/30%. Error ±5% of fsd. Permissible deviation of test frequencies from nominal value ±3% at 40 Hz, ±5% at the other frequencies. Impedance of balanced input: > 10 kΩ, permissible voltage 50 mV to 4 V. Impedance of unbalanced input: 1 MΩ shunted by 40 pF, permissible voltage 50 mV to 150 V.

General data

AC supply	115/125/220/235 V (40 VA)
Dimensions, weight	540 mm × 199 mm × 378 mm, 25 kg
Order designation	▶ Direct-reading Distortion Meter FTZ 100.6100.02

VHF-UHF Receiver ESM 2,
system-compatible special receiver
with remote-control capability
for radiomonitoring tasks;
details on page 194

radiomonitoring equipment



Schematic of a radiomonitoring network with central station, slave stations and mobile stations

Radiomonitoring

The continuing increase in the number of radio stations, the more frequent transmission of information and the longer operating hours of radio services all result in denser crowding of the frequency bands. Due to this development the technical requirements for frequency stability, occupied bandwidth, etc. of the radio stations have become more exacting. International conventions are necessary to guarantee the smooth functioning of worldwide radio communications.

A suitable legal basis for radiomonitoring was laid down by the International Telecommunications Union, which was acknowledged by the UNO in 1945.

Article 35 of the International Telecommunications Convention (Madrid 1932) states that all radiocommunications should be carried out without causing interference to those of other members of the Convention. With **Radio Regulations** the governments of the member countries undertook to ensure adherence to these conditions and to cooperate on an international basis.

In addition to the provisions of the ITU, all members are bound by regulations which deal with the administration of radio services and the technical requirements. Accordingly, technical test methods are to be used for international radio monitoring. Recommendations for the installation and equipment of radiomonitoring stations have been worked out by CCIR and published by ITU.

Complying with these recommendations, **Rohde & Schwarz designs and produces stationary and mobile systems** for radiomonitoring and radio observation in the frequency range of 10 kHz to 1.3 GHz (or higher if required).

These systems permit the following tasks to be carried out with all common types of modulation (amplitude and angle modulation):

- ▷ manual or automatic measurement and recording of frequency band occupancy
- ▷ very accurate measurement and recording of frequencies and frequency deviations (also with F3)
- ▷ taking fieldstrength measurements
- ▷ checking or determining the modulation of transmissions
- ▷ identification of radio signals by determining the direction of polarization or the point of emission
- ▷ measurement of coverage with mobile equipment.

Apart from installations based on conventional principles of operation, systems can be supplied which provide the required information (band occupancy frequency, field strength, type of modulation, etc.) by **program-controlled data acquisition** and **data processing in computers** (and suitable peripherals).

Remote frequency measurement

One of the most important tasks of radiomonitoring is the measurement of signal frequencies with the highest possible accuracy from a central receiving station. The high-precision Frequency Monitor GU 027 is available for frequency comparison and display.

The CCIR methods employed in GU 027 are:

Offset frequency method with AM (the difference signal formed by the unknown and the reference frequency is used as measure of the unknown frequency),

Intercarrier method with FM (the mean value of an auxiliary frequency formed by the unknown and the reference frequency is determined by an integrating counter),

Substitution method with FSK (the reference frequency is adjusted to equal the unknown frequency).

All have the advantage that the measurement accuracy depends only on the stability and accuracy of the reference frequency.

Frequency Monitor GU 027 with 6-digit frequency indication and CRT for the display of Lissajous figures, frequency markers and positions, FM spectra and levels

Accompanying the GU 027, the Signal Distributor GV 027 is used to select and combine antennas, receivers and reference signal sources, to adjust the levels of the antenna and reference signals and for aural monitoring. By harmonic generation it extends the range of the frequency synthesizer in the frequency measuring system to 1.3 GHz.

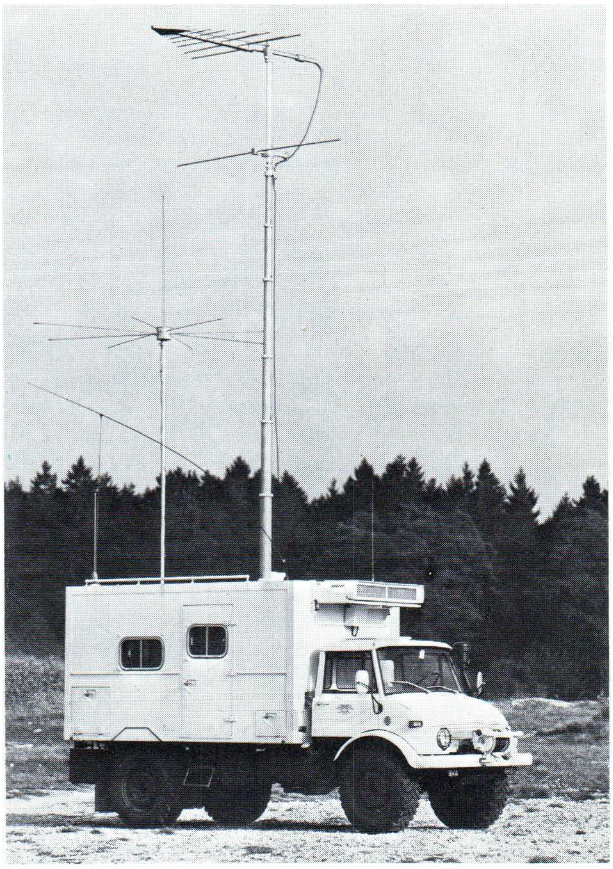
Radiomonitoring systems for stationary and mobile use
♦ 10 kHz to 1.3 (1.8) GHz

Antennas
Various antennas and antenna systems are available to suit particular frequency ranges and applications:
rod antennas, loop antennas, DF antennas,
log-periodic antennas (fixed and rotatable),
passive and active antennas for measurement and monitoring.

Air-conditioned test van with independent power source, equipped with two independent radiomonitoring positions for:
frequency and field-strength measurement, 10 kHz to 1 GHz,
TV monitoring in all bands,
RF and IF analyses, 6 kHz to 1.8 GHz,
band occupancy checks, 25 to 1000 MHz.

The test runs are calculator-controlled to a large extent; logging by telex, magnetic tape or recorder is possible. HF and VHF transceivers are provided for voice communication with the operations centre.

The receiving and evaluating equipment is completed by various active and log-periodic antennas including a 10-m mast.



Multicouplers and signal distributors
Up to 10 receivers can be operated from one antenna with the aid of multicouplers. Each of the receivers is supplied with the full energy picked up. Signal distributors are used for rapid switchover to the required antenna.

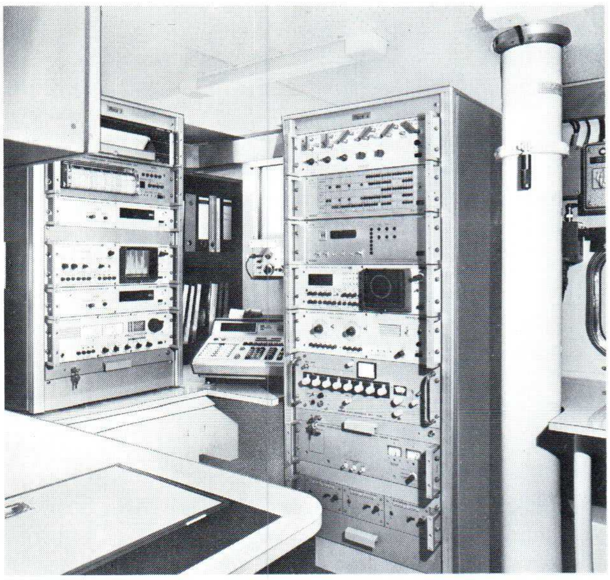
Receivers
The receiver best suited for the purpose at hand can be chosen from a great variety of types:
test receivers, radio communication receivers,
monitoring receivers, TV monitors.
Accessories: panoramic displays, telegraphy demodulators.

Measuring instruments and recorders
The following instruments are used for measurement and recording of the measured data:
frequency standards, frequency counters, spectrum analyzers, oscilloscopes, band-occupancy, XY and YT recorders, magnetic tape recorders, video recorders, teletypers.

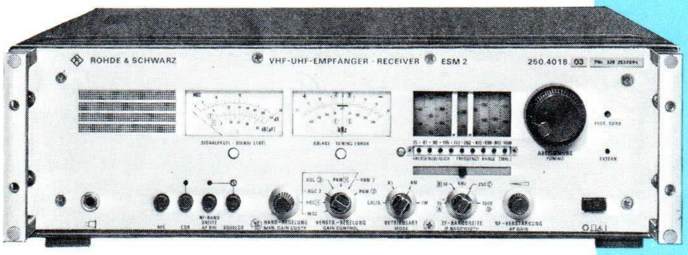
Equipment for special tasks
Complementary equipment may be integrated in the radiomonitoring system to obtain optimum solutions to special problems:
visual direction finders, emergency receivers, radio communication equipment.

In addition to the design and supply of complete radiomonitoring and radio-observation systems Rohde & Schwarz offers **training courses for operating staff** at the R&S training centre.

Interior of radiomonitoring test vehicle; left rack from bottom to top: VHF-UHF Receiving System ET 001 (with ESM 2, EZK and EZP), Frequency Controller EZK, Radiomonitoring Recorder ZSG 3 and YT recorder; right rack (from top): Antenna Splitter GV 061, two interface units, Signal Distributor GV 027, Frequency Monitor GU 027, Frequency Synthesizer ND 100 M, Atomic Frequency Standard XSR and multicoupler.



ESM 2



VHF-UHF Receiver ESM 2
♦ 25 to 1000 MHz

- Special receiver featuring a wide frequency range for use in radiomonitoring
- Excellent selectivity, imagefrequency and interference rejection
- System-compatible unit with centralized control logic permitting optimum adjustment in manual and remote operation

The **VHF-UHF Receiver ESM 2** has been especially designed for radiomonitoring. It features excellent noise performance and optimum intermodulation suppression and can be used as

separate search receiver or
part of a monitoring system.

Its particular advantages are:

- ▷ Wide frequency coverage with rapid frequency selection; AFC
- ▷ High input sensitivity – unambiguous evaluation of input signals as small as 1 μV
- ▷ Built-in demodulators for all types of modulation common in this frequency range
- ▷ Outputs for AM-video, FM-video and AF recording voltage for further evaluation
- ▷ Switch-selected variable carrier squelch for noise suppression during intermittent operation
- ▷ Carrier-controlled output (COR) for recording on a tape
- ▷ Switch-selected modes of gain control for optimum adaptation to the varying receiving conditions
- ▷ Added application possibilities by connection of accessory units, such as Frequency Controller EZK, Panoramic Adapter EZP, Ten-Channel Control Unit EZK-Z as well as Radiomonitoring Recorder ZSG 3.

In conjunction with the EZK and the EZP the ESM 2 constitutes the VHF-UHF Receiving System ET 001 (see page 198), which meets all requirements in the wide field of radio detection (similar to the Selective Test Equipment MSU on page 176).

Characteristics, function

Frequency setting and accuracy. The total range of 25 to 1000 MHz is divided into nine subranges which can be selected by means of a slide switch. The frequency is continuously adjustable on a drum scale without reversal of the sense of rotation, the resolution being for instance 100 kHz/mm in the lowest range. The internal 10-MHz crystal frequency spectrum permits recalibration of the subrange scales to achieve a setting error smaller than $\pm(1 \times 10^{-3} f_{in} + 100\ \text{kHz})$.

Frequency tuning with the coarse and fine drive is checked against the two moving-coil meters for tuning error and signal level and can at the same time be aurally monitored. Changing from one range to another is continuous and requires no reversal of sense of rotation. For each subrange a tuner with tracking preselection circuits is provided.

The ESM 2 can be supplied with a tracking oscillator permitting

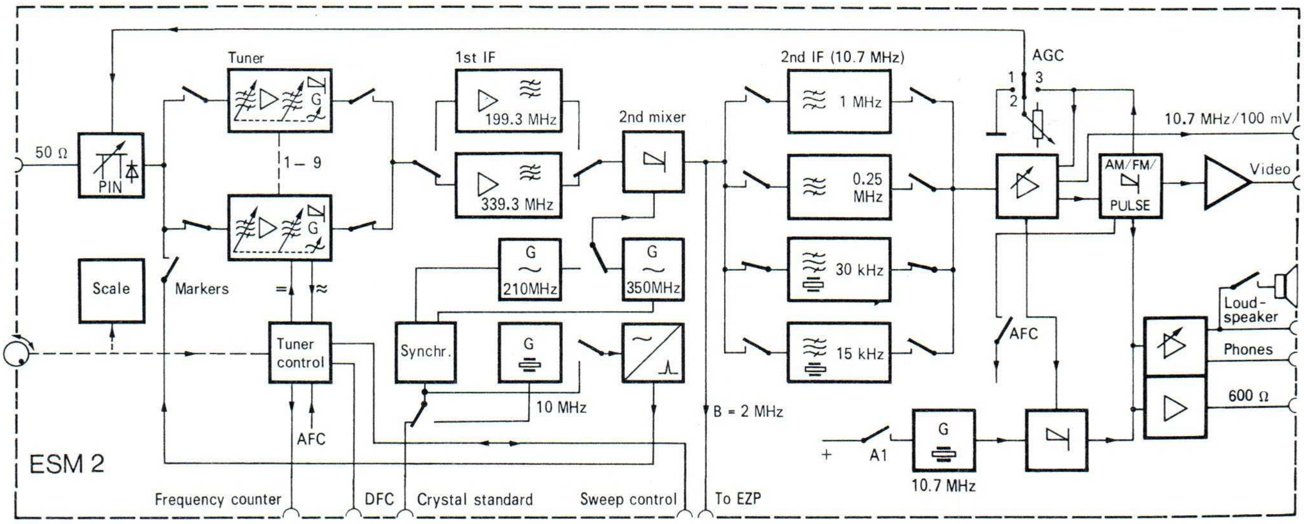
superposition of receiver-tuning marker on screen of panoramic display unit;
direct measurement of exact frequency of incoming signal by means of connected counter;
checking of complete receiving system;
generation of signals for DF testing.

Sensitivity, AGC. The noise figure is 8 dB up to 400 MHz and 10 dB up to 800 MHz. Thus input signals as small as 1 μV can be evaluated using the Panoramic Adapter. Depending on the input level, the ESM 2 can be set to automatic IF gain control – AGC 1, V_{in} reading 0 to 80 dB(μV); automatic RF-IF gain control – AGC 3, up to 120 dB(μV), additional RF input attenuation with PIN diodes; or combined gain control – AGC 2. In position MGC, the IF gain is manually variable by 80 dB.

Bandwidths. The fixed bandwidth of the 10.7-MHz signal for the Panoramic Adapter (after the second mixer) is 2 MHz. Four selectable bandwidths are provided for further signal evaluation: 1 MHz for broadband analysis, 250 kHz for FM broadcasting, 30 and 15 kHz for channel operation.

Demodulation, outputs. The VHF-UHF Receiver ESM 2 is suitable for AM, FM and pulse modulation and, in addition, has a video output, e.g. for subcarrier processing. The AF section comprises a monitoring loudspeaker, a switch-selected AF filter, squelch, a carrier-controlled relay with adjustable hold time for tape recorder control (COR output), phones and recorder outputs.

For purposes of further evaluation a level-controlled IF output of 100 mV is available. The receiver features switch-selected **frequency and amplitude demodulation** or **A1 beating,** the latter being useful for recalibration of the scale or checking the indication of centre frequency on the tuning-error meter.



Block diagram of VHF-UHF Receiver ESM 2

Remote control. The ESM 2 is normally operated from its front panel. However, it is also possible to trigger all functions via the rear panel, for example in remote control. The operation of the unit is governed by central logic circuitry which prevents any incorrect or non-optimal settings.

Special features of receiver. Double-heterodyne receiver with range-dependent first IF; second IF = 10.7 MHz; tuned preselection; voltage-controlled frequency tuning; separate panel meters for frequency tuning error and signal level.

Specifications

Frequency range	25 to 1000 MHz
Subranges	24 to 42 MHz; 40 to 70 MHz; 67 to 110 MHz; 100 to 175 MHz; 170 to 270 MHz; 265 to 420 MHz; 410 to 605 MHz; 595 to 805 MHz; 800 to 1005 MHz
Frequency setting	range selection: slide switch tuning: coarse and fine drive for drum scale (length 2 m)
Resolution	100 kHz/mm (1 MHz/mm)
Setting error	$<\pm(1\times10^{-3} f_{in} + 100\ \text{kHz})$ after calibration
AFC	capture range ±30 kHz, lock range depending on subrange; disconnectible
RF input	Z_{in} = 50 Ω, N female connector, adaptable
VSWR	< 3
Noise figure up to 400 MHz	< 10 dB (typical 8 dB)
up to 1000 MHz	< 14 dB (typical 12 dB)
Input voltage indication	on meter, range switchover with AGC, max. 0 to 120 dB(μV)

Interference immunity

S/N ratio (V_{in} = 100 μV, m = 30%, div. = 10 kHz, f_m = 1 kHz)	40 dB (typical)
Image-frequency rejection	> 70 dB
IF rejection	> 80 dB
Intercept point (P_{in} for a_{d3} = 0 dB)	−2 dBm (typical)
Oscillator reradiation at RF input with 50-Ω termination	< 10 μV (typical 2 μV)

Intermediate frequencies

1st IF	199.3 MHz or 1st, 2nd and 6th range, 339.3 MHz for remaining ranges
2nd IF	10.7 MHz
3-dB bandwidths, switchable	15/30/250 kHz/1 MHz

Gain control AGC 1	IF control for $V_{in} \leqq$ 80 dB (μV)
AGC 3	RF-IF control for $V_{in} \leqq$ 120 dB (μV) (AGC of carrier or pulse peak)
MGC	IF control (20 dB lin scale)
AGC 2	combination of manual RF control and AGC 1

Demodulation	AM, FM, pulse modulation
Squelch	adjustable and disconnectible

Outputs

IF output	10.7 MHz, bandwidth see 2nd IF output EMF 100 mV, Z_{out} = 50 Ω
AF outputs	frequency range 50 Hz to 15 kHz
for loudspeaker (Z ≧ 8 Ω)	4 V_{rms} (Z_{out} ≈ 0 Ω)
for phones	4 V_{rms} (Z_{out} = 600 Ω)
AF filter	300 Hz to 3.3 kHz
Line connection (unbal.), P_{out}	0 to +6 dBm (Z_{out} = 600 Ω)
Video outputs	AM: 20 Hz to 500 kHz; FM: 0 to 500 kHz
Recorder outputs	for frequency: 0 to 10 V; for level: 5 V at fsd

General data

Nominal temperature range	0 to +40 °C
Shelf temperature range	−40 to +70 °C
AC supply	115/125/220/235 V +10/−15%, 47 to 440 Hz (60 VA)
Dimensions, weight	
19" bench model	492 mm × 161 mm × 514 mm, 25 kg
19" rackmount	483 mm × 132 mm × 508 mm, 22 kg

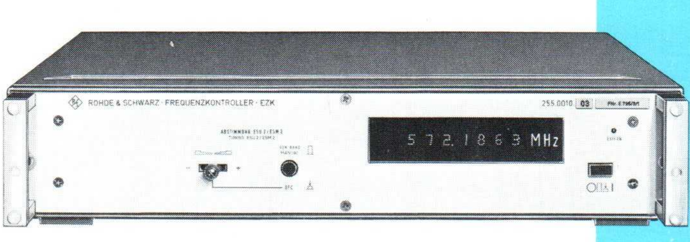
Order designations	▶ VHF-UHF Receiver ESM 2 Basic model	with tracking oscillator
19" bench model	250.4018.02	250.4018.06
19" rackmount	250.4018.03	250.4018.07

Accessories supplied: power cable, 2 50-pole connectors (Amphenol) for programming input and ESM 2 outputs

Recommended extras

Headphones	110.2959.00 (with plug PL 55)
Frequency Controller EZK	255.0010.02 or .03
Ten-channel Control Unit EZK-Z	255.3503.02 or .03
Panoramic Adapter EZP	254.0017.02 or .03
Radiomonitoring Recorder ZSG 3	242.6015.91
Patch cord EZP-ZSG 3	251.9488.00
XY Recorder ZSK 2	247.4010.04
XYT Recorder ZSKT	301.9010.02

EZK



Frequency Controller EZK

- Control unit for communication and test receivers up to 1000 MHz
- Digital readout of receive frequency (resolution 100 Hz), also with manual tuning (resolution 1 kHz)
- Quasi-continuous tuning, without range limitation, in three speeds – manual or external control

The **Frequency Controller EZK** in conjunction with a receiver, e.g. the ESU 2 or ESM 2, and a panoramic adapter, such as the EZP, performs the following functions:

1. Measurement of a manually set receive frequency between 25 and 1000 MHz, which is displayed as a frequency marker on the panoramic adapter
2. Crystal-controlled locking to set receive frequency
3. Quasi-continuous digital tuning
4. Digital setting of receiver (range selection and tuning) to a BCD-programmed frequency
5. Master-slave operation.

To perform function 1, the EZK measures the oscillator frequency of the receiver and, taking into account the intermediate frequency of the receiver range selected, indicates the receive frequency (data output available after each measurement).

For performing functions 2 to 5, the EZK contains, in addition to the frequency meter, an adjustable up/down counter, which serves as a nominal-value store, and a comparator which controls the receiver (range selection and tuning voltage).

Modes. Three modes of operation are possible:

manual, digital frequency control (DFC) and external (remote control).

After manual operation of the range switch and the tuning knob, the Frequency Controller gives a 6-digit readout of the set frequency and outputs the frequency information in BCD.

In the DFC mode, the EZK keeps the receive frequency constant with crystal accuracy. With external control, the frequency information is applied in TTL to the BCD inputs and entered upon an external command. In both cases, the frequency is displayed to seven digits.

Quasi-continuous tuning (in 100-Hz steps) for searching or fine adjustment is possible at three different switch-selected speeds.

Slave operation, e.g. in DF systems. For this purpose, the EZK control input and data output are wired such that the output of the master unit simply has to be connected to the input of the slave unit. Slave units can be operated in series or in parallel and set to different modes. In unattended operation, the receivers of the slave units can deliver the information content via CORs to magnetic tape recorders.

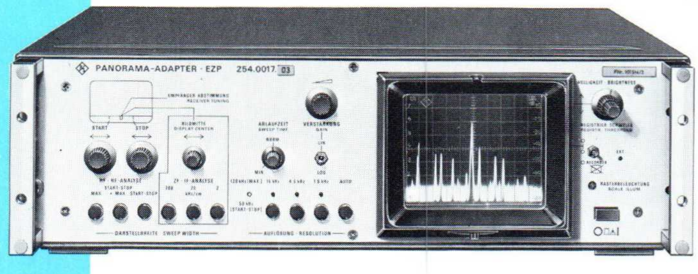
Specifications

Frequency range	approx. 0 to 1000 MHz
Range with Receivers ESU 2, ESM 2	24 to 1000 MHz, subranges see under receiver specifications
Crystal aging after 30 days of operation	$\leqq 2\times10^{-9}$/day
Modes	
Local operation	
Receive frequency measurement	front-panel switch set to MANUAL
Receiver tuning	by crank-type knob on receiver
Measurement rate	10 measurements/s
Display	6-digit LED display; resolution 1 kHz
Receive frequency hold mode	front-panel switch set to DFC
Quasi-continuous receiver tuning (DFC int.)	relative to instantaneous frequency: freely selectable by means of Kellog switch on EZK front panel; tuning rate in pos. and neg. direction: 1 kHz/s, 10 kHz/s, 100 kHz/s (others upon request)
Measurement rate	10 measurements/s
Display	7-digit LED display, resolution 100 Hz (blanked during broadband sweeping of receiver)
Remote control (DFC)	programmable via control line
Nominal frequency entry	BCD parallel, by store command, setting time with Receivers ESU 2 and ESM 2: typical 0.5 s
Display	7 digits
Quasi-continuous tuning	same as for local operation
Master-slave operation	by connecting data output of master EZK to control input of slave EZK
Data output	after each measurement; output released by print command
Inputs, outputs	
Control input/data output	50-pole female connector (Amphenol), 7 decades BCD-coded, TTL pos. (adaptation to negative logic possible)
General data	
Nominal temperature range	0 to +40 °C
Shelf temperature range	−40 to +70 °C
AC supply	115/125/220/235 V +10/−15%, 47 to 440 Hz (50 VA)
Dimensions, weight	
19″ bench model	492 mm × 116 mm × 514 mm, 13,3 kg
19″ rackmount	483 mm × 88 mm × 508 mm, 12.3 kg
Order designations	► Frequency Controller EZK
19″ bench model	255.0010.02
19″ rackmount	255.0010.03
Accessories supplied	cable 251.9494.00 for connection of EZK to receiver; power cable 025.2365.00

Panoramic Adapter EZP

- Spectral display with interference-free dynamic range > 70 dB
- Five resolution bandwidths; automatic selection of minimum sweep time
- One- or two-line broadband display

EZP



The **Panoramic Adapter EZP** in conjunction with a suitable receiver, such as the ESU 2 or ESM 2, permits spectral display within a particular frequency range. The screen display supplies information on band occupancy, and on the level, modulation and frequency spacing of the individual signals.

The panoramic display covers a wider band than the receiver and thus considerably facilitates receiver tuning, the exact tuning frequency being marked on the screen by a light spot.

Display modes and sweep widths

a) Broadband display – RF analysis – over the full subrange width (max. 200 MHz for ESU 2 and ESM 2). By setting start/stop markers, a particular section of this range can be displayed either alone or together with the latter in the two-line mode, the receiver tuning frequency remaining marked.

b) IF analysis with a maximum sweep width of 2 MHz and automatic setting of optimal sweep time or resolution bandwidth.

In both cases, lin or log amplitude display can be selected. The gain is continuously adjustable in the linear mode.

Recording of screen displays. The EZP delivers output signals with TTL and analog levels for driving auxiliary units, such as recorders and recording systems. In addition to semi-automatic recording of screen displays by means of an XY or a YT recorder, it is possible to perform long-term recordings of the frequency band occupancy, using for instance the Radiomonitoring Recorder ZSG 3. Reference lines for frequency calibration can be set easily and accurately on the EZP. The adjustable recorder threshold can be inserted on the screen display as a level reference line.

External control. The essential switching functions, e.g. all pushbutton functions, lin-log switchover, free selection of sweep times, stopping and triggering the internal sawtooth generator, can be remote-controlled. It is also possible to blank the CRT or to insert additional frequency markers.

The internal graticule of the CRT can be illuminated. The frame in front of the screen can be folded up to accept a camera.

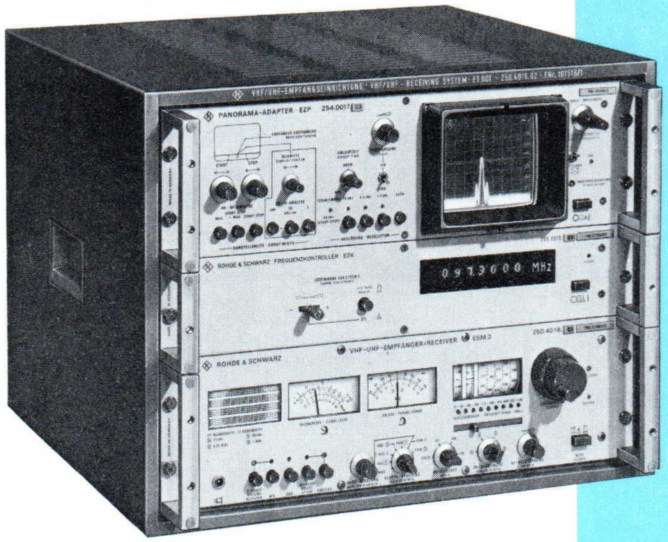
Specifications

Frequency	10.7 MHz ±1 MHz
Dynamic range (interference-free)	≧70 dB
Range of indication log	70 dB (10 dB/cm)
lin	gain manually adjustable over 70 dB
Required signal level for full output	9 to 40 mV, adjustable
Limit sensitivity with 1.5-kHz resolution	≦2 µV (S + N/N = 2)
RF analysis (Receiver ESU 2 or ESM 2)	
Sweep width	
Maximum	range or subrange of receiver (200 MHz with ESU 2)
Start/stop	any section of full sweep width
Max. + start/stop	simultaneous (two-line) display of range or subranges and section
Resolution (corresponding to 3-dB bandwidth)	
for maximum sweep width	120 kHz (according to CISPR Rec.)
for start/stop mode	50 kHz
Shape factor of filter	≈1/15
Frequency marking	by shiftable markers, frequency indication on receiver
Sweep time	40 to 200 ms, adjustable
IF analysis	
Sweep width	2 MHz / 200 kHz / 20 kHz
corresponding to	200 kHz/cm / 20 kHz/cm / 2 kHz/cm
Resolution (corresponding to 3-dB bandwidth)	15/4.5/1.5 kHz; shape factor ≈ 1/6
Automatic mode	sweep width ganged with resolution (minimum sweep time automatically selected)
Sweep time	40 ms
Centre-frequency marking	by crystal-controlled frequency marker
Remote control	digital programming of all functions, TTL neg.; adaptable to pos. logic
Control inputs for	sweep width, resolution, lin/-log, time control, local oscillator "off", trace blanking, external marker, stopping and triggering of sawtooth
Outputs	control sawtooth return sweep, trigger ready, RF analysis
Recorder outputs	
Digital	Z (intensity) control, paper feed
Analog	sawtooth voltage, X and Y control for recorder, general Y control, recorder drive control
Operating voltage for external units	+5 V (100 mA), ±15 V (50 mA)
Display	rectangular CRT with GL (P2) screen; internal graticule 10 cm × 8 cm, 0 to −70 dB
General data	
Nominal temperature range	0 to +40 °C
Shelf temperature range	−40 to +70 °C
AC supply	115/125/220/235 V +10/−15%, 47 to 440 Hz (35 VA)
Dimensions, weight	
19" bench model	492 mm × 161 mm × 514 mm, 14 kg
19" rackmount	483 mm × 132 mm × 508 mm, 12 kg

Order designations	▶ Panoramic Adapter EZP Normal version	IF analysis only (no remote control)
19" bench model	254.0017.02	254.0017.04
19" rackmount	254.0017.03	254.0017.05

Accessories supplied	power cable 025.2365.00, connecting cable 251.9494.00 for receiver, filter 254.2149.00
Recommended extras	
Siemens Polaroid Camera	Rel. 3B952a (please order direct from Siemens)
Camera adapter	110.2571.02
Intermediate tube	110.2588.02
or Steinheil Camera with Adapter for OKF	please order direct from Steinheil

ET 001



VHF-UHF Receiving System ET 001
♦ 20 to 1000 MHz

- Receiving system for radio detection
- Continuous and crystal-controlled quasi-continuous frequency adjustment; frequency indication on drum dial and on 7-digit frequency readout
- Suitable for all types of modulation common in the VHF-UHF range; video output
- Broadband and IF panoramic display (switch-selected) with superimposed receiver marker

The **VHF-UHF Receiving System ET 001** is designed for radio observation and radiomonitoring in the frequency range 20 to 1000 MHz. It consists of

VHF-UHF Receiver ESM 2,
Frequency Controller EZK,
Panoramic Adapter EZP,

which are fully transistorized and use, to a large extent, ICs. The ET 001 offers optimum performance with regard to noise figure, suppression of intermodulation and spurious responses.

The measuring facilities and operating convenience of this system satisfy all requirements prevailing in the wide field of radio detection: rapid frequency selection; high resolution and accuracy (crystal standard); digital readout; panoramic display (lin or log) with display widths up to 200 MHz and spreading of certain portions in start/stop operation with automatic adjustment of the minimum sweep time or of the optimum resolution bandwidth; recorder outputs (also for long-time measurements); TTL logic for remote control, and outputs for connection of slave units. The receiver characteristics are described in more detail after this system description.

Frequency setting and accuracy. The total range of 20 to 1000 MHz is divided into nine subranges; the subranges can be selected by means of a slide switch. The frequency is continuously adjustable on the drum dial without reversal of the sense of rotation. The internal 10-MHz crystal frequency spectrum permits recalibration of the subrange scales.

If the free-running receiver oscillator is synchronized with the Frequency Controller (DFC button), the adjusted frequency is kept constant to crystal accuracy, and quasi-continuous frequency adjustment is possible at three selectable speeds with an error as small as ±100 Hz. The receiver frequency can also be set by remote control (BCD programming). In both cases the counter of the EZK gives a digital readout of the frequency setting (7 digits: remote control or DFC; six digits: manual adjustment); maximum resolution: 100 Hz and 1 kHz, respectively.

Sensitivity, AGC. Carefully selected and extremely low-noise semiconductor components plus a high-power ring mixer ensure satisfactory receiving characteristics, making for a noise figure of 8 dB up to 400 MHz and 12 dB up to 1000 MHz. Input signals as small as 1 μV are adequate for evaluation on the display screen. According to the input level, automatic IF control – AGC 1, V_{in} reading 0 to 80 dB(μV) –; automatic RF-IF control – AGC 3, up to 120 dB(μV), additional RF input attenuation with PIN controller –, or combined control – AGC 2 – can be selected. In position MGC, the IF gain is manually variable by 80 dB.

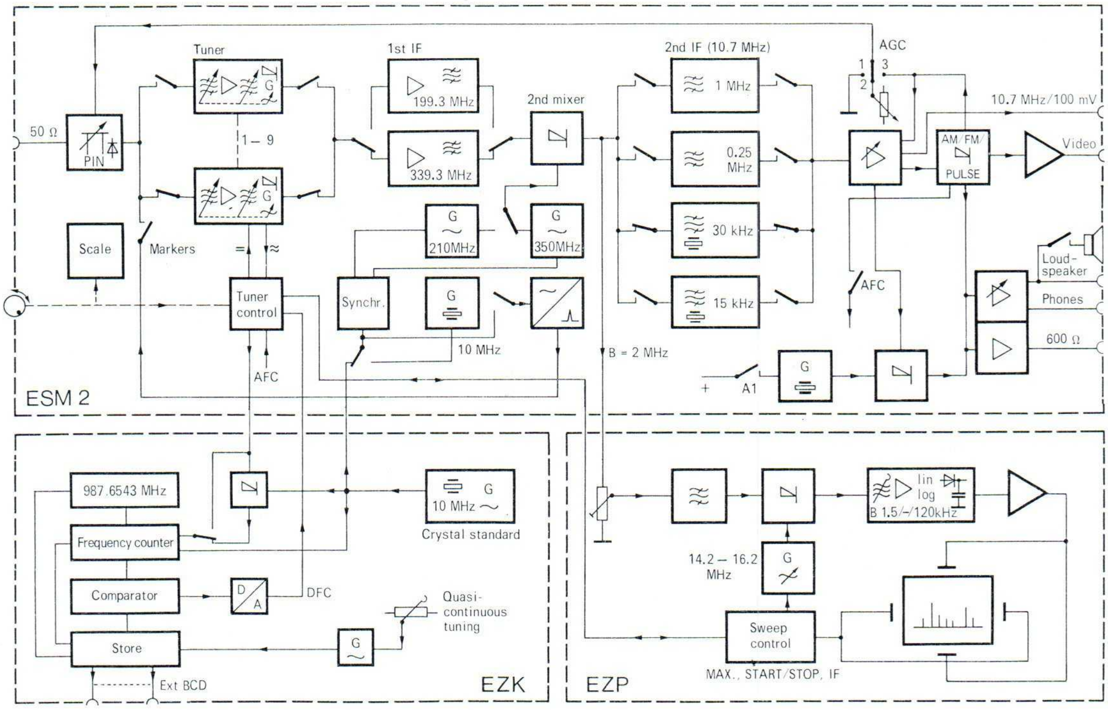
Bandwidths. The fixed bandwidth of the 10.7-MHz signal for the Panoramic Adapter (after the 2nd mixer) is 2 MHz. Four selectable bandwidths are provided for further signal evaluation: 1 MHz for broadband analysis, 250 kHz for FM broadcasting, 30 and 15 kHz for channel operation.

Panoramic display. Panoramic Adapter EZP permits spectral display of the signals received with the ESM 2, supplying information on band occupancy, level, frequency (spacing) and modulation. At the same time, tuning of the receiver is simplified by a marker produced in the EZP.

The following display types or widths are possible:

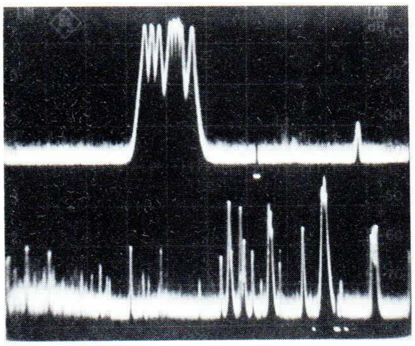
a) Broadband display over the entire subrange (with ESM 2: 200 MHz, max.). By setting start/stop markers, any section thereof can be displayed by itself or, in the case of two-line display, together with the subrange. The receiver tuning marker remains superimposed.
b) IF analysis with a maximum display width of 2 MHz and automatic optimum adjustment of sweep time or resolution bandwidth.

