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Precision telecom and datacom test equipment

Our company

Today, Wandel & Goltermann is recognised worldwide as one of the foremost manufacturers of electronic test equipment for telecommunications and data communications.
The company was founded in 1923 by two engineers, Wolfram Wandel and Ulrich Goltermann. Until the end of the 1940s, the company was involved in installing private radio and telephone systems, but then began concentrating on test equipment.
In 1985, Wandel & Goltermann employed around 2000 people all over the world. The company head office, and the major part of our production and development facilities, are located in Eningen, a small town at the foot of the Swabian Jura, about 50 km south of Stuttgart. Affiliated companies in the USA and Great Britain also have development laboratories and production facilities.



The head office in Eningen

Our market

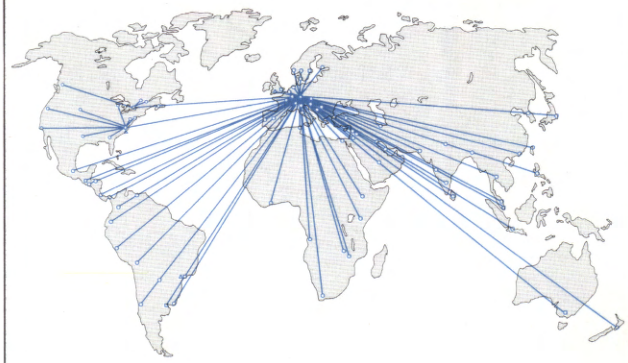
Wandel & Goltermann is among the few companies specialising on the international level in the development and production of state-of-the-art telecom and datacom test equipment. The technical characteristics of our instruments, as listed in the specification sheets, are designed to give many years of excellent everyday service. A large proportion of our production (about 70 %) is exported, and shows how much the high quality of our instruments is appreciated abroad. The major proportion of our turnover was earned with telecom test equipment and test and monitoring systems for analog and digital communications systems. Products for interface testing and data network diagnostics are assuming ever greater importance. Laboratory test equipment makes up a small part of our production.

Worldwide sales organisation

Ten affiliated companies around the world, more than 60 agents and service centres, make up a network which ensures that the customer has easy access to qualified sales and service engineers. You can expect effective advice on any test problems you might have.
The specialists at our head office will be able to help you solve extremely complex or unusual problems. You will find a complete list of addresses on pages 355 to 360.

Research and development

About 250 engineers and technicians are now designing test equipment to cope with the measurement problems of tomorrow. As a matter of course our employees ensure the quality, reliability and servicability of our instruments at the design stage and continually strive to refine production methods and push out the frontiers of technology.



Worldwide sales and service network

Quality assurance

For decades, Wandel & Goltermann products have been noted for their high standards of construction, extreme accuracy and excellent reliability. To ensure long-term quality assurance, a system of QA procedures has been established for the entire company. This system encompasses all activities of the worldwide Wandel & Goltermann group of companies. This, of course, includes development and production as well as sales and service. Our common goal is to please every one of our customers through the consistent quality of our products.

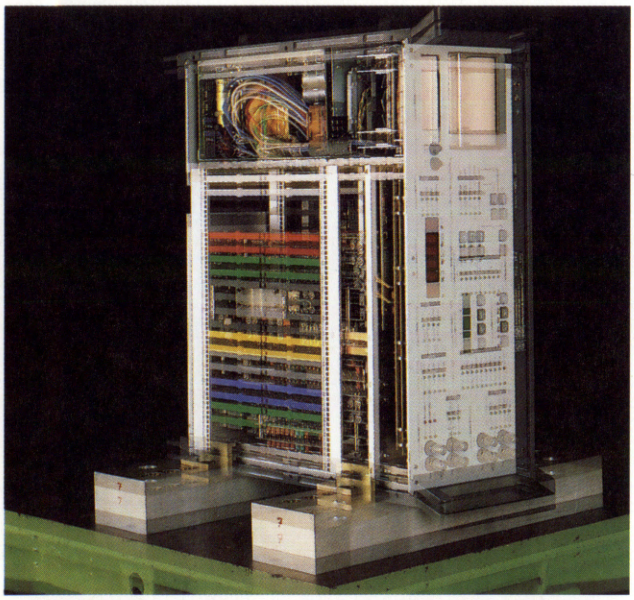
Publication authorised by Reg. Präsidium Stuttgart No. 2/56 769 C.

Customer training

In recent years, the use of the latest technologies has continually increased the number of applications for modern test equipment. Microprocessors give easy and straightforward operation. Test systems continue to gain in importance because of the need to increase productivity and cost effectiveness.
To help you orient yourself in this new field we organise practical courses run by specialists from the appropriate agent or from our head office.
There are two possibilities: an in-house course or a course at our head office. Contact your W & G sales engineer for more information.

Repairs and service

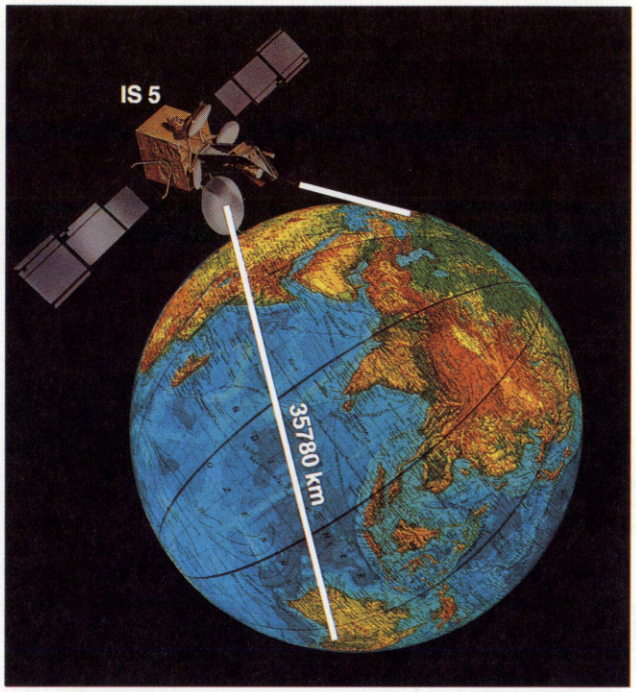
When you purchase W & G equipment you can be sure of a durable, highly reliable top quality product that will not let you down.
Our worldwide service network which is renouned for its efficiency is always ready to help you if you have problems with your equipment, this also applies to our affiliated companies or agents.
They ensure that repairs are carried out by an expert service engineer. However, if the equipment is very complex or has a fault that is difficult to repair, it will be sent to a W & G service centre. Streamlined organisation minimises equipment downtime.
Wandel & Goltermann also organise a variety of specialised and general service courses so that the customer will be able to service equipment himself.



Drop testing unpacked instruments

Test systems

Whenever faster, more accurate and reliable measurements are required, or wherever extensive processing of results must be made, human error can be excluded if a test system is used.
There are many possibilities in the field of telecommunications for which test systems can be used, e.g. in system monitoring, acceptance testing, test departments, etc. This fact was recognised early by Wandel & Goltermann, and so all of the latest generation of test instruments can be remote-controlled. We have a Systems Department, specifically concerned with the projection and development of test systems, including software development.



Automatic line-up between two-earth stations using the SMS test system

The RDS Remote Diagnostic System, developed by Wandel & Goltermann, enables accurate fault diagnosis within minutes, by means of a direct dialogue between the test system and the central service department in Germany, using the public telephone system.
The latest automatic test system by Wandel & Goltermann, the SMS system, can be used to perform complete line-up between two earth stations.

General comments about our products

Our test instruments are developed and manufactured to conform to the relevant national and international standards and regulations, and CCITT and CCIR Recommendations. Conformity with these and other standards, such as the safety regulations VDE 0411 and IEC Publication 348, is indicated in the specification sheet for each instrument.
The specifications are determined according to DIN 43745 or IEC Publication 359, and the operating manuals conform to DIN 43750 or IEC Publication 278.
Many of our test instruments can be supplied as bench versions, or as slide-in modules for 19" rack systems. Conversion can easily be done at a later date. For details, see catalogue section "19" enclosures".

Most of our instruments are fitted with the Versacon® 9 Universal Connector System, which can easily be converted to mate with all of the connector systems commonly used in telecommunications systems (see catalogue section "Versacon® 9).

Guarantee
All Wandel & Goltermann products have a 12 month guarantee. Each W & G instrument is manufactured and tested using stringent quality control and safety standards.
The test and measuring instruments used are all traceable to German standards. Only carefully selected materials and components are used.

Modifications, terms of delivery
We are constantly improving the quality of our instruments, and we therefore reserve the right to make modifications, particularly where these result from improved technology.
The normal guarantee and delivery terms apply, and these will be forwarded on request.

Ordering information
The order numbers of equipment and accessories are identified with the abbreviation "BN". The appropriate information is given at the end of the table of specifications listed for each set.

Wandel & Goltermann, a member of the German Calibration Service

As a member of the German Calibration Service, Wandel & Goltermann operate the DKD 0501 Calibration Laboratory for particular measuring ranges and values.
The calibration laboratory is directly controlled by the PTB (Physikalisch-Technische Bundesanstalt), the state metrological institute for the Federal Republic of Germany. The laboratory is equipped with all the technical instrumentation required for calibration to high accuracy, and it is run by experienced, expert personnel. The standards and standard measuring equipment used are directly traceable to the corresponding German standards, or those of the PTB. The service is strictly impartial. The aim of the DKD 0501 Calibration Laboratory is for all interested persons to make use of its facilities, that is, to calibrate your instruments under controlled conditions to an accuracy directly traceable to national standards.
If you would like more information about the DKD 0501 Calibration Laboratory, please put a cross beside number E 146 on the literature service card in the appendix of this catalogue.

Measurement facilities of calibration laboratory DKD 0501

Measured quantity	Measurement range	Frequency [1]	Measuring uncertainty	Notes
D.C. voltage	0.1 to 10 V		$\pm 1 \cdot 10^{-4}$	
A.C./D.C. conversion	0.22 V [2] 0.27 V [3]	1, 6, 20 kHz	$\pm 3.5 \cdot 10^{-4}$	
	10 V		$\pm 1.5 \cdot 10^{-4}$	
A.C. voltage	0.22 V [2] 0.27 V [3]	1, 6, 20 kHz	$\pm 5 \cdot 10^{-4}$	Coaxial
		200 Hz to 1 MHz	$\pm 6 \cdot 10^{-4}$	
		1 MHz to 5 MHz	$\pm 1 \cdot 10^{-3}$	
		5 MHz to 30 MHz	$\pm 2 \cdot 10^{-3}$	
		30 MHz to 70 MHz	$\pm 3 \cdot 10^{-3}$	
		70 MHz to 200 MHz	$\pm 4 \cdot 10^{-3}$	
		200 MHz to 300 MHz	$\pm 5 \cdot 10^{-3}$	
	10 V	1, 6, 20 kHz	$\pm 2.5 \cdot 10^{-4}$	
A.C. power	1 mW (0 dBm)	1, 6, 20 kHz	$\pm 1.3 \cdot 10^{-3}$	Coaxial Z = 50 Ω Z = 75 Ω
		200 Hz to 150 MHz	$\pm 3.0 \cdot 10^{-3}$	Coaxial Z = 75 Ω
		150 MHz to 250 MHz	$\pm 6.2 \cdot 10^{-3}$	
		250 MHz to 300 MHz	$\pm 1.2 \cdot 10^{-2}$	

1) If a frequency value appears twice (as the upper and lower limit value of a range), the line with the smaller measuring uncertainty is valid.
2) Voltage across 50 Ω when 1 mW (0 dBm) is dissipated.
3) Voltage across 75 Ω when 1 mW (0 dBm) is dissipated.

Wandel & Goltermann electroacoustics

We also supply electroacoustic systems for public transport services, police, fire and rescue services, armed forces, civil defence, industry and commerce. These include electronic siren systems, warning and command systems for deployment vehicles, as well as station announcement systems and passenger information systems. A special catalogue for our electroacoustics products range is available.

About this catalogue

A new edition of this complete catalogue of telecommunications test instruments is published in January every year, which ensures that it is always up-to-date. Our customer information brochure, "bits", is published three times a year. This contains reports on new instruments, improvements, and interesting applications. If you have not yet received a copy of "bits", please use the postcard, found in the appendix of the catalogue, to order your free, personal copy.



At the start of each chapter, there is an overview of the test instruments. To help you locate a particular item, indexes, arranged according to code-name (page 5), and order number (page 10), are provided.
Please note that this catalogue does not show all of the equipment that we can supply. Instruments which are no longer in production are shown only by their code- and order-numbers in the index. In such cases, please use the postcard in the appendix of the catalogue for your enquiry or call our agent. A list of addresses is given on pages 355 to 360.
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9510/..	RAS-2 Remote Access Switch System d.c. to 100 MHz	**115**
9850/..	PJM-1 PCM Jitter Meter	**271**
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6001 to 7000

7001 to ...

Audio and LF Measurement Technology



Overview

Audio and LF Measurement Technology

Level measuring instruments

Frequency range	With generator section	Wideband	Selective	Sweep mode	Noise measurements to CCITT Rec. P. 53	Noise measurements to CCIR Rec. 468-2	Return loss measurements	Impedance measurements	Frequency measurements	D.C. measurements	Battery operation	A.C. line operation	Special features	Name	Page
200 Hz to 6 kHz		•								•	•		For the ED 1000 data communication system; small, hand-held	**PM-928 Level Meter** [1]	26
80 Hz to 20 kHz	•	•									•		With 820 Hz generator section; small, hand-held	**PM-10 Digital Level Meter**	20
30 Hz to 20 kHz		•			•					•	•		Small, hand-held	**PMP-20 Digital Level and Noise Meter**	22
20 Hz to 20 kHz	•	•			• 2)	• 2)			•		•	•	Level measurements to 110 kHz; synthesizer; quantizing dist. measurement	**PMG-3/VF-1 Transmission Measuring Set**	34
20 Hz to 20 kHz	•	•	•	external	•				•			•	VFT applications; tracking generator; tracking filter	**PMG-13 Level Measuring Set**	40
20 Hz to 20 kHz	•	•		•	•	•	•	•	•			•	With digital image storage	**WM-20 AF Sweep Measuring Setup**	37
15 Hz to 20 kHz		•								•	•		Small, hand-held	**PM-20 Digital Level Meter**	22
15 Hz to 20 kHz	•	•		•	•	•	•	•	•		•	•	Speech and monitoring facilities	**PMG-2 AF Measuring Set**	31
30 Hz to 120 kHz	•	•									•		With 820 Hz generator section; small, hand-held	**PM-40 Digital Level Meter**	24
15 Hz to 200 kHz	•	•	•	•	•	•			•			•	For sound recorders; two channel inputs/outputs; digital image storage; <IEC 625>	**NFA-1 Audio Analyzer**	51
15 Hz to 200 kHz	•		•	external								•	Harmonic analysis; 2nd. and 3rd. order harmonic ratios; 2nd. order diff. freq. distortion	**SPM-11 Selective Level Meter** **PSE-11 Generator Section**	43
15 Hz to 20 kHz/ 300 Hz to 200 kHz	For balanced measurements with the SPM-11/PSE-11; AFC for long-term monitoring													**SPMZ-110 Balancing Attachment**	47
15 Hz to 20 kHz/ 300 Hz to 200 kHz	For balanced measurements with the SPM-11/PSE-11; sweep facility; +26 dB output													**SPMZ-111 Balancing Attachment**	47

1) Available as plug-in version PGS-1 on request
2) VF-1 weighting filters to IEEE 743

Level generators

Frequency range	Fixed frequencies	Sine signal	Noise	Sweep mode	Battery operation	A.C. line operation	Special features	Name	Page
200 Hz to 4 kHz	•	•		•	•		Small, hand-held; d.c. loop-holding circuit; ten fixed frequencies	**PS-10 Level Generator**	18
20 Hz to 20 kHz	•				•	•	Small, hand-held; 30 fixed frequencies	**PS-20 Level Generator**	18
0 to 108 kHz			•			•	White noise; pink noise; noise for simulating speech	**RG-1 Noise Generator**	60
Other level generators are built into level measuring setups as generator sections. See the Table "Level measuring instruments".									

Further audio and LF equipment

Characteristics	Name	Page
Frequency setting 16 Hz (1 Hz) to 32 kHz; can be used as a low and high pass filter up to 148 dB/octave; bandpass, bandstop and branching filters, weighting network, delay network	**UN-1 Universal Network and Filter**	56
Sampling rate 4 Hz to 2 MHz; two channels each with 2 K memory; easily adapted to a conventional oscilloscope or XY plotter; data access	**TR-940 Transient Recorder**	62
Facility for setting up telephone line between two measuring sites; a measuring setup is connected to a two-wire line via a two-wire switch-over; integral d.c. loop holding circuit	**SZU-969 Speech Attachment and Two-wire Switch-over**	28
Accommodates three small measuring instruments	**TPK-21 Equipment Carrying Case** [1)]	30

1) Cf: DMS-1 Data Measuring Set for checking the analog and digital transmission characteristics of data circuits, page 212

PS-10, PS-20
Level Generators

Frequency range 200 Hz to 4 kHz or 20 Hz to 20 kHz



- **Signal source for the telephone/voice quality and sound-programme frequency ranges**
- **10 or 30 fixed frequencies**
- **Sweepable voice frequency range (PS-10 only)**
- **Send level of +16 dBm (PS-20)**
- **Level settings in fine steps**
- **Internal batteries (dry or rechargeable) or a.c. adaptor/charger**
- **Battery monitor and warning light**
- **Rugged, shockproof case**
- **Transport case or leather carrying case on request**
- **Complementary digital level meters: PM-20, PM-40 and PMP-20**

Applications

The PS-10 and PS-20 Level Generators were designed as signal sources for measurements on telephone and sound-programme frequency transmission equipment. They are mainly used by postal administrations, railways, oil companies, system manufacturers, utility companies providing energy, and broadcasting companies.
Their low weight, compact form, and the independence from other power sources afford these instruments a special capability for field service where maintenance and operation of AF communication equipment requires mobility for measuring instruments.
In stationary operation, for instance, in laboratories or test departments in factories, the Level Generators can be operated from an a.c. adaptor/charger.

The PS-10 and PS-20 are about the size of a pocket calculator, and can be used with the *PM-20, PM-40* and *PMP-20 Digital Level Meters* to form complete AF Measuring Setups.

Characteristics

The send frequency on the PS-10 and PS-20 is selected from a set of fixed frequencies, the PS-10's send frequency can also be swept. The smallest possible increment in send level is 0.1 dB. Special features of the PS-20 are its +16 dBm send level and the high harmonic ratio of 60 dB.
The PS-10 contains an internal d.c. loop-holding circuit for maintaining the d.c. exchange loop.
A holding circuit, in the form of a plug-in adaptor, can be purchased for the PS-20. The *TPK-21 Equipment Carrying Case* is also available to accommodate up to three small measuring instruments, a.c. adaptor/charger and spare batteries. The batteries will provide power for 80 hours. An LED flashes when the battery voltage is too low and so prevents invalid measurements.

Fixed frequencies, PS-10	10
PS-20	30
Max. send level, PS-10	0 dBm
PS-20 (Z_{out} = 0)	+16 dBm
Output impedances	600 Ω, 0 Ω (≦3 Ω)
Power supply	batteries or a.c. line
Weight	approx. 0.5 kg

Unless otherwise noted, the specified performance characteristics are valid under rated operating conditions

Measuring output

Balanced, floating,
short-circuit proof . . . . . 3 pole CF jack connector

PS-10 contains an internal loop-holding circuit for holding the d.c. exchange loop
Output impedance, selectable
PS-10 . . . . . 600 Ω in series with C = 4.7 µF and 0 Ω (≦3 Ω)
PS-20 . . . . . 600 Ω and 0 Ω (≦3 Ω)
Tolerable holding current (at Z_{out} = 600 Ω)
PS-10 . . . . . ≦60 mA (if Z_{out} = 0 Ω no d.c. permissible)
PS-20 . . . d.c. voltage and d.c. current load not permissible [1]
Tolerable short-term ringing voltage 25 or 50 Hz,
max. 10 s duration, Z_{source} ≧500 Ω,
r.m.s. value . . . . . ≦100 V
Signal balance ratio conforming to CCITT Rec. O.121
at output level ≧− 40 dB . . . . . ≧40 dB
Tolerable d.c. voltage to ground . . . . . ≦100 V

Frequency

Model	PS-10	PS-20
Frequency range	0.2 to 4 kHz	20 Hz to 20 kHz
Fixed frequencies	0.2, 0.3, 0.4, 0.6, 0.8, 1, 1.6, 2.4, 3.4, 4 kHz	20, 30, 40, 50, 75 *), 100, 125, 150, 160, 200 Hz Multiplication factor x1, x10, x100
Error limits of send frequency	at 800 Hz: ±2 % otherwise: ±3 %	f ≦10 kHz: ±2 % otherwise: ±3 %

*) 85 Hz in Version BN 902/02

Sweep capability (PS-10 only)

Sweep range . . . . . 0.2 to 3.5 kHz
Rate of change with time . . . . . exponential
Sweep rate . . . . . sweep-out 2 s, return 2 s

Send level

Signal wave shape . . . . . sinusoidal

Level range	PS-10	PS-20
$Z_{out} = Z_L$ = 600 Ω . .	−59.9 to 0.0 dBm	−59.9 to +10.0 dBm
Z_{out} = 0, Z_L ≧600 Ω	−59.9 to 0.0 dBm	−59.9 to +16.0 dBm

Level setting . . . . . with thumb-wheel switch
smallest increment 0.1 dB

Error limits of send level
at $Z_{out} = Z_L$ = 600 Ω, or at Z_{out} = 0, Z_L ≧600 Ω
f = 700 to 1 100 Hz . . . . . ±0.15 dB
Variation with frequency referred to 1 kHz

	0.02	0.2	0.3	4	20 kHz
PS-10	—	±0.15 dB	±0.1 dB	—	
PS-20	±0.1 dB				

Total error . . . . . ±0.25 dB

Spectral purity of output voltage

at $Z_{out} = Z_L$ = 600 Ω or $Z_{out} = Z_L$ ≧ 600 Ω

Intrinsic harmonic ratio, a_{k_2} and a_{k_3}	PS-10	PS-20
f = 0.2 to 4 kHz	≧40 dB	≧60 dB
f = 40 Hz to 15 kHz	—	≧60 dB
f = 20 Hz to 20 kHz	—	≧55 dB

Suppression of nonharmonic spurious signals
over whole frequency range,
at output levels ≧−40 dBm . . . . . ≧70 dB
≧−59.9 dBm . . . . . ≧50 dB

General Specifications

Power supply
Battery or a.c. power line trickle charging
Dry batteries (supplied with set) . . . . . two 9 V IEC 6 F 22
If required: rechargeable batteries (2 pieces) . . VARTA Tr 7/8

Operating time with intermittent operation at +23°C and Z_L ≧ 600 Ω, V_{out}	≦0 dBm	≦+16 dBm (PS-20)
Dry batteries Mallory MN 1604 . . .	approx. 80 h	approx. 40 h
VARTA	approx. 35 h	approx. 18 h
Rechargeable batteries VARTA Tr 7/8	approx. 15 h	approx. 7 h

Charging time with instrument switched OFF . . . approx. 40 h
Automatic battery cutoff supply after . . . . . approx. 4 min
RFI/EMI suppression . . . . . Class K

Permissible ambient temperature
Rated range of use . . . . . 0 to +50°C
Storage and transport . . . . . −40 to +70°C

Dimensions (w x h x d) in mm . . . . . 98 x 164 x 54

Weight with batteries . . . . . approx. 0.5 kg

Ordering Information

Level Generator PS-10	**BN 904/01**
Level Generator PS-20	**BN 902/01, BN 902/02** [2]
Accessories (at extra cost)	
A.C. adaptor/charger with	
Standard European power plug (193 to 242 V, 47.5 to 63 Hz)	BN 964/00.02
U.S. type power plug (105 to 132 V, 47.5 to 63 Hz)	BN 964/00.03
U.K. type power plug (211 to 264 V, 47.5 to 63 Hz)	BN 964/00.04
mains cable, but without plug (211 to 264 V, 47.5 to 63 Hz)	BN 964/00.05
NiCad batteries (two required)	BN 820/00.50
Carrying strap	BN 820/00.52
Plug-in Adaptor with holding circuit (only for use with the PS-20)	BN 902/00.01
Equipment Carrying Case TPK-21 (holds 3 small measuring instruments)	BN 926/07
Leather Carrying Case for the PS-10 or PS-20	BN 926/09
Leather Carrying Case for the PS-10 or PS-20 and the a.c. adaptor/charger	BN 926/11

1) D.C. loading possible with Plug-in Adaptor BN 902/00.01
2) 85 Hz instead of 75 Hz as fixed frequency

PM-10
Digital Level Meter

for wideband level measurements in the frequency range 80 Hz to 20 kHz



- **Wideband level measurements on telephone and sound-programme channels**
- **Large level range −40 (−50) to +10 dBm**
- **Autoranging**
- **Measurement input is protected against d.c. voltages and calling voltages**
- **Integral 820 Hz generator**
- **Integral NiCad or dry-cell**
- **Facility for monitoring the battery charging state**
- **Handy, robust, shock-proof case**

Applications

The PM-10 Digital Level Meter was designed for operational measurements on telephone and voice-frequency equipment. It will be especially useful to PTTs, railway companies, oil companies, and public utility companies that supply energy.
Signal levels can be measured over a large range, and the integral generator means that loop-back measurements, or measurements on a path that is carrying traffic, can also be carried out. The PM-10 is ideal for use in the field, i.e. maintenance and troubleshooting, as it is a lightweight set with a compact construction, and can be battery-operated.

Characteristics

Level measurements can be carried out rapidly with the PM-10 because it has an autoranging facility and a large, easy-to-read, digital display which gives the correct sign. The resolution of the level display is 0.1 dB. One of two fixed levels, (−10 and −27 dBm) output by the internal generators can be selected by means of a switch. Both signals have a frequency of 820 Hz.

Special versions, which have levels and frequencies differing from those previously mentioned, can also be ordered. The level meter is accommodated in a robust housing that can easily cope with the rough treatment an instrument for troubleshooting will get.
The PM-10 can be powered from normal dry batteries, or, if required, from rechargeable NiCads. An automatic battery cut-off circuit ensures the dry cells are used in the most efficient way possible. The PM-10 switches itself off automatically when the battery voltage drops below a certain threshold to prevent the operator from making incorrect measurements.

Level measurements	−50 to +10 dBm
Input, balanced	600 Ω and approx. 100 kΩ
Send signal,	
Frequency	820 Hz
Levels	−10 or −27 dBm
Output, balanced	600 Ω
Power supply	dry battery or NiCad

Specifications of the Digital Level Meter — PM-10

If nothing to the contrary is stated the specifications are valid for the rated ranges of use immediately after switch-on.

Measurement input

Balanced, floating . . . . . 3 pole CF connector
Input impedance,
switch-selectable (in series with 10 µF) . . . . 600 Ω ±0.5 %
or (in series with 0.2 µF) . . . . . approx. 100 kΩ ‖ 100 pF
Signal balance ratio complying
with CCITT Rec. O.121 . . . . . ≧46 dB
Permissible d.c. voltage at input . . . . . ≦100 V
Permissible ringing voltage, 25 or 50 Hz, and superimposed
d.c. voltage, max. duration 10 s, peak value . . . V_p ≦ ± 135 V
Permissible d.c. voltage to ground . . . . . ≦100 V

Level measurements

Frequency range . . . . . 80 Hz to 20 kHz

Autoranging . . . . . −50 to +10 dBm
Level display . . . . . 3 digits and sign
Resolution . . . . . 0.1 dB

Error limits
Error limits on the level display including frequency response,
digital errors, and matching errors, over the frequency range
200 Hz to 4 kHz
Range −40 to +10 dBm . . . . . ±0.25 dB
Range −50 to −40 dBm . . . . . ±0.4 dB
Additional error for the frequency ranges 80 Hz to 200 Hz
and 4 kHz to 20 kHz . . . . . approx. ±0.5 dB

Integral generator

Output . . . . . balanced, floating
Connector . . . . . 3 pole CF connector
Output impedance (in series with 3.3 µF) . . . . 600 Ω ±0.5 %
Signal balance ratio at the send frequency complying
with CCITT Rec. O.121 . . . . . ≧46 dB

Permissible d.c. voltage at output . . . . . ≦100 V
Permissible ringing voltage, 25 or 50 Hz, and superimposed
d.c. voltage, max. duration 10 s, peak value . . . V_p ≦ ± 135 V
Permissible d.c. voltage to ground . . . . . ≦100 V

Send frequency . . . . . 820 Hz [1] ±1 %

Send level, switch-selectable . . . . . −10 or −27 dBm [1]
Error limits . . . . . ±0.1 dB
Harmonic ratios a_{k_2}, a_{k_3}, 600 Ω load . . . . . ≧40 dB

General specifications

Power supply
Integral, dry battery
or rechargeable NiCad (on request) . . . . . 9 V IEC 6 F 22
Recommended type of dry battery . . . . MALLORY MN 1604
or VARTA 438

Recommended type of NiCad,
rechargeable . . . . . VARTA Tr 7/8

Separate charger for charging the NiCad
Rated range of use of the mains voltage . . . . . 198 to 242 V
Rated range of use of the mains frequency . . . . 45 to 60 Hz

Operating time, continuous
dry battery, depends on type . . . . . up to 100 h
NiCad . . . . . approx. 20 h
PM-10 automatically switches off power supply
after about 5 min.

Permissible ambient temperature
Rated range of use . . . . . 0 to +50°C
Storage and transportation . . . . . −20 to +60°C

Additional rated ranges of use
Battery voltage . . . . . 6 to 9.5 V
Receive frequency . . . . . 200 Hz to 4 kHz
Impedance . . . . . high impedance (bridging)
or Z_o = 600 Ω
Operating modes . . . . . balanced or coaxial

Dimensions (w x h x d) in mm . . . . . 90 x 160 x 42

Weight with battery . . . . . 0.5 kg

Ordering Information

Digital Level Meter PM-10 — **BN 820/..**
Z_o = 600 Ω

Send frequency	Send level	Order number
820 Hz	−27 and −10 dBm	BN 820/01 *)
820 Hz	−27 and 0 dBm	BN 820/09
820 Hz	−10 and 0 dBm	BN 820/11
800 Hz	−27 and −10 dBm	BN 820/30
800 Hz	−27 and 0 dBm	BN 820/44
1010 Hz	−16 and 0 dBm	BN 820/55

*) Standard version

Accessories (at extra cost):

NiCad	BN 820/00.50
Charger 521	BN 820/00.51
Carrying strap	BN 820/00.52
Leather case for PM-10	BN 926/09
for PM-10 and charger	BN 926/11

1) Values for standard version

PM-20, PMP-20
Digital Level Meters

for level and noise measurements in the frequency range (15) 30 Hz to 20 kHz



- **Level measurements on telephone and sound-programme channels**
- **Noise measurements on telephone channels with weighting filter conforming to CCITT Rec. P. 53 (PMP-20)**
- **True r.m.s. detector**
- **Autoranging**
- **Digital display of result with correct sign**
- **D.C. voltage measurements 0 to 100 V**
- **Internal dry battery or rechargeable NiCad**
- **Battery monitor and warning light**
- **Robust, shockproof housing**
- **Case or leather carrying pouch on request**

Applications

The PM-20 and PMP-20 Digital Level Meters have been designed for operational measurements on telephone and sound-programme transmission equipment and are particularly useful to postal administrations, railways, oil companies, utility companies that deliver energy, and broadcasting organisations. The PM-20 and PMP-20 both measure signal levels and d.c. voltages. The PMP-20 can be used to measure weighted and unweighted noise levels as well.

As the PM-20 and PMP-20 are light, robust, and can be operated from their own internal power supplies, they are particularly useful for carrying out maintenance and troubleshooting in the field.

Measurements on 150 Ω and 300 Ω test items can be carried out using the Plug-in Adaptor (BN 876/00.01) which is available as an accessory.

The PM-20 and the PMP-20 are about the size of a pocket calculator and are, therefore, very handy to use.

Combining the PM-20 and PMP-20 with the *PS-10* and *PS-20 Level Generators* produces a complete AF Level Measuring Setup.

Characteristics

Because of their autoranging capability and large digital displays, which always give the correct sign, the PM-20 and PMP-20 make measurements fast and easy. Levels up to +30 dBm can be measured with the PM-20, levels of this magnitude could be found, for example, at audio engineers' consoles in radio studios.

The special feature of the PMP-20 is that it weights a noise measurement according to the frequency response curve specified in CCITT Recommendation P. 53. A true r.m.s. detector correctly weights the measured noise.

A calibration facility has been provided for accurate absolute measurements.

Both instruments can be used on subscriber lines with a d.c. holding loop.

The *TPK-21 Equipment Carrying Case* will hold up to three small measuring instruments, their a.c. adaptor/chargers and spare batteries. This Case will be delivered on request.

An automatic cutoff circuit ensures that no power is wasted when the instruments are operated on batteries, in fact, the PMP-20 and the PM-20 will work for 70 hours on dry cells (MALLORY MN 1604). An alarm light shows when the battery voltage is too low and so prevents invalid results.

Level range, PM-20	−50 to +30 dBm
PMP-20	−70 to +10 dBm
Resolution of level display	0.1 dB
Input impedance	600 Ω, 100 kΩ
Permissible d.c. current load (Z_{in} = 600 Ω)	≦60 mA
Power supply	dry cell or rechargeable battery
Weight	approx. 0.5 kg

Specifications of Digital Level Meter — PM-20/PMP-20

Unless otherwise are stated, the specified data are valid under rated conditions of the influence quantities.

Level measurement

	PM-20	PMP-20
Frequency range	15 Hz to 20 kHz	30 Hz to 20 kHz
Frequency band limiting (3 dB limits)	8 Hz to 38 kHz	15 Hz to 38 kHz
Level measuring range (autoranging)	−50 to +30 dBm [1]	−70 to +10 dBm

Level display, with correct sign, resolution . . . . . 0.1 dB

Error limits
Error limits of level reading after calibration including variation with frequency, digital error, error caused by intrinsic noise and error caused by reflection when matched at $Z_{source} = Z_{in} = 600\ \Omega$

PM-20:

Frequency range	Level range	Ambient temperature	Error limits
700 Hz to 1100 Hz	−11 to +5 dBm −50 to +30 dBm	(23 ±10) °C 0 to +50°C	±0.15 dB ±0.2 dB
200 Hz to 4 kHz	−50 to +30 dBm	0 to +50°C	±0.25 dB
40 Hz to 16 kHz			±0.35 dB
15 Hz to 20 kHz			±0.5 dB

PMP-20:

Frequency range	Level range	Ambient temperature	Error limits
700 Hz to 1100 Hz	−11 to +5 dBm −70 to +10 dBm	(23 ±10) °C 0 to +50°C	±0.15 dB ±0.2 dB
200 Hz to 4 kHz	−70 to +10 dBm	0 to +50°C	±0.25 dB
40 Hz to 16 kHz			±0.35 dB
30 Hz to 20 kHz			±0.5 dB

Intrinsic noise, PM-20 . . . . . approx. −75 dBm
PMP-20 . . . . . approx. −95 dBm

Noise measurement (only PMP-20)
Weighted noise measurement
Variation of level
with frequency . . . . . conforms to CCITT Rec. P. 53 A
Detector . . . . . true r.m.s.
Level measuring range (input level),
with white noise . . . . . −85 to +10 dBm
with discrete frequencies . . . . . −85 to 0 dBm
Resolution . . . . . 0.1 dB

Error limits of level reading at 800 Hz after calibration including digital error, error caused by reflection when matched $Z_{source} = Z_{in} = 600\ \Omega$, and error due to intrinsic noise, level display −75 to +10 dBm . . . . . ±0.5 dB

D.C. voltage measurement

Measuring range . . . . . 0 to ±100 V
Error limits of display,
at (23 ±10) °C . . . . . ±0.5 % of reading ±0.1 V
at 0 to +50°C . . . . . ±1 % of reading ±0.1 V

Measurement inputs

Input for level and noise measurement
(only PMP-20) . . . . balanced, floating, 3 pole CF connector
Input impedance, switchable . . . 600 Ω ± 0.5 % and 100 kΩ
Return loss at 800 Hz, $Z_{in} = 600\ \Omega$ . . . . . ≧40 dB

Signal balance ratio
measurement mode "Level Measurement" conforming to CCITT O.121
(PM-20: $V_{in} < +6$ dBm, PMP-20: f < 4 kHz) . . . . . ≧40 dB
(only PMP-20) . . . . . conforms to CCITT P. 53 A

Tolerable d.c. current load at $Z_{in} = 600\ \Omega$ . . . . . ≦60 mA
Tolerable applied d.c. voltage at $Z_{in} = 100\ k\Omega$ . . . . . ≦100 V

Tolerable short term ringing voltages 25 Hz or 50 Hz,
max. 10 s duration, $Z_{source} \geqq 500\ \Omega$, r.m.s. value . . . . ≦100 V
Tolerable d.c. voltage to ground . . . . . ≦100 V

Input for d.c. voltage measurement . . . . . floating, 2 banana jacks
Input impedance . . . . . 1 MΩ
Tolerable d.c. or a.c. voltage (50 Hz, r.m.s. value) . . . ≦100 V
Tolerable d.c. or a.c. voltage to ground . . . . . ≦100 V

General Specifications

Power supply
Internal dry battery . . . . . 9 V IEC 6 F 11
or NiCad rechargeable battery on request
Separate charger (198 to 242 V, 45 to 60 Hz) for the PM-20 and PMP-20, BN 876/01
RFI/EMI suppression . . . . degree of suppression, Class K

Tolerable ambient temperature
Rated range of use . . . . . 0 to +50 °C
Storage and transportation . . . . . −20 to +60 °C

Dimensions (w×h×d) in mm . . . . . 98×164×54

Weight with battery . . . . . approx. 0.5 kg

Ordering Information

Digital Level Meter PM-20	**BN 881/01**
Digital Level and Noise Meter PMP-20	**BN 876/01** **BN 876/04** [2]
Accessories (at extra cost)	
NiCad rechargeable battery	BN 820/00.50
Charger (for PM-20 and PMP-20, BN 876/01)	BN 820/00.51
A.C. adaptor/charger (for PMP-20 BN 876/04) with	
Standard European power plug (193 to 242 V, 47.5 to 63 Hz)	BN 964/00.02
U.S. type power plug (105 to 132 V, 47.5 to 63 Hz)	BN 964/00.03
U.K. type power plug (211 to 264 V, 47.5 to 63 Hz)	BN 964/00.04
mains cable, but without plug (211 to 264 V, 47.5 to 63 Hz)	BN 964/00.05
Carrying strap	BN 820/00.52
Plug-in Adaptor 150/300 Ω	BN 876/00.01
Equipment Carrying Case TPK-21 for 3 small measuring instruments	BN 926/07
Leather carrying pouch for PM-20 or PMP-20,	BN 926/09
for PM-20 or PMP-20 and charger or a.c. adaptor/charger	BN 926/11

1) in frequency range, 200 Hz to 4 kHz: −65 to +30 dBm
2) like version BN 876/01 but with connection for a.c. adaptor/charger

PM-40
Digital Level Meter

for wideband measurements in the frequency range 30 Hz to 120 kHz



- **Wideband level measurements on voice-grade and sound-programme channels, and also at basic group level**
- **Large frequency and level range**
- **True r.m.s. detector**
- **Autoranging**
- **Selectable input impedance**
- **Measurement input protected against d.c. voltages, and ringing voltages**
- **Built-in 820 Hz generator**
- **Built-in NiCad or dry battery**
- **Charging condition of the battery is monitored**
- **Robust, shockproof casing**

Applications

The PM-40 Digital Level Meter has been designed for operational measurements on voice-grade and sound-programme channel systems. The PM-40 is particularly useful to postal administrations, railways, oil companies and public utility companies that provide energy. Because of the PM-40's large frequency range it is possible to measure the power levels of basic groups. Measurements on transmission paths that are not in use, or loop-back measurements, can be carried out using the built-in generator. As it is light, robust, and does not need an a.c. line power point to run on, the PM-40 is ideal for maintenance and troubleshooting in the field.

Characteristics

Signal levels can be measured quickly and easily using the PM-40 because it has an autoranging facility and a large digital display which always gives the correct sign. Four different input impedances can be selected so that the measuring input can be matched to various test ports. An r.m.s. detector and a built-in calibration source ensure a high measurement accuracy. It is impossible to make invalid measurements as the PM-40 switches off automatically when the battery voltage drops below a certain value. The charging condition of the battery is also monitored. Depending on the type of battery used, it is possible to run the PM-40 for up to 70 h.

Level range	−60 to +10 dBm
Level display resolution	0.1 dB
Measuring accuracy at 800 Hz, (23 ± 10) °C	± 0.2 dB
Input impedance, balanced	75, 150, 600 Ω, high impedance
Send signal,	
Frequency	820 Hz
Level	−10 dBm
Output, balanced	600 Ω
Power supply	dry or rechargeable battery

Specifications of the Digital Level Meter — PM-40

If nothing to the contrary is stated, the specified data is valid under the rated operating conditions for the influence quantities immediately after switch-on.

Measurement input

Balanced, floating . . . . . 3 pin CF connector
Input impedance, selectable . . . . . 75, 150, 600 Ω, high impedance
Return loss at 800 Hz, input terminated . . . . . ≧ 40 dB
Signal balance ratio complying with CCITT Rec. O.121, at 20 kHz . . . . . ≧ 40 dB
Tapping loss with high impedance termination . . . . ≦ 0.1 dB
Tolerable d.c. voltage, Z_{in} = 600 Ω . . . . . ≦ 50 V
Z_{in} high impedance . . . . . ≦ 60 V

Permissible voltage to earth (0 to 50 Hz)
D.C. or r.m.s. . . . . ≦ 60 V
Measurement input is protected against ringing voltages of short duration

Level measurements

Frequency range . . . . . 30 Hz to 120 kHz

Level measuring range (autoranging) . . . . . −60 to +10 dBm

Level display, 3 digits with correct sign
Resolution . . . . . 0.1 dB

Error limits of level display for the level range −60 to +10 dBm

	(23 ± 10) °C	0 to +50 °C
Error at 800 Hz, after calibration	± 0.2 dB	± 0.3 dB
Frequency range, referred to 800 Hz		
in the range 30 Hz to 50 kHz	± 0.2 dB	+0.2/−0.4 dB
in the range 30 Hz to 120 kHz	± 0.3 dB	+0.3/−0.5 B

Integral send section

Output . . . . . balanced, floating
Connector . . . . . 3 pin CF connector
Output impedance . . . . . 600 Ω
Return loss . . . . . ≧ 40 dB
Signal balance ratio as per CCITT O.121 . . . . . ≧ 40 dB

Send frequency . . . . . 820 Hz ± 2 %

Send level . . . . . −10 dBm
Error limits . . . . . ± 0.2 dB

Harmonic ratio a_{k_2}, a_{k_3}, 600 Ω load . . . . . ≧ 40 dB

General Specifications

Power supply
Internal, replaceable dry battery . . . . . 9 V IEC 6 F 22
or rechargeable NiCad battery (on request)
Recommended dry battery type . . . . . MALLORY MN 1604 or VARTA 438
Recommended NiCad type, rechargeable . . . . . VARTA Tr 7/8
Separate A.C. adapter/charger for NiCad battery

Operating time for intermittent operation at +23 °C
MALLORY MN 1604 dry battery . . . . . approx. 70 h
VARTA 438 dry battery . . . . . approx. 30 h
VARTA Tr 7/8 NiCad . . . . . approx. 20 h
The PM-40 switches off automatically after 4 min
RFI/EMI suppression . . . . . Class k

Permissible ambient temperature
Rated range of use . . . . . 0 to +50 °C
Storage and transportation . . . . . −20 to +60 °C

Dimensions (wxhxd) in mm . . . . . 98 x 164 x 54

Weight, with batteries . . . . . approx. 0.7 kg

Ordering Information

Digital Level Meter PM-40	**BN 4508/01**
Accessories (at extra cost)	
NiCad battery	BN 820/00.50
A.C. adapter/charger [1] with	
Standard European power plug (193 to 242 V, 47.5 to 63 Hz)	BN 964/00.02
US power plug (105 to 132 V, 47.5 to 63 Hz)	BN 964/00.03
UK power plug (211 to 264 V, 47.5 to 63 Hz)	BN 964/00.04
Mains cable, but without plug (211 to 264 V, 47.5 to 63 Hz)	BN 964/00.05
Carrying Strap	BN 820/00.52
Leather Carrying Pouch	
for the PM-40	BN 926/09
for the PM-40 and charger	BN 926/11

1) The PM-40 cannot be operated using the mains adaptor

PM-928
Level Meter

for level measurements on data communication equipment Type ED 1000



- **Wideband level measurements on telephone channels in frequency range 200 Hz to 6 kHz**
- **Switch selectable filters for separate level measurements of the dual signal frequencies employed in the data communication system ED 1000**
- **D.C. measurements on telephone circuits at 0 to 60 V**
- **Digital display of results with correct sign**
- **Power supplied from internal dry battery or rechargeable NiCad**
- **Hand-held rugged, shock-proof case**

Applications

The Wideband Level Meter PM-928 was designed for level measurements on data communication equipment Type ED 1000. The ED 1000 System is used in networks set-up for telegraphy and for dial-up data lines carrying communications by binary signals. The d.c. signals are converted to audio frequency signals for transmission between the subscriber's side and exchanges and in reversed directions. The equipment operates with two separate frequency modulated signals (go and return) transmitted over two wires, but with one signal conveyed in each direction. This technique, therefore, permits full duplex operation.
Besides the capability for wideband level measurements in frequency range 200 Hz to 6 kHz, the switch selectable filters (500 to 700 Hz or 2.25 to 3.15 kHz) allow separate level measurements of the dual signal frequencies in the two directions. The PM-928 also performs d.c. measurements in range 0 to 60 V.

Characteristics

The PM-928 has separate inputs for level and d.c. voltage measurements. It operates with autoranging and has a large 3 digital display with correct sign. Calibration is implemented by depression of a push-button along with a screwdriver slot adjustment to the displayed value of "00.0".
The Level Meter is constructed in a rugged shock-proof case and is most suitable for coping with the rough handling it takes while being used on telephone circuits in the field. It operates independent from a.c. power and is powered by either an internal dry battery or a rechargeable NiCad.

Level Measurement	−50 to +10 dBm
Resolution	0.1 dB
Frequency range	
Wideband	200 Hz to 6 kHz
Filter I	500 to 700 Hz
Filter II	2250 to 3150 Hz
Input impedance	600 Ω, bridging (high impedance)
D.C. voltage measurement	0 to ± 60 V
Resolution	0.1 V
Input impedance	200 kΩ
Weight	approx. 0.5 kg

The PM-928 is switched ON and OFF by a push-button switch, but to improve battery life an automatic switch cuts off the current supply after about 4 min. of operation. This extends operational life of the internal dry battery.
Battery voltage condition is continuously monitored by a special circuit. The letters "BAT" appear in the display to show that about two hours of operating time are still possible. And when the battery voltage drops lower, the PM-928 switches itself off to prevent erroneous readings.
After this automatic switch-off, the PM-928 does not allow switch-on, so the battery must be changed or else the NiCad needs rechargeing.

Specifications of Level Meter — PM-928

Unless otherwise noted, the specified data is valid under rated conditions of use of the influence quantities.

Level measurement

Measurement input . . . . . balanced, floating 3 pole CF jack
Input impedance, switchable . . . . . 600 Ω, bridging
Tapping loss at $Z_{source} \leq 300\ \Omega$, Z_{in} = bridging . . . . . ≦ 0.1 dB
Receiver signal balance ratio to CCITT O.121 . . . . ≧ 35 dB
Tolerable d.c. voltage load at
Z_{in} = bridging . . . . . ≦ 60 V
Z_{in} = 600 Ω . . . . . ≦ 30 V
Tolerable d.c. voltage to ground . . . . . ≦ 60 V

Frequency range, switch selectable
Wideband . . . . . 200 Hz to 6 kHz
Filter I . . . . . 500 Hz to 700 Hz
Filter II . . . . . 2250 Hz to 3150 Hz

Level
(autoranging) . . . . . −50 to +10 dBm

Level display . . . . . 3 digit with correct sign
Resolution . . . . . 0.1 dB

Calibration by potentiometer with slotted shaft
Nominal display 00.0 dBm

Error limits of level reading
(including digital error, error caused by intrinsic noise and error due to input impedance when fed at $Z_{source} = Z_{in} = 600\ \Omega$)
in wideband position (200 Hz to 6 kHz) . . . . . ± 0.25 dB
in filter I position (at f = 500 Hz or 700 Hz) . . . . . ± 0.5 dB
in filter II position (at f = 2250 Hz or 3150 Hz) . . . ± 0.5 dB

Filter's attenuation curve in stop-band
Filter I: band-stop attenuation referred to f = 500 Hz or 700 Hz at
f ≦ 50 Hz . . . . . > 20 dB
f ≦ 150 Hz . . . . . > 1 dB
f ≦ 250 Hz . . . . . > 1 dB
f = 2250 or 3150 Hz . . . . . > 40 dB
Filter II: band-stop attenuation referred to f = 2250 or 3150 Hz at
f ≦ 800 Hz . . . . . > 35 dB
f = 500 Hz or 700 Hz . . . . . > 40 dB

Detector rectifier . . . . . true r.m.s. detection

D.C. Voltage measurement

Input connector . . . . . floating two pole banana jack
Input impedance . . . . . 200 kΩ

Measuring range . . . . . 0 to ± 60 V
Display . . . . . 3 digit, correct sign
Resolution . . . . . 0.1 V
Error limits of display . . . . . 1 % of reading ± 0.1 V
Tolerable d.c. voltage . . . . . ≦ 60 V
Tolerable a.c. voltage (r.m.s. value) . . . . . ≦ 60 V
Impulsive overload capability . . . . . 2 times
Tolerable d.c. voltage to ground . . . . . ≦ 60 V

General Specifications

Power supply
Internal, replaceable
dry battery . . . . . 9 V/IEC 6 F 22
or NiCad . . . . . e.g. Varta Tr 7/8
Rated range of use of battery voltage . . . . . 7 to 9.5 V
Current drain . . . . . approx. 6 mA
Operating times with intermittent operation and at +23°C
Mallory MN 1604 . . . . . approx. 70 hours
Varta 438 . . . . . approx. 30 hours
NiCad Tr 7/8 . . . . . approx. 20 hours
Automatic switch-off of power supply after approx. 4 minutes.
Separate battery charger for NiCad, BN 820/00.51,
for 198 to 242 V a.c. line voltage/45 to 60 Hz a.c. line frequency

RFI/EMI suppression . . . . degree of suppression, class K

Tolerable ambient temperature
Rated range of use . . . . . 0 to +50°C
Storage and transport range . . . . . −20 to +60°C

Dimensions (wxhxd) in mm . . . . . 97.5 x 54 x 164

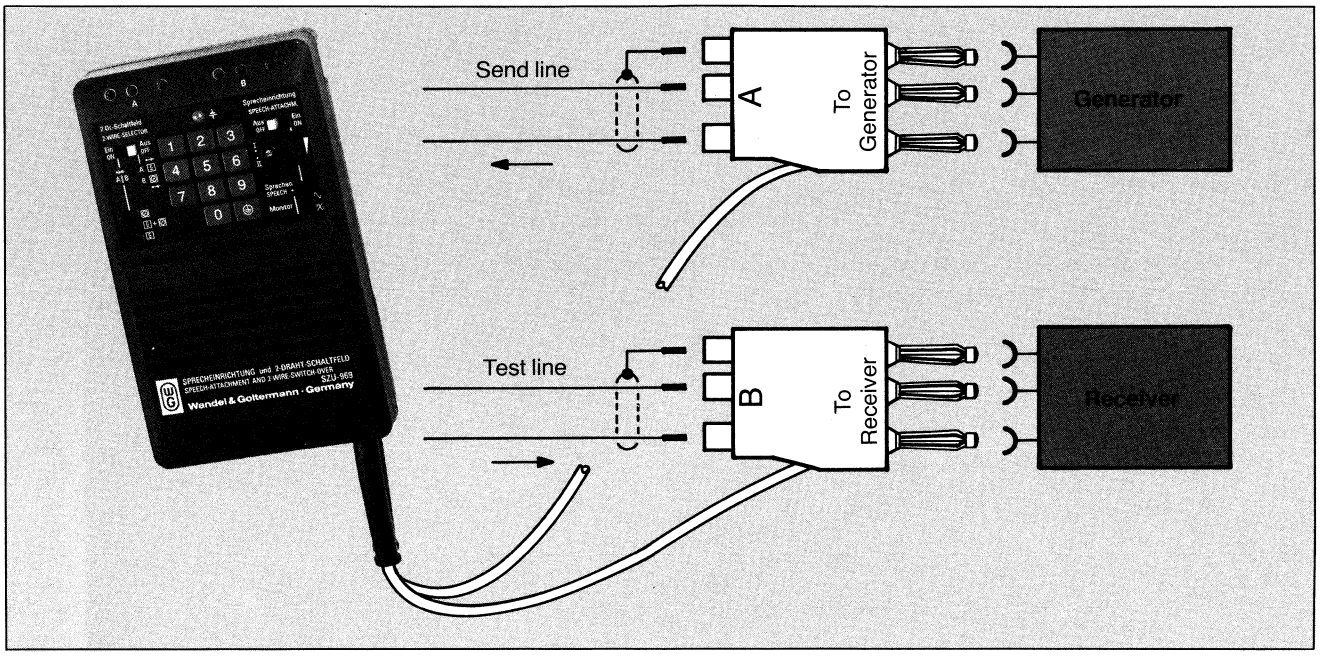
Weight with battery . . . . . approx. 500 grams

Ordering Information

Level Meter PM-928	**BN 928/01**
Accessories (at extra cost)	
NiCad rechargeable battery	BN 820/00.50
Battery charger	BN 820/00.51
Carrying strap	BN 820/00.52
Leather case with space for PM-928	BN 926/09
Leather case with space for PM-928 and battery charger	BN 926/11
Plug-in adaptor 150/300 Ω	BN 876/00.01

SZU-969
Speech Attachment and Two-wire Switch-over

for telephonic connection between measuring sites via the test channel



- **Establishes an intercommunications circuit between measurement personnel at access ports of a test channel**
- **Application in conjunction with all AF measuring devices (e.g. level measuring sets, AF sweep measuring sets, data circuit measuring equipments)**
- **For talking with the opposite site while measuring**
- **For listening to the test signal**
- **Operates as telephone handset with dial-up facility**
- **Switch-selectable connection of level meter or level generator to a 2-wire line, without replugging for access**

Applications

When end-to-end measurements are implemented on AF transmission equipment, an intercommunications connection between the craftspersonnel stationed at each end is a necessary prerequisite for any effective measurement. Frequently this type of circuit is available only via the test circuit itself while measurements are being made.
This problem is solved by the SZU-969 Speech Attachment and Two-wire Switch-over in conjunction with an AF Measuring Setup, e.g. *Level Generators PS-10/PS-20* and *Digital Level Meters PMP-20/PM-20, A.F. Sweep Measuring Setup WM-20* or *Data Circuit Test Sets DLM-3/4* or *DLM-20.*
The SZU-969 is used on either 4-wire lines or 2-wire lines and on d.c. current-holding exchange loops.
Two connector-adaptors permit the SZU-969 to be inserted between the measuring equipment and the measuring leads. These adaptors contain switching devices that allow the connection and disconnection of the measuring leads from the measuring equipment. By this means the SZU-969 can be operated as a Speech/Monitor device or, via the 2-Wire Switch-over, the generator or the receiver can be selected for connection to the test leads. As a result, operation on 2-wire lines does not require replugging when modes are changed over.

Characteristics

The Speech Attachment can be operated, as selected, either as a telephone handset or deskset (Operating modes I/II). Loudspeaker and microphone are integral to the SZU-969. Volume is adjustable.
When the Speech Attachment is switched ON and the function selector switch is placed at SPEECH, normal intercommunications with the opposite site are possible. In position "MONITOR without Test Tone Suppression" the loudspeaker serves for aural assessment of the received test voltage. And not only the send signal from the opposite end can be monitored, but

Handset telephone functions:
– Talking and listening
– Monitoring
– Speech detection switch
Deskset telephone functions:
– Talking, listening, and dialling-up a circuit
– Monitoring
– Speech detection switch
2-wire switch-over:
– 2-wire send
– 2-wire receive
– 2-wire send/receive

also other typical signals like random circuit noise, signalling noise etc. can be listened to. In switch position "MONITOR with Test Tone Suppression" the test tone is suppressed because it is disturbing to the operator. A speech detection circuit switches in the loudspeaker immediately when the receive signal has the characteristics of a speech signal, so that the user can always be contacted.
If the SZU-969 is switched to desksset telephone mode, then any incoming signalling tone produces a call tone in the loudspeaker: switching ON the SPEECH ATTACHMENT corresponds to lifting the receiver at a telephone set. The keypad is used for dialling-up a subscriber, if operating through a d.c. exchange loop.
With the 2-WIRE SELECTOR switched ON, the A and B pairs jacks on the SZU-969 and the connector-adaptors are connected in parallel. Then the function selector switch permits the Two-wire Switch-over to be controlled in a way that either the Generator or the Receiver, or both, are simultaneously connected to the 2-wire line plugged into jacks A or B.
When the SZU-969 is operated on a 4-wire line, the 2-WIRE SELECTOR remains switched OFF. If the battery is in a discharged condition, the SZU-969 automatically assumes this operating state.
This small hand-sized instrument can be operated either with dry batteries or rechargeable NiCads.
A flashing green LED shows that the SZU-969 is ready for operation. When the colour of the LED changes to red this means that the batteries are almost flat. The SZU-969 can be driven from the a.c. line via the a.c. adaptor/charger if the rechargeable batteries are in place.

Specifications of the Speech Attachment and Two-wire Switch-over SZU-969

Speech Attachment . . . . . switch selectable

Handset telephone function ("I") . . . . . talk and listen, monitoring while measurement is being performed, ready to respond to speech while measurement is being performed (suppressed test tone)

Deskset telephone function ("II")

"Off-hook" mode
(Speech Attachment ON) . . . . . talk and listen, dial-up, monitoring while measuring, ready to respond while measurement is being performed (suppressed test tone)

"Hung-up" mode
(Speech Attachment OFF) . . . ready to receive incoming call

Line termination (in SPEECH position) . . . . . 600 Ω
Volume . . . . . adjustable

2-Wire Switch-over . . . . . switch selectable

2-WIRE SELECTOR, ON
controlling of measurement functions:
- 2-wire line connected to generator
- 2-wire line connected to generator and receiver
- 2-wire line connected to receiver

2-WIRE SELECTOR, OFF . . . . . measuring function corresponds to 4-Wire operation

Connector Adaptors
Signal level
Version BN 969/01 (Exchange voltage 60 V) . . ≦+10 dBm
Version BN 969/02 (Exchange voltage ≧36 V) . . . ≦0 dBm
Resistance between a and b conductors
(MONITOR, position "I") . . . . . ≧400 kΩ
Capacitance between a and b conductors
2-WIRE SELECTOR, OFF . . . . . ≦150 pF
2-WIRE SELECTOR, ON . . . . . ≦300 pF

Signal balance ratio according to CCITT Rec. O.121
(combined with an ideal generator or receiver) . . . ≧60 dB [1)]

Voltage between a and b conductors . . . . . ≦190 V
(signalling voltage, V_{rms} = 90 V superimposed on d.c. exchange voltage)

Voltage a-, b-conductor to earth . . . . . ≦100 V
Loop-holding current . . . . . ≦100 mA

A Colour Brochure is available on request

General Specifications

Power supply
Battery operated . . . . . 2x7.2 V NiCad sintered electrode rechargeable batteries (e.g. Sanyo 6N-75 P) or 2x9 V dry batteries (IEC 6F 22)
A.C. power (only with rechargeable batteries) . . . . . with a.c. adaptor/charger
Safety class to IEC 348 and VDE 0411 . . . . . Class II

Tolerable ambient temperature
Rated range of use . . . . . 0 to +55 °C
Storage and transport . . . . . −40 to +70 °C

Dimensions (w×h×d) in mm . . . . . 98×164×54

Weight with batteries . . . . . approx. 0.9 kg

Ordering Information

Speech Attachment and Two-wire Switch-over SZU-969 Exchange voltage 60 V	**BN 969/01**
Speech Attachment and Two-wire Switch-over SZU-969 Exchange voltage ≧36 V	**BN 969/02**
Accessories (at extra cost)	
A.C. adaptor battery charger with	
Standard European power plug (193 to 242 V, 47.5 to 63 Hz)	BN 964/00.02
U.S. type power plug (105 to 132 V, 47.5 to 63 Hz)	BN 964/00.03
U.K. type power plug (211 to 264 V, 47.5 to 63 Hz)	BN 964/00.04
Mains cable, but without plug (211 to 264 V, 47,5 to 63 Hz)	BN 964/00.05
NiCad rechargeable batterie (Two are necessary)	BN 969/00.01
Equipment carrying case TPK-21 for SZU-969 and 2 small measuring instruments	BN 926/07
Leather case with places for SZU-969 and a.c. adaptor/charger	BN 926/11
Neck-strap	BN 820/00.52
Mount for attaching the SZU-969 to 19" type equipment	BN 969/00.02

1) When operated with a psophometer the signal balance ratio is guaranteed to comply with CCITT Rec. P.53.

TPK-21
Equipment Carrying Case

for small measuring instruments



- **Elegant design**
- **Ensures that valuable equipment is safe from damage**
- **Small measuring instruments and accessories can be packed neatly together in one case**

Applications

Nowadays small measuring devices are in demand for mobile field service, troubleshooting and maintenance work on telephone, radio and data comm equipment. They are small, handy and can be run on batteries. The TPK-21 Equipment Carrying Case has room for three small measuring instruments, their accessories and operating manuals. This means that everything you need is close at hand. During transportation and storage the instruments are protected from damage of any kind.
The PS-10/PS-20 Level Generators, the PM-10/PM-20/PM-928 Digital Level Meters, the PMP-20 Digital Level and Noise Meter and the SZU-969 Speech Attachment and Two-wire Switch-over are all the right size for the TPK-21.

Characteristics

The TPK-21 Equipment Carrying Case looks like a briefcase. It is covered with simulated leather and can be locked. The case contains a moulded plastic foam base with compartments to accommodate the instruments and their accessories such as spare batteries and a.c. adaptor/chargers. There are pockets in the lid for Operating Manuals, graph paper and test cables.

Ordering Information

TPK-21 Equipment Carrying Case (empty)	**BN 926/07**
can accommodate:	
PS-10 [1] Level Generator, 200 Hz to 4 kHz or	BN 904/01
PS-20 [1] Level Generator, 20 Hz to 20 kHz	BN 902/....
PM-20 [1] Digital Level Meter, 15 Hz to 20 kHz or	BN 881/01
PMP-20 [1] Digital Level and Noise Meter, 15 Hz to 20 kHz or	BN 876/....
PM-10 [1] Digital Level Meter, 80 Hz to 20 kHz or	BN 820/....
PM-928 [1] Digital Level Meter, 200 Hz to 6 kHz	BN 928/01
SZU-969 Speech Attachment and Two-wire Switch-over	BN 969/01

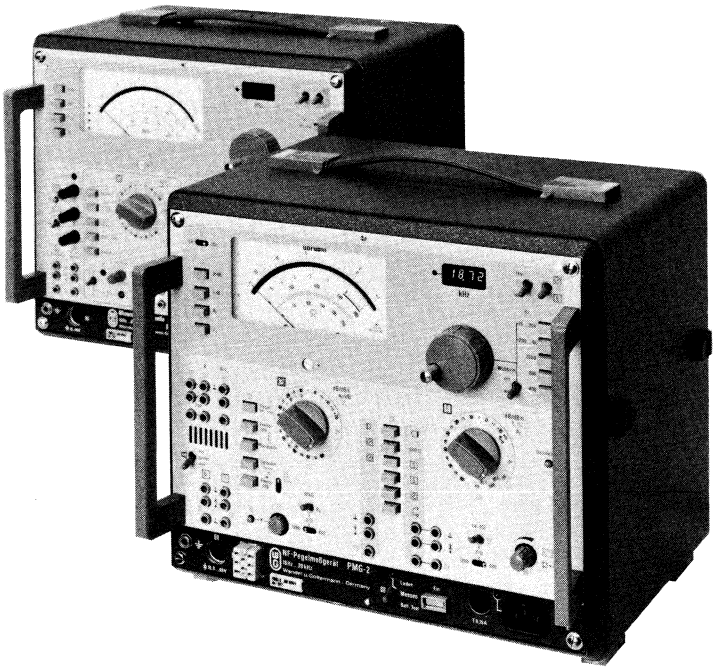
1) These instruments have a wide range of accessories. See the relevant Specification Sheet for more information.

Dimensions and weight

Dimensions, w × h × d (in mm)	425 × 100 × 305
Weight (emphy)	approx. 1.5 kg

PMG-2
AF Measuring Set

for level and noise measurements in the frequency range 15 Hz to 20 kHz



- **Generator and receiver in one unit**
- **Generator has fixed frequencies and continuous tuning**
- **Wideband receiver with true r.m.s. detector**
  Depending on version:
- **Filter for weighted noise measurements on voice-grade channels according to CCITT Rec. P.53A**
  in the sound-programme channel according to CCIR Rec. 468-2
- **Filter for selective measurements**
- **Measurement Accessories for impedance, return loss, signalling distortion**
- **Speech and monitoring attachment – either built-in or as accessory**
- **A.C. line or battery operation**

Applications

The PMG-2 AF Measuring Set is suitable for measuring levels in the frequency range from 15 Hz to 20 kHz. Internal filters make possible weighted and unweighted noise voltage measurements complying with CCITT Recommendation P.53A or CCIR Recommendation 468-2. Selective measurements or quantizing distortion (i.e. total distortion including quantizing distortion) measurements on PCM channels can also be carried out with extra filters. Impedance, return loss, and signalling distortion can also be measured.

Characteristics

The compact Measuring Set comprises a send and receive section with balanced inputs and outputs. The send or receive level is displayed on a large meter with 20 dB and 5 dB scales. The receive section contains a true r.m.s. detector, so the result of the measurement does not depend on the waveform of the signal. There is a quasi-peak value detector for measuring noise as described in CCIR 468-2. Various filters and Measurement Accessories increase the PMG-2's range of applications. Power for the PMG-2 comes from the a.c. line, or from an internal or external battery.

Send frequency, setting	fixed frequencies continuous, sweepable
Send level	−65 to +11 dB/dBm
Receive level (0 dB reading)	−80 to +20 dB/dBm
Input/output	balanced
D.C. current taken when $Z_{in} = 600\ \Omega$	≦60 mA
Weight	approx. 10 kg
Ambient temperature	0 to +55 °C

Notable features:

- the *four-digit frequency display:* It precisely indicates the continuously-adjustable send frequency and receive frequency, even if end-to-end measurements are being carried out.
- the *Speech Attachment:* If the PMG-2 has an internal Speech and Monitoring Attachment, and a plug-in handset is inserted, the PMG-2 can be used as an intercom over 2- and 4-wire lines, so permitting communication between distant measuring sites. With other versions the *SZU-969 Speech Attachment* can be used to the same end.

The following overview shows what versions of the AF Measuring Set are available:

The characteristics of the various PMG-2 versions			BN 815/06	BN 815/04 [1] BN 815/08 [2]	BN 815/05 [1] BN 815/09 [2]
Send section	Frequency setting	fixed frequencies	●	●	●
		continuous	●	●	●
		sweepable, internal		●	●
		sweepable, external	●		
	Send frequency display by counter		●	●	●
	Level setting	in 5 dB steps	●	●	●
		in 1 dB steps	●		
		also continuous	●	●	●
Receive section	Wideband frequency range		●	●	●
	Receive frequency display by counter		●	●	●
	Level measuring range adjustable in 5 dB steps		●	●	●
	Filter for noise voltage measurements				
	for in voice-grade channels as per CCITT Rec. P.53A		●	●	●
	in broadcast channels as per CCIR Rec. 468-2			3)	●
	Filter for selective measurements		●		
	Filter for measuring the quantizing noise on PCM transmissions		●		
Measuring Accessories	Impedance measurements		●	●	●
	Signalling distortion measurements		●		
	Return loss measurements			●	●
	Speech and monitoring attachment			●	●
	Speech Attachment SZU-969 (external, on request)		●		

1) Lettering in German 2) Lettering English/German 3) Retrofittable on request

Specifications of AF Level Measuring Set — PMG-2

If nothing to the contrary is stated, specifications are valid for the rated ranges of use for a.c. line voltage, line frequency, battery voltage and ambient temperature immediately after switch-on.

Generator

Output, floating, balanced . . . . . 3pole CF connector
Output impedance, selectable . . . . . 0 (≦4 Ω), 600 Ω
BN 815/04, 05, 08, 09 also . . . . . 1200 Ω
D.C. loading at Z_{out} = 0 and 600 Ω . . . . . ≦60 mA

Frequency

Frequency setting

Version	Continuous	Fixed frequencies/kHz	Sweep
BN 815/06	15 Hz to 20 kHz 200 Hz to 4 kHz	0.85; 0.3; 0.4; 0.6; 2.4; 3; 3.4	external
BN 815/04, 08 BN 815/05, 09		0.4; 0.8; 3	internal [1]

1) exponential, outward and return times each 2 s.

Error limits on the fixed frequencies
at 800 (850 Hz) or 1 kHz . . . . . ±1%

Frequency display . . . . . 4 digits
Resolution, selectable . . . . . 10 Hz, 1 Hz
Error limits of display . . . . . $\pm 2 \times 10^{-4} \pm 1$ digit

Send level

Setting range at $Z_{out} = Z_L = Z_0$ . . . . . −65 to +11 dBm
Send level display . . . . . on receiver meter

Frequency limits of the send level
for $Z_{out} = Z_L = Z_0$
at f = 800 Hz or 850 Hz (BN 815/06)

Version	Temperature range	Level	Error limits
BN 815/06	+15 to +35 °C	0 dBm	±0.1 dB
BN 815/04, 05, 08, 09	(23 ±5) °C	−10 dB/dBm	±0.05 dB

in the send level setting range and from +15 to +35 °C

Version	Frequency	Error limits
BN 815/06	0.2 to 4 kHz	±0.2 dB
	15 Hz to 20 kHz	±0.4 dB
BN 815/04, 05, 08, 09	0.2 to 4 kHz	±0.2 dB
	30 Hz to 15 kHz	±0.25 dB

Harmonic ratio
at the fixed frequency 800 (850) Hz . . . . . ≧60 dB
at all other frequencies ≧30 Hz . . . . . ≧46 dB

Receiver

Measurement input,
floating, balanced . . . . . 3pole CF connector
Input impedance, selectable . . . . . 600 Ω, ≧50 kΩ
BN 815/04, 05, 08, 09 also . . . . . 1200 Ω
D.C. loading at Z_{in} = 600 Ω . . . . . ≦60 mA

Frequency range . . . . . 15 Hz to 20 kHz

Level

Level measurement ranges
for 0 dB meter reading . . . . . −80, −75, ..., +20 dBm
Meter scales,
selectable . . . . . −20 to +2 dB and −5 to +1 dB

Error limits of the receive level meter
after calibration and $Z_{source} = Z_{in}$ = 600 Ω
at f = 800 Hz or 850 Hz (BN 815/06) and +15 to +35 °C

Version	Measuring range	Display	Error limits
BN 815/06	0 dBm	5 dB scale	±0.15 dB
BN 815/04, 05, 08, 09	−10 dB/dBm	−5 to +1 dB	

in the frequency range up to 4 or 15 (20) kHz and +15 to +35 °C

Version	Frequency	Measurement range	Display	Error limits
BN 815/06	0.2 to 4 kHz	−80 to +20 dBm	5 dB scale	±0.25 dB
	15 Hz to 20 kHz			±0.4 dB
BN 815/04, 05, 08, 09	0.2 to 4 kHz	−60 to +20 dB/dBm [1]	−5 to +1 dB	±0.2 dB
	15 Hz to 15 kHz			±0.25 dB

Measurement detector . . . . . true r.m.s. detector
Peak factor . . . . . ≦5

Filters

Psophometric filter . . . . . as per CCITT Rec. P.53 A

Filter for sound programme channels
weighted and unweighted . . . . . as per CCIR Rec. 468-2
Detector type . . . . . quasi-peak value
in the versions BN 815/05 and /09
BN 815/04 and 08 can be retrofitted.

Extra filters
BN 815/06 version
Voice channel filter, 3 dB bandwidth . . . . . 0.2 to 3.4 kHz
850 Hz band-pass for selective measurements
850 Hz notch filter for quantizing distortion measurements
in tandem with the psophometric or voice channel filter

A Specification Sheet with more details is available on request

Outputs

D.C. and a.c. outputs
(not BN 815/06)

X/Y plotter output (BN 815/06) . . . . . 0 to +5 V

Impedance measurements
Frequency range . . . . . 15 Hz to 20 kHz
Measurement ranges (f.s.d.) . . . . . 80, 250, ..., 8000 Ω
BN 815/06 . . . . . 40, 120, ..., 4000 Ω

Return loss measurements (BN 815/04, 05, 08, 09)
Frequency range . . . . . 15 Hz to 20 kHz
Measurement ranges for 0 dB reading . . . . . 0 to 50 dB

Signalling distortion (BN 815/06)

Signalling character generator,
frequency . . . . . 10 Hz ±5 %
Duty factor (mark : space) 1:1

Signalling character receiver,
measurement range . . . . . ±10 ms
Error limits of display . . . . . ±0.6 ms

General specifications

Power supply
Rated range of use for
a.c. line voltage . . . . . 187 to 242 V
a.c. line frequency . . . . . 45 to 66 Hz
Power consumption . . . . . approx. 20 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I
(protective conductor not connected to casing)
Operating time with fully charged battery . . . . . approx. 6 h
Connection for external battery . . . . . floating
Voltage range for external battery . . . . . 11.5 to 68 V

Permissible ambient temperature
Rated range of use . . . . . 0 to +55 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions
with cover (w × h × d) in mm . . . . . 330 × 280 × 280

Weight . . . . . approx. 10 kg

FTZ-K number
for version BN 815/04 . . . . . 276 098 068
for version BN 815/05 . . . . . 276 098 069

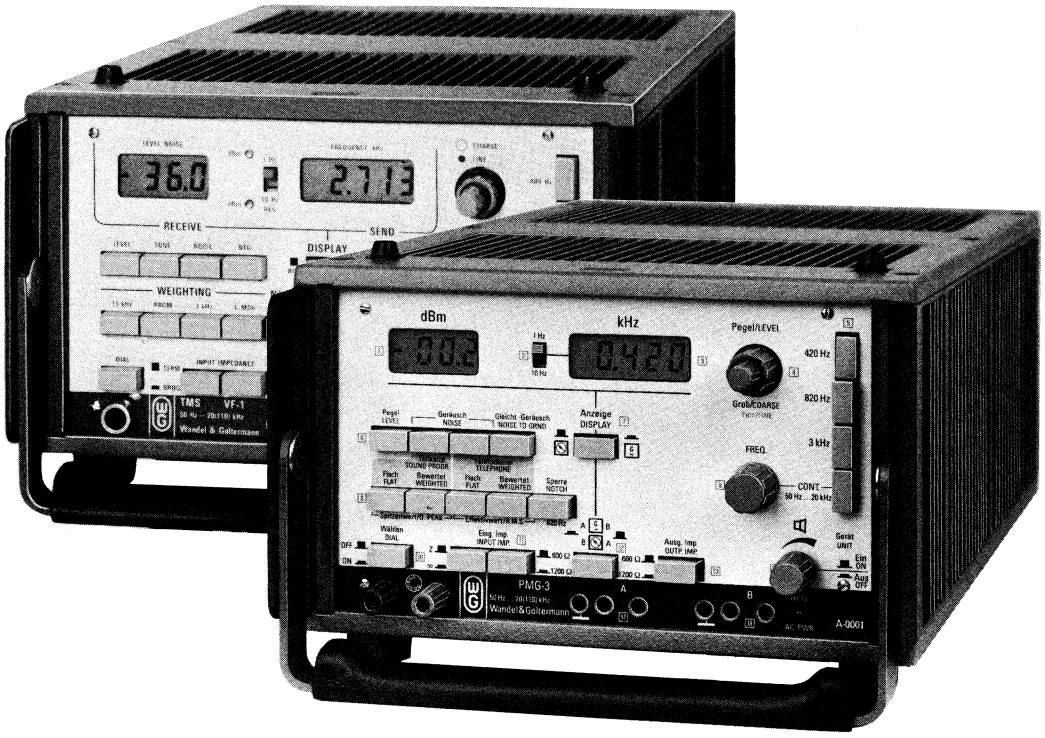
Ordering Information

AF Measuring Set PMG-2 with battery, depending on version	**BN 815/04; BN 815/05; BN 815/06; BN 815/08; BN 815/09**
Accessories (at extra cost)	
Speech Attachment SZU-969 [1] for BN 815/06	
Exchange voltage 60 V	BN 969/01
Exchange voltage ≧36 V	BN 969/02
Handset [2] for BN 815/04, BN 815/05, BN 815/08, BN 815/09	Siemens, Order No. S 42025-A-172-A 1
Conversion Kit for BN 815/04 and /08: Filter card as per CCIR Rec. 468-2	BN 815/00.01

1) For Specifications see SZU-969 Specification Sheet
2) Order direct from manufacturer

PMG-3/VF-1
Transmission Test Set

for measuring level, noise, and frequency in the frequency range 20 Hz to 64 (110) kHz



- **Generator and receiver in one unit**
- **Generator has fixed frequencies and continuous frequency setting**
- **Synthesizer provides send frequency with high accuracy and stability**
- **Simultaneous digital level and frequency display**
- **Autoranging**
- **Weighting filters for voice and sound-programme channels complying with CCITT Rec. P. 53 and CCIR Rec. 468-2 (PMG-3) or Bell Spec. 41009 (VF-1)**
- **Quantizing distortion measurements with 820 Hz notch filter**
- **Connection for dial-up facility for forming d.c. loop holding circuit**
- **AC mains or (optional) battery operation**

Applications

All the most important standard parameters encountered in telephone, broadcast and datacom work, such as level, gain, loss, frequency response and noise, can be measured using the PMG-3/VF-1 Transmission Test Set. Weighted noise measurements on voice and sound-programme channels are also possible.
A notch filter can be switched in for quantizing distortion measurements on PCM systems.
Batteries can be fitted for in-the-field measurements on transmission paths.

The VF-1, a version for the North American market, conforms to *Bell Spec. 41009.*

Characteristics

The synthesizer in the PMG-3/VF-1 provides accurate and stable transmission frequencies. The transmission frequency can be adjusted continuously, or by means of three fixed-frequency keys. Autoranging in the Receive Section ensures fast, straightforward measurements. This applies to measurements on voice-grade channels using r.m.s. detectors and also to measurements in the sound-programme frequency range using quasi-peak value detectors. The smallest measurable noise level is −89 dBm or 1 dBrn. The PMG-3/VF-1 has a loudspeaker for qualitative assessments.

Frequency range, Generator Section	20 Hz to 64 kHz
Receive Section	20 Hz to 110 kHz
Fixed frequencies (Generator Section)	
PMG-3	420, 820, 3000 Hz
VF-1	404, 1004, 2804 Hz
Transmission level, setting range	−50 to +10 dBm
Level measurements, level range	−79 to +10 dBm
Noise measurements,	
level range (weighted) PMG-3	−89 to +9.9 dBm
VF-1	1 to 99.9 dBrn
Weighting filter	as per CCITT P. 53 or CCIR 468-2
	or C-message or sound-programme filters
Weight (with batteries)	approx. 8 kg

Further Characteristics and Applications

In addition to those already mentioned, the following characteristics are also of interest:

- Digital level and frequency display: For rapid, precise settings and readings. The maximum resolutions of the display are 0.1 dB or 1 Hz.
- Connector for dial-up facility: The connector is located on the front panel. The two balanced outputs may be interchanged by pushbutton. Thus, when the PMG-3/VF-1 is operated in 2-wire mode, the receive and send cables may be switched without plugging and unplugging test cables.

The SZU-969 Speech Attachment can be ordered for setting up telephone communications with the remote site. The SZU-969 contains a microphone, a loudspeaker, a dial-up keypad, and a 2-wire selector field.

Specifications of the Transmission Test Set — PMG-3/VF-1

Unless otherwise stated, the specifications are valid in the rated ranges of use for a.c. line voltage, a.c. line frequency and ambient temperature. The values in brackets refer to VF-1.

Level Meter

Measurement input

For PMG-3:
Balanced . . . . . 3 pole CF connector
Input impedance, switchable . . . . . 600 Ω, 1200 Ω, high impedance (bridged)

For VF-1:
Balanced . . . . . female connector for WECO 310 plug
Input impedance, switchable . . . . . 600 Ω/900 Ω/high imp.
Signal balance ratio at 50 Hz . . . . . ≧80 dB

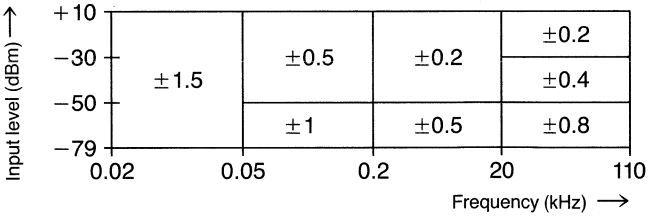
Level measurements

suitable for wideband measurements

Level range . . . . . −79 to +10 dBm
Level display resolution . . . . . 0.1 dB

Frequency range . . . . . 20 Hz to 110 kHz
Detector type . . . . . r.m.s.
Crest factor (for levels <0 dBm) . . . . . 12 dB

Error limits of receive level display
(Tabulated values in dB)



Noise measurements

weighted and unweighted noise measurements

Noise level range
(weighted) . . . . . −89 to +9.9 dBm (1 to 99.9 dBrn)
Noise level display resolution . . . . . 0.1 dB

Frequency range . . . . . 20 Hz to 35 kHz

Noise measurement detector type
Voice channel . . . . . r.m.s.
Sound-programme channel . . . . . quasi-peak

Weighting filters
Voice channel, PMG-3 . . . . . to CCITT Rec. P. 53
VF-1 . . . . . C-message filter
Sound-programme channel,
PMG-3 . . . . . to CCIR Rec. 468-2
VF-1 . . . . . program filter (USA)
Psophometer weighting,
switchable . . . . . weighted/unweighted

Quantizing distortion measurements
PMG-3:
with 820 Hz notch filter in tandem with weighting filter
Filter curve complying with CCITT Rec. O.132
Attenuation in notch between
800 and 855 Hz . . . . . ≧50 dB
Attenuation in pass-band
325 Hz ≧ f ≧ 1360 Hz . . . . . ≦0.5 dB
570 Hz ≧ f ≧ 1105 Hz . . . . . ≦1 dB
690 Hz ≧ f ≧ 1000 Hz . . . . . ≦3 dB

VF-1:
Notched noise measurement with 1010 Hz notch filter
in tandem with weighting filter
Attenuation in notch between 955 and 1025 Hz . . . . ≧50 dB
Attenuation in pass-band
400 Hz ≧ f ≧ 1700 Hz . . . . . ≦0.5 dB
862 Hz ≧ f ≧ 1182 Hz . . . . . ≦3 dB

Common mode noise measurement
Level range . . . . . −49 to +30 dBm (41 to 139.9 dBrn)
Resolution of the displayed level . . . . . 0.1 dB
Frequency range . . . . . 20 Hz to 20 kHz

Error limits of noise level display
Voice channel,
weighted, in range:
−89 to +9.9 dBm (1 to 99.9 dBrn) . . . . . ±1 dB
unweighted, in range:
−80 to +9.9 dBm (1 to 99.9 dBrn) . . . . . ±1 dB
−89 to −80 dBm . . . . . +3 dB/−1 dB
Sound-programme,
weighted, in range:
−70 to +9.9 dBm (10 to 99.9 dBrn) . . . . . ±1 dB
−85 to −70 dBm (1 to 10 dBrn) . . . . . +3 dB/−1 dB
unweighted, in range:
−70 to +9.9 dBm (10 to 99.9 dBrn) . . . . . ±1 dB
−80 to −70 dBm (1 to 10 dBrn) . . . . . +3 dB/−1 dB

Common mode noise,
weighted in range
−49 to +30 dBm (41 to 139.9 dBrn) . . . . . ±1 dB
unweighted, in range:
−40 to +30 dBm (41 to 139.9 dBrn) . . . . . ±1 dB
−49 to −40 dBm . . . . . +3 dB/−1 dB

Frequency measurements

Frequency range . . . . . 20 Hz to 110 kHz
Sensitivity . . . . . −69 dBm
Frequency display . . . . . 5 digit, LCD
Resolution and accuracy
20 Hz to 20 kHz . . . . . 1 Hz
20 kHz to 110 kHz . . . . . 10 Hz

D.C. loop-holding circuit

Voltage drop across holding circuit

with	600 Ω	1200 Ω (900 Ω)
holding current:		
I = 20 mA	approx. 9 V	approx. 9 V (9 V)
I = 50 mA	17 V	34 V (25 V)
I = 80 mA	35 V	max. 40 V at I = 55 mA (66 mA)

Generator Section

Generator output

For the PMG-3:
Balanced . . . . . 3 pole CF connector
Output impedance, switchable . . . . . 600 Ω/1200 Ω
For the VF-1:
Balanced . . . . . female connector for WECO 310 plug
Output impedance, switchable . . . . . 600 Ω/900 Ω

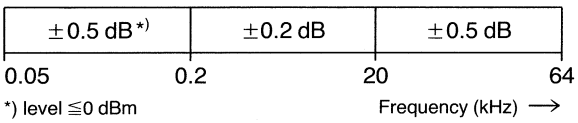
Transmission frequency

Frequency setting
Continuously adjustable . . . . . 20 Hz to 64 kHz
Smallest frequency increment . . . . . 1 Hz
Fixed frequencies, switch-selectable
PMG-3 . . . . . 420, 820, 3000 Hz
VF-1 . . . . . 404, 1004, 2804 Hz
Error limits: accuracy and stability . . . . . 1 Hz

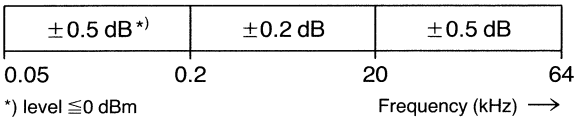
Transmission level

Setting range . . . . . −50 to +10 dBm
Resolution of transmission level setting . . . . . 0.1 dB

Error limits of send level for $Z_{out} = Z_L = Z_o$

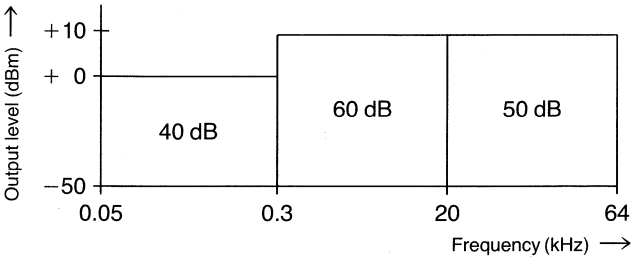


Frequency response, referred to 820 Hz



Harmonic ratio a_{k_2}, a_{k_3}

$Z_{out} = Z_L = Z_o$



General Specifications

Power supply
A.C. line operation
Rated ranges of use for a.c. line voltage, switch-selectable . . . . . 120 V, 220 V, ± 10 %
Rated range of use of a.c. line frequency . . . . . 45 to 66 Hz
Power consumption with a.c. line operation . . . . . approx. 15 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I

Battery operation
Operating time (at 25 °C) . . . . . approx. 5 h
(level display flashes when battery is flat)
Recharge time . . . . . approx. 16 h

Ambient temperature
Rated range of use . . . . . 0 to +55 °C
Storage and transportation . . . . . −40 to +60 °C

Dimensions (h x w x d) in mm . . . . . 222 x 155 x 414

Weight (without batteries) . . . . . approx. 8 kg

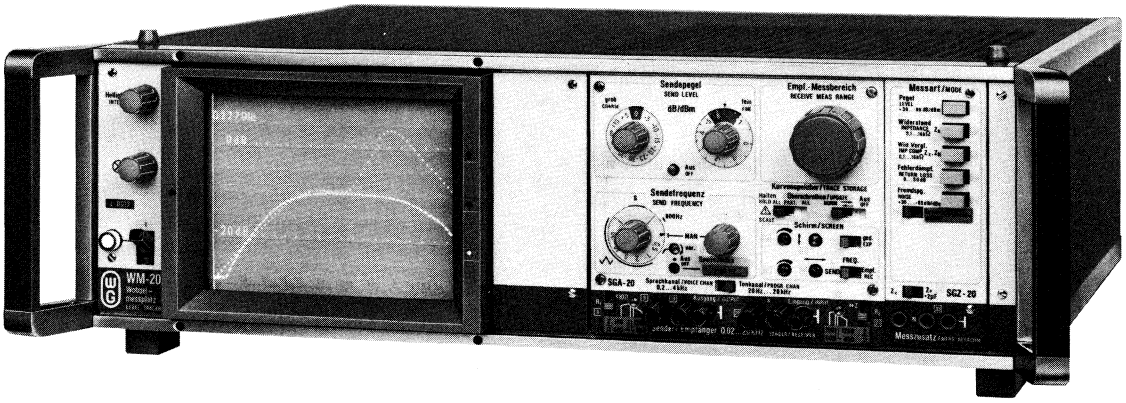
Ordering Information

Transmission Measuring Set PMG-3	**BN 9202/03**
Transmission Measuring Set VF-1 (without batteries in both cases)	**BN 9202/01**
Option (at extra cost):	
Set of rechargeable batteries	BN 9202/00.01
Accessories (at extra cost):	
Speech Attachment and 2-Wire Switch-over SZU-969 [1] for PMG-3	
for 60 V exchange voltage	BN 969/01
for exchange voltage ≧36 V	BN 969/02
Set of protective covers SD-35	BN 900/00.23
Carrying case AT-052 S	BN 9000/01
19" conversion kit	BN 9000/00.02

1) See Spec. sheet for specs. and ordering information

WM-20
AF Sweep Measuring Setup

for the frequency ranges: 200 Hz to 4 kHz and 20 Hz to 20 kHz



- **Stable flicker-free picture by digital image storage**
- **Simultaneous presentation of measurement and reference traces**
- **Storage of measurement and reference traces**
- **High accuracy and reliable evaluation via reference lines with alphanumeric markings on the screen**
- **Alphanumeric display of send or receive frequency on screen**
- **Easy operation because of central range switch**
- **Measures level, impedance and return loss**
- **Weighted or unweighted noise level measurements if required**
- **Five different impedances**
- **Realisation of a voice connection by the SZU-969 Speech Attachment and Two-wire Switch-over for connecting the WM-20 to a two-wire circuit**

Applications

The WM-20 AF Sweep Measuring Setup was designed for measurements on telephone channels (frequency range 200 Hz to 4 kHz) and sound-programme channels (frequency range 20 Hz to 20 kHz).
The WM-20 measures all the essential transmission parameters, such as signal level, overall loss, crosstalk attenuation, return loss and impedance, that characterise AF transmission paths. Impedance comparison measurements are also possible. If required, weighted or unweighted noise levels can be measured on telephone or sound-programme channels as laid down in CCITT Rec. P.53 or CCIR Rec. 468-2. The result appears on the screen as a horizontal line.
The WM-20 is ideal for postal administrations, companies with their own communication networks (telecontrol, data, or power-line carrier networks), broadcasting organisations, audio studios and the manufacturers of electroacoustic devices. The field of applications for the WM-20 ranges from the repair and monitoring of communication networks to the manufacture, development and servicing of AF equipment.

Characteristics

Because of digital image storage the measurement curve is stable and flicker-free. A special feature is a facility for immediately updating and reading out the memory contents when the input signal changes (UPDATE). There are therefore no long waiting times caused by low deflection speeds.
Besides single traces, the outgoing and return traces can also be displayed at the same time. This is especially useful when comparing impedances. Two impedances can be compared and their magnitudes as a function of frequency displayed as separate curves. One curve is overwritten by the outgoing trace, the other by the return trace.
A reference trace can also be stored. For later analysis, measurement and reference traces can be "frozen" (HOLD ALL) on the screen. By allocating different numbers of image points, both traces can be clearly distinguished.
With trace storage, exact evaluation in the frequency domain is possible. By means of manual frequency adjustment a cursor can be positioned along the measurement and reference curves, at the same time the frequency, to which the cursor is set, is displayed on the screen.
For all measurements, the measuring range is selected with a single centralised switch and is clearly shown on the screen by two horizontal reference lines with alphanumeric lettering.

Output or input impedance [1], switch-selectable	150, 600, 850, 1200 Ω or ≈10 Ω/bridging
Frequency range, switch-selectable	200 Hz to 4 kHz/20 Hz to 20 kHz
Send level range	−46 to +11 dB/dBm
Receive level range	−99 to +30 dB/dBm
Impedance measurements	100 Ω to 16 kΩ
Return loss measurements	0 to 50 dB
Noise level measurements in voice-grade and sound-programme channels	−85 to +30 dB

The double exponential sweep prevents distortion caused by transients at the test specimen; short sweep times may therefore be used. Two vertical reference lines mark the limits of the selected frequency range.
A frequency discriminator, built into the send section, provides the X deflection voltage for end-to-end sweep measurements.
To prevent dial-tone receivers being activated when carrying out measurements on the system, two dial-tone filters can be switched in. One filter can have any centre frequency in the range 1 to 4 kHz.
The Main Frames are delivered with two graticule screens for the voice and sound-programme channels.
For the WM-20 a device is available for copying traces and tolerance masks onto a transparent film. These graticule screens and graticule films can be stored in a graticule compartment available on order.
Oscilloscope camera mounts for the WM-20 are available for rapid photographic documentation of the measured results on the CRT screen. The results can also be recorded with an X-Y recorder.

The handy SZU-969 is available as a Speech Attachment and Two-wire Switch-over. With this device, measurements on two-wire connections are possible without unplugging cables. Besides a microphone and loudspeaker, the SZU-969 also contains a dial-up keypad by which a voice connection between two measurement locations can be established over a d.c. holding loop.

Specifications of the AF Sweep Measuring Setup — WM-20

When not otherwise stated, specifications are valid for the rated operating ranges of a.c. line voltage, a.c. line frequency and ambient temperature after a 15 min warm-up time.

Send Section

Output,
balanced, floating . . . . . 3 pole CF-Connector
Output impedance,
switchable . . . . . 150 Ω [1], 600 Ω, 850 Ω [2], 1200 Ω [2]
and approx. 10 Ω + 350 µH
Return loss, 600 Ω ≦ Z_o ≦ 1200 Ω . . . . . ≧40 dB
Signal balance ratio complying with CCITT Rec. O.121
600 Ω ≦ Z_o ≦ 1200 Ω . . . . . ≧60 dB
150 Ω ≦ Z_o < 600 Ω . . . . . ≧46 dB
D.C. voltage to ground . . . . . ≦100 V
D.C. loading for levels ≦0 dBm . . . . . ≦30 mA

Frequency
Two ranges (common switch
for Send and Receive Sections) . . . . . 200 Hz to 4 kHz [3]
and 20 Hz to 20 kHz
Setting . . . . . swept, manual, fixed at 800 Hz,
or 1 fixed value between 1 and 4 kHz
Sweeping . . . . . double exponential
Time interval for out sweep or return . . . 0.5, 1, 2 [4], 5, 10, 20 s
Display . . . . . digital on CRT screen
Resolution . . . . . 1 Hz
Frequency bandstop filter . . . . . 250 Hz [4], 2280 Hz [5],
one frequency can be chosen (1 to 4 kHz)
Stop-band . . . . . approx. 300 Hz

Send level

Level range
600 Ω ≦ Z_o ≦ 1200 Ω . . . . . −46 to +11 dB/dBm [6]
300 Ω ≦ Z_o < 600 Ω . . . . . −46 dB to +11 dB
150 Ω ≦ Z_o < 300 Ω . . . . . −46 dB to 0 dB
Level blanking by the depression of a key or continuously
Level setting in steps of . . . . . 5 dB
Fine level setting . . . . . −6 to +1 dB

Error limits
Error limits of send level at 1 kHz and
0 dB/dBm, 600 Ω ≦ Z_o ≦ 1200 Ω . . . . . ±0.1 dB
0 dB, 150 Ω ≦ Z_o < 600 Ω . . . . . ±0.3 dB

Error limits of send level setting at 1 kHz,
referred to 0 dB/dBm . . . . . ±0.05 dB

Error limits of the frequency response
referred to 1 kHz, in the range 20 Hz to 20 kHz
600 Ω ≦ Z_o ≦ 1200 Ω . . . . . ±0.05 dB
150 Ω ≦ Z_o < 600 Ω . . . . . ±0.3 dB

Spectral purity
Harmonic distortion ratio a_{k_2}, a_{k_3}, load ≧300 Ω . . . . ≧46 dB
Discrete, nonharmonic spurious tones
with ≧200 Hz separation from carrier . . suppression ≧60 dB
or absolute value ≦ −100 dBm

Receive Section

Input,
balanced, floating . . . . . 3 pole CF-connector
Input impedance,
switchable . . . . . 150 Ω [1], 600 Ω, 850 Ω [2], 1200 Ω [2]
and approx. (80 kΩ ‖ 40 H ‖ 1 nF)
Return loss in frequency range
0.2 to 4 kHz, 600 Ω ≦ Z_o ≦ 1200 Ω . . . . . ≧34 dB
Signal balance ratio
"level" operating mode, complying with
CCITT Rec. O.121 . . . . . ≧60 dB
Operating mode "weighted and unweighted noise"
(option) . . . . . complies with CCITT Rec. P.53
D.C. voltage to ground . . . . . ≦100 V
D.C. loading . . . . . ≦30 mA
Signalling voltage
(25 or 50 Hz, 10 s duration, Z_{source} ≧500 Ω) . . . . . ≦90 V

Frequency . . . . . see Send Section

Level reading

Overall range
600 Ω ≦ Z_o ≦ 1200 Ω . . . . . −99 to +30 dB/dBm [6]
150 Ω ≦ Z_o < 600 Ω . . . . . −99 to +30 dB
Range display . . . digital on the CRT screen at two reference
lines located at 25 % and 75 % of image height
Reference line settings . . . . . stepped in 1 dB increments
unexpanded position . . . . . −89 to +20 dB/dBm
expanded position . . . . . −73 to +20 dB/dBm

Error limits of display at 1 kHz, expanded,
level −10 dB/dBm, at upper reference line . . . . . ±0.2 dB
any other level settings at both reference lines . . . ±0.25 dB
Scale division error between the reference lines:
in expanded position . . . . . ±0.3 dB
in unexpanded position . . . . . ±1.5 dB

Frequency response, referred to 1 kHz,
level range ±1 dB around upper reference line
(tabulated values in dB):

	20 Hz	40 Hz	20 kHz
600 Ω ≦ Z_o ≦ 1200 Ω	±0.25	±0.1	
150 Ω ≦ Z_o < 600 Ω	+0.45/−0.25	±0.15	

Intrinsic noise level . . . . . approx. −100 dB

Trace storage
Display modes . . . . . measuring trace alone,
measuring trace outgoing and return trace,
measuring trace plus storage reference trace,
measuring trace plus reference trace, both stored (HOLD ALL),
real time operation (storage "OFF")

Impedance measurements
The magnitude of the impedance connected to input X[7] is measured.

Overall range . . . . . 100 Ω to 16 kΩ

Range display . . . . . digital on the CRT screen
and with two reference lines

Display error limits
for resistances and reactances from 200 Ω to 6 kΩ,
on reference lines, 200 Hz to 4 kHz . . . . . ±7 % of reading
20 Hz to 10 kHz . . . . . ±17 % of reading
additionally between the reference lines . . . . ±3 % of f.s.d.

Impedance comparison measurements
As for impedance measurements, but during the "out" sweep the impedance at input X[7] is measured, during the return sweep the impedance at input N, 2 pole switchover from X to N.

Return loss measurements
The return loss is measured by comparing the impedance connected across the X[7] input with the impedance connected to the N input

Overall range . . . . . 0 to 50 dB
Range display . . . . . digital on the CRT screen
with two reference lines
Intrinsic return loss of the measuring bridge for X = N
600 Ω ≦ X ≦ 1200 Ω . . . . . ≧60 dB
150 Ω ≦ X < 600 Ω . . . . . ≧48 dB

Option

Noise Measurement Device, BN 803/00.01
meets CCITT Rec. P.53 and CCIR Rec. 468-2
Measurement range . . . . . −85 to +30 dB
Digital measurement range display on screen.

Result evaluation, weighted and unweighted
in voice-grade channels, 200 Hz to 4 kHz . . . . . true r.m.s.
in sound-programme channels, 20 Hz to 20 kHz . . quasi-peak
complies with CCIR Rec. 468-2
Error limits in expanded setting
Reference lines at 800 Hz or 1 kHz . . . . . ±0.35 dB
Scale division error between the reference lines . . . ±0.3 dB

Variation with frequency, unweighted
in voice-grade channels, 20 Hz to 20 kHz . . . +0.45/−0.25 dB
in sound-programme channels . . . . . corresponds to flat
response curve CCIR 468-2

Variation with frequency, weighted
in voice-grade channels . . . . . weighting curve complying
with CCITT P.53
in sound-programme channels . . . . . weighting curve
complying with CCIR 468-2

General Specifications

Cathode ray tube,
useable screen area . . . . . height 8.5 cm, width 12 cm

Power supply
Rated ranges of use of a.c. line voltage,
switch-selectable . . . . . 110, 117, 220, 227, 235 V
Rated range of use of a.c. line frequency . . . . 45 Hz to 66 Hz
Power consumption . . . . . approx. 70 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I

Tolerable ambient temperature
Rated range of use . . . . . +10 to +35 °C
Limits range of operation . . . . . 0 to +45 °C
Limits range for storage and transport . . . . . −25 to +60 °C

Dimensions (w×h×d) in mm . . . . . 478×155×407

Weight . . . . . approx. 15 kg
German Post Office Certificate
of Approval . . . . . No. 274 247 036 (BN 805/03)

Ordering Information

AF Sweep Measuring Setup WM-20[6]	**BN 805/04**
Options (at extra cost)	
Noise Measurement Device	BN 803/00.01
Graticule compartment	BN 429/00.06
Accessories (at extra cost)	
Speech Attachment and Two-wire Switch-over SZU-969[8]	
Exchange voltage 60 V	BN 969/01
Exchange voltage ≧36 V	BN 969/02
Protective Transportation Cover DE-22	BN 476/00.06
Camera mounting adapters	
FVR-4 (for Siemens CRT camera B 952)	BN 644/00
FVR-5 (for Tektronix camera of Series C 50)	BN 673/00
Graticule film copying device for WM-20 with 10 films for voice and sound-programme channels	BN 429/00.03
Graticule film for voice channel (10 pieces)	BN 429/00.05
Graticule film for sound channel (10 pieces)	BN 429/00.04
Case for 7 graticules/tolerance masks	BN 926/08

1) If requested, another value (at extra cost) can be selected, range 150 Ω ≦ Z_o < 600 Ω.
2) If requested, another value (at extra cost) can be selected, range 600 Ω < Z_o ≦ 1200 Ω.
3) When in sweep mode, 3.6 kHz (if requested 4 kHz).
4) Suitable for open-circuit/short-circuit Switching Device of the German Postal Administration (DBP). Additional setting with 2 s deflection time and 250 Hz stop-band filter (Stop-band approx. 50 Hz).
5) If requested, another value between 1 and 4 kHz can be selected (at extra cost).
6) The standard display is in dB; on request a dBm display will be provided however only for 600 and 1200 Ωor 600 Ω and 850 Ω, please state which you require when placing your order.
7) A 2 µF signalling blocking capacitor can be connected in series with input X.
8) See Specification Sheet for further details and extra Ordering Information.

PMG-13
Level Measuring Set

Frequency range: selective 20 Hz to 20 kHz, wideband 20 Hz to 50 kHz



- **Wideband and selective measurements**
- **Seven different bandwidths between 10 Hz and 1.6 kHz**
- **Continuous frequency tuning over the complete range; 0.1 Hz resolution**
- **Built-in tracking generator with adjustable send level**
- **Switchable as wideband amplifier**
- **Applicable as tunable filter and as frequency counter**
- **Psophometric weighting filter as per CCITT P.53 available as option**
- **Special version with VFT channel tuning as option**
- **External battery operation as option**

Applications

The PMG-13 Level Measuring Set is used for selective, wideband, level, voltage, attenuation, noise and frequency measurements. The signal source is a built-in, tracking generator with low distortion. The PMG-13 can also be used as a wideband amplifier or as a selective amplifier with an adjustable centre band frequency (tunable filter). Even signals which have been subjected to strong interference can be regenerated by using the tunable filter. The narrow 10 Hz bandwidth is particularly useful for analysing frequency mixtures. Three bandwidths have been specially designed for operational measurements on telecontrol and VFT systems operating at 50, 100 and 200 baud. Operation of the PMG-13 is considerably simplified by immediate tuning to the channel centre frequency (max. 28 VFT channels at 50 baud). The *SDG-40 Balanced Attenuator* is available as an aid for measurements on high levels up to +50 dBm.

Characteristics

The PMG-13 is a superhetrodyne receiver with wideband section and tracking generator. Several bandwidths are realised by using a commutating filter. The send and receive frequencies are shown on a flicker-free display with a resolution of 1 or 0.1 Hz. The PMG-13 may also be used as a frequency counter. Depending on the type of measurement being undertaken, either a low noise or a low distortion drive signal can be selected. The high accuracy of selective measurements is achieved by means of the tracking calibration frequency.

Frequency range	20 Hz to 20 kHz
Frequency counter and wideband level meter	20 Hz to 50 kHz
Level range, selective or wideband	−90 to +22 dB
Bandwidths	10, 20, 40, 100, 200, 400 Hz and 1.6 kHz
Output level of send section	−40 to +12 dB
Input, balanced or coaxial	600 Ω; approx. 100 kΩ
Version with channel selector	max. 28 VFT channels

Further Characteristics and Applications

The PMG-13 Level Measuring Set is especially well-suited for

- Line-up work on FM-VFT Systems:
  - Measuring static signals that are not keyed
  - Determining channel frequency deviation
  - Measuring discrete impairment frequencies inside and outside VFT channels
  - Measuring continuous signals in telecontrol systems
  - Weighted and unweighted noise measurements
- Operational level measurements on FM-VFT and telecontrol systems using appropriate bandwidths
  - in a keyed channel
  - on the ED 1000 single channel data communication system
  - on data and telecontrol systems operating at 600 to 2400 bit/s
- Operation as tunable filter
  This operating mode provides a tunable filter with selectable bandwidths for removing harmonic and nonharmonic spurious signals from signal sources so that they can be used for harmonic ratio measurements for example.
- Power from external battery: The PMG-13 Level Measuring Set can be powered from a d.c. source, e.g. from an exchange or vehicle battery or from the *BAK-450 Battery Pack* (with a voltage range 11.5 V to 30 V) or via the *WR-450 Inverter.*

Specifications of Level Measuring Set — PMG-13

If nothing to the contrary is stated, the given data are valid for the rated ranges of use for ambient temperature, a.c. line voltage and frequency immediately after switch-on.

Input and Outputs

Input of receive section . . . . . CF connector
switchable . . . . . coaxial, balanced
Input impedance
coaxial, switchable . . . . . 600 Ω; approx. 100 kΩ
balanced, switchable . . . . . 600 Ω
or . . . . . approx. 100 kΩ || 100 H || 1 nF
Signal balance ratio (CCITT Rec. O.121) . . . . . ≧40 dB
Common-mode rejection when operated as noise voltage meter with psophometrically weighted filter (Option BN 677/00.21), complying with CCITT Rec. P. 53)
Overload limit, input impedance 600 Ω . . . . . $V_{r.m.s}$ ≦ 10 V
Permissible d.c. voltage,
input impedance: bridging . . . . . ≦50 V

Output of send section . . . . . CF connector, balanced
Output impedance . . . . . 600 Ω
Signal balance ratio (CCITT Rec. O.121) . . . . . ≧40 dB

D.C. voltage output . . . . . short-circuit proof, Z_{out} = 5 kΩ
Output voltage for +2dB meter reading,
open-circuit . . . . . +5 V

Frequency range

Level meter, selective . . . . . 20 Hz to 20 kHz
wideband . . . . . 20 Hz to 50 kHz
Tracking generator . . . . . 20 Hz to 20 kHz
Amplifier, selective or wideband . . . . . 20 Hz to 20 kHz
Frequency counter, selective . . . . . 20 Hz to 20 kHz
wideband . . . . . 20 Hz to 50 kHz

Level range

Receive section, selective or wideband when used as
level meter . . . . . −90 dB to +22 dB
Frequency meter . . . . . −80 dB to +22 dB
Output level when used as
amplifier or tracking generator . . . . . −40 dB to +12 dB

Measured quantity display

Input level of level meter or amplifier
Meter reading with measuring range switch
Level reading in voltage (V) or voltage level (0 dB ≅ 0.775 V)
Weighting r.m.s. value reading for sinusoidal and noise signals
Settling time 0 to 99 %,
switchable fast/slow . . . . . approx. 200 ms/2 s

Meter scale ranges,
level . . . . . −20 dB to + 2 dB
voltage . . . . . 0 to 3 V; 0 to 10 V

Measuring ranges for 0 dB meter reading (3 V, 10 V)
selective and wideband,
level . . . . . −70, −60, −50 to +20 dB
voltage . . . . . 0.3 mV, 1 mV, 3 mV to 10 V

Frequency
Common tuning of receive and send sections. Frequency continuously tunable over complete range with coarse and fine adjustment,
or lockable to the centre frequencies of the VFT channels of systems FM 120, FM 240, FM 480, when channel number is selected using a switch (only with versions
BN 677/05 and BN 677/06)

Frequency display . . . . . flicker-free digital reading
for selectable display of tuning frequency or signal frequency
Resolution, switchable with fixed decimal point . . 1 Hz; 0.1 Hz

Summed errors

Error limits of level readings,
after the receive section has been calibrated at f = 10 kHz, coaxial input, $Z_{in} = Z_L$ = 600 Ω; level range −80 to +22 dB
unmodulated sinusoidal signal
selective low noise, f = 20 Hz[1] to 20 kHz
or wideband . . . . . ± 0.4 dB
Additional error, balanced input selective and
wideband, 200 Hz to 4 kHz . . . . . ± 0.1 dB
20 Hz to 20 kHz . . . . . ± 0.2 dB
only wideband, 20 Hz to 50 kHz . . . . . ± 0.6 dB

VFT signals
Tuning to channel centre, bandwidth depends on system:

System	FM 120	FM 240	FM 480
Bandwidth	100 Hz	200 Hz	400 Hz
Baud rate	50 baud	100 baud	200 baud

In level range – 80 dB to +22 dB, low noise . . . . . ± 1 dB

Error limits of send level
when used as amplifier or tracking generator
and $Z_{out} = Z_L = 600\ \Omega$ . . . . . ± 0.4 dB

Error limits of the frequency display
for tuning and signal frequencies . . . . . $\pm 2 \times 10^{-5} \pm 1$ digit

Individual errors of the level reading
unmodulated, sinusoidal signal and
"low noise" drive signal, $Z_{in} = Z_L = 600\ \Omega$
Error limits of 0 dB level reading in measuring range 0 dB at f = 10 kHz, after calibration
Input: balanced or coaxial . . . . . ± 0.07 dB

Error limits of level range switching at f = 10 kHz,
selective or wideband . . . . . ± 0.07 dB

Error limits of level reading, owing to frequency response, referred to f = 10 kHz,
Input, coaxial in frequency range

selective:	50 Hz to 20 kHz	± 0.05 dB
	20 Hz to 20 kHz	± 0.1 dB
wideband:	50 Hz to 50 kHz	± 0.05 dB
	20 Hz to 50 kHz	± 0.1 dB

Input, balanced selective and

wideband:	200 Hz to 4 kHz	± 0.07 dB
	20 Hz to 20 kHz	± 0.25 dB
only wideband:	20 Hz to 50 kHz	± 0.6 dB

Scale division error of meter . . . . . ≦ 1.2 % f.s.d.

Selectivity of receive section and of tunable filter

Bandwidths, switchable

3 dB bandwidth (nom. value)	Applied on VFT Systems	Attenuation when separated △f from band centre ≦ 0.5 dB	≧ 17 dB	≧ 45 dB	≧ 50 dB
10 Hz		± 3 Hz	± 9 Hz	–	± 35 Hz
20 Hz		± 6 Hz	± 18 Hz	–	± 70 Hz
40 Hz		± 12 Hz	± 36 Hz	–	± 140 Hz
100 Hz	FM 120	± 30 Hz	± 90 Hz	–	± 350 Hz
200 Hz	FM 240	± 60 Hz	± 180 Hz	–	± 700 Hz
400 Hz	FM 480	± 120 Hz	± 360 Hz	–	± 1.4 kHz
1.6 kHz	ED 1000	± 450 Hz	± 1.5 kHz	± 5 kHz	–

IF and image frequency suppression . . . . . ≧ 60 dB

Spurious signals

Level meter
Intrinsic harmonic ratio, a_{k2} and a_{k3} sensitivity 40 dB greater than that of fundamental frequency measuring range, drive signal: "low distortion" . . . . . ≧ 60 dB
Signal-to-noise ratio for 0 dB reading, wideband . . . ≧ 30 dB
Selective, drive signal: "low noise"
Bandwidth: 10 Hz to 400 Hz . . . . . ≧ 50 dB
1.6 kHz . . . . . ≧ 40 dB

Tracking generator
Harmonic ratio, a_{k2} and a_{k3}
for meter reading ≦ 0 dB . . . . . ≧ 60 dB
Attenuation of nonharmonic spurious frequencies
referred to wanted signal . . . . . ≧ 60 dB

PMG-13 Versions and Options

PMG-13 with channel selector device
For setting to the centre frequency of VFT channels of VFT systems: FM 120, FM 240, FM 480; by setting to the channel number with a selector switch.
Version BN 677/05 . . . . . for 24, 12 and 6 VFT channels
BN 677/06 . . . . . for 28, 14 and 7 VFT channels

Psophometric weighting filter, BN 677/00.21
For measuring noise in frequency range . . 300 Hz to 3.4 kHz
Weighting . . . psophometric, according to CCITT Rec. P. 53
Overload capability
in the measurement ranges – 70 to – 20 dB . . . . . ≧ 40 dB

General Specifications

Power supply
Rated ranges of use for a.c. line voltage, selectable . . . 110/117/127/220/227/237 V, – 12 to +10 %
Rated range of use for a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 38 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Permissible ambient temperature
Rated range of use . . . . . – 10 to +55° C
Storage and transportation . . . . . – 40 to +70° C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	155	Height (3 units)	131
Depth with handles	434	Depth	379

19" conversion kit . . . . . BN 700/00.03

Weight . . . . . approx. 14 kg

Ordering Information

Level Measuring Set PMG-13	**BN 677/04**
Version with channel selector device,	
for 24, 12 and 6 VFT channels	**BN 677/05**
for 28, 14 and 7 VFT channels	**BN 677/06**
Options (at extra cost)	
Psophometric weighting filter complying with CCITT Recs.	BN 677/00.21
Accessories (at extra cost)[2]	
Balanced Attenuator SDG-40	BN 608/00.01
Inverter WR-450	BN 864/00.02
Battery Pack BAK-450	BN 864/00.03
Covers for front and back panel (1 set) SD-3	BN 700/00.23

1) Only with 10 Hz bandwidth. If the bandwidth ist increased there is a proportional increase in the lower frequency limit.
2) See spec. sheet "Measuring Accessories" for data and additional Ordering Information.

SPM-11
Selective Level Meter

with Level Generator PSE-11 for the frequency range 15 Hz to 200 kHz



- **Switchable bandwidths, 8 Hz and 15 Hz**
- **Continuous frequency tuning in one range**
- **Flicker-free digital frequency readout with 1 Hz resolution**
- **High impedance, floating input and Test Probe connector**
- **High sensitivity, full scale deflection at −110 dB (3 μV) input level**
- **Available option with Level Generator PSE-11**
- **PSE-11 facilitates k_2, k_3 and d_2 measurements**
- **Operational functions remote controllable if desired**

Applications

The Selective Level Meter and Harmonic Distortion Analyzer SPM-11 includes a frequency range from 15 Hz to 200 kHz for measurements in the audio frequencies and the lower carrier frequency region. Because of its having switchable bandwidths plus high sensitivity, the SPM-11 is especially suitable for analyzing frequency mixtures and for measuring distortion and mixer products.
If the Level Meter is equipped with Level Generator PSE-11, then a measuring setup exists for selective measurements of gain and attenuation. This instrument combination contains a special device for measuring the distortion (k_2 and k_3) and the difference tone intermodulation (d_2) according to DIN 45 403.
Owing to Measuring Setup SPM-11/PSE-11 having such special features it may be used for a great variety of measurements: in acoustic, electronic, broadcast, telephone and carrier frequency techniques and in analysis of vibration and mechanical resonances.

Characteristics

The SPM-11 tuning frequency may be continuously tuned over one range. A crystal controlled frequency counter displays the tuning frequency with a resolution of 10 Hz or 1 Hz.
The level is read on a large scale analog meter. Besides linear voltage scales calibrated for voltage and dB reading, a linear level scale encompassing 80 dB can be switched in. This large dynamic range is especially advantageous with harmonic ratio measurements because the fundamental and harmonic levels can be read without switching ranges.
The additional section, Level Generator PSE-11, available for the SPM-11, operates as a tracking generator. Thereby, gain and attenuation measurements may be easily and quickly made.
Moreover, the tuning frequency of the level meter, by appropriate push-buttons, can be switched to 2 times or 3 times the generator frequency. This operating mode simplifies measuring the harmonic ratios a_{k_2} and a_{k_3}. And the SPM-11/PSE-11 Measuring Setup is as easily tuned during difference tone intermodulation measurements.

Measuring ranges for 0 dB meter reading	
Input I (100 kΩ)	−110 to +20 dB (3 μV to 10 V)
Input II (1 MΩ)	−90 to +40 dB (30 μV to 100 V)
Scale ranges	−20 to +2 dB/−80 to 0 dB
Send level range adjustable in steps and continuously	
PSE-11	−70 to +12 dB (0.3 mV to 3 V)
Output impedance	5 Ω

Further Features and Applications

Selective Level Meter SPM-11
The *high impedance (bridging) measurement inputs* of the SPM-11 are floating so that ground loops are avoided. Terminations can be plugged in when matched impedance measurements are made. A 10 : 1 Test Probe permits low capacitance access to the measuring signal.
With *semi-automatic calibration,* it is possible to verify at any time the correct absolute level reading on the SPM-11. In order to maintain as small as possible the measuring error introduced by intrinsic noise or intrinsic distortion, the SPM-11 may be operated according to need in either low noise or low distortion measurement mode.
At a *d.c. voltage output,* the measured result is available for instance as the Y drive signal for an Yt-recorder or for further processing in an automatic measuring system.
The SPM-11 is available as either a bench model or a 19" rack mounted model. All coaxial inputs and outputs are equipped with the Universal connector, Versacon® 9, which allows use of all commercially available connector types.

Level Generator PSE-11
The *frequency setting and display* are implemented for the generator and the receiver in common on the SPM-11. For k_2, k_3, and d_2 measurements the Level Meter is switched by push-button switches that select the appropriate tuning frequency. Owing to the generator having such a high intrinsic distortion ratio, an extra filter is not required for these measurements.
If the measurement task at hand demands an exceptionally constant send level over the frequency band, then automatic level control is possible. For this purpose the *EPM-1 Milliwatt Power Meter* (see EPM-1 Specification Leaflet) is particularly suitable as an automatic level controller.

External Control
The SPM-11 Selective Level Meter and the PSE-11 Tracking Generator operate according to the heterodyne frequency and the beat frequency principles. The frequency of the measuring setup, therefore, can be tuned by means of an externally applied *carrier frequency.* But a separate input connector, however, allows the send frequency alone to be externally controlled.

Swept Frequency Measurements
By the feeding in of a sweepable carrier frequency via the external tuning input, the SPM-11/PSE-11 is extended to become a *sweep measuring setup.* Thereupon, curves of attenuation and distortion-ratio variations with frequency can be measured.
The *SPMZ-111 Sweep and Balancing Attachment* incorporates a suitable sweep device. It produces a one-time sweep between pre-selectable limits in the voice and sound-programme frequency band. The resulting frequency response curves may be plotted on an X-Y recorder that can be connected. As a result of the exponential frequency sweep, the recording paper is divided in a logarithmic frequency scale. In the 5 kHz to 200 kHz range a linear sweep between any limits can be chosen.

Balanced Measurements
The *Balancing Attachment SPMZ-110* or *SPMZ-111* complements the SPM-11/PSE-11 so that the combination is applicable for telecommunications where balanced test points are accessed for measurements. The impedances for the send and receive sections are switch selectable for all the usual values. Also the impedances, 200 Ω and 300 Ω, are provided; since these are usually used in audio studios and with sound-programme equipment.
Continuous monitoring of a test signal, e.g. a pilot level, is supported by the *AFC circuit.*
Furthermore, the Balancing Attachment SPMZ-111 contains a sweep device and a *send level amplifier.* The latter device supplies gain to the send signal, so +26 dB level max. is thus made available for distortion ratio measurements as found in sound-programme transmission technology.

Specifications of Selective Level Meter with Level Generator — SPM-11/PSE-11

Unless otherwise noted, the specifications are valid for the rated ranges of use of the ambient temperature, the a.c. line voltage, and the a.c. line frequency.

Receiver SPM-11

Measurement inputs
The point of zero potential is separable from the chassis.
Capacity between point of zero potential (measurement ground) and chassis . . . . . approx. 1.5 nF
Input I, unbalanced* . . . . Universal connector Versacon® 9 parallel 3 pole CF connector
Input impedance . . . . . 100 kΩ ‖ 50 pF
Input II, unbalanced* . . . . Universal connector Versacon® 9
Input impedance . . . . . 1 MΩ ‖ 30 pF
(suitable for connecting to test probe)

Frequency tuning
Frequency range . . . . . 15 Hz to 200 kHz
Frequency tuning . . continuously tunable over complete range

Frequency readout . . . through frequency counter with 5 digit, flicker-free incandescent numerals, with overflow indicator

Frequency resolution, switchable . . . . . 10 Hz or 1 Hz
External tuning and sweep facility

Level indicator

Measurement ranges for 0 dB meter reading
Switchable in steps of . . . . . 10 dB
Input I (100 kΩ) . . . . . −110, −100, ..., +20 dB
3 μV, 10 μV, ..., 10 V
Input II (1 MΩ) . . . . . −90, −80, ..., +40 dB
30 μV, 100 μV, ..., 100 V

Instrument scales, switchable
Voltage linear scale ranges . . . . . −20 dB to +2 dB
0 to 3 V/0 to 10 V
Level linear scale range . . . . . −80 dB to 0 dB

Drive signal for the voltage linear scale ranges switchable in 3 steps between low noise, average and low distortion
Time constant of meter, switchable . . . . . slow/fast

Calibration, semi-automatic
Voltage level . . . . . 0 dB ≅ 0.775 V
Setting range for gain . . . . . coarse approx. ±6 dB
fine approx. ±0.8 dB

Error limits

Frequency reading . . . . . $\pm 5 \times 10^{-6} \pm 1$ digit of the last displayed place

Input level reading,
after calibration at the utilized bandwidth
Error limits of level reading in measurement range 0 dB at 0 dB reading and at f = 1 kHz

	Input I	Input II
Voltage linear scale range	±0.1 dB	±0.3 dB
Level linear scale range	±0.5 dB	±0.7 dB

Error limits of measurement range switch at f = 1 kHz . . . . . ±0.1 dB

Error limits of variation with frequency referred to f = 1 kHz in all level measuring ranges and drive-signal stages

	Input I	Input II
in frequency range		
50 Hz to 110 kHz	±0.1 dB	±0.3 dB
20 Hz to 200 kHz	±0.2 dB	±0.3 dB
15 Hz to 200 kHz	±0.35 dB	±0.35 dB

Error limits of meter scale divisions, referred to scale mark 0 dB
Voltage linear scale ranges . . . . . ±1 % f.s.d.
Level linear scale ranges 0 to −60 dB . . . . . ±1.5 dB
−60 dB to −80 dB . . . . . ±2.5 dB

Selectivity
Switch-selectable bandwidths

Narrow
Frequency range . . . . . 15 Hz to 200 kHz
3 dB bandwidth . . . . . 8 Hz
Equivalent noise bandwidth . . . . . approx. 6 Hz
Bandstop at Δf = ± ≧ 22 Hz . . . . . ≧60 dB

Wide
Frequency range . . . . . 200 Hz to 200 kHz
3 dB bandwidth . . . . . 40 Hz
Equivalent noise bandwidth . . . . . approx. 30 Hz
Bandstop at Δf = ± ≧150 Hz . . . . . ≧60 dB

IF rejection (200 Hz and 400 kHz) . . . . . ≧80 dB

Image frequency suppression
Tuning frequency plus 800 kHz . . . . . ≧80 dB
Tuning frequency minus 400 Hz . . . . . ≧70 dB

Self-introduced distortion and noise

Intrinsic harmonic ratio, a_{k_2} and a_{k_3}
With tuning at receiver . . . . . ≧80 dB
With tuning by k_2 and k_3 push-buttons on PSE-11 . . . ≧70 dB

Intermodulation product ratio, a_{d_2}
according to DIN 45 403 . . . . . ≧80 dB

These values are valid in voltage linear range with drive signal "low distortion" and a 60 dB raise in sensitivity compared to total level, in level linear range for total level ≦0 dB, in both cases at any setting of calibration potentiometer.

Intrinsic noise level, referred to the input
Input I terminated with 1 kΩ, connecting link between measurement ground and chassisc, drive signal, "low noise".
Noise and carrier leak:
Bandwidth 40 Hz, f ≧ 500 Hz . . . . . ≦−130 dB
8 Hz, f ≧ 500 Hz . . . . . ≦−135 dB
8 Hz, f ≧ 30 Hz . . . . . ≦−125 dB

Option, Level Generator PSE-11

Generator output*
Unbalanced, short-circuit proof . . . . . Universal connector Versacon® 9, parallel 3 pole connector
Output impedance . . . . . 5 Ω
Permissible load impedance . . . . . ≧75 Ω
Generator blanking via switch

Frequency range . . . . . 15 Hz to 200 kHz
Frequency tuning and reading at receiver, tuning possible in common with SPM-11 or separated

Send level

Level ranges for 0 dB meter reading . . . . . −50 dB to +10 dB
3 mV to +3 V
adjustable in steps of . . . . . 10 dB
additionally continuously adjustable . . . . −20 dB to +2 dB

Reading of send level (open circuit voltage) via push-button for receiver meter

Error limits

Error limits of frequency display
(after synchronization with SPM-11
at 8 Hz bandwidth) . . . . . $\pm 5 \times 10^{-6} \pm 2$ Hz ± 1 unit of the last displayed digit

Total error of level reading
Error limits of send level reading
for meter readings −10 dB to +2 dB . . . . . ±0.5 dB

Individual errors of level reading
Error limits of send level reading in level range 0 dB, at 0 dB reading on meter and at f = 1 kHz . . . . . ±0.2 dB

Error limits of level range attenuator
at f = 1 kHz and $Z_L \geqq 150\,\Omega$ . . . . . ±0.1 dB

Variation of frequency with real load impedance
and constant meter reading . . . . . ±0.2 dB
Temperature coefficient of
generator output voltage referred to +23°C . . . . ±0.01 dB/K

Impairment voltages at generator output

Self-introduced harmonic ratio and intermodulation product ratio, a_{k_2}, a_{k_3}, a_{d_2}, according to DIN 45 403
at output voltages ≦0 dB . . . . . ≧80 dB
at output voltages >0 dB . . . . . ≧70 dB

Signal-to-inharmonic noise ratio
in frequency range 15 Hz to 200 kHz from wanted signal,
in the level ranges −30 dB to +10 dB
at meter reading +2 dB to −2 dB . . . . . ≧80 dB
at meter reading −2 dB to −10 dB . . . . . ≧70 dB

Measuring Device for Harmonic Ratios (k_2, k_3) and Difference Frequency Intermodulation Ratio (d_2)

k_2 and k_3 measurements according to DIN 45 403
The frequency tuning of receiver SPM-11 is switchable from
the fundamental frequency f to . . . . . 2f and 3f

Frequency range of fundamental frequency f
for k_2 measurements . . . . . 30 Hz to 99 kHz
for k_3 measurements . . . . . 15 Hz to 66 kHz

d_2 measurements according to DIN 45 403
The send signal from the PSE-11 in this operating mode
comprises two frequencies . . . . . f and f −200 Hz
The Receiver is fixed tuned to . . . . . 200 Hz
Frequency range for d_2 measurement . . . 800 Hz to 200 kHz

Auxiliary outputs and inputs

IF output*
unbalanced . . . . . Universal connector Versacon® 9
outer conductor is connected to measuring ground
Output impedance . . . . . 600 Ω
Output level at meter reading 0 dB
and $Z_L = Z_{out} = 600\,\Omega$ . . . . . approx. 0 dB

D.C. voltage output,
unbalanced . . . . . 2 banana jacks
one side connected to measuring ground
Output impedance . . . . . 5 kΩ
Output open circuit voltage at f.s.d. . . . . +5 V

Inputs for external tuning*
unbalanced . . . . . Universal connector Versacon® 9
Permissible level . . . . . −10 dB to +10 dB
Input impedance . . . . . 75 Ω

When the 4 MHz to 6 MHz control frequency is applied, the SPM-11 switches itself to external tuning mode.
Through one input, both the SPM-11 and the PSE-11 are externally tuned in common, but through the other input, only the PSE-11 is externally tuned.

Additional connection
for external supplementary devices: e.g. for increasing the meter time constant, for fine tuning the internal tuning frequency etc.

Connection for stabilizing
the send level through the Milliwatt Test Set EPM-1

General Specifications

Power supply
Rated range of use of a.c. line voltage,
selectable . . . . . 110/117/127/220/227/237 V
for SPM-11 . . . . . each −15 to +10 %
for SPM-11 with PSE-11 . . . . . each −12 to +10 %
Rated range of use of a.c. line frequency . . . . . 45 to 66 Hz
Power consumption: SPM-11 . . . . . approx. 45 VA
SPM-11 with PSE-11 . . . approx. 60 VA
Safety class according to IEC 348 and VDE 0411 . . . . Class I

Permissible ambient temperature
Rated range of use . . . . . +5 to +40°C
Storage and transport . . . . . −40 to +70°C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	478	Width	443
Height overall	155	Height (3 units)	132
Depth with handles	407	Depth	353

19" conversion kit . . . . . BN 556/00.03

Weight SPM-11 . . . . . 12.5 kg
SPM-11 with PSE-11 . . . . . 14 kg

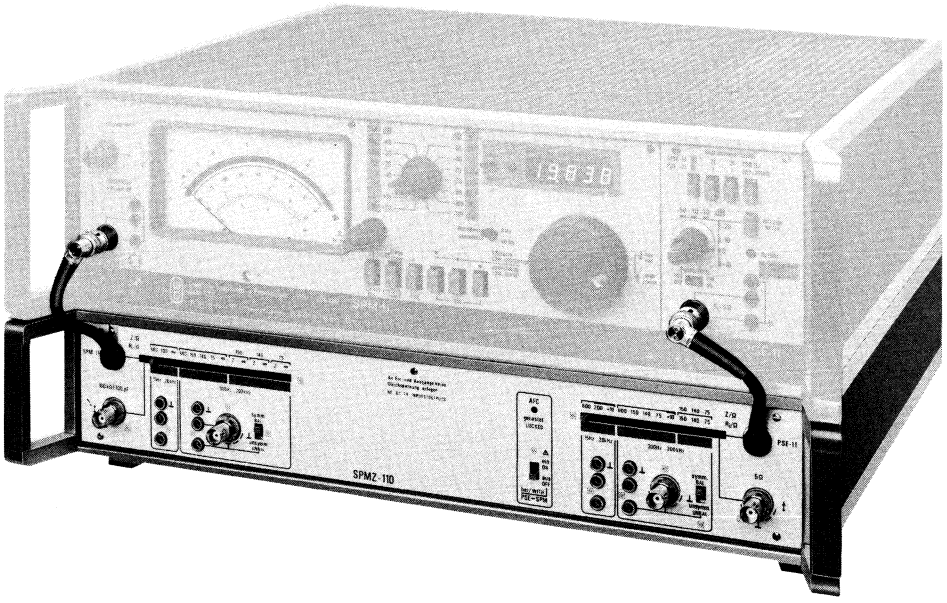
Ordering Information

Selective Level Meter SPM-11 *	**BN 604/00**
Option (at extra cost)	
Level Generator PSE-11*	BN 628/00
Augmentation (at extra cost)	
Balancing Attachment SPMZ-110 [1)]	BN 613/01
Sweep and Balancing Attachment SPMZ-111 [1)]	BN 860/01
Accessory (at extra cost)	
Transport Protection Cover for SPM-11, DE-2	BN 476/00.02

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.
1) See Specification Leaflet SPMZ-110/SPMZ-111 for technical specifications.

SPMZ-110, SPMZ-111
Balancing Attachment

for the SPM-11 Selective Level Meter with PSE-11 Send Section



- **Balanced input and output sections**
- **All usual impedances for balanced telecommunications technology, special impedances for broadcast-studio measuring techniques**
- **AFC permits permanent monitoring of a test signal**
- **SPMZ-111 with sweep attachment output for X-Y recorder to chart frequency responses**
- **SPMZ-111 with send level amplifier for up to +26 dB**

Applications

The measurement of distortion products is one of the most important measuring problems involved in sound-programme and audio-studio measuring technology. At present, the high demands placed on modern studio equipment are even more demanding of the measuring instruments used for the testing and maintenance of that type of high quality equipment.
The *SPM-11 Selective Level Meter and Distortion Analyzer* is a precision measuring instrument for applications in studios, acoustics and general electronics. In combination with the *PSE-11 Send Section,* it forms a measuring set which permits not just selective gain and loss measurements but also, through an especially simple method, harmonic ratio measurements.
A worthwhile complement for the SPM-11/PSE-11 Measuring Setup is available with the SPMZ-110 or SPMZ-111 Balancing Attachment. Thus, the combination of basic measuring setup plus the SPMZ-110 or SPMZ-111 permits many interesting applications to be offered in the fields of telecommunications and sound-programme techniques using balanced lines. Continuous surveillance of a test signal, e.g. a pilot, is made possible by the AFC circuit.

The sweep device in the SPMZ-111 allows an output to an X-Y recorder for plotting the curves of the attenuation or harmonic distortion variation with frequency.

Characteristics

To perform these measuring tasks, the SPMZ-111 is equipped with input and output transformers for matching the balanced system under test to the unbalanced inputs and outputs of the basic instrument, the SPM-11/PSE-11. In addition to using the transformers as baluns, they have the function of level correction at the changeover from voltage level to power level calibration.
For universal application, the Balancing Attachment is fitted with all the impedances usually used in telecommunications and especially those usually found in studio and sound-programme technology.
A balanced amplifier output of the SPMZ-111 permits the raising of the send signal to a maximum level of +26 dB for harmonic distortion measurements in sound-programme transmission techniques. As shown in the photograph the Balancing Attachment and the Basic Instrument are linked to form a unit.

Balanced Inputs and Outputs	
Input I	15 Hz to 20 kHz
Input impedance	300 Ω, 600 Ω, ≈50 kΩ
Input II	300 Hz to 200 kHz
Input impedance	75 Ω, 140 Ω, 150 Ω, 600 Ω, ≈12 kΩ
Output I	15 Hz to 20 kHz
Output impedance	600 Ω, 200 Ω, ≈10 Ω
Output II	300 Hz to 200 kHz
Output impedance	600 Ω, 150 Ω, 140 Ω, 75 Ω, ≈10 Ω

Further Characteristics and Applications

Inputs and outputs of the SPMZ-110 or SPMZ-111

The input and output sections of the SPMZ-110 and SPMZ-111 are for the audio frequency range 15 Hz to 20 kHz and the frequency range 300 Hz to 200 kHz.
Applications in the audio frequency range are provided for with 600 Ω impedance, and for use with studio measurements, 200 Ω sender impedance and 300 Ω receiver impedance are also available. The inputs and outputs in the 300 Hz to 200 kHz band permit changeover from voltage to power level calibration with the 600 Ω, 150 Ω, 140 Ω and 75 Ω impedances. Furthermore, the sender output can be switched to low impedance (≈10 Ω), and the receiver input to high impedance for bridging measurements.
Direct connection of an unbalanced system under test to the SPM-11/PSE-11 basic instrument is done through separate inputs and outputs.

Features of the SPMZ-111 Sweep and Balancing Attachment

Send level amplifier

The balanced output for the audio frequency range, 15 Hz to 20 kHz, is fed out as an amplifier output. It has switchable gains of −20 dB, 0 dB and +20 dB. Thereby, the send level of the PSE-11 can be raised to +26 dB max., which is used for harmonic ratio measurements in sound-programme technology. In order to avoid overloading the amplifier, especially important during harmonic distortion measurements, the input level is monitored by an overload warning lamp.

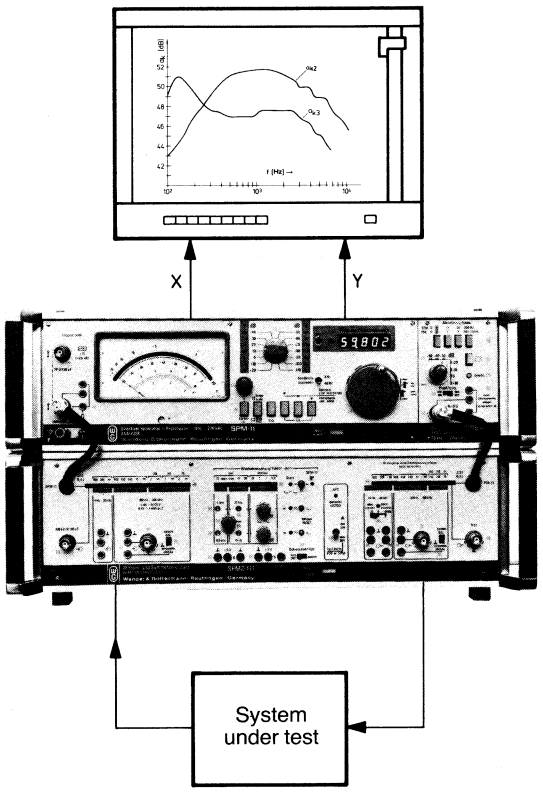
Sweep frequency device

The SPMZ-111 contains a sweep frequency device for extending the SPM-11/PSE-11 Level Measuring Setup so that it becomes a swept frequency measuring setup. This equipment combination permits fast and easy frequency response measurements that can be recorded by a connected X-Y recorder.
Thus for instance AF amplifier gain can be plotted gap-free over the frequency band. Examples of applications in the design and testing of Hi-Fi sub-assemblies are the frequency response curves of cutter characteristics, equalizer-preamplifiers, tone controls, rumble and noise filters and so on.
Within the voice and audio frequency band (sound-programme band) a one-shot sweep takes place between preselected limits. The frequency run is exponential, so the frequency scale on the recorder paper is accordingly logarithmic. No transient response problems occur because the sweep rates are matched to the narrow bandwidth of the SPM-11 and the plotting operation. Furthermore, the frequency can also be tuned manually by means of a 10 turn helical potentiometer. During the setting of the sweep limits, the SPM-11 displays the set-up frequencies. Therefore, the frequencies can be transferred to the recording paper at high accuracy. The sweep is linear in the frequency range, 5 kHz to 200 kHz.
Besides the level and frequency proportional deflection signals provided by the SPM-11, it furnishes a pen-lift signal for the plotter.
Periodic sweeping is implemented by a plug-in adaptor, available as an accessory, that automatically starts a new sweep immediately after a one-shot sweep has taken place.

Distortion ratio measurements

Nonlinear distortions in telecommunications or broadcast technology are measured according to methods that determine the harmonic distortion factor or else the intermodulation distortion products. The SPM-11/PSE-11 Measuring Setup is particularly suitable for both measuring methods.

Frequency response curves of harmonic ratios, a_{k_2} and a_{k_3}



Sweep Measuring Setup with SPM-11/PSE-11, SPMZ-111 and X-Y recorder

For distortion ratio measurements, the Level Meter, by means of push-button selection, is tuned to the second or third multiple of the send frequency. Thereupon, the a_{k_2} and a_{k_3} distortion ratio values are indicated direct.
But in audio-studio and broadcast technologies the harmonics (k_2, k_3) do not disturb as much as the sum and difference tones that form discordant sounds that degrade the quality. So the Measuring Setup is equipped for the difference tone measuring method by having special functions: the send section supplies two tones, separated by 200 Hz. If an item under test has a nonlinear transfer characteristic its output signal contains the 200 Hz difference frequency to which the SPM-11 is permanently tuned. At the measuring meter, therefore, the difference tone ratio a_{d_2} is indicated direct.
Also the frequency response of the distortion ratios a_{k_2}, a_{k_3}, and a_{d_2} can be measured in one sweep. Plotting the measured results on an X-Y recorder provides a decided advantage in this case because strong nonlinear distortions appear occasionally within narrower frequency bands. Manual measurements tend to allow these points to be easily overlooked.

Specifications of Balancing Attachment — SPMZ-110, SPMZ-111

These specifications are intended as supplementary to the SPM-11/PSE-11. And only those characteristics newly arrived at by means of the SPMZ-110 or SPMZ-111 are specified in this sheet. However, the error limits given are stated for all combinations of these instruments.

Measuring inputs

Input I, balanced, floating . . . . . 3 pole CF connector
Frequency range . . . . . 15 Hz to 20 kHz
Input impedance,
switchable . . . . . 300 Ω, 600 Ω, 50 kΩ ‖ 140 H ‖ 700 pF
Permissible input voltage . . . . . $V_{r.m.s.} \leqq 20$ V
Calibration . . . . . voltage level (0 dB ≅ 0.775 V)

Error limits of frequency response referred to 1 kHz:
with a source impedance $Z_s \leqq 600\ \Omega$,
input impedance $Z_{in} = 600\ \Omega$
or else $Z_s \leqq 300\ \Omega$, $Z_{in} = 300\ \Omega$ or bridging,
in frequency range: 100 Hz to 4 kHz . . . . . ± 0.1 dB
40 Hz to 16 kHz . . . . . ± 0.2 dB
15 Hz to 20 kHz . . . . . ± 0.4 dB

Intrinsic harmonic ratio [1] a_{k_2} and a_{k_3}
with $Z_s \leqq 600\ \Omega$, $Z_{in} = 600\ \Omega$
or else $Z_s \leqq 300\ \Omega$, $Z_{in} = 300\ \Omega$ or bridging

Tuning	at SPM-11		with k_2 and k_3 push-buttons on PSE-11	
Summed level / Frequency	≦0 dB	≦+20 dB	≦0 dB	≦+20 dB
100 Hz to 20 kHz	≧75 dB	≧75 dB	≧68 dB	≧67 dB
40 Hz to 20 kHz	≧70 dB	≧60 dB	≧67 dB	≧60 dB
k_2: 30 Hz to 20 kHz k_3: 15 Hz to 20 kHz	≧60 dB	≧50 dB	≧60 dB	≧50 dB

Signal balance ratio [2]
with $Z_s = Z_{in} = 600\ \Omega$,
in frequency range 15 Hz to 20 kHz . . . . . ≧ 60 dB

Input II, selectable
balanced, floating/unbalanced* . . . . . 3pole CF connector
parallel Universal Connector Versacon® 9
Frequency range . . . . . 300 Hz to 200 kHz
Input impedance,
switchable . . . . . 600 Ω, 150 Ω, 140 Ω, 75 Ω,
and 12 kΩ ‖ 2 H ‖ 900 pF
Permissible input voltage . . . . . $V_{r.m.s.} \leqq 10$ V
Calibration, switchable . . . . . voltage level (0 dB ≅ 0.775 V)
power level (0 dBm ≅ 1 mW in Z_o)
Additional error of level reading . . . . . ± 0.05 dB [3]

Error limits of frequency response
referred to 1 kHz with $Z_s = Z_{in} = Z_o$

Level calibration	dB	dB	dBm
Z_{in} / Frequency	600 Ω	150 Ω, 140 Ω, 75 Ω	
1 kHz to 110 kHz	±0.15 dB		±0.2 dB
300 Hz to 200 kHz	±0.3 dB		

Intrinsic harmonic ratio [1] a_{k_2} and a_{k_3}
with $Z_s = Z_{in} = Z_o$
or else $Z_s \leqq Z_o/2$ and Z_{in} = bridging (high impedance)

Tuning	at SPM-11		with k_2 and k_3 push-buttons at PSE-11	
Summed level / Frequency	≦0 dB	≦+20 dB	≦0 dB	≦+20 dB
1 kHz to 200 kHz	≧70 dB	≧60 dB	≧67 dB	≧60 dB
300 Hz to 200 kHz	≧60 dB [4]	approx. 40 dB	≧60 dB [4]	approx. 40 dB

Signal balance ratio [2]
in frequency range 300 Hz to 200 kHz . . . . . ≧ 40 dB

Input III* . . . . . Universal connector Versacon® 9
direct connection to SPM-11 measuring input
Input impedance . . . . . 100 kΩ ‖ 100 pF

Sender outputs

Output I, balanced, floating
SPMZ-110 . . . . . 3 pole CF connector
SPMZ-111 . . . . . 2 parallel 3 pole CF connectors
Frequency range . . . . . 15 Hz to 20 kHz
Output impedance, switchable . . . . . 600 Ω, 200 Ω, ≈ 10 Ω
SPMZ-111 only:
Gain of PSE-11 send level,
switch-selectable . . . . . −20 dB, 0, +20 dB
Max. output level . . . . . +26 dB
Additional error of send level reading . . . . . ±0.05 dB [5]

Error limits of frequency response, referred to 1 kHz
with real load impedance, $Z_L = Z_{source} = 600\ \Omega$
with SPMZ-110: $Z_L \geqq 150\ \Omega$, $Z_s = 200\ \Omega$ or $\approx 10\ \Omega$
with SPMZ-111: $Z_L \geqq 100\ \Omega$ [6], $Z_s = 200\ \Omega$
or $Z_L \geqq 300\ \Omega$, $Z_s \approx 10\ \Omega$,
in frequency range 100 Hz to 4 kHz . . . . . ±0.15 dB
40 Hz to 20 kHz . . . . . ±0.25 dB
15 Hz to 20 kHz . . . . . ±0.40 dB

Intrinsic harmonic ratio a_{k_2} and a_{k_3}
with real load impedance $Z_L = Z_s = 600\ \Omega$
with SPMZ-110: $Z_L \geqq 150\ \Omega$, $Z_s \approx 10\ \Omega$, output level ≦ 0 dB
in frequency range 300 Hz to 20 kHz . . . . . ≧70 dB
40 Hz to 20 kHz . . . . . ≧60 dB
with SPMZ-111: $Z_L > 100\ \Omega$ [6], $Z_s = 200\ \Omega$ or $Z_L \geqq 300\ \Omega$,
$Z_s \approx 10\ \Omega$, output level ≦ +20 dB
in frequency range 100 Hz to 20 kHz . . . . . ≧70 dB
40 Hz to 20 kHz . . . . . ≧65 dB
15 Hz to 20 kHz . . . . . ≧60 dB

Signal balance ratio [2]
in frequency range 15 Hz to 20 kHz . . . . . ≧60 dB

Output II, selectable:
balanced, floating/unbalanced* . . . . . 3 pole CF connector in parallel Universal Connector Versacon® 9
Frequency range . . . . . 300 Hz to 200 kHz
Output impedance,
switchable . . . . . 600 Ω, 150 Ω, 140 Ω, 75 Ω, ≈10 Ω
Calibration, switchable . . . . . voltage level (0 dB ≙0.775 V)
power level (0 dBm ≙1 mW in Z_o)
Additional error of send level reading
at $Z_L = Z_{out} = Z_o$,
or $Z_L = \infty$ and $Z_{out} \approx 10\ \Omega$ . . . . . ±0.05 dB[4)]

Error limits of frequency response referred to f = 1 kHz
with real load impedance $Z_L = Z_{out} = Z_o$ or $Z_L \geqq 150\ \Omega$
and $Z_{out} \approx 10\ \Omega$
in frequency range 1 kHz to 110 kHz . . . . . ±0.25 dB
300 Hz to 200 kHz . . . . . ±0.40 dB

Intrinsic harmonic ratio a_{k_2} and a_{k_3}
with real load $Z_L = Z_{out} = Z_o$ or $Z_L \geqq 150\ \Omega$, $Z_{out} \approx 10\ \Omega$,
output level ≦+10 dB
in frequency range 300 Hz to 200 kHz . . . . . ≧65 dB
1 kHz to 200 kHz . . . . . ≧70 dB

Signal balance ratio[2)]
in frequency range 300 Hz to 200 kHz . . . . . ≧40 dB

Output III* . . . . . Universal Connector Versacon® 9 direct connection to PSE-11 output

Automatic Frequency Control (AFC)
effective with the two receiver filter bandwidths
Frequency capture range . . . . . approx. ±9 Hz from filter's center frequency

Frequency locking range
with tuning frequency ≦1 kHz . . . . . ±150 Hz
200 kHz . . . . . ±500 Hz

Required level
referred to 0 dB meter reading . . . . . −20 to +2 dB

Sweep Attachment for X-Y recorder operation
(with SPMZ-111 only)
Sweep limits display
f_{min}, f_{max} . . . . . SPM-11 frequency display
Sweep . . . . . one time $f_{min} \rightarrow f_{max}$
Manual sweep . . . . . 10 turn helical potentiometer

Sweep range	I voice-grade channel 200 Hz to 4 kHz	II Sound-progr. channel 15 Hz to 20 kHz	III 5 kHz to 200 kHz
Sweep limits: range for f_{min} range for f_{max}	 200 Hz to 300 Hz 3 kHz to 4 kHz	 15 Hz to 40 Hz 15 kHz to 20 kHz	($f_{min} < f_{max}$) 5 kHz to 200 kHz 5 kHz to 200 kHz
Time function of freq. sweep Sweep time, switchable Sweep rate	Exponential 10 s	Exponential 10 s, 30 s	Linear 0.3, 1, 3, 10 kHz/s

Output for X deflection voltage
Output impedance . . . . . 5 kΩ
Output voltage over the frequency band
in sweep ranges I and II . . . . . log., 0 to approx. +5 V
in sweep range III . . . linear, approx. 0.25 V/10 kHz deviation

Output for Y deflection voltage
Output impedance . . . . . 5 kΩ
Output voltage proportional to
SPM-11 meter reading . . . . . max. approx. +5 V

Pen-lift control floating

Adaptor "Periodic Sweep" (for SPMZ-111 only)
Sweep, switchable . . . . . periodic or one-shot $f_{min} \rightarrow f_{max}$

General Specifications

Power supply
SPMZ-110 . . . . . via connecting cable from SPM-11
SPMZ-111, a.c. line voltage . 110/117/127/220/227/237 V
Power consumption . . . . . 36 VA

Tolerable ambient
temperature . . . . . as with SPM-1/PSE-11

Dimensions (SPMZ-110/SPMZ-111) in mm

Bench model		19" rack mounting (DIN 41494)	
With with handles	478	Width	443
Height overall	110/155	Height	87/132
Depth with handles	407	Depth	353

19" conversion kit . . . . . BN 556/00.02/BN 556/00.03

Weight, SPMZ-110/SPMZ-111 . . . . . 7.5 kg/14 kg

Ordering Information

Balancing Attachment SPMZ-110*	**BN 613/01**
Sweep and Balancing Attachment SPMZ-111	**BN 860/01**
Connection cable to SPM-11 (contained in standard package)	
for SPMZ-110	K 200
for SPMZ-111	K 197 and K 200
Accessories (at extra cost)	
Adaptor for periodic sweep (for SPMZ-111 only)	BN 860/00.01
Protective Transportation Cover	
common for SPM-11/SPMZ-110, DE-23	BN 476/00.07
SPM-11/SPMZ-111, DE-33	BN 476/00.08

1) Margin conditions referred to drive signal and increased sensitivity corresponding to SPM-11 specifications
2) Measurement according to CCITT O.121
3) This error must be added to the error limit of the level reading in the 0 dB measuring range at 0 dB reading and at f = 1 kHz (see SPM-11 specifications)
4) ≧50 dB at $Z_s = Z_{in} = 600\ \Omega$
5) This error must be added to the error limit of the send level reading in level range 0 dB at 0 dB reading and at f = 1 kHz (see PSE-11 specifications)
6) The output level is orientated towards the relevant selected load impedance Z_L
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

NFA-1
Audio Analyzer

for a wide range of measuring tasks in the frequency range 15 Hz to 200 kHz

IEEE 488
IEC 625



- **Easy measurement of:**
  - **Wideband and selective level, level difference and gain measurements using selectable bandwidths**
  - **Frequency, frequency shift (also using a reference)**
  - **Phase difference between the NFA-1's inputs**
  - **Nonlinear distortions (harmonic distortion, difference frequency distortion)**
  - **Weighted and unweighted noise to CCITT or CCIR recs.**
  - **Wow and flutter to DIN, IEC, NAB and JIS**
  - **Run-up time to DIN and NAB**
- **Balanced and floating paired inputs and outputs for measurements on stereo equipment**
- **User-friendly operation through:**
  - **Menu-driven operation**
  - **Up to 49 setups can be stored in non-volatile memory**

Applications

Audio equipment, i.e. devices or subassemblies that transmit, process or record audio signals, give rise to a wide range of measuring tasks.
The NFA-1, with all its measuring capabilities, can easily handle any measuring task of this kind. The transfer constant and transfer angle of four terminal networks can be measured as a function of frequency or level.
Nonlinear distortions can be expressed in terms of the harmonic ratio for a single harmonic, as the total harmonic ratio or determined using the difference tone method.

Two channel devices are connected to both the input and output of the NFA-1: the level difference, gain difference, phase difference and also the crosstalk attenuation are determined automatically.
This means that the NFA-1 is a useful aid for development, production, installation, maintenance and testing of audio and similar equipment.

Characteristics

Even complex measurement procedures are easy to carry out because the NFA-1 is ergonomically designed and for the most part automatically controlled.
More than 30 measurement modes have standard settings which can be called up by the user. To make operation even more easy any front panel setup can be stored. The memory contents are not lost when the NFA-1 is disconnected from the a.c. line.

Frequency range	
Level meter, frequency meter	15 Hz to 200 kHz
Level generator	15 Hz to 60 kHz
Phase difference meter	15 Hz to 20 kHz
Level measuring range	
selective	−135 to +30 dB
wideband	−115 to +30 dB
Transmission level range	
Single-tone signal	−77 to +26 dB
Two-tone signal	−83 to +20 dB
Seventeen-tone signal	−94 to +8 dB

A screen is provided as a display and allows dialog between the operator and NFA-1. The results are displayed in an alphanumeric form or as a graph with frequency, level or time along the X-axis.
As well as a selective and wideband receive section the NFA-1 has a generator section to generate a variety of signal forms, a frequency meter and a phase meter. Depending on the operating mode selected, the synthesiser controlled generator and receive sections can have separate or common tuning. Signals for difference frequency measurements and a multifrequency signal intended for overview measurements on the variation of attenuation with frequency are produced in the generator section. Because of the NFA-1's high harmonic ratio, extra filters are not required for distortion factor or difference frequency distortion measurements.

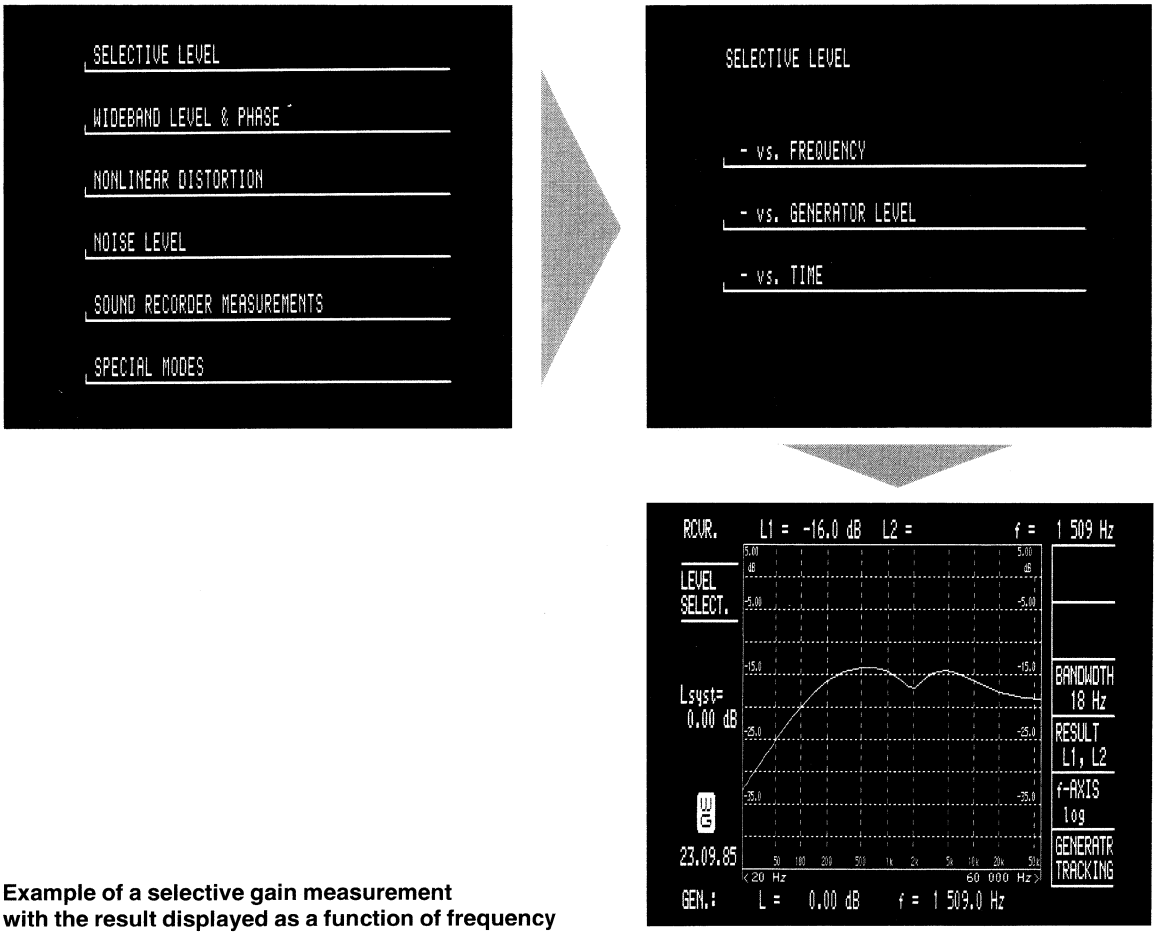
Further applications and characteristics

- When carrying out end-to-end measurements, a special sweep routine is used to perform automated, selective and wideband frequency response measurements without a synchronising connection. Overview measurements giving the variation in attenuation with frequency – whether manual or automated – can be executed quickly and easily using this arrangement.

- An option (also retrofittable) gives the NFA-1 the capability to measure, in accordance with all common standards, wow and flutter, run-up time, and rumble etc. of tape recorders and record players.
  It is therefore possible to carry out complete checks on *sound recorders* of this kind with a single instrument.

- The NFA-1 can perform wideband and selective measurements up to 200 kHz on all types of sources (if required an external filter can be looped in). An option can be used to measure weighted or unweighted noise to various standards.

- The "<IEC 625>/IEEE 488 Interface Bus" option makes the remote control of all the NFA-1's functions via an external computer possible. Moreover, all measured values can be interrogated via this interface which complies with international standards. The user can, therefore, choose the type of data evaluation he wants e.g. comparison with reference values or classification.



Example of a selective gain measurement with the result displayed as a function of frequency

Unless otherwise stated, the data given are valid for the nominal operating ranges of a.c. line voltage, a.c. line frequency and ambient temperature.

Generator section

The level limits given below apply to outputs 1 and 2.
The limits are 6 dB lower for output 3.

Outputs

Balanced output 1 and 2 . . . . . floating, 3 pole CF connectors
Signal balance ratio (transmission level ≧ −19 dB, Z_{out} = 150 Ω or 600 Ω), 15 Hz to 20 kHz (60 kHz) . . . . . ≧60 dB (≧40 dB)

Coaxial output* 3

Output impedance, switchable . . . . 150, 200 and 600 Ω and 10 Ω (balanced) or 5 Ω (coaxial)

Sinusoidal signals

Transmission frequency, set via keypad, in steps via up/down keys, quasi-analog setting using knob.
Frequency range . . . . . 15 Hz to 60 kHz
Smallest step to 20 kHz . . . . . 0.5 Hz
>20 kHz to 60 kHz . . . . . 30 Hz

Intrinsic harmonic ratio (2nd and 3rd order), levels ≦0 dB
15 Hz to 20 kHz . . . . . ≧80 dB
15 Hz to 60 kHz . . . . . ≧70 dB
Level range . . . . . −77 to +26 dB

Two-tone signal

Frequency range . . . . . 30 Hz to 20 kHz
Smallest frequency step . . . . . 10 Hz
Frequency separation, in steps of 10 Hz . . . 20 Hz to 10 kHz
Difference frequency attenuation, levels ≦0 dB . . . ≧80 dB
Level range . . . . . −83 to +20 dB

Multitone signal

The following frequencies are output simultaneously:

31.5 Hz	40 Hz	63 Hz	125 Hz	250 Hz	315 Hz	500 Hz	1 kHz	2 kHz
4 kHz	6.3 kHz	8 kHz	10 kHz	12.5 kHz	14 kHz	16 kHz	18 kHz	—

Level range . . . . . −94 to +8 dB
The level of each tone can be set and displayed separately.
The rms value of the total level is also displayed.

Transmission level

Entry via keyboard or in steps via increment keys
Smallest level step . . . . . 0.01 dB

Level blanking
Outputs 1 and 2 can be blanked separately.
Blanking attenuation . . . . . ≧80 dB
Separation between output channel 1 and 2
levels ≧ −60 dB . . . . . ≧65 dB
≧ −13 dB . . . . . ≧100 dB

Error limits of the transmission level
Frequency response error limits, levels ≧ −60 dB, referred to 1 kHz . . . . . ±0.15 dB
Total error . . . . . ±0.25 dB

Receive section

Inputs

Balanced inputs 1 and 2 . . . . . floating, 3 pole CF connectors
Signal balance ratio
15 Hz to 20 kHz . . . . . ≧65 dB
15 Hz to 200 kHz . . . . . ≧40 dB
Noise level measurements . . . . . to DIN 45 405
Max. measurable level . . . . . +32 dB
Max. d.c. voltage to casing . . . . . ≦60 V
Phantom power supply.

Coaxial input* 3 (alternative to input 2)
Highest measurable level . . . . . +22 dB

Input impedance, switchable . . . . . 150, 300, 600 Ω and ≧100 kΩ
Max. input voltage . . . . . ≦30 V
at Z_{in} ≧100 kΩ . . . . . ≦48 V

Measurement modes

Selective measurements
Frequency range . . . . . 15 Hz to 200 kHz
Frequency setting . . . . . see generator section
Smallest frequency increment . . . . . 1 Hz
Error on frequency setting . . . . . $\pm 3 \times 10^{-6} \pm 0.6$ Hz
3 dB bandwidths . . . . . 6, 12, 18, 30 and 100 Hz
Autoranging . . . . . automatic or via keypad
Level range . . . . . −135 to +30 dB

Error limits of the level display

All values in dB, referred to 1 kHz, $Z_{out} = Z_{in} \leqq 600\ \Omega$ (level difference ≦20 dB)

		15 Hz	40 Hz	20 kHz	60 kHz	110 kHz	200 kHz
Input level ≦+32 dB, bal.	Frequency response	±0.25	±0.1	±0.2			
	Total error	±0.4	±0.25	±0.3		±0.35	
	Total error (level difference)	±0.3	±0.1	±0.2			
Input level ≦+22 dB, unbal.	Frequency response	±0.25	±0.1	±0.25	±0.35		
	Total error	±0.4	±0.25	±0.35	±0.45		

Intrinsic harmonic ratio (2nd and 3rd order), f ≧ 30 Hz . . . . . ≧80 dB
Intrinsic difference frequency attenuation (2nd and 3rd order) . . . . . ≧80 dB
Intrinsic noise level, referred to the input terminated with Z_o, bandwidth 6 Hz, f ≧ 500 Hz . . . . . ≦−135 dB
30 Hz, f ≧ 500 Hz . . . . . ≦−130 dB
100 Hz, f ≧ 1 kHz . . . . . ≦−125 dB

Wideband measurements
Frequency range . . . . . 15 Hz to 200 kHz
Band limiting, selectable via softkey . . . . . 15 Hz to 200 kHz
15 Hz to 20 kHz, external filter
Level range . . . . . −100 to +30 dB

Error limits of the level display

All values in dB, referred to 1 kHz, $Z_{out} = Z_{in} \leqq 600\ \Omega$
(level difference ≦20 dB)

		15 Hz	40 Hz	15 kHz	20 kHz	200 kHz
Band limiting 20 kHz input level ≦+32 dB, bal. or input level ≦+22 dB, unbal.	Frequency response	±0.25	±0.1	±0.25	—	
	Total error	±0.4	±0.25	±0.4	—	
Band limiting 200 kHz, input level ≦+32 dB, bal.	Frequency response	±0.25	±0.1		±0.4	
	Total error	±0.4	±0.25		±0.6	
	Total error (level difference)	±0.3	±0.1		±0.2	
Band limiting 200 kHz, input level ≦+22 dB, unbal.	Frequency response	±0.25	±0.1		±0.5	
	Total error	±0.4	±0.25		±0.7	

Intrinsic noise level
Band limiting 15 Hz to 20 kHz . . . . . ≦−100 dB
15 Hz to 200 kHz . . . . . ≦−95 dB
Result evaluation . . . . . r.m.s.

