ROHDE&SCHWARZ

Operating manual

SIGNAL GENERATOR SMPD

376.8011.52

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VOLUME I

Manual consists of 3 volumes

Contents of SMPD Manual

VOLUME I

1. Data Sheet
2. Preparation for Use and Operating Instructions
3. Maintenance

VOLUME II

4. Service Instructions for Complete Unit
5. Service Instructions for PC Boards Y1 to Y10

VOLUME III

5. Service Instructions for PC Boards Y11 to Y105, Option SMPD-B1 and Option SMPD-B2

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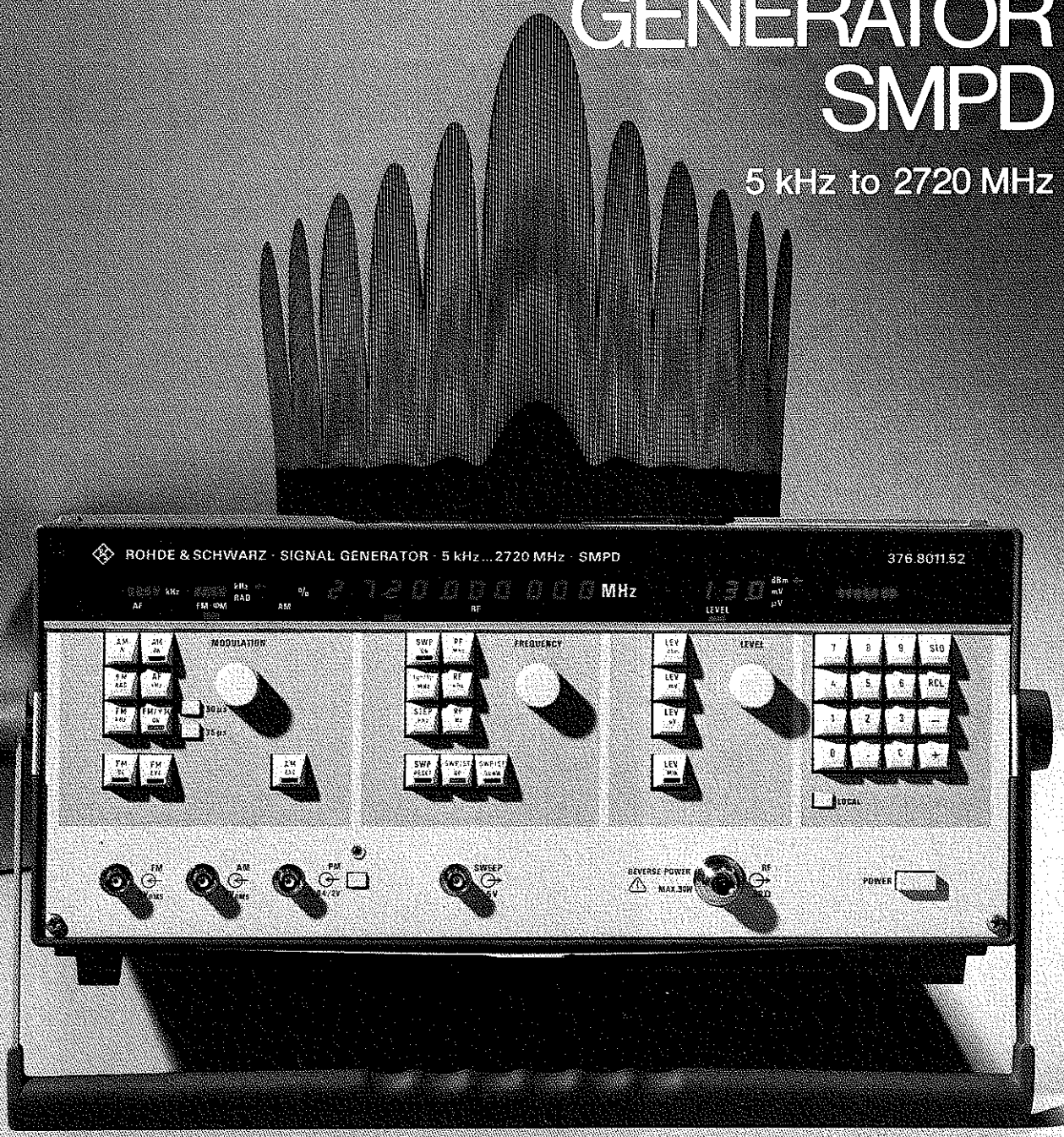
ROHDE&SCHWARZ