In both cases, the amplitude can be displayed on a lin or a log scale.



Block diagram of VHF-UHF Receiving System ET 001

Demodulation, outputs. The Receiver ESM 2 is suitable for AM, FM and pulse modulation and, in addition, has a video output, e.g. for subcarrier demodulators. The AF section comprises a loudspeaker, a switch-selected AF filter, a squelch, a carrier-controlled relay with adjustable hold time for tape recorder control (COR output), phones and recorder outputs.



Two-line display with start/stop and receiver markers (below); range of public land mobile services (105 to 172 MHz); spread display of marked section on upper line, making for higher resolution at the same time

Operation, slave units. All functions of the receiver, which is normally operated from the front panel, can also be remote-controlled via inputs at the rear. A central logic circuit largely prevents any maladjustments in either case. Operation of slave units is possible by means of simple connections via the control input and data output of the Frequency Controller EZK. Thus, a slave unit (with ESM 2 + EZK) can be operated in an unattended station, storing information via COR on magnetic tapes.

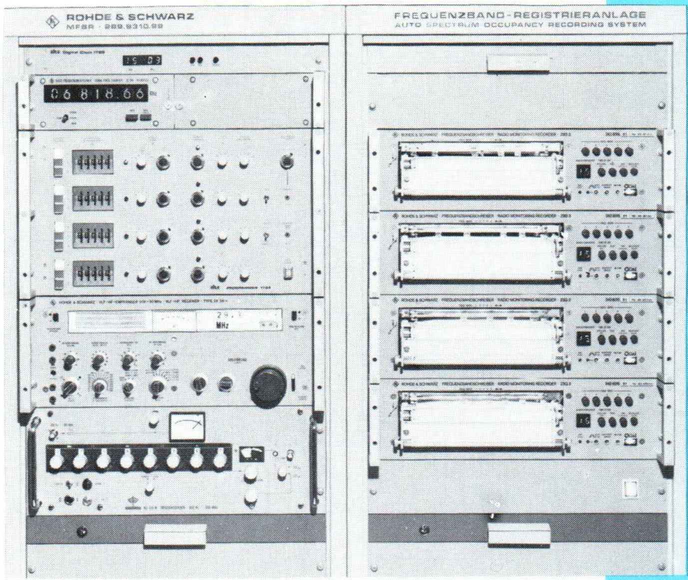
Special features of receiver

Double-heterodyne receiver with range-dependent 1st IF, 2nd IF = 10.7 MHz; automatic adjustment of input selectivity; voltage-controlled frequency tuning; separate panel meters for frequency tuning error and signal level.

Specifications

Frequency range	20 to 1000 MHz in 9 overlapping subranges: 20 to 42 to 70 to 110 to 175 to 270 to 420 to 605 to 805 to 1005 MHz
Frequency adjustment	(a) continuous with rotary knob coarse/fine; drum dial with total scale length of 2 m, resolution 100 kHz/mm in lowest range (b) quasi-continuous at 3 speeds on frequency controller with digital readout, 100-Hz digits and resolution (c) external in BCD; typ. setting time 0.5 s including automatic range selection
Frequency error	< 100 Hz in all ranges with quasi-continuous and external tuning
Noise figure	up to 400 MHz: typ. 8 dB up to 1000 MHz: typ. 12 dB
IF bandwidth of ESM 2	15 kHz/30 kHz/250 kHz/1 MHz
Image-frequency and IF rejection	> 80 dB
Gain control AGC 1	IF control with $V_{in} \leqq 80$ dB (µV)
AGC 3	RF-IF control with $V_{in} \leqq 120$ dB (µV) (AGC at carrier or pulse peak)
MGC	IF control (20 dB lin scale)
AGC 2	combined manual RF control and AGC 1
Demodulation	AM and FM up to f_{mod} = 500 kHz, pulse
Panoramic display	
Broadband display	max. 1 subrange with 120 kHz resolution, or any section thereof with 50 kHz resolution
Narrowband display	IF analysis (max. 2 MHz) with resolution bandwith 1.5/4.5/15 kHz
Recording	internal recorder control with selectable level threshold for band-occupancy recording on the Radiomonitoring Recorder ZSG 3
CRT	screen 10 cm × 8 cm; internal graticule 10 dB/cm, calibrated; dynamic range > 70 dB (+40 dB with AGC 2 at receiver)
Nominal temperature range	0 to +40 °C
Shelf temperature range	−40 to +70 °C
AC supply	115/125/220/235 V +10/−15%; 47 to 440 Hz (130 VA)
Dimensions, weight	520 mm × 400 mm × 535 mm, 55 kg
Order designations (complete system, standard version)	▶ VHF-UHF Receiving System ET 001 255.4016.99
System with tracking generator option	255.4039.99
Optional add-on	tracking generator

MFBR



Spectrum Occupancy Recording System MFBR

♦ 10 kHz to 30 MHz

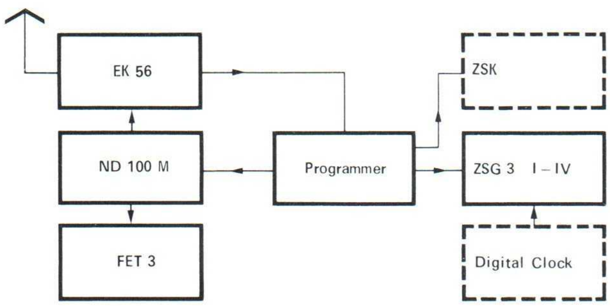
- Automatic recording of frequency-band occupancy
- Observation bandwidth 1 kHz to 5 MHz
- Electronically controlled recording process

MFBR arranged at eye level

The **Spectrum Occupancy Recording System MFBR** permits automatic and sequential recording of the occupancy of up to four frequency bands which can be selected between 10 kHz and 30 MHz. This system consists of the following units (see block diagram):

1	HF Receiver	EK 56
1	Frequency Synthesizer	ND 100 M
1	Programmer	1724
1	Communication Frequency Counter	FET 3
4	YT Recorders	ZSG 3
1	XY Recorder	ZSK (optional)

The MFBR complies with the CCIR Recommendation 182-1 and is described in CCIR document 1/110 E (2nd Nov. 1973).



Block diagram of Spectrum Occupancy Recording System MFBR

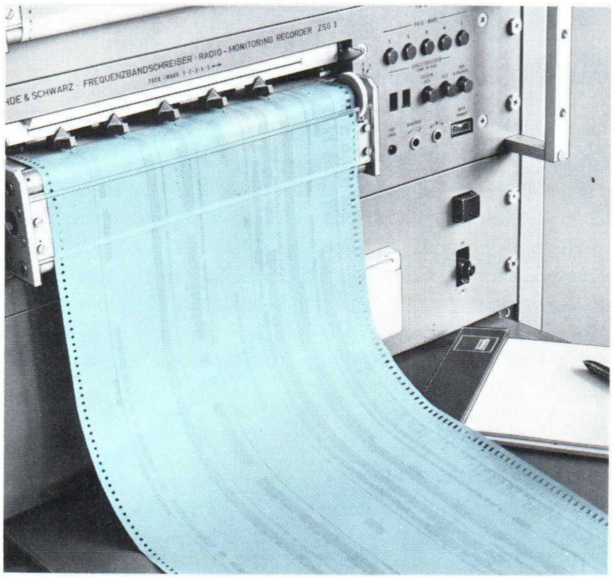
Sweeping and coupling between receiver and recording system are made fully electronically, contrary to conventional systems. Consecutive switching of the frequency bands occurs automatically. The sweep width (1 kHz to 5 MHz) is set on the Programmer in discrete steps with a switch and continuously with a potentiometer. The frequency under observation at any particular moment is indicated by the Communication Frequency Counter FET 3. The sweep time can be set to 30 or 60 s.

The information that can be extracted from the recording are operating time and frequency (with limitations also bandwidth, class of emission, type of modulation and frequency stability).

The YT Recorders ZSG 3 (section 6) have voltage-controlled recording electrodes for electrosensitive paper. The paper has a recording width of 200 mm and can flow out freely or be taken up automatically. Five marking electrodes can be adjusted manually to write frequency calibration lines. The operating hours are marked by horizontal lines and 7-segment figures at the right-hand margin.

The instruments are accommodated in a 19″ twin-bay rack at eye level. Each bay is provided with a drawer table.

► Order No. 289.9310.99

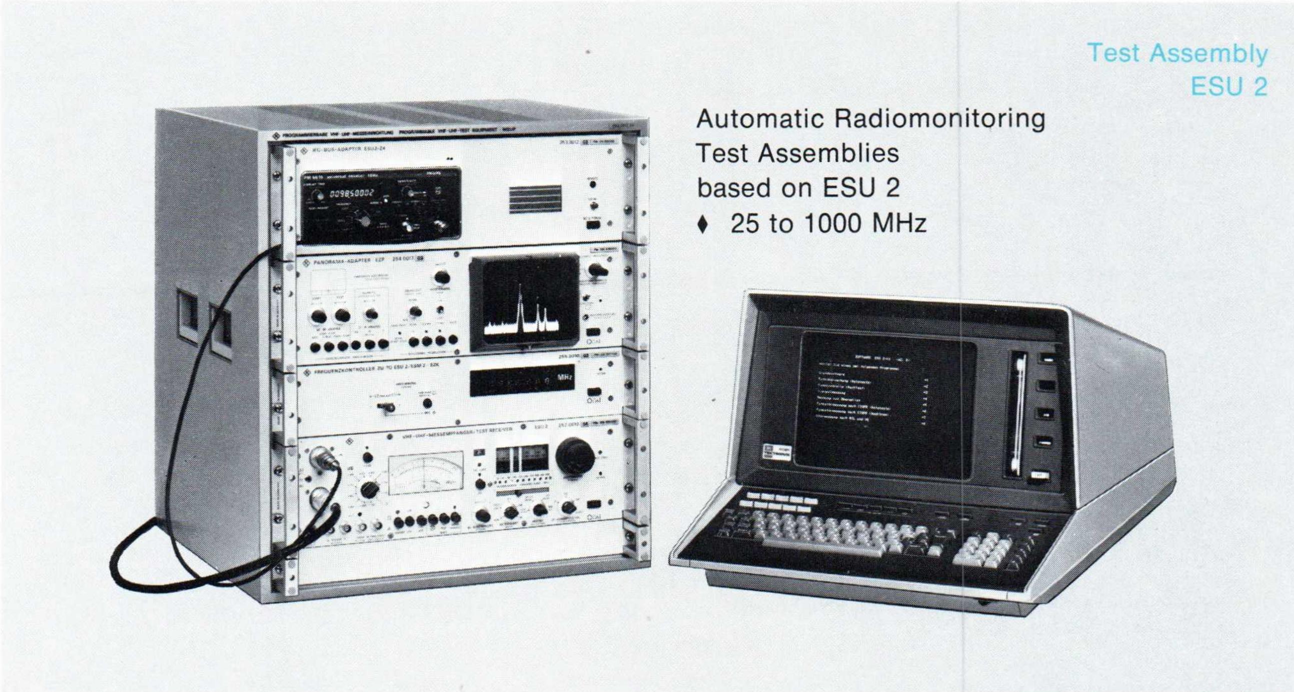


YT Recorder ZSG 3 with two-day recording

Test Assembly ESU 2

Automatic Radiomonitoring Test Assemblies based on ESU 2

♦ 25 to 1000 MHz



The VHF-UHF Test Receiver ESU 2 and the VHF-UHF Selective Test Equipment MSU can be augmented to form semi-automatic or fully automatic IEC-bus compatible test assemblies for economical performance of radiomonitoring tasks.

In the simplest configuration all settings of the ESU 2 are controlled by the Card Reader PCL via the Frequency Controller EZK and the Code Converter PCW. This punched-card control features the following advantages.

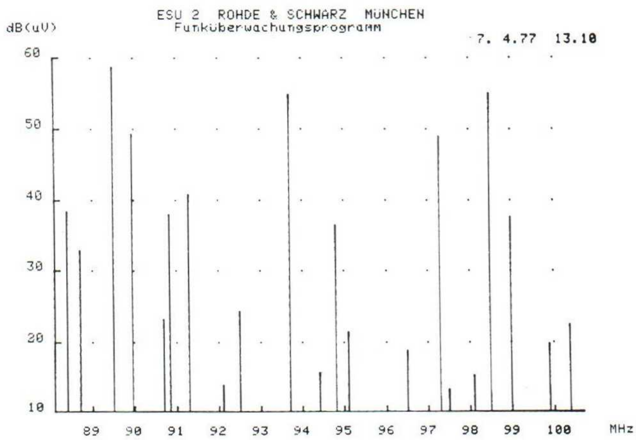
Free **combination of automatic and manual operation**: all or any of the settings of the ESU 2 can be made with the aid of punched cards. The operator makes all the settings that are not controlled by punched cards and reads off the test result. The punched-card control eases the task of the operator, in particular during regular checks on radio services operating with fixed frequencies, types of modulation and spectral widths. The correct automatic setting of the ESU 2 considerably recudes the measuring-error rate in routine measurements.

The **punched cards** available for the Card Reader PCL **are semi-perforated** so that changes as to the card contents or preparing of new cards is possible without special tools being required.

The programmable VHF-UHF Test Equipment MSUP comprises the IEC-bus Adapter ESU 2-Z4, the Panoramic Adapter EZP, the Frequency Controller EZK and the VHF-UHF Test Receiver ESU 2. These instruments are combined in a desktop rack and form, in conjunction with the Tektronix desktop calculator 4051, a fully automatic test assembly for radiomonitoring, offering the following advantages.

The test sequence is controlled by the calculator; the necessary software is available on a magnetic-tape cartridge. It contains the test routines in modular form so that they can easily be combined into programms by the user. For a number of frequently occurring measurement tasks the cartridge contains **dialog programs,** which reduce the programming work of the operator to the answering of questions which appear in clear text on the display of the calculator. Important dialog programs for radiomonitoring are: remote level and frequency measurements at fixed frequencies and a search program with measurement of all levels exceeding a preset value. For remote frequency measurements an IEC-bus compatible counter is additionally required, such as the Philips counter PM 6615/04 with PM 9679, which can be inserted in the IEC-bus adapter ESU 2-Z4. The ESU 2-Z4 also contains a loudspeaker for aurally monitoring the modulation of the received signal.

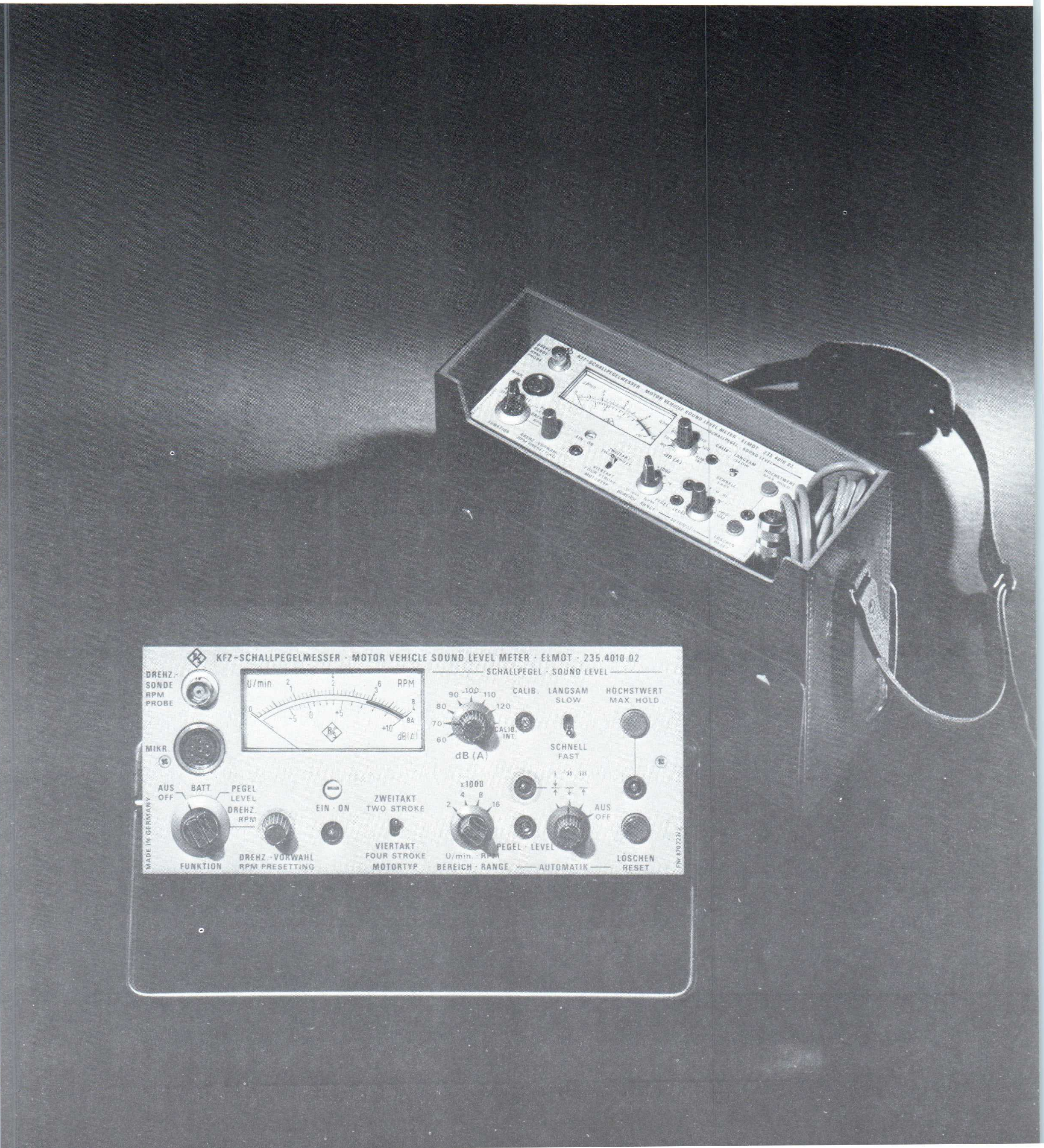
The test results are **graphically and alphanumerically** displayed on the memory screen. They can be recorded with the aid of a printer, plotter or hardcopy unit Tektronix 4631 that can be connected directly to the computer. The results can also be stored, e.g. for later evaluation, in the magnetic-type cartridge of the desktop calculator.



Level and frequency graph obtained by remote measurement using the ESU 2-based automatic test assembly in the VHF range (place of evaluation: Munich); above: display of tabulated values on the screen

Motor-vehicle Sound-level Meter ELMOT
for rpm-dependent measurements;
details on page 212

acoustic test equipment sound-level meters · noise meters



Why sound-level measurement?

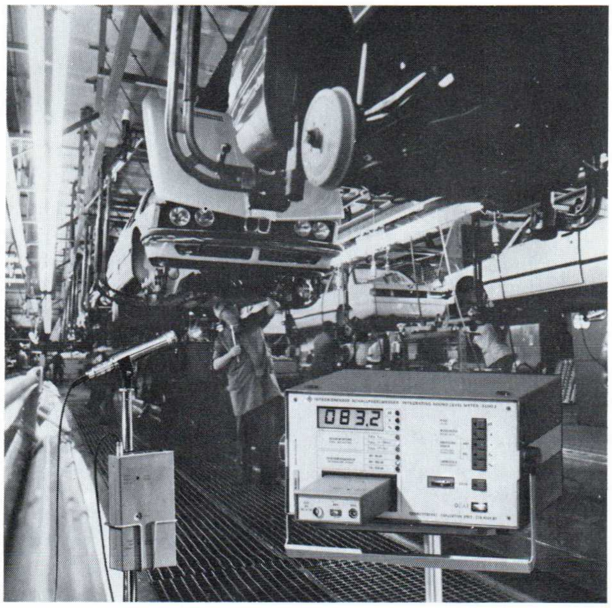
The most frequent objective of sound-level measurement is **noise abatement**: the advance of civilization and industrialization is accompanied by an increasing noise exposure suffered by man, which has reached such a level that countermeasures are urgently called for. Noise surrounds us by day and night, where we dwell, where we work, where we travel.

Noise **at the place of work** is of particular concern, considering that loss of hearing induced by noise is the No. 1 occupational illness in industrialized nations. Prolonged exposure to noise levels exceeding 85 dB is injurious to hearing. Even much lower levels – depending on the physical and mental condition and the activities of the people concerned – may cause them considerable annoyance, reduce their productivity and have adverse effects on their nervous systems eventually leading to damage to their health. To counteract these risks, legislative bodies and unions have worked out regulations defining appropriate noise limits.

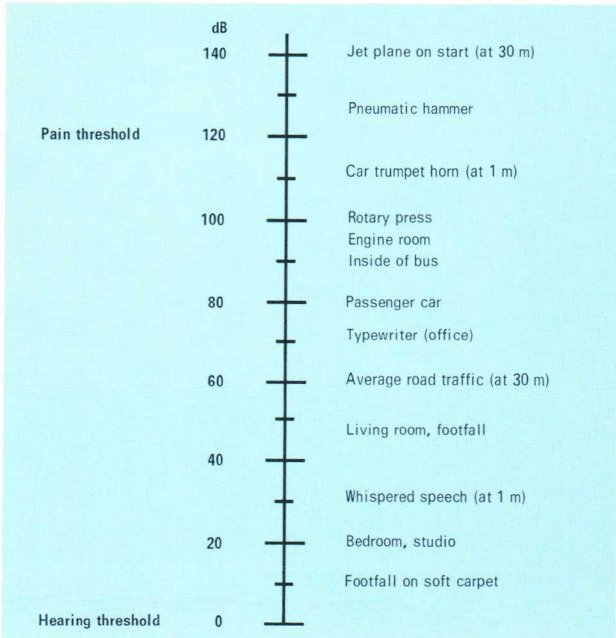
Such differentiated noise-limit regulations exist already in some countries or are under preparation, the regulations being partly enforced by law and partly laid down in management-union agreements. For example, the regulations concerning noise at the place of work issued by the government of the Federal Republic of Germany in May 1976 give the following noise level limits averaged over 8 hours (**rating sound level**, see page 176),

- 55 dB (A) for primarily mental work
- 70 dB (A) for simple or to a great extent mechanized office work or comparable activities
- 85 dB (A) for any other activities; under certain circumstances, which must be explained, up to 90 dB (A).

Sound-level measurement in residential area (above) and at working place (below)



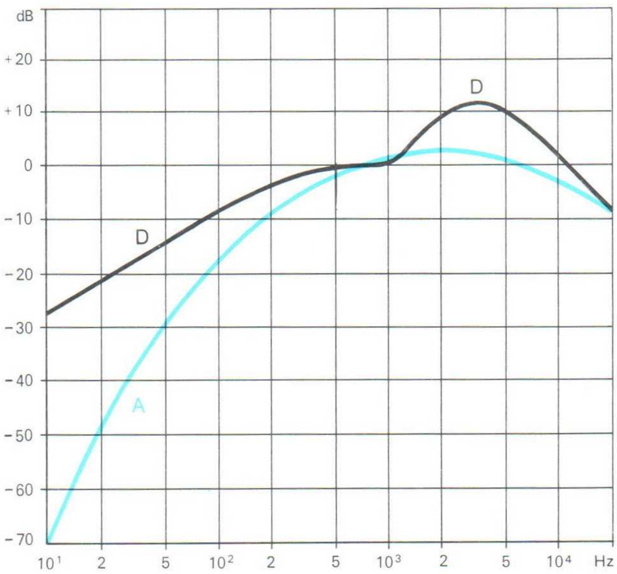
Environmental noise and average sound levels



Some notions in sound measurements

The physical measure of sound effects is the rms value of the (alternating) **sound pressure p** measured in pascals (Pa) with 1 Pa = 10 µbar or 1 N/m². Considering the very wide dynamic range of human sound perception, extending over six decades, the logarithmic measure, i.e. **sound-pressure level L**, is more convenient, giving more easily grasped figures. L is 20 times the logarithm of sound pressure referred to the hearing threshold of 2×10^{-5} Pa and is **measured in dB**. The human ear responds to sound-pressure levels from 0 to 130 dB (see dB scale on preceding page). A level increase of 10 dB corresponds to a doubling of the loudness sensation as registered by the ear.

To take account of the strong frequency dependence of loudness sensation, sound-level meters must be provided with **frequency weighting** networks. Four weighting curves, A, B, C and D are internationally standardized. The present tendency toward unification and simplification has led to curve A now being prescribed for the large majority of measurements. Aircraft noise is measured using curve D, see diagram below.



Relative attenuation of weighting networks referred to 1 kHz

The measured quantity is denoted **weighted sound level** – or simply **sound level** – if a weighting filter is used for the measurement (without filter, sound-pressure level is measured). The weighting curve used is indicated as an index to the symbol L, for instance L_A, L_D. When specifying results, the index letter is often added in parentheses to the unit, e.g. 70 dB (A).

Noise measurements, in particular, call for a distinction to be made between the

instantaneous sound level L and the
equivalent sound level L_{eq} averaged over a predetermined period of time.

A measurement of **instantaneous values** permits observation or recording of sound-level variations with time. Applications are most diversified, e.g. checking noise-abating measures on machines or determining sound propagation in rooms, buildings or dwelling areas.

Time weighting. Almost all instantaneous-value sound-level meters have analog meter indication since this is best suited to the visualization of varying levels. Depending on the elaborateness and price class of the instrument, the time weightings

fast,
slow,
impulse,
peak and
maximum hold

can be switch-selected.

In the **fast** mode the indication follows the varying level as quickly as permitted by the meter response (τ = 125 ms); with **slow** very unsteady pointer movements are electrically damped. With **impulse** weighting a circuit whose time constant is τ = 3 s holds impulse sound events such that their rms value can be read. The **peak** mode measures the peak value (not rms) of even shorter sound pulses, e.g. shots.

The time weighting is indicated by a second index to the quantity symbol: F meaning fast, S slow and I impulse. With frequency weighting A, for example, there are three level designations: L_{AF}, L_{AS} and L_{AI}.

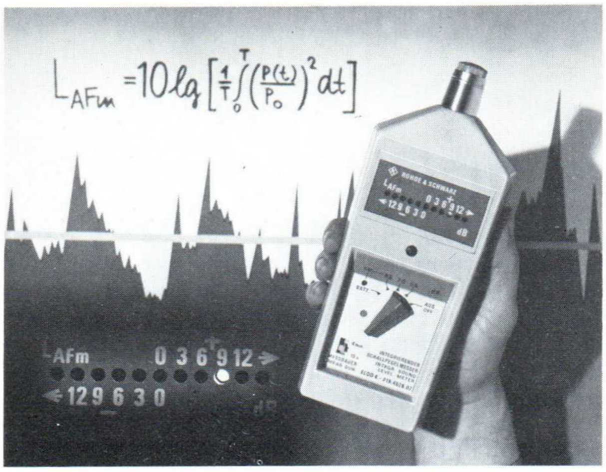
Below: Instantaneous-value measurement using Impulse Sound-level Meter EGT on large building site

Characteristics of sound-level meters. The requirements are laid down in IEC and DIN standards. Precision instruments must comply with the roughly equal standards IEC 179 and DIN 45 633, whereas somewhat wider tolerances are allowed by DIN 45 634 and still wider by IEC 123. The qualification corresponding to DIN 45 633 or 45 634 can be certified in Germany by **type-approval through PTB** (Federal-German office of standards). Thereby the instruments are admitted for official calibration, which is required in many cases. The user of a type-approved instrument is always sure that it complies with the relevant standard specifications.

Integrating sound-level meters have gained special importance in the last few years. They evaluate the varying sound level occurring over a predetermined time, e.g. a work shift, and form the **mean sound level** whose annoyance effect is assumed equal to the actual sound effect. The mean level is a measure of the **exposure** to noise suffered by the person concerned.

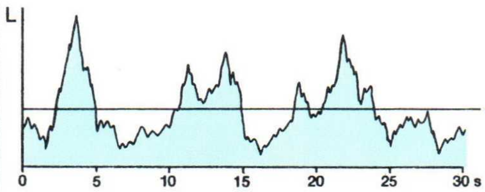
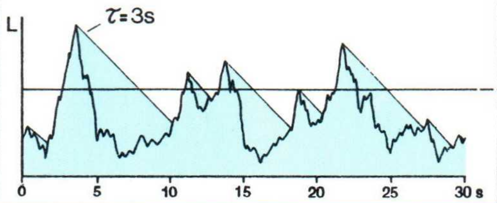
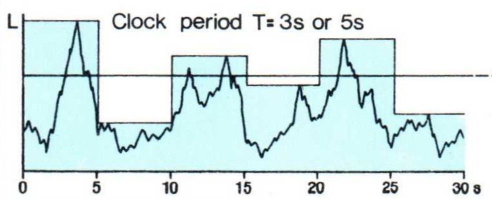
DIN 45 641 and 45 645 specify two variants of mean level, namely the **equivalent continuous sound level** L_{eq} and the **rating level** L_r. The latter rates impulse sound higher than L_{eq} because of the higher annoyance it causes to man. In the Federal Republic of Germany L_r is commonly referred to for noise at places of work, whereas traffic noise, which contains few impulse components, is generally assessed by L_{eq}. The present international standards ISO R 1996 and ISO R 1999 refer to L_{eq} only.

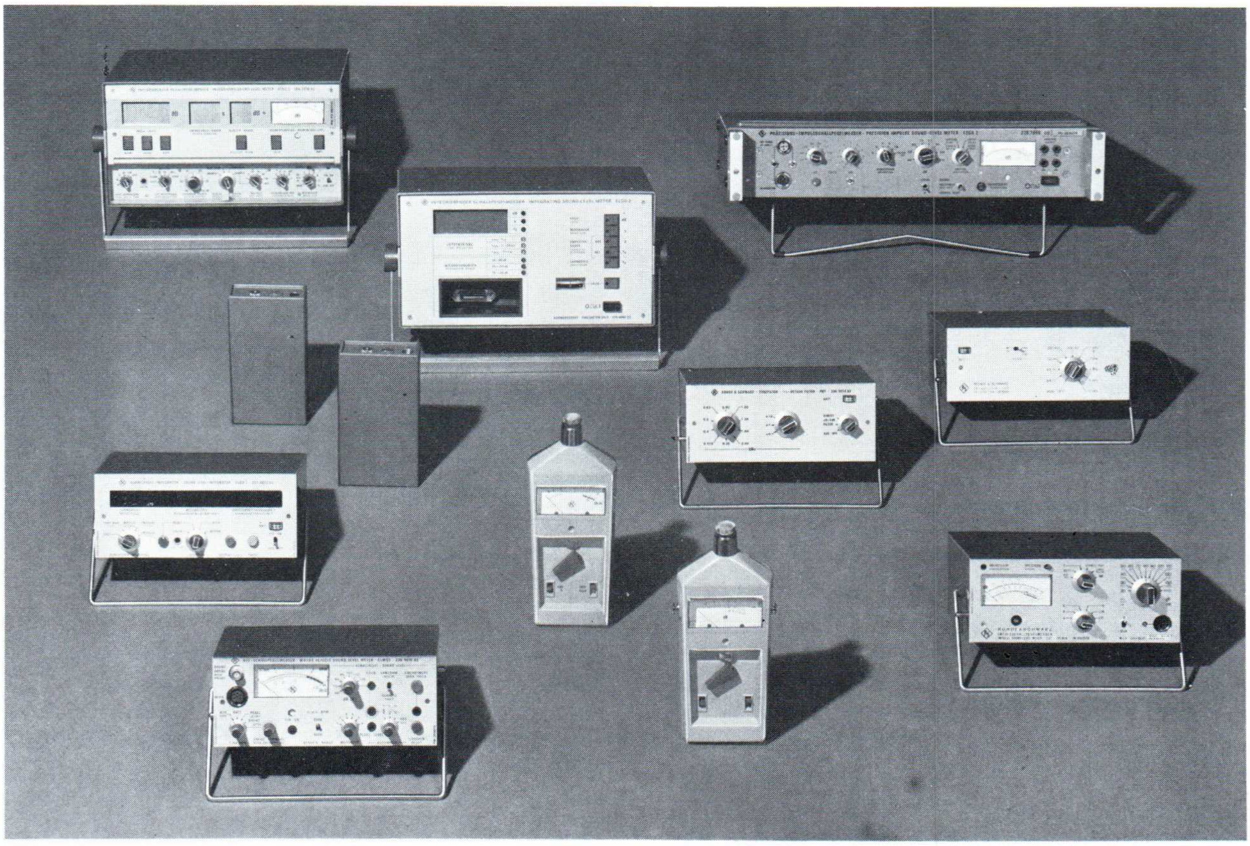
The rating level can be obtained by two different methods leading practically to the same result. Graphs of the different weighting modes and associated designations are compiled in the table below, as many users may not yet be familiar with these distinctions.



The Integrating Sound-level Meter ELDO 4 gives a direct indication of the mean sound level for the selected measurement duration

Below: Relationship between time-weighting modes and mean levels

Mean levels L_m with different time weightings acc. to DIN 45645 $L_m = 10 \log_{10}\left[\frac{1}{T}\int_0^T 10^{0.1L(t)}dt\right]$			
Time weighting	Measured quantity before averaging	Sound-level integration (example: impulsive sound)	Designation of mean level
FAST or SLOW $L_{AFm} = L_{ASm} = L_{eq}$	L_{AF}		equivalent continuous level L_{eq}
IMPULSE	L_{AI}		L_{AIm} — rating sound level L_r — mean level L_m
FAST with clocked max. hold	L_{AFT}		L_{AFTm}
Index A stands for frequency weighting according to curve A			L_r weighting of impulsive sound gives higher value than L_{eq}



Apart from ELT 3 all instantaneous-value reading R&S sound-level meters are type-approved, meaning that they are admitted for calibration by PTB (Federal-German office of standards).

Overview of sound-level meter data

Frequency range	Designation	Type	Order No.	Measurement range	Time weighting, meas. quantity	Error limits	Standard	Dimensions W × H × D in mm	Text on page
Instantaneous-value sound-level meters									
10 Hz to 20 kHz	Precision Sound-level Meter	ELT 2	221.7406.02	55 to 120 dB	F/S	1 dB	DIN 45 633 IEC 179	104 × 233 × 43	208
16 Hz to 16 kHz	Sound-level Meter	ELT 3	215.8510.02	25 to 120 dB	F/S	1 dB	DIN 45 634 IEC 123	104 × 233 × 43	209
10 Hz to 20 kHz	Portable Impulse Sound-level Meter	EGT	220.5174.02	24 to 160 dB	F/S/I max.-value store	1 dB	DIN 45 633 Bl. 1 & 2 IEC 179	212 × 88 × 158	210
10 Hz to 20 kHz	Precision Impulse Sound-level Meter	EZGA 2	220.7660.02	20 to 160 dB	F/S/I/Peak max.-value store	1 dB	DIN 45 633 Bl. 1 & 2 IEC 179	484 × 105 × 336	211
10 Hz to 20 kHz	Motor-vehicle Sound-level Meter	ELMOT	235.4010.02	55 to 130 dB	F/S max.-value store	1 dB	DIN 45 633 IEC 179	218 × 88 × 158	212
Integrating sound-level meters									
10 Hz to 20 kHz	Sound-level Integrator	ELDO 1	257.4013.02	20 to 120 dB	$L_{Fm}/L_{Im}/L_{FTm}$	0.5 dB	DIN 45 633, ...45 IEC 179 ISO R 1996, 1999	212 × 88 × 158	214
10 Hz to 20 kHz	Integrating Sound-level Meter	ELDO 2	278.5360.02 + 278.4064.02	30 to 120 dB	$L_{eq}/L_{AIm}/L_{AFTm}$	1 dB	same as ELDO 1	280 × 180 × 270	216
16 Hz to 16 kHz	Integrating Sound-level Meter	ELDO 4	219.4026.02	43 to 100 dB	L_{eq}	1 dB response tolerance of LEDs		104 × 233 × 43	218

ELT 2

Precision Sound-level Meter ELT 2

♦ 10 Hz to 20 kHz/55 to 120 dB

- Type-approved by PTB; admitted for official calibration and for measurements good in law
- Precision data in line with DIN 45 633, IEC 179, ANSI Type 1
- Easily adapted for vibration measurements (acceleration) with an acceleration pickup

The **Precision Sound-level Meter ELT 2** measures sound levels from 55 to 120 dB and weights the results according to the curves A, B or C (switch-selected). The set complies with the German DIN requirements 45 633 and with the IEC 179.