Level difference measurements
between input 1 and 2, selective or wideband.
Frequency range . . . . . 15 Hz to 200 kHz
Level range . . . see selective and wideband measurements
Error limits of the level difference display . . . . . see selective and wideband measurements
Crosstalk attenuation
between input 1 and input 2, f≦20 kHz . . . . . ≧90 dB

Phase difference measurements
between input 1 and input 2, referred to input 1.
Frequency range . . . . . 15 Hz to 20 kHz
Level range ($Z_{in} \leqq 600\ \Omega$) . . . . . −60 to +32 dB
Measurement range . . . . . ±200°
Resolution of digital display . . . . . 1°
Error limits . . . . . ±2°

Frequency measurements
Frequency range . . . . . 15 Hz to 200 kHz
Level range . . . . . −62 to +32 dB
Display . . . . . 5 digits
Error limits of the frequency display . . . $\pm 1 \times 10^{-5} \pm 0.5$ digit

Frequency shift measurements
(Difference between reference frequency and actual frequency)
Reference frequency range . . . . . 1000 to 9000 Hz
Resolution of digital display
Frequency measurements . . . . . 1 Hz
Frequency shift measurements, absolute . . . . . 0.1 Hz
relative 0.01%

Distortion factor measurements
Frequency range . . . . . 15 Hz to 200 kHz
Wideband level range . . . . . −52 to +32 dB
Order . . . . . 2, 3, 2 to 3, ... 2 to 9
Bandwidth . . . . . 6, 12, 18, 30 and 100 Hz
Resolution of digital display . . . . . 0.1 dB or 0.001 %
Intrinsic harmonic ratio (2nd and 3rd order) . . . . . ≧80 dB

Difference frequency attenuation measurements
Frequency range . . . . . 15 Hz to 200 kHz
Wideband level range . . . . . −52 to +32 dB
Order . . . . . 2, 3, 2 and 3
Difference frequency . . . . . 20 Hz to 10 kHz
Bandwidth . . . . . 6, 12, 18, 30 and 100 Hz
Resolution of digital display . . . . . 0.1 dB or 0.001 %
Intrinsic difference frequency attenuation . . . . . ≧80 dB

Autostep mode
Sweep is made by increasing or decreasing the frequency or level in discrete steps. Autostep mode can also be selected for either the generator or receiver, single or repetitive sweep.

Frequency sweep
Linear or logarithmic, limits and number of steps (max. 247) are entered via numerical keypad.
User programmable table with 17 tone signal or 16 fixed frequencies, frequencies can also be entered via numerical keypad.

Level sweep
Linear, limits and number of steps (max. 247) entered via numerical keypad.
Measurement time/step, depends on operating mode, number of channels, bandwidth, averaging etc. . . . . approx. 0.1 s
Max. meas. time/step (value can be changed via numerical keypad) . . . . . 10 s

Result display
Numerical and graphical display on 7" flat-screen.
Resolution in graphics area (w×h) . . . . . 248×241 pixels

Selftest
Automatically checks the whole digital section when the NFA-1 is switched on.
Automatic calibration is carried out at regular intervals, so checking important test circuits.

Setup memory
Non-volatile storage of up to 49 user definable front panel setups.

Additional inputs and outputs
Input and output for external filter*
Output for 10 MHz standard frequency
Video output (composite video signal, BNC connector)
Wideband level output (mutiple connector)

Options

Noise Level Filter CCIR/CCITT, BN 959/00.11 [1)]
For measuring weighted and unweighted noise to CCIR 468-3, or DIN 45 405 (11.83) and CCITT P.53 or O.41
Level range . . . . . −100 to 0 dB

Additional Stop Filter, BN 959/00.12 [1) 2)]
Connected in series with the Noise Level Filter.
For measuring the modulation noise of tape recorders.
Quantising distortion and compander system noise by means of a stimulus tone.
Level range . . . . . −80 to 0 dB

Band-stop, centre frequency selectable . . 1000/1020 Hz
Attenuation at centre frequency ±1 Hz . . . . . ≧60 dB

High-pass, 3 dB cutoff . . . . . 400 Hz
Attenuation to 85 Hz . . . . . ≧60 dB

Noise Level Filter A IEC, BN 959/00.14 [1)]
For measuring weighted and unweighted noise levels to DIN E 45 412 (01.84) or after DIN IEC 651 (12.81).
Level range . . . . . −80 to 0 dB

Sound Recorder Measuring Section, BN 959/00.21
For special measurements on sound recorders, e.g. tape recorders and record players etc.
to . . . . . DIN 45 507, IEC 386, NAB, JIS
Test signal frequency . . . . . 2820 to 3310 Hz
Level range . . . . . −50 to +30 dB

Wow and flutter
Measurement ranges, 1, 2, 5 . . . . . 0.05 % to 10 %
Resolution of digital display . . . . . to 0.001 %

Statistical evaluation
Calculates and displays σ values digitally.

Spectral analysis of frequency variations
Frequency range . . . . . 0 to 120 Hz

Drift
Measurement range . . . . . ±10 %
Resolution of digital display . . . . . 0.01 %

Run-up time
The time taken for frequency variations to fall below a certain settable limit.
Measurement interval . . . . . 1 to 10 s
Resolution of digital display . . . 0.1 % of measurement interval

<IEC 625> Interface Board
With connectors to IEEE 488 or to IEC 625 with IEEE 488/IEC 625 adaptor S 832

General specifications

Power supply
Nominal ranges of use of a.c. line voltage, switchable . . . . 110/117/127/220/227/235 V, −12 to 10 %
Nominal range of use of a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 120 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I

Data retention
A built-in, trickle-charged NiCad ensures that setups stored in memory are not lost.

Ambient temperature
Nominal range of use . . . . . 0 to +40 °C
Storage and transportation . . . . . −40 to +65 °C

Dimensions (w×h×d) in mm
Bench version . . . . . 477×288×434
19" frame (6 U) . . . . . 443×264×379
19" conversion kit . . . . . BN 700/00.06

Weight (including options) . . . . . approx. 30 kg

Ordering information

Audio Analyzer NFA-1 Display in German	**BN 959/01**
Option (no extra charge) Display in English	BN 959/00.01
Options (charged extra) Noise Level Filter CCIR/CCITT [1] for noise level measurements to CCIR 468-3 or DIN 45 405 (11.83) and CCITT P.53 or O.41	BN 959/00.11
Additional Stop Filter [1) 2)] 1000 Hz bandstop and 400 Hz high-pass for compander and quantising distortion measurements using a 1000 or 60 Hz activating tone	BN 959/00.12
Noise Level Filter A IEC 651 [1] for noise level measurements to DIN IEC 651 or DIN 45 412	BN 959/00.14
Sound-recorder Measuring Section for testing mechanical sound recorders	BN 959/00.21
<IEC 625> Interface Board Connector to IEEE 488 (female connector)	BN 958/21
Accessories (at extra cost)	
IEEE 488/IEC 625 adaptor	S 832
Front and back panel covers SD-6 (1 set)	BN 700/00.26

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adaptor. For other adaptor types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

1) Option combinations BN 959/00.11 ... 14:

	00.11	00.12	00.14
00.11	—	×	×
00.12	×	—	—
00.14	×	—	—

× = possible combination

2) Only with option BN 959/00.11

A Colour Brochure is available on request

UN-1
Universal Network and Filter

for a wide range of measurement tasks and signal shaping: 0 to 150 kHz

IEEE 488
IEC 625



- **Offers a wide selection of functions ranging from low-pass, high-pass, band-pass, band-stop and branching filters to weighting and delay networks**
- **Signal shaper in the time domain**
- **Octave, half-octave, third-octave band filters, electro-acoustic, low-pass and high-pass filters with switch selectable A or B frequency sequences conforming to DIN/IEC requirements**
- **Weighting filters (A, B, C, D) and pink noise network for acoustic measurements, conforming to DIN or IEC requirements**
- **Weighting filters for the voice and sound-programme channels conforming to CCITT or CCIR Recs.**
- **Additional transfer functions can be provided on request**
- **Dialog program for any function on request**

Applications

Telecommunications technology

– Manufacturers of frequency division multiplex, time division multiplex and data transmission equipment.
– Manufacturers of audio systems, amplifiers, filter networks and speech coding devices.
– Telecommunication administrations, radio and TV companies and their research departments.

Mechanical engineering

– The automotive industry and avionics
– Manufacturers of control systems
– Materials research departments

Vibration technology

– Institutes investigating architectural acoustics
– Universities, polytechnics and research institutes carrying out mechanical and acoustic vibration research

Medicine

– Manufacturers and users of medical instruments for analysis of complex vibrations
– Biomedical clinics, E.N.T. clinics and research institutes

Characteristics

The UN-1 Universal Network and Filter can be set to any of the most frequently used transfer functions in the AF range. Over 30 different operating modes are provided in the standard version. In addition to more than 2000 frequency settings, various filter slopes, relative bandwidths or delay times can be entered depending on which operating mode has been selected.
The filter you want is therefore ready in seconds.
In spite of the immense number of possible settings the UN-1 is easy to operate via its keyboard.
Using the IEC Bus Interface (available on request), all the UN-1's functions can be remotely controlled – by an external computer for example. This means that the UN-1 can be economically incorporated in automatic test systems.
For special applications, a maximum of 20 extra operating modes, specified by the customer, can be retrofitted for tasks that even the standard UN-1 with its wide range cannot handle.
A dialog program for use on a desktop computer is also available and with this practically any transfer function can be realised.

Frequency range	0 to 150 kHz
Frequency settings	16 Hz (1 Hz) to 32 kHz
Operating modes	low-pass, high-pass, band-pass, band-stop, branching, weighting filters, delay network
Slope for high/low-pass filters up to	72 dB/octave
for the Cauer filter	158 dB/octave
Signal input and output	V_p max. 6 V
Impedances, switchable	75, 150, 600 Ω
additionally	Z_{in} = 1 MΩ and Z_{out} = 5 Ω
Intrinsic noise ($V_p \leqq 1$ V), typically	0.1 mV
Intrinsic distortion factor ($V_p \leqq 1$ V)	≦0.1 %

Further Applications and Characteristics

Standard operating modes

The filter operating modes that are permanently stored (low-pass, high-pass etc.) and the filter characteristics (Butterworth, Chebishev, Bessel, Cauer, IEC) can be called up with a two digit code number.

Depending on the filter operating mode, the frequency setting entered via the keypad is interpreted as a cutoff frequency or a centre frequency in the range 16 Hz to 32 kHz, or with limited accuracy in the range 1 Hz to 35.7 kHz. The STEP buttons provide a facility for stepping through the frequency range and so considerably simplify operation. The minimum step length is 1 Hz.

The range of slope settings for the high- and low-pass filters is very large. The greatest slope (158 dB/octave) is attained by the Cauer filters.

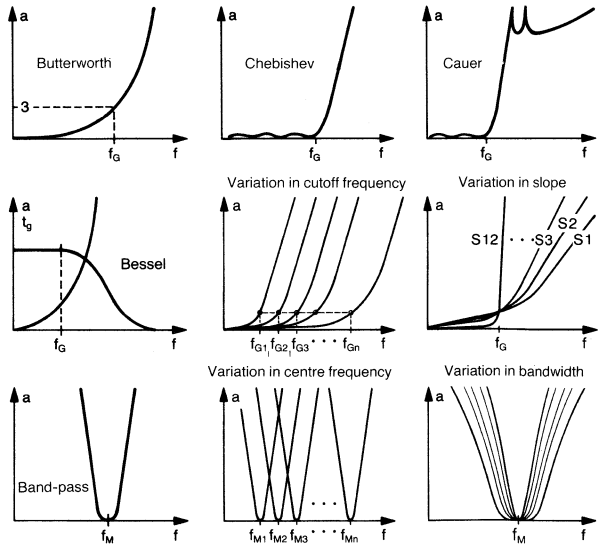
The Bessel low-pass filters have a linear phase response in the pass-band which gives a practically transient-free response to a step input. In the "narrow band-pass" operating mode certain relative bandwidths in the range 7 % to 30 % can be selected.

The notch filter has an attenuation of at least 60 dB at any frequency selected. The upper and lower cutoff frequencies for the wide band-pass and band-stop filters are not mutually dependent, and so can be selected as required.

Standard *octave, half-octave and third-octave band-pass filters* are available for acoustic measurements, acoustic *low-pass* and *high-pass* filters as specified by DIN/IEC can also be obtained. The possibility of stepping through the frequency range according to the standard A or B series is also an advantage for frequency analysis.

The A, B, C and D weighting filters, which comply with international specifications, are provided for weighted acoustic level measurements.

The UN-1 also contains those weighting networks which are widely used in the telecommunications industry for carrying out noise-voltage measurements in the voice or sound-programme channels as defined in CCITT/CCIR Recs. and Bell specifications.



Examples illustrating the operating modes, filter characteristics and settings available on the UN-1

In the "delay network" operating mode, delays between 0.2 and 20 ms can be set depending on bandwidth.

User-specific functions

A maximum of twenty operating modes can be retrofitted for special applications. Forms for ordering *Special Networks* are available. When filling in these forms the user may specify the transfer function with its poles and zeroes, or use the polynomial form. The function required can also be expressed in terms of its variation of attenuation with frequency.

In many applications a large variety of different networks have to be setup in a short time. To handle these situations a *dialog program* on a cassette for use with a desktop computer (CU-85 Control Unit or HP 85 computer) or on diskette for use with the HP 200 series computers, is available.

The program, which provides dialog prompts on a screen, can be used to obtain practically any transfer function when the UN-1 is contolled via the <IEC 625>/IEEE 488 Interface Bus. The transfer functions are expressed as poles or zeroes or as coefficients of the relevant polynomial. If a transfer function is to be used frequently it can be stored on the data storage media for later use.

Remote control

All front panel settings of the UN-1 can be controlled by an external computer connected via the <IEC 625>/IEEE 488 Interface Bus (interface card on request).

This means that the UN-1 can be integrated in automatic test systems, e.g. for harmonic distortion measurements on electroacoustic and telecom subassemblies and equipment, testing PCM codec modules, noise investigations on drive mechanisms, and vibration measurements on motors etc.

Balanced inputs or outputs

When used in conjunction with the *SPMZ-110 Balancing Attachment* the UN-1 can be connected to balanced inputs or outputs.

The SPMZ-110 contains balancing transformers for the frequency ranges 15 Hz to 20 kHz and 300 Hz to 150 kHz (200 kHz). The impedances are switch selectable, and the values of 200 Ω and 300 Ω, which are common in broadcasting, are also available.

The Adaptor BN 884/00.02 is provided for matching the UN-1 input to the SPMZ-110.

Special characteristics of the UN-1

The device has a signal input and two outputs which can normally be used interchangeably. In the "branching" operating mode, however, one output is used for the low frequency output and the other for the high frequency output.

The input impedance can be switched from the high impedance setting to 75 Ω, 150 Ω or 600 Ω. Depending on the range, selected peak values of 1 V or 6 V are permissible for the input voltage. An overload indicator shows if the input level is too high. When the output is switched from the low impedance setting to 75 Ω, 150 Ω or 600 Ω, the output level increases by +6 dB. This also means that the insertion loss of the network can be neglected for matching purposes.

The coaxial connectors at the inputs and outputs of the UN-1 can be converted to all standard systems.

Mounting brackets for fitting the UN-1 into a 19" rack are also available. Covers for the front and back panels are provided to protect the UN-1 from water and mechanical damage during transportation and storage.

Specifications of the Universal Network and Filter — UN-1

Unless otherwise noted, the given specifications are valid for the rated ranges of use of a.c. line voltage, a.c. line frequency and ambient temperature.

Frequency [1]

Frequency range . . . . . 10 Hz (0 Hz) to 150 kHz
Normal frequency settings . . . . . 16 Hz to 32 kHz
Extended range . . . . . 1 Hz to 35.7 kHz

Frequency setting
Single keypad entries, size of frequency step in range
16 Hz (1 Hz) to 1 kHz . . . . . 1 Hz
1 kHz to 10 kHz . . . . . 10 Hz
10 kHz to 32 kHz (35.7 kHz) . . . . . 100 Hz

STEP mode (slow or fast)
All frequency values as per single keypad entries. Switchable to the A or B frequency sequence according to DIN 45 401, and DIN 45 654 and IEC Publ. 225.

Signal input and outputs *

Signal input . . . . . unbalanced
Input impedance, switchable . . . 75, 150, 600 Ω each ±0.5 % and ≧ 1 MΩ ‖ ≦ 50 pF

Signal outputs I and II[2] . . . . . unbalanced
Output impedance, switchable . . . . . ≦5 Ω ‖ ≦ 100 pF and 75, 150, 600 Ω each ±0.5 %
Permissible load impedance Z_L . . . . . ≧ 75 Ω
Max. input and output voltage (peak value V_p)
Voltage range ≦ 1 V . . . . . 1.1 V
Voltage range ≦ 6 V . . . . . 6 V
Overload indicator

Intrinsic harmonic ratio a_{k_2}, a_{k_3}

at max. input voltage
High pass (2.0 to 2.3), band-stop (4.0; 4.1), and delay network (7.0) operating modes . . . . . ≧50 dB
All other op. modes . . . . . ≧60 dB

Intrinsic noise at outputs I or II

Input terminated with 75 Ω,
weighted frequency range 10 Hz to 150 kHz
Voltage range ≦1 V . . . . . ≦−70 dB
typical values for low-pass, band-pass, band-stop . . . . . −80 dB
Voltage range ≦ 6 V . . . . . ≦−54 dB
typical values for low-pass, band-pass, band-stop . . . . . −64 dB

Operating mode 0.0

Connection between input and output
Attenuation at 1 kHz . . . . . 0 ±0.2 dB
Max. variation in attenuation referred to 1 kHz over frequency range
10 Hz to 100 kHz . . . . . ±0.15 dB
100 kHz to 150 kHz . . . . . ±0.30 dB

Standard operating modes and settings

No.	Operating mode	Parameters
	Low-pass	F: cutoff freq., S: Slope f >> F
1.0	Butterworth	F/kHz, S = 6, 12, 18, ..., 72 dB/octave
1.1	Chebishev	F/kHz, S = 12, 18, 24, ..., 60 dB/octave
1.2	Bessel[3]	F/kHz, S = 12, 24, 36, 48, 60 dB/octave
1.3	Cauer	F/kHz (atten. for f ≧ 1.3 F: ≧60 dB)
1.4	Electro-acoustic as per DIN 45 654 (IEC)	F/kHz
	High-pass	F: cutoff freq., S: Slope f << F
2.0	Butterworth	F/kHz, S = 6, 12, 18, ..., 72 dB/octave
2.1	Chebishev	F/kHz, S = 12, 18, 24, ..., 60 dB/octave
2.2	Cauer	F/kHz (atten. for f ≦0.76 F: ≧60 dB)
2.3	Electro-acoustic as per DIN 45 654 (IEC)	F/kHz
	Band-pass	F: centre freq., Δf/F: bandwidth, f_- and f_+: lower or upper cutoff freq.
3.0	Octave complying with DIN 45 651	F/kHz
3.1	Half-octave complying with IEC-Publ. 225	F/kHz
3.2	Third-octave complying with DIN 45 652	F/kHz
3.3	Octave } with A-weighting	F/kHz
3.4	Half-octave } complying with	F/kHz
3.5	Third-octave } DIN 45 633	F/kHz
3.6	Octave } with A-weighting	F/kHz
3.7	Third-octave } and pink noise	F/kHz
3.8	Narrow band	F/kHz, Δf/F = 7, 10, 15, 20, 30 %
3.9	Wideband	f_-/kHz, f_+/kHz

1) All specifications are valid for the frequency range 10 Hz to 150 kHz or for the entry range 16 Hz to 32 kHz. The transfer function is guaranteed in the extended frequency range 0 to 10 Hz or the entry range 1 Hz to 35.7 kHz.
2) Both outputs are interchangeable – expect in operating mode BRANCHING where output I is the high frequency output and II the low frequency output.
3) Low-pass with transient-free step response and linear phase response.

No.	Operating mode	Parameters
	Band-stop	F: notch frequency, f_- and f_+: lower and upper cutoff frequency
4.0	Notch	F/kHz
4.1	Wideband-stop	f_-/kHz, f_+/kHz
	Branching filter	F: crossover frequency, S: slope
5.0	Butterworth	F/kHz, S = 12, 24, 36 dB/octave
	Weighting networks	
6.0	A-weighting filter to DIN 45 633	
6.1	B-weighting filter to DIN 45 633	
6.2	C-weighting filter to DIN 45 633	
6.3	D-weighting filter to IEC-Publ. 573	
6.4	Pink noise network 3 dB/octave in range 16 Hz to 20 kHz	
6.5	Psophometer filter to CCITT Rec. P.53	
6.6	C-message weighting network to Bell-Publ. 41 009	
6.7	C-message weighting with 1010 Hz notch filter to Bell-Publ. 41 009	
6.8	Sound-programme network to CCIR Rec. 468-2 and DIN 45 405 (Draft)	
6.9	Programme-weighting network (USA) to CCITT and Bell Specifications	
	Group delay networks	F: Cutoff freq. , t_g: group delay f ≦ F
7.0	Delay network	F = 20 Hz to 20 kHz or t_g = 0.2 ms to 20 ms; F x t_g = 4

General Specifications

Power supply
Rated ranges of use of a.c. line voltage, selectable . . . 110/117/127/220/227/237 V, −12 to +10 %
Rated range of use of a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 115 VA
Safety class according to IEC 348 and VDE 0411 . . . . Class I

Ambient temperature
Rated range of use . . . . . +5 to +40°C
Storage and transport . . . . . −40 to +70°C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	199	Height (4 units)	175
Depth with handles	434	Depth	379

19" conversion kit . . . . . BN 700/00.04
Weight . . . . . approx. 14 kg

Options

<IEC 625>/IEEE 488 Interface Bus
for remote control of all UN-1 operating functions.

Special Networks [1)]
Operating mode numbers 8.0 to 8.9 and 9.0 to 9.9 are reserved for user specified networks.

Accessories

Dialog Program
Cassette for CU-85 control unit or HP 85 desktop computer, diskette for HP Series 200 computers. Practically any transfer function can be realised via the <IEC 625>/IEEE 488 Interface Bus.

SPMZ-110 Balancing Attachment
for connecting the UN-1 to balanced devices

Connectors, balanced, floating . . . . . 3 pole CF connectors
Input I/output I . . . . . 15 Hz to 20 kHz
Input impedance . . . . . 300 Ω, 600 Ω, 50 kΩ
Output impedance . . . . . 200 Ω, 600 Ω, ≈10 Ω

Input II/output II . . . . . 300 Hz to 150 kHz
Input impedance . . . . . 75 Ω, 140 Ω, 150 Ω, 600 Ω, 12 kΩ
Output impedance . . . . . 75 Ω, 140 Ω, 150 Ω, 600 Ω, ≈10 Ω
For extra data consult the SPMZ-110/SPMZ-111 Specification Sheet

Balancing adaptor
for matching the UN-1 input to the SPMZ-110

Ordering Information

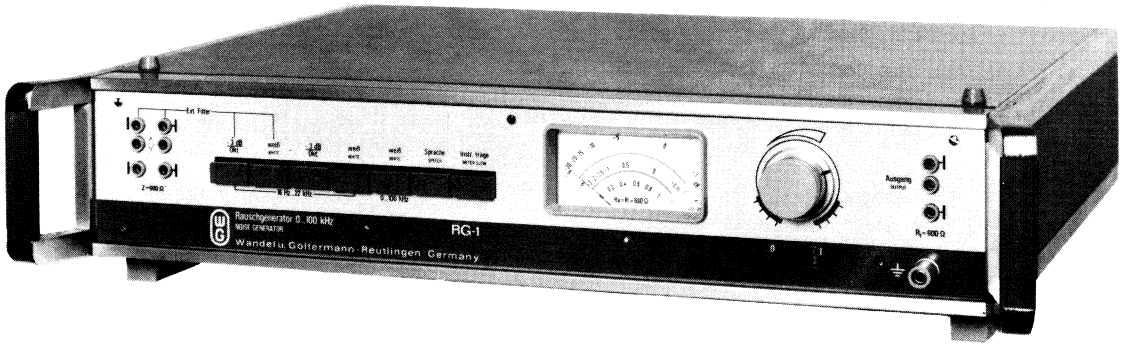
Universal Network and Filter UN-1 *	**BN 884/01**
Options (at extra cost)	
Interface Bus <IEC 625> Card with Adaptor plug IEC 625/IEEE 488 (S 834)	BN 853/06
Special Networks [1)]	BN 884/00.04
Accessories (at extra cost)	
Dialog Program for CU-85/HP 85, German	BN 884/00.01
English	BN 884/00.03
for HP 9000 Series 200 computer 3½" diskette, German/English	BN 884/00.06
5¼" disk, German/English	BN 884/00.07
Balancing Attachment SPMZ-110	BN 613/01
Balancing Adaptor	BN 884/00.02
Connecting cable for Interface Bus <IEC 625>; 120 cm	K 343
200 cm	K 344
Front and back panel covers (1 set), SD-4	BN 700/00.24
Control Unit CU-85	BN 981/01

1) Order form No. 0884/00.79 (graph/table) or Order form No. 0884/00.78 (poles/zeroes or polynomial) available on request.
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

A Specification Sheet with more details and a Colour Brochure are available on request

RG-1
Noise Generator

for acoustic, medical, control system and telecommunications measurements



- **White and pink noise, speech-simulating noise as per CCITT**
- **Gaussian amplitude distribution to 8 x $V_{r.m.s.}$**
- **Connections for external filters**
- **r.m.s. display in volts, dB and Np**

Applications

– Architectural and room acoustics, electro-acoustics

Airborne and impact sound insulation measurements
Determining sound distribution in rooms
Reverberation times
Checking the nominal loading of loudspeakers
The *UN-1 Universal Filter and Network* will prove very useful in these applications.

– Medicine

Applications in neurology, physiology and psychology
Audiological examinations.
The Noise Generator produces speech-simulating noise.
Special frequency responses can be obtained by connecting external filters.

– General measurements, measurements on servo- and control systems

Simulating vibration-stress on aircraft and rocket models, machines, materials and buildings.
Checking servo- and control systems.
Simulating random physical, cybernetic and economic processes.

– Telecommunications

Checking data-modems.
The *TLN-1 Cable Simulator* will prove useful in these applications.

Characteristics

The RG-1 Noise Generator produces a white noise spectrum. Internal filters, which are pushbutton selectable, enable it to handle a variety of measurement situations. The noise level which has been set can be read off on a calibrated meter with volt, dB and Np scales.
External filters can be connected in via the connectors on the front and back panels of the instrument. The loss that results when filters with a narrow bandwidth are used can be compensated by an extra gain of up to 24 dB which is switched in on the RG-1.
If narrow bandwidth filters are connected into the signal path of the Noise Generator, the display will not give a steady reading, a longer integration time can be selected via a pushbutton, so providing an almost steady send level reading.
The send signal from the generator can be blanked by means of an external contact – a useful feature for reverberation measurements.

White noise spectrum	0 Hz to 108 kHz
White noise spectrum	16 Hz to 22 kHz
Pink noise spectrum	16 Hz to 22 kHz
Speech-simulating noise as per CCITT	
Output level (continuous setting)	–20 dB to +3 dB

Specifications for the Noise Generator — RG-1

If nothing to the contrary is stated, the given specifications are valid for the rated range of use of the influence quantities.

Noise spectra
pushbutton selectable

Spectrum 1 . . . . . white noise
Frequency range . . . . . 0 to 108 kHz
Effective bandwidth . . . . . 110 kHz ± 10 %

Variation with frequency ref. to mean
$Z_{out} = Z_L = 600\ \Omega$
Range 30 Hz to 100 kHz . . . . . ± 0.5 dB
Range 30 Hz to 108 kHz . . . . . ± 1 dB

Spectrum 2 . . . . . white noise
Frequency range . . . . . 16 Hz to 22 kHz
Effective bandwidth . . . . . 26 kHz ± 10 %

Variation with frequency ref. to mean
$Z_{out} = Z_L = 600\ \Omega$
Range 30 Hz to 20 kHz . . . . . ± 0.5 dB

Spectrum 3 . . . . . pink noise
Frequency range . . . . . 16 Hz to 22 kHz
Roll-off with frequency . . . . . − 3 dB per octave

Variation with frequency ref. to mean
− 3 dB roll-off per octave in range
30 Hz to 20 kHz . . . . . ± 1 dB

Spectrum 4 . . . . Speech simulating noise as per CCITT[1)]

Output level
at $Z_{out} = Z_L = 600\ \Omega$ (0 dB = 0 Np ≙ 1 mW in 600 Ω ≅ 0.775 V)
continuous setting . . . . . − 20 to + 3 dB

Outputs
Connector type . . . . . 3 pin, CF connectors

Output 1
Output impedance . . . . . 600 Ω ± 3 %

Output 2 (on back panel) . . . . . low impedance

Amplitude distribution
Gaussian
for output levels ≦ 0 dB . . . . . to at least 4 x $V_{r.m.s.}$
for output levels ≦ − 6 dB . . . . . to at least 8 x $V_{r.m.s.}$

Level display
r.m.s. calibrated mean value rectifier
Scale 1 . . . . . − 30 to + 3 dB
Scale 2 . . . . . − 3.5 to + 0.35 Np
Scale 3 . . . . . 0 V to 1.1 V

Error on scale calibration . . . . . ± 2 % f.s.d.

Error limits on meter reading
at 0 dB, $Z_{out} = Z_L = 600\ \Omega$
Spectrum 2 and 4 . . . . . ± 0.2 dB
Spectrum 1 . . . . . ± 0.35 dB

Variation with frequency for meter reading
when using octave or third-octave filters
Range 30 Hz to 20 kHz . . . . . ± 0.1 dB

External filter connections
for spectra 2 and 3
Characteristic impedance of the connections . . . . . 600 Ω
Level at filter input . . . . . approx. 0 dB
Loss compensation . . . . . up to 24 dB

General Specifications

Power supply
Rated ranges of use for a.c. line voltage,
selectable . . . . . 110/117/127/220/227/235 V, ± 10 %
Rated range of use for a.c. line frequency . . . . . 45 to 60 Hz
Power consumption . . . . . approx. 6 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Permissible ambient temperature
Rated range of use . . . . . + 5 to + 40° C
Storage and transportation . . . . . − 40 to + 70° C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	478	Width	443
Height overall	110	Height (2 units)	87
Depth with handles	407	Depth	353

19" conversion kit . . . . . BN 556/00.02

Weight . . . . . 8 kg

Ordering Information

Noise Generator RG-1	**BN 413/00**
Accessories (at extra cost)	
Protective Transportation Cover DE-1	BN 476/00.01

1) If required another filter can be built in instead of this filter.

TR-940
Transient Recorder

Two channel transient memory with sampling rates to 2 MHz



- **Records transient or slow periodic phenomena – also continual recording mode**
- **Two recording channels with separate A/D converters and memories**
- **Easy adaptation to oscilloscope by output of calibration traces; trigger position shown**
- **Playback of channels A, B, separately or together; A-B difference for comparison measurements**
- **Horizontal post-expansion to 20 x**

Applications

The TR-940 Transient Recorder stores transients or periodic signals that change slowly. For example, these could also be nonelectrical quantities like displacement, velocity, acceleration, rate of rotation, torque, force, pressure, volume, temperature and sound pressure. These are all physical quantities that are convertible to electrical quantities by means of suitable transducers. There is, therefore, a wide variety of applications.
In electrical measuring technology the TR-940 can be used to examine switching transients and other transient effects, to monitor power supplies, to detect impairments on data signals and to record sweep curves and characteristics.
The TR-940 is useful for materials testing and machine construction applications where strain, fracture, tearing, impact and crash tests are carried out. Vibrations and resonant behaviour can be investigated and torque characteristics or force/displacement diagrams can be recorded.
The TR-940 has many applications in acoustics, such as sound analysis and delay investigations, in the chemical industry for monitoring reactions, in medicine (e.g. heart functions, brain voltages) and in geological or seismological applications.

Characteristics

The TR-940 Transient Recorder samples at the A and/or B input at an adjustable sampling frequency, digitises the samples, and writes into a RAM (digital memory) the ascertained data. With that, events that occur before the trigger is initiated may be acquired. For playback the memory contents are reconverted into an analog signal and presented on an oscilloscope. A stationary image is displayed as a result of repetitive read-out from the memory.
The TR-940 is simple and easy to operate. Matching to the magnitude and duration of the signal to be measured is done in the same way as with an oscilloscope.
Hard-to-detect signals and the events preceding their occurrence can be captured and electrical disturbances can be analysed within context because of the many possibilities that the TR-940 offers for recording and reproduction.

Ordering Information

Transient Recorder TR-940 (Standard Version)	**BN 940/01**
Transient Recorder TR-940	**BN 940/02**

Version with the following additional features:
- Connector for X-Y graphic recorder
- Connector for external clock
- Several Transient Recorders can be synchronised
- Built-in batteries for data retention
- Digital memory Output

Accessories (at extra cost)

Test Probe HZ 36	BN 6160/00.01
Inverter WR-450 [1] with protective flanges	BN 940/00.01
Battery Pack and Charger BAK-450 [1]	BN 864/00.03
Front and back panel covers (1 set), SD-94	BN 960/00.04

1) Technical Specifications see Specification Sheet "Measuring Accessories"

Analog inputs, A and B	1 MΩ || 35 pF
Signal voltage ranges for full vertical memory	80 mV to 80 V
Digitisation	8 bits (resolution 0.4 %)
Sampling rate, switch-selectable	4 Hz to 2 MHz
Recording times for full memory length	1 ms to 500 s
Storage, separate for each channel	2048 words

A Specification Sheet with more details is available on request

Voltage and Level Measurement Technology
OWG Measurement Technology



Overview

Voltage and Level Measurement Technology, OWG Measurement Technology

Level meters

Frequency range	Generator section	Selective	Wideband	Synthesizer	Sweep mode	<IEC 625>/IEEE 488 Interface Bus	Battery operation	Voltage display	Digital frequency display	Automatic level display	Fast signal detector	Other features	Name	Page
200 Hz to 620 kHz	•	•	•	•			•	•	•		•	Three bandwidths; light; small	**SPM-31 Selective Level Meter**	68
200 Hz to 1.62 MHz	•	•	•	•			•	•	•		•	Three bandwidths; light; small	**SPM-30 Selective Level Meter**	68
200 Hz to 6 MHz		•	•		external		•		•			Three bandwidths; frequency locking facility	**SPM-12 Level Meter**	on re-quest
50 Hz to 10 MHz	•	•	•	•		•	•		•	•	•	Light; small	**SPM-15 Selective Level Meter**	75
6 kHz to 18.6 MHz		•					•		1)			Fixed frequencies; three band-widths; pilot-level meter	**SPM-6 Selective Level Meter**	on re-quest
200 Hz to 18.6 MHz		•							•		•	Frequency locking facility; three bandwidths; pilot-level meter	**SPM-60 Selective Level Meter**	on re-quest
50 Hz to 25 MHz		•		•			•		•		•	Phase jitter measurements; four bandwidths	**SPM-18 Selective Level Meter**	82
50 Hz to 25 MHz		•	•	•	•	•		•	•	•	•	Fixed frequency and setup storage; automatic frequency adjustment; five bandwidths; phase jitter measurements	**SPM-19 Selective Level Meter**	90
10 kHz to 160 MHz		•	•	•	•	•		•	•	•	•		**SPM-16 Selective Level Meter**	103
Test frequencies: 80.15, 280.25 and 287.25 MHz		•					•			•		Broadband CATV pilot level measurements to CCIR System B. Dig. display, chart recorder output	**TPM-10 TV Pilot Level Meter**	107
0 to 300 MHz			•									True r.m.s. measurements	**EPM-1 Milliwatt Power Meter**	108

1) With mechanical counter

Test systems

50 Hz to 25 MHz	Routine and monitoring measurements on FDM systems as specified by CCITT Recs. and INTELSAT and US norms, local and remote measurements; interactive and monitor modes	**SPM-190 [1]/SPM-197 Measuring Systems**	35

1) Suitable software packages: SWP-11 for local measurements on FDM systems to CCITT Recs./INTELSAT norms
SWP-13 for local and remote measurements on FDM systems to CCITT Recs./INTELSAT norms

OWG measurement technology

★ = new

Wavelength	Features	Name	Page
850, 1300, 1550 nm	Very wide measuring range, no range switching: Tests on multimode (step- and graded-index) and monomode fibres. Quick-change adaptor system copes with all common connector types; analog output for long-term monitoring; battery or mains operation	**OLP-1 Optical Power Level Meter**	112 ★

Level generators

Frequency range	Synthesiser	Sweep mode	Digital frequency display	<IEC 625>/IEEE 488 Interface Bus	Battery operation	External tuning with:	Other features	Name	Page
50 Hz to 1.62 MHz	•		•		•	SPM-30 SPM-31	Level and frequency entry via keypad; light; compact	**PS-30 Level Generator**	66
200 Hz to 6 MHz			•		•	SPM-12	Decadic level setting	**PS-12 Level Generator**	on re-quest
50 Hz to 10 MHz	•		•	•	•	SPM-15 SPM-18 SPM-19	Level and frequency entry via keypad; light; compact	**PS-15 Level Generator**	72
6 kHz to 18.6 MHz			1)		•	SPM-6 SPM-60	Crystal-accurate fixed frequencies	**PS-6 Level Generator**	on re-quest
80 Hz to 25 MHz	•		•		•	SPM-18 SPM-19	Level entry via keypad	**PS-18 Level Generator**	79
80 Hz to 25 MHz	•	•	•	•		SPM-19 SPM-18	Fixed frequency and setup storage; level entry via keypad	**PS-19 Level Generator**	86
80 Hz to 25 MHz				2)		SPM-19 SPM-18	External tuning only; setup storage; level entry via keypad	**PSS-19** [3] **Generator Section**	86
10 kHz to 160 MHz	•	•	•	•		SPM-16	Fixed frequency and setup storage; frequency parameters; level entry via keypad	**PS-16 Level Generator**	100
10 kHz to 160 MHz				•		SPM-16	External tuning only; level entry via keypad	**PSS-16** [4] **Generator Section**	100

1) With mechanical counter
2) Remote control via SPM-19 by means of extra data connection
3) Complements the SPM-19 to form a level measuring setup
4) Complements the SPM-16 to form a level measuring setup

Display unit

Characteristics	Name	Page
Can be used with the SPM-16 and SPM-19 Level Meters; digital image storage; internal electronic graticule plus alphanumerics; programmable and storable tolerance masks; video output	**SG-4 Storage Display Unit**	97

Remote access switches

★ = new

Frequency range	Coaxial through-switching	Balanced through-switching	<IEC 625>/IEEE 488 Interface Bus	Other features	Name	Page
0 to 128 kHz		•	•	For LF measurements on PCM equipment in conjunction with PCM-4 Channel Measuring Set. Through-switching of 30 LF channels; switching cycles for channel- and idle channel noise and crosstalk measurements	**MU-30 Test Point Scanner**	236 ★
0 to 100 MHz	•		•	24 test ports; expandable to 864.	**RAS-2 Remote Access Switch System**	115
0 to 160 MHz	•		•	6 test ports	**MU-7 Test Point Selector**	117

PS-30
Level Generator

Frequency range: 50 Hz to 1.62 MHz



- **Synthesizer ensures high frequency stability**
- **Frequency and level setting via keyboard or via stepkey (any step size)**
- **Digital frequency and level displays**
- **Output impedance 0, 75, 150, 600 Ω**
- **External tuning with the SPM-30 or SPM-31 Level Meters**
- **A.C. line or battery operation**
- **Compact and lightweight**

Applications

The Level Generator provides a signal source for measurements on FDM communication systems with up to 300 channels. Because it is compact, battery-operated and unaffected by large temperature changes it is ideal for field operation. The PS-30 can be used to carry out in-service maintenance on postal systems, and would be useful to railways, and utility companies who supply energy.
The PS-30 can be operated in conjunction with either the SPM-30 or SPM-31 Level Meter to give a complete Measuring Setup, which is especially well-suited for carrying out end-to-end measurements or measurements where different send and receive frequencies are required.

Characteristics

The send frequency of the PS-30 is generated by a synthesizer and so has a high spectral purity, accuracy and stability. Both the frequency and a wide range of output levels can be selected quickly via the keypad or by increment keys. Both parameters are shown on easy-to-read digital displays. The send signal, which is held constant at the value selected, can also be blanked for measurements in channel gaps. The send level can be selected as a voltage or a power level.

Frequency range, coaxial	50 Hz to 1.62 MHz
balanced	50 Hz to 620 kHz
Output impedance, coaxial	75 Ω
balanced	600 Ω, 150 Ω, < 5 Ω
Send level range (depends on impedance)	−92.9 to +15.9 dB or −83.9 to +21.9 dBm
Operating time of batteries	approx. 8 h
Weight (with batteries)	approx. 10.5 kg

Specifications of the Level Generator — PS-30

The given specifications are valid, when not otherwise stated, for the rated operating ranges of the ambient temperature, a.c. line voltage and line frequency.

Outputs

Coaxial output . . . . . Versacon® 9 Universal Connector Conversion system, convertible to all standard connector systems
Output impedance . . . . . 75 Ω
Frequency range . . . . . 50 Hz to 1620 kHz
Return loss, at 10 kHz . . . . . ≧40 dB

Balanced output . . . . . 3 pole CF connector
Output impedance, switchable . . . . . 600 Ω, 150 Ω, < 5 Ω
Frequency range . . . . . 50 Hz to 620 kHz
Return loss at 10 kHz . . . . . ≧40 dB
Generator balance ratio conforming to CCITT Rec. O.121 . . . . . ≧40 dB

Frequency

Frequency setting
digital via keyboard, resolution . . . . . 1 Hz
in steps via increment button, smallest step . . . . . 1 Hz

Frequency display . . . . . 7-digit LCD
Resolution . . . . . 1 Hz
Error limits of frequency . . . . . $\pm 3 \times 10^{-6}$
Input for external tuning control from SPM-30 or SPM-31 (to 620 kHz only)

Send level

Switchable from voltage levels (0 dB ≅ 0.775 V) to power levels (0 dBm ≅ 1 mW in Z_0)

Level control
Digital selection from keyboard entry, resolution . . . . 0.1 dB
Incremental level stepping, smallest step . . . . . 0.1 dB
Fine adjustment, continuously variable over . . . . . ± 0.1 dB

Level ranges (fine adjustment at 0 dB)
Coaxial output
$Z_{out} = Z_L = 75\ \Omega$ . . . . −92.9 to +5 dB (−83.9 to +14 dBm)

Balanced output, $Z_{out} = Z_L = 150\ \Omega$,
200 Hz to 620 kHz . . . −87.9 to +10 dB (−81.9 to +16 dBm)
50 Hz to 200 Hz . . . . . −87.9 to 0 dB (−81.9 to +6 dBm)

$Z_{out} = 0$, $Z_L = 150\ \Omega$,
200 Hz to 620 kHz . . . −82 to +15.9 dB (−76 to +21.9 dBm)
50 Hz to 200 Hz . . . . . −82 to +5.9 dB (−76 to +11.9 dB)

$Z_{out} = Z_L = 600\ \Omega$,
200 Hz to 620 kHz . . . . . −87.9 to +10 dB/dBm
50 Hz to 200 Hz . . . . . −87.9 to 0 dB/dBm

$Z_{out} = 0$, $Z_L = 600\ \Omega$,
200 Hz to 620 kHz . . . . . −81.9 to +16 dB/dBm
50 Hz to 200 Hz . . . . . −81.9 to +6 dB/dBm

Error limits
Error limits at 0 dB/dBm output at 10 kHz
for $Z_{out} = Z_L = Z_0$ . . . . . ± 0.2 dB
over temperature range of (23 ± 3)°C . . . . . ± 0.1 dB

Additional error
for output impedance $Z_{out} = 0$, $Z_L = Z_0$ . . . . . ± 0.2 dB
for any level ≧ −80 dB . . . . . ± 0.15 dB

Error limits of frequency response referred to 10 kHz, for $Z_{out} = Z_L = Z_0$ (levels ≧ −80 dB)
Output $Z_0 = 75\ \Omega$,
50 Hz to 620 kHz . . . . . ± 0.1 dB
50 Hz to 1.62 MHz . . . . . ± 0.15 dB

Output $Z_0 = 150\ \Omega$, 600 Ω . . . . . ± 0.15 dB
Overall error for $Z_{out} = Z_L = Z_0$ . . . . . ± 0.35 dB

Spurious Voltages

Harmonic ratio, a_{k2}, a_{k3}
For levels ≦ 0 dB, coaxial output,
or ≦ +10 dB, balanced output . . . . . ≧40 dB
Attenuation of discrete, nonharmonic spurious signals, for send levels ≧ −60 dB/dBm . . . . . ≧60 dB

Signal-to-noise referred to 1 Hz bandwidth and at least 10 kHz away from the wanted signal, for measuring frequencies > 10 kHz at 0 dB/dBm output level . . . . . ≧120 dB
Send level
in blanked state at the measuring frequency . . . . ≦ −120 dB

Auxiliary Inputs

Control inputs (BNC) for external tuning from SPM-30 or SPM-31 Level Meter

Standard-frequency input . . . . . 1 MHz
Input level required at 75 Ω . . . . . approx. 0 dBm

Carrier frequency input . . . . . 4 to 5.62 MHz
Input level required at 75 Ω . . . . . approx. 0 dBm

General Specifications

Power supply
A.C. line operation
Rated range of use for
a.c. line voltage, selectable . . . 93.5 to 141 V/187 to 262 V
a.c. line frequency . . . . . 45 to 66 Hz
Power consumption . . . . . approx. 25 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Battery operation with optional rechargeable battery pack BN 4502/00.02
Operating time . . . . . approx. 8 h
Charging time . . . . . approx. 14 h

Tolerable ambient temperature
Rated range of use . . . . . 0 to +50°C
Storage and transportation range,
with batteries . . . . . −40 to +60°C
without batteries . . . . . −40 to +70°C

Dimensions (wxhxd) in mm 317x175x342

Weight (excluding batteries) . . . . . approx. 8.5 kg

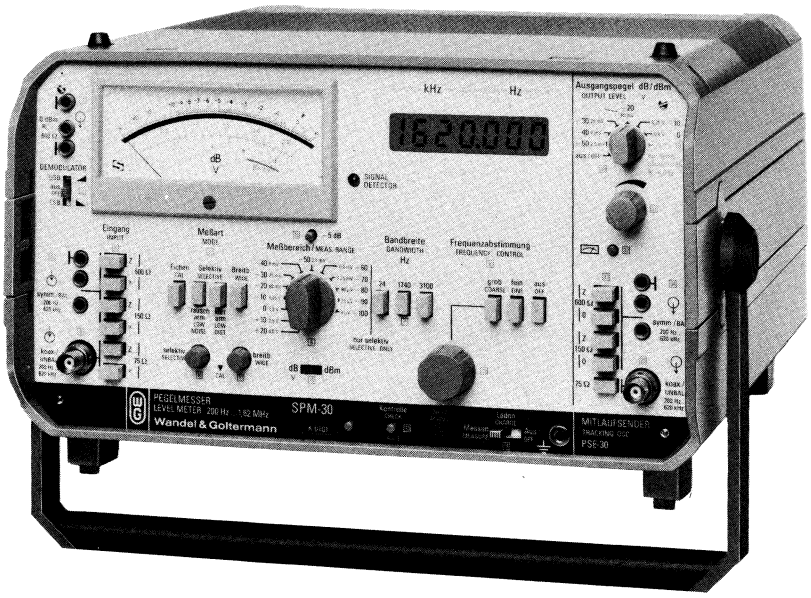
Ordering Informations

Level Generator PS-30*	**BN 4501/01**
Option (available at extra cost)	
Rechargeable battery-pack	BN 4502/00.02
Accessories (at extra cost)	
Transportation protection covers SD-940	BN 4502/00.03

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

SPM-30, SPM-31
Selective Level Meters

for the frequency range 200 Hz to 1.62 MHz or 620 kHz; with generator section



- **Selective and wideband measurements**
- **Scaled in dB, dBm or volts**
- **Synthesizer ensures excellent frequency accuracy**
- **Digital frequency display with 1 Hz resolution**
- **Fast signal detection**
- **Demodulator output**
- **Mains and battery operation**
- **Lightweight, compact, and easy to operate**

Applications

The SPM-30 and SPM-31 Level Meters are used for level measurements on FDM communications systems operating with a small or medium number of channels. Owing to their compactness and operation free of a.c. power, these Level Meters are particularly suitable for mobile service in maintenance and for measuring on communications systems actually carrying traffic. So the SPM-30 and SPM-31 are especially useful to Postal Administrations, Railways, or Public Utility Companies. Moreover, in-service measurements on the VFT System FM 120 is possible (100 Hz bandwidth version). Owing to the accuracy and versatility of the SPM-30 and SPM-31, many applications are also found in the original manufacture and testing of these systems or of the individual modules in a system. If the Generator has been incorporated, the combination is a complete measuring setup for attenuation and gain measurements. The send and receive frequencies can be offset from one another while making end-to-end measurements when the PS-30 Level Generator is used also.

Characteristics

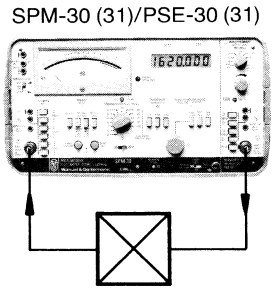
A frequency synthesizer produces the local oscillator frequencies of the Selective Level Meter. Thus, the high accuracy and stability are assured by this modern technique. A manually rotatable knob gives a smooth flywheel effect while swiftly tuning over the complete frequency band in one range. Frequencies are presented on a digital display with 1 Hz resolution. Levels are measured in various bandwidths as either low noise or as low distortion. A large scale analog meter provides the level readings. The fine scale divisions of 0.1 dB and 5 dB scale offset assist the operator so that measurement errors may be kept small. Both voltage level and power level as well as voltages are measurable.

Frequency range	
SPM-30, coaxial	200 Hz to 1.62 MHz
balanced	200 Hz to 620 kHz
SPM-31, coaxial and balanced	200 Hz to 620 kHz
Input impedance,	
coaxial	75 Ω, high impedance
balanced	(135) 150 Ω, 600 Ω, high impedance
Measurement range for 0 dB reading (2.5, 8 V), selective	
Level	−100 to +20 dB/dBm
Voltage	8 μV, 25 μV, ..., 8 V
Bandwidths, switch selectable	24 Hz*), 1.74 kHz, 3.1 kHz
	*) if requested, 100 Hz
Send level range	
(PSE-30 or PSE-31)	−60 to +1 dB/dBm
Voltage	0.8 mV, 25 mV, ..., 0.8 V
Weight, with PSE-30/PSE-31	approx. 12 kg

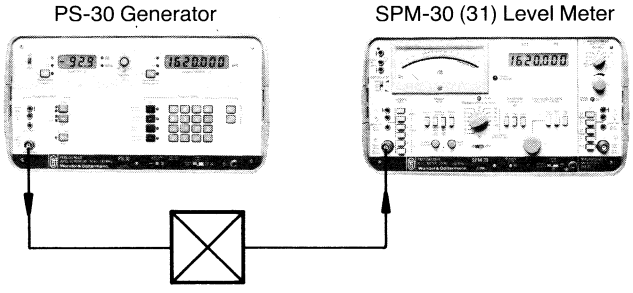
Further Characteristics and Applications

Besides the aforementioned features of the Level Meter, it has some exceptional characteristics:

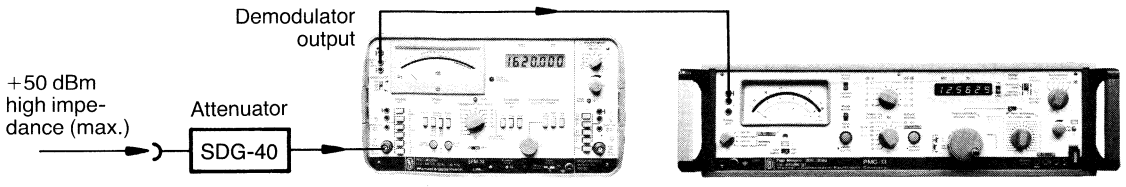
- Blocking of the frequency setting: if a selected frequency ought to be held constant over the long-term, e.g. when a test signal is monitored continuously, then the frequency setting may be *frozen* by means of a depressed key. After that the SPM-30 or SPM-31 cannot be manually tuned, but the set-up frequency is maintained with high accuracy.
- The switchable frequency display: an LCD display presents the frequency values at 100 Hz resolution with coarse frequency setting or 1 Hz with fine frequency setting.
- The fast signal detector: to search for discrete frequencies within a band, e.g. for spurious signals, the Level Meter is equipped with a *fast signal detector.* This signal detector is a signal lamp that responds when, during the scanning of a frequency band, a signal appears within the receive bandwidth of the Level Meter and also exceeds a certain level threshold. This device is useful also when the frequency tuning is done at a rapid rate and signals are discovered that otherwise would be missed by the analog meter because of the slow meter movement response. Some signals are not noticeable if the meter needle does not move, so they escape being recognized as valid signals.
- The high sensitivity: the level measuring range is switchable in 10 dB steps. A meter with a 20 dB scale presents the level reading, so that the lowest still readable level is −120 dB/dBm. A push button allows the indicated level to be shifted by −5 dB, so the reading accuracy is raised, as a consequence.
  Applications in the sector of electric utility companies and in general electronics are assisted by voltage measurements with the SPM-30 and SPM-31.
- The variable bandwidths: the Receiver bandwidths are switch selectable according to measurement task. Bandwidths of 24 Hz (or 100 Hz), 1.74 kHz, and 3.1 kHz are incorporated. The 24 Hz bandwidth is used for very selective measurements, e.g. while searching for noise or interference signals or for the measurement of pilot levels. Level Meters with the 100 Hz bandwidth are particularly useful for in-service measurements on FM voice frequency telegraph systems operating at a 50 baud transmission rate. The 1.74 kHz and 3.1 kHz bandwidths permit faster tuning and are intended for measuring within voice-grade channels. The effective noise bandwidth of the 1.74 kHz filter corresponds to the equivalent noise bandwidth of the CCITT Psophometer Filter; but the 3.1 kHz bandwidth corresponds to the telephone channel bandwidth. For overview measurements, or for end-to-end measurements that do not have frequency synchronization between generator and receiver, the SPM-30/31 is also equipped with a wideband receiver section.
- The semi-automatic calibration: a tracking calibration signal, synchronized with the tuned frequency, is used for calibrating the Receiver in selective mode. Calibration is done semi-automatically, therefore no extra frequency tuning is needed during this process.
- The switch selectable demodulation: the incorporated demodulator allows demodulation of single sideband signals in upright or inverted position. The converted signal is available at the demodulator output for further processing externally.
- The compact die-cast metal enclosure: the Level Meters are assembled in strong cases that are just right for the rough conditions of service found in mobile operation; the cases are easily carried by swing handles that lock in position. Also the battery chargers for the rechargeable batteries (Option) are incorporated in the Level Meters.



a) Loop measurement



b) End-to-end measurement or measuring at differing (offset) frequencies



SPM-30 (31) Level Meter
B = 3.1 kHz

PMG-13 Level Measuring Setup, swtich selectable bandwidths for 50, 100, and 200 baud

c) Measuring with SPM-30 (31) in VFT channels at the CF level
SDG-40 Attenuator is necessary when levels are high

Examples of Applications

The given specifications are valid, when not otherwise stated, for the rated operating ranges of the ambient temperature, a.c. line voltage and line frequency.

Inputs

Coaxial input* . . . . . Universal connector Versacon® 9, adaptable to all commercially available connector systems
Input impedance, switchable . . . . . $Z_o = 75\ \Omega$ and high impedance (bridged)
Frequency range: SPM-30 . . . . . 200 Hz to 1620 kHz
SPM-31 . . . . . 200 Hz to 620 kHz
Return loss at 10 kHz . . . . . ≧40 dB
Tapping loss for high impedance (bridged) input . . ≦0.05 dB

Balanced input . . . . . 3 pole CF connector
Input impedance, switchable . . . . . $Z_o = 150\ \Omega$ *); 600 Ω; and high impedance (bridged)
*) 135 Ω on request
Frequency range . . . . . 200 Hz to 620 kHz
Signal balance ratio . . . . . ≧40 dB
Return loss at 10 kHz . . . . . ≧40 dB
Tapping loss for high impedance input
$Z = 150\ \Omega$ . . . . . ≦0.05 dB
$Z = 600\ \Omega$ . . . . . ≦0.1 dB

Permissible input voltage for all inputs
Overload limit with Z_o . . . . . $V_{r.m.s.}$ ≦10 V
D.C. voltage limit across high impedance (bridged) termination . . . . . ≦70 V

Frequency

Frequency setting
Continuously adjustable over the whole frequency range without change-over
fine, in steps of . . . . . 1 Hz
coarse, in steps of . . . . . 100 Hz

Frequency display . . . . . 6 or 7 digit LCD
Resolution . . . . . 1 Hz

Error limits of frequency display for
f ≦ 100 kHz . . . . . ±1 Hz
f ≦ 620 kHz . . . . . ±10 Hz
f ≦ 1.62 MHz (only SPM-30) . . . . . ±20 Hz
Synchronous tuning of the Level Generator PS-30 is possible.

Level indication

Reading in voltage level calibration (0 dB ≅ 0.775 V), power level calibration (0 dBm ≅ 1 mW in Z_o) or voltage (V)

Measuring ranges for 0 dB (2.5 V, 8 V) meter reading
Level: selective . . . . . −100 to +20 dB/dBm
wideband . . . . . −50 to +20 dB/dBm
Switchable in steps of . . . . . 10 dB
with depressed push button . . . . . additional 5 dB

Voltage: selective . . . . . 8 μV, 25 μV, ..., 8 V
wideband . . . . . 8 mV, 25 mV, ..., 8 V

Meter scale ranges
Level . . . . . −20 dB to +1 dB
Maximum resolution . . . . . 0.1 dB
Voltage . . . . . 0 to 2.8 V, 0 to 8.5 V

Fast signal detector with LED
Threshold referred to 0 dB meter reading . . . approx. −15 dB

Level calibration
Wideband . . . . calibration signal frequency, 10 kHz (fixed)
Selective . . . . . calibration signal frequency tracks synchronously with Receiver tuning

Individual errors

for selective and wideband measurements

Error limits of meter reading in range 0 dB (0 dBm) at 0 dB reading; $Z_{in} = Z_{source} = Z_o$ and f = 10 kHz
Selective after calibration and (23 ± 3)°C . . . . . ±0.1 dB
In range 0 to 50°C and wideband . . . . . ±0.15 dB

Error limits of range switching
referred to 0 dB (0 dBm) range at f = 10 kHz
Selective, level range +20 to −70 dB/dBm . . . . . ±0.15 dB
level range −80 to −100 dB/dBm . . . . . ±0.2 dB
Wideband . . . . . ±0.15 dB
Variation of level reading with frequency, referred to 10 kHz at $Z_{in} = Z_{source} = Z_o$

Frequency *)	200 Hz	1 kHz	100 kHz	620 kHz	1.62 MHz
$Z = 75\ \Omega$ (23 ± 3) °C	±0.1 dB				
$Z = 75\ \Omega$ 0 to +50°C	±0.15 dB				
$Z = 150, 600\ \Omega$	±0.2 dB	±0.15 dB		—	

*) SPM-31 up to 620 kHz

Error limits of meter scale
for readings +1 to −3 dB . . . . . ±0.1 dB
−3 to −6 dB . . . . . ±0.2 dB
−6 to −10 dB . . . . . ±0.3 dB

Total error

(Combination of all individual error limits introduced previously)
Total error limits after calibration at $Z_{in} = Z_{source} = Z_o$ and meter reading −6 to +1 dB
Selective measurements, levels ≧−80 dB/dBm . . . ±0.5 dB
Wideband measurements, levels ≧−50 dB/dBm . . ±0.5 dB

Selectivity

Bandwidth, switchable amongst

Bandwidth	24 Hz *)	1.74 kHz	3.1 kHz
3 dB bandwidth	24 Hz	—	—
Effective noise bandwidth	—	1.74 kHz	3.1 kHz
Rejection at: Δf = ±70 Hz	≧40 dB	—	—
Δf = ±250 Hz	≧70 dB	—	—
Δf = ±2 kHz	—	≧60 dB	≧60 dB

*) If requested, 100 Hz (≧50 dB rejection at Δf = ±350 Hz)

Image frequency and IF suppression . . . . . ≧70 dB

Harmonic ratio, a_{k_2} and a_{k_3}

in low distortion mode with a sensitivity increase of 50 dB over the measuring range for the total power, total power ≦ 0 dB (0 dBm)
Fundamental frequency
≧3 kHz . . . . . ≧70 dB
≧1 kHz, bandwidth 24 Hz . . . . . ≧70 dB
≧300 Hz, bandwidth 24 Hz . . . . . ≧65 dB

Intrinsic noise
Input terminated by Z_o
Wideband measurements . . . . . ≦−70 dB/dBm
Selective measurement, 24 Hz bandwidth, low noise, ≧10 kHz
for Z_o = 75 Ω, 600 Ω . . . . . ≦−130 dB/dBm
for Z_o = 150 Ω . . . . . ≦−130 dB (−125 dBm)
The values are 15 dB higher for the 1.74 kHz bandwidth and 18 dB higher for the 3.1 kHz bandwidth.

Outputs

Demodulator output, Z_{out} = 600 Ω . . 3 pole CF connector
Output level
0 dB meter indication . . . . . approx. 0 dB at 600 Ω load
Single-sideband demodulation, switchable to upright or inverted
Mid-band output frequency . . . . . 2 kHz

D.C. output . . . . . 3 pole CF connector
Voltage proportional to meter indication,
Z_{out} = 5 kΩ . . . . . 0 V to +5 V

Control output*
for remote tuning of Level Generator PS-30 . . . coaxial, BNC
Output level at $Z_{source} = Z_o$ = 75 Ω . . . . . approx. 0 dBm
Frequency range: SPM-30 . . . . . 4 MHz to 5.62 MHz
SPM-31 . . . . . 4 MHz to 4.62 MHz

Reference frequency output* . . . . . coaxial, BNC
for synchronization of PS-30 in remote tuning mode
Output level at $Z_{source} = Z_o$ = 75 Ω . . . . . approx. 0 dBm
Frequency . . . . . 1 MHz

General Specifications

Power supply
Mains operation
Rated ranges of use for a.c. line voltage,
switch selectable . . . . . 93.5 to 141 V/187 to 262 V
Rated range of use for a.c. line frequency . . . . . 45 to 66 Hz
Power consumption,
while measuring or recharging battery . . . . . 25 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I
Battery operation with option, BN 4502/00.02

Tolerable ambient temperature
Rated range of use . . . . . 0°C to +50°C
Storage and transport . . . . . −40°C to +60°C

Dimensions (w x h x d) in mm . . . . . 317 x 175 x 342

Weight
(with batteries and Tracking Generator) . . . . approx. 12 kg

Options

Rechargeable battery pack, BN 4502/00.02
for SPM-30 or SPM-31
Operating time . . . . . approx. 8 h
Charge time . . . . . approx. 14 h

Tracking Generator PSE-30 for SPM-30
PSE-31 for SPM-31

Frequency range	PSE-30	PSE-31
Balanced output	0.2 to 620 kHz	
Coaxial output (unbalanced)	0.2 to 1620 kHz	0.2 to 620 kHz

Frequency tuning and display see Level Meter

Generator outputs

Coaxial output* . . . . Universal connector Versacon® 9
Output impedance . . . . . 75 Ω
Level range . . . . . −60 to +1 dB/dBm or 0.8 mV to 0.85 V

Balanced output . . . . . 3 pole CF connector
Output impedance, selectable . . . . . 150 Ω*); 600 Ω; <5 Ω
*) 135 Ω on request
Level range . . . . . −60 to +1 dB/dBm or 0.8 mV to 0.85 V
with impedance Z_{source} <5 Ω . . . . . −60 to +11 dB/dBm
or 0.8 mV to 2.8 V

Return loss at 10 kHz . . . . . ≧40 dB
Signal balance ratio . . . . . ≧40 dB

Output level
Send level displayed on receiver's meter when push button is pressed

Level setting range
in 10 dB steps . . . . . −50 to +0 dB/dBm
or 2.5 mV, 8 mV, ..., 0.8 V
Balanced output, $Z_{source} \approx 0$ Ω . . . . . −50 to +10 dB/dBm
or 2.5 mV, 8 mV, ..., 2.5 V
continuous with pot . . . . . −10 to +1 dB
Error limits of output level for $Z_{source} = Z_{out} = Z_o$ at f = 10 kHz,
output level 0 dB/dBm . . . . . ±0.2 dB
Extra errors at any level, $Z_{source} = Z_{out} = Z_o$ . . . . . ±0.15 dB
Frequency response error limits referred to 10 kHz
Coaxial output . . . . . ±0.15 dB
Balanced output . . . . . ±0.3 dB
Total error limits for $Z_{source} = Z_{out} = Z_o$
referred to indicated level . . . . . ±0.5 dB

Harmonic ratio a_{k_2} and a_{k_3}
for meter readings ≦0 dB . . . . . ≧40 dB
Suppression of nonharmonic spurious signals
for output levels ≧ −40 dB . . . . . ≧60 dB

Ordering Information

Level Meter

SPM-30*, bandwidths 24 Hz, 1.74 kHz, 3.1 kHz	**BN 4502/01**
bandwidths 100 Hz, 1.74 kHz, 3.1 kHz	**BN 4502/03**
SPM-31*, bandwidths 24 Hz, 1.74 kHz, 3.1 kHz	**BN 4505/01**
bandwidths 100 Hz, 1.74 kHz, 3.1 kHz	**BN 4505/03**

Options (at extra cost)

Tracking Generator PSE-30* for SPM-30	BN 4502/00.01
Tracking Generator PSE-31* for SPM-31	BN 4505/00.01
Rechargeable battery pack	BN 4502/00.02
Impedance 135 Ω instead of 150 Ω [1]	

Accessories (at extra cost)

Return Loss Measuring Attachment RFZ-12 [2]	BN 810/01
Signal Balance Ratio Measuring Attachment SDZ-12 [2]	BN 811/01
Impedance Measuring Attachment SFZ-1 [2]	BN 385/04
Balanced Attenuator SDG-40 [2]	BN 608/00.01
Adaptor CF (F) – WE (M)	S 132
Front and back panel covers SD-940 (1 set)	BN 4502/00.03

1) SPM-30: BN 4502/00.12, SPM-31: BN 4505/00.12
PSE-30: BN 4502/00.05, PSE-31: BN 4505/00.05
2) For specifications and further information for ordering see Measurement Accessory Leaflet.
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

PS-15
Level Generator

for the frequency range 50 Hz to 10 MHz

IEEE 488
IEC 625



- **Synthesizer ensures that the send frequency is highly accurate and stable**
- **Digital display for frequency and level**
- **Coaxial and balanced outputs**
- **Low distortion factor**
- **Simple operation via keyboard**
- **External tuning from SPM-15 Level Meter**
- **Can be expanded to give a level standard**
- **A.C. line and battery operation**
- **Compact, handy and light**
- **Version BN 954/02 has female connectors for WECO male connectors**

Applications

The PS-15 Level Generator provides a signal source for measurements on coaxial and balanced FDM communication systems, for measurements at the baseband frequency level of radio-link and satellite systems with a max. of 1872 channels and for measurements on single voice channels and sound-programme channels.
Because the PS-15 is compact and robust it is ideal for mobile, field service (e.g. maintenance and in-service measurements) on postal systems, systems run by the railways or by public utility companies providing energy. As the PS-15 is highly accurate and has a high spectral purity it can be used in research and development, in production departments or in test departments. When used with the *SPM-15 Level Meter*, a complete Measuring Setup is created for level, loss and gain measurements. As the PS-15 has a remote control capability, it can be incorporated in *measuring systems.*

Characteristics

The send frequency of the PS-15 is generated by a synthesizer and has exceptionally high spectral purity, accuracy and stability. Both the frequency and the send level, which has a wide range, can be set rapidly via a keyboard or a step facility. The results are shown on an easy-to-read display.
The low-distortion send signal, which is held constant at the set value, can be "soft" blanked for measurements in channel gaps. The send level can be switched to voltage or power level.

Frequency range	50 Hz to 10 MHz
Error limits of frequency	$\pm 3 \times 10^{-6}$
Send level range (impedance dependent)	−63.9 to +19 dBm or −69.9 to +16 dB
Harmonic ratio, levels ≦0 dB/dBm	≧50 dB
Output impedance,	
coaxial	75 Ω
balanced	600, 150 (135), 124 Ω; approx. 0 Ω

Further Characteristics and Applications

- High frequency stability: The small error of 3×10^{-6} on the set send frequency means that even high frequencies can be set with high accuracy. The error stated is valid for the rated range of temperature and includes the ageing of the reference crystal.
- Digital level display: For setting the send level rapidly and accurately with high resolution. A continuous fine setting is also available.
- Use as a level standard: The PS-15 can be used as a precise a.c. voltage source delivering a level of 0 dBm. This is achieved by setting up a control loop in which the setting voltage of the *EPM-1 Milliwatt Power Meter,* acting as an ALC amplifier, is fed into the control voltage input of the send section. If long leads are used it is possible to eliminate losses and matching errors using the arrangement described above.
- Battery power facility: If required the *BAZ-15 Battery Pack* can be purchased. It is mounted on the back panel of the PS-15; the charger is contained in the Main Frame.
- Remote control capability: When used in non-mobile applications the PS-15 can be fitted with a IEC 625/IEEE 488 remote control connector instead of the BAZ-15 Battery Pack. This means the PS-15 can be computer controlled in automatic test systems.

Specifications of the Level Generator — PS-15

If nothing to the contrary is stated, the data are valid for the rated ranges of use for ambient temperature, a.c. line voltage and a.c. line frequency immediately after switch-on.

Outputs

Coaxial output* . . . . . Versacon® 9 universal connector system, can be converted to all commercially available connectors
BN 954/02: Female conn. for WECO 358 A male conn.
Output impedance . . . . . 75 Ω
Frequency range . . . . . 50 Hz to 10 MHz
Return loss . . . . . ≧40 dB

Balanced output . . . . . 3 pole CF connector
Signal balance ratio complies with CCITT O.121 . . . . . ≧40 dB

Output impedance, switch-selectable . . . . . 124, 150 Ω
BN 954/02: Only 124 Ω
Female conn. for WECO 372 A/379 A male conn.
Frequency range . . . . . 6 kHz to 10 MHz
Return loss at 100 kHz . . . . . ≧50 dB

Output impedance, switch-selectable . . 600 Ω, approx. 5 Ω
BN 954/02: Also 135 Ω
135 Ω female conn. for WECO 241 A male conn.
600 Ω female conn. for WECO 310 male conn.
Frequency range . . . . . 50 Hz to 620 kHz
Return loss at 10 kHz . . . . . ≧40 dB

Frequency

Frequency setting
digital via keyboard, resolution . . . . . 1 Hz
in steps via increment key, smallest step . . . . . 1 Hz
Frequency display . . . . . 7 digits, LED
Error limits of frequency including 1 year's ageing . . . . . $\pm 3 \times 10^{-6}$
External tuning (to 10 MHz) via the SPM-15, SPM-18 and SPM-19 Level Meters.

Send level

Calibration for either voltage levels (0 dB ≅ 0.775 V) or power levels (0 dBm ≅ 1 mW into Z_o)

Level setting
digital via keyboard, resolution . . . . . 0.1 dB
by steps via increment key, smallest step . . . . . 0.1 dB
Continuous level setting . . . . . ±0.1 dB
Level display . . . . . LED display, 3 digits and sign

Level ranges[1)]
Coaxial output
$Z_{out} = Z_L = 75\ \Omega$ . . . −60.9 to +19 dBm (−69.9 to +10 dB)
Balanced output
$Z_{out} = Z_L = 124\ \Omega$ . . −63.1 to +16.8 dBm (−69.9 to +10 dB)
BN 954/02:
$Z_{out} = Z_L = 135\ \Omega$ . . . . . −63.4 to +16.4 dBm (−69.9 to +10 dB)
$Z_{out} = Z_L = 150\ \Omega$ . . . −63.9 to +16 dBm (−69.9 to +10 dB)
$Z_{out} = Z_L = 600\ \Omega$ . . . . . −69.9 to +10 dBm/dB
$Z_{out} = 0\ \Omega, Z_L = 600\ \Omega$ . . . . . −63.9 to +16 dBm/dB
1) See "Outputs" for impedances for BN 954/02

Error limits
Error limits of the send level
for $Z_{out} = Z_L = Z_o$ or $Z_{out} = 0\ \Omega, Z_L = Z_o$
at 10 kHz or 100 kHz (124, 150 Ω),
output level 0 dB/dBm, at (23 ± 3) °C . . . . . ±0.1 dB
additional error at any send level . . . . . ±0.1 dB

Error limits of the frequency response at (23 ± 3) °C

Output[1)]	Referred to	50	200 Hz	6	100	620 kHz	10 MHz
$Z_o = 75\ \Omega$	10 kHz	±0.1 dB					
$Z_o =$ 124, 150 Ω	100 kHz	—		±0.15 dB			
$Z_o = 600\ \Omega$ $Z_{out} = Z_L = Z_o$	10 kHz	±0.2 dB		±0.15 dB			—
$Z_o = 600\ \Omega$ $Z_{out} = 0\ \Omega$, $Z_L = Z_o$	10 kHz	±0.2 dB		±0.15 dB		±0.5 dB	—

1) See "Outputs" for the impedance for BN 954/02

Average temperature coefficient of the send level in the range 0 to +50°C, referred to +23°C . . . . . ±0.006 dB/K

Overall error limits
at $Z_{out} = Z_L = Z_o$ or $Z_{out} = 0\ \Omega$, $Z_L = Z_o$

Output [1]	Referred to 50	200 Hz	6	100	620 kHz	10 MHz
$Z_o = 75\ \Omega$	10 kHz	±0.25 dB				
Z_o = 124, 150 Ω	100 kHz	—	±0.3 dB			
$Z_o = 600\ \Omega$ $Z_{out} = Z_L = Z_o$	10 kHz	±0.4 dB	±0.3 dB		—	
$Z_o = 600\ \Omega$ $Z_{out} = 0\ \Omega$, $Z_L = Z_o$	10 kHz	±0.4 dB	±0.3 dB	±0.6 dB	—	

1) See "Outputs" for the impedance for BN 954/02

Spurious voltages
at $Z_{out} = Z_L = Z_o$ or $Z_{out} = 0\ \Omega$, $Z_L = Z_o$

Harmonic ratio a_{k_2} and a_{k_3}
for output levels ≦0 dB/dBm . . . . . ≧50 dB

Attenuation of discrete, nonharmonic, spurious voltages
in the range 50 Hz to 10 MHz . . . ≧70 dB below wanted signal
Noise level . . . . . ≦−110 dBm (−120 dB)

Signal-to-noise ratio
referred to 1 Hz bandwidth,
output level 0 dB/dBm, f ≧ 10 kHz
≧20 kHz from signal . . . . . ≧120 dB
≧200 kHz from signal . . . . . ≧130 dB

Level blanking,
manually via key, blanking attenuation . . . . . ≧80 dB

Auxiliary inputs

Control input
for external control by the SPM-15 (SPM-18, SPM-19) Level Meter

BNC input for standard frequency . . . . . 10 MHz
Required input level for 75 Ω . . . . . approx. 0 dBm

BNC input for carrier frequency . . . . . 40 to 50 MHz
Required input level for 75 Ω . . . . . approx. −10 dBm

Input for regulating the amplitude of the send signal with the EPM-1 . . . . . 3 pole, CF connector

Options

Remote control capability via the <IEC 625>/IEEE 488 [1] Interface Bus, BN 955/00.03
Interface functions SH1, AH1, T6, L4, SR1, RL1, PP2, DC1, DT1, C0

Battery Pack BAZ-15 [1], BN 955/00.01
Operating time . . . . . approx. 5 h
Charging time . . . . . approx. 14 h

General Specifications

Power supply
A.C. line operation
Rated ranges of use for a.c. line voltage,
switch-selectable . . . . . 110/117/127/220/227/237 V, −12 to +10 %
Rated range of use for a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption (measurements or charging) . . . 35 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I
Battery operation
with BAZ-15 Battery Pack, BN 955/00.01

Permissible ambient temperature
Rated range of use . . . . . 0 to +50°C
Limits operating range . . . . . −10 to +55°C
Storage and transportation . . . . . −40 to +60°C

Dimensions (w x h x d) in mm . . . . . 317 x 175 x 342

Weight
PS-15 (without option) . . . . . approx. 11 kg
BAZ-15 . . . . . approx. 2.8 kg
<IEC 625> Interface Board . . . . . approx. 1 kg

Ordering Information

Level Generator PS-15 *	**BN 954/01**
Level Generator PS-15 with WECO connectors	**BN 954/02**
Options (at extra cost)	
Battery Pack BAZ-15; rechargeable NiCads [1]	BN 955/00.01
Interface <IEC 625> board [1] with IEC 625/IEEE 488 (S 834) adaptor	BN 955/00.03
135 Ω impedance instead of 150 Ω (for BN 954/01)	BN 954/00.21
Accessories (at extra cost)	
Connecting cable for the <IEC 625> Interface Bus	
120 cm	K 343
200 cm	K 344
Protective Transportation	
Cover SD-940 (1 set)	BN 960/00.02
19" conversion kit	BN 4502/00.16

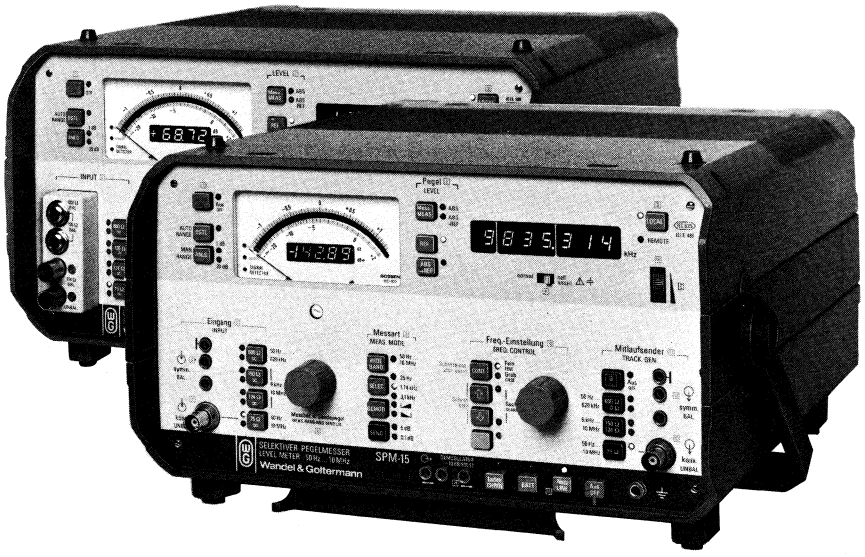
1) The BAZ-15 and the Interface Bus cannot be used simultaneously
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9, and order chosen type when ordering instrument.

A Colour Brochure is available on request

SPM-15
Selective Level Meter

for the frequency range 50 Hz to 10 MHz, send section available

IEEE 488
IEC 625



- **Selective and wideband measurements**
- **Synthesizer for high accuracy and stability of tuned frequency**
- **Frequency is set quasi-continuously, by increments or by search-scan**
- **Analog or digital level display with autoranging; resolution 0.01 dB**
- **Absolute and relative measurements**
- **Automatic level calibration**
- **Fast signal detector**
- **Integral demodulator and loudspeaker**
- **A.C. line and battery operation**
- **Compact, handy, light**

Version BN 955/02:

- **Measures noise, reading in dBrnC**
- **Connectors for WECO male connectors**

Applications

The SPM-15 Selective Level Meter is used for level measurements on balanced and coaxial FDM systems, at the baseband of radio-link and satellite systems with up to 1872 channels and also in single voice-channels and sound programme channels. Because the SPM-15 is compact, robust and can be battery powered it is ideal for the servicing and maintenance work carried out on postal systems, on railways and on the networks of public utility companies supplying energy. The SPM-15 is particularly effective for detecting spurious signals, or for long-term monitoring applications.
As the SPM-15 is accurate, flexible and remote controllable, it can be used during the development, production and testing of system components. When the send section is fitted, a complete measuring setup for loss and gain measurements is formed. The *PS-15 Level Generator* is available for measurements at different send and receive frequencies, and for end-to-end measurements.

Characteristics

Frequency conditioning in the SPM-15 is carried out in a synthesizer with an especially high spectral purity, accuracy and stability. The frequency can be tuned continuously, by increments or automatically (search-scan).
The frequency is shown on an LED display with a resolution of 1 Hz. The receive level can be displayed on a meter or digitally with greater resolution. The automatic level calibration and linearity check ensure a high accuracy of measurement. If required, the Level Meter can be delivered with a tracking generator, (inclusive batteries) or, alternatively, with the Interface Bus <IEC 625>/IEEE 488 for control by a computer.

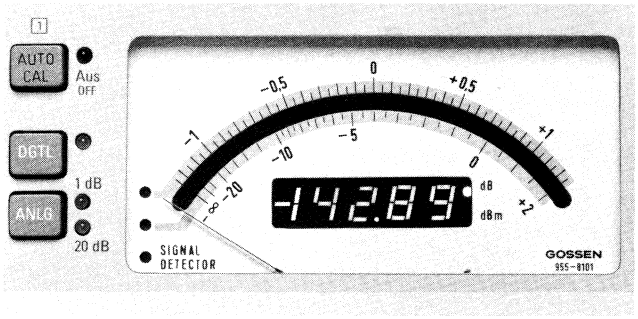
Frequency range	50 Hz to 10 MHz
Frequency adjustments	quasi-continuous, by increments or search-scan
Error limits of the frequency	$\pm 3 \times 10^{-6}$
Display range (Z_o = 75 Ω)	
selective	−140 to +20 dB/−130 to +20 dBm
wideband	−60 to +20 dB/−50 to +20 dBm
Input impedance	
coaxial	75 Ω, high impedance
balanced	124, 150 (135), 600 Ω, high impedance
Intrinsic harmonic ratio	≧80 dB
Send level range (with PSE-15)	−60 to +11 dB/dBm

2578 SPM-15

Further characteristics and applications

SPM-15 Level Meter, BN 955/01

- High frequency accuracy: The small deviation of 3×10^{-6} from the set frequency means that the frequency selected is also accurate at high frequencies, e.g. when measuring pilot levels or carrier leaks. The error stated is valid in the rated range of temperature and includes ageing of the reference crystal.
- Search-scan: This facility is used to rapidly locate hot tones or discrete impairments whose level exceeds a set threshold. The scan speed is set automatically for the selected bandwidth.
- Automatic level calibration: Ensures high measuring accuracy in the selective mode, by using a tracking calibration signal which has the same frequency as the tuned frequency. This signal is switched into the signal path at regular intervals or when important setting parameters are altered.
- Digital and analog level display: The digital display has a resolution of 0.01 dB when autoranging is used. When the analog display is used (overview measurements, alignments) the 20 dB range or the *expander* with a range of ±1 dB can be selected.
- Absolute and relative level measurements: The absolute level (in dB or dBm) can be stored as a reference level so that the deviations from this value in subsequent measurements can be read off on the digital or analog display. This simplifies both frequency response and distortion measurements.
- Measuring very high levels: High impedance level measurements (+50 dBm) on power-line carrier equipment and installations, for example, can be carried out by connecting in the *SDG-40 Balanced Attenuator.*
- Switch-selectable bandwidths: Pilots, carrier leaks, or frequency spectra can be investigated using the narrow 25 Hz filter. On the other hand, weighted noise measurements can be carried out in single voice channels at the carrier frequency level using a 1.74 kHz effective noise bandwidth filter. A flat 3.1 kHz filter for measurements over the whole channel bandwidth (e.g. via the demodulator output) can also be switched in.
- Remote control: All important functions can be remote controlled using the remote control board option. The board complies with IEC 625/IEEE 488. The board is fitted in the back panel instead of the *BAZ-15 Battery Pack.*
  If you have to perform rapid level measurements or to handle large amounts of data (e.g. system monitoring), we recommend the use of the SPM-19 Selective Level Meter (50 Hz to 25 MHz).
- Economical design: Depending on the application, the SPM-15 can be used with the *PSE-15 Send Section* (same send and receive frequency), or with the *PS-15 Level Generator* (translator and distortion measurements) to form a measuring setup.



Analog and digital level display

SPM-15 Level Meter, BN 955/02

like version BN 955/01, but also has
- built-in tracking generator (PSE-15)
- CF-channel noise displayed in dBrnC
- 75, 124, 135 and 600 Ω impedances
- Female WECO connectors

Specifications for the Selective Level Meter with tracking generator — SPM-15

If nothing to the contrary is stated, the data for the nominal ranges of ambient temperature, a.c. line voltage and a.c. line frequency are valid immediately after switch-on.

Inputs

Coaxial input* . . . . . Versacon® 9 Universal Connector System suitable for all usual connector types
BN 955/02: fem. connector for WECO 358 A male connector
Input impedance, switchable . . . . 75 Ω and high impedance
Frequency range . . . . . 50 Hz to 10 MHz
Return loss . . . . . ≧36 dB

Balanced input . . . . . 3 pole CF connector
Input impedance, switchable . . . . . 124, 150 Ω and high impedance
BN 955/02: only 124 Ω
fem. connector for WECO 372 A/379 A male connector
Frequency range . . . . . 6 kHz to 10 MHz
Signal balance ratio as per CCITT O.121, f = 6 kHz to 1 MHz . . . . . ≧40 dB
Return loss at f = 100 kHz . . . . . ≧40 dB

Input impedance, switchable . . . 600 Ω and high impedance
BN 955/02: also 135 Ω
135 Ω fem. connector for WECO 241 A male connector
600 Ω fem. connector for WECO 310 male connector
Frequency range . . . . . 50 Hz to 620 kHz
Signal balance ratio as per CCITT O.121 . . . . . ≧40 dB
Return loss at f = 10 kHz . . . . . ≧50 dB

Tolerable input voltage for all inputs
Overload limit when terminated with Z_o, $V_{r.m.s.}$ . . . . . 10 V
Tolerable d.c. voltage at high impedance input . . . . . 60 V

Frequency

Frequency settings
Manual quasi-continuous adjustment over the whole range without switchover, resolution . . . . . 1 Hz
also by increments with variable increment width and automatic search-scan. Stopped by signal detector.
Synchronous tuning of the PS-15 Level Generator can also be carried out.

Frequency display . . . . . 7 digits with LED
Error limits for the tuning frequency including ageing over a year . . . . . $\pm 3 \times 10^{-6}$

Level display

Display of power level (dBm) referred to . . . . . 1 mW
of voltage level (dB) referred to . . . . . 0.775 V
the level difference between an absolute and a stored reference level . . . . . dB
Noise level (dBrnC) [1] with Option BN 955/00.23 instead of noise voltage level
1) 0dBrnC ≅ −90 dBm
Display, switchable . . . . . digital or analog
Digital display, resolution . . . . . 0.01 dB
Analog display via meter, ranges . . . . . ±1 dB and 20 dB

Fast signal detector with LED
Activation threshold on the 20 dB scale . . . . approx. −15 dB (≦ −10 dB)

Display ranges

Input *)	Selective	Wideband 1)
Z_o = 75 Ω	−130 to +20 dBm −140 to +20 dB	−50 to +20 dBm −60 to +20 dB
Z_o = 124, 150 Ω	−120 to +20 dBm −130 to +20 dB	−40 to +20 dBm −50 to +20 dB
Z_o = 600 Ω	−130 to +20 dB/dBm	−50 to +20 dB/dBm

*) "Inputs" describes the impedances for BN 955/02
1) In analog measurement mode, the lower limit is 10 dB less

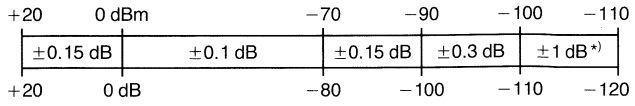
Measurement range selection
Autoranging for digital display
Manually in steps of 1 dB or 10 dB for analog display

Measurement errors

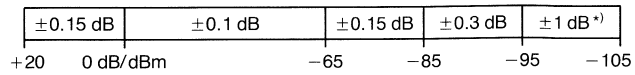
Selective measurements
for $Z_{in} = Z_{out} = Z_o$ and automatic level calibration
Error limits of level display for 0 dBm (dB) input level, display digital or analog (±1 dB scale),
f = 10 kHz (100 kHz at Z_o = 124, 150 Ω)

	Coaxial	Bal.
in the range (23 ±3)°C	±0.06 dB	±0.1 dB
in the range 0 to +50°C	±0.15 dB	±0.2 dB

Additional error for any input level
coaxial input

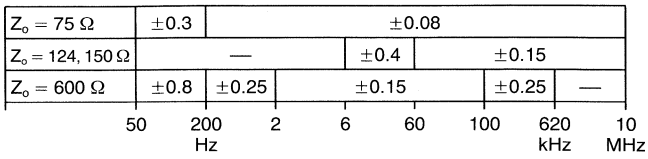


balanced input



*) Error limits only apply to the 25 Hz bandwidth.

The variation of level display with frequency referred to 10 kHz (100 kHz at Z_o = 124, 150 Ω), for input levels at least 40 dB greater than intrinsic noise (values in dB).



Additional error for analog display 20 dB scale, in the range −10 to +2 dB . . . . . ±0.3 dB

Wideband measurements
Overall error in the range 0 to +50°C, $Z_{in} = Z_{out} = Z_o$ and after calibration

Input *)	Level range	Error limits
Z_o = 75 Ω	−60 to +20 dB/−50 to +20 dBm	±0.6 dB
Z_o = 124, 150 Ω	−50 to +20 dB/−40 to +20 dBm	±0.7 dB
Z_o = 600 Ω	−50 to +20 dB/dBm	±0.7 dB

*) See "inputs" for impedances for BN 955/02

Selectivity

The bandwidths are switchable between:

Bandwidth		25 Hz 1)	1.74 kHz 2)	3.1 kHz
Eff. noise bandwidth (±10 %)		—	1.74 kHz 2)	3.1 kHz
Distance Δf from centre frequency for an attenuation of	≦3 dB	±7 Hz	±650 Hz	±1.5 kHz
	≧50 dB	±80 Hz	—	—
	≧60 dB	±250 Hz	±2 kHz	±2 kHz

1) Values apply to a temperature range of +5 to +40°C
2) 1.95 kHz for BN 955/02

Image frequency rejection and IF suppression . . . . ≧70 dB

Harmonic ratio a_{k_2}, a_{k_3}

level of the fundamental ≦0 dB/dBm,
with automatic calibration, frequency of the fundamental
f ≧3 kHz . . . . . ≧80 dB
f ≧300 Hz (bandwidth 25 Hz) . . . . . ≧70 dB

Noise power ratio (NPR)

when loaded with noise having the bandwidth 12 kHz to 8160 kHz, wideband level −25 to +10 dBm, slot anywhere in the band with B_{eff} ≧ 20 kHz, bandwidth 1.74 kHz (1.95 kHz) and with automatic calibration . . . . . ≧54 dB

Noise floor

Intrinsic noise and discrete spurious signals, selective, bandwidth 25 Hz, input terminated with Z_o, f ≧ 3 kHz
Input 75 Ω . . . . . ≦−135 dB (−125 dBm)
Input 124, 150 Ω (f ≧6 kHz) . . . . . ≦−125 dB (−120 dBm)
Input 600 Ω . . . . . ≦−125 dB/dBm
When the bandwidths 1.74 kHz (1.95 kHz) and 3.1 kHz are used, the level values increase by +10 dB.

Additional outputs

Demodulator output
3 pole CF connector . . . . . Z_{out} = 600 Ω
BN 955/02: fem. connector for WECO 310 male connector
SSB demodulation . . . . . erect/inverted position
Frequency of the translated channel when tuned to channel carrier . . . . . 0 to 4 kHz

A.C. voltage output (BNC), short circuit proof
Output level for $Z_{out} = Z_L = 75\ \Omega$ and
0 dB range display . . . . . 0 dBm
Output frequency,
operating mode, selective . . . . . 10 kHz
wideband . . . . . as input signal

D.C. output
3 pole CF connector . . . . . $Z_{out} = 5\ k\Omega$
Open-circuit voltage for f.s.d. . . . . +5 V

Output for internal standard frequency (BNC) . . . . 10 MHz

Control output for external tuning (BNC)
of the PS-15 Level Generator,
frequency range . . . . . 40 to 50 MHz

Options

PSE-15 Tracking Generator, BN 955/00.02
(Standard in BN 955/02)

Frequency range . . . . . same as Level Meter

Frequency adjustment
and display . . . . . same as Level Meter

Generator outputs
Coaxial output, fem . . . . . same as Level Meter
Output impedance . . . . . 75 Ω
Return loss at 10 kHz . . . . . ≧50 dB
Balanced output, fem . . . . . same as Level Meter
Output impedance,
switchable . . . . . 600, 150, 124 Ω, approx. 15 Ω
BN 955/02: 600, 135, 124, approx. 15 Ω
Return loss
at f = 100 kHz or 10 kHz (600 Ω) . . . . . ≧36 dB
Signal balance ratio as per CCITT O.121 . . . . . ≧40 dB

Send level
Send level is displayed digitally by
pressing a button, resolution . . . . . 0.1 dB

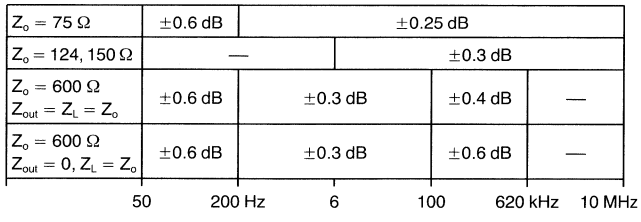
Send level range

Coaxial	$Z_o = 75\ \Omega$	−51 to +10 dBm	−60 to +1 dB
Balanced	$Z_o = 124\ \Omega$	−53 to +6.8 dBm	−60 to +1 dB
	$Z_o = 150\ \Omega$	−54 to +7 dBm	
Balanced [1]	$Z_o = 600\ \Omega$, $Z_{out} = Z_o$	−60 to +1 dBm	−60 to +1 dB
	$Z_o = 600\ \Omega$, $Z_{out} \approx 0$	−50 to +11 dBm	−50 to +11 dB

1) BN 955/02: 135 Ω as alternative to 150 Ω

Level adjustment in steps of . . . . . 5 dB or 0.1 dB

Error limits of the send level
for $Z_{out} = Z_L = Z_o$ or $Z_{out} = 0$, $Z_L = Z_o$



Intrinsic harmonic ratio a_{k_2} and a_{k_3}
f = 50 Hz to 10 MHz . . . . . ≧40 dB

Attenuation of nonharmonic spurious signal,
at least 50 dB below wanted signal.

A Colour Brochure is available on request

BAZ-15 Battery Pack [2], BN 955/00.01
Operating time . . . . . approx. 5 h
Charging time . . . . . approx. 14 h

Interface Bus <IEC 625>/IEEE 488 [2], BN 955/00.03
Interface functions . . . . . SH1, AH1, T6, L4, SR1, RL1, PP2, DC1, DT1, CØ

General Specifications

Power supply
A.C. line
Nominal ranges of use for a.c. line voltage,
switchable . . . 110/117/127/220/227/237 V, −12 to +10 %
Nominal range of use for a.c. line frequency . . . 47.5 to 63 Hz
Power consumption, measuring or charging . . approx. 38 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Battery powered from BAZ-15 Battery Pack, BN 955/00.01.

Ambient temperature
Nominal range of use . . . . . 0 to +55°C
Limits operating range . . . . . −10 to +55°C
Storage and transportation . . . . . −40 to +70°C *)
*) with BAZ-15 Battery Pack, BN 955/00.01, −40 to +60°C

Dimensions (w x h x d) in mm . . . . . 317 x 175 x 342

Weight
SPM-15 with PSE-15 . . . . . approx. 13 kg
BAZ-15 . . . . . approx. 2.8 kg
<IEC 625> Interface Bus Card . . . . . approx. 1 kg

Ordering Information

Level Meter SPM-15 *	**BN 955/01**
Level Meter SPM-15 with Tracking Generator PSE-15, noise measurements in dBrnC [1], and WECO connectors	**BN 955/02**
Options (at extra cost)	
Tracking Generator PSE-15 * (for BN 955/01)	BN 955/00.02
Battery Pack BAZ-15, rechargeable [2]	BN 955/00.01
Interface <IEC 625> board [2] with IEC 625/IEEE 488 (S 834) adaptor	BN 955/00.03
Impedance: 135 Ω instead of 150 Ω (for BN 955/01)	BN 955/00.21
Noise measurements in dBrnC [1] (for BN 955/01)	BN 955/00.23
Accessories (at extra cost) [3]	
Test Probe TK-12, coaxial and balanced	BN 574/00
Power Supply TKN-12, for TK-12	BN 623/00
CF Plug for TK-12	S 804
Return Loss Measuring Attachment RFZ-12 200 Hz to 4.5 MHz	BN 810/01
Reflection Coefficient Measuring Device RFZ-5 10 kHz to 36 MHz	BN 394/00
Signal Balance Ratio Measuring Attachment SDZ-12 200 Hz to 4.5 MHz	BN 811/01
Impedance Magnitude Measuring Attachment SFZ-1 300 Hz to 612 kHz	BN 385/04
Balanced Attenuator SDG-40	BN 608/00.01
Connection cable for the Interface Bus <IEC 625>	
120 cm	K 343
200 cm	K 344
Protective Transportation Cover SD-940 (1 set)	BN 960/00.02
19" conversion kit	BN 4502/00.16

1) has bandwidth of 1.95 kHz instead of 1.74 kHz
2) The BAZ-15 and the Interface Bus cannot be used at the same time
3) For specifications and more ordering information see the Specification Sheet "Measuring Accessories". Accessories suitable for BN 955/01.
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adaptor. For other adaptor types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

PS-18
Level Generator

Frequency range: 80 Hz to 25 MHz



- **Synthesizer ensures high accuracy and stability of send frequency**
- **Digital frequency and level displays**
- **Coaxial and balanced output**
- **Output impedance 0; 75; 124; 150 (135); 600 Ω**
- **Low harmonic distortion**
- **External tuning by the SPM-18 or SPM-19 Level Meter**
- **Extendable to Level Standard**
- **Rechargeable battery pack for a.c. line-free power supply, if requested**

Applications

The PS-18 Level Generator provides a signal source for measurements on balanced and coaxial FDM communication systems with up to 3600 channels. The PS-18 can also handle the lower multiplex range of single sideband radio-link systems. Because of its accuracy, the PS-18 is particularly useful in development, manufacturing and testing. As it can operate over a wide temperature range and may be battery powered (if required), it is well suited for in-service monitoring and maintenance on postal systems. The PS-18 can be used for the same purpose by railways, and public utility companies which supply energy.

A complete Level Measuring Setup is created when the PS-18 is used in conjunction with the SPM-18 or SPM-19 Level Meter, so allowing level, loss and gain measurements to be carried out (end-to-end or loop-back).

Characteristics

The PS-18's send frequency is generated in a synthesizer which has an outstandingly high spectral purity, accuracy and stability. The send frequency can be set via a keypad entry or by continuous adjustment. The send level can be set via a keypad or can be stepped through. The send signal can be "soft" blanked for in-service measurements in channel gaps. Version BN 898/20 has a female connector for a WECO male connector.

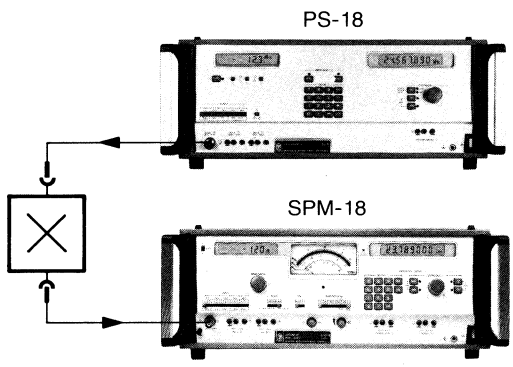
Frequency range, coaxial	80 Hz to 25 MHz
balanced	80 Hz to 14 MHz
Error limits on frequency	$\pm 3 \times 10^{-7}$
Send level range,	
coaxial	−83.9 to ± 1 dB/−74.9 to +10 dBm
Harmonic ratio	≧ 50 dB
Ambient temperature,	
Rated range of use	0 to +50 °C

Further Characteristics and Applications

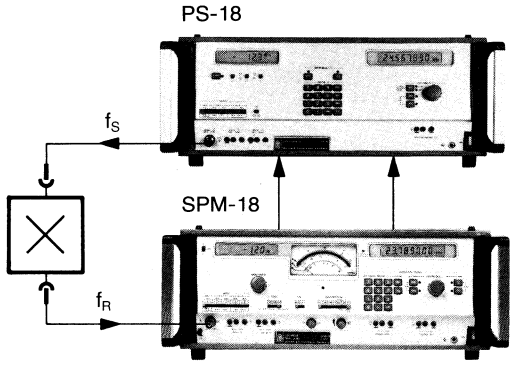
- Frequency accuracy: In the basic version the frequency uncertainty in the rated range of use for temperature (incl. ageing) is only 3×10^{-6}. A reference crystal with an uncertainty of 3×10^{-7} can be fitted, on request, to increase frequency accuracy even more.
- Digital level display: For setting the send level accurately and rapidly with a high resolution of 0.1 dB.
- Use as a level standard: The PS-18 can be used as an exact a.c. signal source producing a level of 0 dBm. This is achieved by forming a control loop in which the *EPM-1 Milliwatt Power Meter* acts as an ALC amplifier and feeds a control voltage to the control voltage input of the PS-18. This setup eliminates the losses and matching errors introduced by long leads.
- Frequency compatibility with the SPM-19 Level Meter: When used with the SPM-19 (version BN 829/02, /03 or /22) the voltage output from the PS-18 can be frequency swept. The sweep curve can then be shown, for example, on the *SG-4 Display Unit.*
- Power from external batteries: The *WR-450 Inverter* can be used to supply power from batteries, if required. It is mounted on the back panel of the PS-18. An external battery (11.5 V to 30 V) or the *BAK-450 Battery Pack,* which contains rechargeable batteries and a charger, can be connected to the WR-450.



a) PS-18 battery-operated
WR-450 Inverter mounted on back panel



b) End-to-end measurements and measurements using different send and receive frequencies



c) Loop-back measurement ($f_S = f_R$)

Possible applications for the PS-18 Level Generator

Specifications of the Level Generator — PS-18

Unless otherwise noted, the specifications are valid for the rated ranges of use of a.c. line voltage, a.c. line frequency, and ambient temperature 15 min after the instrument has been switched on.

Outputs

Coaxial output* . . . . . Universal connector Versacon® 9 adaptable to all usual commercial connector systems
Version BN 898/20 has a fem. conn. for a WECO 358 A male conn.
Output impedance . . . . . 75 Ω
Frequency range . . . . . 80 Hz to 25 MHz

Balanced outputs[1] . . . . . 3 pole CF connector
Output impedance, switchable . . . . . 124 Ω, 150 Ω
Frequency range . . . . . 60 kHz to 14 MHz
Signal balance ratio, according to CCITT Rec. O.121 . . . . . ≧ 40 dB

Output impedance, switchable . . 600 Ω, 150 Ω, approx. 0 Ω
Frequency range . . . . . 80 Hz to 620 kHz
Signal balance ratio, according to CCITT Rec. O.121 . . . . . ≧ 40 dB

1) BN 898/20: 135 Ω instead of 150 Ω
124 Ω fem. conn. for WECO 372 A/379 A male conn.
135 Ω fem. conn. for WECO 241 A male conn.
600 Ω fem. conn. for WECO 310 A male conn.

Frequency

Frequency range . . . . . see "Outputs"

Frequency setting
digital through keyboard, resolution . . . . . 1 Hz
quasi-continuous manual tuning over the complete range, without bandswitching, smallest step . . . . . 1 Hz

Error limits of frequency,
including ageing over 1 year . . . . . $\pm 3 \times 10^{-6}$
with Option BN 865/00.02 . . . . . $\pm 3 \times 10^{-7}$
Slave tuning from Level Meter SPM-18, SPM-19 is possible.

Send level

Calibration switchable from voltage levels (0 dB ≅ 0.775 V) to power levels (0 dBm ≅ 1 mW into Z_0)

Level setting
digital through keyboard, resolution . . . . . 0.1 dB
in steps through increment key with automatic overflow to the next decade, smallest step . . . . . 0.1 dB
Level display . . . . . 3 digits and sign

Level ranges
coaxial output
$Z_{out} = Z_L = 75\ \Omega$ . . . −83.9 to +1 dB (−74.9 to +10 dBm)
balanced output I
$Z_{out} = Z_L = 124\ \Omega$ . . −82.2 to +2.7 dB (−75.3 to +9.6 dBm)
$Z_{out} = Z_L = 150\ \Omega$ . . −82.2 to +2.7 dB (−76.2 to +8.7 dBm)
balanced output II [1]
$Z_{out} = Z_L = 150\ \Omega$ . . −83.9 to +11 dB (−77.9 to +17 dBm)
$Z_{out} = 0, Z_L = 150\ \Omega$ . . −78 to +16.9 dB (−72 to +22.9 dBm)
$Z_{out} = Z_L = 600\ \Omega$ . . . . . −83.9 to +11 dB/dBm
$Z_{out} = 0, Z_L = 600\ \Omega$ . . . . . −77.9 to +17 dB/dBm

Total error for $Z_{out} = Z_L = Z_0$ or $Z_{out} = 0, Z_L = Z_0$

Output $Z_0 = 75\ \Omega$, f ≧ 200 Hz
Level > −20.0 dB/dBm . . . . . ±0.20 dB
Level ≦ −20.0 dB/dBm . . . . . ±0.25 dB

Output $Z_0 = 124, 150\ \Omega$
Level > −20.0 dB/dBm . . . . . ±0.30 dB
Level ≦ −20.0 dB/dBm . . . . . ±0.35 dB

Output $Z_0 = 150, 600\ \Omega$, f = 200 Hz to 100 kHz . . . ±0.35 dB

Error limits of frequency response for $Z_{out} = Z_L = Z_0$ or $Z_{out} = 0, Z_L = Z_0$ (included in total error)
(values in dB)

Output	Referred to	80	200 Hz	1	60	100	620 kHz	5	14	25 MHz
Z_0 = 75 Ω	20 kHz	±0.25	±0.1	±0.08				±0.1		
Z_0 = 124, 150 Ω	200 kHz	—			±0.15			±0.2	—	
Z_0 = 150, 600 Ω	20 kHz	±0.25 [2]	±0.15	±0.13		±0.25		—		

Spurious voltages

Harmonic ratio a_{k_2} and a_{k_3}
for $Z_{out} = Z_L = Z_0$ or $Z_{out} = 0, Z_L = Z_0$
Coaxial output, $Z_0 = 75\ \Omega$, 800 Hz to 25 MHz . . . . . ≧ 50 dB
Balanced outputs
$Z_0 = 124\ \Omega, 150\ \Omega$, 60 kHz to 14 MHz . . . . . ≧ 50 dB
$Z_0 = 150\ \Omega, 600\ \Omega$, 800 Hz to 100 kHz . . . . . ≧ 50 dB

1) at f < 200 Hz send level ≦ 0 dB/dBm 2) send level ≦ 0 dB/dBm

Suppression of discrete, nonharmonic spurious signals, in range 200 Hz to 25 MHz,
signal-to-spurious signal ratio . . . . . ≧ 60 dB
or spurious level . . . . . ≦ −120 dB (−110 dBm)
or ≦ −100 dB (−90 dBm)
when WR-450 Inverter is connected

Additional inputs and output

External automatic level control
from EPM-1, control range . . . . . approx. ± 1 dB

Control input* for external tuning
from Level Meter SPM-18 or SPM-19

Input* for external standard frequency . . . . 1; 2; 5; 10 MHz

Output* for internal standard frequency . . . . . 10 MHz

General Specifications

Power supply
Rated ranges of use for a.c. line voltage, selectable . . . . . 110/117/127/220/227/237 V, ±10 %
Rated range of use for a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 75 VA
Safety class according to IEC 348 and VDE 0411 . . . . Class I

Tolerable ambient temperature
Rated range of use . . . . . 0 to +50 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	199	Height (4 units)	175
Depth with handles	432	Depth	377

19" conversion kit . . . . . BN 700/00.04

Weight . . . . . approx. 18 kg

Option

Higher frequency accuracy, BN 865/00.02
Frequency error limits . . . . . $\pm 3 \times 10^{-7}$

Ordering Information

Level Generator PS-18* **BN 898/..**
The following versions are available:

Standard version*	BN 898/01
WECO connectors Z_0 = 75, 124, 135, 600 Ω and approx. 0 Ω	BN 898/20

Option (at extra cost)
Higher frequency accuracy BN 865/00.02

Accessories (at extra cost)
Inverter WR-450 [1] BN 864/00.02
Battery Pack BAK-450 [1] BN 864/00.03

Front and Back Covers SD-4 (1 set) BN 700/00.24

1) For specifications see "Measuring Accessories Specification Sheet"
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

SPM-18
Selective Level Meter

for the frequency range 50 Hz to 25 MHz



- **Synthesizer ensures high accuracy and stability of tuning frequency**
- **Automatic search scan for spurious signals and hot tones**
- **Coaxial and balanced measurement inputs**
- **Level expander with 1 dB scale range**
- **Fast signal detector**
- **Built-in demodulator with high dynamic range**
- **High intrinsic NPR value**
- **Phase jitter measuring device, as option**
- **Battery pack and inverter on request**
- **Version with WECO connectors (BN 864/20)**

Applications

Level, noise, and phase jitter on balanced and coaxial FDM communication systems with up to 3600 channels in the CF level, and in single telephone channels, can be measured with the SPM-18 Selective Level Meter. The SPM-18 can also handle the lower multiplex range of single sideband radio-link systems and is particularly useful in development, manufacturing and testing. As it can operate over a wide temperature range and may be battery powered (on request), it is well-suited for in-service monitoring and maintenance, and ideal for locating spurious signals and carrying out long-term monitoring.
A complete Level Measuring Setup is created when the SPM-18 is used in combination with the *PS-18 Level Generator* or the *PSS-19 Generator Section.*

Characteristics

The Level Meter contains a synthesizer which has outstandingly high spectral purity, and remarkably low spurious modulation when frequencies are changed. Frequency setting and tuning can be carried out via the keypad, continuously, or via search-scan. The high sensitivity of −140 dB (−130 dBm) is produced by a narrow selective filter. The semi-automatic level calibration facility, the level scale with a large expansion, and the switch-over between low noise and low distortion measurements guarantee high measurement accuracy. The BN 864/20 version of the SPM-18 is fitted with WECO-compatible sockets.

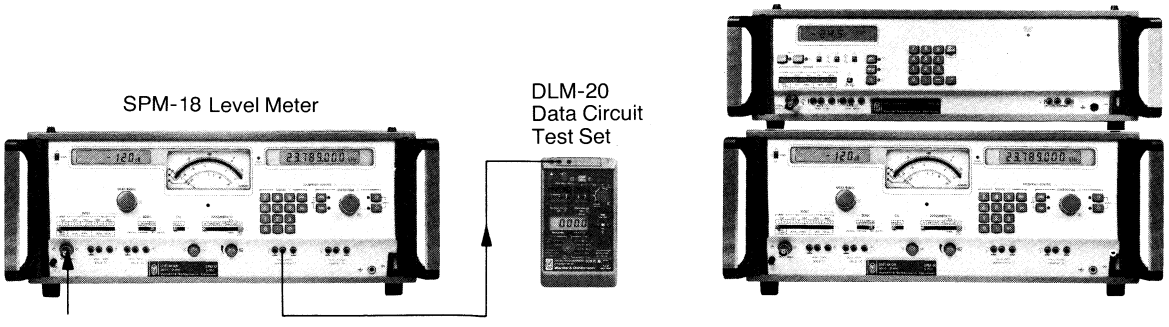
Frequency range, coaxial	50 Hz to 25 MHz
balanced	50 Hz to 14 MHz
Error limits on frequency	$\pm 3 \times 10^{-7}$
Measuring range for 0 dB reading, coaxial	−120 to +20 dB/−110 to +20 dBm
Bandwidth, selectable	25 Hz, 0.4, 1.74, 3.1 kHz
Input impedance, coaxial	75 Ω, high impedance
balanced	124, 150 (135), 600 Ω, high impedance
Intrinsic NPR	approx. 60 dB
Ambient temperature Rated range of use	0 to +50°C

Further Characteristics and Applications

- Frequency accuracy: In the basic version the frequency uncertainty in the rated range of use for temperature (incl. ageing) is only 3 x 10^{-6}. The SPM-18 can be delivered with an uncertainty of 3 x 10^{-7}, e.g. for pilot or carrier leak measurements, on request.
- Selectable bandwidth: The bandwidth of the SPM-18 can be switched to 25 Hz, 400 Hz, 1.74 kHz or 3.1 kHz. The 25 Hz filter is used for measurements below 2 kHz, for measuring pilots or for locating spurious signals. The effective noise bandwidth of the 1.74 kHz filter corresponds to the equivalent noise bandwidth of the CCITT Psophometric Filter, while that of the 3.1 kHz filter is equal to the bandwidth of a telephone channel.
- Cannot be overdriven: The Level Meter is tailor-made for harmonic distortion measurements, frequency analyses and, because of its high intrinsic NPR of approx. 60 dB, is ideal for measuring intermodulation and thermal noise on FDM cable and radio-link systems.
- Measuring very high levels: High impedance measurements of high levels as found for instance on equipment and systems employed in power line carrier frequency systems (+50 dBm) can be carried out by connecting in the *SDG-40 Balanced Attenuator*.
- Built-in demodulator: This allows the demodulation of single sideband signals in the upright or inverted position. The demodulated signal can either be qualitatively evaluated by means of a built-in loudspeaker, or tapped at the demodulator output for further processing. The very large dynamic range of this output is a particularly useful feature and ideal when connecting instruments which measure impulsive noise or interruptions (e.g. the *DLM-20 Data Circuit Test Set).*
- Phase jitter measuring attachment: This attachment can be built-in on request if evaluation of the transmission quality of telephone circuits used for data communication is required. Its weighting filter and detector characteristics conform to CCITT Recommendation O.91 or IEEE 743.
- Battery power: If required the *WR-450 Inverter* can be mounted on the SPM-18's back panel. In this way the SPM-18 can be powered from an external battery (11.5 V to 30 V) or from the *BAK-450 Battery Pack.* The BAK-450 contains rechargeable batteries and a battery charger.



a) The SPM-18 Level Meter in battery mode; the WR-450 Inverter is mounted on the back panel



b) Phase jitter measurements (using Option). Impulsive noise and interruptions can also be measured with the DLM-20 Data Circuit Test Set

c) Level Measuring Setup, comprising the SPM-18 and the PSS-19 Send Section

Possible Applications for the SPM-18 Selective Level Meter

Unless otherwise noted, the specifications are valid for the nominal range of use for a.c. line voltage, a.c. line frequency, and ambient temperature 15 min after the SPM-18 has been switched on.

Inputs

Coaxial input* . . . . . Universal connector Versacon® 9 adaptable to all commercially available connector systems
BN 864/20 has connector compatible with . . . . . WECO 358 A
Input impedance,
switchable . . . . . 75 Ω or high impedance
Frequency range . . . . . 50 Hz to 25 MHz

Balanced inputs [1] . . . . . 3 pole CF connector
Input impedance,
switchable . . . . . 124 Ω, 150 Ω, and high impedance
Frequency range . . . . . 10 kHz to 14 MHz
Signal balance ratio for f = 60 kHz to 5 MHz . . . . . ≧40 dB

Input impedance,
switchable . . . . . 150 Ω, 600 Ω, and high impedance
Frequency range . . . . . 50 Hz to 620 kHz
Signal balance ratio . . . . . ≧40 dB

Frequency

Frequency range . . . . . see "Inputs"

Frequency setting,
digital, entered at keyboard, resolution . . . . . 1 Hz
quasi-continuously, manually over complete range without changeover; smallest step . . . . . 1 Hz
Automatic frequency search-scan with stop from signal detector

Error limits of frequency,
including ageing over 1 year . . . . . $\pm 3 \times 10^{-6}$
with Option BN 865/00.02 . . . . . $\pm 3 \times 10^{-7}$
Slave tuning of Level Generator PS-18, PS-19 or PSS-19 is possible.

Level reading

Calibration switchable from:
Voltage level (0 dB ≅ 0.775 V) to power level (0 dBm ≅ 1 mW into Z_o)

Measuring ranges for meter reading 0 dB, switchable in steps of . . . . . 1 dB or 5 dB
Coaxial input,
$Z_o = 75\ \Omega$ . . . . . −120 to +20 dB (−110 to +20 dBm)
Balanced inputs,
$Z_o = 124, 150\ \Omega$ . . . −110 to +20 dB (−100 to +20 dBm)
$Z_o = 600\ \Omega$ . . . . . −110 to +20 dB (−110 to +20 dBm)

Level reading
Meter with two level scales and digital range-indication, level reading switchable between fast and slow,
expanded range . . . . . −1.5 dB to +0.3 dB
normal range . . . . . −20 dB to +2 dB

Fast signal detector with LED
Response threshold referred to 0 dB meter reading
in normal range . . . . . approx. −15 dB
in expanded range . . . . . approx. −1.2 dB

1) BN 864/20: 135 Ω instead of 150 Ω
124 Ω connector compatible with WECO 372 A/379 A
135 Ω connector compatible with WECO 241 A
600 Ω connector compatible with WECO 310

Total error
Error limits of level reading in expanded range after calibration for input level 35 dB above intrinsic noise level and $Z_{in} = Z_{out} = Z_o$ (values in dB)

Input	0.2	60	100	620 kHz	5	14	25 MHz
Z_o = 75 Ω	±0.25				±0.40		
Z_o = 124, 150 Ω	—	±0.30			±0.40	—	
Z_o = 150, 600 Ω	±0.30		±0.40		—		

Single errors (contained in total error)
Error limits of reading, in 0 dB measurement range (0 dBm), expanded scale, at 0 dB meter reading, after calibration at $Z_{in} = Z_{out} = Z_o$ and f = 10 kHz or 100 kHz,
for 0 to +50 °C . . . . . ±0.1 dB
for +20 to +25 °C . . . . . ±0.06 dB

Error limits of range changeover referred to 0 dB (0 dBm) at f = 10 kHz after calibration in the range being used at the time, 400 Hz bandwidth, for level range
−100 to +20 dB (−90 to +20 dBm) . . . . . ±0.07 dB

Error limits of variation with frequency referred to 10 kHz or 100 kHz, for input level 35 dB above intrinsic noise level, $Z_{in} = Z_{out} = Z_o$ (values in dB)

Input	Referred to	0.2	10	60	100	620 kHz	5	14	25 MHz
Z_o = 75 Ω	10 kHz	±0.12	±0.08				±0.15		
Z_o = 124, 150 Ω	100 kHz	—	±0.15 dB				±0.25	—	
Z_o = 150, 600 Ω	10 kHz	±0.15				±0.25	—		

Selectivity, switchable

Bandwidth	Effective noise bandwidth	Δf from centre frequency for attenuation of ≧50 dB	≧60 dB
25 Hz		±80 Hz	±250 Hz
400 Hz	400 Hz		±2 kHz
1.74 kHz	1.74 kHz		±2 kHz
3.1 kHz	3.1 kHz		±2 kHz

Harmonic ratio, a_{k_2} and a_{k_3},
low distortion measurement mode, at a loading level ≦0 dB (0 dBm) and a 50 dB raise in sensitivity, compared to the measuring range of the loading level, f ≧3 kHz . . . . ≧80 dB
Image frequency and IF-rejection . . . . . ≧70 dB

Noise power ratio (NPR) with white noise loading in a frequency band 300 kHz to 12 MHz, measured in stop-band slot, B_{eff} ≧20 kHz anywhere in band, low distortion measurement mode, 1.74 kHz bandwidth for wideband noise level +10 to −25 dBm and 35 dB sensitivity increase above measurement range of noise level without stop-band slot . . . approx. 60 dB

Intrinsic noise
25 Hz bandwidth, low noise measurement mode, input terminated with Z_o

Input 75 Ω; f ≧10 kHz . . . . . ≦−140 dB (−130 dBm)
Input 124, 150 Ω . . . . . ≦−130 dB (−125 dBm)
Input 150, 600 Ω; f ≧3 kHz . . . . . ≦−125 dB (−120 dBm)
The levels increase by +6 dB at bandwidth 400 Hz, +12 dB at bandwidth 1.74 kHz and by +15 dB at bandwidth 3.1 kHz

Outputs and inputs

IF output* . . . . . 10 kHz

D.C. voltage output, Z_{out} = 5 kΩ . . . . . 0 to +5 V

Demodulator output, ... 3 pole CF connector, Z_{out} = 600 Ω
BN 864/20: Connector compatible with . . . . . WECO 310
Output frequency when tuned to centre of filter curve . . 2 kHz
Single sideband demodulation . . . . upright position/inverted

Psophometrically weighted intrinsic noise at demodulator output in the measurement range −50 to +10 dBm, low noise measurement mode, Z_{in} = 75 Ω and f ≧100 kHz . . −65 dBm
Incorporated loudspeaker and volume control

Output for internal standard frequency* . . . . . 10 MHz

Input for external standard frequency* . . . . 1, 2, 5, 10 MHz

Control outputs for slave tuning of the Level Generator, PS-18, PS-19, or PSS-19

Test Probe Connector for TK-11

General Specifications

Power supply
Rated ranges of use of a.c. line voltage, selectable . . 110/117/127/220/227/237 V, −12 % to +10 %
Rated range of use of a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 70 VA
Safety class according to IEC 348 and VDE 0411 . . . . Class I

Tolerable ambient temperature
Rated range of use . . . . . 0 to +50°C
Limits range for storage and transport . . . . . −40 to +70°C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	199	Height (4 units)	175
Depth with handles	432	Depth	377

19" conversion kit . . . . . BN 700/00.04
Weight . . . . . approx. 20 kg

Options

Higher Frequency Accuracy, BN 865/00.02
Frequency uncertainty . . . . . $\pm 3 \times 10^{-7}$

Phase Jitter Measuring Attachment, BN 864/00.01
Measurement of peak-to-peak jitter
Weighting filter and detector characteristics conform to CCITT Recommendation O.91 or IEEE 743
Reading on analog meter, measuring range . . . . . 0.3° to 30°

Error limits of reading at 150 Hz jitter frequency for input level ≧−60 dB (−50 dBm) and level measurement range for meter reading −10 to +2 dB, low noise measurement mode . . ±10 % ±0.3°

Ordering Information

Level Meter SPM-18 **BN 864/..**
The following versions are available:

Standard version*	BN 864/01
Version with WECO connectors Z_o = 75, 124, 135, 600 Ω	BN 864/20

Options (charged extra)

Higher Frequency Accuracy	BN 865/00.02
Phase Jitter Measuring Attachment	BN 864/00.01

Accessories (charged extra) [1]

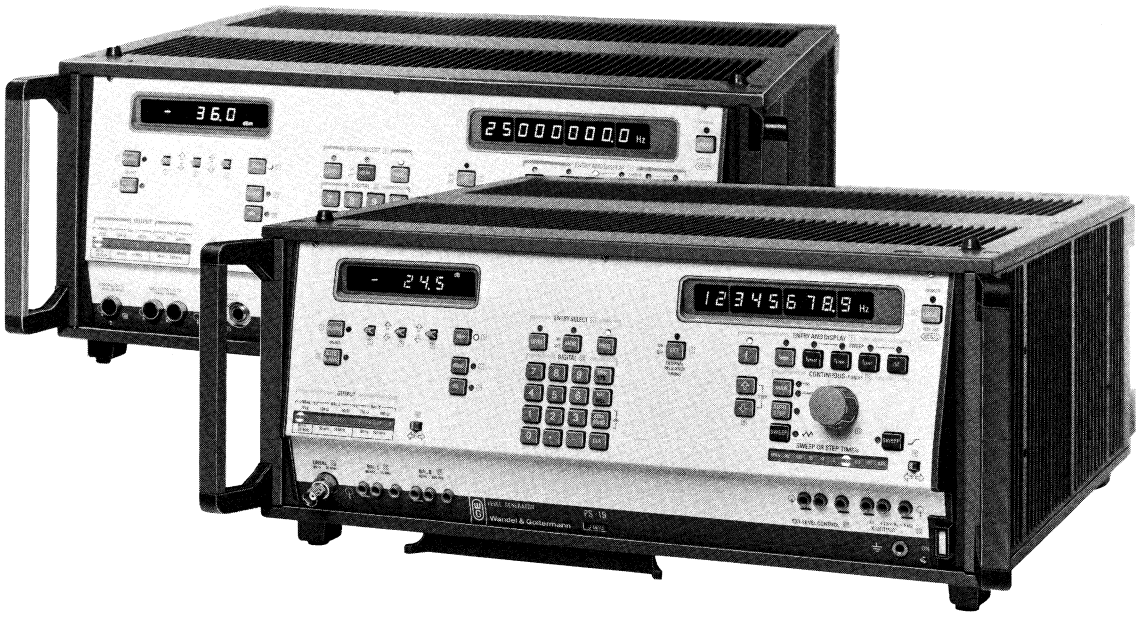
Active Test Probe TK-11, coaxial	BN 573/00
Active Test Probe TK-12, coaxial and balanced	BN 574/00
Mains Unit TKN-12 for TK-12	BN 623/00
Inverter WR-450	BN 864/00.02
Battery Pack BAK-450	BN 864/00.03
Return Loss Measuring Attachment RFZ-5, 10 kHz to 36 MHz	BN 394/00
Return Loss Measuring Attachment RFZ-12, 200 Hz to 4.5 MHz	BN 810/01
Return Loss Measuring Attachment RFZ-14, 100 kHz to 100 MHz	BN 830/00.01
Signal Balance Ratio Measuring Attachment SDZ-12, 200 Hz to 4.5 MHz	BN 811/01
Balanced Attenuator SDG-40	BN 608/00.01
Front and Back Covers SD-4 (1 set)	BN 700/00.24

1) For Specifications, see Measuring Accessories Specification Sheet
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

PS-19/PSS-19
Level Generator

for the frequency range 80 Hz to 25 MHz

IEEE 488
IEC 625



- **Crystal controlled frequency settings through keyboard; stepwise or continuous**
- **High accuracy of frequency, max. resolution 0.1 Hz**
- **Send level adjustable in 0.1 dB steps**
- **Level displayed in dB/dB0 or in dBm/dBm0**
- **Coaxial and balanced outputs**
- **Slave tuning by SPM-19 Level Meter (SPM-18)**
- **Sweepable send frequency, if requested**
- **Storage and call-up of any fixed frequencies, and a menu of complete instrument settings**
- **Economical Measuring Setup design with PSS-19 Send Section and SPM-19 Level Meter (SPM-18)**
- **Point-by-point and sweep measurements with frequency offset (PS-19/SPM-19)**
- **Extendable for use as level standard**

Applications

The PS-19 Level Generator provides a signal source for use in the development, manufacture, installation and maintenance of balanced and coaxial FDM systems with up to 3600 voice-grade channels. It can also be used for measurements in the lower multiplexer range of single sideband radio-link systems and in individual telephone channels.
Because of its remote control facility, the PS-19 can be used in automatic test systems. When used in conjunction with the SPM-19 Level Meter a complete Measuring Setup for level, gain and loss measurements is created.
The setup can be provided with a sweep facility on request. Measurements using frequency offsets, e.g. on translators, are also possible.

Characteristics

The PS-19's send frequency is derived from a synthesizer, which has a remarkably high spectral purity, accuracy, stability and freedom from phase-hits at frequency changeovers (this applies particularly to sweep measurements).
The send frequency on the PS-19 can be entered digitally via a keyboard, a continuous adjustment control or an increment key. The resolution is 0.1 Hz for all three methods.
To all intents and purposes, any number of fixed frequencies and PS-19 settings can be stored to facilitate repetitive measurements.
The built-in data retention capability ensures that the memory contents are not lost if there is a power failure. The send level, which may be "soft" blanked, can be set very precisely in 0.1 dB steps. After the microprocessor controlled, fully programmable Level Generator has been switched on, a self-check is carried out to ensure the PS-19 will function correctly. The PS-19 has female connectors for WECO male connectors.

Frequency range, coaxial	80 Hz to 25 MHz
balanced	80 Hz to 14 MHz
Frequency setting	via keyboard, quasi-continuous, by increments manual or automatic, frequency sweep (on request)
Frequency error limits	$\pm 3 \times 10^{-7}$ or $\pm 1 \times 10^{-7}$
Level range, coaxial	−83.9 to +1 dB (−74.9 to +10 dBm)
Send level error at 20 kHz and $Z_0 = 75\ \Omega$	±0.1 dB
Output impedances	0, 75, 124, 150 (135), 600 Ω
Storable fixed frequencies (100/200) and PS-19 settings (10/50)	

PS-19
2599

Further Characteristics and Applications

- High frequency accuracy: The very small uncertainty of 3×10^{-7} on the set frequency (1×10^{-7} as option), means that frequencies can be set very accurately – even at the high frequencies required for making in-service measurements in the channel gaps of FDM systems, for example. The error stated is valid in the rated range of use for temperature and includes ageing of the reference crystal.

- Sweep capability: The send frequency can be swept over the whole of the PS-19's frequency range (BN 870/02 and /22). The rapid and easy-to-set sweep limits are particularly useful for wideband end-to-end measurements. The centre frequency and sweep width are also adjustable.

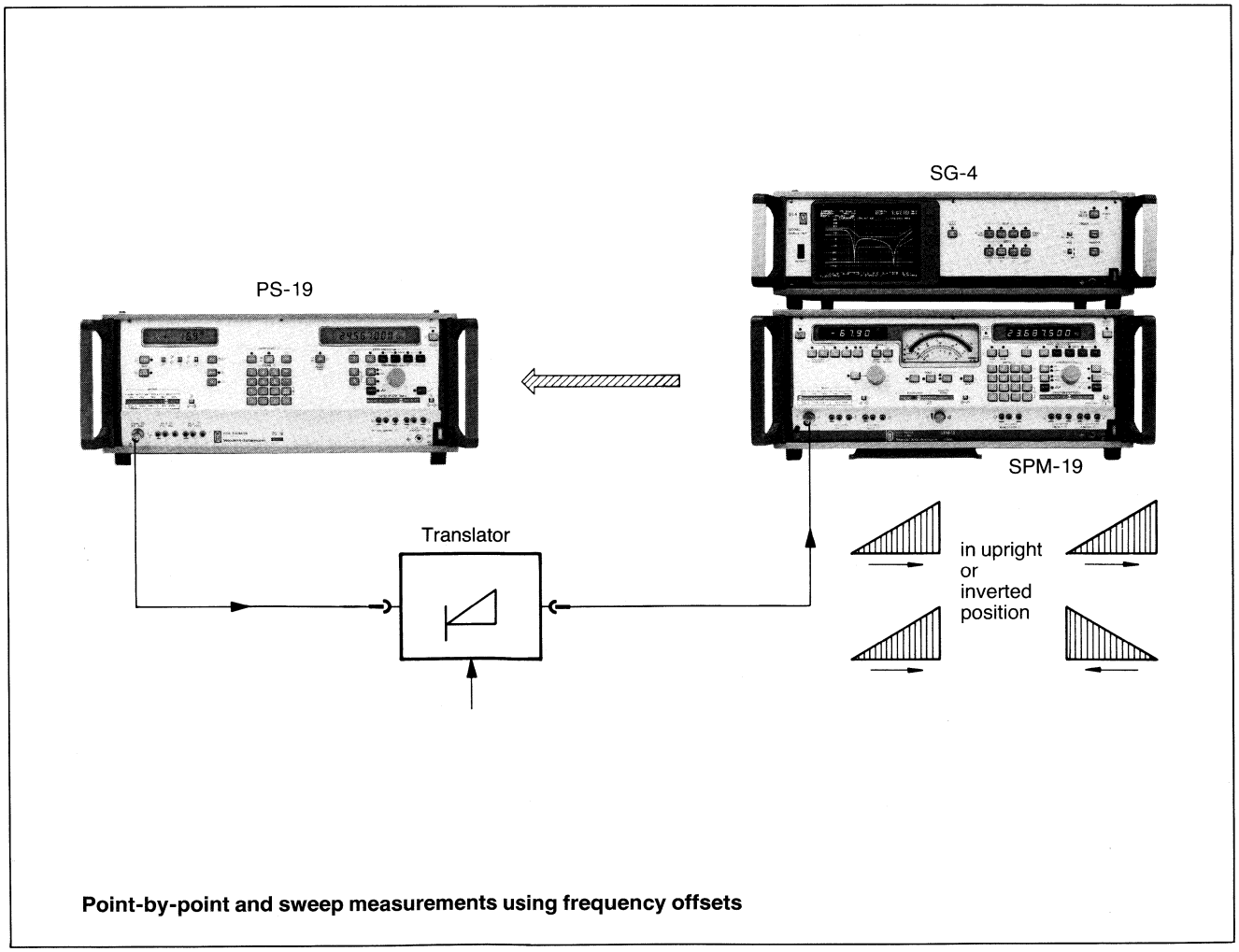
- Storage of fixed frequencies and PS-19 settings: The possibility of calling up 100 (with EPROM 200) fixed frequencies and 10 or 50 PS-19 settings takes the tedium out of repetitive measurements. The fixed frequencies can be stepped through in sequence automatically or manually.
  If the SPM-19 (or SPM-16) is connected at the remote site, selective end-to-end measurements can be carried out in this operating mode without additional synchronisation. When a frequency is changed it is possible to "soft" blank the send level.

- Measurement with frequency shift: Point-by-point and sweep measurements using frequency offsets, e.g. on translators, are possible with the PS-19/SPM-19 setup. The send and receive frequencies can be detuned in the same or opposite direction by an amount equal to the frequency offset.

- Digital level display: This means that the send level can be set quickly and precisely with high resolution. The absolute level referred to a point of zero relative level (dBm0 or dB0) and the relative level of the measurement point (dBr) can also be set for measurements on FDM systems.

- Use as a level standard: The PS-19 can be used as a precise a.c. signal source producing a level of 0 dBm. This is achieved by forming a control loop in which the *EPM-1 Milliwatt Power Meter* acts as an ALC amplifier and feeds a control voltage to the control voltage input of the PS-19. This arrangement eliminates the loss and matching errors introduced by long leads.

- Economical design: Only one tuning oscillator is required for frequency setting when measurements with the same send and receive frequency are carried out. The *PSS-19 Send Section/SPM-19 Level Meter* combination is ideal for measurements of this kind.



Point-by-point and sweep measurements using frequency offsets

Unless otherwise noted, the specifications are valid for the rated range of use of the a.c. line voltage, a.c. line frequency and the ambient temperature 15 min after the set is switched on. The level ranges for dBm calibration are shown in brackets.

Outputs

Coaxial output* . . . . . Versacon® 9 Universal Connector System adaptable to all commercially used connectors
BN 870/21 and /22: Fem. conn. for WECO 358 A male conn.
Output impedance . . . . . 75 Ω
Frequency range . . . . . 80 Hz to 25 MHz

Balanced outputs[1] . . . . . 3 pole CF jacks

Output impedance, switchable . . . . . 124 Ω, 150 Ω
Frequency range . . . . . 60 kHz to 14 MHz
Signal balance ratio according to CCITT Rec. O.121 . . . . . ≧40 dB

Output impedance, switchable . . . 150 Ω, 600 Ω, approx. 0 Ω
Frequency range . . . . . 80 Hz to 620 kHz
Signal balance ratio according to CCITT Rec. O.121 . . . . . ≧40 dB

Frequency

Frequency setting at PS-19,
digital keyboard, resolution . . . . . 0.1 Hz
quasi-continuous manual tuning over the whole range without band switching smallest step . . . . . 1 Hz
in steps by increment keys, smallest increment . . . . . 1 Hz
Error limits of frequency
including ageing over 1 year . . . . . $\pm 3 \times 10^{-7}$
with Option Device BN 865/00.03 . . . . . $\pm 1 \times 10^{-7}$
Slave tuning . . . . . through Level Meters SPM-19, SPM-18

Frequency setting at PSS-19
through . . . . . Level Meters SPM-19, SPM-18

Automatic frequency adjustments

Auto-step
Automatic incrementation of the frequency between two limits entered on the PS-19.
Entry of increment, limits and speed of incrementation via keyboard.

Sweep mode
with PS-19, BN 870/02 and BN 870/22
with PSS-19 through SPM-19, BN 829/02, /03 or /22

Setting of upper and lower sweep limits or setting of centre frequency and sweep width
Sweep . . . . . periodic (triangular), single shot, and manual
Sweep duration for one half period . . . . . 0.03, 0.1, 0.3, ..., 300 s

Send level

Calibration switchable from voltage level (0 dB ≅ 0.775 V) to power level (0 dBm ≅ 1 mW in Z_o)

Setting
of absolute level, display in . . . . . dBm, dB
or absolute power (voltage) level referred to a point of zero relative level, display in dBm0, dB0
and the relative level, display in . . . . . dBr
digital through keyboard, resolution . . . . . 0.1 dB
in steps through increment keys with automatic overflow into the next decade, smallest level step . . . . . 0.1 dB
Level display . . . . . 3 digits and sign

Level ranges
coaxial output
$Z_{out} = Z_L = 75\ \Omega$ . . . −83.9 to +1 dB (−74.9 to +10 dBm)
balanced output I
$Z_{out} = Z_L = 124\ \Omega$ . . . . . −82.2 to +2.7 dB (−75.3 to +9.6 dBm)
$Z_{out} = Z_L = 150\ \Omega$ . . . . . −82.2 to +2.7 dB (−76.2 to +8.7 dBm)
balanced output II
$Z_{out} = Z_L = 150\ \Omega$ . . . . . −83.9 to +11 dB (−77.9 to +17 dBm)
$Z_{out} = 0, Z_L = 150\ \Omega$ . . . . . −78 to +16.9 dB (−72 to +22.9 dBm)
$Z_{out} = Z_L = 600\ \Omega$ . . . . . −83.9 to +11 dB/dBm
$Z_{out} = 0, Z_L = 600\ \Omega$ . . . . . −77.9 to +17 dB/dBm
Max. send level for f <200 Hz . . . . . 0 dB/dBm

Total error

Limits of total error for $Z_{out} = Z_L = Z_o$ or $Z_{out} = 0, Z_L = Z_o$
Output Z_o = 75 Ω, f ≧ 200 Hz
Level > −20.0 dB/dBm . . . . . ±0.20 dB
Level ≦ −20.0 dB/dBm . . . . . ±0.25 dB
Output Z_o = 124 Ω, 150 Ω, f = 60 kHz to 14 MHz
Level > −20.0 dB/dBm . . . . . ±0.30 dB
Level ≦ −20.0 dB/dBm . . . . . ±0.35 dB
Output Z_o = 150 Ω, 600 Ω, f = 200 Hz to 100 kHz . . ±0.35 dB

Individual errors (contained in total error)
Error limits of send level
for $Z_{out} = Z_L = Z_o$ or $Z_{out} = 0, Z_L = Z_o$ at f = 20 kHz or 200 kHz
(Tabulated values in dB)

Output	at f =	p_{min} −29.9	−19,9 p_{max} dBm
Z_o = 75 Ω	20 kHz	±0.15	±0.10
Z_o = 124, 150 Ω	200 kHz	±0.15	±0.10
Z_o = 150, 600 Ω	20 kHz	±0.18	±0.15

Error limits of the frequency response
for $Z_{out} = Z_L = Z_o$ or $Z_{out} = 0, Z_L = Z_o$
(Tabulated values in dB)

Output	referred to f at	80	200 Hz	1	60	100	620 kHz	5	14	25 MHz
Z_o = 75 Ω	20 kHz	±0.25	±0.10	±0.08				±0.10		
Z_o = 124, 150 Ω	200 kHz	—		±0.15				±0.20		—
Z_o = 150, 600 Ω	20 kHz	±0.25[1]	±0.15	±0.13		±0.25		—		

1) for send level ≦0 dB/dBm

1) BN 870/21 and /22: 135 Ω instead of 150 Ω
Fem. conn. (124 Ω) for WECO 372 A/379 A male conn.
Fem. conn. (135 Ω) for WECO 241 A male conn.
Fem. conn. (600 Ω) for WECO 310 A male conn.

Spurious voltages

Harmonic ratio a_{k_2}, a_{k_3}
for $Z_{out} = Z_L = Z_o$ or $Z_{out} = 0$, $Z_L = Z_o$
Coaxial output, $Z_o = 75\ \Omega$, 800 Hz to 25 MHz . . . . . ≧50 dB
Balanced outputs
$Z_o = 124\ \Omega$, $150\ \Omega$; 60 kHz to 14 MHz . . . . . ≧50 dB
$Z_o = 150\ \Omega$, $600\ \Omega$; 800 Hz to 100 kHz . . . . . ≧50 dB

Suppression of discrete, nonharmonic spurious signals,
in range 200 Hz to 25 MHz,
signal-to-spurious signal ratio . . . . . ≧60 dB
or spurious level . . . . . ≦−120 dB (−110 dBm)

Auxiliary inputs and outputs

External automatic level control from EPM-1,
controlled range . . . . . approx. ±1 dB

Slave control input * . . . . . for external tuning from Level Meters SPM-19, SPM-18

Input * for external standard frequency . . . . 1, 2, 5, 10 MHz

Output * for internal standard frequency . . . . . 10 MHz

Memory

100 fixed frequencies (only PS-19) and 10 complete menus of instrument settings (PS-19, PSS-19) user programmable, entry and call-up via keyboard, erasure by writing over stored information.

General Specifications

Power supply
Rated range of use for a.c. line voltage, selectable . . . . . 96 to 140 V/193 to 261 V
Rated range of use for a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption PS-19 . . . . . approx. 50 W
PSS-19 . . . . . approx. 35 W

Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Tolerable ambient temperature
Rated range of use . . . . . +5 to +40°C
Limits range for storage and transport . . . . . −40 to +70°C

Dimensions (in mm) and weight

Bench model	PS-19	PSS-19
Width with handles	477	477
Height overall	199	155
Depths with handles	432	432
19" conversion kit	BN 700/00.04	BN 700/00.03
Weight	approx. 18 kg	approx. 14 kg

German Post Office Certificate of Approval
for PSS-19 . . . . . No. 279 094 190
for PS-19, BN 870/02 . . . . . No. 279 094 195

Options

Higher Frequency Accuracy, BN 865/00.03
for PS-19, frequency error limits . . . . . $\pm 1 \times 10^{-7}$

Interface <IEC 625> Card, BN 853/05
for external control of all PS-19 instrument functions through an external computer.
Connection to the IEEE-Bus by adaptor plug.

EPROM, BN 870/00.01
for PS-19; storage of 100 fixed frequencies and 40 instrument settings, according to user's choice.

EPROM, BN 871/00.01
for PSS-19; storage of 40 instrument settings according to user's choice.

Ordering Information

Level Generator PS-19 **BN 870/..**

Standard version *	No sweep	BN 870/01
	With sweep	BN 870/02
WECO connectors [1]	No sweep	BN 870/21
	With sweep	BN 870/22

Send Section PSS-19 (for SPM-19 and SPM-18) **BN 871/..**

Standard version *	BN 871/01
WECO connectors [1]	BN 871/21

Options (at extra cost)	
Higher Frequency Accuracy for PS-19	BN 865/00.03
Interface <IEC 625> Card for PS-19 with adaptor plug IEC 625/IEEE 488 (S 834)	BN 853/05
EPROM for PS-19 [2]	BN 870/00.01
EPROM for PSS-19 [2]	BN 871/00.01
Accessories (at extra cost)	
Connecting cable 24 pin, 50 cm long [3]	K 366
Connecting cable to <IEC 625> Interface Bus	
120 cm long	K 343
200 cm long	K 344
Front and Back Panel Covers (1 set)	
SD-4 for PS-19	BN 700/00.24
SD-3 for PSS-19	BN 700/00.23

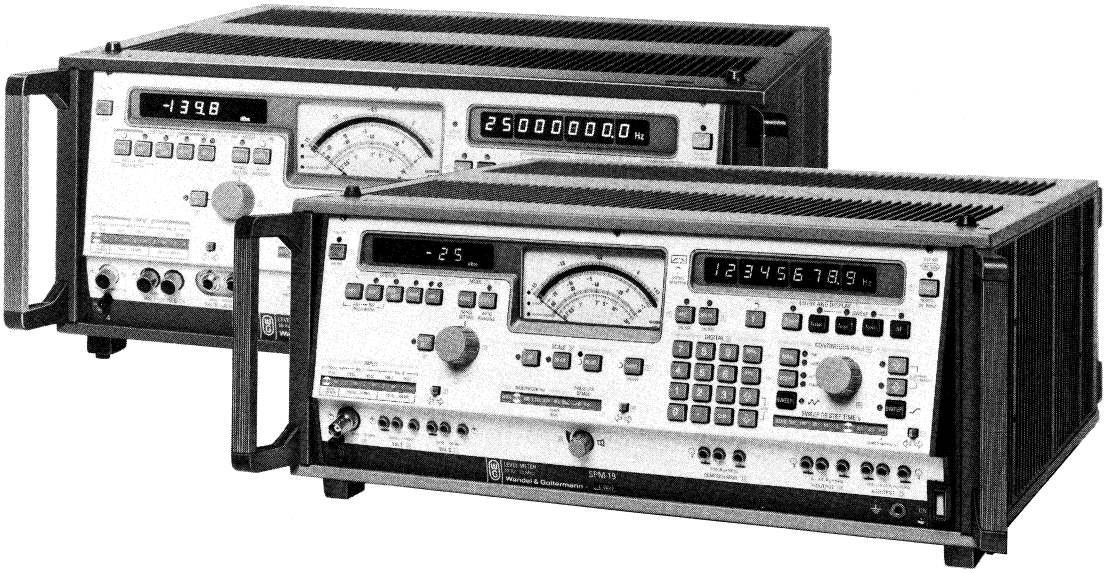
1) Impedances $Z_0 = 0, 75, 124, 135, 600\ \Omega$
2) State chosen fixed frequencies (PS-19) and instrument settings when placing order (ask for Order Form No. 5/785 a, b; or 5/785 a for the PSS-19).
3) Cable is required for sweep and offset frequency measurements with PS-19/SPM-19.
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

A Colour Brochure is available on request

SPM-19
Selective Level Meter

with wideband section, for level measurements in the frequency range 50 Hz to 25 MHz

IEEE 488
IEC 625



- **Crystal controlled frequency setting via keyboard, stepwise or continuous**
- **High frequency accuracy; max. resolution 0.1 Hz**
- **Swept tuning frequency on request**
- **Absolute and relative measurements with high resolution**
- **Voltage measurements in the range 1 μV to 2 V (Version BN 829/03)**
- **Fast search-scan and selective end-to-end measurements**
- **Storage and call-up of any fixed frequency and of complete instrument settings**
- **SSB demodulation and phase jitter measurements**
- **High intrinsic NPR makes noise measurements possible**
- **External tuning of the PS-19 (PS-18) Generator or the PSS-19 Send Section**
- **Point-by-point measurements and sweep measurements with frequency offset (PS-19/SPM-19)**

Applications

The SPM-19 Level Meter is used for carrying out the level, noise and phase jitter measurements that occur when balanced and coaxial FDM communication systems with up to 3600 speech channels are developed, manufactured, installed and maintained. The SPM-19 is also suitable for measurements at the lower multiplex level of single sideband radio-link systems, and on single telephone channels. The SPM-19 has facilities for fast search-scans with low signal-to-noise ratio, panorama reception or long-term monitoring. As the SPM-19 has a remote control capability it can be used to form part of an automatic test system. A complete Level and Sweep Measuring Setup is obtained if the PSS-19 Send Section or the PS-19 Level Generator are used in conjunction with the SPM-19.

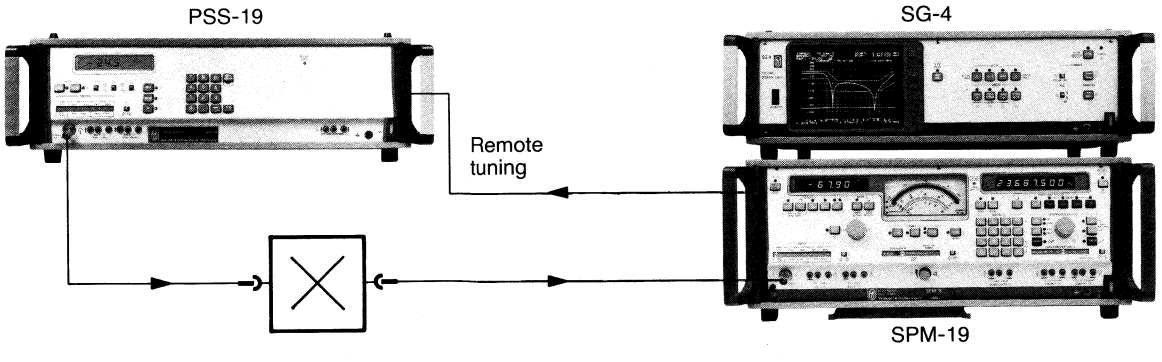
Characteristics

The SPM-19 contains a synthesizer whose spectral features are low spurious modulation and high spectral purity. The SPM-19's frequency can be set via a keypad, tuned continuously, or tuned via step and automatic step facilities. The SPM-19 is ideal for sweep measurements as the frequency can be changed without causing phase discontinuities.
When measuring the total signal level, the microprocessor control ensures that the signal drive range of the level measuring section is optimal. The result of this is high sensitivity, high resolution (0.01 dB) and a large dynamic range for the display (80 dB). Selected frequencies or complete SPM-19 settings can be stored to take the tedium out of repetitive measurements. These parameters are not lost if there is a power failure.

Frequency range, coaxial	50 Hz to 25 MHz
balanced	50 Hz to 14 MHz
Methods of setting frequency	via keypad, quasi-continuously, manual step or auto-step, sweep (as option)
Error limits of tuned frequency	$\pm 3 \times 10^{-7}$ or $\pm 1 \times 10^{-7}$
Level range, selective	−140 to +22 dB (−130 to +32 dBm)
Error on level display, selective, $Z_0 = 75\ \Omega$, at 0 dB (dBm)	±0.1 dB
Intrinsic NPR, signal-to-noise ratio 0.3 to 12 MHz	approx. 60 dB
Input impedances	75, 124, 150 (135), 600 Ω, high impedance
Fixed frequencies (100/200) and complete settings (10/50) can be stored	

Further Characteristics and Applications

- High frequency accuracy: The small uncertainty of 3×10^{-7} (1×10^{-7}, if required) means that the tuned frequency can be set accurately – even at high frequencies. Measuring pilot levels is one of many applications where this requirement is essential. The error given is correct over the rated range of use for temperature and includes reference-crystal ageing.
- Sweep facility (BN 829/02, /03 and /22): When a sweep is being carried out, the phase of the swept frequency does not vary; this means that accurate measurements on test items with steep frequency responses and high attenuations can be made. Sweep curves may be displayed on the *SG-4 Storage Display Unit.*
- Fast search scan with automatic printout: The SPM-19 finds any spurious signals or hot tones that exceed a certain level entered on the SPM-19 and that lie between two selected frequency limits independent of each other. If required their levels and frequencies can be printed out automatically. The correct scan-speed for the bandwidth used is also selected automatically.
- Selective end-to-end measurements: In the operating mode *receiver track* the SPM-19 tunes itself automatically to the discrete frequencies sent from the opposite end. No additional synchronisation is required. If the transmission path is very noisy (e.g. power-line carrier systems), the Generator and Receiver can be switched to the *autostep* operating mode, and a special routine called up which ensures frequency synchronism.
- Digital and analog level display: The maximum resolution of the digital level display is 0.01 dB; an autoranging facility is provided. Ranges of 1 dB, 20 dB or 80 dB can be selected for the analog display (alignment work, sweep measurements). The measurement range can be set manually in steps of 1 dB or 5 dB, or automatically.
- Voltage display: Precise voltage measurements in the range 1 μV to 2 V can be performed with version BN 829/03 [1]. An autoranging facility and a digital display (in mV) with a max. resolution of 1 μV are provided.
- Absolute or relative level measurements: Absolute or relative level measurements (display dB or dBm) can be made. The level which is to act as the reference level is measured digitally and stored. Deviations from this reference level in subsequent measurements (e.g. frequency response measurements) are shown on a digital or analog display. When making measurements on transmission paths the relative level of one test point (dBr) can be stored and subsequent results displayed as a level referred to point of zero relative level (dBm0, dB0).
- Level difference measurements: The level difference (N-X or X-N) between two items-under-test can be measured precisely with digital methods using the *RU-3 Relay Changeover Switch.* The RU-3 is controlled by the SPM-19 and can be purchased as a separate item [2]. The resolution is 0.01 dB.
- Selectable bandwidths: A narrow 25 Hz filter is used to measure pilots, carrier leaks or frequency spectra. The 400 Hz bandwidth is required for sensitive level measurements.
  A 1.74 kHz filter is used to make weighted noise measurements in single voice-channels at the CF level. A 3.1 kHz filter with a flat response is also available. Noise power in a basic group (48 kHz) can also be measured. If required, the 400 Hz filter can be replaced by a *2.5 kHz Channel Filter* so that the channel power of submarine-cable systems can be measured.
- Internal demodulator with large dynamic range: This device demodulates SSB signals in the erect or inverted positions. The demodulated signal can be assessed qualitatively using the built-in loudspeaker. Alternatively, the signal can be processed further externally. The large dynamic range is especially useful for making accurate noise or impulsive noise measurements (with extra instrument) on translated voice channels.
- Phase jitter measuring device: Phase jitter measurements can be carried out directly in voice channels or at the CF level using a 1 kHz test tone. Jitter measurements on pilot and carrier frequencies can also be carried out during trouble-shooting. These measurements conform with CCITT Recommendation O.91 or IEEE 743. Two weighting filters are available (20 Hz to 300 Hz and 4 Hz to 300 Hz).



PSM-19 Level and Sweep Measuring setup and the SG-4 Display Unit Storage

- Measurements with frequency offset: Using the PS-19/SPM-19 combination, point-by-point and sweep measurements with frequency offset (e.g. on translators) can be performed. Any combination of positive or negative frequency offsets can be chosen for the send and receive frequencies[2].
- Use as a white noise receiver: As the SPM-19 has a high immunity to overloading when loaded with white noise, it can be used for intermodulation and thermal noise measurements on FDM cable, radio-links or satellite links. The *white noise measuring program* can be called up to measure noise power (in pW0p), noise level (in dBm0p) or NPR (in dB). The measuring frequencies, as specified by CCITT/CCIR and INTELSAT, are entered via a keypad or can be stored in the working memory (RAM) of the SPM-19.
- Economical design: Only one tuning oscillator is required to set the frequency when measurements are performed at the same send and receive frequencies. This oscillator can be provided by the *PSS-19 Send Section* which is used in conjunction with the SPM-19. The SPM-19 has a *tracking generator output* for simplified measurements of this kind.
- Wide range of accessories:
  - TK-11 or TK-12 Active Test Probes (also balanced) for high impedance, low capacitance measurements.
  - RFZ-5, RFZ-14 and RFZ-12 Return Loss Measuring Attachments (also balanced) for measuring the variation in return loss with frequency.
  - SDZ-12 Signal Balance Ratio Measuring Attachment for measuring the variation in signal balance ratio with frequency.
  - SDG-40 Balanced Attenuator for high impedance measurements on levels up to +50 dBm. Power-line carrier systems, for example, use levels of this magnitude.
  - V.24/V.28 Printer Interface for listing results in various formats (printout of generator and receiver data).
  - Interface <IEC 625>/IEEE 488 for controlling the SPM-19 when it is used (instead of the printer interface) in an automatic test system. It must be used when the SG-4 Storage Display Unit and the SPM-19 are operated together.

1) Without dBm0 display and White Noise Measuring Program
2) K 366 control cable is necessary (can be purchased as accessory)

Specifications of the Selective Level Meter — SPM-19

Unless otherwise stated, the specifications are valid for the rated ranges of use of a.c. line voltage, a.c. line frequency and ambient temperature 15 min after the SPM-19 has been switched on. The level and measuring ranges for the dBm calibration are given in brackets.

Inputs

Coaxial input . . . . . Versacon® 9 Universal Connector adaptable to all commercially available connector systems
BN 829/21 and /22: fem. connector for a WECO 358 A male connector
Input impedance, switchable . . . . . 75 Ω, and high impedance (bridging)
Frequency range[1] . . . . . 50 Hz to 25 MHz

Balanced inputs[2] . . . . . 3 pole CF connectors
Input impedance, switchable . . . . . 124 Ω, 150 Ω, and high impedance (bridging)
Frequency range . . . . . 10 kHz to 14 MHz
Signal balance ratio,
60 kHz to 5 MHz . . . . . ≧40 dB
60 kHz to 14 MHz . . . . . ≧30 dB

Input impedance,
switchable . . . . . 150 Ω, 600 Ω, and high impedance
Frequency range[1] . . . . . 50 Hz to 620 kHz
Signal balance ratio . . . . . ≧40 dB
Tolerable input voltage for all inputs,
overload limit when terminated by Z_o . . . . . $V_{r.m.s.}$ ≦10 V
Tolerable d.c. input voltage
at high impedance input . . . . . ≦60 V

Frequency

Frequency setting
Digital, entered at keypad, resolution . . . . . 0.1 Hz
Quasi-continuously, manually
over complete range without changeover;
smallest step . . . . . 1 Hz
in steps via increment key, smallest step . . . . . 1 Hz

1) The lower frequency limit is 200 Hz for wideband measurements
2) BN 829/21 and /22: 135 Ω instead of 150 Ω
124 Ω female connector for a WECO 372 A/379 A male connector
135 Ω female connector for a WECO 241 A male connector
600 Ω female connector for a WECO 310 male connector

Automatic frequency-setting modes

Search-scan
One shot over the complete frequency range, stopped by signal detector and automatic fine-tuning.
Periodic between adjustable frequency limits.

Auto-step
Automatic stepping of frequency between adjustable frequency limits.
Entry of step values, frequency limits, and stepping rate via keypad.

Receiver tracking
Automatic advancing of the tuning frequency between adjustable frequency limits by a set frequency-step when the level display disappears.

Sweep mode (Versions BN 829/02/03 and /22)
Setting of upper and lower sweep limit or setting of centre frequency and sweep width
Sweep . . . . . periodic (triangular), single shot and manual
Sweep duration for one half period . . . . 0.1, 0.3, 1, ..., 300 s

Error limits of frequency:
including ageing over 1 year . . . . . $\pm 3 \times 10^{-7}$
or with Option BN 865/00.03 . . . . . $\pm 1 \times 10^{-7}$

Level and voltage display

Display of:
power level (dBm) referred to . . . . . 1 mW
voltage level (dB) referred to . . . . . 0.775 V
level difference . . . . . dB
absolute level in decibels referred to a point of
zero relative level dBm0, dB0
relative level . . . . . dBr
voltage shown by Version BN 829/03 in . . . . . mV
or else of noise power by "white noise program"
with Versions BN 829/01, /02, /21 and /22 in . dBm0p, pW0p

Display, switchable . . . . . digital/analog
Digital display, max. resolution . . . . . 0.01 dB
Analog meter, switchable scale ranges . . 1 dB, 20 dB, 80 dB

Level range

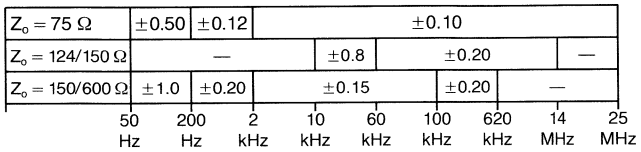
Input [1]	Selective	Wideband
Z_o = 75 Ω	−140 to +22 dB −130 to +32 dBm	−60 to +22 dB −50 to +32 dBm
Z_o = 124/150 Ω	−130 to +22 dB −120 to +22 dBm	−50 to +22 dB −40 to +22 dBm
Z_o = 150/600 Ω	−130 to +22 dB (dBm)	−50 to +22 dB (dBm)

1) BN 829/21 and 22: Z_o = 135 Ω instead of 150 Ω

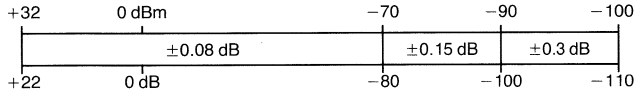
Error limits of level display

Operating mode selective, bandwidths 25 Hz to 3.1 kHz

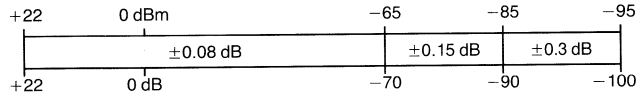
Error limits at input level 0 dB (0 dBm), display digital or analog (1 dB scale), with reading averaged, $Z_{in} = Z_{out} = Z_o$ and at (23 ± 3) °C (Table values in dB)



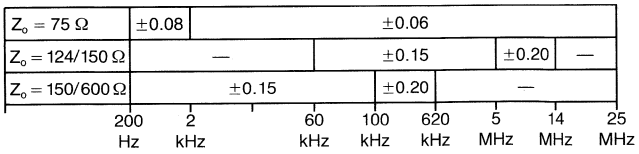
Additional error for any input level ≧25 dB above the intrinsic noise level, after calibration
Z_o = 75 Ω, f = 200 Hz to 25 MHz



Z_o = 124/150/600 Ω, f = 200 Hz to 620 kHz

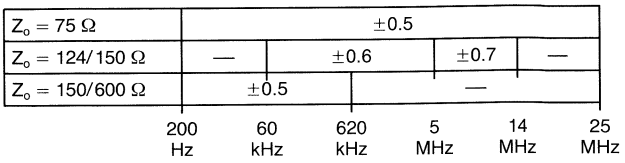


Variations in level reading with frequency, automatic calibration on, $Z_{in} = Z_{out} = Z_o$, at (23 ± 3) °C
Digital display with noise averaging, or analog display, bandwidth 25 Hz to 3.1 kHz, referred to 10 kHz (coaxial) or 100 kHz (Z_o = 124/150 Ω), in the ranges
at Z_o = 75 Ω . . . . . −80 to +22 dB (−70 to +32 dBm)
at Z_o = 124/150/600 Ω . . . . . −70 to +22 dB (−65 to +22 dBm)
(Tabulated values in dB)



Error limits of the voltage display (BN 829/03)
Operating mode selective, f ≧ 200 Hz
Coaxial input . . . . . ±3 % of reading ±1 μV

Total error, operating mode wideband
with digital reading, and $Z_{in} = Z_{out} = Z_o$ (tabulated values in dB)



Additional analog display errors
20 dB scale, in range −5 to +2 dB . . . . . ±0.2 dB
80 dB scale . . . . . ±2 dB

Phase jitter measurement complies with CCITT Rec. O.91 or IEEE 743.
Measurement of peak-to-peak jitter
Display digital or analog . . . . . 0.3 to 30°
Maximum resolution . . . . . 0.1°
Measurement bandwidths, switchable . . . . 20 Hz to 300 Hz
4 Hz to 300 Hz
Error limits of reading at a jitter frequency of 150 Hz, input level ≧ −60 dB (−50 dBm) . . . ±10 % of reading ±0.3°

Selectivity, bandwidth switchable between

Bandwidth	Effective noise bandwidth	Separation, Δf, from the centre of filters for attenuation ≧50 dB	≧60 dB
25 Hz	—	±80 Hz	±250 Hz
400 Hz [1]	400 Hz	—	±2 kHz
1.74 kHz	1.74 kHz	—	±2 kHz
3.1 kHz	3.1 kHz	—	±2 kHz
48 kHz	48 kHz	±35 kHz	—

1) The 400 Hz filter and the 2.5 kHz Channel Filter cannot both be fitted

Harmonic ratio, k_2 and k_3, when level of fundamental ≦0 dB (+10 dBm), with autoranging or with manual range selection and sensitivity raised
by 50 dB over fundamental, f ≧ 3 kHz . . . . . ≧80 dB
Image frequency and IF rejection . . . . . ≧70 dB

Noise-power-ratio (NPR)

with white noise loading in a frequency band 300 kHz to 12 MHz, measured in any band-stopped slot in a band with B_{eff} ≧ 20 kHz, bandwidth 1.74 kHz and wideband level −25 dBm to +10 dBm . . . . . approx. 60 dB

Intrinsic noise

selective, 25 Hz bandwidth, input terminated with Z_o and summed level ≦ −60 dB (−50 dBm), f ≧10 kHz
Input 75 Ω . . . . . ≦ −140 dB (−130 dBm)
Input 124 Ω, 150 Ω . . . . . ≦ −130 dB (−125 dBm)
Input 150 Ω, 600 Ω . . . . . ≦ −125 dB (−120 dBm)
The level values increase: by +6 dB for the 400 Hz bandwidth, by +12 dB for the 1.74 kHz bandwidth, by +15 dB for the 3.1 kHz bandwidth, by +27 dB for the 48 kHz bandwidth (f ≧ 60 kHz).

Outputs and Inputs

IF output* . . . . . 10 kHz
Y-d.c. voltage output . . . . . Z_{out} = 5 kΩ, 0 to +5 V
X-d.c. voltage output . . . . . Z_{out} = 5 kΩ, ±2.5 V
Demodulator output . . . . . 3pole CF connector
BN 829/21 and 22: female connector for WECO 310 male connector
Single sideband demodulation . . . . . upright inverted
Frequency position of translated channel when SPM-19 is tuned to the channel centre . . . . . 0 to 4 kHz
Tracking generator output* . . . . . 200 Hz to 25 MHz/ −10 dBm
Output* for internal standard frequency . . . . . 10 MHz
Input* for external standard frequency . . . . 1, 2, 5, 10 MHz
Control outputs for slave tuning the Level Generators PS-18, PS-19 or PSS-19

Penlift function for activating an X-Y recorder

Type of test probe
that can be connected TK-11

AFC
can be switched off, functional with all receive filter bandwidths to 3.1 kHz.
Automatic Frequency Control of the tuning frequency to track with the receive frequency in operating mode search-scan in conjunction with the fast signal detector.
Frequency holding range . . . . . whole frequency range

Memory
100 fixed frequencies and 11 complete instrument settings (RAM area) can be user programmed.
Entry and call-up via keyboard.
Memory contents are erased by writing over them.
Retention of the data entered in the store, if the a.c. power is interrupted.

