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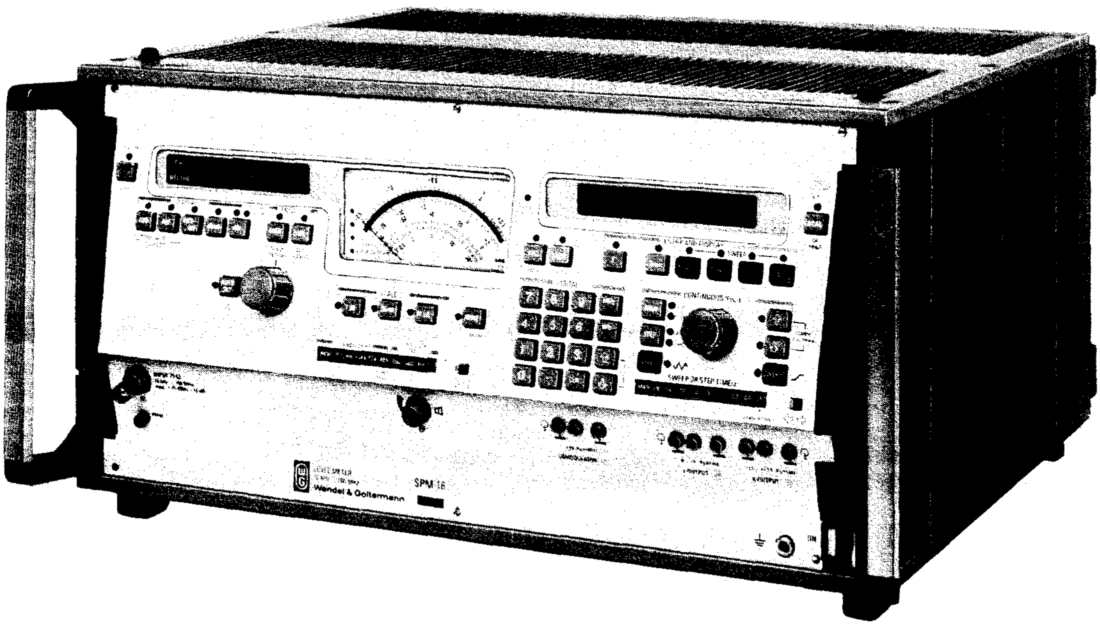
Description and Operating Manual



Selective Level Meter SPM-16

with wideband section

frequency range, 10 kHz to 160 MHz

SELECTIVE LEVEL METER SPM-16

with wideband section
frequency range, 10 kHz to 160 MHz

Description and Operating Manual 874 A

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Wandel & Goltermann
PRECISION ELECTRONIC
MEASURING INSTRUMENTS

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INTRODUCTION

Although digital communication systems are gaining increasing significance in local and district circuits, carrier frequency systems using FDM are still the principal means for long distance traffic. Level Measurements play an important part in measuring and checking the analog characteristics of these systems and the individual sub-assemblies. But modern measuring instruments must be used for new, additional measuring tasks.

Consequently, the Selective Level Meter SPM-16 was designed with application of the most modern circuit technology and employment of an internal microcomputer. These provide a high degree of accuracy and comfort.

Owing to the SPM-16's wide span of frequencies from 10 kHz to 160 MHz and to its performance characteristics, the Level Meter is as equally applicable in development, production, installation and maintenance of analog communication systems of up to 10800 voice channels as it is for measurements on single sideband radio-link systems. But also the SPM-16 is suitable for measurements on submarine cable systems and for investigations on cables carrying digital communications at higher bit rates (140 Mbit/s). Because of its capability for external control, it is also applicable in automatic measuring systems.

According to the measuring task, the SPM-16 frequency can be selected either digitally through a keyboard or continuously in one range, with 1 Hz resolution. For tuning in equal steps of frequency, (e.g. by channel separation), the frequency may be manually or automatically stepped. Up to 100 fixed frequencies of frequently repeated measurements can be stored via keyboard entry, to be called out in any sequence or in consecutive order. Moreover, with an available option, more fixed frequencies can be stored in a user specified Non-volatile Memory. All the means for setting the frequency make use of an internal synthesizer for attaining high stability and accuracy of the tuning frequency.

The SPM-16 has a coaxial input at 75 Ω input impedance. Test Probe TK-11 is intended for applications in high impedance (bridging) and low capacitance measurements. Decoupling Transformers REO-60 (50 kHz to 14 MHz) and REO-56 (300 kHz to 60 MHz) permit interaction-free measurements on system test points. They are transformer-Type attenuators (20 dB) each of which has a loop-trough input and two decoupled outputs. In selective mode, measurements can be made at levels between -130 dBm and +20 dBm (-140 and +10 dB): in wideband mode, between -50 dBm and +20 dBm (-60 and +10 dB).

Results are indicated on either a digital display, with autoranging at the highest resolution of 0.01 dB, or an analog meter. When the analog meter is used, three push buttons, offering selection of three scale ranges, 1 dB, 20 dB or 80 dB permit the choice of the best scale range to fit the appropriate measuring task. The measurement range setting is accomplished either manually in 1 or 5 dB steps or automatically after a push button has been pressed.

For attaining the highest possible measurement accuracy, the microprocessor adjusts the pre-attenuator and the IF attenuator, taking into account the overall input level so that the SPM-16 always makes measurements with the optimum drive signal applied.

Besides absolute level measurements, the SPM-16, in a very simple way, executes relative level measurements. For that purpose a digital level measurement is stored as a reference value in a buffer, and each subsequent measurement is displayed as either a digital or an analog value deviating from the reference value. Many measurements made on communications systems are not given as direct values but instead are referred to the relative level (dBr) of a test point. To simplify the evaluation of a measured result in this case, the relative level of the test point can be adjusted in 0.1 dB steps, and the result can be readout direct in level expressed as reduced to dBm0 (dB0).

The relative level push button can also be used generally for setting the reference value (e.g. for frequency response measurements).

Various bandwidths are available for adapting to the appropriate measuring task. Pilot level, carrier leak, or "hot tones" are measured with the 25 Hz narrow-band filter. Sensitive level measurements are made with an IF band filter of 400 Hz bandwidth fitted within the SPM-16. For weighted noise measurements at the CF level in voice channels not carrying traffic, a filter with 1.74 kHz equivalent noise bandwidth can be switched in.

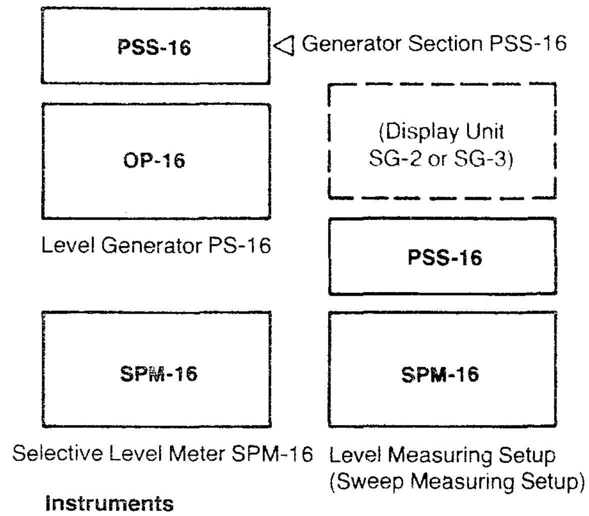
Another position of the bandwidth switch allows level measurements at the 3.1 kHz channel bandwidth. And also measurable is the noise power of a 48 kHz wide basic group.

The internal demodulator allows single sideband signals to be presented in upright or inverted position. The converted signal can be judged for quality either via the incorporated loudspeaker or at the demodulator output for further processing externally. The demodulator is especially noteworthy because of its great dynamic range needed for example with exact measurements of noise or impulsive noise in translated voice channels.

To assess the transmission quality of telephone circuits used for data communications, phase jitter measurements are performed. Weighting filter and detector characteristic for measuring the peak-to-peak value conform to CCITT Recommendation 0.91. The indication appears on a digital display or on a logarithmic scaled meter in range 0.3° to 30°.

An automatic level calibration facility eliminates the necessity of manual calibration and thus assures high measuring accuracy over the complete frequency range, additionally noticeably decreasing measuring time, and giving high long-term stability. Therefore, the Level Meter is suitable for long-term monitoring. The microprocessor control of the SPM-16, besides the previously mentioned settings of frequency, permits various other automatic frequency runs. An exceptionally valuable aid for operating and tuning during the search for spurious levels or overloading signals is the fast signal detector in conjunction with the automatic search-scan of the tuning frequency. Hereby, the tuning oscillator is retuned until the incoming signal is at a level higher than the preselected level threshold and located within the display range, then the search-scan stops. Simultaneously, an AFC comes into action and tunes the oscillator exactly to the input signal frequency. Restart occurs either manually by the actuation of a push button or automatically after the level and frequency have been printed out. The search-scan rate is matched to the bandwidth selected. The AFC can also be switched in for all the usual level measurements at all bandwidths to 3.1 kHz. It has the property of recontrolling the oscillator over the whole frequency range.

End-to-end selective measurements within interstitial channel gaps (during the voice channels are actually carrying traffic) are possible because of an electronic device functional in operating mode TRACK, whereby the Level Meter is automatically tuned to the frequency of a generator with similar signal frequency conditioning.



Instruments and Measuring Setups of the type series 16

If an SG-2, or SG-3 Display Unit is combined with the SPM-16 the combination is a panoramic receiver. Because of the fast switching by the synthesizer between adjacent frequencies, the entire frequency range, in all operating modes, can be searched without gaps, so that all receiver frequencies present within the band can be unambiguously identified. The sweep circuit incorporated in the SPM-16 is particularly noteworthy because phase hits are not produced. This effect allows systems under test to have very steep attenuation characteristics and be still measured at correct accuracy. According to application, the two cut-off frequencies or the center frequency and sweep width can be entered digitally with crystal accuracy. Level Generator PS-16 or the Generator Section PSS-16 are each suitable for use as a signal source in the sweep measuring setup.

Many measuring problems may be solved particularly easily if the user takes advantage of the possibilities for storing the complete menu of instrument settings and when needed, the stored settings can be called out. After a push button (address inquiry) has been depressed, the SPM-16 correctly sets itself to all measuring conditions preselected for a definite measuring task. A trickle charged battery is incorporated in the circuitry to hold the stored data in the event of a power dropout.

All functions of the SPM-16 can be controllable by an external IEC Bus compatible computer if the auxiliary device, the Interface Bus ⟨IEC 625⟩ Card [1], has been fitted.

Other controllable peripheral equipment such as Level Generator, Test Point Selector, external storage system can be added-on to configure a powerful Automatic Level Measuring Setup for use in test departments and FDM surveillance systems. A suitable Test Point Selector (100 MHz) is the MU-7 or the RAS-1 with Interface Card. Instead of the Interface Bus ⟨IEC 625⟩ Card a printer interface for the V.24/V.28 interface could be used for printing out the measured results arranged in various printed formats (SPM-16 commencing with Series B). Another measurement accessory is the Return Loss Measurement Bridge RFZ-14. This device permits the measurement of frequency variant return loss in the frequency range 100 kHz to 100 MHz. Impedance matching networks, 75 Ω/50 Ω, are available for measurements on modules and systems that have 50 Ω characteristic impedance.

Despite the multiplicity of functions, the SPM-16 has been assembled in an enclosure of low height. Connection-, setting-, and display-field are arranged for easy viewing and operation on an ergonomically designed front panel. Light emitting diodes placed above or next to the operator's push buttons show the functions with which the operator is involved at the time. The SPM-16 is available either as a bench model or as suitable for mounting in a 19" rack. Covers are available for the SPM-16 front and back panels' protection against dust and water spray during transport or storage.

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1) Connection to IEEE-Bus (IEEE 488) by adapter plug S 834

1 SPECIFICATIONS

1.1 FREQUENCY

1.1.1 FREQUENCY RANGE

FOR SELECTIVE AND WIDE-BAND MEASUREMENTS .... 10 kHz to 160 MHz

1.1.2 FREQUENCY DISPLAY .... digital, 9-decade, with LCD

Resolution .... 1 Hz

1.1.3 FREQUENCY TUNING

Digital with keyboard,
in frequency steps with direction keys, input of the step increment with keyboard,
quasi-continuously with handwheel over the complete frequency range, switchable between coarse and fine tuning

Smallest frequency step, digital .... 1 Hz
continuous, fine .... 1 Hz
coarse .... 100 Hz

1.1.4 AUTOMATIC FREQUENCY SEQUENCES

1.1.4.1 Frequency Search

over the whole frequency range with stop by signal detector and automatic fine tuning to the detected signal with AFC, search speed matched to the bandwidth:

Bandwidth	3.1 kHz	1.74 kHz	400 Hz	25 Hz
Search speed	1 MHz/s	250 kHz/s	20 kHz/s	200 Hz/s

1.1.4.2 Auto Step

Automatic stepping of the tuned frequency in increments between preset frequency limits.

Increments and frequency limits entered by keyboard,
Stepping speed adjustable .... 0.1; 0.3; 1; ...; 300 s

1.1.4.3 Tracking

Automatic switching of the tuned frequency between preset frequency limits by a frequency instrument as soon as the level indication disappears, input of the increment and frequency limits by the keyboard.

1.1.4.4 Sweep Frequency Operation

Sweep limits are set with the keyboard by entering either the start and stop frequency or the center frequency and the deviation.
Sweep sequence: periodic (triangular) or single sweep
Sweep duration adjustable .... 0.1; 0.3; 1 ...; 300 s

Additional facility .... manual sweep and continuous search with optimum search speed as specified in section 1.1.4.1

1.1.5 AUTOMATIC FREQUENCY CONTROL (AFC)

The capture range corresponds to the nominal bandwidth of the selected bandwidth filter as specified in section 1.4.1 (switched off in the case of 48 kHz). The locking range corresponds to the frequency range specified in section 1.1.1.

1.1.6 ERROR LIMITS OF THE TUNED FREQUENCY .... $\pm 1 \cdot 10^{-7}$

The above error limits are valid for the rated ranges of operation of influence quantities listed in section 1.9, including aging in the first year.

1.2 LEVEL

1.2.1 MEASURED PARAMETERS

Absolute level
as power level (dBm), refered to 1 mW or
as voltage level (dB), refer to 0.7746 V

Differential level (dB) between an absolute level and a stored reference level. Any absolute level can be stored as a reference level by depressing a pushbutton.

Reduced level (dBm0 or dB0)

1.2.2 RESULT INDICATION, RESOLUTION, RANGE SELECTION

1.2.2.1 Result Indication[1)], switchable .... digital or analog

Digital display .... LCD with 5 digits and sign

Analog display .... Analog meter with switchable ranges and digital display of the level value for 0 dB meter reading.

Ranges of the meter:	1 dB scale	-1.5 to +0.3 dB
	20 dB scale	-20 to +2 dB
	80 dB scale	-80 to +0 dB

1.2.2.2 Resolution

Selective mode, indication averaging on .... 0.01 dB

indication averaging off .... 0.1 dB

Wide-band mode .... 0.1 dB

Levels which cause wide variations of the indication, for example due to superimposed interference signals or to insufficient separation from the intrinsic noise, are displayed with a resolution of 0.1 dB, even if indication averaging is switched on.

1.2.2.3 Range Selection

For digital display: Automatic with overload checking of the wide-band section during selective measurements.

---

1) Noise signals such as the loading level of CF systems actually carrying traffic, thermal noise, or intermodulation noise result, due to the rectifier characteristic, in practically the same reading as a sinusoidal signal with the same RMS value. Crest factor: 12 dB.

For analog display: Single automatic cycle by depression of a push-button with overload checking of the wide-band section for selective measurement or manually with the range switch in 1 dB or 5 dB steps, depending on the selected range of the meter.

In addition to remote control (BN 853/02):
Adjustment of the measurement range in 1 dB steps, with the choise of the wide-band drive signal from 3 modes: low noise, normal, low distortion
Dynamic range in the selected range .... ± 10 dB
(over- and underloading are indicated)
For very fast measurements, the short averaging feature permits a measurement to be made even when the receive section has not fully settled.

1.2.3 MEASURING RANGES

1.2.3.1 Absolute Level:

Input	Selective mode		Wide-band mode	
	dBm	dB	dBm	dB
Coax. 75 Ω	-130 to +20	-140 to +10	-50 to +20	-60 to +10

1.2.3.2 Reduced Level

According to the range of the absolute level specified in 1.2.3.1 for relative level (resolution 0.1 dB): .... -99.9 to +20.0 dBr

1.2.4 AUTOMATIC LEVEL CALIBRATION

Automatic level calibration is carried out every two minutes and whenever a parameter change could cause an error in the level indication.

In selective mode, the frequency of the calibration signal tracks the tuning of the receiver; in wide-band mode, the calibration frequency is fixed at 10 MHz.

For measurements in which the measuring sequence could be disturbed by insertion of a calibration cycle, as during sweep frequency measurements, the automatic level calibration can be switched off.

When in external control, the SPM-16 can be calibrated as "single shot". (Auxiliary device BN 853/02).

1.2.5 BASIC INTERFERENCE

1.2.5.1 Intrinsic Noise Level (maximum value) when the measuring input is terminated by Z = 75 Ω:

<table>
<tr><td>Bandwidth</td><td colspan="3">Intrinsic noise level/dBm (dB)</td></tr>
<tr><td>25 Hz</td><td>-121 (-130)</td><td colspan="2">-130 (-139)</td></tr>
<tr><td>400 Hz</td><td>-109 (-118)</td><td colspan="2">-126 (-135)</td></tr>
<tr><td>1.74 kHz</td><td>-102 (-111)</td><td colspan="2">-120 (-129)</td></tr>
<tr><td>3.1 kHz</td><td>-100 (-109)</td><td colspan="2">-118 (-127)</td></tr>
<tr><td>48 kHz</td><td></td><td></td><td>-104 (-113)</td></tr>
</table>

10 kHz 50 kHz 300 kHz 160 MHz

1.2.5.2 Level of interference lines

Synchronous (tracking as receiver is tuned) ..... ≦ -130 dBm (-139 dB)
Tunable (not tracking as receiver is tuned) ......≦ -127 dBm (-136 dB)

1.2.6 FAST SIGNAL DETECTOR FOR RAPID SIGNAL IDENTIFICATION, ACTIVE ONLY WITH ANALOG DISPLAY

The threshold referred to 0-dB meter reading
on the 1 dB scale .... approximately -1.2 dB
on the 20 dB scale .... approximately -15 dB
on the 80 dB scale (for search only) .... approximately -40 dB

1.2.7 ERRORS OF THE LEVEL INDICATION

Unless otherwise stated, the specified error limits are valid for the rated range of use shown in section 1.9, with automatic level calibration on, with the input supplied from a source with an internal impedance Z. Level errors caused by the reflection coefficient of the input impedance are thus included in the error limits.

1.2.7.1 Errors in Selective Mode

Error limits with digital display, or with analog indication with indication averaging (1-dB-scale) for bandwidths 25 Hz to 3.1 kHz under inclusion of the basic interference given in para. 1.2.5.

Level	Error limits/dB 10 kHz to 50 kHz	Error limits/dB 50 kHz to 110 MHz	110 MHz to 160 MHz
+20 dBm (+10 dB) to +10 dBm (0 dB)	±0.4	±0.4	±0.9
+10 dBm (0 dB) to 0 dBm (-10 dB)	±0.3	±0.3	±0.8
0 dBm (-10 dB) to -70 dBm (-80 dB)	±0.25	±0.25	±0.35
-70 dBm (-80 dB) to -100 dBm (-110 dB)		±0.6	±0.7

Additional errors to those values shown in the table:

with 48 kHz bandwidth (level ≧ -70 dBm/-80 dB) .... ±0.5 dB

with an analog reading: 20 dB scale (-5 to +2 dB) .... ±0.2 dB

80 dB scale .... ±2 dB

For short averaging (only with auxiliary device BN 853/02) ... ±0.4 dB

For digital display with switched off indication averaging, the tabulated values raise by the rounding off error of the decreased resolution according to para. 1.2.2.2.

For attenuation measurements at the same frequency (level difference from two measurements, whereby the first measurement serves for the reference level), the tabulated values are also valid if the reference level is located in range -60 dBm to 0 dBm (-70 to -10 dB).

1.2.7.2 Variation of level reading with frequency, Selective Mode

Error limits

Referred to f = 10 MHz, in level range -60 to 0 dBm (-70 to -10 dB)

Automatic calibration, switched off

10 kHz – 300 kHz	300 kHz – 60 MHz	60 MHz – 110 MHz	110 MHz – 160 MHz
±0.35 dB	±0.25 dB	±0.35 dB	±0.6 dB

1.2.7.3 Error in Wideband Mode

Error limits with digital display

10 kHz – 110 MHz	110 MHz – 160 MHz
±1 dB	±2 dB

Error additional to tabulated values
with analog reading, 20 dB scale (-5 to +2 dB) .... ±0.2 dB

1.3 PHASE JITTER

The weighting filter and the rectifier characteristic for measurement of phase jitter (peak-to-peak value) comply with CCITT recommendation 0.91.

For measurements with the test tone 1020 ± 10 Hz in the speech channel or in a CF channel, the receiver must be tuned to the center of the channel; otherwise, it is tuned to the test signal frequency.

1.3.1 MEASURING RANGE

Phase jitter is indicated digitally or on the analog meter
Indication range .... 0.3 to 30°
Resolution of the digital display .... Max. 0.1°

1.3.2 ERROR LIMITS OF THE INDICATION

at 150 Hz jitter frequency and signal level
≧ -60 dBm (-70 dB) .... ±10 % ±0.5°
(The most favorable level range is automatically selected and an error is indicated if the signal level is too low).

1.4 SELECTIVITY AND HARMONIC RATIO

1.4.1 SELECTIVITY, SWITCHABLE: 25 Hz/400 Hz/1.74 kHz/3.1 kHz/48 kHz

Effective Noise Bandwidth					
	Attenuation value with separation from midfrequency of filter				
Bandwidth	±70 Hz	±250 Hz[1]	±2 kHz[1]	±5 kHz	±15 kHz
25 Hz	≧ 25 dB	≧ 60 dB			
400 Hz			≧ 55 dB	≧ 60 dB	≧ 70 dB
1.74 kHz			≧ 50 dB	≧ 54 dB	≧ 63 dB
3.1 kHz			≧ 45 dB	≧ 50 dB	≧ 60 dB
48 kHz[2]	approx. 50 dB when separated by ±35 kHz				

1.4.2 IMAGE FREQUENCY REJECTION AND IF SUPPRESSION .... ≧ 70 dB

Intermediate Frequencies at .... 220 MHz, 40 MHz, 10 kHz

Image frequencies at .... f_{in} + 440 MHz, f_{in} - 80 MHz, f_{in} + 20 kHz

1.4.3 DISTORTION PRODUCTS

for basic frequency level ≦ +10 dBm (0 dB) and digital measurement mode or analog with manual range selection and ≦ 40 dB sensitivity above the measuring range of the basic frequency level (authenticate with bandwidth 25 Hz).

1.4.3.1 Harmonic Distortion Products a_{K2} and a_{K3} for

Load in the frequency range ≧ 4 MHz .... ≧ 65 dB

< 4 MHz .... ≧ 60 dB

1) 10 dB lower values valid for frequencies > 110 MHz

2) The specified filter characteristics are achieved by sweeping the tuned frequency over a 48 kHz band and integrating the input signal spectrum which falls within this band.

1.4.3.2 Non-harmonic Distortion Products

for load in frequency range < 110 MHz .... ≧ 75 dB
≧ 110 MHz .... ≧ 55 dB

1.4.4 NOISE POWER RATIO NPR .... approx. 45 dB

when loaded with a noise band signal of 4 to 60 MHz.
Wide-band level -25 to +10 dBm, measuring bandwidth 1.74 kHz and digital measurement mode.

1.5 MEASUREMENT PERIODS

The following specifications are guide line values, with which the measurement periods are sufficiently described for practical measurements.

1.5.1 LEVEL MEASUREMENTS WITH AUTORANGING, AUTOMATIC CALIBRATOR SWITCHED OFF

Bandwidth		25 Hz 1)	400 Hz 1)	1.74 kHz 1)	3.1 kHz 1)	Wideband
Averaging:	normal (OFF)	0.6 s	0.4 s	0.4 s	0.4 s	0.4 s
	long (ON)	1.8 s	1.5 s	1.5 s	1.5 s	0.4 s

1.5.2 LEVEL MEASUREMENT WITH ADJUSTMENT OF THE MEASURING RANGE AND THE WIDE-BAND DRIVE SIGNAL VIA AN IEC-BUS. (Auxiliary device BN 853/02).

Automatic calibration switched OFF:

Bandwidth		25 Hz	400 Hz	1.74 kHz	3.1 kHz	48 kHz
	short 2)	100 ms	20 ms	20 ms	20 ms	350 ms
Averaging:	normal (OFF)	500 ms	150 ms	150 ms	150 ms	350 ms
	long (ON)	1.5 s	1.5 s	1.5 s	1.5 s	350 ms

1) The specified measurement periods are valid for levels with ≦40 dB separation from the signal loading level. With separation > 40 dB, the values are lengthened through the linearity check by 1 s + 300 ms/5 dB.

2) measured with not completely settled receive section (see para. 1.2.7.1)

1.5.3 LENGTHENING OF THE MEASUREMENT PERIODS WHEN AUTOMATIC CALIBRATOR IS SWITCHED ON:

(The bracketed values are for input level ≧ -10 dBm/dB)

Bandwidth		25 Hz	400 Hz/1.74 kHz/3.1 kHz	48 kHz	WIDEBAND
Averaging:	normal (OFF)	1 s	100 ms	300 ms	600 ms
	long (ON)	1 s	600 ms	---	600 ms

1.5.4 PHASE JITTER MEASUREMENT: .... 3 s

1.5.5 DATA TRANSFER, TRANSFER TIME PER CHARACTER .... 1 ms

1.6 INPUT FOR MEASURING

Coaxial .... System Versacon® 9
Input impedance .... 75 Ω
Return loss .... ≧ 30 dB
Tolerable input level (AC and DC components) .... ≦ +25 dBm (16 dB)
Discrete spurious output signals

1.7 ADDITIONAL INPUTS AND OUTPUTS

1.7.1 INPUT FOR EXTERNAL STANDARD FREQUENCY

Input connector .... Versacon® 9 conversion system
Frequencies .... 1, 2, 5 or 10 MHz
Necessary level .... -10 to +10 dBm
Input impedance .... 75 Ω

1.7.2 OUTPUT FOR STANDARD FREQUENCY

Output connector .... Versacon® 9 conversion system
Frequency .... 10 MHz
Output level into 75 Ω load .... 0 dBm +2/-4 dBm

1.7.3 INPUT FOR CONTROL FREQUENCY

For control of the Receive Section through the synthesizer

Input connector .... Versacon® 9 conversion system, floating

Frequency range .... 220 to 380 MHz

Level into 75 Ω load .... (+3 ±2) dBm

1.7.4 IF OUTPUT

Output connector .... Versacon® 9 conversion system

Output frequency when tuned to
center of band .... 10 kHz

Output level proportional to meter reading,
Level for 0-dB indication into 600 Ω
load .... -10 dB

1.7.5 Y-OUTPUT VOLTAGE (DC) .... 3-pole CF connector

DC output voltage proportional to meter reading,
open circuit voltage for full scale deflection .... +5 V

Output impedance .... 5 kΩ

1.7.6 X-OUTPUT VOLTAGE (DC) .... 3-pole CF connector

DC output voltage proportional to frequency
within the start and stop frequency limits,

Open circuit voltage: at start frequency .... -2.5 V
at stop frequency .... +2.5 V

Output impedance .... 5 kΩ

1.7.7 DEMODULATOR OUTPUT .... 3-pole CF socket

Built-in loudspeaker with adjustable volume.