The ELT 2 is battery-driven and fully transistorized. When switched on, it is immediately ready for operation. Thanks to its small size (plastic case 104 mm × 233 mm × 43 mm) it is easily carried in a pocket. The microphone is a capacitor type with a spherical characteristic.

The high-impedance microphone is matched to the low-impedance amplifier by a field-effect transistor. Pressure equalization ensures uniform sensitivity of the microphone even when subjected to different air pressures. The polarizing voltage is stabilized.

The meter scale has a resolution of 1 dB and covers from −5 to +10 dB. The test result is the sum of the indication and the selected measurement range, expressed in dB.

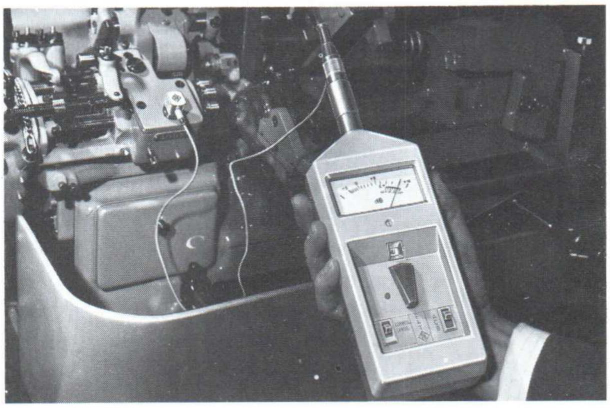
A checking facility allows performance checks to be made whenever required.

The lateral screws holding the carrying strap can be removed to give access to the ¼" thread used for mounting the ELT 2 onto a tripod for example, for measurements extending over a longer time. The set is fed from a dry cell (Mikrodyn IEC 15 F 20; 22.5 V).

Typical applications: Measurement of

- ▷ Industrial noise caused by machines in factories and offices and in residential areas
- ▷ Traffic noise, including measurements made on stationary and moving vehicles by inspection authorities and police
- ▷ Building noise, construction and machinery
- ▷ Aircraft noise
- ▷ Vibration and acceleration

Acceleration measurements are possible between 0.01 and 20 m/s^2 in the frequency range 31.5 to 8000 Hz when the microphone inset is exchanged for an adapter (100.5803.02) permitting connection of the Acceleration Pickup EBVB.



Vibration measurement using Precision Sound-level Meter ELT 2 and Acceleration Pickup EBVB on an automatic lathe

Specifications

Overall measurement range for weighting acc. to curves A, B, C	55 to 120 dB above p_0 ($p_0 = 2 \times 10^{-4}$ µbar or 2×10^{-5} Pa)
Weighting curves	A, B or C, switch-selected
Range switching	in 10-dB steps
Frequency range	10 Hz to 20 kHz
Indication	with rms-responsive rectification
Meter speed	fast and slow acc. to DIN 45 633 and IEC 179
Scale range, overlapping	0 to 10 dB, −5 to 0 dB
Error limits of absolute value under normal conditions	±1 dB
Calibration check	internal
Power supply	battery complying with IEC 15 F 20 (Mikrodyn 22.5 V)
Life of battery	>20 h
Dimensions, weight	104 mm × 233 mm × 43 mm, 0.56 kg
Order designation	► Precision Sound-level Meter ELT 2 221.7406.02
Accessories supplied*	Battery, carrying strap

Recommended extras

Carrying Case for ELT 2	215.9069.00
Wind Screen MKPM-Z	100.5810.02
Adapter EBVB-Z	100.5803.02
Acceleration Pickup EBVB	100.5890.02
Tripod Bracket ELT-Z3	215.8940.02
Tripod MKPM-Z2	154.5899.02
Transport Case ELT-Z	100.5826.02

* If a calibration certificate is required, the instrument will be forwarded to the respective authority for calibration and delivery.

Sound-level Meter
ELT 3
♦ 16 Hz to 16 kHz/25 to 120 dB

- High-performance and inexpensive sound-level meter with measuring range starting at 25 dB, thus also suitable for measuring nighttime noise
- With capacitor microphone; insensitive to structure-borne vibrations
- AC output: for connection of Sound-level Integrator ELDO 1
- Minimal current drain: battery operation > 200 h

ELT 3

(shown in larger scale than usual)

The **Sound-level Meter ELT 3** is a new and very inexpensive instrument with measuring characteristics in line with DIN 45 634 and IEC 123. Several features, such as pickup pattern and sound-volume range, also comply with DIN 45 633, IEC 179, and ANSI Type 2.

Like the well established Precision Sound-level Meter ELT 2, the ELT 3 also comes in a flat and compact format at low weight.

Due to the good performance and portability, the Sound-level Meter ELT 3 is suitable for a wide variety of applications, e.g. for noise measurements in industry or traffic, in residential areas or for investigations made by health services. The wide level range permits measurements of sound events ranging from the loudest noise to levels that lie below the values permissible in residential areas at night.

Simple operation renders the ELT 3 suitable for use even by technically unskilled persons.

Microphone. The capacitor microphone that is used makes the instrument largely insensitive to structure-borne vibrations, e.g. in applications in vehicles. Pressure compensation in the microphone eliminates the effects of fluctuating air pressure.

Indication, weighting. The ELT 3 indicates the rms value of sound level with A weighting in dB, and can be switched to fast or slow response.

Calibration. Absolute calibration of the sound-level meter is possible with the Sound-level Calibrator ELEB; see page 221.

Output. An AC output (0.8 V_{rms} at fsd) enables connection of the Sound-level Integrator ELDO 1 for example. This combination is an extremely favourably priced, portable measuring setup for determining equivalent continuous sound level L_{eq} or mean level of varying noise, for example.

The 9-V battery of the power supply suffices for over 200 hours of operation.

Combination of Sound-level Meter ELT 3 and Sound-level Integrator ELDO 1 for the averaging of varying noise at work

Specifications

(Characteristics comply with DIN 45 634 and IEC 123)

Measuring range	25 to 120 dB (A) over p_0 ($p_0 = 2 \times 10^{-5}$ Pa)
Range switching	in 10-dB steps
Error limits	±1 dB
Frequency range	16 Hz to 16 kHz
Indication	built-in meter with rms-responding rectification
Meter speeds	fast/slow
Scale	−5 to 0 to +10 dB, battery check
Precision microphone	capacitor microphone, omnidirectional characteristic
Main direction of sound incid.	from front along longitudinal axis of set
Operating temperature range	−10 to +40 °C
Temperature dependence, referred to 20 °C	<±1 dB
AC output	0.8 V_{rms} at fsd
Power supply	9-V battery (IEC 6 F 22); battery check on built-in meter
Average battery life	> 200 h
Dimensions, weight	104 mm × 233 mm × 43 mm, 0.55 kg
Order designation	► Sound-level Meter ELT 3 215.8510.02
Accessories supplied	battery, carrying case
Recommended extras	Wind Screen MKPM-Z 100.5810.02 Tripod Bracket ELT-Z3 215.8940.02 Tripod MKPM-Z2 154.5899.02
For measurements near ground level	Tripod Mount ELT-Z 215.9469.02

EGT

Impulse Sound-level Meter EGT
♦ 10 Hz to 20 kHz/24 to 160 dB

- Type-approved by PTB; admitted for official calibration and for measurements good in law
- Precision data in line with DIN 45 633 and IEC 179
- Noise measurement with weighting curves A, B, C and D, with linear response or via external filters
- Recording outputs; AC or battery power supply

(shown in larger scale than usual)

The **Portable Impulse Sound-level Meter EGT** covers the wide test range of 24 to 160 dB and fulfils the requirements of the German Standard DIN 45 633 Bl. 1 for **precision sound-level meters,** and Bl. 2 for impulse sound-level meters, of IEC 179 + 179 A and of ANSI Type 1.

Microphone. The Standard Microphone MKPM is used as an electro-acoustic transducer (capacitor-type microphone with two-stage impedance transformer), receiving its polarizing and supply voltages from the EGT. Its low-impedance output makes the use of long connecting cables possible (up to 100 m). The microphone capsule can be replaced by the Adapter 100.5803.02 for connection of the **Acceleration Pickup** EBVB. **Acceleration measurements** from 0.01 to 2000 m/s² can then be performed.

Test range (sensitivity). The total range of 24 to 160 dB is covered as follows: Switchable in 10-dB steps from 24 to 130 dB, +10 dB fsd on panel meter, +20 dB by reducing the polarizing voltage of the microphone from 150 to 15 V.

Weighting. A, B, C, D and linear can be selected as required. In addition, **external filters** can be connected via BNC sockets, the 3-dB insertion loss being compensated in the EGT.

Indication. The test result is shown on a moving-coil meter with rms rectification. Scale calibration −5 to +10 dB with resolution of 1 dB. **Overdriving** (e.g. extreme peak factors) is signalled by a warning lamp. By means of a push/slide switch it is possible to **hold the maximum meter indication** of a transient event, e.g. explosive sound.

Calibration check is provided by feeding an internal calibration voltage to the microphone capsule.

Outputs. The weighted AC signal voltage is available at the AF output, e.g. for recording on tape or for an AC-voltage recorder. The amplified voltage from the rectifier is present at the DC output.

Power supply. Instead of the usual 1.5-V single cells an accumulator or a power supply/charger can be employed.

Carrying case. This is supplied with the instrument and can also hold the microphone and spare batteries. A double case accommodating the EGT plus an octave or third-octave filter (see page 220) is available as an extra.

Specifications

Frequency range	10 Hz to 20 kHz
Ranges	
for weighted sound level	24 to 160 dB
with external filters	15 to 160 dB
for sound-pressure measurement	0.01 to 20,000 µbar
for acceleration measurement	0.01 to 2000 m/s²
for voltage measurement	0.01 to 2000 mV
Equivalent noise level (with microphone)	weighting A B C D lin dB 18 18 21 24 27
External filter connection	BNC, Z = 600 Ω
Indication	rms fast/slow/impulse stored: discharge < 0.5 dB/min
Scale	−5 to 0 to +10 dB
Error limits (normal)	±1 dB
Outputs, AC	2 V, 600 Ω
DC	2 V fsd, 200 kΩ
Dimensions, weight	212 mm × 88 mm × 158 mm, 2.7 kg

Order designations	► Impulse Sound-level Meter EGT
EGT incl. carrying case and batteries, plus Microphone MKPM, 1.2-m cable and Wind Screen	220.5174.02
EGT as above, but with PTB calibration certificate	220.5174.12

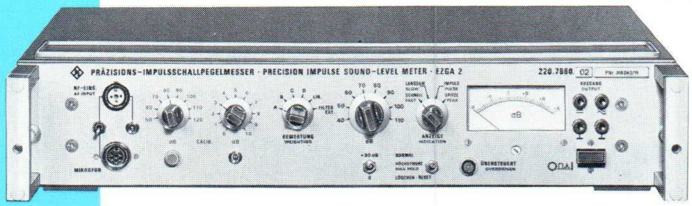
Recommended accessories for the EGT

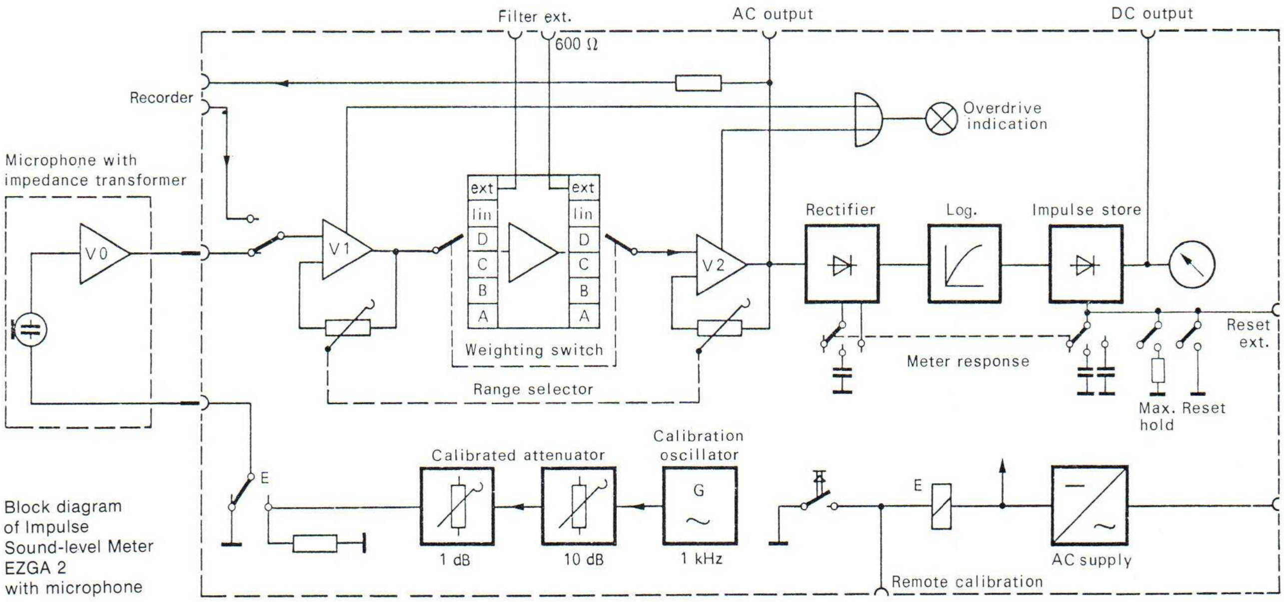
For airborne-sound measurements	► Order Nos.	Page
Standard Microphone MKPM (second microphone with 1.2-m cable)	220.5180.02	221
Microphone connecting cable		
1.2 m	100.5784.05	
5 m	100.5784.02	
10 m	100.5784.03	
20 m	100.5784.04	
50 m	100.5784.06	
Tripod MKPM-Z2	154.5899.02	
For vibration measurements		
Acceleration Pickup EBVB		
sensitive to acceleration	100.5890.02	221
sensitive to force and acceleration	100.5884.02	221
EBVB Adapter	100.5803.02	
Impedance Transformer	110.0410.02	
For selective measurements		
Octave Filter PBO	201.5520.02	220
Third-octave Filter PBT	235.3014.02	
Connecting Cable EGT-Z (PBO/PBT)	205.3016.02	
For voltage measurements		
Voltage Adapter EGT-Z	201.5489.02	
Power supply		
Lead Storage Battery EGT-Z	201.5437.00	
Power Supply/Charger EGT-Z	201.5414.00	
Calibration equipment		
Sound-level Calibrator ELEB	201.5443.90	221
Recording equipment		
YT recorder	please enquire	
Connecting cable for tape recorder	201.5514.02	
Carrying Case EGT-Z	201.5508.02	
Double case	257.5961.00	

Precision Impulse Sound-level Meter EZGA 2
♦ 10 Hz to 20 kHz/20 to 160 dB

- Precision data in line with DIN 45 633 and IEC 179
- Weighted (A, B, C, D) and linear response; type-approved by PTB
- Meter indication FAST, SLOW, IMPULSE, PEAK, MAX., HOLD; dynamic range 50 dB

EZGA 2





Block diagram of Impulse Sound-level Meter EZGA 2 with microphone

The **Impulse Sound-level Meter EZGA 2** is ideal for use in test setups or systems for acoustic measurements. It is particularly suitable for long-term noise monitoring and recording, for the determination of the noise-exposure index, and for sound analyses in conjunction with external filters. The EZGA 2 complies with DIN 45 633 Bl. 1 + 2, IEC 179 + 179 A and ANSI Type 1.

Indication and dynamic range. The extremely wide logarithmic indicating range of 50 dB and the 70-dB dynamic range of the rms-responding rectifier enable long-term measurements to be made without range switching.

Level calibration. With the aid of the built-in, continuously adjustable calibration facility, the EZGA 2 can be calibrated at any desired test level by local or remote control.

Recording outputs. The EZGA 2 is provided with AC and DC outputs and with a socket for the connection of a tape recorder. IEC-bus interface is provided.

Microphone. The capacitor-type Standard Microphone MKPM (page 221) can be electrically heated and is thus optimally protected against environmental influences. For fixed outdoor use, the microphone can also be supplied with a weather shield. The low output impedance of the MKPM permits the use of connecting cables up to 100 m long.

Acceleration measurements between 0.003 and 3000 m/s^2 can be made in conjunction with an acceleration pickup and adapter, see under MKPM.

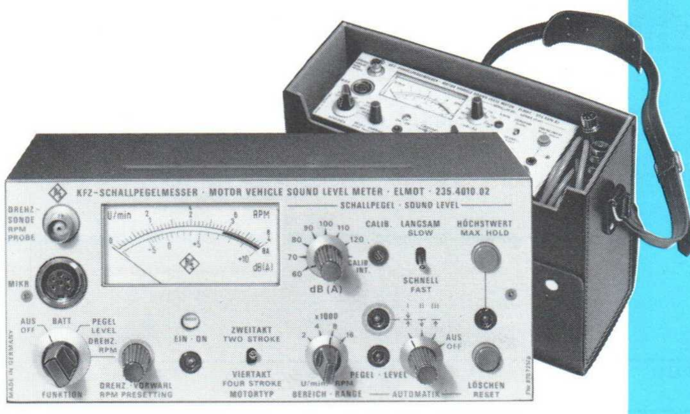
Specifications

Frequency range	10 Hz to 20 kHz
Overall measurement range	20 to 160 dB
Range of panel meter (log)	50 dB (scale: −20 to +30 dB)
Range setting	in 10-dB steps
Equivalent sound level with MKPM with weighting curves A/B/C/D/lin	18/21/23/25/27 dB
External filter	BNC sockets, Z = 600 Ω
Meter response	fast/slow/impulse/peak/max. hold
Level calibration	built-in 1000-Hz oscillator for reference voltage calibration; remote control possible; adjustable to any level
Error limits under normal conditions	±1 dB
Inputs	for Standard Microphone MKPM and recorder
Outputs	DC: 50 mV/dB, 600 Ω AC: 0 to 2.5 V, 600 Ω
Recorder connection	input sensitivity adjustable output 0 to 250 mV
AC supply	115/125/220/235 V +10/−15%
Dimensions, weight	484 mm × 105 mm × 336 mm (2 A), 7.1 kg

Order designations	▶ Precision Impulse Sound-level Meter EZGA 2
19" cabinet model	220.7660.02
19" rackmount	220.7660.03
Recommended extra*	
Standard Microphone MKPM	220.5180.02

* If a calibration certificate is required, the instrument will be forwarded to the respective authority for calibration and delivery.

ELMOT



Motor-vehicle Sound-level Meter ELMOT

♦ 10 Hz to 20 kHz
55 to 130 dB (A)

- Sound-level meter and rpm counter in one instrument, combined indication
- Characteristics comply with ISO standard, ISO/DIS 5130 and EC guidelines for measurement of noise in immediate vicinity of stationary vehicles
- Sound-level measurement according to DIN 45 633 and IEC 179; type-approved by PTB; admitted for official calibration and for measurements good in law
- Logic circuit enables one-man operation in combined sound-level/rpm measurement
- Rapid readiness for use with non-contact rpm probe

General remarks on motor-vehicle noise measurement

Noise measurements on motor vehicles according to the earlier valid standard ISO R 362 were practically impossible on a large scale and in vehicle maintenance and traffic checks because of the test conditions laid down, for instance the large distance of 7 meters at which the measurement was to be made.

The **measurement of noise in the immediate vicinity of stationary vehicles** offers a better solution. And relevant standards – ISO/DIS 5130 and EC guidelines – have already been introduced. The measuring distance will be reduced to 0.5 meters and the disturbance caused by ambient noises and reflections thus largely eliminated.

The **measuring method** provides for the testing of a stationary motor vehicle under certain conditions and with the microphone located very near: to one side of the exhaust outlet at a distance of 0.5 meters, and at an angle of 45° to the vertical plane of the direction of the exhaust emissions with the engine running at 75% of the speed at which maximum horsepower is developed.

To enable rational measurements under these conditions (one-man operation) and with optimum setting accuracy, Rhode & Schwarz developed the

Motor-vehicle Sound-level Meter ELMOT

The combination in this instrument of rpm and sound-level measurement, plus a logic circuit, simplifies and automates the measurement of vehicle noise. The measurement becomes devoid of problems and can be performed by a single person with no worries about errors in setting or readout.

Rpm is measured by means of a contactless inductive rpm probe clamped on a spark-plug cable. Apart from two-stroke and four-stroke engines no further distinction need be made between engine types as in the case of capacitive probes. The ELMOT is battery-powered, compact and complies in precision with DIN 45 633; it is type-approved by PTB and admitted for official calibration.

Uses

The features of the ELMOT were selected so that it can be employed by automobile manufacturers in development and testing, by vehicle-inspection authorities, motor workshops and, primarily, by the police. In addition to its mode of operation with automatic coupling of rpm and sound-level measurement, this instrument can also be used as an independent sound-level meter or revolution counter. With an XY recorder connected to the DC outputs it is also possible to display logarithmic sound-level characteristics over 40 dB as a function of rpm.

Operation

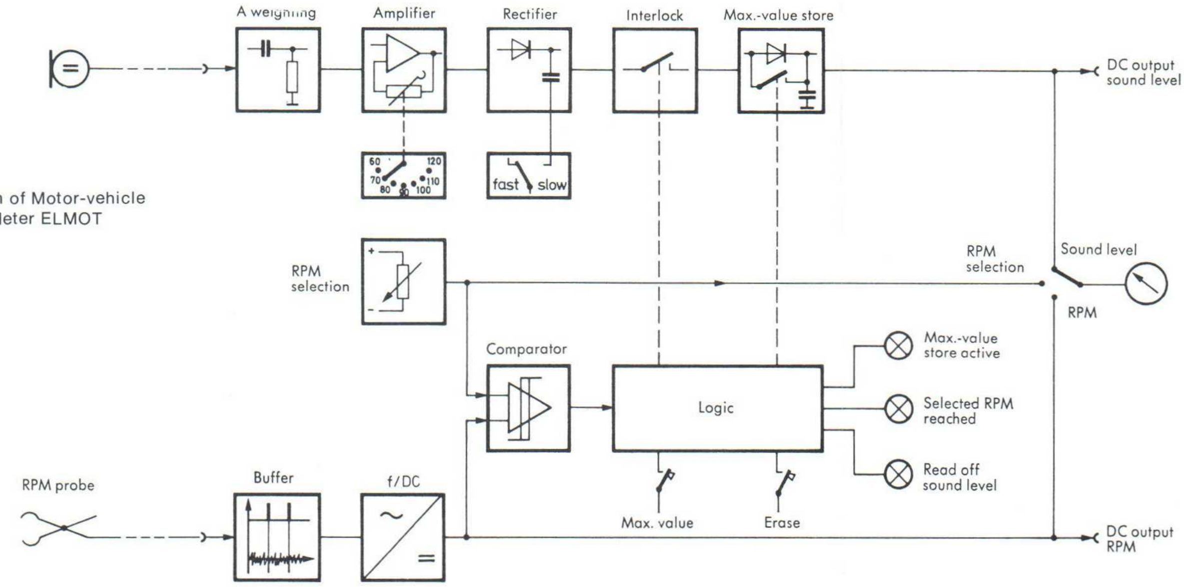
Setting, reference value. The reference value for the operating conditions of an engine is the engine speed S at which it produces its maximum horsepower. The standard gives three versions:

I Stabilization to $^3/_4$ S (or $^1/_2$ S for motorcycles with S > 5000 rpm).
II As under I and then sudden release of the throttle; only the highest sound level that occurs is noted.
III Sudden increase of rpm (or by pumping) to $^3/_4$ S ($^1/_2$ S), and again only the highest sound level is noted.

Measuring procedure. The complete process is as follows:

1) Set up microphone next to exhaust.
2) Lift engine bonnet and clamp rpm probe to spark-plug cable.
3) Sit in driver's seat with ELMOT and start engine. Turn ELMOT rotary switch "automatic" to setting 1 ($^3/_4$ S), for example, and select rpm.

When the throttle is operated, the ELMOT meter indicates the rpm and a red LED signals when the preselected rpm (±2%) are reached. At the same time the measured sound level is electronically stored. If the rpm figure remains within the tolerance for at least 1 s, a yellow LED ("level") signals that the held sound-level value can be read off.



Block diagram of Motor-vehicle Sound-level Meter ELMOT

Features

With diesel engines the rpm cannot be electrically determined. This is possible using an optical probe which is available as an accessory.

Indication of maximum sound level. This device enables reliable measurement of the noise of moving vehicles. From the side of the road, for example, it is possible to ascertain immediately whether a conspicuously loud vehicle is louder than prescribed limits and should be stopped for a noise measurement which could then, if necessary, be used as legal evidence.

Shortened measurement time. The measurement time can be factory-adjusted to 0.1 s instead of 1 s on the customer's request. This is preferable, for example, for measuring racing motorcycles of very high rpm, which by present rules have to be tested before every contest.

DC output for logarithmic sound-level characteristics. In many special investigations it is desirable to plot sound level versus rpm using an XY recorder. Here logarithmic level representation offers better evaluation.

Robust and handy tripod and microphone holder. These parts are designed to withstand the rough handling encountered in practice, for example, in motor car repair shops. The holder is provided with a device for setting distance and angle.

Specifications

Sound-level meter
(all characteristics comply with DIN 45 633 and IEC 179)

Frequency range	10 Hz to 20 kHz
Measurement range	55 to 130 dB(A)
Range selection	in 10-dB steps
Indication	moving-coil meter with rms-responding rectification
Scale range	−5 to 0 to +10 dB
Time weighting	fast, slow, max. hold
Frequency weighting	curve A
Error limits	±1 dB
Precision microphone	Type MKPM (DIN 45 633)
Internal calibration	by stabilized voltage, f = 1 kHz
DC output	log 50 mV/dB

Rpm counter

Measurement ranges	2000/4000/8000/16 000 rpm
Error	±3%
Rpm measurement	via spark-plug cables by means of inductive rpm probe
DC output	+2 V
Automatic evaluation circuit	holds sound level when preset rpm are reached
Engine conditions	I for n 3/4 S II for n ≦ 3/4 S downwards III for n ≦ 3/4 S upwards

General data

Nominal temperature range	−10 to +50 °C
Power supply	4 single cells IEC R 20 or storage battery or power supply
Duration of battery-powered operation	≈100 h
Dimensions, weight	218 mm × 88 mm × 158 mm, 2.6 kg
Order designations	▶ Motor-vehicle Sound-level Meter ELMOT 235.4010.02
ELMOT with calibration certificate	235.4010.12
Accessories supplied	Standard Microphone MKPM with 5 m microphone cable, tripod and setting-up plate, rpm probe, set of single cells and carrying cases for ELMOT and for accessories

Recommended extras

Lead Storage Battery EGT-Z	201.5437.00
Power Supply/Charger EGT-Z	201.5414.00
Optical RPM Probe ELMOT-Z for diesel engines	235.5900.02

ELDO 1

Sound-level Integrator ELDO 1

♦ 20 to 160 dB with EGT

- Precision instrument – including clocked maximum hold with period of 5 s
- Dynamic range up to 44 dB
- Measurement-duration readout up to 99.99 h; battery capacity up to 100 operating hours

For the control of noise damaging to health at work and in residential areas, measuring procedures are to be used which enable the amount of noise exposure of humans to be determined within a definite time period. In the case of varying noise, the instantaneous level must be averaged in order to calculate an equivalent (to duration of measurement) sound level having the same harmful or annoying effect (L_{eq}).

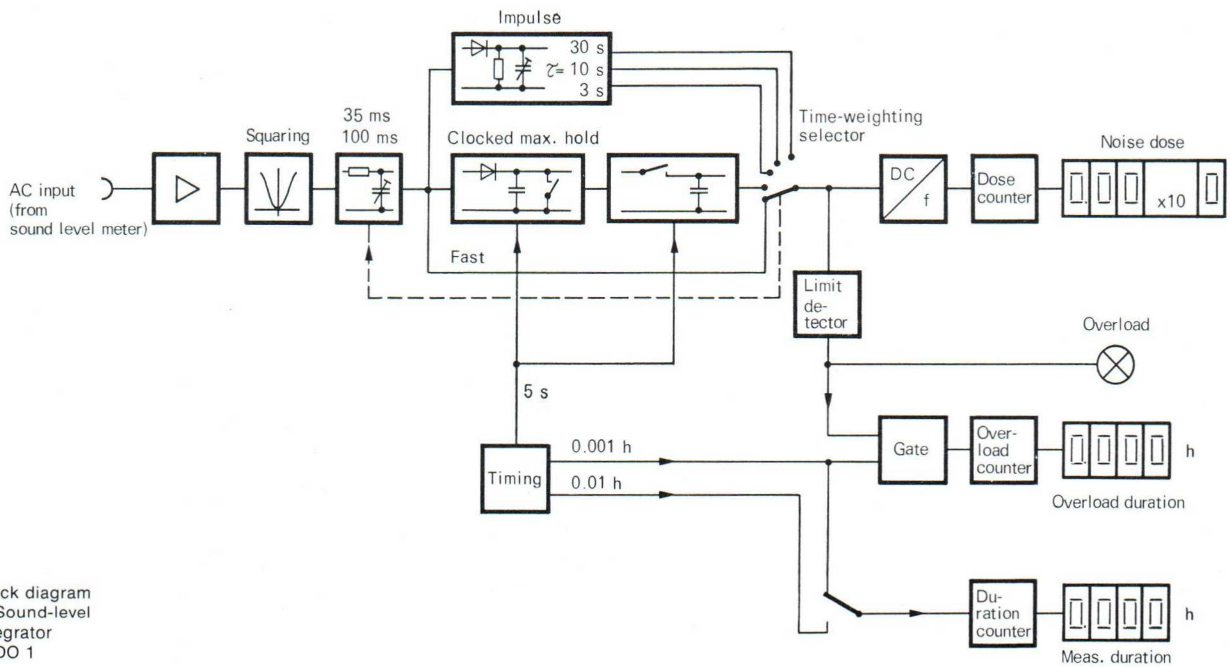
There are standards and recommendations at the international level dealing with this problem (ISO 1996, ISO 1999, IEC Draft SC 29 c WG 11) as well as at the national level (DIN 45 641, VDI 2058). DIN and VDI include different weightings with respect to time, thus the annoyance of various types of noise can be evaluated more accurately.

The Sound-level Integrator ELDO 1 is connected to the AC output of a sound-level meter (e.g. EGT) and automatically performs the integration of sound levels with high accuracy. All weighting modes covered by the standards mentioned can be selected on the ELDO 1. In addition, time weightings relevant for future use have already been taken into consideration.

Functioning of ELDO 1

The AC voltage derived from the sound-level meter is squared in an rms-responsive rectifier. The very wide dynamic range of this patented squaring circuit is – referred to the input – 33 dB if driven with a sinusoidal voltage and increases to 40 dB if driven with a crest factor 3 (corresp. to 10 dB) and even to 44 dB with a crest factor of 5 (corresponding to 88 dB on the DC voltage side).

Time weighting (switch-selectable). The rectified voltage obtained in this manner is passed via different time elements using the WEIGHTING switch. Relative to the position FAST (for L_{AFm} or L_{eq}), the integrated result of pulsed noise is higher, according to the greater degree of annoyance, when the weighting IMPULSE (for L_{AIm}) or clocked maximum hold (for L_{ATm}) is selected. With clocked maximum hold weighting, the maximum level occuring within 5 s is evaluated for the entire interval.



Block diagram of Sound-level Integrator ELDO 1

Indication of absolute noise dose. A DC/f converter produces a DC-voltage-proportional frequency, the variations of which are integrated by a binary counter. The momentary count corresponding to the absolute noise dose is digitally displayed – limited to three places for better legibility. The exponent indicates the place value.

Equivalent sound level L_{eq} noise dose in %. L_{eq} is determined by setting the values for noise dose and measurement duration indicated by the ELDO 1 on the calculator disk supplied (see photo): the result $\triangle L$ on the calculator disk + measurement range of the sound-level meter give L_{eq}. The relative noise dose in percent can be determined in a similar manner with an additional calculator disk that is also supplied.

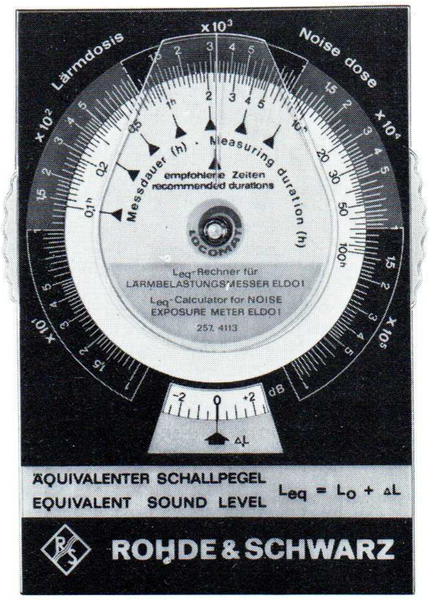
Measurement-duration readout. The measurement duration is recorded by a binary counter, which can be switched to the range 0.001 to 9.999 h or 0.01 to 99.99 h and is driven by a crystal-controlled timing-pulse generator. Time count and dose integration begin as soon as the function switch is set to INTEGRATION. If a measurement is interrupted, either by turning to STOP or temporarily depressing the button PAUSE, all displayed values remain stored until measurement resumes.

Readout of overload-level duration. The exceeding of level threshold is signalled by a limit detector and its duration indicated on a time counter. Durations that last several per cent of the measurement duration do not affect the measured result.

Calibration. The signal path from microphone to the integration readout can be checked in switch position CALIBRATION using the Sound-level Calibrator ELEB (correction is possible on the front panel).

Construction of ELDO 1. The dimensions are exactly the same as those of the Impulse Sound-level Meter EGT. Both instruments together with the Standard Microphone MKPM can be accommodated in a leather carrying case and put to use at any time independent of the AC supply. The digital section of the ELDO 1 consists of MOS components – a total of 60.

Complete outfit for continuous sound-level measurements: Sound-level Integrator ELDO 1, underneath Impulse Sound-level Meter EGT, Standard Microphone MKPM and calculator disk for L_{eq}



Calculator disk for determination of L_{eq} (supplied with instrument)

Specifications

Input voltage	adjustable from 0.8 to 3 V (factory-adjusted to 2 V for EGT), rear connectors
Input impedance	> 50 kΩ
Frequency range	10 Hz to 20 kHz
Dynamic range including crest factor S = 1.4 (sine)/3/5	33 dB/40 dB/44 dB
Measurement range	depends on range of sound-level meter; with EGT: 20 to 160 dB
Time weighting	FAST τ = 35 ms TAKT MAX. T = 5 s (clocked max. hold) IMPULSE τ = 3/10/30 s
Exchange rate	3 dB
Integration capacity	270 h × measurement range of sound-level meter (with EGT: 270 h × 150 dB)
Measurement duration	0.001 to 9.999/0.01 to 99.99 h LED digital display
Noise-dose indication (absolute value)	0.01×10^0 to 9.99×10^5 (corresp. to $Pa^2 \times s$ with 90-dB range)
Indication of overload-level duration	0.001 to 9.999 h
Calibration	with Sound-level Calibrator ELEB to dose indication 1.00×10^0
Measurement pause	temporary: by pressing PAUSE button; for longer or end of measurement: turn to STOP
Error limits	±0.5 dB with correct range selection on sound-level meter
DC output	+4 V/≧ 10 kΩ (squared signal)
General data	
Nominal temperature range	−10 to +50 °C
Power supply	4 single cells of 1.5 V (IEC R 20) or 1 lead storage battery (rechargeable via power supply) or power supply
Capacity of single cells	> 100 h
of storage battery	> 50 h
Dimensions, weight	212 mm × 88 mm × 158 mm, 2.6 kg
Order designation	▶ Sound-level Integrator ELDO 1 257.4013.02
Accessories supplied	1 calculator disk for L_{eq} 1 calculator disk for rel. dose 1 connecting cable EGT – ELDO 1 1 sun shield 4 single cells, 1.5 V, IEC R 20 1 plug strip for connecting other sound-level meters
Recommended extras	
Power pack and charger	201.5414.00
Sound-level Calibrator ELEB	201.5443.90
Sound-level Meter	EGT, ELT 2, ELT 3 or EZGA 2
Carrying case	235.5869.00
Double case for ELDO 1 + EGT	257.5961.00

ELDO 2

Integrating Sound-level Meter ELDO 2
♦ 10 Hz to 20 kHz/30 to 120 dB

- Precision instrument in line with DIN 45 633 and IEC 179
- Micrprocessor-controlled determination of mean levels L_{AFm} (L_{eq}), L_{AIm}, L_{AFTm} or % noise dose in line with DIN 45 645, VDI 2058 and ISO 1996/1999
- High freedom of movement through separation into integrator and evaluation unit
- Protected against unauthorized intervention

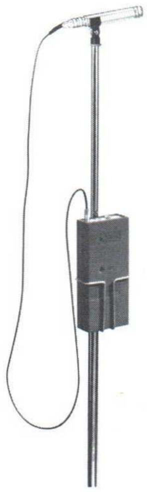
Users

The **Integrating Sound-level Meter ELDO 2** ranks as a precision instrument and is intended for users demanding the highest degree of accuracy and adaptability. It is ideally suited to state-run supervisory authorities and largish noise-producing industrial enterprises.