General Specifications

Power supply
Rated ranges of use for a.c. line voltage, selectable . . . . . 96 to 140 V/193 to 261 V
Rated range for a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 50 W
Safety class according to IEC 348 and VDE 0411 . . . . Class I

Tolerable ambient temperature
Rated range of use . . . . . +5 to +40 °C
Limits range for storage and transport . . . . . −40 to +70 °C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	199	Height (4 units)	175
Depth with handles	432	Depth	377

19" conversion kit . . . . . BN 700/00.04

Weight . . . . . approx. 21 kg
German Post Office Certificate of Approval No.
for the SPM-19, BN 829/01 . . . . . 272 181 823
BN 829/02 . . . . . 272 181 824

Options

Facility for higher frequency accuracy, BN 865/00.03
Error limits of frequency . . . . . $\pm 1 \times 10^{-7}$

ROM, BN 829/00.03
stores 100 fixed frequencies (e.g. measurement frequencies for the white noise program) and 40 setups as specified by the customer.

Interface <IEC 625> board, BN 853/02
for control by external computer

Printer interface, BN 905/01
instead of Interface <IEC 625> board BN 853/02 in SPM-19.
For connecting printers with V.24/V.28 interfaces.
Printout of mode, measuring run information, measuring parameters, address and measured result.

A Colour Brochure is available on request

2.5 kHz Channel Filter, BN 829/00.06
replaces the 400 Hz filter
Effective noise bandwidth . . . . . 2.5 kHz ±10 %
Attenuation at centre freq. ±1.5 kHz . . . . . ≧60 dB

Ordering Information

Selective Level Meter SPM-19* **BN 829/..**
The following versions are available

Level display			WN-*) program	Sweep facility	WECO-**) connectors	Order No.
dB dBm	dBm0	V				
■	■		■			**BN 829/01**
■	■		■	■		**BN 829/02**
■		■		■		**BN 829/03**
■	■		■		■	**BN 829/21**
■	■		■	■	■	**BN 829/22**

*) White noise program
**) Impedances 75, 124, 135, 600 Ω

Options (at extra cost)

Facility for higher frequency accuracy	BN 865/00.03
EPROM [1]	BN 829/00.03
Interface <IEC-625> board [2]	
with IEC 625/IEEE 488 (S 834) adaptor	BN 853/02
or	
V.24/V.28 Printer Interface	BN 905/01
Channel Filter [3], bandwidth 2.5 kHz (instead of 400 Hz bandwidth)	BN 829/00.06

Accessories (at extra cost) [4]

Test Probe TK-11, coaxial	BN 573/00
Test Probe TK-12, coaxial and balanced	BN 574/00
Power Supply TKN-12, for TK-12	BN 623/00
Balanced Attenuator SDG-40	BN 608/00.01
Relay Changeover Switch RU-3 (order cable K 366 as well)	BN 323/02
Return Loss Measuring Attachments	
RFZ-5, 10 kHz to 36 MHz	BN 394/00
RFZ-12, 200 Hz to 4.5 MHz	BN 810/01
RFZ-14, 100 kHz to 100 MHz	BN 830/00.01
Signal Balance Ratio Measuring Attachment SDZ-12, 200 Hz to 4.5 MHz	BN 811/01
Impedance Measuring Attachment SFZ-1, 300 Hz to 612 kHz	BN 385/04
Connecting cable for Interface-Bus <IEC 625>:	
120 cm	K 343
200 cm	K 344
Control cable for RU-3 and/or frequency offset measurements	K 366
Front and Back Panel Covers SD-4 (1 set)	BN 700/00.24

1) State chosen fixed frequencies and instrument settings when order is placed (ask for order form 5/784 a, b).
2) Essential for operation with the SG-4 Storage Display Unit, and for computer operation.
3) Specify whether or not you want this Option for your SPM-19 when you place your order (cannot be fitted by the customer).
4) See Measuring Accessory Specification Sheet for more data and Ordering Information.
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9" and order chosen type when ordering instrument.

SPM-190/SPM-197 Test Systems

for monitoring and routine tests at the basebands of FDM systems



- **Measurements at the basebands of FDM systems**
- **Stored frequency plans comply with CCITT, INTELSAT and US standards**
- **Results are output as graphs**
- **Fully automatic monitoring**
- **Operated via user-friendly dialog mode**
- **Can be expanded to 24 (SPM-190) or 864 (SPM-197) test ports using the RAS-2 Remote Access Switch System**
- **Easily expanded for the centralised operation of a number of remote measuring stations**

Applications

The SPM-190 and SPM-197 Test Systems have been designed for routine monitoring on basebands and for fast troubleshooting.
These systems can be used when:
- Complex measurements have to be carried out rapidly and simply
- Routine measurements have to be made in minutes instead of hours
- Automatic measurements have to be carried out when the station is not manned
- Measurements have to be performed that would be uneconomical or unfeasible with conventional methods
- An overview of a large number of results is required in the form of tables or graphs
- The old measuring techniques are unreliable or imprecise
- When centrally controlled measurements have to be performed at remote manned or unmanned sites.

Characteristics

The SPM-190 and the SPM-197 Test Systems have two distinct operating modes, i.e.
- Interactive mode
- Automatic monitoring mode

In the *interactive mode* all the data required to perform measurements is obtained by a series of prompts. In the case of the SPM-197 all the data entered to perform measurements is shown as a diagram on the screen.
The data entered is checked for integrity and consistency so that operating errors are practically impossible.
In the *automatic monitoring mode,* all the required measurements are carried out cyclically at specified test points. The results and all the necessary identifying information such as test point name, date, time etc. are output as easy-to-read tables or graphs.
In both operating modes, the interpretation of the results is simplified because test cable loss is automatically taken into account (resolution 0.01 dB).

Frequency range	50 Hz to 25 MHz
Frequency plans	6 as per CCITT (SPM-190 and SPM-197) 18 as per INTELSAT (SPM-190 and SPM-197) 2 as per US standards (SPM-197)
Measurement modes	pilots, various types of noise, carrier leads, channel levels, baseband power etc.
Display modes	tables or graphs
Output facilities	screen or printer (SPM-190)

Remote test stations can be controlled with the SWP-13 Software Package

2626 SPM-190/197

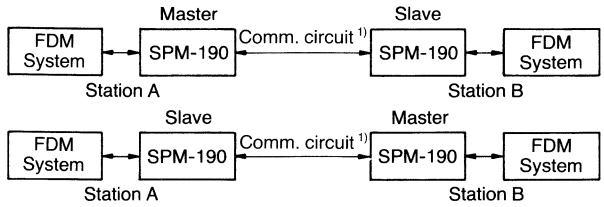
Further characteristics and applications

The *SPM-190 Test System* comprises the CU-85 Control Unit, the SPM-19 Selective Level Meter and the SWP-11 Software Package. The System can be expanded at any time using the RAS-2 Remote Access Switch System (24 test points), the PS-19 Level Generator or the PSS-19 Send Section.
The *SPM-197 Test System* comprises the SPM-19 Selective Level Meter and the HP 86 B desktop computer with a 3½″ floppy disk drive (9121 S) and an 82905 B printer. Because of its larger screen and a memory capacity of up to 512 kbyte the entry dialog is simpler and more user friendly, measurements are also performed more rapidly.
The System can be expanded at any time to handle up to 36 RAS-2 Remote Access Switch Systems each for 24 test points, i.e. a total of 864 test points; the software already takes this possibility into account.
Specific parameters relating to a test point (e.g. test point name, relative level, group and supergroup pilot frequencies, frequency plan type and test cable length) are stored in both Systems.
Several test routines containing several measuring tasks can be defined and stored on a data medium.
No previous experience with the computers or their programming is required to operate the Test Systems.
The following measurements can be carried out in the interactive or automatic monitoring mode.

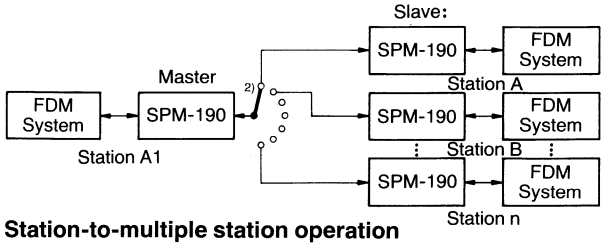
- Measurement and tolerance comparison of pilots and carrier leaks, noise or speech power via a speech channel or group, measurements on noise in the gaps between supergroups, on signals referred to channels or groups (e.g. 3825 Hz signaling tone), or frequency response at selectable, equidistant intervals.
- Power measurements on the whole of the baseband
- Location of signals with certain levels.

In the case of FDM systems the three group pilots and the three supergroup pilots, which conform to CCITT Recs, can be measured using automatic pilot frequency switching. In each measurement run all the pilots present are found, i.e. correct measurements will be carried out if a variety of standard pilots are present.
If there is a power failure when measurements are being performed in the automatic monitoring mode, the Test System will return to this mode when the power returns.
The Test System can also transfer results and control test sequences via data comm links, i.e. one or more separate unmanned test stations can be remotely operated (SPM-190 with SWP-13 Software Package). There are several ways of carrying this out (see Fig.).

Any remote station in the automatic monitoring mode, when part of the setup containing a Data Circuit Switch (SPM-197 only), can automatically dial-up the central station and transfer results, including identifying information, to the screen or printer. Centrally controlled systems with more than 16 remote stations can be operated in this way. The SPM-197 Test System, which is an integral part of the remote station, can also be used for local measurements.

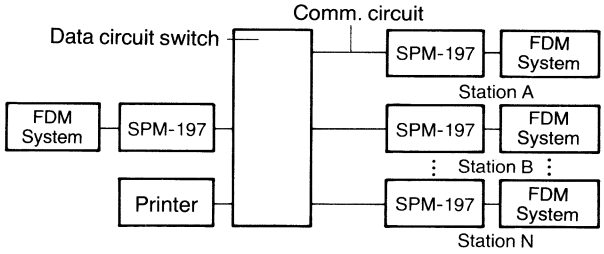


Station-to-station operation



Station-to-multiple station operation

1) Provided by the user
2) Not supported by software; the Master can communicate with only one slave at a time



One or more station can be operated with the Data Circuit Switch

Some applications for the SPM-190 Test System when equipped with the SWP-13 and the SPM-197 Test System

Ordering information

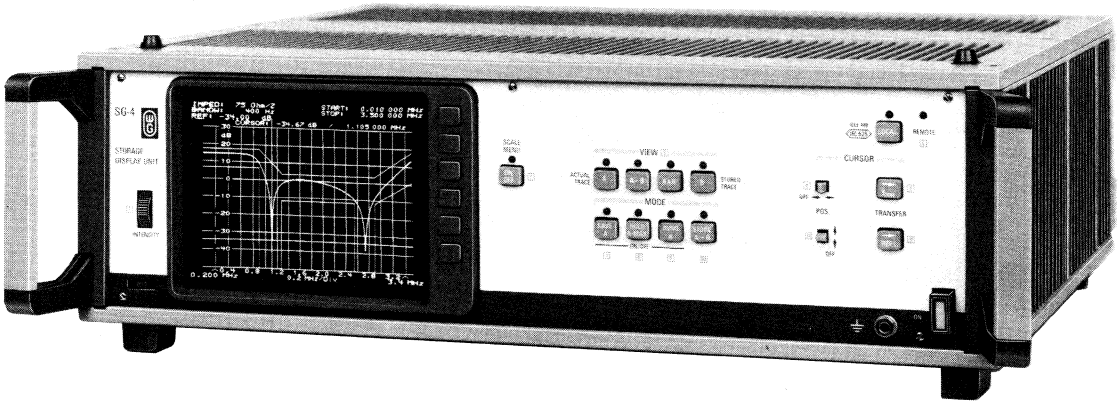
Test System SPM-190	**BN 6609/01**
for local measurements on CCITT and INTELSAT FDM systems	
Test System SPM-190	**BN 6609/02**
for local and remote measurements on CCITT and INTELSAT FDM systems	
Test System SPM-197	on request from factory

A Specification Sheet with more details and a Colour Brochure are available on request

SG-4
Storage Display Unit

with digital image storage for use with the SPM-16 and SPM-19 Selective Level Meters

IEEE 488
IEC 625



- **Stationary, flickerfree image**
- **Measurement and reference traces can be displayed separately, together or as a difference curve**
- **Electronic internal graticule with alphanumeric lettering**
- **Line-cursors for level and frequency. Value is displayed on screen**
- **Noise averaging and peak value display (Max. Hold)**
- **Programmable tolerance masks can be stored**
- **Video output**
- **Straightforward operation, automatic calibration**
- **Direct keypad entry of main functions; programmed functions selected via softkeys**

Applications

The SG-4 Storage Display Unit can be used to convert the sweepable SPM-16 and SPM-19 Selective Level Meters to panoramic receivers or to sweep measuring setups if a suitable level generator is available. The SG-4 produces a stationary, flicker-free sweep trace, even for slow sweeps. The SG-4 is, therefore, eminently suited for measurements on test items with long settling times. The SG-4 is also invaluable for displaying spectral lines or the system traffic on FDM systems. Comparison measurements, normalizer operation or analysis of signal drift are also possible. Because of the standard IEC/IEEE Interface, the SG-4 can be used with computer controlled measuring systems.

Characteristics

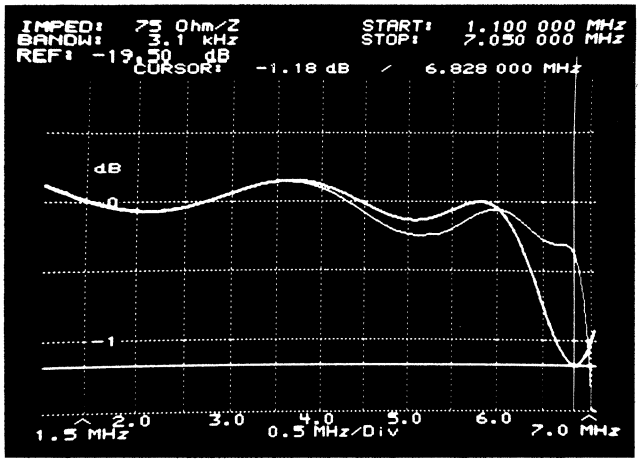
The Storage Display Unit has two digital curve stores. And, besides the current measuring curve, a reference curve can also be stored as a measurement aid. A facility for providing the difference between a measured curve and a reference curve is available too and is useful for eliminating errors from a measurement setup. The measured curve can be analysed using an electronic, calibrated internal graticule with lettering, and a level and frequency line-cursor with alphanumeric information. Noise averaging can be used to smooth sections of the trace which are distorted by noise. The "Max. Hold" facility is used to obtain the highest level that occurs during measurement. Programmable tolerance masks allow quick decisions on GO/NO GO values. Video information for further processing can be output via the video-output and displayed on large monitors or on video-plotters.

CRT	7" flat screen
Curve storage	two digital memories
Trace display, two curves	separately, together or difference
Resolution of the 80, 20, 1 dB ranges on the SPM-16/SPM-19	0.33, 0.1, 0.01 dB
Dimensions (w x h x d) in mm	477 x 155 x 434
Weight	approx. 12 kg

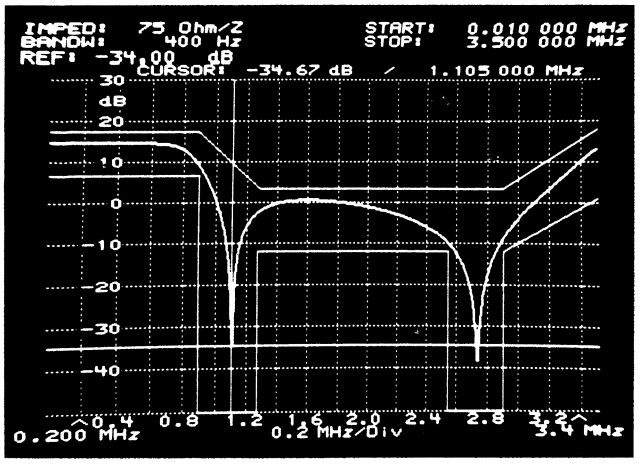
Further Characteristics and Applications

High accuracy

Dual curve storage offers the possibility of displaying level differences, and so achieving a higher degree of measurement and alignment accuracy. The X/Y resolution is 511 x 256 pixels. If the frequency responses of the Receiver and Generator in back-to-back operation are stored before a measurement is carried out, the intrinsic errors of the measuring setup can nearly be eliminated. If the required characteristics of the test object are stored as the memory curve, one can rapidly see what adjustments have to be made. Any change in level of the measured curve is shown immediately. The noise averaging facility allows a noisy signal to be read with greater accuracy – longer sweep times are not necessary.



Measurement curve and reference curve



Measured curve and tolerance mask

Exact evaluations

The SG-4 has a large, flat CRT. The electronically generated and calibrated internal graticule means that the measured level can be read from a linear scale (dB, dBm, or dBm0) without parallax errors. Important receiver parameters are also displayed on the screen. The level and frequency can be read accurately from the screen using the line cursor provided for each parameter. The maximum resolutions are 0.01 dB and 0.1 Hz.

When acting as a control unit the SG-4 can transfer both the level and frequency values to the Level Meter, where they can be used as the new reference level or centre frequency. This means that the most interesting section of the curve can be selected. The curve can also be frozen.

Electronic tolerance masks

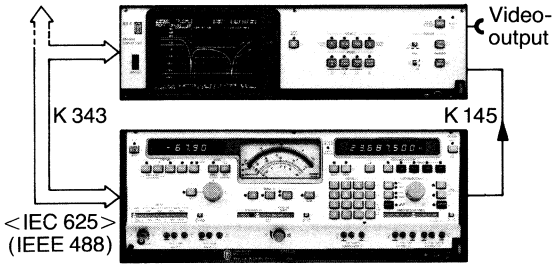
Tolerance masks are often used to determine whether the level of a trace lies within certain prescribed limits. Usually the trace must lie between two regions bounded by two piecewise continuous curves made from line segments. These masks can be displayed or stored by the SG-4. If required further tolerance masks can be stored in the SG-4 via the MEMORY key on the level meter.

Hardcopy and graphics plotter

The SG-4 Storage Display Unit has a video output to a video plotter and so the whole display can be recorded as hardcopy.

An external monitor can also be connected to this output to obtain a larger display or to allow the display to be viewed at a location remote from the SG-4. Moreover, an HP 7470 A graphics plotter may be connected. The flat screen makes photography easier. It is also possible to obtain a simple printout of the measurement curve without the extra information, using an X-Y plotter at the output of the level meter.

The SG-4 is compact and only three units in height. Two cables delivered with the SG-4 are used to connect it to the SPM-16 or SPM-19. The Level Meter must be fitted with the standard IEC/IEEE Interface Bus Board. If a desktop computer is available, the above system can be extended to form an easy-to-use automatic test system.



SG-4 connected to level meter

Specifications of the Storage Display Unit — SG-4

If not otherwise stated the values refer to the rated ranges of use of a.c. line voltage, a.c. line frequency, and the ambient temperature.

Curve Storage

Two digital memories, X/Y resolution . . . . . 511 x 256 pixels

Display

Measurement curve and reference curve . . . singly, together or the difference of the two curves

Cursors

Frequency cursor, resolution . . . . . 511 pixels
Level cursor, resolution . . . . . 256 pixels
The relevant frequencies and levels are alphanumerically displayed on the screen with a resolution in the

X direction of . . . . . $\frac{\text{Frequency deviation}}{511}$ or 0.1 Hz

Y direction of . . . . . 0.01, 0.1 or 0.33 dB (depends on measurement range selected)

Low brightness display

Electronically generated graticule with frequency and level values.
Additional Receiver parameters are shown outside the graticule.

Screen

CRT . . . . . flat, seven inch
Adjustable intensity . . . . . phosphor GH (yellow-green)

Resolution and measurement error

Measuring Range SPM-16 or SPM-19	80 dB range	20 dB range	1 dB range
Display range on the SG-4 linear dB scale	−80 to +5 dB	−23.5 to +2 dB	−1.5 to +1.05 dB
Resolution on SG-4	0.33 dB	0.1 dB	0.01 dB
SG-4 Errors Error limits	±0.8 dB	±0.2 dB	±0.03 dB
Overall Error: the value given for the analog display of the SPM-16 or SPM-19 can be taken as the overall error for the SG-4 and Level Meter			

Additional functions

Noise Averaging

Smooths signal to be measured by averaging out noise.

Max. Hold (indication of peak value)

Displays the highest signal level for each sampling point.

Tolerance masks

The cursor is used to set up tolerance masks. These masks are constructed from line segments. The corners of these masks can be placed at any chosen position and displayed on the screen or stored (max. 32 corner points/mask). A store is available for 11 extra masks (max. 250 corner points).

Controller

The cursor values for level and frequency can be transferred to the Level Meter as a new reference level and a new centre frequency.

Additional inputs and outputs

Connection for IEC (IEEE) Bus

for connecting the SG-4 to the SPM-16 or SPM-19 and for controlling the SG-4 from a computer.

Display Unit input

A 14-pin socket for the K 145 cable from the SPM-16 or SPM-19.

Video output

for external monitor or video plotter
Peak voltage when terminated with 75 Ω . . . . . 1 V_{pp}
Frame frequency . . . . . 50 Hz
Image, return trace . . . . . <1 ms
Line frequency . . . . . 15.6 kHz
Line, return trace . . . . . <12 µs

General Specifications

Power Supply

Rated ranges of use for mains voltage,
switchable . . . . . 110/117/127/220/227/237 V, in all cases −12 to +10 %
Rated range of use for mains frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 70 VA
Safety class according to IEC 348 and VDE 0411 . . . Class I

Tolerable ambient temperature

Rated range of use . . . . . +5 to +40°C
Storage and transportation . . . . . −40 to +70°C

Data retention

A built-in trickle charged NiCd battery ensures that the memory contents for device settings, the reference curve and tolerance masks are not lost after a power failure.

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	155	Height (3 units)	131
Depth with handles	434	Depth	379

19" conversion kit . . . . . BN 700/00.03

Weight . . . . . approx. 12 kg

Ordering Information

Storage Display Unit SG-4	**BN 957/01**
Accessories (at extra cost) [1]	
Photographic mount FVR-8 for Shackman B 20 Camera	BN 980/00.01
Protective covers for front and back panel SD-3 (1 set)	BN 700/00.23

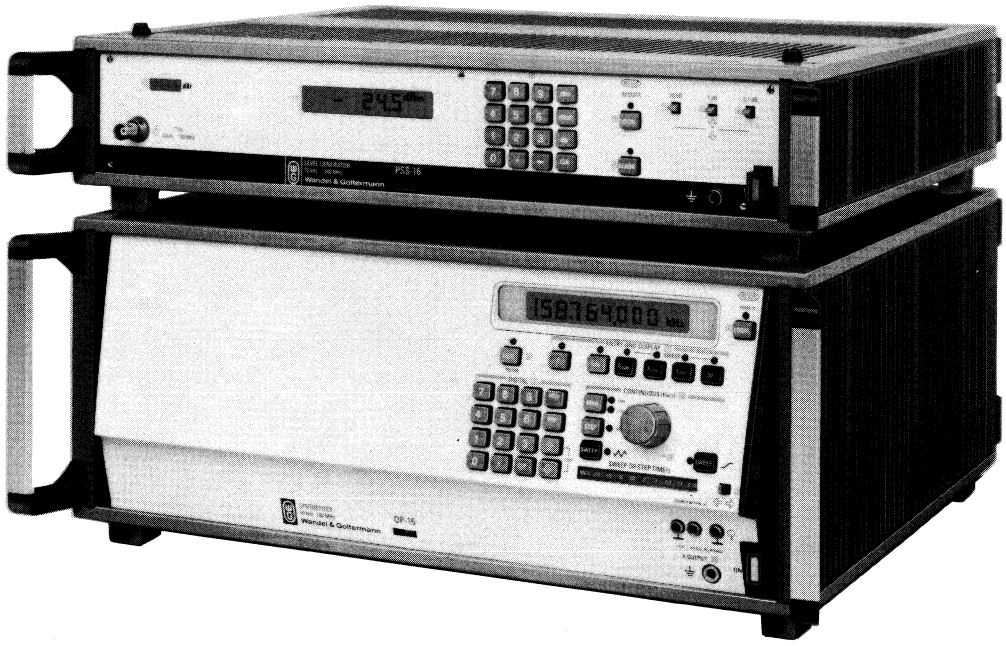
1) Connection cable K 145, K 343 contained in standard product package

A Colour Brochure is available on request

PS-16
Level Generator

Frequency range 10 kHz to 160 MHz

IEEE 488
IEC 625



- **Crystal controlled frequency settings via keyboard, stepwise or continuous**
- **High frequency accuracy; uncertainty less than 1×10^{-7}**
- **Send level adjustable in 0.1 dB steps**
- **Level displayed in dB/dBm, in dB0/dBm0 or dBr**
- **Built-in sweep capability**
- **Storage and call-up of any fixed frequencies**
- **Economical Measuring Setup design using the PSS-16 Send Section and the SPM-16 Selective Level Meter**
- **Extendable for use as level standard**

Applications

The PS-16 Level Generator provides a signal source for use in the development, manufacture, installation and maintenance of FDM systems with up to 10800 voice-grade channels, and for measurements on single sideband radio-link systems. The PS-16 is also suitable for carrying out measurements on submarine cable systems and investigating cables for carrying data at higher bit rates (140 Mbit/s). Because of its remote control facility, the PS-16 can be used in automatic test systems. When used in conjunction with the SPM-16 Selective Level Meter a complete sweepable Measuring Setup for level, gain and loss measurements is created.

Characteristics

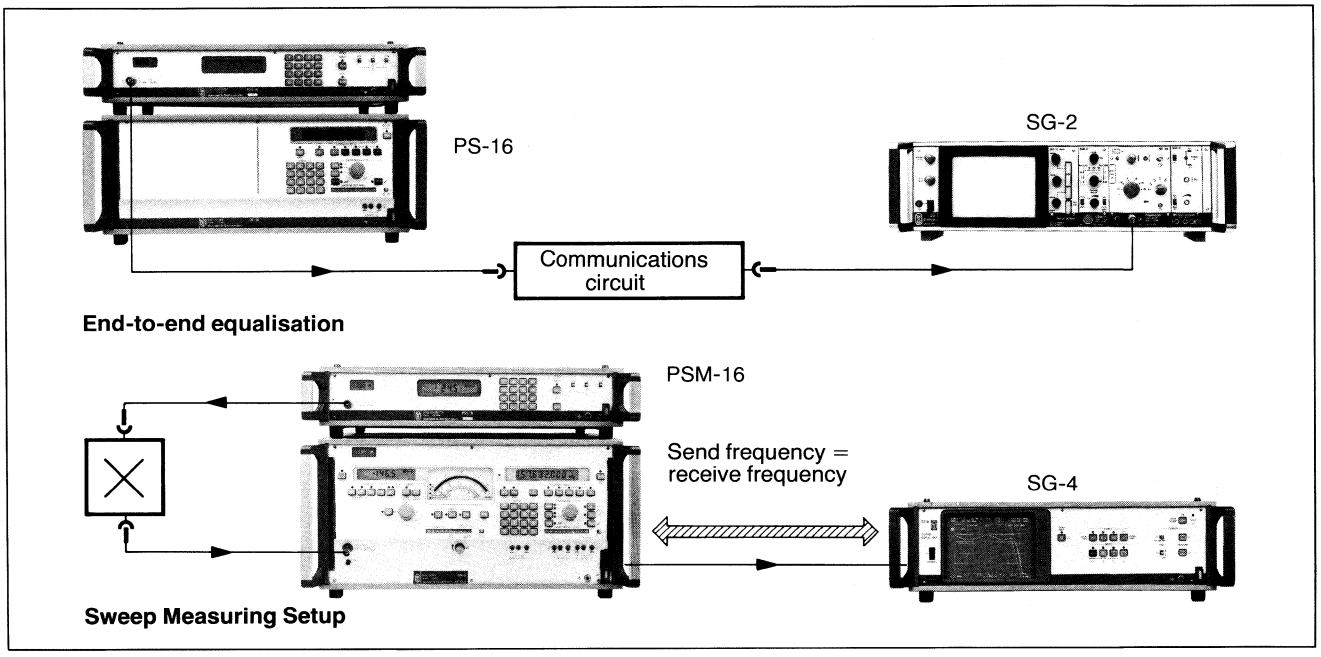
The PS-16 Level Generator comprises the PSS-16 Send Section, which carries out level conditioning, and the OP-16 Synthesizer which has a remarkably high spectral purity, accuracy, stability, and freedom from phase hits when the frequency is altered (this applies particularly to sweep measurements). The send frequency on the PS-16 can be entered digitally via a keyboard, by a continuous adjustment control or by an increment key. To all intents and purposes any number of fixed frequencies and PS-16 settings can be stored to facilitate repetitive measurements. The built-in data retention capability ensures that the memory contents are not lost if there is a power failure. The send level, which may be "soft" blanked manually, can be set very precisely in 0.1 dB steps.

Frequency range	10 kHz to 160 MHz
Frequency setting	via keyboard, quasi-continuous, manual or automatic step, sweep
Level range	−69.9 to +10.0 dBm (−69.0 to +1.0 dB)
Total error to 100 MHz, level > −40 dBm	±0.12 dB

Fixed frequencies (100/200) and PS-16 settings (10/50) can be stored.

Further Characteristics and Applications

- High frequency accuracy: The very small uncertainty of 1×10^{-7} on the set frequency means that frequencies can be set very accurately – even at high frequencies. The error stated is valid for the rated range of use for temperature and includes ageing of the reference crystal.
- Sweep capability: The send frequency can be swept over the whole of the PS-16's frequency range. The rapid and easy-to-set sweep limits are particularly useful for wide-band end-to-end measurements. The centre frequency and sweep width can also be varied.
- Storage of fixed frequencies and PS-16 settings: The possibility of calling up (with EPROM 200) fixed frequencies and 10 or 50 PS-16 settings takes the tedium out of repetitive measurements. The fixed frequencies can be stepped through in sequence – automatically or manually.
- Digital level display: This means that the send level can be set quickly and precisely with high resolution. The absolute level referred to a point of zero relative level (dBm0 or dB0) and the relative level of the measurement point (dBr) can also be set for measurements on FDM systems.
- Use as a level standard: The PS-16 can be used as a precise a.c. signal source producing a level of 0 dBm. This is achieved by forming a control loop in which the *EPM-1 Milliwatt Power Meter* acts as an ALC amplifier and feeds a control voltage to the control voltage input of the PS-16. This arrangement eliminates the losses and matching errors introduced by long leads.
- Economical design: Only one tuning oscillator is required for frequency setting when measurements with equal send and receive frequencies are carried out. The PSS-16 Send Section/SPM-16 Selective Level Meter combination is ideal for measurements of this kind. The *SG-4 Storage Display Unit* can be used for sweep measurements.



Specifications of the Level Generator — PS-16

Unless otherwise stated, the specifications are valid for the rated range of use of a.c. line voltage, a.c. line frequency and ambient temperature 15 min after the instrument has been switched on. The level and measuring ranges for the dB calibration are given in brackets.

Synthesizer OP-16

Frequency

Frequency range . . . . . 10 kHz to 160 MHz

Frequency setting
Digital through keyboard, resolution . . . . . 1 Hz
Quasi-continuous manually over complete range
without bandswitching, smallest step . . . . . 1 Hz
In steps by increment key, smallest step . . . . . 1 Hz
Error limits of frequency,
including ageing over 1 year . . . . . $\pm 1 \times 10^{-7}$

Automatic frequency adjustments

Auto-step
Automatic frequency incrementation between adjustable limits. Increment size, frequency limits and speed of incrementation entered via keyboard.

Sweep mode
Setting of upper and lower sweep limits or
Setting of centre frequency and sweep width
Sweep run . . . periodic (triangular), single-shot, and manual
Sweep duration for 1 half period . . . . 0.03, 0.1, 0.3, to 300 s

Outputs and Input

Tracking generator-output
For signal drive to Level Generator PSS-16 or fixed level output, level into $Z_{out} = Z_L = 75\,\Omega$ . . . . . −15 dBm

Output* for internal standard frequency . . . . . 10 MHz

Input* for external standard frequency . . . . 1, 2, 5, 10 MHz

Memory

100 fixed frequencies and 10 instrument settings, programmable, entry and call-up via keyboard, erasure by writing over stored information.
Internal stand-by battery for data retention if a.c. power drops out.

Send Section PSS-16

Generator output

Coaxial output* . . . . . Universal connector Versacon® 9 adaptable to all commercially used connectors
Output impedance . . . . . 75 Ω
Frequency range . . . . . 10 kHz to 160 MHz

Send level

Calibration can be switched over from voltage level (0 dB ≅ 0.775 V) to power level (0 dBm ≅ 1 mW in Z_0)

Setting
of absolute level, display . . . . . dBm, dB
or absolute power (voltage) level in dB referred to a point of zero relative level, display dBm0, dB0
and the relative level, display . . . . . dBr
digital through keyboard, resolution . . . . . 0.1 dB
in steps through increment keys with automatic overflow into the next decade, smallest level step . . . . . 0.1 dB

Level range . . . . . −69.9 to +10 dBm (−69.9 to +1.0 dB)

Total error

Limits of total error		
in level range	in frequency range 50 kHz to 100 MHz	10 kHz to 160 MHz
with 0 dBm (− 9 dB) for level > − 40 dBm (− 49 dB) for level > − 70 dBm (− 70 dB)	± 0.05 dB ± 0.12 dB ± 0.20 dB	± 0.10 dB ± 0.25 dB ± 0.35 dB

Limits of variation with frequency referred to 20 kHz		
in level range	in frequency range 50 kHz to 100 MHz	10 kHz to 160 MHz
with 0 dBm (− 9 dB) for level > − 40 dBm (− 49 dB) for level > − 70 dBm (− 70 dB)	± 0.03 dB ± 0.09 dB ± 0.15 dB	± 0.08 dB ± 0.18 dB ± 0.30 dB

Spurious voltages

Harmonic ratio a_{k_2}, a_{k_3}
Send level ≦ + 5 dBm (− 5 dB)
for send frequencies: 10 kHz to 100 MHz . . . . . ≧40 dB
100 MHz to 160 MHz . . . . . ≧34 dB

Suppression of discrete nonharmonic spurious signals
at variable separation from the send frequency for send and spurious frequencies < 110 MHz . . . . . approx. 65 dB

Level blanking
manually, attenuation when blanked . . . . . >70 dB

Auxiliary inputs

External automatic level control
from EPM-1, controlling range . . . . . approx. ± 1 dB

Signal frequency input 10 kHz to 160 MHz for frequency tuning through OP-16 Synthesizer or SPM-16 Level Meter,
$Z_{out} = 75\,\Omega$, input level . . . . . (− 15 ± 0.5) dBm

General Specifications

Power supply
Rated range of use of a.c. line voltage, selectable . . . . 110/117/127/220/227/237 V, − 12 to + 10 %
Rated range of use of a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption, PSS-16 . . . . . approx. 30 VA
OP-16 . . . . . approx. 90 VA
Safety class as per IEC 348 and VDE 0411 . . . . . class I

Tolerable ambient temperature
Rated range of use . . . . . +5° C to +40° C
Storage and transport . . . . . −40° C to +70° C

Dimensions (in mm), weight

Bench model	OP-16	PSS-16
Width with handles	477	477
Height overall	199	110
Depth with handles	432	425
19" conversion kit	BN 700/00.04	BN 700/00.02
Weight	approx. 16 kg	approx. 10 kg

Options

Permanently stored values (EPROM), BN 872/00.01
For the OP-16 Synthesizer, storage of 100 fixed frequencies and 40 instrument settings (frequency parameters) in a nonvolatile memory (EPROM), according to user's request.

Interface Bus <IEC 625>, BN 853/02 and BN 873/00.01
For controlling the OP-16 and PSS-16 through a computer.

Ordering Information

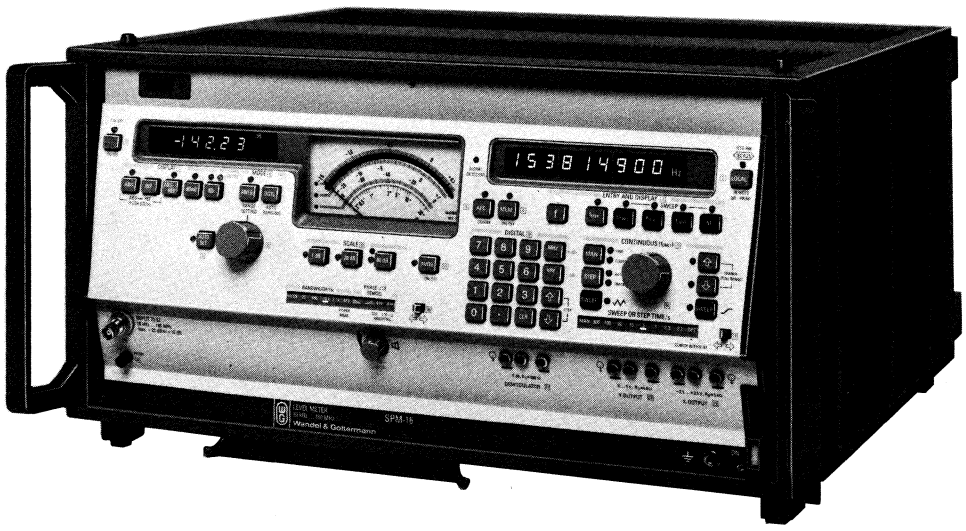
Synthesizer OP-16	**BN 872/01**
Send Section PSS-16*	**BN 873/01**
Options (at extra cost)	
Interface <IEC 625> Card with adaptor plug IEC 625/IEEE 488 (S 834)	
for OP-16	BN 853/02
for PSS-16	BN 873/00.01
Permanently stored values[1] (EPROM), for OP-16	BN 872/00.01
Accessories (at extra cost)	
Interconnecting cable for Interface <IEC 625>	
120 cm long	K 343
200 cm long	K 344
Front and back panel (1 set)	
SD-4 for OP-16	BN 700/00.24
SD-2 for PSS-16	BN 700/00.22

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.
1) State chosen fixed frequencies and instrument settings (frequency parameters) when ordering. (Ask for ordering Form No. 5/797 a, b)

SPM-16
Selective Level Meter

with wideband section, for level measurements in the frequency range 10 kHz to 160 MHz

IEEE 488
IEC 625



- **Crystal-controlled frequency set at keyboard, stepwise or continuous**
- **High frequency accuracy, uncertainty less than 1 x 10^{-7}**
- **Absolute and relative measurements with high resolution**
- **Digital and analog level display**
- **Voltage measurement in range 1 μV to 2 V (Version BN 874/03)**
- **Fast search-scan and selective end-to-end measurements**
- **Store and call-up of any fixed frequency and of complete instrument settings**
- **Built-in sweep device**
- **SSB demodulation and phase jitter measurements**
- **External tuning of the PS-16 Generator or the PSS-16 Send Section**
- **Printout of measured results; printer connection through V.24/V.28 interface, as option**

Applications

The SPM-16 Level Meter is used for carrying out level, noise and phase jitter measurements that arise when FDM communication systems with up to 10,800 speech channels are developed, manufactured, installed and maintained. The SPM-16 is also suitable for measurements on single sideband radio-link systems, submarine cable systems and for investigating cables carrying digital communications at higher bit rates (140 Mbit/s). The SPM-16 has facilities for fast search-scan with low signal-to-noise ratio, panorama reception or long-term monitoring. As the SPM-16 has a remote control capability it can be used as a part of an automatic test system.

A complete Level and Sweep Measuring Setup is obtained if the *PSS-16 Send Section* or the *PS-16 Level Generator* are used in conjunction with the SPM-16.

Characteristics

The SPM-16 contains a synthesizer whose special features are low spurious modulation at frequency changeovers and high spectral purity. The SPM-16's frequency can be set via a keypad, tuned continuously, or tuned via step and automatic step facilities. The SPM-16 is ideal for sweep measurements as its frequency can be varied without causing phase discontinuities. When measuring the total signal level, the microprocessor control ensures that the signal drive range of the level measuring section is optimal. The result of this is high sensitivity, high resolution (0.01 dB) and a large dynamic range for the display (80 dB).
Particular frequencies or complete SPM-16 settings can be stored, so taking the tedium out of repetitive measurements. These parameters are not lost if there is a power failure.

Frequency range	10 kHz to 160 MHz
Methods of setting frequency	via keypad, quasi-continuously, manual step or auto-step and sweep
Level range, selective	−130 to +20 dBm (−140 to +10 dB)
Bandwidths	25; 400 Hz; 1.74; 3.1; 48 kHz
Total error to 110 MHz, 0 to −70 dBm	≦±0.25 dB
Fixed frequencies (100/200) and complete settings (10/50) can be stored	

Further Characteristics and Applications

SPM-16 Level Meter, BN 874/01

- High frequency accuracy: The small uncertainty of $1 \cdot 10^{-7}$ means that the tuned frequency can be set accurately – even at high frequencies. Measuring pilot levels is one of many applications where this requirement is essential. The error value given is correct over the rated range of use for temperature and includes reference crystal ageing.
- Sweep facility: High spectral purity is the special feature of this device which is retained in the sweep mode; this means that accurate measurements on test items with steep frequency responses and high attenuations can be made. Sweep curves may be displayed on the *SG-4 Storage Display Unit.*
- Fast search-scan with automatic printout: The SPM-16 finds any spurious signals or hot tones that exceed a certain level entered on the SPM-16, and that lie between two independent, selectable frequency limits. If required their levels and frequencies can be printed out automatically. The correct scan-speed for the bandwidth used is selected automatically.
- Selective end-to-end measurements: In the operating mode *receiver track* the SPM-16 tunes itself automatically to the discrete frequencies sent from the opposite end. No additional synchronisation is required. If the transmission path is very noisy the Generator and Receiver can be switched to the *autostep* operating mode, and a special routine called up which ensures synchronism of frequency tuning.
- Digital and analog level display: The maximum resolution of the digital level display is 0.01 dB in autoranging mode. The ranges of 1 dB, 20 dB or 80 dB can be selected for the meter (alignment work, sweep measurements). The measurement range can be set manually in steps of 1 dB or 5 dB, or automatically.
- Absolute or relative level measurements: Both absolute and relative level measurements (display in dB or dBm) can be made. The level which is to act as the reference level is measured digitally and stored. Deviations from this reference level in subsequent measurements (e.g. frequency response measurements) are shown on a digital or analog display. Levels referred to a point of zero relative level (dBm0, dB0) are obtained by storing the relative level (dBr) at a test point. This is useful for measurements on communication systems.
- Level difference measurements: The level difference (N-X or X-N) between two items-under-test can be measured precisely with digital methods using the *RU-3 Relay Changeover Switch.* The RU-3 is controlled by the SPM-16 and can be purchased as a separate item. The resolution is 0.01 dB.
- Switch-selectable bandwidths: A narrow 25 Hz filter is used to measure pilots, carrier leaks or frequency spectra. The 400 Hz bandwidth is required for sensitive level measurements. A 1.74 kHz filter is used to make weighted noise measurements in single voice channels at the CF level. A 3.1 kHz filter with a flat response is also available. Noise power in a basic group (48 kHz) can also be measured.
- Internal demodulator with large dynamic range: This device demodulates SSB signals in the erect or inverted positions. The demodulated signal can be assessed qualitatively using a built-in loudspeaker. Alternatively, the signal can be processed further externally. The large dynamic range is especially useful for making accurate noise or impulsive noise measurements (with ext. Option) on translated voice channels.
- Phase jitter measuring device: Phase jitter measurements can be carried out directly in the voice channel or at the CF level using a 1 kHz test tone. Jitter measurements on pilot and carrier frequencies can also be carried out during troubleshooting. These measurements comply with CCITT Recommendation O.91. Two weighting filters are available (20 Hz to 300 Hz and 4 Hz to 300 Hz).

SPM-16 Level Meter, BN 874/03

Like version BN 874/01, but with

– extra voltage measuring capability in the range 1 μV to 2 V. Autoranging and a digital display (in mV) is provided. The max. resolution of the display is 1 μV [1].

Options

– V.24/V.28 Printer Interface for listing the results in various formats (printouts of send and receive measurement data).
– Remote control board (IEC 625/IEEE 488) for controlling the SPM-16 when it forms part of an automatic test system (instead of printer interface).
– EPROM for 100 fixed frequencies and 40 complete devices settings specified by the customer to simplify repetitive measurements.
– 2.5 kHz Channel Filter (for BN 874/01). The 400 Hz filter can be replaced by a 2.5 kHz filter and used to measure the channel power of submarine cable systems.

1) dBm0 display not possible

Specifications of Selective Level Meter — SPM-16

Unless otherwise noted, the specifications are valid for the rated range of use of a.c. line voltage and ambient temperature 15 min after the SPM-16 has been switched on. The level and measuring ranges for the dB calibration are given in brackets.

Coaxial input* . . . . . Versacon® 9 Universal Connector adaptable to all usual commercial connectors

Input impedance . . . . . 75 Ω

Permissible input level (a.c. and d.c. components) . . . . . ≦ +25 dBm (+16 dB)

Frequency

Frequency range, selective and wideband . . . . . 10 kHz to 160 MHz

Frequency setting digital through keyboard, resolution . . . . . 1 Hz

quasi-continuous manually over the complete range
without band switching, smallest step . . . . . 1 Hz
in steps through increment key, smallest step . . . . . 1 Hz

Automatic frequency settings

Search-scan
Single scan over the complete frequency range, stopped by signal detector, and automatic fine tuning by AFC to the found signal.
Periodic search between adjustable frequency limits.

Auto-Step
Automatic stepping of tuning frequency in frequency steps between adjustable frequency limits.
Pushbutton entry of step width, frequency limits, and stepping rate.

Receiver tracking
Automatic stepping of tuning frequency between adjustable frequency limits by a frequency step as needed when the level reading disappears. Pushbutton entry for adjusting the step width and frequency limits.

Sweep mode
Setting of upper and lower sweep limits or setting of centre frequency and frequency deviation.
Sweep . . . . . periodic (triangular), single-shot, or manual
Duration of sweep for one-half period . . . 0.1; 0.3; 1; ...; 300 s

Error limits of tuning frequency,
including ageing over 1 year . . . . . $\pm 1 \cdot 10^{-7}$

Level and voltage display
Display of:
power level (dBm) referred to . . . . . 1 mW
voltage level (dB) referred to . . . . . 0.775 V
the difference level in . . . . . dB
absolute power level in dB referred to a point
of zero relative level in dBm0, dB0
and the relative level in . . . . . dBr
the voltage (only BN 874/03) in . . . . . mV

Smallest step for adjusting relative level (dBr) . . . . . 0.1 dB

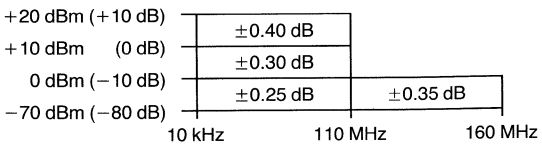
Display, switchable . . . . . digital or analog
Digital display, max. resolution . . . . . 0.01 dB
Analog readings on meter,
switchable scale ranges . . . . . 1 dB, 20 dB, 80 dB

Level ranges
selective . . . . . −130 to +20 dBm (−140 to +10 dB)
wideband . . . . . −50 to +20 dBm (−60 to +10 dB)

Measurement range selection
Automatic ranging for digital display with overload check.
Manual switching in steps of 1 dB or 5 dB for analog readings or single reading automatically after pressing the key.

Measurement errors

Selective measurements
Error limits of level reading, digital mode or analog with expanded scale, bandwidth ≦ 3.1 kHz, with automatic calibration.



Additional error for analog display
in 20 dB scale range (−5 to +2 dB) . . . . . ±0.2 dB
in 80 dB scale range . . . . . ±2 dB
Error limits for voltage display
(BN 874/03) . . . . . ±3 % of reading ±1 µV

Wideband measurements
Error limits of digital level display, after calibration
Frequency range 10 kHz to 110 MHz . . . . . ±1 dB
Frequency range 110 MHz to 160 MHz . . . . . ±2 dB

Additional error for analog display
in the 20 dB scale range (−5 to +2 dB) . . . . . ±0.2 dB

Phase jitter
complies with CCITT Rec. O.91

Measurement of peak-to-peak jitter
Display, digital or analog . . . . . 0.3 to 30°
Maximum resolution . . . . . 0.1°
Measurement bandwidths, switchable . . . . 20 Hz to 300 Hz
4 Hz to 300 Hz
Error limits of display at jitter frequency 150 Hz
for input level ≧−60 dBm (−70 dB) . . ±10 % of reading ±0.5°

Selectivity
in the frequency range to 110 MHz

Bandwidth ≅ effective noise bandwidth	Attenuation at ±Δf from centre frequency		
	±2 kHz	±15 kHz	±35 kHz
48 kHz	—	—	approx. 50 dB
3.1 kHz	≧45 dB	≧60 dB	—
1.74 kHz	≧50 dB	≧63 dB	—
400 Hz [1]	≧55 dB	≧70 dB	—

1) The 2.5 kHz Channel Filter and the 400 Hz filter cannot be used together

Bandwidth 25 Hz
3 dB bandwidth . . . . . ≦25 Hz
Attenuation ≧48 dB at centre frequency . . . . . ±80 Hz
Attenuation ≧60 dB at centre frequency . . . . . ±250 Hz
Image frequency rejection and IF suppression . . . . ≧70 dB

Harmonic ratio a_{k_2}, a_{k_3}
for a fundamental frequency level ≦+10 dBm (0 dB).
Operating mode digital or analog with manual range selection and 40 dB raised sensitivity compared to measuring range of the fundamental frequency level
in frequency range, f ≧ 4 MHz . . . . . ≧65 dB
in frequency range, f < 4 MHz . . . . . ≧60 dB

Intrinsic noise
Selective operating mode, f = 50 kHz to 160 MHz,
bandwidth 25 Hz . . . . . ≦−130 dBm (−139 dB)
The levels increases by +4 dB for the 400 Hz filter, by +10 dB for the 1.74 kHz filter, by +12 dB for the 3.1 kHz filter and by +26 dB (f ≧300 kHz) for the 48 kHz filter.

Outputs and inputs

IF output* . . . . . 10 kHz

D.C. voltage output . . . . . Z_{out} = 5 kΩ, 0 to +5 V

X deflection voltage . . directly proportional to frequency

Demodulator output . . 3 pole CF connector, Z_{out} = 600 Ω
Output frequency when tuned to centre frequency . . . 2 kHz
Single sideband demodulation . . . . . erect/inverted position

Output * for internal standard frequency . . . . . 10 MHz

Input * for external standard frequency . . . . 1; 2; 5; 10 MHz

Tracking generator output,
($Z_{out} = Z_L = 75\ \Omega$) . . . . . −15 dBm

Pen lift function for controlling an X-Y recorder

Test Probe connection TK-11

Automatic Frequency Control AFC
can be switched off, functions with all receiver filter bandwidths to 3.1 kHz.
Automatic frequency control over tuning frequency at the receive frequency in operating mode search-scan, in association with the fast signal detector.
Frequency locking range . . . . . whole frequency range

Memory
100 fixed frequencies and 10 menus for complete instrument settings freely programmable; entry and call-up via keyboard; erasure by writeover.
Data protection circuit in case of a.c. line dropout.

General Specifications

Power supply
Rated ranges of use of a.c. line voltage, selectable . . . . . 96 to 140 V/193 to 261 V
Rated range of use of a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 65 W
Safety class to IEC 348 and VDE 0411 . . . . . Class I

Tolerable ambient temperature
Rated range of use . . . . . +5 to +40°C
Limits range for storage and transport . . . . . −40 to +70°C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	244	Height (5 units)	220
Depth with handles	432	Depth	377

19" conversion kit . . . . . BN 700/00.05
Weight . . . . . approx. 22 kg

Options

Read only memory (EPROM), BN 874/00.01
Storage of 100 fixed frequencies and 40 menus of complete instrument settings in an EPROM.

Interface Bus <IEC 625> Card, BN 853/02
for controlling the SPM-16 through an external computer.

Printer Interface, BN 905/02
Applicable with SPM-16 instead of Interface <IEC 625> Board, BN 853/02. For connection of a printer with V. 24/V. 28 Interface, with printout of measurement mode, measurement run information, measurement parameter, address and measurement results.

2.5 kHz Channel Filter, BN 829/00.06 (for BN 874/01)
replaces the 400 Hz bandwidth
Effective noise bandwidth . . . . . 2.5 kHz ±10 %
Attenuation ±1.5 kHz from centre frequency typically . 60 dB

Ordering Information

Level Meter SPM-16 *
The following versions are available: **BN 874/..**

Bandwidth	Level display			Phase jitter measurements		IEC/IEEE-Bus	Order number
				Measuring bandwidth			
48 kHz 3.1 kHz 1.74 kHz 400 Hz 25 Hz	dB dBm	dBm0	V	20 to 300 Hz	4 to 300 Hz		
■	■	■		■	■	□	BN 874/01
■	■		■	■	■	□	BN 874/03

□ on request (see Options)

Options (at extra cost)

Interface <IEC 625> Board [1) 2)] with adapter IEC 625/IEEE 488 (S 834)	BN 853/02
Printer Interface V. 24/V. 28 [2)]	BN 905/02
EPROM [3)]	BN 874/00.01
Channel Filter with 2.5 kHz bandwidth for SPM-16, BN 874/01 (instead of 400 Hz) [4)]	BN 829/00.06

Accessories (at extra cost) [5)]

Test Probe TK-11	BN 573/00
Return Loss Coefficient Measurement Bridge RFZ-14	BN 830/00.01
Relay Changeover Switch RU-3	BN 323/02
plus: control cable	K 366
Matching Pad FEDA-1 75 Ω/50 Ω	BN 319/00
Decoupling Transformer REÜ-56	BN 839/00.01
Decoupling Transformer REÜ-50	BN 839/00.02
Connection cable for Interface Bus <IEC 625> 120 cm	K 343
200 cm	K 344
Front and Back Panel Covers SD-5 (1 set)	BN 700/00.25

1) Required for operation with the SG-4 Storage Display Unit and for computer control.
2) Either the BN 853/02 or the BN 905/02 can be used.
3) Specify the fixed frequencies and/or complete device settings that you require when you place your order. Request ordering forms No. 5/798 a, b.
4) Order when placing order for SPM-16 (can only be fitted in our factory).
5) For specifications and extra Ordering Information see "Measuring Accessories" spec. sheet.
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

TPM-10
TV Pilot Level Meter

for broadband cable television systems



- **Rapid and accurate measurement of pilot levels**
- **Autoranging**
- **Backlit digital display**
- **Automatic self-calibration**
- **Pen recorder output for long-term monitoring**
- **Mains or battery powered**
- **Portable and lightweight**

Applications

The TPM-10 TV Pilot Level Meter has been designed to make rapid and accurate measurements of pilot levels within certain broadband television systems corresponding to CCIR system B. The levels to be measured, at fixed frequencies, may either be continuous-wave or vision carrier signals. In the latter case the instrument measures the r.m.s. level of the line synchronisation pulses, and is therefore not affected by modulation due to the picture content. Simple operation and a clear display mean that semi-skilled personnel can carry out reliable analyses and measurements at the interface between postal administration and subscriber equipment.

Characteristics

Level measurements at the three switch-selected frequencies are fully automatic; any level within the range of the instrument may be displayed with a resolution of 0.1 dB on the backlit LCD display. Levels outside this range activate an over-range or an under-range indicator.

A Specification Sheet with more details is available on request

A d.c. output is provided for a pen recorder, which may be used for long-term monitoring on pilots. The TPM-10 can be operated from normal a.c. mains, internal rechargeable batteries, or an external d.c. supply, e.g. from a car battery.
When operating from internal batteries, a built-in timer switches off the instrument after 5 minutes to conserve the battery charge. If the supply voltage becomes too low for correct operation, the instrument will automatically switch itself off.
The TPM-10 carries out automatic self-calibration when it is switched on, after approx. 10 mins in operation, or when a marked key is pressed. The user, therefore, does not need to carry out calibration, or vary settings himself.

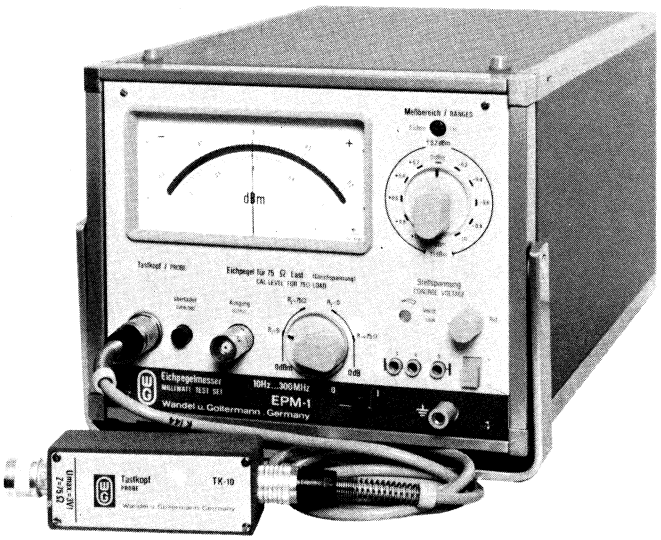
Ordering Information

TV Pilot Level Meter TPM-10 with neck strap, built-in rechargeable cells, and external d.c. supply lead for car cigar-lighter socket	**BN 4509/01**
Accessories (at extra cost)	
Leather Carrying Case for TPM-10 with compartment for accessories	BN 4509/00.01

Measurement frequencies, 3 channels	80.15 MHz, 280.25 MHz, 287.25 MHz
Level measurement	
Range	+60 to +110 dBµV
Display resolution	0.1 dB
Impedance	75 Ω

EPM-1
Milliwatt Power Meter

Frequency range d.c.; 10 Hz to 300 MHz



- **High absolute accuracy of level measurement**
- **Excellent resolution of level, expanded scale ±0.2 dB**
- **High relative accuracy on expanded scale**
- **True r.m.s. measurements, independent of signal waveform**
- **Calibration with built-in calibration source for 0 dBm and 0 dB**
- **Overload proof through protective circuit**
- **Application as constant level amplifier for voltage stabilisation of a generator's output**
- **Test probes for balanced and coaxial measurements**
- **Each EPM-1 has its own calibration curve**
- **The EPM-1 can be calibrated and certificated by the DKD 0501 Calibration Service**
- **Wide range of accessories**

Applications

The EPM-1 Milliwatt Power Meter was primarily designed for carrying out very precise r.m.s. measurements on the 0 dB and 0 dBm levels encountered in communication systems. Other applications include calibrating noise sources and checking level meters to see if they are calibrated accurately. It can also be used as an ALC amplifier. Level and signal generators can be connected to the EPM-1 to give a standard voltage source. If a second instrument is added to this setup very accurate frequency response measurements can be carried out.

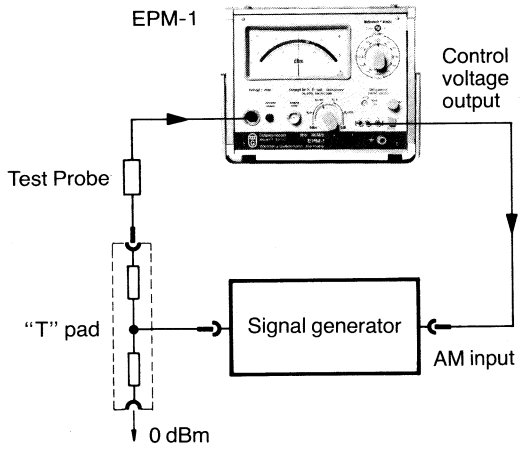
Characteristics

The *TK-10 Unbalanced Test Probe,* an integral part of the EPM-1, contains a thermo-couple which measures the heat produced by the signal. The waveform of the signal is therefore not important. Variations in the measured result that would be caused by temperature changes are eliminated by means of a reference thermo-couple. Special attenuators can be purchased so that voltage levels of 0 dB or +10 dB can be measured. Balanced measurements require the *TKS-10 Balanced Test Probe* and adaptors with various impedances. "T" branches, adaptor couplings and matching pads complete the range of accessories for the EPM-1.

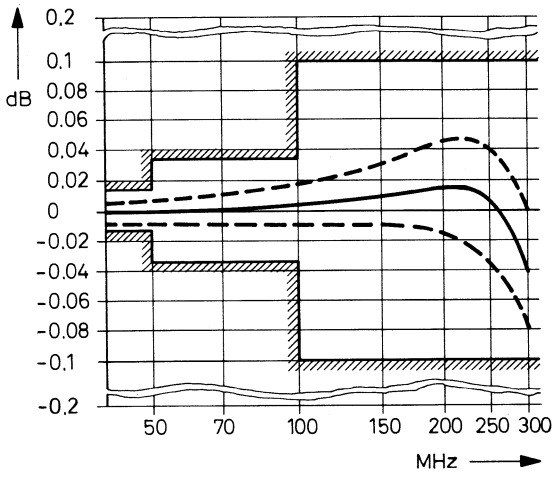
Frequency range (coaxial)	d.c.; 10 Hz to 300 MHz
Input impedance,	
coaxial	75 Ω or 50 Ω
balanced (on request)	124, 150, 600 Ω
Measurement range,	
unexpanded display	0 dBm ±1 dB
expanded display	−1; −0.8; ...; +1 dBm ±0.2 dB

Further Characteristics and Applications

- Test Probe is connected directly to test point: Connection leads, which cause losses and mismatches, may, under certain circumstances, vitiate the results. The TK-10 or TKS-10 Probes can be connected directly to test points and so eliminate these problems.
- Calibration by a precision reference element: A very precise and stable d.c. voltage is derived from a silicon reference element and this voltage is used to generate the calibration level.
- Use as an ALC amplifier: The EPM-1 generates a d.c. voltage which is proportional to the difference between the target value and the actual value. This voltage is then fed to the control input or the d.c. coupled AM input of a level or signal generator (send power +6 dBm) where it is used to regulate the output power. As the frequency response is practically constant, the user has a 0 dBm *a.c. voltage standard* at his disposal which he can use for laboratory or test applications. Levels of 0 dB or +10 dB can also be kept constant if an attenuator is connected in tandem with the Test Probe.
- X-Y plotter output: A d.c. voltage, which is proportional to the display value, can be extracted at the plotter output so that a graphic record of the measurement procedure can be obtained.
- Calibration curve: A calibration curve is prepared for each TK-10 Test Probe and delivered, together with the probe, to the customer. The curve gives a precise description of the frequency response of the TK-10 in question so that adjustments can be made to obtain more accurate measurements.
- Calibration of the EPM-1 by the DKD 0501 Calibration Service: DKD 0501 is a Calibration Service that will calibrate the EPM-1 on payment of a fee. The results of the calibration are officially guaranteed and certificated. The W&G Standards Department can offer services (e.g. measurement of reflection coefficient and calibration of other accessories) that the Calibration Service does not offer (see Table for their range).



EPM-1 used as an ALC amplifier



Typical frequency response referred to 10 Hz (continuous line). The measuring uncertainty is shown by a dotted line

Calibration Programme for the EPM-1 Milliwatt Power Meter provided by the DKD 0501 Calibration Service

No.	Measured quantity			Measuring uncertainty
1	Absolute and relative power reading (EPM-1/TK-10)	Display of a d.c. power after calibration with the internal calibration source at +23 °C (Selector setting 0 dBm, Z_{out} = 75 Ω)	1 mW ≅ 0 dBm (75 Ω) (The polarity of the d.c. voltage is the same as that of internal calibration source)	±0.003 dB
2		Variation of power display with frequency referred to d.c. (d.c. voltage has the same polarity as the calibration level) (Reference frequency of 20 kHz if required)	1 mW ≅ 0 dBm (75 Ω) at 20, 50, 70, 100, 140 MHz 200, 250 MHz 300 MHz	 ±0.015 dB ±0.030 dB ±0.055 dB
3	Absolute and relative voltage reading (EPM-1/TK-10)	Display of a d.c. voltage after calibration with the internal calibration level source at +23 °C (Selector setting 0 dBm, Z_{out} = 0)	0.274 V ≅ 0 dBm (75 Ω) (The d.c. voltage has the same polarity as the internal calibration source)	±0.002 dB
4		Variation of voltage display with frequency referred to 0 Hz (d.c. voltage has the same polarity as the calibration level) (Reference frequency of 20 kHz if required)	0.274 V ≅ 0 dBm (75 Ω) at 20 MHz 50, 70 MHz 100, 140, 200 MHz 250, 300 MHz	±0.020 dB ±0.030 dB ±0.035 dB ±0.045 dB

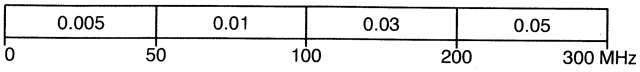
Specifications of the Milliwatt Power Meter — EPM-1

If nothing to the contrary is stated, the specifications are valid for the rated range of use of the a.c. line voltage, of the a.c. line frequency and of the ambient temperature 1 hour after switch on.

Frequency range . . . . . d.c.; 10 Hz to 300 MHz

Input (via TK-10 Test Probe)

Input impedance, coaxial . . . . . 75 Ω or 50 Ω
Reflection coefficient of the input:



Largest permissible input voltage . . . . . $V_{r.m.s.} = 3$ V
Permitted peak factor [1] of the test level . . . . . ≦10
Connector for Test Probe input
at $Z_o = 75\ \Omega$ . . . . . (IEC 75-7) 1.6/10 (M)
at $Z_o = 50\ \Omega$ . . . . . "N" connector (M)

Level display

Measurement range [2]
unexpanded scale . . . . . 0 dBm ±1 dB
expanded scale . . . . . −1; −0.8 to +1 dBm ±0.2 dB

Error limits of display
after calibration, taking into account the calibration curve of each Test Probe, $Z_{in} = Z_o$ and $Z_{in} = 0$

Meter Measurement range Temperature range	0 dBm *) 0 dBm ±0.2 dB (23 ±3) °C	Total range **), expanded and unexpanded meter scale +5 to +40 °C
f = 10 Hz to 50 MHz	±0.015 dB	±0.035 dB
at 100 MHz	±0.025 dB	±0.045 dB
at 200 MHz	±0.040 dB	±0.060 dB
at 300 MHz	±0.050 dB	±0.070 dB

For version BN 564/03 : *) at −10 dB extra error is ±0.015 dB
**) −10 dB ±0.2 dB

Frequency response of meter, referred to 10 Hz
(Table values in dB)

Fed by	0	50	100	200	300 MHz
$Z_{in} = Z_o$	±0.015	±0.035	±0.060	±0.100	
$Z_{in} = 0$	±0.020	±0.035	±0.120	±0.200	

Effect of instrument temperature on the meter reading . . . . . ≦0.0015 dB/K
Effect of Test Probe temperature on the meter reading . . . . . ≦0.003 dB/K

Outputs

Calibrated level (d.c. voltage)
Selectable calibrated levels with $Z_{out} = Z_o$ and $Z_{out} = 0$ . . . . . 0 dBm in Z_o and 0 dB

X-Y plotter voltage output
(Z_{out} = 5 kΩ; short-circuit proof)
Open circuit voltage,
unexpanded scale . . . . . approx. 0.25 V/0.1 dB
expanded scale . . . . . approx. 1.25 V/0.1 dB

Control voltage output, Z_{out} approx. 500 Ω, for stabilising a generator (short-circuit proof), setting range (open circuit voltage) . . . . . approx. 30 mV/0.01 dB to 300 mV/0.01 dB
Control range . . . . . ≧±2 V

General specifications

Power supply
Rated ranges of use of a.c. line voltage, selectable . . . . 110/117/128/220/227/238 V, −15 %/+10 %
Rated range of use of a.c. line frequency . . . . . 45 to 66 Hz
Power consumption . . . . . approx. 16 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Permissible ambient temperature
Rated range of use . . . . . +5 to +40 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions and weight	EPM-1	TK-10
Overall width	256 mm	36 mm
Overall height	199 mm	36 mm
Overall depth	370 mm	93 mm
Weight	approx. 7 kg	approx. 0.2 kg

German Post Office Certificate of Approval No. for the EPM-1, BN 564/03 . . . . . 272 181 810

Measurement accessories

TKS-10 Balanced Test Probe, BN 668/00
for use with EPM-1, BN 564/00 and BN 564/03

Frequency range with Test Probe Adaptor
TKSA-124 . . . . . d.c.; 10 Hz to 12 MHz
TKSA-150 . . . . . d.c.; 10 Hz to 2 MHz
TKSA-600 . . . . . d.c.; 10 Hz to 620 kHz

Input impedance
balanced, depending on which TKSA is used . . . . . 124, 150, 600 Ω
Reflection coefficient for the input 0.01
Connector plugs for the TKSAs . . . . . see "Ordering Info."

Error limits of reading
at 0 dBm, in the range 0 dBm ±0.2 dB, after calibration, for an ambient temperature of (23 ± 3) °C and at f = 1 kHz . . . . . ±0.015 dB

Over the whole level range, expanded or unexpanded, after calibration, in the rated range of use of ambient temperature for $Z_{in} = Z_o$ and at f = 1 kHz . . . . . ±0.035 dB

Frequency response of display
Error limits, referred to 1 kHz, $Z_{in} = Z_o$ . . . . +0.02/−0.03 dB

General specifications

	Dimensions (w×h×d) in mm	Weight
TKS-10 Test Probe	36×36×93	approx. 0.2 kg
TKSA-... Test Probe Adaptor	36×36×80	approx. 0.1 kg
TKSE-... Calibration Adaptor	36×32×63	approx. 0.1 kg

1) Ratio of peak value to r.m.s. value
2) Also measurement of level at −10 dB with version BN 564/03

Attenuator networks (for TK-10 and TKS-10)

Type	Z value	Insertion loss for d.c. voltages	Frequency range
BN 594/01 BN 594/02	75 Ω coaxial	9.03 dB ±0.15 dB 19.03 dB ±0.20 dB	0 to 300 MHz
BN 594/03 BN 594/04	50 Ω coaxial	10.79 dB ±0.15 dB 20.79 dB ±0.20 dB	0 to 300 MHz
BN 594/05	150 Ω balanced	6.02 dB ±0.01 dB	0 to 5 MHz

Variation in insertion loss with frequency referred to d.c. (Values in dB)

Coaxial	±0.01				±0.03
Balanced	±0.01	+0.01/−0.02	+0.01/−0.05	—	—
0	0.62	2	5	100	300 MHz

Reflection coefficient

Coaxial	0.01				0.03
Balanced	0.015	0.025	0.05	—	—
0	0.62	2	5	100	300 MHz

Connectors . . . . . see "Ordering Information"

"T" pads
(See Ordering Information for different versions and connectors)

Coaxial . . . . . d.c. to 300 MHz
Balanced, $Z_o = 150\ \Omega$ . . . . . d.c. to 2 MHz
$Z_o = 600\ \Omega$ . . . . . d.c. to 620 kHz

Voltage difference between the two outputs when terminated with Z_o

Version	coaxial	balanced
d.c. voltages	≦0.03 dB	≦0.025 dB
whole frequency range	≦0.04 dB	≦0.03 dB

Matching pads, couplings (see "Ordering Information")

Ordering Information

EPM-1 Milliwatt Power Meter with TK-10 Test Probe

The following versions are available:

Version			Order No.	
Impedance	Level	Connector	EPM-1	TK-10
75 Ω, coaxial	0 dBm	1.6/10 (M)	BN 564/00	BN 572/00
75 Ω, coaxial	0 dBm/ −10 dB	1.6/10 (M)	BN 564/03	BN 572/00
50 Ω, coaxial	0 dBm	Conn. N (M)	BN 564/01	BN 572/01

Accessories (at extra cost):
Protective Transport Cover DE-13 BN 476/00.10

Accessories for balanced measurements
(possible with EPM-1, BN 564/00 and BN 564/03):

Balanced Test Probe TKS-10 BN 668/00
with Test Probe Adaptors TKSA-/
Calibration Adaptors TKSE-
for 600 Ω: TKSA-600, 3 pole CF plug BN 668/00.12
TKSE-600, 3 pole CF socket BN 668/00.22
for 150 Ω: TKSA-150, 3 pole CF plug BN 668/00.11
TKSE-150, 3 pole CF socket BN 668/00.21
for 124 Ω: TKSA-124, 3 pole CF plug BN 668/00.14
TKSE-124, 3 pole CF socket BN 668/00.24
TKSA-124, WE No. 379 A (M) BN 668/00.10
TKSE-124, WE No. 470 C (F) BN 668/00.20

Accessories for TKS-10 (balanced measurements):

Description	Z value	Connector	Order No.
Attenuator network 6.02 dB "T" pads	150 Ω 600 Ω 150 Ω	3pole CF (F-M) 3pole CF (F-F-F) 3pole CF (F-F-F)	BN 594/05 BN 595/05 BN 595/04

Meaning of abbreviations: (M) pin connector
(F) socket connector

Accessories for the TK-10 (coaxial measurements):

Description	Z value	Connector type	Order No.
Attenuator network 9.03 dB	75 Ω	1.6/10 (F-M)	BN 594/01
19.03 dB	75 Ω	1.6/10 (F-M)	BN 594/02
10.79 dB	50 Ω	N-Conn. (F-M)	BN 594/03
20.79 dB	50 Ω	N-Conn. (F-M)	BN 594/04
"T" pad	75 Ω	1.6/10 (F-F-F)	BN 595/01
	75 Ω	1.6/10 (F-M-F)	BN 595/03
	50 Ω	N-Conn. (F-F-F)	BN 595/02

Matching pads [1], Z = 75 Ω, from 1.6/10 (F)		
On	Reflection coefficient at 100/300 MHz	Order No.
BNC (M)	0.02/0.04	S 391
BNC (F)	0.02/0.04	S 392
2.5/6 (M)	0.03/0.05	S 393
2.5/6 (F)	0.03/0.05	S 394
1.6/5.6 (M)	0.015/0.03	S 395
1.6/5.6 (F)	0.015/0.03	S 396

1) Further matching pads can be purchased

Matching pads, Z = 50 Ω, from N-conn. (F)		
On	Reflection coefficient at 100/300 MHz	Order No.
BNC (M)	0.01/0.025	S 407
BNC (F)	0.01/0.025	S 408
4.1/9.5 (M)	0.01/0.01	S 409
4.1/9.5 (F)	0.01/0.01	S 410
C-Conn. (M)	0.01/0.015	S 411
C-Conn. (F)	0.01/0.015	S 412

Coupling, Z = 75 Ω		
Connector type	Reflection coefficient at 100/300 MHz	Order No.
1.6/10 (M-M)	0.01/0.015	S 390

Coupling, Z = 50 Ω		
Connector type	Reflection factor at 100/300 MHz	Order No.
N-Conn. (M-M)	0.01/0.015	S 406

A Specification Sheet with more details is available on request

new

OLP-1
Optical Power Level Meter

for wavelengths between 800 and 1600 nm



- **Measures optical power level at all commonly used wavelengths without the need to change detectors**
- **Single range covers all level measurements**
- **High accuracy**
- **Quick-change adaptors for all connector systems in current use**
- **Easy to read LCD digital display**
- **Analog output for continuous monitoring of optical power level**
- **Built-in dry or rechargeable battery**
- **Low battery warning indicator**
- **Robust shockproof casing**
- **Compact size**
- **Leather case for instrument plus adaptors together with a.c. adaptor/charger unit**

Applications

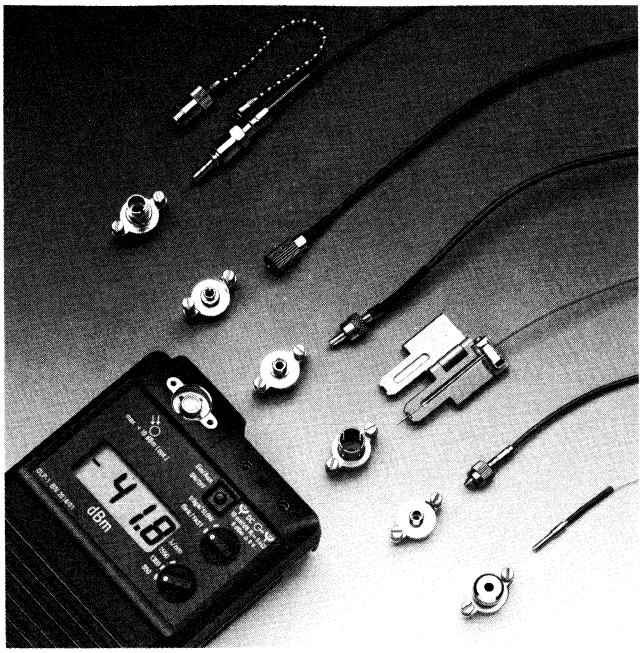
The OLP-1 Optical Power Level Meter can be used for measuring optical power levels on connectors and unterminated (bare) optical fibres. All types of optical fibres that are in common use for telecommunications with a core diameter up to 200 µm and numerical aperture up to 0.30 can be accommodated. Due to the high dynamic range of the instrument, power levels at the outputs of emitters and at the inputs of regenerators and receivers can be measured with high accuracy.
The quick-change adaptor enables measurements on systems from various manufacturers to be made simply and rapidly.
Simple operation, coupled with a clear, easy to read display of the result means that this instrument is especially suitable for
– use by systems manufacturers for quality control and development
– alignment and fault location on optical communications cables
– maintenance of optical communications systems.

Characteristics

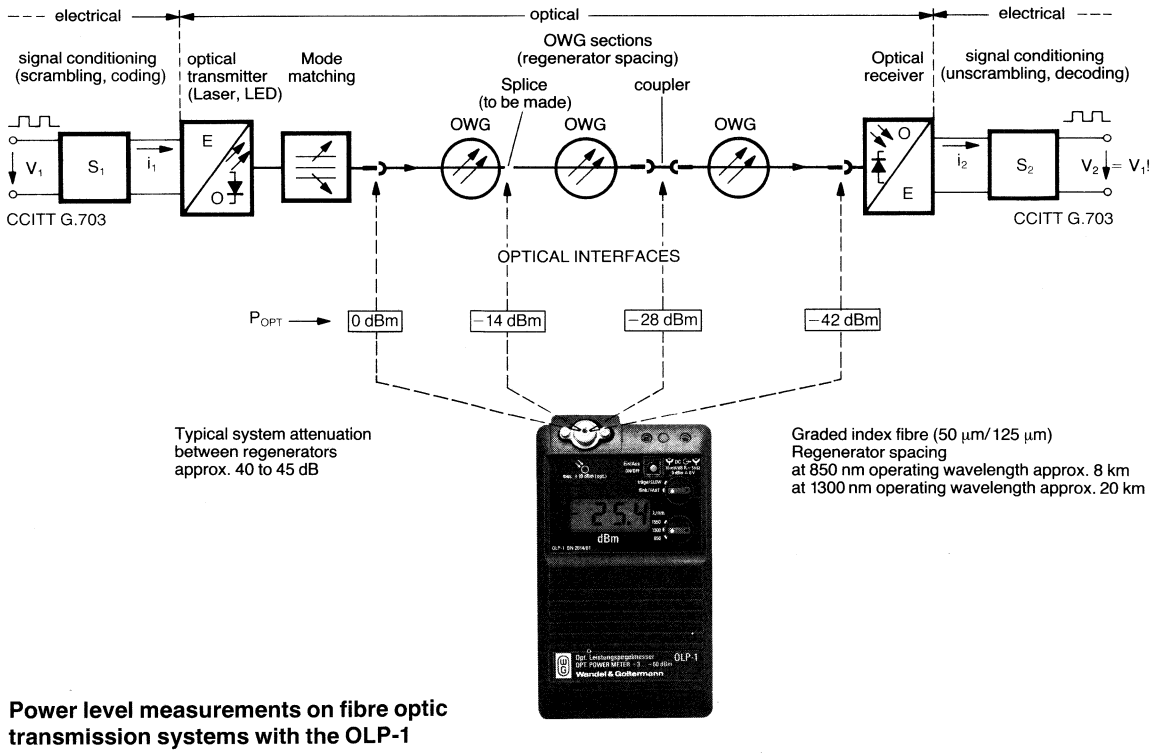
The optical power at the test port is detected by a Ge photodiode. The resultant current is processed in a logarithmic amplifier followed by an analog to digital converter, the output of which is fed to the display.
The OLP-1 can be used to measure constant (unmodulated) optical power levels or the average power level of a modulated signal (e.g. system transmitter output). The result is displayed in dBm, referred to 1 mW.
For maximum accuracy in power level measurements, all the available power must be received. Since the various types of optical fibre have different core diameters and numerical apertures, the spot of light formed on the active surface of the

Standard wavelengths	850, 1300, 1550 nm
Level range	−60 (−50) to +3 dBm
Resolution	0.1 dB
Adaptors available for	Amphenol, Diamond, F & G, Hirschmann, NEC, Stratos, etc.
Power supply	dry or rechargeable batteries
Weight	approx. 600 g

photodiode will vary in size. It is therefore essential that a defined distance is maintained between the end of the fibre and the surface of the photodiode. Additionally, the responsivity characteristics of the diode must be taken into account.
The OLP-1 fulfils the above-mentioned conditions by means of a system of adaptors, which covers all commonly used optical fibre connectors and bare fibres.
The photodiode, which is sensitive to light within the wavelength range 800 to 1600 nm, is an integral part of the instrument. This means that the sensor does not need to be changed if measurements are being made on systems which operate at various wavelengths. The adaptor is removed by undoing two knurled screws, allowing access to the photodiode surface for cleaning purposes if necessary. Normally, a dust cap is used to protect the test port.
A three-position, positive action rotary switch is used to select the standard wavelength, enabling measurements to be made directly and accurately, without the need to apply correction factors.
Calibration of the OLP-1 at 850 nm, 1300 nm and 1550 nm is based on comparison with a control standard which is calibrated and regularly checked by the PTB (Federal German Bureau of Standards, Braunschweig).
The result is shown with correct sign on a large 3-digit LCD display as soon as the instrument is switched on. Adjustments, such as zeroing the display or range selection, are not necessary. A very wide measurement range coupled with automatic overrange indication makes all measurements quick and easy to perform.
The display settling characteristic can be selected using a second rotary switch, ensuring that the measured level can be displayed as quickly and as accurately as possible.
The instrument is fully portable, operating from either dry- or rechargeable Nicad batteries. If long-term operation is required, the instrument can be run from an a.c. mains adaptor/charger unit. Battery life is extended by an automatic switch-off circuit.
A compact leather case is available, in which the instrument together with the a.c. adaptor/charger unit and 5 adaptors can be housed. This is ideal for field work, offering ease of operation and protection for the instrument.



Adaptors for various OWG connectors



Power level measurements on fibre optic transmission systems with the OLP-1

Specifications for Optical Power Level Meter — OLP-1

Unless otherwise stated, the specifications are valid within the rated ranges of use for battery or mains voltage, mains frequency and ambient temperature.

Wavelengths (standard)
switchable . . . . . 850, 1300, 1550 nm
The instrument is calibrated against PTB standards at the standard wavelengths.

Level measurement
The power level of unmodulated light or the average power of modulated light (f >1 MHz) coupled out of the fibre is measured and displayed.

Level range
for 850 nm . . . . . −50 to +3 dBm
for 1300 and 1550 nm . . . . . −60 to +3 dBm [1]

Max. tolerable input level . . . . . +10 dBm

Level display (dBm) . . . . . 3 digit LCD
Resolution . . . . . 0.1 dB
Overrange indication
(<−60 dBm or >+3 dBm) . . . . . flashing sign
Measurement rate . . . . . 3 per second
Display settling time (switchable)
fast . . . . . 0.5 s
slow . . . . . 5 s

Level display error limits

Wavelength		1300 nm/1550 nm			850 nm		
Level (range)		−30 dBm	−50 to +3 dBm	−60 to −50 dBm	−30 dBm	−40 to +3 dBm	−50 to −40 dBm
Temperature range	+23 ±1°C	±0.25 dB	±0.5 dB	±1.5 dB	±0.25 dB	±0.5 dB	±0.7 dB
	+10 to +30 °C		±1 dB	±2.5 dB		±1 dB	
	0 to +50 °C		±2.5 dB (<0 dBm)			±1.5 dB (<0 dBm)	

Test port
Adaptor system [2] for all common connector types:
Amphenol, Diamond, Ericsson, F&G, Hirschmann, NEC, Seiko, SEL, Stratos
Adaptor for unterminated (bare) fibres with
Fibre diameter . . . . . 120 to 145 µm
Overall diameter (inc. secondary coating) . . 0.5 to 1.05 mm

Fibre Types
connection via plug and corresponding adaptor
Monomode . . . . . to CCITT G.652
Multimode
Graded index . . . . . to CCITT G.651
Step index, core diameter . . . . . ≦200 µm
numerical aperture . . . . . ≦0.28 [3]

Sensor (integrated) . . . . . Germanium photodiode
Active surface diameter . . . . . 2 mm

D.C. output
proportional to level display . . . . . −600 to +30 mV
Output impedance . . . . . 5 kΩ
Connectors . . . . . 4 mm sockets

General specifications

Power supply
Built-in interchangeable dry battery . . . . . 9 V IEC 6FL22
or rechargeable Nicad battery . . . . . e.g. Varta Tr 7/8
Rated range of use . . . . . 7.5 to 10 V

Operating life of dry batteries assuming 4 h intermittent use per day . . . . . approx. 70 h
Automatic battery cutoff . . . . . after approx. 5 min
A.C. mains operation [4] possible with adaptor/charger unit.

Ambient temperature
Rated range of use . . . . . 0 to +50°C
Storage and transportation . . . . . −40 to +70°C

Dimensions (w×h×d) in mm . . . . . 97×65×164

Weight, including battery . . . . . approx. 600 g

Ordering Information

OLP-1 Optical Power Level Meter **BN 2014/01**
One or more of the following adaptors will be needed:

Adaptors (charged extra) [2]
No. 1 NEC D4 — BN 2014/00.01
No. 2 To SMA standard:
Amphenol 906, Diamond GFS-24 A
Hirschmann OSMA, SEL OS-5 — BN 2014/00.02
No. 3 Stratos series 430 — BN 2014/00.03
No. 4 Diamond GFS-1/2/3 and MMS-1/3 [5] — BN 2014/00.04
No. 7 To DIN 47255 (2.5 mm dia.)
F&G series 2000, Siemens — BN 2014/00.07
No. 8 For unterminated (bare) fibres — BN 2014/00.08
No. 9 Seiko D3 (FC type NTT) — BN 2014/00.09
No. 10 Diamond GFS-11/13 and
MMS-11/13 [5] — BN 2014/00.10
No. 11 Ericsson TSR 301 — BN 2014/00.11
No. 12 Stratos series 530 — BN 2014/00.12
Adaptors for other connector types will be available shortly.

Accessories (charged extra)
A.C. mains adaptor/charger with
Standard European power plug (193 to 242 V, 47.5 to 63 Hz) — BN 964/00.02
US type power plug (105 to 132 V, 47.5 to 63 Hz) — BN 964/00.03
UK type power plug (211 to 264 V, 47.5 to 63 Hz) — BN 964/00.04
mains cable, but without power plug (211 to 264 V, 47.5 to 63 Hz) — BN 964/00.05
Nicad battery — BN 820/00.50
Leather case for OLP-1 for 5 adapters and mains adaptor/charger — BN 926/13
Carrying strap — BN 820/00.52

1) equivalent to 1 nW to 2 mW
2) for plugs with optical fibres to CCITT G.651 and G.652
3) multimode fibres with core dia >200 µm and NA >0.28 can be accommodated on request
4) only when rechargeable battery is fitted
5) screw and BNC connection

A Colour Brochure is available on request

RAS-2
Remote Access Switch System

for selecting coaxial test points

IEEE 488
IEC 625



- **Frequency range 0 to 100 MHz**
- **Each RAS-2 unit switches up to 24 test points**
- **Gold-plated contacts for reliable switching**
- **System can be expanded economically to handle 864 test points**
- **All channels have the same insertion loss – even when the system has been expanded**
- **Modular construction for flexibility**
- **Switching configuration shown by signal lamps**

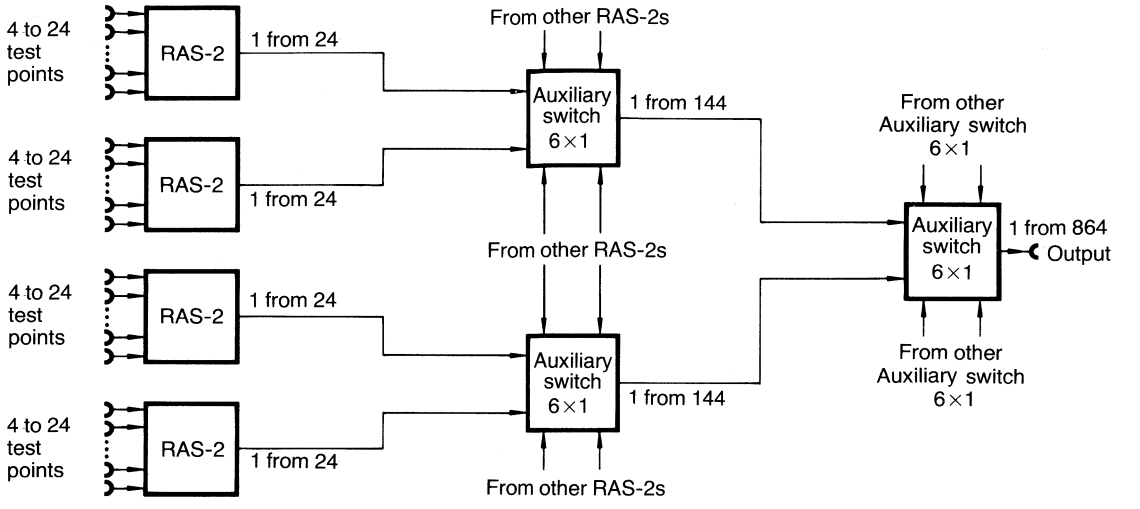
Applications

The RAS-2 Remote Access Switch System is ideal for providing 1 out of 24 selection on coaxial systems. Several RAS-2s can be connected together, and a fully expanded system can handle 864 test points.
Because of its fast switching time, high isolation, and because all channels have the same electrical characteristics, the RAS-2 is well-suited for use in computer-controlled monitoring systems for FDM communication equipment, handling up to 10 800 voice channels. The RAS-2 can also be used effectively during the manufacture and testing of equipment of this kind.
The main application of the RAS-2 is connecting test points to level measuring equipment, in particular the SPM-19 and SPM-16 Level Meters, or the PS-19 and PS-16 Level Generators. Because of its modular construction the RAS-2 is flexible and economical to use.

Characteristics

The switching hierarchy of the RAS-2 is realised using a system of modules. Each mainframe can be fitted with six plug-ins. Each module has a 1 out of 4 switching facility. Two different versions of the RAS-2 are available to set up a remote access switch system, – a version with a control unit and a version without a control unit. The mainframe with the control unit can control up to 35 main frames without a control unit, so giving a system that can handle 864 test points. The RAS-2 with the control unit also contains the power supply and the connector for the built-in interface bus. To realise a measuring system containing more than 1 RAS-2, one or more auxiliary switch assembly (1 from 6) are required. Each switch assembly can control a maximum of 6 RAS-2s (144 test points). The auxiliary switch assembly is housed with the switch modules in a mainframe. To expand an RAS-1 measuring system (0 to 25 MHz) a special version of the RAS-2 mainframe is available.
Both versions have an easy-to-read display panel with 24 signal lamps to show which channel has been switched through.
The mainframe with the control unit has two switches and an indicator for selecting one of the connected RAS-2s, and the test point that is to be accessed.

Switching capability, coaxial	1 from 24
Frequency range	0 to 100 MHz
Insertion loss (25 MHz)	≦0.3 dB
Insertion loss match between any two channels (25 MHz)	≦0.04 dB
Switching time	≦4 ms



The largest possible RAS-2 Remote Access Switch System

Specifications of the Remote Access Switch System — RAS-2

Unless otherwise stated, the data is valid for the rated ranges of use of the a.c. line voltage, the a.c. line frequency and the ambient temperature.

Remote Access Switch, BN 9510/03, BN 9510/04

Frequency range . . . . . 0 to 100 MHz

Connectors . . Versacon®9 Universal Connector System, adaptable to all commercially available connector systems

Characteristic impedance . . . . . 75 Ω, coaxial

Max. permissible level . . . . . +23 dBm

Switching time . . . . . ≦4 ms

Insertion loss with no termination mismatch [1]	0 to 25 MHz	0 to 100 MHz
Basic version 1 from 24	≦0.3 dB	≦0.75 dB
Insertion loss match between any two channels [2]	≦0.04 dB	≦0.1 dB
Return loss of a channel that has been selected and terminated with Z_0	≧30 dB	≧20 dB
Return loss of channel that has not been selected and is terminated	≧34 dB	≧26 dB
Isolation input to input, one input operated	≧105 dB	≧90 dB
Input to input, both inputs are not switched through, terminated with Z_0	≧105 dB	≧90 dB

Remote control (only with mainframe and control unit)
via < IEC 625 > interface bus with IEEE 488 connector
Interface functions . . . . . SH 1, AH 1, TØ, L 1, ST Ø, RL 1, PP Ø, DC 1, DT Ø, C Ø, E 2

General Specifications

Power Supply
Rated ranges of use of a.c. line voltage, selectable . . . . . 100, 120, 220, 240 V, ±10 %
Rated range of use of a.c. line frequency . . . . . 45 to 65 Hz
Power consumption
System with 36 RAS-2s . . . . . 20 VA
Mainframes that do not have a control unit are fed from the mainframe with control unit.

Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature
Rated range of use . . . . . +5 to +40 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	155	Height (3 units)	131
Depth with handles	425	Depth	370

19" conversion kit . . . . . BN 700/00.03

Weight
Mainframe with control unit, all plug-ins fitted . . approx. 12 kg
Mainframe without control unit, all plug-ins fitted . approx. 10 kg

Ordering Information

Remote Access Switch RAS-2	**BN 9510/..**
Mainframe with control unit *	BN 9510/03
Mainframe without control unit *[3]	BN 9510/04
Mainframe without control unit for expanding RAS-1 measuring systems	BN 9510/05
Switch module *, coaxial (4 x 1) (max. of six per mainframe)	BN 9510/00.03
Options (at extra cost)	
Auxiliary switch *[4], coaxial (6 x 1) (for connecting several RAS-2s together)	BN 9510/00.04
Accessories (at extra cost)	
IEEE 488/IEC 625 Adaptor (m-m) for Interface Bus < IEC 625 >	S 832
Protective Transportation Covers (1 set) SD-3	BN 700/00.23

1) Does not include loss of interconnecting cables
2) With matched cables
3) When the number of test points exceeds 24 the mainframe with a control unit controls, and supplies power to up to 35 mainframes without control units.
4) Incorporated in the mainframe
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

MU-7
Test Point Selector

for the frequency range d.c. to 160 MHz

IEEE 488
IEC 625



- **6 coaxial measuring channels**
- **Manual adjustments as well as remote control**
- **Minor insertion loss, high isolation**
- **Reference channel for comparison measurements**
- **Controls 6 external (max.) coaxial switching elements**
- **Switched condition indicated by signal lamps**

Application

The Test Point Selector MU-7 is used to simplify programmed measurements, and it is especially efficient in connection with the Measuring Setups PS-19/SPM-19 and PS-16/SPM-16. The MU-7 is applicable during the development and automatic testing of FDM systems. Automatic surveillance systems are a particular sector of application where the MU-7 provides efficient testing. The Test Point Selector changes over the connection of coaxial HF feeders or test ports at a common connector for Generator or Receiver.

Characteristics

The MU-7 Test Point Switch Selector contains a 6 channel switch with which at any time any one of the 6 coaxial chassis connectors on the test object side can be connected to the connector on the measuring equipment side. When two MU-7 equipments are being operated, one MU-7 can be connected to the Generator, and the second can be connected to the Level Meter. The switches are exceptional because of their low insertion loss when closed and high isolation when open, so that the high accuracy of the Level Meter is maintained. Channels not switched through are terminated with 75 Ω. All switching functions are operable either manually or by remote control. Signal lamps indicate the switched status of each channel.

Frequency range	d.c. to 160 MHz
Characteristic impedance	75 Ω
Channels	6
Insertion loss to 15 (100) MHz	0.12 (0.2) dB
Isolation	≧110 dB

2487 MU-7

Further Characteristics and Applications

- A reference channel, which has characteristics identical to those of the utilized channel, permits difference measurements that eliminate the measuring error caused by the insertion loss and frequency response of the switch.
- External Individual Switch Elements MUS-7 are available for connection to the MU-7 via control lines. This implements choices of locations for use at ports best suited for the frequency range to 160 MHz. These Switch Elements act as coaxial changeover switches. One MU-7 can control up to six individual MUS-7s.

Specifications of the Test Point Selector MU-7

Frequency

Frequency range . . . . . d.c. to 160 MHz
Characteristic impedance . . . . . 75 Ω, coaxial
Connections . . . . . Universal connectors, Versacon® 9
Convertible to usual commercial adaptor systems
Max. allowable level . . . . . +8 dB
Max. allowable input current I_{rms} . . . . . 40 mA

	10 kHz to 15 MHz	over 15 MHz to 100 MHz	over 100 MHz to 160 MHz
Return loss of a switched-through channel with ideal termination or a "switched-out" channel	≧30 dB	≧23 dB	≧20 dB
Insertion loss from the 6 channel switch when a channel is "switched-through"	≦0.12 dB	≦0.2 dB	≈0.3 dB
Isolation of a channel when "switched-out" by the 6 channel switch	≧110 dB	≧110 dB	≧110 dB
Insertion loss of Individual Switch Element MUS-7	≦0.06 dB	≦0.12 dB	≈0.2 dB
Isolation of Individual Switch Element MUS-7	≧90 dB	≧90 dB	≧90 dB

Option

Remote Control, BN 590/00.01
Interface Bus < IEC 625 >/IEEE 488 for remote control of MU-7 functions.

General Specifications

Power supply
Rated range of use of a.c. line voltage, switchable . . . . . 110/117/128/220/227/238 V; −15 % to +10 %
Rated range of a.c. line frequency . . . . . 45 to 66 Hz
Power consumption . . . . . approx. 35 VA
Safety class according to IEC 348 and VDE 0411 . . . Class I

Tolerable ambient temperature
Rated range of use . . . . . +5 to +40 °C
Range for storage and transportation . . . . . −40 to +70 °C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	478	Width	443
Height overall	155	Height (3 units)	132
Depth with handles	407	Depth	353

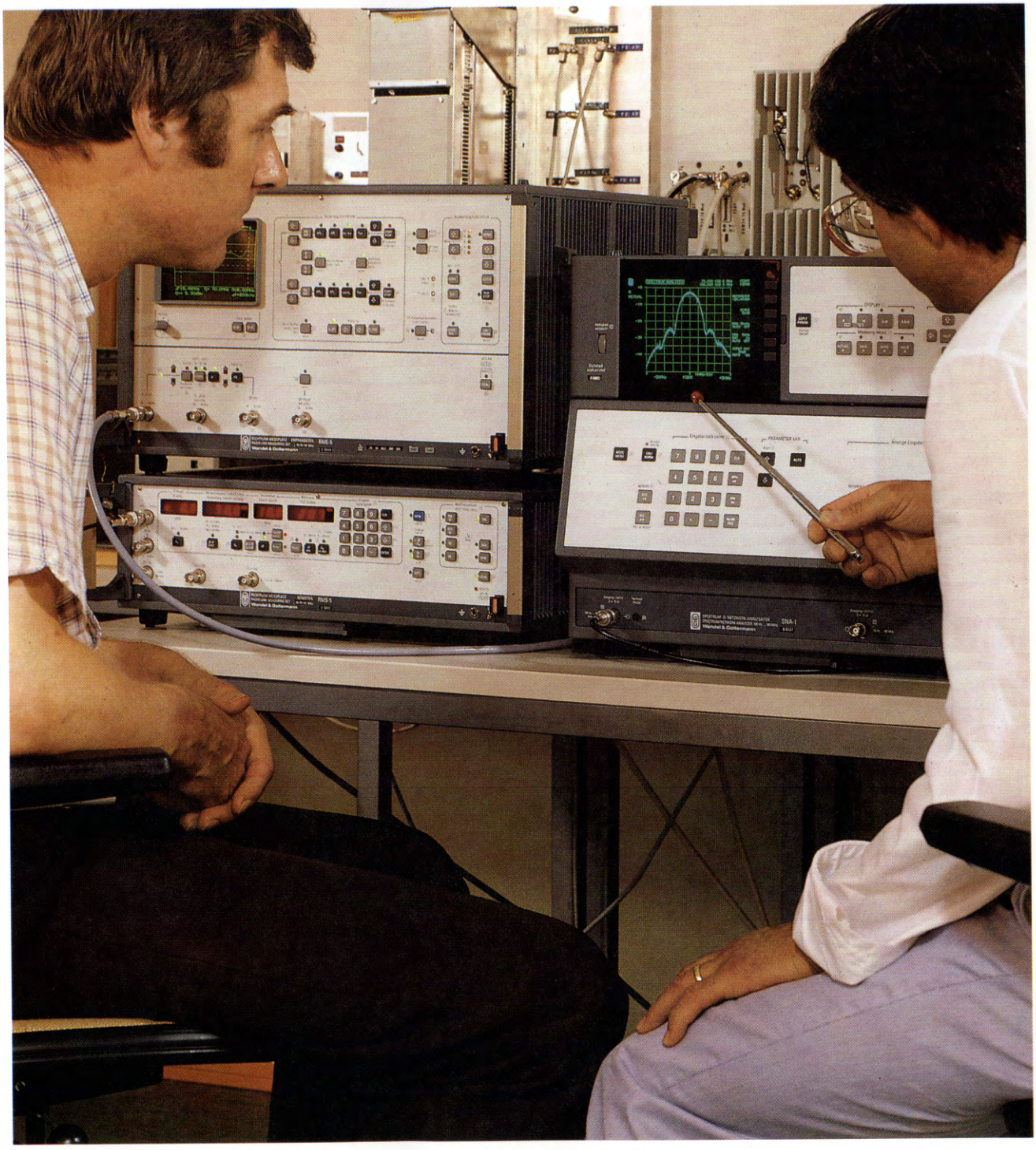
19" conversion kit . . . . . BN 556/00.03
Weight MU-7 . . . . . approx. 9 kg
MUS-7 . . . . . approx. 0.8 kg

Ordering Information

Test Point Selector MU-7 *	BN 590/00
Individual Switch Element MUS-7	BN 620/00
Option (at extra cost)	
Interface-Bus < IEC 625 > card with adaptor IEC 625/IEEE 488 (S 834)	BN 590/00.01
Accessory (at extra cost)	
Transport protection cover DE-2	BN 476/00.02

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adaptor. For other adaptor types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

Spectrum and Network Analysis



SNA-1
Spectrum and Network Analyzer

for the frequency range 100 Hz to 180 MHz

IEEE 488
IEC 625



- **Synthesiser for precise, stable frequency tuning; resolution 0.1 Hz**
- **Smallest bandwidth that can be resolved is 3 Hz**
- **Selectable display ranges 1 dB to 100 dB**
- **Version BN 956/02 measures group delay and phase**
- **Automatic calibration for high accuracy and normalisation for magnitude and phase**
- **Digital image storage for measurement and reference curves**
- **Various cursors and tolerance masks can be displayed**
- **Softkeys for easy operation**
- **Connector for graphics plotter and video printer**
- **All SNA-1 functions can be remote controlled**

Applications

The SNA-1 Spectrum and Network Analyzer is well-suited for a wide range of selective measurements in the frequency range 100 Hz to 180 MHz.
Because of its precise synthesiser tuning the SNA-1 is ideal for carrying out spectrum analyses on wanted and noise signals that are encountered in telecommunications and telecontrol work, for example, analog and digital telecommunications systems with cable, radio-relay or satellite sections up to the 140 MHz IF level. Because the frequency tuning has a high resolution of 0.1 Hz, and a high bandwidth resolution of 3 Hz is available, dense line spectra can be analysed, e.g. in the audio frequency range, or the sideband noise of oscillators near the carrier.

As the integral tracking generator is always tuned to the centre of the receiver bandwidth, a sinusoidal signal of this frequency is available.
The gains and losses introduced by transmission systems and system components such as filters, amplifiers, audio subassemblies and video subassemblies are easily measured with the integral tracking generator. Even filters with very high stopband attenuations can be investigated using selective measuring techniques.

Characteristics

Because a spectrum analyser and a network analyser are combined in one instrument, it is possible to measure all types of network distortions. The spectrum analyser measures nonlinear distortions, i.e. distortion and intermodulation products, as well as noise and other spurious signals.

Measured parameters	
BN 956/01	amplitude (spectrum) and attenuation
BN 956/02	parameters above plus group delay and phase
Frequency range	100 Hz to 180 MHz
Smallest resolvable bandwidth	3 Hz
Level measurement range	−130 to +20 dBm or −140 to +10 dB
Display range	1, 2.5, 5, 10, 25, 50 and 100 dB
Phase measurement range	−180 to +180° ± n × 360°
Group delay measurement range	500 ps to 1 s
Resolution	0.1 Hz, 0.01 dB, 0.1°, 0.1 ns
Input impedance	50 Ω or 75 Ω

The network analyser handles frequency-dependent or linear distortions. Version BN 956/01 allows you to measure attenuation/frequency distortion, the most important type of distortion encountered in telephone networks. With version BN 956/02 it is possible to measure group delay and phase as well.

Accuracy of measurement, ease of operation

The most important basic characteristics of the SNA-1 are, apart from its versatility, high accuracy of measurement and foolproof ease of operation.

The precise synthesiser tuning and the automatic amplitude calibration are the main factors contributing to the accuracy of the SNA-1. The SNA-1's large, flat screen with an electronically scaled internal graticule makes it possible to precisely evaluate measurement curves. Parallax errors are, therefore, also eliminated. The SNA-1 has cursors for frequency and other parameters such as level, attenuation, phase and delay. An alphanumeric display superimposed on the screen shows the values indicated by the cursors.

To ensure maximum ease of operation, the number of control elements has been kept to a minimum using softkeys (see Fig.). The SNA-1 software assigns each softkey a function depending on the measurement to be performed. The function of the softkey is shown on the screen next to the softkey. Six softkeys are sufficient to select the measurement mode (including self-test), the measurement parameters and the display format.

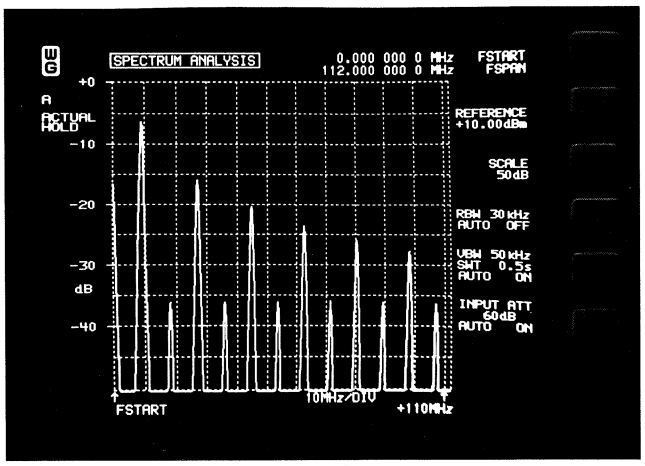
There are two ways of selecting the most important Analyzer settings, i.e. the frequency range and the measured parameter range:

Quasi-analog settings – centre frequency, frequency span and reference are each set by means of a separate knob. They can also be entered via the numerical keypad.

This means that fast overview measurements can be carried out and spurious signals located. The exact settings for performing measurements inside known ranges can also be selected.

The other parameters (e.g. scale range, resolution bandwidth, sweep time etc.) are set by means of step-keys. The bandwidth and the sweep time can be linked to frequency span when spectrum analysis is being performed. In this case, only the three knobs are required to operate the instrument.

Frequently used setups can be stored and called up when required. An integral battery ensures that the memory contents are not lost when the SNA-1 is switched off.



Screen and softkeys

Spectrum analysis

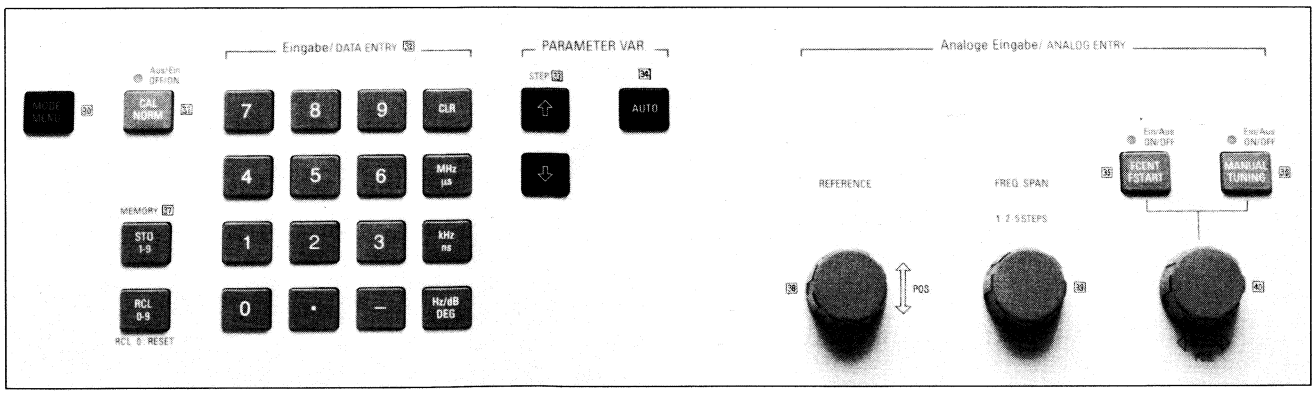
In this mode, the amplitude spectrum of the input signal is measured and displayed on the screen. The results may be displayed in power level (dBm) (−130 to +20 dBm) or voltage level (dB) (−140 to +10 dB or −22 to 128 dBμV). The highest resolution is 0.01 dB.

Network analysis

An integral tracking generator allows the user to measure frequency-dependent network parameters. The variation of attenuation or gain with frequency of a two-port network can be measured with version BN 956/01. The tracking generator covers the range from 100 Hz to 180 MHz and has a fixed output level of 0 dBm.

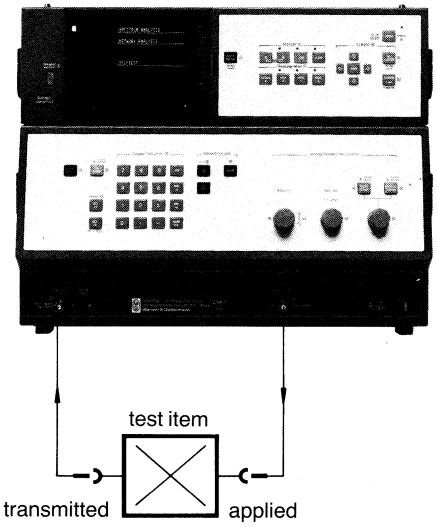
A transmission level that can be varied over the range −65 to 0 dBm is available with Option BN 956/00.04.

The variable transmission level facility is a standard feature of version BN 956/02. Phase and delay time can also be measured between 100 Hz and 180 MHz. The phase angle display range is selectable between ±10° and ±400°; the highest resolution is 0.1°. The group delay measurement range is 500 ps to 1 s and the highest resolution is 100 ps. Delay times introduced by components such as test cables can be compensated for.

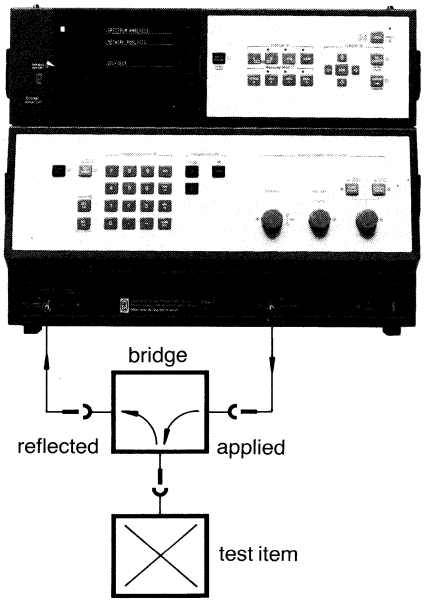


Quasi-analog adjustment of display parameters using three knobs or digital entry of these parameters via a numerical keypad

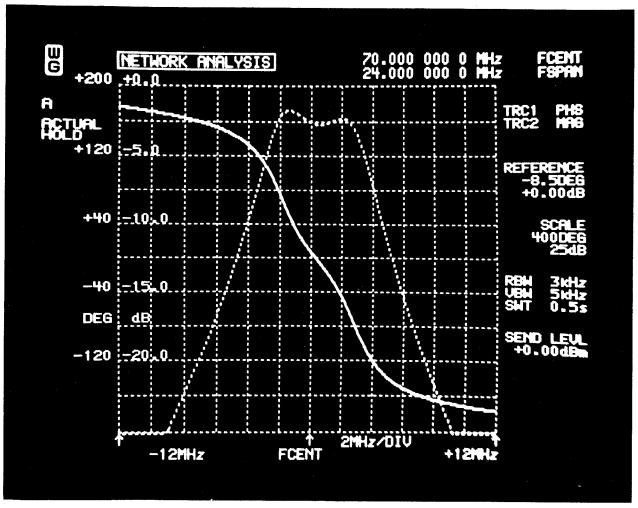
The output signal of a network will suffer distortion if the network has a nonlinear phase response. Version BN 956/02 shows the deviation from linear phase.
The most fundamental network analysis measurements are transmission and reflection measurements. A transmission measurement determines the frequency dependent characteristics of two-port networks. The result is the ratio of the output parameter to the input parameter. When reflection measurements are being performed, the input or output of the object under test is connected to a return loss bridge. The result is the ratio of the reflected parameter to the input parameter.



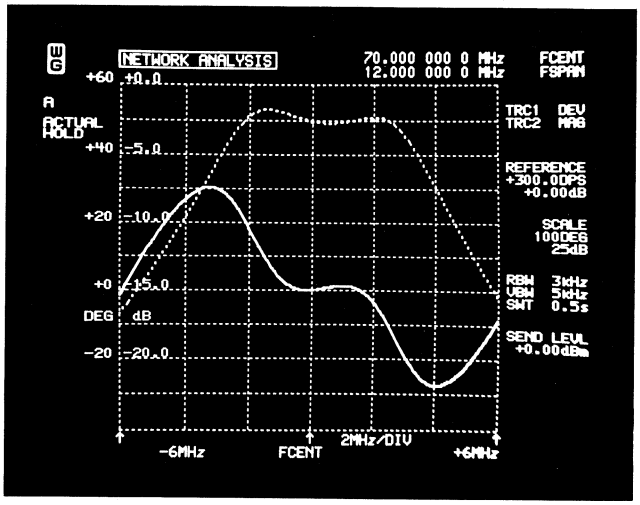
Transmission measurements with the SNA-1



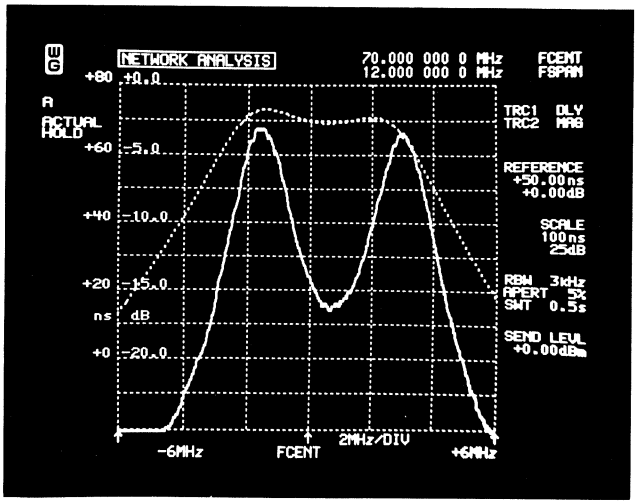
Reflection measurements with the SNA-1 and a return loss bridge



Frequency response (dotted line) and phase response of a 70 MHz band-pass filter.



Deviation from linear phase response



Group delay in the pass-band of a filter

High display accuracy

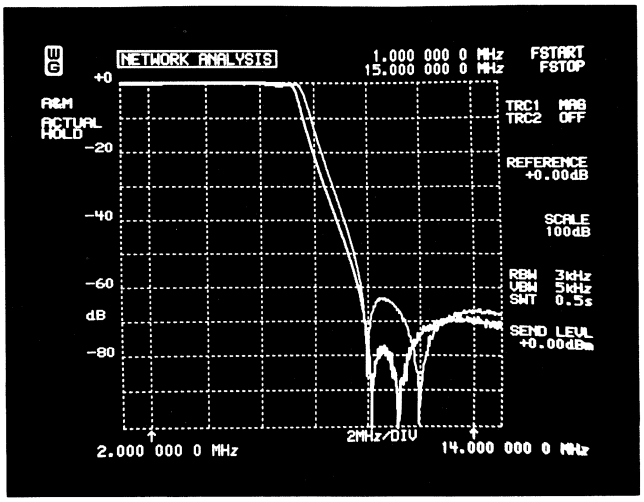
The traces are displayed on the integral screen with a resolution of 500 × 256 pixels along the X axis and Y axis resp. When spectrum analysis is being performed, a very fast detector circuit that uses digital signal analysis ensure that signals having a frequency which does not coincide with one of the 500 frequency points are recorded. All the max. and min. level values that occur during a sweep are recorded and displayed on current trace A.

If the network analysis mode is selected on version BN 956/02, the variation of magnitude and phase with frequency can be shown simultaneously by means of current curve A. Phase deviation or group delay can be displayed instead of phase.

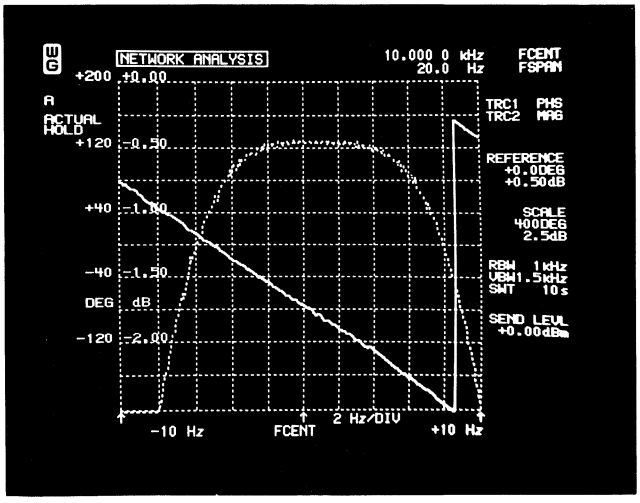
Digital trace storage gives a flicker-free display of the measured curve (A) – even at low sweep rates. The second trace memory can be used to store a target curve (M) so that two traces can be compared. The A curve and the M curve can be displayed simultaneously or separately. The simultaneous display mode makes measurement procedures, such as determining the frequency response of filters and amplifiers etc. by simple comparison, extremely easy. The trace difference can also be displayed.

The display range is wide enough to deal with most types of measurement. The frequency range can be set in steps (min. = 0.1 Hz) between 100 Hz and 180 MHz. The frequency can be entered as a start and stop frequency, as centre frequency and frequency span, or as start frequency and frequency span. A logarithmic frequency scale can also be selected for network analysis. In this way, the magnitude and phase of a transfer function can be expressed in terms of a Bode diagram. An idea of the flexibility of the electronic graticule can be obtained from the figures.

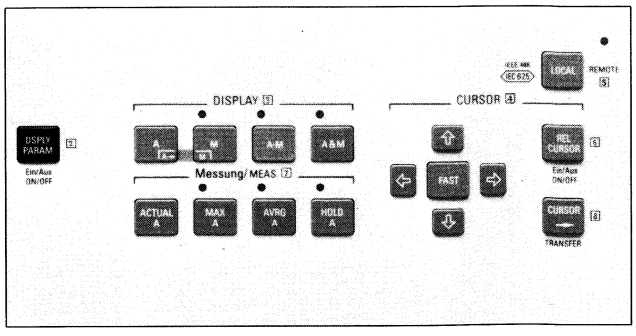
The Y-scale can be adjusted in steps. The display range can be expanded by up to 1 dB, 10° or 10 ns to read a result more accurately, or to see small differences.



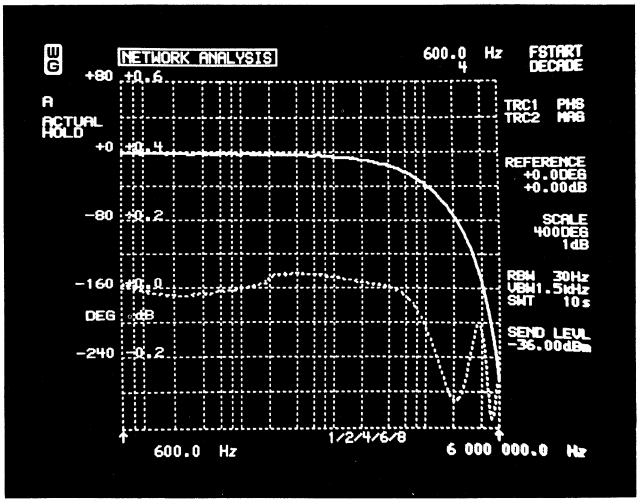
Simultaneous display of measured trace A and reference trace M, e.g. to adjust the attenuation of low-pass filters



Variation of attenuation and phase for the pass-band of a quartz filter (expanded display)



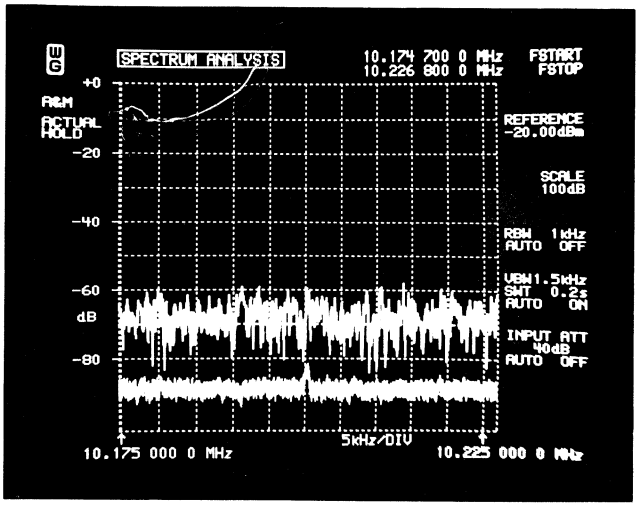
Keypad for test traces, reference trace, memory, peak value display, cursor position and cursor transfer.



Variation of gain and phase for a wideband amplifier, shown as a Bode diagram with logarithmic frequency scale

Calibration and normalisation

The absolute level measuring accuracy is crucial for spectrum analysis. The SNA-1 therefore has an automatic calibration facility, that uses an internal reference level whose frequency is that of the centre frequency. Calibration is performed each time a parameter that could affect the level measurement accuracy is changed. Calibration is also carried out at regular intervals to eliminate errors caused by temperature drift. The calibration facility can be switched off for rough measurements.
In the network analysis mode, the measured parameter is referred to input signal of the item under test. For this reason, only the relative accuracy is important. For network analysis the SNA-1 uses single channel measurements. Before the actual measurement is made, an error correction curve, determined by a reference measurement, is made and stored. This eliminates the errors introduced by the test setup, cables adaptors etc.
This normaliser procedure is carried out by pressing a button. The output signal is then referred to the input signal. Version BN 956/02 has a normaliser memory for frequency and phase responses. Errors caused by temperature drift are eliminated by the calibration facility.



Digital noise averaging (lower trace) for enhancing signals that have been swamped by noise (upper trace shifted by 20 dB)

Noise averaging

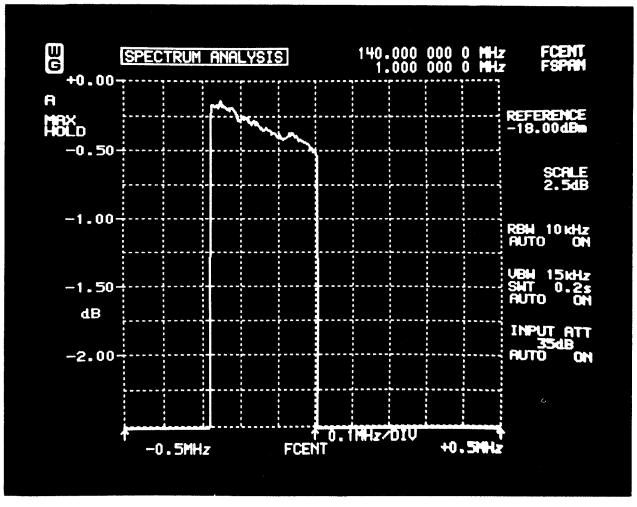
Video filters with various bandwidths have been provided to investigate noisy signals. A digital noise averaging facility has also been incorporated in the SNA-1. At high sweep rates, the smoothness of the trace is increased with each sweep. In this way, discrete signals that have been lost in noise can be recovered and measured.

"Max. Hold" function

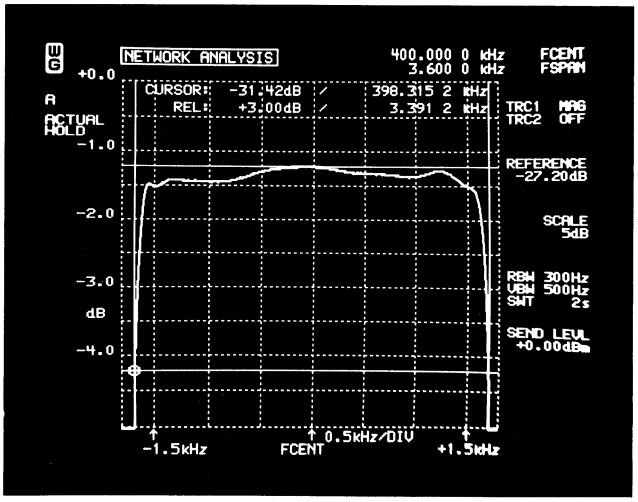
Normally the trace memory is refreshed after each sweep. In the special operating mode MAX. HOLD, the new value will not be transferred to the memory unless it is greater than the old value in memory. This means that it is easy to see how amplitude and frequency vary with time. Long-term measurements on the peak loading of voice-grade and sound-programme channels can be made. The required bandwidth for frequency modulated signals can also be measured.
This operating mode is also ideal for investigating the frequency stability of oscillators. By storing the maximum value at the relevant frequency, the signal drift over a certain observation period can be held in view on the screen.

Special cursor features

The horizontal and vertical cursors can be used to display the absolute values of any pixel.
When modulated signals are investigated, for example, the absolute frequency and level differences are not of prime importance because relative values are more useful. Simply mark the carrier signal with the line-cursors and then switch over to the relative cursor display mode. A second pair of line-cursors can then be set on a spectral line. Carrier/sideband frequency difference and carrier-to-sideband ratio are shown on the screen. Screen settings can also be made with the aid of the cursor. By pressing a button (transfer), the current cursor values are converted to new reference values for level and frequency, or to new start, stop or centre frequencies.
As the position of the cursor line is not changed by the transfer function, each time a button is pressed, the display is moved in the same direction. When line spectra are being investigated, it is possible to shift the next highest harmonic to the middle of screen by pressing a button if suitable settings are chosen.



Frequency and level drift of an oscillator in the first 15 min after switch-on



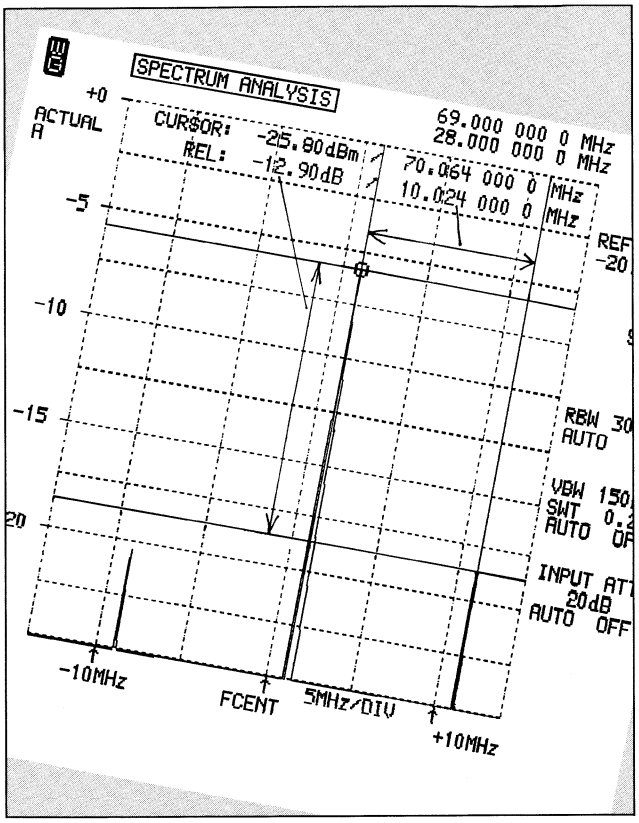
Exact and straightforward determination of the 3 dB bandwidth of a voice channel filter

Electronic tolerance masks

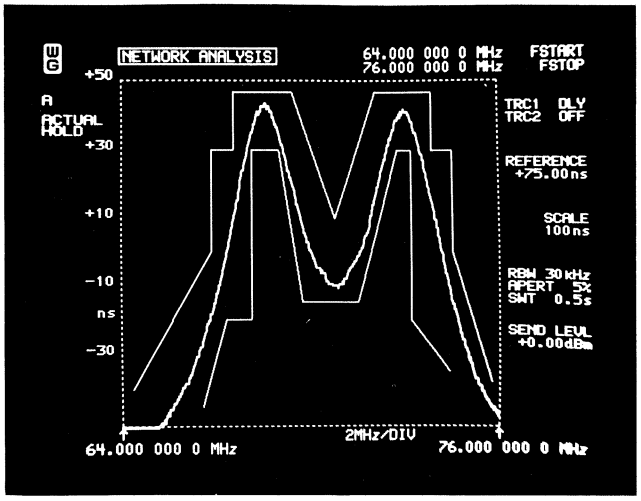
Tolerance masks can be superimposed on the screen to check curve limits. Tolerance masks formed from several line segments can be setup and stored via the keyboard. If required, other tolerance masks and the appropriate setups can be stored.

Remote control and documentation facilities

If required, the SNA-1 can be fitted with an <IEC 625>/IEEE 488 Interface Board so that all the SNA-1's most important functions can be remote controlled. When a computer is connected to this interface, it is possible to program comprehensive test routines



Hardcopy from a videoplotter, showing the absolute values of level and frequency of a carrier signal, and the relative values of a spectral line



Group delay curve with tolerance mask (electronic graticule off)

rapidly. All the test results can be called up and evaluated, stored or documented in a variety of ways. Because of its remote control and programming facility, the SNA-1 can be used in test systems.

All the information shown on the screen, that is the results and the SNA-1 parameters, can also be documented via the IEC interface. A graphics plotter can be directly controlled by the SNA-1, the program output is in HP-GL (Hewlett Packard Graphic Language). A video printer which can be connected to the video output of the SNA-1, gives a hardcopy version of all the information on the screen. Because of the SNA-1's flat screen, photographs of the results can be made in the usual way.

Measurement accessories

The TK-11 Active Test Probe is available for high impedance, low capacitance measurements in the frequency range 1 kHz to 180 MHz.

The FEDA-1 Matching Pad can be used to match 75 Ω to 50 Ω and vice versa.

Reflection coefficient measurement bridges are available for measuring frequency-dependent return loss (magnitude and phase).

Our 75 Ω program "Versacomp® 75" also contains other measuring accessories such as attenuator networks, terminating impedances and "T" adaptors.

Unless otherwise stated, the given data is valid for the nominal ranges of use of a.c. line voltage, a.c. line frequency, and ambient temperature 15 min after switch-on.

Frequency

Measurement range . . . . . 100 Hz to 180 MHz

Display modes
Electronic graticule, the scale of the horizontal axis takes the frequency span into account. Scaling switchable to start/stop frequency, centre frequency/frequency span or start/frequency span

Start frequency and stop frequency or centre frequency
Entry via keypad or by transferring a cursor value. Also quasi-analog setting of centre frequency and start frequency via knob.
Setting range . . . . . 0 Hz to 180 MHz
Resolution, keypad . . . . . 0.1 Hz
knob or cursor transfer . . . . . $2\times10^{-3}\times$f.span

Frequency span
Via keypad or in steps via rotary switch or increment buttons
Setting range . . . . . 0 Hz to 180 MHz
Resolution, keypad . . . . . 0.1 Hz
Rotary switch, incr. buttons . . 100 Hz to 180 MHz in 1, 2, 5 sequence

Measuring frequency
Linear sweep between start and stop frequency, also manual tuning via knob.
Resolution, sweep mode . . . . . ≧0.1 Hz
manual tuning . . . . . $10^{-4}\times$f. span

Error limits of the start, stop and measuring frequency
including ageing for 1 year . . . . . $\pm3\times10^{-7}$
with the BN 865/00.03 option . . . . . $\pm1\times10^{-7}$

Resolution bandwidth
Switchable selective filters with approximately Gaussian transfer function. Filter selection takes place automatically when the frequency span is set, or is initiated manually via the increment buttons.
3 dB bandwidth . . . . . 3 Hz to 300 kHz in 1, 3 sequence
60 dB: 3 dB bandwidth ratio for bandwidths
3 Hz to 30 kHz . . . . . ≦11:1

Measured parameters

Amplitude (level)

Calibration, selectable . . . . . dBm, dB, dBμV

Version	dBm (0 dBm ≅ 1 mW)	dB (0 dB ≅ 0.7746 V)	dBμV (0 dBμV ≅ 1 μV)
$Z_o = 50\ \Omega$	0	−10.79	+107.00
$Z_o = 75\ \Omega$	0	− 9.03	+108.76

All levels are given in dBm. Values in dB, dBμV can be calculated using the conversion factors in the table.

Measurement range
$Z_o = 50\ \Omega$ . . . . . −130 to +20 dBm
$Z_o = 75\ \Omega$ . . . . . −135 to +20 dB

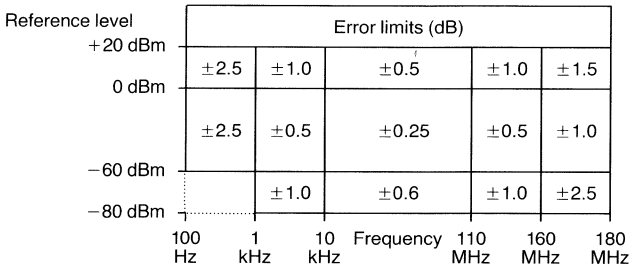
Display modes
Electronic graticule, vertical axis has 10 divisions.
Amplitude is equal to the sum of the scale value and reference value.
Scaling . . . 0.1 to 10 dB/div. adjustable in 1, 2.5, 5 sequence

Reference value
Entry via keypad, rotary switch, increment buttons, or by transferring a cursor value
Smallest increment . . . . . 0.1 dB

Automatic calibration (can be switched off)
carried out at the centre frequency after each change of parameter that could affect the amplitude accuracy, and approx. every 3 min.

Error limits
with the automatic calibration on, and fed from a source with $Z_{source} = Z_o$

Error limits of the reference level
at the centre frequency, input attenuation ≧10 dB, bandwidths 30 Hz to 30 kHz. The values given in the table should be increased by 0.5 dB for the 3 Hz and 10 Hz bandwidths.

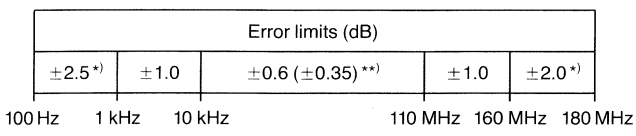


Scaling errors when the input attenuator is set automatically, including the resolution error of the digital image memory.

Error limits (dB)						
0.1 dB/ div.	0.25 dB/ div.	0.5 dB/ div.	1 dB/ div.	2.5 dB/ div.	5 dB/ div.	10 dB/ div. *)
±0.05	±0.06	±0.20	±0.30	±0.40	±0.50	±1.0 (±1.5)

*) In the case of 10 dB/div. the error given is only valid in the limited range 0 to −70 dB (0 to −90 dB)

Frequency response
Error limits from −70 to 0 dBm referred to the centre frequency, input attenuation ≧10 dB



*) Typical value ±1.5 dB
**) The value in brackets is valid for spans ≦30 MHz and an ambient temperature between +20 and +26 °C

Attenuation/gain
Results given in terms of gain (difference between output level and input level)

Measurement range

SNA-1 versions	Attenuation	Gain
BN 956/01	0 to 130 dB	0 to 20 dB
with option BN 956/00.04	0 to 130 dB	0 to 80 dB
BN 956/02	0 to 130 dB	0 to 80 dB

Display modes
Electronic graticule, vertical axis has 10 divisions.
Gain is equal to the sum of the scale value and the reference value
Scaling . . . . . 0.1 dB/div. to 10 dB/div. in 1, 2.5, 5 sequence

Reference value
Set via keypad, rotary switch, or by transferring a cursor value
Smallest increment . . . . . 0.01 dB

Calibration/normalisation
The error response of the test setup can be measured and stored, so eliminating the intrinsic error of the Analyzer and the test cables.
The correction curve is stored in internal memory by pressing a button.

Error limits
Error limits of the reference value
in the range −60 to +60 dB, for input levels ≧−60 dBm after normalisation

Error limits (dB)		
±0.08		±0.4
100 Hz	110 MHz	180 MHz

Scaling errors
including the resolution error of the digital image memory

Error limits (dB)						
0.1 dB/ div.	0.25 dB/ div.	0.5 dB/ div.	1 dB/ div.	2.5 dB/ div.	5 dB/ div.	10 dB/ div.
±0.05	±0.06	±0.20	±0.30	±0.40	±0.50	±2.0

Phase and phase deviation
(version BN 956/02 only)
The result displayed is the phase difference between the measured signal and an applied reference signal.

Measurement range . . . . . −180° to +180° ± n × 360°

Display mode
Electronic graticule, vertical axis has 10 divisions.
The phase is given by the sum of the reference value and the scale value
Scaling, selectable . . . . . 1°, 2°, 4°, 8°, 20°, 40°/div.

Reference value
Entry via keypad, rotary switch, or by transferring a cursor value.
Setting range, phase . . . . . ±3200°
Phase deviation . . . . . ±3200°/span
Smallest increment . . . . . 0.1°

Calibration/normalisation
Mode for measuring and storing an error correction curve (normalisation) to eliminate intrinsic errors and errors arising from test cables.

Error limits
for input levels ≧ −60 dBm, after normalisation, resolution bandwidth 1 kHz
Error limits of the reference value
at f = 100 kHz . . . . . ±1.0°
Additionally, 100 Hz to 110 MHz . . . . . ±0.5°
110 MHz to 180 MHz . . . . . ±1.5°
Error caused by level difference between normalising and measured signal (level scale 1 to 50 dB) . . . ±1° ± 1°/10 dB
Scaling error . . . . . ±3 % of display range ±0.1°

Group delay (version BN 956/02 only)

Measurement range . . . . . 500 ps to 1 s

Display mode
Electronic graticule, vertical axis has 10 divisions.
Group delay displayed is equal to the sum of the reference value and the scale value
Scaling . . . . . 1 ns to 200 ms/div. in 1, 2, 5 sequence

Reference value
Entry via keypad or by transferring a cursor value
Smallest increment . . . . . 100 ps

Aperture . . . . . 0.2 % to 10 % of span in 1, 2, 5 sequence

Error limits
for input levels ≧ −60 dBm and a resolution bandwidth of 1 kHz after normalisation . . . . . ±2 % of screen range

$$\pm 1\ \text{ns} \pm \frac{1.5\ \text{ns}}{\text{aperture (MHz)}}$$

Addition errors caused by level dependence, level scales 25 to 100 dB . . . . . $\pm \frac{3\ \text{ns/10 dB}}{\text{aperture (MHz)}}$

Dynamic range (intrinsic spurious signals)

Spurious signals when an input signal is present, the reference level is ≦+10 dBm and the input attenuator is set automatically (resolution bandwidth ≦1 kHz)
Harmonic ratio (2nd and 3rd order)
loaded with a single tone ≦ reference level . . . . . ≧70 dB

Intermodulation products (2nd and 3rd order)
Level difference between intermodulation products and the larger of two signals each of which is at least 6 dB below the reference signal . . . . . ≧70 dB

Attenuation of nonharmonic spurious signals . . . . . ≧70 dB

Image frequency and IF suppression
(IF = 220 MHz, 40 MHz, 4 MHz, 400 kHz)
at 110 MHz and 220 MHz . . . . . ≧55 dB
at 400 kHz, 4 MHz and 40 MHz . . . . . ≧70 dB
at tuning frequencies ±2 IF . . . . . ≧70 dB

Signal to sideband noise ratio
Resolution bandwidth ≦1 kHz and
sideband frequency ≧20 kHz . . . . . ≧70 dB

Intrinsic spurious signals when no input signal is present, input terminated with Z_o, input attenuation 0 dB

Discrete spurious signals	$Z_o = 50\ \Omega$	$Z_o = 75\ \Omega$
f ≧ 300 kHz	≦ −125 dBm	≦ −130 dBm
f ≧ 100 Hz	≦ −110 dBm	≦ −115 dBm

Intrinsic noise level for Z = 75 Ω
For Z = 50 Ω the values are 5 dB higher

Resolution bandwidth	Limits of the intrinsic noise level (dBm) (dB = dBm −10)			
30 kHz				−105
10 kHz				−115
3 kHz			−100	−120
1 kHz			−105	−125
300 Hz			−110	−125
100 Hz		−100	−115	−130
30 Hz		−105	−120	−135
10 Hz	−110		−125	−135
3 Hz	−115		−130	−135

100 Hz 3 30 300 kHz 180 MHz

Deflection, videofilter

Waveform saw tooth. Also single deflection in remote control mode (<IEC 625>/IEEE 488 interface).

Sweep duration . . . 200 ms, 500 ms, 1 s, 2 s, 5 s, ..., 20 h
Automatically set with the frequency span and resolution bandwidth, or manually via increment keys.

Video filters
Automatic filter selection in conjunction with resolution bandwidth, or manual filter selection via increment buttons.
Video bandwidth . . . . . 5 Hz to 150 kHz in 5, 15 sequence

Display section

CRT . . . . . 7" flat screen
Adjustable brightness.

Trace memory
X-resolution . . . . . 500 pixels
Y-resolution . . . . . 256 pixels

Trace display
Measurement and reference traces . . . . . separately, simultaneously, or trace difference

Cursor display
Cursor switchable over for absolute and relative measurements.
Two cursor pairs for relative measurements.
Vertical frequency-cursor, resolution . . . . . 500 pixels
Parameter-cursor, resolution . . . . . 256 pixels
The values indicated are shown alphanumerically on the screen and have the following resolutions:
Frequency . . . . . $2\times10^{-3}\times$f. span ±0.1 Hz
Level, attenuation, gain . . . $4\times10^{-3}\times$display range ±0.01 dB
Phase . . . . . $4\times10^{-3}\times$display range ±0.1°
Group delay . . . . . $4\times10^{-3}\times$display range ±100 ns

Background display
Internal, electronically generated graticule with scale, alphanumeric display of all the most important measurement parameters. User-programmable tolerance masks are also available.

Additional functions
Digital noise averaging to reduce the fluctuations in noisy signals.

Peak-value memory (max. hold) to display the highest level that occurs in any display column (only spectrum analysis).

Memory for additional tolerance masks.

Input and output connectors

System impedance, coaxial . . . . . 50 Ω (BNC)
or . . . . . 75 Ω (Versacon® 9 Universal Connector System, compatible with all common connector types)

Input

Input impedance . . . . . 50 Ω or 75 Ω
Return loss when the input attenuator is set to values ≧10 dB
f ≦ 100 MHz . . . . . ≧26 dB
f ≦ 180 MHz . . . . . ≧20 dB
Max. continuous input power . . . . . 100 mW
Max. peak input-voltage . . . . . 20 V

See accessories for high-impedance measurements with the TK-11 Active Test Probe.

Tracking-generator output

tracks the frequency of the Analyzer
Output impedance . . . . . 50 Ω or 75 Ω
Return loss . . . . . ≧20 dB
Level range,
Version BN 956/01 . . . . . 0 dBm, fixed
With option BN 956/00.04
or version BN 956/02 . . . . . −65 to 0 dBm, adjustable in 0.01 dB steps
Level error limits, $Z_L = Z_o$ . . . . . ±1.0 dB

Other inputs and outputs

Input* for external standard frequency . . . 1, 2, 5, 10 MHz
Level . . . . . −10 to +10 dBm
Input impedance . . . . . 75 Ω

Output* for internal standard frequency . . . . . 10 MHz
Level into 75 Ω, nominal value . . . . . 0 dBm

Input* and output*
for control frequency . . . . . 220 to 400 MHz
for synthesiser control of the analyser section

IF output* . . . . . 400 kHz
Output impedance . . . . . 75 Ω

Video output (BNC)
for external monitor or video-printer
Output voltage, 75 Ω termination . . . . . $V_{p-p} = 1$ V
Frame frequency . . . . . 50 Hz
Line frequency . . . . . 15.6 kHz
Complies with CCIR television recommendations.

Test probe connector, power supply for the TK-11
Automatic compensation for loss introduced by test probe.

General specifications

Power supply
Nominal ranges of use for a.c. line voltage, selectable . . . . 110/117/127/220/227/237 V, −12 to +10 %
Nominal range of use for a.c. line frequency . . . 47.5 to 63 Hz
Power consumption, analyser section . . . . . 100 VA
display section . . . . . 80 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature
Nominal range of use . . . . . +5 to +40°C
Storage and transportation . . . . . −40 to +70°C

Data retention
Integral, trickle-charged NiCad for preserving the device settings, the reference curve and the tolerance masks stored in memory when there is an a.c. line failure.

Dimensions of the bench model (w×h×d) in mm
Analyser section . . . . . 479×240×452
Display section . . . . . 479×137×414
19" conversion kit . . . . . BN 700/00.13

Weight
Analyser section . . . . . approx. 22 kg
Display section . . . . . approx. 10 kg

Options

Higher Frequency Accuracy, BN 865/00.03
Error limits plus aging over 1 year . . . . . $\pm 1 \times 10^{-7}$

Adjustable Transmission Level, BN 956/00.04
(for version BN 956/01, series E and after)
Frequency range . . . . . 100 Hz to 180 MHz
Transmission level . . . . . −65 to 0 dBm in 0.01 dB steps

<IEC 625> Interface Bus, BN 958/01

Remote control input
For remote controlling all device functions except brightness.
It is connected to the IEEE bus using the S 834 adaptor.
Interface functions . . . . SH1, AH1, T6, L4, SR1, RL1, PP2, DC1, DT1, CØ

Graphics plotter connector
The interface bus can also be used to control a graphics plotter (e.g. hp 7470 A)
Functions . . . . . prints out screen contents, up to 5 colours
prints out test curve only

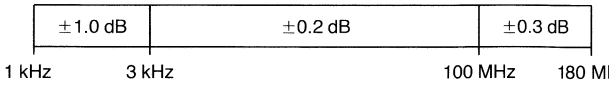
Accessories

TK-11 Active Test Probe, BN 573/..
Frequency range . . . . . 1 kHz to 180 MHz

Input impedance
f ≦ 25 MHz . . . . . approx. 50 kΩ ‖ 3.5 pF*)
f ≦ 100 MHz . . . . . approx. 5 kΩ ‖ 3.5 pF*)
f ≦ 180 MHz . . . . . approx. 2 kΩ ‖ 3.5 pF*)
*) The capacitance values apply to the test probe and test prod

Insertion loss
at 100 kHz, +20 °C . . . . . 10 dB ± 0.1 dB

Error limits of the frequency response, referred to 100 kHz



Return Loss Coefficient Measurement Bridge RFZ-14,
BN 830/00.01
Frequency range . . . . . 100 kHz to 100 MHz
Characteristic impedance . . . . . 75 Ω
Connectors* . . . Versacon® 9 Universal Connector System, compatible with all standard connectors

Return Loss Coefficient Measurement Bridge RFZ-4,
BN 697/00.04
Frequency range . . . . . 10 MHz to 200 MHz
Characteristic impedance . . . . . 75 Ω
Connectors* . . . Versacon® 9 Universal Connector System, compatible with all standard connectors

Ordering Information

Spectrum and Network Analyzer SNA-1* **BN 956/..**
The following versions are available:

Measured parameter				Trans. level		Order number
Amplitude	Gain or attenuation	Phase	Delay time	Fixed	Adjustable	
■	■			■	□	**BN 956/01**
■	■	■	■		■	**BN 956/02**

□ if required (see options)

Options (no extra charge)
50 Ω input and generator output[3] (instead of 75 Ω) BN 956/00.01

Options (charged extra)
Higher Frequency Accuracy[3] BN 865/00.03
Adjustable Transmission Level[3] for BN 956/01 from series E BN 956/00.04

<IEC 625> Interface Board with IEC 625/IEEE 488 adaptor (S 834) BN 958/01

Accessories (charged extra)
Active Test Probe TK-11[1], $Z_o = 75\ \Omega$ BN 573/00
$Z_o = 50\ \Omega$ BN 573/02
Return Loss Coefficient Measurement Bridges $Z_o = 75\ \Omega$
RFZ-4 BN 697/00.04
RFZ-14 BN 830/00.07
Matching Section FEDA-1, 75 Ω/50 Ω *[1] BN 319/00
Decoupling transformers[1], attenuator pads, terminations, T adaptors[2]

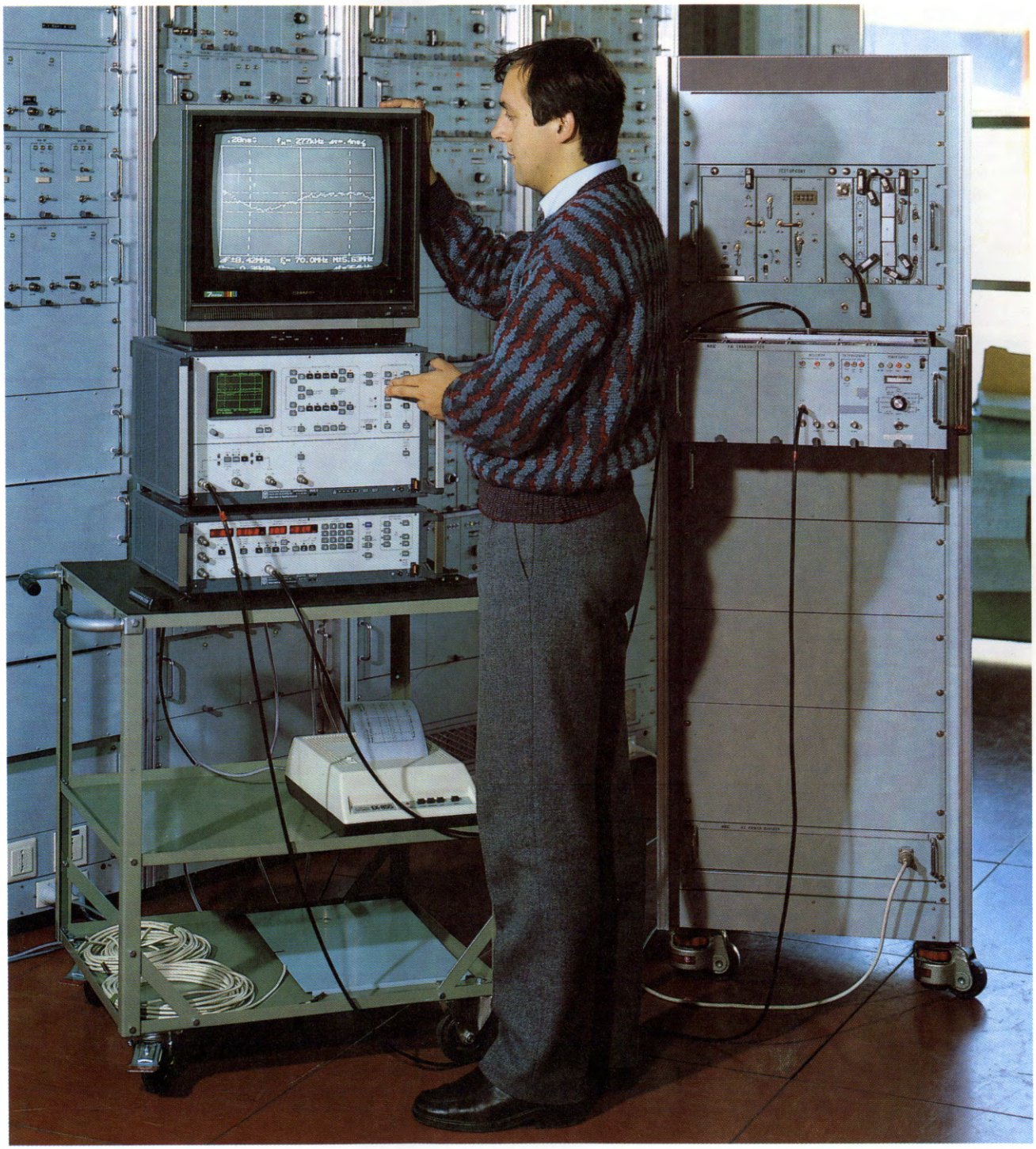
<IEC 625> Interface Bus Connection cables
120 cm K 343
200 cm K 344

19" conversion kit BN 700/00.13

Front and Back Panel Covers (1 set)
for the analyser section, SD-50 BN 700/00.28
for display section, SD-30 BN 700/00.27

1) See the Measuring Accessory for ordering information and more data
2) See the Versacomp® 75 Specification Sheet for data and ordering information
3) Fitted ex-works, order with mainframe
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see Specification Sheet "Versacon® 9", and order chosen type when ordering instrument.

Distortion Measurement Technology



Overview

Distortion Measurement Technology

Instruments for white noise measurements and noise monitoring

Applications	Frequency range	Special features	Name	Page
Cable, radio-link and satellite systems with up to 2700 channels	**6 kHz to 12.5 (14) MHz**	• Easy to use measuring set for "in-service" testing • Linear meter scale; 30 dB range • "System parameter" switch makes noise measurements easier • Digital wideband meter option	**RK-50 White Noise Measuring Setup**	133
Cable, radio-link and satellite systems with up to 3600 channels	**6 kHz to 25 MHz**	• Can be integrated into test systems using the <IEC 625>/IEEE 488 Interface Bus • Digital result display • Digital wideband level meter option • Noise power display • Simplified NPR measurements	**RK-25 White Noise Measuring Setup**	137
Noise monitoring on radio-link systems	**6 kHz to 25 MHz**	• Long-term monitoring of up to 8 radio-link circuits; up to 6 measuring channels • Dialog operation • Result evaluation and display conform to CCIR Recommendations	**GA-250 Noise Monitoring System** [1]	141
Cable, radio-link and satellite systems with up to 10 800 channels	**6 kHz to 100 MHz**	• Integrable into test systems via the <IEC 625>/IEEE 488 Interface Bus • Digital result display • Noise and power level display • Simplified NPR measurements	**RK-100 White Noise Measuring Setup**	145
For use with white noise measuring setups	—	Complete filter and converter program comprising: • Band limiting filters and band selection filters • Bandstop filters • Pilot tone stop filters • Converter plug-ins	**Filter and Converter Plug-ins**	149
For measurements at the IF level of radio-link and satellite systems with up to 2700 channels	—	• Frequency response and attenuation measurements comply with CCIR Recommendations • Inputs and outputs convertible to all usual connector types	**Pre-emphasis and De-emphasis Networks**	155

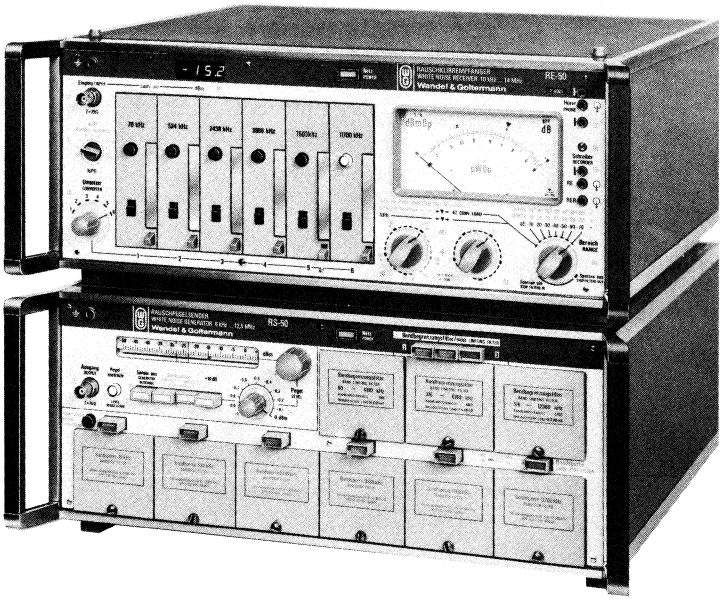
1) Uses SWP-12 software package

Radio-link measuring setup

Applications	IF frequency	Special features	Name	Page
Radio-link and satellite systems	**35/70/140 MHz**	• Seven test frequencies between 25 kHz and 5.6 MHz • BB level meter 10 kHz to 12.5 MHz • Wideband test modem • Microprocessor control for easy operation • IF counter for centre frequency and sweep limits • All data is output on screen • Video output • <IEC 625>/IEEE 488 Interface Bus	**RM-5 Radio-link Measuring Setup**	157

RK-50
White Noise Measuring Setup

for noise and NPR measurements using noise bandwidths up to 12.5 MHz



- **In-service measurements are easy to perform**
- **Measuring setup and filter specifications correspond to the newest CCITT and CCIR Recommendations**
- **Intrinsic noise ≦−85 dBm0p**
- **Simplified noise measurements by means of "system parameter" switch**
- **Large, linear meter scale with 30 dB range**
- **New: Digital display for wideband level measurements (REBZ-25 Option)**

Applications

White noise measurements are a recommended method of assessing the quality of FDM cable, radio-link and satellite systems and are used world-wide – especially for in-service measurements.
White noise measurements are made by system manufacturers and operators. Typical operators are postal administrations, oil companies, electricity and gas utility companies, the police, the armed services and railways.
The RK-50 White Noise Measuring Setup, frequency range 6 kHz to 12.5 MHz, can be used on systems with a maximum transmission capacity of 2700 channels.
The Generator and Receiver of the RK-50 can be fitted with various Filter and Converter Plug-ins for selecting the correct noise bandwidths and suitable measuring channels for a range of systems. A wide variety of Filters and Converters can be purchased, and, of course, all the noise bands and frequencies recommended by CCITT/CCIR and INTELSAT are available.

As small noise levels down to 1 pW often have to be measured, the RK-50 has not been designed as a tunable, selective level meter with multiple frequency conversion, but instead, as a fixed-tuned receiver with simple frequency conversion. This design and the high stop-band attenuation of the bandstops ensure that the Measuring Setup has the required low intrinsic noise value.

Characteristics

A maximum of three RSB Band-limiting Filters and a maximum of six RSS Bandstop Filters can be accommodated in the RS-50 White Noise Generator; the RE-50 White Noise Receiver accommodates a maximum of six REU Converter Plug-ins. All the Plug-ins are easy to exchange which means that adaptability is no problem.

Frequency range	6 kHz to 12.5 MHz
Send signal	white noise
Send level	−50 to +15 dBm
Display range	
for noise measurements	−90 to 0 dBm0p
	or 1 to 10^9 pW0p
for NPR measurements	−90 to 0 dB
Range for setting relative level	−60 to −8 dBr
Wideband Level Meter (Option)	−39.8 to +9.8 dBm

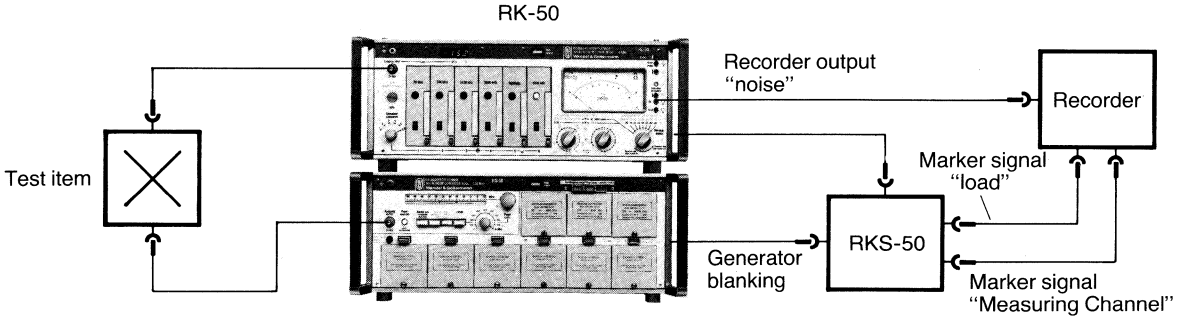
2419 RK-50

A special feature of the Measuring Setup is its ease of operation; no calibration is required. For loop-back measurements a control connection can be made between the Generator and Receiver. In this way the Band-stop Filters can be controlled from the Receiver. On the receive side the "system parameter" switch can be used to check whether the system is correctly aligned or whether the send level has been correctly set on the RS-50 Generator.
Results can be read quickly and accurately thanks to a large, linear meter scale with a 30 dB range; frequent range changes are therefore unnecessary.
The Receiver accepts relative levels down to −60 dBr, noise readings are referred directly to the 0 dBr point.

Further Characteristics and Applications

Further notable features of the RK-50 White Noise Measuring Setup are:

- *Automatic alignment of the pass-band attenuation in the Bandstop Filters:* The controlling variable for the automatic send level control is obtained after the Bandstop Filters, so that an automatic alignment of the loading loss results when the Bandstop Filters are switched in; the attenuators are automatically adjusted so that a favourable load can be applied to the Bandstop Filters, so preventing distortion in the Bandstop Filters.
- *External control facilities:* Important RK-50 settings (e.g. send level, noise band and frequency selection, send level blanking, Stop Filter blanking and reference frequency switchover) can all be program controlled; if a controller and a noise level meter are available, certain measuring procedures can be automated and the results printed out on hard-copy. It is not necessary to use the full range of control facilities offered – a suitable, restricted range may also be selected (e.g. using the RKS-50 Control Unit).
- *REBZ-25 Wideband Level Meter:* The REBZ-25 is a self-adjusting, digital wideband level meter for the frequency range 6 kHz to 14 MHz, available as an auxiliary device, for retrofitting in the RE-50 White Noise Receiver. The measured result in range −39.8 to +9.8 dBm is read but on a separate LED display. The REBZ-25 Wideband Level Meter is connected at high impedance (bridged) to the input of the RE-50.
- *Recorder output for noise and wideband levels:* The relationship between the load on a radio-link system, which is subject to large variations within any 24 hour period, and the noise in an out-of-band channel can be clearly seen when they are displayed as two separate traces on a y-t recorder.
- *Wide range of Filter and Converter Plug-ins:* All the Filter and Converter Plug-ins recommended by CCITT/CCIR and INTELSAT can be purchased, as well as numerous special filters for submarine cable systems, small channel balanced systems, and systems for the USA. Filters for group translator measurements are also available (cf. Specification Sheet "Filter and Converter Plug-in Units").
- *Further Special Plug-ins for the RS-50 Generator:* The RSP Pilot Stop Filters are available for white measurements on FDM cable systems; the RST-5000, a 5 MHz low-pass with a notch filter for the TV sound carrier region, is available for TV systems. The RSI-50 Timer blanks the send level at preselected intervals and so makes a special form of long-term monitoring possible. The RSSA-50 Bandstop Filter Adaptor is used to connect external bandstops, i.e. in addition to those already in the Generator.
- *Useful measuring accessories:* Transformers for Matching and Decoupling, Test Probes, Multi-way Splitters, Pilot Stop Filters, Pre- and De-emphasis Networks etc.



Recording the thermal and intermodulation noise in several measuring channels

Specifications of White Noise Measuring Setup — RK-50

The specifications of the available Plug-in Units, i.e. Band-limiting Filters, Band Selection Filters, Bandstop Filters, Converter Plug-in Units and Pilot Stop Filters, are listed in the Specification Sheet "Filter and Converter Plug-in Units".

Measuring weighted noise referred to a 0 dBr point

Display
Linear level scale . . . . . −20 to +10 dB
Power display . . . . . 0.01 to 10 pW0p
Measurement range . . . . −90 to 0 dBm0p or 1 to 10^9 pW0p

Relative level, setting range . . . . . −60 to −8 dBr

Error limits
After reference alignment with meter scale in the range −5 to +5 dB . . . . . ±0.5 dB + F[1)]
After setting the relative level with meter scale in the range −5 to +5 dB . . . . . ±1.3 dB

Noise floor of Receiver
for a coarse setting of the relative level ≦−38 dBr . . . . . ≦−126 dBmp

Intrinsic noise value of the Measuring Setup
Intrinsic noise referred to a 0 dBr point . . . . . ≦−85 dBm0p or ≦3 pW0p
(for relative level ≧40 dBr and baseband loading to about 10 dB overload for system with ≧240 channels, and approx. 5 dB overload for systems with <240 channels)

Equivalent noise bandwidth
for psophometric weighting . . . . . 1.74 kHz

NPR measurements

Display
Linear level scale . . . . . −20 to +10 dB
Measurement range . . . . . −90 to 0 dB

Channel loading level . . . . . −70 to −18 dBm

Error limits for a meter display in the range −5 to +5 dB . . . . . ±0.5 dB

Intrinsic NPR of the Measuring Setup (after reference alignment with a channel load ≧−50 dBm . . . . . ≧75 dB

Frequency range

of the RS-50 White Noise Generator . . . . 6 kHz to 12.5 MHz
of the RE-50 White Noise Receiver . . . . . 6 kHz to 14 MHz

Send signal

Signal shape . . . . . white noise
Noise voltage distribution
Gaussian distribution in the range . . ±4 σ (CCIR Rec. 399-3)

Output level
settable in 1 dB steps . . . . . −50 to +5 dBm
with 10 dB level increase . . . . . −40 to +15 dBm
Fine setting in 0.1 dB steps . . . . . 0 to −1 dB
Error limits of the send level when terminated with $Z_L = Z_o$, fine setting at 0 dBm . . . . . ±0.5 dB
Send signal blanking, decrease in level . . . . . ≧40 dB

1) | F | ≦0.26 dB, depends on system. This partial error can be eliminated during the measurements.