Single sideband demodulation, switchable to upright or inverted
position, frequency position of converted channel
when tuned to center of channel .... 0 to 4 kHz

Frequency response in the range 0.6 to
3.4 kHz, referred to 2 kHz .... ±1 dB

Output level proportional to meter reading

Level for 0-dB-indication into 600 Ω
load .... approx. 0 dB

Psophometrically weighted intrinsic noise at the demodulator output, for Transmission Level Point (TLP) settings in the range -50 to +10 dBr,
at f ≧ 100 kHz, ... -65 dBm

Intrinsic phase jitter (in accordance with CCITT
recommendation 0.91) .... ≦ 0.5°

1.7.8 DISPLAY UNIT CONNECTION SOCKET

for X, Y, and reference trace voltages. Control input for switching the meter for display of the reference trace voltage of the display unit. A TTL signal for control of the pen lift of an X-Y plotter is also available (series B and later).

1.7.9 INTERFACE BUS ⟨IEC 625⟩ (with auxiliary device BN 853/02)

for control of all SPM-16 functions through an external computer.

1.7.10 DIGITAL INTERFACE

for control of two additional units.

1.7.11 POWER SUPPLY CONNECTION FOR TEST PROBE TK-11 ..... short-circuit proof

with automatic compensation for pass-band attenuation of .... 10 dB

1.7.12 TRACKING GENERATOR OUTPUT

Output connector .... Versacon® 9 conversion system
for controlling the PSS-16 Send Section or
as fixed level output, level into Z = 75 Ω .... -15 dBm

1.8 <u>MEMORIES FOR FIXED FREQUENCIES AND SPM-16 SETTINGS</u>

1.8.1 NUMBER OF FIXED FREQUENCIES
freely programmable[1)] 100
preprogrammed (Auxiliary device BN 874/00.01) 100

---

1) Maintenance of stored data in the case
of a.c. dropout .... approx. 30 days

The fixed frequencies can be advanced automatically by one step per address step as described in sections 1.1.4.2 and 1.1.4.3.

1.8.2 NUMBER OF EQUIPMENT SETTINGS

freely programmable[1)] 11
preprogrammed (auxiliary device BN 874/00.01) 40

1.9 POWER SUPPLIES AND AMBIENT CONDITIONS

All error limits specified in the preceeding specifications are applicable for the following rated ranges of use of the influence quantities, unless otherwise specified.

1.9.1 POWER SUPPLIES

A.C. line voltage range without switching,
rated range of use .... 96 to 261 V

A.C. line frequency, rated range of use .... 47.5 to 63 Hz
Current consumption I_{rms} .... approx. 1.5 A
Power consumption .... approx. 65 W
Protection class in accordance with
IEC 348 and VDE 0411 I

Warming up time .... ≧ 15 min

1.9.2 OPERATING CLIMATE

Permissible ambient temperature
Nominal operating range .... +5 to -40°C
Storage and transport range .... -40 to +70°C
Radio frequency interference
suppression .... in accordance with VFg. 526/1979 of the Federal German Post Office

---

1) Maintenance of stored data in the case of a.c. dropout .... approx. 30 days

1.10 DIMENSIONS, WEIGHT

Weight .... approx. 22 kg

Overall dimensions without cover (w x h x d in mm):
Table-top unit .... 477 x 244 x 432
19" chassis (DIN 41 494) .... 443 x 220 x 377
(5 units)
19" conversion kit .... BN 700/00.05

1.11 AUXILIARY DEVICES

1.11.1 EPROM, ORDER NO. BN 874/00.01

Storage of 100 fixed frequencies and menu of 40 instrument settings in a non-volatile memory, according to users own needs.
(Request Ordering Form No 5/798 a, b)

1.11.2 INTERFACE BUS ⟨IEC 625⟩ CARD BN 853/02

for control of all unit functions.

1.11.3 PRINTER INTERFACE, BN 905/02

Applicable in SPM-16 commencing with Series B, instead of ⟨IEC-625⟩ Interface. For the connection of a printer with a V.24/V.28 Interface with printout of measurement mode, measurement parameters, and measured results.

1.12 MEASURING ACCESSORIES

1.12.1 TEST PROBE TK-11, ACTIVE TEST PROBE (SERIES D...)

Frequency range .... 2 kHz to 160 MHz

Input level
Maximum permissible AC voltage .... 1 V or +10 dBm (+2 dB)
Maximum superimposed DC voltage .... 50 V

Attenuation when terminated with $R_i = R_a = 75\ \Omega$ at 100 kHz
and 20 °C .... 10 dB $\pm$0.1 dB
(with automatic gain correction in SPM-16).

Affects of ambient temperature on attenuation
within the rated range of use .... $\leq$ 0.05 dB

Frequency response, referred to 100 kHz: up to 100 MHz ...... $\leq$ 0.2 dB
up to 160 MHz approx. 0.2 dB

Input impedance: up to f = 25 MHz .... approx. 50 kΩ || 3.5 pF[1)]
up to f = 100 MHz .... approx. 5 kΩ || 3.5 pF[1)]
up to f = 160 MHz .... approx. 2 kΩ || 3.5 pF[1)]

Intrinsic harmonic ratio for input levels $\leq$ 0 dB .... $a_{k2} \geq$ 40 dB,
$a_{k3} \geq$ 50 dB
for input levels $\leq$ -20 dB .... $a_{k2} \geq$ 60 dB, $a_{k3} \geq$ 70 dB

Power supplies .... from SPM-16

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

Standard accessories:
Connection to unit being tested .... Test prod and ground clamp with prod
Receiver connection .... Element of the Versacon® 9 Conversion system (pin contact)

Optional accessories:
Versacon® 9 adaptor: S 222
Elements of the Versacon® 9 conversion system

Weight .... 150 g

Dimensions, in mm, with test prod .... 11 dia. x 105

1.12.2 REFLECTION FACTOR MEASURING BRIDGE RFZ-14

Frequency range .... 100 kHz to 100 MHz
Rated impedance .... 75 Ω
Insertion loss with Z_x connection open .... approx. 8 dB
Frequency response in the range 300 kHz to 60 MHz .... approx. ±0.5 dB
Reference impedance .... Built-in

1) The capacitance is valid for TK-11 without conversion to Versacon® 9.

Error limits after calibration, with plug connector BNC, TNC or 1,6/10

300 kHz to 60 MHz .... $0.007 \pm 0.10\ r^2$

100 kHz to 100 MHz .... $0.015 \pm 0.13\ r^2$

Permissible input power .... 0.5 W

Connections for transmitter and receiver .... Universal socket Versacon® 9

Connections to unit being tested .... Universal socket Versacon® 9

Optional connections .... BNC; TNC; 1,6/5, 6; 2,5/6; 1,6/10

Weight .... 200 g

Dimensions, w x h x d in mm, without connections .... 54 x 33 x 27

1.12.3 ADAPTER FEDA-1 (75 Ω/50 Ω)

The data are valid for the adapter without connecting elements at an ambient temperature of 23°C ± 5°C.

Impedances 75 Ω/50Ω

Frequency range .... 0 to 100 MHz

Attenuation .... 6 dB

Error limits of attenuation .... ± 0.1 dB

Reflection factor .... ≦ 0.01

Maximum load .... ≦ 1 W

Maximum permissible ambient temperature at rated load ..... 0 to +45°C

Storage temperature .... -55°C to +60°C

Socket adapters

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)

Weight .... 50 g

Dimensions without adapters, l x d in mm .... 47 x 16

Abbreviations: (M) = male connector; (F) = female connector.

1.12.4 REO-50/REO-56 MATCHING TRANSFORMER

Frequency range

REO-56 .... 300 kHz to 60 MHz

REO-50 .... 50 kHz to 14 MHz

Input

Loop-through of useful signal, characteristic impedance .... 75 Ω

Outputs

Splitting the test signal for two test connectors,

output impedance .... 75 Ω

Return loss

Return loss of loop (both measuring connectors loaded with 75 Ω):

REO-50 .... 26 dB

REO-56 .... 20 dB

Insertion loss of the through-loop (both measuring connectors loaded with 75 Ω): REO-50 .... 0.25 ± 0.1 dB

REO-56 .... $0.25^{+0.4\ dB}_{-0.1\ dB}$

1.12.5 TWO-WAY SPLITTER REV-56

Frequency range .... 6 kHz to 200 MHz

Input

Input impedance .... 75 Ω

Outputs

Signal splitting to 2 test connectors, output impedance .... 75 Ω

Loss with 75 Ω termination .... 10 dB

Error limits of attenuation in ranges:

- 6 kHz to 100 MHz .... ±0.2 dB
- 100 MHz to 200 MHz (with Series B) .... approx. ±0.3 dB

Return loss in ranges:

- 6 kHz to 100 MHz .... ≧ 30 dB
- 100 MHz to 200 MHz (with Series B) .... ≧ 25 dB

1.13 ORDERING INFORMATION

Level meter SPM-16+	BN 874/01
Auxiliary device (at extra cost)	
EPROM, Storage of fixed frequencies and instrument settings in a non-valible memory 1)	BN 874/00.01
Interface Bus Card ⟨IEC 625⟩ with adapter plug IEC 625/IEE 488 (S 834)	BN 853/02
Alternatively:	
Printer Interface V.24/V.28	BN 905/02
Measuring accessories (at extra cost)	
Test Probe TK-11 (with test prod)	BN 573/00
Versacon® 9 adapter	S 222
Reflection factor measuring bridge RFZ-14	BN 830/00.01
Test Point Selector MU-7	BN 590/00
IEC-Bus-Interface For MU-7	BN 590/00.01
Matching Transformer REO-56+	BN 839/00.01
REU-50+	BN 839/00.02
Two-way Splitter REV-56+	BN 839/00.03
Adapter FEDA-1 (75 Ω/50 Ω)	BN 319/00
Display unit SG-2 (screen size 85 mm x 120 mm)	BN 429/00
Display unit SG-3 (screen size 150 mm x 210 mm)	BN 593/00
Display unit inserts see	SG-2/SG-3
Printer Trend 800 RO 8	++
Connection cable for ⟨IEC 625⟩ interface bus	
120 cm long	K 343
200 cm long	K 344
19" conversion kit for SPM-16	BN 700/00.05
Front and rear covers for SPM-16 (1 set)	SD-5
Equipment case TPK-5	BN 626/11
Transport case TPG-65	BN 621/65

+) Equipped with the basic 75 Ω socket Versacon® 9 and with BNC element. Other elements must be specified when ordering the equipment - see data sheet for Versacon® 9.

1) The required fixed frequencies and equipment settings must be specified with ordering form No. 5/798 a, b.

++) See data sheet TREND 800 RO for ordering details and data.

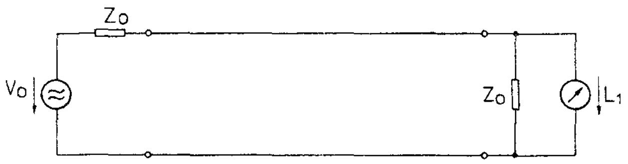
Return Loss

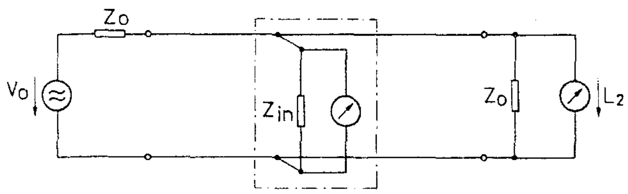
The effect introduced by the return loss of the receiver input or the generator output is included in the error specified for the level reading of a receiver or the output level of a generator.

Moreover, the specified error takes into account that a level meter is operated as "terminated" (input impedance = source impedance = Z_0). This is also valid for a level generator (output impedance = load impedance = Z_0).

Bridging Loss

A receiver operated in the "high impedance" (bridging) mode introduces a level error due to the finite input impedance. The error's maximum value when measured at a testpoint of source impedance Z/2 is expressed as a_B, the bridging loss.





The bridging loss is defined as follows:
Bridging loss $a_B = L_2 - L_1$

$$a_B = 20\ \lg \left| 1 + \frac{1}{2}\ \frac{Z_0}{Z_{in}} \right|$$

Therefore, the bridging loss is the level difference caused by the high impedance level meter input bridging a system terminated with Z_0.

In every case, $Z_{in} \gg Z_0$, which results in:

$$a_B \leqq 4.3 \frac{Z_0}{Z_{in}} \quad [\mathrm{dB}]$$

For that reason, the specified value of $a_{B,1}$ related to the value Z_1 (e.g. 600 Ohms) can be easily recalculated to yield the value of $a_{B,2}$ for the value Z_2 (e.g. 900 Ohms):

$$a_{B,2} = a_{B,1} \cdot \frac{Z_2}{Z_1}$$

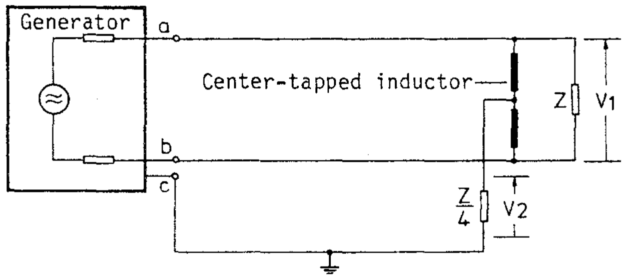
Impedance balance ratio

The specifications given for the input or output balance are provided by the methods defined in CCITT Recommendation O. 121.

This same Recommendation states that:
"The signal balance ratio is an overall measurement of the symmetry of a device and includes the influence of the impedance balance ratio as well as the influence of unwanted longitudinal voltages produced by a generator or the influence of the common-mode rejection ratio of a receiver."

To describe the degree of balance of a device (generator or receiver) under operational conditions in most cases it is sufficient to measure and specify the signal balance ratio only. Thus, the specifications in this Operating Mannual are provided by measurement of signal balance ratio. This is done through emploment of an accurately center-tapped inductor with both of the tightly-coupled half windings being completely symmetrical. Each half represents Z/2.

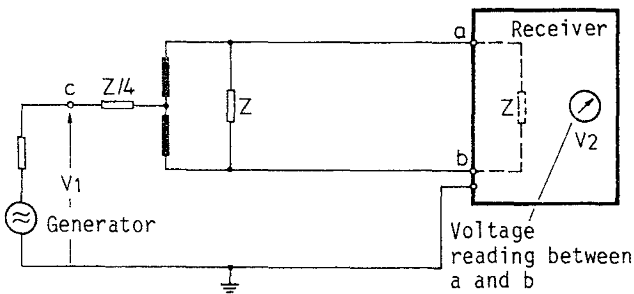
Measurement of Generator Signal Balance Ratio



Generator signal balance ratio is defined as:

$$a_B = 20\ \log \left| \frac{V_1}{V_2} \right| \quad [\mathrm{dB}]$$

Measurement of Receiver Signal Balance Ratio



Receiver signal balance ratio is defined as:

$$a_B = 20\ \log \left| \frac{V_1}{V_2} \right| \quad [\mathrm{dB}]$$

The dotted impedance, Z, is the input impedance of the device under test. If the input impedance is a high value, then this impedance must be externally connected in the parallel.

2 TECHNICAL DETAILS

The Selective Transmission Measuring Set SPM-16 with the wide-band section comprises mainly the modules: receiver section, synthesizer, and control section; the latter section includes the microcomputer and the control and display panel. The signal processing and the various modules are described in detail below (See Figure 2-1).

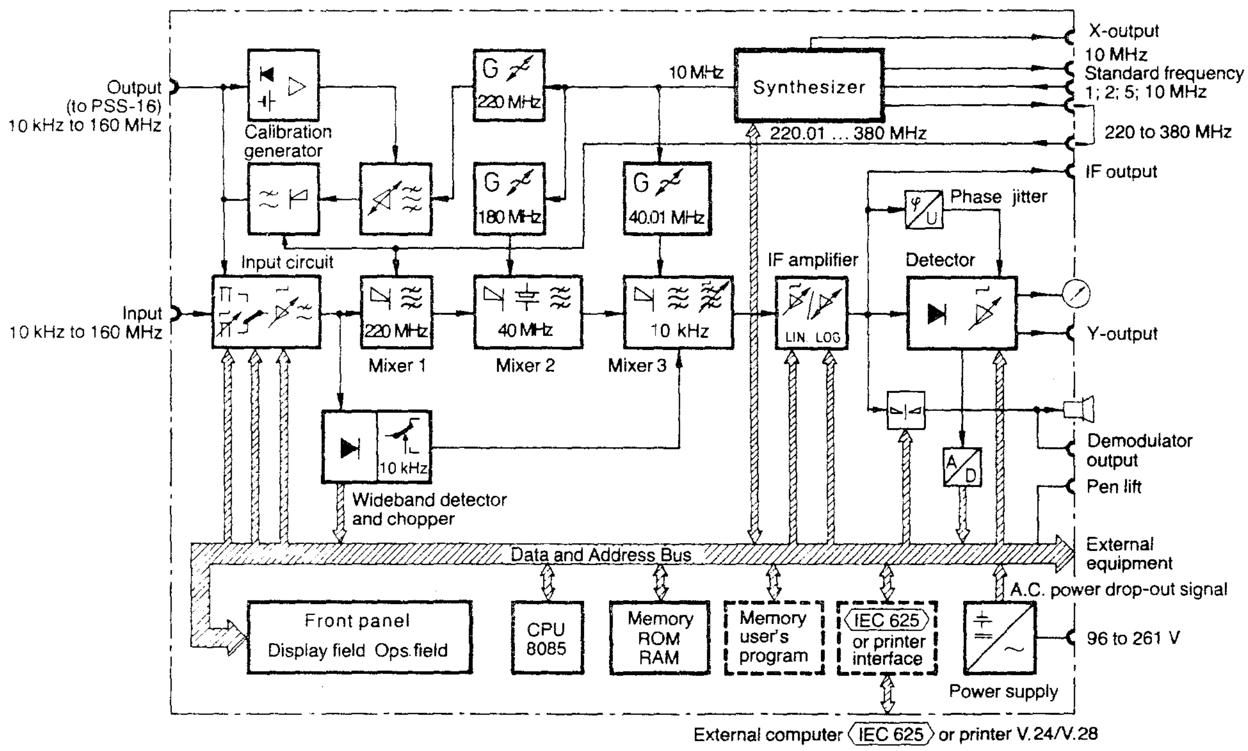


Figure 2-1 Simplified block diagram of the Level Meter SPM-16

2.1 RECEIVER SECTION

2.1.1 INPUT CIRCUIT AND FREQUENCY CONVERSION

The Level Meter operates on the triple superhet principal. In order to achieve good decoupling between the measuring circuit and the chassis ground for measurement of high losses on two port networks (see section 5.2), the input circuit is decoupled, for high frequency purposes, by a coaxial choke.

The input signal passes from the coaxial input to the remote controllable Calibrated Attenuator (FED-2, BN 802/2) and then to the preamplifier. For wide-band level measurements, the measuring signal is connected to a quasi-rms rectifier, converted to 10 kHz, and injected into the IF signal path. Here, it is rectified and displayed. For selective level measurements, the wide-band detector acts as a level monitor for optimum matching of the loading signal (at the level meter input) to the input circuit and the first mixer. The input attenuator and the IF attenuator are so adjusted by the microcomputer that the best possible measuring accuracy is always achieved. This makes manual "low noise/low distortion" switching superfluous.

The preamplifier is followed by a further attenuator which permits the optimum matching of the mixer to the wide-band load and the switching of the measuring range in 5 dB steps. The low-pass input filter suppresses all spurious and image frequencies which lie above the reception band. The receive frequencies are converted to the first intermediate frequency of 220 MHz in the first mixer, using the 220.01 to 380 MHz conversion signal from the synthesizer. The second IF is 40 MHz. This is applied to the 40 MHz crystal band-pass filter which permits direct conversion to the last IF of 10 kHz by the third mixer.

The necessary carrier signal for this is produced in a phase-locking oscillator, synchronized to the reference frequency in the synthesizer. The selectivity of the Level Meter is determined by the flat 3.1 kHz wide 10 kHz band-pass filter. Various filters with differing noise bandwidths can be connected after this point according to the application.

2.1.2 IF AMPLIFIER, DETECTOR, AND OUTPUT CIRCUIT

The converted received signal passes through a stage for power level matching, according to the selected measuring conditions, either to a logarithmizing circuit with a level range of 80 dB or to the switchable IF amplifier, whose gain can be switched in 1 dB steps with extremely precise transformer-type attenuators. The maximum overall gain is 89.9 dB. This module also contains the calibration attenuator for level calibration (see section 2.1.3). Signal detection is carried out in a true rms detector. The crest factor of the detector circuit is 12 dB. The detected measured voltage either is amplified and connected to the meter for analog display or passes through an analog-digital converter for digital level display.

2.1.3 AUTOMATIC LEVEL CALIBRATION

In order to achieve the high measuring accuracy, the SPM-16 is equipped with an automatic level calibration circuit which is automatically switched on at preset intervals or if the equipment settings (e.g. bandwidth, frequency) are changed. The calibration frequency is tuned along with the measured frequency in order to achieve a very low intrinsic frequency response. The extremely precise and temperature constant calibration level is produced in the calibration generator. The calibration frequency is obtained by conversion of the modified control frequency and the fixed, multiplied standard frequency from the synthesizer (see section 2.2).

2.1.4 FAST SIGNAL DETECTOR

A signal voltage at the input to the unit, and which lies within the indication range of the analog meter is indicated, with the aid of a fast signal detector, by illumination of an LED. For this purpose, the 10 kHz IF voltage is compared with a reference voltage which corresponds to a level threshold of approximately -15 dB or approximately -1.2 dB on the meter scale. If this threshold is exceeded by the IF voltage, 10 kHz pulses trigger a monoflop, with an active time of approx. 1 s, and this causes the LED to illuminate. During frequency search operations, the signal detector is used to stop the search. When operating in logarithmic mode, the LED is continuously illuminated; however, search operation is possible at a level threshold of -40 dB as indicated on the instrument.

2.1.5 PHASE JITTER MEASURING ATTACHMENT

For measurement of the phase jitter, the IF signal is connected to a phase comparator, where it is compared with the average phase position of a low jitter reference oscillator signal that has a slow restoration control characteristic.

The measured voltage, which is proportional to the phase, is connected via a weighting filter which includes all jitter components in the frequency range $\pm$(20 to 300 Hz) to the peak-to-peak rectifier, and is then logarithmized amplified, and displayed. The weighting filter and the rectifier characteristic comply with CCITT recommendation 0.91.

2.1.6 TEST PROBE CONNECTION

For high impedance (bridging), unbalanced measurements, the active Test Probe TK-11 is provided. This has the function of an impedance transformer with an input capacitance of only 3.5 pF when a test prod is used. It receives its power supply from the Level Meter. The insertion loss of 10 dB is automatically compensated in the SPM-16 when the TK-11 is connected.

2.1.7 OUTPUTS

Several outputs are available for further processing of the converted received signal.

In analog mode, a single sideband demodulator permits reconversion of any voice channel from the CF plane to the audio frequency band.

Conversion is carried out with the aid of a switchable carrier signal of 8 or 12 kHz for the upright or inverted position. This carrier is derived from the standard frequency. For a reproduction true to the original, therefore, the tuning must be to midchannel. The demodulated received signal can be either connected to the built-in loudspeaker for qualitative assessment or extracted at the demodulator output for further external processing (e.g. connection of interruption or impulsive noise counters). The demodulator is characterised by low intrinsic noise of about 65 dB below the meter reading of 0 dB, thus permitting correct conversion of a CF channel.

The last intermediate frequency of 10 kHz can be extracted at the decoupled output which follows the IF amplifier.

The Level Meter has a fixed-level output for delivering the Generator Signal to the level conditioning in the Generator Section of the PSS-16. This output can also be used as a source of generated signal (tracking generator) for frequency response measurements.
For connection of a plotter or similar device, the Level Meter has a Y-output at which a DC voltage proportional to the meter indication is available.
An X-output supplies a DC voltage which is proportional to the frequency within the adjustable limits f_{START} and f_{STOP}.

At two other outputs, the variable carrier frequency and the standard frequency can be extracted for the external tuning of a level generator. An input for application of an external standard frequency of 1, 2, 5 or 10 MHz permits substitution for the internal standard frequency.

2.1.8 POWER SUPPLY UNIT

The Level Meter is equipped with a switching power supply unit which permits connections to a.c. line voltage in the range 96 to 261 V without further switching. It is characterized by a high efficiency, which results in low internal heating in spite of the compact construction.

This provides higher reliability of the Level Meter.

A built-in rechargeable battery buffers all of the existing memory modules if the a.c. line voltage fails or if the unit is switched off, thus maintaining all stored data and settings.

2.1.9 FREQUENCY TUNING

Frequency tuning is carried out digitally, in BCD code, in all operating modes. For quasi-continuous frequency tuning over a continuous range, a small DC generator (tacho-generator) is driven by the tuning knob and a subsequent voltage-frequency converter generates setting pulses for the internal counters. The frequency information is transferred to the frequency display and the synthesizer via display buffers.

2.2 SYNTHESIZER

The control frequency of 220.01 to 380 MHz necessary for tuning the Level Meter, and the fixed frequencies necessary for synchronization are generated in a synthesizer (BN 869) with the following characteristics:

- High frequency accuracy and stability
- High spectral purity (very high adjacent channel rejection and high signal-to-noise ratio)
- Phase continuity when the frequency is changed
- Quick settability
- Compact construction.

The construction and the most important modules are shown in the extremely simplified block diagram of the synthesizer in Figure 2-2.

The control frequency f_T (220.01 to 380 MHz) is generated in a voltage controlled oscillator which is adjusted so that the control frequency is precisely the sum of the frequency f_R of the locked oscillator and the frequency f_I of the interpolation oscillator.

The locked oscillator operates in the frequency range 219.8 to 379.7 MHz, and can be tuned in 100 kHz steps by another phase lock loop. For this purpose, the oscillator frequency is divided down to 100 kHz in a programmable locked divider and compared with the standard frequency in a zero phase controller.

Interpolation within the 100 kHz steps is carried out in a single interpolation loop. This operates with fractional division ratios, thus it permits frequency settings with values after the decimal point [1].

This configuration permits short settling times, even with small step increments.

The interpolation oscillator runs at a relatively high frequency between 40 and 60 MHz in order to permit, in the following 200 : 1 divider, reduction of the phase hits resulting from the phase lock loop.

As the interpolation frequency should be adjustable in steps of 1 Hz, the 200 : 1 divider means that the interpolation divider must be adjustable in 200 Hz steps. In order to permit rapid reprogramming, the output frequency of the interpolation divider is 100 kHz. This is compared with the divided standard frequency in the phase meter. Frequency settings in 1 Hz to 1 kHz positions would divide into fractional values and result in phase hits. For this reason, a compensation voltage with the same shape as the interference voltage, but with opposite polarity, is superimposed on the output signal from the phase meter.

Further measures, such as synchronous transfer of frequency setting information into the locking and interpolation dividers or the block-

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[1] P. Harzer: "Frequency Synthesis in Modern Level Measuring Setups" translated from original NTZ publication, Volume 33 (1980), No. 2, pp. 90-94

ing of the carrier loop during the so-called interpolation exchange, permit maximum suppression of the spurious frequencies in the control signal.

The 100 kHz reference frequency and further synchronization frequencies are generated in the time base. This comprises mainly the standard frequency oscillator and the 10 MHz crystal controlled oscillator, with a low proportion of spurious frequencies and locked in a rigid phase to the reference frequency via the standard frequency synchronization. The standard frequency oscillator, which can also be replaced by an external frequency standard of 1, 2, 5, or 10 MHz, is thermostatically controlled to achieve the high accuracy of 1×10^{-7}.