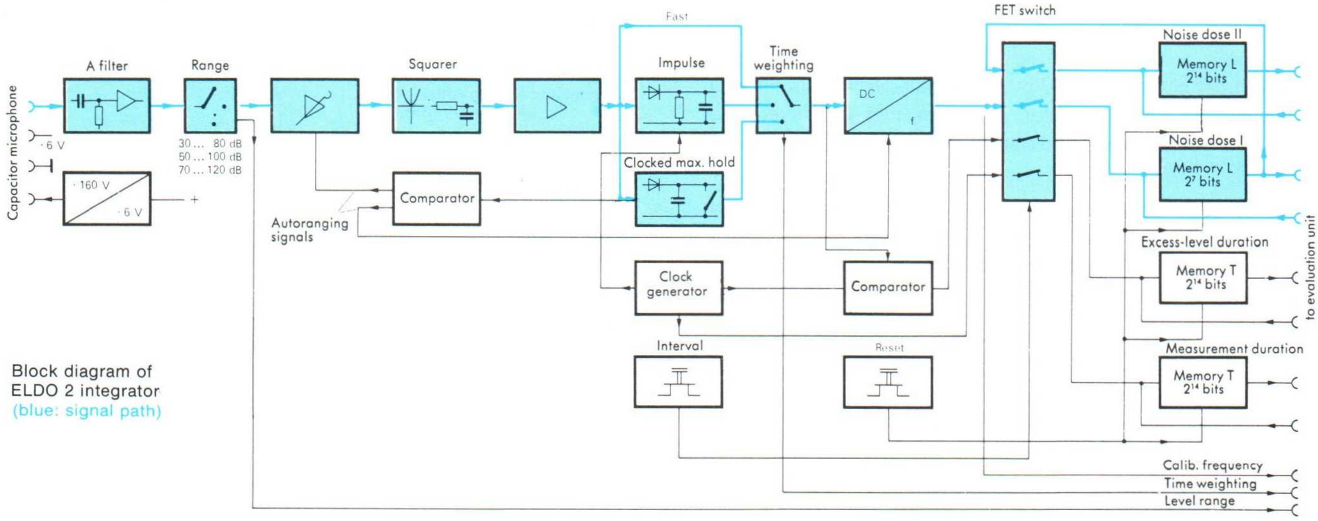
Characteristics

ELDO 2 is made up of the evaluation unit with digital display and one or more battery-powered integrators each with its own precision microphone set up at a certain distance. This construction affords extremely high freedom of movement and unprecedented versatility. The compact integrator can be set up virtually everywhere to store the noise dose without obstructing any work that is in progress.

Another great advantage is the possibility of using several independent integrators simultaneously at different locations; this feature can save a lot of time, for example, when checking noise in factories.



Battery-powered independent **integrator** with microphone and tripod



Block diagram of ELDO 2 integrator (blue: signal path)

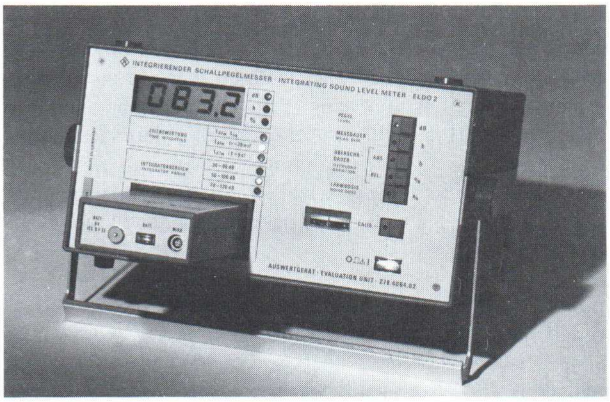
Simultaneous measurements are a necessity, for example, in the production of noise-contour plots or when measuring sound insulation of windows for dwelling places near traffic roads. The integrator stores the measured data as long as desired after the set has been switched off.

Level range, measured data. The level range of 30 to 120 dB covers all events from nocturnal noise in residential areas to the loudest industrial noise. The test quantities (L_{eq}, L_{Alm}, L_{AFTm}) prescribed for the different types of noise can be switch-selected. Irrelevant sound events can be eliminated from the measurement by pressing an interrupt button.

Description

The integrator includes the analog input circuit with power supply for the microphone, the input amplifier with A-weighting filter and the squaring stage, the time-weighting network and a DC/f converter for the noise-dose store. Another two stores hold the measurement duration and the excess-level duration, if any. The MOS stores remain connected to the power supply when the set is switched off.

The Standard Microphone MKPM with connecting cable, holder, tripod and bracket is supplied together with the integrator. The tripod carries another holder for the integrator, see photo on left.



Integrating Sound-level Meter ELDO 2 (evaluation unit with integrator inserted); it calculates and displays the values called up by pushbutton action

The evaluation unit transfers to its microprocessor the values stored in the integrator when this is plugged in. The calculating routine and the data display can then be started by pushbutton and repeated as often as required.

Overall calibration is made with the Sound-level Calibrator ELEB (recommended extra) while the integrator with the microphone is plugged into the evaluation unit.

Specifications

Integrator	precision characteristics in line with DIN 45 633 and IEC 179 as far as relevant
Dynamic range	50 dB + 14 dB peak factor
Measurement ranges	presettable I 30 to 80 dB II 50 to 100 dB III 70 to 120 dB
Frequency weighting	A
Amplitude weighting	presettable I clocked max. hold in line with DIN 45 645, clock time 5 s (changeable to 3 s) II impulse III fast
Exchange rate	3 dB
Level integrator	binary counter with DC/f converter
Capacity	9 h at 110 dB (range 70 to 120 dB)
Sound-level suppression	by pushbutton
Time integrator	binary counter
Capacity	21 h
Excess-level duration integrator	binary counter for max. 1.4 h duration
Microphone (separate from integrator: connected through cable, see photo p 216)	Standard Microphone MKPM
Power supply	9-V battery; check by panel meter; capacity > 20 h
Automatic switchoff	with undervoltage integration is stopped and storage contents are held
Interruption of measurement	by pushbutton
Error limits	$\leqq \pm 1$ dB
Nominale temperature range	−10 to +50 °C
Dimensions, weight	38 mm × 90 mm × 194 mm. 500 g

Evaluation unit	
Display	4 digits, switch selection of 1) mean level (L_{eq}, L_{Alm}, L_{AFTm}) 2) measurement duration 3) abs. excess-level duration 4) rel. excess-level duration 5) noise dose in percent
Readout	24-way connector
Readout time	< 2 s
LED indication	level range and time weighting mode
Error limits	no error inherent to evaluation unit
Calibration	using sound-level calibrator, e.g. ELEB; covers integrator and evaluation unit
Nominal temperature range	0 to 40 °C
Power supply	110/125/220/235 V ±10%
Dimensions, weight	280 mm × 180 mm × 270 mm, 5.3 kg

Order designations	► Integrating Sound-level Meter ELDO 2
Integrator with microphone, connecting cable, tripod bracket, switching tool and 9-V battery	278.5360.02
Evaluation unit with power cable	278.4064.02

Recommended extras	
Tripod MKPM-Z2	154.5899.02
Boom MKPM-Z3	154.5901.02
Sound-level Calibrator ELEB	201.5443.90

ELDO 4

(shown in larger scale than usual)

Integrating Sound-level Meter ELDO 4

♦ 16 Hz to 16 kHz/43 to 100 dB

- For quick noise measurements at places of work and in residential areas – hand-held or on tripod
- Direct indication of equivalent continuous sound level L_{eq} in line with DIN 45 641 and 45 645
- Choice of six measurement durations from 15 s to 8 h
- Inexpensive

Measuring and averaging sound levels

Noise exposure caused by sound events varying in time can only be determined by averaging the sound level over the period in question. **Mean sound levels** cannot be measured with conventional instantaneous-value sound-level meters. The integrating sound-level meters required for this purpose need more elaborate circuitry and are consequently more expensive.

The **Integrating Sound-level Meter ELDO 4** from Rohde & Schwarz, based on a new circuit concept, indicates the equivalent continuous sound level directly in dB. It is offered at an exceptionally low price.

To take a measurement with ELDO 4 simply

- select measurement duration
- select level range
- wait until measurement duration has elapsed and
- take reading

Characteristics and uses

Three measurement ranges adapted to the German regulations concerning noise at places of work
Signalling by LEDs in 3-dB steps:
red if level is above limit,
green if level is below limit.

Hand-held for quick rough measurements,
mounted on tripod for long-term measurements.

This novel noise meter makes noise control as laid down by national and international regulations easy. Thanks to its light construction intended for mobile use it is equally suitable for measuring traffic noise or for noise evaluation in dwelling areas.

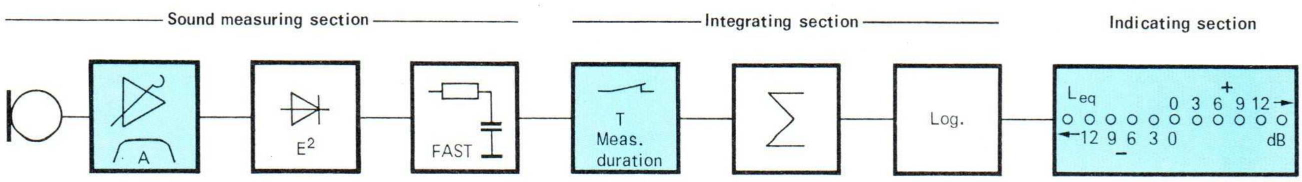
Operation is simple: there are only two switches, one for measurement duration and one for measurement range.

Measurement duration is selected by means of a sliding switch. It is factory-adjusted to 15 s and 4 min. Any desired combination of two of the available times – 15 s, 1 min, 4 min, 15 min, 1 h, 8 h – can be taken to the switch by changing the soldering, say 15 s and 8 h. A duration of 8 hours (full work shift) is required for measurements at places of work with greatly varying noise levels, while by random measurements of short duration it is possible to get a rough idea of the noise environment.

The measurement range extends from 43 to 100 dB and is divided into three switch-selected, generously overlapping subranges. The subranges are based on the Federal-German regulations for places of work stipulating noise limits for different types of work:

55 dB(A)	for primarily mental work
70 dB(A)	for simple or to a great extent mechanized office work or comparable activities
85 dB(A)	for any other activities; under certain circumstances, which must be explained, up to 90 dB(A).

Block diagram of ELDO 4



These limits are the centre values of the ELDO 4 subranges. A symmetrically arranged LED scale (red for + and green for −) directly indicates the amount by which the measured value is above or below the selected noise limit. The measured value is always to the right of the indicated figure. If, for example, +6 dB is indicated and the range selected is 70 dB, the measured value is above 76 dB, more precisely between 76 and 79 dB.

The 3-dB resolution is adequate for coarse measurements. The response tolerance of the LEDs is ±1 dB.

Although not used for traffic-noise measurements, a **rating sound level** L_r is encountered in the regulations governing noise at work. This quantity accounts for the higher annoyance effect of **impulsive noise** and can be computed from the equivalent noise level L_{eq} by adding 3 or 6 dB as given in DIN 45 645. Some examples:

add 0 dB — for constant or slowly varying noise levels such as from motors and textile machinery;

add 3 dB — for moderately impulsive noise such as in offices, workshops and assembly areas;

add 6 dB — for markedly impulsive noise such as encountered in press shops and forges.

Quick rough measurement with hand-held ELDO 4

Description

The Integrating Sound-level Meter ELDO 4 consists of an analog sound measuring section (similar to that of the Sound-level Meter ELT 3), a digital integrating section and an indicating section (see block diagram at the bottom of preceding page).

The sound measuring section is made up of a capacitor microphone, a switchable amplifier with frequency weighting filter according to curve A and a square-law rectifier with FAST time weighting.

The DC signal is applied to the integrator by means of the measurement duration selector. After several logic functions have been performed in the integrator the logarithmized integration value is passed on to the indicating section in 3-dB steps.

The three measurement ranges are switched over in the analog section. The eleven indicating LEDs are symmetrically arranged about the reference level values 55/70/85 dB, i.e. each range covers 27 dB, namely −12 to 0 to +15 dB. Moreover, another two LEDs are provided to indicate when the range is exceeded or not reached.

Still another LED is provided beside the measurement range selector (position BATT./CAL.) for checking the battery voltage and for calibration. Use of CMOS integrated circuits ensures that very little current is required by the circuit, which is fed from a commercially available 9-V battery.

The plastic case is very handy and robust. Its shape takes into consideration the omnidirectional pickup pattern of the microphone, allowing for any direction of incidence of the noise. For long-time measurements the meter can be mounted on a tripod by means of a bracket. A carrying case is supplied with the meter for protection during transportation.

Specifications

Frequency range	16 Hz to 16 kHz
Indication	equivalent continuous sound level L_{eq} according to ISO R 1996, ISO R 1999 and DIN 45 645
Measurement ranges (A weighting)	55 dB −12/+15 dB 70 dB −12/+15 dB 85 dB −12/+15 dB
Display of test value	by LEDs

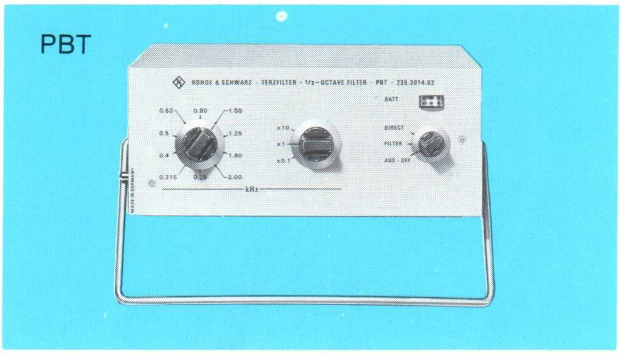
Reference level		Colour	Indication in dB	Test value step in dB
	Not reached		←	below −12
		green	−12	−12 to −9
			−9	−9 to −6
			−6	−6 to −3
			−3	−3 to 0
	Exceeded	red	0	0 to +3
			+3	+3 to +6
			+6	+6 to +9
			+9	+9 to +12
			+12	+12 to +15
			→	above +15

Error of LED response	< 1 dB
Error of range switching	< 0.5 dB max.
Inherent noise	10 dB below lower range limit
Type of rectifier	rms-response square-law rectifier
Crest factor	14 dB above +12-dB indication
Exchange rate	3 dB
Frequency weighting	A weighting curve
Time weighting	FAST
Measurement duration,	
switch-selected	15 s/4 min (factory-adjusted)
adjustable	to any combination of two out of 15 s, 1 min, 4 min, 15 min, 1 h, 8 h by changing the soldering
Precision microphone	capacitor microphone with omnidirectional pickup pattern
Power supply	9-V battery IEC 6 F 22
Battery life	> 50 h
Dimensions	104 mm × 233 mm × 43 mm
Order designation	▶ Integrating Sound-level Meter ELDO 4 219.4026.02

Accessories supplied
9-V battery IEC 6 F 22
Adhesive labels for other measurement durations (in the meter)
Carrying case

Recommended extras

Wind Screen MKPM-Z	100.5810.02
Tripod Bracket ELT-Z3	215.8940.02
Tripod MKPM-Z2 (with folding legs)	154.5899.02
Tripod MKPM-Z5 (with screw-in legs)	155.0303.02
Sound-level Calibrator ELEB	201.5443.90



Third-octave Filter PBT

♦ 22.4 to 22 400 Hz (f_m = 25 to 20 000 Hz)

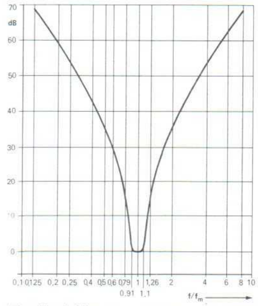
- Auxiliary instrument for acoustic and vibration tests
- High skirt selectivity, passband attenuation 3 dB; performance complying with relevant standards
- AC supply or battery operation

Third octave filters are required, for example, in sound-level and vibration analyses or measurements in the field of architectural acoustics to select particular frequencies from wide spectra or to separate harmonics from fundamentals.

The **active Third-octave Filter PBT** consists of 30 bandpass filters which are switch-selected in 1/3-octave steps. Each is made up of two filter sections which together yield an attenuation characteristic complying with DIN 45 652.

Selection of the bandpass filter (midband frequency) with rotary switches. A DIRECT position is provided to bypass the filter via an internal 3-dB section.

The active section is fed from four 1.5-V single cells (or a power supply or a 6-V storage battery; to be ordered separately).



Typical filter response of a PBT

The plastic cabinet is metallized on the inside. It can be accommodated together with the EGT (Impulse Sound-level Meter) in a carrying case.

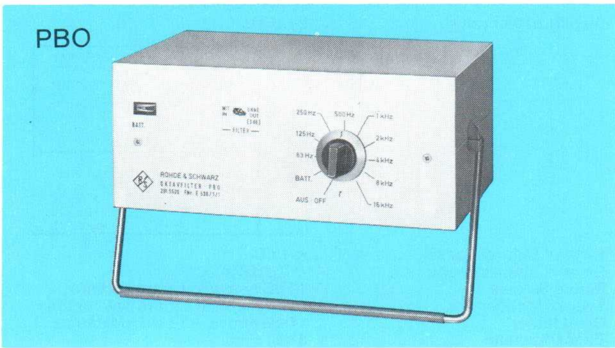
Specifications

Frequency range	22.4 to 22400 Hz (30 steps)
Midband-frequency intervals	1/3 octave
Passband attenuation	3 dB
Max. input voltage	3.5 V
Characteristic impedance	600 Ω
Connectors	BNC and 1/3.9 mm coaxial
Dimensions	212 mm × 88 mm × 158 mm
Weight	2.1 kg (with single cells)

Order designation (incl. four single cells) .... ▶ Third-octave Filter PBT 235.3014.02

Recommended extras

2 RF patch cords (100 cm, 75 Ω) 100.6980.10
1 Connecting Cable EGT-Z 205.3016.02 (PBT – EGT)
1 Storage Battery EGT-Z (6 V) 201.5437.00
1 Power Supply EGT-Z (6 V, weight 0.5 kg) 201.5414.00
1 Carrying case 235.5869.00



Octave Filter PBO

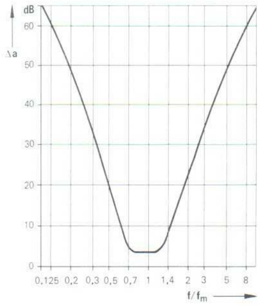
♦ 45 to 22 400 Hz (f_m = 63 to 16 000 Hz)

- Auxiliary equipment for acoustic and vibration analysis
- Chebishev filter complying with pertinent standards; high skirt selectivity, passband attenuation 3 dB
- AC supply or battery operation

Octave filters are used for the measurement and analysis of the sound level or structure-borne sound in architectural acoustics to separate certain frequency regions from a larger spectrum or harmonics from the fundamental frequency.

The **active Octave Filter PBO** contains nine filters selectable in octave steps. The three filter circuits of each octave filter provide an attenuation characteristic according to DIN 45 651.

Selection of the filter or the midband frequency by means of a rotary switch. The selected filter can be bypassed by an internal 3-dB attenuator with the help of a toggle switch. The active section can be fed either from four 1.5-V dry batteries, a 6-V storage battery or a power-supply unit, which must be ordered separately.



Typical filter characteristic of a PBO

The PBO is in a plastic box, metallized on the inside and can be accommodated together with the EGT (Impulse Sound-level Meter) in one carrying case.

Specifications

Frequency range	45 to 22400 Hz (9 steps)
Midband-frequency intervals	1 octave
Passband attenuation	3 dB
Max. input voltage	3.5 V
Characteristic impedance	600 Ω
Connectors	BNC and 1/3.9 mm coaxial
Dimensions	212 mm × 88 mm × 158 mm
Weight	2.1 kg (with single cells)

Order designation (incl. four single cells) .... ▶ Octave Filter PBO 201.5520.02

Recommended extras

2 RF patch cords (100 cm, 75 Ω) 100.6980.10
1 Connecting Cable EGT-Z 205.3016.02 (PBO – EGT)
1 Storage Battery EGT-Z (6 V) 201.5437.00
1 Power Supply EGT-Z (6 V, weight 0.5 kg) 201.5414.00
1 Carrying case 235.5869.00

Standard Microphone MKPM
♦ 8 Hz to 20 kHz

- Sound-pressure measurement range 10 to 150 (166) dB on a sine wave
- Precision measurements according to DIN 45 633 and IEC 179, and noise analyses with suitable test equipment

The capacitor-type **Standard Microphone MKPM** is a multipurpose, electro-acoustic transducer. On account of its excellent characteristics it is mainly used for noise measurements requiring the highest accuracy. It has a low-impedance output so that long connecting cables (up to 100 m) can be used. Precision measurements according to the German Standard DIN 45 633 can be made in conjunction with the Impulse Sound-level Meters EGT and EZGA 2. Accurate noise analyses can be carried out with an analyzer. The MKPM can be electrically heated.

The 150-V polarizing voltage and the supply voltage for the two-stage impedance transformer (30 V; 1 mA) are derived from the test equipment connected, or from batteries. With the polarizing voltage of 150 V it is possible to measure a peak sound pressure of 150 dB, and with 15 V a pressure of 166 dB.

For acceleration measurements it is merely necessary to exchange the microphone capsule for the Adapter EBVB-Z 100.5803.02 in order to connect the Acceleration Pickup EBVB (below).

► Order designations

Standard Microphone MKPM (incl. case, calibration certificate, wind screen and microphone attachment)					220.5180.02
Weather Shield MKPM-Z (wind and rain protection)					220.9005.03
Connecting Cable MKPM-Z	1.2 m	5 m	10 m	20 m	50 m
	100.5784.05	.02	.03	.04	.06
Portable Tripod MKPM-Z1					154.5882.02
Tripod MKPM-Z2 (with folding legs)					154.5899.02
Boom MKPM-Z3					154.5901.02
Tripod MKPM-Z5 (with screw-in legs)					155.0303.02

Sound-level Calibrator ELEB
♦ 1000 Hz

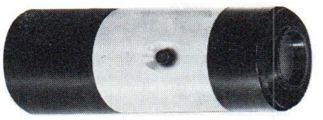
- Acoustic calibrator for sound-level meters
- Sound-pressure level 93.6 dB (94 dB = 1 N/m² = 10 μbar)
- Calibration check independent of weighting

The small, battery-powered **Sound-level Calibrator ELEB** is used for accurate calibration of sound-level meters (e.g ELT 2, EGT, EZGA 2 from R&S). A 1000-Hz calibration frequency with a sound level of 93.6 dB (±0.25 dB) is generated independently of the weighting filters. The effect of static air pressure is ±0.05 dB/100 mbar between 500 and 1100 mbar.

Calibration. The microphone of the sound-level meter is inserted into the coupler opening of the Sound-level Calibrator, and by pressing a button the 1000-Hz calibration signal of 93.6 dB is switched on. The duration of the signal – approx. 1 min if the 9-V battery is fully charged – indicates the condition of the battery. The sound pressure is independent of the microphone's equivalent volume.

The Sound-level Calibrator is supplied in a leather case. Dimensions of ELEB: dia. 44 mm, length 110 mm; weight 260 g.

► Order No. 201.5443.90.

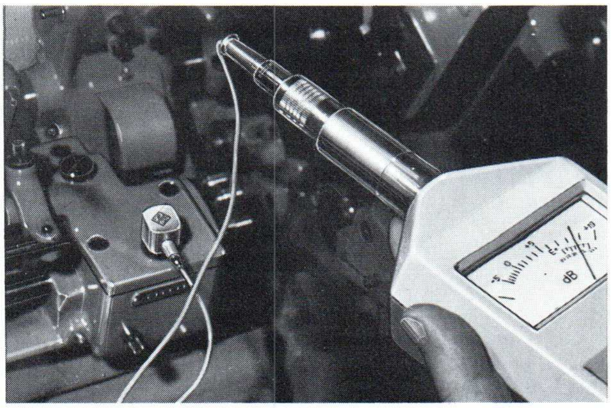


ELEB
(shown in larger scale than usual)

Acceleration Pickup EBVB ♦ 1 Hz to 20 kHz

Two different types of Acceleration Pickups are available: (1) **Acceleration Pickup sensitive to acceleration only,** held by a permanent magnet. Safe upper load limit 1000 m/s². Resonance frequency approx. 60 kHz. ► Order No. 100.5890.02. (2) **Acceleration Pickup sensitive to acceleration and force.** Safe upper load limit 3000 m/s² or 30 N. Resonance frequency approx. 20 kHz. ► Order No. 100.5884.02. Adhesive waxes are available for attaching the Acceleration Pickup:

100.5855.02 for an operating temperature range from +5 to +40 °C.



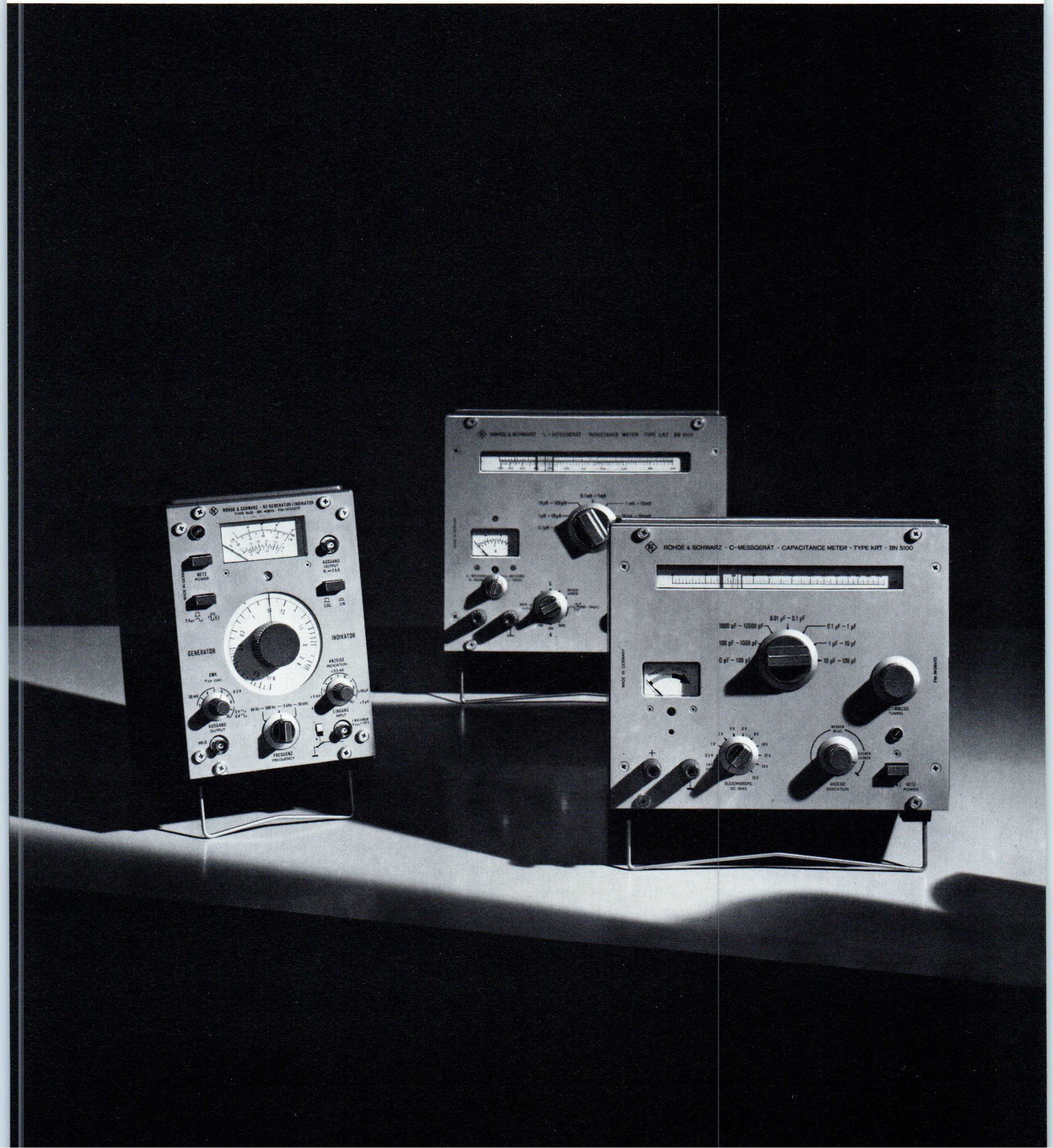
Right: Measurement using Acceleration Pickup and ELT 2

Inductance Meter LRT,
Capacitance Meter KRT and
RC Generator/Indicator SUB

Refer to section 3 (pp. 82 to 89) for automatic measurements on components and subassemblies for the AF and RF range with computer-controlled Test Assembly **SMPU.**

10

test equipment for passive and active components and subassemblies



Instruments for measurements on components and materials

The following pages of this catalog present instruments for measuring resistors, coils, capacitors and insulating materials in the entire RF range. The measurements are made with direct or alternating current at frequencies from 50 Hz to approx. 10 MHz.

Equivalent circuits of lossy circuit elements

Besides the wanted properties each circuit element has unwanted components: resistors are affected by leakage inductances and stray capacitances; capacitors by dielectric losses and lead and winding inductance; coils by losses in the windings and the core. Equivalent circuit diagrams for the different test items facilitate the determination of the test conditions (Fig. 1), the test frequency being of particular importance for accurate measurements. Depending on its origin, the disturbing component is represented in series or parallel with the ideal quantity. The component of interest can be exactly determined if the correct frequency is selected. Further details, also as to the recommended test power, are given in the manual supplied with the instrument.

The different measuring methods express the measured quantity in terms of a series or parallel equivalent circuit. The form in which the result is presented depends in many cases on the measuring technique of the instrument used. The measured inductive or capacitive reactance is theoretically not the same for the two equivalent circuits. If the dissipation factor tanδ is less than about 3×10^{-2} or the Q factor is greater than 32 (Fig. 2), the difference is only 0.1%.

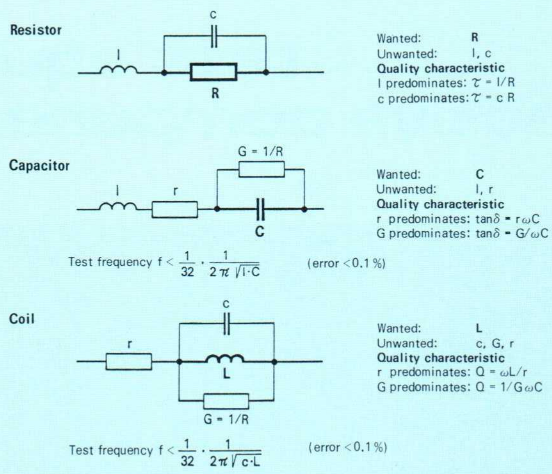


Fig. 1 Equivalent circuit diagrams for R, L and C and their unwanted components

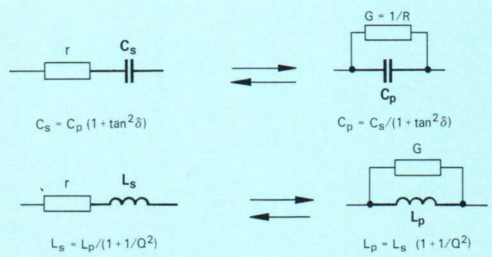


Fig. 2 Representation of the measured L and C in equivalent series and shunt circuits

Measuring methods and accuracy

Three measuring methods are commonly used (Fig. 3): voltmeter-ammeter method for measurements of limited accuracy (Fig. 3a), resonance method with an error of 1% (Fig. 3b) and balance or bridge method offering an accuracy of even better than 0.1% (Fig. 3c). The instruments **measure the wanted component** (R, C or L) or the wanted together with the **unwanted component**. Losses are indicated as series resistance r, parallel conductance G = 1/R or as resistance-to-reactance ratio, expressed by the dissipation factor tanδ or Q factor; the reactive component is sometimes indicated as time constant τ. The **measuring error** may be greater for the unwanted component than for the wanted component, the share of the unwanted component in the total impedance being in most cases insignificant. The often required **Q factor** of coils can be measured either by resonance step-up in a series tuned circuit or by employing a more recent method in which the number of decaying oscillations in a pulse-excited parallel resonant circuit are counted within given amplitude limits and indicated as a digital readout (see under Q measurement).

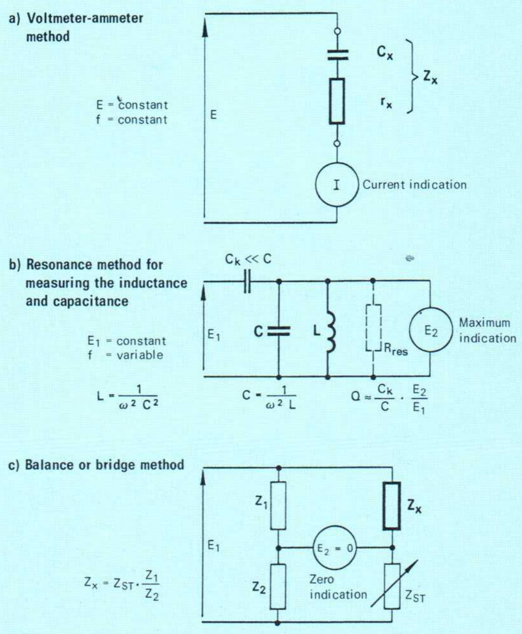


Fig. 3 Circuits for measuring passive circuit elements

Parameter	Measurement range	Designation	Type	Order No.	Test frequency	Method	Error	Dimensions (W × H × D) in mm	Text on page
R	10 kΩ to 1200 MΩ	High-voltage Tester	UHP	100.2404.02	direct current	voltmeter-ammeter	±20%	286 × 227 × 226	225
L	0.1 μH to 1 H	Inductance Meter	LRT	100.6568.92	↗ 4.5 MHz to 2.2 kHz	resonance	for Q > 10: ±1% ±0.01 μH	269 × 238 × 277	226
C	1 pF to 100 μF	Capacitance Meter	KRT	100.6300.92	↗ 285 to 2.2 kHz	resonance	for tanδ < 2 × 10^{-2}: ±1 (2)% ±0.5 pF	269 × 238 × 277	226
	0.3 μf to 1 F	High-capacitance Meter	KZG	100.6345.92	50/60/100/120 Hz	voltmeter-ammeter	±2 (3)%	162 × 238 × 247	227
R, L or C	10 mΩ to 12.2 MΩ 1 μH to 1220 H 1 pF to 1220 μF	Automatic Precision Bridge	RLCB	100.3023.92	1 kHz (50 Hz to 20 kHz)	bridge	±1 (2)%	270 × 238 × 250	228

↗means: frequency depends on value of test item.

UHP

High-voltage Tester UHP
♦ 10 kΩ to 1200 MΩ

- Safe checking of dielectric strength
- Maximum test voltage 2000 V

The **UHP** permits safe checking of the dielectric strength of circuit components and all types of wires, such as insulators, bushings, soldering-lug and terminal strips, switches, variable air capacitors and other capacitors. The shortcircuit current is limited to max. 0.4 mA.

The output voltage of the High-voltage Tester can be adjusted in 8 steps from 50 V to 2000 V, the voltage steps being chosen such that all values required according to DIN 57 870 for checking paper, foil and metallized-paper capacitors can be set. Simultaneously the panel meter indicates the insulation resistance.

Specifications

Voltage range .... 50 to 2000 V DC
in steps of .... 50/250/350/500/700/1000/1500/2000 V
Source resistance .... 0.5/2.2/2.9/3.8/4.6/5.3/4.8/11 MΩ
Shortcircuit current .... max. 0.4 mA
Resistance range .... 10 kΩ to 1200 MΩ
Dimensions, weight .... 286 mm × 227 mm × 226 mm, 7 kg

Order designation .... ► High-voltage Tester UHP 100.2404.02

Inductance Meter LRT ♦ 0.1 µH to 1 H

- Wide measurement range, seven subranges
- Error limits (at Q > 10) ±1% ±0.01 µH

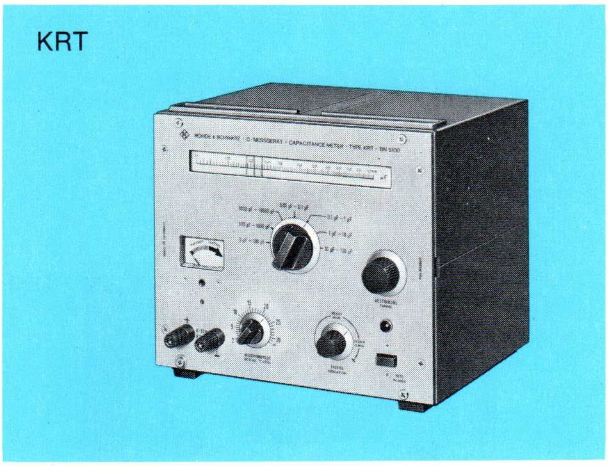
The **Inductance Meter LRT** permits direct measurement of the self-inductance of coils and chokes. It determines the Q factor in the range 2 to 1000 at the test frequency and also the distributed capacitance of coils. It is fully transistorized and operates according to the resonance method with a test voltage of ≦ 80 mV; the test frequency, depending on the test item, is from 4.5 MHz to 2.2 kHz.