Connectors*

Generator output, Receiver input . . . . . coaxial, 75 Ω

Auxiliary outputs

X-Y Recorder output
Voltage at output varies linearly with level
Open circuit voltage at f.s.d., adjustable . . . . . 0 to 200 mV
Output impedance . . . . . approx. 2.4 kΩ

D.C. voltage output
at point 12 on the 50 pole remote control connector
Open circuit voltage at meter reading 0 dB . . . . . 5 V
Output impedance . . . . . 5 kΩ

Headphone output
Open circuit voltage at meter reading 0 dB . . approx. 275 mV
Output impedance . . . . . 600 Ω

AF output I
Increase of noise power density compared to the REU input . . . . . approx. 60 dB
Output impedance . . . . . 4.6 kΩ

AF output II
for external S/N evaluation
S/N range for measuring range switch settings between −70 and −20 dBm0p . . . . . −90 to −10 dBm0p
Corresponding level of open circuit voltage at output . . . . . −79 to + 1 dB
Output impedance . . . . . 1 kΩ

REBZ-25 Wideband Level Meter

Level measurement . . . . . wideband
Frequency range . . . . . 6 kHz to 14 MHz

Signal weighting . . . . . r.m.s.
Peak factor for <1 dB compression . . . . . 17 dB

Level display . . . . . digital
Resolution . . . . . 0.1 dB
Measurement span, without range changeover . . . . . −39.8 to +9.8 dBm

Error limits when REU is decoupled to maximum
Error limits at 1 MHz . . . . . ±0.3 dB

Variation with frequency, referred to 1 MHz
in range 10 kHz to 14 MHz . . . . . ±0.3 dB
at 6 kHz . . . . . −0.5 dB

Overall error for sinusoidal, square wave, white noise at bandwidth >48 kHz, in range 10 kHz to 14 MHz . . ±0.5 dB

Analog output
−40 to +10 dBm equivalent to . . . . . 0 to +5 V
Output impedance . . . . . 5 kΩ

Input . . . . . looped in RE-50
Characteristic impedance . . . . . 75 Ω

Generator Specifications

Power supply
Rated ranges of use of a.c. line voltage . . . . . 110/117/127/220/227/235 V; −15 %/+10 %
Rated range of use of a.c. line frequency . . . . . 45 to 66 Hz
Power consumption
RS-50 White Noise Generator . . . . . approx. 60 VA
RE-50 White Noise Receiver with 6 REU . . approx. 30 VA
RE-50 White Noise Receiver with 6 REU and a REBZ-25 Wideband Level Meter . . . approx. 45 VA

Permissible ambient temperature
Rated range of use
(≙ limits range of operation) . . . . . +5 to +40°C
Storage and transport . . . . . −40 to +70°C

Dimensions (w x h x d) in mm
RS-50 White Noise Generator . . . . . 478 x 199 x 407
RE-50 White Noise Receiver . . . . . 478 x 199 x 407
19" conversion kit for the RS-50, RE-50 . . . . BN 556/00.04

Weights
RS-50 White Noise Generator (without RSB and RSS) . . . . . 12 kg
RE-50 White Noise Receiver (without REU) . . . . . 12 kg
RSB Band-limiting Filter . . . . . approx. 0.5 kg
RSS Bandstop Filter . . . . . approx. 0.5 kg
REU Converter Plug-in . . . . . approx. 0.9 kg

Ordering Information

White Noise Generator RS-50 *	**BN 642/00**
White Noise Receiver RE-50 *	**BN 643/00**
Band-limiting Filters RSB Band Selection Filters RSBZ Bandstop Filters RSS Converter Plug-in Units REU Pilot Stop Filters RSP	See special Specification Sheet
Low-passes RST-5000 (5 MHz)	BN 8528/50
RST-5000 (5 MHz with 7.5 MHz TV sound-carrier notch filter)	BN 8528/51
Option for the RE-50 (at extra cost) Wideband Level Meter REBZ-25	BN 863/00.04
Accessories (at extra cost) Bandstop Filter Adapter RSSA-50 for connecting extra external Band-stops (e.g. also for Band-stops for the RK-5 Measuring Setup)	BN 674/01
Timer RSI-50 (for periodic generator blanking)	BN 847/00
Control Unit RKS-50 (for automatic measuring channel changeover)	BN 848/00
Adaptor for controlling the RS-50 with the RKS-50	BN 848/00.01
Matching transformer 150 Ω bal./75 Ω coax. * [1] in small casing in RSS casing in REU casing	 BN 419/00.20 BN 419/00.22 BN 419/00.23
Decoupling Transformer, REÜ-4 [1]	BN 464/02
Matching Transformer REÜ-56 * [1] Matching Transformer REÜ-50 * [1]	BN 839/00.01 BN 839/00.02
Two-way Splitter REV-56 * [1] Five-way Splitter RSV-50 * [2] (for group translator measurements)	BN 839/00.03 BN 849/50
Test Probe TK-9 * [1]	BN 265/00
Pre- and De-emphasis networks	See special Specification Sheet
Control cable (for controlling the RS-50 from the RE-50)	K 176
Storage Case RSA-50 (for 12 RS-Filters; looping in of a max. of 9 band-stops via a Bandstop Filter Adaptor RSSA-50)	BN 407/01
Storage Case RSA-5 (for RK-5 Bandstops, looping in Bandstops via the RSSA-50 Band-stop Adaptor)	BN 412/00
Storage Case RSK-50 (for 6 RS Filters and 3 REU Converters)	BN 428/02
Transport Case TPK-50 for 12 RS Filters for 10 REU Converters for 6 RS Filters and 5 REU Converters	 BN 428/03 BN 428/04 BN 428/05
Protective Transportation Cover DE-3 for RS-50, RE-50, RSA-50 or RSK-50 DE-1 for RSA-5 or RKS-50	 BN 476/00.03 BN 476/00.01
Noise diagrams in English Noise diagrams in German	BN 6390/00.04 BN 6390/00.10

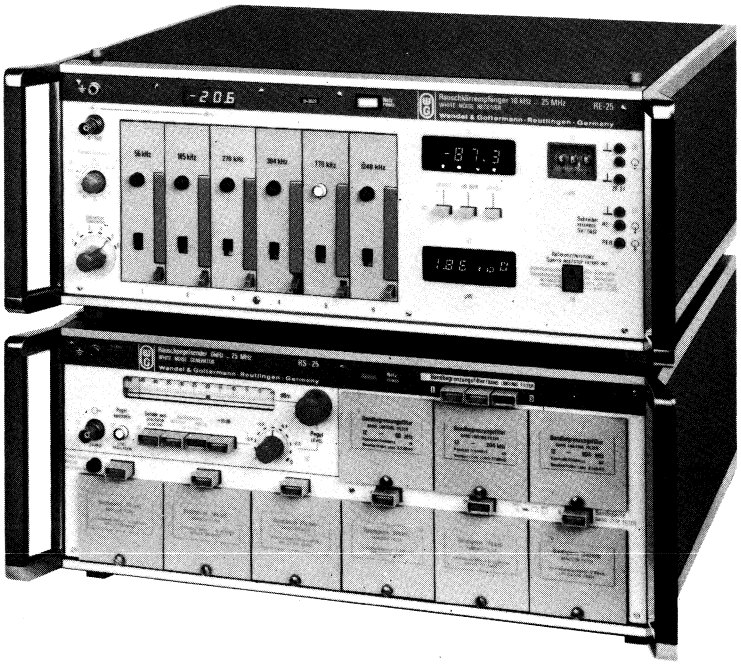
1) For more extensive data and extra Ordering Information see Specification Sheet "Measurement Accessories".
2) For more information see Technical Information Leaflet "White Noise Tests of FDM Group Translators" (Order No. 153).

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

RK-25
White Noise Measuring Setup

for noise and NPR measurements using noise with bandwidths up to 25 MHz

IEEE 488
IEC 625



- **Measuring Setup and filters conform to latest CCITT and CCIR Recommendations**
- **Minor intrinsic noise: ≦−85 dBm0p**
- **Easily integrated into any automatic test system**
- **Facility for checking the relative level at the measurement connection**
- **Additional options for the RE-25 Receiver:**
  - **Separate noise power display**
  - **REBZ-25 Digital Wideband Level Meter Unit**
  - **20 dB measuring range extension**

Applications

The most important aspect in the development of new white noise measuring setups is the provision of facilities for automatic operation, however the simplification of operating procedures in the manual mode must also be given due consideration. A measuring setup that has been expanded to give an automatic test setup has many advantages – e.g. no setting, measurement or read-off errors, and no time is wasted recording and evaluating results by hand.
The importance of these two considerations has been fully recognised in the design of the RK-25 White Noise Measuring Setup. As the RK-25 covers the wide frequency range from 6 kHz to 25 MHz, it can handle all systems carrying up to 3600 telephone channels. Over and above this the RK-25 has capacity in reserve for future systems.
A comprehensive range of Filter and Converter Plug-ins means that a variety of noise bandwidths can be realised and the correct measuring channels selected. All the noise bandwidths and measuring frequencies recommended by CCITT/CCIR and INTELSAT are, of course, also available.

The facility for digitally evaluating the results is the basis for the automation of the measuring setup. The RK-25 can be controlled via the <IEC 625> Interface.

Characteristics

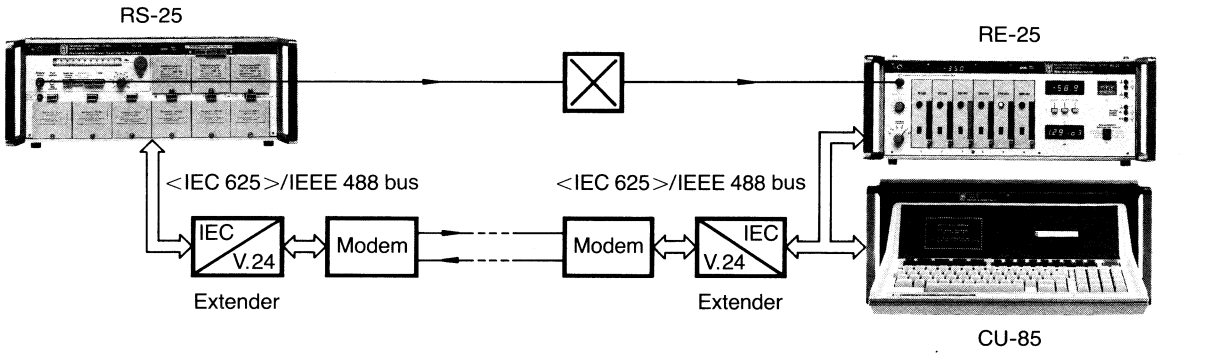
The RS-25 White Noise Generator can accommodate a max. of three RSB Band-limiting Filters and a max. of six RSS Band-stop Filters. The RE-25 White Noise Receiver accepts up to six REU Converter Plug-ins. The Setup can be used in any application as its filters are easy to reconfigure. The digital display on the Receiver is easy to read as the measured value is output in an unambiguous way. Noise levels to −89.9 dBm0p or 0.1 dBrnC0 and NPRs to 79.8 dB can be read off; a second display shows noise powers up to $1 \cdot 10^6$ pW.

Frequency range	6 kHz to 25 MHz
Send signal	white noise
Send level	−50 to +15 dBm
Measurement of noise referred to 0 dBr	
Display range for noise levels	−89.8 to −30.1 dBm0p or 0.1 to 59.8 dBrnC0
for noise power	1 to 10^6 pW0p or pWC0
Setting range for relative levels	−69.9 to −10 dBr
NPR measurements	
Display range	79.8 to 20.1 dB

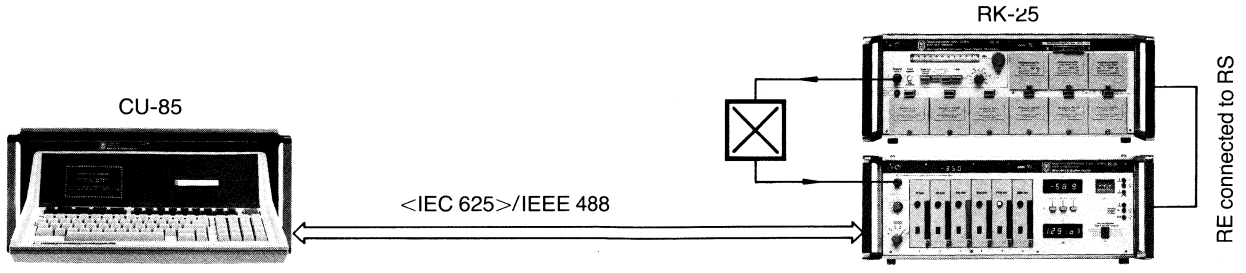
Autoranging considerably simplifies operation and further efforts are being made to make operating procedures for NPR measurements less complicated.
The Band-stops can be controlled from the Receiver via a control cable.

As well as the characteristics of the RK-25 previously mentioned, the following list should be of interest:

- *LED trend indicator:* Clearly indicates if a measured result is increasing or decreasing. The LED array is part of the digital display.
- *Simplified NPR measurements:* A reference alignment procedure is initiated by pressing a button on the RE-25 (Bandstop is switched out via a control cable). After about 6 s an automatic switchover to measurement alignment occurs and the display shows the NPR value. The reference alignment is also initiated when the send level setting is changed.
- *Facility for checking the relative level:* When the reference key is pressed during noise measurements the actual relative level at the measurement connection is shown; thumbwheel switches allow the relative level to be set or corrected.
- *Bandstop Filters are controlled at the RE-25:* After a control cable has been connected between the RS-25 and the RE-25 the Receiver assumes the control over the Bandstop Filters.
- *20 dB measurement range extension:* For applications that deal with high noise levels an Option is available which permits the upper display range to be offset by 20 dB to −10.1 dBm0p or 79.8 dBrnC0 and 0.1 dB (NPR).
- Controlling the RK-25 via the <IEC 625>/IEEE 488 bus:
  - Both the RS-25 and the RE-25 can be fitted with an <IEC 625> interface; the controller addresses the generator and the receiver separately (ideal for end-to-end measurements).
  - Only the RE-25 is fitted with an <IEC 625> interface; the RS-25 is controlled via a cable from the RE-25 (ideal for loop-back measurements).
- *Filter and Converter Plug-in product line:* Noise bands and measuring frequencies correspond to the newest CCITT/CCIR Recommendations; comprehensive list with all available special filters, e.g. for submarine cable systems, small channel balanced systems, and USA systems, besides those for noise measurements on group translators (see Specification Sheet "Filter and Converter Plug-in Units"); all Plug-in Units can be easily exchanged.
- *Low intrinsic noise of the Measuring Setup:* The high stopband attenuation of ≧80 dB by the Bandstop Filters (CCITT requirement: 70 dB) ensures a very low intrinsic noise in the Measuring Setup even when overloaded. It is therefore possible to measure noise levels right down to −90 dBm0p.
- *Suitability of the RS-25 for general measuring tasks:* The RST-25 000 Low-pass Filter is available as a Plug-in Unit for band-limiting so that the whole frequency range is useable up to 25 MHz. The RST-5000 Low-pass can be used for crosstalk measurements in the sound-programme channel of TV transmission systems.
- The *RE-25* can be extended to form the *GA-250 Noise Monitoring System* (see special specification sheet).



a) End-to-end measurements (RS and RE fitted with <IEC 625> interface)



b) Loop-back measurements (only the RE is fitted with <IEC 625> interface)

Ways of automating the RK-25 White Noise Measuring Setup

- *REBZ-25 Wideband Level Meter Unit:* The REBZ-25 is a self-adjusting, digital wideband level meter for the frequency range 6 kHz to 25 MHz, available as an auxiliary device, for retrofitting in the RE-25 White Noise Receiver. The measured result in the range −39.8 to +9.8 dBm is read out on a separate LED display. The REBZ-25 Wideband Level Meter Unit is connected at high impedance (bridged) to the input of the RE-25.
- *RSSA-50 Bandstop Adaptor:* Allows external Bandstops to be connected – in addition to those already in the Generator. It is accommodated in the RS-25 Generator instead of a Bandstop Plug-in.

Specifications of the White Noise Measuring Setup — RK-25

The technical specifications for the Plug-in Units, Band-Limiting Filters, Band Selection Filters, Bandstop Filters, Converters and Pilot-stop Filters, applied in the RK-25 White Noise Measuring Setup, are found in the Specification Sheet "Filters and Converter Plug-in Units".

Noise measurements referred to a 0 dBr point

Level display . . . . . digital
Resolution . . . . . 0.1 dB
Level scale switchable dBm0p, dBrnC0

Display range . . . . . −89.8 to −30.1 (−10.1) [1] dBm0p
or . . . . . 0.1 to 59.8 (79.8) [1] dBrnC0

Indication of range violation
at . . . . . ≦−89.9 and ≧−30.0 (−10.0) [1] dBm0p
or . . . . . ≦0.0 and ≧59.9 (79.9) [1] dBrnC0

Power indication . . . . . digital

Resolution . . . . . 3.3 % of measured value

Display range . . . . . 1 to $1 \cdot 10^6$ ($100 \cdot 10^6$) [1] pW

Relative level, p_r
Range of adjustment . . . . . −69.9 to −10.0 dBr

Display range for level check . . . . . −69.8 to −10.1 dBr
Indication of display range
limit violation at . . . . . ≦−69.9 and ≧−10.0 dBr

Error limits
of noise level display . . . . . ±1 dB

Intrinsic noise of measuring setup
for relative levels ≧−40 dBr,
up to an overload of 6 dB . . . . . ≦−85 dBm0p

Equivalent noise bandwidth
with psophometric weighting (dBm0p) . . . . . 1.74 kHz
with C-message weighting (dBrnC0) . . . . . 1.95 kHz

NPR measurements

Display . . . . . digital
Resolution . . . . . 0.1 dB

Range of display . . . . . 79.8 to 20.1 (0.1) [1] dB
Indication of range violation at . . . ≧79.9 and ≦20.0 (0.0) [1] dB

Reference
Alignment range for p_σ . . . . . −79.9 to −20.0 dBmp

Range of display for p_σ . . . . . −79.8 to −20.1 dBmp
Indication of range violation at . . ≦−79.9 and ≧−20.0 dBmp

Error limits
of the NPR display for p_σ ≧−70 dBmp . . . . . ±0.5 dB

Intrinsic NPR of the Measuring Setup
for a load in the measuring channel ≧−50 dBmp . . . . ≧75 dB

Recorder output

Open circuit voltage proportional to level display . . 5 V/60 dB
Output impedance . . . . . 5 kΩ

Send signal

Signal form . . . . . white noise
Probability distribution of the send signal v (t)
with the r.m.s. value V:
Standard distribution in range . . . . . −4 V ≦ v ≦ +4 V

Send level
adjustable in 1 dB steps . . . . . −50 to +5 dBm
(permissible attenuation of the switched-in band-stop filter combination: 12 dB)
with a 10 dB increase . . . . . −40 to +15 dBm
(permissible attenuation of the switched-in band-stop filter combination: 2 dB)
Vernier setting in 0.1 dB steps . . . . . 0 to −1 dB
Error limits of the send level . . . . . ±0.6 dB
Blanking, decrease in level . . . . . ≧40 dB

Signal connectors

Generator output, Receiver input . . . . . coaxial, 75 Ω

REBZ-25 Wideband Level Meter Unit

Level measurement . . . . . wideband
Frequency range . . . . . 6 kHz to 25 MHz

Signal weighting . . . . . r.m.s.
Peak factor for <1 dB compression . . . . . 17 dB

Level display . . . . . digital
Resolution . . . . . 0.1 dB
Measurement span,
without range changeover . . . . . −39.8 to +9.8 dBm

Error limits when REU is decoupled to maximum
for sinusoidal, squarewave, white noise at bandwidth >48 kHz,
in range 10 kHz to 25 MHz . . . . . ±0.5 dB

Analog output . . . . . linear with level
−40 to +10 dBm equivalent to . . . . . 0 to +5 V
Output impedance . . . . . 5 kΩ

Input . . . . . looped in the RE-25

1) Bracketed values are valid when the RE-25 is fitted with the 20 dB Measuring Range Extension Device.

General Specifications

Power supply
Nominal ranges of use of a.c. line voltage,
switchable . . 110/117/127/220/227/237 V, −15 %/+10 %
Nominal range of use of a.c. line frequency . . . . 45 to 66 Hz

Power consumption
White Noise Generator RS-25 . . . . . approx. 65 VA
White Noise Receiver RE-25 . . . . . approx. 30 VA
with "Noise Power Display" . . . . . approx. 40 VA
with "Noise Power Display" and
Wideband Level Meter Unit . . . . . approx. 55 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature
Nominal range of use
(≙ limits range of operation) . . . . . +5 to +40°C
Limits range for storage and transportation . . . −40 to +70°C

Dimensions in mm (RS-25 and RE-25)

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	478	Width	443
Height overall	199	Height (4 units)	176
Depth with handles	407	Depth	353

19" conversion kit . . . . . BN 556/00.04

Weights
RS-25, RE-25 . . . . . approx. 17 kg
RSB Band-limiting Filter . . . . . approx. 0.5 kg
RSS Bandstop Filter . . . . . approx. 0.5 kg
REU Converter Plug-in . . . . . approx. 0.9 kg

Ordering Information

White Noise Generator RS-25 * **BN 880/01**

White Noise Receiver RE-25 * **BN 863/01**

Band-limiting Filters RSB
Band Selection Filters RSBZ
Bandstop Filters RSS
Converter Plug-in Units REU
Pilot Stop Filters RSP
— see Specification Sheet "Filter and Converter Plug-in Units"

Low-pass Filters
RST-25000 (25 MHz) BN 8526/50
RST-5000 (5 MHz) BN 8528/50
RST-5000 (5 MHz and 7.5 MHz TV sound carrier stop) BN 8528/51

Option for the RS-25 (charged extra)
< IEC 625 > interface bus board BN 880/00.12
with IEEE 488 connector

Options for the RE-25 (charged extra)
Noise Power Display BN 863/00.07
< IEC 625 > interface bus board BN 863/00.12
with IEEE 488 connector
Wideband Level Meter Unit REBZ-25 BN 863/00.04
20 dB Measuring Range Extension Device BN 863/00.06

Accessories (charged extra)
IEEE 488/IEC 625 (m-m) S 832
for < IEC 625 > interface board
Bandstop Adapter RSSA-50 BN 674/01
(for connecting more external Bandstop Filters e.g. also for Bandstop Filters from the RK-5 White Noise Measuring Setup)

Timer RSI-50 BN 847/00
(for periodic blocking of Generator)

Impedance Matching Transformer 150 Ω bal./75 Ω coax. * [1]
in small casings BN 419/00.20
in RSS casings BN 419/00.22
in REU casings BN 419/00.23

Decoupling Transformer REÜ-4 [1] BN 464/02
Decoupling Transformer REÜ-56 * [1] BN 839/00.01
Decoupling Transformer REÜ-50 * [1] BN 839/00.02
Two-way Splitter REV-56 * [1] BN 839/00.03
Five-way Splitter RSV-50 * BN 849/50
(for group translator measurements) [2]
Test Probe TK-9 BN 265/00 [2]
Pre- and De-emphasis Networks see separate Spec. Sheet

Storage Case RSA-50 BN 407/01
(for 12 RS-Filters, including max. 9 Bandstop Filters for looping-through the Bandstop Adaptor RSSA-50)

Storage Case RSA-5 BN 412/00
(for Bandstop Filters of RK-5 White Noise Measuring Setup, including the Bandstop Filters through the Bandstop Adapter RSSA-50)

Storage Case RSK-50 BN 428/02
(for filters and converters not needed for measurements, holds 6 RS-Filters and 3 REU Converters)

Transport Case TPK-50
for Filters and Converters of the RK-25:
for 12 RS Filters BN 428/03
for 10 REU Plug-in Units BN 428/04
for 6 RS Filters and REU Plug-in Units BN 428/05

Protective Transportation Covers
DE-3 for RS-25, RE-25, RSA-50 or RSK-50 BN 476/00.03
DE-1 for RSA-5 BN 476/00.01

Noise Diagrams (in English) BN 6390/00.04
Noise Diagrams (in German) BN 6390/00.10

1) See the specification sheet "Measuring Accessories" for more details and extra Ordering Information.
2) See the technical information sheet "White Noise Tests of FMD-Group Translators", order no. 153.

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

GA-250
Noise Monitoring System

for radio-link systems having line-of-sight and trans-horizon capabilities



- **For long-term monitoring up to 8 radio-relay links**
- **Up to 6 different measuring channels**
- **One minute-mean value**
  Short-duration mean values (5 or 500 ms)
  Instantaneous value (0.1 ms)
- **Measured results protected against a.c. power dropout**
- **Formatted printout of results**
- **Immediate printout with time and date when tolerable upper noise limit is exceeded**

Applications

Noise measurements are used world-wide to determine the thermal and intermodulation noise on wideband cable, radio-link and satellite systems. However, only a particular, momentary system state is analysed and parameters such as fading and the long-term stability of transmission and reception equipment, especially important for satellite and radio-link systems, are not taken into account.
Long-term monitoring which takes account of noise criteria such as the minute mean value and the short-duration mean value are therefore essential. The transgression times for certain thresholds defined for these criteria should also be monitored.
The relevant CCIR Recommendations (Recs. 393-3 and 395-2 for line-of-sight radio-links and Rec. 397-3 for trans-horizon radio-links) define what limit values are to be monitored and the permissible transgression times. The monitoring period is stated as one month.

Characteristics

The GA-250 Noise Monitoring System has been designed to evaluate the CCIR criteria and is a development of the RE-25 White Noise Receiver, which has been expanded using the REGA-25 Noise Analyzer Plug-in. With the CU-85 Control Unit, it is possible to continuously monitor up to eight radio-links in a maximum of six measuring channels. If more than one circuit is to be monitored, the system can be expanded by one or two REW-25 Link Selectors.

The computer polls each of the measuring channels in turn and then analyses the minute mean-value results, stores and sums the transgression events and prints out the results as current state printouts, daily printouts or monthly final printouts.

Noise monitoring on FDM/FM radio-link systems complying with CCIR 393-3, 395-2 and 397-3
System components:
RE-25 White Noise Receiver
plus the REBZ-25 Wideband Level Meter Unit,
REGA-25 Noise Analyzer Plug-in
and REU-Converter Plug-ins
REW-25 Link Selector (for connecting several systems)
CU-85 Control Unit with screen and keyboard
for dialog mode.

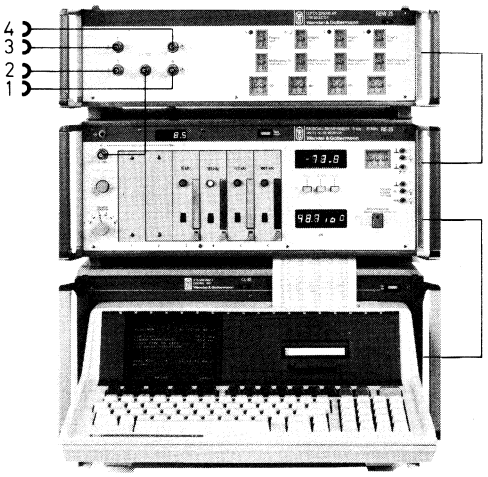
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Further Characteristics and Applications

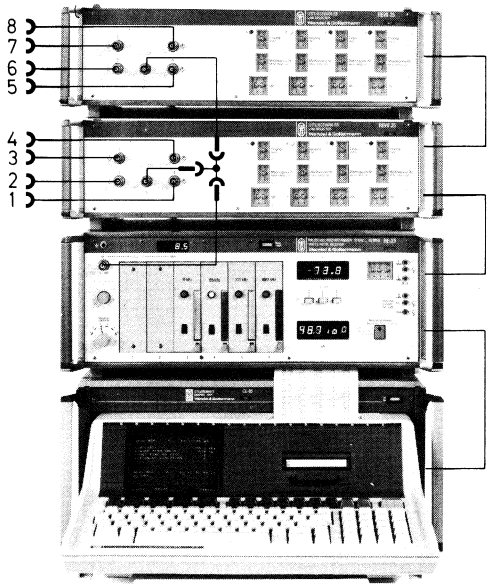
- Functions of the REGA-25 Noise Analyzer Plug-in accommodated in the RE-25 White Noise Receiver:
  - Measuring the one-minute mean noise power and transferring the value to the computer
  - Reporting the per minute threshold transgressions of the 5 ms or 500 ms mean power to the controller
  - Reporting the number of instantaneous value transgressions (0.1 ms) per minute to the controller
  - Generating the minute clock and transferring it to the computer
- Functions of the CU-85 Control Unit
  - Comparing the one minute mean power with the three stored limit values (line-length dependent one minute mean power and 47 500 pW0p one minute mean power or 63 000 pW0p one minute mean power for troposcatter systems).
  - Comparing threshold transgressions of the short-duration mean power with a selectable limit value
  - Comparing threshold transgressions of the 0.1 s mean power with an adjustable limit value
- Evaluation of the measurement results
  - Immediate printout when transgressions occur (e.g. minute mean power >47 500 pW0p or short-duration mean power >1 000 000 pW0)
  - Daily printout of the cumulative frequency of transgression events
  - Monthly final printout
- Standard software package for the GA-250:
  - Easy to operate, dialog mode
  - Measured results are evaluated and displayed as required by CCIR Recs.
  - Data retention in case of power failure
- Use of REW-25 Link Selector for monitoring several radio-link circuits:

	Circuits that can be monitored	Channels that can be monitored
Basic version	1	1 to 4
Basic version and 1 REW-25	4	1 to 4
Basic version and 2 REW-25s	8	1 to 6

- Matching to system specific parameters:
  Matching to the relative level of each of the systems to be monitored is accomplished with the REW-25 Link Selector
- Recording wideband levels
  The REBZ-25 Wideband Level Meter Unit takes account of variations in system loading with traffic during long-term monitoring
- Dual purpose RE-25 White Noise Receiver:
  During the alignment phase of a radio-link system the RE-25 and the RS-25 White Noise Generator form a "classic" White Noise Measuring Setup, later the RE-25 can be used for noise monitoring.



a) GA-250 monitoring 4 radio-link systems in 4 measuring channels



b) GA-250 monitoring 8 radio-link systems in 4 measuring channels

Possible stages of development for the GA-250 Noise Monitoring System

Specifications of Noise Monitoring System — GA-250

The basic version of the GA-250 System comprises the RE-25 White Noise Receiver, the CU-85 Control Unit, and a Software Package. The Basic System can be extended by the addition of two REW-25 Link Selectors. The specifications are a combination of the individual components' relevant specifications.

RE-25 White Noise Receiver [1)]

Frequency range . . . . . 10 kHz to 25 MHz
Intrinsic noise (for out-of-band channels, at level of conventional load) reduced to relative level p_r at the RE-25 input
with $p_r \geqq -40$ dBr . . . . . $\leqq -85$ dBm0p $\cong 3.2$ pW0p
with $p_r < -40$ dBr . . . . . $\leqq -125$ dBmp $- p_r$
Range of relative level p_r . . . . . -69.9 to -10.0 dBr

REBZ-25 Wideband Level Meter Unit

Frequency range . . . . . 6 kHz to 25 MHz
Measuring range (0.1 dB resolution) . -39.8 to $+9.8$ dBm

REGA-25 Noise Analyzer

Range of minute-mean value . . . . . 10^2 to 10^5 pW0p
Integration time . . . . . 1 min; 3 thresholds
Storage capacity for counting the number of transgressions . . . . 3 memories, each with 10^5

Range of short-duration mean value threshold
Switchable integration time
with 5 ms integration time . . . . . 1×10^4 to 15×10^5 pW0
with 500 ms integration time . . . . 1×10^3 to 15×10^5 pW0
Storage capacity for counting the number of transgressions . . . . . 10^{10}

Range of the instantaneous value threshold . . . . . 10 to 10^6 pW0p
0.1 ms increments are used for counting threshold transgressions.
Storage capacity for the number of events . . . . . 10^{10}

REW-25 Link Selector

Number of monitored circuits . . . . . up to 4
Circuits not switched-through to the RE-25 are terminated with 75 Ω
Coordination of relative level and REU Plug-in for each circuit is individually adjusted at the REW-25
Range of relative level p_r . . . . . -69 to -10 dBr
Choice of REU Plug-in Units . . . . . positions 1 to 6

CU-85 Control Unit

Components: CRT with 123 mm screen
tape cartridge drive unit
keyboard
thermal printer
Memory . . . . . 32 kbytes
CRT screen . . . . . 16 lines of 32 characters
Graphic resolution (CRT screen) . . . . . 196×256 pixels
Printer . . . . . 32 characters/line
Graphic resolution (Printer) . . . . . 196×256, 196×512, 196×768 etc.
Speed . . . . . >2 lines/s
Keyboard . . . . . typewriter keyboard and separate numerical keypad
four special function keys with dual action
Magnetic tape cassette, capacity . . . . . approx. 210 kbytes
BCD Interface
Multiple outlet with three mains receptacles

1) For more data see the Specification Sheet "RK-25 White Noise Measuring Setup"

General Specifications

Power supply
RE-25 White Noise Receiver
Rated ranges of use of a.c. line voltage, switchable . . . . . 110/117/127/220/227/237 V, $-15\%/+10\%$
Rated range of use of a.c. line frequency . . . . . 45 to 66 Hz

REW-25 . . . . . power supply from the RE-25

CU-85 Control Unit
Rated range of use of a.c. line voltage, switchable . . . . . 90 to 127 and 200 to 254 V
Rated range of use of a.c. line frequency . . . . . 47.5 to 63 Hz

Power consumption
RE-25 White Noise Receiver
with REGA-25 Plug-in . . . . . approx. 34 VA
with "noise power display" . . . . . approx. 44 VA
with "noise power display and Wideband Level Meter Unit" . . . . . approx. 50 VA
additional per REW-25 . . . . . approx. 4 VA

CU-85 Control Unit . . . . . approx. 40 VA

Tolerable ambient temperature
RE-25 with REGA-25 Plug-in, REW-25
Rated range of use (≅ limits operating range) . . . . . +5 to +40°C
Storage and transportation . . . . . −40 to +70°C

CU-85 Control Unit

Rated range of use . . . . . +5 to +40°C
Storage and transportation . . . . . −40 to +65°C

Dimensions in mm

RE-25 White Noise Receiver

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	478	Width	443
Height overall	199	Height (4 units)	176
Depth with handles	407	Depth	353

19" conversion kit . . . . . BN 556/00.04

REW-25 Link Selector

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	478	Width	443
Height overall	155	Height (3 units)	132
Depth with handles	407	Depth	353

19" conversion kit . . . . . BN 556/00.03

CU-85 Control Unit

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	244	Height (5 units)	220
Depth with handles	425	Depth	370

19" conversion kit . . . . . BN 700/00.05

Weights
RE-25 without REUs . . . . . approx. 13 kg
REU Converter Plug-ins . . . . . approx. 0.9 kg
REW-25 . . . . . approx. 6 kg
CU-85 . . . . . approx. 15 kg

Ordering Information

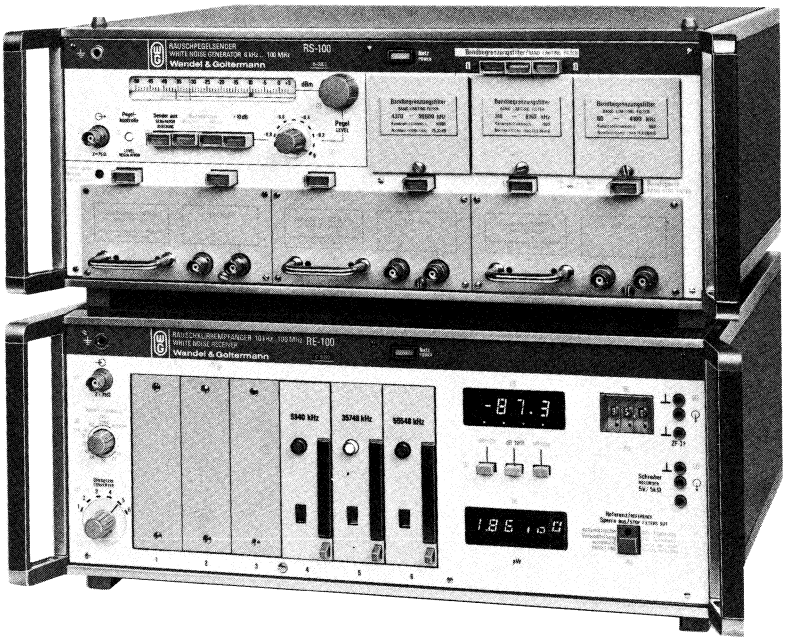
Noise Monitoring System GA-250 comprising RE-25* with REBZ-25 and REGA-25, CU-85 and the SWP-12 Software Package	**BN 6609/03**
Necessary for operation:	
Converter Plug-ins (at extra cost)	see Spec. Sheet "Filters and Converter Plug-ins"
Options (at extra cost)	
Noise power display for the RE-25	BN 863/00.07
Extension for monitoring several radio-link circuits (at extra cost)	
Link Selector REW-25* (for 4 circuits) [1]	BN 927/01
Accessories (at extra cost)	
Matching transformer 150 Ω bal./75 Ω coax.* [2]	
external transformer	BN 419/00.20
transformer in REU casing (Plug-in for RE-25)	BN 419/00.23
Decoupling Transformer REÜ-4* [2]	BN 464/02
Decoupling Transformer REÜ-56* [2]	BN 839/00.01
Decoupling Transformer REÜ-50* [2]	BN 839/00.02
Two-way Splitter REV-56* [2]	BN 839/00.03
Passive Test Probe TK-9 with coax. test item connector* [2]	BN 265/00
Transport Case TPK-50	
for 12 RS Filters	BN 428/03
for 10 REU Plug-ins	BN 428/04
for 6 RS Filters and 5 REU Plug-ins	BN 428/05
Bandstop Filters RSS* [3]	see Spec. Sheet "Filters and Converter Plug-ins"
Transport Case TPK-4 for RE-25	BN 626/10
TPK-3 for REW-25	BN 626/09
Protective Transportation Cover	
DE-3 for RE-25	BN 476/00.03
DE-2 for REW-25	BN 476/00.02

1) If two REW-25s are purchased up to 8 circuits can be monitored.
2) For more details and Ordering Information see the Spec. Sheet "Measuring Accessories".
3) For looping-in at the modulator input of the system to be monitored. It suppresses any noise.
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

RK-100
White Noise Measuring Setup

for noise and NPR measurements using noise bandwidths up to 100 MHz

IEEE 488
IEC 625



- **Suitable for all common FDM transmission systems**
- **Fully integrable in automatic test systems**
- **Comprehensive filter and converter plug-in unit program**
- **Measuring Setup's intrinsic noise ≦−85 dBm0p (≦−83 dBm0p at f >25 MHz)**
- **Device for checking the relative level**
- **Trend in results shown on LED bargraph**
- **Digital noise level and power display are standard features**

Applications

The RK-100 White Noise Measuring Setup, which has a range from 6 kHz to 100 MHz, is used for determining the transmission quality of:
- FDM land and submarine cable systems
- FM radio-link and satellite systems
- Single sideband AM radio-link systems.

White noise measurements are undertaken by:
- System manufacturers in their design laboratories and test departments
- Postal administrations and private operating companies during system commissioning, maintenance, and service
- Organizations that operate their own communication networks, e.g. utility companies supplying electricity and gas, oil companies, the armed services and railways.

A comprehensive range of filters and converters is available so that you can select the noise bands and measurement channels you require. In fact, all of the CCITT/CCIR and INTELSAT noise bands and measurement frequencies are taken into account.

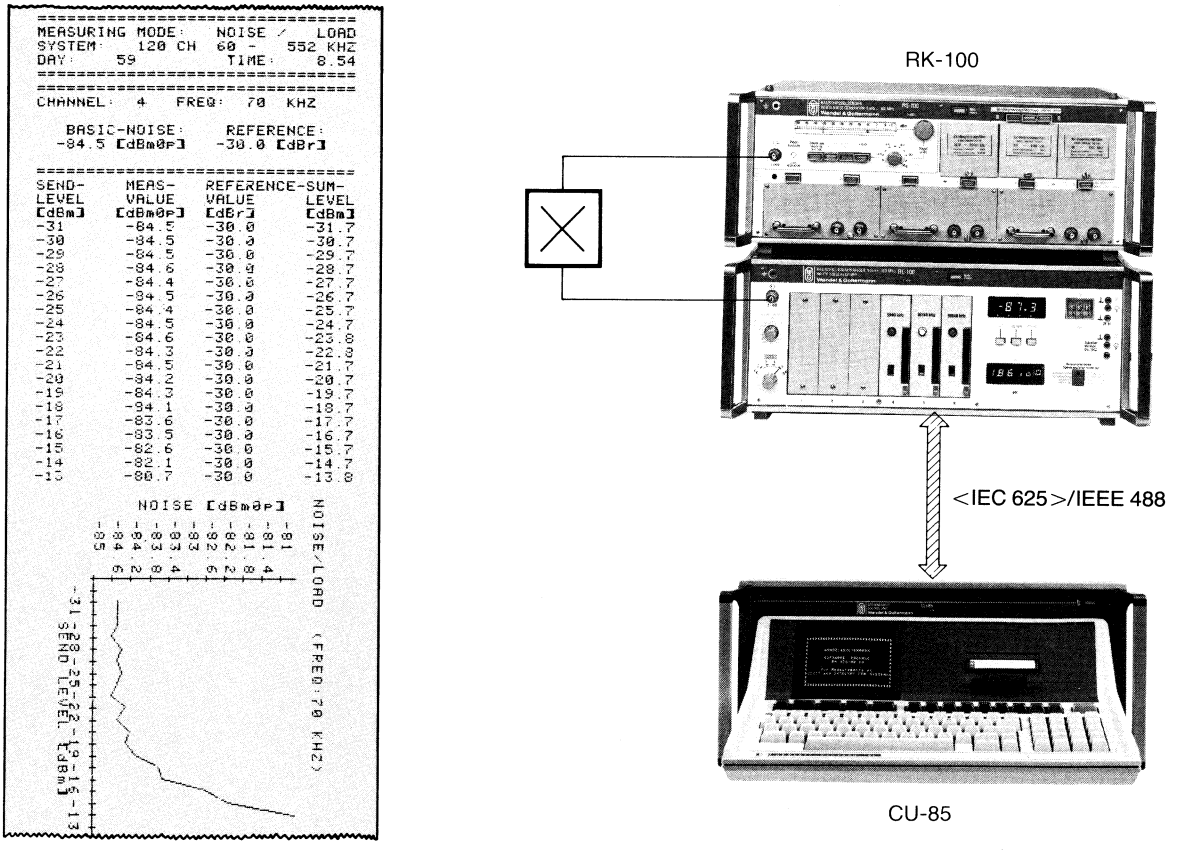
Characteristics

The RS-100 White Noise Generator accommodates three RSB Band-limiting Filters (max.) and six RSS Bandstop Filters (max.). The RE-100 White Noise Receiver accommodates six REU Converter Plug-in Units (max.). This wide range of filters makes the RK-100 highly versatile.
The main digital display of the Receiver is easy to read because the result is shown in a standard format. Noise levels can be read down to −89.9 dBm0p or 0.1 dBrnC0 and also NPR values up to 79.8 dB. A second digital display indicates noise power values to 1 x 10^6 pW.
Autoranging considerably facilitates the operation of the RK-100; extra effort was made to simplify the complexities of NPR measurements. The Bandstop Filters can be controlled from the Receiver if a control cable has been connected between Receiver and Generator.
The Measurement Setup can be controlled via the <IEC 625>/IEEE 488 Interface.

Frequency range	6 kHz to 100 MHz
Transmission signal	white noise
Transmission level	−50 to +13 dBm
Weighted noise measurements	
Display range	
for noise level	−89.8 to −30.1 dBm0p or 0.1 to 59.8 dBrnC0
for noise power	1 to 10^6 pW0p or pWC0
NPR measurements	
Display range	79.8 to 20.1 dB

Besides the already mentioned features of the RK-100 White Noise Measuring Setup, some additional features are noteworthy:

- *Trend indication of measured values*: Fast recognition of change in direction of measured results; LED array integrated into the digital display.
- *Simplified NPR measurement run*: Pressing a pushbutton on the RE-100 initiates the reference alignment (Bandstop Filter is switched out by control signal over cable), after about 6 s automatic-changeover to measurement alignment with display of NPR value; the reference alignment is also initiated by the send level changeover.
- *Relative level may be checked*: For noise measurements, after the reference pushbutton has been pressed, the actual relative level at the test point is displayed; thumbwheel switches allow the relative level to be set or corrected.
- *Bandstop Filters are controlled at the RE-100*: After a control cable has been connected between the RS-100 and the RE-100 the Receiver assumes control over the Bandstop Filters.
- *20 dB measurement range extension*: For applications that deal with high noise levels, an Option is available which permits the upper display range to be offset by 20 dB to −10.1 dBm0p or 79.8 dBrnC0 and 0.1 dB (NPR).
- *Setup's control facilities:* Control via <IEC 625>/IEEE 488 Bus; the interface cards are accommodated in the RE-100, the RS-100 is controlled from the RE-100.
- *Filter and Converter Plug-in product line*: Noise bands and measuring frequencies correspond to the newest CCITT/CCIR Recommendations; comprehensive list of available special filters, e.g. for submarine cable systems, small channel balanced systems, and USA systems, besides those for noise measurements on group translators (see Specification Sheet "Filter and Converter Plug-in Units"); all Plug-in Units can be easily exchanged.
- *Low intrinsic noise of the Measuring Setup*: The high stopband attenuation of ≧80 dB given by the Bandstop Filters (CCITT requirement: 70 dB) ensures very low intrinsic noise in the Measuring Setup even when overloaded; it is therefore possible to measure noise levels right down to −90 dBm0p.
- *Suitability of the RS-100 for general measuring tasks*: The RST-100 000 Low-pass Filter is available as a Plug-in Unit for band-limiting so that the whole frequency range is useable up to 100 MHz; the typical 3 dB bandwidth of the Generator (without band-limiting) is 120 MHz.
  The RST-500 Low-pass can be used for crosstalk measurements in the sound-programme channel of TV transmission systems. (Ask for a separate RS-100 Specification Sheet).
- *Automatic alignment of the pass-band attenuation in the Bandstop Filters*: The controlling variable for the automatic transmission level control is first obtained after the Bandstop Filters, so that an automatic alignment of the loading loss results when the Bandstop Filters are switched in; the atten-



Computer-controlled RK-100 White Noise Measuring Setup

uator is automatically adjusted so that a favourable load can be applied to the Bandstop Filters, thus distortion in the Bandstop Filters is avoided.

- *Indispensable measuring accessories*: Transformers for Matching and Decoupling, Test Probes, Multi-way Splitters, Pilot Stop Filters, Pre- and De-emphasis networks etc.

Specifications of the White Noise Measuring Setup — RK-100

The technical specifications for the Plug-in Units used in the RK-100 White Noise Measuring Setup, i.e. Band-limiting Filters, Band Selection Filters, Bandstop Filters, Converters and Pilotstop Filters, are found in the specification sheet "Filters and Converter Plug-in Units".

Noise measurements referred to a 0 dBr point

Level display . . . . . digital
Resolution . . . . . 0.1 dB
Level scale switchable dBm0p, dBrnC0

Display range . . . . . −89.8 to −30.1 (−10.1) [1] dBm0p
or . . . . . 0.1 to 59.8 (79.8) [1] dBrnC0

Out-of-range
indication at . . . . . ≦−89.9 and ≧−30.0 (−10.0) [1] dBm0p
or . . . . . ≦0.0 and ≧59.9 (79.9) [1] dBrnC0

Power display . . . . . digital
Resolution . . . . . 3.3 % of measured value
Display range . . . . . 1 to 10^6 ($100 \cdot 10^6$) [1] pW

Relative level, p_r
Range of adjustment . . . . . −69.9 to −10.0 dBr
Display range of checking . . . . . −69.8 to −10.1 dBr
Out-of-range indication at . . . . . ≦−69.9 and ≧−10.0 dBr

Error limits
of noise level display . . . . . ±1 dB

Intrinsic noise of measuring setup
for relative levels ≧−40 dBr with an overload of up to 6 dB
in measuring channels ≦25 MHz . . . . . ≦−85 dBm0p
in measuring channels >25 MHz . . . . . ≦−83 dBm0p

NPR measurements

Level difference measurements
receive partial loading level p_σ – noise level p_N

Display . . . . . digital
Resolution . . . . . 0.1 dB

Range of display . . . . . 79.8 to 20.1 (0.1) [1] dB
Out-of-range indication at . . . . . ≧79.9 and ≦20.0 (0.0) [1] dB

Reference
Alignment range for p_σ . . . . . −79.9 to −20.0 dBmp
Range of display for p_σ . . . . . −79.8 to −20.1 dBmp
Out-of-range indication at . . . . ≦−79.9 and ≧−20.0 dBmp

Error limits
of the NPR display for p_σ ≧−70 dBmp . . . . . ±0.5 dB

Intrinsic NPR of the Measuring Setup

Receive partial load p_σ	<−50 dBmp	≧−50 dBmp
For measuring channels ≦25 MHz	≧p_σ +125 dB	≧75 dB
For measuring channels >25 MHz	≧p_σ +123 dB	≧73 dB

1) The values in brackets apply when the 20 dB measurement range extension is fitted (Option).

Equivalent noise bandwidth of receive noise

with psophometric weighting (dBm0p) . . . . . 1.74 kHz
with C-message weighting (dBrnC0) . . . . . 1.95 kHz

Recorder output

Open circuit voltage proportional to level reading . . 5 V/60 dB
Output impedance . . . . . 5 kΩ

Transmission signal

Signal shape . . . . . white noise
Probability distribution of the send signal v (t)
with the r.m.s. value of V:
Gaussian distribution in range . . . . . −4 V ≦ v ≦ +4 V

Transmission level p_Σ
coarse settings in 1 dB steps

	Level p_Σ	Tolerable pass-band attenuation for the switched-in Bandstop Filters
Normal	−50 to +3 dBm	10 dB
With 10 dB increase	−40 to +13 dBm	+13 dBm $-p_\Sigma$; max. 10 dB

Fine settings in 0.1 dB steps . . . . . −0.9 to 0 dB
Level blanking, level drop . . . . . ≧40 dB

Signal connectors

Generator output, Receiver input . . . . . coaxial, 75 Ω
basic connector Versacon® 9

General Specifications

Power supply
Nominal ranges of use of a.c. line voltage,
selectable . . . . . 110/117/127/220/227/237 V,
−15 %/+10 %
Nominal range of use of a.c. line frequency . . . . 45 to 66 Hz

Power consumption
White Noise Generator RS-100 . . . . . approx. 55 VA
White Noise Receiver RE-100 (with REUs) . . . approx. 40 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature
Nominal range of use
(≅ limits range of operation) . . . . . +5 to +40°C
Storage and transport . . . . . −40 to +70°C

Dimensions in mm (valid for RS-100 and RE-100)

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	478	Width	443
Height overall	199	Height (4 units)	176
Depth with handles	407	Depth	353

19" conversion kits (one for each Main Frame) . . . . . BN 556/00.04

Weights

White Noise Generator RS-100 (without RSB and RSS) . . . . . approx. 13 kg
White Noise Receiver RE-100 (without REU) . . approx. 13 kg
Band-limiting Filter RSB . . . . . approx. 0.5 kg
Bandstop Filter RSS, single width . . . . . approx. 0.5 kg
Bandstop Filter RSS, double width . . . . . approx. 1 kg
Converter Plug-in Unit REU . . . . . approx. 0.9 kg

Ordering Information

White Noise Generator RS-100 * [1] **BN 915/01**

White Noise Receiver RE-100 * **BN 863/02**

Band-limiting Filters RSB
Band Selection Filters RSBZ
Bandstop Filters RSS
Converter Plug-in Units REU
Pilot Stop Filters RSP
} see spec. sheet "Filter and Converter Plug-in Units"

Low-passes
Low-pass Filter RST-5000 (5 MHz) BN 8528/50
Low-pass Filter RST-5000 (5 MHz with 7.5 MHz TV sound carrier stop) BN 8528/51
Low-pass Filter RST-100 000 (100 MHz) BN 8527/50

Options for RE-100 (charged extra)
20 dB Measuring Range Extension Device BN 863/00.06
< IEC 625 > Interface Bus Board BN 863/00.12
with IEEE 488 connector

Accessories (charged extra)
Adaptor IEEE 488/IEC 625 (m-m) S 832
for < IEC 625 > Interface Board
Bandstop Adapter RSSA-100 BN 674/02
(for connecting more external Bandstop Filters e.g. also for Bandstop Filters from the RK-5 White Noise Measuring Setup)

Timer RSI-50 BN 847/00
(for periodic blocking of Generator)

Impedance Matching Transformer 150 Ω bal./75 Ω coax. * [2]
in small casings BN 419/00.20
in RSS casings BN 419/00.22
in REU casings BN 419/00.23

Decoupling Transformer REÜ-4 [2] BN 464/02
Decoupling Transformer REÜ-56 * [2] BN 839/00.01
Decoupling Transformer REÜ-50 * [2] BN 839/00.02

Two-way Splitter REV-56 * [2] BN 839/00.03
Five-way Splitter RSV-50 * [3] BN 849/50
(for measurements on group translators)

Test Probe TK-9 * [2] BN 265/00

Pre- and De-emphasis Networks see separate Spec. Sheet

Storage Case RSA-50 BN 407/01
(for 12 RS Filters; looping-through a max. of nine Bandstop Filters via Bandstop Adaptor RSSA-100)

Storage Case RSA-5 BN 412/00
(for Bandstop Filters of RK-5 White Noise Measuring Setup, including the Bandstop Filters looping through the Bandstop Adaptor RSSA-100)

Storage Case RSK-50 BN 428/02
(for filters and converters not needed temporarily, holds 6 RS-Filters and 3 REU Converters)

Transport Case TPK-50
for Filters and Converters of the RK-100:
for 12 RS Filters BN 428/03
for 10 REU Plug-in Units BN 428/04
for 6 RS Filters and 5 REU Plug-in Units BN 428/05

Protective Transportation Covers
DE-3 for RS-100, RE-100, RSA-50 and RSK-50 BN 476/00.03
DE-1 for RSA-5 BN 476/00.01

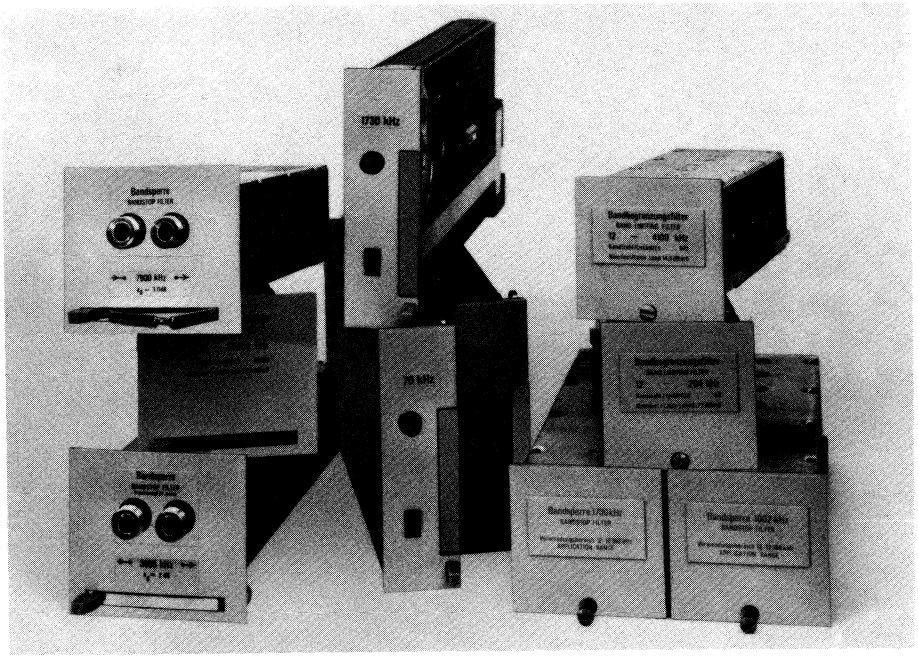
Noise Diagrams (in English) BN 6390/00.04
Noise Diagrams (in German) BN 6390/00.10

1) A separate spec. sheet is available.
2) For detailed data and further ordering information, see Specification Sheet, "Measuring Accessories".
3) For more information see the Technical Information Booklet "White Noise Tests of FDM-Group Translators" (Order No. 153).

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

Filter and Converter Plug-in Units

Supplement to the Specification Sheets for White Noise Measuring Setups



- **Complete Filter and Converter Plug-in Unit program**
- **Filter specifications according to CCITT/CCIR Recommendations**
- **Plug-in Units save time and money**
- **Future efficiency assured by modular units**

Applications

The W & G Filter and Converter Plug-in Unit program for carrying out white noise measurements with our White Noise Measuring Setup range (RK-50, RK-25, RK-60 and RK-100) comprise the following:

- Band Limiting Filters RSB and Band Selection Filters RSBZ
- Bandstop Filters RSS
- Converter Plug-in Units REU
- Pilot Stop Filters RSP

First and foremost these filters cover all the noise bands and measurement frequencies recommended by CCITT, CCIR and INTELSAT, but there is also a wide variety of Filters and Converter Plug-in Units for special applications – e.g. submarine cable systems, balanced small channel systems and domestic satellite systems. To make filter choice easier, all the CCITT/CCIR noisebands and measurement frequencies are shown in Table 1, as are the pertinent Recommendations.

Characteristics

The Band Limiting Filter RSB limits the band of the white noise representing the substitute loading signal, and the Bandstop Filter RSS, by causing a deep, selective lowering of the noise power density, forms the measuring channels in which the noise is to be acquired. A Converter Plug-in Unit REU converts a measuring channel into a fixed lower frequency (IF) channel and then, in conjunction with the IF filter of the main frame, a fixed, sharply limited, low-noise receive channel is formed whose excellent characteristics remain the same – even when high overloads appear at the receiver input.
In the usual case, these measuring channels lie within the band of the loading signal (in-band-measurement). But out-of-band measurements are also possible. These are made to monitor or surveil the system noise while the system is actually carrying traffic. In this situation, a Bandstop Filter RSS is employed in the system to define the notch cut out of the noise loading signal being surveilled.

Specifications and Ordering Information

Band Limiting Filters RSB . . . . . Table 2
Bandstop Filters RSS for in-band applications, Converter Plug-in Units REU . . . . . Table 3
Bandstop Filters RSS for out-of-band applications . . . . . Table 4
Band Selection Filters RSBZ . . . . . Table 5
Pilot Stop Filter RSP . . . . . Table 6

Table 1 CCITT/CCIR and INTELSAT Noise Bands and Measuring Frequencies

System Mode	System Channels	Noise band (effective corner frequencies of band limiting filter in kHz)		Recommended measuring frequencies (center frequencies of bandstop and converter plug-in units, in kHz) In-band measurement							Out-of-band measurement		
Balanced	12	6 to 54		16									
	12	6 to 60		16	57								
	24	6 to 108		16	57	98							
	12	12 to 60		16	57								
	24	12 to 108		16	57	98							
	60	12 to 252		16	57	98	230				10	119	to CCIR Rec. 398-3, 1974
	120	12 to 552		16	57	98	270	534			10	331[1]	
											10	600	
Coaxial	12	12 to 60	to CCIR Rec. 482-1, 1978 and INTELSAT SSOG, Vol. II	16	56					to CCIR Rec. 482-1, 1978 and INTELSAT SSOG. Vol. II			
	24	12 to 108		16	98								
	36	12 to 156		16	140								
	48	12 to 204		16	185								
	60	12 to 252		16	240								
	72	12 to 300		16	270								
	96	12 to 408		16	240	394							
	132	12 to 552		16	240	534							
	192	12 to 804		16	394	770							
	252	12 to 1052		16	534	1002							
	312	12 to 1296		16	534	1248							
	372	12 to 1548		16	534	1002	1490						
	432	12 to 1796		16	534	1002	1730						
	492	12 to 2044		16	534	1248	1940						
	552	12 to 2292		16	770	1730	2150						
	612	12 to 2600		16	770	1730	2438						
	792	12 to 3284		16	1002	2438	3150						
	972	12 to 4100		16	1002	2438	3886						
	1092	12 to 4892		70	1002	2438	4650						
	1332	12 to 5884		70	1002	3150	4650	5340					
	1872	12 to 8160		70	1002	3150	5340	7600					
	60	60 to 300	to CCITT Rec. G.228, 1976 or CCIR Rec. 399-3, 1978	70	270					to CCITT Rec. G. 228, 1976 or CCIR Rec. 399-3, 1978	50	331	to CCIR Rec. 398-3, 1974
	120	60 to 552		70	270	534					50	600	
	300	60 to 1296		70	270	534	1248				50	1549	
	600	60 to 2600		70	270	534	1248	2438			50	3200	
	960	60 to 4100		70	270	534	1248	2438	3886		50	4715	
	1260	60 to 5600		70	270	534	1248	2438	3886	5340	50	6300	
	900	316 to 4100		534	1248	2438	3886				270	4715	
	1200	316 to 5600		534	1248	2438	3886	5340			270	6300	
	1800	316 to 8160		534	1248	2438	3886	5340	7600		270	9073	
	2700	316 to 12360		534	1248	2438	3886	5340	7600	11700	270	13677	
	3600[2]	316 to 17300		534	770	1248	2438	3886	5340	7600			
	10800	4370 to 59600		11700	16400								
				5340	11700	(26948)[3]	35748	55548					
Basic group		61 to 107	to CCITT G.230, 1976	70	98					to CCITT G.230, 1976			
Basic supergroup		312 to 546		331	534								
Basic mastergroup		840 to 2004		1002	1248	1730							
Basic arrangement for 15 supergroups		320 to 4070		534	1248	1730							
Bas. sup. mastergroup		8560 to 12250		9073	11700								

1) A value deviating from the CCIR-Recommendation.
2) Preliminary values suggested by CCITT.
3) No CCITT filter specification available! Substitute, e.g. 27 300 kHz

Other filter types solve special measurement problems: thus a Pilot Stop Filter RSP can prevent a change in the automatic level control if a component of the loading signal appears in the pilot channel. A Band Selection Filter RSBZ produces in the stopped -band such a sharp drop in the noise power density that white noise measurements on group translators can be made under the conditions of by-passing the group through-connected filters.

Plug-in Unit dimensions

The size of the enclosures for the various types of Plug-in Units in the generator is unified. Different front panel dimensions are necessary because the latching mechanism on filters for the White Noise Generator RS-5 is different to that on the filters for the RS-100, RS-50 or the RS-25.

Some Bandstop Filters, owing to their circuit configuration, are placed in double width enclosures. A part of these filters is equipped with front panels for employment in the White Noise Generator RS-5 only. However, these Bandstops cannot be plugged into White Noise Generators RS-100, RS-50 and RS-25: but the Bandstop Filter Adaptor RSSA-50 or RSSA-100 resp. provides the opportunity for the connections. The other part of Bandstop Filters with double width enclosures can be ordered with both front panel versions. The enclosure dimensions of the Bandstop Filters are listed in Tables 3 and 4. The Converter Plug-in Units are universally applicable in White Noise Receivers RE-50, RE-25, RE-100 and RE-5.

Ordering Information

The order numbers of the Filter and Converter Plug-in Units are listed in Tables 2 to 6. Two different order numbers are given for each filter type in the table; the first number is for the RS-5 White Noise Generator, the second for the RS-100, RS-50 or RS-25. Only high frequency Plug-in Units compatible with the frequency band of the Main Frame can be used. Some Bandstop Filters are available in several versions to permit a choice depending on the range of application or the effective stop-band width.

Out-of-band bandstop filters can be employed for measurements while the system is actually carrying traffic (Table 4). In this case the bandstop filters are looped into the signal paths of the CF multiplex signals carried on coaxial cables. For that reason the connectors at the ports of the bandstop filters are equipped with Versacon® 9 adaptor system fittings and can be adapted to any of the different types of connector usually found in commercial use. The type of connector required should be stated when an order is made.

Table 2 Band-Limiting Filters RSB

Band Limiting Filters Type	System channel count	Noise band effective limits f_l and f_u kHz	Tolerance for effective band limits Lower kHz	Upper kHz	Flat range kHz	Order Number RSB for RS-5	RSB for RS-50, RS-25 and RS-100
RSB-6/32	6	6 to 32	±0.1	±0.3	8.5 to 31	BN 8599/00	BN 8599/50
RSB-6/36	6	6 to 36	±0.1	±0.4	8.5 to 35	BN 8597/00	BN 8597/50
RSB-12/44	8	12 to 44	±0.2	±0.4	13 to 40	BN 8598/00	BN 8598/50
RSB-6/54	12	6 to 54	±0.1	±0.4	8.5 to 52	BN 8530/00	BN 8530/50
RSB-6/60	12	6 to 60	±0.1	±0.4	8.5 to 58	BN 8531/00	BN 8531/50
RSB-12/60	12	12 to 60	±0.2	±0.4	13 to 58	BN 8546/00	BN 8546/50
RSB-60/108	12	60 to 108	±1	±0.8	68 to 100	BN 8547/00	BN 8547/50
RSB-6/108	24	6 to 108	±0.1	±0.8	8.5 to 100	BN 8556/00	BN 8556/50
RSB-12/108	24	12 to 108	±0.2	±0.8	13 to 100	BN 8532/00	BN 8532/50
RSB-12/156	36	12 to 156	±0.2	±1	13 to 142	BN 8572/00	BN 8572/50
RSB-12/204	48	12 to 204	±0.2	±1.5	13 to 187	BN 8591/00	BN 8591/50
RSB-12/252	60	12 to 252	±0.2	±2	13 to 242	BN 8533/00	BN 8533/50
RSB-60/300	60	60 to 300	±1	±2.5	68 to 272	BN 8535/00	BN 8535/50
RSB-300/552	60	300 to 552	±5	±4	329 to 536	BN 8588/00	BN 8588/50
RSB-316/552	60	316 to 552	±5	±4	340 to 536	BN 8548/00	BN 8548/50
RSB-12/300	72	12 to 300	±0.2	±2.5	13 to 272	BN 8573/00	BN 8573/50
RSB-24/264	80	24 to 264	±0.4	±2	54 to 242	BN 8593/00	BN 8593/50
RSB-12/408	96	12 to 408	±0.2	±3	13 to 396	BN 8559/00	BN 8559/50
RSB-108/504	96	108 to 504	±1.8	±4	138 to 396	BN 8594/00	BN 8594/50
RSB-660/1052	96	660 to 1052	±12	±7	768 to 1004	BN 8595/00	BN 8595/50
RSB-60/552	120	60 to 552	±1	±4	68 to 536	BN 8536/00	BN 8536/50
RSB-312/804	120	316 to 804	±5	±6	392 to 772	BN 8589/00	BN 8589/50
RSB-12/552	120/132	12 to 552	±0.2	±4	13 to 536	BN 8534/00	BN 8534/50
RSB-12/708	168	12 to 708	±0.2	±5	13 to 602	BN 8514/00	BN 8514/50
RSB-12/804	192	12 to 804	±0.2	±6	13 to 772	BN 8560/00	BN 8560/50
RSB-60/1052	240	60 to 1052	±1	±7	68 to 1004	BN 8549/00	BN 8549/50
RSB-12/1052	252	12 to 1052	±0.2	±7	13 to 1004	BN 8561/00	BN 8561/50
RSB-60/1296	300	60 to 1300	±1	±8	68 to 1250	BN 8537/00	BN 8537/50
RSB-308/1552	300	308 to 1552	±5	±10	392 to 1250	BN 8575/00	BN 8575/50
RSB-812/2044	300	812 to 2044	±10	±14	1246 to 1942	BN 8566/00	BN 8566/50
RSB-12/1296	312	12 to 1300	±0.2	±8	13 to 1250	BN 8574/00	BN 8574/50
RSB-12/1452	348	12 to 1452	±0.2	±9	13 to 1250	BN 8515/00	BN 8515/50
RSB-12/1548	372	12 to 1548	±0.2	±10	13 to 1492	BN 8517/00	BN 8517/50
RSB-12/1796	432	12 to 1796	±0.2	±12	13 to 1732	BN 8562/00	BN 8562/50
RSB-60/2044	480	60 to 2044	±1	±14	68 to 1942	BN 8587/00	BN 8587/50
RSB-316/2292	480	316 to 2292	±5	±17	392 to 2152	BN 8555/00	BN 8555/50
RSB-12/2044	492	12 to 2044	±0.2	±14	13 to 1942	BN 8518/00	BN 8518/50
RSB-12/2292	552	12 to 2292	±0.2	±17	13 to 2152	BN 8571/00	BN 8571/50
RSB-60/2600	600	60 to 2600	±1	±20	68 to 2440	BN 8538/00	BN 8538/50
RSB-12/2600	612	12 to 2600	±0.2	±20	13 to 2440	BN 8563/00	BN 8563/50
RSB-12/3284	792	12 to 3284	±0.2	±24	13 to 3152	BN 8564/00	BN 8564/50
RSB-12/3532	852	12 to 3532	±0.2	±25	13 to 3202	BN 8516/00	BN 8516/50
RSB-316/4100	900	316 to 4100	±5	±30	532 to 3888	BN 8540/00	BN 8540/50
RSB-8516/12360	900	8516 to 12360	±200	±100	9071 to 12000	BN 8568/00	BN 8568/50
RSB-60/4100	960	60 to 4100	±1	±30	68 to 3888	BN 8539/00	BN 8539/50
RSB-12/4100	972	12 to 4100	±0.2	±30	13 to 3888	BN 8565/00	BN 8565/50
RSB-12/4892	1092	12 to 4892	±0.2	±38	13 to 4652	BN 8570/00	BN 8570/50
RSB-316/5600	1200	316 to 5600	±5	±50	532 to 5342	BN 8542/00	BN 8542/50
RSB-60/5600	1260	60 to 5600	±1	±50	68 to 5342	BN 8541/00	BN 8541/50
RSB-12/5884	1332	12 to 5884	±0.2	±52	13 to 5342	BN 8583/00	BN 8583/50
RSB-316/6016	1380	316 to 6016	±5	±53	532 to 5342	BN 8579/00	BN 8579/50
RSB-316/7284	1500	316 to 7284	±5	±67	532 to 6902	BN 8585/00	BN 8585/50
RSB-316/8160	1800	316 to 8160	±5	±75	532 to 7602	BN 8543/00	BN 8543/50
RSB-12/8160	1872	12 to 8160	±0.2	±75	13 to 7602	BN 8558/00	BN 8558/50
RSB-316/10164	2100	316 to 10164	±5	±80	532 to 9626	BN 8580/00	BN 8580/50
RSB-316/11404	2400	316 to 11404	±5	±90	532 to 10914	BN 8578/00	BN 8578/50
RSB-812/11464	2580	812 to 11464	±10	±90	1000 to 9626	BN 8586/00	BN 8586/50
RSB-316/12360	2700	316 to 12360	±5	±100	532 to 11702	BN 8544/00	BN 8544/50
RSB-4332/17300	3000	4332 to 17300	±70	±150	5200 to 16400	BN 8513/00	BN 8513/50
RSB-316/17300	3600	316 to 17300	±5	±150	532 to 16402	BN 8596/00	BN 8596/50
RSB-1900/19000	3600	1900 to 19000	±30	±150	2436 to 18000	BN 8581/00	BN 8581/50
RSB-27200/44300	3600	27200 to 44300	±150	±150	29500 to 42000	BN 8582/00	BN 8582/50
RSB-4370/59600	10800	4370 to 59600	±70	±600	5338 to 55553	BN 8590/00	BN 8590/50
RSB-3252/64908	13200	3252 to 64908	±70	±800	3884 to 62155	BN 8592/00	BN 8592/50

Table 3 Bandstop Filters RSS for in-band applications, Converter Plug-ins REU

Bandstop Filter Type	Measuring channel kHz	Range of application kHz	Eff. stop-band width kHz	Attenuation curve <0.5 dB Δf/kHz	<3 dB Δf/kHz	>3 dB Δf/kHz	>30 dB Δf/kHz	>50 dB Δf/kHz	>55 dB Δf/kHz	>70 dB (CCITT/ CCIR) Δf/kHz	>75 dB (W & G) Δf/kHz	>80 dB (W & G) Δf/kHz
RSS-10	9.24	6 to 552	4.7	±2.8	±2.5	—	±1.9	±1.76	±1.66	—	—	±1.5
RSS-14	14	6 to 552	10.1	±6.5	±6	—	±3.0	—	±2.0	—	—	±1.5
RSS-16	16	6 to 4100	9.6	±7	±5	—	±2.7	—	±2.1	—	—	±1.5
RSS-34	34	6 to 4100	7.9	±10	±4.5	—	±2	—	±1.8	—	—	±1.5
RSS-50	50	6 to 8160	12.3	±10	±7.5	—	—	±2.2	—	—	—	±1.5
RSS-56	56	6 to 5600	8.7	±10	±5	—	±2.5	—	±2.0	—	—	±1.5
RSS-57	57	6 to 2600	8.7	±7	±5	—	±2.5	—	±2.0	—	—	±1.5
RSS-70	70	6 to 8160	15.4	±13	±12	—	±3.5	—	±2.2	—	—	±1.5
RSS-70	70	6 to 8160	8.1	±10	±5	—	±2.0	—	±1.7	—	—	±1.5
RSS-98	98	6 to 5600	7.7	±8	±4	—	±2.5	—	±2.0	—	—	±1.5
RSS-119	119	6 to 8160	14	+21/−11	±8	—	—	±2.6	—	—	—	±1.5
RSS-140	140	12 to 8160	7.7	±14	±5	—	±2.2	—	±1.8	—	—	±1.5
RSS-185	185	6 to 8160	10.1	±15	±5	—	±2.2	—	±1.8	±1.5	—	—
RSS-230	230	12 to 12360	21.6	±25	±12	—	±4.0	—	±2.5	—	—	±1.5
RSS-240	240	12 to 8160	10.6	±20	±5	—	±2.5	—	±1.9	±1.5	—	—
RSS-270	270	12 to 5600	16.2	±19	±8	—	±2.9	—	±2.3	—	—	±1.5
RSS-270	270	12 to 12360	29	±50	±17	—	—	±3.35	—	—	—	±1.5
RSS-331	331	12 to 12360	31	±30	±17	—	±6.0	±3.66	±3.0	—	—	±1.5
RSS-394	394	12 to 8160	22.4	±35	±11	—	±4.7	—	±2.9 (±3.0)	—	—	±1.5
RSS-534	534	12 to 17300	33	±36	±15	—	±7.0	—	±3.5	—	—	±1.5
RSS-600	600	12 to 8160	61	±50	±35	—	—	±5.0	—	—	—	±1.5
RSS-770	770	12 to 17300	43	±70	±21	—	±8.7	—	±3.8	—	—	±1.5
RSS-1002	1002	12 to 12360	58	±90	±29 (±27)	—	±10	—	±4.0	—	—	±1.5
RSS-1248	1248	12 to 17300	62	±70	±35	—	±11	—	±4.0	—	—	±1.5
RSS-1490	1490	6 to 12360	70	±135	±42	—	±12	—	±4.1	—	—	±1.5
RSS-1549	1549	12 to 12360	205	±350	±110	—	—	±9.75	—	—	—	±1.5
RSS-1730	1730	12 to 12360	100	±155	±46	—	±14	—	±4.3	—	—	±1.5
RSS-1940	1940	6 to 12360	110	±175	±52	—	±15	—	±4.3	—	—	±1.5
RSS-2150	2150	6 to 12360	120	±195	±55	—	±17	—	±4.4	—	—	±1.5
RSS-2438	2438	12 to 17300	129	±188	±60	—	±19	—	±4.5	—	—	±1.5
RSS-3150	3150	12 to 25000	173	±285	±85	—	±24	—	±9.0	—	—	±1.5
RSS-3200	3200	12 to 12360	327	±450	±200	—	—	±18	—	—	—	±1.5
RSS-3886	3886	12 to 17300	244	±280	±110	—	±30	—	±15	—	—	±1.5
RSS-3886	3886	12 to 12360	14	+264/ −110 (±100)	±12	±7.5 (±8.0)	±3.5	—	±1.8	—	—	±1.5
RSS-4650	4650	12 to 12360	17	±120	±13	±7.0 (±8.5)	±3.8	—	±2.0	—	—	±1.5
RSS-4715	4715	12 to 12360	458	±500	±250	—	—	±25.6	—	—	—	±1.5
RSS-5340	5340	12 to 17300	15	+200/ −140 (±150)	±14	±8.0 (±8.5)	±4.0	—	±2.2	—	—	±1.5
RSS-5340	5340	12 to 100000	21.3	±150	±14	±8.5	±4.0	—	±2.2	—	—	±1.5
RSS-6300	6300	12 to 17300	343	±1000	±350	—	—	±33.5	—	—	—	±1.5
RSS-7600	7600	12 to 17300	20	±200	±16	±9.5	±4.6	—	±2.4	—	—	±1.5
RSS-9073	9073	316 to 30000	877	±1000	±500	—	—	±47.5	—	—	—	±1.5
RSS-9073	9073	316 to 17300	21	±233	±18	±10	±5.8	—	±2.7	—	—	±1.5
RSS-11700	11700	316 to 30000	33	±300	±20	±11	±7.0	—	±3.0	—	—	±1.5
RSS-11700	11700	316 to 60000	28	±300	±20	—	±7.0	—	±3.0	—	—	±1.5
RSS-13677	13677	316 to 30000	932	±1850	±500	—	—	±70	—	—	±1.5	—
RSS-16400	16400	316 to 30000	41	±500	±30	±14	±9	—	±4	—	—	±1.5
RSS-27300	27300	316 to 60000	200	±2800	±100	—	±9	—	±7	—	—	±1.5
RSS-35748	35748	316 to 100000	28.2	±150	±20	±5.0	±3.5	—	±2.2	±1.8	—	±1.5
RSS-43762	43762	316 to 60000	250	±4400	±90	—	±14	—	±7	—	—	±1.5
RSS-55548	55548	316 to 100000	41.1	±200	±30	±9.5	±6	—	±3.5	±2.5	—	±1.5

Bandstop Filter Type	Pass-band insertion loss dB	Enclosure Plug-in unit widths	Electrical configurat. of Bandstop Filter	**Order Number** RSS for RS-5	RSS for RS-50, RS-25 and RS-100
RSS-10	—	2	LC	BN 701/00	—
RSS-14	—	1	LC	BN 702/01	BN 702/50
RSS-16	—	1	LC	BN 707/01	BN 707/50
RSS-34	—	1	LC	BN 759/00	BN 759/50
RSS-50	—	1	LC	BN 703/01	BN 703/50
RSS-56	—	1	LC	BN 755/00	BN 755/50
RSS-57	—	1	LC	BN 704/01	BN 704/50
RSS-70	—	1	LC	BN 705/00	BN 705/50
RSS-70	—	1	LC	BN 705/01	BN 705/51
RSS-98	—	1	LC	BN 706/01	BN 706/50
RSS-119	—	2	LC	BN 708/00	—
RSS-140	—	1	LC	BN 729/00	BN 729/50
RSS-185	—	1	LC	BN 754/00	BN 754/50
RSS-230	—	1	LC	BN 710/00	BN 710/50
RSS-240	—	1	LC	BN 709/00	BN 709/50
RSS-270	—	1	LC	BN 711/00	BN 711/50
RSS-270	—	1	LC	BN 711/01	BN 711/51
RSS-331	—	1	LC	BN 712/00	BN 712/50
RSS-394	—	1	LC	BN 713/00	BN 713/50
RSS-534	—	1	LC	BN 714/00	BN 714/50
RSS-600	—	1	LC	BN 716/00	BN 716/50
RSS-770	—	1	LC	BN 717/00	BN 717/50
RSS-1002	—	1	LC	BN 718/00	BN 718/50
RSS-1248	—	1	LC	BN 719/00	BN 719/50
RSS-1490	—	1	LC	BN 767/00	BN 767/50
RSS-1549	—	1	LC	BN 720/00	BN 720/50
RSS-1730	—	1	LC	BN 721/00	BN 721/50
RSS-1940	—	1	LC	BN 768/00	BN 768/50
RSS-2150	—	1	LC	BN 769/00	BN 769/50
RSS-2438	—	1	LC	BN 722/00	BN 722/50
RSS-3150	—	1	LC	BN 724/00	BN 724/50
RSS-3200	—	1	LC	BN 725/00	BN 725/50
RSS-3886	—	1	LC	BN 726/00	BN 726/50
RSS-3886	2	1	Crystal	BN 726/10	BN 726/60
RSS-4650	2	1	Crystal	BN 730/00	BN 730/50
RSS-4715	—	1	LC	BN 727/00	BN 727/50
RSS-5340	2	1	Crystal	BN 728/10	BN 728/60
RSS-5340	4	2	Crystal	BN 728/03	BN 728/33
RSS-6300	—	1	LC	BN 731/00	BN 731/50
RSS-7600	2	1	Crystal	BN 732/10	BN 732/60
RSS-9073	—	1	LC	BN 735/00	BN 735/50
RSS-9073	2	1	Crystal	BN 735/10	BN 735/60
RSS-11700	2	1	Crystal	BN 736/10	BN 736/60
RSS-11700	4	2	Crystal	BN 736/03	—
RSS-13677	—	1	LC	BN 742/01	BN 742/50
RSS-16400	2	1	Crystal	BN 757/10	BN 757/60
RSS-27300	2	1	Crystal	BN 748/00	BN 748/50
RSS-35748	2.5	2	Crystal	BN 750/03	BN 750/33
RSS-43762	2	1	Crystal	BN 753/00	BN 753/50
RSS-55548	4	2	Crystal	BN 758/03	BN 758/33

Converter Plug-in Type	Measuring channel kHz	**Order Number**
REU-10	9.24	BN 402/01
REU-14	14	BN 402/02
REU-16	16	BN 402/07
REU-34	34	BN 402/59
REU-50	50	BN 402/03
REU-56	56	BN 402/55
REU-57	57	BN 402/04
REU-70	70	BN 402/05
REU-98	98	BN 402/06
REU-119	119	BN 402/08
REU-140	140	BN 402/29
REU-185	185	BN 402/54
REU-230	230	BN 402/10
REU-240	240	BN 402/09
REU-270	270	BN 402/11
REU-331	331	BN 402/12
REU-394	394	BN 402/13
REU-534	534	BN 402/14
REU-600	600	BN 402/16
REU-770	770	BN 402/17
REU-1002	1002	BN 402/18
REU-1248	1248	BN 402/19
REU-1490	1490	BN 402/67
REU-1549	1549	BN 402/20
REU-1730	1730	BN 402/21
REU-1940	1940	BN 402/68
REU-2150	2150	BN 402/69
REU-2438	2438	BN 402/22
REU-3150	3150	BN 402/24
REU-3200	3200	BN 402/25
REU-3886	3886	BN 402/26
REU-4650	4650	BN 402/30
REU-4715	4715	BN 402/27
REU-4765	4765	BN 402/45
REU-5340	5340	BN 402/28
REU-6300	6300	BN 402/31
REU-7600	7600	BN 402/32
REU-9073	9073	BN 402/35
REU-11700	11700	BN 402/36
REU-13677	13677	BN 402/42
REU-16400	16400	BN 402/57
REU-27300	27300	BN 402/48
REU-35748	35748	BN 402/50
REU-43762	43762	BN 402/53
REU-55548	55548	BN 402/58

Table 4 Bandstop Filters RSS for out-of-band applications

Bandstop Filter Type	Measuring channel kHz	Attenuation curve >50 dB Δf/kHz	Attenuation curve >80 dB (W & G) Δf/kHz	Limit frequency f_l kHz	Limit frequency f_u kHz	Attenuation curve >50 dB Δf/kHz	Attenuation curve >80 dB (W & G) Δf/kHz	Enclosure Plug-in unit widths	Electrical configurat. of Band-stop Filter	**Order Number** RSS for RS-5	RSS for RS-50, RS-25 and RS-100
RSS-10	9.24	±1.76	±1.5	12.5	552	—	—	2	LC	BN 701/00	—
RSS-50	50	±2.25	±1.5	60	5600	—	—	1	LC	BN 703/01	BN 703/50
RSS-270	270	±3.35	±1.5	316	12360	—	—	1	LC	BN 711/01	BN 711/51
RSS-70	70	—	—	6	60	±2	±1.5	1	LC	BN 705/01	BN 705/51
RSS-119	119	—	—	6	108	±2.6	±1.5	2	LC	BN 708/00	—
RSS-331	331	—	—	12	300	±3.66	±1.5	1	LC	BN 712/00	BN 712/50
RSS-600	600	—	—	12	552	±5	±1.5	1	LC	BN 716/00	BN 716/50
RSS-1549	1549	—	—	60	1300	±9.75	±1.5	1	LC	BN 720/00	BN 720/50
RSS-3200	3200	—	—	60	2600	±18	±1.5	1	LC	BN 725/00	BN 725/50
RSS-4715	4715	—	—	60	4100	±25.6	±1.5	1	LC	BN 727/00	BN 727/50
RSS-6300	6300	—	—	12	5600	±33.5	±1.5	1	LC	BN 731/00	BN 731/50
RSS-9073	9073	—	—	60	4100	±47.5	±1.5	1	LC	BN 735/00	BN 735/50
RSS-13677	13677	—	—	316	12360	±70	>75 dB : ±1.5	1	LC	BN 742/01	BN 742/50

Note: The Converter Plug-in Units associated with the Bandstop Filters of Table 4 can be found in Table 3.

Table 5 Band-Limiting Filters RSB and Band Selection Filter RSBZ for Group Translator Measurements

Group to be translated	Number of channels	Assigned band kHz	Noise band nominal kHz	Noise band, effective limits kHz	Tolerance of eff. limits lower kHz	Tolerance of eff. limits upper kHz	Flat range kHz	Stop-band >75 dB kHz	Pass-band insertion loss RSBZ dB	**Order Number** RSB/RSBZ for RS-5	RSB/RSBZ for RS-50, RS-25 and RS-100
Basic group	12	60 to 108	60/108	61 to 107	±2	±2	68 to 100	6 to 52 116 to 1200	2	BN 8547/00 BN 8520/00	BN 8547/50 BN 8520/50
Basic supergroup	60	312 to 552	300/552	312 to 546	±8	±10	330 to 535	6 to 288 577 to 8500	0.4	BN 8588/00 BN 8521/00	BN 8588/50 BN 8521/50
Basic mastergroup	300	812 to 2044	812/2044	840 to 2004	±16	±30	1000 to 1850	6 to 412 2318 to 26000	0.4	BN 8566/00 BN 8523/00	BN 8566/50 BN 8523/50
Basic arrangement for 15 supergroups	900	312 to 4028	316/4100	320 to 4070	±8	±60	532 to 3888	6 to 288 4544 to 30000	0.7	BN 8540/00 BN 8524/00	BN 8540/50 BN 8524/50
Basic supermaster group	900	8516 to 12388	8516/12360	8560 to 12250	±200	±180	9071 to 11702	6 to 7686 13085 to 135000	3	BN 8568/00 BN 8522/00	BN 8568/50 BN 8522/50
Arrangement for 15 supergroups	900	8620 to 12336									

Table 6 Pilot Stop Filters RSP

Pilot Stop Filter	Stopped frequency kHz	Pass-band insertion loss dB	Pass-band a < 0.5 dB Δf/kHz	Pass-band a < 3 dB kHz	Stop-band a > 30 dB Δf/kHz	**Order Number** RSP for RS-5	RSP for RS-50, RS-25 and RS-100
RSP-2604	2604	1 ±0.2 (at f_l = 6 kHz)	6 to 2444 2764 to 12360	≦ 2589 ≧ 2619	2602.5 to 2605.5	BN 764/00	BN 764/50
RSP-4092	4092	0.6 ±0.2 (at f_l = 6 kHz)	6 to 3892 4292 to 12360	≦ 4072 ≧ 4112	4090.5 to 4093.5	BN 765/00	BN 765/50
RSP-12435	12435	1 ±0.2 (at f_l = 316 kHz)	316 to 11700	–	12438.5 to 60000 (a > 29 dB)	BN 760/00	BN 760/50
RSP-18480	18480	1.5 ±0.2 (at f_l = 6 kHz)	6 to 17300	–	18380 to 18580	BN 766/00	BN 766/50
RSP-61160	61160	4 ±0.2 (at f_l = 4 MHz)	4370 to 59600 62000 to 100000	–	61158 to 61162 (a ≧ 35 dB)	BN 763/03	BN 763/33

A Specification Sheet with more details is available on request

Pre- and De-emphasis Networks

as accessories for measurements on radio-link and satellite systems



- **Small, light, and handy**
- **Available for all commercial radio-link and satellite systems**
- **Variation of attenuation with frequency conforms to CCIR Recommendations**
- **Inputs and outputs adaptable to all the usual RF connector families**

Applications

With frequency modulated radio-link and satellite systems, the wanted signal is accompanied by a noise voltage that becomes greater as the baseband frequency increases, whereas the level of the wanted signal remains constant. For that reason, a telephone channel located in the upper part of the transmission band would suffer a degradation in quality if compared to that in the lower part. But suitable measures can be taken to flatten the frequency response curve.

To improve the signal-to-noise ratio, the higher signal frequencies are raised in level by a pre-emphasis network before being modulated, i.e. the higher frequencies are transmitted with greater frequency deviation than the lower. After demodulation, the frequency response characteristic of the signal is flattened by a de-emphasis network.

Pre-emphasis and de-emphasis networks are components of the modulators and demodulators used in radio-link and satellite systems. Therefore, white noise measurements made between baseband ports do not require additional pre-emphasis or de-emphasis.

But white noise and frequency response measurements between IF test ports, as made with the wideband facility of the Wandel & Goltermann RM-4, do require pre-emphasis and de-emphasis networks. The RM-4 is a universally applicable Radio-Link Measuring Setup, and consequently may be used for measurements on all the usual channel numbered systems and TV systems. For that reason, it does not contain any special pre-emphasis and de-emphasis circuits. Adaptation to the relevant system results from inserting external pre-emphasis and de-emphasis networks.

Characteristics

All pre-emphasis and de-emphasis networks specified in CCIR Recommendations 275-3, 405-1 and 464-1 for radio-link and satellite systems up to 2700 channels or TV transmission are available as measuring accessories. The networks conform to the CCIR Recommendations for variation of attenuation with frequency.

Nominal value of input and output impedances	75 Ω
Input and output connectors	coaxial, basic connector Versacon® 9
Adapters, can be screwed on to the basic connector Versacon® 9	at choice BNC; TNC; 1.6/5.6; 2.5/6 etc. see Specification Sheet "Versacon® 9"

2587 Pre-De-emph.

Max. input level . . . . . +10 dBm

Networks for TV transmission over FM Radio-Link Systems (Rec. CCIR 405-1)

TV-System, Number of lines	f_c kHz	f_n kHz	a_{EP} at f_n dB	a_{ED} at f_n dB	Order numbers Pre-emphasis	De-emphasis
405 [1]	3000	853	2	12	BN 445/01	BN 446/01
525	4000	761.6	3.4	10	BN 445/02	BN 446/02
625	5000	1512	3	11	BN 445/03	BN 446/03
819	10000	1402	7	7	BN 445/04	BN 446/04

1) Conforms to CCIR Recommendation 405, Oslo, 1966

f_c: highest transmission frequency of video band
f_n: neutral frequency
a_{EP}: insertion loss of pre-emphasis networks at the neutral frequency, f_n
a_{ED}: insertion loss of de-emphasis networks at the neutral frequency, f_n

Error limits of insertion loss
as a function of frequency . . . . . $\pm(0.1 + 0.05\, f/f_c)$ dB

Networks for telephone transmission over FM Radio-Link Systems (Rec. CCIR 275-3)

System, Number of channels	f_{max} kHz	f_n kHz	Order numbers Pre-emphasis	De-emphasis
24	108	66.2	BN 445/05	BN 446/05
60	300	184.0	BN 445/06	BN 446/06
120	552	338.5	BN 445/07	BN 446/07
300	1300	797.1	BN 445/08	BN 446/08
600	2660	1631	BN 445/09	BN 446/09
960	4188	2568	BN 445/10	BN 446/10
1260	5636	3456	BN 445/11	BN 446/11
1800	8204	5031	BN 445/12	BN 446/12
2400	11067	6787	BN 445/32	BN 446/32
2700	12388	7596	BN 445/13	BN 446/13

Networks for telephone transmission over FM satellite systems (Rec. CCIR 464-1)

System, Number of channels	f_{max} kHz	f_n kHz	Order numbers Pre-emphasis	De-emphasis
12	60	36.8	BN 445/15	BN 446/15
24	108	66.2	BN 445/05	BN 446/05
36	156	95.7	BN 445/16	BN 446/16
48	204	125.1	BN 445/17	BN 446/17
60	252	154.5	BN 445/18	BN 446/18
72	300	184.0	BN 445/19	BN 446/19
96	408	250.2	BN 445/20	BN 446/20
132	552	338.5	BN 445/21	BN 446/21
192	804	493.0	BN 445/22	BN 446/22
252	1052	645.1	BN 445/23	BN 446/23
312	1300	797.2	BN 445/24	BN 446/24
372	1548	949.2	BN 445/33	BN 446/33
432	1796	1101	BN 445/25	BN 446/25
492	2044	1253	BN 445/34	BN 446/34
552	2292	1405	BN 445/35	BN 446/35
612	2540	1558	BN 445/26	BN 446/26
792	3284	2014	BN 445/27	BN 446/27
972	4028	2470	BN 445/28	BN 446/28
1092	4892	3000	BN 445/29	BN 446/29
1332	5884	3608	BN 445/30	BN 446/30
1872	8120	4979	BN 445/31	BN 446/31

f_{max}: highest frequency in transmission band occupied by telephone channels
f_n: $0.6132 \times f_{max}$; neutral frequency at which the frequency deviation of the frequency modulated system remains unchanged with and without the pre-emphasis network, with compensation of the insertion loss a_{EP} at f_n.

Insertion loss at the neutral frequency f_n:
Pre-emphasis $a_{EP} = 5.0$ dB $\pm$ 0.13 dB
De-emphasis $a_{ED} = 3.98$ dB $\pm$ 0.13 dB

Error limits of insertion loss
as a function of frequency . . . . . $\pm(0.1 + 0.05\, f/f_{max})$ dB

General Specifications

Dimensions
Diameter . . . . . 27 mm
Length with BNC type adapter mounted on Versacon® 9 (see photograph) . . . . . 108 mm

Weight
with BNC adapter on Versacon® 9 (see photograph) . . . 90 g

Ordering Information . . . . . see Tables [1]

1) The Versacon® 9 basic connector has a BNC type connector mounted on it. If different adapter is required, it should be ordered at the same time as network is ordered.

RM-5
Radio-link Measuring Setup 35/70/140 MHz

for distortion measurements on radio-link and satellite systems

IEEE 488
IEC 625



- **All standard IF ranges:**
  70 MHz (basic version), 35 MHz and/or 140 MHz (options)
- **Test frequencies from 25 kHz**
- **The set IF is highly accurate, no calibration required**
- **Easy-to-use, all important data is displayed on the screen**
- **IF frequency-counter for centre frequency and sweep limits**
- **Digital noise-averaging and normaliser**
- **Wideband facility for 70 and 140 MHz (option)**
- **Facility for calculating intermodulation noise from distortion measurement results (option)**
- **Two INTELSAT tolerance masks can be displayed simultaneously on the screen**
- **All generator and receiver functions can be remote-controlled**

Applications

Because of its exceptional versatility, the RM-5 Radio-link Measuring Setup can handle any radio-link or satellite system:

– FM wideband radio-link systems for telephone and TV transmission.
  The RM-5 has IF ranges of 70 and 140 MHz, test frequencies into the MHz range, and also colour-subcarriers
– PM and FM narrow-band radio-link systems
  The RM-5 has IF ranges of 35 and 70 MHz, test frequencies from 25 kHz
– Digital radio-link systems
  The RM-5 has IF ranges of 70 and 140 MHz and a larger dynamic range for IF-to-IF frequency response measurements
– FDMA and TDMA satellite systems
  The RM-5 has IF ranges of 70 and 140 MHz and test frequencies from 55.55 kHz. The RM-5 can detect test signals when the C/N ratio is as low as 10 dB. A noise averaging facility is provided.

The RM-5 is eminently suited for use in test departments where more rational and more flexible test procedures will have to be adopted to cope with the increasing number and variety of test items.
All generator and receiver functions can be remote-controlled via the standard <IEC 625>/IEEE 488 interface. It is therefore possible to incorporate the RM-5 in a measuring system. A wideband facility (test modem) is available as an option for white noise loading and BB-to-BB frequency response measurements between the IF ports of analog, wideband radio-link systems. The necessary pre- and de-emphasis networks can be purchased separately.

Characteristics

The modern design of the RM-5 ensures simple, fool-proof operation. The generator and the receiver are pushbutton-

IF range	70 ±30 MHz
as options	140 ±50 MHz
	and/or 35 ±5 (10) MHz
Seven test frequencies between	25 kHz and 5.6 MHz
Sweep frequencies	18 and 70 Hz

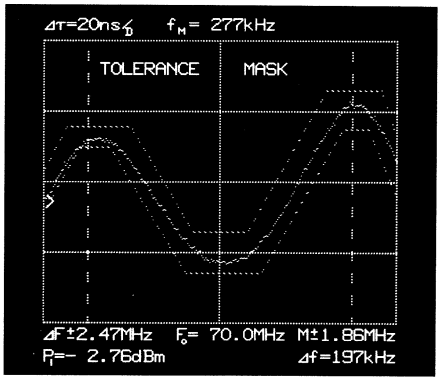
controlled; the measuring parameters have a high setting accuracy. Many of the best features of older W&G Radio-link Measuring Setups have been retained. For example, the automatic deviation correction for all test frequencies, the gap pulse in the RMS-5 Generator and the automatic test frequency recognition facility in the RME-5 Receiver.
A multi-digit, seven segment LED display on the RMS-5 Generator shows all important send-parameters. The RMS-5 can be set via a keyboard, or quasi-continuously via direction keys. Frequently used generator setups can be stored and called up when required. A built-in battery retains the memory contents – even when the instrument is switched off.
All the measurement-trace data is shown on the screen of the RME-5 Receiver. This information is, therefore, always present when the results are photographed or output on a video printer. The new frequency marker is an adjustable line-cursor pair symmetrical to the vertical axis. The frequency indicated by the cursors is also shown alphanumerically on the screen, making trace values easy to determine. A pair of adjustable horizontal lines are also available. The value difference of the two cursors is also shown on the screen.

The Measuring Setup is very easy-to-operate because of various automatic features which have been built into the RME-5 Receiver:

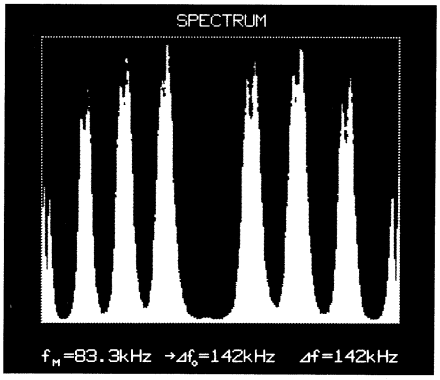
- The RME-5 automatically adjusts itself to accommodate a wide range of input levels and frequencies at the IF and BB level – even when the dynamic range of the input signal is high.
- Calibrated distortion-measurement ranges can be selected by pushbutton, the scale is displayed immediately on the screen.

The RME-5 also carries out several test settings automatically for the user:
- The RME-5 determines the deviation and the centre frequency of the IF signal using a frequency counter.
- The IF level at the centre frequency and the sweep curves are shown together.
- The test deviation is displayed so that the operator is always sure that the correct test conditions are maintained.

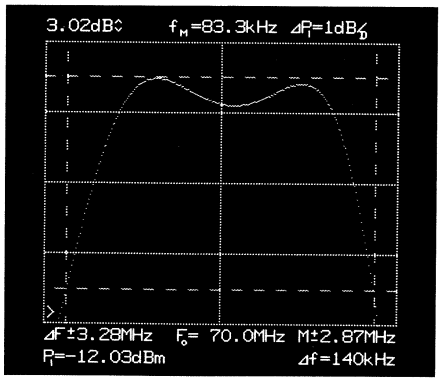
Using the RME-5's microprocessor and screen, other attractive display, evaluation and documentation facilities can be realised.
- SLOPE CONTROL, corrects the test setup's linear frequency response
- NORMALISER, stores a reference trace, and displays the difference between this trace and the measured trace
- AVERAGING, smoothes noisy traces. An averaging factor between 2 and 32 can be selected.
  Digital averaging is superior to analog noise averaging because the fine structure of the measured results is not lost (reducing the test bandwidth causes transient problems).
- Curve analysis, numerical display of the linear and parabolic distortion components is determined by a measurement between the two frequency markers
- Horizontal cursors, for displaying a given tolerance band, or for determining the separation between two lines on the screen.
- Video output, for a video printer, or for a monitor to obtain a larger display or a display at a remote location
- X-Y plotter interface[1] (option): The measured traces and other data can be printed out to give a complete test protocol. The protocol contains the measured traces, the measurement range lines (f.s.d.), the frequency markers and the horizontal cursors, if they are used.



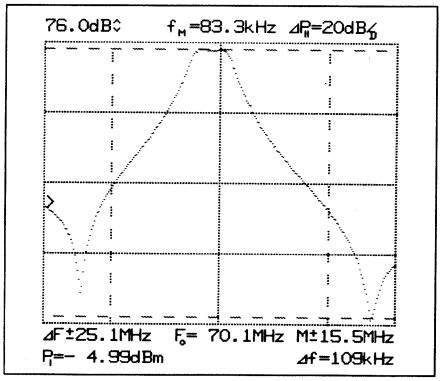
<
Group delay distortion of an IF filter, text and tolerance masks have been transferred via the <IEC 625> interface bus



>
Mode "Spectrum": IF spectrum with 83.3 kHz modulation frequency, IF carrier suppressed (Bessel null)



<
Determination of the 3 dB band limits of an IF filter by means of frequency markers and horizontal cursors



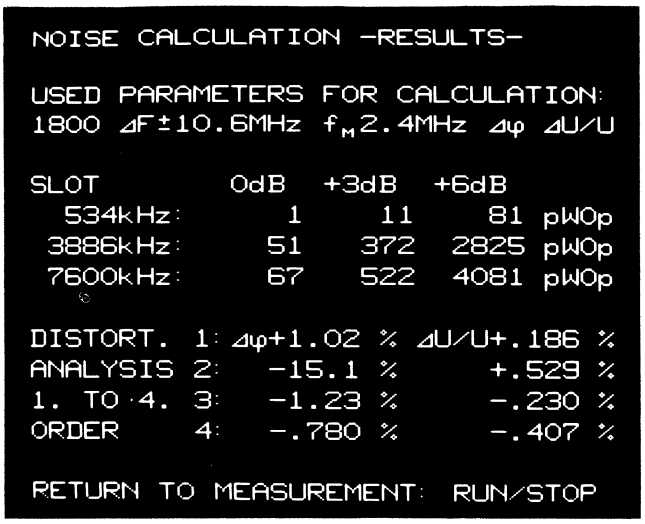
>
Display of the total attenuation curve of an IF filter when the P_{II} input is used. A video printer provides the printout

CRT display and result printed out by video printer

- <IEC625>/IEEE 488[1] (option): The computer can be used to evaluate the results in a variety of ways via the interface bus. For example, the computer can be used to input tolerance masks instead of the horizontal cursors, or reference curves for the normaliser can be defined. All generator and receiver functions (except brightness) can be remote controlled.
- Noise calculation (option): The intermodulation noise in the baseband noise slots is calculated by the RM-5 from the differential phase distortion $\Delta\varphi$ and the differential gain $\Delta U/U_o$ measured between the IF ports of the system.
- INTELSAT tolerance masks (option): Displays all the tolerance masks for IF-to-IF frequency response and IF-to-IF group delay response.
  A combined result for the transmit and receive path can be shown, or the results for the transmit and the receive path can be shown separately.
  Two masks can be shown simultaneously (ΔP and $\Delta\tau$).

Wideband facility for the RM-5
The RM-5's wideband facility is as important as ever for analog, wideband radio-link systems with IF ports. Using this device, white noise loading and BB-to-BB frequency response measurements can be carried out at the IF level.
The wideband facility comprises the Wideband Modulator Option for the RMS-5 Generator, and the RMED-5 Wideband Demodulator which is an instrument in its own right (two 19" units in height). The RMED-5 can therefore be used for certain monitoring tasks in repeater stations without blocking the RME-5 Receiver.

1) The X-Y plotter interface and the <IEC625> interface cannot be used simultaneously.



Results of the noise calculation and the analysis of the distortion curves

Specifications of the Radio-link Measuring Setup — RM-5

If not otherwise stated, the data is valid in the rated range of use for the a.c. line voltage, the a.c. line frequency and the ambient temperature. When the test frequencies f_M = 25 and 50 kHz or 27.778 and 55.556 kHz are used the sweep frequency f_A = 18 Hz must be used.

IF and BB distortion measurements

The data applies to the whole IF input-level range P_I from −20 to +10 dBm, and to the IF ranges 70 MHz (standard) and 35 MHz and 140 MHz (options), or to the whole BB input-level range from −50 to −10 dBm. All measurement ranges are displayed over the full height of the screen.

Group delay distortion "$\Delta\tau$" (f_M <1 MHz)
Measurement ranges:
f_M = 500 or 555.556 kHz . . . . . 0.8, 2, 4, 8, ..., 80 ns
f_M = 250 or 277.778 kHz . . . . . 1.6, 4, 8, 16, ..., 160 ns
f_M = 83.3 or 92.593 kHz . . . . . 4, 10, 20, 40, ..., 400 ns
f_M = 50 or 55.556 kHz . . . . . 8, 20, 40, 80, ..., 800 ns
f_M = 25 or 27.778 kHz . . . . . 16, 40, 80, 160, ..., 1600 ns
Max. sensitivity at f_M = 500 or 555.556 kHz . . . . 0.2 ns/div.

Non-linearity distortion "$\Delta U/U_o$" (f_M < 1 MHz)
Measurement ranges . . . . . 0.4, 1, 2, 4, ..., 40 %
Max. sensitivity . . . . . 0.1 %/div.

Differential phase "$\Delta\varphi$" (f_M >1 MHz)
Measurement ranges . . . . . 0.4, 1, 2, 4, ..., 40 % rad
Max. sensitivity . . . . . 0.1 % rad./div.

Differential gain "$\Delta U/U_o$" (f_M > 1 MHz)
Measurement ranges . . . . . 0.4, 1, 2, 4, ..., 40 %
Max. sensitivity . . . . . 0.1 %/div.

Further IF measurements and measuring parameters

Attenuation/frequency distortion "ΔP_I"
(IF-to-IF frequency response)
Measurement ranges . . . . . 0.4, 0.8, 1.6, ..., 16 dB
Max. sensitivity . . . . . 0.1 dB/div.

Attenuation/frequency distortion, "ΔP_{II}" (selective)
(An IF reference signal with the same frequency is applied to input P_I)
Level range at input P_{II} . . . . . −50 to −10 dBm
Measurement ranges . . . . . 8, 16, 40, 80 dB
Max. sensitivity . . . . . 2 dB/div.

IF return loss, "ΔP_{II}"
(use the RFZ-4 or RFZ-14 Return Loss Coefficient Measurement Bridges)
Measurement ranges . . . . . 8, 16, 40, 80 dB

"$Y_{external}$" (e.g. for RF detector signals)
Measurement ranges . . . . . 8, 20, 40, 80, ..., 800 mV
Max. sensitivity . . . . . 2 mV/div
Input impedance . . . . . 10 kΩ

IF level "P_I" (at centre frequency F_o)
Measurement range . . . . . −20 to +10 dBm
Resolution . . . . . 0.01 dB

Test frequency deviation "Δf" (r.m.s.)
Measurement range . . . . . 15 to 500 kHz
Resolution . . . . . 0.01 dB
Modulation frequency
in the 70 and 140 MHz IF ranges . . . . . 25 kHz to 5.6 MHz
in the 35 MHz IF range . . . . . 25 to 556 kHz
(calibrated with the Bessel-zero method, f_M = 250/277.778 kHz and 83.3/92.593 kHz)

Sweep width "Δ̂F"
Measurement range . . . . . ±0.2 to ±50 MHz
Resolution
0.2 to 9.99 MHz . . . . . 0.01 MHz
10 to 50 MHz . . . . . 0.1 MHz

Frequency markers "M"
(Two vertical lines symmetrical about F_o)
Setting range . . . . . ±0.03 to ±50 MHz
Resolution
0.03 to 9.99 MHz . . . . . 0.01 MHz
10 to 50 MHz . . . . . 0.1 MHz

Centre frequency "F_o" (see IF counter)
Measurement range . . . . . 25 to 190 MHz
Resolution . . . . . 0.1 MHz

IF counter for unswept IF signals
Measurement range . . . . . 25 to 190 MHz
Resolution . . . . . 0.01 MHz

Spectrum mode
For setting the sensitivity of modulators and demodulators
Test frequencies for calibrating the deviation meter
frequency series I [1] . . . . . 92.593 and 277.778 kHz
frequency series II [1] . . . . . 83.3 and 250 kHz
Carrier suppression
at 92.593 and 83.3 kHz . . . . . ≧40 dB
at 277.778 and 250 kHz . . . . . ≧50 dB

Further BB Measurements

BB level for signals between 10 kHz and 12.5 MHz that are not swept
Measurement range . . . . . −50 to −10 dBm
Resolution . . . . . 0.01 dB

BB return loss
For sinusoidal signals between 100 kHz and 12.5 MHz that are not swept. The RFZ-14 Return Loss Coefficient Measuring Bridge is used as a test aid.
Level range at BB level-meter input . . . . . −50 to −10 dBm
Resolution . . . . . 0.01 dB

Horizontal cursors

For reading the results of IF and BB swept measurement. The cursors are symmetrical about the horizontal axis, and are adjustable. The separation between the two cursors is shown on the screen in terms of the scale selected.

Wideband Facility for the RM-5 (70 and 140 MHz)

Wideband Modulator, BN 916/00.31

BB input
Sensitivity at 277.778 or 250 kHz . . . . . 10 MHz/V ±5 %
Modulation frequency range
for (70) 140 MHz IF . . . . . 50 Hz to (12.5) 13.6 MHz

1) See Ordering Information for more details

Max. baseband level for noise signals
corresponding to (1800) 2700 channels
at 6 dB overload . . . . . (−2.2) −0.4 dBm
Max. level for sinusoidal signals . . . . . −10 dBm

IF output
Centre frequency . . . . . 70 MHz and 140 MHz
Level range, smallest step 0.1 dB . . . . . −59.9 to +10 dBm

Basic noise
(70 MHz/1800 channels)
140 MHz/2700 channels . . . . . ≦(15) 20 pW0p

RMED-5 Wideband Demodulator, BN 2018/01
IF input
Centre frequency . . . . . 70 MHz ±50 kHz
switchable to . . . . . 140 MHz ±100 kHz
Level range . . . . . −4 to +6 dBm

BB output
Sensitivity . . . . . 50 mV/MHz ±10 %
Demodulation frequency range
(70) 140 MHz IF . . . . . 50 Hz to (12.5) 13.6 MHz

Basic noise
(70 MHz/1800 channels)
140 MHz/2700 channels . . . . . ≦(7.5) 12.5 pW0p

Characteristics of the modem-loop
Basic and intermodulation noise
(70 MHz/1800 channels) 140 MHz/2700 channels
under CCIR conditions
Nominal load . . . . . ≦(40) 50 pW0p
3 dB overload . . . . . ≦(60) 80 pW0p

BB-to-BB frequency response
from 50 Hz to 12.5 MHz (at 70 MHz IF) . . . . . ±0.5 dB
from 50 Hz to 13.6 MHz (at 140 MHz IF) . . . . . ±0.5 dB

Transmission of TV signals
Droop for a 50 Hz rectangular modulation signal . . . . ≦1 %

General Specifications
Power supply
Rated ranges of use for a.c. line voltage . . . . . 96.5 to 140 V and 193 to 261 V
Rated range of use of the a.c. line frequency . . 47.5 to 63 Hz
Power consumption
RMS-5 Generator . . . . . approx. 80 VA
RME-5 Receiver . . . . . approx. 60 W
RMED-5 Wideband Demodulator . . . . . approx. 20 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I
EMI/RFI suppression to . . . . . Bundespost 1115/1982

Ambient temperature
Rated range of use (≅ Limits range of operation)

Height of use above sea-level	With cooling fan (accessory)	Without cooling fan
Up to 1000 m	0 to +50 °C	0 to +40 °C
Up to 3000 m	0 to +40 °C	0 to +30 °C

Storage and transportation . . . . . −40 to +70 °C

Dimensions (w×h×d) in mm
RMS-5 Generator . . . . . 477×155×434
RME-5 Receiver . . . . . 477×288×434
RMED-5 Wideband Demodulator . . . . . 477×110×434

Weight
RMS-5 Generator . . . . . approx. 13 kg
RME-5 Receiver . . . . . approx. 19.5 kg
with cooling fan . . . . . approx. 20.5 kg
RMED-5 Wideband Demodulator . . . . . approx. 8 kg

Ordering Information

Radio-Link Measuring Setup (70 MHz), RM-5 [1] comprising: **Generator RMS-5** * **BN 916/..**
Sweep frequencies, 18 and 70 Hz **Receiver RME-5** * **BN 917/..**

Test frequencies						Order Number
Series I: 27.778 kHz 55.556 kHz 92.593 kHz 277.778 kHz and 555.556 kHz	Series II: 25 kHz 50 kHz 83.3 kHz 250 kHz and 500 kHz	2.4 MHz	3.580 MHz or 3.579545 MHz	4.430 MHz or 4.433619 MHz	5.6 MHz	
■		■	◪	◹	■	BN 916/11 [2] BN 917/11
	■	■	◪	◹	■	BN 916/12 BN 917/12

■ Standard ◪ Colour subcarrier (on request) replaces the 2.4 or 5.6 MHz test frequency: see options
◹ Colour subcarrier (on request) replaces the 2.4 or 5.6 MHz test frequency: see options

Wideband Facility for the RM-5

Wideband Modulator * (Option, built-in in RMS-5)	BN 916/00.31
Wideband Demodulator RMED-5 *	BN 2018/01

Permanently mounted options:
(Unless otherwise stated, options are fitted in the factory and an extra charge is made)

	Fitted in the RMS-5	Fitted in the RME-5
35 MHz extension	BN 916/00.03	BN 917/00.03
140 MHz extension	BN 916/00.30	BN 917/00.30
IF calibrating generator		
35/70 MHz *	BN 916/00.02	—
35/70/140 MHz *	BN 916/00.20	—
<IEC 625> Interface Board [3] with IEEE 488 fem. connector	BN 958/21	BN 853/21
X-Y plotter interface [3]	—	BN 917/00.01
Colour subcarriers		
M/NTSC, 3.580 MHz [4]	BN 916/00.06	BN 917/00.06
M/NTSC, 3.579545 MHz [4]	BN 916/00.04	BN 917/00.04
B, G, H, I/PAL 4.430 MHz [5]	BN 916/00.07	BN 917/00.07
B, G, H, I/PAL 4.433619 MHz [5]	BN 916/00.05	BN 917/00.05
Noise calculation device [6]	—	BN 917/00.11
INTELSAT tolerance masks [6]	—	BN 917/00.12

Accessories (at extra cost)

Cooling fan for the RME-5	BN 917/00.10
Return loss measurement bridges [7]	
RFZ-4 * (IF bridge, 10 to 200 MHz)	BN 697/00.04
RFZ-14 * (BB/IF bridge, 100 kHz to 100 MHz)	BN 830/00.01
RFZ-12 * (BB bridge, 200 Hz to 4.5 MHz)	BN 810/01
Frequency Splitter RMSF-5	BN 916/00.10
Pre- and De-emphasis Networks	see relevant Spec. Sheet
IEEE 488/IEC 625 adaptor (m – m) for the IEC 625 Interface Board	S 832
Plotter paper, 50 sheets, Ger/Eng.	BN 917/00.79
Transport Containers	
TPK-3 for the RMS-5 Generator	BN 626/09
TPK-6 for the RME-5 Receiver	BN 626/12
Protective Transportation Covers (1 set, front and back panels)	
SD-3 for the RMS-5 Generator	BN 700/00.23
SD-6 for the RME-5 Receiver [8]	BN 700/00.26
SD-2 for the RMED-5 Demodulator	BN 700/00.22
19" conversion kit	
for the RMS-5 Generator	BN 700/00.03
for the RME-5 Receiver	BN 700/00.06
for the RMED-5 Demodulator	BN 700/00.02

* Fitted with the Versacon® 9, 75 Ω basic connector and BNC adapter. If you require other types of adapter please state this in your order–see the Versacon® 9 Specification Sheet.
1) 35 MHz and/or 140 MHz, see Options
2) Fitted with the INTELSAT test frequencies of 55.556 kHz, 95.593 kHz and 277.778 kHz
3) The <IEC 625> interface and the plotter interface cannot be used simultaneously
4) 3.580 or 3.579545 MHz are available instead of the 2.4 or 5.6 MHz test frequency
5) 4.430 or 4.433619 MHz are available instead of the 2.4 or 5.6 MHz test frequency
6) The noise calculation option and the INTELSAT tolerance masks cannot be fitted simultaneously
7) See the "Measuring Accessory" spec. sheet for data and more ordering information
8) When the cooling fan is fitted the back panel cover for the RME-5 cannot be used

A Specification Sheet with more details is available on request

Data Circuit Measurement Technology



Overview

Data Circuit Measurement Technology

Data circuit measuring instruments

Frequency range	With send section/ generator	Level measurements	Noise level measurements	Frequency measurements	Frequency shift measurements	Phase jitter measurements	$\Delta\tau_g$ measurements	Δa measurements	Nonlinear distortion measurements	Event counting	<IEC 625>/IEEE 488 Interface Bus	Battery operation	Special features	Name	Page
—										•		•	Measurement of impulsive noise and interruptions; small; handy	**DLM-20 Data Circuit Test Set**	165
200 Hz to 4 kHz	•	•	•	•	•	•	•	•	•	•	•		Fixed and user-selectable device settings; printer interface	**DLM-4 Data Line Test Set**	167
200 Hz to 600 kHz	•						•	•				•	Loop-back and end-to-end measurements; sweep mode; freq. difference meas.	**LD-2 Group Delay and Attenuation Measuring Setup**	173

See "Data network diagnostics and data analysis" for information about the DMS-1 Data Measuring Set which measures analog and digital transmission characteristics on data circuits.

Test system

Frequency range	Special features	Name	Page
200 Hz to 4 kHz	System components: DLM-4 Data Line Test Set; automatic and interactive mode; loop-back and end-to-end measurements; local and remote measurements; results displayed in table or graph form.	**DLM-400 Data Circuit Monitoring System** [1]	171

1) Uses SWP-16 software package

Line simulator, line equalizer

Frequency range	Special features	Name	Page
0.3 to 3.4 kHz	Simulation of group delay and attenuation distortion of telephone channels	**TLN-1 Telephone Channel Simulator**	175
0.3 to 3.4 kHz	Simultaneous equalization of attenuation and group-delay in telephone channels	**DLZ-4 Attenuation and Group Delay Equalizer**	177

DLM-20
Data Circuit Test Set

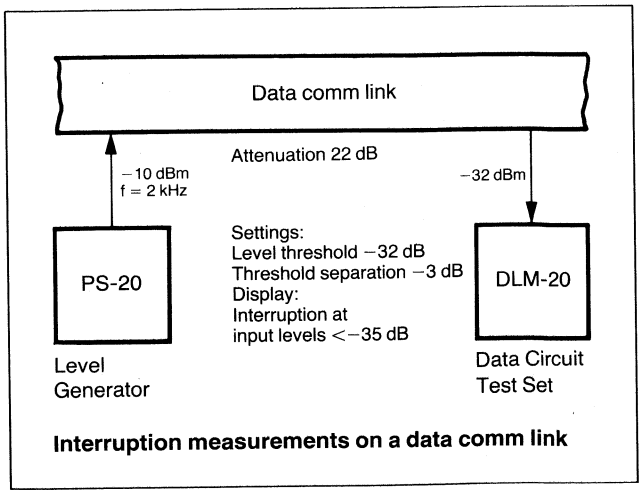
for measuring impulsive noise and interruptions



- **Impulsive noise measurements complying with CCITT Recommendation O.71**
- **Impulsive noise measurements with 850 Hz test signal**
- **Interruption measurement complying with CCITT Recommendation O.62**
- **Switch-selectable dead times**
- **Battery operation**
- **Handy, light, robust**

Applications

Random impairments cannot be eliminated on data transmission paths. At higher bit rates these impairments reduce the quality of transmission when certain prescribed limits are transgressed.



Interruption measurements on a data comm link

It is particularly important to determine figures for impulsive noise and interruptions. Both these parameters can be measured accurately and reliably with the DLM-20 Data Circuit Test Set. It is ideal for measurements on data connections on dial-up or leased telephone lines.
Because it has a compact construction and can be battery operated the DLM-20 is tailor-made for mobile, field service.

Characteristics

The DLM-20 Data Circuit Test Set measures impulsive noise and interruptions according to CCITT Recs. O.71 and O.62. Impulsive noise can also be measured using a test signal (e.g. on PCM circuits). An 850 Hz notch filter suppresses the test signal. To carry out impulsive noise measurements select a level threshold and a measurement interval. The threshold transgressions are recorded by a counter for the selected threshold and two other counters for a threshold 3 dB above and a threshold 3 dB below the selected threshold. In this way cumulative and class frequencies can be determined. Each of the three thresholds has a dead time that does not depend on that of the other two. Two dead time values can be selected – 125 and 3 ms.

Impulsive noise measurements	
Three counters, counting capacity	0 to 9999
adjustable level threshold	−49 to 0 dB
additional thresholds	separation +3 dB/−3 dB
Dead time, switchable	3/125 ms
Interruption measurements	
Six counters, counting capacity	0 to 9999
setting range of test signal nominal level	−49 to +10 dB
Thresholds for interruption counting	−3, −6, −10, −20 dB
Dead time, switchable	0/125 ms
Input impedances	150, 600 Ω, 100 kΩ

2617 DLM-20

In the case of interruption measurements interruptions are classified and recorded on the basis of six duration classes. A 2 kHz test signal is used to carry out this type of measurement on transmission paths for the audio band. The nominal level of this signal is set on the DLM-20. A decrease in level or an interruption lasting >0.3 ms is recorded.
As the dead time can be switched from ≈0 to 125 ms the measurements made with the DLM-20 can be compared with those made with mechanical counters.

When the measurement interval has been selected a timer in the DLM-20 takes over control; all counters are zeroed and the measurement runs for the selected period.

The result recorded by each of the three counters is displayed on a large 4 digit LCD display by turning a selector switch to the appropriate positions.

Although the DLM-20 is primarily a battery device it can be powered from the a.c. line by an a.c. adaptor/charger.

Specifications of the Data Circuit Test Set — DLM-20

When not otherwise stated, the specified data is valid under the rated conditions of use for the influence quantities.

Input . . . . . balanced, floating 3 pole CF jacks
Input impedance, switchable . . . . . 150, 600 Ω, 100 kΩ
Return loss (f ≦ 6 kHz, Z_{in} = 150 Ω, 600 Ω) . . . . . ≧40 dB
Signal balance ratio
for impulsive noise measurements . . . . . ≧60 dB
for interruption measurements
(f = 0.3 to 6 kHz) . . . . . ≧50 dB
Tolerable d.c. voltage (Z_{in} = 100 kΩ) . . . . . ≦60 V
Tolerable direct current loading (Z_{in} = 150, 600 Ω) . . ≦60 mA
Tolerable signalling voltage, 25, 50 Hz
(Z_{source} ≧500 Ω, max. 10 s) . . . . . ≦100 V

Display
Four digit LCD display . . . . . range 0 to 9999
Indicator for . . . . . "measurement in progress"

Timer
selectable in steps of 1 min . . . . . range 1 to 99 min
Continuous measurement . . . . . setting "00"
Start-stop key

Impulsive noise measurements . . . . . complying with CCITT Rec. O.71
Counting with three thresholds each with a counter
Capacity . . . . . 0 to 9999
Level range . . . . . −49 to 0 dB
centre threshold . . . . . adjustable in 1 dB steps
upper/lower threshold,
separation from set threshold . . . . . −3/+3 dB
Error limits, centre threshold . . . . . ±0.5 dB
Error limits, upper/lower threshold . . . . . ±0.2 dB
Guard interval
count/no count . . . . . pulse duration ≧50/≦20 µs
Dead time, switchable . . . . . 125 ±25 ms, 3 ±0.7 ms
Frequency range (1 dB limits) . . . . . 275 to 3250 Hz
Attenuation at 200 (≦200) Hz . . . 3 dB ±1 dB (18 dB/octave)
Notch filter, can be switched in or out . . . . . 850 Hz
Attenuation at 850 Hz ±20 Hz (±50 Hz) . . ≧50 dB (≧35 dB)
at ≦400 Hz and ≧1500 Hz . . . . . ≦0.5 dB

Interruption measurements . . . . comply with CCITT O.62
Six counters, capacity . . . . . 0 to 9999
Classes . . . . . 0.3 to 3 ms/3 to 10 ms/10 to 30 ms/30 to 300 ms/300 ms to 1 min/>1 min
Display by LCD point . . . . . duration ≧100 ms
Level range for nominal level of
test signal . . . . . −49 to +10 dB adjustable in 1 dB steps
Thresholds referred to nominal level . . . . . 3, 6, 10, 20 dB
Error limits of nominal level . . . . . ±0.5 dB
Error limits
of thresholds −3 to −10 dB (−20 dB) . . . . . ±0.5 (±1.5 dB)
Frequency of test signal . . . . . 2000 Hz ±100 Hz
Dead time, switchable . . . . . ≈0/125 ±25 ms

General Specifications

Power supply
Built-in, throw-away dry battery . . . . . 9 V, IEC 6 LF 22
or NiCd rechargeable battery
(on request) . . . . . VARTA Tr 7/8
Operating time with dry battery . . . . . approx. 70 h
with NiCd . . . . . approx. 15 h
Separate a.c. adaptor/charger for normal and trickle charging.

Permissible ambient temperature
Rated range of use . . . . . 0 to +50°C
Storage and transportation . . . . . −40 to +70°C
Dimensions (w x h x d) in mm . . . . . 98 x 164 x 74
Weight . . . . . approx. 0.7 kg

Accessories (part of standard package)
One 9 V dry battery

Accessories (at extra cost)
A.C. adaptor/charger
NiCd rechargeable battery 9 V, BN 820/00.50

Ordering Information

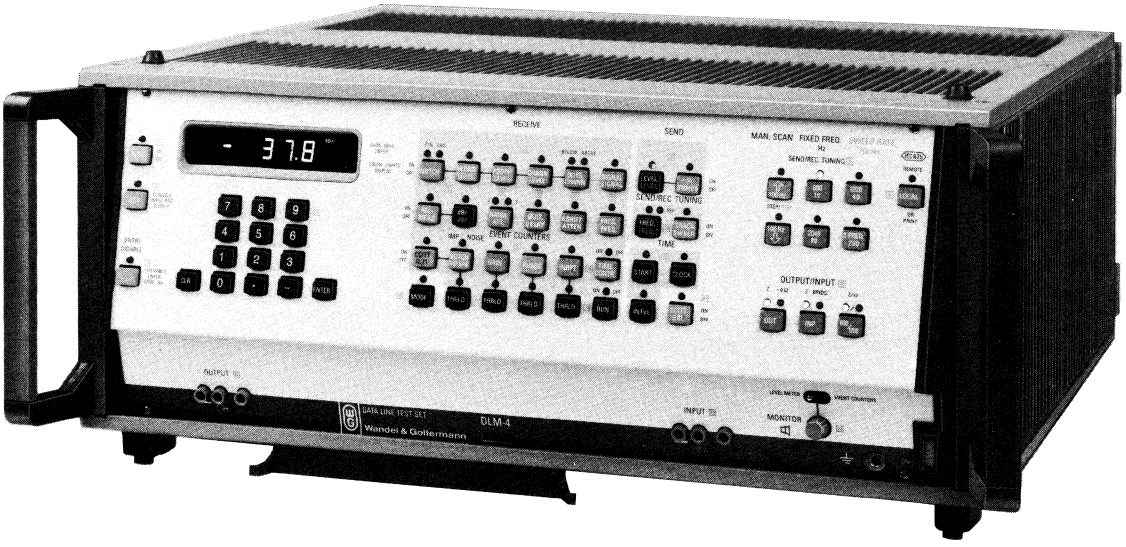
Data Circuit Test Set DLM-20	**BN 961/01**
Accessories (at extra cost)	
A.C. adaptor/charger with	
Standard European power plug (193 to 242 V, 47.5 to 63 Hz)	BN 964/00.02
U.S. type power plug (105 to 132 V, 47.5 to 63 Hz)	BN 964/00.03
U. K. type power plug (211 to 264 V, 47.5 to 63 Hz)	BN 964/00.04
Mains cable, but without plug (211 to 264 V, 47.5 to 63 Hz)	BN 964/00.05
NiCd rechargeable battery	BN 820/00.50
Leather carrying case, with space for DLM-20, a.c. adaptor/charger and cable	BN 926/11
Plug-in adaptor (for extra impedance of 300 Ω)	BN 876/00.01
Carrying strap	BN 820/00.52

A Colour Brochure is available on request

DLM-4
Data Line Test Set

for the frequency range 200 Hz to 4 kHz

IEEE 488
IEC 625



- **Measures all the most important parameters as prescribed in CCITT Rec. M.1020**
  Group delay and attenuation frequency distortion, level, frequency shift, phase jitter, noise level, nonlinear distortion, impulsive noise, interruptions, phase and gain hits
- **Measurements comply with CCITT O.61, O.62, O.71, O.81, O.91, O.95, O.111**
- **All parameters are measured simultaneously**
- **Results and event counts are stored when there is a power failure or when the DLM-4 is switched off**
- **Fixed and selectable setups**
- **Digital display of results**

Applications

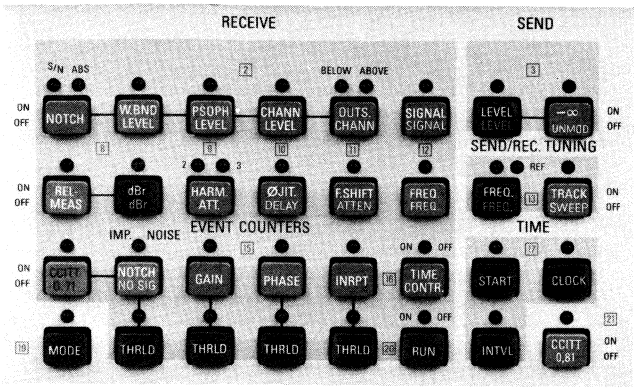
Data circuits are being used to carry traffic at increasingly higher speeds. This requires careful equalisation of the variation of group delay with frequency and the attenuation frequency distortion in the frequency range 0.3 to 3.4 kHz. The characteristics of special quality international leased circuits are laid down in CCITT Rec. M. 1020.
There is also an increasing demand for measurements on time-dependent parameters.
The DLM-4 Data Line Test Set fulfils both these requirements. As the DLM-4 has a universal range of measuring capabilities, and can measure time dependent parameters simultaneously, it is ideal for installation and maintenance work and trouble-shooting on data comm equipment.

Characteristics

For reasons of compatibility, the measurement of variation in group delay with frequency and attenuation frequency distortion are carried out using the method described in CCITT O.81, a modified Nyquist method.
Two signals generated in the send section (carriers) are periodically changed over and continuously amplitude modulated. One carrier frequency (measure frequency) is swept over the required frequency range, the other carrier (reference frequency) has a fixed reference value. When the combined signal passes through a test object with a nonlinear phase response, a phase discontinuity occurs in the envelope on carrier changeover. When a suitable modulation frequency is chosen the magnitude of the phase discontinuity is a measure of the group delay distortion $\triangle\tau_g$.
Attenuation differences alter the carrier amplitude. These changes are evaluated and displayed by the receiver.
All the function keys required for carrying out group delay distortion and attenuation frequency distortion measurements are clearly marked in different colours, and they are activated by a special key.

Group delay distortion	10 μs to 10 ms
Attenuation frequency distortion	0.1 dB to ± 50 dB
Level measurements	−100 dB to +10 dB
Frequency measurements	200 Hz to 20 kHz
Frequency shift measurements	± 0.01 to 9.99 Hz
Impulsive noise measurements	
3 counters, count limits	0 to 9999
Interruption measurements	
5 counters, count limits	0 to 9999

DLM-4 2568



Function keyboard

The other measurement parameters –
level, frequency, frequency shift, phase jitter, noise, nonlinear distortion, impulsive noise, interruptions, phase hits and gain hits are all selected by function keys and displayed.

Impulsive noise, interruptions, phase hits and gain hits can be counted manually with the start/stop function or they can be counted over user-selectable time intervals by means of a built-in clock. Keyboard entry is disabled when a count is being carried out to prevent inadvertent operation. The keyboard can also be disabled by means of a special button, and is released by entering a code number.
Fixed or user-selectable setups make the DLM-4 easy to operate. Once a measurement sequence has been defined, it can be called up and used over and over again. The user saves time and eliminates operating errors.
The user can create three different setups of his own choice, store them, call them up or modify them when he requires.
A test program, controlled by the microprocessor, is used for localising faults. In addition to this, the microprocessor calculates frequency shift and signal-to-noise ratio and performs averaging.

All the functions set on the DLM-4, including the counter results, are stored when the DLM-4 is switched off or if there is a power failure.
If required the Interface <IEC 625>/IEEE 488 Card can be fitted so that all the DLM-4's functions can be remote controlled and the measurement data interrogated. The Bus Card also allows the DLM-4 to be integrated into automatic test sets.

Example of a fixed setup

AVRG	(Averaging):	off
NOTCH	(Receive level):	off
∅ JIT	(Phase jitter measurement):	on
LEVEL	(Send level):	−10 dBm
− ∞	(Send blanking):	off
REL.MEAS	(Relative measurement):	off
dBr	(Relative level):	0.0 dBr
FREQ.	(Send/receive frequency):	1020 Hz
TRACK	(Autom. frequency tracking):	off
NOTCH	(Impulsive noise):	off
THRLDS	(Tresholds) for:	
CCITT O.71	(Impulsive noise):	−18 dBm
GAIN	(Gain hits):	3 dB
PHASE	(Phase hits):	15°
INRPT	(Interruptions):	10 dB
TIME CONTR	(Time control):	off
INTVL	(Counting interval):	0.15 = 15 min
RUN:		off
CCITT O.81	(Group delay):	off
CCITT O.71	(Impulsive noise):	off
ENTRY DISABLE	(Disable):	off
LOCAL	(Remote control):	off
IMP	(Input/output impedance):	
OUT:		Z
INP:		Z
Z:		600 Ω
MODE	(For printer):	4.00
MODE	(For plotter):	5.20
Sweep limits	f_l:	200 Hz
Sweep limits	f_u:	4 kHz

Specifications of the Data Line Test Set — DLM-4

Unless otherwise noted, the given specifications are valid within the rated range of use for a.c. line voltage, a.c. line frequency and ambient temperature.

Send Section

Send signal complies with CCITT O.81 in the "group delay" measurement mode

Output . . . . . balanced, floating
Output impedance, switchable . . . low impedance (≦ 12 Ω), 600 Ω and an extra value between 150 Ω and 1200 Ω
Return loss
600 to 1200 Ω (≦ 600 Ω) . . . . . ≧ 40 dB (≧ 10 dB)
Signal balance ratio
600 to 1200 Ω (< 600 Ω) . . . . . ≧ 60 dB (≧ 40 dB)
Tolerable d.c. voltage to earth . . . . . ≦ 100 V
Tolerable d.c. current . . . . . ≦ 30 mA

Send frequency . . . . . 0.2 to 20 kHz
Setting digital/incremental . . . . . in 10/100 Hz increments
Three fixed frequencies . . . . . 800, 1020, 2040 Hz
Two tone signal . . . . . 1020/2040 Hz
Sweep limits of the measurement frequency . . . . adjustable between 0.2 and 4 kHz in 100 Hz increments
Sweep speed . . . . . 10, 40, 80, 200 Hz/s
Reference frequency, digital adjustment . . . . . 0.4 to 4 kHz

Send level
Digital adjustment in 0.1 dB increments . . . −70 to +10 dBm
Error limits
Frequency setting . . . . . $\pm 2 \times 10^{-5}$

Harmonic ratio a_{k_2}, a_{k_3},
send frequency f = 0.2 to 4 kHz (≧ −40 dBm) . . . . ≧ 50 dB

Receive Section

Input . . . . . balanced, floating
Input impedance,
switchable . . . . . high impedance (approx. 80 kΩ),
600 Ω and an extra value between 150 Ω and 1200 Ω
Return loss, to 4 kHz (20 kHz)
Input impedance 150 to 600 Ω . . . . . ≧40 dB (≧20 dB)
600 to 1200 Ω . . . . . ≧34 dB (≧14 dB)
Signal balance ratio . . . . . ≧50 dB
CCITT Rec. P.53 and O.71 are also complied with
Tolerable d.c. voltage to earth . . . . . ≦100 V
Tolerable d.c. current . . . . . ≦50 mA
Tolerable ringing voltage (25/50 Hz, max. duration 10 s,
Z_{source} ≧500 Ω) . . . . . ≦90 V

Frequency tuning
common tuning with generator
measuring frequency . . . . . 0.2 to 4 kHz
Digital/incremental adjustment . . . . . in 10/100 Hz steps
automatic (track) . . . . . in 10 Hz steps

Combined instrument

Group delay distortion measurement
Range/resolution . . . . . 0 to 10 ms/10 μs

Error limits
after correction for intrinsic distortion
for attenuation distortion
± ≦5 dB (± ≦30 dB) . . . . ± 15 (± 20) μs ± 3 % of reading
Intrinsic distortion to 400 Hz/600 Hz/4 kHz
of send section . . . . . ≦10 μs/≦30 μs/≦1 μs
of receive section . . . . . ≦90 μs/≦27 μs/≦4 μs

Attenuation frequency distortion
Range/resolution . . . . . ± 50 dB/0.1 dB

Error limits
after correction for intrinsic distortion . . . . ± 0.1 dB ± 3 % of reading or ± 0.2 dB (whichever error is greater)
Intrinsic distortion
of send section . . . . . ± 0.05 dB
of receive section . . . . . ± 0.05 dB

Level measurements
Range/resolution . . . . . − 100 to + 10 dBm/0.1 dB
selective . . . . . − 50 to + 10 dBm
Spectral weighting (3 dB limits)
wideband/psophometric . . . . . 10 Hz to 50 kHz as per CCITT P.53 A
Channel filter . . . . . 200 Hz to 4 kHz
Out-of-channel weighting . . . . . 10 Hz to 200 Hz/4 kHz to 50 kHz
Signal-to-noise ratio . . . . . 0 to 50 dB

Intrinsic noise (Z_0 ≧ 600 Ω),
weighting channel filter/wideband . . . . ≦ − 105/≦ − 95 dB

Error limits of level display
(0 dBm, 800 Hz, wideband or selective,
+15 to +35° C) . . . . . ± 0.2 dB

Frequency measurements[1)]
Range/resolution . . . . . 0.2 to 20 kHz/1 Hz
Error limits of digital display . . . . . ± 1 Hz ± 2×10^{-5}

Frequency shift measurements[1)]
Range/resolution . . . . . ± 0.01 to ± 10 Hz/0.01 Hz
Error limits . . . . . ± 5 % of reading or ± 0.05 Hz (whichever is greater)

Phase jitter measurements complying with CCITT O.91[1)]
Range/resolution . . . . . 0.1 to 30°/0.1°

Evaluation . . . . . peak-to-peak
3 dB limits as per CCITT O.91 . . . . . approx. 16 to 370 Hz
or . . . . . approx. 2 to 370 Hz

Error limits of the digital display
(+5 to +40° C) . . . . . ± 0.2° ± 5 %

Harmonic ratio a_{k_2}, a_{k_3}[1)]
Range/resolution . . . . . 10 to 50 dB/0.1 dB
3 dB bandwidth . . . . . approx. 100 Hz
Error limits of the digital display (10 to 30 dB) . . . . . ± 0.7 dB

Event counting
Impulsive noise, interruptions, gain hits and phase hits are counted

Impulsive noise measurements complying with CCITT O.71
Three counters each with
three thresholds . . . . . capacity 0 to 9999

Level range . . . . . − 60 to 0 dBm/dBm0

The centre threshold can be adjusted in 1 dB steps
upper/lower threshold separation from
set threshold . . . . . +3/−3 dB
Error limits on threshold setting . . . . . ± 0.5 dB

Guard interval . . . . . 35 μs ± 15 μs

Dead time . . . . . 125 ms ± 20 %

The test tone used to carry out impulsive noise measurements is automatically suppressed.
Test tone attenuation (+ 15 to +35° C) . . . . . ≧50 dB

Interruption measurements complying with CCITT O.61
Level range for the nominal level
of the test signal . . . . . − 50 to + 10 dB
Activation thresholds referred to the nominal value,
adjustable in 1 dB steps over the range . . . . . 3 to 20 dB
Error limits of the activation thresholds,
3 to 10 dB (> 10 dB) . . . . . ± 1 dB (± 2 dB)

Frequency of the test tone . . . . . 700 Hz to 4 kHz

Guard interval . . . . . 2.75 ms ± 0.75 ms

Dead time (convertible) . . . . . 125 ms ± 20 %/3 ms ± 1 ms

Interruption measurements complying with CCITT O.62
Five extra counters are used. They have a common threshold setting but the guard intervals may be different
Classification . . . . . 0.3 to 3 ms/3 to 30 ms/30 to 300 ms, 300 ms to 1 min/> 1 min

Dead time . . . . . 125 ms ± 20 %

Frequency of the test tone . . . . . 2 kHz ± 100 Hz

Gain hit measurements complying with CCITT O.95[1)]
Adjustment range of the thresholds . . . . . ± 2 dB to ± 9 dB, adjustable in 1 dB steps
Error limits (2 to 6 dB) . . . . . ± 0.5 dB

Guard interval . . . . . 4 ms ± 10 %

Dead time . . . . . 125 ms ± 20 %

Frequency of test tone . . . . . 700 Hz to 4 kHz

Phase hit measurements complying with CCITT O.95[1)]
Adjustment range of the thresholds . . . . 5 to 45°, in 1° steps
Error limits . . . . . ± 0.5° ± 10 %
For other specifications see gain hits.

Time settings
Integral crystal clock, display . . . . . hours and minutes
Settings for the event counter . . . . start time, count duration
Operating time, trickle charged . . . . . > 100 h

Additional functions

Monitor loudspeaker
for listening to the measurement signal and noise.
When counting gain hits, phase hits, impulsive noise and interruptions, the loudspeaker is used as a hit indicator.

Slow measured value evaluation
so that noisy signals can be displayed more clearly.

Entry disable
Prevents unintentional entries.

Setups
Fixed or user-selectable setups containing sequences of entry and operating functions.

D.C. voltage outputs
X-output connector,
Frequency, interval time . . . . . 0 to + 5 V

Y-output
Level, group delay, attenuation,
frequency shift, phase jitter, harmonic ratio,
events . . . . . − 2.5 V to + 2.5 V

Data output connector for connecting external instruments
Impulse output events
Phase jitter output
Total noise level output
Monitor

General Specifications

Power supply
Rated ranges of use of a.c. line voltage,
switchable . . . . 110/117/127/220/227/235 V, + 10/− 12 %
Rated range of use of a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 75 VA
Safety class as per IEC 348 and VDE 0411 . . . . . class I

Tolerable ambient temperature
Rated range of use . . . . . 0 to + 50° C
Storage and transportation . . . . . − 40 to + 70° C

Dimensions (bxhxt) in mm
Bench version . . . . . 477 x 199 x 433
19" rack mounting (4 units) . . . . . 443 x 175 x 379
19" conversion kit . . . . . BN 700/00.04

Weight . . . . . approx. 20 kg

Options

Interface Bus <IEC 625>/IEEE 488, BN 853/04
For remote controlling all the DLM-4's functions and for interrogating the measurement data

or alternatively

Printer interface BN 905/03
For connecting a printer with a V.24/V.28 interface

Ordering Information

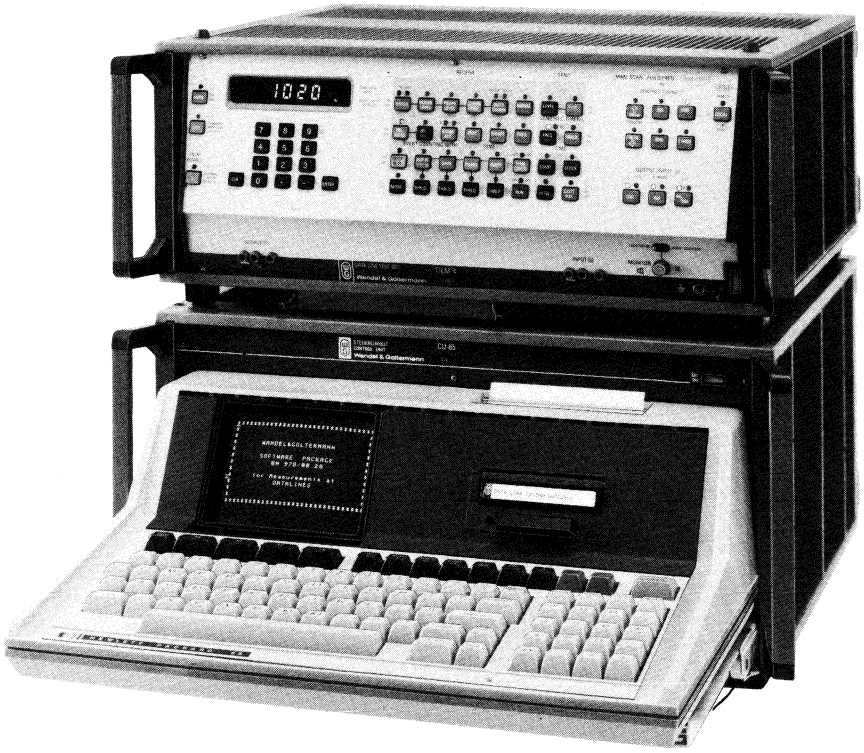
Data Line Test Set DLM-4	
with group delay measuring device	
English lettering, 600/1200 Ω	**BN 914/01**
German lettering, 600/1200 Ω	**BN 914/11**
without group delay measuring device	
English lettering, 600/1200 Ω	**BN 914/03**
German lettering, 600/1200 Ω	**BN 914/13**
Options (at extra cost)	
<IEC 625> Bus Card	
with IEC 625/IEEE 488 Adaptor (S 834)	BN 853/04
or alternatively	
V.24/V.28 printer interface	BN 905/03
Impedance modification 600/900 Ω	BN 914/00.02
600/800 Ω	BN 914/00.03
600/150 Ω	BN 914/00.04
Accessories (at extra cost)	
Impulsive noise weighting filter	
as per CCITT O.71 (600 Hz to 3 kHz)	BN 878/00.02
X-Y plotter paper, group delay distortion	
Engl./Germ., for BN 914/01 and /11	BN 6390/00.36
X-Y plotter paper, attenuation frequency distortion	
Engl./Germ., for BN 914/01 and /11	BN 6390/00.37
Connecting cable for Interface <IEC 625>	
1.2 m long	K 343
2 m long	K 344
Front and backpanel covers, SD-4 (1 set)	BN 700/00.24

1) For all selective measurements the level range is − 50 to + 10 dB

A Colour Brochure is available on request

DLM-400
Data Circuit Monitoring System

for automatic measurements on data circuits



- **Measures the analog parameters of data circuits**
- **Loop-back and end-to-end measurements**
- **Local and remote controlled measurements on the remote ends of data circuits**
- **Results are displayed as tables or graphs**

Applications

The current demand for more and more information services has led to a marked expansion in the field of teleprocessing. To transfer large volumes of data, high transmission speeds are required and this in turn means high quality transmission channels. To obtain a small error rate at the digital interfaces, the transmission paths must be of high quality, however it is not sufficient just to monitor the analog, frequency-dependent parameters to obtain a GO/NO GO criterion for transmission paths, it is extremely important to prevent impairments such as impulsive noise, phase hits, interruptions etc. from lowering the quality of data transmission.
The DLM-400 Monitoring System is the right instrument to ensure the quality of data transmissions as it carries out program controlled and automatic monitoring on all the most important circuit parameters.

Characteristics

The basic version of the DLM-400 has the following components:
- DLM-4, an instrument which measures analog data circuit parameters in voice channels.
- CU-85, a control unit for sequencing measurements and processing results.

Group delay, attenuation distortion, level, frequency shift, phase jitter, noise, nonlinear distortion, impulsive noise, phase hits, gain hits and interruptions can all be measured with the DLM-400. Parameters such as interruptions, impulsive noise, amplitude hits etc. are determined simultaneously by the DLM-400.

Monitoring the data circuit parameters as specified in CCITT M.1020
Measurements as per CCITT O.61, O.62, O.71, O.81, O.91, O.95, O.111
System components:
DLM-4 Data Line Test Set
CU-85 Control Unit
SWP-16 Software Package
Expandable by using the MU-30 Test Point Scanner

2581 DLM-400

Further characteristics and applications

System expansion

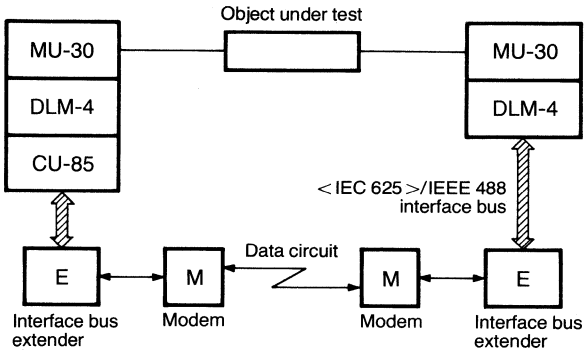
The DLM-400 can be expanded in a variety of ways. The basic version of the DLM-400 is ideal for loop-back measurements and with an interface-extender, end-to-end measurements can be performed.
The most powerful version of the DLM-400 has an independent test station at both ends of the circuit-under-test. These stations can operate independently or in master-slave mode. Both, this version of the DLM-400 and the DLM-400 with the interface extender, need a separate channel to exchange data.
When end-to-end measurements are made, the results are output by the master. If test point scanners are included in the system, several circuits can be investigated.

Possible stages of expansion

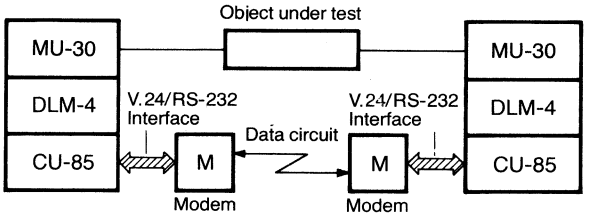
CU-85	Ext.	RS 232	DLM-4	MU-30	No. of channels	Loop-back	End-to-end
1	–	–	1	– 1 2	1 30 60	•	
1	–	–	2	– 2	1 60	•	
1	•	–	1 + 1	– 1 + 1	1 30		•
2	–	•	1 + 1	– 1 + 1 2 + 2	1 30 60		•
2	–	•	2 + 2	– 2 + 2	1 60		•

Operation

The user himself determines what measurement sequence the DLM-400 Monitoring System will perform. By means of a screen dialog the user can select which operating modes he requires and the order in which the measurements are to be performed. Measurements are carried out cyclically on specified circuits or at specific times. A measurement can be defined and performed immediately in the so-called "interactive mode" so that results can be given a quick check. The results are displayed as tables or as graphs on the screen, or printed out on the system's own printer.
The results are stored on magnetic tape to prevent loss should a power failure occur. This means that monitoring is continued after a power failure and no supervision is required.



a) Control via interface bus extender



b) Control using V.24/RS-232 interface

Possible ways of expanding the DLM-400 Data Circuit Monitoring System

Specifications of the Data Circuit Monitoring System — DLM-400

The specifications of the system comprise the specifications of the individual components where relevant.

DLM-4 Data Line Test Set

Generator section
Frequency range . . . . . 200 Hz to 20 kHz
Level range . . . . . −70 to +10 dBm

Receive section
Frequency range . . . . . 200 Hz to 20 kHz
Level measurements, wideband . . . . . −100 to +10 dBm
Frequency shift measurements . . . . . ±0.01 to ±10 Hz
Phase jitter measurements . . . . . 0.1 to 30°
Group delay distortion . . . . . 10 µs to 10 ms
Attenuation frequency distortion . . . . . ±50 dB
S/N display range . . . . . 0 to 50 dB
Harmonic ratio a_{k_2}, a_{k_3} . . . . . 10 to 50 dB
Event counting capacity . . . . . 0 to 9999
Time measurements using crystal controlled clock

MU-30 Test Point Scanner

Number of balance-switched telephone channels 30

CU-85/4 Control Unit

Screen . . . . . 123 mm
Printer . . . . . 32 characters/line
Keyboard . . . . . typewriter
Tape cassette . . . . . approx. 210 kbyte

SWP-16 Software Package

Automatic and interactive measurements
Local and remote control

Ordering Information

Data Circuit Monitoring System DLM-400 **BN 6609/04**
comprising the DLM-4 Data Line Test Set,
the CU-85/4 Control Unit, and the SWP-16 Software Package

LD-2

Group Delay and Attenuation Measuring Setup

for the frequency range 200 Hz to 600 kHz



- **Group delay and attenuation distortion measurements**
- **Split frequency 41.66 Hz complies with CCITT Rec. O.81**
- **Measures the frequency difference between the measure and reference frequency**
- **Point-by-point and sweep measurements**
- **Loop and end-to-end measurements**
- **A.C. line and battery operation**

Applications

At present there is a trend towards increasing data transmission speeds on voice-grade lines. To eliminate errors these lines must be precisely aligned to tight group delay and attenuation distortion tolerances.
The LD-2 Measuring Setup can measure the variation with frequency of these parameters over the telephone range of 200 Hz to 4 kHz and on CF systems.
Because of the LD-2's high measuring accuracy and resolution, even very small errors at the subassembly levels of communication systems can be detected.

Characteristics

The Nyquist method is used to measure group delay. This involves determining the phase shift of the envelope of an amplitude modulated signal when it passes through a test object. This phase shift is a direct measure of group delay if a suitable modulation frequency is used. The variation with frequency is determined by varying the carrier amplitude.
A modification of carrier amplitude indicates any attenuation differences.
Sweep and point-by-point measurements can be carried out.

Three different meters are used to show delay, attenuation and frequency differences. All the measured quantities can be output on an external x-y plotter.

Frequency range	200 Hz to 600 kHz
Group delay distortion	± 1 µs ... ± 10 ms, +20 ms
Attenuation distortion	± 0.05 ... ± 50 dB
Frequency difference	± 0.02 ... ± 500 kHz

2426 LD-2

Specifications of the Group Delay and Attenuation Measuring Setup — LD-2

If nothing to the contrary is stated, the data given are valid for the rated conditions of use.

Measuring Setup

Frequency range . . . . . 200 Hz to 600 kHz

Level ranges
Generator, switchable . . . . − 15 to + 10 dB/− 35 to − 10 dB
Receiver . . . . . − 50 to + 10 dB

Split frequency . . . . . 41.66 Hz ± 0.5 %
Changeover signal . . . . . 4.16 Hz

Sweep limits,
independently adjustable,
continuous and by increments,
referred to reference frequency f_{ref} . . . ± 200 Hz to ± 500 kHz
Sweep speed adjustment,
seven settings . . . . . 15 Hz/s to 13 kHz/s

Measurement ranges

Group delay distortion
11 subranges . . . . . ± 10, ± 20, ± 50, ± 100 µs ... ± 10 ms, ± 22 ms
Smallest measurable value . . . . . ± 1 µs

Attenuation distortion
7 subranges . . . . . ± 0.5, ± 1, ± 2, ± 5 ... ± 50 dB
Smallest/largest measurable value . . . . ± 0.05 dB/± 40 dB

Frequency differences
11 subranges . . . . . ± 0.2, ± 0.5, ± 1, ± 2 ... ± 500 kHz
Max. permissible level difference
between measure and reference carrier . . . . . 40 dB

Error limits

Group delay distortion . . . . . ± 3 % ± 1.5 µs
for f = 1 to 600 kHz, △a ≦ 10 dB,
and input level ≧ − 10 dB

Attenuation distortion . . . . . ± 3 % ± 0.025 dB

Frequency difference . . . . . ± 3 % ± 25 Hz
at a max. level difference of 10 dB between
measure and reference frequency

Output/input,
balanced, floating . . . . . 3 pole CF connector
Generator output also coaxial
Generator output impedance,
switchable . . . . . $Z_{out} \approx 0, 75, 150, 600\ \Omega$
Receiver input impedance,
switchable . . . . . $Z_{in} \approx 10\ k\Omega, 75, 150, 600\ \Omega$
D.C. current load . . . . . max. 50 mA

Analog output . . . . . 3 pole CF connector
for all three measured quantities
Meter f.s.d. . . . . approx. ± 4 V
Output impedance . . . . . approx. 40 kΩ

General Specifications

A.C. line operation
Rated ranges of use of a.c. line voltage,
switchable . . . . . 99... 132 V, 198...264 V
Rated range of use of a.c. line frequency . . . . . 45 to 65 Hz
Power consumption . . . . . 60 VA per device
Battery operation
Rated range of use of battery voltage . . . . . 20 to 30 V
Power consumption . . . . . 48 W per device

Permissible ambient temperature
Rated range of use . . . . . + 10 to + 35° C
Storage and transportation . . . . . − 25 to + 60° C

Dimensions (wxhxd) in mm
Bench version . . . . . 478 x 288 x 407
19" rack mounting (6 units) . . . . . 433 x 265 x 353

Weight . . . . . 25 kg per device

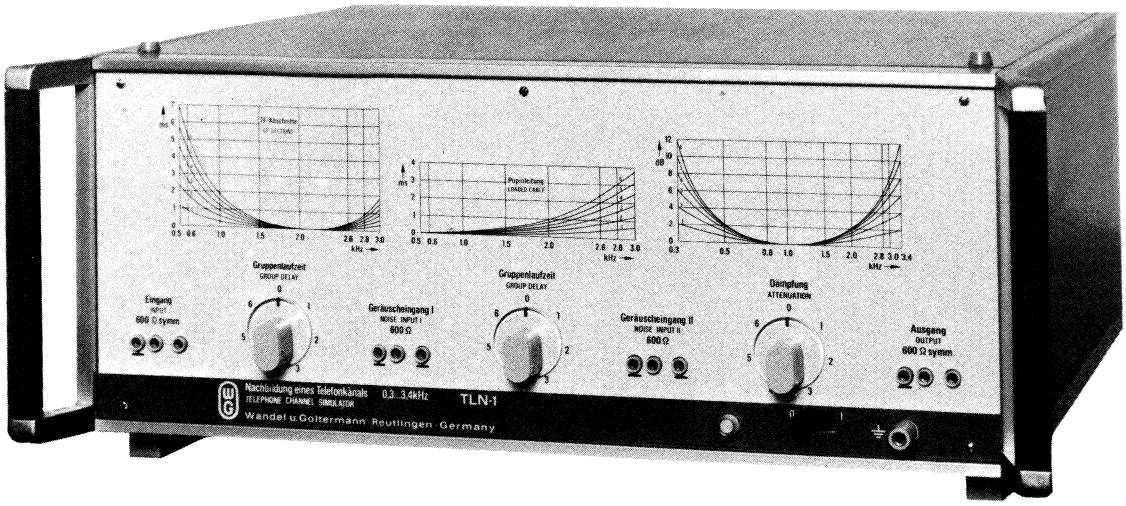
Ordering Information

Group Delay and Attenuation Measuring Setup LD-2
comprising
Generator LDS-2 — BN 280/00
Receiver LDE-2 — BN 281/00

Accessories (at extra cost)
Protective Transportation Covers
(1 set per device) DE-5 — BN 476/00.05

TLN-1
Telephone Channel Simulator

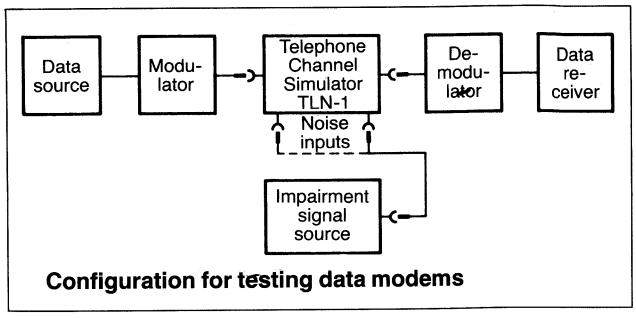
for simulating the group delay and attenuation distortion of a telephone channel



- **Simulation of the group delay behavior of a maximum of 6 CF sections and 6 loaded cable sections**
- **Simulation of attenuation distortion**
- **Independent settings for the characteristics of attenuation distortion and group delay**
- **Decoupled inputs for injecting any impairment signal at the input or output**

Applications

For purposes of data transmission, it has become expedient to use telephone circuits (freq. range 0.3 to 3.4 kHz). These are made up from carrier frequency sections and various lengths of loaded trunk cables. Thus, the existence of attenuation distortion and group delay distortion can cause errors in the transmission of data. Knowledge of these distortion characteristics is especially important in the development and testing of data-modems. The TLN-1 Telephone Channel Simulator is most useful for simulating the distortions in the above-mentioned telephone circuits.



Configuration for testing data modems

Characteristics

With the TLN-1, each of 3 switches provide independent control (with no interaction) of 6 different frequency responses for group delay of CF sections and loaded cable circuits. Also, the attenuation distortion for the complete path can be set up. Thus, the TLN-1 permits separate examinations of the effects of group delay distortion and attenuation distortion. If the simulation of the transmission characteristics of 6 CF sections or of 6 cable sections is not sufficient (e.g. extremely distorted international circuits), then two or more TLN-1s can be used in cascade.
The effects of an impairment signal (e.g. white noise) on the simulated channel can be examined with the TLN-1 Simulator because it has two additional decoupled inputs. This provides the possibility of feeding in an impairment signal either at the input or at the output. An especially suitable source of impairment signals for the TLN-1 is the RG-1 [1] Noise Generator. However, sine wave generators and tape recordings of selector and relay noises etc. can also be used.

1) see data sheet

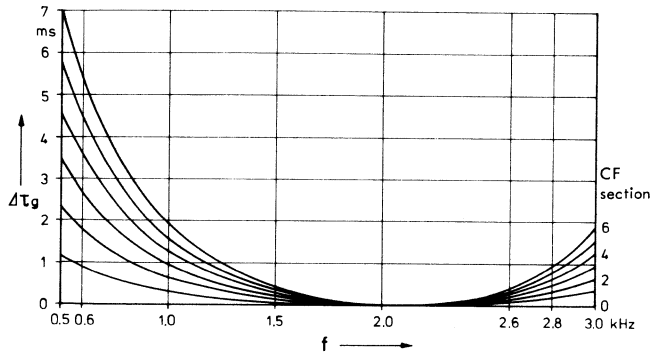
Frequency range	0.3 to 3.4 kHz
Signal input or output impedance, balanced	600 Ω

Specifications of the Telephone Channel Simulator — TLN-1

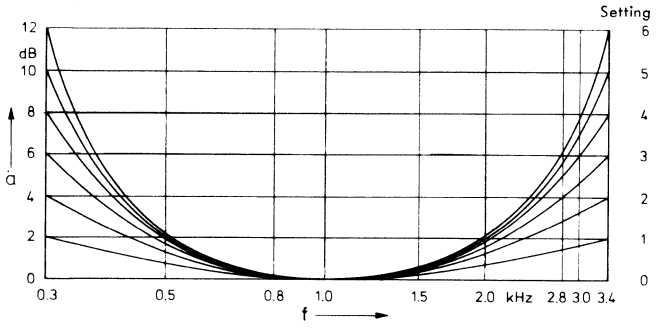
If nothing to the contrary is stated the specifications are valid for the rated range of use of the a.c. line voltage, a.c. line frequency and ambient temperature.

Frequency range . . . . . 0.3 to 3.4 kHz

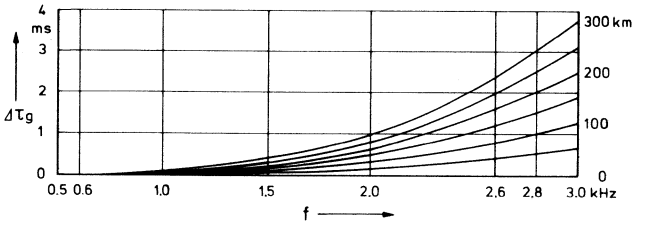
Group delay distortion of CF sections
Nominal values in frequency range 0.5 to 3.0 kHz referred to 2.1 kHz



Attenuation frequency distortion of CF section
Nominal values referred to 1 kHz



Group delay distortion of loaded cable sections
Nominal values in frequency range 0.5 to 3.0 kHz referred to 0.5 kHz. A section corresponds to a 50 km long, lightly loaded cable (approx. 80 mH/1.7 km).