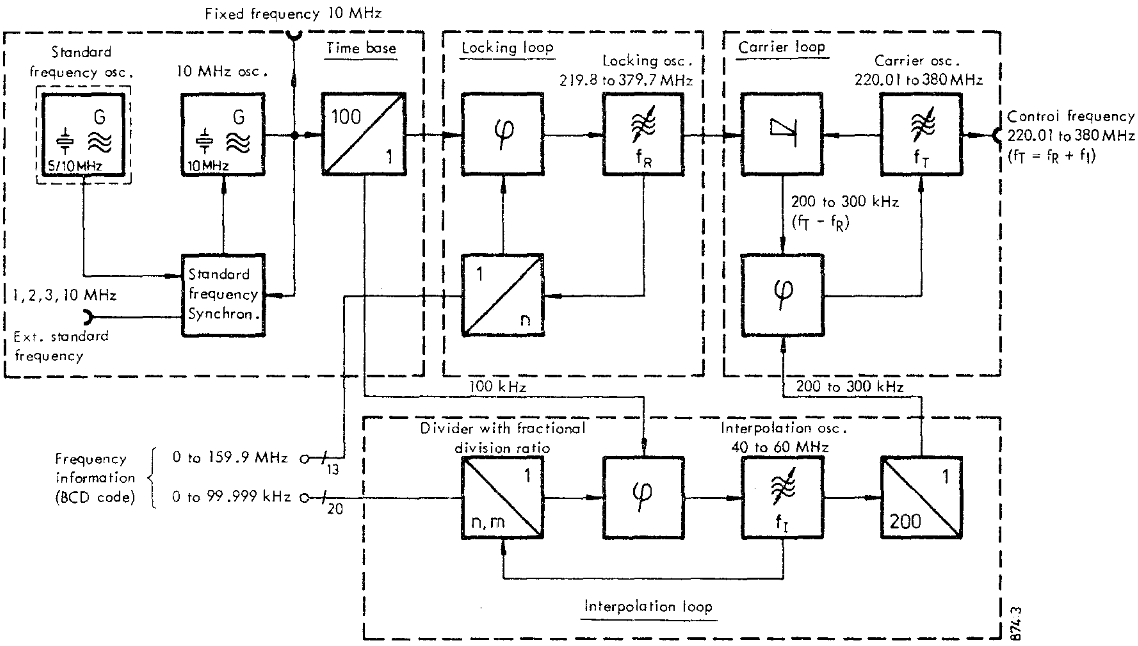


Figure 2-2 Simplified block diagram of the synthesizer BN 869

2.3 CONTROL SECTION WITH MICROCOMPUTER

The microcomputer comprises the central processing unit (CPU) - a type 8085 microprocessor - the program memory (ROM), the working memory (RAM), and the input and output gates. The displays and controls on the front panel are connected to the microcomputer via data and control lines. The keyboard of the control panel is used, amongst other things, for entry of fixed frequencies and of complete equipment settings into the RAM (Random Access Memory). Battery buffering of the RAM power supplies is provided to maintain the stored data in the case of an a.c. power dropout.

If required, an additional customer-specific EPROM can be fitted for fixed frequencies and equipment settings. A results log can be produced on an external printer connected via a printer interface for V.24/V.28 interfaces (SPM-16, commencing with series B). Instead of the printer interface, an IEC interface can be fitted for connection of an external computer. Remote control facilities exist for all functions of the SPM-16.

After power is switched on, an automatic RAM/ROM self test is executed. Functional testing of the most important modules can also be initiated by the operator. In the case of a fault, the test sequence is stopped and the fault number is displayed.

3 C O M M I S S I O N I N G

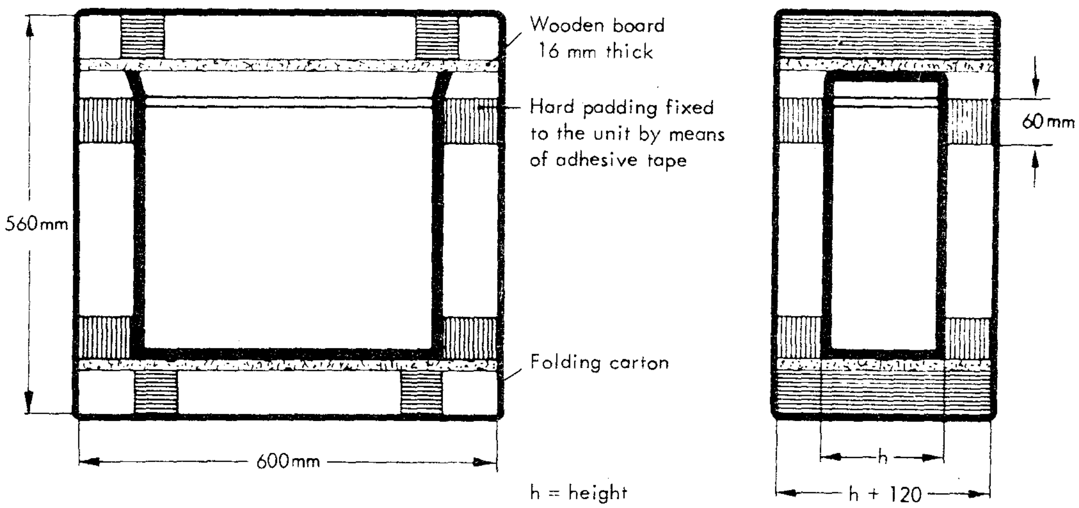
3.1 UNPACKING THE UNIT

The SPM-16 is shipped in a special packing case which was subjected to comprehensive stress testing at Wandel & Goltermann.

This case guarantees that the test equipment will arrive without damage, even under rough transport conditions. The unit should be removed carefully from the appropriate side of the packing case. It is recommended that the orginal packing materials be retained for possible future shipment. If this is not done, please read the following notes.

3.1.1 NOTES FOR SHIPPING

Safe transportation of the SPM-16 is guaranteed only by correctly designed packing materials. If the original packing case has been lost, we recommend that the unit be packed as shown in Figure 3-1.



Firgure 3-1 Packing notes

3.1.2 TRANSPORT IN THE EQUIPMENT CASE TPK-5 OR TRANSPORT CASE TPG-65

The equipment case TPK-5 protects the SPM-16 against dust and mechanical damage for light transport operations (e.g. in a motor vehicle). It also provided suitable protection against splash water. Further protection of the inclined front panel is provided by placing the rear cover SD-5 on the front of the SPM-16 before putting the unit into the case. For increased climatic and mechanical stresses (e.g. rail or air transport), the transport case TPG-65 is recommended, as this protects the equipment against extreme effects.

3.1.3 USE IN 19" RACKS

The case dimensions of the SPM-16 are matched to DIN Standard 41 494 or American Standard ASA C 83.9 "Racks and front panels". The SPM-16 is thus suitable for installation in 19" racks; it is only necessary to modify the front panel dimensions by fitting two mounting brackets as shown in Figure 3-2. The complete 19" conversion kit including mounting screws, is available under order No. BN 700/00.05.
The feet on the bottom of the unit and the guide studs on the top of the unit must be removed before installation (see also Figure 3-2).

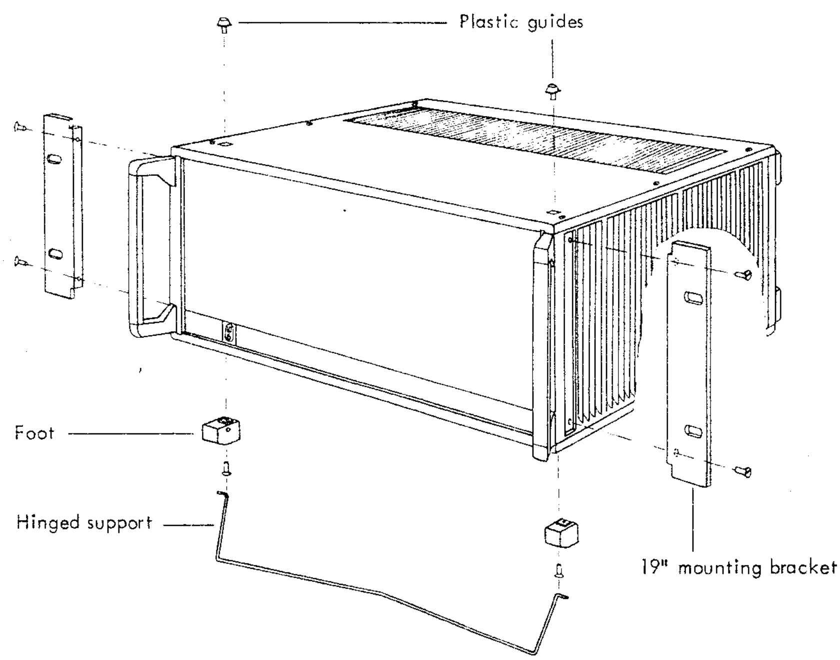


Figure 3-2 Converting the table-top unit for rack installation

<u>Caution:</u> When installing the unit in equipment cabinets, care must be taken that the upper limit of the rated range of use for the ambient temperature is not exceeded (see section 3.2). Generally, the following measures are necessary:

A space of one height unit (44.4 mm) must remain free between the units.

If necessary, fans must be fitted to extract the heat produced in the cabinet. Suitable filters should be provided to prevent accumulation of dust on the units.

3.2 INSTALLING THE UNIT

The Level Meter SPM-16 can be used at ambient temperatures between +5 and +40°C. If used within larger systems or if installed in racks, care must be taken that this temperature range is not exceeded. (e.g. by spacing the various units as mentioned in section 3.1.3).

Temperatures between -40 and +70°C are permissible for storage or transport. In such cases, it is recommended that the displays and controls are protected by the Transport Protection Cover SD-5 (see section 1.13, ordering information) on the front and back of the unit; these prevent mechanical damage and protect against dust and splash water.

The angled front panel makes the unit easy and comfortable to use. In addition, the Level Meter can be installed at an angle by swinging down the supports attached to the front feet. The SPM-16 will also operate reliably in this position.

The liquid crystal displays for frequencies and levels decrease the current needed, and consequently the internal heating of the unit. No fan is necessary and a higher reliability is achieved. When the unit is put in place, the ambient light should be bright because then the displays are particularly easy to read.

3.3 CONNECTION AND SWITCHING ON

Before switching on, connect the control output [52] of the oscillator section to the control input [45] of the receive section using the included short BNC cable (K 336) as shown in Figure 3-3. (Longer connection cables should not be used).

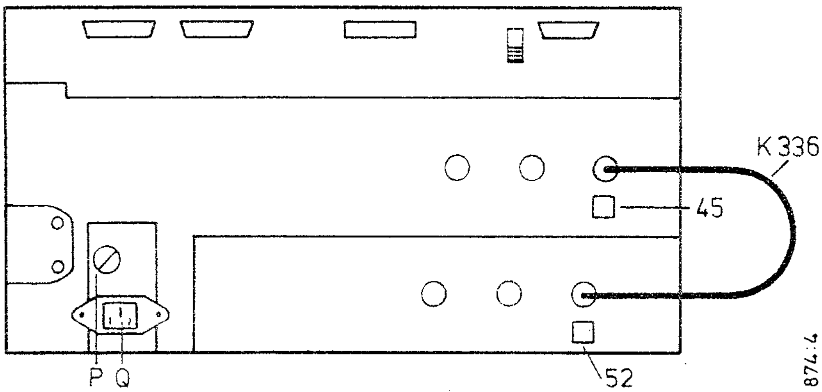


Figure 3-3 Rear connections on the SPM-16

3.4 POWER SUPPLIES

The Level meter is supplied with power by a switching power supply unit which is installed on the right side wall of the SPM-16. It can be operated from AC voltages between 96 and 261 V without additional switching, the a.c. line frequency lying between 47.5 and 63 Hz.

The enclosed a.c.power cord should be used for connection to the a.c. lines. The Level Meter complies with protection class I of VDE 0411, i.e. the case and the ground socket are connected to the protective conductor. If a different a.c. power cord is used, ensure that a protective conductor is included and connected.

After inserting the a.c.power cord in the a.c. socket Q (see Figure 4-2) on the rear of the unit, insert the plug into the a.c. outlet socket and switch on the Level Meter with the a.c. power switch H on the front (by depressing the pushbutton). The specified error limits are valid only after a warming up period of 15 minutes.

3.4.1 REPLACING THE FUSE

If, after the Level Meter SPM-16 has been switched on, there is neither a level nor a frequency display ond none of the indicator lamps are lit, first unscrew the fuse holder P on the rear of the unit and check the fuse.

The replacement fuse should be type T 3, 15 A (3.15 A, slow-blow); two spare fuses are included with the unit.

3.5 SELF-TEST

When the Level Meter is switched on, an automatic RAM/ROM test is executed to check the functions of the RAM and the system software (ROM). If the test is executed successfully, the symbols 0----- appear momentarily on the frequency display, followed by the last parameters for frequency and level values stored in the unit. In the case of an error in the control section, an error number is displayed in the frequency display. The digits in the level display (address in hexadecimal code) contain further information for localization of the fault.

Example:

Level display

Frequency display

The meanings of the symbols and digits are explained in Table 6-2.

A functional test of the most important modules (internal hardware test) can be initiated by entering the address No. 9003 (in Series A the address number 9001 should be pressed before 9003). No external connections are necessary for this purpose as the internal calibration signal is used as a signal source.

The self-test ought to be executed after a waiting time of a few minutes.

Sequence:
Depress the following pushbuttons:

[MEM] 9001 [RCL] (in Series A only)

[MEM] 9003 [RCL]

If the test is successful, the symbols 1----- appear in the frequency display. In the case of a fault, a fault number (e.g. 1--003) appears in the frequency display; the meanings of these numbers are explained in Table 6-2. The unit can be switched back from the test programm to the measuring program by again entering 9001 [RCL]. After that, the Standard Set-up appears again (see para. 3.6).

3.6 STANDARD SET-UP

All equipment set-ups are stored in a semiconductor memory which is supplied with voltage from a rechargeable accumulator when the a.c. power is switched off. For this reason, the last equipment set-up which was stored always appears when the unit is switched on again. Stored fixed frequencies are also retained when the power is switched off.

If the unit is switched off for a longer period, however, it is possible that the buffer battery is exhausted and that the stored information is lost. In this case, the following standard set-up is automatically selected when the power is switched on again:

f = 100.000 kHz
f_{STEP} = 1.000 kHz
Bandwidth 3.1 kHz
Mode: ABS, ANLG, 20 dB scale
Measuring range: 0 dB
Display "SWEEP OR STEP TIME" = 1 s

It may be necessary to disconnect the buffer battery during repair work, which also results in loss of the stored data. In order to obtain the defined initial state, the pushbutton [T] (see Figure 6-2) should be depressed after the unit has been switched on again; this pushbutton is accessible on the control p.c. board after the upper case cover has been removed. Depression of the pushbutton again loads the standard set-up in the memory. (See also the note in section 4.22.1).

If a fault occurs during operation, switch the unit off and on again to call out the RAM/ROM test. The test is executed automatically as described above. After this, the hardware test can be executed as described previously.

If neither of the tests results in a fault indication, although there is a fault in the unit, it is recommended to carry out a reset by calling out program number 9000 before resuming measurements. The program is initiated by depressing the following pushbuttons:

[MEM] 9000 [RCL]

Note: This reset clears all stored fixed frequencies (address range 0 to 99); the stored front panel settings (address range 100 to 110) are replaced by a standard set-up as described in section 3.6 (see also the note in section 4.22.1).

Important Safety Instructions

This instrument left the manufacturer in perfectly safe operational condition. To maintain this condition and resulting safety for the operator the following precautions ought to be carefully noted.

A.C. power line voltage

The operating voltage of the instrument should be the same as the a.c. line voltage, so check whether or not the two voltages are equal.

Safety Class

This instrument is categorized as Safety Class I according to VDE 0411 or IEC Publ. 348. The power cord delivered with the equipment has a protective ground conductor. The a.c. power plug must be plugged into an a.c. power receptacle that has a third wire to ground, except in rooms that are particularly certified otherwise. Any disconnection of the protective ground conductor either inside or outside of the instrument is not permitted.

Connection to measuring circuits presenting hazards to personnel

Before the connection is made to a hazardous circuit, a protective ground connection, for protection against the measurement circuit, ought to be connected to the enclosure. In case the protective ground conductor of the a.c. power line can also assume this protective function, the a.c. power connection should be established first of all. If the measuring circuit has an inherent protective ground conductor, then this conductor must be connected to the enclosure before a connection is made to the measuring circuit.

Defects and Exceptional Conditions

When it can be assumed that safe operation is no longer possible, the equipment should be taken out of service and inadvertent operation should be prevented.
This occurs when
- the equipment shows external signs of damage
- the equipment no longer operates
- after being overstressed in any way (e.g. storage, transport) so that the tolerable limits are exceeded.

Fuses

Only specified fuses are permitted for use.

Opening the Instrument

After the covers have been removed or when components are removed with tools, certain components that operate with applied voltage could be exposed. And also connection points might be carrying a voltage.
Therefore, before the instrument is opened for inspection, all voltage sources should be disconnected.
But sometimes calibration, maintenance or repairs require that the instrument be open and operating with applied voltage. So only experienced craftspersons who understand the dangers associated with working on instruments that have exposed voltage points should undertake the job.
Capacitors can retain a voltage charge even after the instrument has been disconnected from voltage sources. Thus, the circuit diagrams should be observed.

Repairs, Replacement of Components

Repairs must be done according to correct technical practice. With that, particular attention must be paid to the characteristics of construction. None of the safety precautions should be changed, especially for leakage paths and air gaps, and separation by insulation must not be reduced.
Only original replacement parts ought to be used. Other replacement parts are only permitted if the safety and protection against human injury are not degraded through the use of non-original components.

Safety Testing after Repair and Maintenance

Testing of the protective ground conductor in the power cord for the instrument:

The resistance of the protective ground conductor shall be measured. It should be $<0.5\ \Omega$. The power cord should be bent and kinked during the measurement so as to reveal any intermittent connection. This gives evidence of a defective power cord.

Testing the insulation of the a.c. power circuit:

The insulation resistance is measured at 500 V between the a.c. power connection and the protective ground conductor connection. For this measurement, the instrument's power switch should be ON.
The insulation resistance ought to be $>2\ M\Omega$.

Important Safety Instructions

This instrument left the manufacturer in perfectly safe operational condition. To maintain this condition and resulting safety for the operator the following precautions ought to be carefully noted.

A.C. power line voltage

The operating voltage of the instrument should be the same as the a.c. line voltage, so check whether or not the two voltages are equal.

Safety Class

This instrument is categorized as Safety Class I according to VDE 0411 or IEC Publ. 348. The power cord delivered with the equipment has a protective ground conductor. The a.c. power plug must be plugged into an a.c. power receptacle that has a third wire to ground, except in rooms that are particularly certified otherwise. Any disconnection of the protective ground conductor either inside or outside of the instrument is not permitted.

Connection to measuring circuits presenting hazards to personnel

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The insulation resistance ought to be $>2\ M\Omega$.

Table 4-1

Controls and Sockets on the Front Panel

(see Figure 4-1)

Control number	Designation in the circuit diagramm	F u n c t i o n	
[1]	20 S 10	AUTO CAL	Calibration pushbutton; automatic level calibration can be switched off.
[2]	20 S 42	LOCAL	Pushbutton for switching to manual mode during remote control or for manual initiation of printer operation
[3]	20 S 7 20 S 4	ABS REF	Pushbuttons for display of: Absolute level in dB or dBm. Stored reference level in dB or dBm, level input by simultaneous depression of the pushbuttons "ABS" and "REF".
	20 S 5	ABS-REF	Level difference between absolute level and reference level in dB.
	20 S 8	dBm0	Level expressed in dBm or dBm0.
	20 S 9	dBr	Relative level in dBr, level input by depressing bushbutton twice.
[4]	20 S 3/ 20 S 1	ANLG DGTL	Selection of operating modes analog or digital
[5]	20 S 18	AFC	Automatic frequency control
[6]	20 S 12	MEM	Memory pushbutton; used together with the pushbuttons "STO" and "RCL" for storage and recall of fixed frequencies or equipment settings.
[7]	20 S 19...24		Control panel for input and display of single frequency ("f"), frequency step ("f_{STEP}"), and sweep limits ("f_{START}", "f_{STOP}" or "f_{CENT}", "Δf").
[8]	20 S 2	AUTO SET	Pushbutton for automatic setting of the measuring range in analog mode with input signal connected.
[9]	22 S 1		Measuring range switch in analog mode, switching in 1 or 5 dB steps, depending on setting of [10].

Control number	Designation in the circuit diagramm	Function	
[10]	20 S 14...16	1 dB 20 dB 80 dB	Selection of the required scale range in analog mode.
[11]	20 S 6	AVRG	Changeover switch for fast or slow display.
[12]	20 S 31...41 20 S 43...47		Decimal keyboard for measuring parameter input: Multi-function keys for frequency, relative level (brown) and memory function (blue), clear key "CLR".
[14]	18 Mo 1		Knob for continuous frequency tuning together with the pushbutton "MAN" .
[16]	20 S 11		Selection of bandwidth, demodulator, or phase jitter measurement.
[17]	20 S 17		Selection of the deflection time for sweep frequency operation or the dwell time in AUTO STEP mode, of manual sweep, or periodic search (OPT).
[18]	2 Bu 7		Power supply for TK-11 probe
[19]	2 Bu 4		Coaxial input, 10 kHz to 160 MHz
[20]	17 P 1		Volume control for built-in loudspeaker.
[21]	17 Bu 1		Demodulator output.
[22]	16 Bu 2		Y-output voltage (DC)
[23]	18 Bu 1		X-output voltage (DC), voltage proportional to frequency within Δf.
A	22 JC 1		Digital display of level, or phase jitter in digital mode.
B	16 J 1		Meter for level and phase jitter display in analog mode.
C	19 GL 2		Signal detector.

Control number	Designation in the circuit diagramm	Function	
D	19 JC 2		Digital display of frequency. Address, test and fault numbers are displayed here for self-test or memory operation.
E	20 S 30	MAN	Pushbutton for frequency resolution 100 Hz (coarse) or 10 Hz (fine) during continuous tuning.
F	20 S 25/27	⇧ ⇩	Direction pushbuttons for frequency search operation.
G	20 S 26/S 28	SWEEP	Pushbutton of periodic or single sweep.
H	1 S 1		Mains switch
I	1 Bu 2		Ground socket
K	20 S 29	STEP	Pushbutton for all automatic frequency stepping with step increment "f_{STEP}" or for "TRACKING".
L	20 S 44, S 47	⇧ ⇩	Direction pushbuttons for manual frequency stepping with step increment "f_{STEP}".

Table 4-2

Controls and Sockets on the Rear

(see Figure 4-2)

Control number	Designation in the circuit diagramm	Function
[40] [41]	21 Bu 1, 2	Digital interface for control of two external devices
[42]	16 Bu 1	Connection socket for Display Unit SG-2 or SG-3
[43]	15 Bu 3	Intermediate frequency (IF) output, 10 kHz.
[44]	10 Bu 2	Generator output, 10 kHz to 60 MHz for controlling the PSS-16 Generator Section
[45]	4 Bu 1	Control frequency input, 220 to 380 MHz, to be connected to [52].
[46]	21 S 2	dB/dBm changeover switch.
[50]	63 Bu 1	Standard frequency output, 10 MHz.
[51]	65 Bu 1	Input for external standard frequencies 1, 2, 5 or 10 MHz.
[52]	58 Bu 1	Control frequency output, 220 to 380 MHz, to be connected to [45].
M	21 (91b)	Installation position for the Interface Bus ⟨IEC 625⟩ Coard or printer interface
N		Battery compartment for Ni-Cd cells needed for data retention
O		Allen wrench for removal of the case
P	1 Si 1	AC power fuse
Q	1 St 1	AC power connector
R		Rating plate

4 OPERATION

4.1 CONTROLS ON THE FRONT AAND REAR SIDES

The front panel of the Level Meter SPM-16 is divided into the three functional panels: connection panel, control panel, and display panel. Most of the parameters necessary for measurement are selected with pushbuttons on the inclined part of the front panel, which simplifies operation and provides the unit with a modern design. On the left half of the control panel are configured the pushbuttons for selecting the required measuring mode, level display, and scale, while on the right half of the front panel are configured the pushbuttons for frequency tuning.

Each pushbutton has an LED which lights when the function is active. Some of the pushbuttons have double or triple functions (MHz, kHz pushbuttons), which are clearly identified by different colored markings or by a second LED.

The rear side of the SPM-16, on which the division of the level meter into control sections, level measuring sections, and synthesizer is visible, contains the connection sockets for analog and digital control signals, the installation position for the Interface Bus ⟨IEC 625⟩ Card, and power supply elements.

The abbreviations used in the operating instructions for controls and sockets are shown in Figures 4-1 and 4-2, which are on fold-out pages for ease of use.

The relationships between the abbreviations (normally numbers within boxes) and the circuit diagrams in the appendix are described in Tables 4-1 and 4-2.

The abbreviations used in the circuit diagrams have the following meaning (for example, 20 S 10): the switch (calibration pushbutton) can be found in circuit diagram 20 and is designated S 10.

The numbers within boxes in the tables are the same as the numbers printed on the front and rear sides of the Level Meter. The table also provides a short summary of the functions of the various components and sockets. All coaxial connection sockets are universal sockets which can easily be converted to the most common socket types used in telecommunications technology (see section 6.3.4).

4.2 EQUIPMENT SETTING AFTER SWITCHING ON

After the commissioning and switching on as described in chapter 3, the SPM-16 automatically sets itself to the parameters and operating modes used for the last measurement before it was switched off. If the built-in buffer battery needed for the retention of data in the CMOS-RAM is exhausted or if it was disconnected from the memories during repair work, a different setting appears. The capacity of the fully charged battery is sufficient to retain the memory data for approximately 30 days with the power switched off.

4.3 INPUTS FOR MEASURING

The Level Meter is equipped with a 75 Ω coaxial input, [19]. Test Probe TK-11 is intended for high impedance (bridging), low capacitance measurements (see para. 4.24.1).

Caution: Input [19] must be protected from the application of d.c. and levels greater than +25 dBm or +16 dB. The max. applied voltage must not be higher than 4.8 V (AC and DC components) because the thin film technology resistors in the input voltage divider could be destroyed.

4.4 TUNING THE RECEIVER FREQUENCY

Frequency tuning is carried out, according to the task, either digitally with the keyboard, continuously, or automatically. (AUTO STEP, TRACK, SEARCH).

The use of a synthesizer, which is characterized by very low spurious frequency and noise levels and by phase continuity when the frequency is changed, achieves both high accuracy and high stability of the selected frequency in all operating modes. The frequency accuracy of the SPM-16 is $\pm 1 \times 10^{-7}$ of the displayed frequency value. These error limits include the temperature response in the rated range of use and the aging errors which occur within one year.

4.4.1 DIGITAL TUNING [12]

The required receiver frequency is entered in MHz or kHz with the aid of the keyboard [12]. (The LED above the blue pushbutton "MEM" must be off).

Example: f = 0.950 kHz [.] 95 "kHz"

Leading and trailing (1 Hz to 100 Hz positions) zeros may be omitted. The synthesizer is tuned to the new value only when the [MHz] or [kHz] pushbutton is depressed (ENTER function).

If an incorrect digit is entered during frequency selection, the display can be cleared with the aid of the clear key [CLR] and the required frequency reentered. Tuning of the synthesizer is not affected by this. The digits are shifted from right to left in the display.

A new frequency is entered by overwriting the old value.

The tuned frequency is displayed with a maximum of nine digits in display window D, with a resolution of 1 Hz. The frequency is always displayed in kHz.

4.4.2 CONTINUOUS FREQUENCY TUNING [MAN]

If the precise value of the frequency to be measured is not known and if it is necessary to tune for maximum level indication (in analog mode), the continuous tuning function can be switched on by depressing the pushbutton [MAN] in functional panel [13].

Frequency tuning is carried out in a pseudo-continuous mode, i.e. in steps of 1 Hz or 100 Hz:

if the pushbutton [MAN] is depressed once, with 1 Hz resolution (FINE)

if the pushbutton [MAN] is depressed twice, with 100 Hz resolution (COARSE).