Specifications

Inductance range	0.1 µH to 1 H
7 subranges	0.1 to 1µH/1 to 10 µH/10 to 100 µH/ 0.1 to 1 mH/1 to 10 mH/10 to 100 mH/ 0.1 to 1 H (test frequency ↗ 4.5 MHz to 2.2 kHz)
Error limits (if Q > 10)	±1% ±0.01 µH
Test voltage	≦80 mV (depending on coil Q)
Coil Q range	2 to 1000 (if L ≧ 1 µH)
4 subranges	30/100/300/1000
Error	approx. ±10% of fsd
Coil self-capacitance range	0 to 200 pF (Q > 20; L > 42 µH)
Error limits	±3% ±1.5 pF
Nominal temperature range	+10 to +35 °C (for L measurement) +15 to +35 °C (for Q measurement)
AC supply	115/125/220/235 V +10/−15% (4.8 VA)
Dimensions and weight	269 mm × 238 mm × 277 mm, 7 kg
Order designation	► Inductance Meter LRT 100.6568.92

Recommended extras

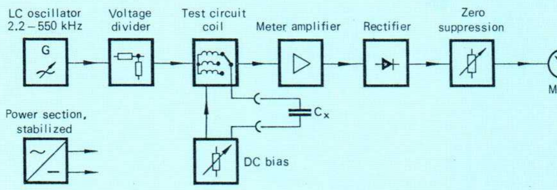
Cabinet cover	043.4566.00
2 quick-connect/disconnect terminals	157.8801.90



Capacitance Meter KRT ♦ 1 pF to 100 µF

- Measurement range in seven subranges
- Test voltage only 2 to 25 mV
- Built-in bias voltage source 0 to 32 V

The fully transistorized **Capacitance Meter KRT** permits all common types of capacitors to be measured. At resonance the test voltage is less than 25 mV so that it is also possible to measure semiconductor capacitors. With the aid of a continuously adjustable polarization voltage (see block diagram on the right) the function C = f(V) of varactors can be determined. The error limits at tanδ ≦ 2 × 10^{-2} are ±1% ±0.5 pF in the range 1 pF to 10 µF and ±2% in the range 10 to 100 µF.



Block diagram of Capacitance Meter KRT

Specifications

Capacitance range	1 pF to 100 µF
7 subranges	0 to 100 pF/100 to 1000 pF/ 1000 to 10,000 pF/ 0.01 to 0.1 µF/0.1 to 1 µF/ 1 to 10 µF/10 to 100 µF
Error limits if tanδ ≦ 2 × 10^{-2} in the range	
1 pF to 10 µF	±1% ±0.5 pF
10 to 100 µF	±2%
Test frequencies	↗ 285 to 2.2 kHz
Test voltage	2 to 25 mV
Polarizing voltage (continuously variable)	0 to 32 V (negative pole to chassis)
Setting error	≦±0.5 V (at 23 °C)
Max. current	5 mA
Test terminals	2 knurled terminals (one connected to chassis)
Nominal temperature range	+10 to +35 °C
AC supply	115/125/220/235 V +10/−15%
Dimensions and weight	269 mm × 238 mm × 277 mm, 7.3 kg
Order designation	► Capacitance Meter KRT 100.6300.92

Recommended extras

Cabinet cover	043.4566.00
2 quick-connect/disconnect terminals	157.8801.90

KZG

High-capacitance Meter KZG

♦ 0.3 µF to 1 F

- Direct reading of capacitances up to 1 F
- Test frequencies 50/60/100/120 Hz; specifications meet VDE and MIL requirements
- Voltage across test item < 10 mV (≦ 100 mV with extreme dissipation factors)
- Capacitance-proportional output voltage

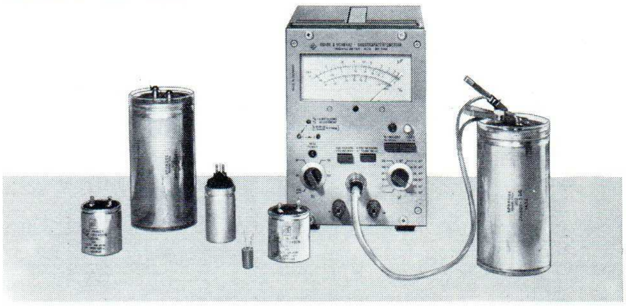
LIMITED-AVAILABILITY PRODUCT

The **High-capacitance Meter KZG** measures capacitors in the range 0.3 µF to 1 F and is particularly intended for electrolytic components. The specifications meet both the VDE and MIL requirements.

Description. The capacitances are measured according to the voltmeter-ammeter method. Dissipation factors up to tanδ = 10 are permissible. Indication of series capacitance. Measurement error ≦ 2% of fsd. Four-terminal connection via Kelvin contacts is possible for capacitors of high value to eliminate the influence of lead and contact resistances. Thus capacitors with impedances of the order of a few milliohms can be measured. A built-in 1.5-V source prevents polarity changes during tests on tantalum electrolytic capacitors. In addition to absolute measurements, the set enables tolerances to be checked in the range of −40%/+100% without the use of calibrated standards.

Application. The KZG is well suited for use in lavoratories and test departments by manufacturers and users of capacitors, for example for goods-inwards inspection.

KZG with test socket for four-terminal measurements via Kelvin contacts



Further processing of measured values in sorting or classifying equipment. The KZG delivers a capacitance-proportional output voltage which can be used for further processing in semi- or fully automatic measuring and sorting equipment (measurement rate 1 measurement/s, R_L = 1 MΩ).

Specifications

Range	0.3 µF to 1 F, 13 subranges
Percentage scale	−40 to +100%
Error limits	±(1% of rdg ±1% of fsd)
Additional error	<±2% of rdg in upper third of scale; <±2% of rdg in 4-terminal measurements in range 0.1 to 1 F
Test voltage	
with small dissipation factors	2.5 to 10 mV (depending on capacitance of test item and test frequency)
with dissipation factor = 1	3.5 to 14 mV
with dissipation factor = 10	25 to 100 mV
Test frequencies	50/60/100/120 Hz ±2%
Four-terminal connection	via special cable (0.5 m) provided; a longer cable may be used in special circumstances
Internal DC polarization voltage (for tantalum electrolytics)	1.5 V ±5%, can be switched off
Voltage at readout socket	proportional to reading; 3 V or 10 V for fsd in each range (one output each)
Permissible load across readout terminals	1 MΩ, floating (output terminals must not be earthed)
Accuracy of readout voltage	indication error plus <±0.5% of fsd
Measurement rate	1 measurement/s with measurement relay
AC supply	115/125/220/235 V +10/−15% (17 VA)
Nominal temperature range	+10 to +35 °C
Shelf temperature range	−20 to +60 °C
Dimensions, weight	162 mm × 238 mm × 247 mm, 4.7 kg
Order designation	► High-capacitance Meter KZG 100.6345.92
Accessories supplied	1 power cable (2 m in length) 1 cable with Kelvin clips for four-terminal measurements (0.5 m in length)
Recommended extras	front-panel cover 043.4372.00, quick-connect/disconnect terminals 157.8801.90

RLCB

Automatic Precision Bridge RLCB

♦ 10 mΩ to 10 MΩ
1 μH to 1000 H/Q = 0.1 to 400
1 pF to 1000 μF/tanδ = 0.001 to 10

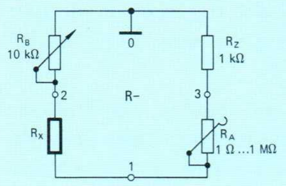
- Universal bridge, accuracy 0.1%, for dissipation and Q-factor measurements 5%
- 1-kHz oscillator and null detector built-in
- Digital readout with decimal point and physical unit

The versatile **Automatic Precision Bridge RLCB** permits comprehensive RLC component tests in the range between 50 Hz and 20 kHz. It is also suitable for all kinds of impedance measurements. It is possible for instance to examine varactors biased from an external supply or to test premagnetized coils by an external direct current.

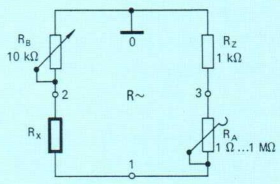
Design, test frequency, accuracy and readout. The small-sized instrument (5/8 of 19″ front-panel width) contains, in addition to the bridge circuit, a 1-kHz oscillator, a selective null detector and a DC voltage source for resistance measurements. In automatic measurements, the losses of coils and capacitors are automatically balanced.

For the majority of applications, the RLCB is a self-sufficient instrument that does not require any accessory units. For measurements with frequencies other than 1 kHz, the test signal can be externally applied. For this purpose, the use of the RC Generator/Indicator SUB is recommended, which may be combined with the RLCB in a 19″ cabinet to form a compact test assembly (see below). The high precision of the RLCB is largely maintained between 50 Hz and 20 kHz. Measurements are possible even up to 50 kHz but with reduced accuracy.

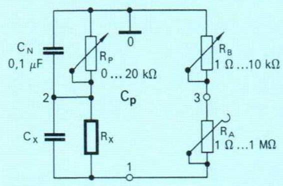
The eight different bridge configurations of the RLCB



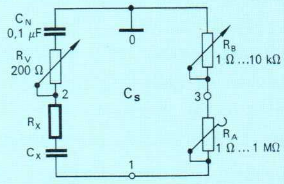
DC resistance bridge



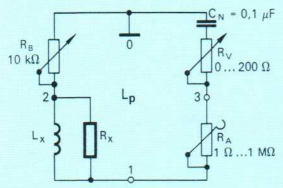
AC resistance bridge



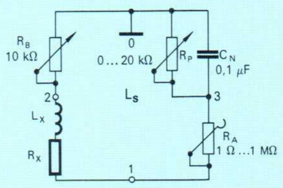
Parallel equivalent circuit of capacitance bridge



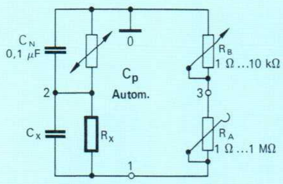
Series equivalent circuit of capacitance bridge



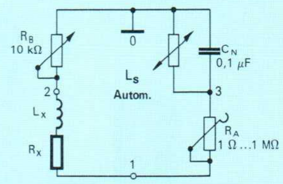
Parallel equivalent circuit of inductance bridge



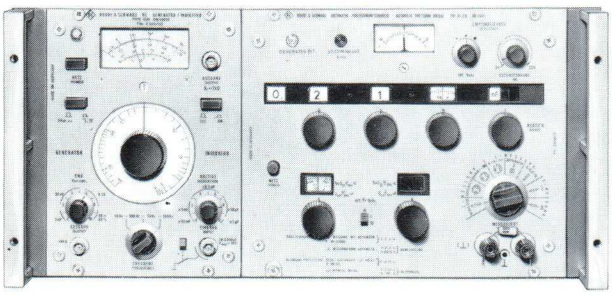
Series equivalent circuit of inductance bridge



Semi-automatic capacitance bridge



Semi-automatic inductance bridge



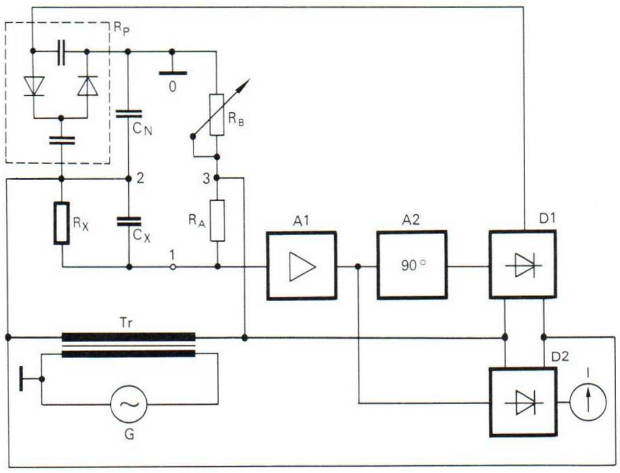
Combination of Automatic Precision Bridge RLCB and RC Generator/Indicator SUB in 19″ cabinet

The error of max. 0.1% does not allow single-knob operation but requires the use of three separate controls. The first two digits of the measured value can be read as figures and the remaining digits appear on a combined digital/analog scale. The last window reads the physical unit involved (Ω, kΩ, μF, etc.). The decimal point is shifted automatically on range switching. Scale resolution in the most adverse case is 1 scale division per 0.1% (2 mm/scale division, 0.2 scale division still discernible), increasing up to 10 scale divisions per 0.1%.

Losses of capacitors and coils are indicated on analog scales as dissipation factor tan δ or as Q factor at f = 1 kHz. For other frequencies, the reading must be multiplied by the frequency ratio. Depending on the magnitude, the losses are determined in equivalent series or shunt circuits. Each of the two equivalent circuits is associated with a separate scale. Moreover, each range may be spread by the factor of 10.

Possible measurement procedures. The **eight different bridge configurations** are shown in the diagram on the facing page. Resistors can be measured with direct or alternating current. Polarization voltages and currents may be externally applied to the test item. All connectors (with the exception of the test sockets) are located at the rear.

Automatic or manual balancing, switch-selected. Balancing a bridge is often rather time-consuming, particularly in the case of test items with loss components of 10% and more. By **automatic balancing,** these difficulties are overcome: the losses are autobalanced while the operator merely has to adjust the C or the L control. The null detector indicates in which direction the adjustment is to be made. This reduces the determination of the reactance of test items with a dissipation factor of 5 and more to a simple measuring process. To determine the dissipation factor in addition to the reactance, the **manual balancing** mode is selected and the dissipation factor control varied until bridge balance is restored.



Block diagram of RLCB used as an automatic capacitance bridge

Specifications

Resistance measurement ranges .. 10 mΩ to 12.2 Ω/10 to 122 Ω/to/ 1 to 12.2 MΩ
Inductance measurement ranges .. 1 μH to 1.22 mH/1 to 12.2 mH/to/ 0.1 to 1.22 kH
Capacitance measurement ranges .... 1 pF to 1.22 nF/1 to 12.2 nF/to/ 0.1 to 1.22 mF

Resistance bridge

AC (if a variable capacitor is externally connected in parallel with R_z – see the corresponding bridge configuration – resistors with inductive components can also be measured):
Measurement error 50 Hz to 1 kHz ≦±0.1%
1 to 20 kHz ... ≦±0.1 to 0.3%
Additional error in range
10 mΩ to 12.2 Ω .... ≦±0.4%
DC (the specified accuracy is obtained with an external millivoltmeter; typical values of built-in meter: ±1 to 2%):
Measurement error of bridge section .... ≦±0.1%
Additional error in range
10 mΩ to 12.2 Ω .... ≦±0.4%

Inductance bridge

Parallel equivalent circuit for measuring high-Q coils
Series equivalent circuit for measuring low-Q coils
Typical measurement error
50 Hz to 1 kHz .... ±0.1% (series: ±0.1 to 0.3%)
1 to 20 kHz .... ±0.3 to 0.5%
Additional error in range
1 μH to 1.22 mH .... ≦±0.4%
Q-measurement range (frequency-dependent) .... 8 to 400 (parallel circuit)
0.1 to 12.5 (series circuit)
Max. measurement error .... ±5% (for × 10: ±10%)

Semi-automatic inductance bridge

for rapid measurement of coils with Q = 0.2 to 100
Measurement frequency (internal only) .... 1 kHz
Permissible Q range of L_x .... 1 μH to 1.22 mH: 1 to 1000
1 mH to 1.22 kH: 0.2 to 1000
Typical measurement error
1 μH to 1.22 mH .... $\pm(1 \pm \frac{1}{Q})\% \pm 2\mu H$
1 mH to 1.22 kH .... $\pm(0.2 \pm \frac{1}{Q})\%$

Capacitance bridge

Series equivalent circuit for measuring low-loss capacitors
Parallel equivalent circuit for measuring high-loss capacitors
Typical measurement error
50 Hz to 1 kHz .... ±0.1% (parallel: ±0.1 to 0.3%)
1 to 20 kHz .... ±0.1 to 0.3% (parallel: ±0.3 to 0.5%)
Additional error in range
0.1 to 1.22 mF .... ≦±0.4%
tanδ-measurement range (frequency-dependent) .... 0.001 to 0.125 (series circuit)
0.08 to 10 (parallel circuit)
Max. measurement error .... ±5% (for × 10: ±10%)

Semi-automatic capacitance bridge

for rapid measurement of capacitors with tanδ = 0 to 5
Measurement frequency (internal only) .... 1 kHz
Permissible tanδ of C_x .... 1 pF to 1.22 nF: 0 to 1
1 nF to 1.22 mF: 0 to 5
Typical measurement error
1 pF to 1.22 nF .... ±(0.5 ±tanδ)% ±2 pF
1 nF to 1.22 mF .... ±(0.2 ±tanδ)%
Additional error in range
0.1 to 1.22 mF .... ≦±0.4%

General data

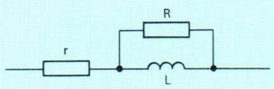
Internal oscillator .... 1 kHz ±1%
Voltage across test item .... ≦100 mV
DC resistance measurement .... 0 to 20 V
External generator (e.g. SUB) .... 50 Hz to 20 kHz; max. 10 V
Voltage across test item .... 0 to 120 mV
Connector .... BNC female (rear panel)
Internal indicator .... selective 1-kHz amplifier, log indication
DC resistance measurement .... ±7.5-μA meter
External indicator (e.g. SUB) ..... detector amplifier with optimum selectivity, 50 Hz to 20 kHz
DC voltage measurement ...... sensitive millivoltmeter
Connectors .... BNC female (rear panel)
Premagnetization/DC bias .... ≦15 mA/≦ 40 V (≦ 300 mW)
Connector for ext. battery ...... 2 telephone jacks (rear panel)
Nominal temperature range ...... +20 to +26 °C
AC supply .... 115/125/220/235 V +10/−15%, 47 to 63 Hz (20 VA)
Dimensions, weight .... 270 mm × 240 mm × 250 mm, 9 kg

Order designations .... ► Automatic Precision Bridge RLCB
Cabinet model 100.3023.92
Combination RLCB + SUB in 19″ cabinet including two connecting cables 100.3023.29

Recommended extras .... 2 quick-connect/disconnect terminals 157.8801.90

Q-factor measurements

The quality of a coil (inductance) is specified by the Q factor, which is defined as the ratio of the reactive component to the resistive component of the coil impedance (Fig. 1).



Below Q_{max}: $Q = \frac{\omega L}{r}$

Above Q_{max}: $Q = \frac{R}{\omega L}$

Fig. 1 Equivalent circuit diagram of a coil

In an air-core coil, losses occur only in the winding. In the equivalent circuit diagram, they are represented by the resistance r connected in series with the inductance L, assumed to be loss-free. The Q factor increases with the frequency until the coil in the proximity of its natural resonance can no longer be considered an inductance.

In the case of coils with a magnetic core, iron losses occur in addition, represented by the resistance R connected in parallel with the inductance. The frequency response of the Q factor has a maximum below which the copper losses and above which the iron losses predominate. At maximum, both losses assume equal values.

For the measurement of the Q factor several methods can be employed, e.g. resonance stepup, the test item being made part of a series or parallel resonant circuit.

A more recent method employed in an R&S instrument (QDM) also uses a capacitor with the coil in a parallel resonant circuit which is periodically excited to set up damped oscillations (Fig. 3). The determination of the Q factor is based on the fact that a definite mathematical relationship exists between the amplitudes of successive cycles: after Q cycles, the amplitude has decayed to E_1/e^{π}, E_1 being the initial value (Fig. 2).

The measuring principle is as follows: If the selected initial value E_1 is no longer obtained, a counter is actuated by a threshold switch, which, when the amplitude falls short of E_1/e^{π}, is switched off again. The number of oscillations thus counted is equal to the Q factor.

The voltage is derived from the test item via a high-impedance amplifier. If the natural frequency of the resonant circuit is to be measured, positive feedback is applied from the amplifier output to the test circuit at the amplifier input to produce continuous oscillations. A variable timebase determines the frequency-indication range (Fig. 3).

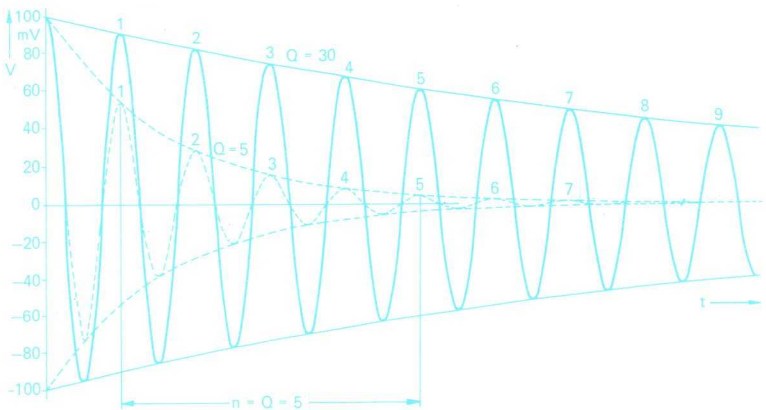


Fig. 2
Amplitude
in the parallel resonant circuit

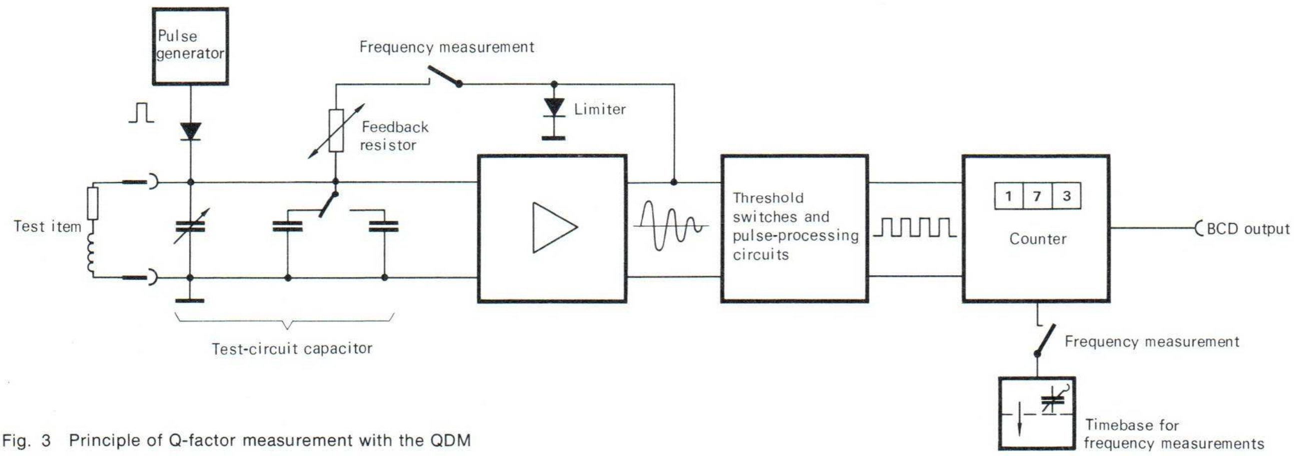


Fig. 3 Principle of Q-factor measurement with the QDM

Digital Q Meter QDM

The **Digital Q Meter QDM** measures the Q of coils at any frequency between 1 kHz and 12 MHz according to the method described on page 230.

The measuring process is **automatic:** Immediately on connection of the test item, the measured Q is indicated as a 3-digit readout at 1.5-second intervals. The test frequency to be used is determined by the coil under test and, apart from this, only by the variable capacitor, the loss of which is so low that it will not affect the test result.

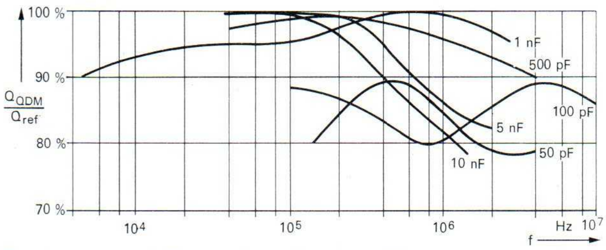
The QDM can be switched over to the frequency-measurement mode by pushbutton. The tuned circuit with the coil to be tested obtains a positive-feedback signal from a broadband amplifier and the frequency of oscillation is measured by the counter. The counter is gated by a built-in, switchable monostable and the frequency is indicated in kHz or MHz. Readouts exceeding 999 are signalled by the lighting up of an overflow lamp.

If coils with the same inductance rating are connected, the frequency setting need not be repeated; the QDM is therefore particularly suitable for batch testing.

The measuring principle is described in the introduction to Q-factor measurements. The parallel resonant circuit is excited by a pulse generator to set up damped oscillations. Via amplifiers, the oscillatory signal is applied to two threshold switches which cut in a counter when the amplitude has fallen below 50 mV, cutting it off again at the instant when the signal amplitude has decayed to a value of 50 mV/e^{π}. The number of oscillations thus counted is equal to the Q factor. For measuring the frequency, the damping of the resonant circuit including the coil under test is removed and the oscillation produced is measured with the counter.

The QDM is **easy to operate**; two knobs for the test-circuit capacitor and the buttons for mode and range selection are on the front panel. The test item is connected to two knurled terminals, one being earthed.

The measured Q is available in **BCD code** at a rear connector for further processing.



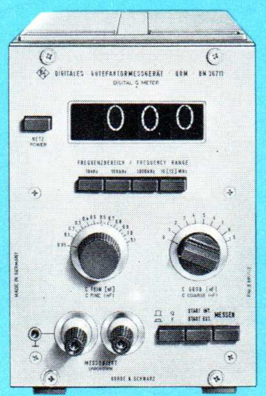
Relative test-circuit Q (typical) as a function of frequency

Additional error. Owing to the principle employed, the QDM does not measure the Q of the test item but indicates the overall Q of the resonant circuit (coil under test and test-circuit capacitor), i.e. the Q of the test-circuit capacitor, the input impedance of the amplifier and the reverse resistance of the coupling diode are comprised in the measured result. This error component can be corrected; see diagram above.

Digital Q Meter QDM

- Q range 20 to 1000
- Inductance range 0.3 µH to 1 H
- Test-frequency range 1 kHz to 12 MHz, with digital readout

QDM



Example: If the ratio Q_{QDM}/Q_{ref} corresponds to 90% according to the diagram, the Q reading must be increased by 10%. The value thus obtained is the Q of the resonant circuit which is formed by the test item and a high-Q calibrated capacitor.

Specifications

Q-factor measurement

Q range	20 to 1000
Inductance range	0.3 µH to 1 H
Test-frequency range	1 kHz to 12 MHz

Accuracy

The total error is composed of a residual error and an additional error which depends on the frequency and the calibrated capacitor.

Residual error (error in evaluation of the decaying function)	typical ±3% of rdg ±1 digit maximum ±5% of rdg ±1 digit
Additional error	see text and diagram on the left
Residual series inductance of test circuit	60 nH
Measuring-signal amplitude in V_{rms}	decaying from 50 mV to 2.2 mV
Maximum starting amplitude in V_{rms} (depending on test item and setting of tuning capacitor)	1.4 V at L of 10 µH and C of 50 pF

Internal tuning capacitor

Total capacitance range	50 pF to 10 nF
Setting error	+5%/−3% of fsd

Frequency measurement

Ranges	1 to 9.9/10 to 99/100 to 999 kHz 1 to 12 MHz 10 to 12 MHz (by means of overflow lamp)

Accuracy

from 1 kHz to 8 MHz	typical ±3% of rdg ±1 digit maximum ±6% of rdg ±1 digit
from 8 to 12 MHz	typical ±6% of rdg ±1 digit maximum ±15% of rdg ±1 digit
with L = 10 µH, C = 50 to 100 pF	maximum ±20% of rdg ±1 digit

Measurement period

Mode "start internal"	1.5 s
Mode "start external"	any, but > 1.5 s

Data output of Q factor or frequency	BCD code, 8-4-2-1 per decade, in TTL

General data

Nominal temperature range	+10 to +35 °C
Shelf temperature range	0 to +50 °C
Warmup period (for guaranteed performance)	30 min
AC supply	115/125/220/235 V ±10%
Dimensions, weight	162 mm × 238 mm × 247 mm, 6 kg
Order designation	► Digital Q Meter QDM 109.3184.02
Recommended extras	2 quick-connect/disconnect terminals 157.8801.90

TSP

Transistor Tester Semitest I TSP

- Quick survey of the static characteristics of transistors and diodes
- Useful in service and test departments and in laboratories

Semitest I checks diodes for their forward and reverse current characteristics and transistors for the current gain. It will identify unknown terminals of diodes and transistors. Sockets for the connection to semiconductors forming an integral part of circuits are provided; pnp-npn switchover is possible. The current resulting from an erroneous connection is limited to protect the test item and test set. Dimensions: 82 mm × 135 mm × 65 mm. Operation from three 1.5-V dry batteries. ► Order No. 100.2640.02.

TDP

Transistor Tester Semitest II TDP

- Checking the dynamic characteristics of diodes and transistors

In Semitest II, the transistor under test is operated with adjustable emitter current (0.5 to 5 mA) in an oscillator circuit. The natural frequency of the oscillator circuit can be switched over to 0.5/3/10/40/100 MHz. The RF amplitude then read is a measure of the cutoff frequency and power gain of the transistor. Using this oscillator as an RF source it is possible to assess the rectification efficiency, and thus the cutoff frequency, by comparison with a built-in diode. Varactors (C and Q) can also be tested by substitution; pnp-npn switchover is possible. The current resulting from an erroneous connection is limited. Dimensions: 145 mm × 135 mm × 70 mm. Operation from six 1.5-V dry batteries. ► Order No. 100.2656.02.

Transistor Tester Semitest V TGP

- Static measurement on transistors, diodes, field-effect transistors, reference diodes and functional tests of thyristors

Semitest V fulfils exacting demands as regards measurement range and accuracy. The handy instrument is particularly suitable for rapid tests in servicing, laboratory uses, production and incoming inspection.

TGP
with two adapters and programming plug

Quantities measured

On transistors	$I_B = f(I_E)$, leakage current and saturation voltage
diodes	leakage current, forward voltage, Zener voltage
FETs	gate leakage current and pinchoff drain current
thyristors (functional test)	leakage current, forward voltage

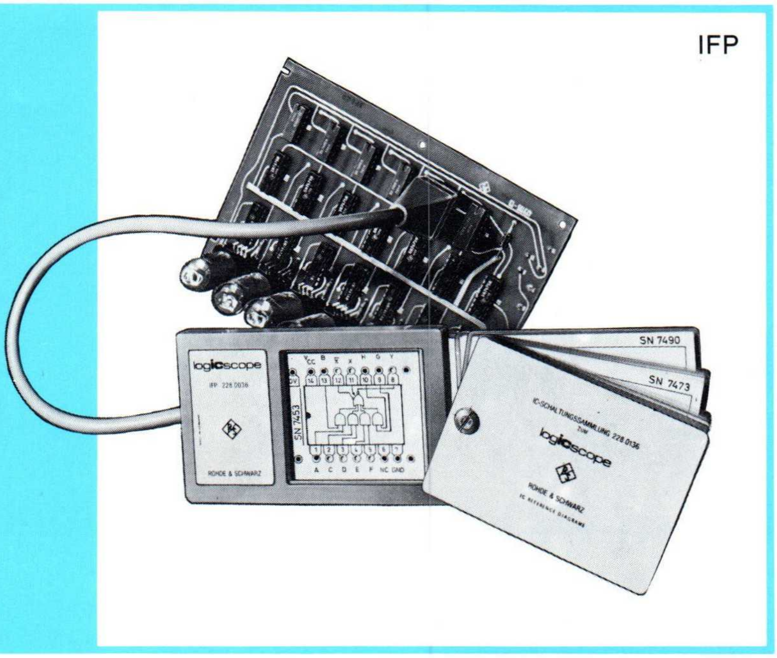
The test item is connected via an adapter (see photo on left) and fed from two built-in voltage generators with 0 to 10 V and 0.5 to 15 V and the constant-current generator 10 μA to 10 mA, open-circuit voltage 10 V, which are adjustable in steps.

Current measurement range 10 nA to 10 mA (error 3% ±2 nA), voltage measurement range 10 mV to 30 V (error 3% ±10 mV of rdg plus meter error of ±2.5%).

Dimensions 220 mm × 180 mm × 100 mm. Operation from four 9-V dry batteries IEC 6 F 22. ► Order No. 220.7090.02.

Logicscope IFP

- Checks soldered 14- or 16-pin integrated DTL and TTL modules in operation
- Displays the logic state on inserted reference diagram cards by means of light emitting diodes
- Fully self-contained, deriving its operating voltage from the test item without significant loading
- Easy to operate



The **Logicscope IFP** is a pocket-sized functional tester, displaying the logic state of all 14 or 16 pins of a soldered IC package.

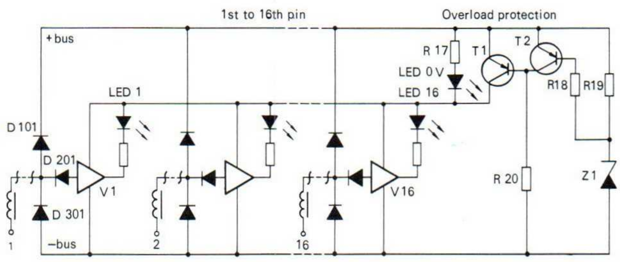
The test item is connected via a DIP clip and a 16-wire cable. With the aid of LEDs in the indicator section, the instantaneous logic state of the test item can be seen on the reference diagram cards, or the signal can be visually tracked as it moves around the perimeter of the card in the case of clock frequencies up to approximately 15 Hz. Single pulses down to 1 ms duration still produce a clearly visible flash. When logic 1 is present at a pin, the corresponding diode lights up. Unused (open) pins appear also as logic 1.

A set of reference diagram cards for the most common logic ICs is supplied with the Logicscope.

The Logicscope requires no power supply of its own. It derives its operating voltage from the test item, locating automatically the positive and the negative poles. Loading of the test item is avoided with the aid of buffer stages. The influence of the cable capacitance on short clock pulses being balanced out by decoupling coils, the functioning of the module under test is not affected.

An overload protection is also provided, ensuring that the instrument is not damaged if ICs with too high an operating voltage (e.g. linear ICs) are connected inadvertently. In this case, an additional diode lights up.

The IFP circuitry is housed in a handy cabinet of 118 mm × 75 mm × 14 mm so that the Logicscope together with its connector, cable and set of IC reference diagrams (comprising the 100 most important circuits of the 74 TTL series) easily fits into the small case which is included in the delivery.



Functional diagram of Logicscope IFP

Specifications

Indication	by LEDs
Logic 0 (dark) at V_{in}	< +1.3 V
Logic 1 (lighted) at V_{in}	> +1.8 V
Test items	all normal TTL/DTL modules (with the exception of modules with expander inputs and decoders with nixie drivers)
Test item loading	typical: −1.2 mA/pin
Operating voltage range	+4.5 to +6.5 V
Overload protection	indication by LED
effective in the range	8 to 30 V
Current drain (from test item)	approx. 90 mA at V_{cc} = 5 V approx. 140 mA at V_{cc} = 6 V
Test item connector	16-point clip for dual-in-line package
Operating temperature range	0 to +60 °C
Dimensions without cable and connector	118 mm × 75 mm × 14 mm
Connector dimensions (clip)	25 mm × 13.5 mm
Cable length	0.6 m
Weight (complete set)	0.16 kg
Order designation	► Logicscope IFP 228.0036.90
Accessories supplied	Collection of reference diagram cards for Logicscope, case

ISP

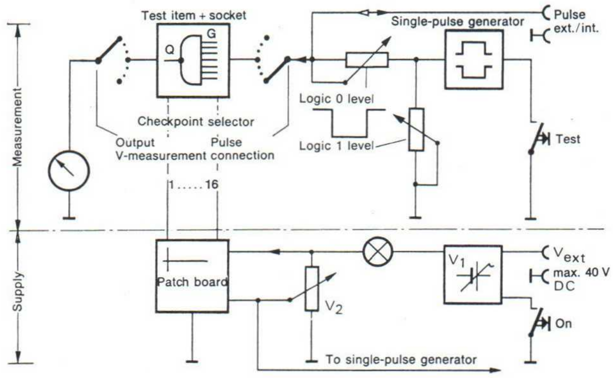
IC Tester Semitest III
ISP

- Tests logic integrated circuits
- Built-in clockpulse generator (rise time 0.1 µs), single and external pulses
- Patch board accommodating up to 16 pins
- Continuous adjustment of logic levels (0 and 1)
- Battery check

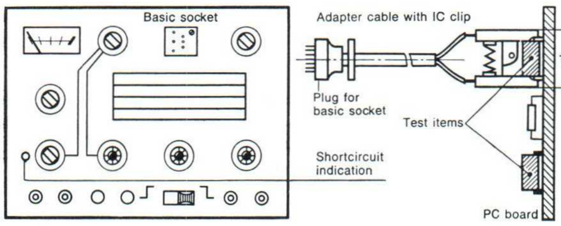
Automatic test assembly for components and subassemblies on page 82

The **IC Tester ISP** is a compact test set for rapidly checking the functions of practically all logic integrated circuits on the market, such as TTL, DTL, DTLZ, ECL, RTL and those of the MOS type. The storage characteristics of, for example, counters, shift registers, flipflops and frequency dividers can be tested with equal ease.