Signal input and output

Input or output impedance, balanced	600 Ω
Return loss	≧34 dB
Max. input level	+6 dBm ≅ 1.55 V
Intrinsic harmonic distortion a_{k_2}, a_{k_3} at max. input level	≧40 dB
Insertion loss (switch position "0")	0 ±1.4 dB
Stop-band attenuation at 4 kHz	≧10 dB
at 4.2 kHz	20 dB

Noise inputs

Noise input I
Impairment signal is added to input signal

Input impedance, unbalanced	600 Ω
Return loss	≧34 dB
Maximum input voltage, V_p	≦1.55 V
Loss up to summing point	0 ±0.2 dB
Isolation from signal input	≧40 dB

Noise input II
Impairment signal is added to output signal

Specs. as with Noise input I

Error limits

Group delay distortion of CF sections

for the 1st CF cable section	+0.16/−0.11 ms
as the preceeding, but with switched-in attenuation frequency distortion	+0.33/−0.11 ms
for every additional CF section	±0.08 ms

Attenuation distortion of CF sections

with switched-out group delay distortion	±0.6 dB
with any optional switched-in group delay distortion of CF section, additionally up to	±0.25 dB

Group delay distortion of loaded cable sections

for the first loaded cable section	+0.12/−0.07 ms
for every additional loaded cable section additionally	±0.04 ms
Attenuation frequency distortion referred to 1 kHz, up to	±0.25 dB

General Specifications

Power supply

Rated range of use of a.c. line voltage	110/117/127/220/227/235 V, −15 % to +10 %
Rated range of use of a.c. line frequency	45 to 66 Hz

Permissible ambient temperature

Rated range of use	+5 to +40 °C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	478	Width	443
Height overall	199	Height (4 units)	176
Depth with handles	407	Depth	353

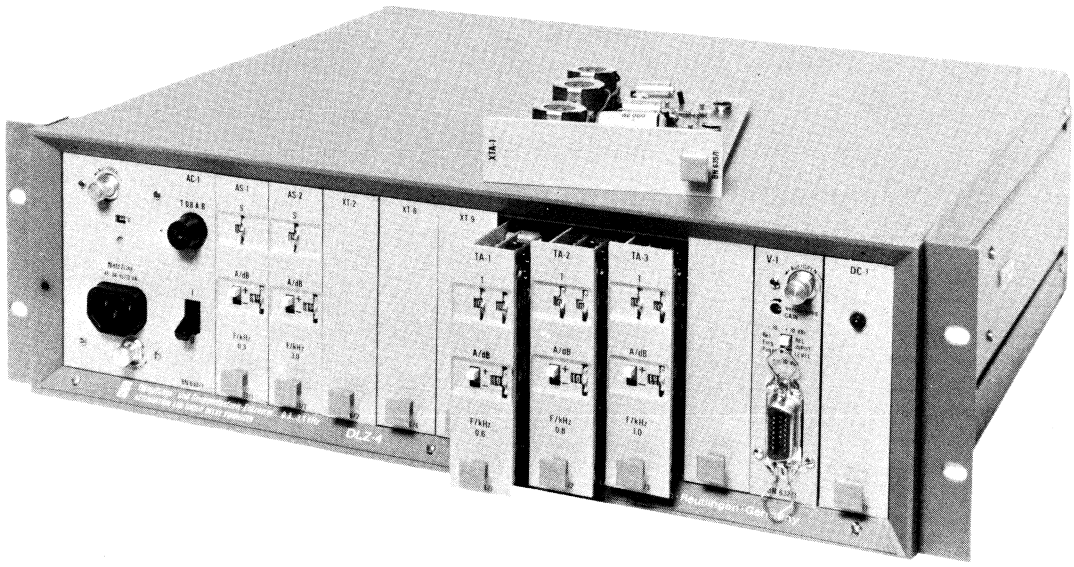
19" conversion kit	BN 556/00.04
Weight	7 kg

Ordering Information

Telephone Channel Simulator TLN-1	**BN 622/00**
Accessories (at extra cost)	
Protective Transportation Cover DE-3	BN 476/00.03

DLZ-4
Attenuation and Group Delay Equalizer

for equalizing attenuation frequency distortion and group delay distortion in voice channels



- **Equalization of FDM channels, coil-loaded sections and combinations thereof**
- **Faster and higher quality alignments with the aid of a computer or equalizing tables**
- **Exact reproducibility and long term stability for any equalizer setting**
- **Group delay equalization of up to 15 ms in a channel**
- **Equalizing a number of channels is possible with only one DLZ-4**

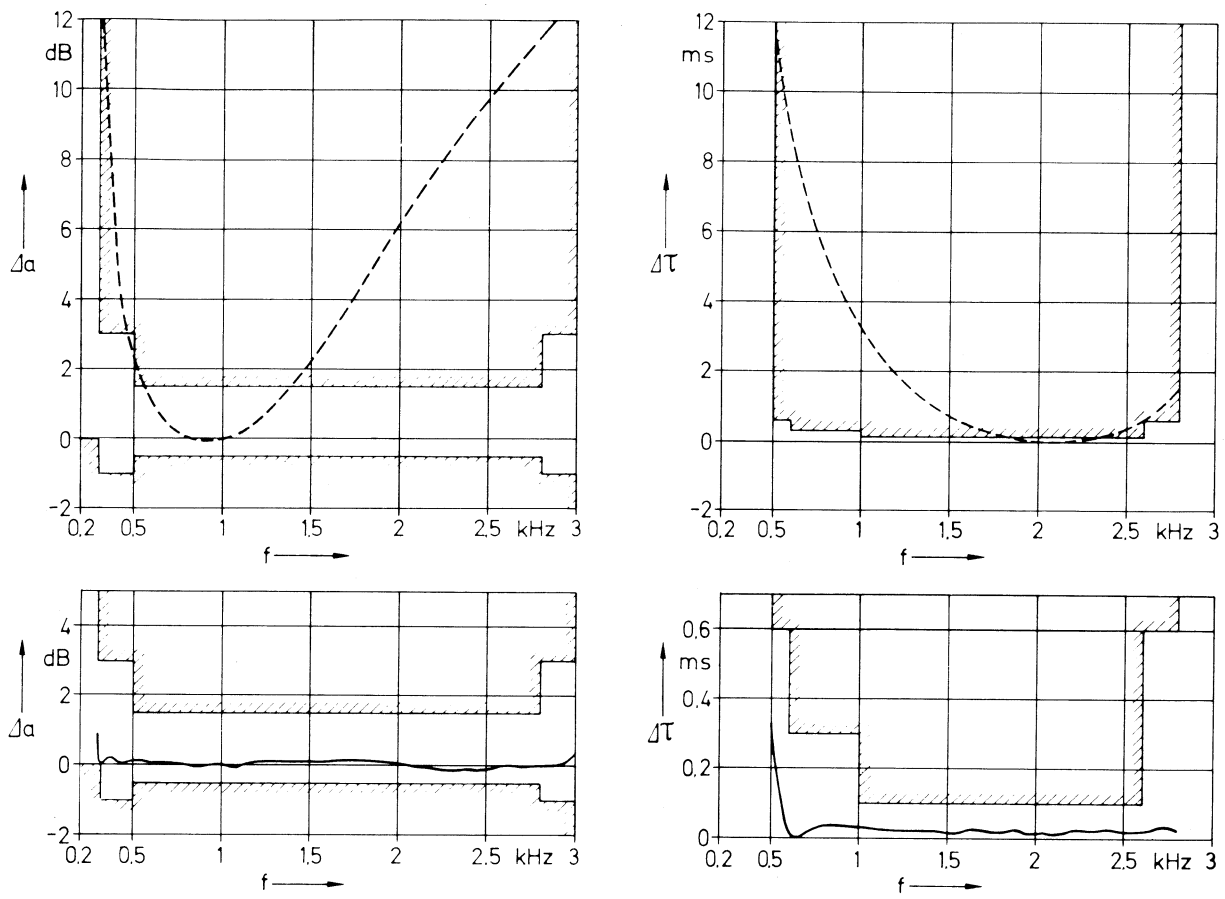
Applications

The Attenuation and Group Delay Equalizer DLZ-4 permit equalizing attenuation frequency distortion and group delay distortion on voice channels, corresponding to CCITT-Recommendation M.1020 or to US Norm S 3. Thus, channels set up for voice communications can be used for highspeed data communications. Several channels can be equalized by means of one DLZ-4.

Characteristics

The principle under which the DLZ-4 Equalizer operates, is that of setting up complementary curves to compensate [1] for the attenuation and group delay distortion curves characterized by a specific transmission path. Individually matched partial equalization combinations facilitate both optimum and cost saving equalizations of a number of voice channels. Equalizer settings are accomplished rapidly and without complicated adjustments when the Equalizer Tables or the FORTRAN IV computer program specially written for the DLZ-4 is used.
Dependent on the degree of distortion exhibited by the transmission path, up to four voice channels can be equalized in one DLZ-4. If a d.c. voltage of 23.5 to 56.5 V is available at the operating site, then the D.C. Power Supply DC-1 is used for supplying power to the DLZ-4. When a.c. power is available the A.C. Power Supply AC-1 is used in addition. The AC-1 operates on 110, 117, 127, 220, 227, or 235 V (−15 %/+10 %).

Frequency range	0.3 to 3.4 kHz
Attenuation frequency distortion equalization according to M.1020 or S 3	up to ±12 dB
Group delay distortion equalization according to M.1020 or S 3	up to 15 ms or 12.5 ms



Equalization of attenuation and group delay in a very heavily distorted FDM channel; the Attenuation and Group Delay Equalizer DLZ-4 was used

----- Attenuation or group delay before equilization
——— Attenuation or group delay after equilization
Template S3 (50 % of attenuation or 20 % of group delay from M.1020)

Specifications of the Attenuation and Group Delay Equalizer — DLZ-4

Frequency range . . . . . 0.3 to 3.4 kHz

Attenuation frequency distortion equalization corresponding to M.1020 or S 3 . . . . . up to ±12 dB

Group delay distortion equalization corresponding to M.1020 or S 3 . . . . up to 15 ms or 12.5 ms

Insertion loss, adjustable . . . . . −7.5 to +7.5 dB

Signal input and output . . . . . balanced, 600 Ω

General Specifications

Tolerable ambient temperature
Rated range of use . . . . . +5 to +40 °C
Storage and transport . . . . . −40 to +70 °C

Dimensions (w×h×d) in mm
Size for fitting in a rack
according to DIN 41494 . . . . . 483×132×380

Weight
completely equipped . . . . . approx. 10 kg

Ordering Information

Attenuation and Group Delay Equalizer DLZ-4	**BN 330/00**

1) The attenuation frequency distortion and group delay distortion of a channel is ascertained with the DLM-4 Data Line Test Set LD-2 or Group Delay and Attenuation Measuring Setup.

A specification sheet with more details is available on request. Besides the detailed specifications, information is given about the plug-in units and partial equalizers for the DLZ-4

Data Network Diagnostics and Data Analysis



Overview

Data Network Diagnostics and Data Analysis

Data network diagnostics equipment

★ = new

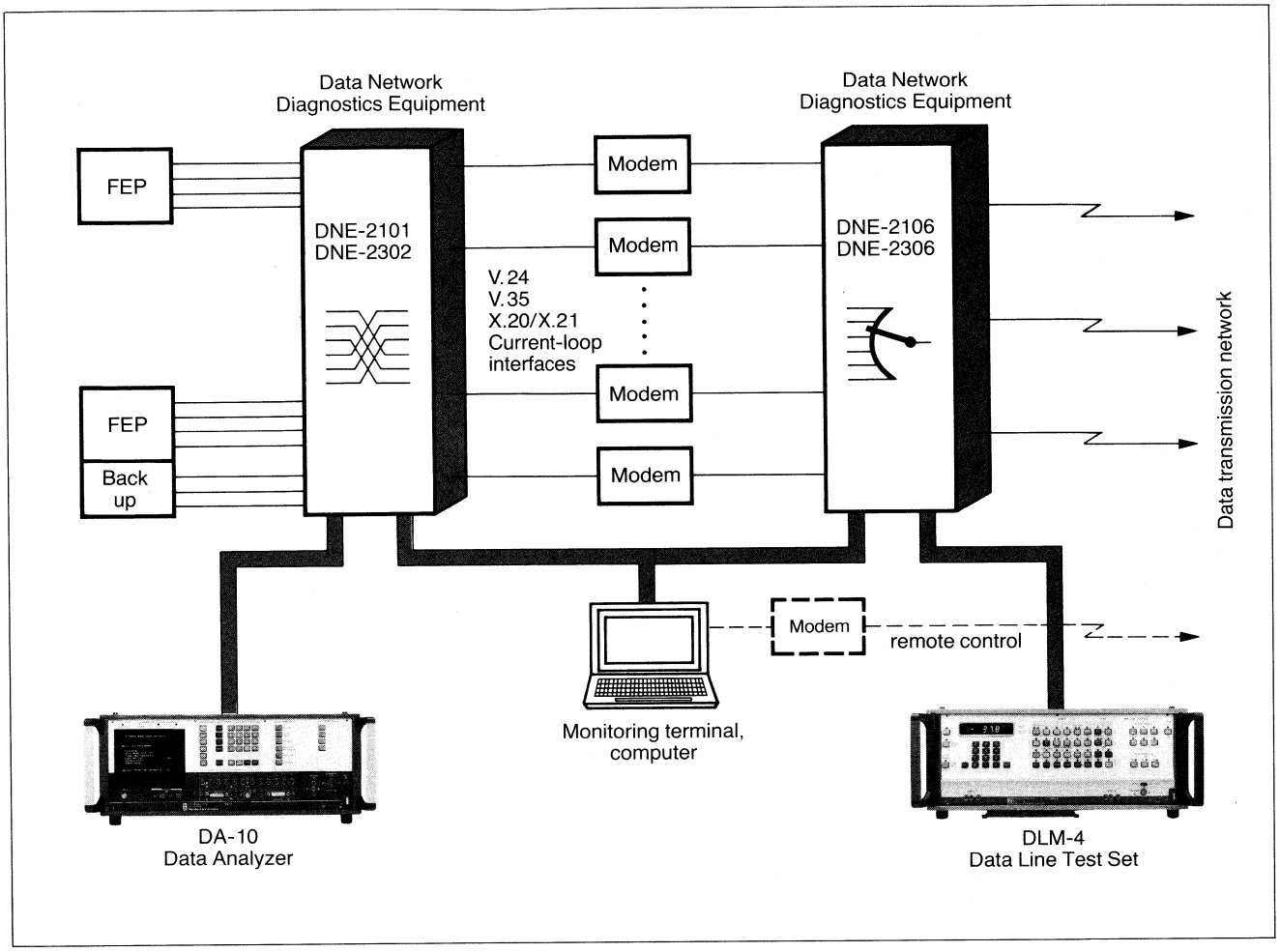
Applications	Special features	Name	Page
Monitoring and diagnostics on data networks	• Diagnostics on digital interfaces to CCITT Recs. V. 24 and X.20/X.21 • Measurements at the analog circuit level • Remote monitoring and diagnostics • Computer-aided diagnostics	**Data Network Diagnostics Systems** [1]	181
Remote-controlled monitoring and switching on digital interfaces	• For interfaces to CCITT Recs. V. 24 and X.20/X.21 (V. 35) • Continuous monitoring of interface signals • Individually selectable alarm criteria • Comprehensive switching and patching capabilities • Central switching of external analysers and test equipment • Remote control from normal ASCII terminal or PC via V. 24 data link	**DNE-2100 Data Network Diagnostics Equipment**	183
Remote-controlled switching on the line side interfaces	• For 2- or 4-wire circuits • Comprehensive switching and patching capabilities • Central switching of external test- and monitoring equipment • Remote control from normal ASCII terminal or PC via V. 24 data link	**DNE-2106 Analog Switch Unit**	188 ★
Monitoring and patching on digital interfaces	• For interfaces to CCITT Recs. V. 24 and X.20/X.21 and for current-loop interfaces • A/B fallback switching via bistable relays • Front-panel jumper plugs for opening and patching of data circuits • LED display of 18 interface signals • Central monitor connection for external data analyser • Manual operation or remote control via DNE-2401 control unit	**DNE-2300 Data Network Diagnostic Equipment**	190
Test port access and switching on the line side interfaces	• For 2- or 4-wire circuits • A/B switching via relays • Front-panel jumper plugs for opening and patching of data circuits • Central monitor connection for external test- and monitoring equipment • Manual operation or remote control via DNE-2401 control unit	**DNE-2306 Analog Switch Unit**	194 ★
Line diagnostics on centrally controlled networks	• For CCITT V. 24 interfaces • Localisation of faults using loop-through circuits or special test transmissions • Can be used as a DTE during network set-up and installation	**DIR-1 Diagnostics Responder**	200
Datacom equipment diagnostics equipment	• For fitting to diagnostics equipment, modems and data switching equipment • Logical organisation of datacom equipment • Separate mains supplies for datacom equipment and diagnostics equipment	**19" rack cabinets**	196

1) See also the DLM-400 Data Circuit Monitoring System, page 171

Data analysis equipment

Applications	Special features	Name	Page
Troubleshooting digital interfaces	• For interfaces to CCITT Recs. V. 24 and X.20/X.21 • Analysis, simulation and testing • Menus for easy operation • V. 24 printer and terminal connection • V. 24 modem connection for remote control • Data stored on cassette recorder	**DA-10 Data Analyzer**	202
Troubleshooting current-loop interfaces	• Analysis and simulation of current-loop interface signals with V. 24/V. 28 measuring instruments • For both active and passive current interfaces	**DAS-10 Current Loop Interface**	207
TELETEX trouble-shooting	• For use with circuit-switched networks • Analyses all protocol levels (DATEX-L), simulation of connection set-up • Results output on LCD screen or printer • Non-volatile memory • Handy case for tester and printer	**DTX-1 TELETEX Tester**	209
Troubleshooting and checking data circuits	• Measures the analog and digital transmission characteristics of data circuits • For interfaces to CCITT Recs. V. 24/V. 28 or X.20/X.21, X.26/X.27 • Battery operation	**DMS-1 Data Measuring Set**	212
Troubleshooting and checking modems	• For interfaces to CCITT Recs. V. 24/V. 28 • Battery and a.c. line operation • Compact robust casing	**DMT-1 Modem Tester**	216
Troubleshooting and checking digital interfaces	• For interfaces to CCITT Recs. V. 24/V. 28 • Battery operation • Handy, robust casing	**DV-24 Interface Tester**	218
Troubleshooting and checking digital interfaces	• For interfaces to CCITT Recs. X.20/X.21 • Battery operation • Handy, robust casing	**DX-21 Interface Tester**	220

Data Network Diagnostics and Data Analysis System Organisation



Applications

Data transmission must be reliable, efficient and economical. This means that all the equipment involved must work at peak performance, which demands continuous monitoring, testing and maintenance. Measures must be taken to prevent the possible occurence of faults, and back-up equipment must be available instantly should a fault occur. Data network topologies are constantly changing and expanding. The operational conditions of the network at a given instant determine the optimum configuration, and so all the lines should be monitored as continuously as possible. The data traffic should be accurately analysed, and system reconfiguration facilities should be as flexible as possible. To avoid maintaining high staffing levels at regional data centres, central monitoring of the entire network is also desirable.

All these requirements are fulfilled by the range of network diagnostics and data analysis equipment manufactured by Wandel & Goltermann. We can supply everything from manually operated test sets to computer-controlled turnkey test systems.

Characteristics

The Data Network Diagnostics Systems DNE-2100 and DNE-2300 make up an important part of any data network

Increased data network availability by means of:

- **continuous monitoring of all data lines**
- **analysis and simulation of data traffic**
- **rapid switch-in of back-up equipment**
- **flexible system configuration facilities**
- **user-oriented software for computer control**
- **long-range remote diagnostics procedures**

DNE 2586

management system. They are linked in at the digital interface side, between the DTE and the modem, so that each circuit is monitored. They are capable of long-term monitoring (alarm conditions are recorded), switching in back-up equipment and system reconfiguration; each data circuit can be tested selectively.
All the functions of the DNE-2100 can be remote-controlled from an ASCII terminal. The DNE-2300 also allows manual operation, plus remote control of the most important functions when fitted with the DNE-2401 Control Unit. Back-up switching takes place via bistable relays, which maintain the connection even when there is a power failure. The versatile switching and reconfiguration facilities of the DNE-2100 make use of solid-state switches.
Both types of DNE are compatible with V.24 and X.20/X.21 interfaces (V.35 compatibility will also be available shortly), and are fully transparent as regards line codes, protocols and transmission speeds, conforming at least to CCITT Recommendations.
The DA-10 Data Analyzer might be considered to be one of the most important test instruments for data analysis and interactive simulation. In passive monitor mode, the DA-10 monitors the data, and, by using specific selection criteria, determines the number of rejected or repeated blocks, the terminal response time and the signals on the data lines during a selected phase of the procedure, etc.
In interactive simulation mode, the DA-10 acts as the source of the data signal, and evaluates the response of the item under test. Applications range from setting up DTEs to operate with a certain protocol, through error ratio measurements, to testing special protocols.
The DTX-1 TELETEX Tester is a compact analyser and simulator which is suitable for use with circuit-switched networks. In analyser mode, the DTX-1 displays all the physical and logical events on the interface between the DCE and DTE. The interpretation of these events, which follows CCITT Recommendations, is shown in a clear, easy-to-understand form:

- Establishment and disconnection of CCITT X.21 connections
- Set up and clearing of the logical levels 2 to 6
- Interpretation of levels 4, 5 and 6

Three simulation modes are available when the DTX-1 is used as an active simulator: simulation towards the DTE, simulation towards the DCE, and simulation between two DTEs.

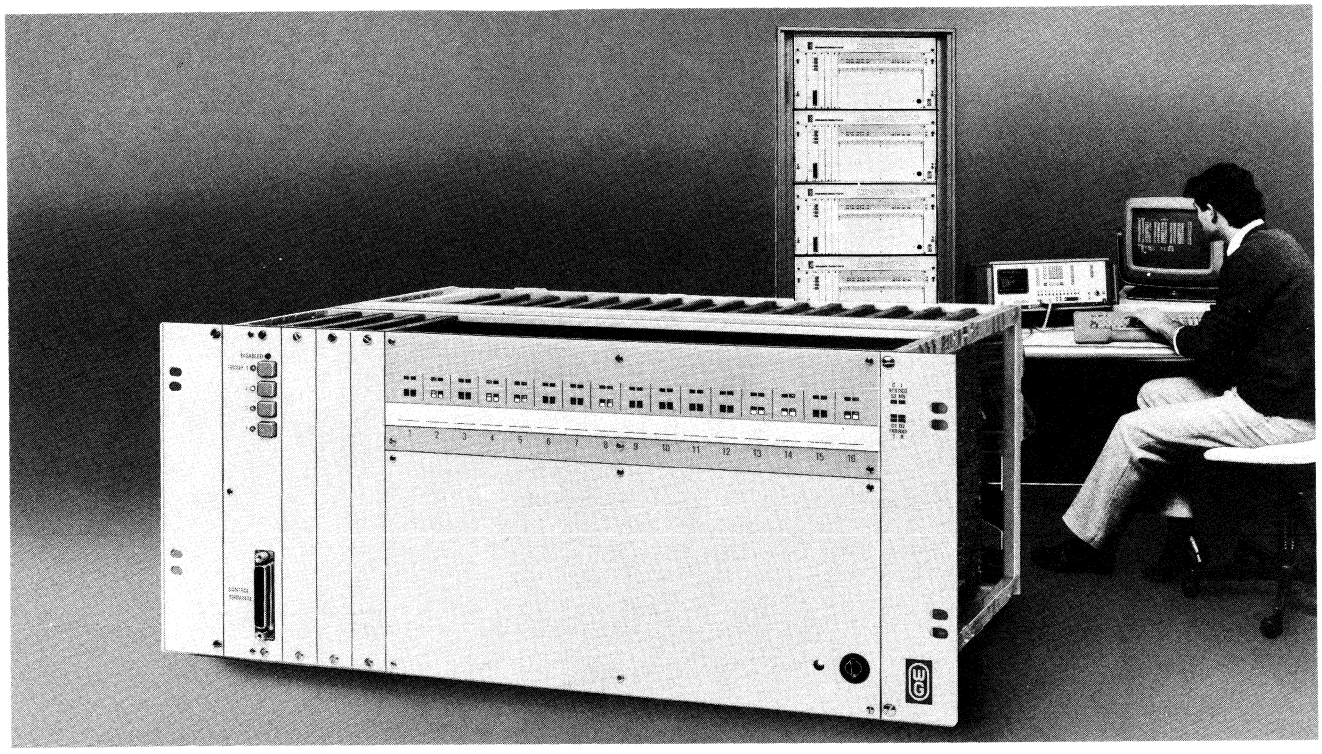
Other compact service instruments which are available for digital interface testing are:

- DV-24 Interface Tester
  (for CCITT V.24 interfaces)
- DX-21 Interface Tester
  (for CCITT X.20/X.21 interfaces)
- DMT-1 Modem Tester
  (for CCITT V.24 interfaces)

The DNE-2100 and DNE-2300 Diagnostics Equipment can be used to connect these test instruments to the data channel being tested. For passive monitoring purposes, the data channel is accessed via a decoupled test port. Interactive simulation is accomplished by interruption of the data channel, the central test port of the DNE system being connected to both "ends" of the data channel.
For end-to-end diagnostics, a loop is usually inserted at the remote end of the line, so that data transmitted is returned to the source end where it can be checked for transmission errors. Remote control of such loops is one of the many functions built-in to the DIR-1 Diagnostics Responder. This instrument is placed between the DTE and the DCE, and is activated from the control centre by means of a device-specific address. As well as the formation of loops, the DIR-1 will generate the 511-bit pseudo-random sequence which is used for bit error ratio measurements, or other standard patterns, such as "fox" messages, and transmit these patterns on command back to the control centre.
The special technical and organisational problems which occur in complex, wide-area networks, together with the desire for centralised monitoring of data management systems, are easily coped with by the above-mentioned equipment, since integration into a computer-controlled system is possible. This type of system only requires network specialists at the control centre.
The diagnostics computer checks the legality and plausibility of entries by means of dialog programming. The operation of these systems has been simplified to the extent where it is possible for relatively inexperienced personnel to carry out network diagnostics. The computer is capable of handling large numbers of lines, and the number of ways in which results can be processed and evaluated is almost limitless. Statistical analysis is possible, and such parameters as line availability and call attemps can be determined. The ability to cope with any test situation or diagnostics philosophy is provided by the diagnostics computer together with the associated software and peripherals.
Where it is permissible to make measurements at the analog interface, the DLM-4 Data Line Test Set is an ideal instrument to use, as it can also be integrated into the diagnostics system. Line parameters, such as group delay distortion, attenuation/frequency distortion, level, frequency, frequency shift, noise level, phase jitter, non-linear distortions and impulsive noise can all be measured, as can interruptions and phase- and gain hits.

DNE-2100
Data Network Diagnostics Equipment

for CCITT V.24 and CCITT X.20/X.21/X.25 interfaces (CCITT V.35 available shortly)



- **Data-circuit monitoring: eliminates cable clutter**
- **Versatile patching facilities, A/B switching**
- **Stored patching-configurations can be quickly activated**
- **Code, protocol, and transmission-rate transparency**
- **V.24/X.21/(V.35) plug-ins in same mainframe**
- **Semiconductor level-regeneration circuits**
- **Test equipment is easy to loop in, data traffic is not affected**
- **Remote control via VDU or personal computer**
- **Channel plug-in system for flexibility**

Applications

The DNE-2100 Data Network Diagnostics Equipment has been specially designed to eliminate data-line "clutter" in computer centres. A clear overview of all data lines is given by the DNE-2100 via a central VDU. It is also possible to connect data circuits to DTEs and DCEs, and to remote control test equipment and simulators.
When there is a fault, the user does not waste time connecting up test equipment by hand, nor does he have to carry out manual sparing. One can therefore say that the DNE-2100 simplifies and speeds up fault localisation and elimination, and so considerably increases the availability of the network.

The operating parameters of all the data channels are sent to the operator's terminal. A printer can be connected to this terminal to output a hard-copy record that shows the network configuration, and what alarms have occurred. When the DNE-2100 is computer-controlled, the computer can provide alarm statistics which can be used to determine the quality of service.

Characteristics

The DNE-2100 Data Network Diagnostics Equipment has code, protocol and transmission speed transparency and so is compatible with any data network from any manufacturer. The plug-in system gives the DNE-2100 a high degree of flexibility so that it can handle a wide range of network sizes, types and expansion rates.

Interfaces	to V.24 and/or X.20/X.21/X.25 V.35 available shortly
Number of channels	up to 16 per mainframe
Expanding the system	up to 8 mainframes can be operated from a VDU
Switching facilities	A/B, 1 from n, crossover
Monitoring facilities	interface states are shown on screen, LEDs on front panel, user-selectable alarm criteria

2593 DNE-2100

Construction

In its simplest form, the Data Network Diagnostics Equipment comprises the DNE-2101 Main Frame. A maximum of 16 plug-in cards can be inserted in the back panel, where connections can be made to DTEs (computers, terminals) and to DCEs (modems). Semiconductor switches are used to loop the channel cards into the data channels, and so connect the DTEs and DCEs. By means of a command, the data channel passing through a particular channel card can be switched to any other channel card via the internal Z bus (see Fig. 1).

At the front of the device there are 3 slots for Y buses and test ports (these slots may be used for other purposes). The Y buses connect several Main Frames together, and so the data channels may be routed through a number of these devices (see Fig. 1). The central test-port is a normal channel card used to connect external test equipment (e.g. DA-10) to any data channel.

The DNE Main Frame is connected to the operator's terminal via the DNE-2110 Control Unit. The DNE-2110 has a microprocessor which controls the menu at the operator's terminal, and which sends commands from the terminal to the Main Frames. The DNE-2110 can control a maximum of 8 Main Frames.

Monitoring, alarms

The DNE system continuously monitors all the data channels connected to it. This procedure is carried out at the physical link layer; all interface signals are monitored continuously and displayed on the terminal in effective real-time. The status of the most important signals (V.24: 103, 104, 105, 109; X.20/21: T, R, C, I) is also displayed by means of LEDs on the front panel of the mainframe.

The DNE-2100 also has an alarm capability, i.e. each data channel can be monitored for one of nine alarm types. It is also possible to delay the actuation of each alarm type by a certain time. The alarms for each data channel are set from the terminal. The occurrence of an alarm is shown on the terminal. When a printer is connected it is possible to get a printout showing either the start of an alarm condition, or the start and end of an alarm condition.

Switching facilities

Both V- and X-channel plug-ins are available with or without A/B fallback switching.

When the version without A/B fallback switching is used, both connectors (DTE, DCE) can be connected together through the channel plug-in, or can be connected to another channel plug-in via the internal Z bus.

When plug-ins with A/B fallback switching are used, it is possible to switch from DTE A to DTE B without the Z bus.

Apart from the above-mentioned facilities, 8 data channels can be handled simultaneously by the Z bus, and the Y buses can be used to connect various Main Frames together.

All these facilities make the DNE-2100 very flexible, and give the user a wide variety of switching configurations.

Operating the DNE-2100 is straightforward. All the operator has to do is specify the DCE and DTE connections. The connection process, whether performed internally, via the Z bus, or via the Y bus, is carried out automatically by the Control Unit.

An important feature of the control logic is the facility for defining and storing switching configurations for all data channels. The switching configuration can then be realised by entering a single command sequence. Six of these switching configurations can be stored in so-called "background" groups.

Operation

A standard VDU is used to control a maximum of 8 Main Frames. The VDU is connected to the DNE-2110 Control Unit via an asynchronous V.24 interface.

The DNE-2100 will not operate until the user enters the correct password which has 6 characters. The password is user-definable. A menu ensures that the operator enters the right instructions in the right order.

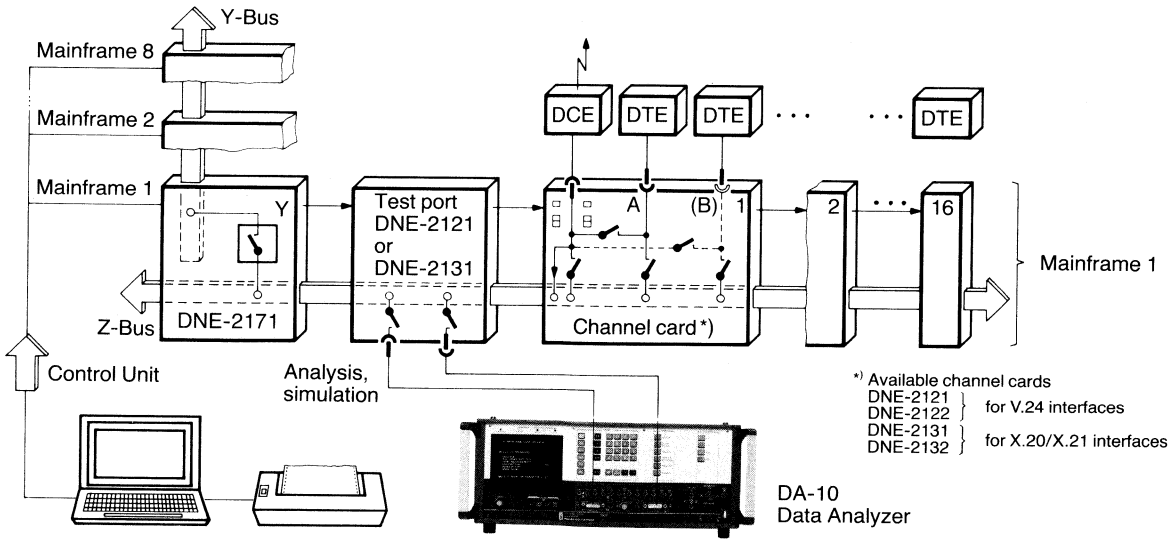


Fig. 1 How the DNE-2100 Data Network Diagnostics Equipment functions

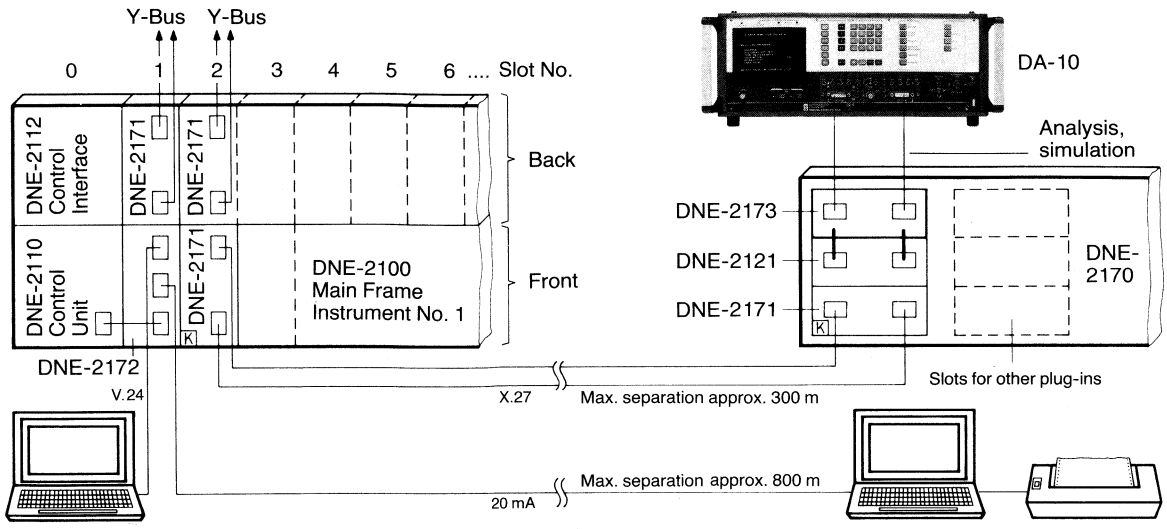


Fig. 2 Operating the DNE and performing data analysis from a remote control centre

Options

DNE-2115 Timer (plug-in board)
Gives the date and time whenever the DNE-2100 is operated and whenever an alarm occurs. The DNE-2115 is set from the operator's terminal.

DNE-2116 Back-up Memory Timer (plug-in board)
Stores all information required by DNE-2110 Control Unit. After a faulty control unit has been replaced, the complete information set can be transferred to the new control unit. Memory contents are retained even if power supply fails. A timer (specification as per DNE-2115) is also included on-board, together with an alarm relay for control of external alarm equipment.

DNE-2119 Back-up Power Supply (for 19" rack)
Powers a maximum of 6 DNE-2101 Main Frames, and is switched in immediately when one of the supplies in the DNE-2101 fails. An error message is sent to the terminal.

The V.24 Control Cable between the DNE and the operator's terminal should be limited to a recommended length of 15 metres. The same applies to the cable between the DNE test port and an external test set. The range can be increased with the following devices (see Fig. 2):

DNE-2172 Terminal Adaptor (plug-in board)
The DNE-2172 allows the user to connect two terminals one of which may be placed some distance (up to about 800 m) away from the DNE.

DNE-2170 Main Frame Extender
A 19" enclosure for accommodating and supplying power to a maximum of 6 DNE plug-ins at a remote operating-location.

DNE-2173 V/X Diagnostics Adaptor (plug-in board)
When the DNE is fitted with both V and X channel cards, the DNE-2173 makes it possible to use a data analyser with a V.24 interface (e.g. the DA-10).

Unless otherwise stated, the data is valid in the rated range of use for a.c. line voltage, a.c. line frequency, and ambient temperature.

DNE-2101 Main Frame

for mounting in a 19" rack [1]
Slots for plug-ins, back panel 16
front panel 3
Each Main Frame can accommodate one DNE-2110 Control Unit. If several Main Frames (max. 8) are operated from a VDU, only one Control Unit is needed. Each Main Frame has a power supply, a Z bus and a control interface.

LED status display for each channel plug-in:
V.24 interfaces 103, 104, 105, 109
X.20/21 interfaces . . . . . T, R, C, I
Number of Background switch configurations that can be stored 6

Alarm display
shown on terminal for each channel plug-in
(Alarm relay contacts actuated when DNE-2116 option fitted)
Alarm conditions:
Type 0 No alarm
Type 1 107 = ON and 109 = OFF
Type 2 109 and 105 = OFF
Type 3 103 and 104 = 1
Type 4 C = OFF and T = 0 or I = OFF and R = 0
Type 5 T = 1 or R = 1
Type 6 109 = ON
Type 7 107 = OFF and 103 = 1
Type 8 107 = ON and 103 = 0

Alarm delay time setting in 3 ranges:
0.2 to 25 seconds, in multiples of . . . . . 0.1 second
0.2 to 25 minutes, in multiples of . . . . . 0.1 minute
0.2 to 25 hours, in multiples of . . . . . 0.1 hour

Channel plug-ins

without A/B fallback switching . . .	**DNE-2121**	**DNE-2131**
with A/B fallback switching	**DNE-2122**	**DNE-2132**
Interface signals and pin connections to	V.24	X.20/X.21
Electrical characteristics to . . .	CCITT V.28	CCITT X.27
Transmission speed, up to	19.2 kbit/s	64 kbit/s
Channel connectors to	ISO-2110 (25-pole)	ISO-4903 (15-pole)

DCE connector . . . . . male
DTE connector . . . . . female

DNE-2171 Y-Bus Plug-in

For routing V.24 and/or X.20/X.21 data channels through several Main Frames, also used to connect an Extender (see fig. 2).
Connectors to ISO-4903 (15-pole)

DNE-2115 Timer

provides the date and time for the terminal or printer
Format . . . . . YY/MM/DD HH:MM
Plug-in board has its own trickle-charged battery

DNE-2116 Back-up Memory/Timer

Stores control unit data in EEPROM, can reprogram control unit if this has to be exchanged.

Timer: functions as per DNE-2115, plus alarm relay for controlling external alarm equipment in the event of:
– power failure
– the occurence of an alarm type 1 to 8
Relay contacts accessible via 9pole ISO-4902 connector
Contact loading . . . . . 30 V/100 mA
Auxiliary voltage . . . . . 10 V at 40 mA

DNE-2119 Back-up Power Supply

can be fitted in a 19" rack [1]
Automatic back-up power supply for one of the 6 connected DNE-2101 Main Frames

DNE-2170 Main Frame Extender

Bench model, can be fitted in a 19" rack

Channel plug-in slots,
Front panel 3
Back panel 3
The device has its own power supply.

DNE-2172 Terminal Adaptor

Connectors for . . . . . 2 terminals
Interface 1 . . . . . V.24, asynchronous [2]
Interface 2 . . . . V.24, asynchronous [2]/20 mA single current
When one terminal is operated, the other terminal is disabled for . . . . . 10 s
Connectors to ISO-2110 (25-pole)

DNE-2173 V/X Diagnostics Adaptor

When this plug-in card is used, a data analyser with a V.24 interface can be used to check V and X interfaces.
Transmission speed . . . . . up to 19.2 kbit/s
Connectors to ISO-2110

Interface for the operator's terminal

Type . . . . . V.24, asynchronous
Transmission speed . . . . . 110, 150, 300, 600, 1200, 2400, 4800, 9600 bit/s [3]

Transmission mode . . . . . duplex
Code . . . . . ASCII
Stop bits . . . . . 1 [3], 1.5, 2
Parity . . . . . odd, even [3]

Specifications for operator's terminal

Data interface . . . . . V.24, asynchronous

Screen . . . . . 24 lines, 80 characters per line
Character set . . . . . ASCII

Recommended features:
Function keys
Second V.24 interface for printer
X_{on}/X_{off} control
Data buffer >256 bytes (depends on printer type)
Independent baud rate setting for the printer interface
Required control characters:
Cursor up, cursor on, cursor off
Printer on, printer off, X_{on}: DC 1, X_{off}: DC3

General Specifications

Power supply
DNE-2101 Main Frame and DNE-2119 Back-up Power Supply:
Rated ranges of use for a.c. line voltage, switch-selectable . . . . . 96 to 141 V/193 to 260 V
Rated range of use of a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption of 1 DNE-2101 (all plug-ins fitted) . . . . . approx. 90 VA
Safety class as per VDE 0804 . . . . . Class 1

DNE-2170 Main Frame Extender
Rated ranges of use for a.c. line voltage, switch-selectable . . . . . 110/117/127/220/227/237 V, −12 to +10 %
Rated range of use for a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption (all plug-ins fitted) . . . . . approx. 40 VA
Safety class as per VDE 0804 . . . . . Class 1

Ambient temperature
Rated range of use . . . . . +5 to +40°C
Storage and transportation . . . . . −40 to +70°C

Dimensions (w×h×d) in mm
DNE-2101 Main Frame (chassis dimensions) . . . . . 444×200×345 (4.5 U)

DNE-2119 Back-up Power Supply (chassis dimensions) . . . . . 444×114×140 (3 U)

DNE-2170 Main Frame Extender (chassis dimensions) . . . . . 444×86×379 (2 U)
(bench model) . . . . . 477×110×433.5

Weight
DNE-2101 Main Frame (all plug-ins fitted) . . . . . 12.5 kg
DNE-2119 Back-up Power Supply . . . . . 4 kg
DNE-2170 Main Frame Extender (all plug-ins fitted) . . . 9 kg

FTZ No. . . . . FTZ 03192 D

Ordering Information

Main Frame DNE-2101	**BN 2001/01**
Control Unit DNE-2110	BN 2001/00.10
Spare Control Interface DNE-2112	BN 2001/00.12
Timer DNE-2115	BN 2001/00.15
Back-up Memory/Timer DNE-2116	BN 2001/00.16
Back-up Power Supply DNE-2119	BN 2001/00.19
Channel Plug-ins for	
V.24 interfaces DNE-2121	BN 2001/00.21
V.24 interfaces with A/B switching DNE-2122	BN 2001/00.22
X.20/X.21 interfaces DNE-2131	BN 2001/00.31
X.20/X.21 interfaces with A/B switching DNE-2132	BN 2001/00.32
Main Frame Extender DNE-2170	BN 2001/00.70
Y-Bus Card DNE-2171	BN 2001/00.71
Terminal Adaptor DNE-2172	BN 2001/00.72
V/X Diagnostics Adaptor DNE-2173	BN 2001/00.73
19" rack cabinets, Interface cables	see separate specification sheets for details
Operator's terminal	on request

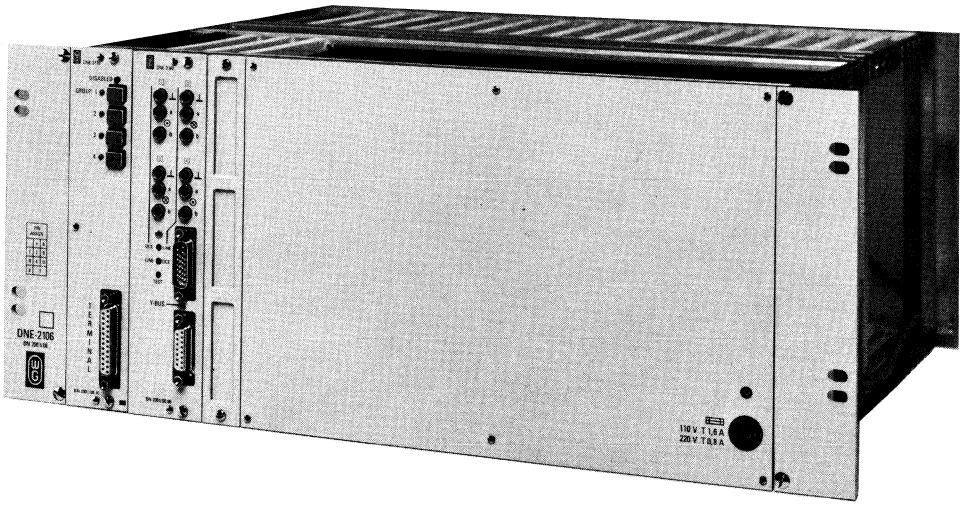
1) These are rack-instruments and do not have an enclosure
2) For further details see "Specifications for operator's terminal"
3) Set at factory

A Colour Brochure is available on request

new

DNE-2106
Analog Switching Unit

for line side interfaces in data network diagnostics equipment



- **Line- and modem sparing on the line side**
- **Test equipment easily looped-in without affecting data traffic**
- **For balanced two- and four-wire systems**
- **Open-circuit lines correctly terminated automatically**
- **Through-switching via encapsulated relays**
- **Preselected background switch configurations can be rapidly activated**
- **Remote-controlled operation from VDU terminal or PC**
- **Can be combined with digital interface diagnostics equipment**
- **Channel plug-in system for flexibility**

Applications

The DNE-2106 Analog Switching Unit further expands the DNE-2100 Data Network Diagnostics Equipment to cope with switching on the line (analog) side interfaces of a data network. It is possible to rapidly switch in spare modems or lines, and also to select a particular line for testing. Test equipment can be connected to any data line with a minimum of effort.

All functions can be controlled from a normal VDU terminal or from a PC. Remote control of the DNE system enables spare modems to be switched in at unmanned stations, even if located a long way from the control unit. This significantly increases the availability of the data network lines.

Characteristics

The Analog Switching Unit is a fully integrated part of the DNE-2100 system. As a result of this, coupled with the modular system of construction, changes in network topology or special requirements can be easily handled.
The data lines are switched through the equipment by means of encapsulated monostable relays, designed for balanced two- and four-wire systems.

Switching capabilities	modem sparing, data line sparing
Test connections	for switching in external data line test- and monitoring equipment
Interfaces	for 2- or 4-wire balanced, floating lines
Number of channels	max. 16 per mainframe
Expansion capabilities	up to 8 mainframes can be controlled from a central control unit
	Combines with the mainframes for digital (V.24, X.20/X.21) interfaces

Construction
The simplest operational unit consists of a single DNE-2106 mainframe which has space on the back panel for up to 16 plug-in analog modules. The incoming lines from the data network are connected to one side of the analog plug-ins, and the other side is connected to the DCE (modem, etc.). Thus, the analog switch units are looped into the line between the DCE and the network proper, through-switching of the 2- or 4-wire lines being accomplished by the plug-in itself.
Both of the connector sockets on the plug-ins have the additional feature of providing controlled access to the internal Z bus, allowing connections from one plug-in to any other plug-in to be set up as required. There are a further three plug-in slots on the front panel of the mainframe, which are intended for the installation of Y bus plug-ins. The Y bus is used to connect several mainframes together, thus allowing connections to be set up between channel plug-ins in different mainframes. The analog plug-ins can be reconfigured to operate as Y bus plug-ins.

The DNE-2160 Monitor Section is used for connecting-in external test equipment. It is looped into a Y bus, through which it has access to all the data circuits as required.
Connection of the mainframes to the VDU terminal or PC is accomplished via the DNE-2110 Control Unit. This unit contains a microprocessor which controls the operating menu dialog procedure with the terminal.
Up to 8 mainframes can be operated from a single control unit. Both types of DNE-2100 mainframe (i.e. DNE-2106 for analog interfaces or DNE-2101 for V.24, X.20/X.21 digital interfaces) can be controlled from the DNE-2110.

Options (see DNE-2100 Specification Sheet)
DNE-2115 Timer (plug-in board)
DNE-2116 Back-up Memory and Timer (plug-in board)
DNE-2119 Back-up Power Supply (19" rack mount unit)
DNE-2172 Terminal Adaptor (plug-in board)

Specifications of the Analog Switching Unit (preliminary) — DNE-2106

DNE-2106 Mainframe
19" rack-mounting unit [1]
Slots for analog plug-ins, back panel 16
front panel 3
Frequency range . . . . . 0 to 120 kHz
There is space in each mainframe for the DNE-2110 Control Unit. Only one control unit is required if several (max. 8) mainframes are used together. Each mainframe is fitted with power supply, Z bus and control interface.

DNE-2161 Analog Plug-in
Straight through-connection of 2- or 4-wire circuits
Monitor section can be connected into the circuit without interrupting the data connection.
Open lines terminated with Z_o automatically.
Inputs/outputs . . . . two twin-wires each, balanced, floating
Terminating impedance . . . . . 600 Ω [2]
Data line connection via . . . ISO-4903 connectors (15 way)

Y bus Plug-in
Identical with the DNE-2161 which can be switched over to Y bus operation.

DNE-2160 Monitor Section
Connection to external test equipment via . . 2 CF connector pairs (TX/RX directions)
The connectors to the modem side and the line side can be used interchangeably.

DNE-2110 Control Unit
DNE-2115 Timer
DNE-2116 Back-up Memory/Timer
DNE-2119 Back-up Power Supply
DNE-2172 Terminal Adaptor
Operator's terminal interface
Operator's terminal specifications
} see DNE-2100 Specification Sheet

General specifications

Power supply
DNE-2106 mainframe
Nominal ranges of use, a.c. line voltage, switch-selectable . . . . . 96 to 141 V/193 to 260 V
Nominal range of use, a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption (fully equipped) . . . . . approx. 90 VA
Safety class, to VDE 0804 . . . . . Class I

Ambient temperature
Nominal range, use . . . . . +5 to +40°C
storage and transportation . . −40 to +70°C

Dimensions (w×h×d) in mm
DNE-2106 Mainframe
(chassis dimensions) . . . . . 444×200×345 (4.5 U)

Weight
DNE-2106 Mainframe (fully equipped) . . . . . 13.5 kg

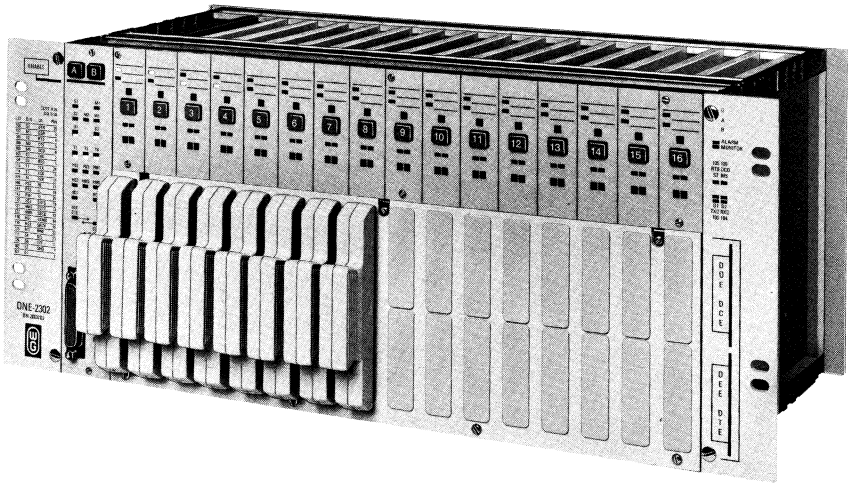
Ordering information

Mainframe DNE-2106	**BN 2001/06**
Monitoring Section DNE-2160	BN 2001/00.60
Analog Plug-in DNE-2161	BN 2001/00.61

1) The instrument is intended for rack mounting and is of open-frame construction.
2) Other impedance values can be soldered in.

DNE-2300
Data Network Diagnostics Equipment

for CCITT V.24, X.20/X.21 and current-loop interfaces



- **Data circuit monitoring and sparing**
- **A/B fallback switching**
- **Bistable relay switching**
- **Code, protocol and transmission rate transparent**
- **Alarm display for each data circuit**
- **Decoupled data analyzer connection**
- **Jumper plugs for straightforward circuit disconnection**
- **Channel plug-ins for system flexibility**

Applications

The DNE-2300 system is particularly suited to the requirements of small or medium-sized computer centres, as it is a manual system which is easy to use.
An important feature of the system is the LED display which allows the status of each data channel to be seen at a glance. It is also possible to link any data channel to a built-in monitoring circuit without affecting the data channel itself.
Front-panel jumper plugs for each channel simplify the disconnection of a data circuit for patching or simulation purposes.

Characteristics

Due to its modular construction, the DNE-2300 Data Network Diagnostics Equipment can be adapted easily to suit particular requirements.

Rack-mounting unit (see photograph)
The simplest unit consists of the DNE-2302 or DNE-2303 mainframe, which has space for up to 13 channel plug-ins on the back panel (a further 3 plug-in slots are required for the DNE-2310 mains unit).

An LED display which indicates the status of the most important interface signals is provided on the front panel for each plug-in slot. The following interface signals are monitored: 103, 104, 105 and 109 for V.24 interfaces; T, R, C, and I for X.20/X.21 interfaces; the status of the a and b wires for current-loop interfaces.
There is also a red alarm indicator LED on the front panel for each plug-in, which lights if a particular combination of signals persists for more than about 10 seconds. If the DNE-2319 Alarm Annunciator (option) is fitted, an alarm signal also sounds for about 6 seconds. The LED goes out as soon as the alarm condition ceases.
A monitoring section is built in to the left-hand part of the mainframe. This can be connected to any of the 13 plug-ins by pressing a button. The LEDs fitted in this section show the status of the most important interface lines for the plug-in selected. A decoupled connection for an external analyzer is also provided.

Interfaces	to CCITT Recs. V.24 or X.20/21, or ±10 to ±80 mA current-loops
Number of channels	max. of 16 (13) per mainframe
Expansion capability	up to 8 mainframes per rack (Control Unit takes over the coordination functions)
Through switching	via jumper plugs on front panel
A/B fallback switching	direct, via bistable relays
Monitoring	LEDs for each data channel indicate 103, $\overline{103}$, 104, $\overline{104}$, 105, 109 (V-type interfaces) T, $\overline{T}$, R, $\overline{R}$, C, I (X-type interfaces) a and b wires (current-loop interfaces)

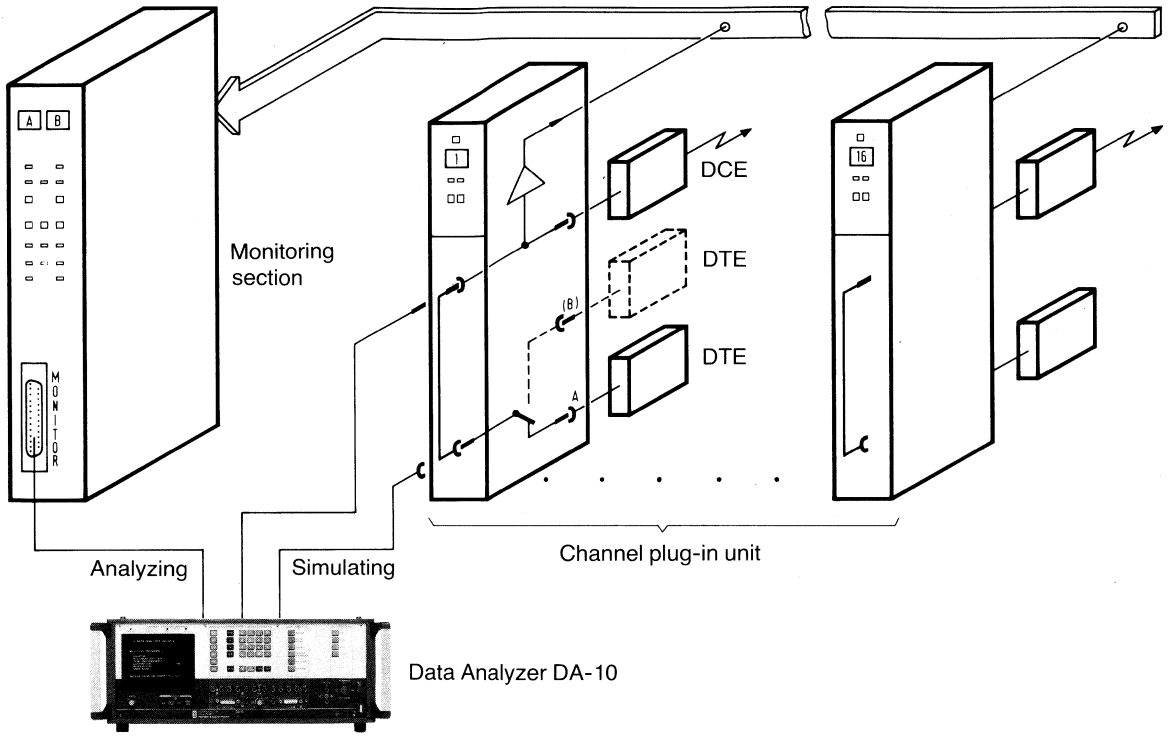


Figure 1 Block diagram of DNE-2300 Data Network Diagnostics Equipment (Mainframe)

Each DCE-DTE connection passes through a channel plug-in. On the front of each plug-in, there is a jumper plug which is used to interrupt the data circuit for the purposes of simulation or patching.
Channel plug-ins are available for the following interfaces: CCITT V.24, CCITT X.20/X.21 and current-loop interfaces. The following types of plug-in are available for each interface type:

Type 1 (DNE-2321, DNE-2331 or DNE-2325)
for loop-through operation

Type 2 (DNE-2322, DNE-2332 or DNE-2326)
for loop-through operation with A/B fallback switching
(switching over to a second DTE connection is possible)

A/B fallback switching for the individual channel plug-ins occurs only when two pushbuttons are actuated simultaneously. This helps to prevent inadvertant operation.

The basic block diagram of the DNE-2300 system is shown in figure 1.

Expansion, centralized control
The diagnostic system can be expanded to cope with data network expansion, simply by adding more mainframes and the appropriate number of channel plug-ins. Since a mixture of V- and X-interface types cannot be fitted in the same mainframe, additional mainframes become necessary if both V-type and X-type interfaces are to be monitored. It is, however, possible to operate current-loop interface plug-ins and either V.24 or X.20/X.21 interface plug-ins in the same mainframe.

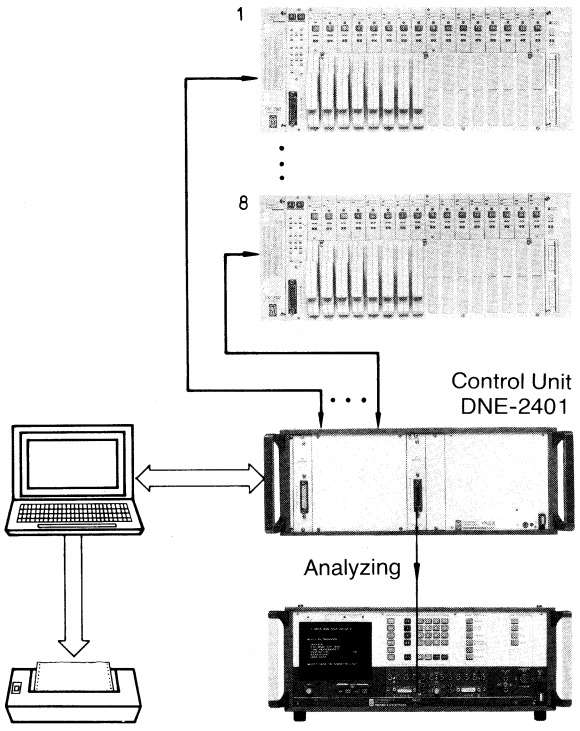


Figure 2 DNE-2300 Data Network Diagnostics Equipment with centralized control

Centralized control and monitoring is very useful if the diagnostics installation consists of several mainframes. This is possible if a standard ASCII VDU terminal is used in conjunction with the 19" rack-mounting DNE-2401 Control Unit, which sends control data to the individual mainframes. A hard-copy terminal with standard ASCII keyboard may also be used. Remote control via a modem is also possible. Up to 8 control interfaces (DNE-2429 for the DNE-2302 mainframe, or DNE-2439 for DNE-2303 mainframes). On the front of the unit, there is space for fitting 2 Analyzer Connector plug-ins (DNE-2420 for V-type interfaces, DNE-2430 for X-type interfaces).
The Control Unit also contains a central power supply unit which will power all the mainframes in the system, so that each mainframe can be expanded to include 16 channel plug-ins since the DNE-2110 Mains Units are no longer required.

A DNE-2300 system with centralized control is shown in figure 2. Operation of the DNE system from a VDU- or hard-copy terminal is very easy, as a menu and dialog technique is used. This means that the system can be correctly operated by persons who are not experienced in computer programming.

It is important that the date and time are noted in the documentation resulting from data network diagnostics. This is provided by a crystal-controlled clock in the control unit, so that the start and end of alarm conditions can be documented.
To prevent unauthorised operation of the system, the dialog facility between the terminal and the DNE can be inhibited after a control sequence. This is done by means of a password, determined by the computer centre manager, which must be entered correctly before further control sequences can be run.

Specifications of Data Network Diagnostics Equipment — DNE-2300

Unless otherwise stated, the specifications are valid for the nominal ranges of use for a.c. line voltage and frequency, and ambient temperature.

DNE-2302 Main Frame
for V-type interfaces, with monitor section
19" rack-mounting unit [1]
with space for . . . . . 16 (13) channel plug-ins [2]

DNE-2303 Mainframe
for X-type interfaces, with monitor section
19" rack-mounting unit [1]
with space for . . . . . 16 (13) channel plug-ins [2]

	DNE-2302	DNE-2303
LED status display (tristate)		
for each plug-in	103, $\overline{103}$, 104, $\overline{104}$, 105, 109	T, $\overline{T}$, R, $\overline{R}$, C, I
for current-loop plug-ins . . .	a and b wires	a and b wires
Monitor section		
with LED status		
indicators for	103, $\overline{103}$, 104, $\overline{104}$,	T, $\overline{T}$, R, $\overline{R}$, S, $\overline{S}$,
(can be selected for	108, 105, $\overline{107}$, 106,	B, C, I
any of the channels)	$\overline{109}$, 113, $\overline{113}$, 114, $\overline{114}$, 115, $\overline{115}$, 118, 119, 120, 121, 122, 140, 141, 142	
for current-loop interface plug-ins	a and b wires	a and b wires
Connection for external analyzer	ISO 2110 (25 way)	ISO 4903 (15 way)

Alarm display
LED for each channel plug-in. If the DNE-2319 Alarm Annunciator (option) is fitted, a buzzer will also sound at the same time.
Alarm conditions
V.24 interfaces . . . . . 107 ON and 109 OFF (>10 s)
X.20 interfaces [3] . . . . . T = 1 or R = 1 (>60 s)
X.21 interfaces [3] . . . . . T = 0 and C = OFF (>60 s) or R = 0 and I = OFF (>60 s)
Current-loop interfaces . . . . . a wire ≠ b wire in both directions (>0.5 ... 5 s, selectable)

Channel plug-ins
Direct through connection of a data channel.
Removal of front panel jumper plug breaks the data circuit.
Non-interruptive, fully decoupled connection to monitor section.

Electrical characteristics:

V-type plug-ins	X-type plug-ins	Current-loop plug-ins
to CCITT V.28	to CCITT X.27	±10 mA to ±80 mA single and double current min. operating current ±5 mA voltage drop per wire: ≦2 V at 20 mA ≦3.5 V at 80 mA
Max. transmission rate:		
19.2 kbit/s	64 kbit/s	19.2 kbit/s
Data channel connector		
ISO 2110 (25 way)	ISO 4903 (15 way)	ISO 4903 (15 way)

Type 1 channel plug-in (without A/B fallback switching):

DNE-2321	DNE-2331	DNE-2325
All interface lines are connected through directly		
DCE connector		multiway plug
DTE connector		multiway socket

Type 2 channel plug-in (with A/B fallback switching)

DNE-2322	DNE-2332	DNE-2326
Interface lines switched:		
all 23	T, R, C, I, S, B	a and b wires TX and RX direction

Bistable relays used for A/B fallback switching; no change in switching configuration if power supply fails.
A/B fallback state indicated by . . . . . LED
DCE connection . . . . . multiway plug
DTE connections . . . . . multiway sockets

DNE-2310 Mains Unit
Power supply for a single DNE-2302 or DNE-2303 Mainframe
Nominal range of use, a.c. line voltage
switchable between . . . . . 96.5 to 121 V and 193 to 242 V

Nominal range of use, a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 30 VA
Safety class, to VDE 0804 . . . . . Class I
Plug-in slots required 3

DNE-2319 Alarm Annunciator (option)
adds onto the monitor unit fitted in the DNE-2302 or DNE-2303 Mainframe
Alarm signal . . . . . buzzer sounds for approx. 6 seconds
Triggering . . . . . same as for alarm LED
Access for switching other equipment via . . . . relay contacts
Only one DNE-2319 is required if several Mainframes are driven from a DNE-2401.

DNE-2401 Control Unit
with central power supply for up to 8 V-type or X-type Mainframes. Enclosed 19" rack-mounting unit.

Plug-ins
Control Interface for connection to
DNE-2302 (V-type Mainframe) DNE-2429
DNE-2303 (X-type Mainframe) DNE-2439
Number of plug-in slots (back panel) 8
Analyzer Connector for centralized monitoring
V-type DNE-2420
X-type DNE-2430
Number of plug-in slots (front panel) 2
If two Analyzer Connectors are fitted, they must be of different types.

Control section
Terminal interface . . . . . asynchronous, V.24
Transmission rate, selectable . . . 110, 150, 300, 600, 1200, 2400, 4800, 9600 bit/s
Data traffic . . . . . full duplex
Character set . . . . . ASCII
Parity . . . . . even
Number of start/stop bits 1/1
Connectors (front panel) . . . . . ISO 2110, 25 way
Can be operated from VDU- or hard-copy terminals with ASCII keyboards or from a computer.
Data retention using . . . . . rechargeable Nicad cells (located in central power supply)

Clock unit
for output of date and time information for events and alarms.
Resolution . . . . . 1 minute

Central power supply
Nominal ranges of use, a.c. line voltage, selectable . . . . . 95.5 to 121 V, 103 to 129 V, 112 to 140 V, 193 to 242 V, 199 to 250 V, 208 to 261 V
Nominal range of use, a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 150 VA
Safety class to VDE 0804 . . . . . Class I

General Specifications

Ambient temperature
Nominal range of use . . . . . +5 to +40 °C
Storage and transport . . . . . −40 to +70 °C

Dimensions (w×h×d in mm)
DNE-2302/DNE-2303 Mainframe (rack-mounting dimensions) . . . . . 422×200×202
DNE-2401 Control Unit (rack mounting dimensions) . . . . . 443×175×379

Weight
DNE-2302/DNE-2303 Mainframe (partially equipped with plug-ins) . . . . . approx. 7 kg
DNE-2401 Control Unit . . . . . approx. 9 kg

Deutsche Bundespost Certificate of Approval No. 03191D

Ordering Information

DNE-2302 Mainframe for V-type and current-loop interfaces, with monitor section, not including mains unit and channel plug-ins	
– DIN 66020 signal designations	**BN 2003/02**
– US standard signal designations	**BN 2003/23**
– CCITT V.24 signal designation	**BN 2003/24**
DNE-2303 Mainframe for X-type and current-loop interfaces, with monitor section, not including mains unit and channel plug-ins	**BN 2003/03**
Channel plug-in for	
V.24 interface, DNE-2321	BN 2003/00.21
V.24 interface, with A/B fallback switching, DNE-2322	BN 2003/00.22
X.20/X.21 interface, DNE-2331	BN 2003/00.31
X.20/X.21 interface, with A/B fallback switching, DNE-2332	BN 2003/00.32
Current-loop interface, DNE-2325	BN 2003/00.25
Current-loop interface, with A/B fallback switching, DNE-2326	BN 2003/00.26
DNE-2310 Mains Unit	BN 2003/00.10
DNE-2319 Alarm Annunciator (option)	BN 2003/00.19
DNE-2401 Control Unit with central power supply	**BN 2004/01**
Control Interface for	
V-type mainframe, DNE-2429	BN 2004/00.29
X-type Mainframe, DNE-2439	BN 2004/00.39
Analyser Connector plug-ins	
V-type interfaces, DNE-2420	BN 2004/00.20
X-type interfaces, DNE-2430	BN 2004/00.30
Accessories (charged extra)	
S.E.I. Julia 100 VDU terminal	BN 6201/01
19" case for 1 Mainframe	BN 2002/21
19" case for 2 Mainframes	BN 2002/22
19" Rack Cabinet	see relevant specification sheets
V.24 and X.20/X.21 round cable, various lengths	see relevant specification sheets

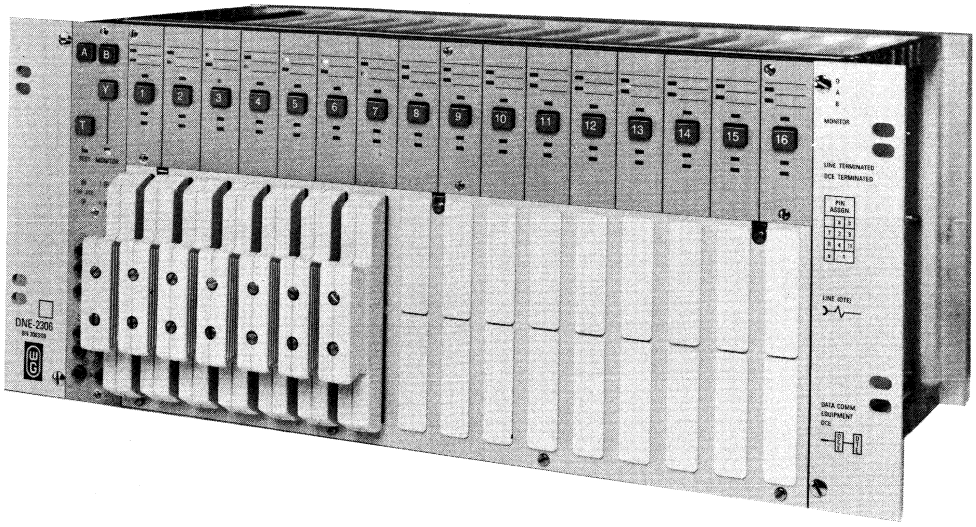
1) The instruments are not intended for free-standing use, and are not supplied fitted into cases
2) The DNE-2310 Mains Unit occupies 3 plug-in slots
3) X interface type selected with switch on channel plug-in

A Colour Brochure is available on request

new

DNE-2306
Analog Switching Unit

for line side interfaces in data network diagnostics equipment



- **Line- and modem sparing on the line side**
- **Test equipment easily looped-in without affecting data traffic**
- **For balanced two- and four-wire systems**
- **Open-circuit lines correctly terminated automatically**
- **Through-switching via encapsulated relays**
- **Operation from VDU terminal or manually**
- **Can be combined with digital interface diagnostics equipment**
- **Channel plug-in system for flexibility**

Applications

The DNE-2306 Analog Switching Unit further expands the DNE-2300 Data Network Diagnostics Equipment to cope with switching on the line (analog) side interfaces of a data network. It is possible to rapidly switch in spare modems or lines, and also to select a particular line for testing. Test equipment can be connected to any data line with a minimum of effort.
All functions can be operated manually, or remotely if a standard VDU terminal is used. Remote control of the DNE system enables spare modems to be switched in at unmanned stations for example, thus significantly increasing the availability of the network lines.

Characteristics

The Analog Switching Unit is a fully integrated part of the DNE-2300 system. As a result of this, coupled with the modular system of construction, changes in network topology or special requirements can be easily handled.
The data lines are switched through the equipment by means of encapsulated bistable relays, designed for balanced two- and four-wire systems.

Switching capabilities . . .	modem sparing, data line sparing
Test connections	for switching in external data line testing and monitoring equipment
Interfaces	for 2- or 4-wire balanced, floating lines
Number of channels	max. 16 (13) per mainframe
Expansion capabilities	up to 8 mainframes can be controlled from a central DNE-2401 control unit
	Combines with the mainframes for digital (V.24, X.20/X.21) interfaces

Construction

The simplest operational unit consists of a single DNE-2306 mainframe which has space on the back panel for up to 13 plug-in analog modules, types DNE-2361, DNE-2362 and DNE-2363. A further three plug-in slots are required for the DNE-2310 power supply unit. The incoming lines from the data network are connected to one side of the analog plug-ins, and the other side is connected to the DCE (modem, etc.). Thus, the analog switch units are looped into the line between the DCE and the network proper, through-switching of the 2- or 4-wire lines being accomplished by the plug-in itself. The three different types of analog plug-in are:

DNE-2361: Straight through-switching of the data channel
DNE-2362: Through-switching and A/B fallback switching to a second DCE connection
DNE-2363: Through-switching and A/B fallback switching to a second line in the network.

There is a jumper plug fitted to the front of all plug-ins which enables you to interrupt the data channel for the purposes of patching or linking in an external simulator. LEDs for each channel indicate when the line is correctly terminated.

A monitor section is fitted into the left hand side of the mainframe; this is used for connecting up to external test equipment. For this purpose, the monitor section can be linked to any of the channel plug-ins via the Y bus system. Connections to test equipment are via CF connectors.

Extension and centralized control

As the number of data circuits increases, the DNE installation can be expanded to keep pace. This is done by simply adding one or more mainframes, together with the required number of channel plug-ins, to the existing system. When several mainframes are used, some form of centralized control is very useful. This can be accomplished by means of the DNE-2401 control unit, which enables you to control the complete system using a normal ASCII standard VDU terminal. Up to 8 mainframes can be controlled from the DNE-2401 via interfaces. All three types of DNE-2300 mainframe (i.e. DNE-2306 for analog interfaces, or DNE-2302 (V.24) and DNE-2303 (X.20/X.21) for digital interfaces) can be controlled from a single DNE-2401. The control unit also contains a central power supply unit, which means that the DNE-2310 power supply plug-ins are no longer needed, so that each mainframe can house up to 16 channel plug-ins.

Specifications of the Analog Switching Unit (preliminary) — DNE-2306

DNE-2306 Mainframe

19" rack-mounting unit [1]
Slots for analog plug-ins . . . . . 16 (13) [2]
Frequency range . . . . . 0 to 120 kHz

Monitor section
Connection to external test equipment . 2 CF connector-pairs (TX/RX directions)
The connectors to the modem side and the line side can be used interchangeably.

Analog Plug-ins

Straight through-connection of 2- or 4-wire circuits.
Monitor section can be connected into the circuit without interrupting the data connection.
Open lines terminated with Z_o automatically
Inputs/outputs . . . . two twin-wires each, balanced, floating
Terminating impedance . . . . . 600 Ω [3]
Data line connection via . . . . ISO-4903 connectors (15 way)
Plug-in without A/B fallback switching DNE-2361
Plug-in with A/B fallback switching (2×DCE) . . . DNE-2362
Plug-in with A/B fallback switching (2×network lines) DNE-2363

DNE-2310 Power Supply
DNE-2401 Control Unit } see DNE-2300 Specification Sheet

General specifications

Ambient temperature
Nominal range, use . . . . . +5 to +40°C
storage and transportation . . . −40 to +70°C

Dimensions (w×h×d) in mm
DNE-2306 Mainframe (chassis) . . . . 422×200×202 (4.5 U)

Weight
DNE-2306 Mainframe plus average fittings . . . . approx. 7 kg

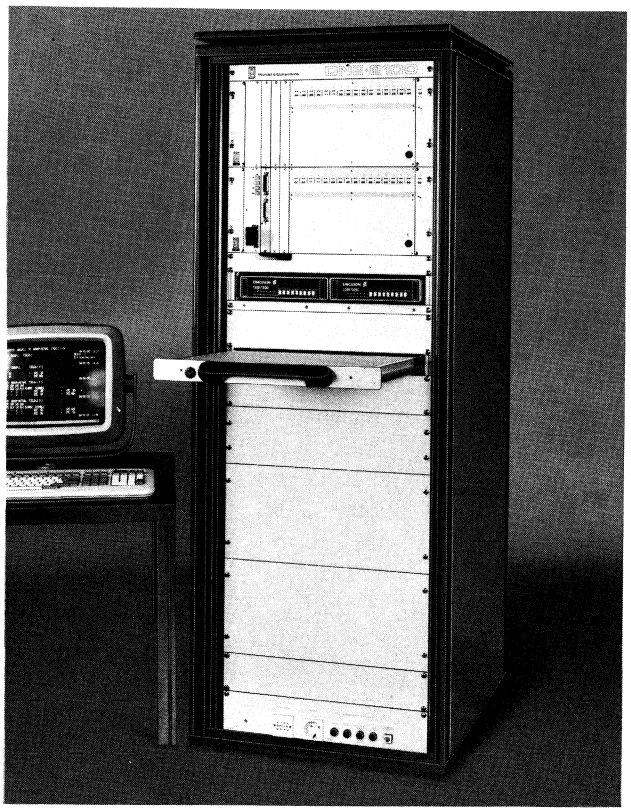
Ordering information

Mainframe DNE-2306	**BN 2003/06**
Power Supply DNE-2310	BN 2003/00.10
Analog Plug-in DNE-2361	BN 2003/00.61
Analog Plug-in DNE-2362	BN 2003/00.62
Analog Plug-in DNE-2363	BN 2003/00.63

1) The instrument is intended for rack mounting and is of open-frame construction
2) 3 plug-in slots are required for the DNE-2310 Power Supply
3) Other impedance values can be soldered in

19" Rack Cabinet

for well-organised interconnection of modems, diagnostics- and data equipment



Increases datacom system-reliability:

- **Clear layout of datacom equipment**
- **Separate power- and data connections provided for each device**
- **CSDN connections routed via distributor with over-voltage protection circuit**
- **Isolated, individually fused a.c. power circuits**
- **Base panels for datacom equipment fitted with cable stowage hardware**
- **Strain-relief hardware provided for V.24/X.21 cables**
- **All labelling clearly visible**
- **Connection for hand-set provided**

Applications

Tangled cables and masses of equipment impair the efficiency of the majority of datacom centres. Data circuits are seldom clearly labelled, which means that the chances of locating a faulty connection among the multitude of modems, plugs and cables are virtually nil, especially if you are not familiar with the installation. This disorganised situation has arisen as a direct result of the rapid expansion which has taken place in the field of data communications.

Usually, the extent of the problem only becomes apparent when something goes wrong, and it becomes necessary to trace a cable between a computer port or terminal and the corresponding modem or data circuit connector, or if a specific circuit needs to be interrupted so that test equipment can be looped-in for the purpose of tracing the fault. Quite often, the wrong circuit is interrupted and the system efficiency is unnecessarily reduced. The range of rack cabinets which we manufacture offers increased reliability for any datacom system, as all system components can be arranged logically.

Characteristics

It is clear that the reliability of a datcom network depends, to a large extent, on the way the equipment is set up, i.e. the design of the rack cabinets used and the facilities available. Simplified layout, ease of access and proper protection for the equipment are necessities for any datacom system if sources of trouble are to be excluded as far as possible. Since Wandel & Goltermann

Construction details:
Material . . . . . aluminium
Colour, rack . . . . . slate grey
back and side panels . . . . . steel grey
Ventilation slots
Blanking panels for covering unused front panel areas
Cable ducting on both right- and left-hand sides
A.C. power connection unit with:
– Central keyswitch for four separate a.c. power circuits
– power on indicators
– a.c. mains sockets
– telephone handset connector
Rack sizes available . . . . . 168 cm (32 U), 186 cm (36 U)
204 cm (40 U)

Rack Cabinets have been specifically designed to fulfil these requirements, they offer the ideal solution to these problems. The Rack Cabinet can be used for housing the DNE-2100 or DNE-2300 Diagnostics Systems together with datacom equipment, such as modems and switching units. Test equipment, such as the DA-10 Data Analyzer, can also be fitted into the rack without any problems.

The advantages offered by these Rack Cabinets are clearly seen during
- installation
- operation
- diagnostics
- repair

of a datacom system.

Installation

Depending on the way the computer centre is organised, efficient system organisation may be achieved by placing the DNE-2100/DNE-2300 Diagnostics Equipment and the datacom equipment together in the same rack, or by separating the diagnostics equipment and the datacom equipment. Both arrangements can be realised with these Rack Cabinets. Three sizes are available:

32 U = 168 cm overall height
36 U = 186 cm overall height
40 U = 204 cm overall height.

As many racks as are required can be fixed together side-by-side. Individual cabinets can be fitted with castors if required; adjustable feet are fitted as standard.
Diagnostics equipment, modems and test equipment (e.g. DA-10 Data Analyzer) designed for rack mounting can be fitted into any position in the rack cabinet. Modems which are not designed for rack mounting can be fitted to the base panels, which are constructed so as to provide stowage facilities for excess lengths of mains-, CSDN-, and interface cables.
The CSDN distribution section, which is accessible from the front of the cabinet, is the connection between the rack system and the rest of the data network. An overvoltage protection circuit can be fitted to this unit if required.

Operation

The special design features incorporated into this range of rack cabinets ensure that the datacom equipment operates at maximum efficiency. All cables leading to and from the rack are secured with strain-relief hardware, and the special system used for cable stowage prevents tangling, so that the whole system retains an orderly appearance.
The power supply to the datacom equipment is via isolated individually fused circuits, which ensures that short circuits occurring in one part of the system do not cause the entire system to fail.
An overvoltage protection circuit for the CSDN connections is available as an option.
The rack cabinet has a plexiglass door fitted on the front which helps to prevent inadvertent operation of switches, etc.

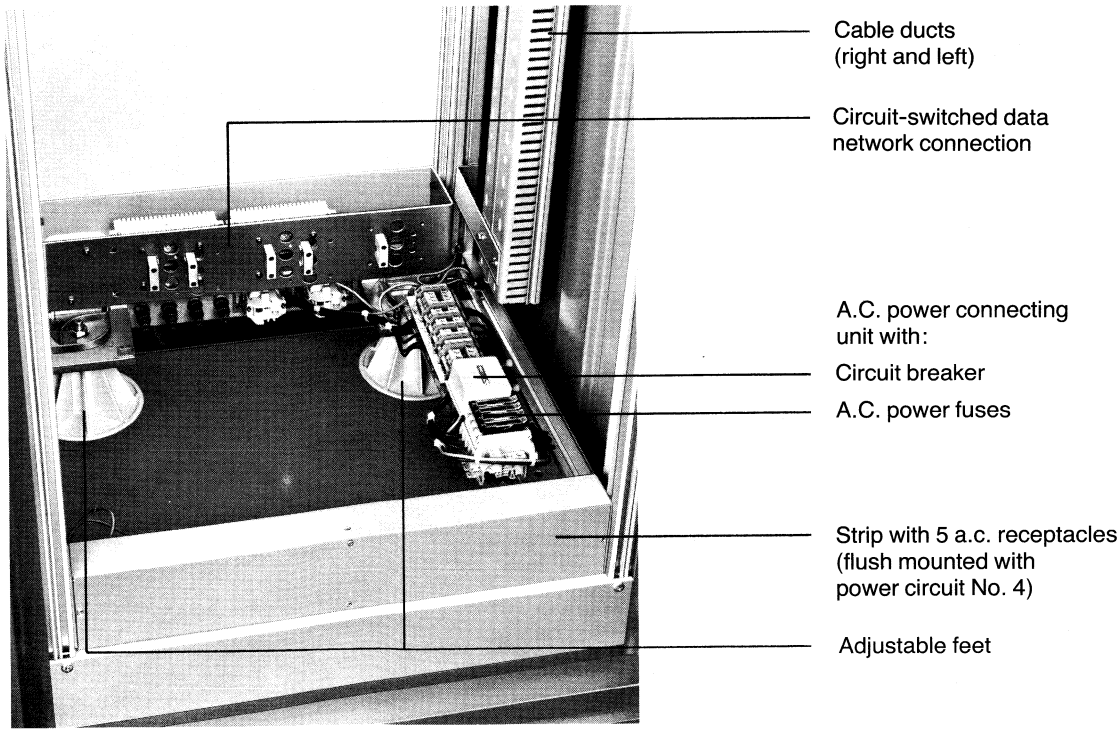
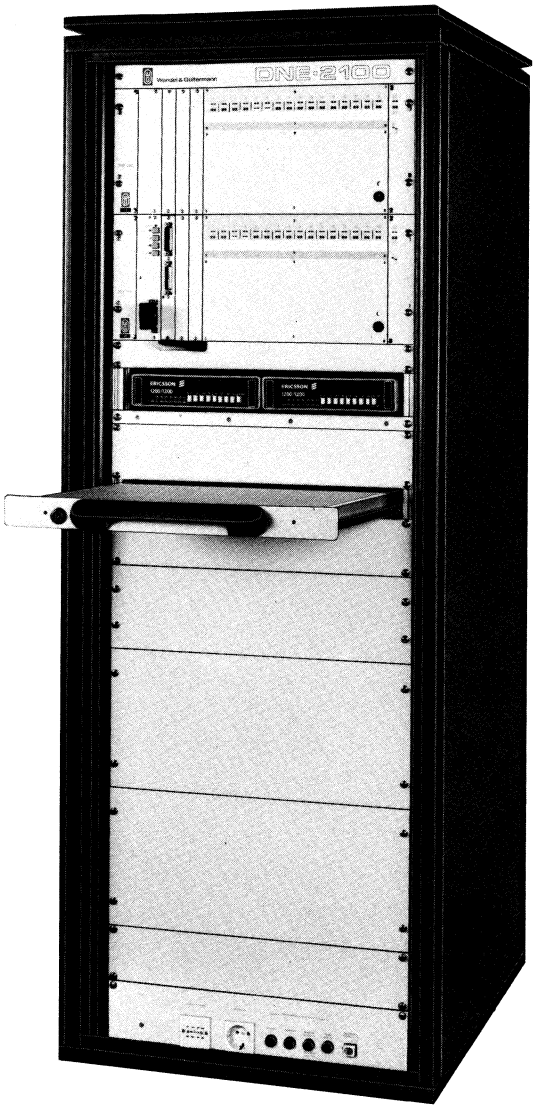


Figure 1: Inside the rack (viewed from the rear)



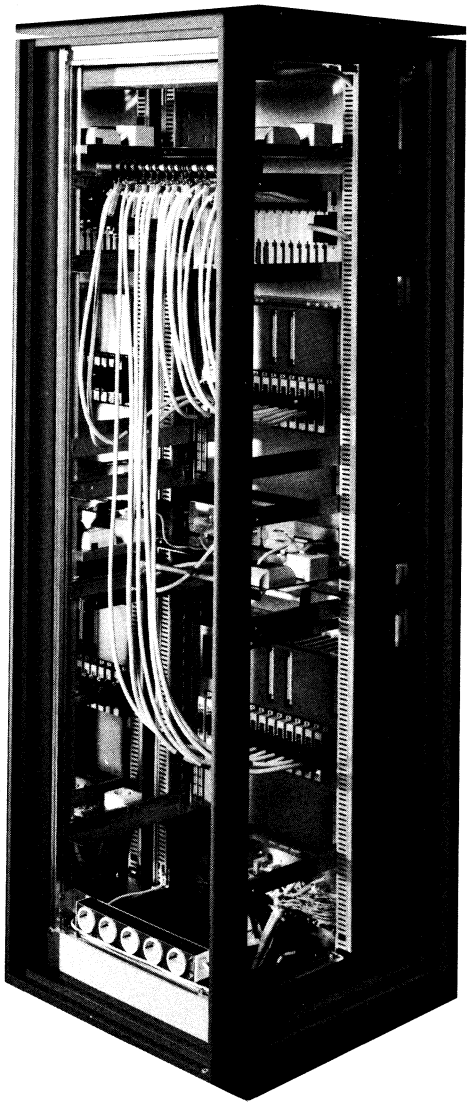


Figure 2: (left) **Front view of 19" Rack Cabinet**
(right) **Complete installation (viewed from the rear)**

Diagnostics
Should it be necessary to carry out diagnostics on a particular data circuit, the rack is arranged so that this can be done without affecting any of the other data channels. The clear layout of the equipment is a great help in this respect.
Auxiliary a.c. power sockets which are isolated from the power supply for the datacom equipment are provided for powering test equipment. The sockets are separately fused to prevent short circuits from affecting the data traffic. Measurements in the data channel can be made using the diagnostics equipment, without the need to interrupt the cable. The test connection does not affect the data circuit in any way.
A connector for a telephone handset is provided on each rack cabinet so that communications between technicians at both ends of the data circuit can be set up easily.

Repairs
If repairs to a particular data channel have to be made, the other data channels need not be affected in any way. Soldering irons and test equipment can be powered from the separately fused auxiliary mains sockets.
Inadvertant removal of the wrong plug is prevented because the power supply and CSDN connections for each modem are fitted to the corresponding base panel. It is also possible to exchange plug-ins within the DNE-2100 or DNE-2300 Diagnostics Equipment without interrupting or removing other circuits.

Rack Cabinet

Type of cabinet . . . . . aluminum, with feet
Color: frame . . . . . slate grey (RAL 7015)
side panels, back panel . . . . . steel grey (RAL 7037)

Dimensions (w×d×h)
in mm . . . . . 32 U 600×815×1680
36 U 600×815×1860
40 U 600×815×2040

Versions: . . . . . free-standing cabinet with 2 side panels
build-in cabinet without side panels

Any number of cabinets of the same height can be joined together in a row.

Mechanical fittings
- rear door (lockable)
- adjustable feet
- ventilation slots
- chassis slides for each unit to be fitted
- blanking panels for covering unused front panel areas
- cable ducts on both right- and left-hand sides
- strain relief hardware for V.24/X.21 cables

Electrical fittings
- a.c. power terminals (max. 25 A load)
- 1 a.c. power socket (lower front panel)
- 5 a.c. power sockets (inside rear panel)
- keyswitch (front panel)
- circuit breaker
- 10 A fuses and indicator lamps for 4 separate a.c. power circuits (1 for modem group 1, 1 for modem group 2, 1 for diagnostics instrument, 1 for other equipment)
- grounding set
- jack for handset connection (front panel)

Modem intermediate base plate

Mechanical fittings
- available area 455×400 mm (w×d)
- approx. 20 mm height
- cable compartment for accepting excess lengths of a.c. power and telephone cables
- intermediate base plate cannot be pulled out

Electrical fittings
- 2 a.c. power sockets (right and left)
- 2 CSDN connectors (right and left)

Circuit-switched data network connection unit

Connection capacity: up to 30 4-wire conductors

Mechanical fittings
- mounting and cover panel, 2 U high for building into cabinet at lower front
- fixing hardware for telephone cable

Electrical fittings
- connect/disconnect terminal strip for 120 conductors

Accessories (optional)
Overvoltage protection for 20 conductors.

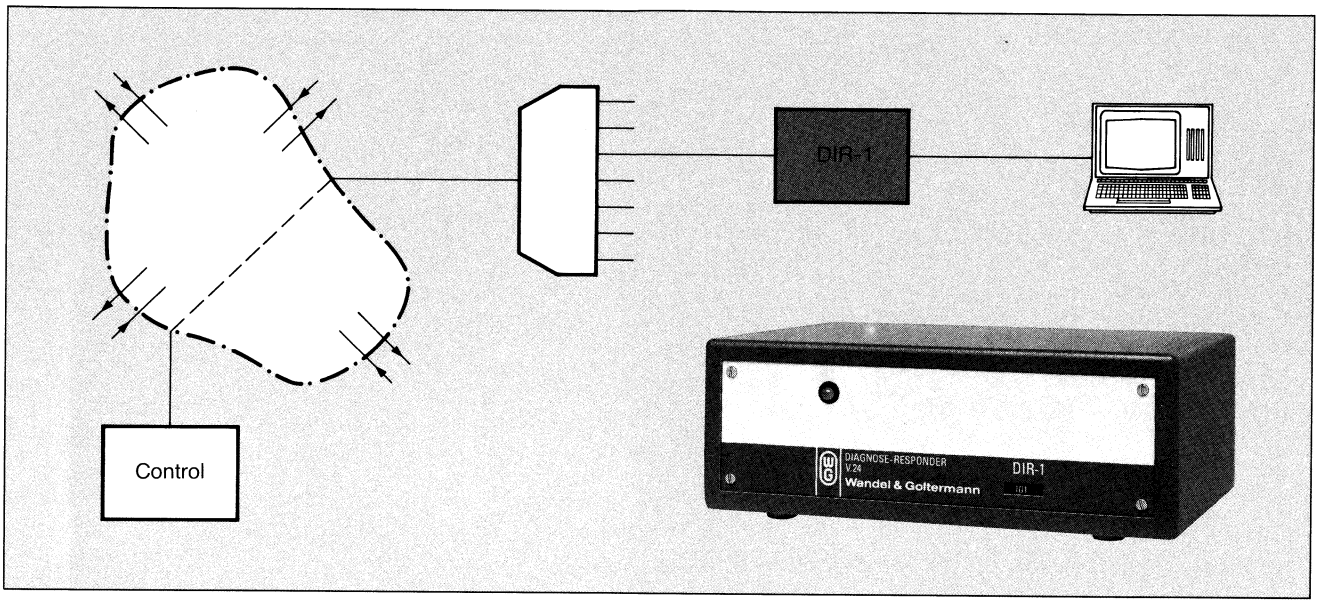
Ordering Information

Free-standing rack cabinet (with two side panels)	
Size: 32 U	**BN 2002/01**
36 U	**BN 2002/02**
40 U	**BN 2002/03**
Build-in rack cabinet(without side panels)	
Size: 32 U	**BN 2002/11**
36 U	**BN 2002/12**
40 U	**BN 2002/13**
Accessories (charged extra)	
Plexiglass front door:	
Size: 32 U	BN 2002/00.01
36 U	BN 2002/00.02
40 U	BN 2002/00.03
Drawer with writing panel, 1 U	BN 2002/00.10
Modem base panel, fixed	BN 2002/00.11
CSDN connection unit, 2 U	BN 2002/00.12
Overvoltage protection for 20 individual conductors [1]	BN 2002/00.13
Fixing brackets for DA-10 (4 U)	BN 2002/00.04

1) Only in combination with CSDN connection unit, BN 2002/00.12

DIR-1
Diagnostics Responder

for diagnostics on synchronous data networks



- **Automatic network diagnostics**
- **Localises faults**
- **Replaces DTEs during the installation phase**
- **Measures availability**
- **Measures error rates**
- **Measures system delay times**

Applications

The DIR-1 Diagnostics Responder is an integral part of the DNE-2000 Data Network Diagnostics System, but can also be used in its own right as a diagnostic tool.
The DIR-1 is connected between a DCE and a DTE and is transparent to normal data traffic. For tests and diagnostics the DIR-1 can be addressed via an internal, adjustable address. The version described here is designed for V.24 Interfaces.
The DIR-1's job is to monitor the availability of paths in a data network. In this way, faults can be localised on a rational basis from the central office and so may be rapidly eliminated.
The low-priced DIR-1 is an economical way of building up a powerful diagnostics system.

Characteristics

The DIR-1 Diagnostics Responder can be used to best effect in centrally controlled data networks. The DIR-1 is located at the periphery between the transmission equipment and the DTEs, where it monitors the receive signal (104, D2, RXD). If the data traffic is free of impairments, the DIR-1 recognises a test call-up sequence from a centralised diagnostics device.
The sequence activates the DIR-1 for a limited time (e.g. 20 s) during which it can receive and carry out test commands. When this time has elapsed the DIR-1 returns to the transparent mode.
The test call-up sequence activates all the DIR-1s installed in a network, whereas the command sequence contains a 16 bit address which is used to activate a certain Responder. Each DIR-1 can be given unique user-selectable address (e.g. a DIR-1 could be assigned the address of its DTE).
The command set of the Diagnostics Responder contains commands for sending out test messages (fox messages, 511 bit patterns), for switching test loops, for putting DTEs on stand-by and providing control pulses at a special output.

The connection between the DTEs and DCEs is made via monostable relays. No matter what the operating state of the DIR-1 happens to be when a power failure occurs these relays ensure that a transparent connection is maintained.

Diagnostics Responder:
- for CCITT V.24 Interfaces
- for use between DCE and DTE
- for synchronous 2 and 4 wire lines
- for bit rates up to 19 200 bit/s
- for use with transparent data circuits

Three safety measures are provided to prevent unintentional activation of the DIR-1 when carrying traffic in the transparent mode.

- The test call-up sequence is only searched for after the receive circuit has gone idle for at least 2 s (hex. FF). This means that call-up sequences within transparent data fields will certainly not be recognised.
- The call-up sequence is different from all the control sequences used in the protocol.
- After a specific time (e.g. 20 s) the DIR-1 returns to the passive mode. In this way the transparent mode is always restored even when the data traffic is impaired.

Signals for test and control purposes are available at four outputs. These signals are activated by particular command sequences. A green lamp on the front panel of the DIR-1 shows when it is operative and also indicates the result of the integral self-test.

Specifications of the Diagnostics Responder — DIR-1

If nothing to the contrary is stated, the data given are valid for the rated ranges of use of a.c. line voltage, a.c. line frequency and ambiant temperature.

Function

Observation of data circuit D2/104/RXD for a test call-up sequence. On finding a call-up sequence the DIR-1 waits for a test command sequence containing its address.

Call-up sequence (hexadecimal) . . . . . 32 32 32 32 37 BA BA BA

Test command sequence (hexadecimal) . . . . . 32 32 37 CMD A1 A2

CMD . . . . . 8 bit character, see command list
A1, A2 . . . . . 16 bit device addresses, set in the DIR-1

Command list

B ≙ Break transmit line from DTE
D ≙ Data connection is to be restored immediately
R ≙ Response from DIR required
Q ≙ Quick brown fox message to be sent by DIR
P ≙ Pseudorandom pattern 511 bit to be sent by DIR
S ≙ Short time loop will be established
L ≙ Long time loop will be established
1 ≙ Pulse to be sent to DIR control port Q1
2 ≙ Pulse to be sent to DIR control port Q2
3 ≙ Pulse to be sent to DIR control port Q3
4 ≙ Pulse to be sent to DIR control port Q4

Command description

B Interruption on the DTE side D1/103/TXD S2/105/RTS

Acknowledgement to DCE, positive voltage S2/105/RTS

D End of test command. This command is obeyed by all connected DIR-1s and is not address specific, i.e. the sequence SYN SYN EOT D is sufficient.

R Acknowledgement – the simplest and shortest test. In the 20 s after an activation sequence many stations on a circuit can be addressed. The "R" command is used to find out which stations can be reached for communication. The response comprises the following sequence: SYN SYN A1 A2 EOT.

Q The DIR-1 sends back a test message – the correct reception of a fox message means that transmissions between the DIR-1 and the receive site are not impaired. The message is in clear text for easy inspection.

P The pseudorandom bit pattern is intended for BER tests in the return direction.

L Loop – this command activates the remote, digital test loop. The clock for the returned data is dejittered beforehand. BER tests with any bit pattern can be carried out with this command.

1...4 Control signals – a single pulse is delivered to a specified DIR-1 control output (open collector, active "low", T = 10 ms).

A Colour Brochure is available on request

Interfaces

DCE connection . . . . . 25 pole male connector complying with ISO 2110
DTE connection . . . . . 25 pole female connector complying with ISO 2110
Voltage and impedances as specified in CCITT V.28

Control output . . . . . 9 pole female, ISO 4902 connector
Q1 ... Q4, active . . . . . V ≦ 0.4 V, I ≦ 1 mA, T = 10 ms
passive . . . . . V ≦ 42 V, I ≦ 1 µA

Loop

Synchronous reception of D2/104/RXD with negative transition T4/115/RCK, buffering of 3.5 to 4.5 bits, sent as D1/103/TXD with positive send clock transition.
Send clock can be T2/114/XCK or T1/113/TCK.

Display

Ready for operation, self-test O.K. . . . . green LED

Behaviour on power failure

The connections between DCEs and DTEs are made via relays with normally closed contacts and so the connections are maintained when the power fails.

General Specifications

Microprocessor . . . . . 80 C 35
RAM . . . . . 64 bytes
EPROM . . . . . 4 kbytes

Power supply
Rated ranges of use for a.c. line voltage, switchable . . . . . 220/110 V, ±10 %
Rated range of use of a.c. line frequency . . . . . 45 to 66 Hz
Power consumption . . . . . approx. 6 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Tolerable ambient temperature
Rated range of use . . . . . +5 to +40 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions (w×h×d) in mm . . . . approx. 180×120×65

Weight . . . . . approx. 1 kg

German Post Office Certificate of Approval No. . . . . FTZ 03719 D

Ordering Information

Diagnostics Responder DIR-1	**BN 2010/01**
Accessories (at extra cost)	
V.24 interface cable Ribbon cable 1.5 m (F-M)	K 363

DA-10
Data Analyzer

for troubleshooting on V.24 or X.20/X.21 interfaces



- **Data analyzer and data tester contained in one compact instrument**
- **Analyzes and simulates all usually used asynchronous, synchronous, and HDLC procedures (up to 64 kbit/s)**
- **Level 2 and Level 3 interpretations with X.25**
- **"User friendly" menu technique**
- **Cassette recorder for storing data**
- **Exchangeable measurement interfaces for V.24/V.28 and X.20/X.21**
- **V.24 printer and terminal attachment**
- **V.24 modem attachment for remote control**
- **Outstanding self-test performance**

Applications

- In the development, manufacture, testing, and installation of data comm systems and modules
- In the maintenance and troubleshooting on data comm systems like those used by:
  - Postal Administrations
  - Railroad and Airline Corporations
  - Insurance Agencies, Banks
  - EDP Organizations
  - Industry in general
  - Commercial enterprises
  - Mail order companies
  - Data comm service stations
  - Civil authorities, Administrations
  - Police, Customs, Military
  - Electric Power Distribution

Characteristics

Because of its modular test programs the DA-10 Data Analyzer is a high performing and flexible measuring system for troubleshooting on data comm systems that have electrical interfaces complying with CCITT Recommendations V.24/V.28 and X.20/X.21 or X.26/X.27. The DA-10 can be exactly matched to the measurement problems and wishes of the user. A data analyzer, a data tester, and an interactive simulator are united in one equipment cabinet. Besides the analyzer and simulator functions, the data tester functions (511/2048 BIT TEST, TIME and DISTORTION MEAS.) are of interest, because the same instrument can also check the data circuit performance characteristics.
Owing to the menu technique and the prompting available to the operator through the dialog procedure, and through the multiplicity of facilities for presenting data and results, the DA-10 can also be quickly and reliably used for monitoring, troubleshooting, and repairing data comm and data text systems.

DA-10 Test Programs

- MONITOR – an intelligent analysis program
- 511/2048 BIT TEST – for checking the data circuit quality
- TIME MEASUREMENT – for measuring the switch-on times at the interface
- DISTORTION MEASUREMENT – qualitative measurements on asynchronous data circuits
- SIMULATION – for testing data terminal equipment

Further Characteristics and Applications of the DA-10 Data Analyzer

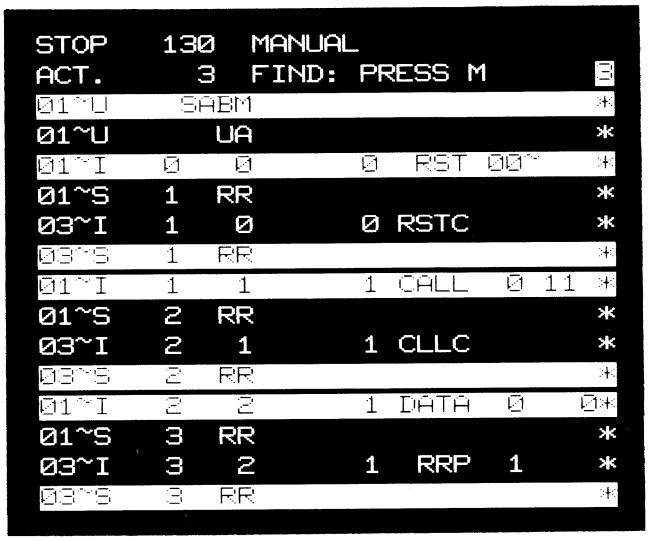
DA-10 as Analyzer

MONITOR – the intelligent analysis program

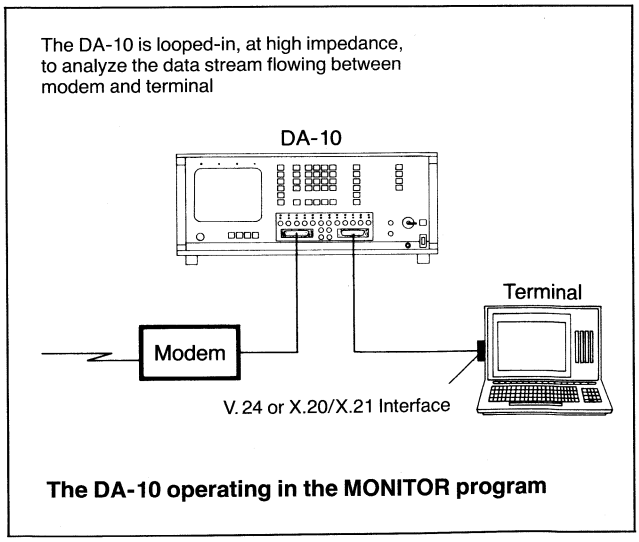
- Analyzes all usual procedures like BSC, MSV, SDLC, HDLC, and X.25
- Easy operation through CRT screen controlled dialog mode and menu presentation
- Simple analysis of procedures through special data presentations adapted to the measuring tasks
  - with byte oriented procedures:
    HDX, FDX, TRACE, HEX, and ALPHAMERIC presentations
  - with bit oriented procedures:
    mnemonic presentation simultaneously for Levels 2 and 3, additionally also with data, superposed display of data block time difference and the number of bytes within the data block
- Comprehensive triggering facilities for troubleshooting
- Several high capacity counters
- Time clock incorporated for real time-of-day acquisition of error events
- For further analysis of the stored data by programmable search criteria.

Particular Features in Detail

- Up to three user specified parameter sets (instrument setups) storable in EPROMs
- Parameter sets, CRT screen pages, and data storable onto magnetic tape in cassette
- Selection function with SDLC/HDLC, simplified entries for selections at the addresses
- Mnemonics can be changed for Levels 2 and 3 in RAM area
- Interpretation for Modulo 128 and for Level 2 and Level 3 also
- CCITT No. 2, SBT and IPARS clear text presentation
- Suitable also for videotext (75, 1200 bit/s)
- ON-LINE CRC recalculation
- Special page for EVENT COUNTER

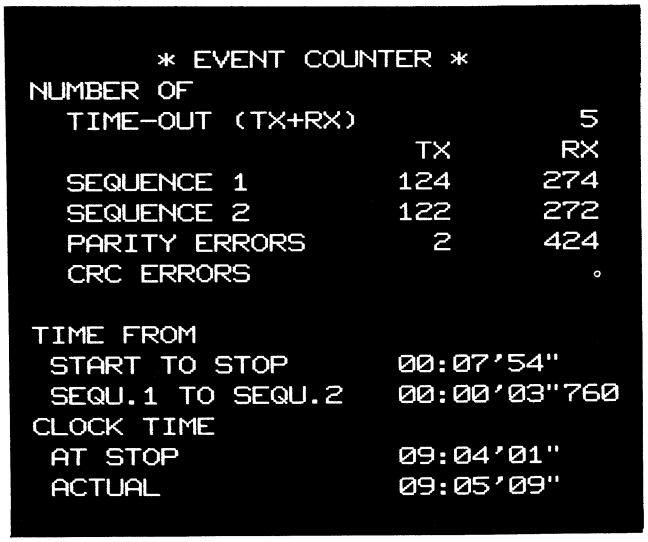


Display of the data with LEVEL 2 and LEVEL 3 interpretation in bit-oriented monitor program



The DA-10 operating in the MONITOR program

The result display of the number of events, with operational clock times presented also

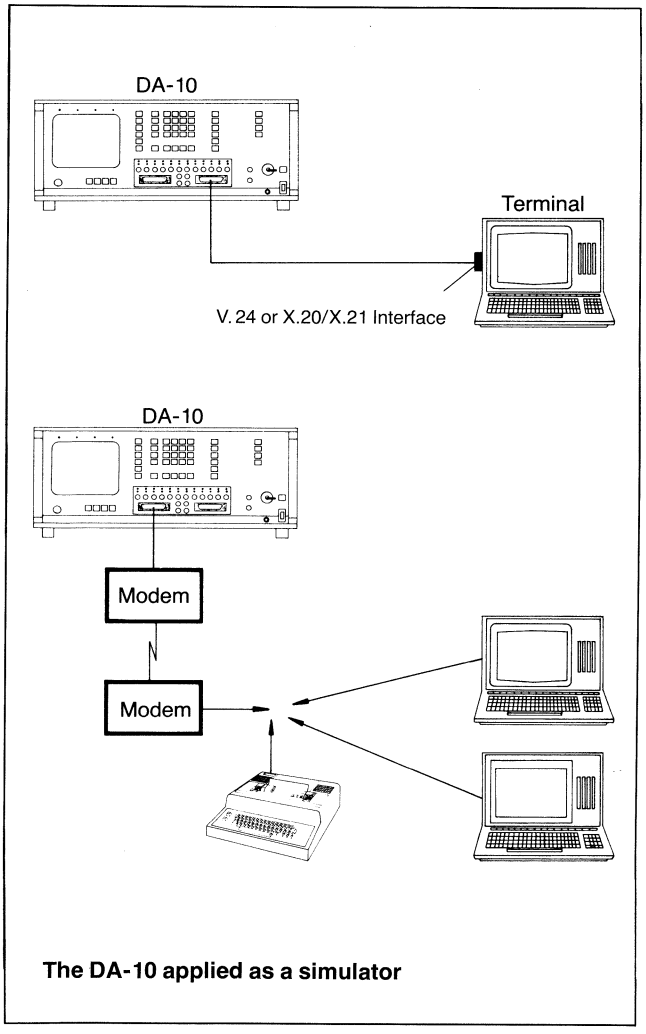


DA-10 as Simulator

SIMULATION – the interactive measuring program for testing data terminal equipment

- Simulation of asynchronous, synchronous, and HDLC procedures
- Efficiently performing set of macroinstructions
- Large send/receive buffer
- Large message buffer – dynamic organization
- Clear text entries on HEX keypad and ASCII keyboard
- Parameter, program, and message storage by integral cassette recorder
- Printout of program, message, and data buffer contents on V. 24 printer
- Easy operation by dialog mode

Particular Features in Detail
- HDX and FDX presentation with hexadecimal and alphanumeric data display
- Send data can be blanked-out
- Character counter for orientation during paging in buffer
- Programmable display messages for displaying test results
- Efficient editing facility when writing in programs and messages
- Specially developed compiler for translating the macroinstructions into machine language
- Checking the simulation program to find syntax errors
- Any programmable interface signals for V. and X. interface



The DA-10 applied as a simulator

```
          * SIMULATION *

SET UP  PARAMETER          1
        PROGRAM            2
        MESS.BUFFER        3

PRINT   PROGRAM            4
        MESS.BUFFER        5
        DATA BUFFER        6

CHECK   RECEIVE BLOCK      7

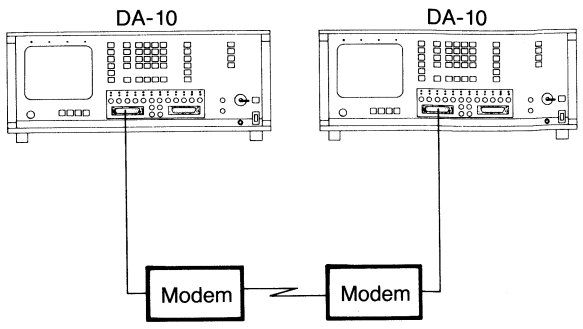

GO ON WITH: No./ENTER/ vv    [1]
 OR START,STOP,STORE,CONT.
```

The master page, the first CRT page of the simulation mode

Entry of simulation program

```
LINE OP MNEMONIC
0220 12 SEND BUF       11
0230 55 GO   SUB          300
0240 62 COMP RCV BUF   12
0250 54 JUMP IF  FALS     520
0260 94 WAIT             2000
0270 52 JUMP              540
0280 21 SET  RCV        1
0290 10 TEST SND RDY
0300 54 JUMP IF  FALS     310
0310 41 SET  TIM OUT     4000
0320 22 TEST RCV CRDY
0330 53 JUMP IF  TRUE     390
0340 40 TEST TIM OUT
0350 53 JUMP IF  TRUE     500
                    EXIT BY [E]
```

DA-10 as Data Tester



Application of the DA-10 for the 511/2048 BIT TEST, for DISTORTION MEASUREMENT and for TIME MEASUREMENT

TIME MEASUREMENT – for measurement of switch-on times at the interface

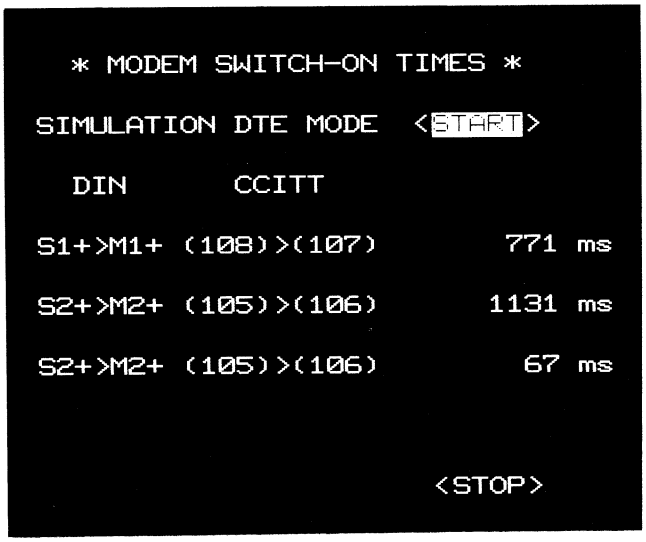
- Prepared programs for fast application
- Measurement of modem switch-on times
  The elapsed times for
  108+→107+ and 105+→106+ are measured
  For line-up purposes the 105/106 measurement is repetitive
- Time measurements on dial-up circuits
  The elapsed time is measured for setting-up a circuit or for disconnecting the circuit, individually listed:
  125+→108+ – accept call
  108+→107+ – connect data set to line
  108+→108– – total period of connection
- Time measurement of a controlled HDX operation
  105+ → 106+ – delay during transmitter switch-on
  106+ → 106– – total transmitting time
  106– → 109+ – changeover time TX/RX
  109+ → 109– – total transmitting time of far-end transmitter
  109– → 105+ – changeover time RX/TX

511/2048 BIT TEST – The test program for checking data circuit quality

- Simultaneous display of bit, character (byte), and block errors
- Error injection
- 511 Bit Test in accordance with CCITT V. 52, compatible with the DMT-1 Modem Tester
- Special 2048 Bit Test for locating errors that vary with the pattern
- Any pattern (e.g. QBF) is applicable for error rate measurement within the scope of the 2048 Bit Test
- Applicable on asynchronous and synchronous systems
- Suitable for HDX and FDX operation.

The 2048 BIT TEST and its evaluation





Measurement of modem switch-on times

DISTORTION MEASUREMENT – the measurement of quality on asynchronous data circuits

- Bias distortion measurement
- Start-Stop distortion measurement
- Isochronous/individual distortion measurement
- Pseudo-analog and digital measured values display for bias distortion measurement
- Additional baud rate measurement with the isochronous/individual distortion measurement

Ordering Information

Data Analyzer DA-10
with X.20/X.21 Interface **BN 907/21**
and byte- and bit-oriented monitor program
and data codes CCITT No. 5 and EBCDIC,

Data Cassette Recorder with cassette and cleaning tape,

Level 3 interpretation and FIND function for
bit-oriented monitor program,

"Dump and Load" program in Intel-Hex format

Data Analyzer DA-10
with V.24/V.28 Interface **BN 907/22**
and byte- and bit-oriented monitor program
and data codes CCITT No. 5 and EBCDIC,

Data Cassette Recorder with cassette and cleaning tape,

Level 3 interpretation and FIND function for
bit-oriented monitor program,

"Dump and Load" program in Intel-Hex format

Options (at extra cost)

Interactive Simulation	BN 907/00.38
511/2048 Bit Test	BN 907/00.07
Time measurement	BN 907/00.08
Distortion measurement	BN 907/00.09
Software retrofitted to the latest relevant status	BN 907/00.21
Extra codes for byte-oriented monitor program: (Further data codes on request; please enclose specification(s) of the codes that are wanted)	
CCITT Code No. 2 [1]	BN 907/00.11
IPARS Code [1]	BN 907/00.18
6 Bit Transcode [1]	BN 907/00.19
Extra code for bit-oriented monitor program:	
Teletex code	BN 907/00.20
Interface Supplement Sets:	
V.24/V.28 Interface Supplement Set for DA-10, BN 907/21	BN 907/00.14
X.20/X.21 Interface Supplement Set for DA-10, BN 907/22	BN 907/00.15
Test Interfaces on DA-10 back panel:	
X.20/X.21 Test Interface on back panel [2] for DA-10, BN 907/21 or for DA-10, BN 907/22 equipped with X.20/X.21 Supplement Set BN 907/00.15	BN 907/00.17
V.24/V.28 Test Interface on back panel [2] for DA-10, BN 907/22 or for DA-10, BN 907/21 equipped with V.24/V.28 Supplement Set BN 907/00.14	BN 907/00.16
Parameter Set [3]	
Standard program and a program [4] specified by the customer	BN 907/00.40
Standard program and two programs [4] specified by the customer	BN 907/00.41
Three programs specified by the customer [4]	BN 907/00.42

Accessories (at extra cost)

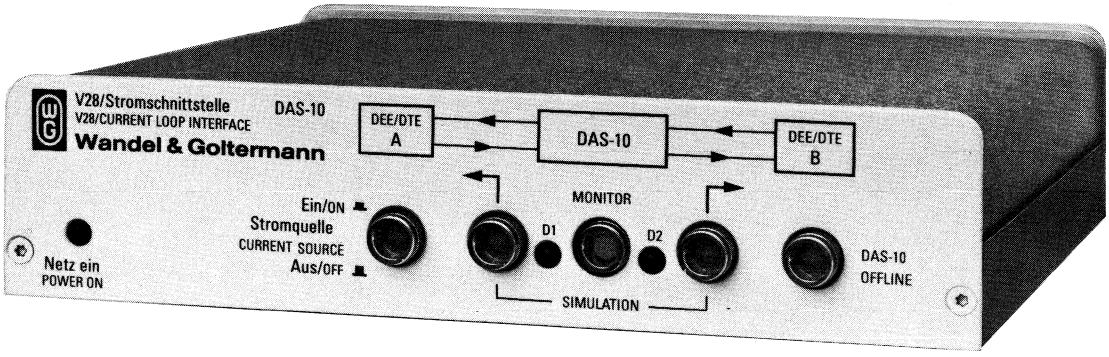
V.28/Current Loop Interface DAS-10	BN 6250/01
Extra cassette for recorder	BN 907/00.30
Cleaning tape for cassette recorder	BN 907/00.31
Transport Case TPK-4	BN 626/10
Front and back panel covers (1 set) SD-4	BN 700/00.24
V.24 interface cable	
Ribbon cable 1.5 m (plug-jack)	K 363
Ribbon cable 1.5 m (plug-jack)	K 364
Ribbon cable 1.5 m (jack-jack)	K 365
Ribbon cable 1.5 m (plug-jack-plug)	K 369
X.20/X.21 interface cable	
Ribbon cable 1.5 m (plug-jack)	K 371
Ribbon cable 1.5 m (plug-plug)	K 370
Ribbon cable 1.5 m (jack-jack)	K 373
Ribbon cable 1.5 m (plug-jack-plug)	K 372

1) The data codes BN 907/00.11; BN 907/00.18 and BN 907/00.19 are stored in EPROMS. A max. of two of these codes can be incorporated in the DA-10. Besides that, data codes are loadable from tape cassette.
2) The Test Interfaces BN 907/00.16 and BN 907/00.17 for mounting onto the DA-10 back panel are only used alternatively as one or the other.
3) A "Parameter Set" is defined as a Menu Program tailored to the user's need for a monitor program. The Standard Program contained in the DA-10 can be supplemented or replaced by a program specified by the customer. The ordering form No. 5/921 ought to be filled out by the user (if a form is required please ask for one) and should be enclosed with the order.
4) Only used alternatively as one or the other.

A Specification Sheet with more details and a Colour Brochure are available on request

DAS-10
V.28/Current Loop Interface

for analysis and simulation of current-loop interface signals with V.24/V.28 measuring instruments



- **Monitor and simulation operation**
- **Analysis (monitor operation) of single and double-current signals to 60 mA**
- **Simulates 20 mA single-current signals**
- **Active and passive simulation**
- **Transmission rates to 9 600 bit/s**

Applications

The DAS-10 V.28 voltage interface/current loop interface allows you to use V.24/V.28 measuring equipment on data systems with current interfaces (20 mA current loop). The signals used in telex and telegraph networks can also be converted to V.28 voltages by the DAS-10.
With the DAS-10 it is possible to simulate 20 mA current-loop terminals using commercially available data simulators or analysers, e.g. the DA-10.
Transmission paths can also be tested with V.24/V.28 data testers.
The DAS-10 is a simple, uncomplicated interface, and for this reason it is used for data communications (in-house), to control electromechanical equipment and to collect measurement data.
The DAS-10 can also be used to operate display boards at airports, railway stations and bus terminals, for example.

Characteristics

The DAS-10 V.28/Current Loop Interface converts current interface signals into V.28 signals, so that the former type of signal can be measured on V.24/V.28 instruments (e.g. DA-10 Data Analyzer). Both double and single-current signals at 20, 40, and 60 mA can be handled.
In addition, the conversion of V.28 signals to 20 mA single-current signals to carry out simulation is possible. Active or passive simulation can be performed. A selector switch allows you to choose where the current source is located – either in the DAS-10 or in the DTE. A specially designed circuit keeps the current constant no matter what the line length is.
Connections to the DAS-10 are made through banana jacks or a 15-pin Cannon connector. The DAS-10 has the usual 25-pin connector for the V.24/V.28 interface.

Transmission rate	max. 9600 bit/s
Monitor mode	
single and double-current	20, 40, 60 mA
Simulation mode	
single current	constant 20 mA
Connectors	
for the Current Loop Interface	
DAS-10	Cannon connector, 15-pin and banana jacks
for the V.28 input-output	Cannon connector, 25-pin

Further Applications and Characteristics

Monitor mode
In monitor mode, the DAS-10 V.28/Current Loop Interface is connected between the two DTEs, using banana plugs or 15 conductor cables. After conversion to V.28 signals, the current-loop signals can be analysed on commercially available V.24/V.28 test equipment (e.g. the DA-10 Data Analyzer).
Two LEDs monitor activity on the data lines. Opto-couplers convert the currents into V.28 signals. The key "DAS-10 OFF LINE" allows the looped-in opto-coupler to be taken out of the line circuit.

Simulation mode
The simulation of either DTE A or DTE B is implemented, without unplugging any cables, by simply pressing a key. Additionally, active or passive simulation is key-selectable. In active simulation mode, the current source for the send and for the receive data circuits is in the DAS-10.

Specifications of the V.28/Current Loop Interface — DAS-10

When not otherwise noted, the specified data is valid in the rated range of a.c. line voltage, a.c. frequency and ambient temperature.

Transmission rate . . . . . max. 9 600 bit/s

Monitor mode
Single and double-current . . . . . 20, 40, 60 mA
Destruction limit . . . . . 80 mA

Simulation mode
Single-current . . . . . constant 20 mA independent of circuit length
Simulation mode, in both directions . . . . . switch-selectable
Selection of current sources (current source for transmitter and receiver) . . . . . can be switched in and out

Connectors
Current Loop Interface connectors . . . . . Cannon connector, 15-pin and banana jacks
Connector for V.28 input-output . . . . . Cannon connector, 25-pin
LEDs monitor activity on the data circuits (positive voltage at V.28 or no current state)

V.28 connection as output
Open circuit voltage V_0 . . . . . $+25\,V \geqq V_0 \geqq -25\,V$
Operating voltage V_1 with a load impedance of Z_L = 3 to 7 kΩ
"1" signal or "off" . . . . . $-5\,V \geqq V_1 \geqq -15\,V$
"0" signal or "on" . . . . . $+5\,V \leqq V_1 \leqq +15\,V$

V.28 connection as input
Input impedance . . . . . 3 to 7 kΩ
Required operating voltage V_1 at the transfer interface
"1" signal or "off" . . . . . $-3\,V \geqq V_1 \geqq -25\,V$
"0" signal or "on" . . . . . $+3\,V \leqq V_1 \leqq +25\,V$

General Specifications

Power supply
Rated range of use of a.c. line voltage . . . . . 220 V −10 % to +15 %
Rated range of use of a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption . . . . . 4 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I

Tolerable ambient temperature
Rated range of use . . . . . +5 to +40°C
Limits range of operation . . . . . +5 to +40°C
Storage and transportation . . . . . −40 to +70°C

Dimensions (w x h x d) in mm . . . . . 193 x 43 x 170

Weight . . . . . approx. 1 kg

Ordering Information

V.28/Current Loop Interface DAS-10	**BN 6250/01**
Accessories (at extra cost)	
V.24 Interface Cable	
Ribbon cable, 1.5 m (f–m)	K 363
Ribbon cable, 1.5 m (m–m)	K 364
Ribbon cable, 1.5 m (f–f)	K 365
Ribbon cable, 1.5 m (m–f–m)	K 369
X.20/X.21 Interface Cable [1]	
Ribbon cable, 1.5 m (f–m)	K 371
Ribbon cable, 1.5 m (m–m)	K 370
Ribbon cable, 1.5 m (f–f)	K 373
Ribbon cable, 1.5 m (m–f–m)	K 372

1) This cable is suitable for connection to the 15-pin Current Loop Interface connector.

DTX-1
TELETEX Tester

Analyzer and Simulator for TELETEX service



- **For application in circuit-switched data networks (e.g. DATEX-L)**
- **Simple connection to all combinations of DTE and DCEs**
- **Analysis and simulation of all procedure levels**
- **Easily understood display of results**
- **Results are displayed on LCD screen and printed out**
- **Non-volatile memory**
- **Simulation in direction of DTE or data network**
- **Replaces the data network between two DTEs**
- **Tester and printer fitted into a briefcase**

Characteristics

Because of its light-weight and compact size, the DTX-1 is suitable not only for design laboratories, but also for rapid deployment to a field site. The stored data is located in a non-volatile memory for either immediate or later analysis. The use of function keys (softkeys) with user prompts displayed on the screen line above the row of keys provides simple and unambiguous operation of the DTX-1

Applications

The DTX-1 TELETEX Tester is a handy, portable Analyzer and Simulator for diagnosis and troubleshooting during the design stage and initial line-up of networks and data terminal equipment. The version described in the following paragraphs was especially designed for dial-up circuit-switched networks complying with CCITT Recommendation X.21 governing synchronous operation on Public Data Networks. The Tester operates at the digital interface between DTE and DCE. Appropriate adaptors permit a trouble-free attachment both with integral and with stand-alone DCEs.

TELETEX Tester:
- for circuit-switched networks (e.g. DATEX-L)
- 2400 bit/s transmission speed
- analysis and interpretation of the call according to CCITT X.21
- analysis and interpretation of Levels 2 to 6
- examination of the HDLC data integrity
- non-volatile memory for stored data
- DTE simulation
- DCE and network simulation
- simulation of the network between two DTEs

2580 DTX-1

Further Characteristics and Applications

When the DTX-1 is operating in the analyzer mode it records all physical and logical procedures passing through the interface between the DTE and the communication equipment. The interpretation complying with CCITT Recommendations X.21, X.25/X.75, S.60, S.62, and S.70 is presented in unambiguous and easily understood forms.

So as to present a better overview, the measured results of the monitor operation are represented in three logical groups:

- Connection and disconnection of the link according to CCITT X.21
  The X.21 states are displayed in clear text. The start and stop points of the procedural time controls as well as the relevant tolerated times and the actual times required are displayed. If noise spikes appear on the data, control, or indication circuits, the message "SPIKES" is displayed and printed out.
- Connection and disconnection of Levels 2 to 6
  Commands and indications of the individual logic levels are written in mnemonic notation. In addition, for Level 2 (HDLC) the addresses and the sequence numbers and also the CRC error check are stated.
- The third group shows the interpreted parameters of Levels 4, 5, and 6 besides the associated length indicators. The parameter groups and parameters are listed in clear text.

The relationship between the three groups presented is established by the line numeration. The example of a recording illustrated below ought to clarify this association.

The printout of the X.21 circuit configuration contains the complete phase of data communications, summarized under the statement "DATA TRANSFER 0" (line 12). Just a simple paging routine furnishes the run-off of this data transfer that is headed by HDLC 0. And the coordination of the parameter fields is as simple too. These are headed by the statement "PARAMETERS 0" and the line numbers of the related HDLC blocks are printed as cross-references.

Measured results can be printed out immediately, but for later evaluations they also remain stored in the non-volatile memory.

When the DTX-1 is used as an active simulator the available modes are:

- simulation in the direction of the DTE
  This operating mode tests elementary functions of a TELETEX machine during the design, installation and servicing of DTEs, moreover, no port to the network is needed.
- simulation in the direction of the DCE
  This operating mode allows the setting up and testing of a TELETEX port, but no operational DTE is needed for the test.
- simulation between two DTEs
  In this mode, the two DCEs and the complete data network between two machines are simulated. By this means, all equipment functions can be completely tested and permanent tests can be implemented without loading the data network.

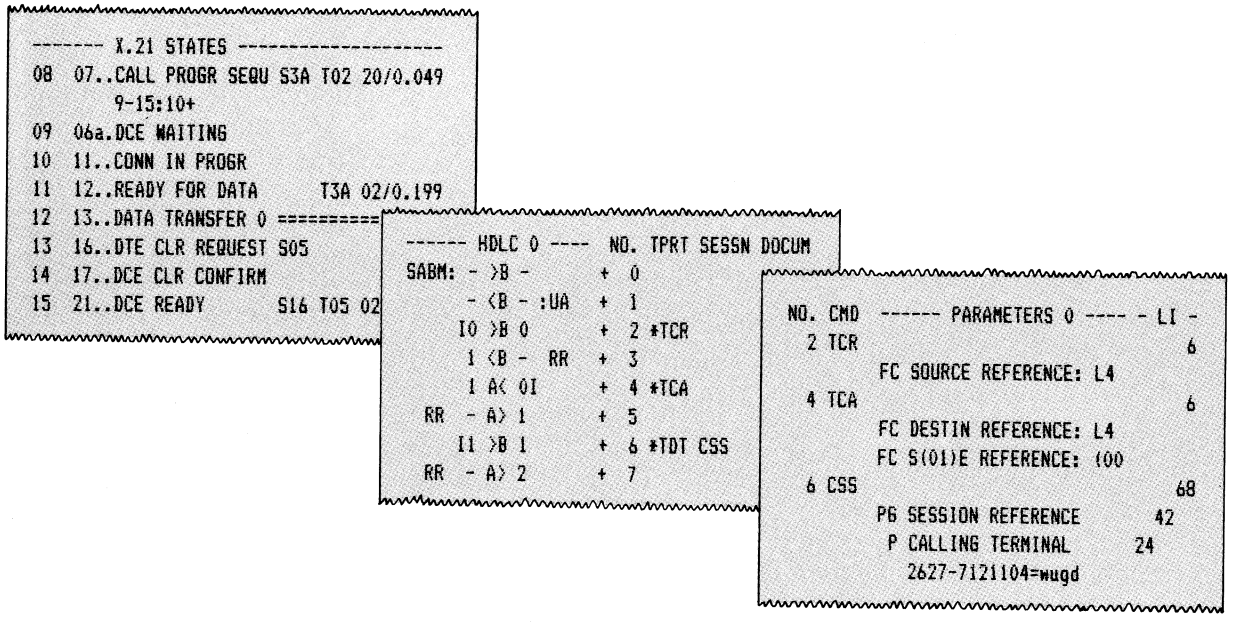


Illustration of results obtained in monitor mode: in three groups

Specifications of the TELETEX Tester

DTX-1

Unless otherwise stated, the specifications are valid for the nominal range of use of a.c. line voltage, a.c. line frequency, and ambient temperature.

Monitor mode

Display and interpreted presentation
- the procedural states during connection and disconnection (in agreement with CCITT Recommendation X.21); display of nominal and actual values obtained by monitoring over time intervals
- the addresses, commands, messages, and sequence numbers of Level 2 (complying with CCITT Recommendation X.25/X.75), display of error control and check results
- the addresses, commands, messages, and parameters of Levels 4, 5, and 6 (Transport, Session, and Document according to CCITT Recommendations S.62 and S.70)
- results printed out by thermal-matrix printer

Simulation mode

- simulation of the elementary functions of data network and far-end station so as to test a TELETEX DTE
- simulation of the elementary functions of a TELETEX DTE so as to test a TELETEX port
- simulation of the elementary functions of a data network between two TELETEX DTEs

Display

LCD display with 8 lines at 40 characters per line. Each interface signal – T, C, R, I and S – has a red and a green LED for displaying the electrical state of the relevant signal.

Operation

Menu-driven via softkeys.

Data store

Non-volatile memory for the storing of about two complete circuits.

Interconnections

Interconnections of DTX-1 in monitor mode
- by the looping-in between teletex machine (TTX, DTE) and DCE
  through using an external DCE (DFG 9600 UE-2) with two 15 conductor cables (Jack-Plug) complying with recommendations of ISO 4903 or X.21,
  through using an extra DCE (DFG 9600 UE-2E) out of the cabinet and with two 25 conductor cables (Jack-Plug) complying with ISO 2110 or V. 24 and the adaptors delivered with the unit.
- by connecting to an inbuilt DCE (DFG 9600 UE-2E) via a 6 conductor monitor cable.

Interconnections of the DTX-1 in simulation mode
- if simulating the DCE or DTE by the looping-in as in monitoring mode. The simulated equipments (DTE or DCE) are separated within the DTX-1
- if simulating the network functions by the looping-in between the two TTX machines. Instead of the DCE an adaptor takes over the necessary transposing of the T and R data circuits and also of the status circuits C and I. The machines are provided with signal element timing from the DTX-1.

General Specifications

Power supply

Nominal ranges of use of a.c. line voltage, selectable	110/220 V, −15 to +17 %
Nominal range of use of a.c. line frequency	45 to 66 Hz
Power consumption	approx. 10 W
Safety class to IEC 348 and VDE 0411	Class I
RFI/EMI to Bundespost standards (Vfg 1046/84)	

Tolerable ambient temperature

Nominal range of use and range limits of operation	+5 to +40°C
Storage and transport	−20 to +60°C
Dimensions (w x h x d) in mm	335 x 238 x 97
Weight without printer and briefcase	approx. 2.6 kg

Ordering Information

TELETEX Tester DTX-1 **BN 2009/01**
with power cord, 5 interface cables, and 5 interface adaptors in the briefcase

TELETEX Tester DTX-1 **BN 2009/02**
as BN 2009/01 but also has matrix thermoprinter (fits into briefcase)

Accessories (charged extra)

Heat-sensitive paper, 110 mm wide 30 m long	BN 2009/00.08

DMS-1
Data Measuring Set

for checking the analog and digital quality-characteristics of data circuits



- **Five instruments can be selected from a program containing Level Generators, Level Meters, a Data Circuit Test Set, a Modem Tester, Interface Testers and a Speech Attachment**
- **Sturdy case with lock; has integral a.c. adaptor/charger**
- **All instruments can be powered by rechargeable batteries**
- **Each instrument is handy, light and robust**

Applications

The continuous expansion of data communications makes fast and reliable servicing essential if long down-times are to be avoided. The DMS-1 Data Measuring Set is ideal for mobile, field service as it provides a logical combination of analog and digital instruments in a protective carrying case.
This universal instrument combination is ideal for effective troubleshooting and maintenance on telephone and sound-programme communications equipment used by postal administrations, railways, broadcasting companies, banks, airlines and public utility companies supplying energy.

Characteristics

Each instrument in the case can be powered from the a.c. line. The rechargeable batteries for each of the instruments are charged together in the case. External a.c. line adaptors/chargers can be purchased for charging batteries outside the case, and also operating the instruments. Several different types of measurement can be carried out simultaneously by using each instrument on its own. For example, bit error ratios, impulsive noise or interruptions can be subjected to long-term monitoring, inside or outside the case.
A pocket is provided for accessories such as an external a.c. line adaptor/charger, a.c. line cables, test cables, operating manuals, measuring documentation and notes.

Level generator	20 Hz to 20 kHz
Level measurements	30 Hz to 120 kHz
	15 Hz to 20 kHz, also psophometric measurements
Impulsive noise measurements	as per CCITT Rec. O.71
Interruption measurements	as per CCITT Rec. O.62
Other measurements	bit and block error ratio, distortion, modem switching times
Interfaces	as per CCITT Recs. V.24/V.28, X.20/21, X.26/27
Checking, patching, simulation	
Intercom on the measurement channel	

Measuring Instruments for the DMS-1 Data Measuring Set

For more details, see the Specification Sheet for each instrument. The DMS-1 will accommodate up to five instruments.

PS-10

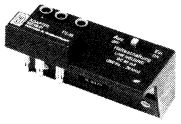


PS-20



Level Generators

	PS-10, BN 904/01	**PS-20,** BN 902/01	**PS-20,** BN 902/02
Frequency range	200 Hz to 4 kHz, sweepable	20 Hz to 20 kHz	20 Hz to 20 kHz
Level range	−59.9 to 0 dBm	−59.9 to +16 dBm	−59.9 to 16 dBm
Fixed frequencies	0.2, 0.3, 0.4, 0.6, 0.8, 1, 1.6, 2.4, 3.4, 4 kHz	20, 30, 40, 50, 75, 100, 125, 150, 160, 200 Hz Scaling factor ×1, ×10, ×100	20, 30, 40, 50, 75, 100, 125, 150, 160, 200 Hz Scaling factor ×1, ×10, ×100
Special frequencies	—	—	85, 850, 8500 Hz instead of 75, 750, 7500 Hz
Power supply	rechargeable batteries and a.c. line adaptor/charger		



Plug-in Adaptor, BN 902/00.01

D.C. loop holding circuit for the PS-20 Level Generator
Send level ≦0 dBm, d.c. loop holding current ≦60 mA

PM-20



PM-40



Digital Level Meters

	PM-20, BN 881/01	**PMP-20,** BN 876/04	**PM-40** *), BN 4508/01
Frequency range	15 Hz to 20 kHz	30 Hz to 20 kHz	30 Hz to 120 kHz
Level measuring range	−50 to +30 dBm	−70 (−50) to +10 dBm	−60 to +10 dBm
Weighted noise measurements	—	with weighting filter complying with CCITT P.53	—
D.C. voltage measurements	0 to 100 V	0 to 100 V	
Digital display	with correct sign	with correct sign	with correct sign
Resolution	0.1 dB	0.1 dB	0.1 dB
Power supply	rechargeable batteries and charger	rechargeable batteries and a.c. line adaptor/charger	

*) Built-in generator: frequency 820 Hz, level −10 dBm, output balanced 600 Ω

PM-10



PM-928



Digital Level Meters

	PM-10, BN 820/..	**PM-928,** BN 928/01
Frequency range	80 Hz to 20 kHz	200 Hz to 6 kHz
Level measuring range	−50 to +10 dBm	−50 to +10 dBm
Send section	820 Hz two switchable fixed-levels	—
Level measurements on the two-tone signalling frequencies as found in the ED 1000 data comm system	—	with switchable filters
D.C. voltage measurements	—	0 to 60 V
Digital display	with correct sign	with correct sign
Resolution	0.1 dB	0.1 dB
Power supply	rechargeable batteries and charger	

SZU-969 Speech Attachment and Two-wire Switch-over, BN 969/01 or /02

- Sets up a telephone link between measurement sites via the measurement channel
- Intercom facility
- Operates like a telephone handset with a dial-up facility and a d.c. exchange loop holding capability
- Connects the measuring equipment to a two-wire line via a Two-wire Switch-over
- Rechargeable batteries and a.c. adaptor/charger



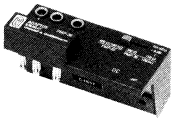
DLM-20 Data Circuit Test Set, BN 961/01

- Interruption measurements comply with CCITT O.62, 6 event counters
- Impulsive noise measurements comply with CCITT O.71, 3 event counters Test-tone measurements (built-in notch filter)
- Switchable dead times
- Rechargeable batteries and a.c. adaptor/charger



Plug-in Adaptor, BN 876/00.01

- Provides 150 Ω and 300 Ω impedances for the PM-20, PMP-20, PM-928, and DLM-20
- Balanced input, floating, 3 pole CF connector
- D.C. current load 60 (40) mA for 150 (300) Ω



DMT-1 Modem Tester, BN 7507/02

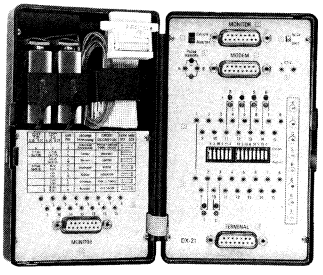
- Tests synchronous and asynchronous modems having V.24/V.28 interfaces
- Automatic, half-duplex operation
- Bit and block error ratios
- Bit pattern 0; 1; 1:1; 1:7; 7:1; 511 bits
- QUICK BROWN FOX (QBF) sequences
- Distortion measurements
- Measurement of modem switching times
- Rechargeable batteries and a.c. adaptor/charger



Interface Testers

	DX-21, BN 7503/02	**DV-24,** BN 7502/04
Monitoring the function sequence (timing) at CCITT interfaces	X.20/X.21 X.26/X.27	V.24/V.28 EIA RS 232
LED display for monitoring interface circuits	all circuits	the 14 most important circuits
Connection and disconnection of data circuits	with miniature switches and test leads	with miniature switches and test leads
Simulation of signal states	with a 1.5 V battery	with a 9 V battery
Monitor connector for external Data Analyser	15 pin	25 pin

DX-21



Specifications of the Data Measuring Set

DMS-1

If nothing to the contrary is stated, the given data is valid for the rated conditions of use of the influence quantities.

General Specifications

Power supply
A.C. line operation via central a.c. adaptor and charger
Rated ranges of use for a.c. line voltage,
switchable . . . . . 94 to 141 V/187 to 264 V
Rated range of use for a.c. line frequency . . . . 47.5 to 63 Hz
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

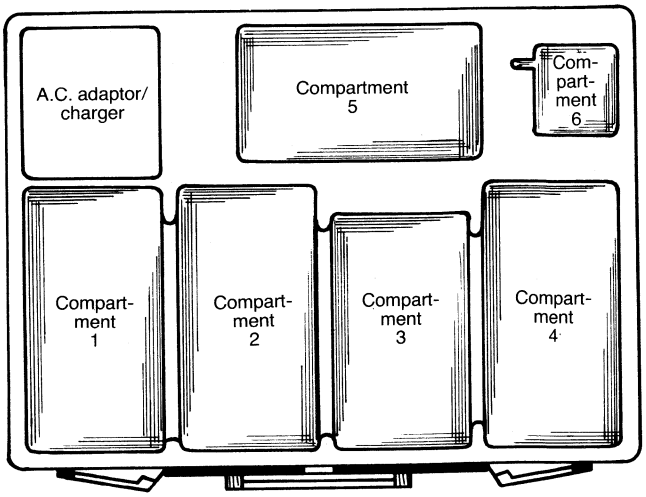
Tolerable ambient temperature
Rated range of use . . . . . 0 to +50 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions (w×h×d) in mm . . . . . 455×340×125

Weight, empty . . . . . approx. 4.5 kg
with five instruments . . . . . approx. 8 kg

Arrangement in compartments:					
Compartment 1	Compartment 2	Compartment 3	Compartment 4	Compartment 5	Compartment 6
PMP-20 PS-10 PS-20 PM-10 [1] PM-20 [1] PM-928 [1] PM-40		DLM-20	DMT-1	SZU-969 DX-21 DV-24	External

1) A.C. line adaptor/charger cannot be connected
Charger BN 820/00.51 is used to recharge the NiCads



A Colour Brochure is available on request

Ordering Information

Data Measuring Set DMS-1 **BN 964/01**
with built-in a.c. adaptor and charger, empty

Up to five instruments can be accommodated:

Level Generator PS-10	BN 904/01
Level Generator PS-20 [1]	BN 902/01 or /02
Plug-in Adaptor (holding circuit for the PS-20)	BN 902/00.01
Digital Level Meter PM-10	BN 820/..
Digital Level Meter PM-20	BN 881/01
Digital Level Meter PMP-20	BN 876/04
Digital Level Meter PM-40	BN 4508/01
Digital Level Meter PM-928	BN 928/01
Speech Attachment and 2-wire Switch-over SZU-969	
for 60 V exchange voltage	BN 969/01
for exchange voltage ≧36 V	BN 969/02
Data Circuit Test Set DLM-20	BN 961/01
Plug-in Adaptor (Impedance extension 150/300 Ω for the PM-20, PMP-20, PM-928, DLM-20)	BN 876/00.01
Modem Tester DMT-1	BN 7507/02
Interface Tester DV-24	BN 7502/04
Interface Tester DX-21	BN 7503/02

Non-optional accessories (at extra cost)
Rechargable batteries for the instruments in the DMS-1 must be ordered separatly.

NiCad rechargeable battery, 9 V — BN 820/00.50
One required for the
PM-10, PM-20, PMP-20, PM-40, PM-928, DLM-20

Two required for the
PS-10, PS-20, DMT-1, DX-21, DV-24

NiCad rechargeable battery, 7.2 V — BN 969/00.01
Two required for the SZU-969

Accessories (at extra cost)

A.C. adaptor/charger with	
Standard European power plug (193 to 242 V/47.5 to 63 Hz)	BN 964/00.02
US power plug (105 to 132 V/47.5 to 63 Hz)	BN 964/00.03
UK power plug (211 to 264 V/47.5 to 63 Hz)	BN 964/00.04
Mains cable, but without plug (211 to 264 V/47,5 to 63 Hz)	BN 964/00.05
Charger (198 to 242 V/45 to 60 Hz)	BN 820/00.51

Interface cable for V.24, 1.5 m for the DMT-1, DV-24

Ribbon cable f-m	K 363
Ribbon cable m-m	K 364
Ribbon cable m-f-m	K 369

Interface cable for X.20/X.21, 1.5 m, for DX-21

Ribbon cable m-m	K 370
Ribbon cable f-m	K 371
Ribbon cable m-f-m	K 372

1) When used with the DLM-20, version BN 902/02 with the 850 Hz option should be ordered.

DMT-1
Modem Tester

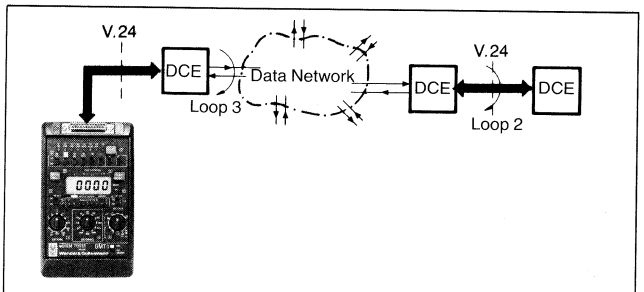
for checking modems with V.24/V.28 interfaces



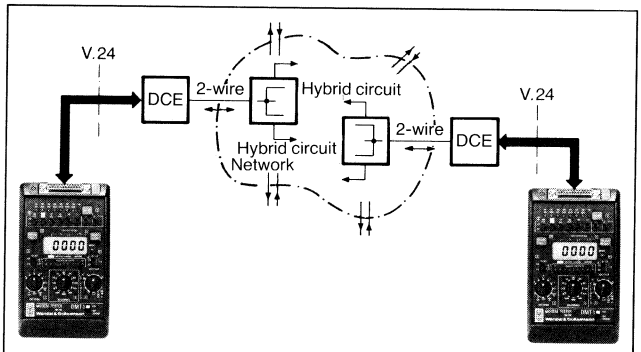
- **Tests synchronous and asynchronous modems**
- **Automatic half-duplex test**
- **Bit and block error counting over 10^4, 10^5 and 10^6 bits or blocks**
- **Generates six bit-patterns as well as QUICK BROWN FOX (QBF) sequences**
- **Distortion measurements**
- **Timing measurements**
- **Battery or a.c. power operation**
- **Small, handy, rugged**

Applications

The DMT-1 Modem Tester is an instrument for checking synchronous and asynchronous modems. The compact, battery powered DMT-1 is ideal for field service applications, and a valuable aid when datacomm equipment is being installed.
To carry out a modem test, all one has to do is substitute the DMT-1 for the DTE which is connected to the modem via the V.24/V.28 interface. The bit or block error ratio can then be measured in synchronous FDX mode using local or remote loop-back. Using QBF sequences the number of incorrectly received characters or messages is shown in asynchronous FDX mode.
Telegraph distortion measurements give a lot of information about transmission quality. The DMT-1 measures bias distortion and individual distortion (early and late). Isochronous distortion can be determined from individual distortion.
It is often the case that the subscriber receives data via a two-wire line operated in half-duplex mode. This form of data transmission can be simulated by the DMT-1. At the same time, bit or block error ratios in the send and receive directions can be measured.



Test on a transmission path suitable for FDX operation



Automatic half-duplex test using 511-bit blocks

Characteristics

The DMT-1 can measure how long it takes the modem to switch between 108/S1 and 107/M1, or 105/S2 and 106/M2. This is an important datacomm parameter.
When the DMT-1 is used to monitor V.24 interfaces, an LED display shows the status of the receive and indication lines. Slide-switches are used to switch the signal lines to the ON or OFF state.

Internal baud rate (113/T1)	50, 75, 110, 150, 200, 300, 600, 1200, 2400, 4800, 9600, 19 200 baud
Baud rate with external clock (114/T2, 115/T4)	50 to 20 000 baud
Send patterns,	
synchronous	0; 1; 1:1; 1:7; 7:1; 511 bit sequence
asynchronous	FOX messages in ASCII or EBCDIC
Stop bits	1 or 2
ASCII parity	none, even, or odd
Weight	approx. 0.9 kg

The following characteristics of the DMT-1 are also worth mentioning:

- During measurements, the numerical results are shown on a 4-digit LCD display, additional indicators provide extra, useful information.
- When the DMT-1 is operated on dry or rechargeable batteries, the "LOW BATTERY" display comes on to warn to operator that the batteries are running down. The DMT-1 will then continue to operate correctly until automatic switch-off occurs.
- The DMT-1, the DV-24 Interface Tester and other hand-held instruments form a complete datacomm test range which can be accommodated in the DMS-1 Data Measuring Set.

Specifications of the Modem Tester — DMT-1

If not otherwise noted, the specified data are valid under rated conditions of use.

Generator

Clock . . . . . internal (113/T1) or external (114/T2)
Internal baud rate (113/T1), selectable . . . . 50, 75, 110, 150, 200, 300, 600, 1200, 2400, 4800, 9600, 19 200 baud
External clock range (114/T2) . . . . . 50 to 20 000 baud
Error limits of internal clock (except 110) . . . . . $\pm 2 \times 10^{-4}$

Send patterns
Synchronous FDX-operation, repeating selectable . . . . . 0; 1; 1:1; 1:7; 7:1; 511 bit sequence (CCITT V.52)
HDX operation with . . . . . 511-bit sequence selectable . . . . . start with transmit (TX) or receive (RX)
Error injection . . . . . by pressing pushbutton
Asynchronous operation, repeating . . QUICK BROWN FOX with internal clock . . . . . up to 19 200 baud
Code . . . . . EBCDIC or ASCII
Stop bits . . . . . 1 or 2
ASCII parity . . . . . none, even or odd

Receiver

Clock . . . . . internally derived or external (115/T4)
Internal baud rate . . . . . same as generator
External clock range (115/T4) . . . . . 50 to 20 000 baud

Error count
Count range . . . . . 0 to 9999 errors
Synchronous simplex, FDX or HDX operation
Evaluation over . . . . . 10^4, 10^5, 10^6, ∞ bits or blocks (1 block = 8 or 511 bits)
Asynchronous operation (FOX)
Evaluation over . . . . . ∞ characters or ∞ messages
Measurement started/stopped . . . . . by pushbutton
Error evaluation . . . . . without parity, start, and stop bits

Distortion measurements

	Bias	Individual
Display in % via	LED array	LCD, early or late indication
Test signal	1:1 sequence	1:1 or 511-bit sequence
Max. baud rate	9600	9600
Measurement range	±15 %	±25 %
Resolution	1.5 % or 2 %	1 %
Display error	±2 % (up to 4800 baud)	±3 % ±1 digit

Switchover time measurements
between . . . . . 108/107 (S1/M1) or 105/106 (S2/M2)
Measurement range . . . . . 0 to 999 ms

LCD display . . . . . 4 digits
Extra indicators "■" measurement in progress . . . . MEAS.
Pattern sync. lost . . . . . NO SYNC.
stored (only FDX) . . . . . →MEM.
Line 109/M5 was OFF (only FDX) . . . . . 109 MEM

A Colour Brochure is available on request

Interface . . . . . complies with CCITT Rec. V.24/V.28
When a button is pressed, signal 0 or ON is shown by red LED for each of following lines 104/D2, 107/M1, 106/M2, 109/M5, 122/HM5, 121/HM2, 125/M3, 142/PM1
Slide switches are used to set the signal states (ON or OFF) of the following lines 108/S1, 105/S2, 111/S4, 120/HS2, 140/PS2, 141/PS3
The external test-loops L2, L3 are provided for the French System, TRANSPAC.

General Specifications

Power supply . . . . . dry batteries, rechargeable batteries or an external mains adaptor/charger
Dry batteries, 2 × 9 V . . . . . comply with IEC 6 LF 22
Recommended type . . . . . Mallory Duracell MN 1604, VARTA 4022 or UCAR Professional 522
NiCads . . . . . e.g. 2 × VARTA Tr 7/8
Operating time (no distortion measurements) of
rec. dry batteries . . . . . approx. 8 h
NiCads . . . . . approx. 2 h, then auto. switch off

Permissible ambient temperature
Rated range of use . . . . . 0 to +50 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions (l × w × d) in mm . . . . . 164 × 98 × 70

Weight . . . . . approx. 0.9 kg

Accessories (part of DMT-1 package)
Two 9 V dry batteries

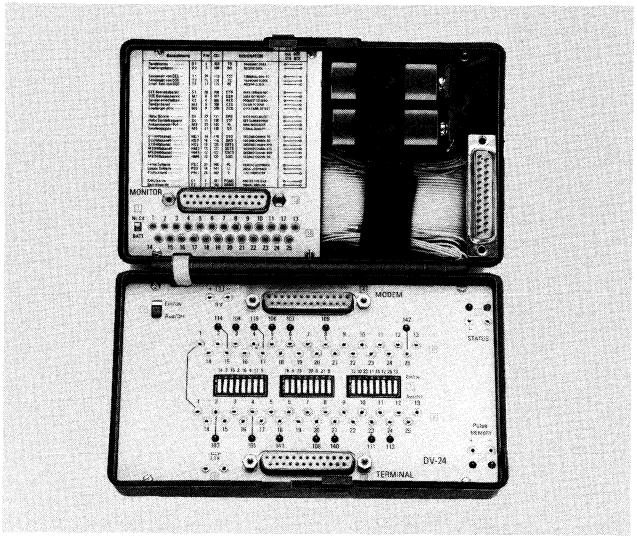
Accessories (at extra cost)
NiCads, Mains adaptor/charger

Ordering Information

Modem Tester DMT-1	**BN 7507/02**
Accessories (at extra cost)	
A.C. adaptor/charger with	
Standard European power plug (193 to 242 V/47.5 to 63 Hz)	BN 964/00/.02
U.S. power plug (105 to 132 V/47.5 to 63 Hz)	BN 964/00.03
U.K. power plug (211 to 264 V/47.5 to 63 Hz)	BN 964/00.04
Mains cable, but without plug (211 to 264 V/47.5 to 63 Hz)	BN 964/00.05
NiCads (2 required)	BN 820/00.50
Leather Case with compartment for charger and cable	BN 926/11
V.24 interface cables, 1.5 m	
Flat cable (f-m)	K 363
Flat cable (m-m)	K 364
Flat cable (m-f-m)	K 369

DV-24
Interface Tester

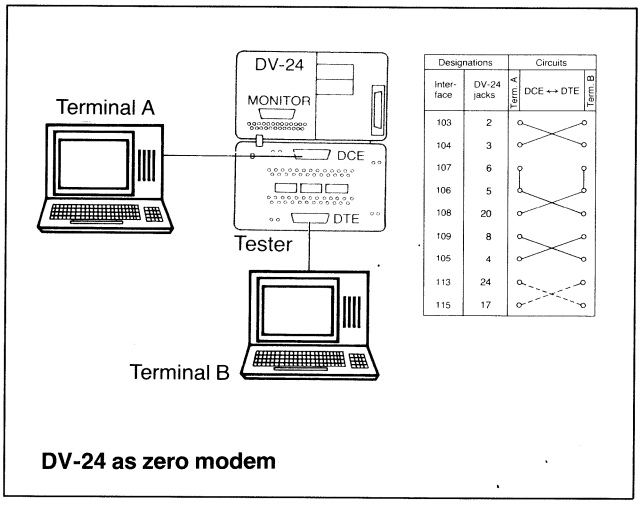
for interfaces conforming with CCITT V.24/V.28 or EIA RS 232



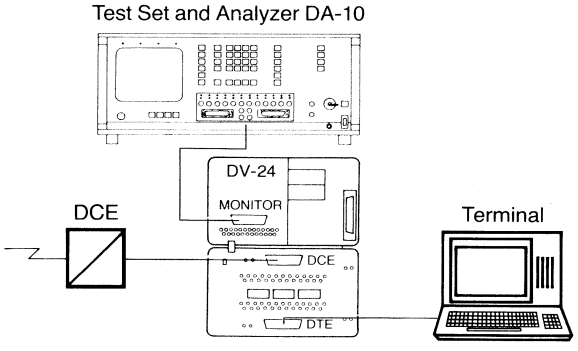
- **LED display for monitoring the 14 most important interface circuits**
- **Breaking-out and crosspatching of interface circuits**
- **Setting of signal states**
- **Pulse memory**
- **Monitor connector for data analyzer**
- **Handy, light and robust**

Applications

The installation and maintenance of data communication equipment provide a particularly good opportunity for the monitoring of a digital interface by the looping-in of an uncomplicated interface tester between the data terminal equipment (DTE) and the data circuit-terminating equipment (DCE). Open it, connect it, switch on and the LEDs on the DV-24 indicate the states of the 14 most important interface circuits. Frequently this is sufficient means of detecting problems in data communications. If the data traffic is to be investigated, a data analyzer can be attached to the connector available for that purpose.
Data traffic between two DTEs (e.g. Terminals) may be tested in a service facility or in a test department via the so-called zero modem. The DV-24 acts as a zero modem because it offers the modem side interface signals for each DTE. Just simple breaking-out and crosspatching of the required interface circuits in the DV-24 substitutes for the pair of modems.
Additional DV-24 applications available to any data comm engineer or technician make it an uncomplicated, inexpensive, and indispensable instrument for testing data circuits.



DV-24 as zero modem



Connection of a Data Analyzer

Characteristics

Miniature switches break-out each circuit (except 101, 102) between modem and terminal connectors. Test jacks arranged at both sides of the switches permit access to each interface circuit at both the DTE and DCE sides. Test leads included with the DV-24 enable crosspatching between the test jacks, so as to permit any combination of interconnection.

Interfaces complying with CCITT V.24/V.28 or EIA RS 232	
LED display for	103, 108, 105, 111, 113, 140, 141 (from terminal)
	104, 107, 106, 109, 114, 115, 142 (from modem)
Weight	approx. 0.4 kg

Further Characteristics and Applications

- Two inputs to a pulse memory, which accepts either positive or negative triggering, permit the monitoring of an interface signal that changes state for a short time. For example, a test lead can connect circuit 109 to the "−" input. When the ON state (FDX mode) is interrupted, the negative transition of the interface signal triggers the pulse memory and causes a green LED to light until it is cancelled.
- Two additional test jacks with associated LEDs implement the monitoring of an interface circuit at a positive signal state (0 or ON) or at a negative signal state (1 or OFF).
- Access to the internal 9 V battery permits the setting of the signal states ON or OFF at an interface circuit. A freely accessible 3.3 kΩ resistor facilitates the termination of the interface circuit.
- The operating current is supplied either by two easily replaced 9 V dry batteries or by two NiCad rechargeable batteries. An external a.c. adaptor/charger can recharge the internal NiCads by feeding current through a plug and jack arrangement. When the two halves of the case are together or when the slide switch is at OFF, the power supply is switched off.
- The DV-24 in combination with other W&G portable analog and digital test sets forms an efficient test setup that fits in the carrying case of the DMS-1 Data Measuring Set.

Specifications of Interface Tester — DV-24

If not otherwise stated, the specified data is valid under the rated ranges of operation of the a.c. line voltage, the a.c. line frequency and the ambient temperature.

Interface circuits
Circuit designations and pin assignments . . . . . according to CCITT Recommendation V.24
Galvanic connection of the interface circuits via miniature switches between TERMINAL and MODEM connectors of the DV-24.
Each circuit broken by miniature switch (except for 101 and 102)

Circuit monitoring
103, 104, 105, 106, 107, 108, 109, 111, 113, 114, 115, 140, 141, 142
State "0"/ON, positive signal . . . . 1 red LED for each circuit

Circuit patching
Broken by switch, crosspatching with test leads plugged into test jacks.

Monitor operation
Input impedance . . . . . ≧30 kΩ
Input voltage limits . . . . . max. ±25 V
for illuminating the LEDs . . . . . > ±2.5 V

Pulse memory
For monitoring short time changes of state
Circuit in OFF state at "+" jack
Ciruit in ON state at "−" jack
Indication cancelled by ON/OFF switch

General Specifications

Power supply
replaceable dry batteries,
2×9 V complying with . . . . . IEC 6 LF 22
or rechargeable NiCad batteries
(on request) . . . . . e.g. 2×VARTA Tr 7/8
Separate a.c. adaptor with charge/trickle-charge mode.

A Colour Brochure is available on request

Tolerable ambient temperature
Rated range of use . . . . . 0 to +50 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions (l×w×h) in mm . . . . . 164×97×60

Weight (with batteries) . . . . . approx. 0.4 kg

Accessories (contained in standard package)
1 interface cable, 25 pins, plug-plug, 150 mm long
10 test leads
2 dry batteries, 9 V

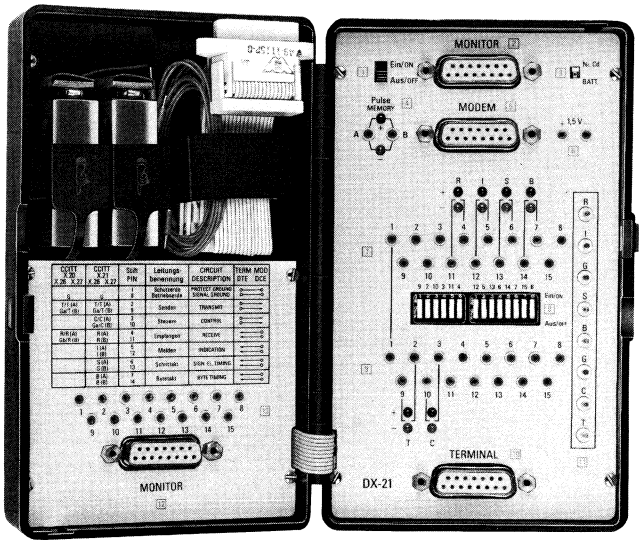
Accessories (at extra cost)
Rechargeable NiCads
A.C. adaptor/charger

Ordering Information

Interface Tester DV-24	**BN 7502/04**
Accessories (at extra cost)	
A.C. adaptor/charger with	
Standard European power plug (193 to 242 V/47.5 to 63 Hz)	BN 964/00.02
U.S. type power plug (105 to 132 V/47.5 to 63 Hz)	BN 964/00.03
U.K. type power plug (211 to 264 V/47.5 to 63 Hz)	BN 964/00.04
Mains cable, but without plug (211 to 264 V/47,5 to 63 Hz)	BN 964/00.05
NiCad rechargeable batteries (two required)	BN 820/00.50
Leather Carrying Case	BN 926/09
Interface cable for V.24 Interface, 1.5 m long	
Ribbon cable socket-plug	K 363
Ribbon cable plug-plug	K 364
Ribbon cable plug-socket-plug	K 369

DX-21
Interface Tester

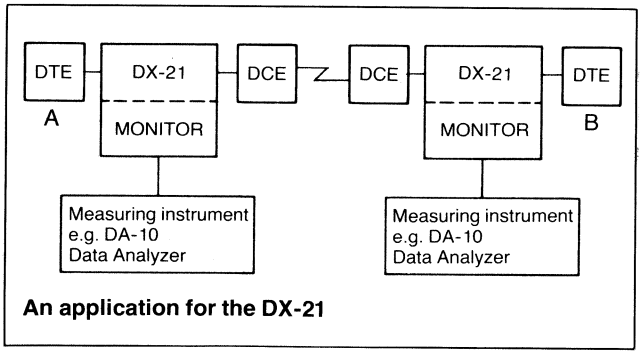
for interfaces complying with CCITT X.20/X.21 or X.26/X.27



- **Tristate LED-display for monitoring interface lines**
- **Capable of patching or interrupting data circuits**
- **Facility for setting the states of interface lines**
- **Pulse transition trap**
- **A data analyser can be connected**
- **Handy, light and robust**

Applications

The new services such as Teletex, are becoming more widespread on public data networks, and so more interest in the CCITT X.21 Recs, has been aroused.
When installation or maintenance work is being carried out on public data networks, the digital interface must be checked. This is done by looping in the DX-21 between the DTE and DCE. All the user has to do is open the DX-21, connect it up and switch on.
The status of the interface lines is then immediately shown on the DX-21's tristate LED-display. Often, it is not necessary to do more than this to find the problem. However, a data analyser can be connected to the DX-21 to monitor data traffic. Like the status of the X.20 und X.21 interfaces, the electrical characteristics as defined in CCITT Recs. X.26 (V.10) and X.27 (V.11) are also of interest. The DX-21 has test pins for the T, R, C, I, S and B interface lines so that coaxial test equipment can be connected.
In other words, the DX-21 is handy, good value for money and essential for finding out what is going on at the digital interface.