Due to the phase continuity of the synthesizer, no phase shifts occur during continuous tuning, which means that no additional sideband spectrum is generated.

After selecting the required resolution "coarse or fine", the receiver can be tuned over the whole frequency range with knob [14], without the necessity of range switching, the rate of frequency change per revolution of the knob increasing if the knob is turned faster. This makes it possible to tune through the whole frequency range very rapidly.

If 100 Hz resolution is selected, the last two digits of the frequency display are always zero.

To return to digital frequency tuning (4.4.1), the required frequency can be entered directly on the numerical keyboard "12].

4.4.3 INCREMENTAL FREQUENCY TUNING

For measurements at constant frequency intervals (e.g. with channel or primary group intervals, for measurement of harmonic frequencies, or for recording of measuring sequences), operation is particularly simple if the frequency of the SPM-16 can be preset with a stored frequency increment. The unit then permits either manual or automatic frequency stepping.

4.4.3.1 Manual Frequency Stepping

- Depress pushbutton "f_{STEP}"
- Enter the required frequency increment in MHz or kHz (see section 4.4.1).
- Depress pushbutton "f" and enter the starting frequency (see section 4.4.1).
- The frequency can now be stepped upwards or downwards with the two direction pushbuttons: ⇧ STEP ⇩
  Tuning is possible over the whole frequency range.

The selected frequency increment can be checked by depressing the pushbutton "f_{STEP}". The value of the frequency increment is changed by overwriting with a new input.

4.4.3.2 Automatic Frequency Stepping

This type of frequency tuning can be used only if the start and stop frequencies are also entered.

Example: Measuring the residual carrier signals in a primary group of 60 kHz to 108 kHz.

Depress the following pushbuttons:

- "f_{START}" 64 "kHz" "f_{STOP}" 108 "kHz"

- "f_{STEP}" 4 "kHz"

- Select the required stepping rate in the window "SWEEP OR STEP TIME/s" with rocker switch [17]. (The rate is stepped automatically as long as the switch is depressed).

- Depress the pushbutton "STEP" twice. The LED alongside "AUTO" must light. The frequency is now stepped automatically. After complete cycle, a new cycle starts at f_{START}. The elapsed time for one frequency change results from the total of the "STEP" time and the measuring time; this depends on the measuring conditions.

The frequency sequence can be stopped by depressing the pushbutton "MHz, kHz" or any other pushbutton in selection panel [7] or [13].

Note: If the frequency sweep $\Delta f = f_{STOP} - f_{START}$ is not an integral multiple of f_{STEP}, then measurements will be carried out only up to an upper frequency $f'_{STOP} = n \cdot f_{STEP} \leqq f_{STOP}$, i.e. the selected limits are never exceeded. The limits can be exceeded only with the two STEP direction pushbuttons "L" . If the pushbutton "STEP" is again depressed (position AUTO), then the SPM-16 again returns to frequencies within the limits.

4.4.4 TRANSFERRING THE FREQUENCY SETTING TO THE MEMORIES FOR f_{STEP} AND THE SWEEP LIMITS

If pushbutton "f" is held down and one of the pushbuttons under ENTRY AND DISPLAY [7] is depressed, then the currently selected frequency can be transferred directly to the memories for f_{STEP} and the sweep limits.

This type of frequency setting is particularly advantageous for measurement of harmonic frequencies or for narrow band sweep frequency operation (with center frequency setting), if the basic frequency or the center frequency (after tuning to the maximum level) has a large number of digits and is an odd number (see section 4.13).

Example: Measurement of harmonic frequencies
(tuning to n · basic frequency).

- Tune the SPM-16 to the basic frequency.
- Hold down the pushbutton "f" and depress pushbutton "f_{STEP}"
- Tune to the 2nd, 3rd, ... harmonic frequency by depressing the direction pushbutton ⇧ the appropriate number of times.

The functions search, TRACK, and sweep are described in sections (4.11 to 4.13).

4.5 AUTOMATIC LEVEL CALIBRATION "AUTO CAL"

The Level Meter SPM-16 has an automatic level calibration circuit which makes manual calibration unnecessary. It guarantees a high measuring accuracy over the whole frequency range, a noticeable reduction in the measuring times, and high long-term stability.

The automatic level calibration circuit is switched on if the red LED above pushbutton "AUTO CAL" is not lit.

Calibration is carried out after any parameter change which could result in an error in the level display, for example:

- after switching on
- after a frequency change of more than 10 % for frequencies < 10 MHz or 1 % for frequencies $\geqq 10$ MHz.
- after switching the bandwidth, the operating mode analog/digital, the meter scale range 1-(20)-80 dB, or the measuring mode absolute/relative (analog measurement).

If no parameters are changed, for example during continuous monitoring, calibration is carried out every two minutes. In selective mode, the calibration frequency is always equal to the frequency to which the meter is tuned (frequency display D), thus the frequency response of the SPM-16 is virtually eliminated. In the "wide-band" position of the Level Meter, calibration is always carried out at 10 MHz.

A black bar and the letters CAL are displayed at the upper left corner of the level display during calibration.

For measuring tasks where the automatic calibration cycle would result in interference, the automatic level calibration circuit can be switched off by depressing pushbutton "AUTO CAL" ; this applies, for example, to measurements with the built-in demodulator. No calibration is carried out during search or sweep frequency operations.

Depression of pushbutton "AUTO CAL" causes the red LED (CAL OFF) to light. Depressing the pushbutton again immediately initiates a calibration operation and switches off the LED; then the SPM-16 operates again in the AUTO CAL mode.

Remarks: With the internal program configuration of the instrument the design has already taken into account that unnecessary switching processes of the HF calibrated attenuator ought to be avoided in order to prevent premature wear.

The user can likewise take this into account through his own meaasuring or program runs, and for instance for overview measurements that have frequent changes of frequency, the calibrator [:] could be switched off.

4.6 SELECTION OF THE OPERATING MODE ANALOG/DIGITAL "ANLG/DGTL"

Analog or digital level display can be selected with the two pushbuttons "ANLG", "DGTL". One of the two LED's above the pushbuttons is always lit. Analog level display is advisable for sweep, search, and TRACK operations or if the demodulator is used.

During analog level measurements, the measuring range can be selected manually or automatically after depressing a pushbutton; for digital level measurements, adjustment of the attenuator is always carried out automatically.

Automatic range setting during selected measurements is always executed with an automatic overload check of the wide-band section. The principle used here has the advantage that measurements are always carried out at the optimum settings of the SPM-16, thus achieving the maximum measuring accuracy. The changeover switch "low noise/low distortion", which previously often caused confusion, is no longer required.

4.6.1 DIGITAL LEVEL MEASUREMENT

Depression of the pushbutton "DGTL" switches off the meter B and the result of measurement is displayed in the digital level display A as follows:

4 digits (resolution 0.1 dB)
for wide-band measurments
for selective measurements with fast display (LED beside pushbutton "AVRG" is off).

5 digits (resolution 0.01 dB)
for selective measurements with slow display (LED beside pushbutton "AVRG" is on).

Input levels which cause major deviation of the display, for example due to superimposed interference signals or insufficient displacement from the intrinsic noise, are always displayed with a resolution of 0.1 dB, even if display averaging is switched on (see also section 4.6.4). The following parameters can be displayed or stored by depressing the pushbuttons on DISPLAY control panel [3]:

4.6.1.1 Absolute Voltage or Power Level "ABS"

Depression of the pushbutton "ABS" causes the absolute value of the signal at the input to be measured and displayed. The required calibration voltage level (dB) or power level (dBm) must be selected with the slide switch [46] on the rear of the unit before switching on the STMS.

The required calibration can also be selected via the keyboard [12].

dB calibration:	"MEM"	9900	"RCL"
dBm calibration	"MEM"	9901	"RCL"

the basic setting after the SPM-16 has been switched on, however, is always according to the position of the slide switch [46].

4.6.1.2 Level Difference

For measurement of the frequency response or of harmonic frequencies, the level referred to a reference value is more interesting to the user than the absolute level. For these measurements, the absolute value is first determined as described in section 4.6.1.1 and then stored as the reference value. This is done by depressing pushbuttons "ABS" and "REF" simultaneously.

Note: The function AFC [5] should be switched off.

The new, stored reference level is now displayed in display A with a resolution of 0.01 dB. To display the reference level, simply depress the pushbutton "REF".

Up to 11 different reference levels (e.g. intrinsic frequency response of a comparison device) can be stored with the MEM function (see section 4.22).

Any required reference levels can be programmed if the SPM-16 is used together with a computer.

Depression of the pushbutton "ABS-REF" causes the difference between the measured level (absolute value) and the reference level stored as described in section 4.6.1.2 to be displayed in dB. The resolution of the display depends on the conditions mentioned in section 4.6.1.

4.6.1.3 Reduced Level

In telecommunications technology, levels are often not specified as absolute values, but as values referred to the relative level of a test point. To simplify evaluation of such levels, the relative can be set between the limits

-99.9 and +20.0 dBr

The measured result is then displayed directly as a "reduced level" in dBm0 (dB0) if the pushbutton "dBm0" is depressed Any reference level can be entered instead of the relative level (dBr).

a) Display of the relative level
   The last relative level which was stored can be displayed by depressing pushbutton "dBr" once (left LED lights).

b) Input of the relative level (dBr)
   - Depress pushbutton "dBr" once or twice until both LED's above the pushbutton are lit.
   - Enter the required dBr level on the keyboard [12]. (Numerical value and units with sign)

     Positive values (+dBr) with pushbutton "MHz"
     Negative values (-dBr) with pushbutton "kHz"

Depression of the unit pushbutton transfers the new value to the memory (and the frequency display again appears).

Actuation of the pushbutton "dBm0" causes the level to be displayed, not as an absolute value, but referred to the stored (relative level) (dBr) as a reduced level in dBm0 or dB0.

The following relationship applies: a dBm0 + b (dBr) = (a + b) dBm

4.6.2 ANALOG LEVEL MEASUREMENT

Depression of the pushbutton "ANLG" switches off the digital level display and switches on the analog meter. The digital display A now shows the measuring range, i.e. the level value for the 0 dB mark of the meter which can be switched, according to the selected scale [10], in

1 dB steps for the 1 dB scale or
5 dB steps for the 20 dB and 80 dB scales.

Result of measurement = digital display (measuring range) + meter reading (scale value).

4.6.2.1 Measuring Range Selection

The measuring range is selected

a) manually via the measuring range switch [9] or
b) automatically through the depressing of pushbutton "AUTO SET"

In the case of manual selection (input of the measuring range for sweep operations or the level threshold for search operations), select a measuring range so that measurements are carried out at the upper end of the 20 dB scale (for accuracy reasons).

If automatic range selection is activated by depressing pushbutton "AUTO SET" once, the measuring range is always set so that the meter indication is to the left of the 0 dB mark.

The advantage of this lies in the simple addition of two negative values (measuring range and analog value) in most applications.

Maximum extent of the measuring range:

for the 1 dB scale : +10 dB (+20 dBm) ... -120 dB (-110 dBm)
for the 20 dB scale: +10 dB (+20 dBm) ... -120 dB (-110 dBm)
for the 80 dB scale: +10 dB (+20 dBm) ... -40 dB (-30 dBm)

Note: If, when the 80 dB scale is selected or when the unit is switched from the coaxial to the balanced input, a direction arrow appears ⇧ in the measuring range display for the most sensitive measuring range (see section 4.6.3), turn rotary switch [9] anticlockwise (against the direction of the arrow) or depress the pushbutton "AUTO SET". If the arrow appears in the 1 dB range, turn the rotary switch anticlockwise and then clockwise again or depress a function key.

4.6.2.2 Scale range

Three scale ranges are available for level display. The desired range is selected by one of the three pushbuttons "1 dB" "20 dB" "80 dB"; at the same time, the LED for the appropriate scale in the meter is lit (see Figure 4-3).

The scales span the following values:

1 dB scale: -1.5 ... +0.3 dB
Used for measurement of single, discrete signals with maximum accuracy or for measurement of small level differences.

20 dB scale: -20 ... +2 dB
Used for general measurements, for noise measurements, during search, or TRACK operations, or for distortion measurements.

80 dB scale: -80 ... +0 dB
Used for overview and sweep frequency measurements with large level differences.

The bottom scale on the meter is used for measurement of phase jitter (see section 4.9) in analog mode. The range extends from 0.3 to 30° and is logarithmically divided to provide maximum resolution for small jitter value readings.

LED's for

Level reading:
expanded (20 Gl 84)
normal 20 dB (20 Gl 85)
normal 80 dB (20 Gl 86)
Phase jitter reading
(20 Gl 87)

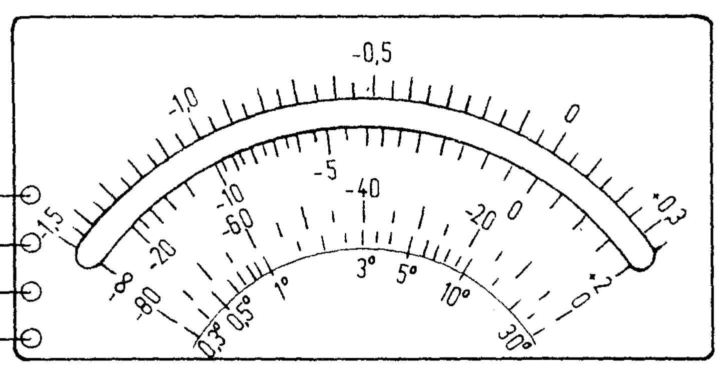


Figure 4-3 Meter scale of the SPM-16

4.6.2.3 Fast Signal Detector

The LED alongside the meter is used as a tuning aid for rapid location of unknown signals when tuning manually in 1 dB or 20 dB scale range.

If the frequency of the Level Meter is changed rapidly with knob [14], see section 4.4.2, the signal detector with the LED reacts more rapidly than the relatively slow analog meter. The LED lights as soon as a signal whose level would result in a deflection outside the scales marked -15 dB or -1.2 dB is present at the receiver input.

In search mode (see section 4.12), illumination of the LED is also used as a criterion for automatic stopping of automatic frequency tuning.

Note: 1) In the more sensitive measuring ranges, the LED may also light at a scale indication < -15 dB, according to the selected bandwidth, because the peak evaluation of the signal detector can permit single noise spikes in the receiver noise to illuminate the LED. This can be prevented by selecting a narrower bandwidth.

2) If the 80 dB scale is selected, the LED lights continuously.

4.6.3 DIRECTION ARROWS IN THE LEVEL DISPLAY

Direction arrows in the level display (Figure 4-4) signal an intolerable measuring range in analog mode and an intolerable result in the digital mode; in digital mode, they also indicate that the level at the meter input is higher ↑ or lower ↓ than the currently displayed level, as the result of a level hit during measurement.

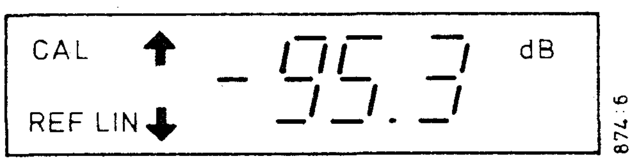


Figure 4-4 Direction arrows in the level display

The direction arrows disappear

In analog mode: in the 20 or 80 dB scale by depressing the pushbutton "AUTO SET" or turning the measuring range switch

[9] one position anticlockwise (against the direction of the arrow).
In the 1 dB scale, by turning the range switch [9] one position anticlockwise and then clockwise again or by depressing a function key in display panel [3] (the direction arrow indicates that the display expander is not measuring a signal).

Digital mode: after one further measurement.

4.6.4 NOISE AVERAGING "AVRG"

Level measurements are normally carried out with noise averaging switched off (LED off). When signals with overlaid noise or the basic noise of a system is measured, the display would be unstable. Thereupon, noise averaging is switched on by the depressing of the pushbutton "AVRG" (LED lights). So the measured value is averaged over a longer period, wherein the digital mode implements formation of the average value from a number of single measurements.

In digital mode, with selected measurements, and with noise averaging on, the resolution is 0.01 dB. If the signal-to-noise ratio is too low or if the signal fluctuates, the display automatically switches to a resolution of 0.1 dB. Wide-band measurements are always carried out with a resolution of 0.1 dB.

4.7 BANDWIDTH

4.7.1 WIDE-BAND SECTION

The Level Meter SPM-16 operates in the frequency range 10 kHz to 160 MHz as a wide-band receiver if the bandwidth switch, [16], is set to the position "WIDE". This mode makes it possible, for example, to measure the wide- band loading level, i.e. the baseband load, in all CF systems with 12 to 10800 channels. Due to the rectifier characteristic, a noise signal like the loading level of CF systems actually carrying traffic, like thermal noise, or like intermodulation noise results in a meter reading of practically the same effective value as for a sinusoidal signal.

The measured level can be displayed in either analog or digital form. In the case of digital display, the resolution is 0.1 dB.

4.7.2 SELECTIVE SECTION

The SPM-16 can be set to five different bandwidths. Typical selectivity curves of the Selective Level Meter are shown in section 5.1. Depending on the application, one of the following bandwidths is selected with the bandwidth switch, [16]:

Bandwidth 25 Hz
The narrowband filter is used mainly for analysis of signal components which are closely spaced, for example for measurement of group or super-group pilot frequencies, or to discriminate against excessive noise at the input.

Bandwidth 400 Hz
This bandwidth is used for sensitive measurements, for analysis of adjacent signals, and to block noise.

Bandwidth 1.74 kHz
This bandwidth permits weighted noise measurements in accordance with CCITT in the voice-grade channels of the CF transmission band.

Bandwidth 3.1 kHz
The bandwidth of this filter corresponds to the width of a telephone channel. It has a very low ripple in the pass-band and has steep skirts at the limits of the band. It is used for measurement of the unweighted noise and of the power in single voice channels and is automatically selected if demodulation of single sideband signals is activated (see section 4.8). It is also possible to measure impulsive noise in carrier frequency speech channels if an external unit (e.g. DLM-3) is connected to the demodulator output [21] (see section 4.8).

Bandwidth 48 kHz
This permits measuring the power in a 48 kHz bandwidth.

As the final intermediate frequency of the Level Meter is 10 kHz, this bandwidth is realized by rapidly sweeping the SPM-16, with the bandwidth set to 3.1 kHz, around the selected frequency, within a bandwidth of 48 kHz, and with integration of the measured values. The function "SWEEP" is thus automatically switched on when the 48 kHz bandwidth is selected. Sweep measurements are therefore not possible with this bandwidth; however, the two directional "STEP" pushbuttons "L" for measurements with constant frequency increments can still be used (the function "AUTO STEP" cannot be switched in).

4.8 DEMODULATOR

The built-in measuring demodulator of the Level Meter SPM-16 permits demodulation of received signals which have been modulated with a single sideband. An important characteristic of the demodulator is its wide dynamic range of approx. 65 dB.

The demodulator is activated with the switch [16], in the two positions . The 3.1 kHz bandwidth is always active for these measurements. In addition, the analog mode must be selected. The demodulated received signal is available at output socket [21] with an output impedance of 600 Ω. The output level is approximately 0 dBm if the meter indicates 0 dB on the 20 dB scale and if the load impedance is 600 Ω. The intrinsic noise at the demodulator output is around -65 dBm, and the overload limit is approximately +10 dBm.

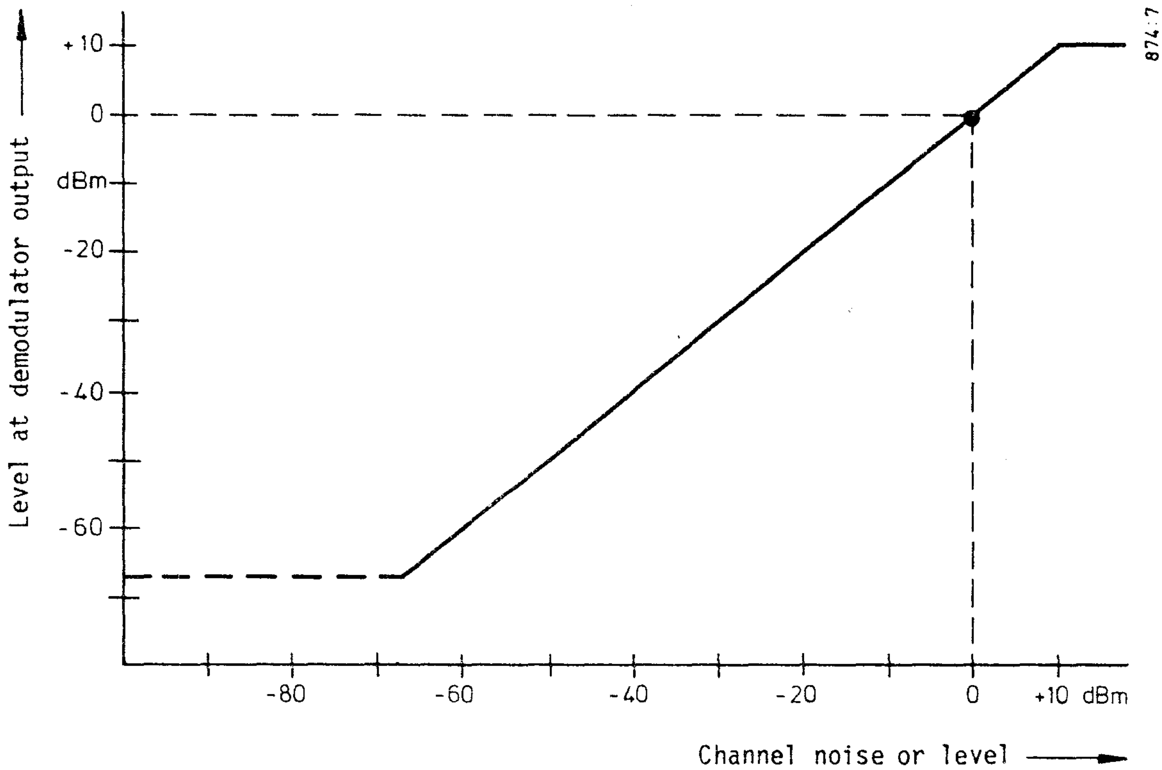


Figure 4-5 Dynamic range of the measuring demodulator
Relative Level -50 to +10 dBr.

If CF systems with up to 10800 channels are used, the best load is achieved if the relative level (dBr) is set to match the system access point and a measuring range of 0 dBm0 is selected. The dynamic range which can be handled by the SPM-16 is shown in Figure 4-5.

Switch [16] permits selection of

= demodulation of the lower sideband (inverted position) and

= demodulation of the upper sideband (upright position).

The center frequency of the band is converted to 2 kHz when tuning is to the midchannel. If the level meter was previously tuned to the suppressed carrier, it must be detuned for correct demodulation, namely by -2 kHz for and by +2 kHz for . With a bandwidth of 3.1 kHz, this results in a demodulated audio frequency band of 450 Hz to 3.55 kHz.

The demodulated input signal can also be monitored with the built-in loudspeaker. The volume of the loudspeaker can be adjusted with potentiometer [20].

The automatic level calibration circuit can be switched off with pushbutton "AUTO CAL" if the short interruptions of the signal cause interference during the measurements (e.g. interruption measurements).

Additional instruments such as interruption meters and impulsive noise counters can be connected to the demodulator output [21] for further processing of the converted signal. The Data Line Test Set DLM-3 from Wandel & Goltermann is suitable for both of the above tasks.

For interruption measurements in accordance with CCITT 0.61, the Selective Level Meter is tuned to the frequency of the carrier frequency test signal and the resulting 2 kHz signal from the demodulator is extracted at output [21]. The automatic level calibration circuit must be switched off.

Owing to the wide dynamic range of the measuring demodulator and to the flat 3.1 kHz filter, the Level Meter is particularly suitable for translating carrier frequency telephone channels into the AF range. In order to avoid measurement errors, particular efforts were made to ensure that all modules which participate in translation reproduce the characteristics of CF channel translators as closely as possible. For this reason, the SPM-16 can be used with an external counter in accordance with CCITT 0.71 for impulsive noise measurements over the whole frequency range of the Level Meter.

The crystal controlled frequency tuning permits precise counting of events over long periods.

4.9 PHASE JITTER MEASUREMENTS

Phase jitter measurements with digital or analog display can be carried out in order to assess the transmission qualities of telephone circuits used for data communications.

4.9.1 CAUSES AND EFFECTS OF PHASE JITTER

Phase jitter on data circuits routed over carrier frequency channels results mainly from unwanted phase modulation of the carrier signals participating in the frequency conversion on the transmit and receive sides. Interference components such as the audio frequency ringing signal or harmonics of the mains frequency are the sources of the phase modulating signals. The intrinsic channel noise also has a certain effect in creating phase jitter. Phase jitter changes the zero crossings of the data signal and can result in erroneous bits on the receive side after regeneration of the signal.

This makes it necessary to check data circuits to ensure that their phase jitter values lie within specific maximum limits. In addition to national PTT Administrations, which have issued regulations governing this impairment, the CCITT also specifies maximum values.

4.9.2 SETTINGS ON THE LEVEL METER

For measurement of phase jitter in the frequency range 10 kHz to 160 MHz, switch [16] is used to select the position Φ_{pp}, and the appropriate operating mode [4] analog "ANLG" or "DGTL" is selected. The bandwidth of 3.1 kHz is automatically selected. The weighting filter and the rectifier characteristics for measurement of the peak-to-peak value comply with CCITT recommendation 0.91.

For measurement, the signal level should be $\geqq$-50 dBm (-60 dB). If the signal is too low or is not present, the SPM-16 produces an

Error Annunciation

for analog display: by full-scale deflection of the meter and by switching off the signal detector C.

for digital display: by a warning arrow ↑ in the level display and a jitter indication of 30.0°.

Tuning

of the receiver depends on the measuring task assigned to it, the following applications being possible:

a) Measurements of a single tone or in a carrier frequency voice channel in a system, in the vicinity of which no signals (adjacent channels, pilot frequencies, dialling tones) exist except for the test tones. In this case, the meter is tuned to the tone to be measured.

b) Measurements in an unoccupied CF channel.
In this case, the SPM-16 should be tuned precisely to the center of the channel. The frequency position of the measured signal within the 3.1 kHz bandwidth has no effect on the measurements.

Display

of the result is either on the logarithmically divided lower scale of the meter or on the digital display, with an indication range of 0.3 to 30°.

The resolution of the digital display is

for phase jitter values $\Phi_{pp} \leqq 4°$: 0.1°
for phase jitter values $4° < \Phi_{pp} \leqq 10°$: 0.2°
for phase jitter values $10° < \Phi_{pp} \leqq 30°$: 0.5°.

The minimum indicated digital value is 0.3°. The intrinsic jitter of the level meter is typically 0.3°.

For external processing of the phase jitter result, the Y-voltage output [22], see section 4.14, can be used for driving a strip recorder.

4.10 AUTOMATIC FREQUENCY CONTROL "AFC"

The AFC serves for automatically tuning the synthesizer to input signals whose frequencies are unstable. It can also be used as a tuning aid for input signals whose frequency is not precisely known. In order to permit AFC to function correctly in the case of selective measurement with bandwidths of 25 Hz to 3.1 kHz, the SPM-16 should first be tuned in analog mode until there is a meter indication on the 1 dB or

20 dB scale. After this, the AFC is switched on by depressing the pushbutton "AFC", causing the synthesizer to tune itself precisely to the signal frequency and the level indication to reach the maximum value.

In the operating mode SEARCH - see section 4.12 - the AFC is switched on automatically when an input signal (single signal or single spectral line) appears within the pass-band of the the IF filter (capture range).

The AFC is also active in the digital mode.

If the signal is missing or noisy, the AFC switches itself off, and the LED above pushbutton [5] starts to flash.

Although the capture range of the AFC is restricted to the nominal bandwidth of the selected filter, the lock range extends over the whole frequency range of the Level Meter. If the signal frequency changes slowly, then the frequency display will change accordingly. In this case, the Level Meter acts as a F R E Q U E N C Y C O U N T E R.