The logic levels and operating voltages of up to 16 test points can be selected via the patch board. Connection to different types of cases (dual-in-line, TO-5 or flat pack) is made possible with adapters. Fault location on circuit boards is facilitated by the use of a special cable which permits the testing of ICs that are already mounted on boards.



Block diagram of the IC Tester Semitest III



Functional test on ICs mounted on circuit boards using adapter cable (to be ordered separately):
Shortcircuit lamp lights up
a) if voltage supply pins are internally short-circuited,
b) in case of faulty wiring on the patch board

Test pulses with jitter-free edges and a rise time of 100 ns are delivered by the built-in logic 1–0 pulse generator. The logic 1 level is continuously adjustable from 0 to 10 V; the logic 0 level can be varied by changing the internal resistance of the generator.

The power supply consists of eight 1.5-V cells. The voltage V_1 is applied to the test item in five steps of 1.5, 3, 4.5, 6 and 12 V. Intermediate values (V_2) in the range from 0 V to V_1 are provided by means of a potentiometer. Higher voltages (max. 40 V) must be applied externally.

The operating voltages at each pin can be read from the meter, which also serves as a battery check.

Specifications

Number of test points	16
Adaptation of test items	test sockets for all types of IC packages (TO-5, DIP, etc.)
Connection	
Voltage supply	via patch board with 3 inputs (V_1, V_2, chassis) and 16 outputs
Logic 1/0 signal	via 16-position switch
Voltage measurement	via 16-position switch
Test signal	
Logic 1	adjustable with voltage divider between 0 V and V_2
Logic 0	< 100 mV with variable source impedance
Voltage measurement, ranges	1/7/14/35 V fsd (±6% of fsd)
Power supply	8 × 1.5 V cells, e.g. Pertrix No. 280
V_1 (adjustable in steps)	1.5/3/4.5/6/12 V
I_{max}	30 mA
V_2 (continuously adjustable as a function of V_1)	0 to 10 V
I_{max}	20 mA
Max. permissible external supply voltage	40 V
I_{max}	30 mA
Shortcircuit indication by lamp on front panel	
Dimensions, weight	220 mm × 180 mm × 100 mm, 1.8 kg

Order designation .... ► Semitest III ISP 100.8548.93

Accessories supplied: 16-lead DIP test sockets, 10-lead TO-5 test sockets; 10 matrix board pins; 5 patch-board pins

Recommended extras (to be ordered separately): Adapter cable for functional test on ICs mounted on circuit boards: ISP-Z 100.8902.02

IC Tester Semitest IV ILP

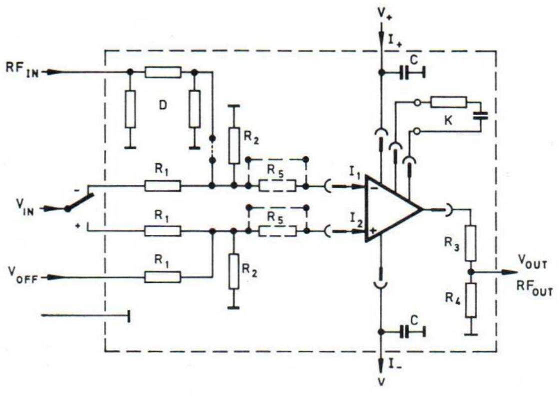
- Checks linear ICs, such as AF, RF and operational amplifiers
- Plug-in adapters for TO-5 and dual-in-line packages
- Power supply either from built-in batteries or power pack
- Input and output of test item brought out for dynamic measurements

Automatic test assembly for components and subassemblies on page 82

The IC Tester **Semitest IV** is designed for rapid checks of **linear ICs.** It is a complete test set with a panel meter and all the required power sources and potentiometers for measuring the DC parameters of ICs.

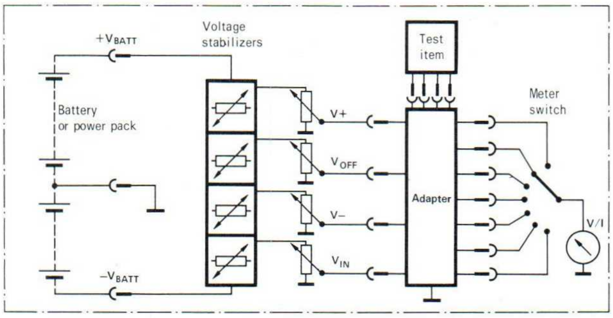
Measured parameters. The ILP measures the principal DC parameters of ICs: offset voltage and current, input voltage and current, output voltage, dynamic range and gain. Since input and output of the test item are brought out, AC parameters, such as noise, distortion or frequency response, can also be measured in conjunction with accessory units (signal generator, sensitive voltmeter, oscilloscope).

Connection of test item. Special plug-in adapters are available to accommodate the various types of IC packages. The ILP is normally supplied with adapters for TO-5 and dual-in-line packages. The adapters are provided with the IC socket, solder pins for permanent internal connections and, where required, for compensating networks.



Simplified circuit diagram of adapter. R_1 to R_4 = fixed voltage divider; R_5 = resistors for determining I_{IN} and I_{OFF}; K = compensation network; D = 50-Ω attenuator; C = filter capacitor for power supply

Power supply. The IC Tester normally operates from built-in batteries which, if a long series of tests is to be carried out, may easily be replaced with a power pack.



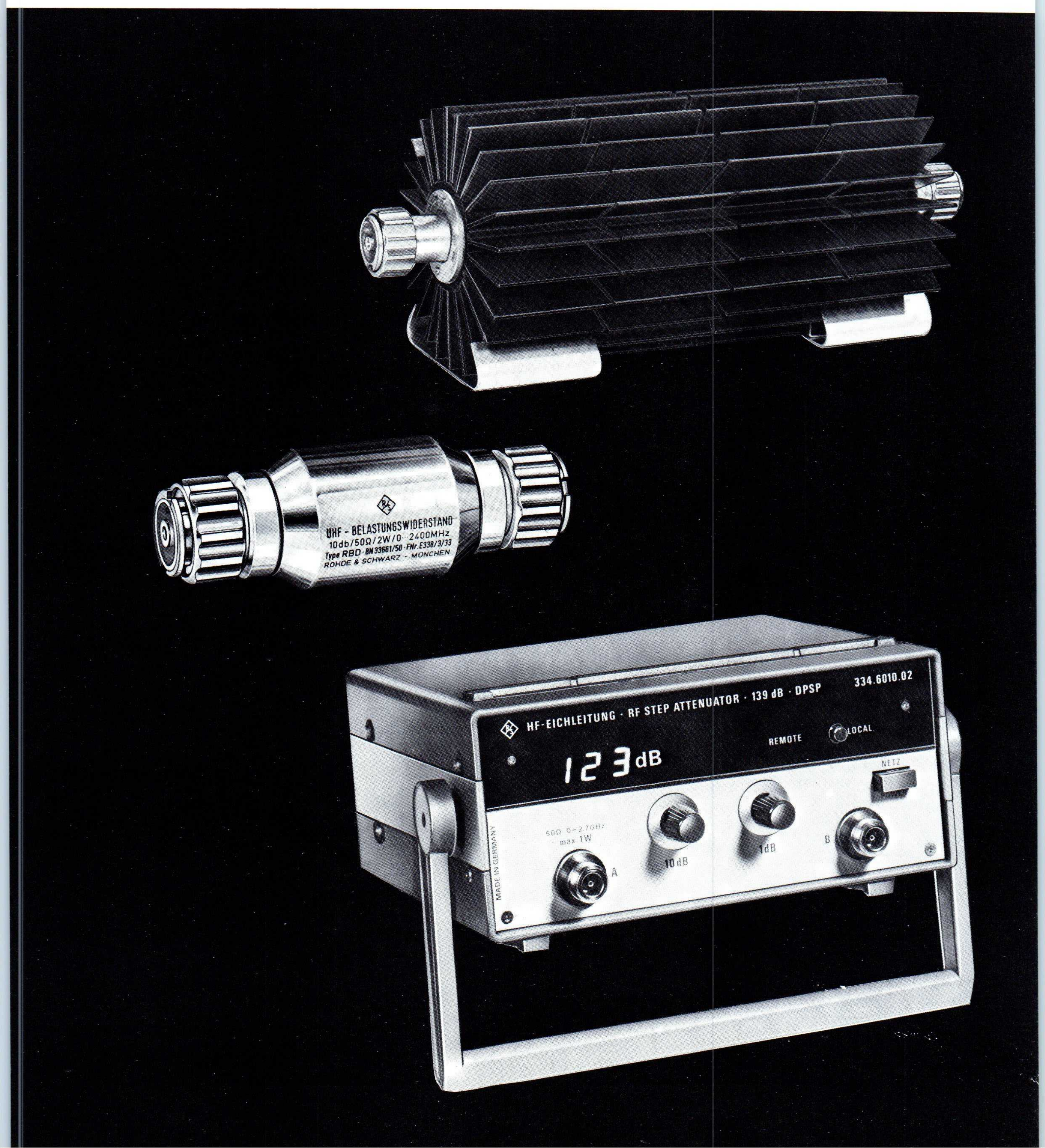
Block diagram of the IC Tester Semitest IV

Specifications

Connection of test item	with special adapters (TO-5, DIP)
Wiring of IC terminals	wire links in the adapters
Voltages applied	
V+	0 to 15 V/15 to 30 V; I_{max} = 30 mA
V−	0 to 15 V/15 to 30 V; I_{max} = 30 mA
V_{IN}	0 to ±1 mV/0 to ±10 mV
V_{OFF}	0 to ±1 mV/0 to ±10 mV
Parameters	
Voltages	ranges: 0.1/0.3/1/3/10/30 V at fsd (calibration in mV for V_{IN} and V_{OFF}), battery-voltage check
Currents	ranges: 1/3/10/30 mA
Meter error	±3.5% (±4%) of fsd
Power supply	8 batteries 9 V/IEC 6 F 22 or power pack available as accessory
Dimensions, weight	233 mm × 180 mm × 92 mm, 1.7 kg
Order designation	► IC Tester Semitest IV ILP 106.8133.02
Accessories supplied	Adapter TO-5 (8 pins) and DIP (14 pins)
Recommended extras ILP-Z	Adapter TO-5, 12 pins, Order No. 103.4408.02; Adapter TO-5, 10 pins, Order No. 110.3103.02; Adapter DIP, 16 pins, Order No. 103.4414.02
Power Pack ILP-Z (Order No. 110.3655.02)	115/125/220/235 V +10/−15%, 47 to 63 Hz (8 VA)

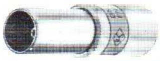
Terminations (dummy antennas)
with test output,
IEC-bus compatible, programmable
attenuator;
details on page 238 ff

terminations
attenuators



RAU – RU


RNA


RMF


RMC


RBD, 3 W


RBD, 20 W


RMA


RMF


RNB


RBU, 100 W
(can be disassembled: 100/80/40/30 W)


RAU, 100 W


RBU, 1000 W
(shown on smaller scale)

Overview

Terminations with a power rating of 100 W to 20 kW are listed in the data sheet N 3-123.

Notes: [1]) adaptable [2]) up to 500 MHz [3]) up to 300 MHz [4]) with calibration curve ±0.1 dB [5]) in bands III, IV/V [6]) according to calibration curve (37 to 46 dB ±0.2 dB)

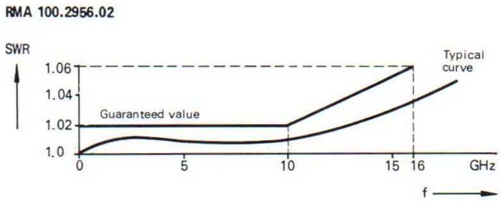
Power rating W	Designation	Type	Order No.	Characteristic impedance Ω	Frequency range GHz	VSWR	Attenuation dB	Connector	Dimensions in mm
0.3	Termination	RMA	100.2956.02 100.2956.03	50 50	0 to 16 0 to 16	< 1.02 (1.06) < 1.02 (1.2)	— —	Precifix A[1])	20 dia. × 37 20 dia. × 37
0.3	Precision Termination	RNA	272.4510.50	50	0 to 12	< 1.02 (1.07)	—	N male	22 dia. × 48
0.25 0.5	Termination	RMF 2 RMF	265.6863.00 100.2910.02	75 75	0 to 0.02 0 to 0.03	< 1.01 < 1.02 (1.1)	— —	BNC male 4/13 RF male	16 dia. × 23 15 dia. × 85
			100.2927.50 100.2927.70	50 75	0 to 0.03 0 to 0.03	< 1.02 (1.06) < 1.02 (1.06)	— —	BNC male	16 dia. × 55 16 dia. × 55
			100.2933.50 100.2933.60 100.2933.70	50 60 75	0 to 0.05 0 to 0.05 0 to 0.05	< 1.04 < 1.06 < 1.13	— — —	4/13 RF male	16 dia. × 53 16 dia. × 53 16 dia. × 53
1	Termination	RMC	100.2940.50 100.2940.60 100.2940.70	50 60 75	0 to 5 0 to 5 0 to 3	< 1.02 (1.03) < 1.02 (1.03) < 1.03	—	Dezifix B[1])	45 dia. × 55
		RNB	272.4910.50	50	0 to 4	< 1.05 (1.2)	—	N male	21 dia. × 35
3	High-power Attenuator	RBD	100.2962.50 100.2962.60	50 60	0 to 2.4	< 1.08[2])	10 ±0.2	Dezifix B[1])	48 dia. × 140
20			100.2985.50 100.2985.60	50 60	0 to 2.4	< 1.10[2])	20 ±0.3[3])	Dezifix B[1])	115 dia. × 280
30 80 100 100	High-power Attenuator	RBU	100.8654.25 100.8654.05 100.8654.35 100.8654.15	50 50 50 50	0 to 1 0 to 1 0 to 1 0 to 1	< 1.05 < 1.05 < 1.05 < 1.05	20 ±0.2 3 ±0.2 30 ±0.2 10 ±0.2	Dezifix B[1]) Dezifix B[1]) Dezifix B[1]) Dezifix B[1])	140 dia. × 160 140 dia. × 140 140 dia. × 370 140 dia. × 300
100	Termination	RAU	200.0019.02 200.0325.02	50 60	0 to 2 0 to 2	< 1.05 (1.4) < 1.05 (1.4)	— —	Dezifix B[1]) Dezifix B[1])	95 × 152 × 235 95 × 152 × 235
400	Termination	RC 040/50 RC 040/60	111.1679.02 111.1662.02	50 60	0.47 to 3.5	< 1.05	—	Dezifix C[1])	65 dia. × 1200
1000	High-power Attenuator	RBU	207.4010.03 207.5016.03	50 60	0 to 1	< 1.05	40 ± 0.4[4])	Dezifix B[1])	830 × 350 × 300
10 000	High-power Attenuator	RU 10/2/50	155.3090.50	50	0 to 0.16	< 1.1	35 to 22 acc. to cal. curve	Dezifix D/B[1])	1550 × 380 × 700
16 000	High-power Attenuator	RD 10/50 RD 10/60	101.0057.50 101.0057.60	50 60	0 to 0.96	< 1.05[5])	40[6])	Dezifix D/B	2100 × 760 × 400

Characteristics and uses of terminations and high-power attenuators

Terminations. Understood here are all the components that are used solely as reflection-free terminations on instruments or cables, i.e. those having no test output. This is naturally applicable for small RF powers up to a few watts (exceptions are the RAU for 100 W and the RC for 400 W).

High-power attenuators. This category embraces the application as termination – e.g. as dummy antenna; the designation was chosen, however, because these terminations have a test output with a uniquely defined attenuation. They can therefore be used also as attenuators for extending the measurement range of power meters with lower ranges. For attenuators with lower power rating see next page.

RMA Precision resistors for line terminations in the 3/7-mm coaxial line system. A special feature is their very low reflection over a wide frequency range, see following diagram for the RMA 100.2956.02.



In addition, there is the lower-priced model RMA 100.2956.03 with a somewhat higher VSWR above 5 GHz; all other data remain the same.

RNA **new** A precision termination with N connector, featuring extremely low VSWR over the whole frequency range from DC to 12.4 GHz, mainly for use in electronic measurements.

RMF Reflection-free termination for instruments and test setups with 4/13 RF or BNC connectors. It has a nonwound resistance element without cap, the inductive reactance being compensated up to 50 MHz. The 75-Ω RMF 100.2910.02 with narrow tolerances is especially suitable for the Video Standard Level Generator SNF.

A new version of the RMF (265.6863.00) with a 75-Ω metal-film resistor for 0 to 20 MHz is available to meet the higher requirements of the insertion test signal technique; its return loss is > 50 dB up to 5 MHz.

RMC Standard component for coaxial test setups (21-mm outer diameter); acts as a termination on slotted lines and in impedance meters which are being used for measurements on cables and two-port networks as well as for adjusting directional couplers.

RNB **new** Termination with N connector for general use in the frequency range from DC to 4 GHz; use of a stable metal-film resistor affords a power-handling capacity of 1 W.

RBD Used, e.g., as dummy antenna and for harmonic measurements on transmitters (via its test output). This high-power attenuator with ladder construction is cooled by air convection currents along the outer surfaces; 20-W model is equipped with cooling fins.

RBU Up to 100 W: The RBU 100 W, air-cooled (100.8654.35), consists of four series-connected attenuators with 1/3/6/20 dB attenuation so that a total transmission loss of 30 dB at 100-W power-handling capacity is available. This RBU can be disassembled. Equipped with connectors, the attenuators can also be used individually, in which case the maximum power-handling capacity of the steps with the above attenuations amounts to 100/80/40/30 W respectively.

The other models of the RBU as separate attenuators of 30 to 100 W are listed in the table.

RAU UHF termination (dummy antenna), especially for mobile or stationary transmitters; a low VSWR makes it also suitable for TV systems.

RBU 1000 W: This high-power attenuator having a test output with a load capacity up to 30 W is also cooled by air convection currents. In addition to functioning as a dummy antenna, it can be used for determining the fundamental-wave power and the harmonic suppression on transmitters as well as for extending the measurement range of microwave power meters. The 1000-W RBU meets the requirements of the ARD standard specifications.

RU Dummy antennas for HF and VHF transmitters up to 10 kW. Cooled by external ventilator.

RD High-power attenuator with a very low reflection; especially suitable for use in TV systems. Cooled by an air blower.

Characteristics and uses of attenuator sets and attenuator pads

Attenuator pads (DPF/DNF) of different attenuation are important accessories in test setups where the attenuation does not have to be changed over long periods of time. Their handy design (easy to replace) makes them particularly valuable for use in mobile test setups.

Matching pads create the necessary match between measuring instruments and transmission lines of different characteristic impedances of the standard values 50, 60 and 75 Ω.

Attenuator sets are two-port networks with adjustable, calibrated attenuation and the same constant characteristic impedance at both input and output. They are used for gain and attenuation measurements (Figs 1 and 2), for determining the noise figure of a receiver (Fig. 3), for linearity measurements (with an attenuator connected before and after the test item; Fig. 4) or as reference attenuator (e.g. the highly accurate DPVP; see Fig. 2). In addition, accurately-known small voltages are obtainable with the aid of an attenuator set when a given, exactly determined input voltage is available. Their special construction has afforded a high degree of accuracy as well as a very wide frequency range.

Programmable attenuator sets in combination with programmable signal generators are suitable for setting up fully or semi-automatic test assemblies, especially in production and test shops. The attenuation settings are made with motor-driven switches. The setting times are very short and always of the same duration as all resistors necessary for obtaining a specific attenuation are switched at the same time (even when switching between the extreme attenuation values). Programming is possible in the ASCII code via the IEC bus (e.g. for DPSP) or with Code Converter PCW and Card Reader PCL.

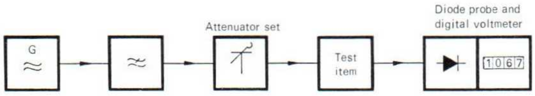


Fig. 1 Test setup with diode probe and digital voltmeter for gain and attenuation measurements at high test voltages

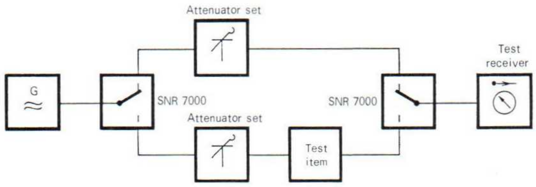


Fig. 2 Test setup with reference attenuator for measuring attenuation and gain with a high degree of accuracy

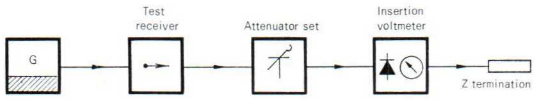


Fig. 3 Test setup for determining the noise figure of a receiver

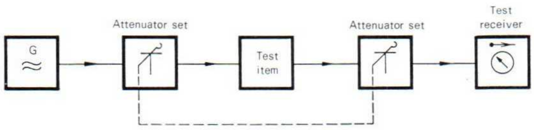


Fig. 4 Setup for measuring the linearity of two-port networks

Overview

Frequency-range	Designation	Type	Order No.	Charac-teristic impedance	Attenuation	Smallest increment	VSWR	Dimensions in mm	Text on page
Attenuator pads (matching pads on right side)									
0 to 4000 MHz	UHF Attenuator	DPF	100.1789.50 100.1789.60 100.1814.50 100.1814.60 100.1820.50 100.1820.60	50 Ω 60 Ω 50 Ω 60 Ω 50 Ω 60 Ω	5 dB 10 dB 20 dB	— — —	< 1.05 (< 1.08)	100 × 36 dia. 100 × 36 dia. 125 × 36 dia.	241
0 to 18 GHz	Attenuator	DNF	272.4010.50 272.4110.50 272.4210.50 272.4310.50 272.4410.50	50 Ω 50 Ω 50 Ω 50 Ω 50 Ω	3 dB 6 dB 10 dB 20 dB 30 dB	— — — — —	≦ 1.1 (≦1.25 up to 12 GHz)	56 × 21 dia.	241
Attenuator sets									
0 to 1000 MHz	UHF Attenuator Set	DPU	100.1750.60 100.1750.70	60 Ω 75 Ω	10 to 19.9 dB	0.1 dB	< 1.15	330 × 140 × 90	241
0 to 2000 MHz	UHF Attenuator Set	DPU	100.8960.50 100.8960.60 100.8960.70 100.8960.55	50 Ω 60 Ω 75 Ω 50 Ω (N connectors)	0 to 140 dB	1 dB	< 1.15 (< 1.3)	335 × 145 × 115	241
0 to 1000 MHz	Programmable Attenuator	DPVP	214.8017.52	50 Ω	0 to 139.9 dB	0.1 dB	< 1.1	484 × 150 × 336	243
0 to 2700 MHz	RF Step Attenuator programmable	DPS DPSP	334.7217.02 334.6010.02	50 Ω 50 Ω	0 to 139 dB	1 dB	< 1.2 (1.3)	241 × 110 × 234	242

Attenuator pads

DNF The DNF attenuators have N connectors and are mainly intended for lab use, integration into systems and range extension of power meters. High attenuation accuracy and flatness of frequency response together with low VSWR guarantee precise measurements. The DNF pads are very robust and immune to vibration according to MIL-A-3933 and will withstand short-time overloading. Models available between 3 and 30 dB (see table on left side); power-handling capacity 2 W for 3-dB and 6-dB models, 1 W for other models.

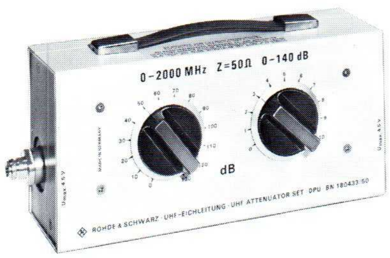
new

DPF These attenuators are designed for a power-handling capacity of up to 0.5 W. They have a maximum permissible pulse voltage of 1 kV. Of particular importance is their symmetrical construction enabling frequency-independent attenuation in both directions. Connectors: Dezifix A or Dezifix B (adaptable).

Attenuator sets

DPU Wide frequency range as well as constant electrical length for every attenuation value (DPU 1000 MHz: 1.6 ns; DPU 2000 MHz: 1.4 ns) are characteristic of these attenuators. The power-handling capacity is 0.4 W (pulse-peak voltages: 300 V); the Dezifix B connectors are adaptable. The DPU 0 to 1000 MHz has a residual attenuation of 10 dB. The DPU 0 to 2000 MHz is of shielded design and has a very wide attenuation range (0 to 140 dB) with high accuracy and low residual attenuation (less than 1 dB at 2000 MHz). Model 100.8960.55 is supplied with N connectors.

DPU

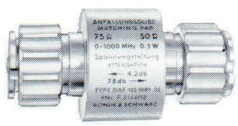


DPF

Matching Pads DAF ♦ 0 to 1000 MHz

- Impedance matching 75:60 Ω, 75:50 Ω, 60:50 Ω
- Power-handling capacity: 0.5 W

Matching Pads DAF are unsymmetrical π sections with differing input and output impedances; they create the necessary match between measuring instruments and transmission lines having different characteristic impedances. Their voltage transformation ratio depends on the direction. The direction is marked by arrows. Series-opposed connection of two identical matching pads gives a total attenuation of 10 or 12 dB.



Matching Pads DAZ ♦ 0 to 1000 MHz

- Impedance matching 50:60 Ω or 50:75 Ω
- Power-handling capacity 7 or 4.5 W

Matching Pads DAZ enable the characteristic impedance to be matched at one end since they only have one series resistor. They are used specifically for matching the output impedance of a signal generator of 50 Ω to lines or leads of 60 Ω or 75 Ω. A 50-Ω cable can be connected here between signal generator and matching pad. The advantage of these matching pads lies in their low attenuation.

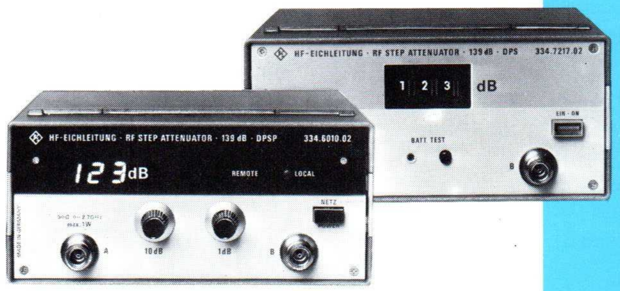
Specifications

Specifications	Matching Pads DAF			Matching Pads DAZ	
Characteristic impedance	75:60 Ω	75:50 Ω	60:50 Ω	50 → 60 Ω	50 → 75 Ω
Frequency range	0 to 1000 MHz	0 to 1000 MHz	0 to 1000 MHz	0 to 1000 MHz	0 to 1000 MHz
Voltage transformation	6 dB → 4 dB ←	7.8 dB → 4.2 dB ←	5.8 dB → 4.2 dB ←	0.8 dB	1.8 dB
Attenuation accuracy					
up to 300 MHz	±0.1 dB	±0.1 dB	±0.1 dB		
up to 1000 MHz	±0.2 dB	±0.2 dB	±0.2 dB	±0.1 dB	±0.1 dB
VSWR (connector: Dezifix B)					
up to 300 MHz	≦1.05	≦1.05	≦1.05		
up to 1000 MHz	≦1.15	≦1.15	≦1.15	≦1.04	≦1.04
Power handling capacity	0.5 W	0.5 W	0.5 W	7 W	4.5 W
Connectors	Dezifix B at both ends, adaptable			Dezifix B at both ends, adaptable	
Dimensions, weight	105 mm × 50 mm dia., 350 g			79 mm × 35 mm dia., 180 g	
► **Order Nos.**	100.1872.02	100.1889.02	100.1895.02	242.1013.02	242.1513.02

DPS
DPSP

new

IEC 625 Bus



RF Step Attenuators DPS and DPSP

♦ 0 to 2700 MHz/0 to 139 dB

- Attenuation steps of 1 dB, low residual attenuation
- High accuracy, small attenuation error
- Very high life expectancy: 10^7 switching operations
- DPSP is system-compatible via IEC bus

Characteristics and uses

The **RF Step Attenuators DPS and DPSP** facilitate the quick and accurate performance of all work characteristic of attenuator sets in the frequency range from DC to 2700 MHz. This includes in the first place measurements of gain, attenuation and sensitivity (receiver noise figure) and the reduction of voltages to very small and uniquely defined values.

Differences between the types. All electrical characteristics are identical for DPS and DPSP, the two types differ only in the mode of operation (for details see below):

DPS manually operated by decade switches

DPSP can be manually operated by rotary switches with automatic carry and remotely controlled via IEC bus.

Common characteristics. With both these attenuators, attenuation values from 0 to 139 dB can be set in steps of 1 dB. Effective shielding guarantees full reliability of the result at the highest attenuation.

The **accuracy** complies with the usual requirements for precision instruments. Very short pulses are handled with the same precision as sinusoidal signals.

Input and output present extremely low reflection. On both types the RF connectors on the front panel can be rerouted by the user to the rear panel, no change of cables being involved.

The **carrying handle** can also be used as a stand or screwed off.

DPSP with stand

Manually operated Step Attenuator DPS

The attenuation value is set by decade switches. Batteries are incorporated for mobile applications; they are recharged during operation from the AC supply.

Programmable Step Attenuator DPSP

Attenuation can be set manually on the DPSP with two rotary switches, carryover being executed automatically. The switching functions are controlled by a microprocessor. In addition the unit has an IEC-bus interface and can be combined with other IEC-bus-compatible instruments and computers in automatic test systems. The setting time of the attenuator is 20 ms. With more than 10^7 switching operations a long service life is guaranteed even if extremely frequent switching is required. The DPSP can be incorporated into 19″ racks by means of an adapter; it occupies 1/2 of 19″ width.

Specifications

Frequency range	0 to 2700 MHz
Attenuation range	0 to 139 dB, 1-dB steps
Attenuation setting DPS	3 decade switches
DPSP	2 decade switches with automatic carry
Attenuation error	≦±0.2 dB +1.3% of setting, max. 1 dB
typical	±0.1 dB +0.6% of setting, max. 0.5 dB
Residual attenuation at 200 MHz	≦0.4 dB
1 GHz	≦0.8 dB; VSWR 1.2
2.7 GHz	≦1.2 dB; VSWR 1.4
Characteristic impedance	50 Ω, P_{max} average 1 W
Programming (DPSP only)	interface to IEC 625-1 standard; control of all functions, data transmission in listener function: AH1, L1, RL1, DC1
Setting time	≦20 ms
General data	
Life expectancy	10^7 switching operations
Connectors	N female on front or rear panel
Power supply AC	115/125/220/235 V ±10%, 47 to 440 Hz (10 VA)
battery (DPS only)	NiCd battery for 5000 switching operations, built-in charger
Nominal temperature range	+5 to 45 °C
Shelf temperature range DPS	−40 to +60 °C
DPSP	−40 to +70 °C
Dimensions, weight	241 mm × 110 mm × 234 mm, 3 kg
Order designation	► RF Step Attenuator
DPS	334.7217.02
DPSP	334.6010.02
Accessory supplied	power cable
Recommended extra	19″ Adapter 078.8016.00

Programmable Attenuator DPVP
♦ 0 to 1000 MHz/0 to 139.9 dB

- Smallest increments of 0.1 dB
- Short setting time: less than 35 ms
- Programmable in BCD code – TTL-compatible
- Built-in store – strobe input

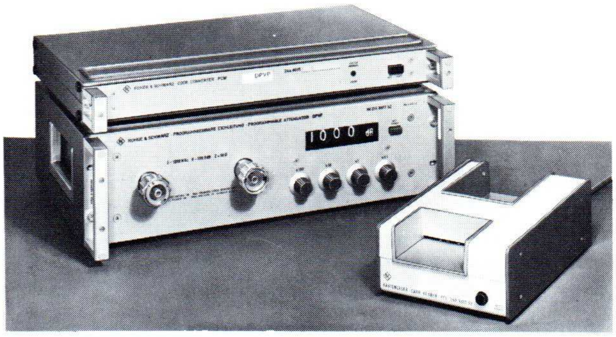
DPVP

Characteristics and uses

The **Programmable Attenuator DPVP** enables very accurately defined attenuation values of between 0 and 139.9 dB to be provided for 50-Ω networks. It can be used up to 1000 MHz.

Attenuation settings. The smallest attenuation step that can be manually set or programmed is 0.1 dB. All setting procedures are completed within 35 ms, even when switching from the lowest to the highest attenuation.

Programming, use in test systems. The DPVP is designed for programming in the BCD code. When using the Code Converter PCW, the Programmable Attenuator can be connected to the IEC bus and thus hooked up to automatic test systems; in this way, several DPVPs can be integrated in a system. The Card Reader PCL (see photo) or a desktop calculator can be used for control.



Programmable Attenuator DPVP plus Code Converter PCW (for serial programming for instance via the IEC bus) and Card Reader PCL

Accuracy. The typical error of the individual attenuator sections (steps) is about 0.02 dB for frequencies < 100 MHz and about 0.07 dB over the entire frequency range; when considering the calibration table supplied with each instrument, the residual error is less than 0.02 dB per attenuator section.

Description

The Attenuator DPVP consists of 15 attenuator sections in steps between 0.1 and 20 dB; the sections are switched into the attenuation path by means of a decoder circuit using noble-metal swivel contacts.

Switchover between manual and programmed operation is performed by means of the programming plug.

Programming itself is in positive-logic BCD code with TTL-compatible programming levels.

Specifications

Frequency range	0 to 1000 MHz
Attenuation range	0 to 139.9 dB in smallest steps of 0.1 dB
Attenuation setting	on four decade switches, manually or programmed
Programming	via 50-pin connector at rear; positive logic, TTL-compatible, BCD code, common strobe input, built-in store
Programming time	< 35 ms

Attenuation error in 10^{-3} dB at test frequency of	0	100	1000 MHz
Attenuator section			
0.1 dB	+3	+5	+36
0.2 dB	−2	+8	+38
0.5 dB	−4	+10	+80
1 dB	+5	+4	+60
2 dB	−4	+6	+55
5 dB	+2	+15	+31
10 dB	0	+13	+31
20 dB	−2	+10	+25
VSWR			
setting 0 dB	—	—	≦1.085
0.1 to 9.9 dB	—	—	≦1.13
10 to 139.9 dB	—	—	≦1.085
Residual attenuation:			
setting 0 dB	≦0.06 dB	≦0.15 dB	≦0.6 dB

Characteristic impedance	50 Ω
Permissible input power	1 W
Connectors	Dezifix B, adaptable, or N female
Nominal temperature range	+10 to +40 °C
Power supply	115/125/220/235 V ±10%, 47 to 440 Hz (33 VA max.)
Dimensions, weight	484 mm × 150 mm × 336 mm, 16 kg
Order designation	▶ Programmable Attenuator DPVP 214.8017.52

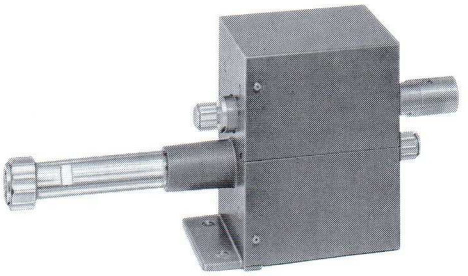
Accessories supplied

1 power cable (2 m long), 50-pin connector for programming input

Recommended extras

Code Converter PCW 244.8015.92 with Coding Board 245.2510.02 for programming according to the IEC-bus standard,
Card Reader PCL 248.6017.02

ZPV-Z3



Directional Coupler ZPV-Z3 for measuring s-parameters
♦ 1 to 1000 MHz

- High precision due to directivity > 45 dB
- Universal application with high and low power levels at test item
- Robust construction

Principle and characteristics

The measurement of current for magnitude and phase (vector measurement) remains a difficult problem. It has therefore become common practice to evaluate derived quantities, i.e. forward wave (a) and reflected wave (b) instead of current and voltage.

$$\text{Forward wave } a = \frac{V}{2\sqrt{Z_L}} + \frac{I\sqrt{Z_L}}{2}$$

$$\text{Reflected wave } b = \frac{V}{2\sqrt{Z_L}} - \frac{I\sqrt{Z_L}}{2}$$

These wave quantities can be measured with good accuracy in a relatively simple way using directional couplers.