An application for the DX-21

Characteristics

Each line (except pin 1) between the modem (DCE) and terminal (DTE) can be interrupted with a DIL switch. Test jacks on both sides of the switch allow the user to access each interface line from the DCE or DTE. Test leads are supplied for patching between the test jacks.

Tristate LED-display shows	T, C (from DTE) R, I, S, B (from DCE)
Weight	approx. 0.4 kg

DX-21
2618

The following applications and features are also worth mentioning:

- The pulse transition trap has two inputs with positive and negative triggering to monitor a particular interface line for momentary state changes. The state change is shown by a red or green LED, which stays on until cancelled.
- Interface lines can be set to the ON or OFF state by means of a floating output, supplied by a 1.5 V internal battery.
- Power is supplied by two easy-to-replace 9 V batteries, or two NiCads. The DX-21 has a jack for connecting an a.c. adaptor/charger.
  The power supply to the DX-21 can be switched off with a slide-switch or when closing its case.
- The DX-21 is one of a powerful combination of handy analog and digital test sets contained in the DMS-1 Data Measuring Set.

Specifications of the Interface Tester — DX-21

If nothing to the contrary is stated, the given data is valid for the rated operating conditions.

Interface circuits . . . . are indicated by CCITT X.24 names

Pin assignment:

CCITT	Pin no.	Circuit designation	Terminal modem DTE DCE
G	1	Protective ground	o——o
G	8	Signal ground	o——o
T	2	Transmit	o——▸
T	9		o——▸
C	3	Control	o——▸
C	10		o——▸
R	4	Receive	◂——o
R	11		◂——o
I	5	Indication	◂——o
I	12		◂——o
S	6	Signal element timing	◂——o
S	13		◂——o
B	7	Byte timing	◂——o
B	14		◂——o

Direct connection of the interface lines between TERMINAL and MODEM connector via miniature switches. The MONITOR connector is in parallel with the MODEM connector. Additional MONITOR connector with 15 test-jacks that can be connected up with the test leads provided.
Lines opened by . . . . . miniature switches (except pin 1)

Line monitoring
T, R, C, I, S, B . . . . . 2 LEDs each
ON/Ø state . . . . . red LED
OFF/1 state . . . . . green LED

Line patching
Lines disconnected with switches, test leads are used for patching the test jacks.

Monitor mode
Input impedance . . . . . approx. 10 kΩ
Input voltage . . . . . max. ±8 V
Voltage to activate LEDs . . . . . approx. ±0.3 V

Pulse transition trap
For monitoring short-duration state changes, (A) line to "A" connector, (B) line to "B" connector.
ON or OFF state is shown by a red or green LED.

A Colour Brochure is available on request

An interruption of the,
ON state is also shown by a . . . . . green LED
OFF state is also shown by a . . . . . red LED
Display is cancelled by the . . . . . ON/OFF switch

General Specifications

Power supply
Integral, replaceable dry batteries . . . . . 2 x 9 V/IEC 6 LF 22
or NiCads (on request) . . . . . e.g. 2 x VARTA Tr 7/8
Dry battery . . . . . 1.5 V/IEC R 6
(for forcing signal states)
Separate a.c. adaptor/charger (on request)

Permissible ambient temperature
Rated range of use . . . . . 0 to +50 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions (w×h×d) in mm . . . . . 164×97×60

Weight . . . . . (with batteries) approx. 0.4 kg

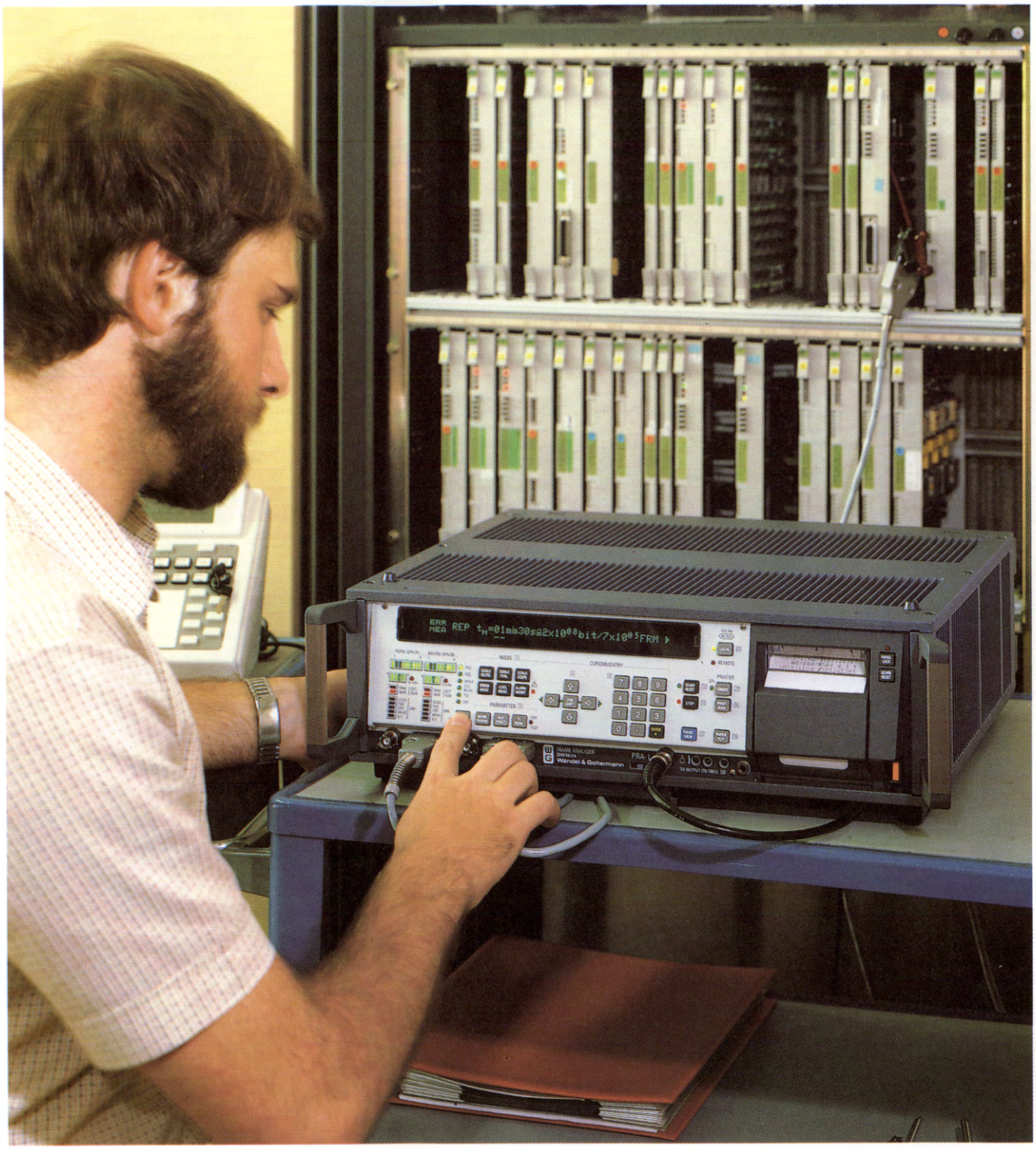
Accessories (supplied with DX-21)
1 interface cable m-m, 15-pin, length 150 mm
5 test leads
2 dry batteries 9 V
1 dry battery 1.5 V

Accessories (at extra cost)
NiCads
A.C. adaptor/charger

Ordering Information

Interface Tester DX-21	**BN 7503/02**
Accessories (at extra cost)	
A.C. adaptor/charger with	
Standard European power plug (193 to 242 V/47.5 to 63 Hz)	BN 964/00.02
US type power plug (105 to 132 V/47.5 to 63 Hz)	BN 964/00.03
UK type power plug (211 to 264 V/47.5 to 63 Hz)	BN 964/00.04
Mains cable, but without plug (211 to 264 V/47.5 to 63 Hz)	BN 964/00.05
NiCads (two required)	BN 820/00.50
Leather case	BN 926/09
Interface cables for X.20/X.21, 1.5 m	
Ribbon cable (m-m)	K 370
Ribbon cable (f-m)	K 371
Ribbon cable (m, f+m)	K 372

Measurement Technology for digital communications and PCM systems



Overview

Measurement Technology for Digital Communications and PCM Systems

Test equipment for PCM systems

★ = new

Applications	Special features	Name	Page
Measurements on analog interfaces	• Acquires all typical PCM analog parameters • Manual measuring setup	**PCM-2 PCM Test Set**	226
Measurement modes A-A, D-A, A-D, D-D	• 30/32 channel (2048 kbit/s) and 24 channel (1544 kbit/s) versions • Graphical display of results on 7" flat screen, electronic scaling and graticule • Digital signal processing for high accuracy and high measuring speed • Microprocessor control for easy, straightforward operation • A and μ-law • Storage of user-programmable measurement modes and setups • <IEC 625>/IEEE 488 Interface Bus	**PCM-4 PCM Channel Measuring Set**	229
LF measurements on PCM systems with the PCM-4	• Through-switching of 30 LF channels (balanced) in the frequency range 0 to 128 kHz • Switching cycles for channel-, idle channel noise- and crosstalk measurements • <IEC 625>/IEEE 488 interface bus	**MU-30 Test Point Scanner**	236 ★
Automatic measurements on codecs and line cards	• Versatile: A-A, A-D, D-A, D-D • Highly accurate due to digital signal processing and automatic system calibration techniques • Modular software and hardware • Matching to all types of codec by changing the personality board	**AMS-964 Automatic Test System**	238 ★
Measurements on PCM multiplexers	• Generates PCM frames with frame alignment information • <IEC 625>/IEEE 488 Interface Bus	**PDG-3/PCG-1 PCM Digital Signal Generator**	243
Measurements on PCM multiplexers	• Measures all the essential parameters on the send side of a PCM multiplexer • <IEC 625>/IEEE 488 Interface Bus	**PDA-3/PCD-1 PCM Digital Signal Analyzer**	245
Measurements on DS-1 and DS-1C digital systems with normal and extended frames	• Interfaces to CCITT Rec. G.703 and AT&T 43801 norm • LED display for frame analysis, for indicating signalling and error modes • Decodes any time slot • Built-in loudspeaker for channel monitoring • Level, noise, frequency, signalling distortion and coder offset can be measured • Standardised DS-1C to DS-1 Demultiplexer	**PCD-2 PCM Channel Decoder**	247
Measurements on codec modules	• Measures all the essential analog codec parameters in a codec module • <IEC 625>/IEEE 488 Interface Bus	**PCA-3 PCM Codec Analyzer**	251

Instruments for error measurements

Applications	Special features	Name	Page
Datacom systems and digitally switched 64 kbit/s channels	• Bit and block error ratio measurements • Clock for error counts over timed intervals • Listings from built-in printer	**DF-64 Error Ratio Measuring Set**	253
Digital communications systems up to the 8 Mbit/s level	• Bit error ratio or error count • Plotter output	**PF-1 Bit Error Measuring Setup**	257
Digital communications systems up to the 8 Mbit/s level	• Code error ratio; error count	**PFT-1 Digital Error Detector**	261
Digital communications systems up to the 8 Mbit/s level	• Bit and code error ratio • Result printout from built-in printer • Clock for error counts over timed intervals	**PF-2 Bit Error Ratio Measuring Set**	263
Digital communications systems up to 34 Mbit/s level	• Counts bit, block and code errors • Measures error ratio and carries out error counts • Has built-in printer • <IEC 625>/IEEE 488 Interface Bus	**PF-3 Bit Error Measuring Set**	272
Digital communications systems up to the 140 Mbit/s level	• Bit, clock and code error measurements • Error ratio or straight error count • Result printout from built-in printer • <IEC 625>/IEEE 488 Interface Bus	**PF-4 Bit Error Measuring Set**	272

Instruments for jitter measurements

Applications	Special features	Name	Page
Jitter investigations on digital communications systems up to the 8 Mbit/s level	• Generation of well-defined jitter on clock and digital signals, complies with CCITT Recs. O.151 and O.171	**PJG-1 Jitter Generator**	266
Jitter measurements on digital communications systems up to the 8 Mbit/s level	• Jitter measurements on clock and pattern signals complying with CCITT Rec. O.171	**PJM-1 Jitter Meter**	269
Jitter investigations on digital communications systems up to the 140 Mbit/s level	• Generation of well-defined jitter on digital signals with the PF-4 Bit Error Measuring Set, complies with CCITT Rec. O.171 • <IEC 625>/IEEE 488 Interface Bus	**PFJ-4 Jitter Modulator**	276
Jitter investigations on digital communications systems up to the 140 Mbit/s level	• Generates clock and pattern jitter; jitter modulation in loop-through mode • Specifications are more exacting than CCITT Rec. O.171 requirements • <IEC 625>/IEEE 488 Interface Bus	**PJG-4 Jitter Generator**	279

Regenerator test equipment

Applications	Special features	Name	Page
Digital communications systems at the 2 Mbit/s level	• Noise immunity measurements on regenerators	**PR-1 Regenerator Measuring Setup**	283
Checking the circuit equipment of digital transmission paths	• Simulates the transmission characteristics of local and area cables	**PKN-1 Cable Simulator**	286

Equipment for frame analysis and measurements on digital exchanges

★ = new

Applications	Special features	Name	Page
Measurements at 2048 kbit/s on primary multiplexers, digital exchanges, DTEs and digital lines	• Complete simultaneous monitoring of two frame signals conforming to CCITT Rec. G.704 § 3.3 • Display and analysis of forward and backward signalling channels with freely selectable triggering criteria • Bit error- and delay measurements at 2048 and 64 kbit/s (option) • Generator (option) and receiver in one instrument • Built-in loudspeaker for channel monitoring and alarm signalling • Pulse diagrams displayed on single channel oscilloscope or printed by built-in printer	**PRA-1 Frame Analyzer**	289 ★
30/32 channel PCM systems	• For investigating digital switching equipment • <IEC 625>/IEEE 488 Interface Bus	**VM-1 Test Set for Digital Exchanges**	293

PCM-2
PCM Test Set

for A-A measurements on PCM coders and decoders



- **Measures the most important PCM parameters described in CCITT Recommendation G.712**
- **Variation of gain with frequency, variation of gain with input level**
- **Idle channel noise as per CCITT Rec. O.41 (P.53)**
- **S/Q measurement (with noise) complies with CCITT Rec. O.131**
- **Relative level can be easily adjusted to all common system levels**
- **Receive section has a true r.m.s. rectification**

Applications

Modern telephone networks all make use of pulse code modulation, a method of transmitting information in digital form. The PCM-2 PCM Test Set has been designed to measure the parameters unique to the PCM technique. Quantizing distortion arises because the analog input signal is approximated by a finite number of amplitude samples and depends on the input level. Total distortion, including quantizing distortion, is easy to measure with the PCM-2. Merely inject narrow-band noise, or a sine signal, at the input of the channel-under-test, adjust the receiver at the channel output and, over the frequency range 815 to 3330 Hz, measure the noise caused by the quantizing distortion.

The variation of gain with input level is another typical PCM parameter which can be measured with noise, or selectively with a sinusoidal signal.
The PCM-2 measures the variation of gain with frequency over the range 300 to 4000 Hz and can also perform selective crosstalk measurements (814 Hz). The generator is blanked to measure idle channel noise; psophometric weighting is used.

Characteristics

The generator of the PCM-2 produces band-limited pseudo-random noise in the range 350 to 550 Hz. The noise has a finite period, and so a discrete line spectrum (5 Hz). For this reason, there are no frequency components less than 5 Hz after rectification. The meter fluctuations that are produced by random signals are eliminated, and the result can be read quickly. Because pseudo-random noise has a well-defined peak factor it is suitable for measurements at the overload limits of the system. The generator produces 14 sinusoidal tones in the range 300 to 3400 Hz. The output level can be adjusted in 2 dB and 0.1 dB steps.

Analog interfaces	600 Ω, balanced, floating
Send-level range	−56.1 to +6.1 dBm0
Receive-level range	(86.1) −56.1 to 6.1 dBm0
Accessory: D.C. Loop Holding Circuit	

A switch is used to set the relative level to the usual system values. There is, therefore, no need to convert absolute levels to relative levels (dBm0). In the receive section, the measured signal passes through the input transformer, along a specially designed filter path, through the relative level switch to a calibrated attenuator with which the sensitivity can be set in 2 dB steps. The calibrated attenuator in the send section is ganged to the calibrated attenuator in the receive section. Various filter paths are available to carry out different measurements. To provide sufficiently high resolution, the meter has a large scale-expansion. If required, the display range can be displaced by ±2 dB with a toggle switch.

Specifications of the PCM Test Set — PCM-2

If nothing to the contrary is stated, the values apply to any operating conditions and instrument settings within the rated ranges of use of a.c. voltage, a.c. frequency and ambient temperature.

Measurement modes and receive frequency ranges

Measurement mode	Measured parameter	Send signal	Send-level range	Receive-level range	Result range	Receive filter
1	Signal-to-total distortion (−10 log S/Q)	Noise or 420 Hz sine wave	−56.1 to +6.1 dBm0	Ganged to send level	−42 to 0 dB	Signal (▲): 350 to 550 Hz Distortion: 815 to 3330 Hz [1] ref. bandwidth: 3.1 kHz
2	Variation of gain with input level	814 Hz sine wave	−56.1 to +6.1 dBm0	Ganged to send level	±4 dB	814 Hz −22/+20 Hz [1]
3	Attenuation/ frequency distortion	Sine wave	−56.1 to +6.1 dBm0	Ganged to send level	±4 dB	300 Hz to 4 kHz
4	Gain	Sine wave	−56.1 to +6.1 dBm0	Ganged to send level	±4 dB	300 Hz to 4 kHz
5	Idle channel noise	OFF	—	−90.1 to −19.9 dBm0p		with psophometric weighting [2]
6	Crosstalk	814 Hz sine wave	fixed level: 0 dBm0	−90.1 to −19.9 dBm0		814 Hz −22/+20 Hz [1]

1) 3 dB limits
2) CCITT Rec. O.41 (P.53)

Send section

Generator output . . balanced, floating, 3 pole CF connector
Output impedance . . . . . 600 Ω
Return loss, 300 to 4000 Hz . . . . . ≧30 dB
Signal balance ratio,
as per CCITT Rec. O.121, 300 to 4000 Hz . . . . . ≧60 dB

Send level

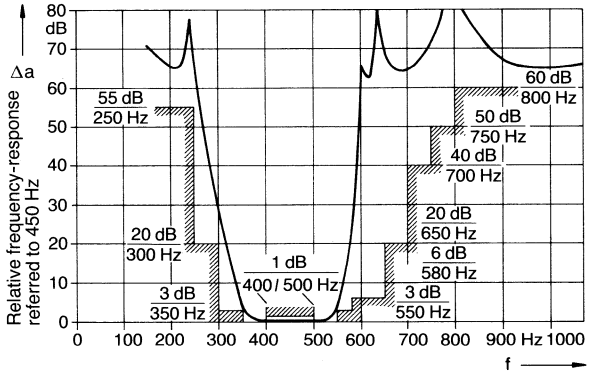
Relative level,
adjustable in 0.5 dB steps . . . . 16.5 to −13/−7.5 to +1 dBr

Level in dBm0
Overall range . . . . . −56.1 to +6.1 dBm0
Setting,
coarse (2 dB steps) . . . . . −56 to +4 dBm0
fine (0.1 dB steps) . . . . . 0.1 to +2.1 dBm0
"Cross talk" mode, fixed level 0 dBm0
"Idle channel noise" mode . . . . . generator off

Send signals

Sinusoidal signals
Selectable fixed frequencies . . . . 300, 420, 500, 814, 840, 1020, 2040, 2400, 2500, 2600, 2800, 2940, 3200, 3400 Hz
Frequency error limits . . . . . ±1.2 %
Frequency error limits at 814 Hz . . . . . ±1 %
Harmonic ratio . . . . . ≧50 dB

Pseudo-random noise
(approximate normal distribution, as per CCITT O.131)
Noise band . . . . . 350 to 550 Hz
Spectral line separation . . . . . approx. 5 Hz
Peak factor (20 log $V_p/V_{r.m.s.}$) . . . . . 10.5 dB ±0.5 dB



Relative frequency-response of the send filter in the PCM-2, normalised frequency 450 Hz; (CCITT tolerance mask)

Error limits

Error limits of the send level for sinusoidal or noise signals over the whole level range . . . . . ±0.35 dB

The send-level error comprises the following error components:
Max. level difference of the sinusoidal signals . . . . ±0.1 dB
Send-level error limits at 0 dBm0 and 0 dBr . . . . . ±0.2 dB
Attenuator error limits referred to −10 dBm
for a fixed relative level setting . . . . . ±0.1 dB

Receive section

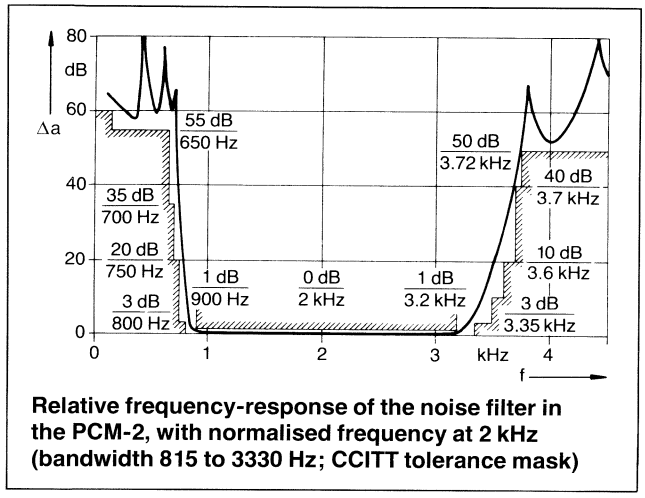
Receiver input . . . . . see "Generator output"

Level display
Power-level calibration (dBm0)

Relative level
adjustable in 0.5 dB steps . . . . −9.5 to +1, 3.5, 4, 6.5, 7 dBr

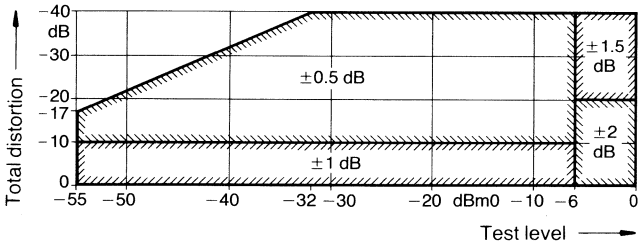
Level in dBm0
Level range
for signal measurements . . . . . −56.1 to +6.1 dBm0
for noise and crosstalk
measurements . . . . . −86.1 to −23.9 dBm0
additional attenuator for S/Q measurement . . . . −40 to 0 dB

Meter
Display range . . . . . −2 to +2 dB
Display range offset, switchable . . . . . −2, 0, +2 dB
Fine calibration setting for
relative level measurements . . . . . ±2 dB



Relative frequency-response of the noise filter in the PCM-2, with normalised frequency at 2 kHz (bandwidth 815 to 3330 Hz; CCITT tolerance mask)

Error limits
Error limits of the displayed signal-to-total distortion ratio (noise) for reference setting



The displayed results have been adjusted to give values for a 3100 Hz channel

Error limits for the "Variation of gain with input level" operation mode, referred to −10 dBm0, and at a fixed relative level . . . . . ±0.1 dB

Error limits of the level displayed in the "Overall gain" mode, sinusoidal signal or noise at 0 dBm0 . . . . . ±0.25 dB
Over the whole receive-level range . . . . . ±0.35 dB

Max. error in the "Idle channel noise" mode over the level range −80 to −24 dBm0p . . . . . ±1 dB

Max. error in the "Crosstalk" mode over the level range −80 to −24 dBm0 . . . . . ±0.8 dB

Connectors for recording apparatus
Output for 0 dB display
A.C. output . . . . . 0 dBm into 600 Ω
D.C. output . . . . . +5 V
Output impedance . . . . . 5 kΩ

Accessories

D.C. Loop Holding Circuit GH-1, BN 984/00.12
Two holding circuits are accommodated in one casing. There are no d.c. components in the circuits' output signals. The circuits maintain the d.c. loop at the analog send and receive sides of multiplex equipment.
Max. d.c. current . . . . . 100 mA
Voltage drop at 60 mA . . . . . approx. 12.5 V

General Specifications

Power supply
Rated ranges of use of a.c. line voltage,
selectable . . . . . 110, 117, 127, 220, 237 V, −12 to +10 %
Rated range of use of a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 15 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Permissible ambient temperature
Rated range of use . . . . . +5 to +40 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41494)	
Width with handles	477	Width	443
Height overall	155	Height (3 units)	131
Depth with handles	425	Depth	370

19" conversion kit . . . . . BN 700/00.03

Weight . . . . . approx. 11 kg

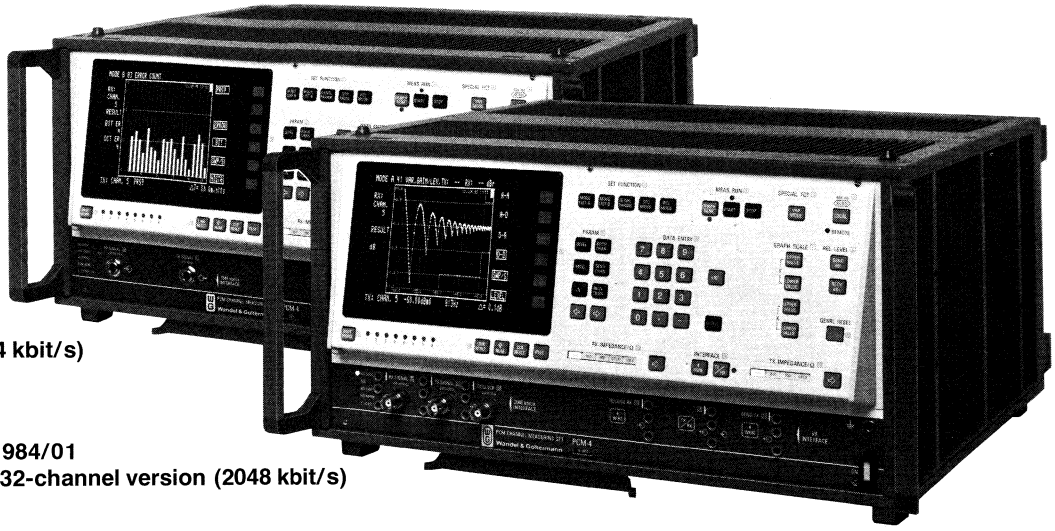
Ordering Information

PCM Test Set PCM-2	**BN 913/01**
Accessories (at extra cost)	
D.C. Loop Holding Circuit GH-1 no d.c. components at output	BN 984/00.12
Front and Back Panel Covers SD-3 (1 set)	BN 700/00.23

PCM-4
PCM Channel Measuring Set

for measurements on PCM coders/decoders between analog and digital interfaces

IEEE 488
IEC 625



BN 984/02
24-channel version (1544 kbit/s)

BN 984/01
30/32-channel version (2048 kbit/s)

- **Compact instrument for A-A, A-D, D-A and D-D measurements to CCITT Rec. O.133, G.700 Series and North American standards (BN 984/02)**
- **Both versions with 64 kbit/s interface (option) complying with CCITT Rec. G.703**
- **30/32-channel version (BN 984/01) with CRC-4 extended frame to CCITT G.704**
- **24-channel version (BN 984/02) with normal/extended (CRC-6) PCM frame structure to CCITT Rec. G.704 and North American standards**
- **Graphical result display with tolerance mask**
- **Numerical result display with out-of-tolerance indication**
- **A-law and μ-law (included in both versions)**
- **Digital signal processing for high accuracy and high measuring speed**

Applications

The use of digital systems for transmission and switching is continuing to expand rapidly. As a result, PCM multiplexers between the digital and analog levels (half channel measurements) must now satisfy new requirements which place considerable demands on conventional measuring technology.
The PCM-4 PCM Channel Measuring Set can handle practically all PCM multiplexer measurements, and also measurements on the constituent subassemblies of digital exchanges. Transmultiplexer measurements are also possible because investigations between digital interfaces can be made. Single modules (e.g. CODECs) may also be checked as it is possible to carry out all measurements via 64 kbit/s interfaces.
All PCM-4 functions are remote controllable via the <IEC 625>/IEEE 488 interface. The user is therefore free to combine the PCM-4 with other instruments to create the measuring system of his choice.

Characteristics

The compact PCM-4 has a complete range of functions for measurements between analog and digital interfaces. Besides the μP control and the interfaces, the PCM-4 has four main subassemblies for carrying out a variety of measurements. These subassemblies are: a digital signal generator, a digital signal receiver, an analog generator and an analog receiver. The PCM-4, which exploits digital signal processing and microprocessor control to the full, is so accurate that it can operate near the theoretical limits of the PCM technique. Great pains have been taken to ensure extremely high measuring speeds.
The integral screen has two advantages: firstly user-friendly operation and numerical display, secondly graphic output display. It only requires a few keystrokes to output graphs showing gain vs frequency, gain vs input level, or total distortion. To adapt to a wide range of test items the PCM-4 has special keys for selecting the X and Y ranges. Other measurements such as idle channel noise, crosstalk or bit error count can be shown as histograms. The telephone channels are shown along the X-axis.

Digital interfaces complying with CCITT Rec. G.703	2048 kbit/s (BN 984/01)
and AT&T standards	1544 kbit/s (BN 984/02)
Analog interfaces	600 Ω, ~~800~~ Ω, 900 Ω and complex impedance
Options	
64 kbit/s digital interfaces	codirectional, serial or parallel
Return Loss and Longitudinal Conversion	
Transfer Loss Bridge complies with CCITT Rec. O.121	
Accessories: D.C. Loop Holding Circuit, Test Point Scanner	

Further characteristics and applications

Operating the PCM-4

The PCM-4 itself gives information in the form of a menu and provides prompts to help the operator. The most important measurement modes are shown in MODE LIST A. It only requires a few key strokes to display results on the screen. Less common measurements are shown in MODE LIST B. Softkeys along the edge of the screen make it easy to switch rapidly between test setups and to quickly select other important parameters.
The PCM-4 user can also define his own measurement setups. If the latter are frequently used, up to 40 such can be stored in non-volatile memory.

Multi-processor system

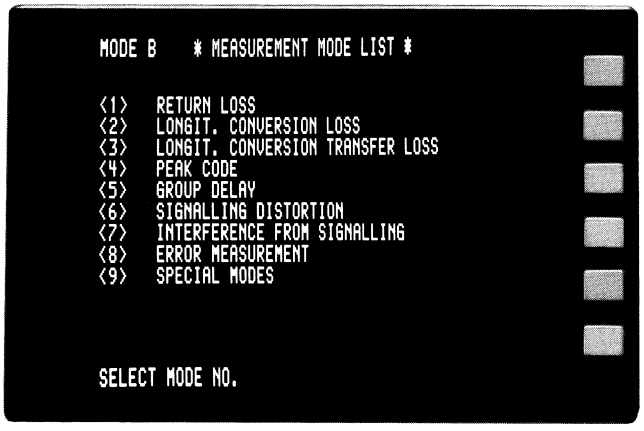
Only because the PCM-4 is controlled by a number of microprocessors is it possible to combine digital signal processing, an enormous range of measurements, and ease of operation in one instrument. There are three microprocessors, one handles the screen, one is responsible for the general control functions of the PCM-4 and remote control via the <IEC 625>/IEEE 488 interface. The last processor evaluates the results.
The multiprocessor system means that measuring speed can be optimised; for example, new setting commands can be sent over the remote-control interface at the same time as the results are being processed.

Special measurements

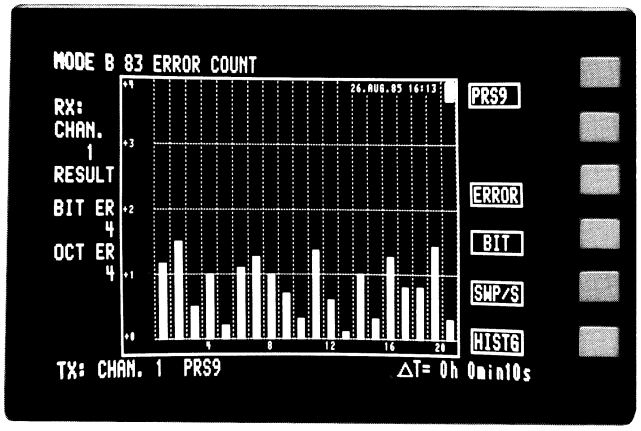
Another special feature of the PCM-4 is the facility for signalling investigation; the usual telephone channel measurements and out-of-band measurements up to 128 kHz can, of course, also be made.
Moreover, it is also possible to check the bit error ratio of a 64 kbit/s channel or the group delay of a "half-channel".
Measurements on two-wire test items are particularly straightforward and easy. While measurements are being carried out on the analog side of the test item, 2 Mbit/s (BN 984/01)/ 1.5 Mbit/s (BN 984/02) or 64 kbit/s loops can be set up on the digital side. The information and signalling bits in any receive channel can be transferred to any other send channel of the 2 Mbit/s/1.5 Mbit/s loop.

System controller

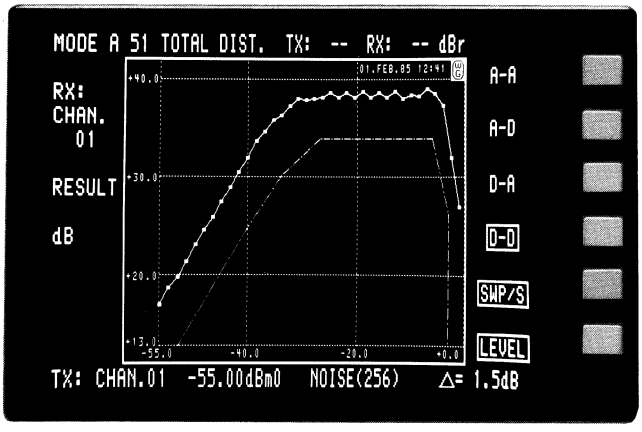
If the measurements required for a PCM multiplexer are to be carried out at an economical rate, a test point scanner must be used in conjunction with the PCM channel test set.
The MU-30 Test Point Scanner has been designed for use with the PCM-4. Remote control of the MU-30 is via the <IEC 625>/ IEEE 488 interface bus from the PCM-4.
Simply pressing a button on the PCM-4 is sufficient to print the screen contents as hardcopy using a graphics plotter (hp-GL) connected via the <IEC 625>/IEEE 488 interface.



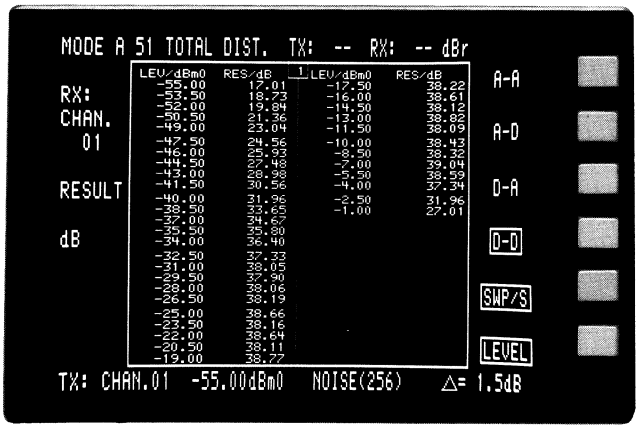
Overview of measurement modes called up via the "MODE LIST B" key



Histogram of an error count in telephone channel 1



Total distortion measurement with noise, selected with "MODE LIST A", "5" and "1" keys



Numerical result display after pressing "GRAPH/NUM" key

Measurement mode	Measurement conditions	A-A	A-D	D-A	D-D
Level measurement	With sinusoidal signal 20 Hz to 4 kHz (72 kHz). With noise signal to CCITT Rec. O.131 and North American standards	● ●	● ●	● ●	● ●
Overall loss Echo return loss Singing return loss Transhybrid loss	With sinusoidal signal at 813 or 1014 Hz [1] and a level of −10 or 0 dBm0 With noise signal ERL and a level of −10 dBm0, to North American standards With noise signal SRL or SRL HI and a level of −10 dBm0, to North American standards 2-wire termination with 910 Ω ‖ 39 nF [2]	● ● ● ●	● ● ● 	● ● ● 	● ● ● ●
Variation of gain with frequency	With sinusoidal signal 20 Hz to 4 kHz and a level of −10 or 0 dBm0. Ref. frequency 813 or 1014 Hz [1] (other reference frequencies available using VAR. MODE)	●	●	●	●
Variation of gain with input level	With sinusoidal signal at 813 or 1014 Hz [1]. With noise signal to CCITT Rec. O.131 and North American standards	●	●	●	●
Total distortion	With noise signal at 350 Hz ... 550 Hz or sinusoidal signal at 422 Hz, to CCITT Rec. O.131 and North American standards. With sinusoidal signal at 813 or 1014 Hz [1], psoph. or C-message weighted to CCITT Rec. O.132 and North American standards. With sinusoidal signal at 300 Hz ... 3350 Hz	●	●	●	●
Idle channel noise	At 300 Hz ... 3350 Hz or weighting with psoph. or C-message filter. Activating tone at 2 kHz possible	●	●	●	●
Crosstalk diff. channel Crosstalk same channel	With sinusoidal signal at 301, 813, 1014 [1] or 3343 Hz. With "Conventional Telephone Signal" to CCITT Rec. G.227 and North American standards, (BN 984/01 psoph. wtd/BN 984/02 C-message weighted). With sinusoidal signal at 301, 813, 1014 [1] or 3343 Hz	● ●	● (●)	● (●)	● ●
Out-of-band measurement	With sinusoidal signal in the range 4.6 ... 72 kHz; receive range 0.2 ... 4 kHz With sinusoidal signal in the range 0.2 ... 4 kHz; receive range 4.6 ... 128 kHz	● ●	● 	 ●	
Harmonic distortion 4-tone intermodulation	2nd or 3rd order harmonic ratio with sinusoidal signal at 1014 Hz [1] 2nd or 3rd order distortion with four equal-level tones at 857 Hz, 862 Hz, 1373 Hz and 1388 Hz	● ●	● ●	● ●	● ●
Return loss (option)	Using BN 984/00.10 bridge: reference impedances 600, 900 Ω and complex [3] Using BN 984/00.11 bridge: reference impedances 600/850 Ω and complex [3]	Audio frequency ports			
Longitudinal conversion loss (option)	Measured to CCITT Rec. O.121 Using BN 984/00.10 bridge: reference impedances 600, 900 Ω Using BN 984/00.11 bridge: reference impedances 600, 850 Ω	Audio frequency ports			
Longitudinal conversion transfer loss (option)	Measured to CCITT Rec. O.121 Using BN 984/00.10 bridge: reference impedances 600, 900 Ω Using BN 984/00.11 bridge: reference impedances 600, 850 Ω	●	●	●	
Overload capacity Peak load Coder offset	With pos. or neg. peak code, at 813 Hz or 1014 Hz [1]		● ● ●		● ●
Absolute group delay Group delay distortion	Loop measurements: AM-Signal with 8 fixed measuring frequencies similar to the signal described in CCITT Rec. O.81 and IEEE Standards	● ●	● ●	● ●	● ●
Signalling distortion	Measures the duty cycle deviation of a rectangular signal of 10 or 20 Hz. Duty cycle settable in steps between 10 and 90 %	●	●	●	●
Interference from signalling	Weighted measurement (to CCITT Rec. O.41 and North American standards) in voice channel. Duty cycle of rectangular signal adjustable	●	●	●	●
Error measurements	Framing errors (FAS and MFAS), CRC errors. Error ratio, error count and error free seconds with pseudorandom sequences or user programable 8 bit word in one channel at 64 kbit/s or via 64 kbit/s interface				●
RX frame evaluation	Evaluation on screen of words and bits		●		●
MUX/DEMUX operation	One channel multiplexer: with 64 kbit/s input (option) only One channel demultiplexer: with 64 kbit/s output (option) only				● ●

1) BN 984/02: 1004 Hz
2) Complex impedance can be modified at factory
3) 220 Ω in series with 820 Ω ‖ 115 nF, can be modified at factory

Note: Measurements on digital Transmit (TX) or Receive (RX) interfaces can be carried out using the 2048 kbit/s (BN 984/01), 1544 kbit/s (BN 984/02) or 64 kbit/s interface (option). The following TX/RX combinations are possible: 2 M/2 Mbit/s; 64 k/64 kbit/s; 64 k/2 Mbit/s; 2 M/64 kbit/s; 1.5 M/1.5 Mbit/s; 64 k/64 kbit/s; 64 k/1.5 Mbit/s; 1.5 M/64 kbit/s.

If nothing to the contrary is stated, the values given below are valid for all operating conditions and device settings within the rated ranges of use for a.c. line voltage, a.c. line frequency and ambient temperature.

Analog generator

Generator output

BN 984/01 . . . . . balanced, floating, 3-pin CF connector
BN 984/02 . . . . . balanced, fem. connector compatible with WECO 310
Output impedance, switch-selectable . . . . . 600, 850, 900 Ω and complex[1]
Permissible d.c. voltage to earth . . . . . ≦60 V

Send signals

Sinusoidal signals
Frequency range . . . . . 20 Hz to 72 kHz

Pseudorandom noise signals

Noise band	CCITT Recommendation	Spectral line spacing	Peak factor 20 log $V_P/V_{r.m.s.}$
350 to 550 Hz	O.131	3.906 Hz	10.5 ±0.5 dB
350 to 550 Hz	O.131	7.813 Hz	10.5 ±0.5 dB
Conventional telephone signal	G.227	7.813 Hz	10.5 ±0.5 dB
560 to 1965 Hz (Echo Return Loss)	North American standards	7.813 Hz	10.5 ±0.5 dB
260 to 500 Hz (Singing Return Loss)	North American standards	7.813 Hz	10.5 ±0.5 dB
2200 to 3400 Hz (Singing Return Loss High)	North American standards	7.813 Hz	10.5 ±0.5 dB

Group-delay measuring signal
Similar to the measuring signal described in CCITT Rec. O.81 and IEEE Standards.

Measuring frequencies . . . . . 292, 500, 604, 1000, 1792, 2604, 2792 and 3396 Hz
Modulation frequency selectable . . . . . 41.66 or 83.33 Hz

4-tone signal
Four equal level tones at . . . . . 857, 862, 1373, and 1388 Hz

Send levels

Display of power levels (dBm0), can be switched over to voltage levels (dB0).

Relative level
Level entry in steps of 0.01 dB from . . . . −19.9 to +9.9 dBr
Displayed on screen in steps of 0.1 dB.

Levels relative to 1 mW at a point of 0 rel. level
Level entry in steps of 0.01 dB.
Level range in the preferred range for relative level −17 to +3 dBr, at 600 Ω
for noise(350 to 550 Hz), at least . . . . . −60 to 2.0 dBm0
for sine signals (f ≧ 200 Hz), at least . . −60.0 to +10.0 dBm0
for all other signals, at least . . . . . −30.0 to +2.0 dBm0

Analog receiver

Receiver input . . . . . see "analog generator output"
Additional input impedance . . . . . ≧30 kΩ

Two-wire input and output
The two-wire connector can be terminated with a complex impedance[2] for transhybrid loss measurements.

Receive levels

Calibration, see "analog generator"

Relative levels, see "analog generator"

Levels relative to 1 mW at a point of 0 rel. level
Level range in the preferred range of the relative level −9.9 to +9.9 dBr and at 600 Ω,
signal level measurements, at least . . −60.0 to +10.0 dBm0
noise and crosstalk measurements, at least . . . . . −80 to +10 dBm0

Receive filters

Wideband filters passband range:	Narrow-band filters passband at:
200 Hz to 4 kHz	301 Hz
20 Hz to 4 kHz	813 Hz
300 Hz to 3350 Hz	1014 Hz[3]
20 Hz to 72 kHz	3343 Hz
4.6 kHz to 128 kHz	350 to 550 Hz

Filters for weighted noise measurements

Psophometer filter (CCITT Rec. P.53/O.41)
C-message weighting filter to North American standards
3 kHz flat filter to North American standards
Psophometer filter with 2 kHz notch-filter
C-message weighting filter with 2 kHz notch-filter
Bandpass 300 to 3350 Hz, with 2 kHz notch-filter

Filters for S/N measurements

Signal filter	Noise filter	Rec.
350 to 550 Hz	800 to 3350 Hz	CCITT O.131
800 to 855 Hz	Channel filter with notch at 813 Hz	—
	Psophometer filter with notch at 813 Hz	CCITT O.132
1000 to 1025 Hz	Channel filter with notch at 1014 Hz[3]	—
	Psophometer filter with notch at 1014 Hz[3]	—
	C-message weighting filter with notch at 1014 Hz[3]	CCITT O.132

Filters for harm./interm. distortion measurements

		Passband range:
2nd order harmonic distortion		2000 Hz to 2028 Hz
3rd order harmonic distortion		3000 Hz to 3042 Hz
2nd order intermodulation product	B-A	480 Hz to 560 Hz
	B+A	2229 Hz to 2251 Hz
3rd order intermodulation product	2B-A	1885 Hz to 1920 Hz
$A = \frac{857\text{ Hz} + 862\text{ Hz}}{2}$ $B = \frac{1373\text{ Hz} + 1388\text{ Hz}}{2}$		

1) Complex impedance: 220 Ω in series with 820 Ω ‖ 115 nF
2) Complex impedance: 910 Ω ‖ 39 nF
3) BN 984/02: 1004 Hz

Digital signal generator

PCM frame structure
BN 984/01

32 channel PCM frames containing:
30 telephone channels . . . . to CCITT Rec. G.704 Para. 3.3
or 31 telephone channels . . . . . time slots 1 to 31
or 32 telephone channels . . . . . all time slots

BN 984/02
Selectable between . . . . . T1 "norm." 12 FRM/MFRM to CCITT G.704 Para. 3.1 and T1 "extd." 24 FRM/MFRM to CCITT G.704 Para. 3.1
Telephone channels per frame 24
Channel sequences . . . . . D3/D4, D2 or D1D

Signalling
μ-law . . . . . CCIS or CAS (7⁵/₆)
A-law . . . . . CCIS

Generator outputs
BN 984/01
Interface characteristics comply with CCITT Rec. G.703.
Line codes . . . . . NRZ, AMI and HDB3
Coaxial output* . . . . . Versacon® 9 Universal Connector System, adaptable to all common connectors
Output impedance . . . . . 75 Ω
Balanced output . . . . . 3 pole, CF connector
Output impedance . . . . . 120 Ω

BN 984/02
Interface characteristics comply with CCITT Rec. G.703 and North American standards.
Line codes . . . . . NRZ, AMI and B8ZS
Output pulse characteristic . . . . . to AT&T Technical Advisory No. 34
W-bit insertion . . . . . ON or OFF
Balanced output . . fem. connector compatible with WECO 310
Output impedance . . . . . 100 Ω

Operation and clock supply

Loop-through operation
A test pattern is injected into one time slot of a PCM frame which has been looped through the PCM-4.

BN 984/01

Generator operation
from internal clock . . . . . 2048 kHz $\pm 25 \times 10^{-6}$
or external clock . . . . . 2048 kHz $\pm 100 \times 10^{-6}$
or external 8 kHz sync.-signal . . . . . 8 kHz $\pm 100 \times 10^{-6}$
or clock derived from receiver signal

Digital loops
2 Mbit/s loop: all time slots are switched through.
2 Mbit/s loop: selected time slots can be switched through (independent selection of the receive and send channel is possible)
64 kbit/s loop: at relevant interfaces (Option).

BN 984/02

Generator operation
from internal clock . . . . . 1544 kHz $\pm 25 \times 10^{-6}$
or external clock . . . . . 1544 kHz $\pm 100 \times 10^{-6}$
or external 8 kHz sync. signal . . . . . 8 kHz $\pm 100 \times 10^{-6}$
or clock derived from receiver signal

Digital loops
1.5 Mbit/s loop: all time slots are switched through.
1.5 Mbit/s loop: selected time slots can be switched through (independent selection of the receive and send channel is possible).
64 kbit/s loop: at relevant interfaces (Option).

Digital words for telephone channels
BN 984/01
Injection of a digital signal in one of the telephone channels 1 to 30 (or 31, 32) or in all telephone channels, or in all telephone channels except the selected channel.
Encoding law, selectable . . . . . A-law or μ-law

BN 984/02
Injection of a digital signal in one of the telephone channels 1 to 24, or in all telephone channels, or in all telephone channels except the selected channel.
Encoding law, selectable . . . . . A-law or μ-law

Send signals

Sine signals
Frequency range . . . . . 20 Hz to 3.99 kHz
Send level range (in steps of 0.1 dB) . . −60.0 to +7.5 dBm0

Noise signals
Pseudorandom noise signal
350 Hz to 550 Hz complies with . . . . . CCITT Rec. O.131
Send level range (0.1 dB steps) . . . . −65.0 to +7.5 dBm0
Wideband noise signal for telephone channels
Noise band . . . . . 300 to 3400 Hz
Send level range . . . . . −65.0 to 0.0 dBm0
Conventional telephone signal . . . . . complies with CCITT Rec. G.227
Send level range . . . . . −30.0 to 0.0 dBm0
Echo return loss and singing return loss signals to North American standards
Noise band of ERL-signal . . . . . 560 to 1965 Hz
Noise band of SRL-signal . . . . . 260 to 500 Hz
Noise band of SRLH-signal . . . . . 2200 to 3400 Hz
Send level range . . . . . −30.0 to 0.0 dBm0

Group delay measuring signal
See: "Analog generator signals"
Send level range . . . . . −30.0 to 0.0 dBm0

4-tone signal
See: "Analog generator signals"
Send level range . . . . . −30.0 to 0.0 dBm0

Idle channel signals
Any fixed word can be selected. It is also possible to select words which vary randomly or periodically between two neighbouring values.

Bit patterns
The following are available for bit error measurements:
Pseudorandom sequence complying with CCITT Rec. V.52 . . . . . 2^9-1 bits long
Pseudorandom sequence complying with CCITT Rec. O.152 . . . . . $2^{11}-1$ bits long
User-programmable 8 bit word

External analog signal (via VAR. MODE)
An external analog signal can be input via an internal PCM coder and injected in one telephone channel or output via 64 kbit/s interface.

Test facilities and error insertion
BN 984/01
AIS transmission (continuous sequence of "1" s)
Frame alignment bit error ratio . . . . . 10^{-3} or 10^{-4}
Frame alignment word errors . . . . . 2 or 3 in 4
Multiframe alignment errors . . . . . 1 or 2 in 2
CRC-4 error rate settable in steps of . . . . . 0.1 %
in the range . . . . . 0.1 to 100 %
based on 1 s (1000 CRC-4 words)

BN 984/02
ALL ONES transmission
Bit 2 alarm transmission
Bit 2 is set to "0" in each channel
S bit alarm (T1 "norm") transmission
S-bit in frame 12 is set to "1"
m bit alarm (T1 "extd") transmission
Eight "0"-bits alternating with eight "1"-bits
FAS errors . . . . . 1 in 6 bits or 2 in 4 bits
S-bit/MFAS errors . . . . . 1 or 2 in 6 bits
CRC-6 error rate settable in steps of . . . . . 0.3 %
in the range . . . . . 0.3 to 100 %
based on 999 ms (333 multiframes)

Signalling facilities
BN 984/01
Static signalling bits
Transmission of signalling bits a b c d in time slot 16 for selected and unoccupied telephone channels
Signalling bit value settable via menu

Dynamic signalling bits
Signalling bit value for selected telephone channel set externally via aux. parallel input

BN 984/02
Static signalling bits
Transmission of signalling bits A, B/A, B, C, D for selected and unoccupied telephone channels
Signalling bit value settable via menu

Dynamic signalling bits
Signalling bit value for selected telephone channel set externally via aux. parallel input for CAS (7⅝) only, or S/m bit value set externally via contradirectional 4 kbit/s input.

Digital signal receiver

PCM frame structure
see "digital signal generator"

Digital signal inputs
BN 984/01
Interface characteristics comply with CCITT Rec. G.703.
Line codes . . . . . NRZ, AMI and HDB3
Coaxial input* . . . . . 75 Ω or >3 kΩ
Balanced input . . . . . 120 Ω or >3 kΩ
Input signal monitoring via LEDs:
NO SIGNAL, AIS, NO FRAME, NO MULTIFRAME.

BN 984/02
Interface characteristics comply with CCITT Rec. G.703 and North American standards.
Line codes . . . . . NRZ, AMI and B8ZS
Balanced input . . fem. connector compatible with WECO 310
Input impedance . . . . . 100 Ω or >3 kΩ
Input signal monitoring via LEDs:
NO SIGNAL, ALL ONES, NO SYNC, REMOTE ALARM.

Evaluation of digital words in telephone channels
BN 984/01
Selecting a telephone channel
A code word from one telephone channel 1 to 30 (or 31, 32) can be evaluated.

Code word measurements
Signalling bits . . . . . a, b, c, d
Encoding law, selectable . . . . . A-law or μ-law
Receive level range, at least . . . . . −80 to +6 dBm0

BN 984/02
Selecting a telephone channel
A code word from one telephone channel 1 to 24 can be evaluated.

Code word measurements
Signalling bits . . . . . A, B/A, B, C, D
Encoding law, selectable . . . . . A-law or μ-law
Receive level range, at least . . . . . −80 to +6 dBm0

Receive filters
see "Analog receiver"

Bit error measurements
on telephone channels (64 kbit/s). Shown as a histogram with the X axis representing measuring periods or channels.
Bit patterns: see "digital signal generator send signals"
Error counts on FAS/MFAS and CRC-signals.

Signalling distortion measurements
Method:
Measure the duty cycle deviation of a rectangular signal.

Generator
Frequency setting . . . . . 10 Hz or 20 Hz
Duty cycle settable in steps
Analog output (back panel)
Output impedance, mark . . . . . <30 Ω
space . . . . . >20 kΩ
Max. d.c. loading . . . . . 200 mA
Max. switching voltage . . . . . 70 V

Signalling receiver
Measuring range . . . . . ±10 ms
Resolution . . . . . 0.1 ms
Analog input (back panel)
Input impedance (connected internally to −15 V) . . . . 750 Ω
Short-circuit current . . . . . 20 mA

Evaluation and monitoring of words and bits
BN 984/01
Monitoring via 8 LEDs (bits 1 to 8)
Codewords of selected channel, FAS, NOT FAS, MFAS, NOT MFAS, Signalling bits a b c d (TX and RX)

Evaluation on screen (MODE B 91)
Codewords of selected channel, FAS, NOT FAS, MFAS, NOT MFAS, Signalling bits a b c d (RX)

BN 984/02
Monitoring via 8 LEDs (bits 1 to 8)
Codewords of selected channel, FAS or MFAS, S bits, Signalling bits A, B/A, B, C, D (TX and RX), m bits (1 ... 6 and 7 ... 12)

Evaluation on screen (MODE B 91)
Codewords of selected channel, FAS or MFAS, S bits or m bits, Signalling bits A, B/A, B, C, D

Auxiliary outputs (back panel)
Activation signal for crosstalk measurements
Analog decoder output for decoded signal of selected telephone channel
Signalling output
Error and alarm outputs

Options

Codirectional 64 kbit/s input, BN 984/00.01
Codirectional 64 kbit/s output, BN 984/00.02
Electrical characteristics comply with CCITT Rec. G.703.

Serial, 64 kbit/s TTL input, BN 984/00.05
Serial, 64 kbit/s TTL output, BN 984/00.06
Depending on operating mode, co- or contradirectional.

Parallel, 64 kbit/s TTL input, BN 984/00.07
Parallel, 64 kbit/s TTL output, BN 984/00.08
Parallel, 8 bit input/output with 8 kHz timing signal.

Return Loss and Longitudinal Conversion Transfer Loss Bridge
Reference impedances (BN 984/00.10) . . . . . 600, 900 Ω [1]
(BN 984/00.11) . . . . . 600, 850 Ω [1]

<IEC 625> Interface Card, BN 958/21
Remote control of all device functions and interrogation of measured values. Connected to the IEC bus with adaptor S 832.

Accessories

Test Point Scanner MU-30, BN 823/11
Balanced connection of 30 (BN 984/01) or 24 (BN 984/02) low-frequency channels in the send and receive direction
Frequency range . . . . . 0 to 128 kHz
Can be remote controlled by the PCM-4 PCM Channel Measuring Set.

D.C. Loop Holding Circuit GH-1, BN 984/00.12
Two d.c. loop holding circuits in one casing.

PCMZ-4, BN 984/00.13
Plug-in unit to remove the d.c. signal component at the audio input and output of the PCM-4 (not for BN 984/02 and not necessary if GH-1 [BN 984/00.12] is used)

1) For return loss measurements: additional complex impedance 220 Ω in series with 820 Ω ‖ 115 nF; can be modified at factory.

General Specifications

Power supply
Rated ranges of use for a.c. line voltage, switch-selectable . . . . . 110/117/127/220/227/237 V, in each case −12 % to +10 %
Rated range of use of a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 150 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature
Rated range of use . . . . . +5 to +40 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions
Bench-top instrument (w × h × d in mm) . . . 477 × 244 × 425

Weight . . . . . approx. 25 kg

Ordering Information

PCM Channel Measuring Set PCM-4	
2048 kbit/s version, menu in English	**BN 984/01**
1544 kbit/s version, menu in English	**BN 984/02**
2048 kbit/s version, menu in German	**BN 984/03**
Options (charged extra)	
Codirectional 64 kbit/s input [1]	BN 984/00.01
Codirectional 64 kbit/s output [2]	BN 984/00.02
Serial 64 kbit/s TTL input [1]	BN 984/00.05
Serial 64 kbit/s TTL output [2]	BN 984/00.06
Parallel 64 kbit/s TTL input [1]	BN 984/00.07
Parallel 64 kbit/s TTL output [2]	BN 984/00.08
Return Loss and Longitudinal Conversion Transfer Loss Bridge 600/900 Ω [3]	BN 984/00.10
600/850 Ω [3]	BN 984/00.11
Software retrofitted to the latest relevant status	BN 984/00.41
<IEC 625> Interface Card with IEEE 488 connector	BN 958/21
Accessories (charged extra)	
Test Point Scanner MU-30 with <IEC 625> Interface Card	BN 823/11
D.C. Loop Holding Circuit GH-1 with capacitor-coupled output	BN 984/00.12
D.C. Decoupling for PCM-4, PCMZ-4 (not for BN 984/02)	BN 984/00.13
IEEE 488/<IEC 625> Adaptor (m-m) for <IEC 625> interface card	S 832
Front and Back Panel Covers SD-5, (1 set)	BN 700/00.25

* Equipped with the Versacon® 9 75 Ω basic connector and BNC adaptor. For other adaptor types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.
1) Only one input can be used at any one time.
2) Only one output can be used at any one time.
3) Only one bridge can be fitted at any one time.

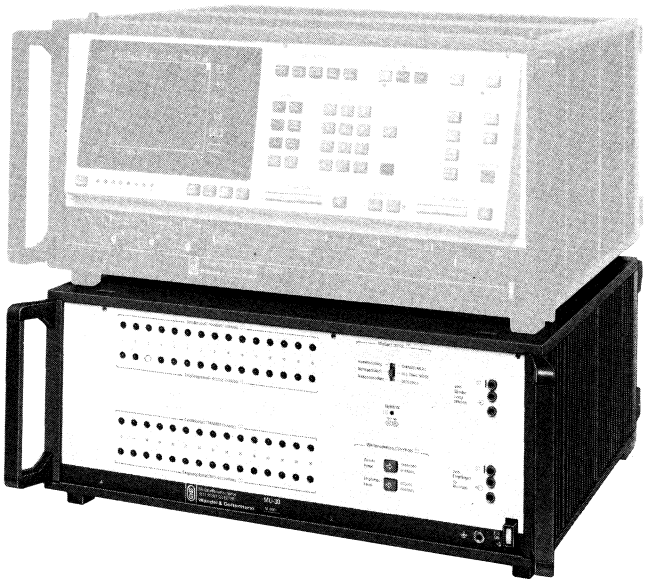
A Specification Sheet with more details and a Colour Brochure are available on request

new

MU-30
Test Point Scanner

for send- and receive-side switching of 30 telephone channels

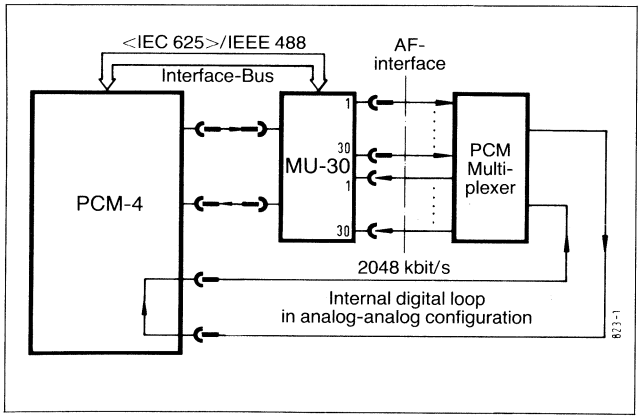
IEEE 488
IEC 625



- **Balanced switching of up to 30 telephone channels, frequency range 0 to 128 kHz**
- **Switching cycle for idle-channel noise and crosstalk measurements and other in-channel measurements**
- **Send- and receive-side switch status indication**
- **<IEC 625> Interface Board with IEEE 488 connector fitted as standard to the MU-30**

Applications

If the measurements required for a 30 channel PCM Multiplexer are to be carried out at an economical rate, a test point scanner must be used in conjunction with the PCM channel test set.



The MU-30 Test Point Scanner has been designed for use with the PCM-4 PCM Channel Measuring Set. It is used to connect sequentially the analog-side send output and the receiver input of the PCM-4 to the 30 AF inputs and outputs of the PCM multiplexer, depending on measuring mode. In analog-analog configuration, a digital loop can be set up with the PCM-4, in which the 2048 kbit/s signal, connected internally from the digital signal receiver input to the digital signal send output, is looped back to the PCM multiplexer.

Characteristics

Remote control of the MU-30 is via the <IEC 625> Interface Bus from the PCM-4 or an external controller. Because of the multiprocessor concept of the PCM-4, the commands for making the next measurement settings can be sent via the remote control interface at the same time as measurements are being processed, thus optimising the rate at which measurements can be made.
For crosstalk measurements, an activating signal from the PCM-4 is fed into an input on the back of the MU-30, which couples this signal into all the idle channels. This auxiliary signal produces a defined coder switch setting, leading to measurements which are independent of the position of the coder zero point.

Termination impedance of switched-out channel	600 Ω
or, using plug-in termination resistance cards (options)	850, 900 Ω
Max. relay switching time	13 ms

Apart from the above, the following features are worthy of note:

- The AF channel terminating resistances are arranged on interchangeable plug-in boards in the AF switching units, so that by exchanging a complete plug-in unit on the back of the MU-30, the terminating resistance can be easily changed. Apart from the standard Z_o of 600 Ω, Z_o = 850 Ω or 900 Ω can be fitted as options.

Specifications of the Test Point Scanner — MU-30

Unless otherwise stated, the data below is valid for the rated range of use.

Switching cycles

Manual operation (RX = Receiving channel, TX = Transmitting channel)

In-channel measurements	RX cycle, TX = RX
Idle-channel noise measurements	RX cycle
Crosstalk measurements	RX cycle, TX fixed

Remote-controlled operation using PCM-4 as controller

In-channel measurements	RX cycle, TX = RX
Idle-channel noise measurements	RX cycle
Crosstalk measurements	RX cycle, TX fixed
	RX cycle, TX = RX + N*)
	RX cycle, TX = RX

*) where N = 0 to 31

If a computer is used for remote-control of the MU-30, the switching cycles can be any desired combination.
LED indication of switch status for RX and TX.

AF Test Point Scanner

Loading

Max. input level	+20 dB
Max. d.c. voltage from system under test	60 V
Max. r.m.s. current through termination resistor	20 mA

Relay specifications (contact ratings)

Max. d.c. current	100 mA
Max. switching time, including bounce	13 ms
No-load contact life	10^8 operations

Insertion loss
switched send- or receive-channel

Frequency range	0 to 20 kHz	20 to 128 kHz
Z_o = 600 Ω	≦0.01 dB	≦0.02 dB
600 < Z_o ≦ 900 Ω	≦0.02 dB	≦0.03 dB

Termination resistance

switched-out channel	600 Ω

Other values, 850 or 900 Ω, obtainable by exchanging plug-in card assembly on back panel

AF inputs and outputs

Balanced input 1 "from generator" (front panel);
Two 36-way female connectors, each with 15 balanced outputs "to system under test" (back panel);
Balanced output 1 "to receiver" (front panel);
Two 36-way female connectors, each with 15 balanced inputs "from system under test" (back panel).

Auxiliary inputs and outputs (back panel)

Balanced inputs 2 and 3;
The following input combinations can be set from the PCM-4: 1, 2, 3, 1 + 2;
Balanced outputs 2 and 3;
The following outputs can be selected from the PCM-4: 1, 2, 3

Activation signal input	coaxial, 600 Ω

A plug-in card assembly with auxiliary inputs and outputs can be fitted instead of the termination resistor card, and is used for connection to an external measuring system

General Specifications

Power supply

A.C. line voltage, switchable	110/117/127/220/227/237 V
A.C. line frequency range	47.5 to 63 Hz
Power consumption	approx. 40 VA
Safety class, to VDE 0411 and IEC 348	Class I

Ambient temperature

Rated range of use	+5 to +40°C
Storage and transport	−40 to +70°C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	199	Height (4 units)	175
Depth with handles	425	Depth	370

19" conversion kit	BN 700/00.04
Weight	approx. 12 kg

Accessories (supplied with set)
4 off 36-way male connectors S 108

If PCM-4 and MU-30 are ordered at the same time:
<IEC 625> interface connecting cable with IEEE connector at each end, 1.2 metres long, K 420
2 off balanced connecting cables, 1 metre long, K 12

Ordering Information

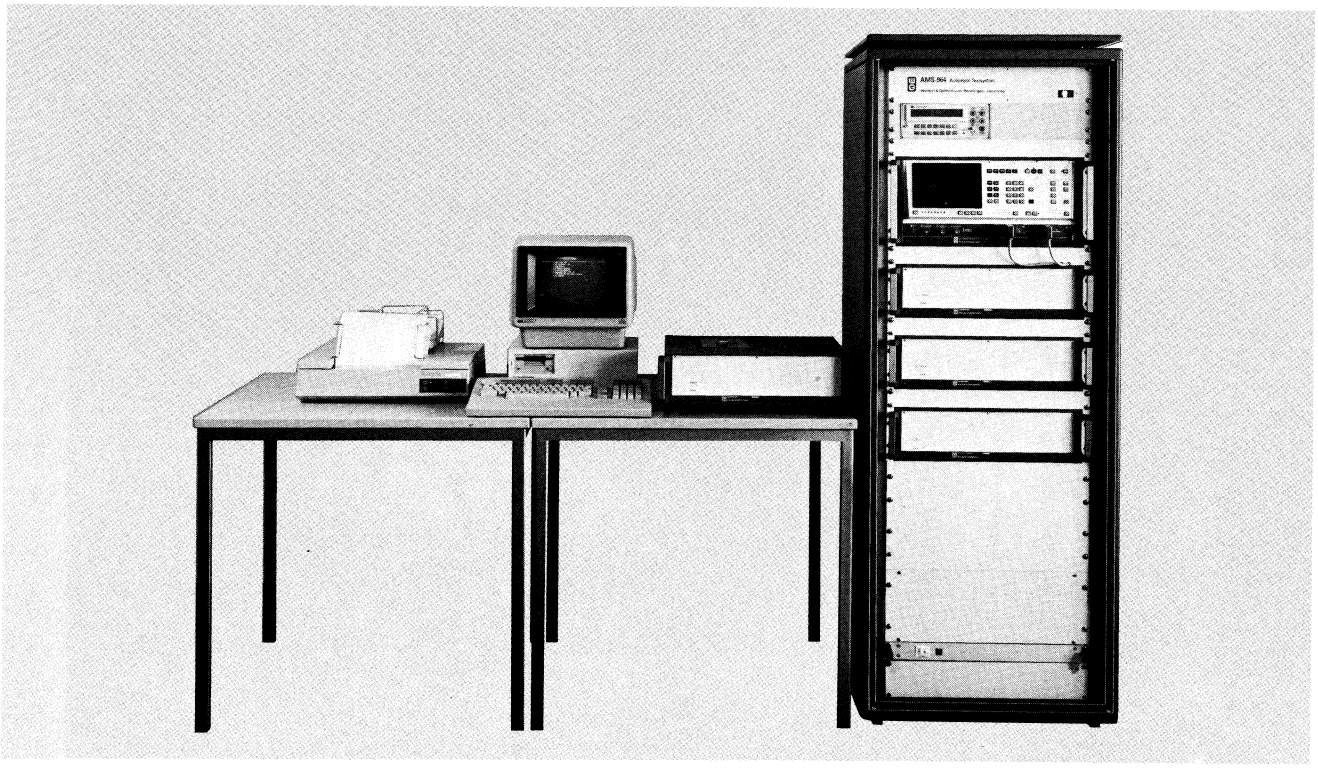
MU-30 Test Point Scanner including <IEC 625> Interface Board with IEEE 488 connector	**BN 823/11**
Accessories (at extra cost)	
Termination resistor cards for receive channels	
with Z_o = 850 Ω (2 required)	BN 824/00.02
with Z_o = 900 Ω (2 required)	BN 824/00.04
Termination resistor cards for send channels	
with Z_o = 850 Ω (2 required)	BN 824/00.06
with Z_o = 900 Ω (2 required)	BN 824/00.07
Connector card (4 required)	BN 824/00.01
Protective covers for transportation SD 4	BN 700/00.24

new

Available shortly

AMS-964
Automatic Test System

for testing codec modules and line cards



- **User-programmable frame structure and bit rates up to approx. 5 MHz**
- **Fully automatic operation; remote-controlled selection of test object also possible**
- **Quickly adapts to different test objects**
- **Versatile test facilities to CCITT Rec. O.133 in A-A, A-D, D-A and D-D ranges**
- **A- and μ-law**

Applications

The codec module, designed to encode speech signals and decode PCM signals, has assumed an important role in the continuing digitization of speech communications networks.
As the production of codecs increases, both in quality and quantity, it becomes necessary to check each item individually by measuring the more important parameters (such as total distortion, attenuation/frequency distortion and variation of gain with input level, etc.) to ensure effective quality control. Due to the large number of measurements which need to be made, an automatic test system such as the AMS-964 is the only way to ensure that all the different types of codec can be tested as quickly as possible and with a high degree of accuracy.

Apart from the many different types of codec and cofidec (codec plus filter), it is also necessary to test complete line cards (consisting of a subscriber connection module, transmit and receive filters, coder, decoder and signalling converter) using a test system. In order to do this, the test system must include equipment which is adaptable to the different requirements, and the software must, of course, be test item oriented. These requirements are met by the AMS-964 with the aid of "personality boards" and a modular system of hardware and software.

Characteristics

The wide range of highly accurate, rapid measurements available from the AMS-964 is provided by the PCM-4 PCM Channel Measuring Set which is an integral part of the system.

Analog interfaces . . . . . 2- or 4-wire
single- or multichannel
programmable holding currents
analog signal path calibration
Modular construction ensures flexibility for matching to both analog and digital interfaces.

All the test instruments in the system are remote-controlled by the powerful software package which runs on the system control computer. Matching of the system software to the test item is performed during a once-only initialisation routine, after which the AMS-964 can carry out complete ranges of tests without further attention. Modules can be exchanged manually or automatically by means of a test item selector which is controlled by the AMS-964. A fully automated test system which is capable of assessing the modules on a pass/fail basis can thus be formed.

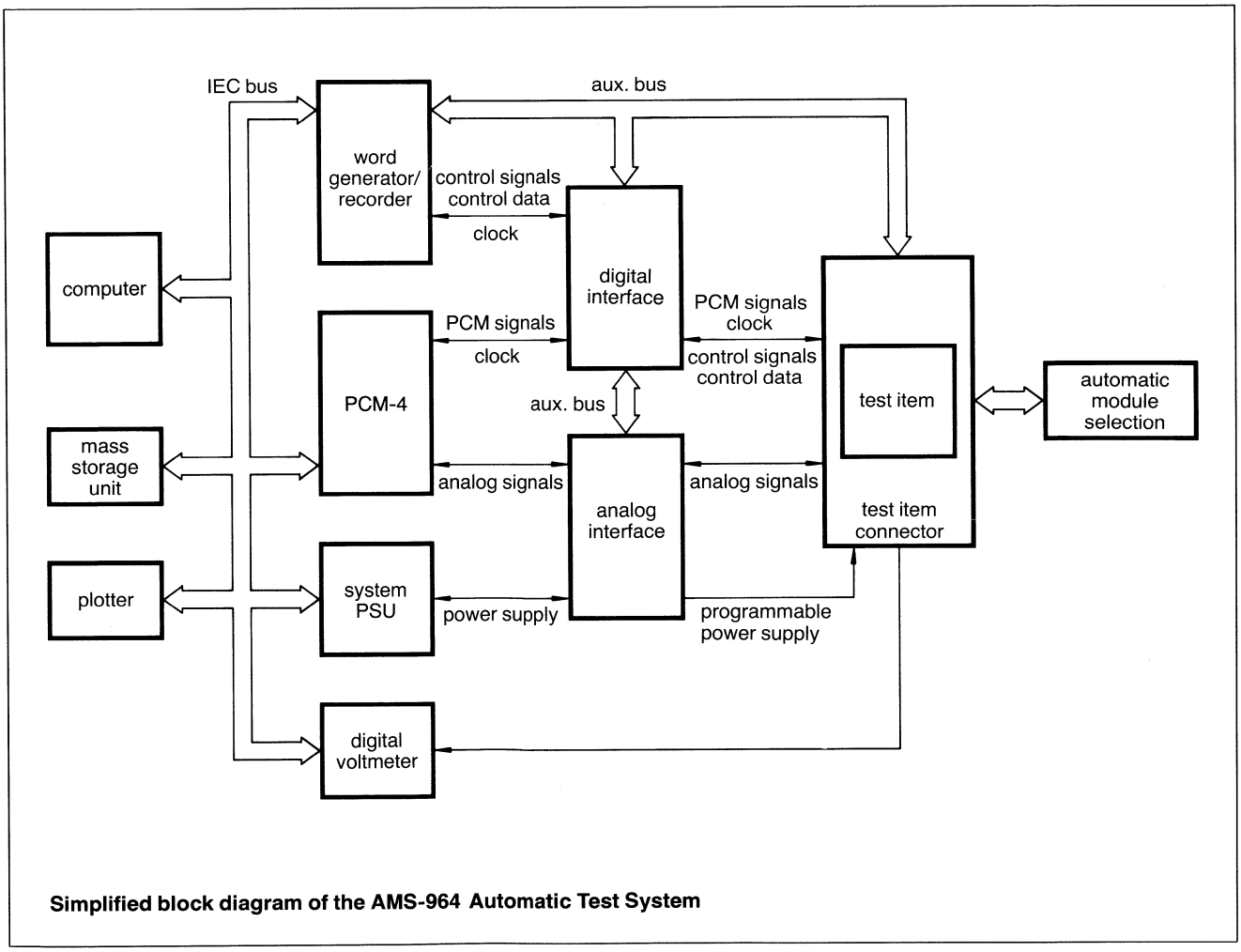
Conversion of the AMS-964 for testing different types of test items is accomplished very rapidly, simply by reloading the software and exchanging the "personality board". This latter is a plug-in unit, which, together with the test item connector unit, serves to match the hardware requirements of the various items to be tested, such as impedance matching, level matching, line code conversion and frame control etc.

The digital signal generator provides up to 23 completely independently programmable bit patterns, thus ensuring that the most varied control signals can be reproduced. Programmable delay lines permit synchronous shifting of PCM-, clock-, and control signals relative to one another within the digital interface unit.

Matching to the 2- or 4-wire analog interface is just as flexible as the digital interface matching with the AMS-964. Plug-in modules for the analog interface unit are available which provide the following: voltage generation, d.c. holding loop cir-

Summary of the most important test modes of the AMS-964

Test mode	A-A	A-D	D-A	D-D
Level measurement	●	●	●	●
Overall loss	●	●	●	●
Echo- and singing return loss	●	●	●	●
Transhybrid loss				●
Variation of gain with frequency	●	●	●	●
Variation of gain with input level	●	●	●	●
Total distortion	●	●	●	●
Idle channel noise	●	●	●	●
Crosstalk	●	●	●	●
Out-of-band measurements	●	●	●	●
Harmonic distortion	●	●	●	●
Intermodulation distortion	●	●	●	●
Return loss	●			
Signal balance ratio	●	●	●	
Overload capacity		●		
Peak load		●		●
Coder offset		●		●
Absolute group delay	●	●	●	●
Group delay distortion	●	●	●	●
Signalling distortion	●	●	●	●
Supply voltage rejection	●	●		
Power consumption (d.c.)				



Simplified block diagram of the AMS-964 Automatic Test System

cuits, return loss- and signal balance ratio measurement bridges. Switch field plug-ins are available for the connection of multichannel line cards.
The easy-to-understand dialog program gives a list of available measurements from which a selection can be made. Test parameter definition and the setting of tolerances is carried out via a menu procedure on the VDU of the control computer. The test results can be displayed in graphical or tabular form on the VDU, or printed out using a graphics plotter. The results can also be stored on floppy disk for further statistical evaluation if required.

Specifications of the Automatic Test System (provisional) — AMS-964

Test equipment rack

PCM-4 PCM Channel Measuring Set

Analog signal generator
refer to "Analog signal generator" data in PCM-4 specification sheet or PCM-4 entry in W & G catalog for details.

Analog signal receiver
refer to "Analog signal receiver" data in PCM-4 specification sheet or PCM-4 entry in W & G catalog for details.

Digital signal generator
Digital signals are transmitted only via the 8 bit parallel 64 kbit/s output of the PCM-4. For further details, refer to "Digital signal generator" data in PCM-4 specification sheet or PCM-4 entry in W & G catalog.

Digital signal receiver
Digital signals are received only via the 8 bit parallel 64 kbit/s input of the PCM-4. For further details, refer to "Digital signal receiver" data in PCM-4 specification sheet or PCM-4 entry in W & G catalog.

Digital word generator/recorder

Slots provided for up to . . . . . 16 modules
comprising . . . . . 1 IEEE/aux. bus converter
1 power supply module
1 active module
1 aux. bus termination module
and up to 12 word generator modules

IEEE/aux. bus converter
and aux. bus termination modules
for remote control of the word generator modules.

Active module
for handling all incoming and outgoing word generator circuits (max. 40).

Word generator module
2 channels per module
Each channel can be programmed as either a generator or as a recorder
Storage capacity per channel, standard . . . . . 16 kbit
optional . . . . . 64 kbit
corresponding to the max. length of a generated or received bit pattern
Max. bit pattern frequency . . . . . approx. 8 MHz
(also independent of the PCM signals)

Relative time shift between two isochronous bit patterns . . . . . max. 5 ns
Propagation delay . . . . . max. 5 ns
Remote control section
Built-in microprocessor clock frequency . . . . . 11.0592 MHz
Data transfer between microprocessor and control computer . . . . . approx. 16 kbit/s

Important operating modes
The following are valid for all operating modes:
If the PCM clock signal is used, all incoming and outgoing bit patterns are synchronous.
Timing delays between bit patterns (also PCM) take place in the digital interface unit.

Control signals to/from test item
Initialisation and reprogramming of test item
Recording of particular sequences from the test item
Real-time comparison of received bit pattern with reference pattern, error counting
(other control signals and data also possible).

Digital interface unit

Slots provided for up to . . . . . 16 modules
comprising . . . . . 1 aux. bus module
1 power supply module
1 active module
1 aux. bus termination module
1 PCM generator/receiver module
1 interface module
1 clock generator module
and up to 9 delay modules

Aux. bus and aux. bus termination modules
for remote control of:
PCM generator/receiver module, delay modules, clock generator module, interface module.

Active module
for handling all incoming and outgoing delay module connections.

PCM generator/receiver module
Interface between 64 kbit/s parallel (8 bit) input/output of the PCM-4 and the serial input/output of the test item.

Interface module
Interface for all digital signals between the test system and the test item
Max. distance from test item . . . . . 2 metres

Clock generator module
8 kHz reference clock generated by PCM-4,
error limits . . . . . $\pm 25 \times 10^{-6}$
or by clock generator module,
error limits . . . . . $\pm 50 \times 10^{-6}$
or externally
with permissible error limits . . . . . $\pm 100 \times 10^{-4}$
Master clock generated by clock generator
module (PLL) . . . . . approx. 25 MHz
Bit rate . . . . . max. 5 MHz
Standard values . . . . . 1544, 2048 and 2560 kHz
other frequencies programmable in multiples of 8 kHz

Delay module
Digital delay-line circuits
Can be used for all digital signals within the system with the exception of the master clock signal.
3 programmable delay lines per module
Max. time-shift per line . . . . . ±620 ns
programmable in steps of . . . . . approx. 40 ns

Analog interface unit
Slots providing for up to . . . . . 16 modules
comprising . . . . . 1 aux. bus module
1 power supply module
plus the following modules, each of which requires two slots:
up to 2 programmable power supply modules
up to 2 d.c. holding loop modules
up to 2 return loss and signal balance ratio modules
up to 6 switch field modules
and 1 analog adaptor module

Aux. bus module
For remote control of all modules fitted in mainframe.

Programmable power supply module
Used to supply test item selector unit, test item and d.c. holding loop modules. Switch-on delay time programmable for each output voltage. Any PCM-4 output signal can be superimposed on the output voltage.
4 programmable voltage regulators per module
Voltage regulator range dependent on power supply to regulator
Standard range . . . . . −12.8 to +12.7 V
in steps of . . . . . 100 mV
or (on request):
Range . . . . . max. 100 V
Positive voltage . . . . . max. +85 V
Negative voltage . . . . . max. −85 V
in steps of . . . . . 100, 200 or 300 mV
Max. no. of steps 256
Set-point accuracy of output voltage, referred to maximum range and 300 mV steps . . . . . ±0.3 %
Output current (short-circuit protected) . . . . . max. 300 mA

DC. holding loop module
for 2-wire connection of the test item
Programmable operating modes . . . . . current source
or current sink
or 2-wire termination
Frequency range . . . . . 90 Hz to 10 kHz
Programmable holding loop current,
standard . . . . . 10, 20, 40 and 60 mA
max. . . . . 250 mA
Permissible d.c. voltage between a and b wires . . . . . 100 V
Standard impedances . . . . . 600, 900 Ω
600 Ω in series with 2.16 µF
900 Ω in series with 2.16 µF
or external impedance

Analog signal path calibration
Insertion loss . . . . . max. 0.02 dB
Signal balance ratio at 10 kHz . . . . . ≧70 dB
Quick charge/discharge unit for decoupling capacitors
charge/discharge time . . . . . approx. 100 ms

Return loss and signal balance ratio module
Programmable as two-pole signal balance ratio measuring bridge or return loss measuring bridge
Frequency range . . . . . 90 Hz to 10 kHz
Required generator level, standard . . . . . 0 dBm
on request . . . . . +10, −20 dBm
Standard reference impedances . . . . . 600, 732 Ω
600 Ω in series with 2.16 µF
900 Ω in series with 2.16 µF
or external impedance
other values on request
Calibration with reference impedance possible.
Compensation for cable- and connector losses.

Switch field module
Standard configurations . . . . . 4×4 or 1×16
For connection of a test item with more than 2 analog channels
Insertion loss . . . . . ≦0.02 dB

Analog adaptor module
For use in calibrations with connection of a test item with a single analog channel only.

Analog adaptor module
For use in calibrations with connection of a test item with a single analog channel only.

Digital voltmeter
Preferred type . . . . . HP 3478 A
For measuring the power consumption of the test item.

Test item connection

Mainframe
Bench-top unit for manual changeover of test items; remote controlled test item selection unit can also be connected.
Size (w×h×d) in mm . . . . . 477×155×434
Max. distance from equipment rack . . . . . 2 metres

Digital section board
Programmable digital interface between the system and the "personality board" for resynchronisation of digital signals
No. of connections to and from test item . . . . . max. 40

Analog section board
Programmable analog interface between the system and the "personality board"
Inputs/outputs to test item . . . . . 2- or 4-wire
with switch field module . . . . . max. 16 channels

"Personality board"
Programmable plug-in board with test item connector for matching system hardware to the test item.

Control unit
The instruments listed below are, at present, used as standard equipment. Other compatible instruments having the same technical specifications can also be used.

Control computer

Preferred type . . . . . HP 9816 S
Technical data
Clock frequency . . . . . 8 MHz
Main memory capacity . . . . . in this case 1 Mbyte
Interfaces . . . . . RS 232 and HP IB
VDU screen size . . . . . 9" (229 mm)
Graphics resolution . . . . . 400×300 pixels
Keyboard . . . . . US ASCII
Real-time clock

Mass storage unit

Preferred type . . . . . HP 9133 D with floppy disk drive
Technical data
Winchester disk drive capacity . . . . . 14.8 Mbyte
Average access time . . . . . 85 ms
Disk size . . . . . 5¼ inch
Floppy disk drive capacity . . . . . 630 to 788 kbyte
Disk size . . . . . 3¼ inch
double sided format

Graphics plotter

Preferred type . . . . . HP 2673 A
Technical data
Plotting speed . . . . . 120 characters/s
Character size . . . . . 7×10 points
Graphics . . . . . 90 points/inch

Software

Programming language . . . . . BASIC
Format . . . . . modular
All test item-, test sequence- and test mode parameters
set via . . . . . menu technique
Test result output
of . . . . . individual tests or test sequences
via . . . . . VDU or printer
storage on floppy disk on request
as . . . . . graphics
or . . . . . tables
of all results and test point parameters, or out-of-spec. results only with test point parameters, or pass/fail decision only.

Ordering information

Due to its flexibility and modular construction, the AMS-964 Automatic Test System can be configured to meet individual requirements. Hardware and software matching is normally carried out at the factory.

PDG-3/PCG-1
PCM Digital Signal Generator

for adjusting the receive-side parameters of PCM-30/PCM-24 multiplexers

IEEE 488
IEC 625



- **PCM code-word sequence which simulates sinusoidal or noise send signals**
- **Code-words encoded to CCITT Rec. G.711; A- or μ-law**
- **"Digital milliwatt" (0 dBm, 1 kHz)**
- **PCM frames to CCITT Rec. G.732 or G.733, and ATT 43801**
- **Any time slot can be selected**

Applications

The independent send- and receive-side alignment of PCM multiplexers became necessary after the introduction of digital switching.
To check the receive-side of PCM multiplex equipment, i.e. the decoder, set the code-word sequence to a particular "level" and "frequency", and apply the signal to the digital interface. Using a level meter, check that the correct level and frequency are received at the analog side. This will show if D/A conversion has been carried out correctly.

Characteristics

Complete PCM frames with frame alignment signal, alarm word and multiframe alignment signal (CCITT Rec. G.732), or PCM frames with frame and multiframe alignment signal plus A and B signalling bits (CCITT Rec. G.733) are produced by the Digital Signal Generators.

Digital code-word sequeces can also be sent in a selected time slot. Filler words are inserted in the remaining time slots to simulate telephone channels that are not carrying traffic. A level meter at the PCM multiplexer output is used to measure the level produced by the digital code-words. The PDG-3 provides both A- and μ-law encoding.
The overall loss of the decoder can be set using an A-law (μ-law) digital signal, which is referred to as the "digital milliwatt". This digital signal is converted to give an analog signal with a level of 0 dBm0 and a frequency of 1 kHz.
The Simulated Noise option provides a code-word sequence that simulates pseudo-random narrow-band noise, which, for example, can be used to measure total decoder distortion. To check idle-channel noise, it is possible to simulate the random-toggling of an undriven decoder about its zero point.

Bitrates	2048 or 1544 kbit/s
Simulated sinusoidal signals	
Frequency range	10 Hz to 3990 Hz
Level range	−60.5 to +7.6 dBm0
"Digital milliwatt"	1 kHz / 0 dBm0
Simulated noise signal	
Frequency range	350 to 550 Hz
Level range	−68.1 to 0 dBm0

Digital output-signal
The bit rates and frame structure of the PDG-3 comply with CCITT Rec. G.732. The bit rates and frame structure of the PCG-1 comply with CCITT Rec. G.733 and ATT 43801.

Bit rate

Internal timing signal (clock) generator
Bit rate, PDG-3 . . . . . 2048 kbit/s ±50 bit/s
PCG-1 . . . . . 1544 kbit/s ±35 bit/s

External-clock input
Clock frequency (nominal value) . . . . . 2048 or 1544 kHz
Input impedance . . . . . 75 Ω

Digital-signal and clock outputs
Interfaces to CCITT Rec. G.703. PCG-1 with w-bit injection

Coaxial output*
Line codes, PDG-3 . . . NRZ, RZ, AMI (½), AMI (1/1), HDB-3
PCG-1 . . . . . AMI (½)
Output impedance . . . . . 75 Ω
Pulse shape . . . . . approx. rectangular
Pulse height, 75 Ω termination
PDG-3 . . . . . 2.37 V ±10 %
PCG-1 . . . . . 2.5 V ±10 %

Balanced output
Line codes, PDG-3 . . . . . AMI (½), AMI (1/1), HDB-3
PCG-1 . . . . . AMI (½)
Output impedances (nominal values)
PDG-3 . . . . . 120/130 Ω
PCG-1 . . . . . 100 Ω
Pulse shape, PDG-3 . . . . . approx. rectangular
PCG-1 . . . . . compatible with DSX-1
Height of pulse generated by the PDG-3
when terminated with 120 or 130 Ω . . . . . 3 V ±10 %

The digital words in time slots 0 and 16, and the unoccupied channels generated by the PDG-3
Stored in ROM. If required, **one** word may be set with an array of 8 slide-switches.

PCG-1 alarm and frame test
AIS signal output (All "1" sequence)
Bit-2 alarm (bit 2 in all telephone channels is set to 0)
Frame errors (1 or 2 errored bits in 6 frame bits)
Multiframe errors (1 errored bit in 6 multiframe bits)

Inserting PCM words in time slots 1 to 30
PCM words can be inserted in any of one of the time slots 1 to 30 (24).

Simulated sinusoidal signals
Send frequency, adjustable in 10 Hz steps
over the range . . . . . 10 to 3990 Hz
Send level, adjustable in steps up to 0.1 dB wide
over range . . . . . −60.5 to +7.6 dBm0

Options

Simulated Noise Signal, BN 895/00.02
Extra memory for generating a pseudo-random signal.

64 kbit/s Interface (input), BN 859/00.03
Serial interface for inserting a 64 kbit/s signal in a selected "telephone channel" time slot (or in time slot 16 [1]).
Electrical characteristics to CCITT Rec. G.703 for 64 kbit/s contradirectional interfaces.

64 kbit/s Interface (output), BN 859/00.04
Serial interface for extracting a 64 kbit/s send signal from a selected "telephone channel" time slot.
The necessary 64 kHz and 8 kHz timing information is also output.

Remote Control, BN 859/00.05
allows remote control via the <IEC 625> interface bus.

Codec Interface, BN 859/00.06
for checking the decoder section of codec building blocks.

General Specifications

Power supply
Rated ranges of use for a.c. line voltage,
switch-selectable . . . . . 110/117/127/220/227/237 V, −12 to +10 %
Rated range of use for a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 50 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature
Rated range of use . . . . . +5 to +40°C
Storage and transportation . . . . . −20 to +60°C

Dimensions (w×h×d) in mm
Bench model (½ 19") . . . . . 222×199×414 (4 U)
19" conversion kit . . . . . order from factory

Weight . . . . . approx. 9 kg

Ordering Information

PDG-3 PCM Digital Signal Generator* for 30-channel systems (2048 kbit/s)	**BN 859/01**
PCG-1 PCM Digital Signal Generator* for 24-channel systems (1544 kbit/s)	**BN 859/02**
Options (at extra cost)	
Simulated Noise memory extension	BN 859/00.02
64 kbit/s interface (input) [2]	BN 859/00.03
64 kbit/s Interface (output) [2]	BN 859/00.04
<IEC 625> Interface Board with IEC 625/IEEE 488 adaptor (S 834)	BN 859/00.05
Codec Interface [2]	BN 859/00.06
Accessories (at extra cost)	
Front and Back Panel Covers SD-45 (1 set)	BN 900/00.24

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.
1) PDG-3 only
2) Alternative

PDA-3/PCD-1
PCM Digital Signal Analyzer

for checking the A/D conversion of PCM 30/PCM 24 multiplexers

IEEE 488
IEC 625



- **All important PCM- multiplexer send-side parameters can be measured**
- **An extremely accurate D/A converter reconverts character signals to analog signals**
- **Displays the maximum or minimum character signal on a particular telephone channel (PDA-3)**
- **Displays coder offset (PDA-3)**
- **Indicates the states of the A and the B signalling bit (PCD-1)**
- **Built-in monitoring loudspeaker (PCD-1)**
- **Remote-controllable**

Applications

When digital switching was introduced it became necessary to carry out separate checks on the receive and on the send sides of multiplexers. A low-frequency sinusoidal signal with low distortion is input at the analog send-side of the system.
At the digital interface, a Digital Signal Analyzer converts the PCM words arriving on a particular telephone channel back into analog form. These analog signals can then be fed to a level meter. The PDA-3 and the PCD-1 are used in this way to measure attenuation, attenuation/frequency distortion, variation of gain with input level, signal-to-total distortion ratio, crosstalk and other PCM multiplexer transmission parameters. The PDA-3 and the PCD-1 can also be used to check analog equipment in digital exchanges, and to investigate data channels.
The 64 kbit/s signals which have been derived from the frames on the selected speech channel (or signalling channel) are available at the relevant interfaces. All functions are remote-controllable so that the user can design the measuring system he requires.

Characteristics

The PDA-3 and the PCD-1 Digital Signal Analyzers are both capable of investigating the characteristics of PCM multiplexers. The digital signal interfaces comply with CCITT Rec. G.703, the frame structure with G.732 or G.733, and ATT 43801. When the Analyzer has established alignment using the frame alignment signal, a demultiplexer in the set extracts the character signal for a channel selected by the user. An extremely precise, low-noise, single-channel decoder then converts the character signals into an analog signal. The decoding process complies with CCITT Rec. G.711. The PDA-3 uses the A-law, the PDC-1 the μ-law. Using the 64 kHz clock, the 64 kbit/s character signals can also be extracted in serial form. This makes it possible to connect a bit error ratio measuring set to measure the bit error ratio of data multiplexers. Frame errors are shown by LEDs.

Frames to CCITT Recs. G.732 or G.733	
Bit rates	2048 or 1544 kbit/s
Line codes	HDB-3, AMI
Level range of the digital/analog converter	
A- (μ-) law	
to CCITT Rec. G. 711	−60 to +3.14 (+3.17) dBm0
Frequency range	50 Hz to 3600 Hz
64 kbit/s TTL input and output	

Digital input-signal
The bit rate, the frame structure of the input signal, the frame alignment conditions and the multiframe alignment conditions all comply with CCITT Recs. G.732 or G.733.

Bit rate
of the digital signal, PDA-3 . . . . . 2048 kbit/s ±200 bit/s
PCD-1 . . . . . 1544 kbit/s ±150 bit/s
Both instrumets have a clock regenerator which ensures that sampling takes place at the centre of each bit.

Digital-signal input

Coaxial * (PDA-3) . . . . Versacon® 9 Universal Connector
Line code . . . . . NRZ, RZ, AMI (½), AMI (1/1), HDB-3
Input impedance . . . . . 75 Ω

Balanced, PDA-3 . . . . . 3 pole CF connector
PCD-1 . . . . . fem. connector compatible with WECO 310
Line code, PDA-3 . . . . . AMI (½), AMI (1/1), HDB-3
PCD-1 . . . . . AMI (½)
Input impedance, PDA-3 . . . . . 120/130 Ω
PCD-1 . . . . . 100 Ω and high impedance

Input voltage range
Required pulse height (PCD-1) . . . . . 30 (100) mV to 3 V

Telephone channel selection

Telephone channel selection PDA-3
Telephone channels 1 to 15 and 16 to 30 can be selected

Telephone channel selection PCD-1
Selectable channel banks . . . . . D1D, D2 or D3/D4
Telephone channels 1 to 24 can be selected

Character signal evaluation
The PDA-3 displays that maximum or minimum character signal received on the selected telephone channel
Slide-switch selects . . . . . max or min char. signal
Character signal observation time (periodic) . . . . . 256 ms
Character signal range . . . . . −127 to +127

D/A converter in the PDA-3
Encoding law to CCITT Rec. G.711, A-law

Analog-signal output . . . . . 3 pole CF connector
Output impedance (unbalanced) . . . . . 600 Ω
Relative level . . . . . 0 dBr

D/A converter in the PCD-1
Encoding to CCITT Rec. G.711, μ-law,
7 5/6-bit or 8-bit coding can be selected

Analog-signal output . . . . fem. connector compatible with WECO 310
Output impedance (unbalanced) . . . . . 600 Ω

Serial 64 kbit/s output
Output for the digital signal carried by the selected telephone channel (or signalling time slot 16) [1] (TTL levels)
Data output . . . . . NRZ
Clock outputs . . . . . 8 kHz and 64 kHz

Further PDA-3 outputs

"8-bit word telephone channel" outputs
8-bit parallel output for the selected voice time slot or signalling time slot 16.

"Frame alignment signal error" output
A TTL pulse is produced every time an errored frame alignment signal is received.

Further PCD-1 input

Serial, 64 kbit/s TTL input
Converts digital test signals to analog signals using the μ-law.

Option

<**IEC 625**> **Interface Board**, BN 867/00.03
with IEC 625/IEEE 488 adaptor (S 834)

General Specifications

Power supply
Rated ranges of use for a.c. line voltage, selectable . . . 110/117/127/220/227/237 V, −12 to +10 %
Rated range of use for a.c. line frequency . . . . . 45 to 66 Hz
Power consumption . . . . . approx. 35 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature
Rated range of use . . . . . +5 to +40°C
Storage and transportation . . . . . −20 to +60°C

Dimensions (w×h×d) in mm
Bench model . . . . . 222×194×414 (4 U)
19" conversion kit . . . . . on request from factory

Weight . . . . . approx. 9 kg

Ordering Information

PCM Digital Signal Analyzer PDA-3 * for 30-channel systems (2048 kbit/s)	**BN 867/02**
PCM Digital Signal Analyzer PCD-1 for 24-channel systems (1544 kbit/s)	**BN 9401/00**
Option (at extra cost)	
<IEC 625> Interface Board with IEC 625/IEEE 488 adaptor (S 834)	BN 867/00.03
Accessories (at extra cost)	
Test Probe TKD-1 [2]	BN 882/01
Front and Back Panel Covers SD-45 (1 set)	BN 900/00.24

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.
1) Only for the PDA-3
2) See the Specification Sheet "Measuring Accessories" for more details

PCD-2
PCM Channel Decoder

for measurements on DS-1 and DS-1C PCM Systems



- **For DS-1 (1544 kbit/s) and DS-1C (3152 kbit/s) systems**
- **LED display for analysis of frame, signalling and error conditions**
- **Decodes any one of the channel time slots**
- **Built-in speaker for monitoring**
- **Option for measuring level, noise, frequency, signalling distortion, and coder offset**

Applications

The increasing demand for PCM systems has also brought about an inprovement in their performance. For example, the 24 channel DS-1 system used in North America and Japan has been upgraded to include an extended multiframe which allows improved digital data performance via error detecting bits.
The PCD-2 PCM Channel Decoder has been designed as the ideal test instrument for these new DS-1 systems as well as the standard DS-1 and DS-1C systems.
The PCD-2 is very compact and fits in a ½19" enclosure, it is ideal for both field and central office use since it has built-in transmission testing capabilities.

Characteristics

The most important monitoring feature of the PCD-2 is the LED indicators which show all the DS-1 frame signal and alarm states of the system under investigation. These indicators are: no signal, "all 1s", code error, frame synchronization loss, framing error, multiframing error, CRC error, remote alarm 2, remote alarm S and remote alarm m. The following DS-1C alarm indicators are also provided: DS-1C frame synchronization loss, DS-1C framing error, DS-1C multiframing error and remote alarm M.
Two indicator alarm modes have been provided. In the first mode, the alarm is displayed for the duration of its occurrence. Alarms of very short duration are displayed for at least 100 ms. In the second mode, the alarm indicator stays lit until reset by the operator.
Alarm indicator signals also appear at a multi-pole connector on the rear of the PCD-2, making further analysis possible.
Another important feature of the PCD-2 is its ability to demultiplex any channel that has been selected. This is possible due to the built-in DS-1C and DS-1 demultiplexers.
To monitor a telephone channel the PCM words in the selected channel are passed through a μ-law decoder and fed to an amplifier and loudspeaker. This decoded signal is also available at a front panel connector so that additional measurements are possible.

Monitors DS-1 and DS-1C PCM systems with normal and extended frames

Decodes any voice channel from DS-1 and DS-1C signals

Provides audio and DS-0 outputs plus signalling and framing status data for comprehensive system analysis

Further applications and characteristics

Interfaces
The receiver input has been designed to AT&T 43801 and CCITT G.703 and is completely compatible with DSX interfaces. The receiver can also operate in the presence of jitter at both bit rates. No matter what the receive bit pattern is, the clock can be recovered if there are not more than 15 consecutive zeroes in the input signal. The recovered clock, which has the same frequency and jitter as the input signal, is available at an output connector on the back panel.
The PCD-2 can, therefore, be connected to other test equipment including frequency counters, oscilloscopes and jitter meters.

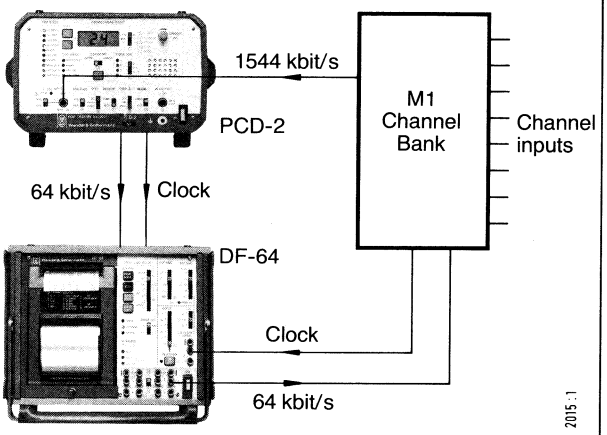
Channel sequences
The PCD-2 can be set to handle the channel sequences used in the D1D, D2 and D3/D4 channel banks. In addition to the decoded voice signal, the 64 kbit/s DS-0 signal and the appropriate clock signals are available at the outputs on the back panel.
Measurements on digital switches employing 32 channel structures is also possible with the PCD-2. The 32 channel (2048 kbit/s) data input and the 2048 and 8 kHz clock inputs are located on the back panel.

Monitoring signalling bits
The PCD-2 can display the status of the signalling bits associated with a telephone channel. The PCD-2 has LED indicators that show the state of the A and B signalling bits used with the standard DS-1 frame (DS-1 "norm"). In the case of the extended frame (DS-1, "extd"), which has four separate signalling channels, the A, B, C and D bits are displayed. When a LED indicator comes on, the bit in question is in the high or "1" state. Outputs for analyzing the signalling states externally have been provided. Regardless of the front panel setting, signalling bit information can be extracted from these outputs in real time.

Cyclic redundancy check (CRC error)
In the case of extended frames (DS-1 "extd."), the PCD-2 calculates the CRC-6 checksum for the multiframe in question and checks the result with the received CRC bits. If these two numbers are different, an indicator on the front panel is activated and a voltage pulse is output at a connector on the back panel for further processing.

Transmission and signalling measurements (Option)
Using this option all important analog parameters of telephone channels can be measured:

- Channel level
- Idle channel noise
- Signal-to-noise ratio
- Frequency
- PCM offset
- Signalling distortion



Measuring the bit- or block-error ratio on a 64 kbit/s channel

Specifications of PCM Channel Decoder **PCD-2**

Unless otherwise stated, the given data is valid for all operating conditions and settings within the nominal ranges of use for a.c. line voltage, a.c. line frequency and ambient temperature.

Measurements can be made on the following PCM systems which comply with CCITT Rec. G.733 and AT&T (North American) standards.
- DS-1 with normal framing
- DS-1 with extended framing
- DS-1C with normal framing
- 32 channel μ-law systems with sync. pulse

Digital-signal input

Line-code format . . . . . AMI or B8ZS
Input . . . . . balanced, fem. connector compatible with WECO 310
Input impedance, switchable . . . . . 100 Ω or >10 kΩ
Return loss (Z_{in} = 100 Ω) in the frequency range from 100 kHz to 3,5 MHz . . . . . ≧20 dB
Input waveform according to CCITT Rec. G.703 and North American standards . . . . . DSX compatible
Input voltage range (V_p) . . . . . 30 mV to 3 V

Bit rates
Internal clock recovery for . . . . . 1544 and 3152 kbit/s
Pulling range of the clock regenerators . . . . . $\pm 500 \times 10^{-6}$

Channel selection
Channels 1 thru 24 (32) selectable via a front panel switch.

Alarm and error display . . . . . with LED

Signalling bits display . . . . . A or A, B or A...D
(with 7 5/6 bit decoding only)

Recovery of frame synchronization

DS-1 systems	DS-1 "norm"	DS-1 "extd."
Frame sync. recovery	after 10 consecutive, correct F_T-bits	
Multiframe sync. recovery	after 12 consecutive correct F_s-bits	after two consecutive, correct FAS sequences

DS-1C System	
Frame sync. recovery	after 15 consecutive, correct F-bits
Multiframe sync. recovery	after two consecutive, correct M_1 M_2 M_3 sequences

Loss of frame synchronization

DS-1 Systems	DS-1 "norm"	DS-1 "extd."
Frame sync. loss	≧2 out of 4 F_T bits in error	
Multiframe sync. loss	2 consecutive F_s-bits in error (this function can be switched off internally)	either 2 consecutive FAS-bits in error or ≧288 out of 320 CRC-checks in error (can be disabled by internal switch)

DS-1C System	
Frame sync. loss	≧3 out of 15 consecutive F-bits in error
Multiframe sync. loss	≧2 M_1 or M_2 or M_3-bit out of 3 M_1 M_2 M_3-sequences in error

VF decoder

Decoding law μ-255

Output . . . . . unbalanced, fem. connector compatible with WECO 310

Impedance . . . . . 600 Ω ± 1 %

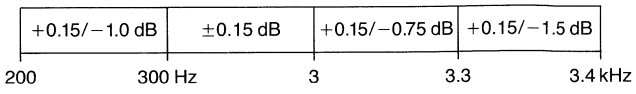
Selectable . . normal 7 5/6 bit operation or CCIS 8 bit operation

Level measurements (without Option BN 2015/00.01)

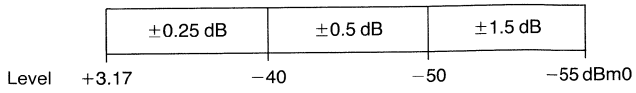
Digital milliwatt input gives . . . . . 0 dBm

Absolute level error
measured with Digital milliwatt . . . . . ±0.18 dB

Frequency response (referred to 1004 Hz)

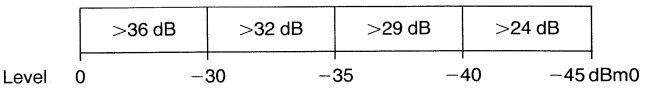


Gain tracking (referred to the value at −10 dBm0)



Idle channel noise, measured with "all 1s" input signal
8 bit decoding, C-weighted 15 dBrnC0

Signal to total distortion ratio measured at 1004 Hz,
8 bit decoding, C-weighted



32-channel inputs . . . . . TTL, BNC connectors
SIGNAL (2048 kbit/s); CLOCK (2048 kHz); SYNC. (8 kHz)
The sampling of SIGNAL and SYNC. with the positive or negative clock edge is internally switchable.
The phase of the synchronization signal can be shifted in 1 bit steps using BCD switches.

DS-0 outputs . . . . . TTL, BNC connectors
SIGNAL (64 kbit/s); CLOCK (64 kHz); CLOCK (8 kHz)
(All positive transitions are approx. in phase).

Analysis outputs . . . . . 36 pole Amphenol socket
Output level . . . . . high speed CMOS
Outputs parallel to the LEDs.

Signals for direct counting with external counter:
Code error
Frame error T1
Multiframe error T1
Frame error T1C
Multiframe error T1C
CRC error
No signal
"All 1s" (AIS)
No DS-1 synchronization
No DS-1C synchronization
Remote alarm (bit-2)
Remote alarm (S-bit)
Remote alarm (m-bit)
Remote alarm (M-bit)
A, B, C, D or $\overline{A}$, $\overline{B}$, $\overline{C}$, $\overline{D}$ signalling bits (internally switchable)
32-channel mode

Additional outputs
m-data signal 4 kbit/s (DS-1 "extd.")
m-clock 4 kHz (DS-1 "extd.")
S-bit 4 kbit/s (DS-1 "norm.")
(internally selectable only by 8-bit-decoding)
Stuffing ratio of the DS-1C/1 or DS-1C/2
Data signal 1544/3152 kbit/s (NRZ)
Multiframe trigger pulse 666.6 Hz (DS-1 "norm.")
333.3 Hz (DS-1 "extd.")
Frame trigger pulse . . . . . 8 kHz
Clock 1544 kHz
Data signal 1544 kbit/s (NRZ)

Recovered clock output . . . . . BNC connector
Recovered clock from the DS-1 or DS-1C input signal (1544 kHz or 3152 kHz) with the same frequency and jitter as the input signal
Output level . . . . . high speed CMOS

Signalling "A-bit-output"
Relay contact corresponding to the status of the signalling bit A at 7 5/6 bit decoding.
A bit status (0/1) . . . . . open/grounded through 10 Ω
Max. d.c. voltage/output current . . . . . ±60 V/0.2 A
The A bit output can internally switched on/off.

DS-1 output
(taken from DS-1 or demultiplexed DS-1C input signal)
Line code . . . . . AMI (½)
Output . . . . . unbalanced, fem. connector compatible with WECO 310
Output impedance . . . . . 100 Ω
Return loss (100 kHz to 1.6 MHz) . . . . . >20 dB
Output pulse shape . . . . . rectangular
Pulse amplitude at 100 Ω . . . . . 3 V ±10 %
Rise time (10 to 90 %) . . . . . approx. 10 ns

Option

Transmission and signalling measurements, BN 2015/00.01

Transmission measurements

Level measurement
Calculation of the wideband level from the digital code words
Measurement range . . . . . −80 to +5 dBm0
Resolution . . . . . 0.1 dB
Error limits of level display
at 0 dBm0 (Digital Milliwatt) . . . . . 0.0004 dB
in level range −65 to +5 dBm0 . . . . . 0.001 dB
−77 to −65 dBm0 . . . . . 0.01 dB
−80 to −77 dBm0 . . . . . 0.02 dB
in frequency range 40 to 170 Hz . . . . . 0.1 dB
170 to 330 Hz . . . . . 0.02 dB
330 to 3990 Hz . . . . . 0.01 dB

Noise mesurements
Measurement of the idle channel noise with C-notch-weighting filter (internally switchable)
Measurement range . . . . . 10 to 90 dBrnC0
Resolution . . . . . 0.1 dB

Signal-to-noise ratio
Measurement of the signal-to-noise (total-distortion) ratio. The signal is calculated from the wideband digital words. The noise is calculated from the filtered digital words (notch-filter 1004 Hz and C-weighting filter in series).
Signal input level range . . . . . −55 to +3 dBm0
Measurement range . . . . . 0 to 43 dB
Resolution . . . . . 0.1 dB

Frequency
Frequency range . . . . . 0.1 to 3.99 kHz
Resolution for, 0.1 to 1.999 kHz . . . . . 1 Hz
2.0 to 3.99 kHz . . . . . 10 Hz
Error limits of frequency display . . . . . ±1 Hz

PCM offset
Average value calculated from 800 digital code words (100 ms) according to the μ-255 law
Measurement range . . . . . ±50 code words
Resolution . . . . . 1 code word
Error limits . . . . . 0.01 code word

Signalling break measurement
Percent break measurement of the selected signalling bit A, B, C or D
Measurement range . . . . . 5 to 95 %
(periodic signal 5 Hz to 20 Hz necessary)
Resolution . . . . . 1 %
Error limits . . . . . 0.4 %

Display Test
After "power on" the display will light up for two seconds:
all LEDs
all segments of the LCD display

General Specifications

Power supply
Nominal ranges of use of a.c. line voltage, selectable . . . . . 100/120/220/240 V, −13 to +10 %
Nominal range of use of a.c. line frequency . . . . . 47 to 63 Hz
Power consumption . . . . . max. 60 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Tolerable ambient temperature
Nominal range of use . . . . . +5 to +40°C
Storage and transportation . . . . . −20 to +60°C

Dimensions (w×h×d) in mm
Bench version . . . . . 240×159×359 (9.5" × 6.3" × 14.6")

Weight . . . . . approx. 6.5 kg (14.3 lbs.)

Accessories

Case T2, BN 926/14
A case to facilitate transportation and to prevent damage when the PCD-2 is used in the field. The case is reinforced, padded with foam, and has an accessory compartment.

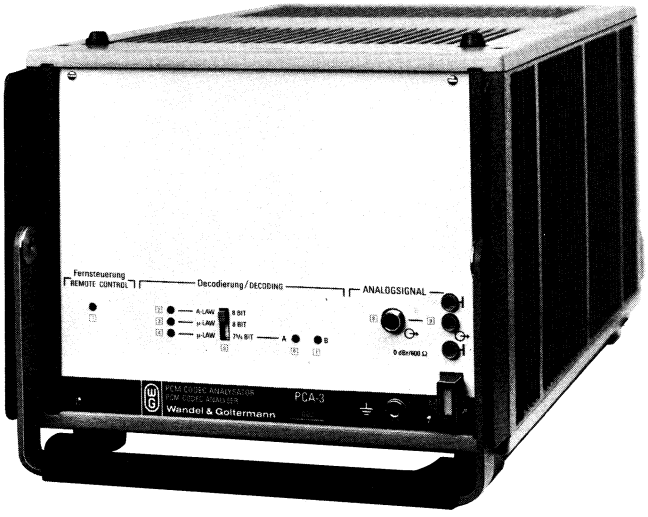
Ordering Information

PCM Channel Decoder PCD-2	**BN 2015/01**
Option (at extra cost)	
Transmission and signalling measurements	BN 2015/00.01
Accessories (charged extra)	
Case T2	BN 926/14

PCA-3
PCM Codec Analyzer

for testing the analog-digital conversion of PCM codec building blocks

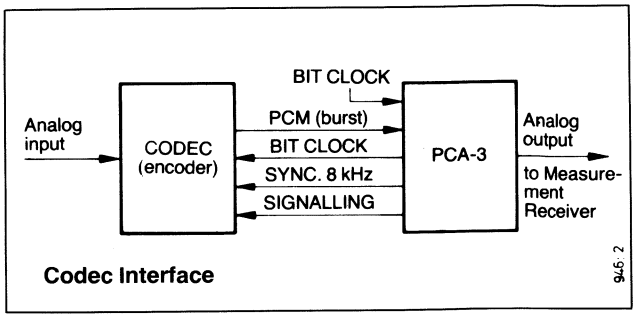
IEEE 488
IEC 625



- **Measures all important analog parameters of coders in PCM codec building blocks**
- **Decoding of single 8-BIT-WORD (burst) and reconversion into an analog signal**
- **Switchable for A-law and μ-law decoding**
- **Interfaces all common codecs through individually settable combinations of clock, synchronization signal- and signalling clock-conditions**

Applications

The PCA-3 Codec Analyzer implements the measurement of A-law and μ-law characteristic codecs. It operates at clock frequencies of 1544, 2048 and 2560 kHz in accordance with the codecs to be tested for 24, 32, and 40 channel time slots. An interface permits the most commonly used codecs to be setup for the encoding law and for combinations of clock signal-, synchronization signal-, and signalling clock-conditions given in the specified characteristics of the codecs.
In addition, the PCA-3 permits the analysis and display of signalling bits A and B transmitted in frames 6 and 12 with μ-law $7^5/_6$ bit encoding.
The PCA-3 may be used as a 64 kbit/s single channel decoder when the codec interface is switched to 64 kbit/s mode. Thereupon, a 64 kbit/s signal is accepted in serial form by the PCA-3 and is converted to a corresponding analog signal. This mode is interesting for instance in conjunction with the *VME-1 Receiver* of the *VM-1 Test Set for Digital Exchanges* because by that means listening to or measuring the digital switched signal is possible.



Characteristics

For testing the encoder side, an analog signal from the send section of a PCM test set (e.g. PCM-2) is applied to the codec. This analog signal is sampled, encoded and compressed, and it appears at the encoder output after being triggered by a synchronizing pulse produced by the PCA-3.
The PCA-3, individually interfaced to the codec, supplies the encoder with the necessary clocks and accepts the 8-bit-word (burst) in serial form, converts it to a parallel signal and feeds it to a high-precision digital-analog converter. After the reconversion, the input signal of the encoder is measured as a corresponding analog signal by the receive section of the PCM test set. By that means, all the encoder's important parameters like variation of gain with both input level and frequency, intrinsic noise, and total distortion are measured on codec components.

Bit rates	1544, 2048, and 2560 kbit/s
Analysis of codecs for	24, 32, and 40 channel systems
Testing of single channel and two channel codecs	
Operating the PCA-3 as a 64 kbit/s single channel decoder	

Specifications of PCM Codec Analyzer

PCA-3

If not otherwise noted, the specified values are valid for any operating conditions and instrument settings within the rated ranges of use for a.c. line voltage, a.c. line frequency and the ambient temperature.

Bit clock input

An external bit clock must be fed-in for operation with codecs
Possible clock frequencies, f_B . . . . 1544, 2048, and 2560 kHz
Tolerable clock frequency tolerance . . . . . $\pm 50 \times 10^{-6}$

Clock signals from PCA-3 to codec

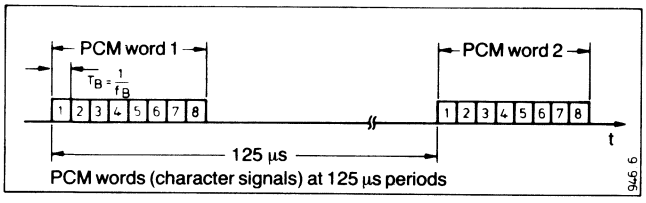
Bit clock
Bit rates . . . . . 1544, 2048, and 2560 kbit/s

8 kHz synchronization signal
for production of the PCM bursts

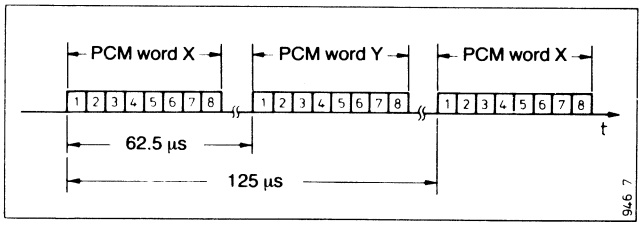
SIGNALLING clock
Clock for insertion of signalling bits A, B into the bursts (T1 frames, $7^5/_6$ encoding)

Burst signal from codec to PCA-3

Single channel codec

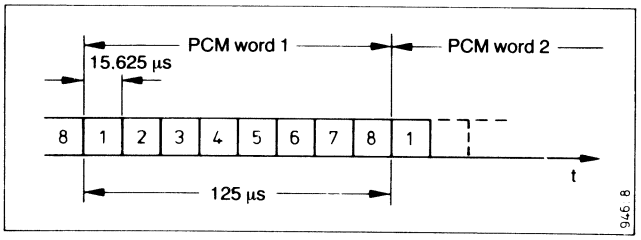


Two channel codec
The PCA-3 analyzes as selected the PCM word X or Y. The selection results through programming at the codec interface subassembly or via remote control.



64 kbit/s mode at the interface

64 kbit/s-input signal
PCM words distributed over 125 µs each



Characteristics of inputs and outputs

Input and output connectors . . . . . BNC
Signal voltages . . . . . low power Schottky (LPS) TTL

Encoding law
and coordination between encoding law and receive level in accordance with CCITT Recommendation G.711
Switch-over possibilities amongst . . . . . A-law
µ-law (8 bits)
µ-law ($7^5/_6$ bits)
LED indication of A and B bits with µ-law ($7^5/_6$)

Character signal encoding (PCM words)
Internal changeover to PCM words without bit inversion when A-law is used, or to general re-inverted PCM words when µ-law is used

Digital-Analog conversion

Analog signal output
Output impedance (unbalanced) . . . . . 600 Ω
Relative level . . . . . 0 dBr
Frequency range . . . . . 50 Hz to 3600 Hz

General Specifications

Power Supply
Rated ranges of use of a.c. line voltage, selectable . . . . . 110/117/127/220/227/237 V
Rated range of use of a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 33 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature
Rated range of use . . . . . +5 to +40 °C
Storage and transport range . . . . . −40 to +70 °C

Dimensions in mm

Bench model		½19" Rack mounting (DIN 41 494)	
Width with handles	214	Width	222
Height overall	199	Height (4 units)	176
Depth with handles	415	Depth	370

19" conversion kit . . . . . on request at factory

Weight . . . . . approx. 8 kg

Ordering Information

PCM Codec Analyzer PCA-3	**BN 946/01**
Options (at extra cost)	
Remote Control and Data Output	BN 867/00.01
Interface Bus <IEC 625> card with adapter IEC 625/IEEE 488 (S 834)	BN 867/00.03
Accessories (at extra cost)	
Protective Transportation Covers (for front and back panels) SD-45	BN 900/00.24

DF-64
Error Ratio Measuring Set

for measuring bit and block error ratios on 48, 56, 64 and 72 kbit/s data comm channels



- **Measurement of the bit and block error ratios on data communication systems and digital switched 64 kbit/s channels**
- **Results of measurement printed out on incorporated printer**
- **"Codirectional" and "contradirectional" interfaces complying with CCITT Recs. V.11 and G.703, also suitable for the PCM-30 D Data Transmission System of the Bundespost**
- **Pseudorandom test patterns 2^9-1 bits and $2^{11}-1$ bits; bit sequences ...1010..., ...1111..., and ...0000...**
- **Error counts over periods ranging from 1 s to 99 hours**

Applications

The DF-64 Error Ratio Measuring Set is used for measuring and recording bit and block error ratios on analog and digital data communications equipments. As the DF-64 is a universal instrument it can be used for testing the PCM-30 D Data Transmission System of the Bundespost. This involves measurements on PCM multiplexers with interfaces conforming to CCITT Rec. G.703 and measurements on modems with interfaces conforming to CCITT Rec. V.11.
When used as an external error counter, the DF-64 can be used to record the bit errors of applied external signals up to 2 Mbit/s. This is possible with any type of communications equipment.
As the DF-64 is compact and easy-to-operate it is ideal for service and maintenance on postal systems. On the other hand, because of its versatility, the DF-64 can be used in research and development, in production departments and for testing data comm systems and their subassemblies.
The integral send section means that the DF-64 forms a complete Measuring Setup for end-to-end and loop-back measurements.

Characteristics

A pattern generator in the send section of the DF-64 generates a variety of pseudorandom sequences and bit patterns with high frequency accuracy. Switchable detuning of the bit rate means that the data comm equipment can be tested at extremes of clock frequency. The send clock can be derived internally, externally or from the input clock of the receiver. By pressing a button, a variety of error ratios or single errors can be injected into the send pattern.
After synchronisation a bit-by-bit comparison of the received bit pattern is made with the reference pattern generated by the DF-64. This comparison takes place in the DF-64's receive section. Both bit and block error ratios and bit and block error counts can be used to evaluate errors.
The observation period and the time of printout can be determined manually or by means of a Timer. As relatively low bit rates require long observation times, the results are printed out on a strip-printer along with date and time.

Send section	
Bit rates, internal	48, 56, 64 and 72 kbit/s
external	1 to 520 kbit/s
The send clock can be derived from the receive clock	
Bit error ratio	
Measurement range	0×10^{-7} to 3.33×10^{-1}
Error counting	
Counting range	0 to 99 999
Timer, for printout of time and date, trickle charge	
Weight	approx. 10.5 kg

Further Characteristics and Applications

The following characteristics of the DF-64 should also be of interest.

- Signal level monitoring: When the signal level falls below a certain threshold, a signal lamp comes on and an error printout is produced. The amplitude threshold is 50 % of the signal level.
- Synchronism monitoring: For continuously monitoring pattern synchronism. If an average error ratio of $>3\times10^{-1}$ is exceeded or a sequence of 128 errors occurs, an "out-of sync" message is given. An error printout is also provided. Synchronism is regained after, at most, 24 consecutive, error-free bits in the receive pattern.
- Comprehensive printouts: The DF-64 has two practical measuring ranges. The result is displayed to three decimal places in exponential form.

  Up to 99 999 bit or block errors can be counted and any counter overflow is indicated. If nothing has been recorded after an error-free measurement period, an error threshold of ≧1 error can be entered.
  A timer with trickle-charged rechargeable batteries means that the start-time of measurement procedures can be recorded, results can be printed out after a certain interval and the time of occurrence of power failures is indicated.
- External jitter modulation: The DF-64's clock signal can be looped through an external jitter modulator to examine the tolerable input jitter or the jitter transfer function of digital equipment.
- D.C. output: The DF-64 has a d.c. output to supply extra equipment (e.g. modems).

Specifications of Error Ratio Measuring Set — DF-64

If nothing to the contrary is stated, the given data is valid for the rated conditions of use for the influence quantities.

Send Section

Bit Rate

Internal clock generator
Adjustable bit rates . . . . . 48, 56, 64 and 72 kbit/s
Variations of $\Delta f/f$,
switchable in three steps . . . . . $+1\times10^{-4}$/CAL./-1×10^{-4}
Error limits of bit rate . . . . . $\pm10\times10^{-6}$

External clock input . . . . . balanced
Clock rate range . . . . . 1 to 520 kbit/s
Input impedance . . . . . 120 Ω
Input voltage V_{pp} (sinusoidal or rectangular) . . . . . 1 to 6 V

Clock derivation from Receiver
switchable; switchover indicated by LED on the front panel of the DF-64

Pulse pattern

Pseudorandom sequences . . . . . 2^9-1 and $2^{11}-1$
Block lengths . . . . . 511 and 2047 bits

Periodic bit sequences:
Sequence of continuously alternating bits . . . .1010...
Sequence of "1's" . . . .1111...
Sequence of "0's" . . . .0000...

Error test

Single error injection . . . . . each press of the button produces 1 error (inversion of signal bits)

Multiple error injection . . . . . 5×10^{-3}, 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6}

Outputs for digital signals and clock timing signals

Pushbuttons located on the back panel permit the selection of interfaces conforming to CCITT Recs. V.11 or G.703, and appropriate to PCM-30D.
The CCITT G.703 and the PCM-30D interfaces are fitted with transformers. These transformers can be switched out.
The selected interface is indicated by the appropriate LED on the front panel of the DF-64.

Arrangement of inputs or outputs

Interface	Generator outputs: Digital signal	Generator outputs: Clock	Send clock: External clock
PCM-30D	Digital signal	Clock	External or internal priority for 64 kbit/s
CCITT V.11	Digital signal	Clock	External or internal
CCITT G.703, "codirectional interface"	Digital signal + clock (256 kbaud)	—	External or internal 64 kbit/s
CCITT G.703, "contradirectional interface"	Digital signal	—	Only external! (64 and 8 kbit/s)

Interfaces

Interface corresponding to PCM-30 D of the German Post Office.
Outputs for 64 kbit/s data signal and timing signal . . balanced
Bit rates . . . . . 1 to 520 kbit/s
Output impedance . . . . . 130 Ω
Line code . . . . . AMI (1/1)
Output pulse shape . . . . . rectangular
Pulse amplitude, when terminated with 130 Ω . . 0.5 V ± 10 %

Interface conforming to CCITT Recommendation V.11.
Outputs for data signal and timing signal . . . . . balanced, CF connector
Bit rate range . . . . . 1 to 520 kbit/s
Output impedance . . . . . 75 Ω ± 10 %
Output voltage $V_{a/b}$:
logic "0":
when terminated with 100 Ω . . . . . +2.5 V ± 0.5 V
logic "1":
when terminated with 100 Ω . . . . . −2.5 V ± 0.5 V
Generator offset voltage $V_{a,\,b/c}$ . . . . . ≦1 V

Interface corresponding to CCITT Recommendation G.703
(Para. 1.2.1 for 64 kbit/s "codirectional")
Output for 256 kbaud:
Data and timing signal . . . . . balanced
Output impedance . . . . . 120 Ω
Code . . . . . corresponds to G.703, Fig. 4
Pulse amplitude at pulse centre when terminated
with 120 Ω . . . . . 1 V ±0.1 V
Pulse shape . . . . . rectangular
Pulse width . . . . . 3.9 µs or 7.8 µs

Interface corresponding to CCITT Recommendation G.703
(Para. 1.2.3 for 64 kbit/s "contradirectional")
Output for 64 kbit/s data signal
External input for 64 and 8 kHz clocks . . . . . balanced
Input or output impedance . . . . . 120 Ω
Code . . . . . corresponding to CCITT G.703, Fig. 6
Pulse amplitude at pulse centre,
when terminated with 120 Ω . . . . . 1 V ±0.1 V
Peak voltage of a "space" (no pulse) . . . . . 0 V ±0.1 V
Pulse shape . . . . . rectangular
Pulse width: data signal . . . . . 15.6 µs
timing signal . . . . . 7.8 µs

Additional inputs and outputs (on back panel)

Outputs for digital signal and clock . . . . . unbalanced
Code . . . . . NRZ
Output voltage . . . . . TTL 74 LS

Clock output to ext. jitter modulator
Output voltage . . . . . CMOS 74 HC
Logic "0" . . . . . 0 to +0.5 V
Logic "1" . . . . . +2.0 to +5.25 V

Clock input from ext. jittermodulator
Input voltage . . . . . CMOS 74 HC
Logic "0" . . . . . 0 to +0.9 V
Logic "1" . . . . . +3.6 to +5.0 V

Receive section

Bit rate . . . . . see send section

Pulse pattern . . . . . see send section

Inputs for digital signals and clock signals
LED "NO SIGNAL" for monitoring the input digital signal and the clock signal.
The CCITT G.703 and the PCM-30 D interfaces are fitted with transformers. These transformers can be switched out.

Interfaces

Interface appropriate to PCM-30 D of the
German Post Office.
Inputs for 64 kbit/s data signal and timing signal . . . balanced
The falling transition of the timing signal $V_{b/a}$ must be located in the centre of the data bit
Bit rate range . . . . . 1 to 520 kbit/s
Input impedance . . . . . 130 Ω
Line code . . . . . AMI (1/1)
Input pulse form . . . . . rectangular
Required pulse amplitude . . . . . 250 mV to 3 V

Interface corresponding to CCITT Recommendation V.11
Inputs for data signal and timing signal . . . . . balanced
The falling transition of the timing signal $V_{a/b}$ must be located in the centre of the data bit
Bit rate range . . . . . 1 to 520 kbit/s
Input impedance (a to b) . . . . . 10 kΩ ± 10 %
Input voltage range $V_{a/b}$:
Logic "0" . . . . . +0.3 V to +6 V
Logic "1" . . . . . −0.3 V to −6 V
Max. common mode voltage:
at ±0.3 V input voltage . . . . . ±7 V
at ±6 V input voltage . . . . . ±4 V
Max. input voltage (difference) . . . . . 12 V

Interface corresponding to CCITT Recommendation G.703
(Para. 1.2.1 for 64 kbit/s "codirectional")
Input for 256 kbaud data and timing signals . . . . . balanced
Input impedance . . . . . 120 Ω
Input signal shape
and code . . . . . corresponds to CCITT Rec. G.703, Fig. 4
Required pulse amplitude . . . . . 0.25 V to 3 V

Interface corresponding to CCITT Recommendation G.703
(Para. 1.2.3 for 64 kbit/s "contradirectional")
Inputs for 64 kbit/s data signal
and for 8 kHz/6 kHz timing signal . . . . . balanced
Input impedance . . . . . 120 Ω
Input signal shape
and code . . . . . corresponding to CCITT Rec. G.703, Fig. 6
Required pulse amplitude . . . . . 0.25 V to 3 V

Additional inputs and outputs (back panel of DF-64)

Inputs for digital signal and clock signal . . . . . unbalanced
Code . . . . . NRZ
Input voltage range . . . . . TTL 74 LS
Logic "0" . . . . . 0 to +0.7 V
Logic "1" . . . . . +2.0 to +5.25 V

Clock output
Output voltage . . . . . CMOS 74 HC
Logic "0" . . . . . 0 to +0.9 V
Logic "1" . . . . . +2.0 to +5.0 V

Conditions for synchronism
The LED display "out of sync" comes on if the average error ratio is $>3\times10^{-1}$ or if 128 consecutive errors occur.
Synchronism is restored after, at most, 24 error-free bits.

Error evaluation
Bit or block error evaluation selectable for the pseudorandom patterns. For the periodic bit sequences, **only** bit error ratio evaluation is possible.

Error count
Counting range . . . . . 0 to 99 999 erroneous bits
Automatic reset of error counter after every printout within the set-in timing interval of the timer.

Bit error ratio
With evaluation over 10^5 timing bits . . . 0×10^{-5} to 3.33×10^{-1}
With evaluation over 10^7 timing bits . . . 0×10^{-7} to 9.99×10^{-3}

Block error ratio (with block lengths of 511 and 2047 bits)
With evaluation over 10^3 blocks . . . . . 0×10^{-3} to 1.00×10^{-0}
With evaluation over 10^5 blocks . . . . . 0×10^{-5} to 9.99×10^{-1}

Error output (back panel)
One 0.5 bit-width impulse per bit error
(independent of the selected error evaluation)
Output voltage . . . . . TTL 74 LS
Logic "0" . . . . . 0 V to 0.5 V
Logic "1" . . . . . +2.4 V to +5.25 V
The error output becomes an error input when none of the interface pushbuttons has been pressed at the DF-64 back panel (no interface indicator lamps are illuminated on the front panel).
Max. count frequency with operation as error input . 2.1 MHz
Required input voltage . . . . . CMOS
Logic "0" . . . . . 0 V to +1.5 V
Logic "1" . . . . . +3.5 V to 5.25 V

Timer
Crystal controlled clock with trickle-charged rechargeable batteries
Number of days (continuous) . . . . . 0 to 6 days
Hours and minutes (real time) . . . . . adjustable
Printout interval for error counting,
adjustable . . . . . 1 to 99 s, min, or h

Display and printout format
An integral strip-printer provides the printout

Print sequence
Error ratio
The printout interval is determined by the number of blocks or bits under observation. A printer block can be actuated to prevent a printout if there are no errors.

Error counts
Manual printout or printout at certain intervals determined by the Timer. The error counter is reset after each printout (the counter is not reset with manual printouts).
Intermediate printout on "out of sync." or "no signal" at most once per observation period or "manual" without resetting the error counter.
An adjustable error threshold prevents printout if there are no errors in the observation period.

General Specifications

Power supply
Rated ranges of use of a.c. line voltage,
switchable . . . 110/117/127/220/227/237 V, −12 to +10 %
Rated range of use of a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . max. 77 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class 1
Power supply for extra equipment
(on DF-64's back panel) . . . . . ±12 V/max. 30 mA,
+5 V/max. 200 mA

Permissible ambient temperature
Rated range of use . . . . . +5 to +40 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions (w×h×d) in mm
Bench version (½19") . . . . . 222×199×414 (4 units)
19" conversion kit . . . . . on request

Weight . . . . . approx. 10.5 kg

German Post Office Certificate of Approval No. for
Version BN 861/01 . . . . . 276 093 090

Ordering Information

Error Ratio Measuring Set DF-64 (English lettering)	**BN 861/04**
Error Ratio Measuring Set DF-64 (German lettering)	**BN 861/01**
Accessories (at extra cost)	
Front and back panel cover SD-45 (1 set)	BN 900/00.24
Printer paper [1]	BN 861/00.03

1) Supplier: Olympia, Order No. 8508.4201 or Bosch, Order No. RMP 81128.

PF-1
Bit Error Measuring Setup

for measuring the bit error ratio of PCM and data telecommunications systems



- **Measures bit error ratio**
- **Error counting**
- **Bit rates: 1536, 2048, and 8448 kbit/s (1544 and 6312 kbit/s) or 256, 512, 576, 1024, 1152 and 2048 kbit/s**
- **Patterns: pseudo-random patterns, periodic bit sequences, and freely programmable 16 bit word (character signal)**
- **Up to 64 bits may be blanked out of pattern**
- **Results evaluated according to errors of injection and omission**

Applications

The bit error ratio is a measure of performance for the circuit equipment used on a data communications link. Its magnitude is essentially determined by the contrast of the regenerator sensitivity (the regeneration process for the digital signals) with the spurious signals caused by cross-talk.
A pseudo-random sequence is used as a test signal that is compared bit-by-bit in a receiver having a pulse sequence pattern of the same structure and synchronized to the received test signal. By the inserting of additional zeros into the test pattern, difficult conditions for regenerator clock recovery are created. Complicated, periodic bit patterns are set-up by employment of a freely programmable and abbreviable 16 bit word (character signal).

Characteristics

The PF-1 Bit Error Measuring Setup is comprised of a Pattern Generator and a Bit Error Meter. It is designed for measuring on digital communication links of 24, 30, or 120 channels. A special version of the PF-1 takes into account bit rates that are primarily found in data comm systems operating with delta modulation.
For adaptation to the great variety of interfaces in use today, the PF-1 is equipped with both balanced and coax. outputs and inputs. The Bit Error Measuring Setup supplies the interface codes that are usually used in digital communications systems; that is, HDB 3 and AMI. In addition, the special version for delta modulation offers the EUROCOM interface at the Pattern Generator outputs. This interface is used on systems operated by NATO.
Besides some of the frequently used bit sequences, the PFG-1 Pattern Generator produces two pseudo-random sequences of lengths 2^9-1 and $2^{15}-1$ bits.

Display range of the bit error ratio	9.99×10^{-3} to 1×10^{-8}
Count capacity for error counting	1 to 10^5
Strip recorder for documenting results obtained during long-term monitoring	

The selected send pattern is simulated in the Bit Error Meter and is used as a reference pattern. The incoming signal is synchronized with its corresponding reference pattern and a bit-by-bit comparison is implemented. Hence, a pattern comparison of a pseudo-ternary coded line signal with a reference pattern can take place by either of two methods:

- the incoming signal is compared with a corresponding pseudo-ternary encoded reference pattern (reference encoded)
- the incoming signal is re-encoded into an NRZ or an RZ signal and then compared with a binary reference pattern (signal decoded).

Application of the pseudo-ternary pattern comparison method is found in bit error measurements on code transparent communications systems, whereas the binary pattern comparison method must be executed on non-transparent communication links.

Specifications of the Bit Error Measuring Setup — PF-1

If not otherwise noted, the specified values are valid for any equipment settings within the rated ranges of use for a.c. line voltage, a.c. line frequency and ambient temperature.

Pattern Generator PFG-1 (Version .../01)

Bit rate

Internal clock generator . . 1536, 2048, and 8448 kbit/s
Error limits of bit rate
(in position "CAL") . . . . . $\pm 30 \times 10^{-6}$
Clock fine setting (continuous) . . . . . $\pm 50 \times 10^{-6}$

External clock input*
Clock frequency range . . . . . 48 to 8500 kHz
Input impedance . . . . . 75 Ω
Input voltage v_{pp} . . . . . 1 V to 4 V

Patterns

Pseudo-random patterns
Length . . . . . 2^9-1 and $2^{15}-1$ bits

Continuously alternating
bit sequence . . . .1010...

Bit sequence corresponds to a HDB signal
of lowest power density . . . .10001000...

Sequence of zeros . . . .0000...

Freely programmable digital word
and 17/15 bit pattern . . . . . Option on plug-in card

Bit blanking
(Zero injection)

"One shot" (1×)
Lengthening the maximum zero sequence of the pseudo-random pattern
(9 or 15 zeros) by . . . . . 8, 16, 24, 32, 40, 48, 56, 64 zeros

"Repeating" (rep.)
Additional periodic injection of the chosen number of zeros into the pseudorandom pattern
Blanking the periodic bit sequence ... 1010 ... or ... 10001000 ... periodically with the chosen number of zeros

Error injection
Injection of one error per 1000 bits, or an error ratio of 1×10^{-3}

External phase modulation*
For bit rates in range . . . . . 1000 to 8500 kbit/s
Input impedance . . . . . approx. 10 kΩ
Sensitivity for each degree of phase modulation . . . . 10 mV
Jitter frequency range (3 dB roll-off) . . . . . 10 Hz to 200 kHz

Max. jitter deviation
at 2048 kbit/s . . . . . ±70 degrees
at 8448 kbit/s . . . . . ±40 degrees

Max. intrinsic jitter (without external modulation range)
at 2048 kbit . . . . . ±0.8 degree

Outputs for digital signal and clock

Coax.* (unbalanced) . . . . . 48 to 8500 kbit/s
Internal impedance Z_i . . . . . 75 Ω
Output pulse amplitude at $Z_i = Z_L$ . . . . . 2.37 V ±10 %
Output pulse shape . . . . . rectangular

Balanced
Internal impedance Z_i (rated value) . . . . . 120 or 130 Ω
Output pulse amplitude at $Z_i = Z_L$ . . . . . ±3 V ±10 %
Output pulse shape . . . . . rectangular

Line codes
Digital signal
coax. . . . . NRZ, RZ, AMI (1/1), AMI (1/2), HDB 3
balanced . . . . . AMI (1/1), AMI (1/2), HDB 3

Trigger output* . . . . . TTL level
Switchable between bit and pattern trigger

Digital Error Rate Meter PFM-1 (Version .../01)

Bit rate

Internal clock regenerator
Bit rates . . . . . as with PFG-1 Pattern Generator

External clock input
Coax. (unbalanced)*
Clock frequency range . . . . . 48 to 8500 kHz
Analysis, switchable for positive or negative clock pulse transitions
Input impedance . . . . . 75 Ω

Balanced
Clock frequency range . . . . . 500 to 8500 kHz
Analysis, switchable for positive or negative clock pulse transitions
Input impedance (rated value) . . . . . 120 or 130 Ω

Detectable patterns . . . . as with PFG-1 Pattern Generator

Bit blanking . . . . . as with PFG-1 Pattern Generator

Signal inputs

Coax.*
Bit rate range . . . . . 48 to 8500 kbit/s
Line codes . . . . . NRZ, RZ, AMI (1/1), AMI (1/2), HDB 3
Input impedance . . . . . 75 Ω

Balanced
Bit rate range . . . . . 500 to 8500 kbit/s
Line codes . . . . . AMI (1/1), AMI (1/2), HDB 3
Input impedance (rated value) . . . . . 120 or 130 Ω

LEDs indicate NO SIGNAL and OUT OF SYNC.

Error analysis, switch-selectable to:
Error caused by injection of positive "1" bits
Error caused by injection of negative "1" bits
Error caused by omission of positive "1" bits
Error caused by omission of negative "1" bits
Total error

Display range
Error ratio
with analysis during 10^7 clock bits . . . . 1×10^{-7} to 9.99×10^{-3}
with analysis during 10^8 clock bits . . . . 1×10^{-8} to 9.99×10^{-4}

Error counting
Count capacity . . . . . 1 to 99 999 erroneous bits

X-Y recorder output
Internal impedance . . . . . approx. 5 kΩ

Output voltages

	Error ratio in 10^7 bits	Error ratio in 10^8 bits	Count	Output open circuit voltage
Counter status	$<1\times10^{-6}$	$<1\times10^{-7}$	<10	approx. 0 V
	$\geqq1\times10^{-6}$	$\geqq1\times10^{-7}$	$\geqq10$	+1 V
	$\geqq1\times10^{-5}$	$\geqq1\times10^{-6}$	$\geqq10^2$	+2 V
	$\geqq1\times10^{-4}$	$\geqq1\times10^{-5}$	$\geqq10^3$	+3 V
	$\geqq1\times10^{-3}$	$\geqq1\times10^{-4}$	$\geqq10^4$	+4 V
No signal, out of sync.				+5 V

Digital outputs
Data output . . . . . BCD code
Error output . . . . . TTL level, ½ bit wide

Remote control
For loop-back measurements, the PFG-1 Pattern Generator can be operated from the PFM-1 Error Rate Meter

Pattern Generator PFG-1 (Version .../81)

The following specifications are only those that deviate from the specifications given for Version .../01

Bit rate

Internal clock generator . . . . . 256, 512, 576, 1024, 1152 and 2048 kbit/s

External clock input*
Clock frequency range . . . . . 16 to 2100 kHz

Error injection
Injection of an error per 10^5 bits or
at an error ratio of . . . . . 1×10^{-5}

External phase modulation*
for bit rates in range . . . . . 250 to 2100 kbit/s

Outputs for digital signal and clock
Coax. (unbalanced)* . . . . . 16 to 2100 kbit/s
Balanced . . . . . 250 to 2100 kbit/s
Pulse amplitude at Z_L = 120 Ω or 130 Ω . . . . . 3 V ± 10 %
Switchable to . . . . . 0.5 V ± 10 % [1]

Digital Error Rate Meter PFM-1 (Version .../81)

The following specifications are only those that deviate from the specifications given for Version .../01

Bit rate

Internal clock regenerator
for the bit rates . . 256, 512, 576, 1024, 1152, and 2048 kbit/s

External clock input
Coax. (unbalanced)*
Clock frequency range . . . . . 16 to 2100 kHz/s
Balanced
Clock frequency range . . . . . 250 to 2100 kHz/s

Detectable patterns . . . . as with PFG-1 Pattern Generator (Version .../01)
Bit pattern detection, switchable . . . . . normal, inverted

Signal inputs
Coax. (unbalanced)*
Bit rate range . . . . . 16 to 2100 kbit/s
Balanced
Bit rate range . . . . . 250 to 2100 kbit/s

General Specifications

Power supply
Rated ranges of use of the
a.c. line voltage . . . . . 110/117/127/220/227/235 V
Rated range of use of the
a.c. line frequency . . . . . 45 Hz to 66 Hz
Power consumption: PFG-1 . . . . . approx. 44 VA
PFM-1 . . . . . approx. 62 VA
Safety class conforming to IEC 348 and VDE 0411 . . Class I

Tolerable ambient temperature
Rated range of use . . . . . +5 °C to +40 °C
Storage and transport . . . . . −40 °C to +70 °C

Dimensions of PFG-1 and PFM-1

Bench model		½19" Rack mounting (DIN 41 494)	
Width with handles	233	Width	222
Height overall	199	Height (4 units)	176
Depth with handles	390	Depth	353

19" conversion kit . . . . . on request at factory

Weight
PFG-1 . . . . . approx. 8 kg
PFM-1 . . . . . approx. 9 kg

1) EUROCOM Interface

Ordering Information

Bit Error Measuring Setup PF-1, comprising: **Pattern Generator PFG-1** **BN 670/..**
Bit Error Meter PFM-1 **BN 671/..**

Bit rates in kbit/s			Line codes		Impedance		Order No.
1536, 2048, 8448	256, 512, 576, 1024, 1152, 2048	1544, 6312	coax.: NRZ, RZ, AMI (1/1), AMI (1/2), HDB3 bal.: AMI (1/1), AMI (1/2), HDB3	coax.: NRZ, RZ AMI (1/1), AMI (1/2), B6ZS bal.: AMI (1/1), AMI (1/2), B6ZS	75 Ω coax. bal.: 120/130 Ω	75 Ω coax. bal.: 100/110 Ω	PFG-1 PFM-1
■			■		■		BN 670/01 BN 671/01
	■ [1]		■		■		BN 670/81 BN 671/81
		■		■		■	BN 670/04 BN 671/04
		■	■		■		BN 670/02 BN 671/02

Option (at extra cost)
Programmable digital word and 17/15 bit pattern [2] BN 670/00.15
(one card each for PFG-1 and PFM-1)

Accessories (at extra cost)
Remote control cable (for controlling the PFG-1 from the PFM-1) K 432
Remote control cable and adjustment device for Digital Word PFF-1 [3] BN 670/00.14
Transport Protective Cover DE-13 (one each for PFG-1 and PFM-1) BN 476/00.10

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adaptor. For other adaptor types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.
1) PFG-1 with EUROCOM Interface
2) Not applicable in PFG-1, BN 670/04 and PFM-1, BN 671/04
3) When plug-in card BN 670/00.15 is used in the PFG-1 and PFM-1, the "digital word" can be externally programmed, besides the PFG-1 can be controlled from the PFM-1; control cable K 432 is not needed.

PFT-1
Digital Error Detector

for measuring the code error ratio of digital communications systems



- **Measures the code error ratio and counts errors**
- **Detects violations of the encoding laws for AMI and HDB-3 codes**
- **Bit rates to 8.5 Mbit/s**
- **Measures on systems actually carrying traffic**
- **A.C. line-free with integral batteries**

Applications

A simple method for monitoring digital transmission circuits is presented by examining the bit flow for violations of the encoding law. Therewith, the number of violations is counted or is given as the ratio of code errors to the total number of transmitted bits. The pseudo-ternary codes enable an especially simple detection of violations and also offer the possibility of measuring on systems actually carrying traffic.
When compared to the classical method of measuring the error ratio, there is practically no difference in measurement accuracy. Thus, for instance, with the PFT-1 used for a pseudo-random, AMI coded signal, the obtained results deviate less than 2% from the true value for error ratios $<10^{-3}$.

Characteristics

The Digital Error Detector PFT-1 is suitable both for measuring code error ratios and for counting errors. When measuring the error ratio, an internal time base is so chosen that the display is referred to 10^7 bits. In order to correctly measure very small code error ratios, an absolute error count can be executed. Beginning and end of the count are selectable through START-STOP push-buttons or with an internal short COUNT TIME clock.
Additionally a separate input permits PULSE COUNT. By this means, TTL level pulses to 8.5×10^6 pulses/s can be counted.
On systems actually carrying traffic, the PFT-1 can be connected through Test Probe TKD-1 to the system. The connection is accomplished at the output of a regenerator.

Error ratio	
Display range	1×10^{-7} to 9×10^{-3}
Error count	
Display range	99999
Pulse counting rate	8.5×10^6 p.p.s.

2607 PFT-1

Specifications of the Digital Error Detector — PFT-1

When not otherwise noted, the specified values are valid under any instrument settings within the rated ranges of use for a.c. line voltage, a.c. line frequency and ambient temperature.

Input signal

Bit rate . . . . . 1536, 1544, 2048, 3152, 8448 kbit/s
Max. permissible deviation from the rated values of the bit rates . . . . . ±2%
Line codes . . . . . AMI or HDB-3
Pulse shape . . . . . half bit or half sinusoidal
Sampling . . . . . at pulse center

Error detection

AMI:
A pulse is counted as an error when preceded by a pulse of the same polarity (bipolar violation)
HDB-3:
Two consecutive violations and each additional bipolar violation of the same polarity represent an error. Violations are not counted as long as they change in polarity.

Inputs for digital signals

Input unbalanced
Input impedance . . . . . 75 Ω

Input balanced
Input impedance . . . . . 120 and 130 Ω
Max. permissible d.c. to ground (chassis) . . . . . 120 V

Input voltage range (switchable)
"normal" . . . . . 300 mV to 3 V
"sensitive" . . . . . 30 to 300 mV
Max. permissible r.m.s. value of input voltage . . . . . 4 V

Display and evaluation

Readout with ERROR COUNTING
Max. counter capacity 99 999
Max. counting speed . . . . . 8.5×10^6 bit/s

Readout of ERROR RATIO
One digit, read with presentation of exponents
Display range . . . . . 1×10^{-7} to 9×10^{-3}

Pen recorder output
Source impedance . . . . . approx. 5 kΩ
Output voltage (decadic steps corresponding to the measured result) . . . . . 0, 1, to 5 V

Input for pulse counting

Coaxial input for signals with . . . . . TTL voltage
Specifications as with ERROR COUNTING

General Specifications

Power supply
A.C. line operation
Rated range of use for a.c. line voltage (automatic change-over) . . . . . from 96 to 262 V
Rated range of use for a.c. line frequency . . . . . 45 to 66 Hz
Power consumption (dependent on a.c. line voltage) . . . . . approx. 10 to 20 VA
Safety class according to IEC 348 and VDE 0411 . . . Class I

Internal battery operation
Internal batteries (only with Option BN 648/00.01) are charged during a.c. operation
Battery type . . . . . 8 SAFT NiCad cells VR 4 D
Rated voltage . . . . . 9.6 V
Voltage range . . . . . 9 to 10 V
Battery check . . . . . with panel meter
Charging time . . . . . ≦20 h
Operating time during max. 5 hours use of digital display . . . . . ≧10 h

External battery operation
When PFT-1 is connected to external batteries, the internal batteries are switched off. The PFT-1 is protected against reversed polarity connection and over-voltage
Voltage range . . . . . +9 to +25 V
Current drain at +12 V, external battery . . . . . approx. 600 mA
Max. permissible external battery voltage . . . . . +30 V

Permissible ambient temperature
Rated range of use
A.C. line operation . . . . . 0 to +40°C
Internal battery operation . . . . . 0 to +50°C
External battery operation . . . . . 0 to +55°C

Storage and transport
without batteries . . . . . −40 to +70°C
with batteries . . . . . −40 to +60°C

Equipment dimensions (in mm)

	Without Transport Protective Cover	With Transport Protective Cover
Width	240	250
Height	150	150
Depth	345	410

Weight (without batteries) . . . . . approx. 5 kg
Weight (with batteries) . . . . . approx. 6.5 kg

Ordering Information

Digital Error Detector PFT-1 * — **BN 648/01**
(without batteries) 1536, 2048, 8448 kbit/s

Digital Error Detector PFT-1 * — **BN 648/04**
(without batteries) 1544, 3152, 2048 kbit/s

Option (at extra cost)
Battery set — BN 648/00.01

Accessories (at extra cost)
Test Probe TKD-1 (balanced) [1] — BN 882/01
48 kbit/s to 8508 kbit/s

Test Probe TK-9 (unbalanced) [1] — BN 265/00
50 kHz to 18.6 MHz

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.
1) For additional specifications, see Specification Sheet, "Measurement Accessories"

PF-2
Bit Error Ratio Measuring Set

for measuring the bit- and code-error ratios on PCM 10, PCM 30 and PCM 120 Systems



- **Measurement of the bit- and code-error ratios, total error count**
- **Pseudo-random test patterns and freely programmable digital character signal (word)**
- **Results printed out for permanent record**
- **Error counting in time interval set by timer**

Applications

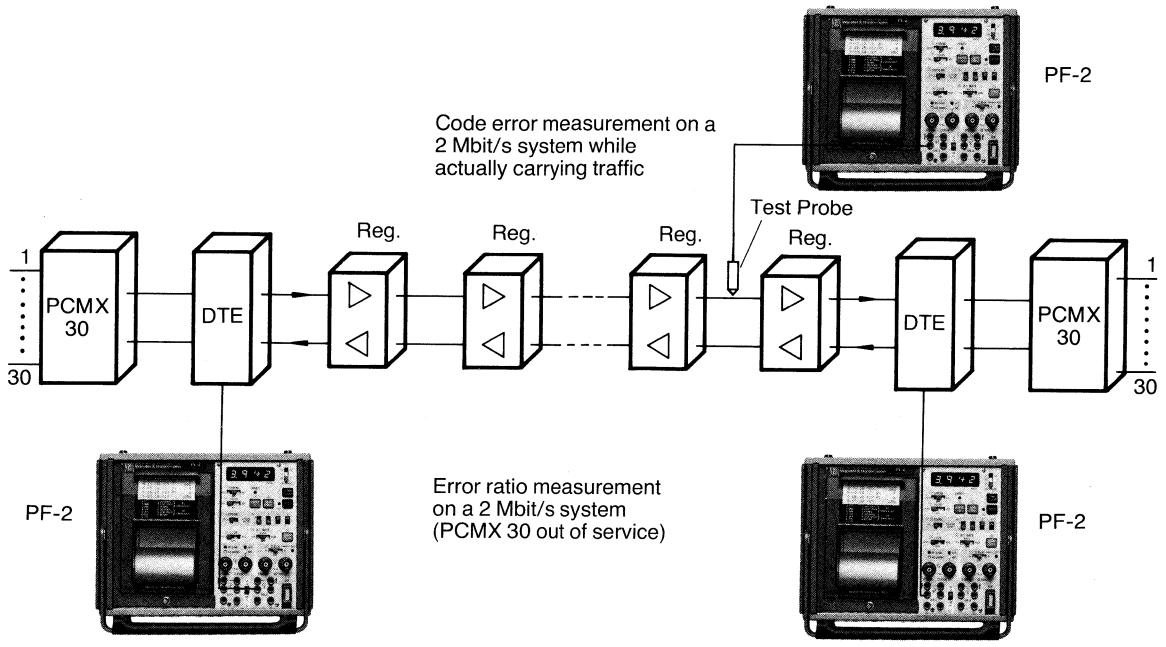
One of the most important objective measures for assessing the quality of digital communications circuits is the bit error ratio. For that reason, a measuring set for the bit error ratio is an indispensable tool when commissioning, monitoring, and servicing digital communications systems.
Another important feature is the capability for formatted printout of the measured results obtained during long-term monitoring periods; e.g. over-night, without the requirement that operating personnel be in attendance.
Further requirements necessitate that a measurement set used for in-service testing must have small dimensions and must be easy to operate.

Characteristics

The PF-2 Bit Error Ratio Measuring Set fulfills the requirements in an ideal manner. It is compact and incorporates a pattern generator, a means of error evaluation, and a printer, all in one enclosure. It permits the measurement of bit- and code-error ratios of HDB-3 or AMI coded signals.

An external error input facilitates the recording of error signals originating in system monitoring equipment, whereby it allows the narrowest acquirable pulse width of 14 ns, and also error pulses from 34 Mbit/s systems can be counted.
A crystal accurate time-clock permits measurements made over preselected time intervals. At the end of the measuring time interval the results are presented in a formatted printout that documents the measured results or the impairment printout along with the real time of the event's occurrence. Thus, the relationship between the appearance of an error and a periodic impairment may be detected. Also, the time of an a.c. line drop-out is recorded in the formatted printout.
The acquiring of code errors while a system is actually carrying traffic is illustrated by the example on the following page: the PF-2 is connected to the system via a Test Probe (the TKD-1 for instance). The multiplex equipment is disconnected during the error ratio measurement. At the each side, the PF-2 is connected to the circuit terminal equipment or also at the receive side, via a Test Probe.

Bit rates	704, 2048 and 8448 kbit/s
External clock frequency range	48 to 8500 kHz
Line codes	NRZ, RZ, AMI and HDB-3
Display ranges:	
Error count	0 to 9.9×10^5 errors
Error ratio	0×10^{-7} to 9.9×10^{-2}
Time intervals	1 to 99 s, min, or h



Code error and error ratio measurement on a 2 Mbit/s system

Specifications of Bit Error Ratio Measuring Set — PF-2

Unless otherwise noted the specified values are valid for any instrument settings within the rated ranges of use for a.c. line voltage, a.c. line frequency and ambient temperature.

Send Section

Bit rate

Internal clock generator
Settable bit rates . . . . . 704, 2048 and 8448 kbit/s
Variations of △f/f, switchable in three steps
at 704 and 2048 kbit/s . . . . . $+50 \times 10^{-6}$/CAL/-50×10^{-6}
at 8448 kbit/s . . . . . $+30 \times 10^{-6}$/CAL/-30×10^{-6}

External clock input (back panel)
Clock frequency range . . . . . 48 to 8500 kHz
Input impedance . . . . . 75 Ω
Input voltage V_{pp} required
sinusoidal or rectangular . . . . . 1 to 4 V

Pulse Pattern

Pseudo-random sequence . . . . . 2^{15}-1
(complies with CCITT Rec. O.151)

Periodic bit sequence
Freely programmable digital character signal . . . 4 bits long

Error injection
One error injected into coded signal by one push on button

Trigger output
1 trigger pulse per pseudo-random sequence
1 trigger pulse for every fourth character signal of the freely programmable digital character signal

Outputs for digital signal and clock

General interface conditions comply with CCITT Rec. G.703
Output pulse shape . . . . . rectangular

Coaxial outputs*
Digital line codes . . . . . NRZ or RZ, AMI, HDB-3
Output impedance . . . . . 75 Ω
Pulse amplitude when terminated with 75 Ω . . . 2.37 V ± 1 %

Balanced outputs
Digital line codes . . . . . AMI, HDB-3
Bit rate . . . . . 500 to 2100 kbit/s
Output impedance . . . . . 120 Ω
Pulse amplitude when terminated with 120 Ω . . . 3 V ± 10 %

Receive Section

Bit rate

Internal clock regenerator
for the bit rates . . . . . 704, 2048 and 8448 kbit/s

Pulse pattern

Pseudo-random sequence . . . . . 2^{15}-1

Periodic bit sequences
Freely programmable digital character signal . . . 4 bits long
AIS or OUT OF SYNC indicated by LED

Inputs for digital signal and clock

Clock inputs
Input voltage range, V_{pp} . . . . . 1 to 4 V
Mark/space ratio (pulse duration/period) 0.5
Evaluation resolderable for positive or negative clock transition

Coaxial input*
Clock frequency range . . . . . 48 to 8500 kHz
Input impedance . . . . . 75 Ω

Balanced input
Clock frequency range . . . . . 500 to 2100 kHz
Input impedance (nominal value) . . . . . 120 Ω

Digital signal inputs
Pulse amplitude required . . . . . 30 mV to 4 V

Coaxial input*
Bit rate . . . . . 48 to 8500 kbit/s
Line codes . . . . . RZ, NRZ, AMI, HDB-3
Input impedance . . . . . 75 Ω

Balanced input
Bit rate . . . . . 500 to 2100 kbit/s
Line codes . . . . . AMI, HDB-3
Input impedance (nominal value) . . . . . 120 Ω
NO SIGNAL indicated by LED

Error evaluation

Bit error evaluation . . . . . for the pulse patterns settable on the PF-2

Code error evaluation . . . . for any pattern with a max. zero sequence of ≦ 15 zeroes

External error evaluation . . . . . see "Error input"

Error ratio
Evaluation interval . . . . . 10^7 bits

Error count
Manually through Start and Stop pushbutton or through interval pulser from Timer
Errors indicated by LED

Auxiliary inputs and outputs (back panel)

Error output
One pulse at 0.5 bit width per bit error

Error input
Max. count frequency when operated as error input . 8.5 MHz
Min. pulse width required . . . . . 14 ns

Display
Measured result shown on 3 digit LED display

Display range
Error ratio . . . . . 0×10^{-7} to 9.9×10^{-2}
Error count < 100 errors . . . . . 0 to 99
≧ 100 errors . . . . . 1.0×10^2 to 9.9×10^5
Indicator for "overflow"

Printer

Result range
Error ratio . . . . . 0×10^{-7} to 9.99×10^{-3}
Error count . . . . . 0 to 99 999

Print sequence
Error ratio
The printout interval is determined through the observed bit count (10^7). The switched in printer inhibit prevents printout if no errors are present.

Error count
Printout in time interval with automatic reset of the error counter after every printout. Printout "in between" with OUT OF SYNC. or NO SIGNAL is a max. of one time per interval, without error counter resetting.
The switchable printout inhibit prevents printout if no error occurs in the time interval.

Timer
Real-time clock with crystal accuracy and trickle-charged standby battery
Number of days . . . . . 0 to 6 days
Days, hours and minutes . . . . . manually settable through thumbwheel switches
Interval adjustable for error count . . . . . 1 to 99 s, min, or h

General Specifications

Power supply
Rated ranges of use for a.c. line voltage, selectable . . . . . 110/117/127/220/227/237 V
Rated range of use for a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption . . . . . max. 117 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class 1

EMI/RFI Suppression
Suppression to the general certification DBP No. 345/1952 and No. 647/1961
Output section EMI/RFI suppressed to the general certification DBP No. 529/1970

Tolerable ambient temperature
Rated range of use . . . . . +5 to +40° C
Storage and transport . . . . . −40 to +70° C

Dimensions in mm

Bench model		½19" Rack mounting (DIN 41 494)	
Width with handles	214	Width	222
Height overall	199	Height (4 units)	176
Depth with handles	415	Depth	370

19" conversion kit . . . . . on request at factory
Weight . . . . . approx. 11.5 kg

Ordering Information

Bit Error Ratio Measuring Set PF-2* with timer and strip printer	**BN 909/02**
Accessories (at extra cost):	
Recording paper	BN 861/00.03
Test Probe TKD-1* [1]	BN 882/01
Transport Protective Cover for front and back panels SD-45	BN 900/00.24

1) For specifications, see "Measurement Accessory Specification Leaflet"
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

PJG-1
Jitter Generator

for testing PCM equipment and digital communications systems



- **Superimposes precisely defined jitter on clock and digital signals**
- **Complies with CCITT Recs. O.151 and O.171**
- **Jitter modulates a looped-through clock or digital signal**
- **Internal and external modulation**
- **$2^{15}-1$ ($20^{20}-1$) bits pseudo-random sequence**
- **Bit rates of 2048/8448, 1544/3152 or 1544/6312 kbit/s**

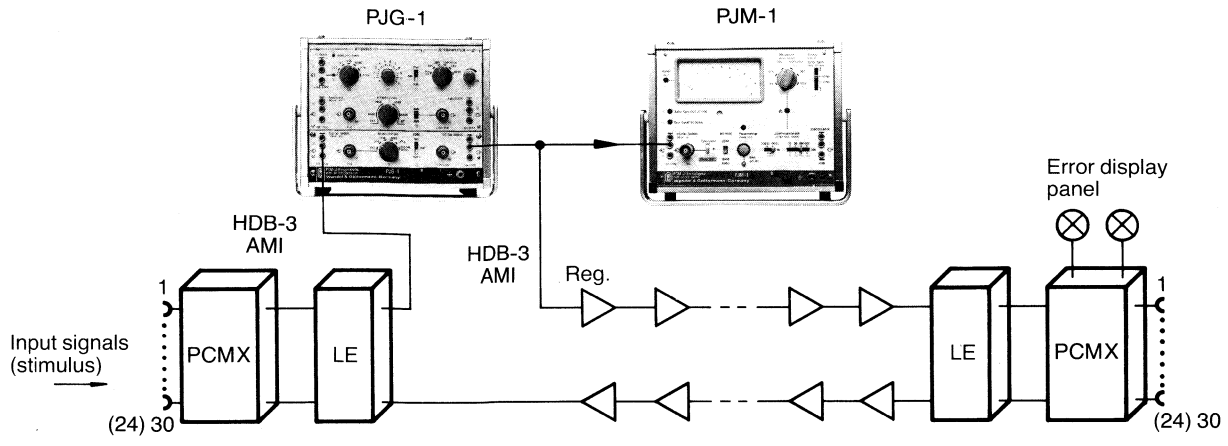
Applications

The error ratio is a fundamental measurement of transmission quality. Jitter is a major cause of errors on long-haul digital transmission circuits. A precisely defined jittered digital signal is required to examine the jitter behaviour of digital communications equipment such as multiplexers, regenerators or multisection digital transmission paths which have several regenerators.
In this case, the most important parameters are tolerable jitter, the jitter transfer function and the intrinsic jitter of the item under test.
These parameters can be measured with the PJG-1 Jitter Generator, an error rate meter, and a jitter meter.
Another interesting feature of the PJG-1 is the facility for jitter-modulating a looped-through signal.
A jitter-free bit stream is fed into the PJG-1, the loop-through jitter device introduces precisely defined jitter, and the signal is output in the same code as the input signal.
The device is code-transparent and can, therefore, be inserted between system interfaces. This means that the tolerable jitter for a digital transmission path can be measured under operating conditions. This test can be carried out during alignment, or during servicing.