SMPD

SIGNAL GENERATOR SMPD

5 kHz to 2720 MHz



IEC 625 Bus

IEEE 488

Data sheet
376801
E - 1

SIGNAL GENERATOR SMPD

The Synthesizer **Signal Generator SMPD** is a remote-controllable signal generator of high spectral purity, wide frequency range, excellent modulation characteristics and great ease of operation.

Frequency, level

- **Frequency range** 5 kHz to 2720 MHz, resolution up to 1000 MHz: 0.1 Hz, up to 2720 MHz: 1 Hz
- **Output level range** −143 to +13 dBm, resolution 0.1 dB

Spectral purity

- **SSB phase noise** < −143 dBc (1 Hz) at 20 kHz offset from carrier (f_c = 100 MHz)
- **Non-harmonic spurious signals** < −78 to −90 dBc, carrier-dependent, at ≥ 1 kHz offset from carrier
- **Harmonics** −30 dBc,
  subharmonics −40 dBc (at f_c ≥ 1360 MHz)

AM, FM, φM and pulse modulation

- **AM frequency range** DC to 50 kHz
- **FM stereo-compatible**, distortion 0.1 %
- **FM deviation** up to 3200 kHz at f_{mod} = DC to 125 kHz
- **Pulse modulator** (option) rise/fall time 10 ns, on/off ratio > 80 dB; simultaneous AM/FM (φM) and pulse modulation
- **Crystal-referenced modulation generator** 10 Hz to 100 kHz