The **directional coupler**, by definition, combines current and voltage according to these formulas and delivers at its outputs voltages proportional to a and b. It is mainly characterized by its directivity, which expresses in dB the degree to which a clear distinction is possible between forward wave and reflected wave.

The Rohde & Schwarz directional couplers here proposed for s-parameter measurements feature high directivity; it is > 45 dB, affording an error < 0.6%.

s-parameter measurement. When the input and output waves (a_1, b_1; a_2, b_2) are measured instead of currents and voltages at a two-port (see diagram), the s-parameters are represented by the following ratios:

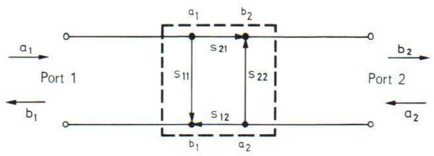
$\frac{b_1}{a_1} = s_{11}$ **Input reflection coefficient** at port 1 with port 2 match-terminated

$\frac{b_2}{a_1} = s_{21}$ **Forward transmission coefficient** from port 1 to port 2 with port 2 match-terminated

$\frac{b_2}{a_2} = s_{22}$ **Output reflection coefficient** at port 2 with port 1 match-terminated

$\frac{b_1}{a_2} = s_{12}$ **Backward transmission coefficient** from port 2 to port 1 with port 1 match-terminated

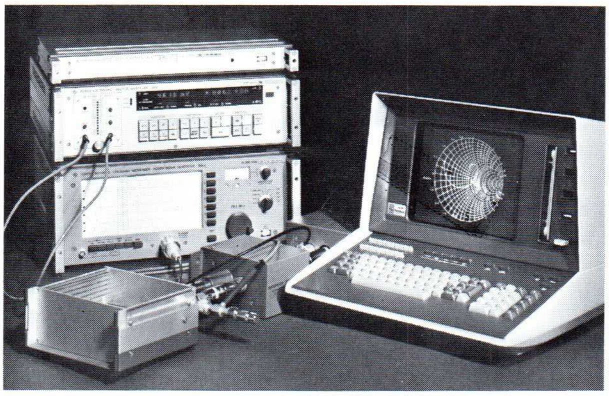
Explanation of s-parameters



For measuring s-parameters one directional coupler for the input quantities, one for the output quantities and a third (reference coupler) for the voltage required to form the ratio are needed.

Construction

The directional couplers are of symmetrical design. It is therefore possible to interchange the connections to the test item and to the indicator, thereby applying alternatively a high level (e.g. for power amplifiers) or a low level (e.g. for antenna amplifiers) to the test item. This opens up a wide range of applications in RF measurements.



Computer-controlled reflection measurement using Vector Analyzer ZPV and Directional Couplers ZPV-Z3

Specifications

Frequency range	1 to 1000 MHz
Characteristic impedance (both ends)	50 Ω
Directivity	45 dB
Coupling attenuation at 1 GHz	3 dB
Max. permissible forward power	0.5 W
Connectors at input	N male
to instrument	N female
to test item	precision N female
Dimensions, weight	360 mm × 150 mm × 100 mm, 2.8 kg

Order designation ► Directional Coupler ZPV-Z3 292.3110.50

Recommended extras

Termination RNA	272.4510.50
1 set of charts DIN-A3 format	274.1619.00

Impedance meters and signal generators

Vector Analyzer ZPV	page 110
Power Signal Generator SMLU	page 50

(For other signal generators see section 2)

Three-port Junction Box DVU 3
♦ 0 to 1000 MHz

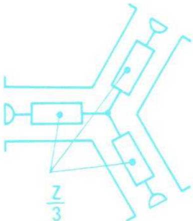
- Three-port junction box for splitting up into or combining two channels with correct impedance matching
- Range of application up to and above 1000 MHz
- VSWR with impedance matching < 1.15

The Three-port Junction Box is equipped with three adaptable Dezifix-B or N female connectors. Matching is achieved by Z/3 impedances in a star configuration.

Characteristic impedance 50 Ω, 60 Ω or 75 Ω
Attenuation 6 dB
Max. load per input 1 W
Max. permissible pulse peak voltage 300 V
Dimensions 120 mm dia. × 35 mm

Order designations: ► Three-port Junction Box DVU 3

50-Ω model	100.5203.50
60-Ω model	100.5203.60
75-Ω model	100.5203.70
50-Ω model, 3 × N female, adaptable	100.5203.03



DVU 3

Four-port Junction Box DVU 4
♦ 0 to 1500 MHz

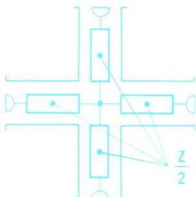
- Four-port junction box for splitting up into or combining three channels with correct impedance matching
- Application, e.g. for measurements on radiotelephone equipment involving three signal generators
- VSWR with impedance matching < 1.05 (up to 1 GHz), < 1.3 (up to 1.5 GHz)

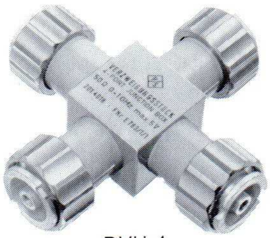
The Junction Box is a coaxial construction of four low-reflection, precision Dezifix-B or N female connectors. The matching is achieved by Z/2 impedances in a star configuration. The Termination RMC or RNB is recommended for terminating any outputs which are not used.

Characteristic impedance 50 Ω
Attenuation 9.5 dB
Max. load per input 0.25 W
Max. permissible peak voltage 300 V
Dimensions 120 mm × 120 mm × 35 mm

Order designations: ► Four-port Junction Box DVU 4

with Dezifix-B connectors (adaptable)	201.4018.02
with N female connectors (adaptable)	201.4018.03





DVU 4

Reflection-coefficient measurement

Directional Coupler ZPW-Z

Measures magnitude of reflection coefficient in conjunction with SWOB 3 (page 96).

Frequency range	Impedance	► Order numbers
87 to 230 MHz	60 Ω	110.1730.60
	75 Ω	110.1730.70
167 to 430 MHz	60 Ω	110.1746.60
	75 Ω	110.1746.70
380 to 1000 MHz	50 Ω	110.1752.50
	60 Ω	110.1752.60
	75 Ω	110.1752.70

VSWR Bridge

For matching measurements in particular in conjunction with SWOB 4 or SWOB 5 (pages 102, 104).

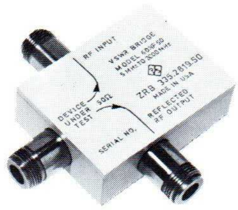
Frequency range	10 to 1000 MHz
Directivity	≧40 dB
Connectors	N male/ N female

► Order numbers

50-Ω model	912.7003.00
75-Ω model	912.7303.00

VSWR Bridge ZRB

The ZRB permits accurate measurement of reflection coefficient for magnitude and phase and is particularly suitable for use in conjunction with the Vector Analyzer ZPV (page 110).



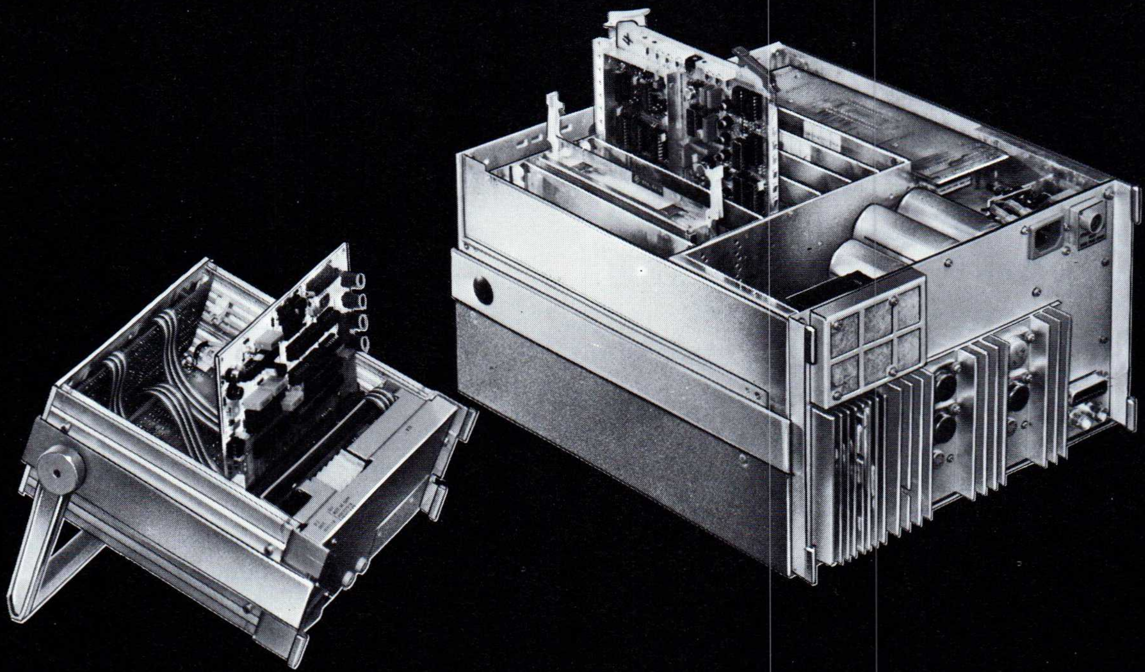
ZRB

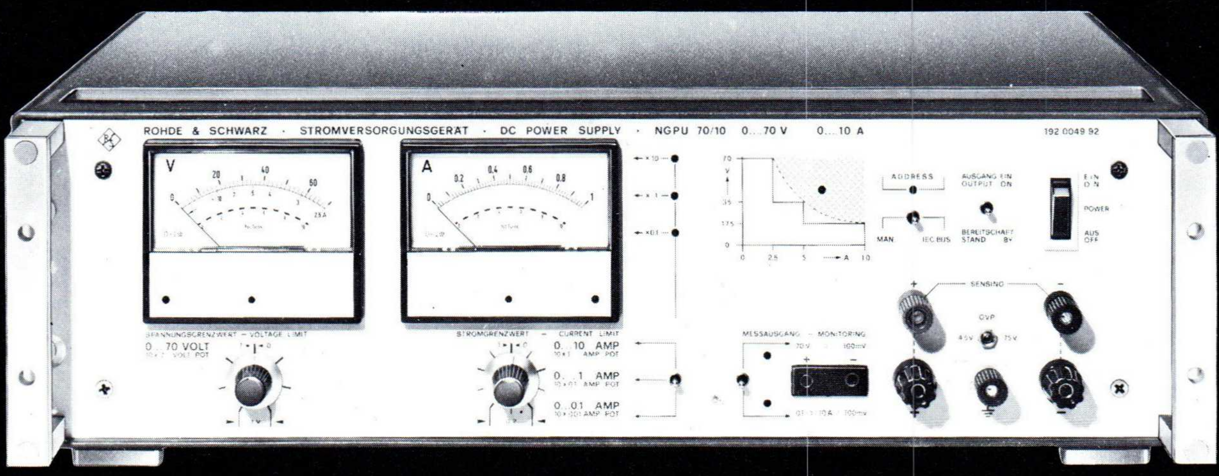
Frequency range	5 to 2000 MHz
Directivity	> 46 dB
Reflection coefficient at test-item connector	< 0.09
Measurement error	$0.005 + 0.09\, r^2$ (r = measured refl. coeff.)
Attenuation	
Input to test-item conn.	6.5 dB
Test-item conn. to output	6 dB
Max. load	0.5 W
Dimensions (without connectors)	66 mm × 50 mm × 24 mm

Order designation ► VSWR Bridge ZRB 335.2819.50

Programmable
DC Power Supply NGPU
and new cabinets
of compact casing system

power supplies
cabinets





Power supplies

The wide Rohde & Schwarz line of power supplies, covering several hundred different models, comprises **two main groups:**

a) Bench models with output powers **up to 350 W** – ten type series with a total of 28 basic models

b) 19″ models with output powers **up to 2000 W** – two type series with a total of 32 basic models plus **two programmable units**

Beyond these, a **programmable voltage source** for IEC-bus systems is now available. It has two independent outputs and its output voltages can be programmed manually or by a computer.

This product line is being continuously expanded and adapted to the state of the art (please specify requirements not covered by the program listed).

The table below includes the **complete line** from which the appropriate type can be selected to meet the maximum voltage and current requirements.

The power supplies of group a) appear in the blue section. For more details on this group see the table on the next page where the different types are listed in alphabetical order.

The power supplies of group b) are listed in the white section. For details see the table on page 252 and the following pages where also the **programmable, IEC-bus-compatible** power supplies are dealt with.

The **Programmable Voltage Source** NGPS is described on page 257.

Common features

If higher currents or voltages are required, all power supplies can be parallel- or series-connected. Protecting diodes ensure that no hazards are created by such connections.

Many models feature overvoltage protection to counteract accidental voltage surges (e.g. in case of maloperation). An external overvoltage protection unit is available for the remaining models:

3.5 to 30 V/10 A Order No. 100.5103.02
10 to 100 V/10 A Order No. 100.5103.03

Complete line of power supplies

Blue section: group a), bench models up to 350 W; for specifications see next page.

White section: group b), high-output power supplies up to 2000 W and programmable 19″ power supplies; for specifications see page 252.

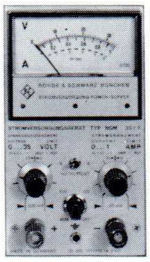
Maximum current A	Maximum settable voltage – V											
	6	7.5	10	15	20	30	32	35	50	70	100	280
0.1												NGM
0.2												NGK
0.4												
0.5										NGM		
0.6								NGL				
1					NGT			NGM/D		NGK	NGR	
1.5											NGRS	
2				NGM				NGK	NGR	NGA		
3									NGRS			
4		NGM		NGK				NGA				
5	NGT				NGR	NGRS	NGG			NGB	NGRE	
8				NGA								
10			NGR	NGG		NGRE	NGB		NGRE	NGPU	NGRE	
15		NGA				NGRE			NGRE	NGC	NGRE	
20			NGRE	NGRE		NGRE			NGRE	NGPU	NGRE	
30	NGRE		NGRE	NGRE		NGRE		NGC	NGRE			
40	NGRE		NGRE	NGRE		NGRE			NGRE			
60	NGRE		NGRE	NGRE		NGRE						
80	NGRE			NGRE								
100	NGRE		NGRE									

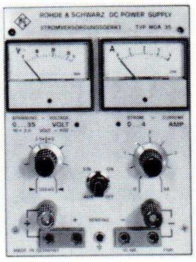
Power supplies for up to about 350 W · compact bench models

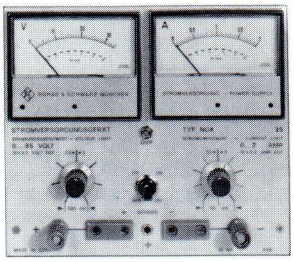
Text on next page ▶

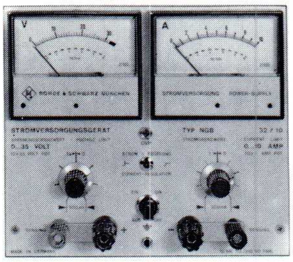
Units for higher power (up to about 2000 W) on page 252

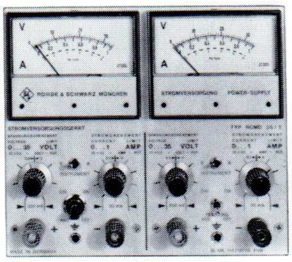
Type		Photo No.	▶ Order No.	Voltage range	Current range	Resolution		Max. dev. of output with ΔV (AC supply) ±10%		ΔT_{amb} −10 to +40 °C		Int. impedance for V	I	t_r for V	Max. ripple rms		Remote sensing/ overvoltage protec.		Dimensions: W × H × D weight
				V	A	V %	I %	V %	I %	V %/°C	I %	mΩ	kΩ	µs	V mV	I mA	S	O	mm / kg
Single Power Supplies																			
NGA	7.5	2	192.0010.02	0.01 to 7.5	0.2 to 15	0.02	1	0.01	0.2	0.01	0.1	0.2	—	75	0.15	—	S	—	129 × 172 × 330 / 8
	15		192.0010.03	0.01 to 15	0.1 to 8	0.02	1	0.01	0.2	0.01	0.1	0.3	—	75	0.15	—	S	—	
	35		192.0010.04	0.01 to 35	0.05 to 4	0.02	1	0.01	0.2	0.01	0.1	0.5	—	75	0.15	—	S	—	
	70		192.0010.05	0.01 to 70	0.025 to 2	0.02	1	0.01	0.2	0.01	0.1	1	—	75	0.15	—	S	—	
NGB	32	4	117.7210.90	0.01 to 32	0.02 to 10	0.02	0.02	0.001	0.001	0.01	0.01	0.2	15	50	0.2	1.5	S	O	190 × 172 × 330 / 10
	70		117.7227.90	0.01 to 70	0.01 to 5	0.02	0.02	0.001	0.001	0.01	0.01	0.4	30	50	0.5	1.5	S	O	
NGG	15	10	100.5078.04	0.3 to 15	max. 10	cont.	—	0.01	—	0.01	—	0.1	—	50	1	—	—	—	125 × 180 × 300 /8
	32		100.5078.11	0.05 to 32	max. 5	cont.	—	0.01	—	0.01	—	0.1	—	50	1	—	—	—	
NGK	15	3	192.0003.02	0.01 to 15	0.01 to 4	0.02	0.02	0.001	0.001	0.01	0.01	0.5	30	50	0.2	0.1	S	O	190 × 172 × 278 / 8
	35		192.0003.03	0.01 to 35	0.01 to 2	0.02	0.02	0.001	0.001	0.01	0.01	1	100	50	0.2	0.02	S	O	
	70		192.0003.04	0.01 to 70	0.01 to 1	0.01	0.02	0.001	0.001	0.01	0.01	5	500	50	0.2	0.01	S	O	
	280		192.0003.05	0.01 to 280	0.002 to 0.2	0.01	0.02	0.001	0.001	0.01	0.01	50	500	50	2	0.002	S	—	
NGM	7.5	1	117.7110.12	0.01 to 7.5	0.01 to 4	0.02	0.02	0.001	0.001	0.01	0.01	0.5	15	50	0.2	0.1	—	O	95 × 172 × 278 / 4
	15		117.7110.13	0.01 to 15	0.01 to 2	0.02	0.02	0.001	0.001	0.01	0.01	1	60	50	0.2	0.05	—	O	
	35		117.7110.14	0.01 to 35	0.01 to 1	0.02	0.02	0.001	0.001	0.01	0.01	2	250	50	0.2	0.01	—	O	
	70		117.7110.15	0.01 to 70	0.01 to 0.5	0.01	0.02	0.001	0.001	0.01	0.01	10	1000	50	0.5	0.005	—	O	
	280		117.7110.06	0.01 to 280	0.002 to 0.1	0.01	0.02	0.001	0.001	0.01	0.01	100	1000	50	2	0.001	—	—	
NGR	10	8	100.5084.02	0.01 to 10	0 to 10	0.02	0.01	0.001	0.005	0.01	0.01	1	5	50	0.2	0.1	S	—	125 × 180 × 300 / 7
	20		100.5084.03	0.01 to 20	0 to 5	0.02	0.01	0.001	0.005	0.01	0.01	1	10	50	0.2	0.1	S	—	
	50		100.5084.04	0.01 to 50	0 to 2	0.01	0.01	0.001	0.005	0.01	0.01	1	20	50	0.2	0.1	S	—	
	100		100.5084.05	0.01 to 100	0 to 1	0.01	0.01	0.001	0.005	0.01	0.01	1	30	50	0.2	0.1	S	—	
NGRS	30	9	100.5090.02	0.01 to 30	0 to 10	0.02	0.01	0.001	0.005	0.01	0.01	1	5	50	0.2	0.3	S	—	125 × 180 × 300 /7
	50		100.5090.03	0.01 to 50	0 to 5	0.01	0.01	0.001	0.005	0.01	0.01	1	10	50	0.2	0.3	S	—	
	100		100.5090.04	0.01 to 100	0 to 3	0.01	0.01	0.001	0.005	0.01	0.01	1	20	50	0.2	0.3	S	—	
Dual Power Supplies																			
NGMD	35	5	117.7127.02	0.01 to 35 (2×)	0.01 to 1	0.02	0.02	0.001	0.001	0.01	0.01	2	250	50	0.2	0.01	—	O	190 × 172 × 278 /8
Triple Power Supplies																			
NGL	35	6	192.0026.02	0.01 to 35 (3×)	0.01 to 0.6	cont.	1	0.01	0.2	0.1	0.1	10	—	75	0.1	—	—	—	190 × 172 × 278 / 7
NGT	20	7	117.7133.02	0.01 to 20 (2×) 0.01 to 6 (1 ×)	0.01 to 1 0.01 to 5	0.02	1	0.01	0.2	0.01	0.1	2 1	— —	75	0.1	—	—	— O	190 × 172 × 278 / 7

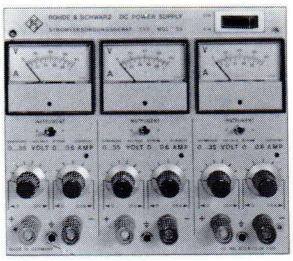
1

NGM

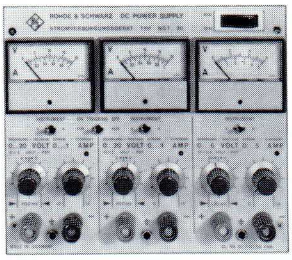
2

NGA

3

NGK

4

NGB

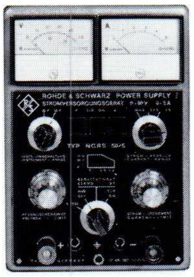
5

NGMD

6

NGL

7

NGT

8

NGR

9

NGRS

10

NGG

General features and definitions

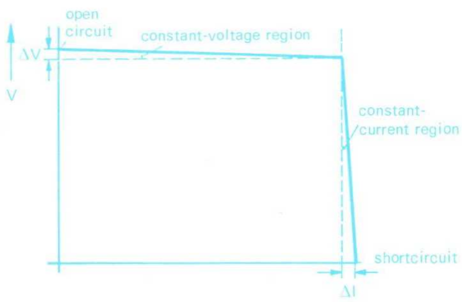
(Information also applies to NGC, NGRE and NGPU; see page 252)

All power supplies of the R&S line are electrically designed to exhibit **almost equal quality;** floating outputs, permissible external voltage to chassis or earth – or with dual or triple power supplies to one another – 500 V. Operating temperature range −10 to +50 °C. Panel engravings German and English. Power cable is supplied. The models of the NG series are designed for operation from 220 V AC. Only the types NGK, NGA, NGT and NGL can be adapted to 110 V (NGPU by means of soldered link); for other types please enquire.

Continuous **setting of voltage and current** starting from a threshold near zero. The NGA, NGB, NGK, NGM, NGR, NGRS, NGC, NGPU, and some models of NGRE (page 252) are equipped with multiturn precision potentiometers (repeatability ±0.1%).

The rated values of voltage and current are the maximum settable levels. All supplies of this line, with the exceptions of the triple supplies NGT and NGL and the surge-withstanding NGG models, are designed to provide **combined regulation of both voltage and current.**

Voltage-current characteristic for combined constant-voltage/ constant-current power supplies



The triple supplies NGT and NGL incorporate **current limiting** which can be **continuously adjusted** to any value between zero and the rated current. In the NGG supplies current limiting takes place at a fixed value, higher than the rated current.

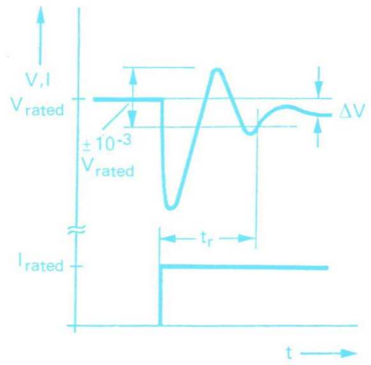
Mode indication. Pilot lamps or LEDs indicate whether the unit is operating in the constant-voltage range or whether current limiting takes place.

Meters. The panel meters are of class 1.5 (indication error ±1.5% of fsd). Units of the series NGM (NGMD), NGL, NGT, NGR and NGG have meters with switch-selected current or voltage indication. The other units have separate meters for simultaneous voltage and current indication.

Internal impedance is specified in the table to describe the effect of load variations on the output quantity. For example, with constant-current operation of a 100 V/1 A unit, the information internal impedance = 30 kΩ implies that a load variation from 0 to 100 Ω with a nominal current of 1 A causes a current deviation of 3 mA or 0.3%.

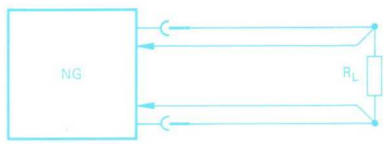
Transient response time t_r. The value here refers to a sudden change from open circuit to full loading with constant-voltage operation. After t_r the output voltage is again within tolerance. In constant-current operation t_r strongly depends on the load (< 100 µs to 1 s).

Transient response time t_r following step change in load



Lead resistance compensation (remote sensing). With the models marked S in the table, and with the NGC (page 255), the voltage drop which varies with the load current on the lead can be corrected, if separate sensor leads are connected to the terminals of the load. A variation of 0.5 V on the plus and minus leads can be compensated.

Use of sensing leads to compensate supply-lead volt drops



Remote control. The standard models of the series NGR can be remote-controlled for voltage and current setting via external resistors. For example, a programming resistance of 1 kΩ/V is required for voltage and 1 kΩ/A for current with the 100-V unit. NGRE series see page 252.

Programming. The Power Supplies NGPU are suitable both for manual operation and for control via the IEC bus, i.e. for integration into automatic test assemblies; for details see page 256.

Cooling. The supplies cannot be damaged by thermal overloading. The models of the NGM and NGK series, and the multiple supplies NGMD, NGT and NGL have rear-mounted convectional heatsinks. For units rated above 100 W (NGA, NGB, NGR, NGRS, NGG and the 19-inch supplies) a two-stage thermostat-controlled cooling fan is used. At low demands the fan is scarcely noticeable; only when high output is required is it switched fully on. The fans are powered by quiet, maintenance-free motors.

Overvoltage protection. To provide protection against undesirably high voltages caused by misuse or faults, the models of the NGB, NGK, NGM, NGMD, NGPU and NGT series are fitted with an independent crow-bar circuit with an **adjustable operating threshold.** Additional overvoltage protection units can be connected externally on the other supplies. Two versions are available for different ratings:

- ► 3.5 to 30 V/10 A Order No. 100.5103.02
- ► 10 to 100 V/10 A Order No. 100.5103.03

Certain models of the NGRE series can be fitted with a built-in overvoltage protection circuit on special request.

Special features

Single power supplies

in order of increasing power

NGM, NGK – 35/70-W laboratory models

- High-resolution ten-turn potentiometers for V and I
- Single switched meter on NGM-series – separate meters on NGK-series models

The supplies of the **NGM series** can be used as either constant-voltage or constant-current sources. The mode of operation at any time is indicated by a pair of light-emitting diodes. These power supplies are precision instruments whose excellent performance will be appreciated in many applications, especially in the laboratory.

The supplies of the **NGK series** provide twice the output current of the corresponding members of the NGM series. For this reason they feature remote-sensing sockets to permit compensation of the voltage drop in the leads connecting the supply to the load.

NGA – compact 120-W models

- High-resolution ten-turn potentiometers for V and I
- Separate meters, remote-sensing sockets

The supplies of the **NGA series** are for use as constant-voltage sources; they incorporate fixed-value current limiting at a level set by a front-panel potentiometer. The onset of current limiting is indicated by a light-emitting diode. These units are particularly suited for supplying assemblies and subassemblies during testing or development.

NGR, NGRS – 100/150-W precision sources

- High-resolution ten-turn potentiometers for V and I
- Large panel meter switchable for voltage or current on NGR, separate panel meters on NGRS

The supplies of the **NGR** and **NGRS series** can be used as either constant-voltage or constant-current sources. The transition from voltage to current regulation and vice versa is automatic. The supplies are fitted with quiet cooling fans with thermostat-controlled two-stage operation, thermal overload protection with automatic reset and remote-sensing sockets.

On the **NGR** both the output voltage and the current can be set remotely by externally connected resistors.

The power switch of the **NGRS** has four positions: off, standby, on and test (for checking the current-limit setting).

NGG – compact 150-W models

- Large panel meter – switchable for voltage or current
- Surge-current capability – several times rated current may be drawn for short periods

The **NGG series** is particularly suited for use with loads characterized by high-surge or impulsive current demands (such as radiotelephone sets powered by converter supply units and automobile electronic test equipment). The rated power output is 150 W, with up to 200 W being admissible for short periods. The NGG supplies are extremely insensitive to RF voltages radiated, for example, by other equipment or a nearby antenna. The NGG 15 is intended for use at 6 or 12 V while the NGG 32 is aimed at loads requiring a 24-V supply. The **delayed current limiting** feature permits 2 to 4 times the rated current to be drawn for up to 0.4 s.

NGB – 350-W benchtop models

- High-resolution ten-turn potentiometers for V and I
- Surge-current capability – several times rated current may be drawn for short periods

Constant-voltage as well as constant-current sources with automatic transition from voltage to current regulation (indication by LEDs). Use as battery eliminators with switch-selected delay for the current regulation (higher surge current), e.g. for incandescent lamps, blinkers, voltage transformers. Additional features: large panel meters for voltage and current, voltage compensation on feeders up to 1 V, adjustable overvoltage protection.

Dual power supplies

NGMD 35 – 2 × 0 to 35 V/1 A max.

- Independent or tracking operation
- Mutually isolated floating outputs, permanent-shortcircuit proof

Two instruments of the type NGM (0.1 to 35 V) are accommodated in a single cabinet and can be used separately or in tracking operation, switch-selected on front panel. With tracking operation, unit II follows unit I; the NGMD supplies, with respect to a common reference point, a positive and a negative voltage each of 0 to 35 V that are equal in quality and can be proportionally varied together (adjustable with helical potentiometer on unit I). The current limits can be adjusted independently of each other.

Triple power supplies

NGL 35 – 3 × 0 to 35 V/0.6 A max.

- Three voltages at the same time; series or parallel mode possible
- Thermal overload protection with automatic cut-in

The **NGL 35** has three separate identical and floating outputs which are independently adjustable between 0 and 35 V; the current-limiting threshold can be set from 0 to 0.6 A. Tripling of the voltage or current limit value is possible by parallel or series connection. These characteristics make the NGL 35 a very versatile power supply.

NGT 20 – 2 × 0 to 20 V/1 A max.
1 × 0 to 6 V/5 A max.

- Independent or tracking operation of 20-V supplies
- Permanent-shortcircuit proof, adjustable overvoltage protection of 6-V supply

The **NGT 20** combines three independent constant-voltage sources in a single instrument. Each output can be monitored on an individual panel meter (switchable for either voltage or current) and the onset of current limiting is annunciated by three separate light-emitting diodes.

The two **20-V supplies** are intended primarily for use with **linear integrated circuits.** They can be used independently, or connected in series or in parallel. A front-panel switch also permits these two outputs to be operated in the tracking mode.

The separate **6-V supply** has a high output-current capability of 5 A making it particularly suitable for powering **digital integrated circuits.** The built-in overvoltage protection has a continuously adjustable threshold.

19″ power supplies from about 20 to 2000 W

Units for lower power on page 249

Voltage range V	Current range A	▶ Order No.[1]	Max. deviation of output values for ΔV AC supply ±10% V (%)	I	for Δt_{amb} (−10 to +50 °C) V (%/°C)	I	Internal impedance const. V mΩ	I kΩ	t_r for V µs	Max. ripple and noise rms V µV	I mA	Power consumption at 220 V/50 Hz kVA	Available as model[2])	Weight incl. cabinet kg
NGRE series														
0 to 6	0 to 30	100.8402 . . .	Values for V: ±0.01% or ±0.001%; depending on model; see table on page 253	±0.001	0.01	0.01	1	1	< 50	300	9	0.9	A, C	22
	0 to 40	100.8419 . . .		±0.001	0.01	0.01	0.1	1	< 50	300	12	0.9	A, C	22
	0 to 60	100.8425 . . .		±0.001	0.01	0.01	0.1	1	< 50	300	18	0.9	A, C	28
	0 to 80	100.8431 . . .		±0.001	0.01	0.01	0.1	1	< 50	300	24	1.8	B, C	39
0 to 10	0 to 20	199.8354 . . .		±0.001	0.01	0.01	1	2	< 50	300	6	0.9	A, C	19
	0 to 30	100.8360 . . .		±0.001	0.01	0.01	1	2	< 50	300	9	0.9	B, C	28
	0 to 40	100.8377 . . .		±0.001	0.01	0.01	0.1	2	< 50	300	12	1.8	A, C	28
	0 to 60	100.8383 . . .		±0.001	0.01	0.01	0.1	1	< 50	300	18	1.8	B, C	37
0 to 15	0 to 20	100.8319 . . .		±0.001	0.01	0.01	1	2	< 50	300	6	0.9	B, C	28
	0 to 30	100.8325 . . .		±0.001	0.01	0.01	1	2	< 50	300	9	1.8	A, C	28
	0 to 40	100.8331 . . .		±0.001	0.01	0.01	0.1	2	< 50	300	12	1.8	A, C	37
	0 to 60	100.8348 . . .		±0.001	0.01	0.01	0.1	1	< 50	300	18	2.5	B, C	39
0 to 30	0 to 10	100.8254 . . .		±0.001	0.01	0.01	1	5	< 50	300	3	0.9	A, C	19
	0 to 15	100.8260 . . .		±0.001	0.01	0.01	1	5	< 50	300	4.5	0.9	B, C	28
	0 to 20	100.8277 . . .		±0.001	0.01	0.01	1	3	< 50	300	6	1.8	A, C	28
	0 to 30	100.8283 . . .		±0.001	0.01	0.01	1	2	< 50	300	9	1.8	B, C	37
	0 to 40	100.8290 . . .		±0.001	0.01	0.01	0.1	2	< 50	300	12	2.5	B, C	39
	0 to 60	100.8460 . . .		±0.001	0.01	0.01	0.1	2	< 50	300	18	3.5	C	50
0 to 50	0 to 10	100.8219 . . .		±0.001	0.01	0.01	1	5	< 50	300	3	0.9	B, C	28
	0 to 15	100.8225 . . .		±0.001	0.01	0.01	1	5	< 50	300	4.5	1.4	A, C	28
	0 to 20	100.8231 . . .		±0.001	0.01	0.01	1	5	< 50	300	6	1.8	A, C	37
	0 to 30	100.8248 . . .		±0.001	0.01	0.01	1	3	< 50	300	9	2.5	B, C	39
	0 to 40	100.8454 . . .		±0.001	0.01	0.01	0.1	2	< 50	300	12	3.5	C	50
0 to 100	0 to 5	100.8160 . . .		±0.001	0.01	0.01	1	10	< 50	500	1.5	0.9	B, C	28
	0 to 10	100.8183 . . .		±0.001	0.01	0.01	1	10	< 50	500	3	1.8	A, C	37
	0 to 15	100.8190 . . .		±0.001	0.01	0.01	1	5	< 50	500	4.5	2.5	B, C	39
	0 to 20	100.8448 . . .		±0.001	0.01	0.01	1	5	< 50	500	6	3.5	C	50
NGC series														
0 to 35	0 to 30	192.0032.02		±0.001	0.01	0.01	0.1	1	< 50	1 mV	20	2.4	B	40
0 to 70	0 to 15	192.0032.03		±0.001	0.01	0.01	0.5	4	< 50	2 mV	20	2.4	B	40
NGPU series (programmable)														
0 to 70	0 to 10	192.0049.92		±0.001	0.01	0.1			< 50	500	3	1	D	14
0 to 70	0 to 20	192.0055.92		±0.001	0.01	0.1			< 50	500	3	2	E	19

[1]) Complete the nine-figure **order No.**: replace the last two periods by the **number of the desired** model as per table on page 253.