Characteristics

The compact PJG-1 contains a pattern generator, a clock modulator, and modulation signal generator which covers the range 1 Hz to 100 kHz. Either the internal modulation generator, or an external signal source can be used to produce modulation.
The PJG-1's bit-pattern section outputs a jittered digital signal which may come from the internal pattern generator or from an external signal generator. If no clock signal is available for the external digital signal, a PLL in the PJG-1 is used to derive the reference clock from the digital signal.
The diagram on next page shows how the PJG-1 is used to jitter modulate digital signals in the loop-through mode.
The jitter generator is looped in between the line terminating equipment (LE) and the first regenerator (Reg.) of a digital communications system. The PJG-1 is code transparent and PCM signals with full frame structure can be looped through. The system can, therefore, be aligned and maintained under real operating conditions.
To perform the measurement, merease the PJG-1's jitter amplitude until the error indicators on the receive side of the multiplexer are activated. The jitter amplitude, indicated by the *PJM-1 Jitter Meter* is a measure of the path's immunity to jitter at a particular frequency. The measured jitter amplitude can be plotted against frequency to give the tolerable jitter characteristics over a particular frequency range.

Internally generated bit pattern	$2^{15}-1$ bits ($2^{20}-1$ bits)
Periodic bit-sequences and programmable digital word	
Modulation signal, internal	1 Hz to 100 kHz
external	0 Hz to 400 kHz
Max. peak-to-peak jitter	20 UI



Measuring the tolerable jitter on a system carrying normal traffic

Specifications of Jitter Generator — PJG-1

Unless otherwise stated, the given values are valid for any device setting within the rated ranges of use for a.c. line voltage, a.c. line frequency, and ambient temperature. The values in brackets refer to 24-channel system versions.

The Jitter Generator is available in several versions with the following features:

Bit rates in kbit/s	2048 and 8448	1544 and 3152, 1544 and 6312
Line codes	NRZ, AMI, HDB-3	AMI-½, B6ZS
Internally-generated pseudo-random sequence, length	$2^{15}-1$ bits	$2^{20}-1$ bits
Periodic bit-sequences, selectable	...1111..., ...1010..., ...1000...	...1111..., ...1010... ...10000000...
Selectable 2 x 8-bit word	Internally programmable	—
Clock input, balanced	120/130 Ω	—
Clock output, unbalanced balanced	2.37 V ±10 % 120/130 Ω; ±3 V ±10 %	2.5 V ±10 % —
Digital-signal input, balanced	120/130 Ω	100/110 Ω
Digital-signal output, unbalanced balanced	2.37 V ±10 % 120/130 Ω; ±3 V ±10 %	2.5 V ±10 % compatible with DSX-1, DSX-2, DS-1C

Clock-jitter generator

Internal clock-generator
Bit rates . . . . . 2048/8448, 1544/3152, or 1544/6312 kbit/s
Error limits for internal bit rates . . . . . $\pm 30 \times 10^{-6}$

External clock-inputs
Clock frequencies . . . . . correspond to bit rates
Max. tolerance of external clock-frequency . . . . $\pm 100 \times 10^{-6}$
Input impedance, coaxial* . . . . . 75 Ω
balanced** . . . . . 120/130 Ω

Clock outputs
Input impedance, coaxial* . . . . . 75 Ω
balanced** . . . . . 120/130 Ω
Output voltage
Pulse shape . . . . . rectangular
Pulse amplitude, coaxial output, switchable, unipolar/bipolar . . . . . 2.37 (2.5) V ±10 %
balanced output . . . . . ±3 V ±10 %

Pattern generator

Internally generated bit pattern
Pseudo-random sequence conforming to CCITT Rec. O.151
Length . . . . . $2^{15}-1$ ($2^{20}-1$) bits

Periodic bit sequences
All "1" sequence . . . .1111...
Alternating "10" sequence . . . .1010...
Bit sequence . . . .1000...(...10000000...)
Internally programmable digital word with a maximum length of 16 bits
Internally programmable digital words (2 x 8 bits) with externally controllable electronic switchover**

External pattern-inputs
Either external clock, or clock can be derived internally from digital signal
Input impedance, coaxial* . . . . . 75 Ω
balanced . . . . . 120/130 (100/110) Ω
Line codes . . . . . NRZ, AMI, HDB-3 (AMI-½, B6ZS)

Digital signal outputs
Output impedance, coaxial * . . . . . 75 Ω
balanced . . . . . 120/130 (100/110) Ω

Output voltage

Bit rates in kbit/s	2048 and 8448	1544, 3152, 6312
Pulse amplitude Coaxial output Balanced output	2.37 V ±10 % ±3 V ±10 %	2.5 V ±10 % Compatible with DSX-1, DSX-2, DS-1C

Pulse shape . . . . . rectangular
Line codes . . . . . NRZ, AMI, HDB-3 (AMI-½, B6ZS)

Jitter ranges

Jitter amplitude
Range end-values . . . . . 10 %, 30 %, 1 bit, 3 bits, 10 bits
Fine adjustment with potentiometer

Jitter frequency range
Lower frequency limit of the modulator . . . . . 0 Hz
Upper frequency limit of the modulator
(depends on the jitter amplitude range and bit rate)

Jitter amplitude range Θ_{max}	Max. jitter frequency at			
	2048 kbit/s	8448 kbit/s	1544 kbit/s	6312 kbit/s
10 %, 30 %	400 kHz	400 kHz	120 kHz	200 kHz
100 % ≙ 1 bit	400 kHz	400 kHz	120 kHz	200 kHz
3 bits	8 kHz	30 kHz	8 kHz	30 kHz
10 bits	4 kHz	8 kHz	4 kHz	8 kHz

Modulation signal

Internal generator
Frequency range . . . . . 1 Hz to 100 kHz
Signal shape, selectable . . . . . sinusoidal, triangular or rectangular

External modulation input
Frequency range . . . . . 0 Hz to 400 kHz
Input impedance . . . . . 600 Ω
Input level for a jitter amplitude of 10 %, 30 %, 1 bit, 3 bits or 10 bits (jitter-range switch) for a sinusoidal signal . . . . . 0 dB
Modulation signal rectangular
Signal amplitude . . . . . ±1.095 V

Intrinsic jitter
Modulation off in the frequency range 20 Hz to 400 kHz

	R.M.S. value [in % of a bit]	Amplitude [in % of a bit]
For clock or digital signal 1111, 1010, 1000, (10000000)	≦0.1 %	≦0.2 %
For $2^{15}-1$, $(2^{20}-1)$ pattern	≦0.15 %	≦0.3 %

Error limits of output jitter
Modulation for clock and pattern jitter switched on, jitter amplitude potentiometer at "CAL"

In the frequency range 20 Hz to 400 kHz, taking into account the restrictions on the upper frequency limits shown in the table for jitter ranges with sinusoidal modulation . . . . . intrinsic jitter ±4 % of $\Theta_{max.}$

Max. intrinsic jitter for clock or the patterns 1111, 1010, 1000, $2^{15}-1$ (10000000, $2^{20}-1$) with modulator switched on:

Jitter amplitude range Θ_{max}	R.M.S. value [in % of a bit]	Amplitude [in % of a bit]
10 %, 30 %	0.15 %	0.3 %
1 bit, 3 bits, 10 bits	0.2 % +0.2 % $\frac{\Theta_{max}}{bit}$	0.5 % +0.7 % $\frac{\Theta_{max}}{bit}$

Jitter frequency-response
Error limits of the generated jitter, at constant jitter amplitude setting, referred to the value at 1 kHz in the frequency range corresponding to the values shown in
jitter range table . . . . . ±2 % of reading

With the additional proviso that the upper frequency limit is restricted to 100 kHz,
and the lower to 20 Hz . . . . . ±1 % of reading

General Specifications

Power supply
Rated ranges of use for a.c. line voltage,
selectable . . . 110/117/127/220/227/237 V, −12 to +10 %
Rated range of use for a.c. line frequency . . . . . 45 to 66 Hz
Power consumption . . . . . approx. 60 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature
Rated range of use . . . . . +5°C to +40°C
Storage and transportation . . . . . −40°C to +70°C

Dimensions (w x h x d) in mm . . . . . 233 x 199 x 390

Weight . . . . . approx. 9 kg

Ordering Information

30-channel system version:
Jitter Generator PJG-1 **BN 866/05**
for bit rates 2048/8448 kbit/s

24-channel system versions:
Jitter Generator PJG-1 **BN 9866/03**
for bit rates 1544/3152 kbit/s

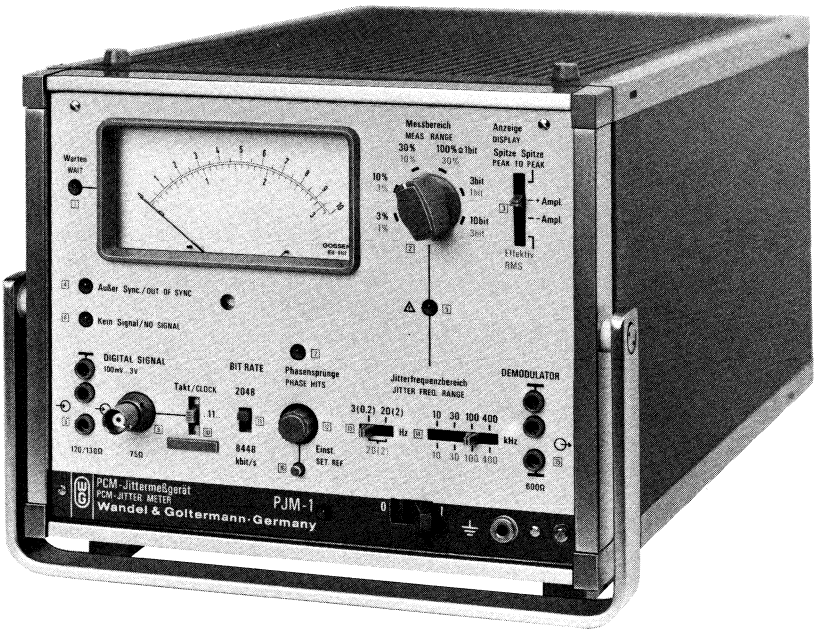
Jitter Generator PJG-1 **BN 9866/02**
for bit rates 1544/6312 kbit/s

Accessories (at extra cost)
Protective Transportation Cover DE-13 BN 476/00.10

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.
** 30-channel system version
1) 1 bit ≙ 100 % ≙ 1 UI (unit interval$_{peak}$) ≙ 2 UI$_{peak\text{-}to\text{-}peak}$

PJM-1
Jitter Meter

for measuring jitter on PCM subassemblies and digital communications systems



- **Jitter measurements, as per CCITT Rec. O.171, on clock signals and signals with any bit-pattern**
- **Bit rates of 2048/8448, 1544/3152 or 1544/6312 kbit/s**
- **The amplitude of the jitter, its peak-to-peak value or its r.m.s. value are displayed**
- **Adjustable threshold for phase hits**

Applications

The quality of a digital communications section is largely determined by the extent to which the regeneration of the signal in the section regenerators is error-free. The ability of the regenerator to regenerate correct signal levels is affected both by fluctuations in the amplitude of the incoming signal (imperfect equalization, crosstalk) and phase jitter.
The jitter produced in regenerators is due to noise, crosstalk, and the transmitted pulse pattern itself (systematic pattern jitter). Jitter is also caused by the insertion of stuffing bits when group frames of higher order are formed.
The jitter which arises in a system is not entirely suppressed in the regenerators. This means that there is an accumulation of jitter which limits the number of regenerators which can be connected together in tandem, and consequently the length of the section. Moreover, the tolerable jitter amplitude determines the dimensioning of the input buffer memories of digital switches and digital multiplexers in higher-order PCM systems.
Using the PJM-1, PCM-subassembly and system jitter can be measured at bit rates of 2048/8448, 1544/3152 or 6312 kbit/s.

Characteristics

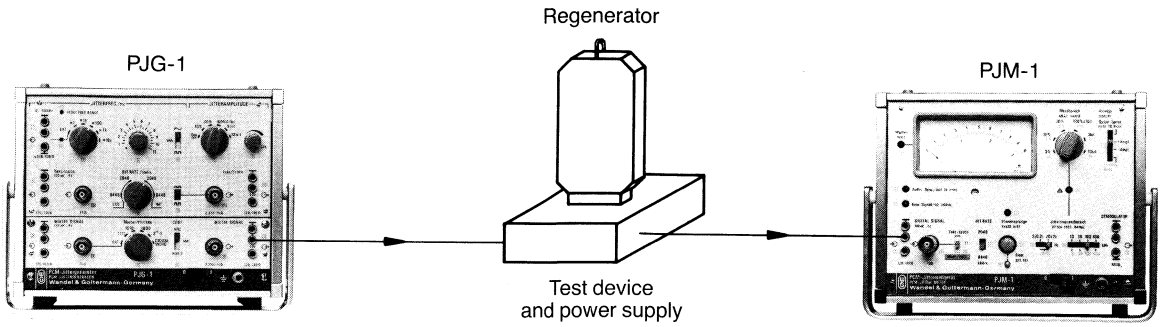
The PJM-1 can be used for both loop-back and end-to-end measurements. The jitter-free reference signal which is required for phase comparison is derived from the input signal. The PJM-1 has the following facilities for displaying and evaluating jitter measurements:

- Positive or negative jitter amplitude up to 10 I_p
- Peak-to-peak jitter values up to 10 UI_{p-p}
- R.M.S. jitter up to 3 $UI_{r.m.s.}$

Using the built-in pattern-clock converter, the jitter on any digital signal can be measured.
The PJM-1 has a continuously adjustable threshold for investigating phase hits. If the demodulated jitter transgresses this threshold, a TTL pulse appears at an output for the duration of the transgression.
The above example shows how to determine the jitter transfer function of a regenerator.

Jitter measurement ranges . . 3 % to 100 % ≅ 1 bit [1], 3 bits, 10 bits
Jitter frequency range . . . . . 3 (20) Hz to 400 kHz
Demodulator output for spectral analysis of jitter
Output for phase hits

1) 1 bit ≅ 100 % ≅ 1 UI

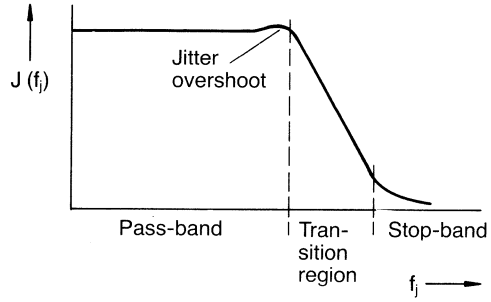


Measuring the jitter transfer function of a regenerator

The jitter transfer function is determined by increasing the jitter frequency on the jitter generator, while keeping the input jitter to the item-under-test constant, and measuring the output jitter amplitude on the PJM-1.

Distinctive regions of the jitter transfer function
Pass-band:
The jitter amplitude of the input signal is equal to that of the output signal. Regenerators are immune to lower frequency jitter, and let it pass without much modification.

Stop-band:
There is a reduction in jitter. Only the intrinsic jitter of the regenerator remains.



Jitter transfer function of a regenerator

Specifications of the Jitter Meter — PJM-1

Unless otherwise stated, the specified values are valid in the rated ranges of use of the a.c. line voltage, a.c. line frequency and ambient temperature. The values in brackets refer to 24-channel system versions.

Input signal

Bit rate, switchable . . . . . 2048/8448, 1544/3152 or 1544/6312 kbit/s
Max. bit-rate error limits . . . . . $\pm 100 \times 10^{-6}$
Evaluable pulse patterns, switchable . . . . . clock, ... 1111 ..., pulse pattern

Digital signal inputs

Balanced input . . . . . floating, 3 pole CF connector
BN 9850/02, BN 9850/03: fem. conn. for WECO 310 male connector
Input impedance . . . . . 120/130 Ω (100/110 Ω)

Coaxial input* . . . . . Versacon® 9 universal connector system for all commercially available connectors
Input impedance . . . . . 75 Ω

Input voltage
Necessary pulse amplitude range for sinusoidal and rectangular signals . . . . . 100 mV to 3 V
Max. input voltage $V_{r.m.s.}$ . . . . . 4 V

Measurement ranges

Jitter measurement range[1)]
Measurement ranges (f.s.d.) for amplitude or peak-to-peak display mode:
3 %, 10 %, 30 %, 100 % ≅ 1 bit, 3 bits, 10 bits

R.M.S. display:
1 %, 3 %, 10 %, 30 %, 100 % ≅ 1 bit, 3 bits

Max. peak factor for r.m.s. measurements and f.s.d.
over range 1 %, 3 % 5
over range 10 % to 3 bits 3.2

Jitter frequency range
Lower frequency limit in amplitude or peak-to-peak display mode:

for the stated error limits	3 dB roll-off
3 Hz or 20 Hz	0.2 Hz/2 Hz

R.M.S. display mode:

for the stated error limits	3 dB roll-off
20 Hz	2 Hz

Upper frequency limit (depends on jitter range and bit rate used)

Jitter-measurement range		Maximum upper frequency limit (kHz) for the stated error limits					
Peak-to-peak amplitude	R.M.S.	2048 kbit/s	8448 kbit/s	1544 kbit/s	3152 kbit/s	1544 kbit/s	6312 kbit/s
3 %, 10 %, 30 % of a bit	1 %, 3 %, 10 % of a bit	400	400	120	120	200	200
100 % ≙ 1 bit [1]	30 %	100	400	45	120	60	200
3 bits	100 % ≙ 1 bit [1]	30	100	15	45	20	60
10 bits	3 bits	10	30	6	15	6	20

Jitter display
selectable . . . . . positive amplitude, negative amplitude, peak-to-peak, r.m.s.

Error limits of displayed jitter
after a warm-up time >5 minutes, the jitter frequencies stated under "jitter frequency range" are not transgressed, clock jitter measurements, the ... 1111 ... pattern, or measurements on the patterns ... 1111 ..., ... 1010 ..., ... 100100 ..., ... 1000 ..., or $2^{15}-1$ ($2^{20}-1$) using the pattern clock converter:

Intrinsic jitter % of a bit	Error on measured value	Error on end value
See following Table	±4 % of reading	±1.5 % f.s.d.

Max. intrinsic jitter as functions of pattern and jitter reading:

Pattern		Jitter reading	Intrinsic jitter (% of a bit) f_L = 20 (2) Hz	f_L = 3 (0.2) Hz
Clock or ... 1111 ...		Amplitude	−0/+0.2 %	−0/+0.8 %
		Peak-to-peak	−0/+0.4 %	−0/+1.6 %
		R.M.S. [2]	−0/+0.1 %	—
Via Pattern-Clock -Converter ... 1111 ... ... 1010 ... ... 100100 ... ... 1000 ...		Amplitude	−0/+0.3 %	−0/+0.8 %
		Peak-to-peak	−0/+0.5 %	−0/+1.6 %
		R.M.S. [2]	−0/+0.2 %	—
$2^{15}-1$	2048 kbit/s	Amplitude R.M.S. [2]	−0/+1.0 % −0/+0.4 %	−0/+1.5 % −0/+0.2 %
	8448 kbit/s	Amplitude R.M.S. [2]	−0/+1.3 % −0/+0.4 %	−0/+1.8 % −0/+0.2 %
$2^{20}-1$	1544 kbit/s	Amplitude R.M.S. [2]	−0/+0.8 % −0/+0.3 %	−0/+1.3 % —
	3152 kbit/s	Amplitude R.M.S. [2]	−0/+1.0 % −0/+0.4 %	−0/+1.5 % —
	6312 kbit/s	Amplitude R.M.S. [2]	−0/+1.3 % −0/+0.4 %	−0/+1.8 % —

Jitter frequency response
Error limits of displayed jitter at constant jitter amplitude referred to the value at 1 kHz within the frequency range given under "jitter frequency range" . . . . . ±2 % of reading

when the upper frequency limit is restricted to 100 kHz and the lower frequency limit to 30 Hz . . . . . ±1 % of reading

Additional inputs and outputs

Connection for external filter
for externally filtering demodulated jitter
Input and output impedance . . . . . 600 Ω

Demodulator output . . . . . 3 pole CF connector
BN 9850/02, BN 9850/03 . . . . . BNC connector
Jitter output for spectrum analysis, external r.m.s. measurements on jitter, or measurements using sweep measuring setups
Output impedance . . . . . 600 Ω

D.C. output
Output impedance . . . . . 5 kΩ ±5 %
Open-circuit voltage for f.s.d. . . . . +5 V ±5 %

Reference frequency output*
Output for the jitter-free reference frequency from the PLL

Output for phase hits*
Threshold can be adjusted using the meter
Pulse output . . . . . pulse is present for the duration of the threshold transgression

General Specifications

Power supply
Rated ranges of use for a.c. line voltage, selectable . . . . 110/117/127/220/227/237 V, −12 to +10 %
Rated range of use for a.c. line frequency . . . . . 45 to 66 Hz
Power consumption . . . . . approx. 56 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature ranges
Rated range of use . . . . . +5 °C to +40 °C
Storage and transportation . . . . . −40 °C to +70 °C

Dimensions (w×h×d) in mm . . . . . 233×199×390

Weight . . . . . approx. 9 kg

Ordering Information

Jitter Meter PJM-1 **BN 850/05**
for bit rates 2048 and 8448 kbit/s

Jitter Meter PJM-1 **BN 9850/03**
for bit rates 1544 and 3152 kbit/s

Jitter Meter PJM-1 **BN 9850/02**
for bit rates 1544 and 6312 kbit/s

Accessories (at extra cost)
Test Probe, TKD-1 [3]* BN 882/01
Protective Transportation Cover DE-13 BN 476/00.10

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.
1) 1 bit ≙ 1 UI (Unit Interval)
2) For readings greater than 1/5 f.s.d. (intrinsic jitter and the jitter which is to be measured add vectorially)
3) See Measuring Accessories data sheet for specifications

PF-3/PF-4
Bit Error Measuring Sets

for measuring bit, block and code errors to 34/140 Mbit/s

IEEE 488
IEC 625

Error analysis to CCITT Rec. G.821



- **Patterns: pseudo-random sequences and freely programmable, abbreviable digital word**
- **New method of synchronization for pseudo-random sequences. No sync-loss with error bursts of any length**
- **Measurement of bit, block, code and external errors**
- **Error ratio measurements or error count in time intervals**
- **Results evaluated according to error thresholds, error increment, and error-free intervals**

Applications

The bit error ratio is an extremely important characteristic used for the assessment of digital transmission system quality. External or internal impairments can influence the digital line signal in a manner that receive-side errors appear as single bit errors or as complete bit-group errors. For the bit error measurement, a known pattern of the most possible random character is sent by a pattern generator. At the receive side, after the pattern has been conveyed to the receiver, a bit error meter is used to examine the received test pattern. By means of code error monitoring the measurement can also be performed while the system is actually carrying traffic.
The PF-3/PF-4 Bit Error Measuring Sets contain all devices needed for the aforementioned measuring tasks and are suitable for operational and maintenance measurements on 30 channel PCM systems of all the orders of hierarchy employed at the present time. When used in combination with the PFJ-4 Jitter Modulator, the PF-3/PF-4 produces jitter modulated digital signals.

Characteristics

The PF-3/PF-4 Bit Error Measuring Sets represent high performance measuring instruments for ascertaining bit, block, and code errors on PCM communications equipments. These compact instruments contain a pattern generator, an error measuring device, and if so ordered, a strip printer for recording the measured values.

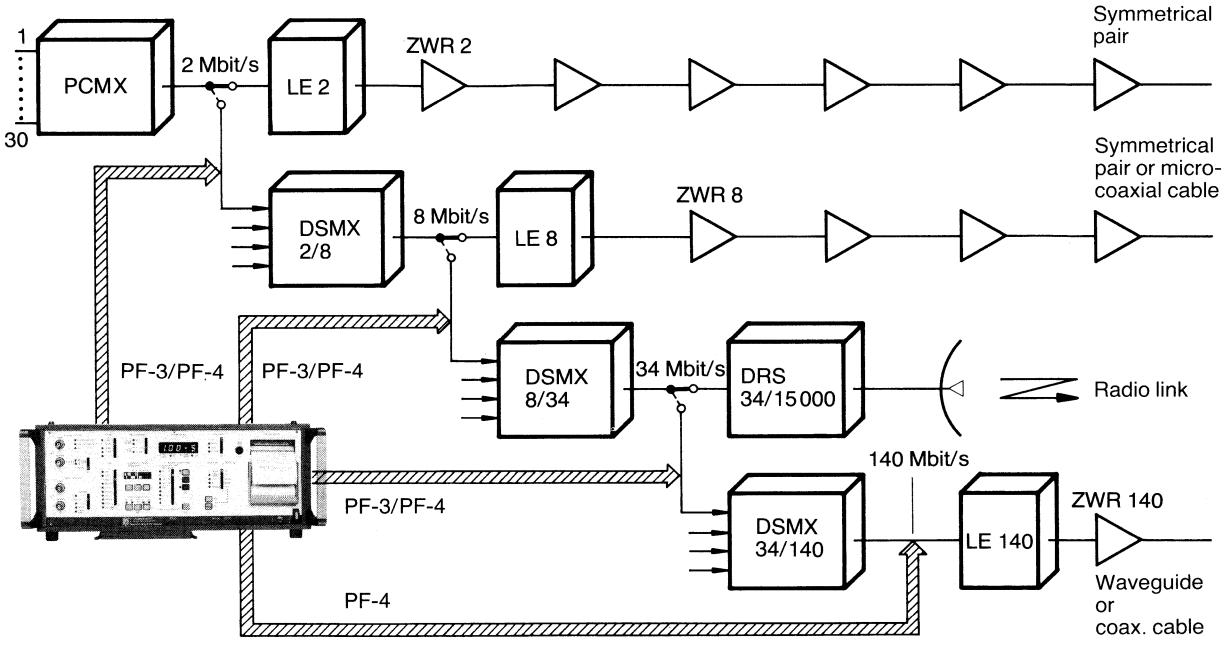
Pseudo-random sequences of length $2^{15}-1$ bits and $2^{23}-1$ bits are used as test patterns. Furthermore, a freely programmable digital word of 16 bits in length, capable of being shortened, and also a 2 x 8 bit word can be transmitted. Errors can be injected into all test patterns. Multiple facilities for setting the selected line code enable the PF-3/PF-4 to be matched to all standardized interfaces of the PCM system hierarchy and also to the usually used logic levels when measurements are carried out on system sub-assemblies. Differing codes can be set-up at the receiver and at the generator.
The Sets' inputs and outputs have been designed to comply with the general interface conditions specified in CCITT Recommendation G.703. The receiver input has a tracking amplitude threshold so that range switching is unnecessary. Internal clock recovery devices operate at all bit rates and with all codes.
If the clock is fed in from an external source, the PF-3/PF-4 operates in the range, 48 kbit/s to (50) 145 Mbit/s. The evaluation of bit and block errors results from the receive signal being compared bit-by-bit with a reference pattern. Also, a code error detector for CMI (PF-4 only), HDB-3, and AMI codes permits measurements on systems actually carrying traffic. The external error input processes error pulses that are at TTL or ECL levels. Error ratio measurements or else error counting over a wide range are possible.

Bit rates PF-3	704, 2048, 8448, 34368 kbit/s
PF-4 is same	plus 139264 kbit/s
Line codes	(CMI), HDB-3 complying with CCITT Rec. G.703; and AMI plus the NRZ and RZ binary codes

Measurement time evaluation after error-free intervals
1 s (error-free second), 0.1 s, 0.01 s
Error thresholds adjustable according to mantissa and exponent
Printout of a bar diagram for recording the totalized errors

The incorporated thermal printer (available as an Option) considerably extends the applications of the PF-3/PF-4, particularly for long-term monitoring without operational personnel. All important parameters like bit rate, code, pattern, measuring range, clock time and date are printed out. The printout can be made dependent, for example, on the exceeding of adjustable error thresholds. Evaluation is performable after error-free intervals (amongst others, error-free seconds). Likewise, impairments and their durations are recorded as hardcopy. Furthermore, a.c. power dropouts and their corresponding times are printed out and thereafter the PF-3/PF-4 is started again. Owing to the clock with calender and all instrument settings being powered by the stand-by battery, these functions remain operational even after a long pause in operating the PF-3/PF-4.
Erroneous settings of the PF-3/PF-4 are indicated.
Control inputs and outputs on the back panel provide for a great number of additional measuring facilities.
Balancing Transformer PFU-4 is available as an accessory for facilitating use of the PF-3/PF-4 on balanced system interfaces at the bit rates of 2048 and 704 kbit/s.

The clock signal amplitude of ±2.37 V across 75 Ω required with balanced interfaces is produced by a Clock Output Stage available as an Option for incorporation in the PF-3/PF-4.



Application of the PF-3/PF-4 at 4 levels of the 30 channel PCM system hierarchy

Specifications of the Bit Error Measuring Sets — PF-3/PF-4

Unless otherwise noted, the specified values are valid for any operating conditions and instrument settings within the rated ranges of use of the a.c. line voltage, a.c. line frequency, and ambient temperature.

Send Section

Bit rate

Internal clock generator
Adjustable bit rates: PF-3 . . . . 704, 2048, 8448, 34368 kbit/s
PF-4 is same . . . . . plus 139264 kbit/s

Variations of Δf/f, switchable in 3 steps
at 704 and 2048 kbit/s . . . . $+50 \times 10^{-6}$/CAL/-50×10^{-6}
at 8448 kbit/s . . . . . $+30 \times 10^{-6}$/CAL/-30×10^{-6}
at 34368 kbit/s . . . . . $+20 \times 10^{-6}$/CAL/-20×10^{-6}
at 139264 kbit/s (PF-4) . . . . $+15 \times 10^{-6}$/CAL/-15×10^{-6}

Error limits of bit rate (in CAL position)
704, 2048, and 8448 kbit/s . . . . . $\pm 10 \times 10^{-6}$
34368 and 139264 kbit/s . . . . . $\pm 5 \times 10^{-6}$

External clock input (back panel)
Clock frequency range PF-3 (PF-4) . . 48 kHz to 50 (145) MHz
Input impedance . . . . . 75 Ω

Input voltage V_p required
(sinusoidal or rectangular) . . . . . ±400 mV to ±1 V
Max. tolerable input voltage $V_{r.m.s.}$ . . . . . 4 V
Mark-space ratio (pulse duration/pulse period) 0.5

Pulse pattern

Two switch-selectable pseudo-random sequences of length $2^{15}-1$ and $2^{23}-1$ bits complying with CCITT Rec. O.151
Freely programmable digital word
Adjustable length . . . . . 1 to 16 bits
Switchable 2 x 8 bit words
Two 8 bit words, any possible setting and changed-over by an external control voltage

Control input
Input impedance . . . . . >10 kΩ
Control voltage . . . . . TTL level
or symm. alternating voltage
Peak voltage required
(sinusoidal or rectangular) . . . . . ±400 mV to ± 4 V

Error test
Injection of bit and code errors in the send pattern
CMI (PF-4): a "1" bit becomes a "0" bit
a "0" bit becomes a "1" bit (polarity as with preceding "1" bit)
HDB-3, AMI: a positive or negative "1" bit becomes a zero
a "0" bit is changed to a positive "1" bit
NRZ, RZ: bits are inverted

One time injection
1 error per depression of key

Error ratios can be produced as follows:
10^{-3}, 10^{-4}, 10^{-5}, and 10^{-6}

External error injection
By external control voltage via input on back panel **one** error is produced for each positive signal transition
Max. input frequency . . . . . 0.2 x bit rate

Digital signal output*
Output impedance . . . . . 75 Ω

Codes and output voltage
Selectable in common for generator and receiver
Switch on back panel permits separate settings

CMI and CMI/ECL
at 139264 kbit/s (PF-4 only)
CMI: corresponding to CCITT Rec. G.703
peak-to-peak voltage . . . . . 1 V ± 0.1 V
CMI/ECL . . . . . ECL level

HDB-3 corresponding to CCITT Rec. G.703, AMI
at 704, 2048, and 8448 kbit/s:
Pulse . . . . . 2.37 V ±0.237 V
No pulse . . . . . 0 V ±0.237 V

at 34368 kbit/s:
Pulse . . . . . 1 V ±0.1 V
No pulse . . . . . 0 V ±0.1 V

Internally switchable from HDB-3 to HDB-2 as well as half-bit and full-bit duration

"OFF"
Digital signal and clock switched off

NRZ/ECL and RZ/ECL
Level . . . . . ECL
HIGH state . . . . . −0.6 V to −0.9 V
LOW state . . . . . −1.7 V −2.0 V

NRZ/TTL and RZ/TTL
Level . . . . . TTL
HIGH state . . . . . +2.37 V
LOW state . . . . . 0 V

Clock output*

Output impedance . . . . . 75 Ω

Output voltage
NRZ/ECL, RZ/ECL, CMI/ECL . . . . . ECL level
HDB-3, AMI, NRZ/TTL, RZ/TTL . . . . . TTL level
CMI (peak-to-peak voltage) . . . . . 1 V ±0.1 V

Trigger output
Output impedance . . . . . 75 Ω

Receive Section

Bit rate

Internal clock recovery
for the bit rates produced in the Send Section
Pulling range limits of the clock regenerators . . . ±2.5 x 10^{-4}

External clock
Clock frequency range
PF-3 (PF-4) . . . . . 48 kHz to 50 (145) MHz
Sampling (switchable) at the positive or negative clock transition
For specifications, see "Clock input"

Pulse pattern
as with the Send Section, however, without the switchable 2 x 8 bit word

Digital signal input*

Codes and input voltages

CMI (PF-4 only)
Input peak voltage . . . . . ±50 mV [1] to ±4 V
Decision threshold . . . . . 0 V
CMI/ECL . . . . . ECL level

AMI and HDB-3
Input peak voltage . . . . . 50 mV to 4 V
Decision threshold . . . . . at 50 % of the input peak voltage

NRZ/ECL and RZ/ECL
Level . . . . . EC
HIGH state . . . . . −0.70 V to −1.16 V
LOW state . . . . . −1.48 V to −2.0 V

NRZ/TTL and RZ/TTL to 50 Mbit/s
Input peak voltage . . . . . 50 mV to 4 V
Decision threshold . . . . . at 50 % of the input peak voltage

Input impedance . . . . . 75 Ω
Reference voltage of the input impedance
AMI, HDB-3, CMI, NRZ/TTL and RZ/TTL 0
NRZ/ECL, RZ/ECL and CMI/ECL . . . . . −2

Clock input*
Input impedance . . . . . 75 Ω
Reference voltage and return loss as with digital signal input

Input voltage required
Mark-space ratio . . . . . 0.
ECL signals . . . . . ECL level

TTL, CMI, AMI and HDB-3 signals
Input peak-to-peak voltage . . . . . ±150 mV to ±8 V
Decision threshold . . . . . at 50 % of the input peak voltage

Additional outputs and input

Error output
for bit-, block-, or code-errors
Error pulse duration . . . . . 0.5 b

Error input
Max. counting frequency . . . . . 50 (145) MH
Min. tolerable pulse duration . . . . . 10 (3.4) n
Level, switch-selectable . . . . . ECL or TTL

Output for recovered clock
This output is for the bit clock derived within the PF-4

1) with signal ...000... ±80 mV

Error detection

Bit errors
for the pseudo-random sequences $2^{15}-1$ and $2^{23}-1$, and the freely programmable digital word

Block errors
with the pseudo-random sequences $2^{15}-1$ and $2^{23}-1$

Code errors
for the HDB-3, AMI, and CMI codes (PF-4 only)
Max. length of contiguous zeros
in a pattern with AMI . . . . . 23 bits

Indication
Indicator lamp ERROR lights with every bit-, block-, code-, or external-error . . . . . approx. 100 ms

Indicator lamp ⚠ lights during the measuring interval in the event of: no signal, AIS, out of sync., or a slip

Synchronization conditions

Indicator "OUT OF SYNC." with LED
Light illuminates for at least . . . . . 100 ms

Pseudo-random sequences
The synchronization procedure employed for the pseudo-random sequences permits measurements up to very high error ratios and also with long error bursts.
A new synchronization takes place only when the pattern at the input, although identical with the selected pattern, however, has been shifted in phase (LED, "SLIP")

Digital word
Mean error ratio for "OUT OF SYNC." . . . . . $>1 \times 10^{-1}$
or an uninterrupted error sequence of 128 bits (resolderable to 2048 bits)
New synchronization after approx. 100 error-free bits

Error evaluation and display

One-shot or repetitive measurements in all measurement modes

Error count
Counting range . . . . . 0 to 1.00×10^9
Display in range 0 to 99999 . . . . . 5 digits
10^5 to 1.00×10^9 . . . . . semi-logarithmic

␣ : symbol for "overflow" indication

Gate controlled by Start-Stop key
or by adjustable time interval . . . . . 1 s to 99 s
1 min to 99 min
1 h to 99 h
1 day to 99 days

Error ratio
Bit-, code-, and external-errors:
Evaluation switchable over 10^n bits . . . . . $n = 6, 7, 8, 9$
Display range . . . . . 0×10^{-n} to 1.00×10^0
Switchover for single or repetitive measurement(s)

Block errors (with $2^{15}-1$ and $2^{23}-1$):
Evaluation switchable over 10^m blocks . . . . . $m = 1, 2, 3, 4$
Display range . . . . . 0×10^{-m} to 1.00×10^0

Option

Printer, BN 911/00.01
Thermal printer with 20 characters per line

Presentation
Format of the result as with the display
Presentation as error count or error ratio

Parameters:
Date, real time, bit rate, pattern, code, mode
Measurement interval length, error-free or error afflicted Intervals (EFI: **E**RROR **F**REE **I**NTERVALS), error-free seconds, amongst others

Error count or error ratio as
Error Threshold (ETH: **E**RROR **TH**RES**H**OLD)
Error Increment (EI: **E**RROR **I**NCREMENT)

General Specifications

Power supply
Rated ranges of use of a.c. line voltage, selectable . . . . . 96.5 to 140 V, 193 to 261 V
Rated range of use of a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 220 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I
EMI/RFI suppression . . . . . corresponds to VDE 0871

Tolerable ambient temperature
Rated range of use . . . . . +5 to +40°C
Storage and transportation . . . . . −40 to +70°C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	199	Height (4 units)	175
Depth with handles	425	Depth	370

19" conversion kit . . . . . BN 700/00.04

Weight . . . . . approx. 17 kg

Ordering Information

Bit Error Measuring Set PF-3*	**BN 911/34**
PF-4*	**BN 911/01**
Options (at extra cost)	
Printer[1]	BN 911/00.01
Interface Bus <IEC 625> Card With the adaptor plug IEC 625/IEEE 488 (S 834)	BN 911/00.02
Clock Output Stage	BN 911/00.03
Accessories (at extra cost)	
Balancing Transformer PFU-4*	BN 911/00.10
Circuit Equalizer PFE-4*	BN 911/00.11
Test Probe TKD-1*[2]	BN 882/01
Recording paper for thermal printer	BN 888/00.02
Transport Protective Cover SD-4 (set)	BN 700/00.24

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.
1) Factory fitted only.
2) See specification sheet Measuring Accessories for more details.

A Specification Sheet with more details is available on request

PFJ-4
Jitter Modulator

for jitter generation up to 140 Mbit/s using the PF-4 Bit Error Measuring Set

IEEE 488
IEC 625



- **Generates selectable jittered digital signals via the PF-4 Bit Error Measuring Set**
- **Operates over a continuous frequency range spanning 1.5 to 45 MHz and 139.264 MHz when clocked externally**
- **CCITT Rec. O.171 is met or improved on**
- **Internal or external modulating signal**
- **Remote control via the <IEC 625>/IEEE 488 Interface Bus**

Applications

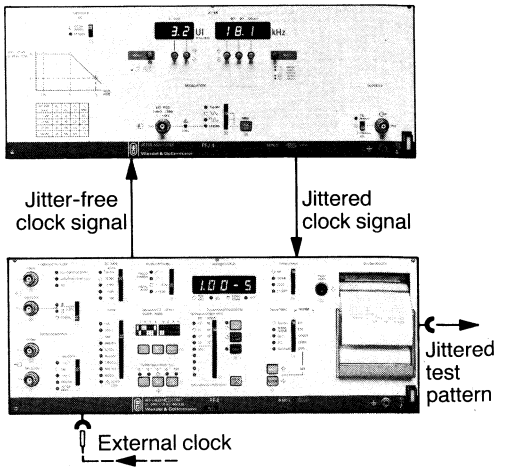
The PFJ-4/PF-4 combination provides a comprehensive jitter generator.
One way of using the jittered test-pattern from the PF-4 is measuring the tolerable jitter at the inputs of digital transmission equipment. The maximum permissible input jitter of the item under test can be measured as a function of jitter frequency.
The jitter frequency (at constant peak-to-peak jitter) is raised at the jitter generator until bit errors occur at the output of the item under test. The errors are detected by a bit error measuring set (e.g. PF-4). The peak value of the input jitter for this modulation signal setting is read from the Jitter Modulator and plotted against the frequency shown. The graph then shows the object under test's tolerable input jitter.

The determination of the jitter transfer function of an item under test, or the amount of jitter it causes when supplied with a jitter -free input signal, are also important measurement objectives which are being perfected at the moment.

Characteristics

The PFJ-4 Jitter Modulator is a valuable supplement for the PF-4 Bit Error Measuring Set and together they can be used to examine digital systems with high transmission rates. The clock signal from the PF-4 is fed into the PFJ-4 where it is modulated and then returned to the PF-4. The jitter deviation and the jitter frequency can be set on the PFJ-4.
In this way, data signals with well defined jitter, having bit rates of 2048, 8448, 34 368 and 139 264 kbit/s, are produced.
When an external clock is used, a continuous frequency range from 1.5 to 45 MHz, can be covered. An external clock can also be used to provide the bit rate of 139 264 kbit/s.

Clock frequency range	1.5 to 45 MHz and 139.264 MHz
Jitter frequency range	0 Hz to 7 MHz
Max. peak-to-peak jitter	20 UI
Internal and external modulation signal	
Option: Remote control	



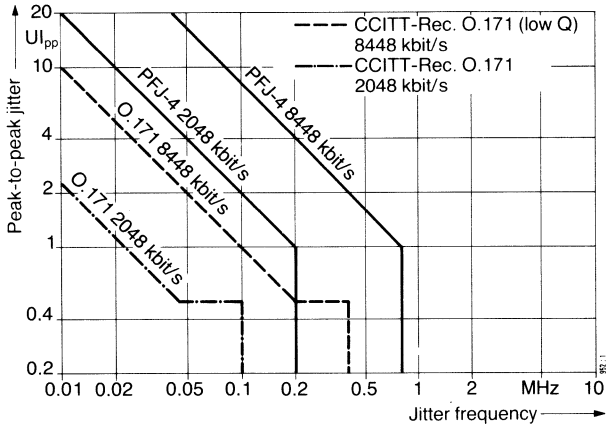
Generation of jitter modulation

As well as containing the actual clock modulator, the modulation source is also built into the PFJ-4 Jitter Modulator. The modulation source produces modulating frequencies between 1 Hz and 5 MHz. This range is split into five quasi-continuously tunable ranges. Sinusoidal or rectangular phase modulation of the clock signal can be performed by the modulation source.

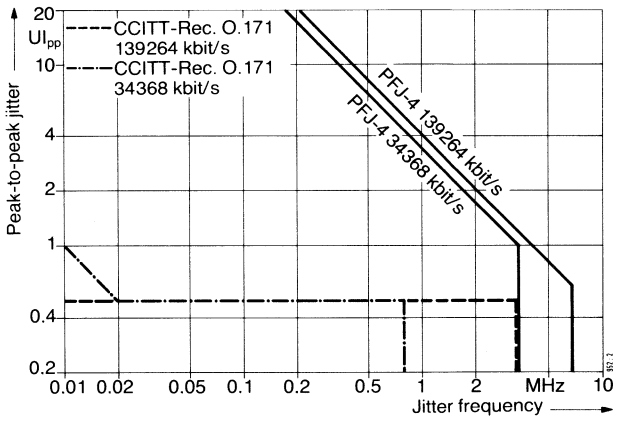
If an external modulating voltage is used, a frequency range of 0 Hz to 7 MHz can be covered. The peak-to-peak jitter setting is indicated on a digital display. If the internal modulation source is used the instantaneous jitter frequency is also shown.

The PFJ-4 Jitter Modulator has been designed in accordance with CCITT Rec. O.171 and in certain areas, such as the frequency dependency of peak-to-peak jitter, even goes beyond CCITT Recommendations. The following diagrams show the jitter values that can be set for the various bit rates.

It is clear from the diagrams that the requirements contained in CCITT Rec. O.171 are greatly improved on – jitter frequency as well as peak-to-peak jitter.



Jitter amplitude as a function of frequency (2048 and 8448 kbit/s)



Jitter amplitude as a function of frequency (34368 and 139264 kbit/s)

Specifications for the Jitter Modulator — PFJ-4

If not otherwise stated, the specified values are valid for any instrument settings within the rated ranges of use of the a.c. line voltage, a.c. line frequency, and the ambient temperature.

Clock interfaces

Clock input on the back panel
Input impedance, unbalanced . . . . . approx. 75 Ω
Required input voltage levels . . . . . ECL
Clock frequency range . . . 1.5 to 45 MHz and 139.264 MHz
Permissible deviation at 139.264 MHz . . . . . $\pm 50 \times 10^{-6}$

Internal clock generator
Selectable instead of the 139 MHz clock source of the PF-4
Clock frequency . . . . . 139.264 MHz
Intrinsic jitter (f = 2 Hz to 7 MHz) . . . . . $<0.008\ UI_{pp}$

Clock outputs
Output on back panel
Output voltage terminated with 75 Ω
against −2 V . . . . . ECL

Output on the front panel
Output voltage when $Z_{out} = Z_{in} = 75\ \Omega$
in the frequency range 1.5 to 45 MHz . . . . . TTL
Return loss (Z_{out} to 0 V)
in the frequency range 20 kHz to 50 MHz . . . . . >15 dB

When the clock frequency exceeds 50 MHz, automatic switch-over to ECL levels takes place
Output voltage when $Z_{out} = Z_{in} = 75\ \Omega$ (Z_{out} to -2 V)
in the frequency range 1.5 to 140 MHz . . . . . ECL
Return loss (Z_{out} to -2 V)
in the frequency range 20 kHz to 210 MHz . . . . . >20 dB

Jitter generation

Peak-to-peak jitter ranges
Range I
Settable in 0.1 UI steps . . . . . 0.1 to 20 UI_{p-p}

Range II
Settable in 0.01 UI steps . . . . . 0.00 to 2.4 UI_{pp}
Modulation voltage can be switched out

Jitter error limits with a jitter-free input clock and external, sinusoidal modulation-voltage at a frequency of 1 kHz
Range I from 0.1 to 20.0 UI . . . ±2 % of reading ±2 % f.s.d.
Range II from 0.00 to 2.0 UI . . . ±2 % of reading ±2 % f.s.d.

Jitter frequency range . . . . . 0 Hz to 7 MHz
Max. frequency dependency of the jitter produced at constant peak-to-peak jitter referred to the value at 1 kHz
up to 300 kHz . . . . . ±2 %
up to 1 MHz . . . . . ±3 %
up to 7 MHz . . . . . ±5 %

Internal modulation source
for sinusoidal and rectangular voltages
Frequency range . . . . . 1 Hz to 5 MHz
Frequency adjustable in 5 ranges.

Range No.	Frequency range	Size of step
1	10 kHz to 5 MHz	10 kHz
2	1 kHz to 500 kHz	1 kHz
3	0.1 kHz to 50 kHz	100 Hz
4	0.01 kHz to 5 kHz	10 Hz
5	0.001 kHz to 0.5 kHz	1 Hz

Sinusoidal signal
Frequency range
Lower frequency limit . . . . . 1 Hz
Upper frequency limit . . . . . 1/10 of the bit rate
(the upper limit is indicated by the flashing frequency display)

Rectangular signal
Frequency range
Lower frequency limit . . . . . 1 Hz
Upper frequency limit . . . depends on the peak-to-peak jitter range selected

Range	Upper frequency limit
0.00 to 2.40 UI	1/100 of the bit rate/≦500 kHz
0.1 to 20.0 UI	1/1000 of the bit rate/≦50 kHz

(the upper limit is indicated by the flashing frequency display)

Input and outputs

Output for modulation voltage
Output voltage, proportional to the peak-to-peak jitter, at 20 UI,
$Z_{out} = Z_{in} = 75\ \Omega$ . . . . . −10 dB

Output for rectangular voltages
(e.g. for switching over the 2 x 8-bit word in the PF-4)
Output waveform . . . . . rectangular
Output voltage (open circuit) . . . . . TTL
Output impedance . . . . . approx. 500 Ω

Output for controlling a plotter, X-axis
Voltage is proportional to the jitter frequency
Output voltage V_{out} . . . . . 0 to +5 V
Output impedance Z_{out} . . . . . 5 kΩ

Input for external modulating voltage
Input impedance . . . . . 75 Ω
Return loss in the frequency
range 200 Hz to 7 MHz . . . . . >40 dB
Sinusoidal input voltage required to produce a peak-to-peak jitter of 20 UI in range I or 2 UI in range II . . . . . 0 dB
corresponds to $V_{peak} = 1.095$ V

Option

Interface Bus <IEC 625>/IEEE 488, BN 958/02
Remote control of all functions.

General specifications

Power supply
Rated ranges of use of a.c. line voltage,
selectable . . . . 110/117/127/220/227/235 V, −12 to +10 %
Rated range of use of a.c. line frequency . . . . 47.5 to 63 Hz
Power consumption . . . . . max. 80 VA
Protection class as per IEC 348 and VDE 0411 . . . . . class I
RFI/EMI . . . . . to VDE 0871

Tolerable ambient temperature
Rated range of use . . . . . +5 to +40°C
Storage and transportation . . . . . −40 to +70°C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	199	Height (4 units)	175
Depth with handles	425	Depth	370

19" conversion kit . . . . . BN 700/00.04

Weight . . . . . approx. 19 kg

Ordering Information

Jitter Modulator PFJ-4	**BN 952/01**
Option (at extra cost)	
<IEC 625> Interface Bus card with <IEC 625>/IEEE 488 (S 834) Adaptor	BN 958/02
Accessories (at extra cost)	
Protective covers for transportation SD-4 (1 set)	BN 700/00.24

PJG-4
Jitter Generator

Clock and pattern generation; loop-through jitter modulation up to 140 Mbit/s

IEEE 488
IEC 625



- **Generation of finely settable jitter on clock and digital signals**
- **Pseudorandom sequences: 2^{10}-1, 2^{15}-1, 2^{20}-1, and 2^{23}-1 bits**
- **Freely programmable 1 bit to 16 bit digital word; 2 x 8 bit word**
- **Jitter modulation applied to looped-through clock or digital signal**
- **Signal codes: CMI, HDB-3 corresponding to CCITT Rec. G.703; AMI, NRZ**
- **Satisfies or exceeds the specifications for jitter measurements as detailed in CCITT Recommendation O.171**

Applications

The PJG-4 Jitter Generator is a powerful measuring instrument for the testing of high speed digital communications systems operating up to 140 Mbit/s.
It contains all devices that are required for the maintenance and in-service measurements on digital communications systems at all of the hierarchical levels used at the present time.
Test patterns generated with a definite jitter, may be fed in to digital multiplex equipment, individual regenerators, or complete digital communications links, and the maximum tolerable input jitter may be ascertained.
Besides, the PJG-4 can also be inserted as code transparent between system interfaces. Incoming jitter-free digital and clock signals are thereby subjected to precisely settable jitter, so that measurements are possible at digital switches and at the circuit side of demultiplexers.

All Jitter Generator functions are remote controllable via the <IEC 625>/IEEE 488 Interface Bus. So the PJG-4 is also applicable within computer controlled measuring systems and remains manually controllable if so needed.

Characteristics

The PJG-4 Jitter Generator produces test patterns whose digital and clock signals have been conditioned by pre-defined jitter. In addition, external digital signals can be modulated by jitter so as to create the desired jitter amplitude at the selected jitter frequency. Moreover, the highest bit rate for both modes is 140 Mbit/s. If an external clock is employed, the frequency range continuously spans from 1.5 to 45 MHz. Operating with an external clock of 139.264 Mbit/s is possible also.
But if no clock signal is available at the interface, the PJG-4 internally recovers from the digital signal a reference clock that is at the bit rates of 2048, 8448, 25 776, 34 368 and 139 264 kbit/s.
Despite being so compact, the PJG-4 contains a pattern generator, a clock modulator, and a generator for producing the modulation signal in the frequency range 1 Hz to 5 MHz. If an external modulation voltage is applied, the jitter frequency range spans from 0 Hz to 7 MHz.

Bit rate	2048, 8448, 25 776, 34 368 and 139 264 kbit/s
External clock	1.5 to 45 MHz and 139.264 MHz
Jitter frequency range	0 Hz to 7 MHz
Generation of peak-to-peak jitter	20 UI
Internal and external modulation signal	
Option: Remote Control	

Further Characteristics and Applications

Test pattern

The PJG-4 Jitter Generator can produce four discrete pseudo-random sequences of length 2^{10}-1, $2^{15}-1$, 2^{20}-1, and $2^{23}-1$ bits. Besides the $2^{15}-1$ and 2^{23}-1 bit patterns that have been recommended by CCITT and other international committees, the pseudorandom sequence length of $2^{20}-1$ bits is also available for North America, where it is frequently used. Bit inverting is verting is programmable within the PJG-4 for each pseudorandom sequence. And with the 2^{20}-1 bit pattern, the PJG-4 can be programmed for bit injection to suppress intolerably long zero sequences (more than 14 zeros). Besides the pseudorandom sequences for certain error investigations, periodic bit patterns are available when needed. So any arbitrary selectable and bit-by-bit modifiable digital word of 1 to 16 bits in length can be sent as a repetitive test pattern.

Another periodic pattern of 2 x 8 bits can be sent instead of the 1 bit to 16 bit word. And, again, any arbitrary bit combination can be set-up, however, an extra facility for changing over, from the first 8 bit word to the second, also causes the changeover to occur, so that the first 8 bit word is alternated with the second 8 bit word. Alternations are controlled by the internal modulation frequency or by the frequency of the signal externally applied to the PJG-4 from an external modulator.

This device is particularly suitable for investigating the transient behavior of clock recovery circuits, e.g. in regenerators. Additionally, jitter can be observed as it changes with the generated test signal.

All test patterns of the PJG-4 can be selected independent of the bit rate in use.

Interfaces

The inputs and outputs for data signals and clock are equipped with coaxial 75 Ω connectors. Since CCITT Recommendation G.703 recommends use of the HDB-3 interface code for bit rates to 34 Mbit/s and use of the CMI code at 139 Mbit/s, both codes are presented by the PJG-4. In addition, the AMI code may be selected up to 34 Mbit/s. And binary signals in NRZ code with TTL and ECL levels are available too.

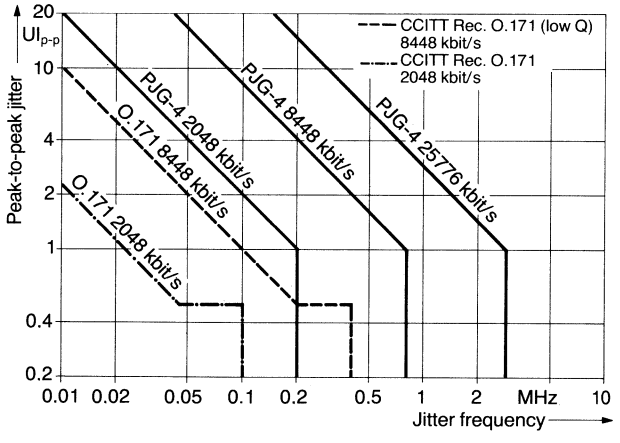
Bit rates

The internal clock frequencies of 2048, 8448, 34368, and 139264 kbit/s facilitate the use of the PJG-4 in all four of the previously standardized hierarchical levels of the PCM 30 System related equipments. The additional 25776 kbit/s clock frequency is intended for digital telecommunications equipment of the third hierarchical level operating with the 4B/3T signal code. When the PJG-4 is operating in loop-through jitter mode, the clock can be either fed in from an external source or recovered internally from the digital signal at the stated bit rate. This clock recovery implements the maximum tolerable clock deviation as recommended by the CCITT for specified digital communications systems.

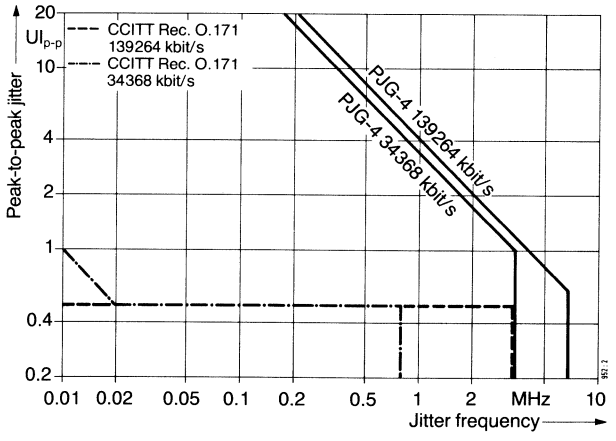
Jitter Generation

The PJG-4 Jitter Generator satisfies or, in fact, exceeds the requirements of CCITT Recommendation O.171 both in the jitter frequency as well as in the peak-to-peak jitter; at all bit rates. The accompanying diagram shows the adjustable jitter at various bit rates.

Besides the actual clock modulator, the Jitter Generator contains a modulation generator for producing sinusoidal and square wave voltages. The modulation frequencies from 1 Hz to 5 MHz are quasi-continuously variable. The relevant set-up peak-to-peak jitter is indicated by the digital display on the front panel. When the internal modulation generator is used, the generated jitter frequency is displayed also. A jitter-free reference clock output is available for oscilloscopic monitoring of the jitter behavior of PCM system sub-assemblies. Outputs are present for modulation voltage and frequency. An X-Y recorder output is available for producing a permanent record of the jitter frequency as one parameter (X axis).



Variation of peak-to-peak jitter with frequency at 2048, 8448 or 25776 kbit/s



Variation of peak-to-peak jitter with frequency at 34368 or 139264 kbit/s

Unless otherwise stated, the specified values are valid for any instrument settings within the rated ranges of use of the a.c. line voltage, a.c. line frequency, and ambient temperature.

Jitter Generator, Send Section

Bit rate

Internal clock generator
Adjustable bit rates . . . . . 2048, 8448, 25776, 34368, and 139264 kbit/s

Error limits of bit rates:
at 2048 and 8448 kbit/s . . . . . $\pm 10 \times 10^{-6}$
at 25776, 34368, and 139264 kbit/s . . . . . $\pm 7 \times 10^{-6}$

External clock input (back panel of PJG-4)
Clock frequency range . . . . 1.5 to 45 MHz and 139.264 MHz
Tolerable deviation at 139.264 MHz . . . . . $\pm 50 \times 10^{-6}$

Input impedance, coaxial . . . . . 75 Ω

Required input voltage . . . . . ECL level
HIGH state . . . . . −0.7 to −1.16 V
LOW state . . . . . −1.48 to −4.5 V

Pulse pattern

Pseudo-random sequences
Length, switchable . . . . $2^{10}-1$, $2^{15}-1$, $2^{20}-1$, and $2^{23}-1$ bits
Bit inversion is freely programmable for any random sequence in the PJG-4.
When operating with pattern $2^{20}-1$ bits, the North American recommendation for bit injection can be programmed.

Freely programmable digital word
(modifiable bit-by-bit)
Adjustable word length (repetitive transmission) . . 1 to 16 bits

2 x 8 bit word
Two 8 bit words, set-up in any sequence, and alternated by the internal modulation generator voltage or an external control voltage.

Digital signal output*

Codes and output voltage, selectable:

NRZ/ECL
to 139.264 Mbit/s . . . . . ECL level
HIGH state . . . . . −0.8 V ±0.1 V
LOW state . . . . . −1.8 V ±0.1 V

NRZ/TTL
to 139.264 Mbit/s . . . . . TTL level
HIGH state . . . . . +2.37 V ±0.5 V
LOW state . . . . . 0 V ±0.5 V

AMI and HDB-3 complying with CCITT Rec. G.703
at 2048 and 8448 kbit/s
Pulse . . . . . 2.37 V ±0.237 V
No pulse . . . . . 0 V ±0.237 V

at 25776 kbit/s
Pulse . . . . . 3 V ±0.3 V
No pulse . . . . . 0 V ±0.3 V

at 34368 kbit/s
Pulse . . . . . 1 V ±0.1 V
No pulse . . . . . 0 V ±0.1 V
Internally resolderable from HDB-3 to HDB-2.

CMI at 139264 kbit/s complies with CCITT Rec. G.703
peak-to-peak voltage . . . . . 1 V ±0.1 V

Output impedance . . . . . 75 Ω

Return loss
for NRZ/TTL, AMI, and HDB-3 interfaces (2048 to 8448 kbit/s)
in range 40 kHz to 10 MHz . . . . . >20 dB

for AMI and HDB-3 interfaces (34368 kbit/s)
in range 40 kHz to 50 MHz . . . . . >20 dB

for NRZ/ECL and CMI interfaces
in range 7 MHz to 210 MHz . . . . . >20 dB

Clock outputs*

Output on the front panel
Output voltage at $Z_{out} = Z_o = 75\ \Omega$:
in frequency range 1.5 to 45 Mbit/s . . . . . TTL voltage
HIGH state . . . . . 2.37 V ±0.5 V
LOW state . . . . . 0 V ±0.5 V

Return loss (Z_{out} to 0 V):
in frequency range 20 kHz to 50 MHz . . . . . >20 dB

If the clock frequency exceeds 50 MHz, automatic changeover to ECL level takes place.
Output voltage at $Z_{out} = Z_o = 75\ \Omega$, terminated to −2 V:
in frequency range 1.5 to 140 Mbit/s . . . . . ECL voltage
HIGH state . . . . . −0.8 V ±0.1 V
LOW state . . . . . −1.8 V ±0.1 V

Return loss (Z_{out} to −2 V):
in frequency range 20 kHz to 210 MHz . . . . . >20 dB

Output on the back panel
Output voltage when terminated by 75 Ω to −2 V . . . . ECL

Trigger output

1 trigger pulse per pattern period; pulse duration: 1 bit
Output impedance . . . . . 75 Ω
Open circuit voltage . . . . . ECL level

Jitter generation

Peak-to-peak jitter ranges
Range I, settable in 0.1 UI steps . . . . . 0.1 to 20 UI_{p-p}
Range II, settable in 0.01 UI steps . . . . . 0.00 to 2.4 UI_{p-p}
Modulation voltage is keyable.

Error limits of generated jitter with sinusoidal modulation voltage at 1 kHz:
for clock jitter and internal clock generation:
in range I from 0.1 to 20 UI . . . . ±2 % of reading ±2 % f.s.d.
in range II from 0.00 to 2 UI . . . . ±2 % of reading ±2 % f.s.d.
for clock jitter and external, jitter-free clock input from 1.5 to 45 MHz and 139.264 MHz:
in range I from 0.1 to 20 UI . . . . ±2 % of reading ±2 % f.s.d.
in range II from 0.00 to 2 UI . . . . ±2 % of reading ±2 % f.s.d.
Additional error for pseudorandom sequences . . . ≦0.04 UI_{p-p}

Jitter frequency range . . . . . 0 Hz to 7 MHz
Jitter frequency response
Max. variation of jitter with frequency at constant setting of the jitter amplitude referred to the value at 1 kHz
up to 300 kHz . . . . . ±2 %
up to 1 MHz . . . . . ±3 %
up to 7 MHz . . . . . ±5 %

Internal modulation generator
For sinusoidal and rectangular voltages
Frequency range . . . . . 1 Hz to 5 MHz
Frequency adjustable in 5 ranges

Range No.	Frequency range	Size of step
1	10 kHz to 5 MHz	10 kHz
2	1 kHz to 500 kHz	1 kHz
3	0.1 kHz to 50 kHz	100 Hz
4	0.01 kHz to 5 kHz	10 Hz
5	0.001 kHz to 0.5 kHz	1 Hz

Sinusoidal signal
Frequency range
Lower frequency limit . . . . . 1 Hz
Upper frequency limit . . . . . 1/10 of the bit rate
(the upper limit is indicated by the flashing frequency display)

Rectangular signal
Frequency range
Lower frequency limit . . . . . 1 Hz
Upper frequency limit . . . . . depends on the jitter amplitude range selected

Range	Upper frequency limit
0.00 to 2.40 UI	1/100 of the bit rate/≦500 kHz
0.1 to 20.0 UI	1/1000 of the bit rate/≦50 kHz

(the upper limit is indicated by the flashing frequency display)
Rise time and decay time of the rectangular voltage are varied inversely proportional to the bit rate.

Inputs and outputs
Output for modulation voltage
Output voltage, proportional to the peak-to-peak jitter, at 20 UI_{p-p}
$Z_{out} = Z_o = 75\ \Omega$ . . . . . −10 dB

Output for modulation frequency
Rectangular voltage (TTL level, Z_{out} is approx. 500 Ω)
(e.g. for switching over the 2 x 8 bit word in the PF-4)

Output for controlling a plotter, X-axis
D.C. voltage is proportional to the jitter frequency within the modulation frequency ranges
Output voltage . . . . . 0 to +5 V
Output impedance . . . . . 5 kΩ

Input for external modulating voltage
Frequency range . . . . . 0 Hz to 7 MHz
Input impedance . . . . . 75 Ω
Return loss (200 Hz to 7 MHz) . . . . . >40 dB
Sinusoidal input voltage required to produce a peak-to-peak jitter of 2 UI or 20 UI . . . 0 dB, corresponds to $V_{peak} = 1.095$ V

Loop-through jitter

Bit rate
Internal clock recovery for 2048, 8448, 25776, 34368, and 139264 kbit/s

Clock
Either fed-in from external source or recovered internally from digital signal.
Tolerable deviation from nominal value of bit rate at
2048 and 8448 kbit/s . . . . . $\pm 50 \times 10^{-6}$
25776 and 34368 kbit/s . . . . . $\pm 20 \times 10^{-6}$
139264 kbit/s . . . . . $\pm 15 \times 10^{-6}$

Inputs for digital signal and clock
Input impedance, unbalanced . . . . . 75 Ω

Return loss
in frequency range 20 kHz to 210 MHz . . . . . >20 dB

Required pulse amplitude . . . . . ≧100 mV

Codes, as in send section.
The PJG-4 is code transparent when operating in loop-through mode.

Peak-to-peak jitter ranges
Range I, settable in 0.1 UI steps . . . . . 0.1 to 8 UI_{p-p}
Range II, settable in 0.01 UI steps . . . . . 0.00 to 2.4 UI_{p-p}
Error limits of generated jitter, as in send section.
Additional error with clock recovery
(pseudorandom pattern) . . . . . ≦ ±0.01 UI_p

Jitter frequency range . . . . . 0 Hz to 7 MHz

Jitter frequency response, as in send section.

Option

Interface Bus <IEC 625>/IEEE 488, BN 958/02
For remote control of all PJG-4 functions.
Adaptor plug for IEEE Bus.

General Specifications

Power supply
Rated ranges of use of a.c. line voltage, selectable . . . . 110/117/127/220/227/237 V, −12 to +10 %
Rated range of use of a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . max. 200 VA
Safety class according to IEC 348 and VDE 0411 . . . Class I
EMI/RFI suppression . . . . . VDE 0871

Tolerable ambient temperature
Rated range of use . . . . . +5 to +40 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41494)	
Width with handles	477	Width	443
Height overall	199	Height (4 units)	175
Depth with handles	425	Depth	370

19" conversion kit . . . . . BN 700/00.04

Weight . . . . . approx. 20 kg

Ordering Information

Jitter Generator PJG-4	**BN 952/02**
Option (at extra cost)	
Interface Bus <IEC 625>/IEEE 488 with adaptor plug <IEC 625>/IEEE 488 (S 834)	BN 958/02
Accessories (at extra cost)	
Front and back panel covers, SD-4 (1 set)	BN 700/00.24

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

PR-1
Regenerator Measuring Setup

for measuring the noise immunity of 2048 kbit/s regenerators



- **Simulates the characteristics of digital communications systems cable sections**
- **Simulates near-end crosstalk**
- **Semi-sinusoidal or trapezoidal test signal**
- **Automatic regulation of the S/N ratio at the regenerator input**
- **Regenerator power supply**

Applications

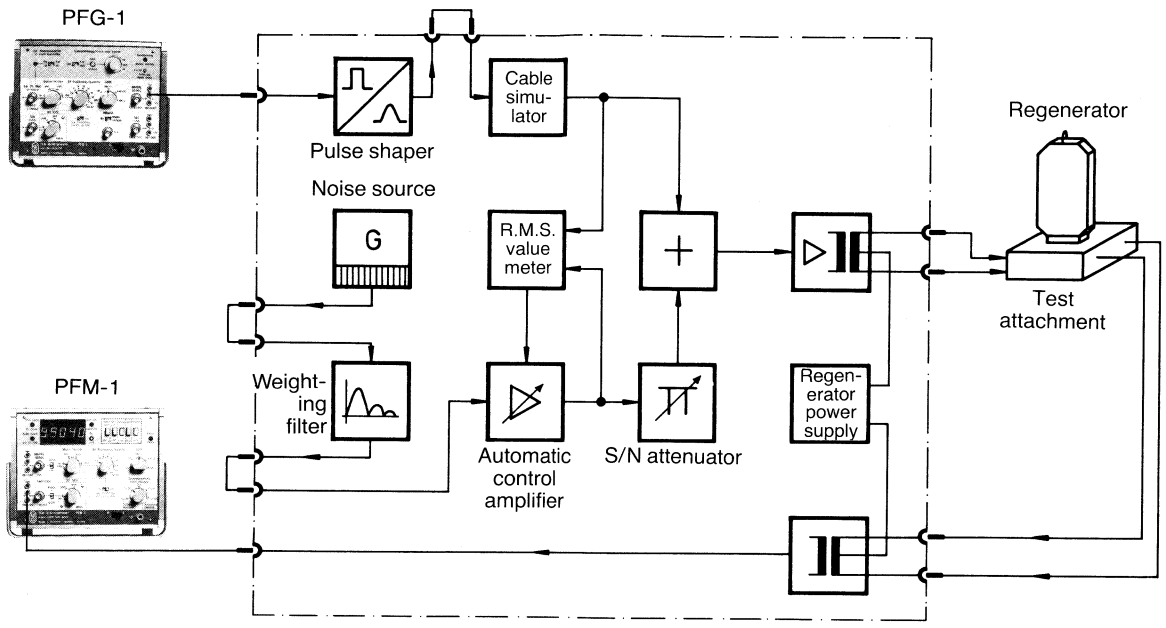
When a pulse code modulated signal is transmitted over a long distance, regenerators are used to recreate the original digital signal and so remove signal degradation caused by cable attenuation, delay, crosstalk and jitter.
Regenerators must also maintain the required signal-to-noise ratio over the transmission path, and ensure that the signal reaches the output of the transmission circuit resembling the original as closely as possible. Regenerators of this kind must therefore have a high noise immunity.
The PR-1 Regenerator Measuring Setup is a powerful and easy-to-operate test device for the practical examination of regenerators e.g. quality tests or tests in the field. The PR-1 comprises the PF-1 Digital Error Rate Measuring Setup and the PRT-1 Regenerator Tester.

Characteristics

The digital signal from the Pattern Generator is fed to the pulse shaper in the Regenerator Tester and, depending on the version, the pulse shaper produces either a trapezoidal or a semi-sinusoidal test signal. The test signal is then fed to a line simulator equipped with a fine control to set the attenuation to correspond to a certain regenerator separation.
Noise can be superimposed on the wanted signal to simulate near-end cross talk.
The noise is generated by a noise generator whose spectrum has been shaped by a weighting filter to make it correspond to the spectrum of a pseudorandom HDB-3 coded digital signal.
The effects of the near-end cross talk are also taken into account in the weighting process. A summing stage forms the test signal for the regenerator from the wanted signal and the noise signal. The regenerator is tested by measuring the bit error rate of the output signal as a function of the signal-to-noise ratio of the test signal.

Line simulation	
attenuation at 1 MHz	0 to 46 dB
Noise source	
for simulating near-end cross talk	
Spectrum of the noise signal corresponds to a HDB-3 coded digital signal	
S/N ratio of the regenerator test signal	
switchable in 2 dB steps	10 to 32 dB
in 0.2 dB steps	0 to 2.2 dB

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Setup for regenerator testing

Specifications of the Regenerator Measuring Setup

PR-1

If nothing to the contrary is stated, the given values are valid for any PR-1 settings within the rated ranges of use for a.c. line voltage, a.c. line frequency and ambient temperature.

Pattern Generator PFG-1
Digital Error Rate Meter PFM-1

see Specification Sheet "Digital Error Rate Measuring Setup PF-1"

Regenerator Tester PRT-1

Version for semi-sinusoidal pulses BN 692/00
Version for trapezoidal pulses BN 692/01

Input signal

Bit rate of digital signal . . . . . 2048 kbit/s
Required pulse amplitude . . . . . 2.37 V ± 10 %
Signal shape . . . . . rectangular
Line codes . . . . . AMI or HDB-3

Input impedance for digital signal and clock input . . . . . 75 Ω, unbalanced

Pulse shaper

Output immediately after the pulse shaper
Output impedance . . . . . 75 Ω, unbalanced
Pulse amplitude (at $Z_L = 75\ \Omega$) . . . . . 2.37 V ± 5 %

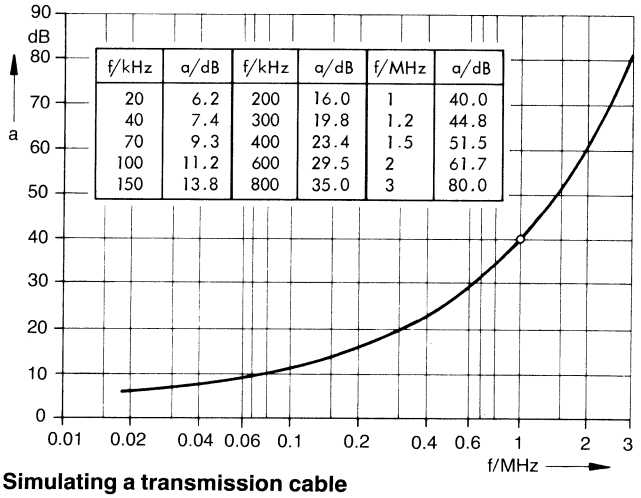
Pulse shape	BN 692/00	BN 692/01
	semi-sinusoidal	trapezoidal

Cable simulation

Input impedance . . . . . 75 Ω, unbalanced

The mean attenuation values of cables with a conductor diameter varying between 0.6 and 1.4 mm over the frequency range 10 kHz to 3 MHz serve as the reference curve for cable simulation (the values stated are valid for a setting of 40 dB).

f/kHz	a/dB	f/kHz	a/dB	f/MHz	a/dB
20	6.2	200	16.0	1	40.0
40	7.4	300	19.8	1.2	44.8
70	9.3	400	23.4	1.5	51.5
100	11.2	600	29.5	2	61.7
150	13.8	800	35.0	3	80.0



Simulating a transmission cable

Attenuation at 1 MHz, selectable in 1 dB steps in the range . . . . . 0 to 46 dB

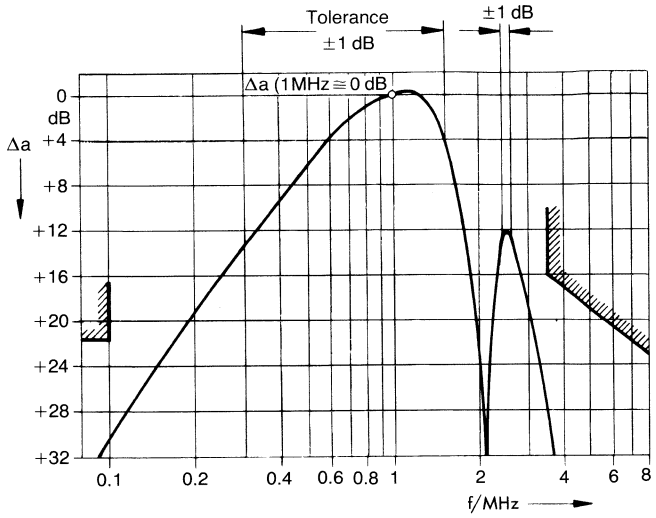
Noise source with weighting filter
The noise source is used to simulate near-end crosstalk

Noise signal

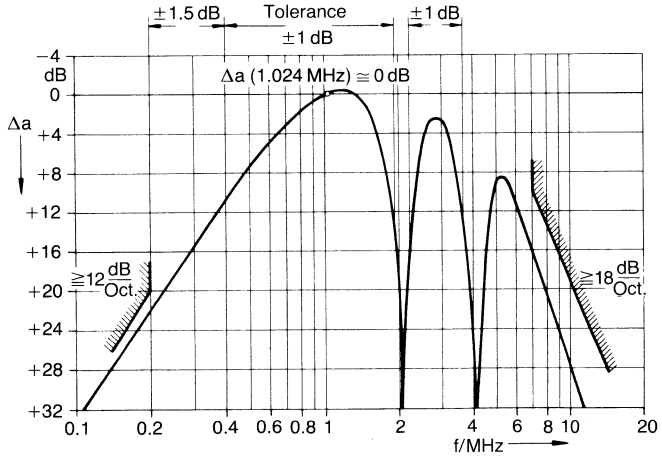
Frequency range at the output of the noise source . . . . . 20 kHz to 6 MHz

Max. variation in noise power over the frequency range (measurement bandwidth 3 kHz) . . . . . ± 0.5 dB

Amplitude distribution of the noise voltage at the output for the regenerator when the attenuation settings for cable simulation are ≧ 10 dB . . . . . Gaussian dist. to ± 5 σ



Spectral distribution of the noise signal after passing through the weighting filter; termination 75 Ω, BN 692/00



Spectral distribution of the noise signal after passing through the weighting filter; termination 75 Ω, BN 692/01

Setting the signal-to-noise ratio
S/N ratio can be set over the range . . . . . 10 to 34.2 dB

The measurement and automatic adjustment to the set signal-to-noise ratio are effected with a true r.m.s. meter

Connection for the Regenerator . . . 16 pole spring contact connector C 42 334-A42-A 34 (Siemens)
A regenerator connecting cable (no connector at one end) is supplied with the PRT-1
Input or output impedance . . . . . 130 Ω, balanced

Power supply for the regenerator

	BN 692/00	BN 692/01
Remote supply current	59 mA ± 1 %	48 mA ± 1 %
via remote control line switchable to	50 mA ± 1 %	75 mA ± 1 %
Max. voltage	13 V	14 V

Remote control input . . . . . 50 pole Amphenol
Remote controllable parameters . . . . . cable simulation attenuation, signal to noise ratio S/N

General Specifications

Power supply
Rated ranges of use of a.c. line voltage, selectable . . . . . 110/117/127/220/227/237 V
Rated range of use for a.c. line frequency . . . . 45 to 66 Hz
Power consumption . . . . . approx. 50 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Permissible ambient temperature
Rated range of use . . . . . +5 to +40° C
Storage and transportation . . . . . −40 to +70° C

Dimensions (w x h x d) in mm . . . . . 477 x 155 x 407

Weight . . . . . approx. 12.5 kg

Ordering Information

Regenerator Measuring Setup PR-1
(Version with semi-sinusoidal pulses) comprises:
Pattern Generator PFG-1* [1] **BN 670/01**
Digital Error Rate Meter PFM-1* [1] **BN 671/01**
Regenerator Tester PRT-1* **BN 692/00**

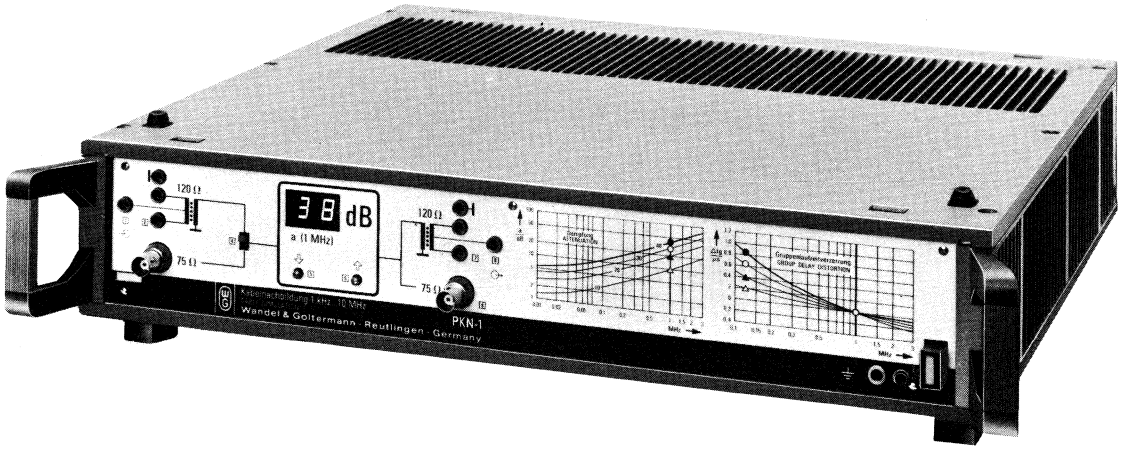
Regenerator Measuring Setup PR-1
(Version with trapezoidal pulses) comprises:
Pattern Generator PFG-1* [1] **BN 670/01**
Digital Error Rate Meter PFM-1* [1] **BN 671/01**
Regenerator Tester PRT-1* **BN 692/01**

Accessories (at extra cost)
Protective Transportation Cover (PFG-1 and PFM-1 have one each), DE-13 BN 476/00.10
Protective Transportation Cover for the PRT-1, DE-2 BN 476/00.02

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.
1) For Specifications and further Ordering Information see Specification Sheet "PF-1 Digital Error Rate Measuring Setup".

PKN-1
Cable Simulator

for digital communications systems



- **Simulates the transmission characteristics of paper- and plastic-insulated cables; i.e. attenuation and group delay response**
- **Version BN 875/02 simulates pulp and PIC cables to North American standards**
- **Attenuation can be set and displayed at the reference frequency**
- **Attenuation setting can be remote-controlled**

Applications

The PKN-1 is essential for checking line equipment of digital communications systems, in particular, regenerators. The PKN-1 simulates the transmission characteristics of paper- and plastic-insulated cables with wire diameters between 0.6 and 1.4 mm. The PKN-1's response complies with standard reference curve used by European postal administrations. A special version of the PKN-1 which simulates pulp and PIC cables complies with North American standards. To ensure that group delay measurements can be made accurately, the PKN-1 simulates the attenuation-frequency response of real cables well beyond the frequencies at which they are normally used.

Characteristics

The PKN-1 is a handy instrument that obviates the need for cable drums, so making the construction of mobile and stationary measuring setups simple and easy. Straightforward operation and the remote control facility for attenuation settings mean that the PKN-1 has a wide variety of uses, e.g. R & D, test depts and for maintaining PCM subassemblies and regenerators.
Over the range 10 kHz to approx. 1.5 MHz, the attenuation curve produced by the PKN-1 agrees well with the curves produced by cables with paper and plastic insulation. Both cable types are equally well simulated by the PKN-1.

Balanced and coaxial inputs and outputs	
Transmission range	1 kHz to 10 MHz
Attenuation setting, f_o = 1 MHz	0 to 47 dB
f_o = 772 kHz	0 to 40 dB

Specifications of the Cable Simulator — PKN-1

Unless otherwise stated, the data is valid for any operating conditions or settings within the rated ranges of use for a.c. line voltage, a.c. line frequency or ambient temperature.

Signal-input and -output

Balanced . . . . . 3-pole CF connector
BN 875/02: Female connector compatible with WECO 310
Input/output impedance . . . . . 120 (100) Ω

Coaxial* . . . . . Versacon® 9 Universal Connector System convertible to all commercially available connector systems
Input/output impedance . . . . . 75 Ω
Maximum input voltage (peak value) V_p . . . . . 3 V
Intrinsic harmonic ratio a_{k_2}, a_{k_3}
at maximum input level . . . . . ≧30 dB

Intrinsic noise at the output, weighted with a band-pass filter having the following cutoff frequencies f_l = 1 kHz ±10 %, f_u = 10 MHz ± 10 % at a (f_o) <32 dB
for balanced operation . . . . . ≦−60 dBm
for unbalanced operation . . . . . ≦−55 dBm

at a (f_o) ≧32 dB
for balanced operation . . . . . ≦−65 dBm
for unbalanced operation . . . . . ≦−60 dBm

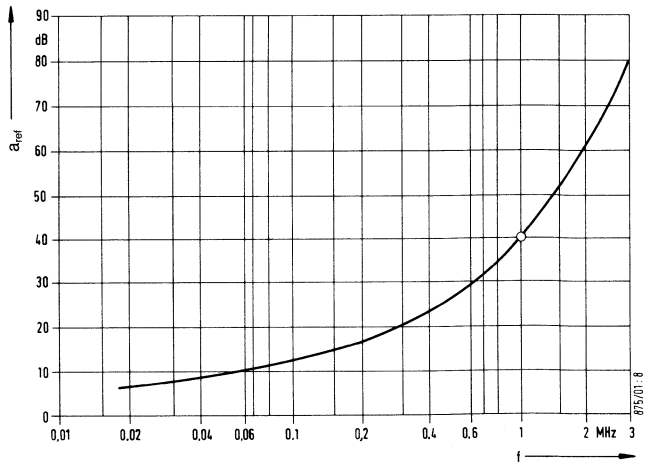
Frequency range

Transmission range . . . . . 1 kHz to 10 MHz
Operating range
for balanced operation . . . . . 20 kHz to 3 MHz
for unbalanced operation . . . . . 1 kHz to 3 MHz

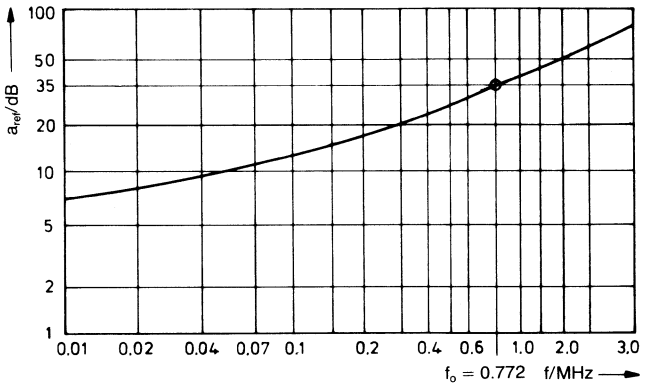
Transmission characteristics

Simulates the operating range of paper- and plastic insulated cables with a wire-diameter between 0.6 and 1.4 mm.

Nominal values of the attenuation-frequency response a_{ref} (f)
Cable-attenuation simulation curve which meets the requirements of European postal administrations a (f_o) = 40 dB:



Cable-attenuation simulation curve for 22-gauge pulp cable that complies with North American standards a (f_o) = 35 dB:



Insertion loss a (f_o) at f_o = 1 MHz (f_o = 772 kHz)
settable in steps of . . . . . 1 dB
in the range . . . . . 0 to 47 dB (0 to 40 dB)

The attenuation values a (f) for arbitrary frequencies and settings a (f_o) can be calculated from the following formulae:

f_o = 1 MHz

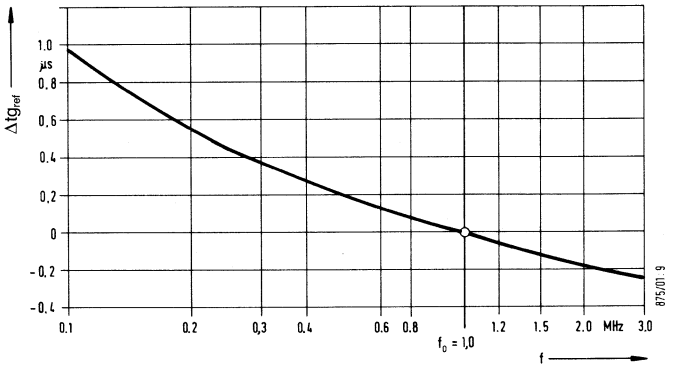
$$a(f) = a_{ref}(f) \times \frac{a(f_o)}{40}\ [dB]$$

f_o = 772 kHz

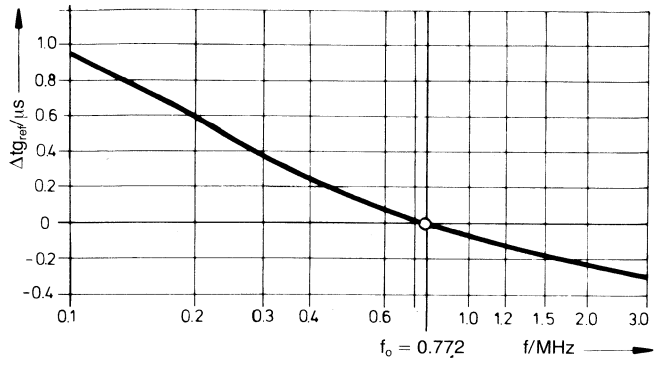
$$a(f) = a_{ref}(f) \times \frac{a(f_o)}{35}\ [dB]$$

Nominal values of group delay distortion $\Delta t_{g\,ref}$ (f)

Group delay distortion referred to the value at f_o = 1 MHz, a (f_o) = 40 dB:



Group delay distortion referred to the value at f_o = 772 kHz, a (f_o) = 35 dB



The group delay values Δt_g (f) for arbitrary frequencies and settings a (f_o) can be calculated from the following formulae:

f_o = 1 MHz

$$\Delta t_g (f) = \Delta t_{g\,ref} (f) \times \frac{a (f_o)}{40} \; [\mu s]$$

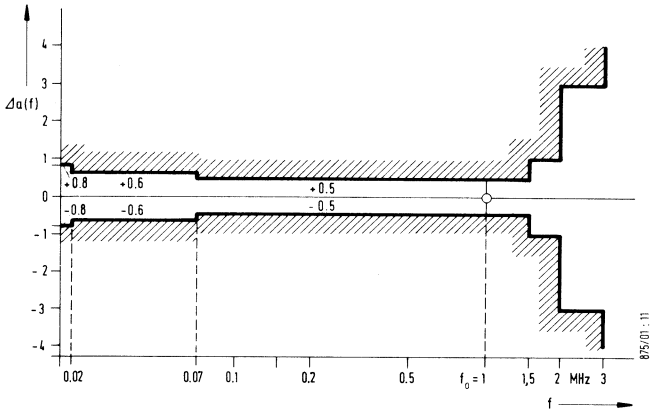
f_o = 772 kHz

$$\Delta t_g (f) = \Delta t_{g\,ref} (f) \times \frac{a (f_o)}{35} \; [\mu s]$$

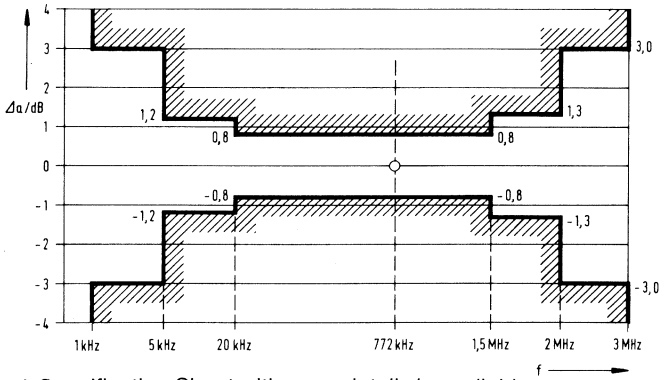
Error limits

The error on the insertion loss a (f) consists of a component that does not depend on frequency $\Delta a (f_o)$ . . . . . ±0.5 dB
and a frequency dependent component . . . . see following tolerance masks

Reference frequency f_o = 1 MHz



Reference frequency f_o = 772 kHz



A Specification Sheet with more details is available on request

Variation of group delay distortion with frequency Δt_g (f)

Reference frequency f_o = 1 MHz

Frequency range	For attenuation values at f_o = 1 MHz	Max. deviation
100 kHz to 200 kHz	0 to 47 dB	±0.16 µs
200 kHz to 1.5 MHz	0 to 20 dB	±0.06 µs
	21 to 47 dB	±0.16 µs

Reference frequency f_o = 772 kHz

Frequency range	For attenuation values at f_o = 772 kHz	Max. deviation
100 kHz to 200 kHz	0 to 40 dB	±0.2 µs
200 kHz to 2 MHz	0 to 20 dB	±0.1 µs
	21 to 40 dB	±0.2 µs

Remote-controlled attenuation setting

Type of remote control . . . . . BCD, parallel
Remote control levels . . . . . TTL

General Specifications

Power supply
Rated ranges of use for a.c. line voltage, switchable . . . . . 110/117/127/220/227/235 (237) V
Rated range of use for a.c. line frequency . . 47.5 to 63 (66) Hz
Power consumption . . . . . approx. 30 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature
Rated range of use . . . . . +5 to +40°C
Storage and transportation . . . . . −40 to +70°C

Dimensions (w×h×d) in mm . . . . . 477×110×425

19" conversion kit . . . . . BN 700/00.02

Weight . . . . . approx. 9 kg

Ordering Information

Cable Simulator PKN-1 * **BN 875/01**
for reference frequency f_o = 1 MHz

Cable Simulator PKN-1 * **BN 875/02**
for reference frequency f_o = 772 kHz

Accessories (at extra cost)
Protective Transportation Cover SD-2 BN 700/00.22

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

new

PRA-1
Frame Analyzer

for measurements on 2048 kbit/s systems

IEEE 488
IEC 625

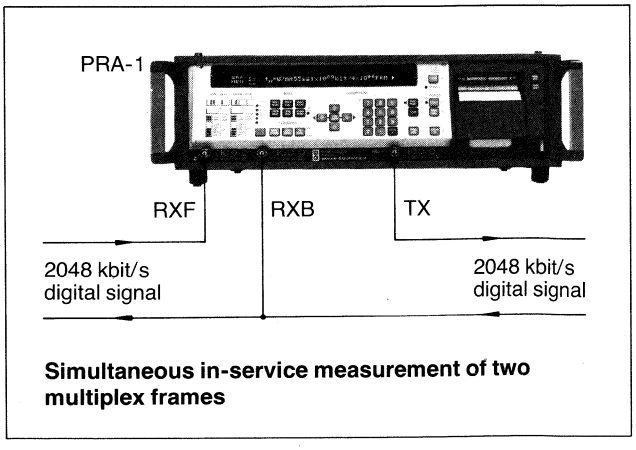


- **Simultaneous and complete monitoring of two 2048 kbit/s multiplexed signals with frame structure to CCITT Rec. G.704, § 3.3**
- **Recording and analysis of forward and backward signalling channels with user selectable trigger criteria**
- **Signalling is shown as a pulse diagram on integral printer or by means of an external, single-channel oscilloscope**
- **Measurements of bit errors and delay time at 2048 kbit/s and in the 64 kbit/s channel (options)**
  Error analysis to CCITT Rec. G.821
- **Receiver and generator section (option) in one instrument**
- **Built-in loudspeaker for channel monitoring and alarms**

Applications

The smooth processing of signalling is not only important to ensure the quality of digital channels, but also plays a crucial role in switching. Time multiplexed data streams can only be transmitted without errors if signalling is performed correctly. All the signalling procedures that are used for dialog traffic between exchanges have strict error and timing specifications. These exacting requirements make high quality test equipment essential.

The PRA-1 Frame Analyzer is indispensable for installing and maintaining transmission and switching equipment that has been connected to a data network. Using the PRA-1, it is easy to monitor incoming and outgoing frames simultaneously, and, in particular, the information in time slot 16. The optional, integral generator section can be used to test all the error recognition circuits in the system; in-service loop-through measurements can be performed for this purpose.



Simultaneous in-service measurement of two multiplex frames

Characteristics

Two completely separate and independent receive sections for both forward and backward channels have been provided so

Line codes	HDB3, AMI, RZ and NRZ
Analog measurements in telephone channel	level, coder offset, frequency
Outputs for	64 kbit/s signal, signalling bits

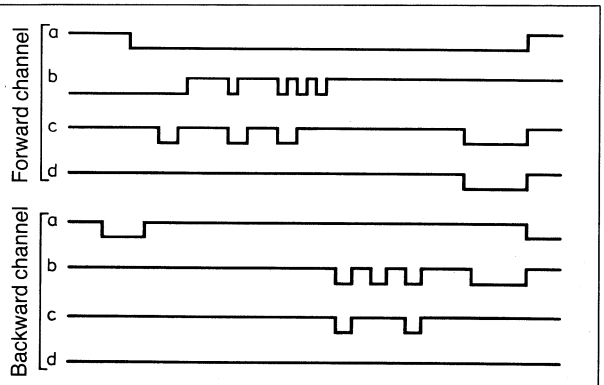
Options
Generator section:
Loop-through measurements in selectable operating modes
Inputs for signalling bits and external analog signal
Bit-error measurement:
Pseudorandom sequences of 2^6-1, 2^9-1, $2^{11}-1$, $2^{15}-1$, $2^{20}-1$ bits, plus digital word
CRC module:
CRC-4 to CCITT Rec. G.704, § 3.3
< IEC 625 >/IEEE 488 interface bus

2635 PRA-1

that two 2048 kbit/s multiplexed frames can be examined simultaneously. This makes it possible for the PRA-1 to fulfil one of its most important functions, namely the monitoring of all frame signals and alarm signals. There are two display modes.
The first mode uses LEDs which display the following: remote alarms in not frame-alignment words and not multiframe-alignment words, code violations, frame errors, CRC errors, multiframe errors and, under certain circumstances, bit errors. Any event is displayed for at least 100 ms. It is also possible to display the octet frame alignment signal, not frame-alignment word, multiframe alignment signal/not multiframe-alignment signal, CRC multiframe alignment signal and the 8-bit words from the selected non-signalling channel in real time.
In the second mode all events can be retrieved at any time from an alarm memory. The memory is erased when a new test interval is started, or whenever the operator requires. The following are also shown: no signal, alarm indication signal, loss of frame sync., CRC multiframe errors, continuous zero signal, and several other events that occur in conjunction with bit error measurements. The microprocessor sorts the alarms that have been recorded according to priority, so giving a very user-friendly display.

Interfaces
The receiver inputs fulfil CCITT Rec. G.703, and in some respects have more stringent specifications. Great care has been taken to ensure a high tolerance to input jitter.
No matter what the received bit pattern might be, the receiver can recover the required timing information from the received signal.

Signalling
The PRA-1 has been specially designed to record, evaluate and display the signalling in time slot 16. Not only is it possible to evaluate the signalling in each frame, but time measurements between outgoing and incoming signalling words can also be made. The user has complete freedom in selecting trigger criteria for starting and stopping measurements, and can vary the recording delay time. The memory has an overwrite mode.



Example of graphics display of signalling bits vs. time

As the PRA-1 has a μP it is particularly easy and simple to evaluate signalling. When time difference deviation or pulse distortion is being measured, various nominal values with independent, adjustable limits can be entered. If the measured parameter is outside the given limits, the PRA-1 indicates the appropriate pulse to the operator and displays the time difference.
Signalling can be shown in the following ways:
The time between any two states can be shown directly on the PRA-1's display, or a single channel oscilloscope can be connected to the PRA-1 to show 8 signalling bits simultaneously. For a particular setting of the oscilloscope, flicker-free display of pulse trains is possible up to 1000 s. Cursors can be displayed on the screen for time difference measurements. It is also possible to adjust delay times. No matter what display range is used, a resolution of 2 ms can be achieved in this way. The PRA-1 can also output the signalling on bits graphically. The whole or part of the pulse diagram can be shown. The resolution is selectable.

Transmission measurements
Measurements to determine digital transmission path quality are of vital importance. The distribution of errors as a function of time is gaining in importance in this context. Recommendation G.821 describes an error analysis procedure that makes use of the all digital Hypothetical Reference Connection (HRX). This procedure does more than simply determine the average error ratio. Bit error measurements (option) are performed using a special synchronisation technique that allows valid measurements to be made at high error ratios and in the presence of long error bursts. These features, and the error analysis capability, widen the instrument's range of applications considerably. The thresholds for errored seconds, degraded minutes and severely errored seconds can be adjusted.
The detection of transmission errors can be improved to a great extent if further check bits are used. In the case of extended frames, the CRC-4 check sum of each multiframe is calculated and the result compared with the received CRC bits.
Error ratio measurements can be performed on the CRC bits and the CRC frames. Using an option which can be connected to the generator and receiver separately, the CRC words are regenerated in loop-through mode in the generator and injected into the transmitted signal. It is also possible to make delay measurements (loop-back measurements) using the bit error measurement facilities when the generator section is fitted.
The performance of the PRA-1 is further enhanced by facilities for certain important analog telephone channel measurements. The PRA-1 calculates the wideband level directly from the code words. Maximal code words, coder offset and signal frequency can also be measured precisely.

Printer
The integral printer is used to output the graphic signalling display, all numerical results, and also the time, date and measurement mode. The printer has manual and remote control facilities. Program control is very useful for long-term monitoring or for unsupervised operation.
Printouts can be produced at regular intervals, or whenever certain set limits are exceeded.

Unless otherwise stated, the values apply to any operating conditions and device settings within the nominal ranges of use for a.c. line voltage, a.c. line frequency and ambient temperature.

Receiver

Frame structure

32-channel frame, with
30 telephone channels . . . . . to CCITT Rec. G.704, § 3.3
or 31 telephone channels . . . . . time slots 1 to 31
or 32 telephone channels . . . . . all time slots

Digital signal inputs

as described in CCITT Rec. G.703
Line codes . . . . . HDB3, AMI, RZ, NRZ

Coaxial input* . . . . . 75 Ω or >5 kΩ

Balanced input . . . . . 120 Ω or >5 kΩ
Input voltage range . . . . . 30 mV to 3 V

Bit rate
Internal clock recovery for . . . . . 2048 kbit/s
Capture range for clock regenerator . . . . . $\pm 250 \times 10^{-6}$

External frame-trigger input for marking the start of the frame when no frame alignment signal is available.

Evaluating digital words in the signalling channel

Internal signalling in time slot 16
Measurements on two multiplexed signals, and extraction of signalling for the selected time slot.

Data or telephone channel selection
Separately for both receivers, or one of the time slots . . . . . 1 to 15 or 17 to 31

External signalling
Two bit-parallel inputs using HCMOS levels

Signalling bit display
Real-time LED display . . . . . bits a, b, c and d

Parallel output for signalling bits

Serial output for time slot 16

Recording signalling information

Simultaneous recording of forward (F) and backward (B) signalling words using appropriate trigger criteria, or an external trigger signal.

Start and stop trigger criteria
Each bit can be set separately . F (bit a, b, c, d), B (bit a, b, c, d)
Signalling bit states, selectable . . . . . H level, L level
positive going edge, negative going edge or "any"

Recording delay time
After start and stop, adjustable . . . . . 0.01 to 999 s

Event memory

Operating mode . . . . . no overwrite/overwrite
Memory capacity . . . . . 256 events
Resolution . . . . . 0.002 s

Evaluating the signalling bits

Signalling table
Displays signalling bits and time
Range . . . . . up to 9999.000 s

Time difference measurements between any two states
Display range . . . . . 0.002 to 999.000 s

Time difference deviation measurements
Pulse duration measurements
Pulse counts
Pulse distortion measurements
Nominal values, settable . . . . . 0 to 999.998 s
Pos./neg. tolerance value . . . . 0 to +999.998 s/−999.998 s

Display of results
If an out-of-tolerance condition occurs the pulse number and the time deviation are shown.
An 8-channel pulse diagram is shown using an external, single-channel oscilloscope.
The time difference can be read off with two cursors.

Error measurements

Separate evaluation for the forward channel and backward channel.

Code errors . . . . . to CCITT Rec. O.161
for . . . . . AMI and HDB3

Frame alignment signal errors
Separate evaluation of bit errors and word errors

Word errors in the multiframe alignment signal

External errors
Max. counting frequency . . . . . 2.1 MHz

Other error measurements . . . . . see options

Error acquisition
Two counters simultaneously count any type of error.
Error count and error ratio are displayed simultaneously
Range . . . . . 0 to 1×10^{14}

Measurement intervals for both counters
Adjustable from . . . . . 1 s to 99 d 23 h
Measurement type . . . . . single shot, or repetitive
Automatic conversion of the measurement interval into $m \times 10^n$ bits or $p \times 10^q$ frames.
When the measurement is running, the elapsed time is shown.

Outputs for error pulses
Bit errors and word errors in the frame alignment signal.
Word errors in the multiframe alignment signal.
CRC-word errors (option)

Evaluation of digital words in telephone channels

Telephone channel selection
Selection of one time slot . . . . . (0), 1 to 15, (16), 17 to 31

Coding law
to CCITT Rec. G.711 . . . . . A-law

Code-word measurements
Determination of peak drive and coder offset

Level measurements (wideband)
Calculation from the code words,
range . . . . . −80 to +5 dBm0

Frequency measurements
in the range . . . . . 0.1 to 3.99 kHz

Analog decoder output

Options

2048 kbit/s Generator, BN 2016/00.01

Frame structure
Like the receiver, but any setting for the frame alignment signal, the not frame-alignment signal, the multiframe alignment signal and the not multiframe-alignment signal.

Outputs for digital signal and clock
Interface . . . . . as described in CCITT Rec. G.703
Line codes . . . . . HDB3, AMI, RZ, NRZ
Coaxial output* . . . . . 75 Ω
Balanced output . . . . . 120 Ω

Clock facilities
Generator with internal clock
Bit rate . . . . . $2048 \pm 25 \times 10^{-6}$ kbit/s
Generator with external clock
Required clock frequency 8 kHz or . . . $2048 \pm 100 \times 10^{-6}$ kHz
Generator operated from receiver clock

Operation
Separate operation
Generator and receiver operate independently.
Generator and receiver (RXF) in loop
2048 kbit/s loop with through switching of all time slots, with selection of one channel for generator or receiver, or injection of a test pattern in a time slot.

Test facilities and error injection
AIS transmission
Frame and multiframe synchronisation test
Signalling words for the selected time slot
Generation of code-violation bit error ratio and frame-alignment signal bit error ratio
of . . . . . 5×10^{-3} and 1×10^{-n}, n = 3, 4, 5, 6

Generator signals
The 64 kbit/s signals can be inserted into one or all of the time slots with the exception of the selected time slot, or in all channels.
Sinusoidal signals
Frequency range,
step width 101.266 Hz . . . . . 101 Hz to 3949 Hz
Level range, step width 5 dB . . . −55 to 0 dBm0 and +3 dBm0
Digital milliwatt to CCITT Rec. G.711
External analog signal

Bit error measurements, BN 2016/00.02
Pattern generation and bit error measurements are independent and so can be set separately. One receive section is needed to evaluate each parameter.

Frame structure
64 kbit/s bit pattern . . . . . see receiver or generator
2048 kbit/s bit pattern
Error measurements with or without frame structure
Bit pattern
Two programmable digital words . . . . . 1 to 16 bits
All ones signal and externally switchable 2 × 8-bit word

Pseudorandom sequence for generator and receiver	2^6-1 bits 2^9-1 bits $2^{11}-1$ bits $2^{15}-1$ bits $2^{20}-1$ bits	— V.52: not inverted O.152: not inverted O.151: inverted V.57: not inverted
Pseudorandom sequence for all generator channels not carrying signalling	$2^{11}-1$ bit/ SHIFTED	Single channel measurement in any channel not carrying signalling

Each pseudorandom sequence may be inverted. Block error measurements can be performed with the pseudorandom sequences.

Available bit error ratios . . . . . see code errors
Delay measurements (loop measurements)
Max. measurable delay time . . . . . 500 ms
Test signal in the 64 kbit/s telephone channel . . . . . $2^{15}-1$
Test signal at 2048 kbit/s without frame . . . . . $2^{20}-1$

CRC module, BN 2016/00.03
Can be connected separately to both receivers and the generator
Receiver
Resynchronisation when ≧920 CRC word errors occur per second. Evaluation of CRC word errors and CRC multiframe errors.
Generator
Generation and injection of CRC-4 words in the transmission signal. Injection of CRC word errors and CRC multiframe errors.

< IEC 625 > Interface Board, BN 958/21
All functions remote controlled, interrogation of measured values

General specifications

Power supply
Nominal range of use for a.c. line voltage, selectable . . . 110/117/127/220/227/237 V, −12 to +10 %
Nominal range of use for a.c. line frequency . . . 47.5 to 63 Hz
Power consumption . . . . . max. 120 VA
Safety class to IEC and VDE 0411 . . . . . class I
RFI/EMI suppression . . . . . to Cert. 1046/1984 of the Deutsche Bundespost

Ambient temperature
Nominal range, use . . . . . +5 to +40 °C
storage and transit . . . . . −40 to +70 °C

Dimensions in mm
Bench model (w × h × d) . . . . . 477 × 155 × 434

Weight . . . . . approx. 16 kg

Ordering information

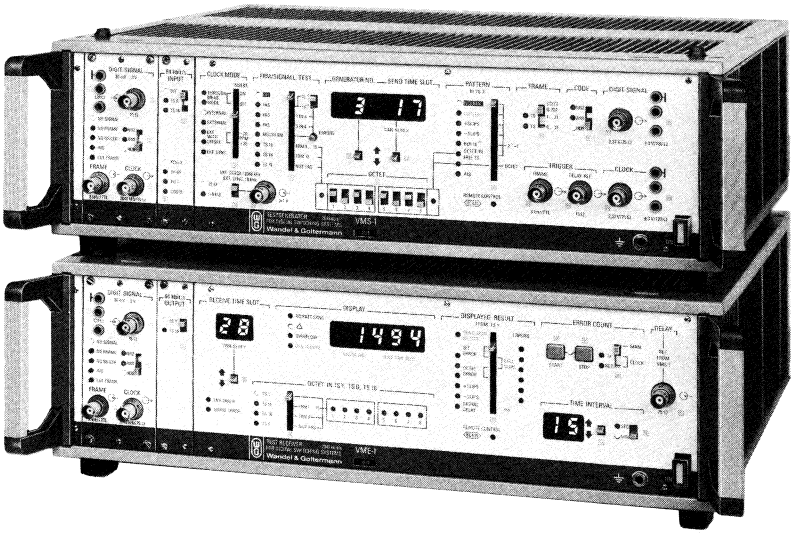
Frame Analyzer PRA-1	**BN 2016/01**
Options (charged extra)	
2048 kbit/s Generator [1]	BN 2016/00.01
Bit Error Measurement [2]	BN 2016/00.02
CRC Module [2]	BN 2016/00.03
< IEC 625 > Interface Board with IEEE 488 connector	BN 958/21
Accessories (charged extra)	
IEEE 488/IEC 625 adaptor (M-M)	S 832
Front and Back Panel Covers SD-3 (1 set)	BN 700.00/23
Transport Case TPK-3	BN 626/09
19" Conversion kit	BN 700/00.03

*) Fitted with the Versacon® 9 75 Ω basic connector and BNC insert. If other types of insert are required – see Versacon® 9 specification sheet – specify when placing your main order.
1) Can only be ordered with mainframe
2) Both options must be ordered together

VM-1
Test Set for Digital Exchanges

for testing digital switching equipment

IEEE 488
IEC 625



- **Tests the through switching of digital exchanges**
- **Acquisition of bit and octet errors**
- **Measures signal transit delay**
- **Analysis and simulation of PCM frame structures**
- **Investigations in signalling channels**

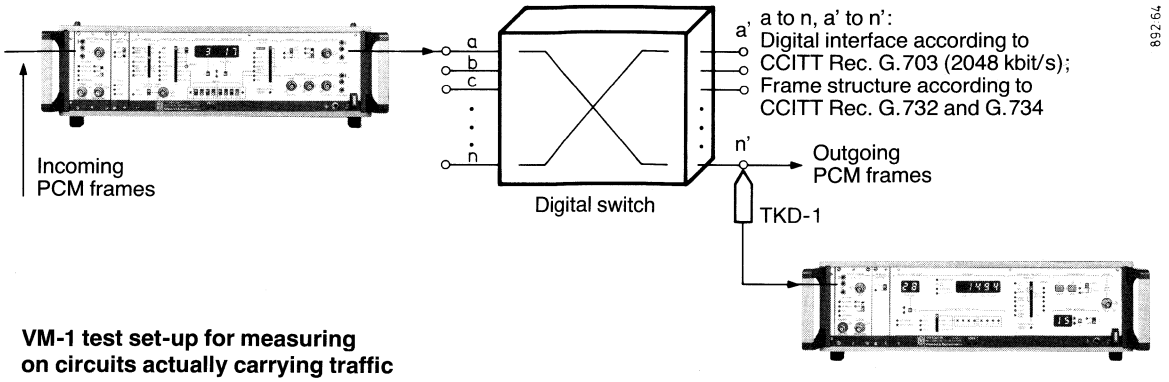
Applications

The heart of a digital exchange is the digital connection device operating between digital interfaces. The data stream transferred through the interfaces mostly corresponds to the transmission capacity of the PCM primary system. Digital exchanges operate, therefore, at exactly the same bit rates as the transmission system, but they have a different transmission behaviour. Whereas, transmission systems generally do not alter the multiplex signals during their conveyance, the signals passing through a digital exchange are dismembered and then reassembled. This process complicates the associated measurement technology, which must be capable of simulating frame structures and analyzing them. Another problem is relevant to the method of matching the clock signal to digital exchanges that, when processing plesiochronous signals, produce impairments in the digital wanted signal.
The usually available digital measuring instruments are generally not capable of coping with the described difficulties. But the VM-1 Test Set developed especially for use with digital exchanges solves these problems because it works with frame structures, and it can handle the problems associated with matching to the relevant clock signal.

Characteristics

A measuring task of fundamental significance to the functioning of a digital exchange is the test of whether or not the channel selected for switching has, in fact, retained its sense while being switched through the digital switching equipment. For that purpose, at the send side, the VM-1 generates a standard PCM frame whose channel time slots 1 to 15 and 17 to 31 are loaded with pseudo-random sequences that simulate real voice traffic carried on communication circuits.
These pseudo-random signals are replaced periodically by the signal that identifies the test signal's position in time and the generator number. The Receiver synchronizes to the PCM frames at the output of the digital exchange, extracts the identification signal from the channel time slot coming from the send side, and then displays the appropriate number accordingly. Since the Receiver, in addition, displays the relevant receive position in time and also since the pertinent spatial output in use at that time is known, the identification signal has, thereby, assisted in establishing unambiguously how a definite channel has been switched through.
As with every digital communication equipment the number of bit errors is also one of the most important characteristics of quality necessary for the assessing of digital switching equip-

PCM frame structure conforms with CCITT Rec. G.732
Internal and external clock supply . . . . . 2048 kbit/s
Test Pattern:
Pseudo-random sequence of length $2^{11}-1$ bits,
or periodic test signals
Acquisition of octet insertions and omissions (slips)



VM-1 test set-up for measuring on circuits actually carrying traffic

ment. For measurement of bit errors the VM-1 Test Set generates a pseudo-random pattern of length $2^{11}-1$ bits, and also at the send end this pattern is inserted into a freely selectable channel time slot of the PCM frame generated by the VM-1. The $2^{11}-1$ bit pseudo-random sequence is that recommended by the CCITT for testing 64 kbit/s channels.
The test pattern is conveyed by groups of 8 bits (octets) in the selected channel time slot, moreover, the remaining channel time slots are loaded with a loading pattern. At the receive end of the VM-1, the Receiver synchronizes to the PCM frames appearing at the output of the digital exchange and extracts the test pattern of $2^{11}-1$ bits contained in the switch selected channel time slot, but which had originally been applied to the input of the digital switching equipment. An identical reference pattern is generated within the Receiver and is clock- and phase-synchronized with the transmitted pattern, so that a bit-by-bit comparison is possible. If any errors exist in the transported 64 kbit/s signal, then these can be detected and registered or recorded.
With a bit error measurement of the usual type, difficulties occur when the digital signals that are presented to the digital switch have not been synchronized with the system clock. "Slips" appear because the digital switching equipment then reacts to the plesiochronous signals. A slip leads to interference when the customary bit error measurement methods are applied; owing to the loss of necessary synchronization between the incoming test signal and the reference pattern used for error evaluation in the Receiver. The VM-1 Receiver can distinguish between random bit errors and errors caused by slips. So the VM-1 avoids the aforementioned difficulties.
Besides the through-switching behaviour and the bit errors, the transit time of the digital signal while passing through the digital switching equipment is an interesting measurement parameter.

The signal transit time in a 64 kbit/s channel may be measured with the assistance of the $2^{11}-1$ bit test pattern. For this measurement, a characteristic bit combination of the specific bit pattern is selected, and when it occurs in the Generator, a reference pulse is produced for feeding to the Receiver via a reference connection. The Receiver measures the time difference between the occurrence of the reference pulse and the existence of the characteristic bit combination at the output of the digital switching equipment. Thereupon, the Receiver provides a display direct in microseconds of signal transit time.

With the previously described measurements, one complete multiplex signal is replaced by the test signal presented by the Generator. This signifies that a corresponding number of telephone channels can not be switched while a measurement is being performed. If this loss of traffic is not feasible, then the VM-1 Generator can be extended with a Signal Insertion Device. This device permits the feeding in of an external PCM signal, and the Test Set operates in a fully transparent mode. So the PCM signal appears without impairment at the Generator's output.

When the mode selected is "Measurement", however, the digital signal is inserted in any selectable channel time slot and is replaced by the test signal of the VM-1 Test Set. For that reason, only one of the 30 telephone channels is taken out of operation, whereas the remaining channels are actually carrying voice traffic. Thus, the Signal Insertion Device is particularly suitable for long-term monitoring. In order that the PCM signal being subjected to the digital switching process may not be interfered with, a high-impedance Test Probe intercepts the PCM signal, as shown in the illustration above.

Specifications of the Test Set for Digital Exchanges — VM-1

When not otherwise noted, the specified values are valid for any operating conditions and instrument settings within the rated ranges of use of the influence quantities.

Generator VMS-1

PCM frame structure

32 channel PCM frame, selectable loading with:

30 telephone channels	corresponding with CCITT Rec. G.732
or 31 telephone channels	channel time slots 1 to 31
or 32 telephone channels	all time slots loaded

Clock supply

Internal clock

Bit rate	2048 kbit/s
Error limits	$\pm 25 \times 10^{-6}$

External clock

Required clock frequency	2048 kHz $\pm 100 \times 10^{-6}$
Offset of clock signal externally applied to VMS-1	$\pm 20 \times 10^{-6}$

Test Patterns

NORMAL . . . . . errorless test pattern $2^{11}-1$, in selected channel time slot
Loading pattern, $2^{15}-1$, in the unloaded channel time slots

IDENTIF . . . . . approx. every 256 ms the Generator and channel time slot numbers, as BCD coded numbers (0 to 31) are alternately inserted into the channel time slots that have been loaded with test and loading patterns

OCTET IN FREE TS . . . . instead of the loading pattern, $2^{15}-1$, an octet can be set-up in the free (unoccupied) time slots

OCTET . . . . . instead of the test pattern, a settable 8-BIT-WORD in chosen time slot

External setting of an octet . . . . . parallel input on the back panel for the external setting of an octet in channel time slot X and in the unloaded channel time slots (TTL voltage)

AIS . . . . . Alarm Indication Signal, i.e. continuous stream of "1" 's in all channel time slots

PCM Frame and Multiframe Tests

Tests in channel time slot 0

Tests in channel time slot 16

Self test

+ SLIPS . . . . . octet doubling approx. every 2 s
− SLIPS . . . . . octet omission approx. every 2 s
BER 10^{-4} . . . . . insertion of a 10^{-4} Bit Error Ratio in the test pattern

Generator outputs*

General interface conditions . . . . . correspond with CCITT Rec. G.703

Digital signal and clock
Line codes . . . . . NRZ, AMI ½, HDB 3
Input impedance, coaxial . . . . . 75 Ω
balanced . . . . . 120 Ω
Output pulse shape . . . . . almost rectangular
Pulse amplitude
Coax. output, 75 Ω termination . . . . . 2.37 V ± 10 %
Bal. output, 120 Ω termination . . . . . 3 V ± 10 %

Trigger outputs*

PCM frame trigger . . . . PCM frame trigger signal (TTL) with positive transition at beginning of channel time slot 0

Pattern trigger . . . . . trigger signal synchronized with pattern $2^{11}-1$ in selected channel time slot
For signal delay measurements, this is a reference signal (DELAY REF.) routed to Receiver VME-1
Output voltage . . . . . TTL signal
Output impedance . . . . . connected as 75 Ω

Receiver VME-1

Evaluable PCM frame

32 channel PCM frames, loaded with:
30 telephone channels . . . . . conforming with CCITT Recommendation G.732
or 31 telephone channels . . . . channel time slots 1 to 31 in case no multiframe alignment signal is present
or 32 telephone channels . . . . in case an external 8 kHz frame trigger signal is available

Receiver inputs

General interface conditions . . . . . conform with CCITT Rec. G.703

Digital signal inputs*
Line codes . . . . . NRZ, AMI ½, HDB 3
Input impedance, coaxial . . . . . 75 Ω
balanced . . . . . 120 Ω
Required pulse amplitude . . . . . 30 mV to 3 V
R.M.S. value of input voltage . . . . . ≦ 4 V

Receive channel display

Possibility for selecting RECEIVE TIME SLOT and displaying choice (TIME SLOT Y)

Measurement quantities

Measured in selected RECEIVE TIME SLOT

Send signal identification . . . . display of send signal identification, i.e. of generator number and send time slot number carried by selected receive channel after send channel has been digitally switched

Error measurement
The following types of errors are simultaneously measured in the received test pattern ($2^{11}-1$), indicated by LED's and consequently are totalized in separate counters:
Bit error . . . . . bit error count in selected time slot; bit errors due to SLIPS are counted as errors
Bit error excl. SLIPS . . . bit error count in selected time slot; bit errors due to SLIPS are not counted as errors
Octet (word error) excl. SLIPS . . . . . PCM word error count in selected channel time slot; word errors due to SLIPS are not counted as errors

Octet (word error) . . . . . PCM word error count in selected channel time slot; word errors due to SLIPS are counted as errors
+ SLIPS . . . . . count of octet insertions
− SLIPS . . . . . count of octet omissions
Signal delay . . . . . measurement of the transit delay of a 64 kbit/s signal from Generator VMS-1, through the digital exchange, to the Receiver VME-1

Displayed result

All measured results are ascertained simultaneously.
One result is shown on the digital DISPLAY; a switch selects the type of result to be displayed

Light Emitting Diode (LED) monitoring for display of:
NO PATTERN SYNC . . . . . no synchronization to Test Pattern $2^{11}-1$
⚠ . . . . . caution, displayed result is not valid (e.g. due to a.c. dropout, loss of timing [sync.], signal interruption etc.)
OVERFLOW . . . . overflow of selected measured value display
GEN. IDENTIF . . . . . generator identification is present

Display of send channel recognition
Generator No. . . . . 1 to 31
Send Time slot, each according to frame type . . . . . 0 to 31

Display of ERROR COUNT
Range of count . . . . . 0 to 99 999

Display of signal delay
Display range . . . . . 0.001 to 9.999 ms
Measuring sequence . . . . . one measurement per 512 ms
Error limits of displayed delay . . . . . ± 0.01 %, − 1/+2 µs

Measurement run for error count

MAN . . . . . error count with Start/Stop mode

1xCLOCK . . . single measurement start with push button, stop after selectable time interval elapses
Count time adjustable in range . . . . . 1 to 99 s
or . . . . . 1 to 99 min

REP. CLOCK . . . . . repeated measurement START with push button. Repeated measurement is implemented during the adjusted time interval. Terminate measurement with STOP. The measured value at the end of the interval is taken from the DISPLAY.

Octet (8-BIT-WORD) indication
LED indication of following octets:
TSY . . . . indication of octet in selected receive time slot Y
TS 16/FRM 1...15 . . . . . indication of the 4-bit-signalling signal coordinated with the selected receive time slot
TS 16/FRM 0 . . . . . indication of multiframe alignment and "not multiframe" alignment signals
TS 0/NOT FAS . . . . . indication of alarm (not frame alignment) signal in time slot 0

Outputs on the back panel
Frame or multiframe error output
Outputs for errors in frame and multiframe alignment signals

Error output (14 pin Amphenol connector)
for output of error count pulse, separated according to error type

Output signal . . . . . TTL voltage

Octet output . . . . . parallel output for octet display on front panel (TTL voltage)

Options for Generator and Receiver

Signal Insertion Device, BN 892/00.02 (only for VMS-1), for insertion of channel time slots into a 2048 kbit/s frame. Thereupon, measurements can be implemented on PCM systems actually carrying traffic.

64 kbit/s TTL input, BN 892/00.04 (for VMS-1)
Interface with TTL voltages for insertion of 64 kbit/s signals in the chosen telephone channel or in time slot 16

64 kbit/s TTL output, BN 893/00.04 (for VME-1)
Interface with TTL voltages for output of 64 kbit/s signals from the selected time slot or from time slot 16

Remote control, BN 892/00.01 (for VMS-1)
Interface Bus < IEC 625 > for remotely controlling all function settings

Remote control (BN 893/00.01 (for VME-1)
Interface Bus < IEC 625 > for remotely controlling all function settings

General Specifications
Common to Generator VMS-1 and Receiver VME-1

Power supply
Rated ranges of use of
a.c. line voltage . . . . . 96.5 to 140 V, 193 to 261 V
Rated range of use of
a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption, Generator or Receiver . . . . each 65 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature
Rated range of use . . . . . +5 to +40° C
Storage and transport . . . . . −40 to +70° C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	155	Height (3 units)	131
Depth with handles	425	Depth	370

19" conversion kit . . . . . BN 700/00.03

Weight
Generator or Receiver . . . . . each approx. 13 kg

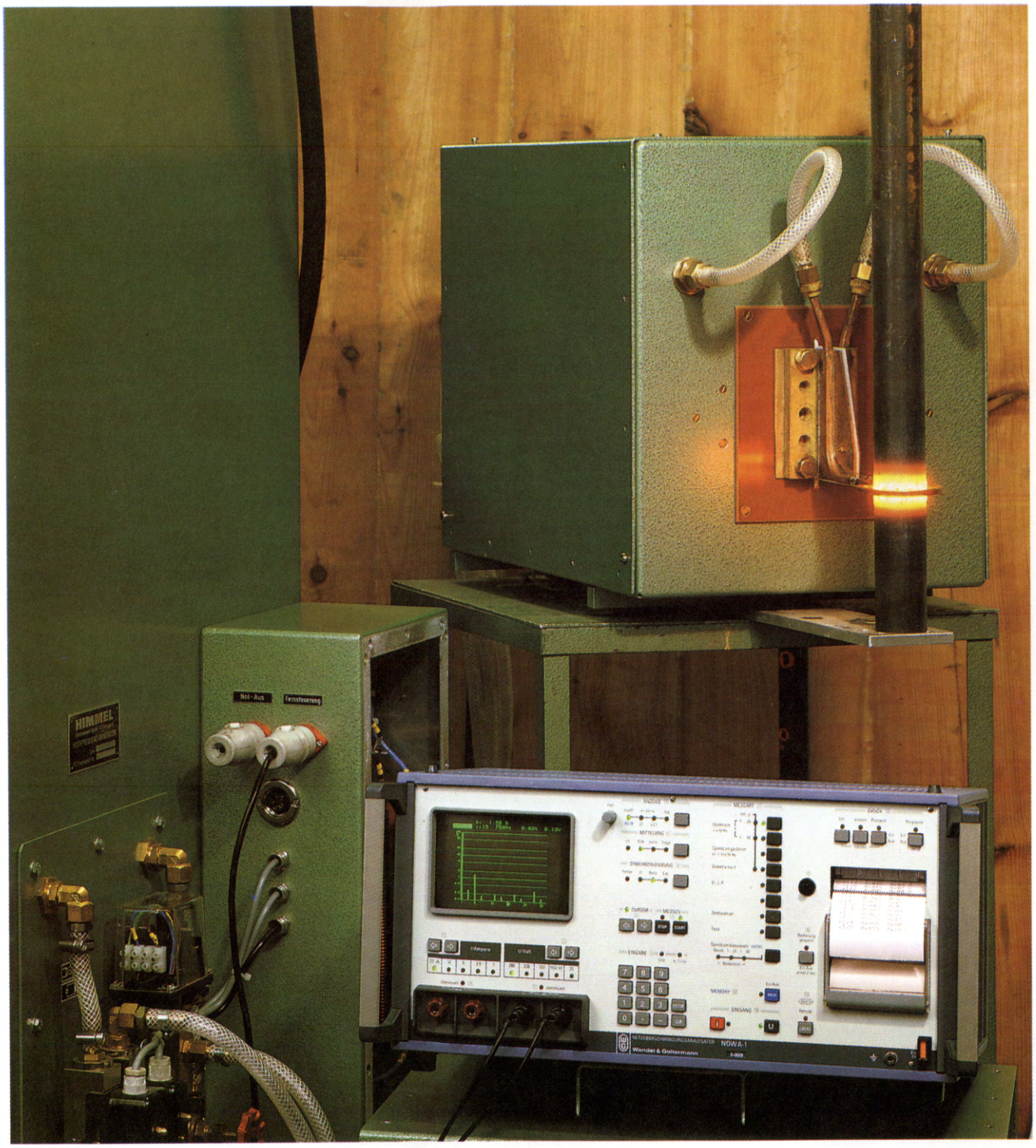
Ordering Information

Test Generator VMS-1*	**BN 892/01**
Test Receiver VME-1*	**BN 893/01**
Options for VMS-1 (at extra cost)	
Interface Bus < IEC 625 > Card[1)]	BN 892/00.01
Signal Insertion Device*	BN 892/00.02
64 kbit/s input	BN 892/00.04
Options for VME-1 (at extra cost)	
Interface Bus < IEC 625 > Card[1)]	BN 893/00.01
64 kbit/s TTL output	BN 893/00.04
Accessories (at extra cost)	
Transport Protective Cover for Generator, SD-3	BN 700/00.23
Transport Protective Cover for Receiver, SD-3	BN 700/00.23

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.
1) With adaptor plug IEC 625/IEEE 488 (S 834)

A Specification Sheet with more details is available on request

Analysis and Stabilisation of Supply Networks



Overview

Analysis and Stabilisation of Supply Networks

Characteristics and applications	Name	Page
• Measures up to the 50th harmonic on 50 (60) Hz networks • Measures current and voltage spectrum, phase angle and true power to EN 50 006 or IEC 555 norms • Bar-graph on screen • Results listed by strip-printer with digital clock • <IEC 625>/IEEE 488 Interface Bus	**NOWA-1 A.C. Power Line Harmonic Analyzer**	299
• Stabilises single or three-phase networks • Large supply voltage range can be stabilised • Low time constants	**WS-5, WS-10 A.C. Voltage/Three-phase Stabilizers**	303

NOWA-1
A.C. Power Line Harmonic Analyzer

for measuring out to the 50th harmonic on 50 Hz a.c. power lines

IEEE 488
IEC 625

Available also for 60 Hz a.c. power



- **Measures the harmonic spectra of voltage, current, phase angle and true power complying with EN 50 006 or IEC 555 (Edition 1982)**
- **Expanded display of a spectrum ±50 Hz about every one of the 50 Hz harmonics**
- **Selective measurements in the range 15 Hz to 2.5 kHz**
- **Measures the r.m.s. values of voltage and current, true, reactive, and apparent power, power factor and the fundamental frequency of the composite signal**
- **Incorporated strip printer with digital timer**

Applications

As power consumers use more and more electronics to control their power supplies, increasing amounts of contamination are observed on the a.c. line. This contamination can impair the function of equipment and installations supplied by the same network.
The NOWA-1 A.C. Power Line Harmonic Analyzer gives generating authorities, public utility companies and operators of industrial networks the means to investigate and monitor their networks.
By measuring instantaneous, maximum or average values, producers of harmonics can determine how they are going to eliminate the introduced contamination, or decide on long term counter-measures.
Manufacturers of household articles or other equipment with electronic controls, manufacturers of thyristor controlled drives, rectifiers, frequency converters and emergency power supplies, and manufacturers of motors and generators can test their equipment at the development stage, at the production stage and during field trials to see if their products meet the prescribed tolerances.
A 60 Hz version is available for carrying out measurements on 60 Hz a.c. power networks.

Characteristics

The European Standard EN 50 006, elaborated by CENELEC (Comité Européen de Normalisation Electrotechnique), contains guide-lines concerning the limitation of disturbances in electricity supply networks. This standard also contains selectivity requirements and prescribes the type of display to be used in measuring instruments. The NOWA-1 A.C. Power Line Harmonic Analyzer meets all these requirements. Over and above this, the NOWA-1, which is easy to operate, can be used to carry out many other measurements.
The NOWA-1 measures out to the 50th harmonic of the 50 Hz fundamental and does this for current or voltage. The result is shown as a bar chart on the integral screen. Nonharmonic impairments (e.g. impairments caused by pulsing harmonic currents or by static converters) can be measured selectively in the range 15 Hz to 2.5 kHz. True power, reactive power, apparent power, power factor, harmonic content (distortion factor) the phase angle between voltage and current, and frequency, can all be displayed depending on the setting selected. An integral strip-printer is supplied for hardcopy records of the results.

Measurement ranges (nominal value)	
Current	1 A, 2.5 A, 5 A, 10 A, 25 A
Voltage	100 V, 100 V/$\sqrt{3}$, 120 V, 230 V, 400 V
Synchronisation, reference frequency	50 (60) Hz ± 5 %
Measurement modes	
50 (60) Hz spectrum	$\nu = 1$ to 25, $\nu = 1$ to 50
Expanded spectrum about each harmonic ($\nu \times 50$ Hz or $\nu \times 60$ Hz)	± 50 (60) Hz
Selective measurements, 1 Hz steps	15 Hz to 2.5 (3) kHz
Total signal	$V_{r.m.s.}$, $I_{r.m.s.}$, P, Q, S, P/S, f

Further Characteristics and Applications

Signal processing in the NOWA-1

The NOWA-1 is fitted with two inputs so that voltage and current can be analysed simultaneously. The measuring ranges of the high impedance voltage input can be switched to all the usual a.c. line voltages. For measurements on intermediate and high voltage supplies the input values can be switched to the usual voltage converter output voltages. The current is measured indirectly using an integral shunt. Current ranges between 1 A and 25 A can be selected.

As the NOWA-1 uses digital processing, it has decisive advantages over analog instruments:

All the harmonics in the harmonic spectrum are calculated simultaneously using fast Fourier transforms. As well as considerably simplifying operation, this method of real time analysis means that the harmonics of a non-stationary signal can be compared legitimately.

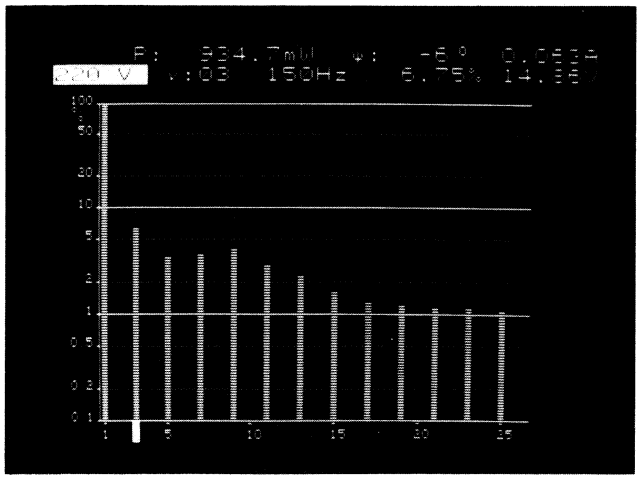
Digital signal processing gives the NOWA-1 a high degree of flexibility so that different operating modes can be selected. By means of certain calculations, parameters such as phase angle, power, harmonic distortion, average values and threshold transgressions can be worked out. Because digital filters are used, temperature changes or component ageing cannot vitiate the results. The digital display means it is almost impossible to make a reading error. The graphic display on the screen makes it easy to follow signal variations and trends.

Measurement modes and display

50 Hz spectrum

The spectrum to the 25th or 50th harmonic is displayed on the screen as a bar-chart. By placing the cursor on a particular bar, the r.m.s. value of the current or of the voltage for that harmonic with absolute and percentage values is displayed on the screen. The percentage is either referred to the selected measuring range (nominal value) or to the instantaneous value of the fundamental. In addition, the harmonic content (distortion factor) can be determined as prescribed in DIN 40 110 or DIN 45 403.

If current and voltage are measured at the same time and the cursor is moved to a particular harmonic, the real power and the phase angle φ between voltage and current will also be shown. As current and voltage are both being measured, the cursor can be used to run through all the values of each current and voltage harmonic. If the measurement is stopped during this time, all the results are derived from the same measurement.



Harmonic spectrum ($\nu = 1 \ldots 25$); values for the 3rd harmonic are shown by an alphanumeric display

Expanded spectrum

The operating mode "expanded spectrum" is used to find non-harmonic spurious signals whose frequencies lie between the 50 Hz harmonics. The frequency range of ± 50 Hz is divided up into 61 equidistant spectral lines.

Selective measurements

In the selective measurement mode, the measuring frequency can be set in 1 Hz increments in the frequency range 15 Hz to 2.5 kHz. Current or voltage can be shown in a quasi-analog form as vertical bars. Because the NOWA-1 can measure voltage and current simultaneously, the real power, the reactive power, the apparent power and the phase angle φ can be displayed, as can absolute values. The maximum values of short-duration signals can be stored. In this modified display mode, the NOWA-1 continuously measures the current or the voltage at the set frequency. The highest measured value is displayed permanently as a graph on the screen and its numerical value is stored for further use. The time at which the maximum measured value was recorded is also displayed. As a rapid measurement sequence of 3 measurements per second is executed by the NOWA-1, the starting pulses of telecontrol signals, for example, can be investigated.

Composite signals U, I, P

The r.m.s. values of the composite signals U and I in the frequency range 15 Hz to 2.5 kHz, the real power, the reactive power, the apparent power and the power factor P/S can all be displayed in this measurement mode. The frequency which is used to synchronize the sampling pulses is also measured.

Sampled input signal

A period of the current or voltage waveform can be shown on the screen to get a rough idea of its characteristics. The curve segment, which is made up of 64 points, can be shifted along the time axis.

Classified harmonics

The "classified harmonics" measurement mode is provided for long-term investigations on current or voltage harmonics. In this mode five harmonics can be selected, and by means of continuous measurements the NOWA-1 determines the transgressions of class limits. Seven class limits between 0 and 99.9 % of the measurement range's normal value can be entered. The 35 class results are shown in the form of a table which shows the relative transgression frequency. The classification process can take up to 100 days.

Measurement conditions

Standard EN 50 006 stipulates a particular *averaging procedure* to prevent the results from being vitiated by impairments of short duration (e.g. switching) on the a.c. line. Apart from the "standard" averaging (time constant approx. 1.5 s) a "slow" averaging mode is also available to ensure a steady display when signals with large fluctuations are investigated. In the "fast" mode the lastest result value is displayed after each measurement cycle. In the case of voltage or current spectra the measurement sequence is about two measurements/s and in the case of selective measurements it is about 3 measurements/s. Continuous and one-off measurement modes are available.

When the measurement signal is digitised, the sampling frequency is synchronised to the 50 Hz fundamental so that variations in the a.c. line frequency will have no effect on the measurements. The reference frequency used for *synchronization* can be the measured signal itself or the reference frequency can be derived from the operating voltage, from an internal crystal or from an external synchronising signal.

Two linear scales and one logarithmic scale have been provided for the graphical display of results on the screen. Because of its large dynamic range of 0.1 % to 100 %, large or small values are easy to read on the logarithmic scale. When the *cursor* is placed on a particular harmonic, the values for this harmonic are displayed as numbers on the screen.

If the measurement and display conditions have been set for a particular measurement mode these conditions are not altered if another measurement mode is selected in the meantime.

When the NOWA-1 is switched off, a battery in the instrument ensures that the contents of the *measurement mode memory* are not lost. Generally, you only need to press the measurement mode button you require and the results appear immediately on the screen.

Strip printer with digital clock
All numerical results displayed on the screen, and the date, time and measurement mode can be printed out on the strip-printer. The printout can be initiated manually or by program; various formats can be selected.
The program-controlled result printout is particularly useful for long term measurements or for unsupervised operation. A printout at particular time intervals or on transgression of adjustable limits can be selected.

Remote control
The optional *interface bus board* allows an external computer to control all the operating functions. Moreover, all the measured values, all the measuring parameters and the time can be interrogated via the <IEC 625>/IEEE 488 interface. This leaves the user free to evaluate the results as he requires (e.g. comparison of reference values, statistical analysis etc.).

Specifications of the A.C. Power Line Harmonic Analyzer — NOWA-1

If nothing to the contrary is stated, the data is valid for the rated conditions of use. The values given for current and voltage refer, if nothing to the contrary is mentioned, to the r.m.s. values of sinusoidal quantities. The data is valid for a reference frequency f_F = 60 Hz in the case of the 60 Hz version.

Measurement inputs

Separate floating inputs for current and voltage.
Maximum tolerable voltage to instrument case . . . . . 500 V

Input I (current)
Rated values of measuring ranges . . 1 A, 2.5 A, 5 A, 10 A, 25 A
Input impedance . . . . . approx. 15 mΩ
Overload limit, continuous . . . . . 30 A
max. 1 s . . . . . 400 A

Input U (voltage)
Nominal values of
measuring ranges*) . . 100 V, 100 V/$\sqrt{3}$, 120 V, 230 V, 400 V
Input impedance . . . . . 300 kΩ

Overload indication when the instantaneous value of the signal exceeds twice the rated measuring range value.

Synchronization
Rated range of use of reference frequency . . . 50 Hz ± 2.5 Hz
Source of synchronizing signal, switchable . . . . . U channel, internal, external

Measurement procedure
During continuous measurements, the measurement sequence can be interrupted.
The NOWA-1 can be switched to the "one-off" mode.

Measurement sequence
Spectrum $\nu \times f_F$, without ψ . . . . approx. 2 measurements/s
Selective at f, without ψ . . . . . approx. 3 measurements/s
The measurement times are doubled in the setting "with ψ".

Display averaging, switchable . . . . fast, normal, slow
In the "fast" setting the full measured value is displayed immediately after completion of the measurement. In the "normal" setting the averaging procedure complies with EN 50006 or IEC 555.

*) The following reference values can be entered: 100 to 130 V, 220 to 240 V, 380 to 420 V

Overview of the Measurement Modes

Measurement mode		Numerical display						
Spectrum, $\nu \times f_F$		ν [1]	U_ν or I_ν	With display "Modified": k_u, k_i [5] Relative value for U_ν or I_ν [6]				
	"with ψ"	f_{50} [2]	U_ν and I_ν	P_ν [7]	—	—	—	ψ_ν [8]
Expanded spectrum $(\nu \pm 1) \times f_F$		f [3] f_{50} [2]	U (f) or I (f)	—				
Selective at f		f [4]	U (f) or I (f)	With display "Modified": [18] Maximum of U (f) or I (f)				
	"with ψ"		U (f) and I (f)	P (f) [9]	Q (f) [10]	S (f) [11]	—	ψ (f) [8]
U, I, P		—	U_{eff}, I_{eff}	P [12]	Q [13]	S [14]	P/S [15]	f_G [16]
Sampled Input Signal		—	u (t) [17] or i (t)	(only graphic presentation)				
Classified Harmonics		ν [1] f_{50} [2]	N° of times the limits [19] for U_ν or I_ν are exceeded (7 classes) (5 values selectable for ν)					

1) Order of harmonic component
2) The display is of $f_{50} = \nu \times 50$ Hz. The true frequency is equal to the displayed frequency times the reference frequency, f_F, divided by 50 Hz. The reference frequency is the frequency to which the measurement is synchronized.
3) One of 30 intermediate values between two harmonic components $f_{50} = \nu \times 50$ Hz, also see 2).
4) Reference frequency: internal crystal frequency or 50 Hz ± 2.5 Hz also see 2.
5) Total harmonic factor in percent DIN 40 110 and DIN 45 403.
6) Referred to U_1 or I_1, in percent.
7) Real power at $\nu \times f$.
8) Phase shift angle between voltage, U_ν, and current, I_ν.
9) Real power at f.
10) Reactive power at f.
11) Apparent power at f.
12) Real power.
13) Reactive power.
14) Apparent power.
15) Power factor; corresponds to the cos φ with sinusoidal U and I.
16) Measured value of reference frequency, f_F. See synchronization.
17) Measured over 8 periods, $T = 1/f_F$.
18) In addition, when printer is incorporated the real time at which the maximum was measured.
19) In addition, when printer is incorporated, the real time at which START took place and results were printed out.

Analog display on the screen
Image size . . . . . approx. 95 mm × 66 mm
Y axis divisions
Display, linear . . . . . 0 to 125 %
linear expanded . . . . . 0 to 12.5 %
logarithmic . . . . . 0.1 % to 100 %

Selectivity
Measurement mode "spectrum"
Mid-band . . . . . $\nu \cdot f_F$
3 dB bandwidth . . . . . 3 Hz
Stop-band discrimination at $\Delta f \geqq 22$ Hz . . . . . $\geqq 60$ dB
Complies with EN 50 006 or IEC 555.

Measurement mode "expanded spectrum"
Separation of spectral lines
from center of band . . . . . $f_F/30 \approx 1.67$ Hz
3 dB bandwidth . . . . . 8 Hz
Stop-band discrimination for $\Delta f \geqq 15$ Hz . . . . . $\geqq 50$ dB

Measurement mode "selective"
3 dB bandwidth . . . . . 10 Hz
Stop-band discrimination for $\Delta f \geqq 18$ Hz . . . . . $\geqq 60$ dB

Measurement mode "classified harmonics" . . . . see measurement mode "spectrum"

Additional inputs and outputs
on the back panel

External inputs U and I*
Rated measuring range value (U and I channel) . . . . . 1 V
Input impedance . . . . . 100 kΩ

Input for external synchronization*
Frequency . . . . . 50 Hz ± 2.5 Hz
Voltage . . . . . 1 V to 42 V
Input impedance . . . . . 100 kΩ

Oscilloscope outputs U and I*
Open-circuit voltage when range is driven
at rated value . . . . . 2.5 V
Output impedance . . . . . 1 kΩ
Tolerable load impedance . . . . . $\geqq 10$ kΩ

D.C. plotter-output
Connector . . . . . two 4 mm jacks
The output voltage is proportional to the r.m.s. value
of the selected parameter:
"spectrum" . . . . . I_ν or U_ν
"expanded spectrum" and "selective" . . . . . I_f or U_f
Switchable scale, 5 V is equal to a relative drive signal (r.m.s. value of signal to nominal measuring
range value) of . . . . . 100 %, 10 %, 2 %
Output impedance . . . . . 5 kΩ

Video output*
Composite video signal, 50 frames/s, line frequency . . 16 kHz
Peak value of voltage when terminated with 75 Ω . . . . +1 V

Strip printer and digital clock
Matrix type printer uses 72 mm wide heat sensitive paper.

Print formats
Manual print initiation
- Screen printout, prints out all current numerical values on screen
- Listing with date and time, measured values as per screen printout or in measurement mode "spectrum" the values of all the current or voltage harmonics can be printed out.
- Clock printout, time and measurement mode

Program-controlled print initiation
at certain intervals or in the measurement modes "spectrum" and "selective" when certain limit values are transgressed.
- Screen printouts and listings as per manual initiation
- Special printout for the "spectrum" measurement mode; measured values for 5 selectable harmonics.

Digital clock, crystal controlled
Output . . . . . year, month, day, hour, minutes

General Specifications

Power supply
Rated ranges of use of the a.c. line voltage,
switchable . . . 110/117/127/220/227/237 V, −12 to +10 %
Rated range of use of a.c. line frequency . . . . . 47.5 to 63 Hz
Power consumption . . . . . approx. 130 VA
Safety class as per IEC 348 and VDE 0411 . . . . . Class I

Tolerable ambient temperature
Rated range of use . . . . . +5 to +40 °C
Storage and transportation . . . . . −40 to +70 °C

Dimensions in mm

Bench version		19" rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Overall height	244	Height (5 units)	220
Depth with handles	434	Depth	379

19" conversion kit . . . . . BN 700/00.05
Weight . . . . . approx. 19 kg

Option

Remote control, BN 853/03
<IEC 625>/IEEE 488 Interface Bus Board for remote controlling all the NOWA-1's functions and interrogating the measured values.

Ordering Information

A.C. Power Line Harmonic Analyzer NOWA-1 *
with strip-printer and digital clock

50 Hz version, German lettering	**BN 888/11**
50 Hz version, English lettering	**BN 888/12**
60 Hz version, English lettering	**BN 888/13**
Options (at extra cost)	
<IEC 625> Interface Bus Board with IEC 625/IEEE 488 Adaptor (S 834)	BN 853/03
Accessories (at extra cost)	
Printer paper (roll)	BN 888/00.02
Safety measuring lead, 1 wire, 200 cm	
black	K 383
red	K 426
Connecting cables for the <IEC 625> interface bus	
120 cm	K 343
200 cm	K 344
Front and back panels SD-5, (1 set)	BN 700/00.25
Transport Container TPK-5	BN 626/11

* Back panel connections equipped with the 75 Ω basic connector Versacon® 9 and BNC adaptor. For other adaptor types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

A Specification Sheet with more details and a Colour Brochure are available on request

WS-5, WS-10
A.C. Voltage Stabilisers

for stabilising single phase power supplies



- **Stabilises a wide range of a.c. line voltages**
- **Small level deviations**
- **True r.m.s. stabilisation**
- **Low intrinsic distortion factor**
- **Extremely short time constants**
- **Double pole circuit breaker as fuse**
- **Parallel operation without equalising choke**
- **Integral r.f. a.c. line filter**

Applications

The *WS-5 and WS-10 A.C. Voltage Stabilisers* are ideal for applications where exact measurements or calibration procedures are hampered or made impossible by the normal disturbances on the a.c. line. Effective stabilisation, even on unstable a.c. lines, is ensured by the large range of a.c. voltage stabilisation and the Stabiliser's short transient recovery time.
An integral r.f. a.c. line filter effectively attenuates short pulses and so increases the operating reliability of sensitive measuring equipment, of digital circuits in computers, in communications equipment, in process computers and control systems.
Three Stabilisers can be connected together, without any extra equipment, to give a *Threephase A.C. Voltage Stabiliser.*

Characteristics

The *WS-5 or WS-10 A.C. Voltage Stabilisers* can be purchased in bench or 19" rack versions. Large meters for the output voltage and current make setting and checking the Stabilisers easy. A special feature is that they can be connected in parallel without an equalising choke.
The output voltage can be extracted at a socket on the front panel or via terminals on the back panel. Voltage extraction via the terminals is advisable when the WS-5 or WS-10 is used on a permanent basis, and is strongly recommended when the voltage to a distant load is *stabilised by a sense-line.* The WS-10 also has a reliable overvoltage protection circuit.

Further Characteristics and Applications

A special feature of the WS-5 and WS-10 A.C. Voltage Stabilisers is their wide a.c. frequency range. They can therefore be used with emergency power equipment or in systems for export.
The curves (see Fig.) of the output voltage for different loads as a function of the a.c. line voltage show the extraordinarily low dependence of the output voltage on the a.c. line voltage and load changes. This characteristic is obtained by a very high amplification in the control circuit, thus making a supplementary compensation for a.c. power line and load changes unnecessary.
The A.C. Voltage Stabilisers hold the r.m.s. value of the output voltage constant. The control element of the control loop is provided by a transductor. A bridge circuit is used to compare the resistance of a PTC resistor, heated by the output voltage, with that of a highly stable metal film resistor. The extraordinarily good static and dynamic compensation of the measuring element ensure that the selected output voltage is highly stable.

Max. output power (cos φ = 0.8)	WS-5	1.1 kVA
	WS-10	2.2 kVA
Output voltage, adjustable		215 to 225 V
Time constant		approx. 40 ms

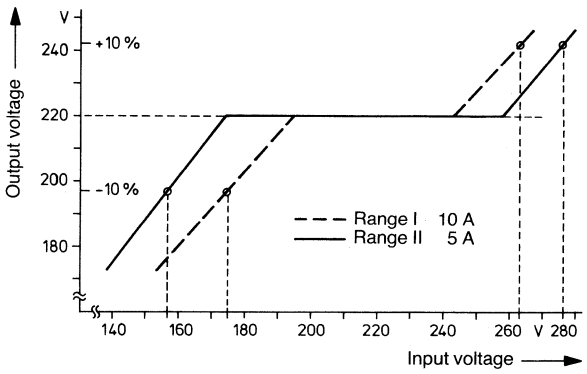
2590 WS-5/10

Even extremely fast changes in ambient temperature or temperature changes inside the device, caused by large variations in load, have little effect on the output voltage.

Because of the Stabiliser's low intrinsic distortion, "r.m.s. loads" can be connected and *peak-value* and *average value rectifiers stabilised.* There is no switching-over of the measurement element. If the rectified voltage is to be kept as stable as possible the sense-line should be connected to the d.c. output of the rectifier.

It is also possible to stabilise *high voltage rectifiers* if the charge and discharge times of the rectifier are simulated by an external auxiliary rectifier in the sense-line.

A special feature of the A.C. Voltage Stabilisers is their *low time constants.* As very unfavourable conditions (e.g. open circuit) are used as a basis for estimating the time constants, the values are, in fact, much better under real conditions.



Output voltage of the WS-10 when the range of regulation is transgressed

Specifications of the A.C. Voltage Stabilisers — WS-5, WS-10

Output power (Tabulated values in kVA)

	WS-5	WS-10	2×WS-10 (in parallel)
cos φ (inductive)	Range I/II	Range I/II	Range I/II
0.8 to 1	0.55/1.1	1.1/2.2	2.0/4.0
0 to 0.3	0.45/0.9	0.9/1.8	1.8/3.6

Output voltage
Nominal value . . . . . 220 V
Adjustable range WS-5 . . . . . 215 to 230 V
WS-10 . . . . . 215 to 225 V

Error limits of the output voltage
For variations in a.c. line voltage, or load changes from open circuit to full load . . . . . ±0.03 %
For variations in a.c. line frequency between 45 and 55 Hz . . . . . ±0.03 %

A.C. line connection
Input a.c. line voltage (range of stabilisation)
Range I . . . . . 187 to 242 V
Range II . . . . . 203 to 231 V
A.C. line frequency . . . . . 45 to 55 Hz

	WS-5	WS-10	2×WS-10 (parallel)
Max. current taken	7A	13A	26A

Time constant
for a step change in a.c. line voltage of 5 % or in load of 20 % . . . . . approx. 40 ms

Total transient recovery time
to 0.1 % for a step change in a.c. line voltage of 5 % or in load of 20 % . . . . . approx. 150 ms

Introduced harmonic content

	Range I	Range II
at 50 Hz	≦1.5 %	≦0.8 %
in the range 45 to 55 Hz	≦3.0 %	≦1.5 %

Suppression of noise pulses
Attenuation of noise pulses from the a.c. line having a rise time <1 ns and a duration of 100 ns . . . . . 30 dB

Temperature coefficient
in the range 0 to +45 °C . . . . . approx. 10^{-4}/K

Overvoltage protection
Threshold voltage . . . . . 240 to 242 V

General Specifications

Ambient temperature
Nominal range of use . . . . . 0 to +45 °C
Storage and transportation . . . . . −25 to +60 °C

Dimensions (w×h×d) in mm, weight

	WS-5	WS-10	2×WS-10 (parallel)
Bench version	478×155×407	478×244×407	478×488×407
19" rack mounting	443×132×353	443×221×353	443×442×353
Weight	22 kg	30 kg	72 kg

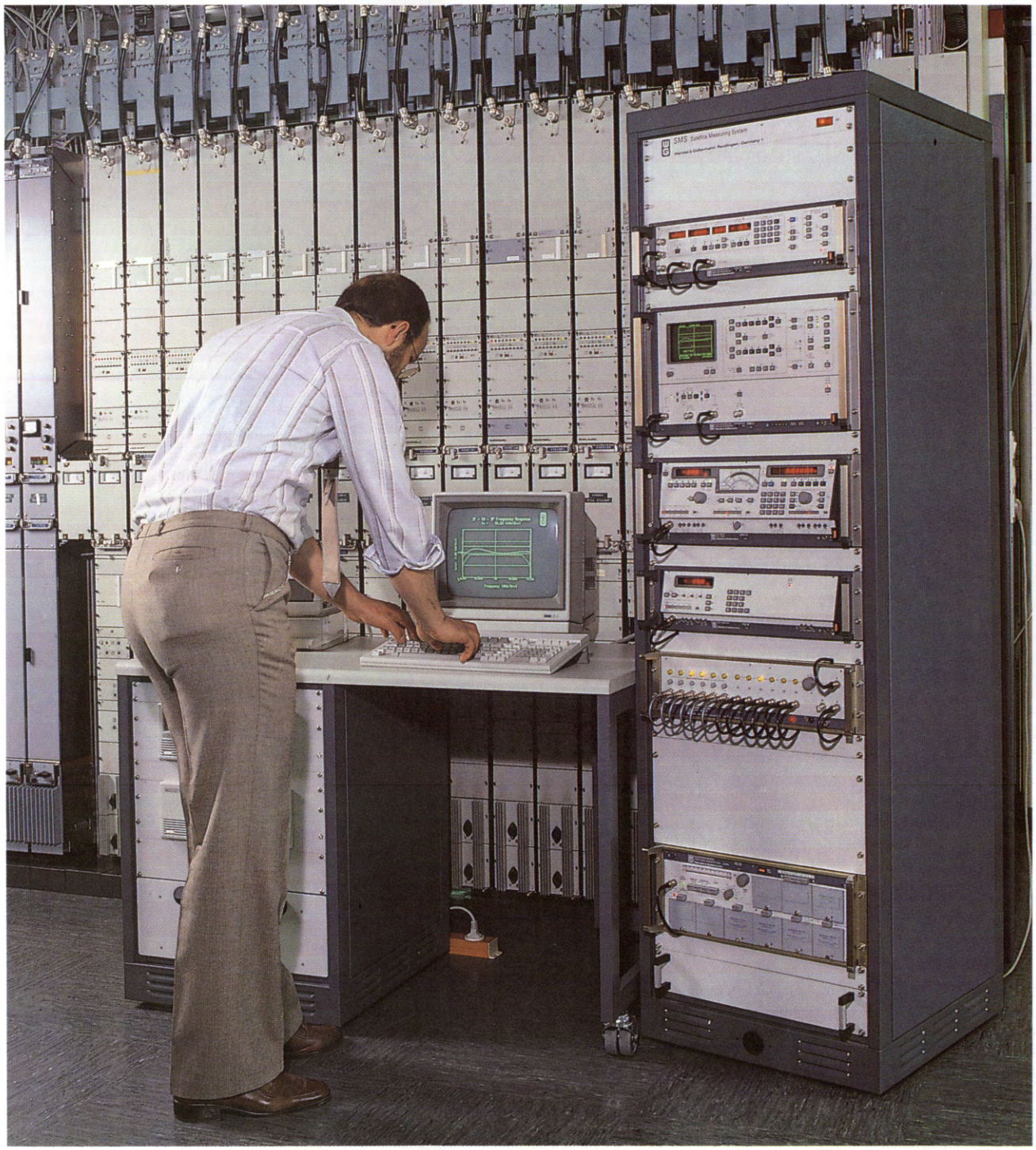
German Post Office Certificate of Approval
WS-5 . . . . . No. 279 094 113

Ordering Information

A.C. Voltage Stabiliser
WS-5 **BN 460/01**
WS-10 **BN 254/00**

Accessories (at extra cost)
Protective Transportation Cover for WS-10, DE-4 BN 476/00.04

Test and Monitoring Systems



Overview

Test and monitoring systems

★ = new

Applications	Software packages	Basic instrument type	Test system	Page
Automatic measurement and monitoring of FDM systems, local and remote modes	SWP-10, SWP-11, SWP-13	SPM-19 Selective Level Meter	**SPM-190/SPM-197 Test Systems**	95
Noise monitoring on radio-link and satellite systems	SWP-12	RE-25 White Noise Receiver	**GA-250 Noise Monitoring System**	141
Computer-aided white noise measurements	SWP-5	RK-25 White Noise Measuring Setup	—	137
Automatic measurement and monitoring of data circuits	SWP-16	DLM-4 Data Line Test Set	**DLM-400 Data Circuit Monitoring System**	171
Data network diagnostics software system	SWP-17	DNE-2100 Data Network Diagnostics Equipment	**DNE-2000 Data Network Diagnostics System**	181
Computer controlled line-up of INTELSAT radio-link systems	SWP-32	RM-5 Radio-link Measuring Setup SPM-19/PSS-19 Selective Measuring Set MU-7 Test Point Selector	**SMS Satellite Testing System**	310 ★
Automatic telecomm module testing	—	PCM-4 PCM Channel Measuring Set	**AMS-964 Telecomm Module Test System**	238 ★

Test and monitoring systems

Introduction

"How can we raise efficiency, increase quality and find better quality assurance procedures, and at the same time cope with the extra test volume" is a question that is being asked by many telecomm system users and manufacturers; automated testing is the only answer.
Wandel & Goltermann decided to develop automated test systems when this field was still in its infancy and was able to exploit the growing trend fully. Since then, we have gathered considerable experience with test systems of various sizes that can be used for many different applications.

Automated test systems have many advantages:

- More precise measurements because the intrinsic errors in the test system are eliminated
- Greater reliability as the system has self-tests
- No human errors
- Result processing
- The system can assess criteria and take appropriate action
- Data storage, e.g. results, telecomm system parameters
- Results evaluated according to statistical criteria

These and many more positive characteristics contribute decisively to the profitability of test systems. Productivity calculations show that the efficiency of an automated test system in contrast to a manual setup is at least 5 times higher. This gives an amortization time of less than 2 years with a daily operation time of 8 hours, and of less than 1.5 years with a daily operation time of 12 hours.
There are two basic types of test system: universal or task specific systems. While the latter are planned right from the start for specific applications, the universal test systems should be very flexible.

Applications for test systems

There are many applications for test systems in the field of telecommunications, e.g.:
- Monitoring communications systems
- Quality assurance
- Development labs
- Acceptance tests
- Test depts.
- Production control etc.

2589

The types of testing performed by W&G test systems can be classified in the following way:
- Level/attenuation measurements
- Radio-link testing
- White noise tests
- Data comm testing
- Distortion measurements
- Digital system tests

Test systems can be configured to perform one or more of the above tasks.

Test system components
Test systems usually comprise various test instruments which are connected to the test ports of the system-under-test by means of access switches.
The access switches and the other instruments are computer controlled via the <IEC 625>/IEEE interface bus. The bus is also used by the instruments to send their results back to the controller.

Test instruments
The following instruments are ideal for test systems:

NFA-1	Audio Analyzer
UN-1	Universal Network and Filter
PS-15	Level Generator (up to 10 MHz)
SPM-15	Selective Level Meter (up to 10 MHz)
PS-19	Level Generator (up to 25 MHz)
SPM-19	Selective Level Meter (up to 25 MHz)
PS-16	Level Generator (up to 160 MHz)
SPM-16	Selective Level Meter (up to 160 MHz)
SG-4	Storage Display Unit
SNA-1	Spectrum and Network Analyzer (up to 180 MHz)
RK-25	White Noise Measuring Setup (up to 25 MHz)
RK-100	White Noise Measuring Setup (up to 100 MHz)
RM-5	Radio Link Measuring Setup
DLM-4	Data Line Measuring Set
DNE-2100	Data Network Diagnostics Equipment
DIR-1	Diagnostics Responder
DA-10	Data Analyzer
PCM-4	Automatic Measuring Set for PCM channels
PDG-3	Digital Signal Generator
PDA-3	Digital Signal Analyzer (PCM)
PCA-3	PCM Codec Analyzer
PF-4/PF-3	Bit Error Measuring Set
PFJ-4	Jitter Modulator
PJG-4	Jitter Generator
VM-1	Test Set for Digital Exchanges
NOWA-1	A.C. Power Line Harmonic Analyzer

Access switches
Access switches which are used to connect an item-under-test to various test instruments contain either balanced or coaxial switches. Various arrangements of access switches can be configured to handle different frequency ranges and different numbers of test points.
The following access switches and scanners by Wandel & Goltermann are essential test system components:

MU-30	Test Point Scanner for the AF range
MU-7	Test Point Selector (up to 160 MHz)
RAS-2	Remote Access Switch System (up to 100 MHz)

Control units
The control unit is the most important test-system component as it coordinates the activities of all other instruments in the system. Many factors determine the type and size of the control unit:
- Number of test points
- Number of test systems connected
- Sequential or simultaneous test system control
- Range of control facilities required
- The type of data display, data reduction and data analysis required
- The size of the data memory

Depending on the type of testing to be carried out, the control unit may contain a computer and a combination of peripherals and data comm devices.
The following types of computer can be used:
- Desk-top computers
- Process computers (for more powerful test systems)

The following types of peripheral can be used:
- Printers
- Floppy discs
- VDUs
- Cassette memories
- Graphics plotters
- Alarm units etc.