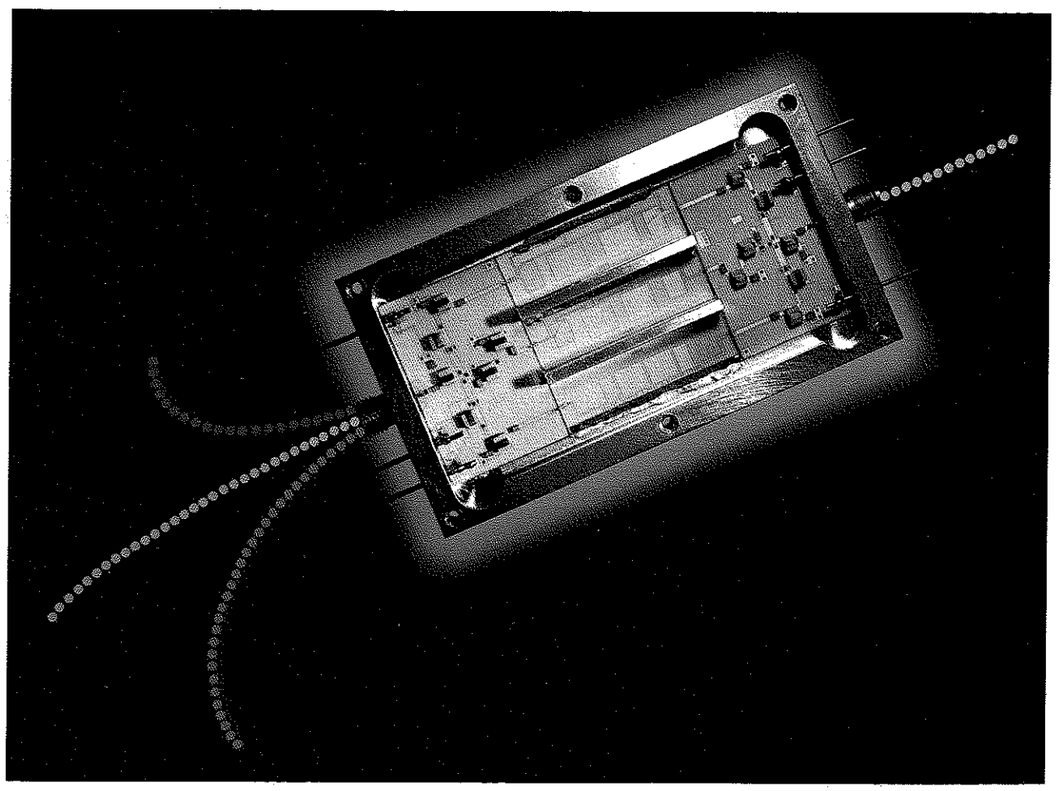
Ease of operation

- Control of all functions via **keyboard** and **IEC bus**
- **Rotary knobs** for quasi-continuous setting of frequency, level and modulation
- Linear and logarithmic **frequency and level variation** with freely selectable step width
- **Non-volatile storage** of 40 instrument setups
- **Automatic self-test** with error indication

Digital sweep

- Linear or logarithmic **sweep**
- **Freely selectable:** start/stop frequency
  sweep width
  dwell time

Thin-film bandpass filters in frequency doubler of SMPD provide for optimal suppression of subharmonic spurious signals



APPLICATION

Applications/Measurements	Special features of SMPD
Measurement of general receiver characteristics	
Sensitivity Bandwidth	Wide dynamic range AM and FM
Dynamic adjacent-channel selectivity Intermodulation Blocking S/N ratio	High spectral purity High suppression of non-harmonic spurious signals
Squelch	Non-interrupting level variation
Spurious responses to CEPT	Frequency range up to 2.72 GHz High spectral purity
Measurements on SSB receivers	
Tuning error	High frequency resolution
Blocking Desensitization Spurious responses	High spectral purity High suppression of non-harmonic spurious signals
S/N ratio	Low residual FM and AM
Measurements on AM/FM sound broadcasting receivers	
Distortion	Low AM/FM distortion
Stereo crosstalk	Stereo capable, high channel separation
Crossmodulation Unweighted and weighted S/N ratio Selectivity	High spectral purity
Low-noise signal source with synchronization capability	
Reference source in phase noise test assemblies Use as local oscillator	High spectral purity Synchronization capability High frequency stability and accuracy
Signal source for narrowband test items	
Filters, resonators Quality determination of crystals	Low residual FM FM/DC High frequency stability, resolution and accuracy
Broadband measurements	
Gain Reflection Transmission characteristics EMC tests	Wide frequency range Digital sweep Low level frequency response
Signal source with pulse modulation capability	
Measurements on radar equipment	Pulse modulation with rise/fall time of 10 ns ON/OFF ratio > 80 dB

Frequency range 5 kHz to 2720 MHz The frequency range of the SMPD covers all important frequency bands for radiotelephony, broadcasting, telemetry, directional radio and UHF radar. It allows measurement of spurious signals up to 2.72 GHz in compliance with CEPT regulations. Up to 1 GHz the resolution is 0.1 Hz, above 1 GHz it is 1 Hz. The frequency accuracy is determined by the internal, oven-controlled 10-MHz crystal oscillator (5×10^{-9}/°C and 2×10^{-9}/day) or an external reference frequency of 10 MHz.

Controlled output level from −143 to +13 dBm The SMPD features a high level accuracy which is particularly important for sensitivity measurements. The total level error including frequency response is, even at 1 µV, within ±1.5 dB up to 1360 MHz and within ±2.0 dB up to 2.72 GHz. The high-precision mechanical attenuator is RF pickup-proof and can be switched in 2-dB steps up to 140 dB. It has been designed for frequent use in automatic test systems and has a resetting accuracy of 0.03 dB. The overload protection fitted as standard prevents the attenuator from being damaged by externally applied RF powers up to 50 W and DC voltages up to 35 V. The non-interrupting level variation over a range of 10 dB starting from any level is important for measurements on squelch circuits, amplifiers susceptible to overdriving or receivers with automatic level control.