[2]) A and B: Cabinet model or 19″ rackmount with different seated depth to be selected as per table on page 253. C: Only cabinet model 608 mm × 394 mm × 284 mm.

For general and special features see next page ▶

DC Power Supplies NGRE (cont'd from page 252; additional characteristics and completion of Order Nos.)

▶ Code number of models	Form of housing	Adjusting V and I: Prec. pot. front panel	Adjusting V and I: Screw-driver adj. front panel	Adjusting V and I: Screw-driver adj. rear panel	I range in three decades (up to 30 A)	Four extra fixed voltages pushbutton selected	Large V and I meters	Outp. volt. dev. for ±10% ΔV AC supply ±0.01%	Outp. volt. dev. for ±10% ΔV AC supply ±0.001	Overload cap. 2 to 3 × I_{nom} switch standard	Overload cap. 2 to 3 × I_{nom} switch extra	Remote control¹) (extra charge)
...11	19″ cabinet³)			×				×			×	31
...13				×					×		×	33
...15		×					×	×		×		35
...17		×			×		×		×	×²)	×	37
...10	19″ rackmount³)			×				×			×	30
...12				×					×		×	32
...14		×					×	×		×		34
...16		×			×		×		×	×²)	×	36
...18	Alu housing⁴)		×						×		×	
...19		×				×	×		×		×	

¹) In case of remote control, master-slave operation is possible (see page 254); when placing an order state the number given in this column instead of the corresponding number in the first column "Code number of models".

²) From 40 A upwards.

³) Model A or B, acc. to table p. 252.

⁴) Model C (waterproof, shock-absorbant aluminium housing).

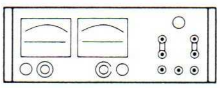
Dimensions

	Cabinet model mm	Rackmount mm	Seated depth d mm
Model A	484×194×436	483×177×425	347
Model B	484×194×509	483×177×498	420
Model C	608×394×284	—	—
Model D	492×161×514	492×132×514	427
Model E	492×205×514	492×177×514	427

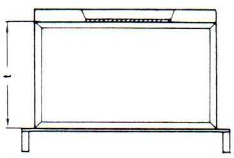
View of Models:

Models A, B, D and E:

Front view of models 10 to 13

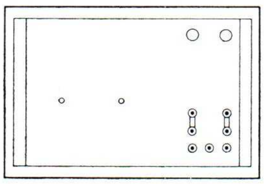


Front view of models 14 to 17

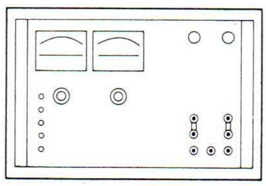


Top view of 19″ rackmount, models A and B

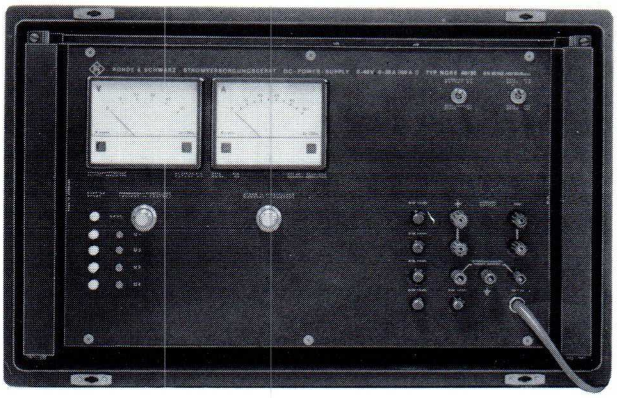
Model C:



Front view of model 18



Front view of model 19 ▼



High-output power supplies

General features

(see also page 250)

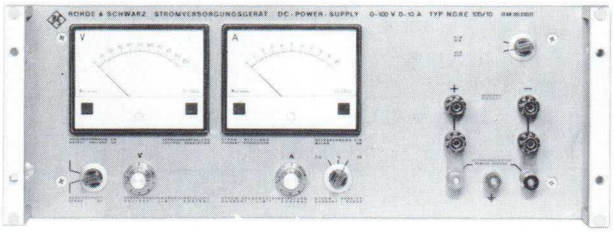
Adjustment of current ranges. Units up to 30 A of NGRE models 16 and 17 are equipped with current ranges switchable in decade steps, e.g. a 10-A supply can be switched to 0.1/1/10 A.

Transient response time t_r. The value given in the table applies for operation at constant voltage at a load varying between no load and full load. With constant current operation, t_r is between < 100 µs and 100 ms and load-dependent to a great extent.

Remote control. The following functions of the models 10 to 17 can be modified for remote control: output voltage, output current (as with NGR, page 249) and power switch "on/off/standby" as well as control of the power regulating element. Instruments of the type series NGRE, which are adapted to remote control, are suitable for

master/slave operation (parallel-connected). This mode of operation – control of the power output only performed by one of the employed instruments – is of great advantage, since, especially with higher powers, equal loading of all units is ensured.

NGRE series



- No voltage peaks when switching on and off
- Protection against sustained short circuit, thermal overload protection
- Series and parallel connection of several units possible

The type series NGRE comprises power supplies with high output power (above approximately 200 W). Extreme versatility is won by the use of standard modules: most of the 27 basic types (see table on page 252) come in 10 different versions. The instruments with the highest current ranges are only available as model C, i.e. in two versions.

The **basic types** differ only in the maximum adjustable values of voltage and current and the internal impedance.

The **available versions** of each basic type are equipped differently – meters, operating controls, connectors – and are designed as cabinet model or as rackmount.

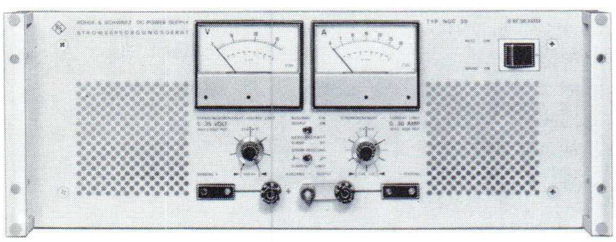
Order designations. Because of the great variety of instruments, division into two groups – basic types and other models – was necessary. A nine-figure number (combination from both tables) should in any case be stated when placing an order.

Overvoltage protection. Each instrument of the type series NGRE is also available as special model with built-in overvoltage protection.

Programmable power supplies
and voltage sources
on next two pages

NGC series

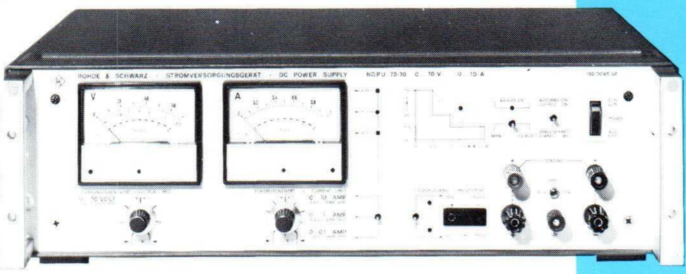
- High efficiency thanks to thyristor preregulator
- Protected against permanent shortcircuits and surges; standby operation
- Meets RFI emission regulations – VDE level K



The (first) two types of a 1000-W series are designed for 35 V/30 A or 70 V/15 A. Thanks to a thyristor preregulator and a subsequent series-pass regulator, the NGC power supplies achieve very high efficiency, feature low interference and are thus suitable for application in any field. Incorporation into 19″ racks is possible.

Voltage and current are set by means of high-resolution ten-turn potentiometers and indicated on separate panel meters. The power supplies are fitted with remote-sensing sockets for output-lead voltage-drop compensation. A quiet cooling fan with two-stage thermostat-controlled operation is incorporated.

NGPU



Programmable power supplies NGPU

- Suitable both for IEC-bus programming and for manual operation
- Three-digit programming of voltage and current (1000 steps), resolution between 10 and 100 mV or 10 and 20 mA
- Three automatically switching decade current measurement ranges
- Additional test signals proportional to both the actual voltage and current values

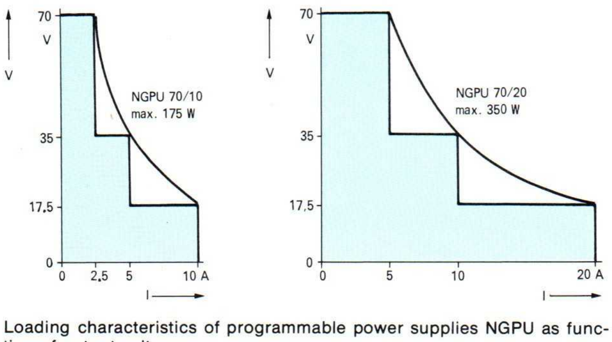
IEC 625 Bus

Increasing automation of test equipment and other possibilities presented by the **IEC-bus** standardization have lately stimulated interest in programmable power supplies. Application of such units is by no means restricted to fully automatic computer-controlled test systems, but can advantageously be extended to less complex situations in which partial automation is used for oft-repeated settings as a way of reducing operator fatigue and saving valuable time.

The **NGPU series of programmable power supplies** represents a valuable extension to the existing R&S range of IEC-bus-compatible test equipment. Two models are available, distinguished by their output powers:
NGPU 70/10: 175 W (70 V/max. 10 A),
NGPU 70/20: 350 W (70 V/max. 20 A).

Both may be operated as either constant-voltage or constant-current sources and are suitable for programmed operation via the IEC bus or manual use.

The maximum load current is a function of the output voltage; the full output power is available over approximately 80% of the output-voltage range. As the figure shows, the output characteristics are a combination of three individual curves: each NGPU combines the performance of three single power supplies.



Loading characteristics of programmable power supplies NGPU as function of output voltage.

Since the current drain of many loads, such as a radiotelephone, falls with increasing supply voltage, this stepped loading characteristic of the power supplies is fully compatible with practical requirements.

In continuous operation the area shown on the diagram can be fully utilized up to the limit-power line. An auxiliary scale on the panel voltmeter indicates the permissible continuous load current at each voltage setting. The unit can withstand brief, impulsive currents which exceed the limit line. If, at set voltages above 15 V, a current greater than the limit value is accidentally drawn for an extended period, the temperature-monitor circuit within the power supply causes the instrument to be disconnected from the AC supply.

The output voltage and/or current may be set via the IEC programming connector. The switchover between programmed and manual control is made on the front panel, separately for voltage and current. The resolution of the voltage setting may be chosen to be fixed at 100 mV or to be variable between 10 and 100 mV.

Programming

The power supplies may be programmed from any **IEC-compatible control device.** The various input lines are electrically isolated from each other. By making use of the settable address it is possible to operate several NGPUs in parallel.

Using the front-panel switches for selection of bus or manual control it is possible to interrupt a programmed sequence at any point to make a precise investigation of a troublesome situation under manual control.

The simplest form of control would involve the Card Reader PCL. For repetitive routine measurements, such as characteristic tracing, an error-free and effort-saving solution is offered by a timed sequence of precisely reproducible voltage or current changes programmed by a punched tape for example.

Specifications (see also table on page 252)

Voltage	10 mV to 70 V, adjustable with ten-turn potentiometer	
Current (ten-turn potentiometer)	**NGPU 70/10**	**NGPU 70/20**
up to 17.5 V	<5 mA to 10 A	<10 mA to 20 A
up to 35 V	<5 mA to 5 A	<10 mA to 10 A
up to 70 V	<5 mA to 2.5 A	<10 mA to 5 A
Programming	three-digit IEC-bus-controlled setting of voltage and current, both 1000 steps, and manual	
Test outputs	test signal proportional to voltage or current, e.g. 100 mV for full 70-V output, max. 1 mA	
Overvoltage protection	adjustable from 4.5 to 75 V	
Operating temperature range	+10 to +40 °C	

Order designations	▶ Programmable Power Supply
NGPU 70/10	192.0049.92
NGPU 70/20	192.0055.92

Recommended extras

IEC-bus Cable PCK 1 m	292.2013.10
or 2 m	292.2013.20
or 4 m	292.2013.40

Programmable Voltage Source NGPS for IEC-bus systems

♦ 2 × ±40 V/ ±16.38 V, max. 100 mA

- Two separate bipolar sources with 0.5 mV or 2 mV resolution:
  65,536 steps in low range
  40,000 steps in high range
- Suitable both for IEC-bus programming and for manual operation
- Six-digit display of input data, shortcircuit-proof outputs
- Learning capability through built-in micro-processor

NGPS

new

IEC 625 Bus

The Programmable Voltage Source NGPS has two independent channels (A and B) and its output voltages can be programmed manually or by a computer. Free combination of the two outputs provides for many applications:

▷ Bipolar voltage source −80 to +80 V, resolution 2 mV
▷ XY operation of analog recorders via digital computer
▷ Threshold voltage test of components, comparators
▷ Waveform simulation, e.g. triangle, square
▷ Use in automated tuner test assemblies
▷ Sinewave generator for extremely low frequencies

Setting, resolution. The bipolar voltages can be set or programmed from −16.3835 V to +16.3835 V in the low range in 65,536 steps (2^{16}, resolution 0.5 mV). Resolution in the high range is 2 mV/step with a maximum output voltage of ±40 V (corresponding to a swing of 80 V).

Maximum permissible current drain is 100 mA. Any increase beyond this limit is signalled as malfunction of the analog section of channel A or B.

The six-digit display permits observation of programmed test sequences. In the programming mode (data acceptance) or listen only (LON) mode of the NGPS the address lamp is lit.

In the combined manual and programmed mode the digital voltage setting can be varied manually. The speed of variation depends on how long the plus or minus button is pressed.

Output-voltage range coding is possible by selecting the secondary instrument address or using the built-in microprocessor, and also by means of special characters.

With up to 31 settable instrument addresses, a listen-only switch and different assignable end-of-message characters for programming, the unit constitutes a universal, flexible listener in IEC-bus systems.

By applying a status byte to the data line of the IEC-bus input through the parallel-poll or serial-poll function the NGPS can notify the selected operating mode or a fault, if any, to a computer.

The trigger facility permits rapid switching of preset voltages and thus uniquely defined timing of test sequences.

Remote-sensing sockets offer the possibility of keeping the voltage at the load or test item (or at the controlling equipment) constant even if high currents and long leads are involved.

The talker capability of the NGPS enables continuous interrogation of the voltage inputs to channels A and B, functional checking of the analog section and notification of the selected trigger states.

Specifications

Outputs	2 separate floating channels (A and B) in parallel with rear outputs
Output voltage per channel	
Low range	−16.3835 to +16.3835 V
High range	−40.00 to +40.00 V
Setting	pushbuttons; variation in steps or continuous within range or programmed
Resolution Low/High range	0.5 mV/2 mV
Indication (with polarity sign)	6 digits for one channel
Output current	100 mA max. limiting threshold approx. 130 mA
Stability, ripple and noise	
Voltage deviation	
w. AC supply variation ±10%	$<10^{-5}$
w. temperature variation	$<8\times10^{-6}$/K +50 µV
w. load variation	$<5\times10^{-6}$
Instability	$<2\times10^{-7}$/hr (low), $<4\times10^{-7}$/hr (high)
Capacitive load	≦0.1 µF (80-V step)
Ripple and noise (rms) up to 3 kHz	< 100 µV (low), < 200 µV (high)
Nonlinearity (Low/High range)	< ±700 µV < ±3 mV
Response time	< 700 µs (100 µs for smallest program step)
Remote-sensing sockets	compensation for 0.5 V max.
Programming	via IEC bus (IEC 625-1) for ranges and voltage, manual operation switch-selected
Connector	24-way, floating
Functions	SH1, AH1, T2, TE2, L1, LE1, SR1, RLØ, PP1, CØ, DC1, DT1
Response time, programming	< 1 µs
Output ON	< 1 µs
OFF	> 62 µs
Data rate	42 kbyte/s max.
Programming time	> 183 µs
General data	
Nominal temperature range	+5 to +40 °C
Power supply	110/220 V ±10%, 50 to 60 Hz (120 VA)
Dimensions, weight	492 mm × 116 mm × 392 mm, 6.2 kg
Order designation	► Programmable Voltage Source NGPS 192.0061.02
Recommended extras	
IEC-bus Cable PCK	lengths 0.5 to 4 m, see p. 13
Relay Matrix PSN	290.9210.02

Dimensions in tables and text, cabinets

Design 80

Compact casing system

The R&S design 80

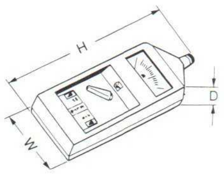
is being used for new instruments. This universal modular system – for details see page after next – extends from 19″ mainframes through panelling (instead of cabinets) to cassettes.

In design 80, the width of a bench model (19″ rackmount plus panelling corresponding to the former cabinet model of W = 484 mm) is 492 mm.

As many instruments are available in several models, their dimensions are given in tables and texts in an abbreviated code form. The actual dimensions may easily be read from the key given on the next page.

The **dimensions** of Rohde & Schwarz instruments are thus expressed as follows:

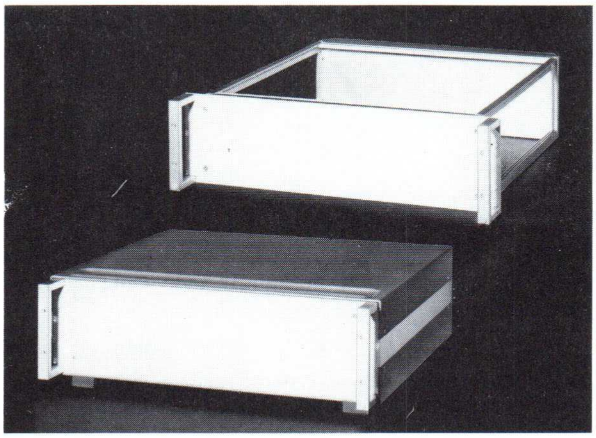
a) Overall **width** × **height** × **depth** in mm, looking onto the front panel; this also holds for pocket-sized instruments (such as the ELT):



In general the indicated dimensions refer to cabinet models.

b) **In addition** to a), the above-mentioned **code** is listed if the instrument is also available as a 19″ rackmount.

The corresponding dimensions and seated depths of the rackmounts are given in the table; for the seated depth d see also the diagram on the next page.



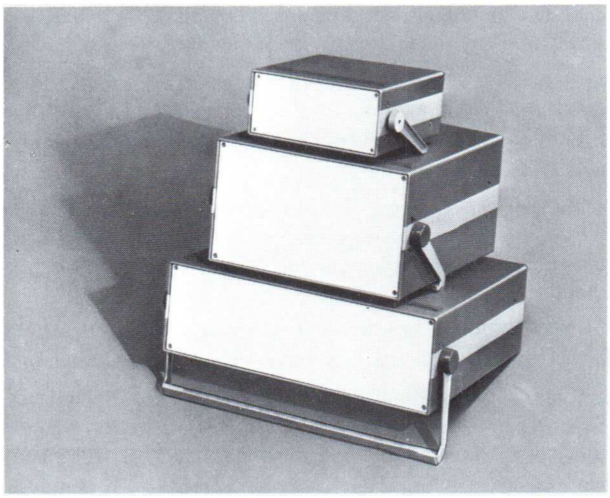
Basic mainframe of design 80 with and without panelling

New R&S compact casing system

The new casing system is specially tailored to small and compact measuring instruments. Compact units have widths*) of $^1/_2$, $^3/_4$ or $^1/_1$ of 19″ and different heights and depths and can be mounted in 19″ racks by means of adapters. For details see table on next page and text on page 261.

*) The actual width is slightly less than the calculated width for constructional reasons.

Compact cases; even stacked units can be set up at an angle (using handle as stand)



Cabinet designs

New designs of cabinets and casing systems are the result of the constantly increasing degree of utilization of instrument volume made possible by ever smaller and more complex components.

The present Rohde & Schwarz line comprises the following three design forms:

Design 70 (present design)

Design 80

Compact casing system

Design 70 – for measuring instruments of mixed design with conventional subassemblies – will be superseded in future by design 80.

Key to dimension code used in tables and texts, order numbers for cabinet covers and 19″ adapters

Instruments of 19″ width

a) present design (designated D 70 in the table)
b) design 80 (designated D 80 in the table)

All dimensions are in mm.

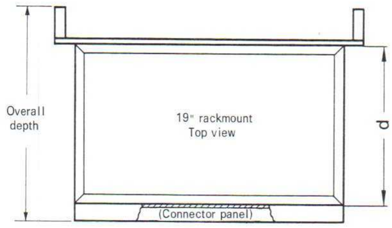
Code for height (= DIN 41 494 Sh. 2) ▼	Height in units (1 E ≈ 44 mm)	19″ instrument dimensions: Rackmount (front-panel width 483) Front-panel height D 70	D 80	Bench model (width D 70: 484, D 80: 492) Overall height D 70	D 80	Cabinet cover: Cover for bench model Order Nos. D 70	D 80
1	1 E	44	—	61	—	082.5882.00	085.6550.00
2	2 E	88	88	105	116	043.3818.00	085.6567.00
3	3 E	133	132	150	161	043.3930.00	085.6573.00
4	4 E	177	177	194	205	043.4037.00	085.6580.00
5	5 E	222	221	239	250	043.4114.00	085.6596.00
6	6 E	266	266	283	294	043.4743.00	085.6609.00
7	7 E	311	—	328	—	043.4820.00	—
8	8 E	355	—	372	—	043.4908.00	—
9	9 E	400	—	417	—	043.4972.00	—
10	10 E	444	—	461	—	043.5040.00	—
11	11 E	488	—	505	—	043.5110.00	—
12	12 E	533	—	550	—	043.5191.00	—

for depth ▼	Overall depth D 70	D 80	Depth d (see drawing) D 70	D 80	Overall depth without cover D 70	D 80
A	326	384	247	305	336	392
B	426	506	347	427	436	514
C	499	—	420	—	509	—

Dimension d

The dimension given in the table indicates the seated depth of 19″ rackmounts according to the diagram below. For the overall depth, 79 mm have to be added: front projection for front panel (4 mm) and handles, including plastic stoppers (51 mm), and rear projection for connecting panel (24 mm).

For details on design 80 see next page ▶

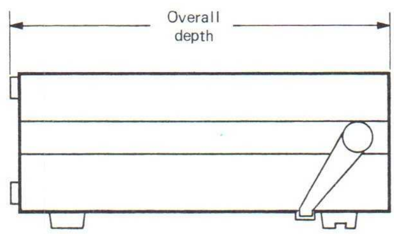


Compact casing system

Dimensions: Width of 19″	overall mm	without handle mm	Height overall mm	in units E	Depth overall (without controls) mm	19″ Adapter Order Nos.
1/2	241	210	110	2	217	078.8016.00
				2	347	078.8174.00
	245	210	154	3	347	078.8351.00
3/4	347	312	198	4	347	078.8500.00
				4	469	078.8645.00
1/1	470	435	110	2	347	078.8274.00
			154	3	347	078.8400.00
				3	469	078.8439.00
			198	4	469	078.8751.00

Note on instrument depth

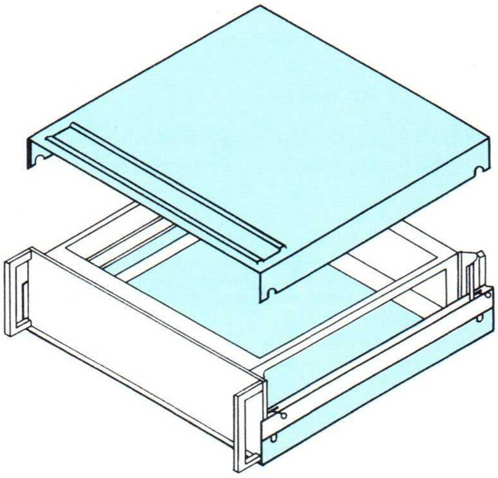
While for designs D 70 and D 80 the overall depth is uniquely defined by the handles, these constituting the largest projections, the depth for compact cases can be given only by the diagram below, since the operating controls differ according to instrument type.



R&S design 80

More and more new Rohde & Schwarz instruments are being produced in design 80, the new style for the eighties which, in its outward appearance, represents the third equipment generation in the company's history of over 40 years.

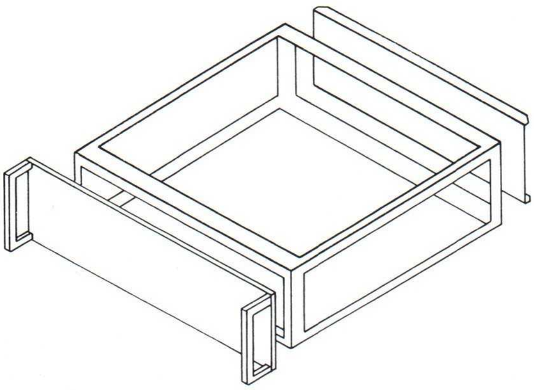
Design 80 is a modern and universal **modular system** which meets differing requirements. It is characterized by exemplary styling, optimum utilization of space, high stability and low weight. The system covers mainframes, panelling, cassettes, adapters for rack incorporation, plug-in PCBs and integrable small equipment.



19″ bench model in design 80:
mainframe plus panelling (enclosure detached)

Basic mainframe

The mainframe corresponds to the 19″ standard in accordance with IEC recommendation 297 and DIN 41 494.



19″ basic rackmount in design 80; frame, front and rear panels

Extruded aluminium profiles are used which can be assembled without any special equipment due to their mutually engaging form and enable unit as well as series assembly. The form of the profiles ensures that the mainframe is true in angle and stable while remaining light in weight and large in capacity, the latter making for high packing density.

Sizes of two to six units in height (1 unit corresponding to 44.45 mm) and two frame depths (305 and 427 mm) have been standardized.

Panelling

For the bench model, the panelling used instead of the cabinet consists of two metal-plate enclosures with extruded aluminium side strips (see photos right). With sizes of six units in height, the side strips are provided with recessed and withdrawable handles.

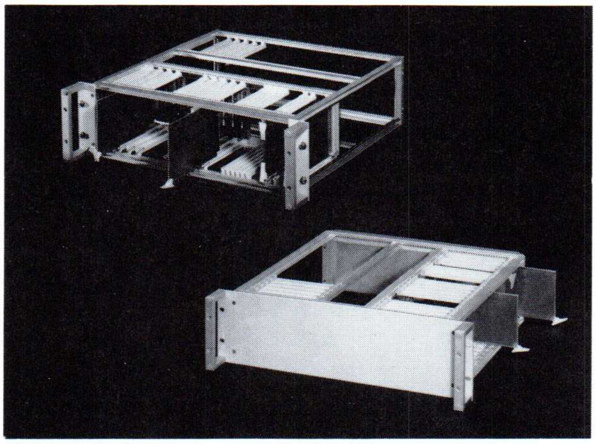
Due to the use of panelling, it is normally only necessary to move the lightweight enclosure and not the heavy equipment when requiring access to the interior.

Insertion of PCBs

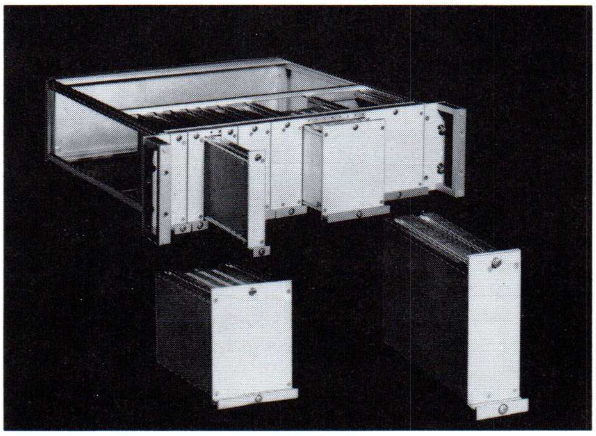
The insertion of PCBs requires but a few standardized accessories (see photo below). The basic format is the 100 mm × 160 mm Eurocard in line with DIN 41 494.

Cassettes

Cassettes for self-contained functional groups are likewise suitable for holding plug-in cards and other subassemblies.



Mainframe with PCBs arranged for ease of maintenance
19″ rackmount with cassettes



R&S compact casing system

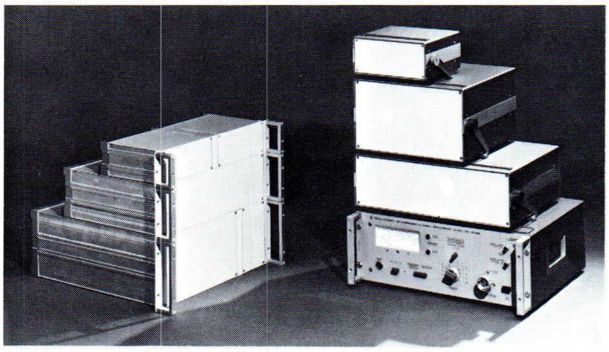
Design 80 is rounded off by a new casing system for small and compact instruments 1/2 or 3/4 or 1/1 of 19" wide (for system compatibility).

This compact casing system copes with the current trend towards complex modules integrating more and more functions in less and less space and complies with the users' requirements for economizing space. on benches and in racks.

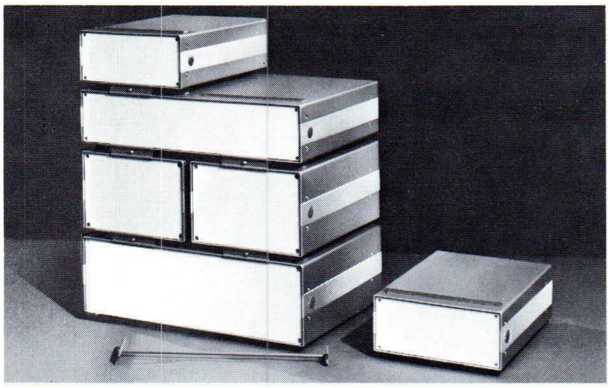
This easily manufactured system is just as much in line with the international 19" standard as design 80, to which it is similar in layout, but is even more compact and thus particularly suitable for space-saving setups on a bench (photo top right).

The emphasis of this new style is on producing compact, light-weight and thus easily transported instruments for use singly and as building blocks in space-saving test setups on the bench.

Right: compact units of 1/2, 3/4 and 1/1 of 19" width stacked on 19" design-70 unit;
left: different compact units adapted for 19" rackmounting



Test assembly made up of compact units, which may be screwed together with connecting elements



The system compatibility of this new packaging style enables simple bench setups of automatic and application-optimized measuring systems, using compact individual components, e.g. units with an IEC-bus interface. The compact casing system reflects the trend towards smaller assembly units; see centre photo.

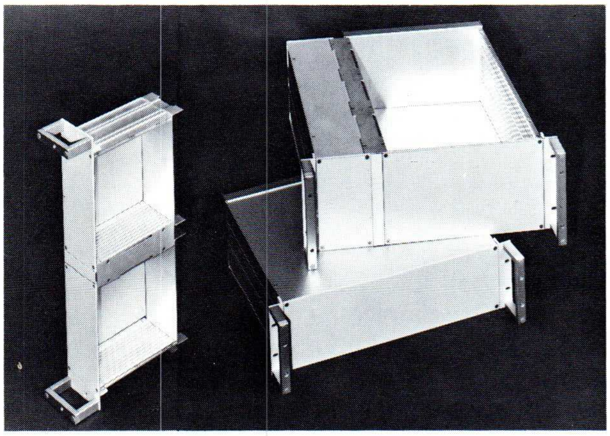
The new compact units can be stacked with 19" design-70 and design-80 units and can be fitted into any 19" rack by means of adapters. The work is easy to do: first the panelling, the handle and the side strips are removed. After fitting a 19" adapter (in the simplest case just two parts) the unit can be pushed into a 19" rack like a 19" instrument built to design 80 (see bottom photo).

The self-supporting construction of the compact cases complies with standards DIN 40 046 (Sheet 8), IEC 68-2-6 and VG 95 332 (Sheet 24/25); it enables sturdy, space-and-weight-saving equipment forms (see photo on page 247). Despite compactness there is no lack of servicing ease. Easily hinged, snap-in/snap-out circuit boards make for good accessibility in testing and servicing.

The swivel handle of the new compact units makes for simple setting down and also serves as a stand. When units are stacked, the handle can be tucked underneath. It is also easily removed by undoing two screws, if this should be desired, for example, in an assembly.

Rear panel. The compact cases also have a recessed rear panel to protect the connectors when the equipment is set down.

Compact cases adapted for 19" rackmounting, with and without cover



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INDEX BY INSTRUMENT TYPE

* Article in the specified issue of house journal NEWS FROM ROHDE & SCHWARZ.

INDEX BY INSTRUMENT TYPE

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INDEX BY INSTRUMENT TYPE

TEST ASSEMBLIES

Test assemblies are generally not allocated a type designation code since they are made up of a number of different instruments.

Although test assemblies can be found by reference to the subject index inside the back cover (e.g. RT test assembly under R), a special alphabetical listing by application area is given here in the interests of clarity and in view of the increasing importance of these rationalized measuring systems.

* Article in the specified issue of house journal NEWS FROM ROHDE & SCHWARZ.

NOTES ON PRESENTATION

Order numbers

In handling orders R&S makes use of electronic data processing and a corresponding system of order numbers. The first seven digits of these **nine-digit numbers** identify the equipment and the last two digits specify the model (50-Ω or 60-Ω impedance, cabinet or rackmount, etc.).

Symbols

The meaning of the symbols used in the tables and texts is given below:

a to b	a is the initial value and b the end value, regardless of whether the intervening range is divided into subranges or not. The range is continuously adjustable between the two values.
a/b/c/d	values a, b, c and d are adjustable in steps
a to b/c/d	short for a to b, a to c, a to d
a/ ... /b	uniform steps, such as decades
↗	this symbol before numbers signifies that these are variable quantities which are dependent on other preset quantities.
I ... II ...	the instrument has various test channels, inputs or outputs, etc.
a (b)	the value in parentheses, which is generally inferior, is only applicable at the limits of the frequency range.
(W × H × D)	overall dimensions: width × height × depth in mm. An additional size code number (e.g. 3B) refers to the rackmount version; for details see page 258.

READER SERVICE

ROHDE & SCHWARZ

Please use the attached reply cards if you would like to receive more information on the products described in this catalog, e.g. data sheets, a detailed quotation or a demonstration.

You will find the address of your nearest R&S representative on pages 262 and 263.

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subject index

this catalog describes

Automated computer-controlled test systems (IEC bus)
Signal generators and AF, RF and RT test assemblies
Swept-frequency test equipment and network testers
Standard-frequency and standard-time systems

Broadband voltmeters, recorders
Power meters, reflectometers

Selective voltmeters
Test receivers and field-strength meters
Wave analyzers and modulation meters

Acoustic test equipment, sound-level meters and noise meters

Test equipment for passive and active components and modules

Radiomonitoring equipment

Load resistors, attenuators
Power supply units

other products

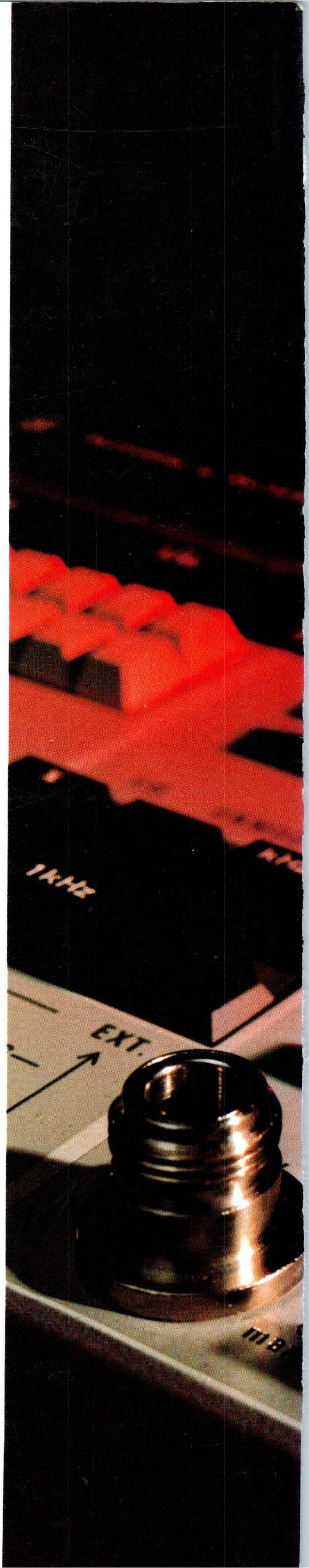
Test equipment for television
and sound broadcasting

Mobile and fixed transmitters, receivers, antennas
for HF, VHF broadcasting and television
of all standards

TV transposers and relay receiving systems

Direction finders, ATC and radiolocation systems
Ground and airborne transceivers
Automated check-out systems

Multicouplers and tuning units
Antenna rotators, remote-control systems



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Printed in the Federal Republic of Germany Subject to change 979 (O)