4.11 TRACK MODE

4.11.1 APPLICATIONS

In this mode, the SPM-16 can be used as a tracking receiver for selective, automatic end-to-end measurement without any additional connection for frequency synchronization. Measurement is carried out in CF systems in the gaps between the contiguous groups, which means that the system can remain carrying traffic, in contrast to end-to-end sweep frequency measurements with a wide-band receiver (see Figure 4-6). A prerequisite for execution of this measurement is that a level generator with a similar frequency generation system and facilities for storage of a specific number of fixed frequencies is available (e.g. PS-19, PS-6/60 with OD-600/ODF-601 or PS-8/PS-12 with OD-4/OD-12 and ODF-601). The fixed frequencies correspond to the CCITT recommendation for gap frequencies (additional measuring frequencies).

If the generator and receiver are programmed with identical frequencies (see section 4.22.3), measurement is started by initiating sequential, cycling transmission of the various frequencies from the level generator (with soft level blanking), while the SPM-16 in the

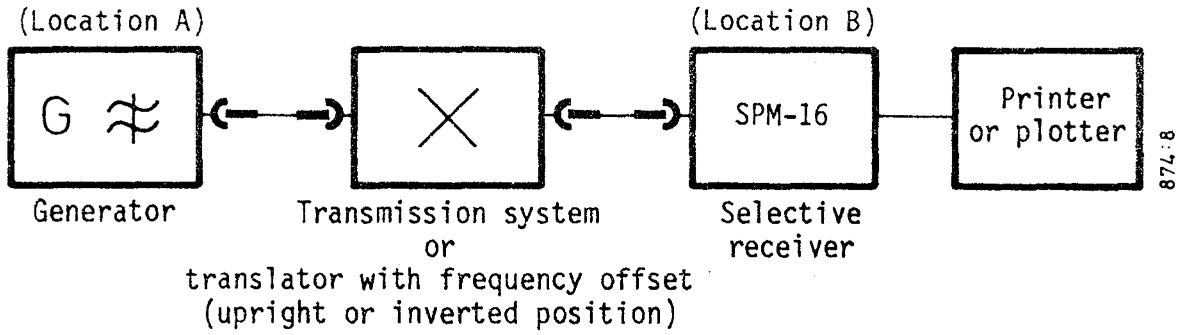


Figure 4-6 Receiver tracking

position TRACK waits at one of the fixed frequencies, f_n. When the generator frequency $f_s = f_n$, the SPM-16 indicates a level on the analog meter during the dwell time at this frequency. When the generator switches to the next frequency, the level indication disappears and the LED of the signal detector C is switched off. The extinguishment of the LED causes the SPM-16 to switch to the next higher or lower fixed frequency, according to the program. The generator and the receiver are now synchronized. A plotter with pen lift function (SPM-16, series B or later) can be connected to the X-Y output [22] [23] or a printer with V.24/V.28 interface can be connected to the printer interface (Auxiliary device for SPM-16, series B or later) for recording the measured values.

For measurements on translators (channel, group translators, etc.), the generator and receiver frequencies can be programmed with any required fixed offset frequency in the upright or inverted position.

4.11.2 SETTINGS ON THE LEVEL METER

- Enter the fixed frequencies with
  - a) Push button "MEM" (see section 4.22.3) or
  - b) Pushbuttons "f_{START}", "f_{STOP}", "f_{STEP}" (see section 4.4.3) (frequency stepping with equal increments).
- Tune the Level Meter to the starting frequency, which can also be f_{STOP} for measurements in the inverted position.
- Select analog mode and the 20 dB scale.
- Set the measuring range switch [9] to the expected level (≅ approximately full-scale deflection).

- Further settings:

STEP TIME/s Generator	Receiver	CAL [1]	AVRG [11]
0.3	0.1	OFF	OFF
1	0.3	ON/OFF	OFF
3	1	ON/OFF	ON/OFF

The switching rate of the generator must be matched to the settling time of the generated level and of the unit being tested, to the settling time of the receiver, and perhaps to the time required for a connected printer to print the results.

- Activate the function "TRACK" by depressing the pushbutton "STEP" once. The Level Meter now waits for the first frequency.

The DC voltage present at the X-output [23] is proportional to the frequency within the start and stop frequency limits.

Open circuit voltage at f_{START} .... -2.5 V

f_{STOP} .... +2.5 V

Open circuit voltage per frequency step $f_{STEP} = 5\ V \cdot \frac{f_{STEP}}{f_{STOP} - f_{START}}$

The DC voltage present at the Y-output [22] is proportional to the meter reading. The open circuit voltage for full-scale deflection is +5 V.

4.12 SEARCH

The function "SEARCH" permits automatic searching for signals of unknown frequencies which lie above a preset level threshold, such as single interference lines or excessively high levels (hot tones) in communications systems.

The level threshold is set in the analog mode with the measuring range switch [9], normally in the 20 dB scale range. As the search stops when the signal detector (LED C) lights, the lower reaction threshold of the signal detector must be taken into account for correct selection of the measuring range. The reaction threshold is as follows for the various scales:

1 dB scale: approximately -1.2 dB
20 dB scale: approximately -15 dB
80 dB scale: at approximately -40 dB (LED lights continuously)

Setting example for the level threshold:

Level values > -80 dB should be searched for in the 20 dB scale range. Set the measuring range to (-80 +15) dB = -65 dB.

In the case of low input levels in the vicinity of the intrinsic noise of the Level Meter, it is recommended to select a narrow bandwidth. Otherwise single noise spikes could cause the signal detector to react and block the search operation (see section 4.6.2.3).

Search operation is possible with the bandwidths 25 Hz to 3.1 kHz. The search speed is matched optimally to the selected bandwidth, as shown in the following table. When the 80 dB scale is switched in, the search speed is lower.

Bandwidth	3.1 kHz	1.74 kHz	400 Hz	25 Hz
Search speed	1 MHz/s	250 kHz/s	20 kHz/s	200 Hz/s

Calibration is carried out in accordance with the criteria specified in section 4.5.

Two different operating modes can be selected, these are described in more detail in sections 4.12.1 and 4.12.2.

4.12.1 SINGLE SEARCH (FULL RANGE) "SEARCH"

In this mode, the search function is executed over the whole frequency range, independent from the stored frequency limits f_{START} and f_{STOP}. It is recommended, particularly for slow search speeds (narrow bandwidths), that a starting frequency be set up by depressing pushbutton "f" or "f_{START}" and entering the frequency via the keyboard [12]. After the level threshold has been set (see section 4.12), the search is started by depressing one of the SEARCH directional pushbuttons "F" . As soon as the signal detector (LED C) lights, the search function stops. At the same time, the AFC [5] is switched on (section 4.10) and tunes the Level Meter precisely to the single tone or to a discrete spectral line at the meter input.

The search can be restarted at any time by depressing one of the two SEARCH directional pushbuttons "F".

If the input signal is not present or if the measuring range is not sensitive enough, the search function stops at the frequency band limits. The search can be halted at any time by depressing one of the pushbuttons "MHz", "kHz", "MAN".

4.12.2 CONTINUOUS SEARCH OPTIMUM

In position OPTimum of the SWEEPTIME changeover switch [17], the search is carried out within the frequency limits specified with f_{START} and f_{STOP}. It is also possible to have the STMS periodically search for excessively high signal levels, with simultaneous evaluation (printout of level and frequency with SPM-16, series B or later). This permits automatic system monitoring.

Settings on the SPM-16:

- Enter the start and stop frequencies (f_{START}, f_{STOP}) as described in section 4.4.3.2.
- Select analog mode
- Select the bandwidth and level threshold as described in section 4.12.
- Select the position "OPT" with changeover switch [17].
- Depress one of the pushbuttons "SWEEP"
  "SWEEP"  for periodic search
  "SWEEP"  for single search
  Select the starting frequency f_{START} or f_{STOP}.

The search can be halted at any time by one of the pushbuttons "MHz", "kHz", "MAN".

A plotter can be connected to the X-Y outputs [22], [23] for recording the interference lines.

In the Level Meter SPM-16, series B or later, an Auxiliary Device, a printer interface, can be fitted, and which permits the connection of printers with V.24/V.28 interfaces. Thereupon, the level and frequency values can be printed, followed by an automatic restart of the search operation.

4.13 SWEEP MODE

Sweep frequency measurements in the analog mode are permitted on test objects having characteristics with extremely steep flanks. The excellent synthesizer properties, like high spectral purity and phase continuity when the frequency changes, allow use of the sweep mode. Figure 4-7 shows the configuration and interconnections of a sweep frequency test set-up with the Generator Section PSS-16 and Display Unit SG-2/SG-3. Operation and calibration of the Display Unit are described in the description and operating manual for the SG-2/SG-3.

The frequency is set digitally with an increment which depends on the sweep range and the deflection time. The microprocessor calculates the increment, taking into account that the frequency is stepped every 60 µs.

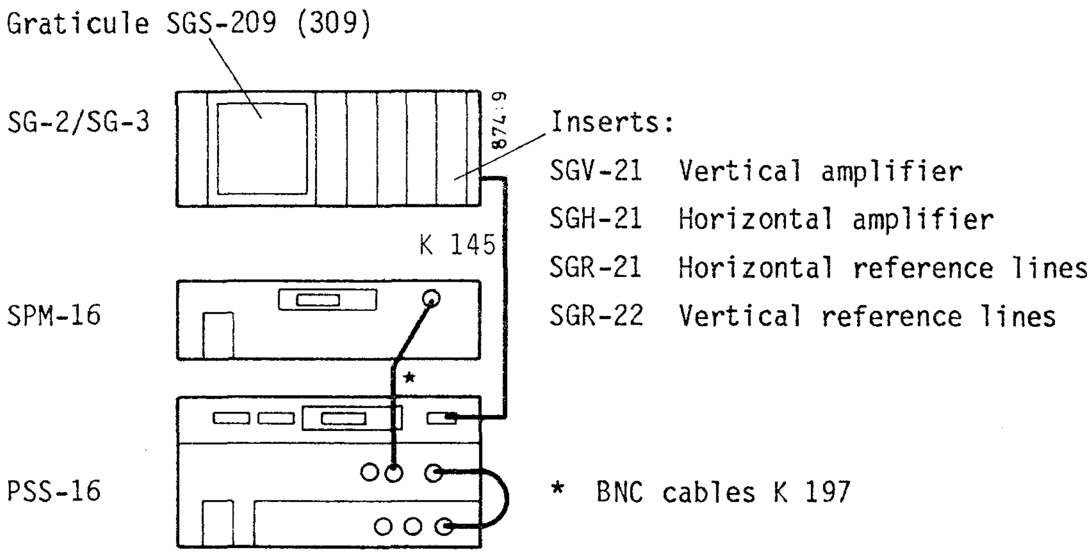


Figure 4-7 Configuration and interconnections of the sweep frequency measuring set-up (rear view)

4.13.1 SETTING UP THE SWEEP LIMITS

This depends on the application.
For wideband test objects, it is advantageous to enter
f_{START} = lower (upper) sweep limit and
f_{STOP} = upper (lower) sweep limit
via the keyboard [12] (see section 4.4.1).

For narrow band test objects,

f_{CENT} = center frequency and
Δf = sweep width (f_{STOP} - f_{START})
are entered (see section 4.4.1).

Example: f_{CENT} = 10 MHz, Δf = 10 kHz

Input: "f_{CENT}" 10 "MHz" "Δf" 10 "kHz"

After depression of the pushbuttons "f_{START}" and "f_{STOP}" , the sweep limits (in this example 9.995 and 10.005 MHz) are displayed in the frequency display D.

Note: A frequency appearing in the frequency display D and assigned to the pushbutton "f" can be transferred to the memories for the parameters in the input panel [7] if pushbutton "f" is held down and one of the pushbuttons in panel [7] is depressed. A typical application of this is measurement of the test objects with extremely noticeable resonance points, as with with crystal filters. (See also section 4.4.4). In this case the SPM-16 is tuned continuously with pushbutton "MAN" to a maximum level indication, and sweep frequency operation is then carried out with center frequency and sweep width settings.

4.13.2 SWEEP SEQUENCE AND SWEEP TIME

The two pushbuttons "SWEEP" permit selection of

"SWEEP"  periodic, triangular sweep

"SWEEP"  single sweep

If the pushbutton whose function is currently active is depressed momentarily during sweep frequency operation, the direction of sweep is reversed.

Sweep Time

is the elapsed time for one sweep. It can be set in the range between 0.1 and 300 s with the SWEEP TIME switch [17].

In the case of single sweep operation, the starting frequency is selected by depressing one of the pushbuttons "f_{START}" or "f_{STOP}", and the sweep is then started by depressing the pushbutton "SWEEP" .

Checking the settling time of the test object can be carried out either visually (the sweep-out and return traces of the swept curve must coincide) or by depressing the pushbutton "SWEEP" ⋀⋀. In the latter case, the deflection is stopped momentarily at regular intervals. If the test object has not settled correctly, this results in a staircase waveform of the sweep curve and the sweep time should be increased. Depression of the sweep pushbutton is particularly advantageous for slow sweep frequency measurements where the display unit screen persistence is not sufficient.

4.13.3 MANUAL SWEEP

In the position "MAN" of the SWEEP TIME switch [17], with one of the two "SWEEP" pushbuttons depressed, the frequency can be swept manually within the limits set as specified in section 4.13.1, using the knob [14]. The X-deflection voltage at output [23] is proportional to the sweep-width and its maximum values are ±2.5 V.

If the manual tuning knob is turned slowly, the frequency changes proportionally; if the knob is turned rapidly, the frequency change is accelerated non-proportionally. But the sweep limits are exactly kept.

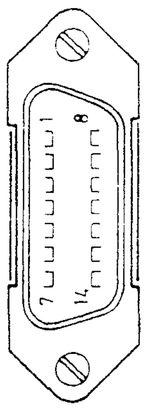
4.13.4 DISPLAY UNIT CONNECTION [42]

The Display Units SG-2 (screen size 120 mm x 85 mm) and SG-3 (screen size 210 mm x 150 mm) from Wandel & Goltermann are suitable for display of a sweep frequency curve.

The Display Unit should be connected via a suitable cable (e.g. K 145, see also Figure 4-7) to socket [42] on the rear side of the SPM-16. No further cable connections are necessary.

The X- and the Y-signals for horizontal and vertical deflection of the sweep curve are available at the Display Unit connector (see Figure 4-8 for pin assignments). The signals are equal to the DC voltages at the Y-output [22] (see section 4.14) and X-output [23] (see section 4.15).

The level values of the horizontal reference trace generated within the Display Unit can be displayed on the SPM-16 with series B, via connector [42]. Three horizontal reference lines (traces) can be set



Pin	Signal designation
4	Switch to reference trace voltage
5	Pen lift function H ≅ pen up
6	H ≅ pen down
9	X-deflection voltage
10	Y-deflection voltage
12	Measuring trace blanking
13	Y-reference trace voltage
14	Ground

Figure 4-8 Pin assignments of the Display Unit connector [42]

up in the Reference Trace Plug-in SGR-21 for measuring the sweep curve. The intensity of one trace can be increased with respect to that of the other two traces by depressing a pushbutton. At the same time, the meter reading of the Level Meter is switched from the received level to the reference trace level. A black bar and the test "REF.LIN." appear in the bottom left corner of the level display A. The display mode should be taken into account as described in section 4.6.2, when reading the level value.

The pen lift control (SPM-16, series B or later) simplifies operation of plotters connected to socket [42]. With suitably equipped plotters with TTL-control (e.g. HP 7015 B), this function ensures that the pen is lifted during setting up of the sweep conditions and is lowered onto the paper only when a single sweep is initiated.

The pin assignments of connector [42] are shown in Figure 4-8.

4.14 DC (Y-) OUTPUT [22]

A Y-deflection voltage which is proportional to the meter indication B is available at output [22], for example for driving a plotter. The open circuit voltage is +5 V for full scale deflection of the analog meter, with an internal resistance of 5 kΩ. This DC voltage is also available at the 14-pin socket [42] on the rear of the SPM-16 (see section 4.13.4).

4.15 DC (X-) OUTPUT [23]

The DC (X-) output [23] supplies a deflection voltage which is proportional to the frequency within the frequency limits f_{START} and f_{STOP}, for example for driving a plotter or a display unit.

Regardless of the selected range, the open circuit voltage is

at f_{START}: -2.5 V
at f_{STOP} : +2.5 V
with an output impedance of 5 kΩ.

This DC voltage is also available at the 14-pin socket [42] on the rear of the SPM-16 (see section 4.13.4).

4.16 10 kHz IF OUTPUT [43]

The last intermediate frequency (IF) of 10 kHz can be extracted at the output socket [43] on the rear of the unit. This output is suitable, amongst other things, for connection of plotters with AC inputs and of very selective analyzers.

The output frequency is always 10 kHz, even in wide-band mode.

At meter indication of 0 dB and with an output impedance of 600 Ω, the output level is -10 dB when terminated with a 600 Ω load.

4.17 REMOTE CONTROL OF THE LEVEL GENERATORS PS-16 AND PSS-16 (TRACKING GENERATOR OUTPUT)

The Level Meter SPM-16 can be combined with the above mentioned level generators to form a complete level measuring set.

If the Generator and Receiver are used at the same location, their frequencies can be tuned synchronously from the SPM-16. This operating mode, in which the Level Meter controls the Level Generator, provides considerable simplification of operations. For remote control of the Generator from the SPM-16, the control output [44] of the SPM-16 is connected by a coaxial cable to the control input of the Generator Section PSS-16. (See Figure 4-7). When this connection is established, the two units operate synchronously.

Output [44] can also be used as a constant level output for frequency response measurements in frequency range 10 kHz to 160 MHz. The output level is -15 dBm, and the output impedance is 75 Ω.

4.18 STANDARD FREQUENCY INPUT [51]

If the specified frequency accuracy of the SPM-16 is not sufficient for specific measuring tasks, an external standard frequency of 1, 2, 5, or 10 MHz can be connected to socket [51] on the rear of the unit to achieve a smaller error in the tuned frequency.

The necessary level with a sinusoidal input signal may lie between -10 and +10 dBm; for square-wave signals, the voltage V_{pp} may lie between 200 mV and 2 V (75 Ω input impedance).

4.19 DIGITAL INTERFACE [40] [41]

The Level Meter SPM-16 includes a digital, device-specific interface which is available externally via the two 24 pin parallel connection sockets [40] and [41] on the rear of the unit. Additional external devices can be connected to these sockets. The cable K 366 is suitable for connection. Address (2), data (8), and control (3) signals are transmitted across the interface.

4.20 COMPUTER CONTROL

All functions of the Level Meter SPM-16 can be controlled by an external controller. This makes it possible to include the Level Meter in automatic measuring systems where it can handle comprehensive measuring tasks not only accurately and reliably, but also rapidly and at low costs. Figure 4-9 shows the configuration of a simple automatic level measuring system, which is capable of further extension.

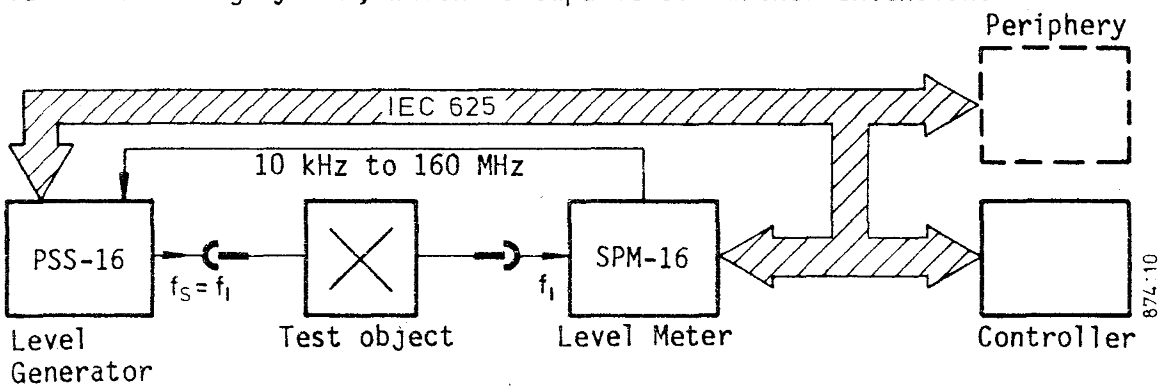


Figure 4-9 Block diagram of a simple automatic level measuring system.

The computer control is connected via the optional Interface Bus ⟨IEC 625⟩ Card, BN 853/02, which is inserted into the rear of the level meter. Connection to systems with IEEE 488 interfaces requires an additional adapter plug S 834. Subsequent installation of the interface board is described in chapter 6. The external control of the SPM-16 is signalled by indication of the red LED above pushbutton "LOCAL". As long as this LED is on, manual operation via keyboard input is blocked.

It is possible to switch to manual control with the computer connected by depressing the pushbutton "LOCAL"; this is done in accordance with conditions specified in the IEC bus standard (remote/local function RL1). Details of programming of the Level Meter can be found in the separate manual "Remote control and programming of the SPM-16".

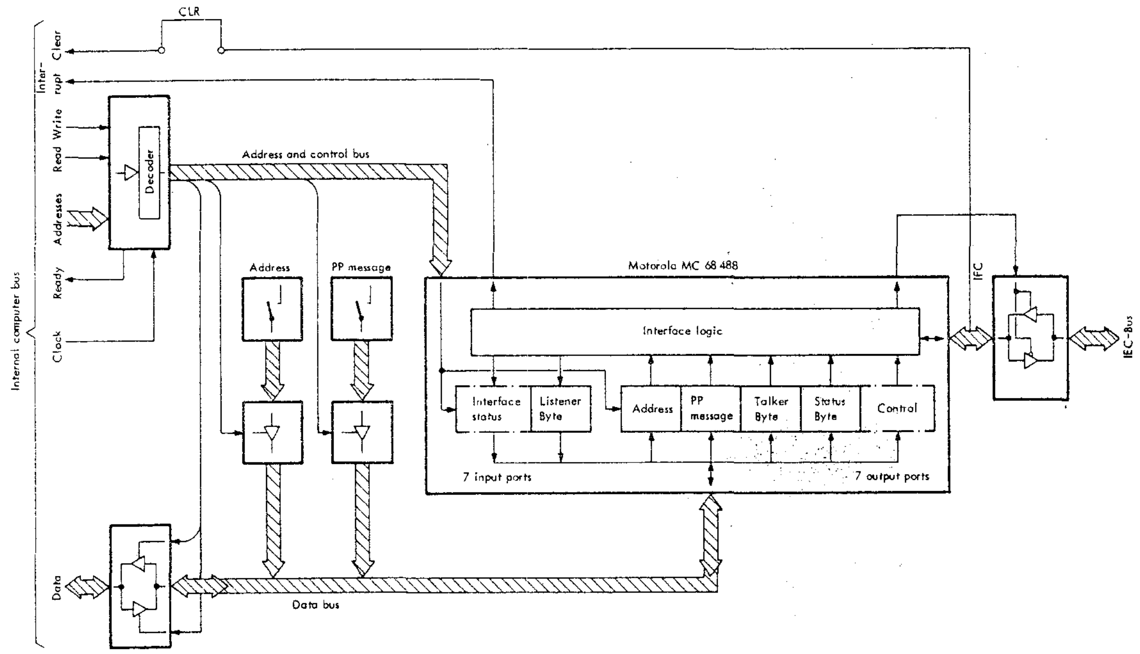


Figure 4-10 Block diagram of the interface Bus ⟨IEC 625⟩

4.20.1 INTERFACE BUS ⟨IEC 525⟩

Figure 4-10 shows the simplified block diagram of the Interface Bus ⟨IEC 625⟩. For better understanding of the following description of the Interface concept reference to the "Interface Bus ⟨IEC 625⟩" Brochure is recommended.

For the microprocessor, the Interface Bus ⟨IEC 525⟩ is nothing more than a group of input and output ports. Data are exchanged between the IEC bus and the Level Meter via these ports, and the exchange is controlled by the IEC bus program. The PROM's which contain this program are not located on the interface board but are within the Level Meter.

The actual interface logic is located in a single integrated circuit: On the one side the interface is connected to the IEC Bus via the required driver and receiver circuits, and on the other side the comb connector is connected for the I/O Bus of the microprocessor within the SPM-16. This interface logic handles a major part of the interface tasks independently, i.e. without using the microprocessor of the Level Meter. It automatically handles for example the IEC bus handshake cycle and decodes all messages which are transferred across the IEC Bus.

The interface statuses resulting from these messages are written into the appropriate input ports.

A further input port is used as a transfer register for listener data, representing data transferred from the IEC Bus to the Level Meter as long as the Level Meter is addressed as a listener, for example, when parameters for setting the SPM-16 are being transferred.

The output ports are used for:

- reception of control commands with which the microprocessor can affect the behavior of the interface logic (for example, in addition to a wide range of other possibilities, it can stop the handshake cycle or transmit a service request signal (SRQ) via the IEC Bus).
- transferring data which are to be transmitted from the Level Meter to the IEC bus, e.g. talker data and status information.
  Talker data are transmitted from the Level Meter to the IEC Bus as long as the Level Meter is operating as a talker, for example when the result of measurement is being transferred.
  The status information is the Level Meter's response to a serial poll and includes the current status.

  The Level Meter address can be set up on an address switch (see Fig. 6-2).

The "PP" switch (see Fig. 6-2) permits selection of the data circuit to the IEC Bus on which the Level Meter is to transmit its Request Service Signal (RQS) if the controller carries out a status request by a parallel poll operation.