Minimum RF leakage of the signal generator ensures that the adjustable minimum useful signals can be used for sensitivity measurements even on unshielded receivers (e.g. paging receivers). The RF leakage of the SMPD is far below the limit values specified in MIL-STD-461A and fully complies with the requirements to VDE 0871. The voltage induced by the radiated interference of the useful signal in a two-turn loop of one inch in diameter held close to the front panel is less than 2 µV (measured into 50 Ω).

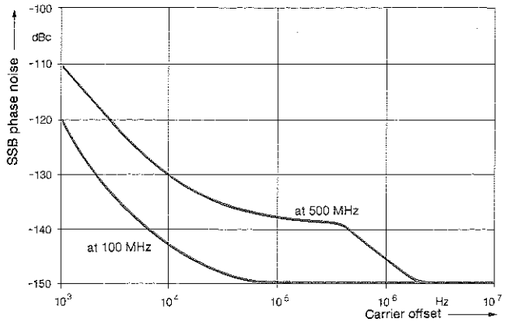
Spectral purity The high spectral purity makes the SMPD suitable without any restrictions for all measurements on receivers including two-signal measurements.

The **single-sideband phase noise** of the SMPD is −134 dBc at 500 MHz with 20 kHz offset from the carrier. By means of frequency division this value can even be improved towards lower frequencies: −147 dBc at 100 MHz (see diagrams on the right). The low SSB phase noise allows the dynamic adjacent-channel selectivity of a receiver to be measured at 500 MHz with a dynamic range of more than 80 dB, 70 dB being specified by CEPT regulation for mobile receivers.

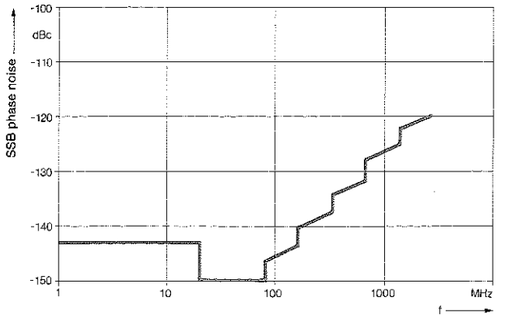
Test signals with extremely low SSB phase noise are also required for desensitization measurements on shortwave SSB receivers. For this purpose the spurious signal must be set 80 dB above the useful signal with 30 kHz offset from the carrier. For a measurement which is to be unaffected by the sideband noise of the spurious signal, only a signal source can be used whose single-sideband phase noise is not greater than −145 dBc at a carrier offset of 30 kHz. The SMPD fulfills this requirement over the entire shortwave range.

Residual FM For measuring the signal-to-noise ratio of SSB receivers a test signal with particularly low residual FM is required. The residual FM of the SMPD weighted to CCITT is less than 0.5 Hz in the shortwave range and still below 1 Hz at 500 MHz.

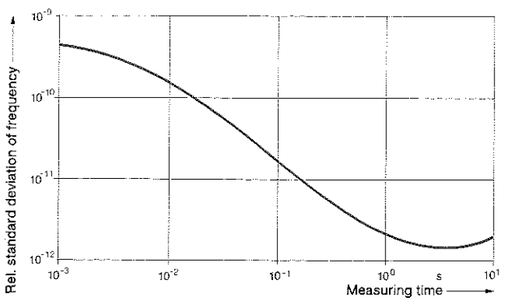
Short-term stability For some applications the short-term stability of the output frequency of the signal generator is of interest in addition to the SSB phase noise and residual FM. The diagram at the very bottom of this page shows the relative standard deviation of frequency of the SMPD measured with a frequency counter and evaluated according to the Allan variance method fulfilling the most exacting requirements.