The data comm equipment includes:
- Modems
- Interface bus extenders (to increase the length the <IEC 625>/IEEE 488 interface cable which is limited to 4 m in the standard version).

Data communications
Test systems centralised or distributed. In the latter case, the components of the test system are connected up by means of data circuits.
There are two types of circuit:
- Leased telephone lines (if a large amount of data is to be transmitted).
- Dial-up telephone lines (for occasional data transmission)

Instruments from other manufacturers
It may sometimes be necessary to use equipment (e.g. computers, modems, printers) that have not been manufactured by Wandel & Goltermann. The <IEC 625>/IEEE 488 interface bus, however, minimises compatibility problems.

Software
The quality of a test system depends on the functions and characteristics of the instruments used, and what is more important, on the software.
The software determines how powerful the test system is, and, in particular, how easy the system is to operate, and how clear the results and status messages are.
Writing efficient system software is impossible unless one has a thorough knowledge of the hardware of the computer concerned, its operating system and how to program it. One must also be familiar with the characteristics of all the other devices in the system and any problems that could arise in special applications.
W&G foresaw the problems that customers would face and to help them set up a System Dept. that deals exclusively with the design and construction of test systems. This dept. also writes the system software.
W&G supplies a range of standard software packages which are sufficiently flexible to handle a wide range of applications. Wandel & Goltermann's System Dept. will write system software to handle special applications.
To keep costs within reasonable limits, software packages and modules that have already been written are used as a basis for special-application software.

RDS remote diagnostics system
The remote diagnostics system has been developed by W&G for large test systems, controlled by process computer, which require rapid troubleshooting. When a fault occurs, the test system is connected via a telephone line to a terminal in W&G's central service dept. in Eningen. A service specialist can then run test programs which localise the fault. The service specialist informs the system operator who can take appropriate action himself, e.g. replace an instrument.
RDS has been designed so that the customer always has complete control over his system. Confidential data (e.g. test results) are only made available to W&G with the customer's express approval.

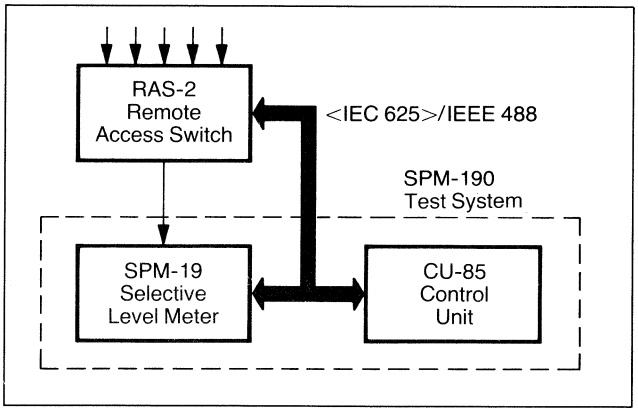
Service system
The degree of importance a user attaches to effective servicing increases the larger his system becomes and the greater the losses he is likely to incur when the system fails.

Modern electronic equipment is often so complex that the user cannot carry out repairs himself. For this reason, we recommend always having spares available for the most important instruments. When the RDS system is called up, faults can be eliminated rapidly.

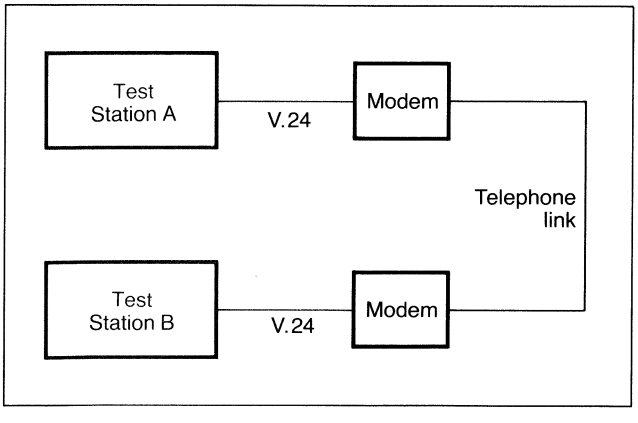
Commissioning, installation and training
Usually the test systems made by Wandel & Goltermann are specially designed, assembled, and tested to meet the unique requirements of the customer. When large or decentralised systems are involved, we recommend that the customer is trained by us, so that he has the opportunity of familiarising himself with all of the system components and can acquire a better understanding of how the system functions as a whole.
After acceptance testing and delivery of the system components to the site, the complete system will be assembled, installed and tested by Wandel & Goltermann staff.
If required, Wandel & Goltermann will also train the system operators.

An automatic level measuring system by Wandel & Goltermann: An example showing the modular construction, the flexibility and expandability of W&G test systems

Test station, baseband test system for FDM systems
- Single measurements or test sequence
- Concatenation of test and monitoring routines
- Fully automated monitoring routines

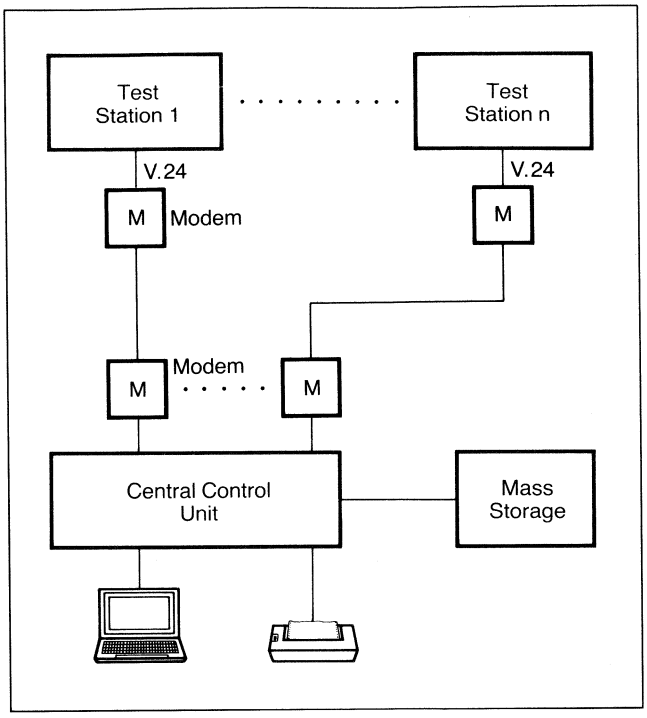


Controlling distributed, unmanned systems
- Local control unit performs single measurements or a sequence of measurements
- Local and remote test system can concatenate test and monitoring routines
- Fully automated monitoring cycle in local and remote test system
- Results are transferred to the controller



Centrally controlled test systems

- Single measurements or measurement sequences initiated by the central control unit or the test system's control unit
- Test routines and monitoring routines can be run from test system's control unit, or from a central control unit if more than one test system is used
- Fully automated monitoring cycle for all test systems connected to the central control unit. Facilities for local monitoring cycles when required, or if the data link is impaired.
- Results are sent back to the central control unit. In monitor mode, only out-of-range results are sent to the control unit.



The type and size of the central control unit depends on the number of test stations used:

- Desk-top computer for up to 5 test stations
- Process computer with real-time multi-tasking operating system for more than 5 test stations.

Standard test systems and standard software packages

Wandel & Goltermann's standard test systems and software packages have been designed for flexibility so that they can cover a large range of applications and form the basis of larger test systems.

The SPM-190/SPM-197 Automatic Test System for use at the baseband level of FDM systems
SWP-11 and SWP-13 Software Packages

The test systems, comprising the CU-85 Control Unit, the HP 85 or the HP series 200 computers and the SPM-19 Selective Level Meter, are ideal for performing tests on FDM systems to CCITT and INTELSAT recs. A large number of frequency plans are stored by the system. The test system is dialog driven. There are two operating modes, the interactive mode which allows the operator to run single measurements or test sequences, and the fully automatic monitor mode. The system also has a remote control facility which allows a local system to control all the functions of a remote system. The results are sent back to the master and are displayed as graphs or tables.
The system can measure pilot level, channel/group power, baseband power, carrier leaks, noise in the gaps between supergroups, tones in channels or groups, level, frequency response etc.. The system can also find signals that exceed a specified threshold.

GA-250 Noise Monitoring System
SWP-12 Software Package

Noise on radio links can be measured to CCIR recs using an HP 85 computer, the SWP-12 Software Package and the GA-250 Noise Monitoring System.
A max. of eight circuits can be monitored in a one-minute monitoring cycle. Noise performance is assessed by measuring the following parameters: system loading, instantaneous noise, short duration noise and mean minute noise.
The Monitoring System is dialog driven; the results are output in tabular form.

SWP-5 System Software for the RK-25

A software package for the CU-85 or the HP 85 computer for controlling the RK-25 Measuring Setup when the RK-25 is performing S/N and NPR measurements on radio-link communications systems and similar equipment.

The system software comprises a dialog system, a measuring program and routines for evaluating results and outputting them on a printer. The user has a choice of graphic output or output in the form of tables. A variety of measurements can be performed, or example, NPR referred to the total loading, variation of NPR with frequency, and variation of S/N with frequency.

DLM-400 Data Circuit Monitoring System
SWP-16 Software Package
The DLM-400, which is controlled by a CU-85 Control Unit or a HP 85 computer, monitors (to CCITT Rec. M. 1020) analog data circuit parameters.
Loop-back and end-to-end measurements can be performed with the DLM-400. It is also possible to use a local system to control all the functions of a remote system. The system is dialog driven.
There are two operating modes, the interactive mode which allows the operator to perform single measurements or a test routine, and the fully automated monitoring mode. The results are output as graphs or tables.

DNE-2000 Data Network Diagnostics System
SWP-17 Software Package
The SWP-17 has been designed for the IBM XT personal computer and the DNE-2100 Data Network Diagnostics Equipment. Several groups containing a max. of 8 DNE-2100 mainframes can be controlled in this way. The System can store a total of 32 switching configurations, automatically records and statistically evaluates circuit alarms and has an easy-to-read clear-text circuit labelling method.

The AMS-964 Test System for telecomm modules
The AMS-964 is used to function test telecomm modules at the average rate of 4 measurements per second.
The system has been designed for system modules, and for this reason standard instruments are usually used.

Computer controlled INTELSAT radio-link line-up measurements

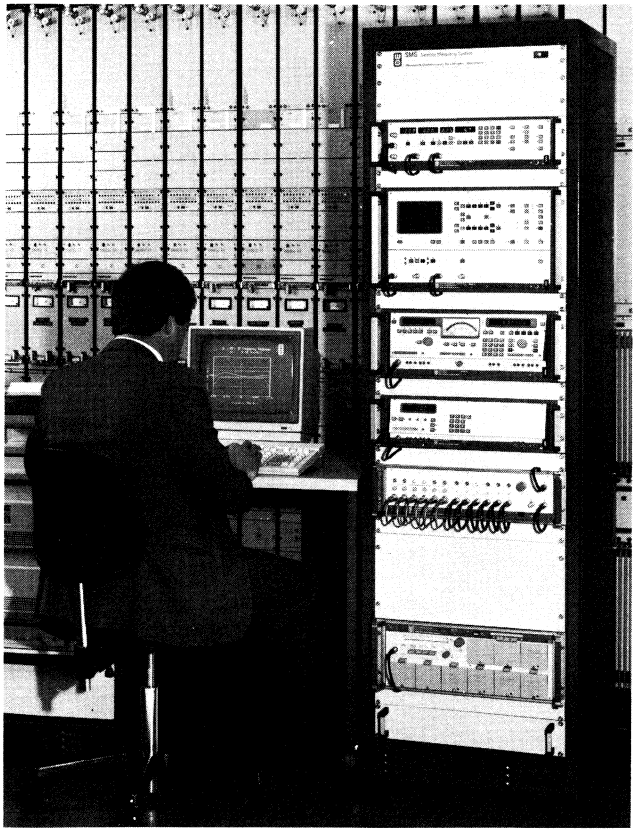
In 1979, INTELSAT made the following recommendation with respect to satellite communications systems:

"Whenever applicable, it is recommended that Administrations consider the provision of suitable automated test equipment to facilitate testing"

SSOG Vol. 2, Section 7.1.3.

The realisation of this recommendation, as developed by Wandel & Goltermann, is:

- Fully automated line-up of a satellite link to SSOG recommendations within 30 minutes
- INTELSAT protocols
- Full measurement program or individual measurements
- Test system for all measurements between two earth-stations comprises only three test sets
- Clear text dialog operating procedure, no complicated programming required
- Automatic control loop ensures that spurious signals are not introduced into the transmission path
- All INTELSAT system parameters (12 to 1872 channels) stored in database
- Results are sent back to the slave station
- Automatic cable attenuation correction
- Computer-controlled line-up also possible without the need for an identical slave station
- Test set and computer system completely mobile.



SMS Satellite Testing System

Measurements
The following table has been reproduced from SSOG (table 7.1) and we have listed suitable test equipment from Wandel & Goltermann against each type of measurement.

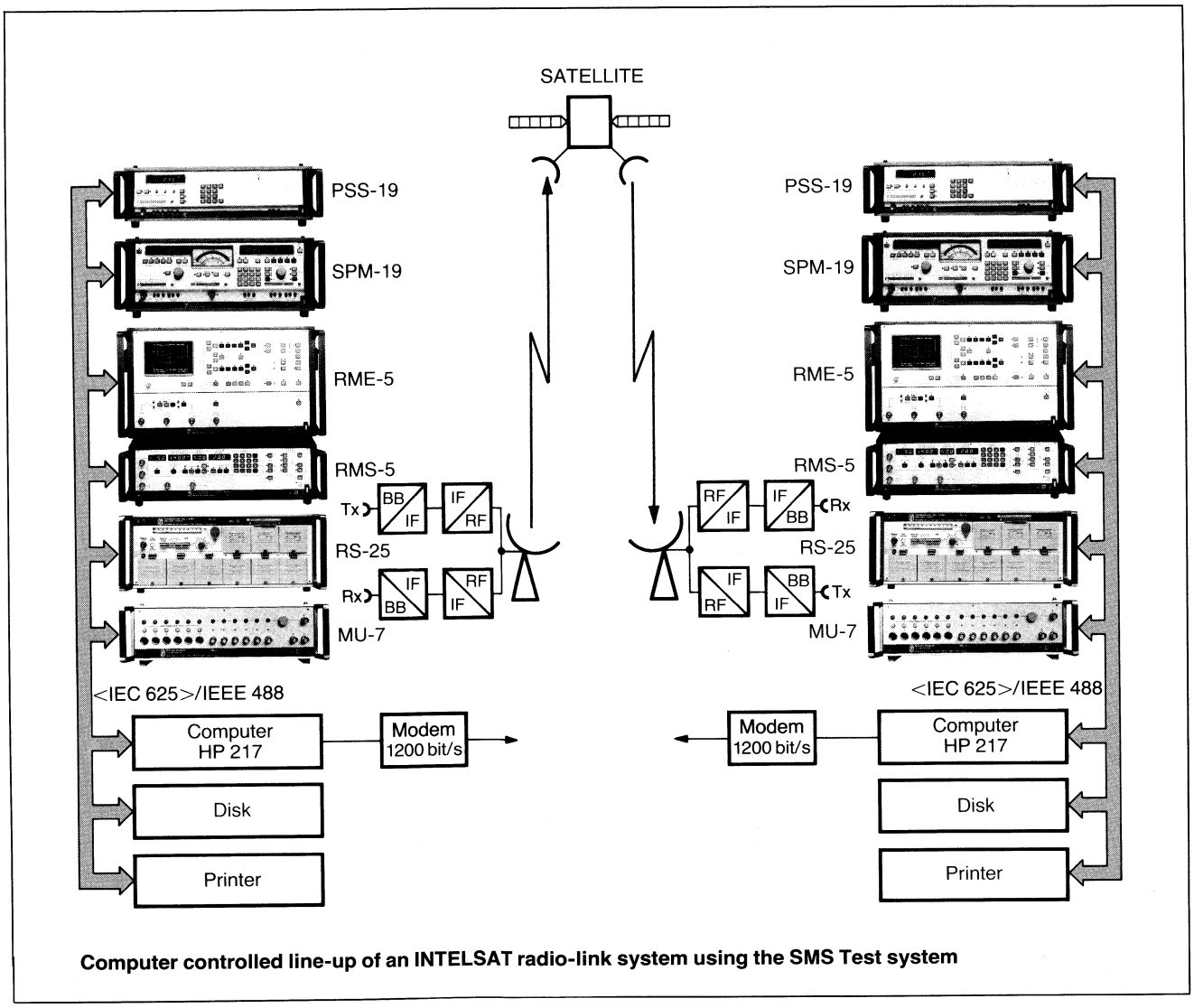
SSOG Section	Title	Test Equipment	Remarks
7.2.1	RF Carrier Frequency, EDF, EIPR and C/N	SNA-1	In-station test and with monitor station
7.2.2	IF-to-IF frequency response	RM-5	
7.2.3	IF-to-IF group delay frequency response	RM-5	
7.2.4	Test-tone deviation and baseband level	RME-5, PS-19/SPM-19	Earth-Station to Earth-Station Tests
7.2.5	60 kHz continuity pilot level	SPM-19	
7.2.6	BB-to-BB non-linearity response	RM-5	
7.2.7	BB-to-BB frequency response	PS-19/SPM-19	
7.2.8	BB-to-BB noise spectrum	SPM-19	
7.2.9	White noise loading	RS-25/SPM-19	

For each test, SSOG lists a large number of different instruments. Wandel & Goltermann Test Sets are so versatile that one instrument can perform the functions of several conventional instruments. The following three test setups cover all the required measurements between two earth-stations:

- RM-5 Radio-link Measuring Set
- SPM-19/PSS-19 Selective Measuring Set
- RS-25 Noise Level Generator

The SMS Satellite Testing System from Wandel & Goltermann goes yet a step further; these test sets are controlled from a central location by a computer and the relevant software, thus enabling the recommendation of SSOG to be realised.

Test System Construction
A HP 217 computer in each earth-station controls the test setup; the setup at each earth-station is identical. The computers are connected together via a 1200 bit/s data circuit. One earth-station is designated as "master", the other as "slave". All equipment settings for bother master and slave are set from the master station computer. The master station is always the receive side, i.e. the measuring side; the slave always acts as transmitter. All the necessary connections between the test system and the communications system are effected by the MU-7 Test Point Selector automatically, under computer control.



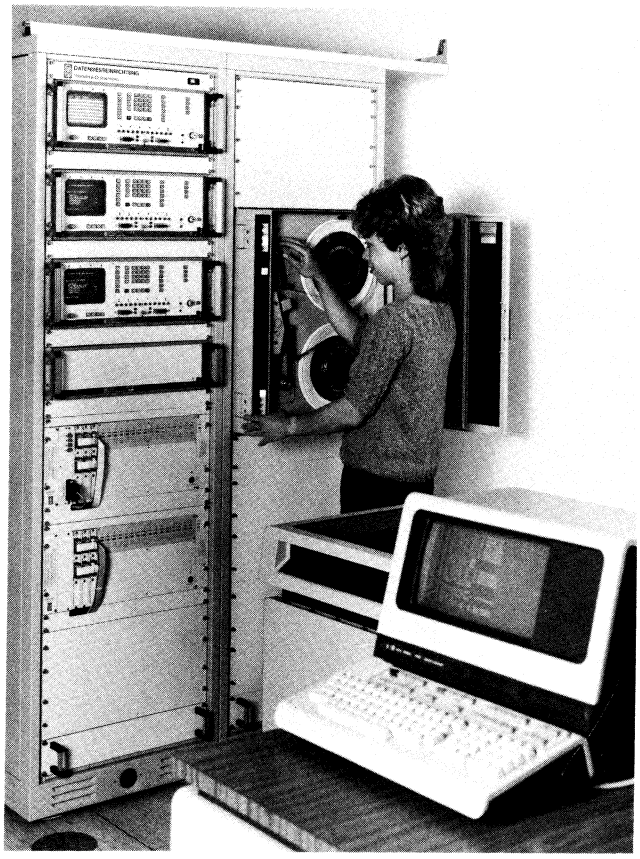
Computer controlled line-up of an INTELSAT radio-link system using the SMS Test system

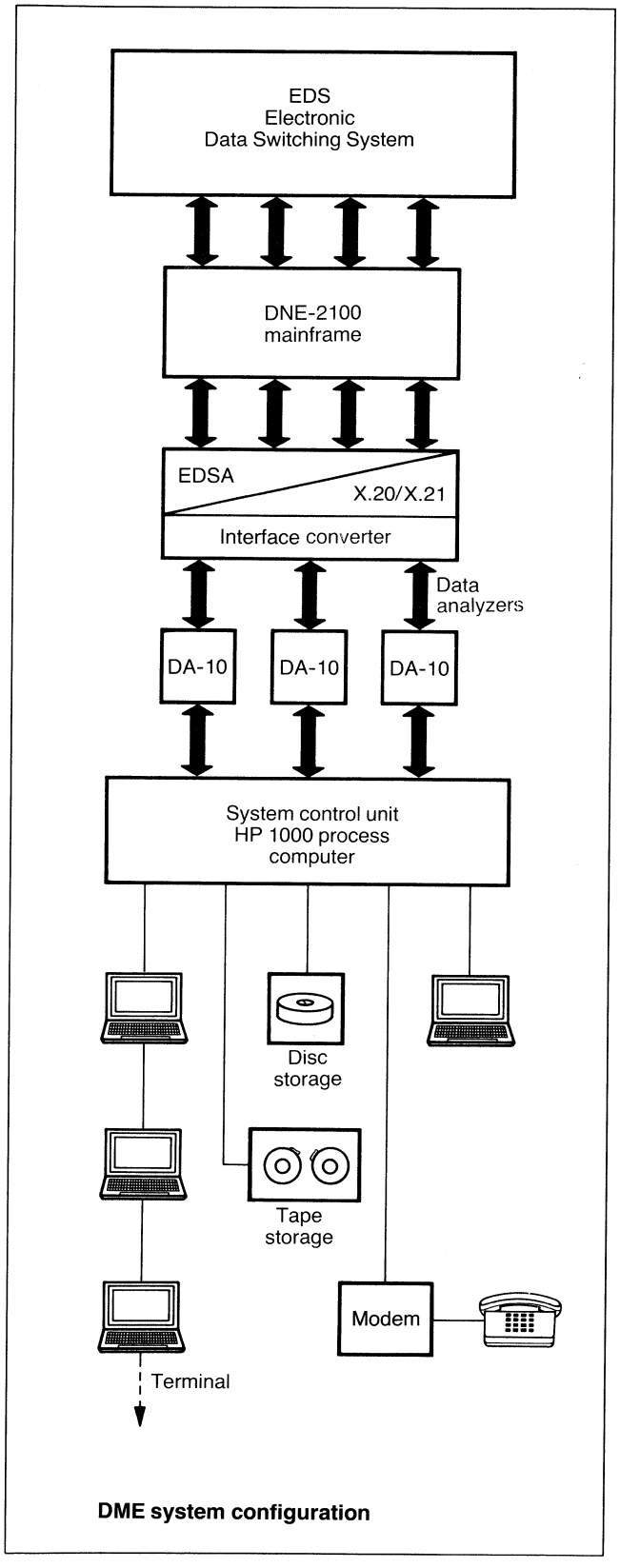
The DME Data Measuring Equipment for the Deutsche Bundespost

Example showing how the DME is used to test a datacomm system

The DME carries out partially and fully automated checks on IDN data lines.
As the DME can be connected to various sections of the IDN, faults can be easily localised. The system has a comprehensive database containing data on the IDN's terminals, components and component interconnections. This allows the DME to perform efficient, fully automated testing.
The DME is modular, flexible and user-friendly and so will be able to handle the complex data networks of the future which will have ever growing numbers of subscribers and services.

Data Measuring Equipment DME





DME system configuration

Accessories



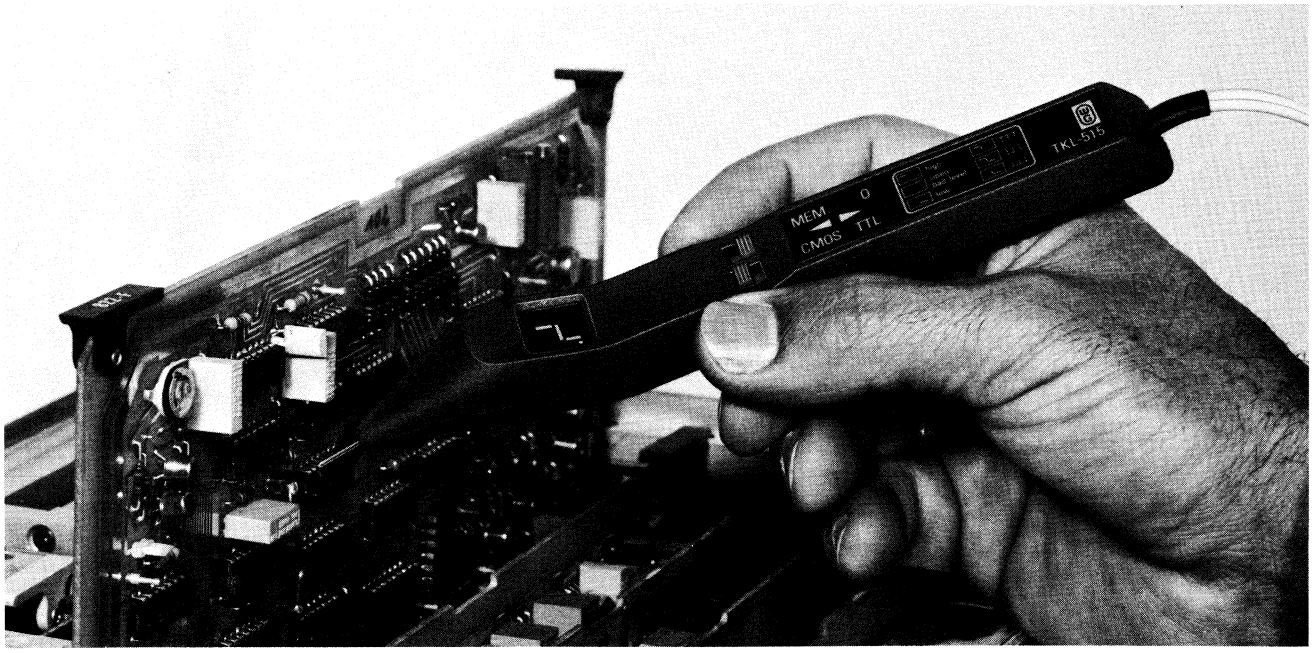
Overview

Accessories

Characteristics/components	Name	Page
Quasi-oscilloscopic display of logic states of pulses and of mark/space ratios in TTL and CMOS circuits; Pulse memory for detecting single pulses; high impedance input	**TKL-515 Digital Probe**	315
Test probes, transformers, measuring attachments, matching pads, change-over switches, coaxial chokes, compensated test cables, d.c. loop holding circuits, ventilator attachment, inverters, battery packs, instrument trolleys	**Measuring Accessories**	317
Connecting cables for all commonly used connectors for telecommunications and general testing; interface cables, cable connectors, adaptors	**Connecting cables**	331
Universal Connector Conversion System (Z_o = 75 Ω); System components: 75 Ω cable with Versacon® 9 basic connector, Versacon® 9 coupling	**Versacon® 9**	336
Attenuators, terminations, standard mismatches, "T" adaptors, Z_o matching pads 75 Ω ⇄ 50 Ω	**Versacomp® 75**	339
For protecting 19" enclosures during transportation and storage	**TPG/TPK Transport Cases/Transport Containers**	349
Construction type, dimensions, covers, handles, connectors	**19" enclosures**	351

TKL-515
Digital Probe

for display of switched states, pulses and mark-to-space ratio of TTL and CMOS circuits



- **Shaped for optimum ease in handling**
- **Quasi-oscilloscopic display gives unambiguous readings**
- **TTL- or CMOS-logic, switchable to either**
- **Switchable pulse memory holds single pulses for identification**
- **Mark-to-space ratio can be estimated**
- **High impedance (bridging) input**
- **Soldering-iron resistant, flexible power cord**

Applications

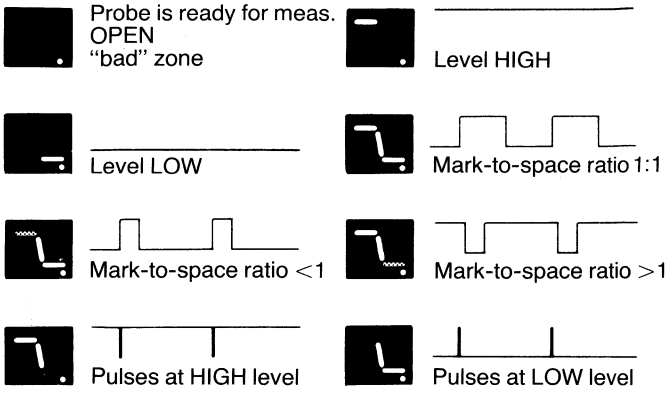
The handy TKL-515 Digital Probe is applicable wherever logical states are to be ascertained in digital circuits. So applications are found in development laboratories, test departments, and service facilities.
Two switch positions, one for TTL (5 V logic) and one for CMOS (4 to 16 V) support the usual logic families employed in microprocessor circuits, computer technology, machine control etc. For seldom used logic levels an individual setting capability is intended for high or low thresholds.
The quasi-oscilloscopic display on the TKL-515 is an efficient substitute for an oscilloscope or a more complicated and difficult-to-operate instrument. Unambiguous results are obtained for static levels, pulses, and mark-to-space ratios. This allows easy and fast location of faults such as short circuits, interrupted signal paths, or defective components.

Characteristics

The TKL-515 displays HIGH or LOW levels as upper or lower horizontal bars. An illuminated spot of light indicates that the probe is operationally ready. If this spot is the only indicator, illuminated during a measurement, then the input potential is in the "bad" zone, or the input has not been correctly applied. From that, for tri-state-outputs in the CMOS technology, the state of "open" can also be determined.
When pulses are displayed, differences can be seen between pulses at LOW level, at HIGH level and pulses in the mark-to-space ratio 1 : 1 (HIGH to LOW) and also pulses in the mark-to-space ratio >1 or <1. The mark-to-space ratio estimations give unambiguous results out to approx. 2 MHz. A memory can be switched on for holding infrequently appearing single pulses until the memory is switched off. For this a plug-on test clip extension permits clipping the TKL-515 to the circuitry.
The Digital Probe TKL-515 is protected against false polarity or overvoltage.

Logic, switchable	TTL/CMOS
Individual setting of HIGH and LOW thresholds	
Power supply V_s, TTL	5 V ±0.25 V
CMOS	4 to 16 V
Input current for $V_s = 5$ V	approx. ±10 µA
Voltage protection	≦ ±42 V

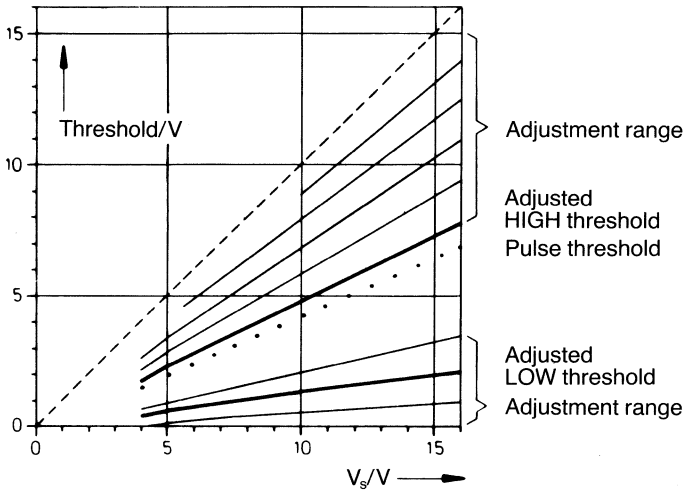
Displayed symbols and their meanings



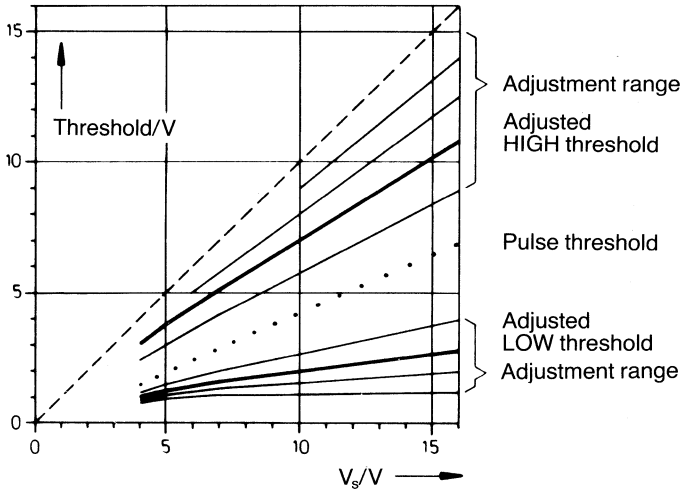
Positions of the thresholds adjusted at the factory

and also their adjustment ranges and dependence on the supply voltage V_s

Operating Mode TTL



Operating Mode CMOS



Logic		
switchable	TTL	CMOS
Display [1]		
Level thresholds		
All HIGH and LOW thresholds are independently adjustable separately for all special requirements. The factory adjustments are referred to a power supply, V_s = 5 V (see diagrams of adjustment ranges). Factory adjusted values follow:		
HIGH	≧2.3 V ±0.3 V	0.75 x V_s
LOW	≦0.6 V ±0.2 V	0.25 x V_s
Mark-to-space ratio, evaluable to [2]		approx. 2 MHz
Pulses		
Pulse duration [2] for V_s = 5 V	≧50 ns	≧50 ns
for V_s ≧10 V	—	approx. 25 ns
Input		
Input current for V_s = 5 V		approx. ±10 µA
Increases proportionally with V_s		
Input capacity		approx. 15 pF
Voltage protection (tolerable voltage)		≦ ±42 V
Power supply		
D.C. voltage, V_s	5 V ±0.25 [3]	4 to 16 V
Current consumption		approx. 100 mA
Protection against false polarity or overvoltage		≦ ±42 V

General Specifications

Tolerable ambient temperature	
Rated range of use	+5 to +40 °C
Storage and transportation	−40 to +70 °C
Dimensions	
with packing (w × h × d) in mm	255 × 37 × 130
Weight (inc. packing)	approx. 250 g

Ordering Information

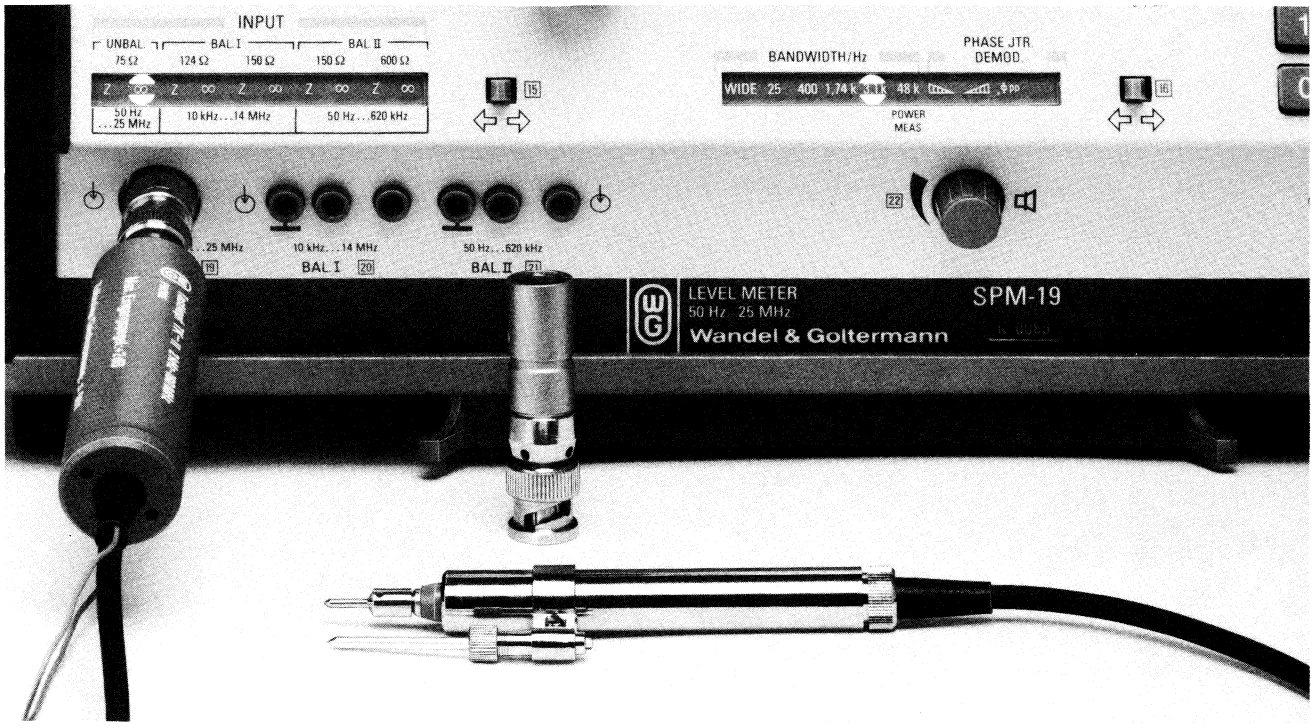
Digital Probe TKL-515 **BN 868/01**

Accessories (contained in standard package)
Plug-in extension cable and spare test prod

1) The display intensity, except for the illuminated spot, is constant in range V_s = 4 to 16 V
2) If the pulse segment alone is used as an indicator, then according to the pulse period the max. frequency is about 10 MHz (V_s = 5 V) or 20 MHz (V_s ≧10 V)
3) Function remains with excessive V_s, but within the range V_s = 4 to 16 V

Accessories

Test probes, transformers, bridges, relay changeover switches, adaptors, attenuators, dc loop holding circuits, compensated test cables, ventilator attachments



- **Wider range of applications for test equipment**
- **Easier matching of test equipment to test item**
- **More accuracy**
- **Simpler testing**

Applications

Without suitable test probes, transformers and other equipment of this kind, it is impossible to connect several items of test equipment together to form an efficient test setup.
Our test probes are ideal for high impedance and low capacitance measurements. As the level is measured at the test points, there are no errors introduced by cables, mismatches etc.
Balancing and matching transformers are used to connect test equipment having coaxial inputs or outputs to balanced items-under-test.
A decoupling transformer is essential for high impedance measurements on balanced systems.

W&G supply a wide range of special bridges for measuring impedance, return loss and signal balance ratio.

A relay changeover switch is useful for measurements where standards and items-under-test have to be connected and disconnected several times.

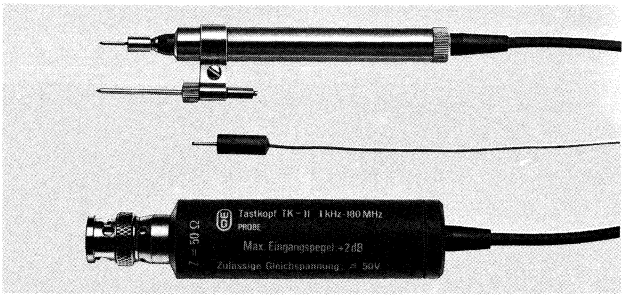
Notes on the specifications:
Unless otherwise stated, the specifications are valid for the nominal ranges of use for the mains voltage and ambient temperature immediately after switch-on.

Test Probes

TK-11 Active Test Probe

for level meters and analysers with $Z_o = 75\ \Omega$ (50 Ω)
Power supply

directly from the level meter or analyser, or from the TKN-12 Power Supply



Specifications

Frequency range . . . . . 1 kHz to 180 MHz

Input

Input level
Max. ac . . . . . 1 V or +2 dB
Max. dc component . . . . . 50 V
Input impedance (with test prod):
to f = 25 MHz . . . . . approx. 50 kΩ ‖ 3.5 pF
to f = 100 MHz . . . . . approx. 5 kΩ ‖ 3.5 pF
to f = 180 MHz . . . . . approx. 2 kΩ ‖ 3.5 pF

Attenuation

at 100 kHz and +20°C . . . . . 10 dB ±0.1 dB

Variation of attenuation with ambient temperature over nominal range of use . . . . . ≦0.05 dB
Variation of attenuation with frequency, referred to 100 kHz

(error limits)

±1 dB	±0.2 dB	±0.3 dB

1 3 kHz 100 180 MHz

Self introduced harmonic ratio:
for input level ≦0 dB . . . . . $a_{k_2} \geqq 40$ dB, $a_{k_3} \geqq 50$ dB
for input level ≦−20 dB . . . . . $a_{k_2} \geqq 60$ dB, $a_{k_3} \geqq 70$ dB

General specifications

Power supply
Operating voltage . . . . . −11 V to −18 V
Current drain . . . . . approx. 24 mA

Ambient temperature
Nominal range of use . . . . . +5°C to +40°C
Storage and tranportation . . . . . −40°C to +70°C
Connection to test object . . . . . test probe with detachable earthing prod
Connection to test instrument . . . . . adaptor from the Versacon® 9 Universal Connector System (pin contacts) *

Ordering information

Test Probe TK-11, $Z_o = 75\ \Omega$	BN 573/00
$Z_o = 50\ \Omega$	BN 573/02
Accessories (charged extra)	
Coaxial connector for item under test	
Versacon® 9 adaptor	S 222
Versacon® 9 insert	
Power Supply TKN-12	see TKN-12 Power Supply

TK-9 Passive Test Probe

Frequency range 50 kHz to 18.6 MHz

Specifications (ambient temperature +20°C)

Frequency range . . . . . 50 kHz to 18.6 MHz

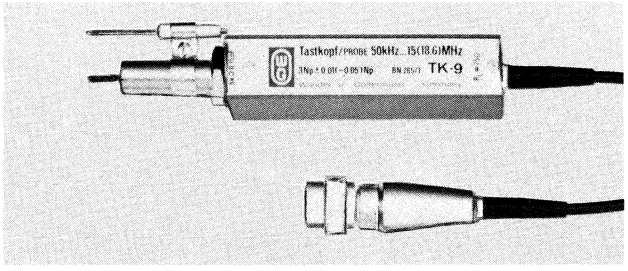
Input

Input impedance . . . . . approx. 5 kΩ ‖ 17 pF
Max. ac voltage . . . . . 8 V
Max. dc component . . . . . 42 V

Attenuation, 75 Ω load		
f ≦13 MHz	f ≦15 MHz	f ≦18.6 MHz
20 dB ±0.10 dB	20 dB $^{+0.10\ dB}_{-0.25\ dB}$	20 dB $^{+0.10\ dB}_{-0.50\ dB}$

General specifications

Ambient temperature . . . . . −10°C to +50°C
Connection to test object . . . . . test probe with detachable earthing prod



Connection to test instrument . . . . . adaptor from the Versacon® 9 Universal Connector System* (pin contacts)

Ordering information

Test Probe TK-9	BN 265/00
Accessories (charged extra) for connecting probe to caoxial test object: Insert from the Versacon® 9 Universal Connector System*	

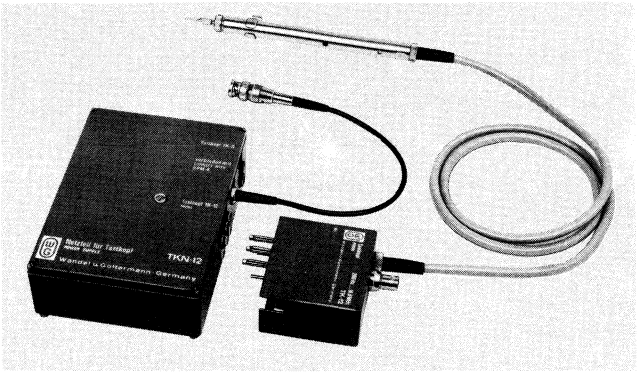
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

TK-12 Active Test Probe

for the SPM-15, SPM-18, and SPM-19

Power supplied by the TKN-12

	Frequency range	Input impedance
unbalanced	200 Hz to 18.6 MHz	approx. 10 kΩ ‖ 15 pF
balanced	200 Hz to 2 MHz	approx. 1 MΩ ‖ 25 pF



Specifications

Frequency range
balanced . . . . . 200 Hz to 2 MHz
unbalanced . . . . . 200 Hz to 18.6 MHz

Input level
Max. measurable level . . . . . 0 dB
Max. ac voltage (rms) . . . . . 10 V
Max. dc voltage . . . . . 42 V

Gain
adjustable . . . . . 0 dB

Input impedance
balanced at: f = 10 kHz . . . . . approx. 1 MΩ ‖ 25 pF
unbalanced at: f = 10 kHz . . . . . approx. 1 MΩ ‖ 15 pF
at: f = 18.6 MHz . . . . . approx. 10 kΩ ‖ 15 pF

Frequency response
Error limits of frequency response referred to 1 MHz
unbalanced 300 Hz to 2 MHz . . . . . ≦±0.05 dB
f≦2 MHz . . . . . ≦±0.1 dB
f≦4.5 MHz . . . . . ≦±0.2 dB
f≦18.6 MHz . . . . . ≦±0.45 dB
balanced f≦2 MHz . . . . . ≦±0.1 dB

Attenuation
Intrinsic harmonic ratio (2nd and 3rd order)
Input level = 0 dB and f = 20 kHz . . . . . ≧50 dB
Input level = 0 dB and f = 6 MHz . . . . . ≧40 dB
Common mode rejection ratio, 200 Hz to 2 MHz . . . ≧40 dB
Impedance balance ratio, 200 Hz to 2 MHz . . . . . ≧40 dB

General specifications
Ambient temperature
Nominal range of use . . . . . +10°C to +35°C
Limits range of operation . . . . . 0°C to +45°C
Storage and transportation . . . . . −25°C to +60°C
Dimensions (in mm) . . . . . 14 ∅ × 150
Weight . . . . . 350 g
Connection for device under test . . . . test prod and earthing attachment; adaptor from the Versacon® 9 Connector System*

Ordering information

Test Probe TK-12	BN 574/00
Accessory (charged extra)	
Balanced CF plug	S 804

TKN-12 Power Supply

for the TK-11 and TK-12 Test Probes

Specifications

A.C. line voltage . . . . . 110/117/127/220/227/235 V +10%, −15%
A.C. line frequency . . . . . 45 Hz to 65 Hz
Power consumption . . . . . approx. 7 VA

Insert from the Versacon® 9 Universal Connector System (pin contact) for TK-12

Test set connection
for TK-11 . . . . . see TK-11

General specifications
Ambient temperature
Nominal range of use . . . . . +10°C to +35°C
Limits range of operation . . . . . 0°C to +45°C
Storage and transportation . . . . . −25°C to +60°C
Dimensions (w × h × d) in mm . . . . . 110 × 50 × 150
Weight . . . . . 850 g

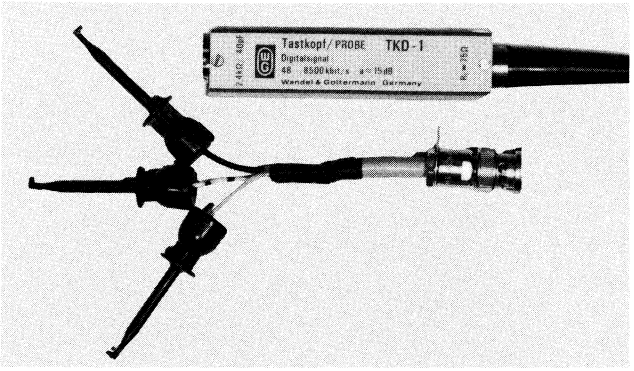
Ordering information

Power Supply TKN-12	BN 623/00

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

TKD-1 Test Probe

for high impedance connection (bridging) of PCM and other digital test equipment to balanced test ports



The TKD-1 is a balanced, passive test probe that is used to connect digital test equipment in bridging mode to test ports that are not decoupled. The most difficult of connections can be made with the hooked prods. Using the Versacon® 9 Universal Connector System, the TKD-1 can be connected to any suitable test set.
Making effective in-service measurements (e.g. jitter and bit error ratio) on PCM and other datacomm equipment means being able to connect test equipment anywhere along the transmission path without affecting traffic.
However, most systems do not have decoupled test ports and this causes loading and matching problems when test sets are connected. Further difficulties are caused by the balanced lines usually used for digital transmissions up to 8.5 Mbit/s.

The TKD-1 eliminates problems of this kind as it allows you to make high impedance connections to balanced test points that are not decoupled.
Special, hooked prods make it easy to contact awkward test points, e.g. inside regenerators.

Specifications

Digital input signal
Bit rate . . . . . 48 kbit/s to 8500 kbit/s
Line code . . . . . dc free (e.g. AMI or HDB-3)

Input
Input impedance . . . . . approx. 2.4 kΩ ‖ 40 pF
Max. ac voltage (rms) . . . . . 8 V
Max. dc component . . . . . 100 V

Attenuation (75 Ω termination)
Attenuation factor . . . . . approx. 5.6
Attenuation . . . . . approx. 15 dB
Lower 3 dB cutoff . . . . . approx. 500 Hz
Upper 3 dB cutoff . . . . . approx. 20 MHz

Connectors
Input . . . . . balanced Amphenol connector in BNC casing (type 31-223), three hooked prods plus connecting cables
Output to test set . . . . . insert from Versacon® Universal Connector System*

General specifications
Ambient temperature
Nominal range of use . . . . . +5°C to +40°C
Storage and transportation . . . . . −40°C to +70°C
Dimensions (w×h×d in mm) . . . . . 88×19×19
Weight . . . . . approx. 250 g

Ordering information

Test Probe TKD-1*	BN 882/01

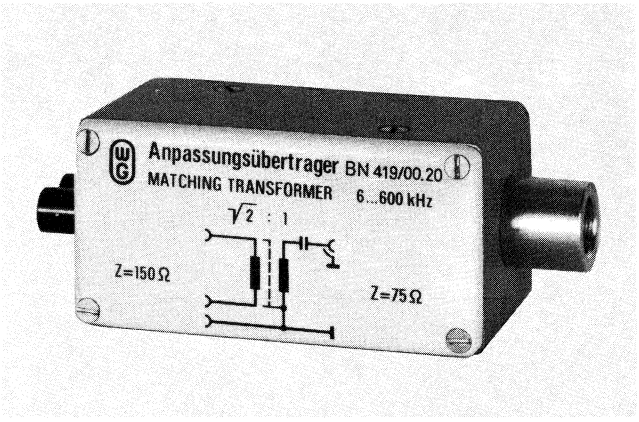
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

Transformers

150 Ω bal./75 Ω coax. Matching Transformer

For measurements on balanced 150 Ω systems with coaxial connectors on the send and receive sides

Frequency range 6 kHz to 600 kHz



Specifications

Frequency range . . . . . 6 kHz to 600 kHz

Attenuation
Insertion loss . . . . . ≦0.2 dB
Return loss at 150 Ω input . . . . . ≧26 dB

Input
Max. a.c. voltage at 150 Ω input . . . . . ≦3.5 V
(No dc)

Connectors
150 Ω . . . . . 3 pole CF connector
75 Ω connectors . . . . . insert from Versacon® 9 Universal Connector System*

Ordering information

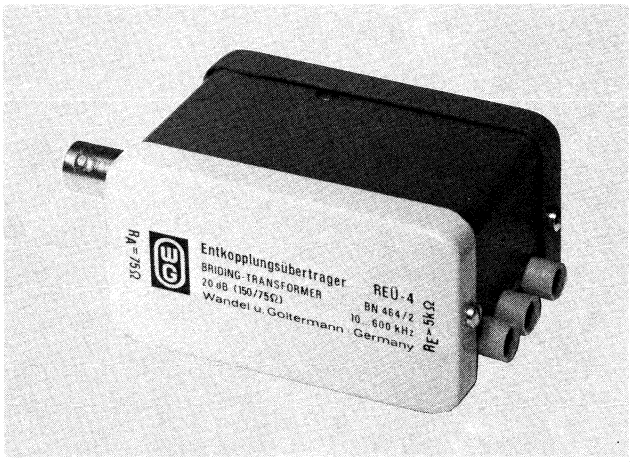
Matching Transformer in small case	BN 419/00.20
Matching Transformer in RSS enclosure for use with RS-25, RS-50, and RS-100	BN 419/00.22
Matching Transformer in REU enclosure for use with RE-25, RE-50, and RE-100	BN 419/00.23

REÜ-4 Bridging Transformer

150 Ω bal./75 Ω coaxial

For high impedance measurements on balanced 150 Ω systems with 75 Ω, coaxial receiver connectors

Frequency range 10 kHz to 600 kHz



Specifications

Frequency range . . . . . 10 kHz to 600 kHz

Frequency response
Error limits . . . . . ±0.1 dB

Input impedance . . . . . ≧5 kΩ

Attenuation
Insertion loss when connected to a balanced, 150 Ω system and terminated with 75 Ω . . . . . 20 dB

Connections
150 Ω connection . . . . . 3 soldering pins or 3 pole CF jack
75 Ω connection . . . . . insert from the Versacon® 9 Universal Connector System*

Ordering information

Bridging Transformer REÜ-4	
150 Ω side: 3 pole CF connector	BN 464/02

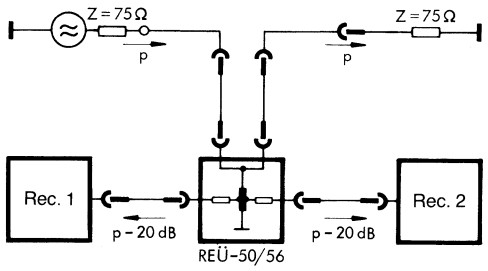
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

REÜ-50/REÜ-56 Matching Transformer

The REÜ-56 and REÜ-50 Matching Transformers permit the simultaneous connection of a wideband level meter and a selective receiver to a system test point. The two Matching Transformers have a looped input and, at levels 20 dB lower, two outputs each decoupled from one another and from the input.

The level range of the wideband level meter is therefore offset by 20 dB. The REÜ-50 operates within a frequency range of 50 kHz to 14 MHz, and the REÜ-56 operates from 300 kHz to 60 MHz.

Owing to their loop-through inputs, the two matching transformers are suitable for decoupled test points on systems carrying traffic.



Application examples for
REÜ-50 and REÜ-56 Matching Transformers

Specifications

Frequency range
REÜ-56 . . . . . 300 kHz to 60 MHz
REÜ-50 . . . . . 50 kHz to 14 MHz

Input*
Loop-through of measured signal,
characteristic impedance . . . . . 75 Ω

Outputs*
Splitts the test signal for two test connectors,
output impedance . . . . . 75 Ω

Return loss
Return loss of loop (75 Ω across each test connector)
REÜ-50 . . . . . 26 dB
REÜ-56 . . . . . 20 dB

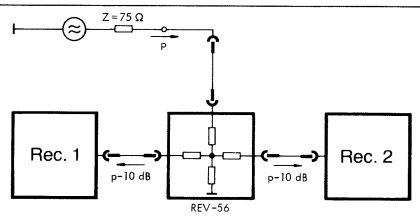
Attenuation (75 Ω termination) . . . . . 20 dB
Insertion loss of the through-loop
(75 Ω across each test connector)
REÜ-50 . . . . . 0.25 ±0.1 dB
REÜ-56 . . . . . 0.25 $^{+0.4\ dB}_{-0.1\ dB}$

Ordering information

Matching Transformer	
REÜ-56*	BN 839/00.01
REÜ-50*	BN 839/00.02

REV-56 Two-way Splitter

Two test instruments with 75 Ω inputs may be connected to one test point when the REV-56 Two-way Splitter is used. It is made up exclusively from resistive components and, therefore, is a very wideband device. When properly terminated, the level difference between the input and either of the two outputs is 10 dB.



Connection via the Two-way Splitter REV-56

Specifications

Frequency range . . . . . 6 kHz to 200 MHz

Input*
Input impedance . . . . . 75 Ω

Outputs*
Signal splits to 2 test connectors,
output impedance . . . . . 75 Ω

Attenuation (75 Ω termination) . . . . . 10 dB
Error limits
6 kHz to 100 MHz . . . . . ±0.2 dB
100 MHz to 200 MHz . . . . . approx. ±0.3 dB

Return loss
6 kHz to 100 MHz . . . . . ≧30 dB
100 MHz to 200 MHz . . . . . ≧25 dB

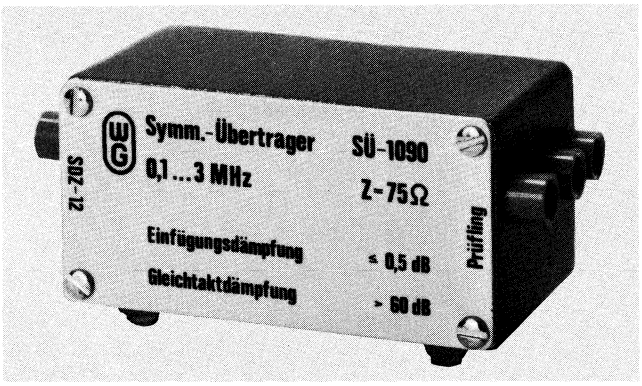
Ordering information

Two-way Splitter REV-56*	BN 839/00.03

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

SÜ-1090 Balancing Transformer

Frequency range 100 kHz to 3 MHz



The SÜ-1090 is used to connect balanced items-under-test to unbalanced generators and receivers. Using the SDZ-12 as an accessory, it is possible to measure signal balance ratio at repeater amplifier- and system-inputs.
The SÜ-1090 Balancing Transformer is used to connect generators and level meters with coaxial outputs and inputs to balanced systems-under-test. The frequency range of the SÜ-1090 is 100 kHz to 3 MHz. The SÜ-1090 can be used between 50 kHz and 5 MHz but its accuracy is reduced.
When signal balance is measured at balanced system test ports, or the signal balance of amplifiers or passive components is measured to CCITT O.121, the SÜ-1090 is ideal for feeding the balanced test voltage to level meters with coaxial inputs.
The SÜ-1090 has been specially designed for 75 Ω systems.

The SÜ-1090 has a transformation ratio if 1:1, its input impedance and output impedance are both 75 Ω. When terminated with 75 Ω, the max. insertion loss is 0.5 dB.
An outstanding feature of the SÜ-1090 is its high common mode rejection, and consequently its high signal balance ratio.

Specifications

Frequency range . . . . . 100 kHz to 3 MHz

Impedance . . . . . ≧1 kΩ

Insertion loss (terminated with 75 Ω) . . . . . ≦0.5 dB

Common mode rejection ratio . . . . . >60 dB

Connectors
To item-under-test . . . . . 2×3pole CF connectors
To test set . . . . . Versacon® 9 insert*

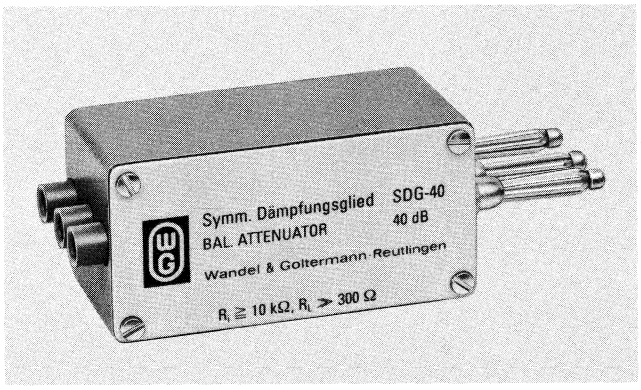
General specifications
Dimensions (w×h×d) in mm
without coax. connector . . . . . 74×35×34
Weight without coax. connectors . . . . . 75 g

Ordering information

Balancing Transformer SÜ-1090	BN 1090/00

SDG-40 Balanced Attenuator

The SDG-40 Balanced Attenuator was designed to increase the range of level meters so that they can be used for measurements on power-line carrier systems where levels up to +40 dB are encountered.
The SDG-40 has minimal reactance and provides an attenuation of 40 dB.



Specifications

Connectors
Input . . . . . 3 pole CF connector
Output . . . . . 3 pole CF connector

Frequency range . . . . . 200 Hz to 620 kHz

Attenuation . . . . . 40 dB ±0.2 dB

Input impedance . . . . . ≧10 kΩ
(Always set the level meter to high impedance)

Max. power rating . . . . . 0.5 W

Ordering Information

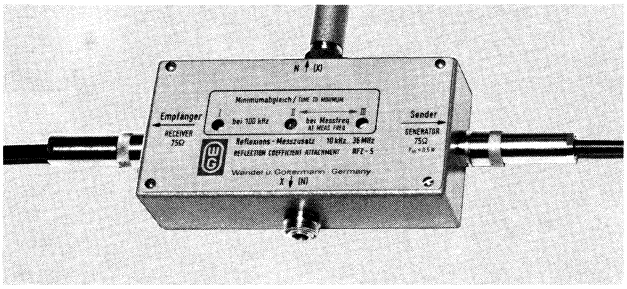
Balanced Attenuator SDG-40	BN 608/00.01

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

Measuring Accessories

RFZ-5 Return Loss Measuring Attachment

Frequency range 10 kHz to 36 MHz



The RFZ-5 is used to determine the reflection coefficients of coaxial items-under-test. Sweep or point-by-point measurements may be made.
A range of impedance standards that includes all common values is available.
The RFZ-5 is basically a Wheatstone bridge, resistive balance can be obtained at low frequencies and capacitative balance at high frequencies.
75 Ω cables are used to connect the RFZ-5 to the test setup so that it can be connected directly to the item-under-test.

Items-under-test that are difficult to access can be connected using one of the two 25 cm test cables provided, the other cable being used to connect the RFZ-5 to the test equipment.
The RFZ-5 and its accessories are delivered in a small carrying case.

Specifications

Impedance values
Standard version . . . . . Z = 75 Ω
Other Z values (charged extra) . . . . . 50, 60, 135 and 150 Ω

Frequency range
at Z = 50, 60, 75 Ω . . . . . 10 kHz to 36 MHz
at Z = 135 and 150 Ω . . . . . 10 kHz to 5 MHz

Max. error
reflection coefficient r at Z = 75 Ω
f ≦ 5 MHz . . . . . ±0.0015 ±0.01 r
f ≦ 15 MHz . . . . . ±0.003 ±0.03 r
f ≦ 36 MHz . . . . . ±0.005 ±0.05 r

Input/output impedance of the bridge . . . . . 75 Ω

Attenuation at r = 1 . . . . . 47 dB

Connectors 2.5/6

General specifications
Dimensions (w×h×d) in mm . . . . . 140×40×90
Weight . . . . . 310 g

Standard accessories
included in standard package . . . . . 1 carrying case
2 cables, Z = 75 Ω (generator or level meter cables)
2 test cables, 25 cm long, Z = 75 Ω
For each Z value . . . . . 1 termination R_N (plug)
1 termination R_N (jack)
1 standard R_{in} (jack)

Ordering information

Return Loss Measuring Attachment RFZ-5, Z = 75 Ω	BN 394/00
without Z = 75 Ω [1]	BN 394/01
Accessories (charged extra)	
Extension set for; Z = 50 Ω	BN 394/00.01
Z = 60 Ω	BN 394/00.02
Z = 124 Ω	BN 394/00.06
Z = 135 Ω	BN 394/00.04
Z = 150 Ω	BN 394/00.05
Conversion set, BNC connectors	3×S 139/1×S 59
Conversion set, 4/13 connectors	3×S 52/1×S 135

1) State value when you place your order

RFZ-4 Reflection Coefficient Measurement Bridge

The RFZ-4 is used to determine the reflection coefficients of coaxial items-under-test. Sweep or point-by-point measurements may be made between 10 MHz and 200 MHz. The RFZ-4 has a 75 Ω reference impedance.
When the RFZ-4 is used with the RM-5 Radio-link Measuring Setup, it is possible to measure the return loss at the IF ports of 2700-channel radio links.
The Versacon® 9 Universal Connector System ensures that the RFZ-4 is compatible with any type of standard connector.

Specifications

Frequency range . . . . . 10 MHz to 200 MHz

Characteristic impedance . . . . . 75 Ω

Insertion loss . . . . . 6.5 dB nominal

Max. error
Error limits [1] . . . . . $0.003 \pm 0.12 \times r^2$

Connectors:
Connector to test equipment*: Insert from the Versacon® 9 Universal Connector System [2]
Generator/receiver connection*: Via accessory cable (K 226), any Versacon® 9 insert can be attached to the cable.

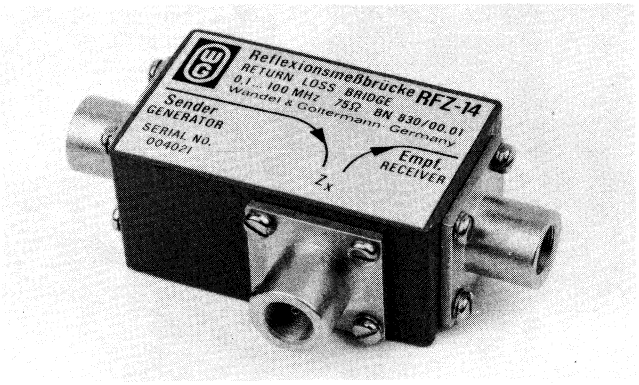
Ordering information

Return Loss Coefficient Measurement Bridge RFZ-4 *	697/00.04

1) r = return loss coefficient of device under test. The specification refers to the Uni 9-connector
2) The stated specifications refer to the adaptor fitted at the factory only
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

RFZ-14 Reflection Coefficient Measurement Bridge

With the RFZ-14 it is possible to measure the variation with frequency of return loss at the ports of FDM systems, or at the inputs and outputs of other equipment.
Both point-by-point and sweep measurements can be made.
Using a suitable signal generator and level meter, e.g. PS-16/SPM-16, or the SNA-1 Spectrum and Network Analyser, this parameter can be measured from 100 kHz to 100 MHz. The reference impedance is 75 Ω.
As the RFZ-14 is fitted with the Versacon® 9 Universal Connector System, it is compatible with all common connector types.



Specifications

Frequency range . . . . . 100 kHz to 100 MHz

Characteristic impedance . . . . . 75 Ω

Insertion loss (Z_X open-circuited) . . . . . max. 8 dB

Frequency response (300 kHz to 60 MHz) . . . . ≦±0.5 dB

Connectors
Any insert from the Versacon® 9 Universal Connector System

Max. error
Error limits after calibration, with BNC, TNC, or 1.6/10
300 kHz to 60 MHz . . . . . 0.007 ±0.1 r^2
100 kHz to 100 MHz . . . . . 0.015 ±0.13 r^2

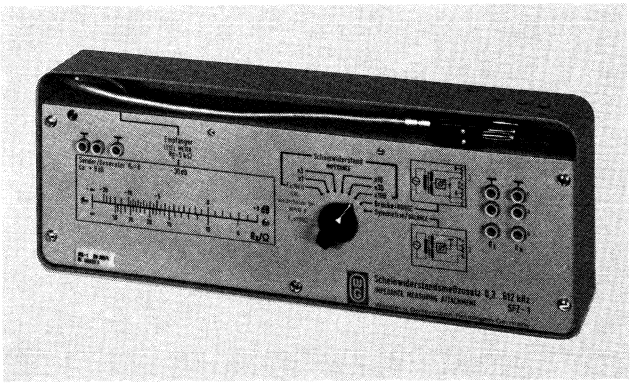
Ordering information

Return Loss Coefficient Measurement Bridge RFZ-14 *	BN 830/00.01

SFZ-1 Impedance Measuring Attachment

Frequency range 300 Hz to 612 kHz

The SFZ-1 is an accessory for level meters with high, balanced input impedance. The SFZ-1 enables measurements of impedances from 10 Ω to 5 kΩ. If suitable references are used, it is possible to measure complex impedances and make return loss and signal balance measurements.



Specifications

The specifications are for the SFZ-1 used with the SPM-30, SPM-31, SPM-15, SPM-18 or SPM-19 at +20°C

Frequency range . . . . . 300 Hz to 612 kHz
Required transmission level, $Z_{out} \approx 0$ . . . . . approx. +9 dB

Impedance measurements
Measurement range
for full scale deflection . . . . . 10 Ω to 1 kΩ
Largest measurable value . . . . . 5 kΩ

Error limits at φ≦30°
30 Ω to 1 kΩ . . . . . ±5 % ±1.5 % f.s.d.
10 Ω to 30 Ω and 1 kΩ to 5 kΩ . . . . . ±10 % ±1.5 % f.s.d.

BRIDGE measurement mode
Measurement range . . . . . 150 Ω to 600 Ω
Intrinsic balance of bridge at $R_X = R_N = 150\ \Omega$ . . . . . ≧60 dB

BALANCE measurement mode
Measurement range . . . . . 0 to 50 dB
Intrinsic balance of bridge . . . . . ≧60 dB

General specifications
Dimensions in mm, (w×h×d) . . . . . 315×120×65
Weight . . . . . 1.3 kg
FTZ-K-Number 272 918 180

Ordering information

Impedance Measuring Attachment SFZ-1 for the SPM-30, SPM-31, SPM-15, SPM-18 and SPM-19	BN 385/04

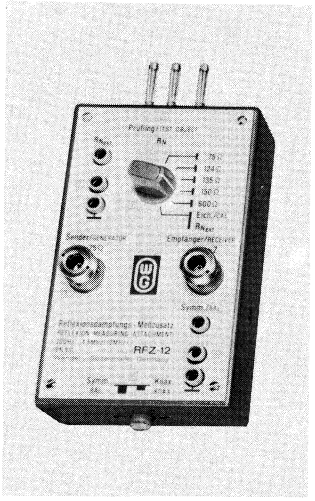
* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

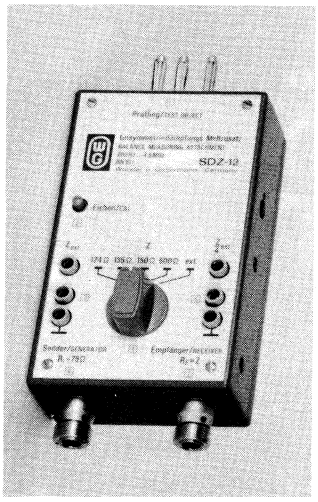
RFZ-12 Return Loss Measuring Attachment
SDZ-12 Signal Balance Ratio Measuring Attachment

Frequency range 200 Hz to 4.5 MHz

When used with the PS-30 (PSE-30)/SPM-30, PSE-30 (PSE-31)/SPM-31, PS-15/SPM-15, PS-18/SPM-18 and PS-19 (PSS-19)/SPM-19, the RFZ-12 enables measurements of return losses of balanced and unbalanced items-under-test simply and easily. The RFZ-12 can be used up to 4.5 MHz[1]. The SDZ-12 is used to perform signal balance ratio measurements to CCITT O.121 on generators and receivers.
From 200 Hz to 4.5 MHz it is possible to carry out both wideband and selective measurements. When the test setup comprising the PS-19 (PSS-19)/SPM-19/SG-4 is used, swept, return loss measurements can be made quickly and efficiently.
The RFZ-12 and the SDZ-12 both contain a bridge.
The RFZ-12 has integral, switchable reference-impedances and the SDZ-12 integral, switchable terminating impedances. This gives ease-of-operation and high accuracy.
Both the SDZ-12 and the RFZ-12 have a connector for external non-standard impedances.

1) The frequency range depends on the instrument used.





Specifications

RFZ-12
Frequency range . . . . . 200 Hz to 4.5 MHz

Impedance standards, integral, switchable
balanced . . . . . 124, 135, 150, 600 Ω
unbalanced . . . . . 75, 124, 135, 150, 600 Ω

Attenuation at r = 1
for unbalanced items-under-test . . . . . 46 dB
for balanced items-under-test . . . . . 40 dB

Max. error on reflection coefficient r

in balanced mode		
in freq. range	for Z =	max. error
200 Hz to 620 kHz	124 Ω to 150 Ω	±0.001 ±0.1 r
200 Hz to 2 MHz	124 Ω to 150 Ω	±0.003 ±0.1 r
200 Hz to 4.5 MHz	124 Ω	±0.006 ±0.2 r
200 Hz to 620 kHz	600 Ω	±0.003 ±0.1 r
in unbalanced mode		
200 Hz to 620 kHz	75 Ω to 150 Ω	±0.001 ±0.1 r
200 Hz to 2 MHz	75 Ω to 150 Ω	±0.002 ±0.1 r
200 Hz to 4.5 MHz and $\|r\| \leqq 0.1$	75 Ω to 150 Ω	±0.003 ±0.2 r
200 Hz to 620 kHz	600 Ω	±0.003 ±0.15 r

Connectors
for item-under-test . . . . . 3 pole CF plug
for generator (Z_{out} = 75 Ω) } inserts from the Versacon® 9
for level meter ($Z_{in} \gg Z_o$) } Universal Connector System*
for level meter (bal. measurement) }
for external impedance standard } 3 pole CF jack

General specifications
Dimensions in mm (w×h×d) without plug . . . . 75×56×133

SDZ-12
Frequency range . . . . . 200 Hz to 4.5 MHz

Terminating and Z/4 impedances
integral, switchable . . . . . 124, 135, 150, 600 Ω
Connector for external impedance standard

Intrinsic bridge inbalance

in freq. range	for Z =	Intrinsic inbal.
200 Hz to 620 kHz	124 Ω to 150 Ω	≧60 dB
200 Hz to 2 MHz	124 Ω to 150 Ω	≧54 dB
200 Hz to 4.5 MHz	124 Ω to 150 Ω	≧50 dB
200 Hz to 120 kHz	600 Ω	≧60 dB

Connectors
for item-under-test . . . . . 3pole CF plug
for generator ($Z_{out} \approx 0$) inserts from the Versacon® 9
for level meter ($Z_{in} \approx Z_o$) Universal Connector System* (jack contact)
for external terminating impedances } 3 pole CF jack
for connection of $Z_o/4$ impedances }

General specifications
Dimensions in mm (w×h×d) without plug . . . . 75×62×125

Ordering information

Return Loss Measuring Attachment RFZ-12	BN 810/01
Signal Balance Ratio Measuring Attachment SDZ-12	BN 811/01

Accessories (charged extra) for RFZ-12
Coaxial connector for item-under-test:
Versacon® 9 adaptor BN 810/00.06
Inserts from the Versacon® 9 Universal Connector System*

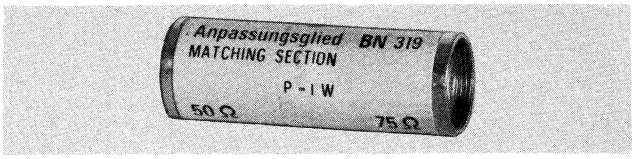
Accessory (charged extra) for RFZ-12, SDZ-12
Carrying case for both RFZ-12 and SDZ-12 BN 626/08

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

Switches, Matching Pads

FEDA-1 Matching Section

Impedance 75 Ω/50 Ω; Frequency range d.c. to 100 MHz



Specifications

The specifications are valid for the Matching Section without adaptor for ambient temperature +23°C ± 5°C

Impedance . . . . . 75 Ω/50 Ω

Frequency range . . . . . d.c. to 100 MHz

Attenuation
Insertion loss . . . . . 6 dB
Error limits . . . . . ±0.1 dB

Reflection coefficient . . . . . ≦0.01

Load . . . . . ≦1 W

General specifications
Ambient temperature with rated load . . . . . 0°C to 45°C
Storage and transportation . . . . . −55°C to +60°C

Dimensions in mm (without adaptors)
Length 47
Diameter 16
Weight . . . . . 50 g

Connections
75 Ω side . . . . . 2.5/6 (F) or 1.6/10 (M/F) or BNC (M/F) or N connector (M/F)
50 Ω side . . . . . BNC (M/F) or N connector (M/F)

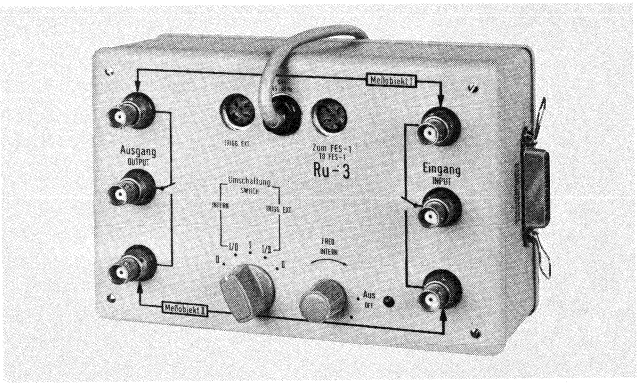
Ordering information

Matching Section FEDA-1	BN 319/00
State required connector types	

RU-3 Relay Change-over Switch

Frequency range dc to 100 MHz

The RU-3 is used to switch between the item-under-test and a standard when reference measurements are made. Switchover can be performed manually, or automatically. The RU-3 can also be used for sweep measurements as it has a facility for synchronising test-channel switchover with the return sweep. Using the digital interface it is also possible to perform precise, manual and computer-controlled, digital level difference measurements with the PS-16/SPM-16 and PS-19 (PSS-19)/SPM-19 level measuring setups.



Specifications

Frequency range . . . . . dc to 100 MHz

Impedance . . . . . 75 Ω

Reflection coefficient
Max. reflection coeff. at input and output
f ≦ 15 MHz . . . . . ≦0.015
f ≦ 36 MHz . . . . . ≦0.03
f ≦ 60 MHz . . . . . ≦0.04
f ≦ 100 MHz . . . . . ≦0.05

Attenuation
Insertion loss
f ≦ 36 MHz . . . . . ≦0.05 dB
f ≦ 60 MHz . . . . . ≦0.1 dB
f ≦ 100 MHz . . . . . ≦0.15 dB
Isolation between both channels
f ≦ 60 MHz . . . . . ≧95 dB
f ≦ 100 MHz . . . . . ≧85 dB

Operating modes
Change-over frequency
internally triggered, continuously variable . . . 1 Hz to 30 Hz
externally triggered . . . . . d.c. to 30 Hz

Contact load
Max. switching power . . . . . 7 W
Max. switchable current . . . . . 0.25 A
Max. switchable voltage . . . . . 30 V

Connection
Inserts from the Versacon® 9 Universal Connector System* (jack contact)
Digital interface, connection to SPM-16, SPM-19

General specifications
Power supply
A.C. line (45 to 65 Hz) . . . . . 110/120/220/240 V ±10 %
Power consumption . . . . . approx. 5 VA
Dimensions in mm (w×h×d) . . . . . 190×100×125
Weight . . . . . 2.7 kg

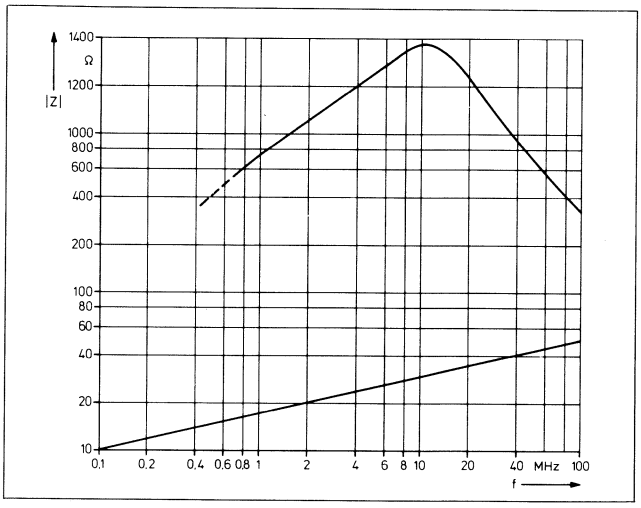
Ordering information

Relay Change-over Switch RU-3*	BN 323/02
Control Cable for SPM-16, SPM-19	K 366

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

Coaxial Choke, Compensated Measurement Cable

MSD-1 Coaxial Choke



When high attenuations are measured, earth-loops may cause a reading that is too low.
The MSD-1 Coaxial Choke reduces errors of this kind by raising the return impedance (decoupling or isolation impedance).
If, for example, test equipment is connected to form a test setup and the generators and level meters are controlled by a common oscillator, low impedance ground paths may be set up via the connection cables. If the MSD-1 is connected to the connection cables, a high-impedance ground loop is formed, whereas the path for the wanted signal has a low impedance.
The diagram shows typical return impedance and insertion loss curves for the MSD-1.
The MSD-1 is fitted with the Versacon® 9 Universal Connector System which is compatible with all common connector types.

Ordering information:

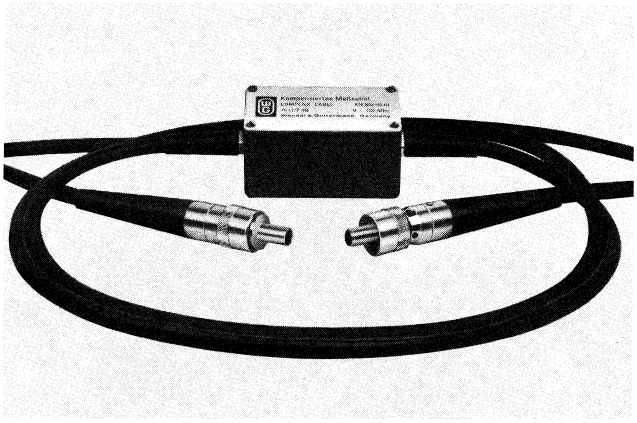
Coaxial Choke MSD-1 *	BN 690/00.01

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

Compensated Test Cable

Frequency range 0 to 100 MHz

The frequency response of connection cables can produce incorrect results when precise level measurements are being made. The cable manufactured by W & G has an equaliser halfway along it giving the cable an almost flat frequency response.
The cable is long enough to be used for end-to-end equalisation in repeater exchanges where the distributer and equaliser racks are at different locations.
The cable is very stable mechanically and electrically and can be fitted with a variety of connectors.



Specifications

Frequency range . . . . . dc to 100 MHz

Impedance . . . . . 75 Ω

Loss
Insertion loss at 100 kHz . . . . . 2 dB ±0.1 dB

Level
Max. level . . . . . +20 dBm (+10 dB)

Frequency response
Error limits referred to 100 kHz
dc to 70 MHz . . . . . ±0.05 dB
dc to 100 MHz . . . . . ±0.07 dB

Reflection coefficient
both ways (connector: BNC, TNC, 1.6/5.6, 1.6/10) . ±0.05
with 2.5/6 connector, additional 0.01

General specifications
Cable length . . . . . 6 m
Weight . . . . . 450 g
Available connectors . . . . BNC; TNC; 1.6/5.6; 1.6/10; 2.5/6

Ordering information

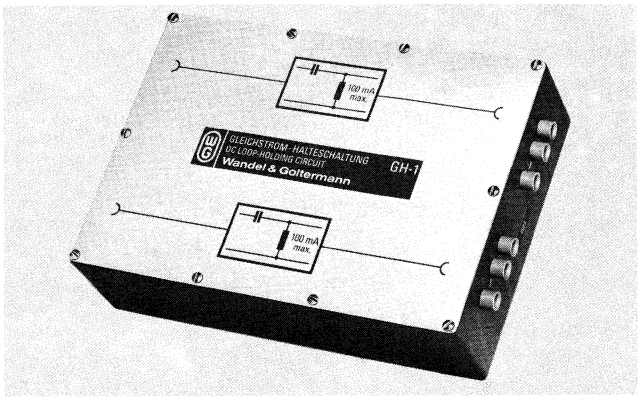
Compensated Test Cable *	BN 862/00.01

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

D.C. Loop Holding Circuit, Ventilator Attachment

GH-1 D.C. Loop Holding Circuit

When test sets are connected to telephone equipment, it is important to prevent interruptions in the dc exchange loop.
The GH-1, which is connected in parallel with the test set, maintains the dc loop and has dc free outputs for connecting test equipment.
The GH-1 contains two loop holding circuits in a compact housing.



Specifications

Inputs . . . . . balanced, floating, 3 pole CF connector
DC voltage to earth . . . . . ≦60 V
Signal balance ratio to CCITT O.121, 200 Hz to 6 kHz
(using ideal generator or receiver) . . . . . >46 dB
Max. dc current . . . . . ≦100 mA
Voltage drop at 60 mA . . . . . approx. 12.5 V

Outputs like inputs, no dc component in output signal
Output impedance
200 Hz to 6 kHz . . . . . approx. 100 kΩ
6 kHz to 20 kHz . . . . . approx. 50 kΩ

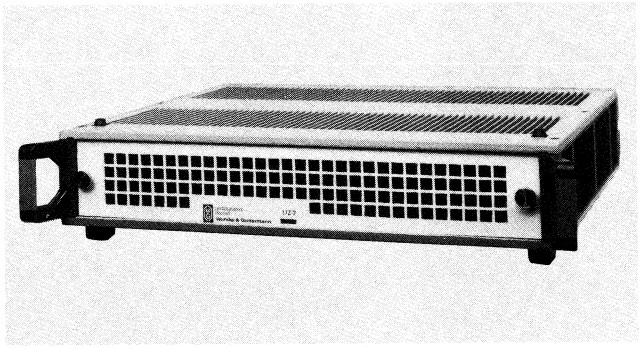
General specifications
Ambient temperature
Nominal range of use . . . . . +5°C to +40°C
Storage and transportation . . . . . −40°C to +70°C
Dimensions in mm (w×h×d) . . . . . 149×47×108
Weight . . . . . 0.4 kg

Ordering information

D.C. Loop Holding Circuit GH-1 Two loop-holding circuits with d.c. free outputs	BN 984/00.12

LTZ-2 Ventilator Attachment

When test equipment is operated in still air, at high ambient temperatures or in racks, fans are necessary to ensure electrical reliability. The LTZ-2 contains two powerful axial fans that have a high air flow and low acoustic noise figures.
Almost all the air that is sucked in through the front panel is directed upwards. The air filter, which is mounted at an angle, is easily replaced, even when the LTZ-2 is operating.



Specifications

Fan type
Axial, number per set . . . . . 2, individually fused

Max. air flow . . . . . 320 m^3/h

General specifications
Power supply
BN 918/01 . . . . . 110 V/60 Hz
Power consumption . . . . . 50 VA
Safety class to IEC 348 and VDE 0411 . . . . . Class I

Ambient temperature
Nominal range of use . . . . . +5 °C to +50 °C

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	110	Height (2 units)	86
Depth with handles	425	Depth	370

19" conversion kit . . . . . BN 700/00.02
Weight . . . . . 6 kg

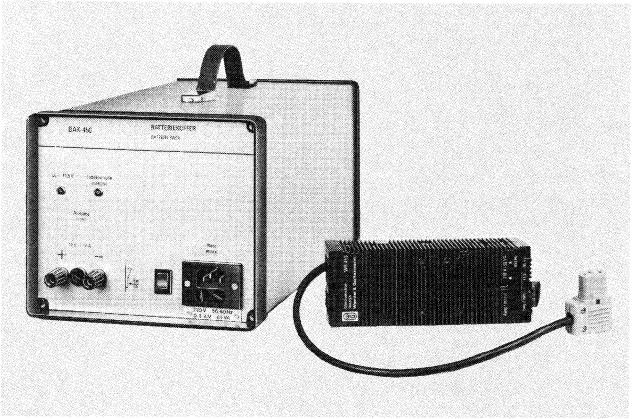
Ordering information

Ventilator Attachment LTZ-2, 110 V/60 Hz Version	BN 918/01
Accessory (charged extra) Protective Transportation Cover for front and back panels (1 set) SD-2	BN 700/00.22

Inverter, Battery Pack

WR-450 Inverter
BAK-450 Battery Pack

Test instruments that are normally supplied from the mains can be battery-powered using the WR-450 and BAK-450. This is particularly useful when test sets are used in the field.
The WR-450 Inverter was developed for the PS-18 Level Generator, the SPM-18 Level Meter and the TR-940 Transient Recorder. The WR-450 is mounted on the back-panel of these instruments and has floating inputs and outputs. The BAK-450 Battery Pack, or a car-battery, provide the dc power for the WR-450. The BAK-450 contains a rechargeable battery and a charger.
The output of both instruments is short-circuit protected. The BAK-450 can, of course, also be used to power test sets that require a 12 V dc supply.



Specifications

WR-450

Input voltage range	11.5 V to 30 V
Output voltage (400 Hz ⎍⎍)	210 V, −10 %/+15 %
Max. power	50 VA[2]

BAK-450

Nominal voltage	12 V
Nominal battery capacity	20 Ah
Charging time after complete discharge	18 h

General specifications

Ambient temperature	−10°C to +50°C[2]
Safety class to IEC 348 and VDE 0411	Class I

Dimensions	WR-450	BAK-450
(w×h×d) in mm	170×53×65	203×186×375
Weight	approx. 1 kg	approx. 13 kg

Ordering information

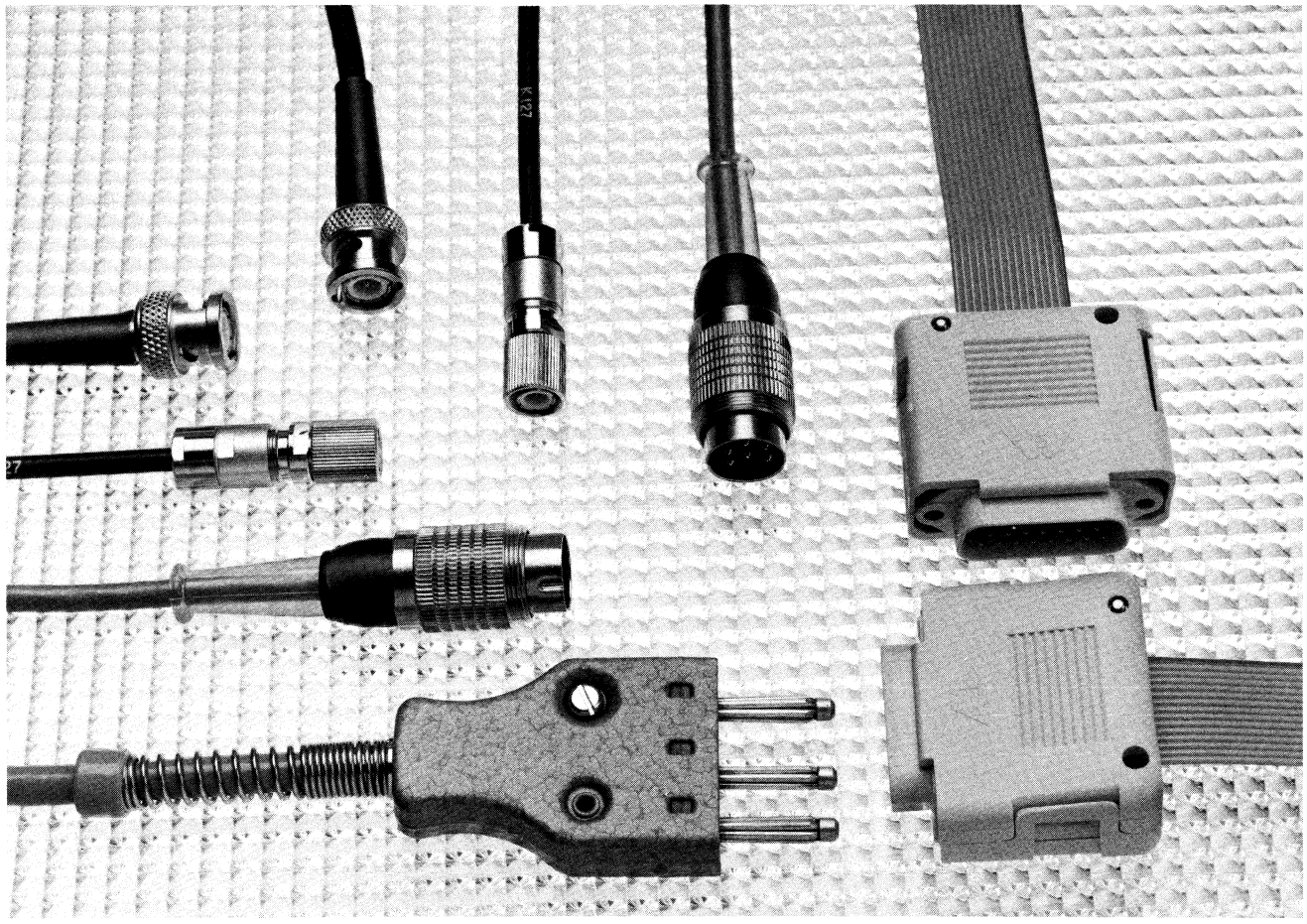
WR-450 Inverter	
for PS-18/SPM-18	BN 864/00.02
for TR-940	BN 940/00.01
BAK-450 Battery Pack[3]	BN 864/00.03

1) PS-18/SPM-18, Series C and after
2) WR-450 mounted on back panel
3) Manufactured by MRS, Rottweil

Note

The following data sheets are available
- Versacon® 9, Universal Connector System with $Z_o = 75\ \Omega$
- Versacomp® 75
- Connection cables, cable connectors and adaptors.

Connecting Cables
Cable Connectors and Adaptors



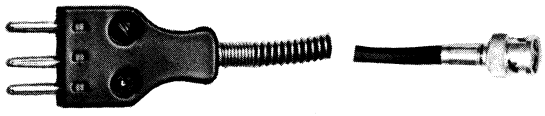
Characteristics

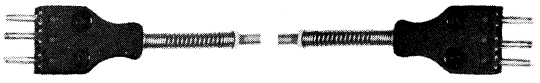
Connecting cables, cable connectors and adaptors are necessary and indispensible accessories for electronic measurement instruments. In addition to the measurement equipments which we produce, we also supply these accessories. However, we must restrict the types which we supply: our deliveries include those connectors usually used in the fields of telecommunications and general electronics. Connecting cables are available in various lengths from stock.

A selection of cable connectors for making your own cable assemblies is also available. The maximum cable diameter for the type of cable connector selected is also listed. Furthermore, by offering a selection of adaptors, we have made possible the matching of different connectors on made-up cables which must be used to interconnect measuring instruments or devices under test that are not fitted with connectors of the same type.

Please use the order numbers listed in the tables when cables, cable connectors and adaptors are ordered. If other cable lengths and connectors are needed, then please request the variation that you want.

Connecting Cables

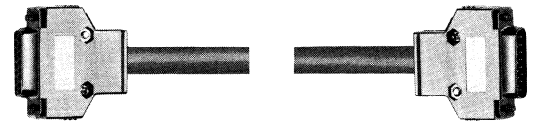
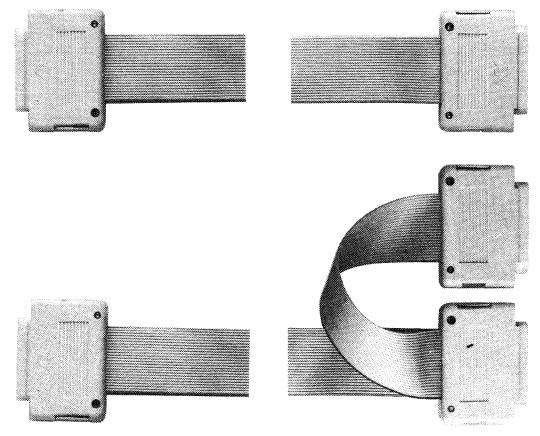
Connectors (a) (b)	Type of cable and connectors	Charac-teristic imped.	Cable length (mm)	Order number
	(a) and (b): BNC RF cable, single shield	50 Ω	250 500 1000 2000	K 74 K 75 K 76 K 77
	(a) and (b): BNC RF cable, single shield	75 Ω	250 500 1000 1500 2000	K 78 K 79 K 80 K 227 K 81
	(a) and (b): BNC RF cable, double shield	75 Ω	250 500 1000 1500 2000	K 228 K 166 K 151 K 168 K 169
	(a) and (b): 1.6/5.6 RF cable (subminax), single shield	75 Ω	250 1000 2000	K 128 K 125 K 127
	(a): open, (b): 1.6/5.6 RF cable (subminax), single shield max. dia. = 3.8 mm	75 Ω	1000	K 114
	(a) and (b): 1.6/10 RF cable, double shield	75 Ω	500 1000 1500 2000	K 129 K 130 K 131 K 133
	(a): Bal. CF connector 2 pole with three plugs (b): BNC RF cable, single shield	75 Ω	1000	K 164

Connectors (a) (b)	Type of cable and connectors	Cable length (mm)	Order number
	(a) and (b): Bal. CF connector, connected to all three poles 2 conductor shielded cable	250 500 750 1000 1500 2000	K 9 K 10 K 11 K 12 K 13 K 14
	(a): 3 banana plugs (b): Bal. CF connector 2 conductor shielded cable	1000 2000	K 70 K 71
	(a) and (b): 50 pole male connector (Amphenol 57-30500 or Cannon JD-50P-C (A)) 50 conductor control cable	500 1000 1500 2000 2500 3000	K 179 K 172 K 173 K 185 K 188 K 186
	(a) and (b): 5 pole AF male connector with threaded locking rings (Amph. T 3360/1) 5 conductor AF shielded cable	1000 1500	K 94 K 134

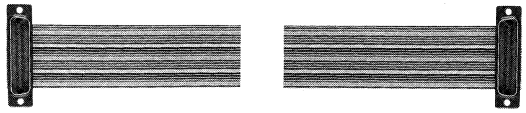
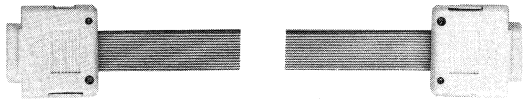
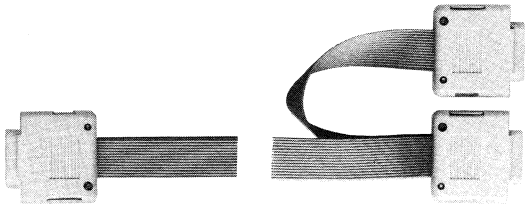
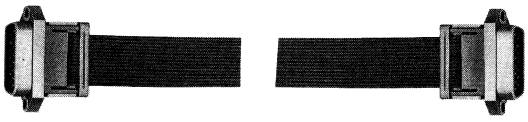
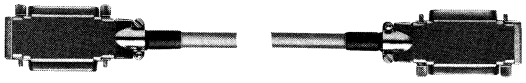
Connecting Cables (continued)

Connectors (a) (b)	Type of cable and connectors	Cable length (mm)	Order number
	(a) and (b): 5 pole AF male connector (Hirschmann Mas 50) 5 conductor AF shielded cable	250 500 750 1000 1500 2000	K 37 K 38 K 39 K 40 K 41 K 22
	(a) and (b): 3 pole AF male connector (Hirschmann Mas 30) 3 conductor AF shielded cable	250 500 750 1000 1500 2000	K 56 K 57 K 58 K 59 K 60 K 61
	(a) and (b): banana plugs Cable: 2 conductor (NYZ)	1200	K 184
	Safety measuring lead, 1 wire black red	2000	 K 383 K 426
	Test lead for DV-24 (red) for DX-21 (blue)	 300 300	 K 377 K 410

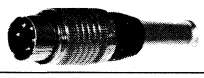
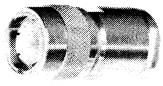
Interface Cables

Connector (a) (b)	Type	Cable length (mm)	Order number
	V.24 Interface cable (25 pin) (a) male con. (b) fem. con.	600 1500 3000 7500 15000	K 391 K 392 K 393 K 394 K 395
	X.20/X.21 Interface cable (15 pin) (a) male con. (b) fem. con.	600 1500 3000 7500 15000 30000	K 385 K 386 K 387 K 388 K 389 K 390
	V.24 Interface cable (25 pin) (a) fem. con. (b) male con. (a) male con. (b) male con. (a) fem. con. (b) fem. con. (a) male con. (b) fem. + male con.	 1500 1500 1500 1500	 K 363 K 364 K 365 K 369

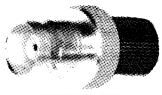
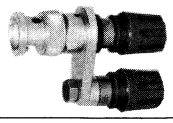
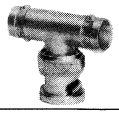
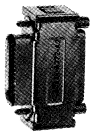
Interface Cables (continued)

Connector (a) (b)	Type	Cable length (mm)	Order number
	V.24 Interface cable (25 pin) (a) male con. (b) male con.	300	K 381
	X.20/X.21 Interface cable (15 pin) (a) male con. (b) male con. (a) fem. con. (b) male con. (a) fem. con. (b) fem.	1500 1500 1500	K 370 K 371 K 373
	(a) male con. (b) fem. + male con.	1500	K 372
	X.20/X.21 Interface cable (15 pin) (a) male con. (b) male con.	300	K 378
	Connection cable for the <IEC 6255> Interface with (a) fem./male IEC 625 connector (b) fem./male IEC 625 connector	1200 2000	K 343 K 344
	Connection cable for the <IEC 625> interface with (a) male/fem. IEEE 488 connector (b) male/fem. IEEE 488 connector	1200 2000	K 420 K 421

Cable Connectors

	Type	Max. cable diameter	Charac-teristic impedance	Order number
	5 pole plug with threaded locking rings	5.5 mm	–	S 89
	Balanced CF plug	6 mm	–	S 2
	RF cable plug BNC	5.5 mm	50 Ω	S 70
	RF cable plug BNC	6.5 mm	75 Ω	S 71
	RF cable plug 1.6/5.6	4 mm	75 Ω	S 150
	RF cable plug 1.6/10	10.3 mm	75 Ω	S 32

Adaptors

	Adaptor from	to	Charact. impedance	Order number
	BNC (f)	– 1.6/5.6 (m)	75 Ω	S 230
	BNC (f)	– 2.5/6 (m)	75 Ω	S 59
	BNC (m)	– 2.5/6 (f)	75 Ω	S 139
	BNC (m)	– 2 x 4 mm banana fem. con.		S 826
	T-adaptor BNC (f-m-f)		50/75 Ω	S 413
	Adaptor IEEE 488 (m) – IEC 625 (m)			S 832
	Adaptor IEC 625 (f) – IEEE 488 (f)			S 834

(m) ≙ male connector, (f) ≙ female connector

Versacon® 9
75 Ω Universal Adapter System (Z_o = 75 Ω)



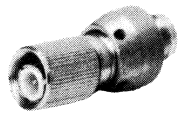
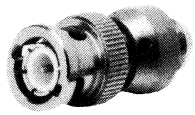
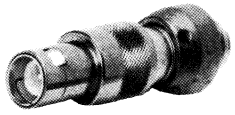
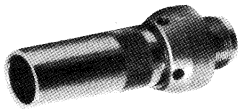
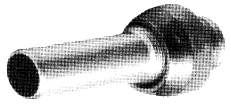
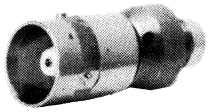
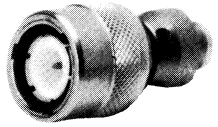
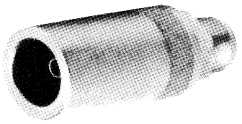
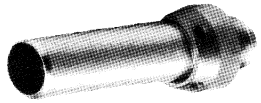
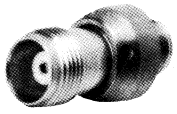
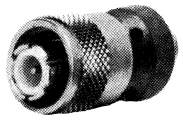
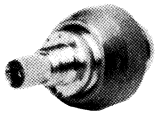
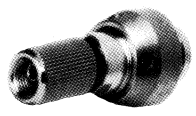
Applications and Characteristics

The universal adapter system Versacon® 9 (characteristic impedance, Z_o = 75 Ω) allows the user of Wandel & Goltermann measuring instruments to easily change coaxial type inputs and outputs from one familiy type to another. The Versacon® 9 basic connectors are mounted on the measuring instrument, and threaded on to them are the special Versacon® 9 adapters of the connector type which had been chosen. The adapter is secured by means of a lock-nut to prevent it from loosening during use. A spanner, W1, is used to tighten the lock-nut.
Furthermore, various lengths of made-up cables are available with Versacon® 9 basic connectors mounted on both ends of each cable. The appropriate Versacon® 9 adapters can be fitted to the cable in order that the cable exactly matches the connectors presented by the unit under test and the measuring instrument.

In telecommunications and general electronics measuring techniques, a great need exists for adapter connectors frequently applied to interconnect different types of connectors as found on the variety of instruments and units under test. But often the correct adapter connector is not at hand. This is when the Versacon® 9 adapter system can help with a simple device. A sleeve is threaded on between any two Versacon® 9 adapters. Thus, any type of connector can be mounted on each end of the sleeve. The great advantage is obtained from the changeover being so easy to accomplish.
The available Versacon® 9 adapters are tabulated in the following table. Adapters are listed as either male or female type of connector.

® Registered trade mark

Adapters for the Versacon® 9 adapter system

Versacon® 9 adapter for:	Female contact (F)	See note	Order Number	Male contact (M)	See note	Order Number
1.6/5.6 (DIN 47 295; 169-13 IEC)		3)	S 224		3)	S 346
2.5/6 (DIN 47 296)		4)	S 225		3)	S 344
BNC (169-8 IEC)		1)	S 226		1) 2)	S 345
BNC 75		1) 3)	S 831		1) 3)	S 825
LEMO No. 1			S 227			S 343
Western Electric 558 A (F); 440 A (M)		4)	S 228		4)	S 341
1.6/10 (159 IEC 75-7)		3)	S 231		3)	S 342
Western Electric 470 C (F); 358 A (M)		5)	S 336		5)	S 338
TNC		1) 2)	S 800		1) 2)	S 801
TNC 75		1) 2)	S 827		1) 2)	S 828
1.0/2.3 (DIN 47 297)		2)	S 821		2)	S 820
Accessory:	Mounting key W 1					

Notes to table:

1) The type BNC and the type TNC connectors are available in two different versions for each type.
The version without an additional symbol is the standard connector with a characteristic impedance of $Z_o = 50\ \Omega$, within the insert. For application at $Z_o = 75\ \Omega$, compensation is required. Taking into account that connectors originating from different manufacturers ought to be freely combinable without affecting the low reflection characteristic of the combination, there must be agreement on which portion of the insert within the connector is to be compendated. For that, the reference plane is used. It is defined for most of the connector families as that vertical plane intersecting the longitudinal axis where the outer conductor is butted against the connector. As a result, the types BNC and TNC are compensated for the total length of insert in the male connector.
For low-reflection, 75 Ω connections, BNC and TNC female connectors are used in practise by elimination of the teflon dielectric surrounding the inner conductor in the standard versions. By these means, the connectors attain the required characteristic impedance of $Z_o = 75\ \Omega$ in the insert. The compensation accomplished in a male connector is different, for that reason, from that of the standard version. The special versions are designated BNC 75 and TNC 75.
2) Delivery dates on request
3) Reflection coefficient $|r| \leqq 0.5\,\%$ at 300 MHz
4) Reflection coefficient $|r| \leqq 1\%$ at 100 MHz
5) Reflection coefficient $|r| \leqq 0{,}5\,\%$ at 25 MHz.

Reflection coefficient specifications for Versacon® 9 adapters not included in notes 3) to 5) are available on request.

75 Ω cable with Versacon® 9 basic connector

Various lengths of pre-assembled 75 Ω cable with Versacon® 9 basic connectors on the two ends ease the connection conditions between unit under test and measuring instrument. The chosen Versacon® 9 adapters can be threaded onto the basic connectors at each end. The cable is double screened and has the tight tolerance of ±2 %.

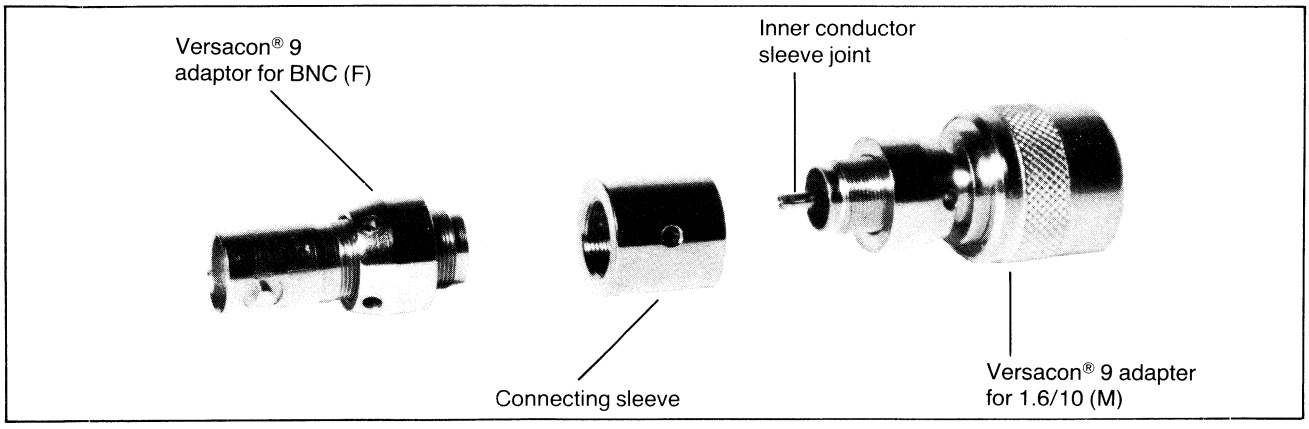
	Cable length (mm)	Order No.
	1000 1500 2000	K 159 K 170 K 195

Versacon® 9 connecting sleeve

Adapter connectors are often required and can be assembled from two Versacon® 9 adapters and a connecting sleeve between the two. The connecting sleeve has internal threads to match the adapter threads. The lock-nut on each adapter secures the assembly. An internal sleeve joint connects the two inner conductors.

Any adapter connector made up from Versacon® 9 system elements can be easily converted to other connector families. A prepared package with 8 connecting sleeves and two W1 keys for assembly is available.

Order No. S 823

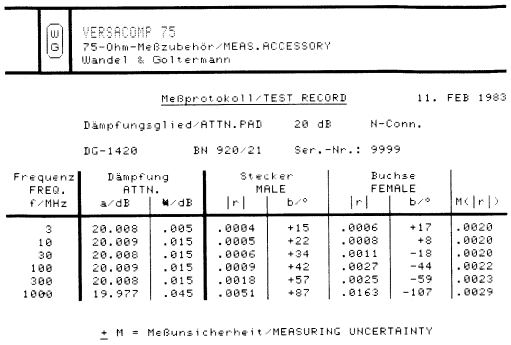


Cables, cable connectors and adapters

are presented in more detail in the Specification Sheet "Cables, Cable Connectors and Adapters". The additional information provides an overview of the measuring accessories available for assembling a great variety of connections between measuring instruments and units under test.
Besides cables with coaxial RF connectors, there are additionally cables with 3 pole CF plugs, control cables, with multi-pole connectors, and cables with multi-pole AF connectors – tabulated according to length.
Various types of connectors are available for the assembly of special cables.
Our easily converted adapter connectors of the Versacon® 9 System are supplemented by a number of conventional, however, not convertable adapters.

Versacomp® 75

Attenuators, Terminations, Standard Mismatches
"T" Adaptors and Z_o Matching Pads 75 Ω ⇄ 50 Ω



VERSACOMP 75
75-Ohm-Meßzubehör/MEAS.ACCESSORY
Wandel & Goltermann

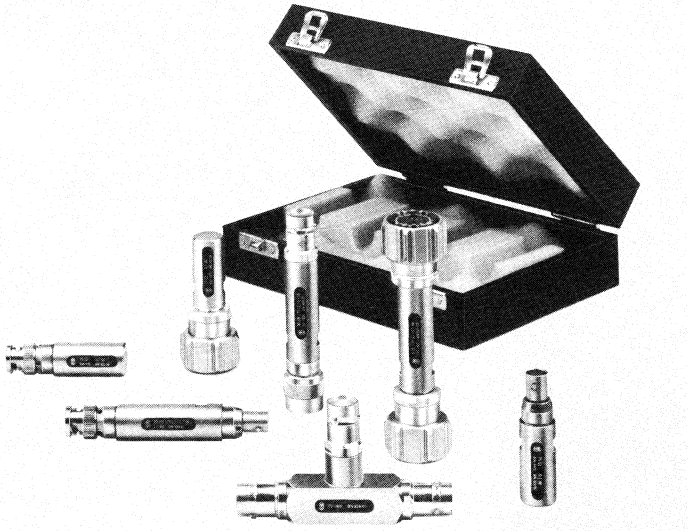
Meßprotokoll/TEST RECORD 11. FEB 1983

Dämpfungsglied/ATTN.PAD 20 dB N-Conn.

DG-1420 BN 920/21 Ser.-Nr.: 9999

Frequenz FREQ. f/MHz	Dämpfung ATTN. a/dB	M/dB	Stecker MALE |r|	b/°	Buchse FEMALE |r|	b/°	M(|r|)
3	20.008	.005	.0004	+15	.0006	+17	.0020
10	20.009	.015	.0005	+22	.0008	+8	.0020
30	20.008	.015	.0006	+34	.0011	-18	.0020
100	20.009	.015	.0009	+42	.0027	-44	.0022
300	20.008	.015	.0018	+57	.0025	-59	.0023
1000	19.977	.045	.0051	+87	.0163	-107	.0029

± M = Meßunsicherheit/MEASURING UNCERTAINTY



- **Outstanding electrical characteristics**
- **Thin film technology construction**
- **Frequency range to 1 GHz**
- **Fixed or convertible connectors**

Applications

Many coaxial measuring tasks require special accessories such as attenuators, terminations, standard mismatches, "T" adaptors and Z_o matching pads.
Attenuators are primarily used for reducing signal levels, for the broadband matching of signal sources and loads to the relevant characteristic impedance and for measuring the gain and attenuation of two port networks. *Terminations* are needed to prevent reflections at unused inputs and outputs of instruments or lines, while *standard mismatches* are required for calibrating instruments that measure return loss and for simulating reflections produced at modules of various kinds.
There are also many applications for *"T" adaptors*. For example, they can be used in control circuits where a reference signal that exactly follows the measurement signal is required. Z_o matching pads are extremely useful if instruments and test items with different impedances are connected together.

The most important criteria for selecting accessories of this kind are:

- Characteristic impedance
- Reflection coefficient or VSWR
- Attenuation and reflection coefficient accuracy
- The type of connectors used

Characteristics

The Versacomp® 75 product line has been designed with characteristic impedances of 75 Ω in mind. Series 1400 and Series 900 have different frequency ranges and connectors. The Accessory Components of Series 1400 have permanently mounted connectors that allow a specification in the frequency range of up to 1 GHz. Our Versacon® 9, Universal Adaptor System is used for Series 900. There is also the possibility of using this Series with connectors which are not specifically mentioned in the Ordering Information. The frequency range for Series 900 Accessory Components extends from d.c. to 300 MHz.
All the usual types of connectors used in coaxial applications are contained in the connector list. Versacomp® 75 Components using the GR 900 precision connector are especially suited for performing precision measurements.
The outstanding electrical characteristics of the Versacomp® 75 Components have been attained by using thin film technology. The thin film chip resistors incorporated in the Accessory Components are made out of a highly-stable, precision etched tantalum nitride layer, deposited on a glass substrate. Gold plated contacts are not subject to contact oxidisation and so eliminate time variant differences in contact resistance.

Frequency range	
Series 1400	d.c. to 1 GHz
Series 900	d.c. to 300 MHz
Max. input power	0.1 W (≅ + 20 dBm)
Rated range of use of ambient temperature	+5 to +40°C

The error limits quoted for the Accessory Components are largely determined by the measuring setup employed in the testing department and the accuracy of the standards used. *Every* Accessory Component is checked thoroughly using a computer controlled network analyzer with an S parameter measuring attachment. A computer printout of the results indicating the uncertainties is delivered with each Accessory Component. This information can then be used to reduce measurement errors to a minimum.
Up-to-date computer printouts are always provided when components are sent to our Customer Service Department.
If requested a calibration certificate from the Wandel & Goltermann Standard Department will be sent to the customer when the component is first delivered or if it is returned to the Department. The certificate includes a new computer printout and a guarantee that measurement results are ultimately based on national or international standards. A calibration mark showing the date when calibration was carried out is also applied to the component.
The Versacomp® 75 Components are delivered in protective cases covered with artificial leather. A maximum of four one port or two port Accessory Components can be stored in a single case. The "T" adaptors can be accommodated in a second version of the storage case. Both types of case can be delivered as an extra item. The order numbers are given at the end of the data sheet.

Specifications (preliminary) — **Versacomp® 75**

Max. permissible input power . . . . . 0.1 W (≅ + 20 dBm)
A higher load (>0.5 W) of short duration will not cause any damage; overloads of longer duration will alter the electrical characteristics of the component.

Ambient temperature
Rated range of use . . . . . +5 to +40°C
Storage and transportation . . . . . −40 to +70°C

The following specifications and guaranteed error limits are valid for the temperature range +23°C ±10 K and input powers of up to 10 mW (≅ +10 dBm).
The temperature and power coefficients can be used to calculate parameters such as return loss over the whole rated range of use for temperature and input power.
The coefficients for each Accessory Component are given at the end of the specifications. The reference temperature is +23°C.
Transmission loss, a_w the characteristic parameter for attenuators, is defined as 20 log $1/|S_{21}|$ where $|S_{21}|$ is the magnitude of the complex transmission coefficient S_{21}.

Attenuators

Series 1400

1.6/10

d.c. to 1 GHz

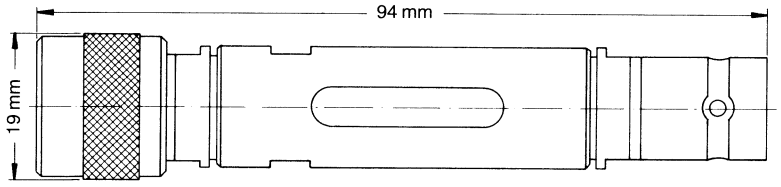


Fig. 1

Transmission loss	Transmission loss error limits at 3 MHz	Transmission loss error limits referred to 3 MHz DC	30 M	100 M	300 M	1 G	Max. reflection coefficient DC	30 M	100 M	300 M	1 G	Weight	Type	Order Number
3.01 dB 5 dB 6.02 dB 9.03 dB 10 dB 19.03 dB 20 dB 30 dB 40 dB	±0.02 dB	±0.02 dB	±0.03 dB ±0.02 dB ±0.03 dB	±0.04 dB ±0.03 dB ±0.04 dB	±0.12 dB ±0.1 dB		≦0.004	≦0.006	≦0.01	≦0.03		97 g	DG-1403 DG-1405 DG-1406 DG-1409 DG-1410 DG-1419 DG-1420 DG-1430 DG-1440	BN 921/10 BN 921/20 BN 921/30 BN 921/40 BN 920/10 BN 921/50 BN 920/20 BN 920/30 BN 920/40

N

d.c. to 1 GHz

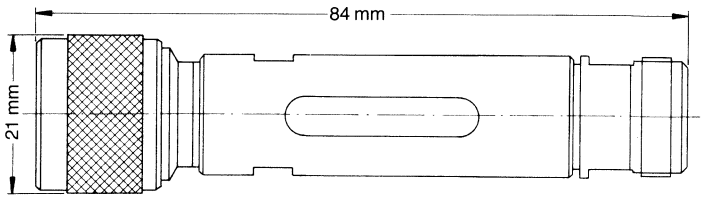


Fig. 2

Trans-mission loss	Transmis-sion loss error limits at 3 MHz	Transmission loss error limits referred to 3 MHz					Max. reflection coefficient					Weight	Type	Order Number
		DC	30 M	100 M	300 M	1 G	DC	30 M	100 M	300 M	1 G			
3.01 dB 5 dB 6.02 dB 9.03 dB 10 dB 19.03 dB 20 dB 30 dB 40 dB	±0.02 dB	±0.02 dB	±0.03 dB ±0.02 dB ±0.03 dB	±0.04 dB ±0.03 dB ±0.04 dB	±0.12 dB ±0.1 dB		≦0.004	≦0.006	≦0.01	≦0.03		102 g	DG-1403 DG-1405 DG-1406 DG-1409 DG-1410 DG-1419 DG-1420 DG-1430 DG-1440	BN 921/11 BN 921/21 BN 921/31 BN 921/41 BN 920/11 BN 921/51 BN 920/21 BN 920/31 BN 920/41

GR 900 (457-3 IEC)

d.c. to 1 GHz

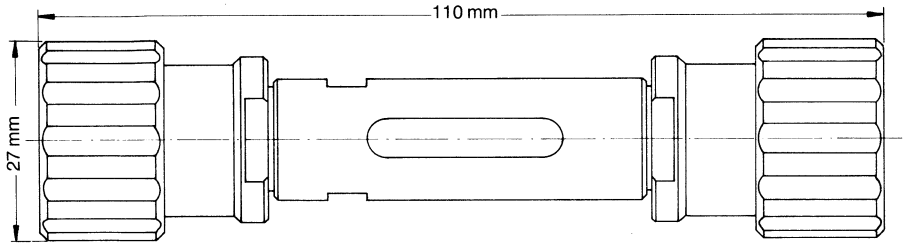


Fig. 3

Trans-mission loss	Transmis-sion loss error limits at 3 MHz	Transmission loss error limits referred to 3 MHz					Max. reflection coefficient					Weight	Type	Order Number
		DC	30 M	100 M	300 M	1 G	DC	30 M	100 M	300 M	1 G			
3.01 dB 5 dB 6.02 dB 9.03 dB 10 dB 19.03 dB 20 dB 30 dB 40 dB	±0.02 dB	±0.02 dB	±0.03 dB ±0.02 dB ±0.03 dB	±0.04 dB ±0.03 dB ±0.04 dB	±0.12 dB ±0.1 dB		≦0.004	≦0.006	≦0.01	≦0.03		194 g	DG-1403 DG-1405 DG-1406 DG-1409 DG-1410 DG-1419 DG-1420 DG-1430 DG-1440	BN 921/12 BN 921/22 BN 921/32 BN 921/42 BN 920/12 BN 921/52 BN 920/22 BN 920/32 BN 920/42

Attenuators

Series 900

BNC

d.c. to 300 MHz

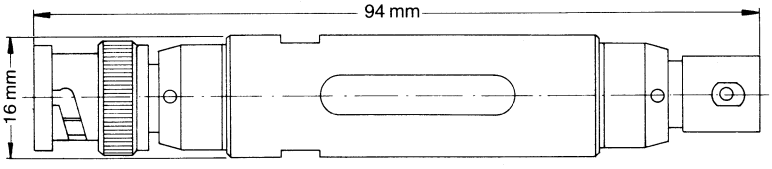


Fig. 4

Trans-mission loss	Transmis-sion loss error limits at 3 MHz	Transmission loss error limits referred to 3 MHz					Max. reflection coefficient					Weight	Type	Order Number
		DC	10 M	30 M	100 M	300 M	DC	10 M	30 M	100 M	300 M			
3.01 dB 5 dB 6.02 dB 9.03 dB 10 dB 19.03 dB 20 dB 30 dB 40 dB	±0.02 dB	±0.02 dB	±0.02 dB	±0.03 dB	±0.06 dB		≦0.004	≦0.006	≦0.01	≦0.02		80 g	DG-903 DG-905 DG-906 DG-909 DG-910 DG-919 DG-920 DG-930 DG-940	BN 921/13 BN 921/23 BN 921/33 BN 921/43 BN 920/13 BN 921/53 BN 920/23 BN 920/33 BN 920/43

1.6/5.6

d.c. to 300 MHz

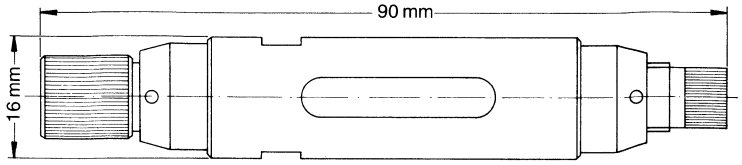


Fig. 5

Transmission loss	Transmission loss error limits at 3 MHz	Transmission loss error limits referred to 3 MHz DC	30 M	100 M	300 M	Max. reflection coefficient DC	30 M	100 M	300 M	Weight	Type	Order Number
3.01 dB 5 dB 6.02 dB 9.03 dB 10 dB 19.03 dB 20 dB 30 dB 40 dB	±0.02 dB	±0.02 dB	±0.03 dB	±0.05 dB	≦0.004	≦0.007	≦0.015	80 g	DG-903 DG-905 DG-906 DG-909 DG-910 DG-919 DG-920 DG-930 DG-940	BN 921/14 BN 921/24 BN 921/34 BN 921/44 BN 920/14 BN 921/54 BN 920/24 BN 920/34 BN 920/44

Temperature and power coefficients (indicate the maximum change in the transmission loss and reflection coefficient of attenuators for a given change in temperature or load).

Transmission loss	Max. change in transmission loss Temperature $dB/10\ K$	Load $dB/10\ mW$	Max. change in reflection coefficient Temperature $10^{-3}/10\ K$	Load Input [1] $10^{-3}/10\ mW$	Load Output [1] $10^{-3}/10\ mW$
3.01 dB	0.002	0.00005	0.25	0.0094	0.0086
5 dB	0.003	0.0001	0.34	0.0185	0.0149
6.02 dB	0.0033	0.00013	0.375	0.0229	0.0167
9.03 dB	0.0038	0.00024	0.435	0.0345	0.017
10 dB	0.0038	0.00029	0.45	0.038	0.016
19.03 dB	0.0043	0.00089	0.495	0.067	0.0048
20 dB	0.0043	0.00096	0.495	0.0695	0.004
30 dB	0.0044	0.00152	0.5	0.088	0.0002
40 dB	0.0044	0.00163	0.5	0.096	0.00007

1) The attenuator terminal that is fed with power is defined as the input terminal

75 Ω Terminations

Series 1400

1.6/10

d.c. to 1 GHz

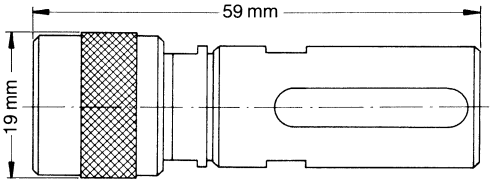


Fig. 6

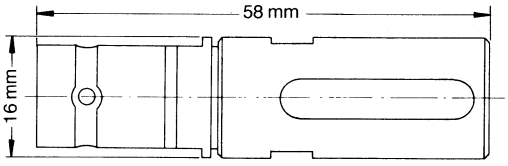


Fig. 7

Connector type	Max. reflection coefficient DC	30 M	100 M	300 M	1 G	Weight	Type	Order Number
1.6/10 (M)	≦0.004	≦0.005	≦0.01	≦0.03		70 g	AW-1475	BN 922/01
1.6/10 (F)	≦0.004	≦0.005	≦0.01	≦0.03		57 g	AW-1475	BN 922/02

N **d.c. to 1 GHz**

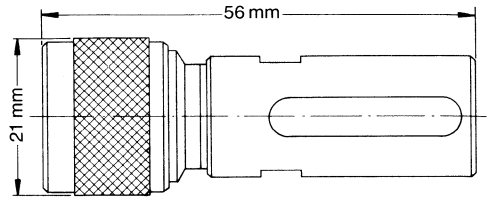


Fig. 8

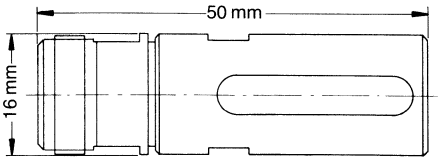


Fig. 9

Connector type	Max. reflection coefficient DC	30 M	100 M	300 M	1 G	Weight	Type	Order Number
N 75 Ω (M)	≦0.004	≦0.006	≦0.01	≦0.03		73 g	AW-1475	BN 922/03
N 75 Ω (F)	≦0.004	≦0.006	≦0.01	≦0.03		59 g	AW-1475	BN 922/04

GR 900 (457-3 IEC) **d.c. to 1 GHz**

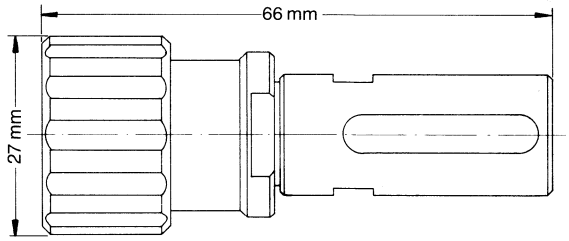


Fig. 10

Connector type	Max. reflection coefficient DC	30 M	100 M	300 M	1 G	Weight	Type	Order Number
GR 900	≦0.004	≦0.004	≦0.006	≦0.01		110 g	AW-1475	BN 922/05

75 Ω Terminations

Series 900

BNC **d.c. to 300 MHz**

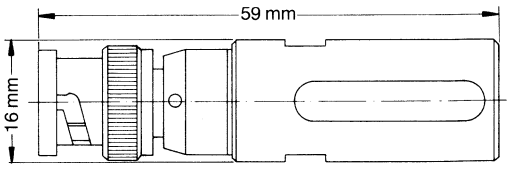


Fig. 11

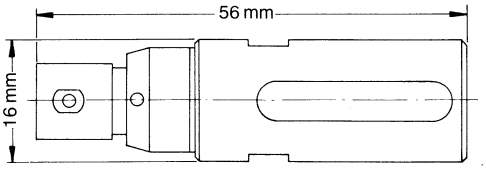


Fig. 12

Connector type	Max. reflection coefficient DC	10 M	30 M	100 M	300 M	Weight	Type	Order Number
BNC 75 Ω (M)	≦0.004	≦0.006	≦0.01	≦0.02		58 g	AW-975	BN 922/06
BNC 75 Ω (F)	≦0.004	≦0.006	≦0.01	≦0.02		54 g	AW-975	BN 922/07

1.6/5.6

d.c. to 300 MHz

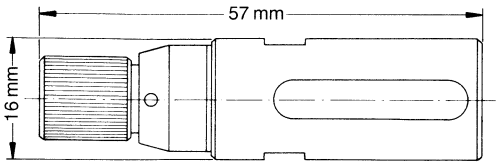
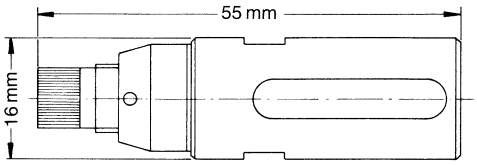


Fig. 13

Fig. 14



Connector type	Max. reflection coefficient DC	30 M	100 M	300 M	Weight	Type	Order Number
1.6/5.6 (M)	≦0.004	≦0.007		≦0.015	56 g	AW-975	BN 922/08
1.6/5.6 (F)	≦0.004	≦0.007		≦0.015	54 g	AW-975	BN 922/09

Temperature and power coefficients for the reflection coefficient of terminations

Temperature coefficient . . . . . 0.5×10^{-3}/10 K

Power coefficient . . . . . 0.1×10^{-3}/10 mW

Standard Mismatches

Series 1400

1.6/10

d.c. to 1 GHz

Return loss	Reflection coefficient	Connector type	Absolute error limits on reflection coefficient DC	100 M	300 M	1 G	Dimensions	Weight	Type	Order Number
20 dB	0.1	1.6/10 (F)	±0.007	±0.007	±0.015		s. Fig. 7	57 g	RN-1420	BN 923/10
		1.6/10 (M)	±0.007	±0.007	±0.012		s. Fig. 6	70 g	RN-1420	BN 923/15
26 dB	0.05	1.6/10 (F)	±0.006	±0.006	±0.015		s. Fig. 7	57 g	RN-1426	BN 923/20
		1.6/10 (M)	±0.006	±0.006	±0.012		s. Fig. 6	70 g	RN-1426	BN 923/25
30 dB	0.0316	1.6/10 (F)	±0.005	±0.006	±0.015		s. Fig. 7	57 g	RN-1430	BN 923/30
		1.6/10 (M)	±0.005	±0.006	±0.012		s. Fig. 6	70 g	RN-1430	BN 923/35

N

d.c. to 1 GHz

Return loss	Reflection coefficient	Connector type	Absolute error limits on reflection coefficient DC	100 M	300 M	1 G	Dimensions	Weight	Type	Order Number
20 dB	0.1	N (F)	±0.008	±0.010	±0.025		s. Fig. 9	59 g	RN-1420	BN 923/11
		N (M)	±0.007	±0.007	±0.012		s. Fig. 8	73 g	RN-1420	BN 923/16
26 dB	0.05	N (F)	±0.007	±0.008	±0.025		s. Fig. 9	59 g	RN-1426	BN 923/21
		N (M)	±0.006	±0.006	±0.012		s. Fig. 8	73 g	RN 1426	BN 923/26
30 dB	0.0316	N (F)	±0.006	±0.007	±0.025		s. Fig. 9	59 g	RN-1430	BN 923/31
		N (M)	±0.005	±0.006	±0.012		s. Fig. 8	73 g	RN-1430	BN 923/36

GR 900 (457-3 IEC) **d.c. to 1 GHz**

Return loss	Reflection coefficient	Absolute error limits on reflection coefficient DC	100 M	300 M	1 G	Dimensions	Weight	Type	Order Number
20 dB	0.1	±0.006	±0.006	±0.010		s. Fig. 10	110 g	RN-1420	BN 923/12
26 dB	0.05	±0.005	±0.005	±0.010		↓	↓	RN-1426	BN 923/22
30 dB	0.0316	±0.004	±0.004	±0.010				RN-1430	BN 923/32

Standard Mismatches

Series 900

BNC

d.c. to 300 MHz

Return loss	Reflection coefficient	Connector type	Absolute error limits on reflection coefficient DC	100 M	300 M	Dimensions	Weight	Type	Order Number
20 dB	0.1	BNC (F)	±0.008		±0.012	s. Fig. 12	54 g	RN-920	BN 923/13
		BNC (M)	±0.008		±0.012	s. Fig. 11	58 g	RN-920	BN 923/17
26 dB	0.05	BNC (F)	±0.007		±0.012	s. Fig. 12	54 g	RN-926	BN 923/23
		BNC (M)	±0.007		±0.012	s. Fig. 11	58 g	RN-926	BN 923/27
30 dB	0.0316	BNC (F)	±0.006		±0.012	s. Fig. 12	54 g	RN-930	BN 923/33
		BNC (M)	±0.006		±0.012	s. Fig. 11	58 g	RN-930	BN 923/37

1.6/5.6

d.c. to 300 MHz

Return loss	Reflection coefficient	Connector type	Absolute error limits on reflection coefficient DC	100 M	300 M	Dimensions	Weight	Type	Order Number
20 dB	0.1	1.6/5.6 (F)	±0.008		±0.010	s. Fig. 14	54 g	RN-920	BN 923/14
		1.6/5.6 (M)	±0.007		±0.007	s. Fig. 13	56 g	RN-920	BN 923/18
26 dB	0.05	1.6/5.6 (F)	±0.007		±0.008	s. Fig. 14	54 g	RN-926	BN 923/24
		1.6/5.6 (M)	±0.006		±0.006	s. Fig. 13	56 g	RN-926	BN 923/28
30 dB	0.0316	1.6/5.6 (F)	±0.006		±0.007	s. Fig. 14	54 g	RN-930	BN 923/34
		1.6/5.6 (M)	±0.005		±0.006	s. Fig. 13	56 g	RN-930	BN 923/38

Temperature and power coefficients for the reflection coefficient of the standard mismatches

Temperature coefficient . . . . . $0.5 \times 10^{-3}/10\,K$

Power coefficient . . . . . $0.1 \times 10^{-3}/10\,mW$

"T" Adaptors 2 x Z_o

Series 1400

1.6/10; N; GR 900 (457-3 IEC)

d.c. to 1 GHz

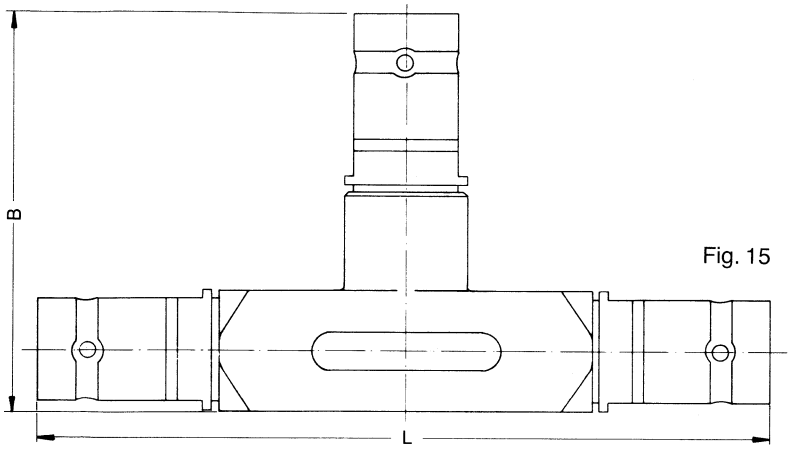


Fig. 15

Type	L	B
1.6/10	92	51
N	79	44
GR 900	110	59

Connector type	D.C. error limits for 75 Ω impedance	Maximum level difference between outputs terminated with Z_o referred to 3 MHz					Weight	Type	Order Number
		at 3 MHz	DC	30 M	100 M	300 M 1 G			
3 x 1.6/10 (F)	±0.3 Ω	±0.02 dB	±0.01 dB	±0.01 dB	±0.015 dB	±0.04 dB	131 g	TV-1402	BN 924/01
3 x N 75 Ω (F)	±0.3 Ω	±0.02 dB	±0.01 dB	±0.01 dB	±0.015 dB	±0.05 dB	141 g	TV-1402	BN 924/02
3 x GR 900	±0.3 Ω	±0.02 dB	±0.01 dB	±0.01 dB	±0.015 dB	±0.04 dB	306 g	TV-1402	BN 924/03

"T" Adaptors 2 x Z_o

Series 900

BNC; 1.6/5.6

d.c. to 300 MHz

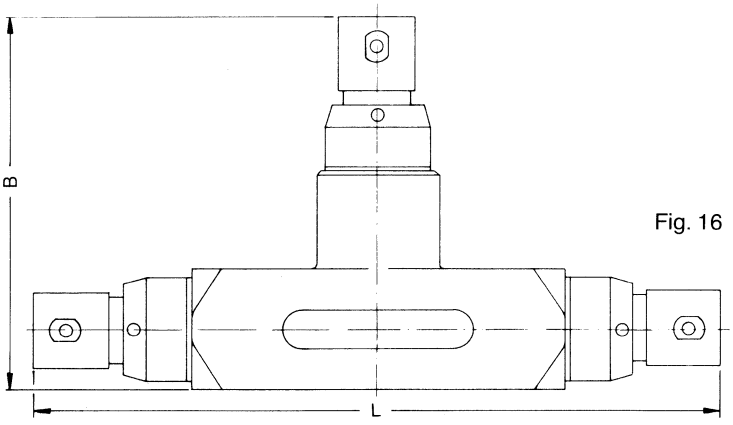


Fig. 16

Type	L	B
BNC	90	50
1.6/5.6	87	48

Connector type	D.C. error limits for 75 Ω impedance	Maximum level difference between outputs terminated with Z_o referred to 3 MHz				Weight	Type	Order Number
		at 3 MHz	DC	30 M	100 M 300 M			
3 x BNC 75 Ω (F)	±0.3 Ω	±0.02 dB	±0.01 dB	±0.02 dB	±0.03 dB	117 g	TV-902	BN 924/04
3 x 1.6/5.6 (F)	±0.3 Ω	±0.02 dB	±0.01 dB	±0.01 dB	±0.02 dB	119 g	TV-902	BN 924/05

Maximum change in resistance (d.c.) as a function of:

Temperature . . . . . $1 \times 10^{-3}/10\,K$

Load . . . . . $0.2 \times 10^{-3}/10\,mW$

Z_o-Matching Pads 75 Ω ⇄ 50 Ω

Series 1400

N 75 Ω - N 50 Ω

d.c. to 1 GHz

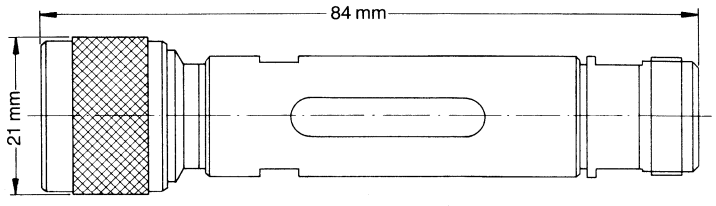


Fig. 17

Connector type from / to	Transmission loss	Transmission loss error limits at 3 MHz	Transmission loss error limits referred to 3 MHz (in dB) DC	30 M	100 M	300 M	1 G	Max. reflection coefficient DC	30 M	100 M	300 M	1 G	Weight	Type	Order Number
N 75 Ω (M) / N 50 Ω (F)	5.72 dB	±0.02 dB	±0.03	±0.04	±0.05	±0.10		≦0.004	≦0.006	≦0.012	≦0.035		102 g	ZA-5075	BN 925/01
N 75 Ω (F) / N 50 Ω (M)	5.72 dB	±0.02 dB	±0.03	±0.04	±0.05	±0.10		≦0.004	≦0.006	≦0.012	≦0.035		102 g	ZA-5075	BN 925/03

1.6/10; 75 Ω - BNC; 50 Ω

d.c. to 1 GHz

Type	L	D
1.6/10 (M) - BNC (F)	90	19
1.6/10 (F) - BNC (M)	90	16

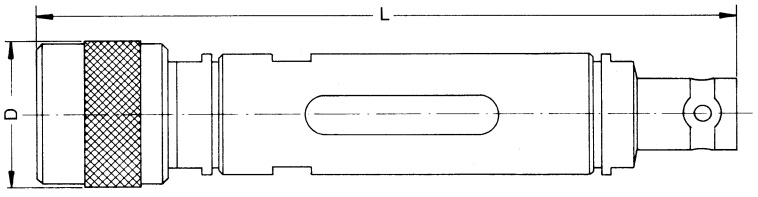


Fig. 18

Connector type from / to	Transmission loss	Transmission loss error limits at 3 MHz	Transmission loss error limits referred to 3 MHz (in dB) DC	30 M	100 M	300 M	1 G	Max. reflection coefficient DC	30 M	100 M	300 M	1 G	Weight	Type	Order Number
1.6/10 (M)	5.72 dB	±0.02 dB	±0.03	±0.04	±0.05	±0.10		≦0.004	≦0.006	≦0.012	≦0.035		89 g	ZA-5075	BN 925/02
BNC 50 Ω (F)								≦0.005	≦0.008	≦0.015	≦0.040				
1.6/10 (F)	5.72 dB	±0.02 dB	±0.03	±0.04	±0.05	±0.10		≦0.004	≦0.006	≦0.012	≦0.035		83 g	ZA-5075	BN 925/04
BNC 50 Ω (M)								≦0.005	≦0.008	≦0.015	≦0.040				

Maximum change in the transmission loss and reflection coefficient of the Z_o Matching Pads as a function of ambient temperature and load (temperature and power coefficients).

Max. change in transmission loss: Temperature	Load	Max. change in reflection coefficient: Temperature	Load: Input [1]	Load: Output [1]
$dB/_{10\ K}$	$dB/_{10\ mW}$	$10^{-3}/_{10\ K}$	$10^{-3}/_{10\ mW}$	$10^{-3}/_{10\ mW}$
0.0032	0.0005	0.377	0.036	0.018

1) The input is defined as that Z_o Matching Pad connector into which power is fed

Explanation of terms used

Reflection-free transmission in an coaxial measuring system cannot be obtained unless all the characteristic impedances of its sub-assemblies are matched correctly.

If a high frequency line is not terminated to prevent reflections, a fraction of the power of incident wave is reflected back down the line. The incident wave and the reflected wave are superposed on the line and give rise to standing waves. The reflection coefficient r and the voltage standing wave ratio VSWR are useful parameters describing this effect. If one parameter is known the other can be deduced from it.

Voltage Standing Wave Ratio: The VSWR is obtained by dividing the maximum voltage across the line by the minimum voltage across the line. The VSWR is related to the reflection coefficient (magnitude) by the following equation:

$$VSWR = \frac{|V_{max}|}{|V_{min}|} = \frac{1+|r|}{1-|r|}$$

Reflection coefficient: The reflection coefficient is the ratio of the amplitude of the reflected wave to the amplitude of the incident wave, both measured across the load. It is a complex quantity but in general only the magnitude is given, as this is constant everywhere on the line; provided the termination impedance is the same:

$$|r| = \frac{|V_r|}{|V_i|} = \frac{|R - Z_o|}{|R + Z_o|} = \frac{VSWR - 1}{VSWR + 1} \;;$$

For small reflection coefficients (r <10 %) the following approximations can be used to convert VSWR to r and vice versa.

$$|r| \approx \frac{1}{2}(VSWR - 1)$$

$$VSWR \approx 2|r| + 1$$

Return loss: The return loss is the logarithm of the reciprocal of the reflection coefficient.

$$\frac{a_r}{dB} = 20 \log \frac{1}{|r|} = 20 \log \frac{|R + Z_o|}{|R - Z_o|}$$

Nowadays, when carrying out high frequency measurements on the transmission characteristics of two port networks, there is an increasing tendency to prefer S parameters. The important thing about the S parameters is that in determining them, the input and output of the measurement system are terminated with the characteristic impedance.

There are 4 S parameters, likewise dealt with as complex quantities, but in this data sheet only the magnitudes of the complex reflection coefficients S_{11}, S_{22} and S_{21}, the complex transmission coefficients, indirectly as a_w (transmission loss $= 20 \log [1/S_{21}]$) have been used as a means of characterizing attenuators.

Storage cases for Versacomp® 75 Program

The Measuring Accessory Components are delivered in storage cases covered in black artificial leather, for which no extra charge is made.

The Storage Case is available in two versions:

- Version ABK-5 BN 926/05
  is designed for storing a maximum of four one port or two port 75 Ω Measuring Accessory Components (DG-..., AW-..., RN-..., ZA-...).

Extra storage cases can be ordered at extra cost.

- Version ABK-6 BN 926/06
  is designed to accommodate a "T" adaptor (TV-...).

Storage Case ABK-5

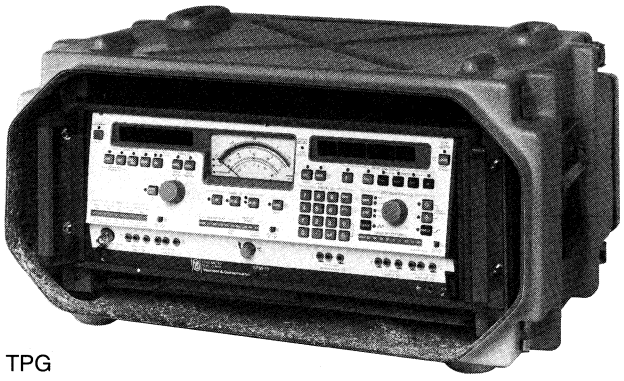


Storage Case ABK-6

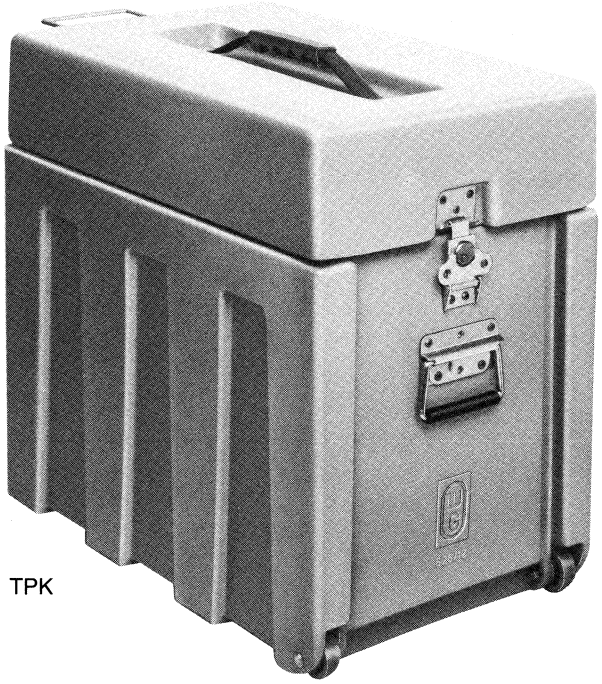


TPG/TPK
Transport Cases/Transport Containers

for protecting 19" equipment against adverse environmental conditions



TPG



TPK

TPG Transport Cases

- **Watertight, dustproof and shock absorbent**
- **Instruments are easily inserted**
- **Measuring equipment accessible at front and back**

TPK Transport Containers

- **Dustproof, watertight and shock absorbent**
- **Unproblematic transportation of measuring instruments**
- **Rollers for easy transportation**

Applications

Measuring instruments are now being used more and more frequently in the field, and so are exposed to greater mechanical and climatic stresses. The TPG range of Transport Cases has been designed to protect 19" equipment from severe environmental stresses such as shocks, water and dust. By contrast, the TPK range of Transport Containers is designed to protect instruments from dust, sprayed water and mechanical damage during normal transportation.

Characteristics

The TPG-... Transport Cases are made from fibre glass reinforced polyester resin and are protected against dust and water by means of front and back covers. The equipment within the case is fastened to a shock absorbing inner frame (shock-mount).
The TPK-... Transport Containers are made from polythene and are lined with shock absorbent foam which protects the instrument inside.
Rollers are fitted to two of the bottom edges of the Container so that it can be pulled along easily using one of the handles provided. Lighter instruments can be carried without difficulty using the handle on the top of the container, or the two other handles on the sides of the container.

Size of instruments that can be accomodated:	
Transport Cases TPG-...	2 to 6 height units
Transport Containers TPK-...	3 to 6 height units
Permissible weight, TPG-...	20 kg
TPK-...	approx. 25 kg

Further Characteristics

TPG Transport Cases

To ensure that measuring instruments are not damaged in transit, the Case must be rigid and stable.
When the equipment (max. 20 kg) is fitted in the Case, semi-sinusoidal impacts of 400 m/s^2 for 6 ms are applied to the Case and cause the equipment to have an acceleration lower than 150 m/s^2. The vibration test produces a mean acceleration of less than 30 m/s^2 on the equipment when a vibration amplitude of ± 0.15 mm and a driving frequency of 5 Hz to 60 Hz are applied.
Furthermore, the Transport Case with a 20 kg test load and subjected to simulation of transport conditions does not exhibit any damage after a 30 minute test conducted in accordance with the bump test specified in DIN 40 046, Section 28, Test Ey and VG 95 332, Sheet 10 (corresponds to IEC 68-2).

Specifications — TPG/TPK

Dimensions and Weights

Type	For 19" instruments. No. of height units:	Corresponding to an instrument height of (mm):	Dimensions in mm			Weight kg
			Width	Height	Depth	
Transport Case TPG*						
TPG-42	2	87.7	577	305	540	14
TPG-43	3	132.5	577	305	540	14
TPG-4	4	176.9	577	305	540	13
TPG-65	5	221.3	577	393	540	approx. 16
TPG-6	6	265.7	577	393	540	approx. 16
Transport Container TPK						
TPK-3	3	132.5	592	552	235	approx. 8.5
TPK-4	4	176.9	592	552	280	approx. 9.0
TPK-5	5	221.3	592	552	325	approx. 9.5
TPK-6	6	265.7	592	552	370	approx. 10.0

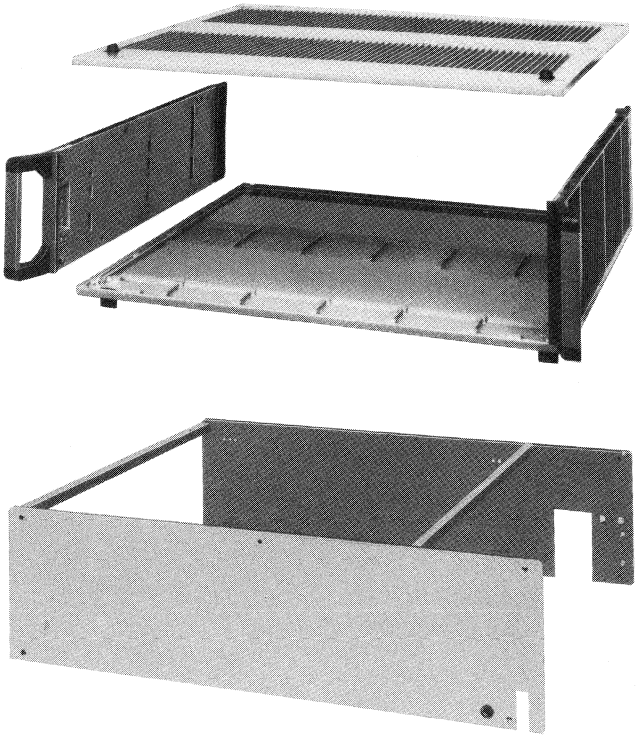
* The max. carried load must not exceed 20 kg

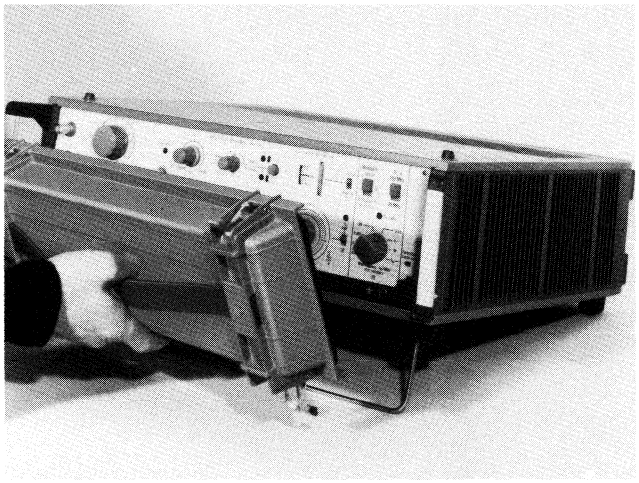
Ordering Information

Transport Cases		**Transport Containers**	
TPG-42 with shock-mount and auxiliary fittings	BN 621/42	TPK-3	BN 626/09
TPG-43 with shock-mount and auxiliary fittings	BN 621/43	TPK-4	BN 626/10
TPG-4 with shock-mount	BN 621/04	TPK-5	BN 626/11
TPG-65 with shock-mount and auxiliary fittings	BN 621/65	TPK-6	BN 626/12
TPG-6 with shock-mount	BN 621/06		

19"-Enclosures

Construction, Dimensions





Characteristics

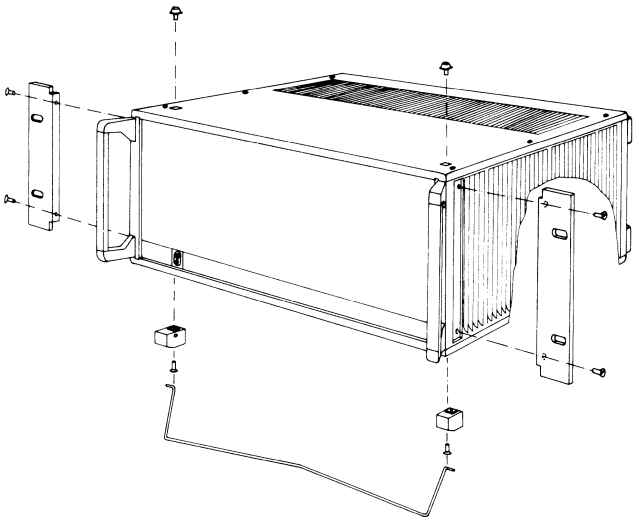
The majority of the Measuring Instruments offered by Wandel & Goltermann are accomodated in 19" enclosures.
This type of enclosure is based on a mechanical kit of panels and fittings and is designed around the standard 19" front panel width. This type corresponds to DIN 41494 and IEC Recommendation 297 and also the American Standard ASA C 83.9. A progressive dimension system with a variety of heights is used. These enclosures are available in two versions: as framework or as diecast housings.
The framework housing is made up from an upper and a lower diecast aluminum frame, angle aluminum struts as well as top, bottom and side panels. Thus, the various instrument heights can be accommodated by corresponding heights of the angle aluminum struts. The metal panels are easily removed for the servicing of the instrument.
The die cast housing is assembled from four die cast aluminum parts held together by screws. The interior is completely enclosed after assembly. For increased heat conductivity and cooling, the upper surface is enlarged by cast cooling fins and special enamel inside and out. The measuring instrument enclosed by this type of housing is protected against water and dust and is easily removed for servicing.
Instruments are delivered as bench models or as 19" rack mounting models. However a bench model can be easily modified for mounting in a 19" rack. The 19" conversion kit makes this possible at any time.

The specifications for the 19" versions are also valid for the ½ size 19" instruments. Either two ½ sized instruments or one instrument and a dummy cabinet can be combined to form a standard 19" module. If requested, a ½ size 19" conversion kit can be put together at the factory.
When a number of 19" instruments are combined to form a Measuring Setup, a unit can be assembled mechanically with joining-brackets.

Enclosures with a unit height of 3 units or more have threaded holes in their side panels so that carrying handles can be mounted (in the factory or afterwards). These handles provide a safer means of carrying the instrument. Enclosures with a height of 5 units or more are fitted with handles at a matter of course.

Ordering Information

Handles for side panels (1 set)	BN 700/00.12



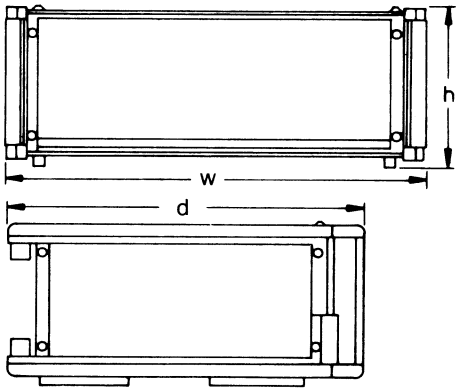
Modification of the bench model for 19" rack mounting (Die cast housing)

19"-Enclosure

Instrument dimensions

Enclosure \ in mm	w	h	d
19" Assembly kit system			
Framework housing	478	see Table 2	407
Die cast housing	477		434
½ size 19" Assembly kit system			
Framework housing	233	see Table 2	390
Die cast housing	222		423

Table 1



Dimensions and Ordering Information for 19" conversion kits, covers and joining-brackets

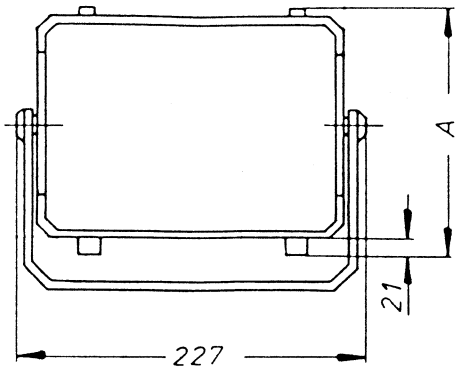
Enclosure height (DIN 41 494)	Unit heights (1 U ≅ 44.45 mm)	Total height (h) of bench model (mm)	Instrument height (h) of 19" equipment (mm)	Ordering Information: Framework housing – 19" conversion kit	Framework housing – cover for front panel	Die cast housing – 19" conversion kit	Die cast housing – covers (1 set) for front and back panels
19" Width							
2	2 U	110	86	BN 556/00.02	DE-1 BN 476/00.01	BN 700/00.02	SD-2 BN 700/00.22
3	3 U	155	131	BN 556/00.03	DE-2 BN 476/00.02	BN 700/00.03	SD-3 BN 700/00.23
4	4 U	199	176	BN 556/00.04	DE-3 BN 476/00.03	BN 700/00.04	SD-4 BN 700/00.24
5	5 U	244	220	BN 556/00.05	DE-4 BN 476/00.04	BN 700/00.05	SD-5 BN 700/00.25
6	6 U	288	264	BN 556/00.06	DE-5 BN 476/00.05	BN 700/00.06	SD-6 BN 700/00.26
½ 19" Width (with swing handle, same depth as 19"-enclosure)							
3	3 U	155	131	on request at factory	DE-12 BN 476/00.09	on request at factory	SD-35 BN 900/00.23
4	4 U	199	176				SD-45 BN 900/00.24
Joining brackets (1 set): Height joiners				BN 556/00.10		BN 700/00.10	

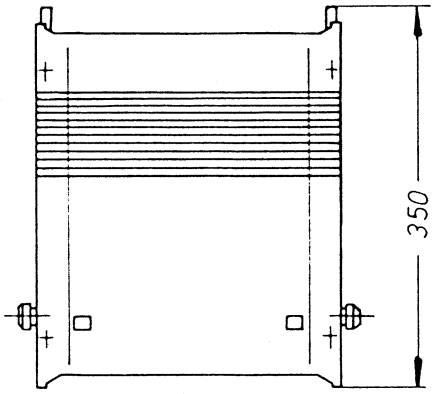
Table 2

1/2 19"-Enclosure (with swing handle)

Dimensions (in mm)

Height	3
Unit height (1 Unit ≅ 44.45 mm)	3 U
Enclosure height (A)	158
Enclosure width	227
Enclosure depth	350

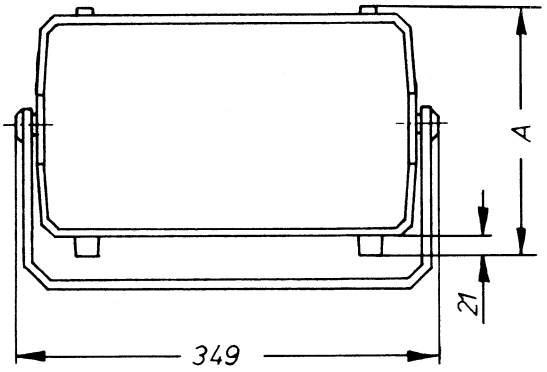


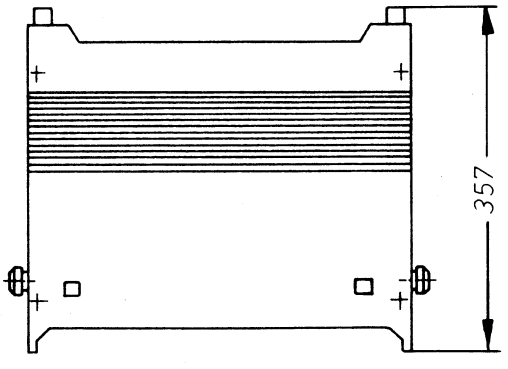


3/4 19" Enclosure (with swing handle)

Dimensions (in mm)

Height	3	4
Unit heights (1 Unit ≅ 44.45 mm)	3 U	4 U
Enclosure height (A)	158	202
Enclosure width	349	349
Enclosure depth	357	357





Ordering information for Transportation Covers
for front and back panel

Enclosure height	3	4
Ordering information	SD-930 BN 960/00.01	SD-940 BN 960/00.02

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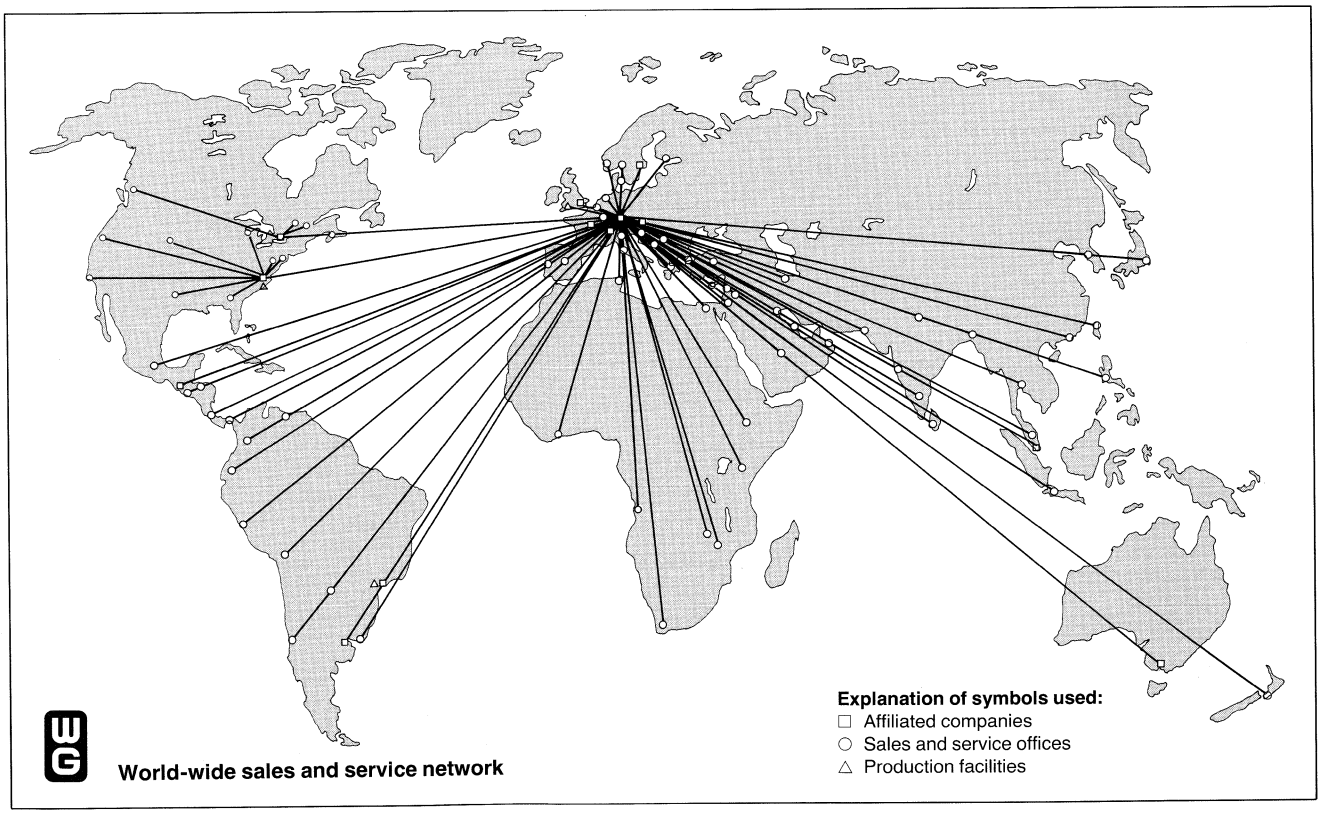
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