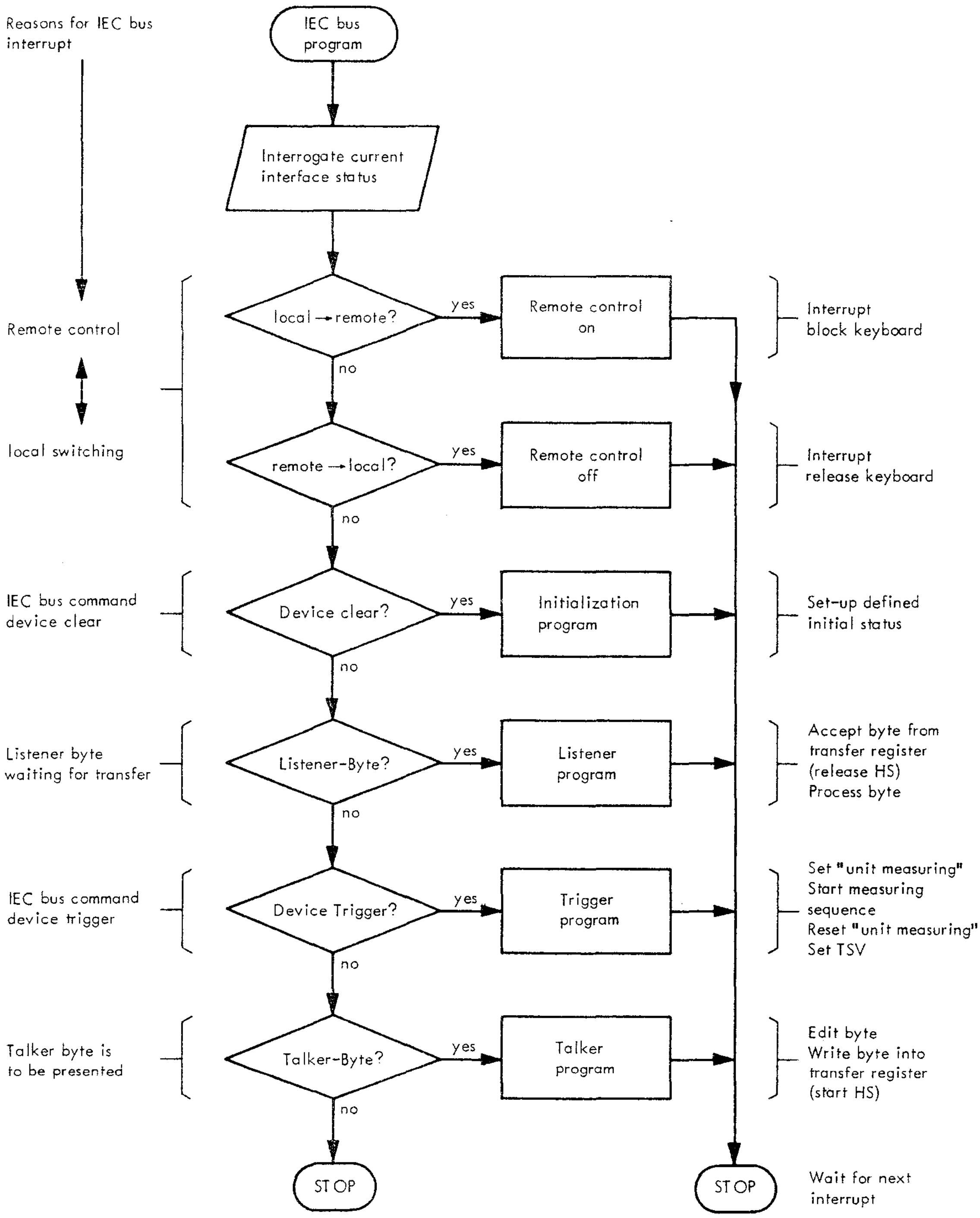
4.20.1.1 INTERACTION BETWEEN THE LEVEL METER AND THE INTERFACE BUS ⟨IEC 625⟩

When the IEC Bus has reached a status in which operation by the internal microprocessor is necessary, the IEC Bus interface transmits an interrupt signal to the Level Meter. As a result of this interrupt, the microprocessor then executes the IEC Bus program. This is always the case:

- if the Level Meter is to be switched from manual control (LOCAL) to remote control or from remote control to manual control.
- if listener data was transmitted across the IEC Bus. The interface logic has then written this data into the transfer register for listener data and stopped the handshake procedure. The handshake procedure remains interrupted until the microprocessor reads this byte (then NDAC transits to false i.e. data accepted). After processing and storage of the listener data, NRFD is false i.e. device ready for data can then be transmitted.
- if the Level Meter must provide a new talker byte. During writing of the new talker byte into the appropriate output port, the handshake procedure is started (DAV is true i.e. data are valid).
- if a measurement is to be initiated in the Level Meter by the IEC Bus command "device trigger (GET = Group Execute Trigger)". The interface logic has interrupted the handshake procedure and this procedure remains interrupted until the microprocessor has started the measurement and again releases the handshake procedure (NDAC is false and NRFD is false).
- if the Level Meter is to be set to a specified initial status by the IEC Bus command "device clear (DCL or SDC = Selected Device Clear)". Again, the interface logic interrupts the handshake cycle and it remains interrupted until the microprocessor has set the Level Meter to the initial state, when the handshake cycle is again released (NDAC is false and NRFD is false).

If the strap CLR is fitted on the interface board, the signal IFC (Interface Clear) causes the Level Meter to be initialized. This permits the Level Meter to be initialized at any time via the IEC Bus, even in the case of a lock-up situation. (This is important for devices in unmanned stations where a lock-up situation resulting from external interference cannot be cleared by switching the a.c. line voltage off and on again).

4.20.1.2 Structure of the Interface Bus ⟨IEC 625⟩ Program



4.20.2 BUS SPECIFICATION AND BUS PLUGS

Up to 15 devices can be interconnected in an IEC Bus compatible automatic measuring system. The devices are connected in parallel via the standard interface.

Each single device is connected to the Bus via a connection cable with a maximum length of 2 m. The total length of the bus must not exceed 20 m. Greater lengths can be implemented by means of interposed interface couplers (by a two-wire or four-wire connection) or modems.

The ISO 7-bit code or ASCII code is used on the interface and is transmitted bit parallel and byte serial.

The pin assignments of the bus plug on the Level Meter are shown in Figure 4-11. The most important difference between the ⟨IEC 625⟩ and the IEEE 488 interface is in the construction of the plug (IEC: 25 pin Cannon plug; IEEE: 24 pin Amphenol plug) and in the pin assignments. However, test equipment with IEC connections can be connected easily to the controllers with IEEE interfaces by using the adapter plug S 834 that is included with delivery of the interface board.

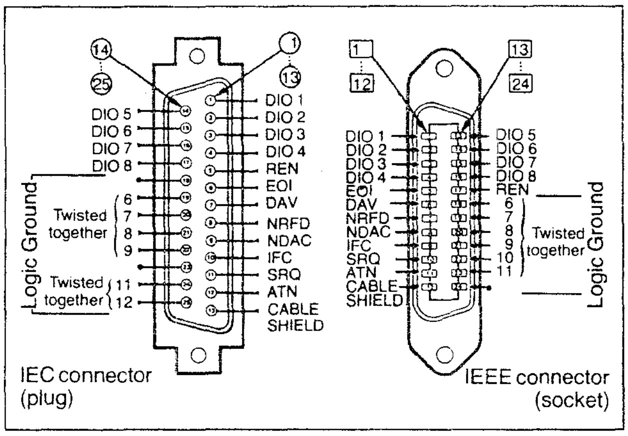


Figure 4-11 Pin assignments of the Bus connector on the Level Meter.

4.21 PRINTER CONNECTION

A printer interface BN 905/02 can be fitted in Selective Level Meter of series B and later for recording and documentation of the measured results on a printer. The interface is installed on the rear of the unit, instead of the Interface Bus ⟨IEC 625⟩ card, as described in chapter 6.

All printers with the CCITT V.24/V.28 interface can be connected.

Wandel & Goltermann recommends connection of the printer

TREND 800 RO 8

from the supplementary program. The technical data and the versions of this printer are available in a separate specification sheet.

Initiation of a printer operation can be carried out manually with pushbutton "LOCAL" or automatically after each measurement. The operating mode and the various print formats are selected on the keyboard [12]. Further details can be found in the operating instructions for the SPM-16, series B.

4.22 MEMORY FUNCTIONS "MEM"

A number of fixed frequencies and equipment settings can be stored and recalled later with the blue pushbutton "MEM". This permits rapid execution of measurements at frequently used frequencies and equipment settings. If the Level Meter is switched off, or if the mains supply fails, a built-in Ni-Cd battery provides the power supplied to the memories, retaining the data for approximately 4 weeks. If it is necessary to retain the parameters and data for longer periods, the EPROM module BN 874/00.01 can be fitted (see section 4.23). This module is programmed in accordance with the customer's specifications.

4.22.1 ADDRESS ORGANIZATION

Table 4-3 provides an overview of the addressable memory positions (address and program numbers) and their contents. As can be seen from this table, 100 fixed frequencies and 11 complete equipment settings can be programmed as required. The parameters and data are stored in a RAM and are not cleared when the unit is switched off (see section 4.22). They can be overwritten at any time with new entries.

In addition, a maximum of 100 further fixed frequencies and 40 equipment settings can be stored in accordance with the customer's specifications in an EPROM (see section 4.23.1). Numerical inputs of 1000 or greater are interpreted by the Level Meter as test program numbers for special measuring or operating modes, such as test programs, or operating programs for connected printers (series B or later).

The built-in test programs listed in Table 4-4 are stored at the address 115 or 119. After the appropriate address has been entered, the currently stored program number appears in the level display A as long as pushbutton "RCL" is depressed. When the pushbutton is released, the Level Meter executes the stored test program.

The Level Meter can be switched back to a normal test program by depressing one of the display pushbuttons (e.g. "ABS").

Address	Memory area	Contents (data)	Remarks
0 ... 99	RAM	Fixed frequencies	Freely programmable After bootstrapping load*: 0 kHz.
100 ... 110	RAM	Equipment settings (set-ups)	Freely programmable After initial program load*: standard set-up.
115	RAM	Printer programs	Input via program number as shown in Table 4-4.
119	RAM	Internal test programs	Input via program number as shown in Table 4-4.
200 ... 299	ROM	Fixed frequencies	Fixed, as specified by customer.
300 ... 339	ROM	Equipment Set-ups	Fixed, as specified by customer.

Table 4-3 Address Organization

Programm number	Memory area	Contents
5000 ...	ROM	Printer programs (see 4.2.1)
9001	RAM	Standard Setup
9900	ROM	Test program, dB calibration
9901	ROM	Test program, dBm calibration

Table 4-4 Program Numbers

*) Note: The program number 9000 (bootstrap load) should be used only when actually required (e.g. to clear the fixed frequency RAM), because the "Standard Setup" clears the contents of

addresses 0 to 99 and loads the contents of addresses 100 to 110 as specified in section 3.6. If the power supply for the RAM from the built-in Ni-Cd battery had been interrupted, for example during repair, it is recommended that address 9000 be also recalled or the pushbutton T below the upper case cover be depressed. (See section 3.6 and Figure 6-2).

If an attempt is made to store or recall fixed frequencies or equipment settings at false addresses, an error number (e.g. 2--001 ≅ false address number) appears in the frequency display D. The meanings of the error numbers are shown in Table 6-2.

4.22.2 THE FUNCTIONS STORE AND RECALL

Data and measuring parameters can be stored and recalled as required with the two pushbuttons "STO" and "RCL" on control panel [12]. After entry of the values, the following pushbuttons must be depressed:

Store: "MEM" address number "STO"

The LED above the pushbutton "MEM" blinks as long as the function key "STO" is not depressed. An error number appears if a false address is selected (see section 4.22.1).

Recall: "MEM" address number "RCL"

The LED above the pushbutton "MEM" blinks as long as the function pushbutton "RCL" is not depressed. An error number appears if a false address is selected (see section 4.22.1). After a successful recall, the MEM function remains active and further addresses can be entered via the keyboard [12] or the addresses can be stepped sequentially by depressing the two directional pushbuttons L. Automatic stepping is possible in the address ranges 0 to 99 and 200 to 299.

When the MEM function is active, the selected address number is displayed in the frequency display D as long as the pushbutton "RCL" is depressed.

4.22.3 STORING THE FIXED FREQUENCIES

Number: Up to 100 fixed frequencies
Address range: 0 ... 99 (see Table 4-3).

- Enter the required frequency on the keyboard (see section 4.4.1).
- Depress "MEM" (LED must light).
- Enter the required address on the keyboard [12]
- Depress "STO"
- Enter the next frequency.

If it is necessary to enter a large number of fixed frequencies in sequential addresses, remembering of the last address which was used can be avoided by using a different input procedure, as described below:

Enter first frequency - "MEM" - on - enter starting address - "STO" - "MEM" on - Step ⇧ - "MEM" off -

Enter second frequency - "MEM" on - "STO" - "MEM" on - Step ⇧ etc.

4.22.4 RECALLING ANY, SINGLE FIXED FREQUENCIES

from the address ranges 0 ... 99 and 200 ... 299
(with auxiliary device BN 874/00.01 only).
- Depress "MEM".
- Enter the required address (frequency) via the keyboard [12].
- Depress "RCL". The required fixed frequency appears in the frequency display.

As the MEM function remains active, further fixed frequencies can be recalled immediately simply by entering the address.

4.22.5 RECALLING A SEQUENCE OF FIXED FREQUENCIES

If measurements are to be carried out with several frequencies, which are stored as sequential addresses in the RAM, settings can be simplified considerably by manual or automatic recall.

a) Manual recall
   - Select the required starting address (frequency) as described in Section 4.22.4.

- The following fixed frequencies are then selected with the two STEP pushbuttons ⇧ ⇩. The function MEM remains active. The corresponding address number is displayed if the pushbutton "RCL" is depressed.

b) Automatic recall

In this mode, the start and stop addresses (frequencies) must be specified. Measurement is then always carried out within the preset limits. This mode is used, for example, for selective end-to-end line measurements (see section 4.11).

- Depress "MEM".
- Depress "f_{START}" and enter the start address on the keyboard [12][1].
- Depress "RCL".
- Depress "f_{STOP}" and enter the stop address via the keyboard [12].
- Depress "RCL".
- Set the STEP TIME with changeover switch [17].
- Depress "STEP" twice (LED "AUTO" must light).

Measurements are now carried out cyclically between the start and stop addresses. After each cycle, the STMS starts again at the start address. Depending on the settings, the frequencies are stepped in ascending or descending order of addresses. If the a.c.line power is interrupted and switched on again, the STMS switches back to the old operating state.

Switching Off

of the automatic address stepping: depress a function pushbutton such as "f" and depress pushbutton "MEM".

4.22.6 STORAGE OF EQUIPMENT SETTINGS (SET-UPS)

Number: up to 11 complete front panel set-ups.

Address range: 100 ... 110 (see Table 4-3)

---

1) If EPROM BN 874/00.01 (auxiliary device) is fitted, the error number 2--004 may be displayed at the transition from the ROM address range to the RAM address range (or vice versa). This will disappear as soon as a stop address is entered.

With the exception of the two functions[2] AUTO STEP and TRACK, all functions and parameters which can be selected on the front panel can be stored. Storage and recall is carried out as described in section 4.22.2:

- Input of the required parameters and data.
- Depress "MEM" (LED must light).
- Select the required memory position (address) on the keyboard [12].
- Depress "STO".
- Enter the next equipment setting.

4.22.7 RECALL OF EQUIPMENT SETTINGS (SET-UPS)

from the address ranges 100 ... 110 and 300 ... 339 (with Auxiliary Device BN 874/00.01) is carried out as described in section 4.22.2:
- Depress "MEM".
- Enter the required address (set-up) on keyboard [12].
- Depress "RCL".

As the MEM function remains active, further set-ups can be recalled by simply entering the address or with the aid of the two STEP direction pushbuttons "L" (see section 4.22.5 a) (see also remarks[2] under 4.22.6).

This facility has an interesting application for sweep frequency measurements. With the aid of the STEP direction pushbuttons L, it is possible to display in consecutive order the overall selectivity and the pass-band of a filter on the screen of a display unit.

4.23 FIXED VALUES MEMORY (AUXILIARY DEVICE) BN 874/00.01

The memory module permits the additional storage of up to 100 fixed frequencies and 40 complete front panel settings. The required frequency values and equipment set-ups should be specified when ordering auxiliary device BN 874/00.01 in order to avoid delivery delays (see section 4.23.1).

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2) AUTO STEP and TRACK functions are possible if, after recall of the required set-up, the start and stop addresses are entered as described in 4.22.5 b.

4.23.1 FIXED FREQUENCIES AND EQUIPMENT SET-UPS

The fixed frequencies and equipment set-ups specified by the customer are permanently stored, as shown in Table 4-3, in

Address area 200 ... 299 for fixed frequencies
Address area 300 ... 339 for equipment settings.

They are recalled as described in section 4.22.2 to 4.22.7. If the EPROM BN 874/00.01 is not fitted in the meter, an error number (e.g. 2--001 = false address number) would appear in the frequency display D. The meanings of the error numbers are explained in chapter 6.

The ordering forms No. 5/798a for equipment settings (Part I) and/or No. 5/798b for fixed frequencies (Part II) must be filled out completely when ordering the EPROM. Figures 4-12 and 4-13 shows samples of these ordering instructions; column 1 of the ordering instructions for instrument setting contains an example of the entries.

If more than five equipment settings are required, further forms No. 5/798a should be used, and the pages of the form numbered sequentially. Please enter all level and frequency values, even if they are not always required.

Aussteller bitte nur die stark umrandeten Felder vollständig ausfüllen — Please fill out completely within thickly drawn frames

SPM-16

Option BN 874/00.01

Bestellvorschrift
Ordering Instructions

Nr.

Blatt / Sheet

Teil I / Part I: Geräteeinstellungen / Instrument settings		Kunde / Customer	Bestell-Nr. / Order No.
SPM-16, Nr.:	AB:		
geprüft: checked:	erstellt (Datum) completed (date)	T:	
		Festfrequenzen / Fixed Frequencies (Teil II / Part II) ja / yes ◯ nein / no ◯	

Gewünschte Einstellungen und Zahlenwerte ● eintragen. Mit Adreßnummer 300 beginnen (Max. bis Adresse 339); bei >5 Setups weitere Vordrucke verwenden.
Enter wanted settings and numerical values. Begin with address No. 300 (Max. to address 339); with >5 Setups, use another printed form.

Adresse / Address No.	Beispiel / Example					
Display: Abs [0], Ref [1], (Abs-Ref) [2], dBm0 [3], dBr [4]	[0]	☐	☐	☐	☐	☐
Mode: (Scale) Digital [1], Analog 1 dB [0], 20 dB [4], 80 dB [2], Φ [6]	[4]	☐	☐	☐	☐	☐
Averaging: On [1], Off [0]	[0]	☐	☐	☐	☐	☐
Auto Cal: On [0], Off [1]	[1]	☐	☐	☐	☐	☐
Bandwidth: Wide [0]; Sel. 25, 400, 1740, 3100 Hz, 48 kHz [1] [2] [3] [4] [5]; Demod: [6], [7]; Phase Jitter Φ [8]	[3]	☐	☐	☐	☐	☐
AFC: On [7], Off; Contin: Man Fine [0], Coarse [1]; Search ⇧ [2] ⇩ [3]; Sweep [5] [6] [1)]	[5]	☐	☐	☐	☐	☐
Rate/s ●	0,3					
Man [2)] [0] Opt [3)] [9]	☐	☐	☐	☐	☐	☐
Ref-Wert / Value [4)] ●	+/ 0 0 0 0 0	+/-	+/-	+/-	+/-	+/-
dBr-Wert / Value [4)] ●	0 0 0 0 0	0	0	0	0	0
Meßbereich / Meas. Range [4)] ●	— 0 1 0 0 0	0 0	0 0	0 0	0 0	0 0
	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz
Frequenz / Frequency f [5)] ●	1 2 3 4 5 6					
f_{START} [6)] ●	1 2 3 4 5 6					
f_{STOP} [6)] ●	6 7 8 9 0 0 0					
f_{STEP} [6)] ●	1 0 0 0					

1) Die Funktionen AUTO und TRACK sind nur manuell aufrufbar
2) zusätzlich bei Sweep 5 eintragen
3) Im Suchlauf zusätzlich bei SWEEP 5 (wenn w) oder 6 (wenn _/‾) eintragen
4) Nur Zahlenwerte eintragen
5) Bei Frequenzabläufen Anfangsfrequenz eintragen
6) Hier stets einen Zahlenwert eintragen, auch wenn Set-up ohne Wobbel- oder f_{STEP}-Funktion

1) The functions AUTO and TRACK are only callable manually
2) enter additionally with SWEEP 5
3) in SEARCH-SCAN mode, additionally enter with SWEEP 5 (if w) or 6 (if _/‾)
4) enter numerical values only
5) enter beginning frequency with frequency run
6) here, always enter a numerical value, even when Set-up without sweep- or f_{STEP}-function

5/798a

Fig. 4-12 Ordering Form No. 5/798a

Aussteller bitte nur die stark umrandeten Felder vollständig ausfüllen — Please fill out completely within thickly drawn frame

SPM-16

Option BN 874/00.01

Bestellvorschrift
Ordering Instructions

Nr. ____ Blatt / Sheet ____

Teil I / Part I: Geräteeinstellungen / Instrument settings		Kunde / Customer	Bestell-Nr. / Order No.
SPM-16, Nr.:	AB:		
geprüft: / checked — erstellt (Datum) / completed (date)	T:		

Festfrequenzen / Fixed Frequencies (Teil II / Part II) ja / yes ◯ nein / no ◯

Gewünschte Einstellungen und Zahlenwerte ● eintragen. Mit Adreßnummer 300 beginnen (Max. bis Adresse 339): bei >5 Setups weitere Vordrucke verwenden.
Enter wanted settings and numerical values. Begin with address No. 300 (Max. to address 339); with >5 Setups, use another printed form.

Adresse / Address No.	Beispiel / Example					
Display: Abs [0], Ref [1], (Abs-Ref) [2], dBm0 [3], dBr [4]	[0]	☐	☐	☐	☐	☐
Mode: (Scale) Digital [1], Analog 1 dB [0], 20 dB [4], 80 dB [2], Φ [6]	[4]	☐	☐	☐	☐	☐
Averaging: On [1], Off [0]	[0]	☐	☐	☐	☐	☐
Auto Cal: On [0], Off [1]	[1]	☐	☐	☐	☐	☐
Bandwidth: Wide [0]; [1] [2] [3] [4] [5] Sel. 25, 400, 1740, 3100 Hz, 48 kHz; Demod: [6], [7]; Phase Jitter Φ [8]	[3]	☐	☐	☐	☐	☐
AFC: On [7], Off; Contin: Man Fine [0], Coarse [1]; Search ⇧ [2] ⇩ [3]; Sweep [5] [6] 1)	[5]	☐	☐	☐	☐	☐
Rate/s ●	0,3					
Man 2) [0] Opt 3) [9]	☐	☐	☐	☐	☐	☐
Ref-Wert / Value 4) ●	+/ 0 0 0 0 0					
dBr-Wert / Value 4) ●	0 0 0 0 0	0	0	0	0	0
Meßbereich / Meas. Range 4) ●	— 0 1 0 0 0	0 0	0 0	0 0	0 0	0 0
	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz
Frequenz / Frequency f 5) ●	1 2 3 4 5 6					
f_{START} 6) ●	1 2 3 4 5 6					
f_{STOP} 6) ●	6 7 8 9 0 0 0					
f_{STEP} 6) ●	1 0 0 0					

1) Die Funktionen AUTO und TRACK sind nur manuell aufrufbar
2) zusätzlich bei Sweep 5 eintragen
3) Im Suchlauf zusätzlich bei SWEEP 5 (wenn ∿) oder 6 (wenn ⟋) eintragen
4) Nur Zahlenwerte eintragen
5) Bei Frequenzabläufen Anfangsfrequenz eintragen
6) Hier stets einen Zahlenwert eintragen, auch wenn Set-up ohne Wobbel- oder f_{STEP}-Funktion

1) The functions AUTO and TRACK are only callable manually
2) enter additionally with SWEEP 5
3) in SEARCH-SCAN mode, additionally enter with SWEEP 5 (if ∿) or 6 (if ⟋)
4) enter numerical values only
5) enter beginning frequency with frequency run
6) here, always enter a numerical value, even when Set-up without sweep- or f_{STEP}-function

Aussteller bitte nur die stark umrandeten Felder vollständig ausfüllen

Orderer: Please fill out completely within thickly drawn fram

SPM-16

Option BN 874/00.01

Bestellvorschrift
Ordering Instructions

Nr.

Teil II / Part II: Festfrequenzen / Fixed Frequencies

SPM-16 No.		AB:
geprüft: checked:	erstellt (Datum) completed (date)	T:

Kunde / Customer	Bestell-Nr. / Order No.

Geräteeinstellungen / Set-ups (Teil I / Part I) ja / yes ◯ nein / no ◯

Gewünschte Festfrequenzen in **Hz** eintragen. Adressbereich 200 – 299 / Enter wanted fixed frequencies in **Hz.** Address area 200 – 299

MEM	MHz	kHz	Hz	MEM	MHz	kHz	Hz	MEM	MHz	kHz	Hz
z. B. / e. g.	1 2 3	4 5 6	7 8 9								
200				235				270			
201				236				271			
202				237				272			
203				238				273			
204				239				274			
205				240				275			
206				241				276			
207				242				277			
208				243				278			
209				244				279			
210				245				280			
211				246				281			
212				247				282			
213				248				283			
214				249				284			
215				250				285			
216				251				286			
217				252				287			
218				253				288			
219				254				289			
220				255				290			
221				256				291			
222				257				292			
223				258				293			
224				259				294			
225				260				295			
226				261				296			
227				262				297			
228				163				298			
229				264				299			
230				265							
231				266							
232				267							
233				268							
234				269							

Aussteller bitte nur die stark umrandeten Felder vollständig ausfüllen — Orderer: Please fill out completely within thickly drawn frames

SPM-16

Option BN 874/00.01

Bestellvorschrift
Ordering Instructions

Nr.

Teil II / Part II: Festfrequenzen / Fixed Frequencies

SPM-16 No.:	**AB:**
geprüft: / checked: — erstellt (Datum) / completed (date)	**T:**

Kunde / Customer	Bestell-Nr. / Order No.

Geräteeinstellungen / Set-ups (Teil I / Part I) ja / yes ◯ nein / no ◯

Gewünschte Festfrequenzen in **Hz** eintragen. Adressbereich 200 – 299 / Enter wanted fixed frequencies in **Hz**. Address area 200 – 299

MEM	MHz		kHz			Hz			MEM	MHz	kHz	Hz	MEM	MHz	kHz	Hz
z. B. / e. g. 1	2	3	4	5	6	7	8	9								
200									235				270			
201									236				271			
202									237				272			
203									238				273			
204									239				274			
205									240				275			
206									241				276			
207									242				277			
208									243				278			
209									244				279			
210									245				280			
211									246				281			
212									247				282			
213									248				283			
214									249				284			
215									250				285			
216									251				286			
217									252				287			
218									253				288			
219									254				289			
220									255				290			
221									256				291			
222									257				292			
223									258				293			
224									259				294			
225									260				295			
226									261				296			
227									262				297			
228									163				298			
229									264				299			
230									265							
231									266							
232									267							
233									268							
234									269							

5/798b

Fig. 4-13 Ordering Form No. 5/798b

4.24 MEASURING ACCESSORIES

4.24.1 TEST PROBE TK-11

The Test Probe TK-11 is designed for high impedance and low capacitance extraction of the test signal from test objects with coaxial connections. The Test Probe is connected to input socket [19] (measured signal) and the test probe socket [18] (power supply).

As soon as a plug is inserted in socket [18], the 10 dB insertion loss of the Test Probe is compensated by a corresponding sensitivity increase within the Level Meter.

In the most sensitive measuring range of -120 dB or -110 dBm (analog mode), the range indication switches to -110 dB or -100 dBm.

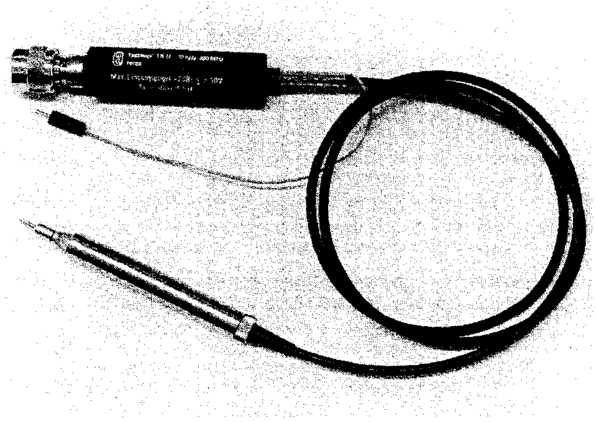

Figure 4-14 Test Probe TK-11

The test prod shown in Figure 4-14 can be replaced by a coaxial socket element S 222 of the Versacon® 9 system.

Adapters for all common connection systems can then be screwed into this element. User of the Versacon element increases the input capacitance of 3.5 pF specified in section 1.11.1 by a value which varies according to the type of connector.

The maximum permissible input level of the TK-11 is +10 dBm or +2 dB; any superimposed DC voltage must not exceed 50 V.

4.24.2 ADAPTER FEDA-1 (75 Ω/50 Ω)

The internal impedance of the generator output or the input impedance of the receiver input can be matched to an impedance of 50 Ω with the adapters 75 Ω/50 Ω. The available socket adapters are listed in section 1.12.3.

If a 75 Ω cable is used as a test lead, then the adapter should be inserted at the end close to the object being tested (see Figure 4-15). If a 50 Ω cable is used, it should be fitted on the level meter inside.

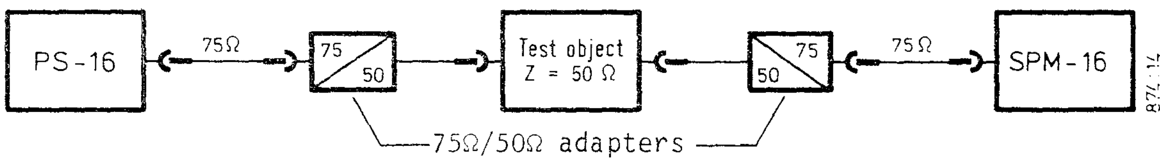

Figure 4-15 Measuring at an impedance of 50 Ω.