SSB phase noise of SMPD as a function of carrier offset (bandwidth 1 Hz)



Typical values of SSB phase noise of SMPD in dBc (1 Hz) as a function of frequency; carrier offset 20 kHz



Relative standard deviation of frequency of SMPD at 1360 MHz (internal reference frequency) as a function of measuring time

Broadband noise For blocking measurements on mobile receivers low broadband noise of the signal source is important. In view of the minimum blocking level of 90 dBµV required by CEPT regulations, measurements can only be performed with signal generators whose broadband noise does not exceed −145 dBc. The SMPD fulfills this requirement for carrier frequencies up to 21.25 MHz; for carrier frequencies from 21.25 to 1360 MHz the broadband noise is even −150 dBc only.

Nonharmonic spurious signals Another critical measurement that can be performed with the SMPD is the determination of the spurious signal suppression of mobile receivers up to and above 2 GHz. To comply with the minimum value of 70 dB specified by CEPT, no spurious signals above −90 dBc from the test generator may fall within the receive channel. Nonharmonic spurious signals of the SMPD remain below −90 dBc in the frequency range 21.25 to 680 MHz which contains the most frequently used radiotelephony bands.

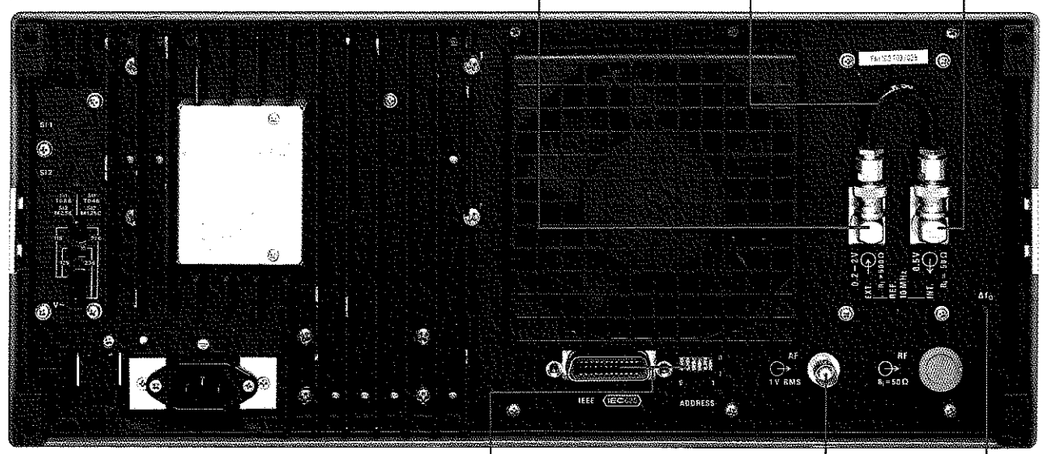
In the frequency range 1360 MHz to 2720 MHz the output signal of the SMPD is generated by frequency doubling. The resulting subharmonics are suppressed to < −40 dBc by bandpass filters made up of thin-film circuits.

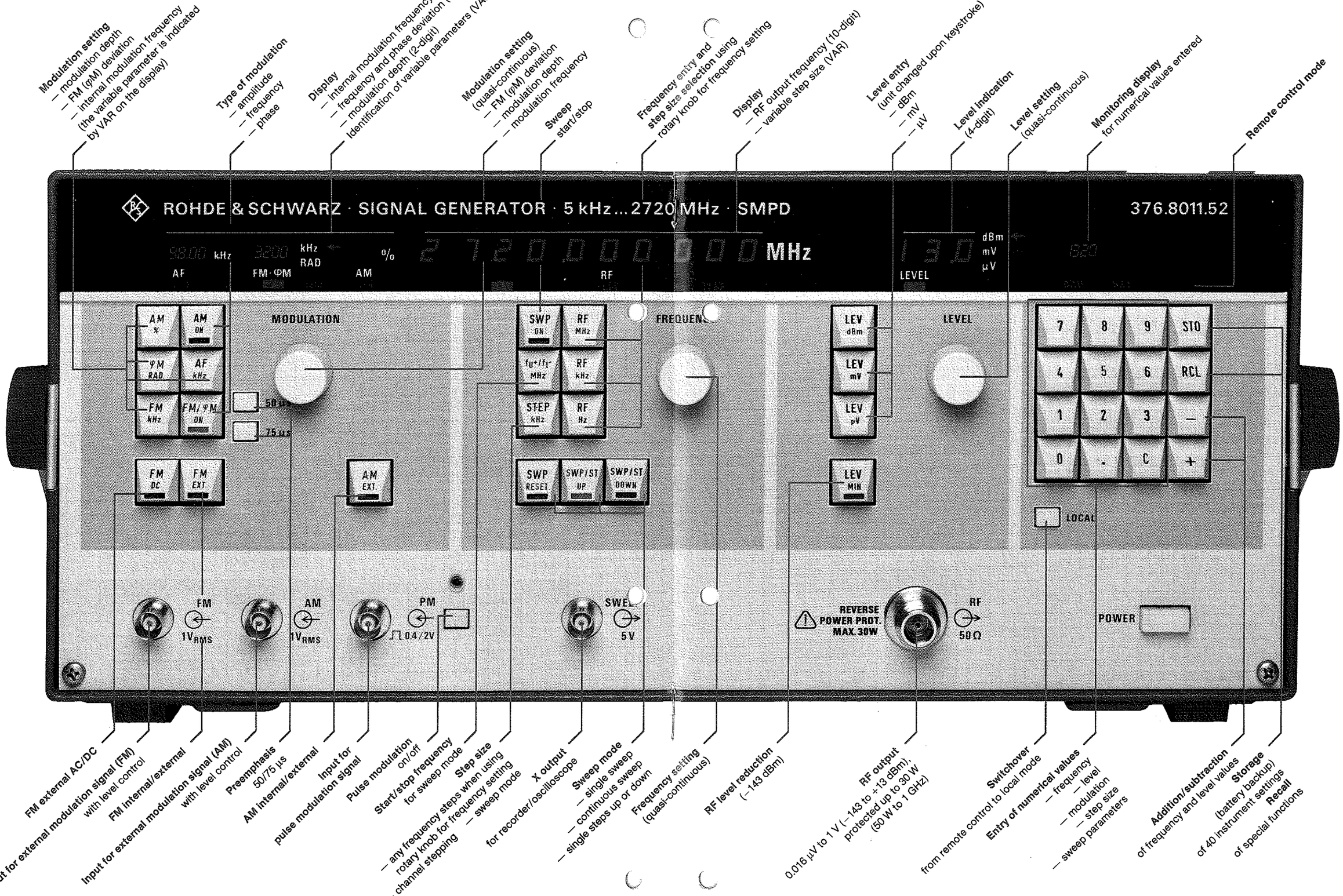
Modulation characteristics The modulation capabilities of the SMPD, i.e. **amplitude, frequency or phase and pulse modulation,** can be set simultaneously and independently of each other. The modulation bandwidth for AM is 50 kHz, for FM 125 kHz up to a deviation of 3.2 MHz. Amplitude modulation is possible down to the lowest carrier frequencies without having any limiting effects on the characteristics. FM-DC allows analog sweep, VCO operation with the possibility of synchronizing to a second signal source and direct carrier keying for digital FSK modulation. In the latter mode it is particularly useful that in the SMPD the frequency error inevitably occurring with FM-DC is minimized by a digital sample-and-hold circuit. AM-DC allows voltage-controlled level variation which can be used for instance for external, analog voltage control or for switching the signal on/off. Thanks to the exceptional quality of the modulation (AM distortion < 1% up to 1360 MHz, FM distortion < 0.1%, stereo crosstalk 56 dB down), the SMPD is also suitable for measurements on AM and FM hifi receivers.