When setting up the generator output level or when reading the level indicated on the receiver, the attenuation (2 x 6 dB) of the adapter must be taken into account. With the combination PS-16/SPM-16, this can be done very easily by transferring the attenuation value to the memory for the reference level (dBr) (see sections 4.6.1.2, 4.6.1.3). The error limits of the level generator and level meter listed in the specifications may be increased by attenuation and frequency response errors and by the reflection factor of the adapter.

4.24.3 REFLECTION AND SIGNAL BALANCE RATIO MEASUREMENTS

Various measuring adapters are available for these measurements:

Reflection measuring unit RFZ-5, 10 kHz to 36 MHz (see description and operating instructions, RFZ-5).

Reflection factor measuring bridge RFZ-14, 100 kHz to 100 MHz.

4.24.3.1 Reflection Loss Measuring Adapter RFZ-14

The measuring bridge RFZ-14 permits measurement and sweeping of the frequency dependent reflection loss on CF transmission systems or single modules. Together with a generator (PS-16/PSS-16) and receiver (SPM-16) such measurements can be carried out in the frequency range

100 kHz to 100 MHz. The reference impedancer is 75 Ω. The interchangeable socket inserts can be adapted to all common connection systems (see also chapter 6).

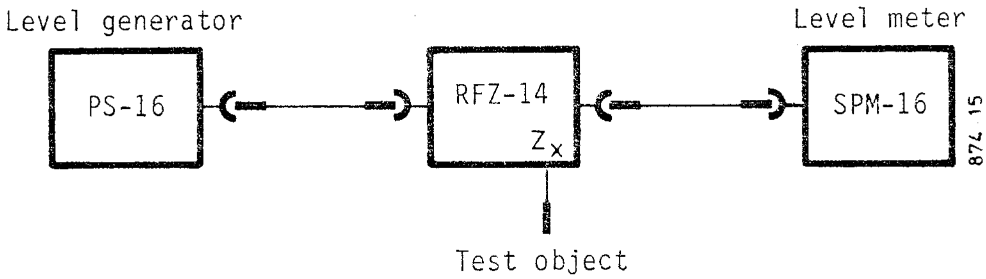

Figure 4-16 Connection of the measuring bridge RFZ-14 to the level measuring set-up.

The measuring adapter is connected to the generator output and the receiver input with 75 Ω cables, as shown in Figure 4-16. The generator output level should be as high as possible, but should not exceed the maximum permissible level at the input to the object being tested by more than 6 dB (overload limit).

The test configuration is calibrated at the required test frequency or, in the case of sweep operation, within the sweep range. For this purpose, the bridge must be disconnected from the object to be tested, resulting in a reflection factor r = 1 or a reflection loss a_r = 0 dB. The voltage-linear display is selected on the level meter SPM-16 with the pushbutton "20 dB". If major variations of the reflection loss are to be expected, for example in sweep mode, then the level-linear 80 dB display is better. The value displayed on the meter B corresponds to the reflection loss a_r = 0 dB. It is recommended to adjust this value to 0 dB on the meter scale by changing the measuring range setting [9] on the SPM-16 and the output level of the generator.

After connection of the object to be tested, its reflection loss results in a different level from that previously displayed. The measuring bridge is connected directly to the object to be tested in order to avoid additional measuring errors resulting from long cables, possibly with inaccurate characteristic impedances (75 Ω).

Example:

Indicated level on receiver for calibration and after correction of the generator level (reference value) .... -20 dBm

Indicated level with object to be tested connected to RFZ-14 (measured value) .... -46 dBm

Reflection loss (reference value minus measured value .... 26 dB

Corresponding reflection factor .... 5 %

4.24.4 REO-50 AND REO-56 MATCHING TRANSFORMERS

For simultaneous connection of the SPM-16 level meter and another receiver (e.g. REB-56 wide band levelmeter or RE-5 white noise receiver in the RK-5 white noise measuring set-up) matching transformers REO-50 and REO-56 are provided at a system point (see Fig. 4-17). They are both transforming dividers with bridging-type input and two outputs decoupled from one another and from the input whose level is 20 dB be-

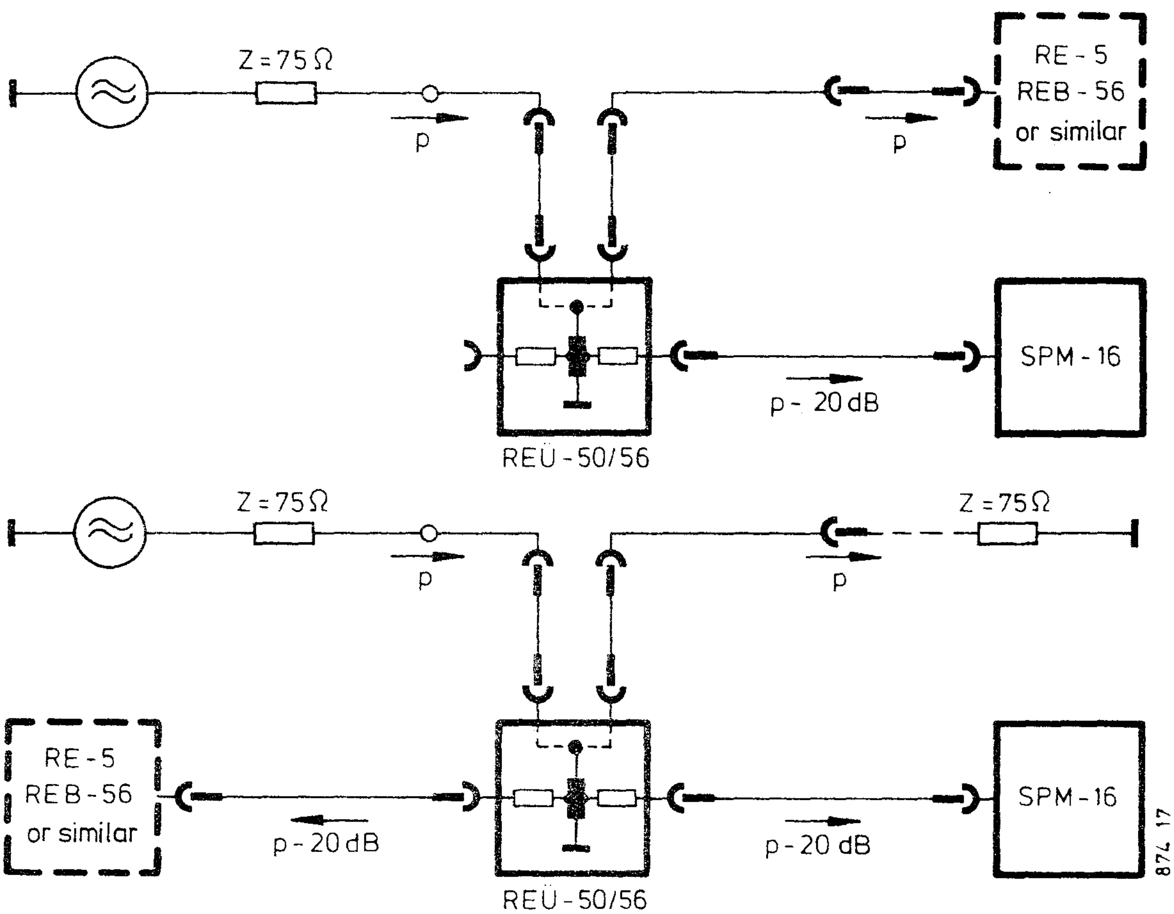

Fig. 4-17 Application of REO-50 and REO-56 matching transf.

low the input level. The REÜ-50 operates in a frequency range between 50 kHz and 14 MHz and the REÜ-56 in one from 300 kHz to 60 MHz.

The two transformers are also suitable on account of their bridging-type input for setting decoupled measuring points on systems in operation.

4.24.5 TWO-WAY DIVIDER REV-56

Another alternative for connecting the SPM-16 level meter and another measuring device with a 75 Ω input at a system point is provided by the REV-56 two-way distributor (see Fig. 4-18). It consists exclusively of resistive components and, therefore, has very wide band application. The attenuation between its three connections is 10 dB in each case. If an output is not in use it should be terminated with a 75 Ω resistance.

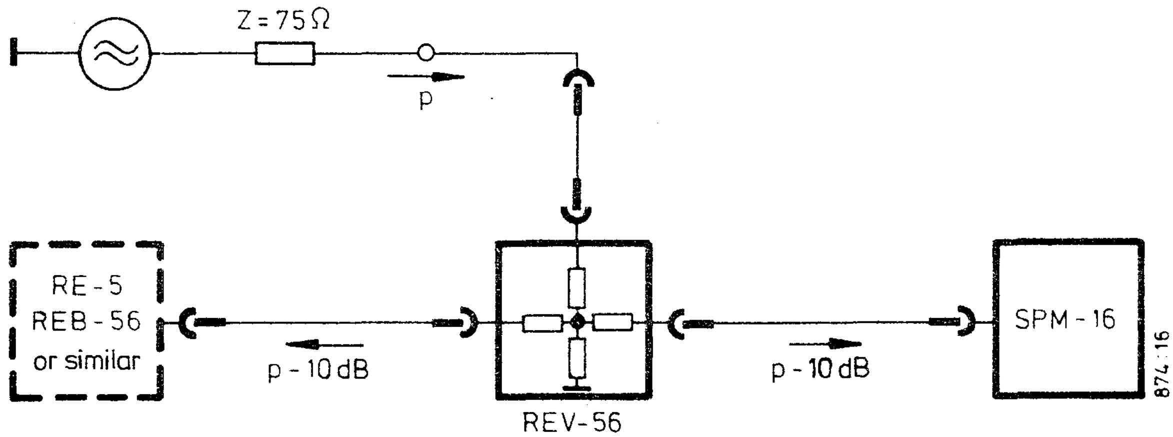

Fig. 4-18 Possible connection using the REV-56 two-way distributor

5 MEASURING NOTES

5.1 SELECTIVITY CURVES OF THE LEVEL METER

Figures 5-1 and 5-2 show the overall selectivity of the Level Meter for the selectable bandwidths 3.1 kHz, 1.74 kHz, 400 Hz and 25 Hz. These figures show typical selectivity curves of a standard production instrument.

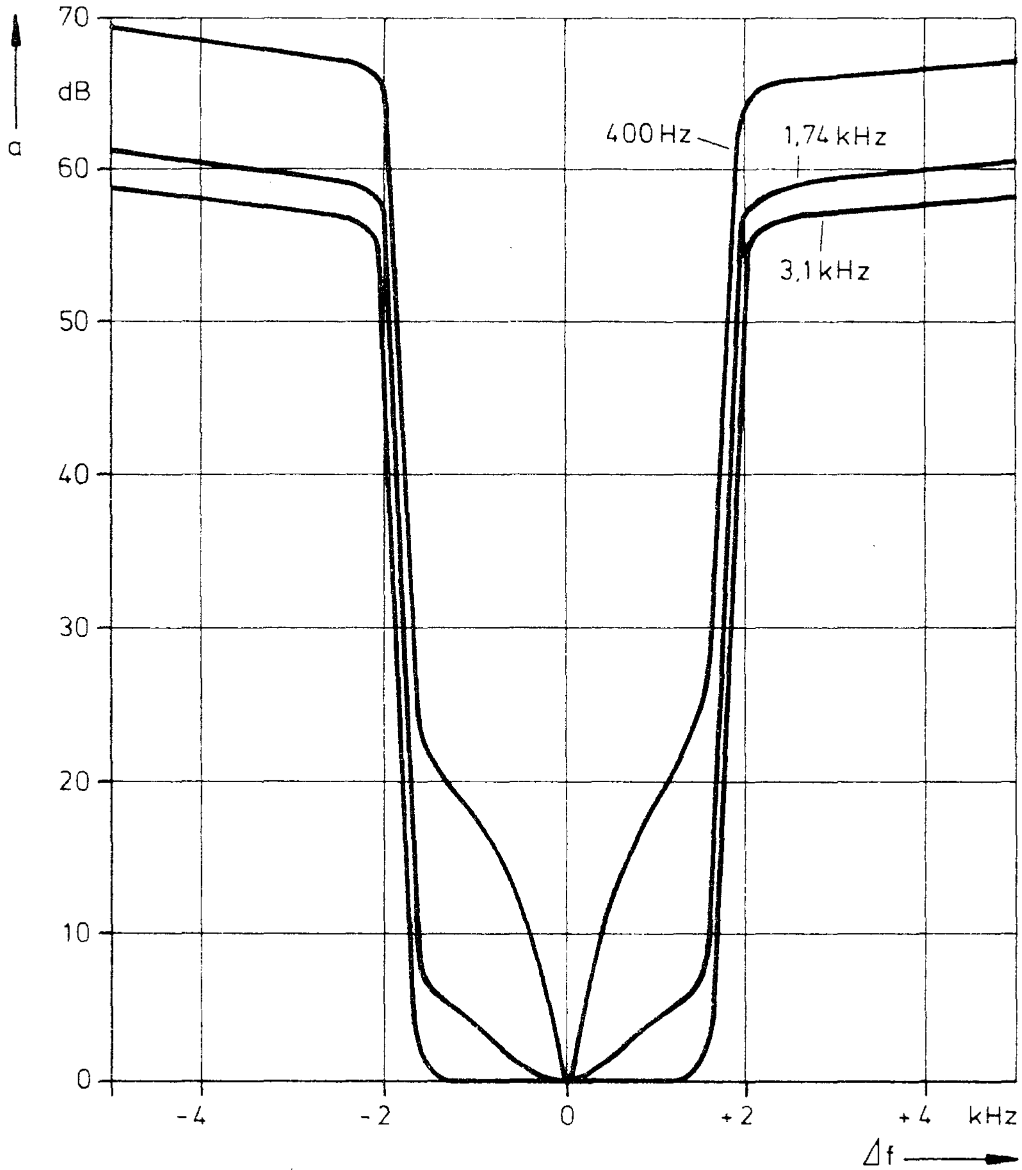

Figure 5-1 Typical selectivity curves for the bandwidths 400 Hz, 1.74 kHz, and 3.1 kHz.

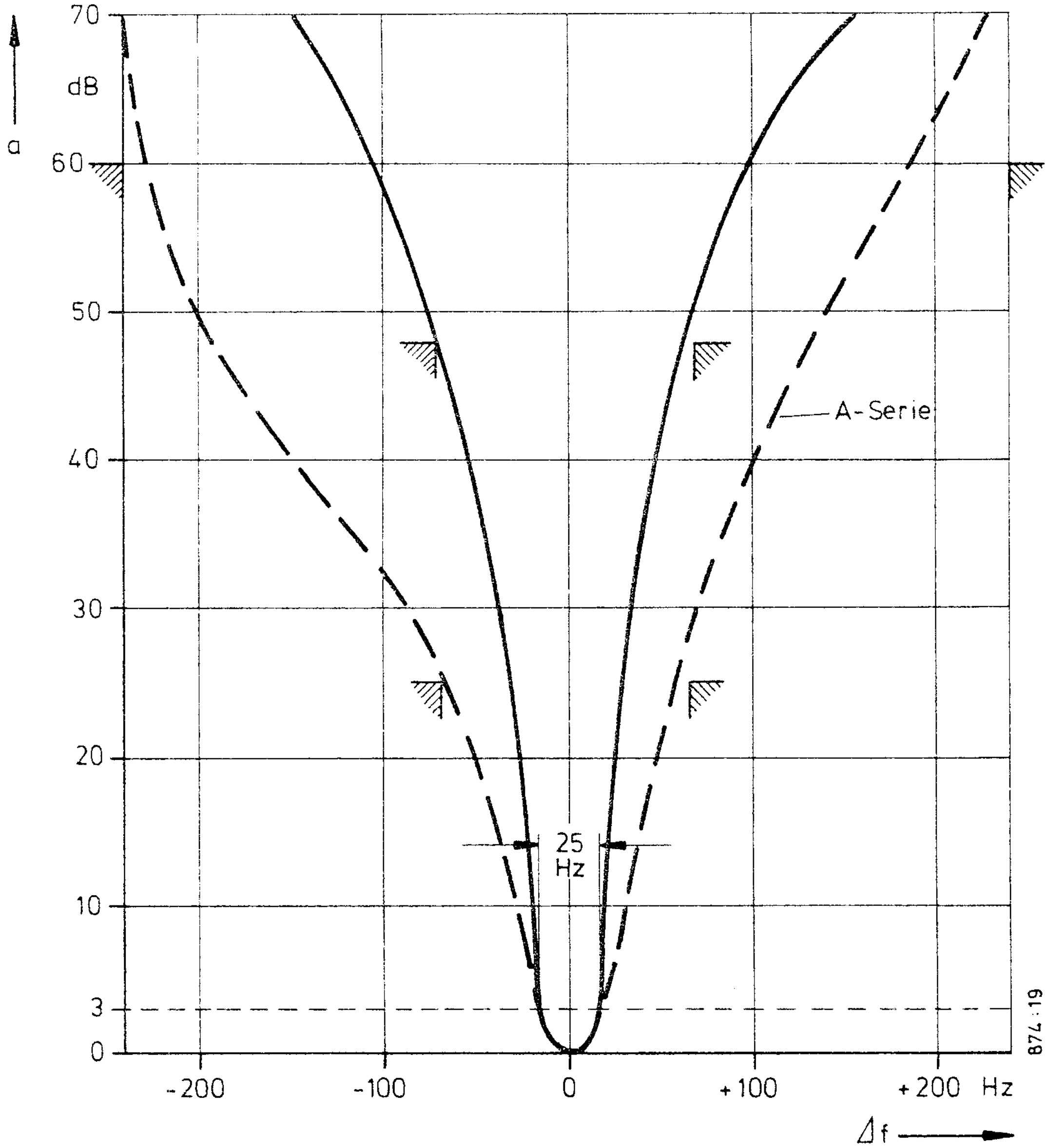

Figure 5-2 Typical selectivity curve of the Level Meter with 25 Hz bandwith.

5.2 MEASUREMENT OF HIGH ATTENUATION VALUES

In the case of level measurements on two port networks with high attenuation values, a high return impedance Z_s between the generator and receiver of the measuring set-up is necessary (see Figure 5-3). If the return impedance is not infinitely large, the voltage drops across the ground line resistances r_1 and r_2 of the test cables used cause additional measuring errors. In order to keep these small, Z_s must be large with respect to r_1 and r_2 for practical applications. In the SPM-16, a high return impedance was achieved through decoupling the ground of the measuring circuit from the chassis ground by a coaxial choke.

The effects of the above-mentioned resistances on the still measurable attenuation are described in the following section.

The object to be tested is a two port network with an infinitely large attenuation. Z_s is the return impedance, r_1 and r_2 are the unavoidable ground conductor impedances[1)], which can also be complex just like Z_s. The voltage drop resulting from the generator current through r_1 causes a voltage to exist between the chassis of the generator and the receiver.

If the return impedance Z_s is finite, a signal current flows through r_2, causing a signal voltage at the receiver input and simulating a finite attenuation of the object being tested.

---

1) r_1 and r_2 are often called "transfer impedances" in coaxial cables, plugs, etc., and are defined as follows:

Transfer impedance =

$$\frac{\text{Voltage drop on the outside of the outer conductor}}{\text{Current on the inside of the outer conductor}}$$

Transfer impedance =

$$\frac{\text{Voltage drop on the inside of the outer conductor}}{\text{Current on the outside of the outer conductor}}$$

A simple calculation, assuming that r_1 and r_2 are small with respect to Z_{out}, Z_{in}, Z and Z_s, shows

$$\frac{V_2}{V_o} = \frac{r_1}{Z_{out} + Z} \cdot \frac{r_2}{Z_s} \cdot \frac{Z_{in}}{Z_{in} + Z}$$

In the case where $Z_{out} = Z_{in} = Z$, the image attenuation is

$$a = 20\ \text{dB} \cdot \log \frac{V_o}{2 \cdot V_2}$$

$$= 20\ \text{dB} \cdot \log \frac{2 \cdot Z \cdot Z_s}{r_1 \cdot r_2}$$

For a maximum measuring error of 0.01 dB, for example, this attenuation must be approximately 60 dB (approximately 40 dB for 0.1 dB) greater than the attenuation to be measured if the worst case is assumed for the phase angle between the measured voltage and the error voltage.

The return impedance Z_s is approximately 40 Ω, starting at 300 kHz.

If r_1 and r_2 are assumed to be at 10 mΩ each - this is the value of the transfer impedance of a good, double-screened coaxial cable with a length of 50 cm - then the image attenuation with Z = 75 Ω and Z_s = 40 Ω for the configuration shown in Figure 5-3 is 156 dB.

With a measurable attenuation of, for example, 96 dB with a Test Setup PS-16/SPM-16, the value of 156 dB calculated under the above assumptions leads to a maximum additional error of 0.01 dB.

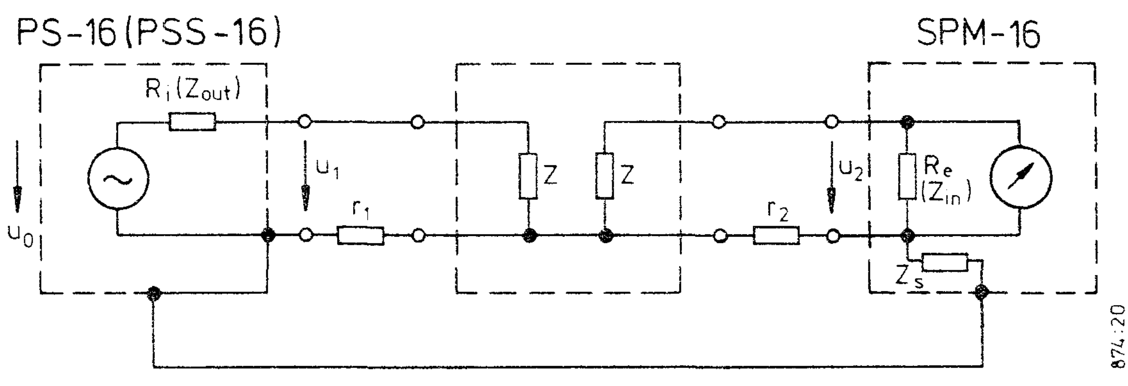

Figure 5-3

5.3 MEASUREMENTS OF IMPULSIVE NOISE AND INTERRUPTIONS

Measurement of the parameters phase jitter, impulsive noise, and interruptions are becoming more and more important for assessing the transmission quality of telephone lines for data communications. Impulsive noise and interruptions cannot be measured directly with the SPM-16, but it can be used together with the demodulator for conversion of single voice channels or measured signals from the CF frequencies to the AF range. In order to avoid measuring errors, particular attention was paid to ensuring that the modules which participate in conversion into the speech channel have, as closely as possible, the characteristics of CF channel converters. For this reason, the Level Meter also has the bandwidth of 3.1 kHz, which corresponds to that of a telephone channel. For faithful reproduction of the voice channel, the Level Meter must be tuned to the center of the CF channel. The demodulator output is characterised by a wide dynamic range, which is necessary for impulsive noise measurement (see section 4.8).

The two performance characteristics mentioned above can be measured with external devices (e.g. DLM-3). For interruption measurements, the converted 2 kHz signal can be extracted at the demodulator output if the SPM-16 is tuned to the carrier frequency measuring tone. Due to the excellent level and frequency stability of the Level Meter, long-term measurements can also be carried out.

5.4 PSOPHOMETRIC WEIGHTING OF NOISE VOLTAGES

It is a well-known fact that the sensitivity of the human ear is frequency dependent. For objective simulation of this property the psophometric filter is used to simulate this frequency response, including the transmission characteristics of the handset (Figure 5-4). This permits correct weighting of the noise existing in telephone channels.

If, however, the noise within a telephone channel is "white", which may be assumed in the case of CF transmission, the psophometric filter can also be replaced by a flat band-pass filter which has the same effective bandwidth (see Figure 5-5). The Level Meter is equipped with the bandwidth of 1.74 kHz for this purpose.

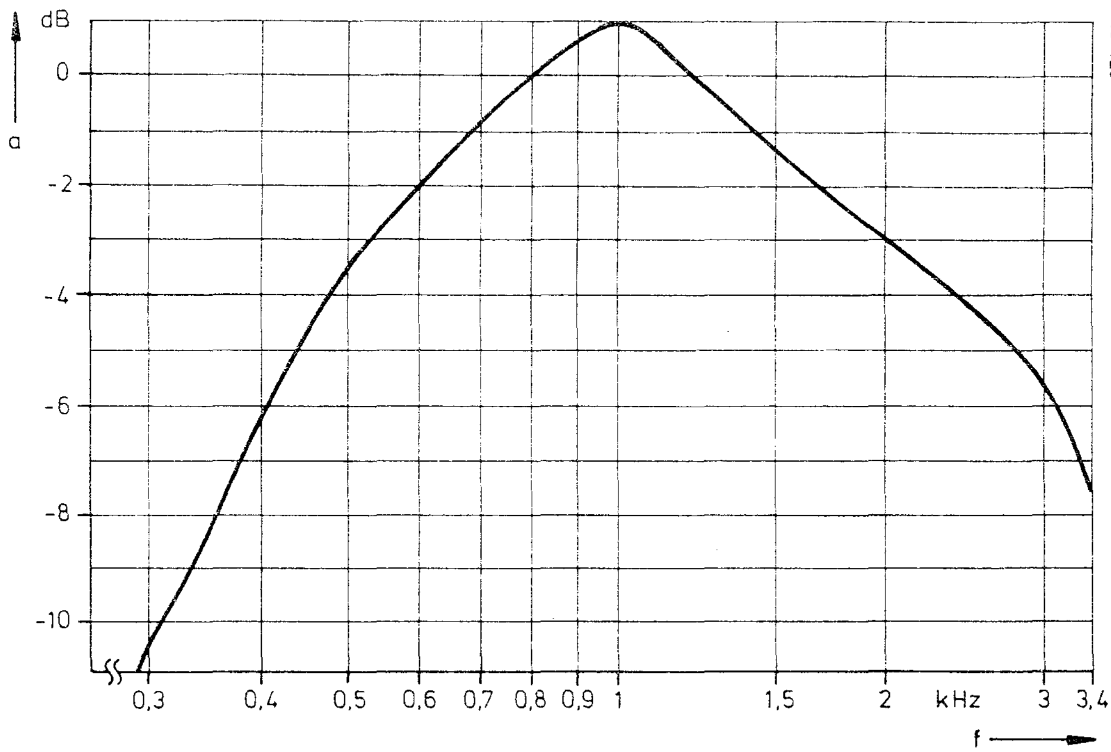

Figure 5-4 Psophometric curve

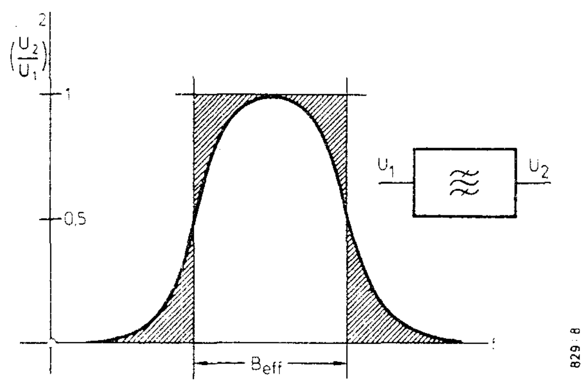

Figure 5-5 Selectivity curve and effective noise bandwidth.

The SPM-16 uses a true rms value meter, calibrated so that the indication for the rms value of a sinusoidal voltage is practically equal to the effective value of the white noise.

The drive levels for the complete signal path, including the rectifier circuit, are selected so that precise noise measurements are possible (crest factor 12 dB).