Internal modulation source for sinewave signals is a low-distortion AF synthesizer from 10 Hz to 100 kHz, with 1 Hz resolution below 10 kHz and 10 Hz above (distortion 0.05%). The crystal-controlled frequency and the phase-continuous frequency change with short switching times (computer control) of less than 10 ms allow the modulation generator to generate selective-call sequences to all standards.

When fitted with the **Pulse Modulator Option** SMPD-B1, the SMPD also provides signals for comprehensive testing of radar receivers. Pulse modulation is possible at carrier frequencies from 500 MHz to 2.72 GHz, encompassing the IF ranges of microwave radar and the UHF radar range. The spurious signals produced by video feedthrough of the drive pulse are at least 30 dB down from the carrier. The output level is also controlled in the pulse-modulation mode and can be set up to 10 dBm. The envelope of the pulsed carrier exhibits rise and fall times of less than 10 ns. The maximum repetition frequency is 1 MHz, the carrier on/off ratio at least 80 dB. The pulsed carrier can be amplitude- and frequency- or phase-modulated.

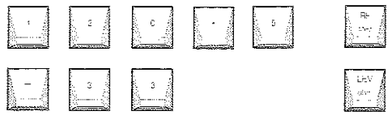
Rear view of SMPD




Modulation setting
– modulation depth
– FM (φM) deviation
– internal modulation frequency
(the variable parameter is indicated
by VAR on the display)
Type of modulation
– amplitude
– frequency
– phase
Display
– internal modulation frequency (4-digit)
– frequency and phase deviation (4-digit)
– modulation depth (2-digit)
– identification of variable parameters (VAR)
Modulation setting
(quasi-continuous)
– FM (φM) deviation
– modulation depth
– modulation frequency
Sweep
start/stop
Frequency entry and
step size selection using
rotary knob for frequency setting
Display
– RF output frequency (10-digit)
– variable step size (VAR)
Level entry
(unit changed upon keystroke)
– dBm
– mV
– µV
Level indication
(4-digit)
Level setting
(quasi-continuous)
Monitoring display
for numerical values entered
Remote control mode
ROHDE & SCHWARZ · SIGNAL GENERATOR · 5 kHz ... 2720 MHz · SMPD
376.8011.52
98.00 kHz
AF
3200 kHz
RAD
FM·ΦM
%
AM
2 7 2 0 . 0 0 0 0 0 MHz
RF
13.0 dBm
mV
µV
LEVEL
820
MODULATION
FREQUENCY
LEVEL
AM %
AM ON
φM RAD
AF kHz
FM kHz
FM/φM ON
50 µs
75 µs
FM DC
FM EXT
AM EXT
SWP ON
RF MHz
fU+/fL- MHz
RF kHz
STEP kHz
RF Hz
SWP RESET
SWP/ST UP
SWP/ST DOWN
LEV dBm
LEV mV
LEV µV
LEV MIN
7 8 9 STO
4 5 6 RCL
1 2 3 –
0 . C +
LOCAL
POWER
FM
1VRMS
AM
1VRMS
PM
0.4/2V
SWEEP
5V
REVERSE
POWER PROT.
MAX. 30W
RF
50Ω
FM external AC/DC
Input for external modulation signal (FM)
with level control
FM internal/external
Input for external modulation signal (AM)
with level control
Preemphasis
50/75 µs
AM internal/external
Input for
pulse modulation signal
Pulse modulation
on/off
Start/stop frequency
for sweep mode
Step size
– any frequency steps when using
rotary knob for frequency setting
– sweep mode
– channel stepping
X output
for recorder/oscilloscope
Sweep mode
– single sweep
– continuous sweep
– single steps up or down
Frequency setting
(quasi-continuous)
RF level reduction
(–143 dBm)
RF output
0.016 µV to 1 V (–143 to +13 dBm),
protected up to 30 W
(50 W to 1 GHz)
Switchover
from remote control to local mode
Entry of numerical values
– frequency
– level
– modulation
– step size
– sweep parameters
Addition/subtraction
of frequency and level values
Storage
(battery backup)
of 40 instrument settings
Recall
of special functions

General The front panel is logically organized in keypads for modulation, frequency, level and data input (see photo on page 6 and 7). A display is provided for each keypad. An additional display above the data input keypad allows checking of the entered values.