5.5 AUTOMATIC DRIVE LEVEL MONITORING

In order to increase the measuring accuracy, some modern level meters have facilities for the operator to select either of the modes low noise or low distortion. With the aid of this control, the gain in the wide-band input stage preceding the first mixer and in the intermediate frequency section after the last conversion can be varied in a specific ratio, while maintaining the same overall gain. However, this solution is a compromise and can cause confusion and errors if the signals are unknown. The Level Meter SPM-16 with its built-in microcomputer offers an optimum solution to this problem, as it automatically selects the most favorable instrument drive signal levels as a function of the wide-band loading present at the test input. To do this, the wide-band gain is increased step-by-step and the microprocessor checks the IF level for non-linear components. As soon as these are detected, the wide-band gain is reduced by one step, so that there is again a linear relationship between the input and output levels. This principle ensures that incorrect settings are not possible and always guarantees the highest possible measuring accuracy.

6 F U N C T I O N A L T E S T I N G , M A I N T E N A N C E , A N D M I S C E L L A N E O U S

The following information is provided to permit correct function of the Level Meter SPM-16 to be checked. This permits the user to determine whether the unit has any major defects (such as could result from transport damage). A test of all functions is carried out as described in section 6.1 when the SPM-16 is switched on for the first time. A functional test of the most important modules (in hardware self-test) can be carried out as described in section 6.5.2.

6.1 FUNCTIONAL TEST WHEN SWITCHING ON FOR THE FIRST TIME

The functional test is carried out when the SPM-16 is switched on for the first time. The cable connections shown in Figures 3-3 and 6-1 must be provided for this test. The test is carried out in the sequence specified in Table 6-1, Pages 6-2 and following.

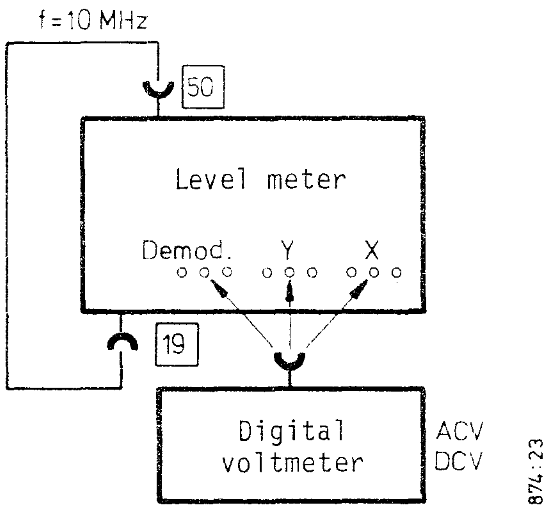

Figure 6-1 Test configuration for the functional test

A C T I O N Pushbutton or setting	R E A C T I O N Level of frequency display, LED
MEM, 9001, kHz	Unit set to standard set-up: f = 100.000 kHz, ABS, ANLG, 20 dB scale, bandwidth 3.1 kHz (the standard set-up is also transferred to the memories for front panel settings, addresses 100- 110).
AUTO CAL	Red LED lights above AUTO CAL
f = 10234 kHz f = 6.78 MHz CLR f_{STEP} f_{START} = 8 MHz f_{STOP} = 12 MHz f_{CENT} Δf	Frequency display: 10.234.000 kHz 6.780.000 kHz 0 1.000 kHz 8.000.000 kHz 12.000.000 kHz 10.000.000 kHz 4.000.000 kHz
MAN Turn knob [14] MAN Turn knob [14]	LED "FINE" lights Frequency change in 1 Hz steps LED "COARSE" lights Frequency changes in 100 Hz steps
f = 10 kHz ⇧ STEP ⇩ STEP	Frequency display: 10.000 kHz 11.000 kHz 10.000 kHz
STEP	LED "TRACK lights
STEP	LED "AUTO" lights. Frequency steps by 1 kHz per second.
SWEEP ⟋ SWEEP ⋀⋀	Frequency sweeps from 8 MHz to 12 MHz or vice versa. Units sweeps between 8 MHz and 12 MHz
f_{STOP} Search ⇩ f_{START} ⇧ Search	Frequency search towards lower frequencies and stop at 10 MHz. Frequency search towards higher frequencies and stop at 10 MHz.
Switch [17] to OPT SWEEP ⋀⋀	Frequency search between 8 and 12 MHz and stop at 10 MHz. Restart by depressing the pushbutton "SWEEP" ⋀⋀

 Table 6-1 Sequence of functional test

A C T I O N	R E A C T I O N
Select all positions with switch [17]	Corresponding LED lights.
f = 9.9985 MHz AFC AFC AUTO CAL	Frequency display: 9.998.500 kHz 10.000.000 kHz Signal detector lights. LED alongside AFC is switched off. Red LED is extinguished
Depress pushbuttons ABS and REF simultaneously (ABS-REF)	Level display: approx. -2 dBm/-12 dB Level display: 0 dB, meter: 0 dB
80 dB scale	Level display: 0 dB, meter: 0 dB LED on 80 dB scale of meter lights.
20 dB scale	LED on 20 dB scale of meter lights.
1 dB scale	LED on 1 dB scale of meter lights Meter indication: 0 dB
Select bandwidth 1.74 kHz, 400 Hz; 25 Hz and WIDE	Corresponding LED lights. Meter indication: 0 dB (WIDE: 0 dB ± 0.1 dB)
Position	Indication: 0 dB 2-kHz-tone audible (if necessary, adjust volume [20])
Φ_{p-p}	LED on 0-scale of meter lights. Indication approx. 0.3°
Bandwidth 3.1 kHz 20 dB scale Depress pushbuttons ABS and REF simultaneously (ABS-REF) Select measuring range 20 dB with switch [9]	Indication 0 dB Meter indication: -20 dB
AUTO SET	Meter indication: -5 dB Measured level: (5-5) dB = 0 dB

Table 6-1 Sequence of functional test (continued)

ACTION	REACTION
DGTL	Level indication: 0.0 dB
AVRG	Level indication: 0.00 dB (±0.02 dB)
REF	Level indication: approx. -2 dBm/-12 dB(reference level)
dBr	Level indication: +0.0 dBr (relative level)
dBr	LED alongside KEYBOARD ENTRY lights
Enter the previously displayed reference level (REF) as a relative level via [12]	The level indication is entered with a resolution of 0.1 dB.
Terminate the input with pushbutton -dBr or +dBr (+/- according to reference level)	Entered level is displayed in dBr LED alongside KEYBOARD ENTRY is switched off.
dBm0	Level indication: 0.00 dBm0/dB0 ±0.1 dB (related level)
Connect digital voltmeter (ACV) to demodulator output [21]	
Switch demodulator on.	AC voltage at output: approx. 1.5 V
Connect digital voltmeter (DCV) to Y-output [22]	
Depress ABS and REF simultaneously (ABS-REF), ANLG Adjust range switch [9] for 0 dB indication on meter	DC voltage at Y-output: 4 V ± 50 mV
Connect digital voltmeter (DCV) to X-output [23]	
f_{START}	DC voltage at X-output: -2.5 V ± 50 mV
f_{STOP}	DC voltage at X-output: +2.5 V ± 50 mV

Table 6-1 Sequence of functional test (continued)

Further tests are carried out as described in sections 6.1.1 to 6.1.3.

6.1.1 CHECKING THE INTERNAL NOISE

Settings on the SPM-16:

- Coaxial input [19] has no test signal applied
- Select digital mode with pushbutton "DGTL" and display of the absolute level with pushbutton "ABS".
- Select bandwidth 3.1 kHz with changeover switch [16].
- Tune the Level Meter to 2 MHz with keyboard [12] (see section 4.4.1).

Maximum measured values:

for bandwidth 3.1 kHz	Noise level -127 dB	(-118 dBm)
for bandwidth 1.74 kHz	Noise level -129 dB	(-120 dBm)
for bandwidth 400 Hz	Noise level -135 dB	(-126 dBm)
for bandwidth 25 Hz	Noise level -139 dB	(-130 dBm)

6.1.2 CHECKING THE RECEIVER SELECTIVITY

Settings on the SPM-16:

As in section 6.1, but

- Enter frequency f = 10 MHz via keyboard [12] (see section 4.4.1).
- Connect the 10 MHz standard frequency (socket [50] on rear of unit) to test input [19].
- Depress pushbuttons "ABS"and "REF" simultaneously.
- Depress pushbutton "ABS-REF"; indication is 0.0 dB.
- Depress pushbutton "f_{STEP}" and enter 2 kHz on keyboard [12] (see section 4.4.1).
- Depress pushbutton "f"; indication is 10 MHz.
- Change the tuned frequency up or down by one step (≅ 12 kHz) with pushbutton "STEP" ⇧ or ⇩ and read the level display.

Attenuation compared with the reference value ≧ 45 dB. These values are also true for the 1.74 kHz and 400 Hz bandwidth. For the 25 kHz bandwidth, the attenuation must stay ≧ 60 dB. at an offset f_{STEP} = ±250 Hz from the center of the band (10 MHz).

6.1.3 FUNCTIONAL TEST OF THE CALIBRATED ATTENUATOR

- Generator output [44] -15 dBm, connected to rear panel Receiver input [19].

- Settings on SPM-16: "ABS, ANLG", 80 dB scale range, "AUTO CAL OFF" (red LED illuminates), (Demod.) (in this position only the WIDE-BAND gain changes),
  f = 10 MHz
- Switch through measuring range with switch [9] in 5 dB steps from +30[1] to -20 dBm (+20 to -30 dB), and check analog meter to determine whether or not the reading changes in 5 dB steps from -45 to >+2 dB (-44 to >+2 dB).

If a 20 dB attenuator is connected ahead of the Receiver input [19], then the calibrated attenuator can also be tested in the measuring ranges, -25 and -30 dBm (-35 and -40 dB). In the measuring range +30 to -30 dBm (+20 to -40dB) the level reading changes from -65 to -5 dB (-64 to -4 dB).

6.1.4 FUNCTIONAL TEST OF THE TEST PROBE CONNECTOR [18]

This test is carried out without a test signal at the inputs.
- Select digital mode with pushbutton "DGTL" and absolute level display with pushbutton "ABS" .
- Note the displayed absolute level.
- Connect the power supply cable of the Test Probe TK-11 to socket [18] and read the indicated level. The digital display is corrected by +10 dB.
  The same result can be achieved if ground potential is connected to socket [18].

6.2 FUNCTIONAL TESTS OF IMPORTANT MODULES (HARDWARE SELF-TEST)

A functional test of the most important modules (hardware self-test) can be executed by recalling program number 9003. No external connections are required for this purpose. The internal calibration signal is the signal source.

Sequence:

Depress the following pushbuttons:

"MEM" 9001 "RCL" (only A Series)
"MEM" 9003 "RCL"

---

1) Max. tolerable level, external signal of +25 dBm/+16 dB (AC plus DC components, see also para. 4.3).

If the test is successful, the message 1----- appears on the frequency display. The Level Meter can then be switched back from the test program to the measuring program via 9001 "RCL". In the case of a fault, a fault number (e.g. 1--003) appears in the frequency display; these fault numbers are explained in Table 6-2. Repairs should be carried out only by trained personnel. If it is not possible to repair the defective module, which means that the SPM-16 has to be sent into the factory for repair, it is recommended that you also specify the fault number which occurred.

An RAM/ROM test is carried out automatically by the Level Meter when power is switched on (see section 3.5). The meanings of the fault numbers for this test are also shown in Table 6-2.

CLASS	0	FAULT IN CONTROL SECTION (NOT VIA IEC BUS)
	0-----	NO FAULT, INDICATION OF TEST EXECUTION
	0--1-L	RAM FAULT ON D0...D3 THE ADDRESS IS SHOWN IN THE LEVEL DISPLAY
	0--1H-	RAM FAULT ON D4...D7 THE ADDRESS IS SHOWN IN THE LEVEL DISPLAY
	0--1HL	RAM FAULT ON D0...D3 AND ON D4...D7 THE ADDRESS IS SHOWN IN THE LEVEL DISPLAY
	0--200	ROM FAULT THE ADDRESS IS DISPLAYED IN HEX WITH THE FOLLOWING CODES: L FOR A H FOR B P FOR C A FOR D - FOR E (BLANK) FOR F

Table 6-2 Overview of fault numbers in the SPM-16

CLASS I: HARDWARE SELF-TEST

INDICATION: 9003 SELF-TEST RUNNING

INDICATION: 1----- SELF-TEST IS COMPLETE AND NO FAULT WAS DETECTED IN THE LEVEL MEASURING SECTION.

TEST GROUP 00X

FUNCTIONS: GENERAL MODULE TEST
THE TEST SIGNAL IS THE CALIBRATION LEVEL

FAULT MESSAGES:

1--001 CALIBRATION LEVEL AT WIDE-BAND DETECTOR TOO LOW

POSSIBLE SOURCES OF FAULT:

CONTROL FREQUENCY NOT CONNECTED; CALIBRATION LEVEL TOO LOW

PREAMPLIFIER 1 or 2

WIDEBAND DETECTOR

1--002 CALIBRATION LEVEL AT WIDE-BAND DETECTOR TOO HIGH

CALIBRATION LEVEL TOO HIGH; PREAMPLIFIER 1 or 2

WIDEBAND DETECTOR, 10 kHz SIGNAL DERIVED FROM

40 MHz GENERATOR IS MISSING

1--003 LEVEL AT SIGNAL DETECTOR TOO LOW.

MEASUREMENT MODE: WIDEBAND

POSSIBLE SOURCES OF FAULT:

10 kHz BANDPASS FILTER, IF AMPLIFIER

1--004 LEVEL AT ANALOG-DIGITAL CONVERTER (ADC) TOO LOW.

MEASUREMENT MODE: WIDEBAND

POSSIBLE SOURCES OF FAULT:

INACCURATE CALIBRATION LEVEL, PREAMPLIFIER 1 or 2

WIDEBAND DETECTOR; 10 kHz BANDPASS FILTER,

IF AMPLIFIER, DETECTOR, ADC

Table 6-2 Overview of fault numbers in the SPM-16 (continued)

1--005	LEVEL ON ANALOG-DIGITAL CONVERTER (ADC) TOO HIGH MEASUREMENT MODE: WIDEBAND POSSIBLE SOURCES OF FAULT: AS UNDER 1--004
1--006	LEVEL ON SIGNAL DETECTOR TOO LOW MEASUREMENT MODE: SELECTIVE (400 Hz) POSSIBLE SOURCES OF FAULT: 220, 180, or 40.01 MHz OSCILLATOR UNLOCKED MIXER 1, 2, or 3; 40 MHz or 10 kHz BANDPASS FILTER
1--007	LEVEL ON ANALOG-DIGITAL CONVERTER (ADC) TOO LOW MEASUREMENT MODE: SELECTIVE (400 Hz) POSSIBLE SOURCES OF FAULT: 220, 180, or 40.01 MHz OSCILLATOR UNLOCKED MIXER 1, 2, or 3; 40 MHz or 10 kHz BANDPASS FILTER
1--008	LEVEL ON ANALOG-DIGITAL CONVERTER (ADC) TOO HIGH MEASUREMENT MODE: SELECTIVE (400 Hz) POSSIBLE SOURCES OF FAULT: MIXER 1, 2, or 3; 40 MHz or 10 kHz BANDPASS FILTER
TEST GROUP	01X:
FUNCTION:	TEST FOR INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE MEASUREMENT MODE: WIDEBAND
FAULT ANNUNCIATION:	
1-011	INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE AT 10 kHz
1-012	INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE AT 1 MHz
1-013	INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE AT 30 MHz
1-014	INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE AT 60 MHz
1-015	INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE AT 110 MHz
1-016	INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE AT 160 MHz POSSIBLE SOURCES OF FAULT: VARIATION OF CALIBRATION SIGNAL WITH FREQUENCY PREAMPLIFIER 1 or 2, WIDEBAND DETECTOR
TEST GROUP	02X:
FUNCTION:	TEST FOR INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE MEASUREMENT MODE: SELECTIVE
FAULT ANNUNCIATION:	
1--021	INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE AT 10 kHz
1--022	INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE AT 1 MHz
1--023	INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE AT 30 MHz
1--024	INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE AT 60 MHz
1--025	INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE AT 110 MHz
1--026	INTOLERABLE DEVIATION FROM FREQUENCY RESPONSE AT 160 MHz POSSIBLE SOURCES OF FAULT: VARIATION OF CALIBRATION SIGNAL WITH FREQUENCY PREAMPLIFIER 1 or 2, MIXER 1

Table 6-2 (continued)

TEST GROUP 10X:	
FUNCTION:	TEST OF SYNTHESIZER (ADDER)
FAULT ANNUNCIATION:	
1--101	FALSE RESULT FROM ADDITION
1--102	ADDER COUNT INCOMPLETE
1--103	ADDER SIGNAL "DAC" REMAINS LOW
1--104	ADDER SIGNAL "DAC" REMAINS HIGH
1--105	ADDER DOES NOT BEGIN TO ADD
CLASS 2:	OPPERATOR ERRORS
2--001	FALSE ADDRESS NUMBER
2--002	ROM ADDRESS: "STORE" NOT POSSIBLE (FIXED FREQUENCY OR SET-UP FROM EPROM)
2--003	ADDRESS CAN BE USED ONLY WITH "RECALL" (TO RECALL PRINTER, AND TEST PROGRAMS)
2--004	START AND STOP ADDRESSES ARE IN DIFFERENT RANGES (BOTH MUST LIE EITHER BETWEEN 0 AND 99 OR BETWEEN 200 AND 299)
2--006	ADDRESS NOT PROGRAMMED
2--101	MEASURING RANGE TOO SENSITIVE
2--102	MEASURING RANGE TOO INSENSITIVE
2--103	WIDE-BAND SECTION OVERDRIVEN (WITH 80 dB SCALE)
2--104	MEASURING RANGE UNSUITABLE FOR "STORE ABS AS REF"
2--201	"STORE ABS AS REF" NOT PERMITTED (SWEEP OR SEARCH MODE)
CLASS 3:	FAULTS IN THE DIGITAL INTERFACE [40] [41]
3--000	INITIALIZATION REQUEST FROM A PERIPHERAL DEVICE (TO BE REGARDED AS AN ACKNOWLEDGEMENT AND NOT AS A FAULT: APPEARS DURING INITIALIZATION OF THE DEVICE)
3--XXX	FAULT AT THE DIGITAL INTERFACE
	IF THE ABOVE FAULTS OCCUR, THE DATA CONNECTION BETWEEN THE RECEIVER AND THE GENERATOR SHOULD BE EXAMINED.

Table 6-2 Overview of fault numbers in the SPM-16 (continued)

6.3 MAINTENANCE AND MISCELLANEOUS

The Level Meter SPM-16 requires no special maintenance provided it is handled correctly. The enclosure protects the electronic cirucuits at all times, even during transport. The use of corresponding Protective Cover SD 5 is recommended in order to protect the controls on the front panel and the sockets on the rear of the unit against splash water, dust, and mechanical damage. In addition, the SPM-16 can be carried with the carrying handle of the protective cover.
For major transport under rough conditions, the use of the TRANSPORT CONTAINER TPK-5 or the Transport Case TPG-65 is recommended (see section 3.1.2).

6.3.1 MECHANICAL CONSTRUCTION

Caution: Before opening the unit, disconnect the a.c.power plug from the outlet socket. The unit must always be switched off before removing or inserting moduler or auxiliary devices.

The case dimensions comply with the DIN Standard 41 494 and the American Standard ASA C 83.9. The unit can therefore be mounted in 19" racks (see section 3.1.3). The cover, baseplate, and side walls are made of rugged cast aluminum. For servicing purposes, it is possible to remove the six Allen head screws (wrench on the rear of the unit), to take off the equipment cover, and to lift the complete chassis including the front panel and the rear wall from the case.

When doing this, remember that the chassis is connected to the power supply unit on the right wall of the case via a plug connector. All modules are accessible from the top and the bottom if the two screws of the two folding chassis are removed.

When assembling, ensure that the blue flat cable is not trapped between the chassis and the case. During repairs, ensure that the upper folding chassis cannot fall, as this could result in damage to the cables.

Figure 6-2 shows details of the components in the upper folding chassis after removal of the equipment cover. Amongst other things, the microprocessor (INTEL 8085) and the free positions for the optional

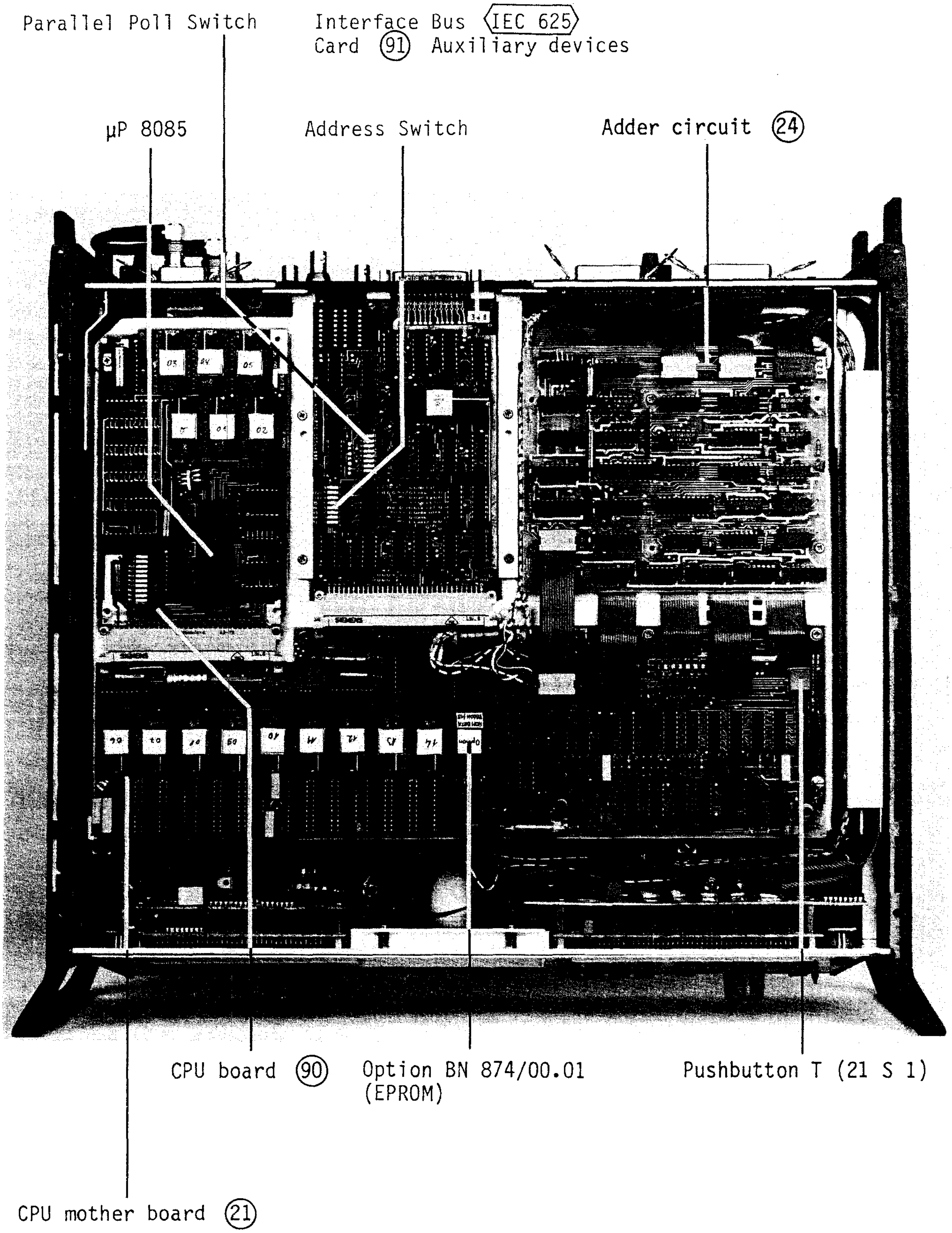

Figure 6-2 Upper side of the upper folding chassis

accessories: IEC- or printer-interface and EPROM (fixed frequencies, set-ups) with customer-specific programs can be seen in this figure. The pushbutton T is depressed only after repair in order to bootstrap the SPM-16 if the buffer battery for the RAM power supplies was disconnected during repair (see section 3.6).

6.3.2 CHANGING OR INSTALLING THE INTERFACE BOARDS

The plug-in modules Printer Interface BN 905/02 (SPM-16, series B or later) or Interface Bus ⟨IEC 625⟩ card BN 853/02 are installed from the rear of the unit (see Figure 4-2). Removing the two outer screws provides access to the compartment and the board can be inserted or changed (component side on the top). The interface board is then held in position with the two screw.

6.3.3 INSTALLING THE EPROM BN 874/00.01

The EPROM BN 874/00.01 can be installed in the SPM-16 at any time. As the customer-specified data are stored in a MOS memory module (EPROM), the board must be installed as described below, owing to the sensitivity of the circuit to static charges.

Generally, whenever working with MOS components, all tools, work benches and technicians should have the same reference potential. For this reason, the MOS module should be installed as follows:

1. Switch off the Level Meter.
2. Remove the six Allen head screws (wrench on the rear of the unit) and take off the equipment cover.
3. Touch the SPM-16 (reference potential) with one hand, remove the MOS module from its packing material with the other hand (holding it at the ends), and insert it in the position shown in Figure 6-2. The module is oriented correctly if the inscription is in the same direction as on the other EPROMs.
4. Fit the equipment cover, screw it down, and switch on the Level Meter.

6.3.4 UNIVERSAL CONVERSION SYSTEM VERSACON® 9

The coaxial input, the inputs and outputs for control in standard frequencies, and the IF output at the Level Meter are equipped with the universal conversion system "Versacon® 9" made by Wandel & Goltermann (Figure 6-3). This has the advantage that it permits rapid conversion to one of the connection sockets shown below without soldering. The required socket adaptor is screwed into the fixed universal socket, using the mounting wrench (Order No. W 1).

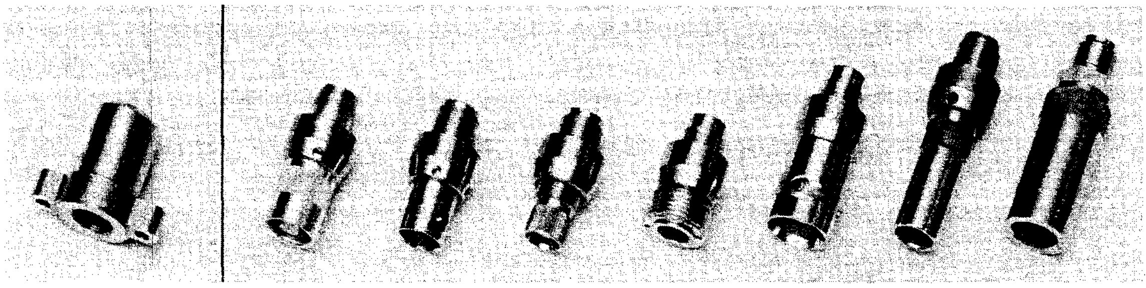

Figure 6-3 Basic socket Versacon® 9 with some of the available Versacon® 9 adaptors

6.3.5 RECHARGEABLE BATTERIES FOR DATA RETENTION

The power supply unit on the right side wall contains rechargeable batteries: 3 Ni-Cd cells 501 RS, type "Mignon" IEC R 6. These ensure, if the mains voltage is interrupted temporarily or switched off, that the last settings which were entered and all stored data are retained. The batteries are trickle-charged whenever the Level Meter is switched on.

If the Level Meter was switched off for a longer period, it is recommended that it be left on for approximately 8 hours in order to fully recharge the batteries. The batteries are stored in the battery compartment N on the rear of the unit (see Figure 4-2). To replace the cells, remove the two philips head screws, permitting the battery holder to be pulled out.
When fitting new cells, ensure that their polarity is correct, as shown on the cover.