The entries are made in the usual order, i.e. numerical value followed by parameter/unit. An RF output frequency of 120.5 MHz and a level of −33 dBm would be entered as follows:



Illuminated sections (VAR) in the displays show the parameters that can be varied with the rotary knob, and the selected step size. The values set for the on/off functions such as modulation, sweep or level remain stored when the instrument is switched off. When the signal generator is switched off or in the case of an AC supply failure the complete setup is retained and automatically restored upon power on.

Inadmissible settings are not accepted and therefore do not change the instrument setting. Out-of-range entries are indicated by flashing of the monitoring display.

A user's guide can be folded out at the bottom of the instrument. It contains operating instructions including a list of all special functions and remote-control commands.

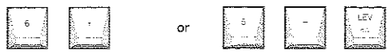
Examples

Level input The output level can be entered in dBm, mV or µV. To change the unit it is only necessary to press the relevant unit key.

Level variation using the rotary knob LEVEL is made in linear steps (0.1 % to 1 %) for level indication in mV or µV or in logarithmic steps (0.1 dB) for indication in dBm.

Non-interrupting level variation After recall of the special function RCL 94 the level can be varied without any interruption over a range of 10 dB, starting from any level. LED bars on the additional display show the available range of variation.

Level variations with any step size in dB, mV or µV are possible by keyboard entries, e.g.



Level reduction is possible using the key  . The level is lowered to −143 dBm, the 50-Ω output impedance being maintained. The previous level is restored when the key is actuated again.

Frequency entry can be made in MHz, kHz or Hz by pressing one of the three RF keys on the frequency keypad. The frequency resolution is 1 Hz. The special function RCL 01 increases the resolution to 0.1 Hz up to a frequency of 1 GHz.

Frequency variation is performed using the rotary knob FREQUENCY. Steps of 1 Hz, 1 kHz, 1 MHz or any value can be selected with the keys

Depending on the selected step width, the VAR display lights up below the Hz-, kHz- or MHz-digits of the frequency readout. With any other step width selected, the VAR displays below the Hz- and MHz-digits are illuminated.

In this case, the step width must be entered in kHz, e.g.:

Remote control All settings of the SMPD (except for power ON/OFF) can also be remotely controlled via the IEC-bus interface (IEC 625-1/IEEE 488) fitted as standard. The control commands are extremely simple, their sequence corresponding to that of the keyboard entry.

Example:

Keyboard entry	Command
	37.5 MH
	−16 DB

A delimiter for terminating a character string is not required. As a listener, the SMPD can receive setting commands and as a talker it can output setting data. It has also service request capability; if there is an error, it sends a corresponding message to the controller.

Two different remote-control modes are possible. The frequency setting time and the IEC-bus transfer time depend on the mode selected. If a frequency change is carried out in **normal mode**, the output frequency is set within 18 ms to an accuracy of 1×10^{-6}.

In the **fast frequency setting** mode the total setting time including the bus transfer is 7 ms. In this mode, up to 34 frequency and FM deviation settings can be stored and recalled via the IEC bus.

For the data acceptance by the IEC bus either **direct command execution** or **block-by-block execution** can be selected. In the direct mode, each setting command is immediately processed before the next command is accepted. With block-by-block command execution up to 50 characters are read in without delay at a rate of 0.4 ms per character. The command block is only processed after a delimiter has been received. In this case the bus holding time is much shorter than in direct mode. NL, CR + NL, ETB, ETX or EOI appended to the last byte are suitable delimiters.

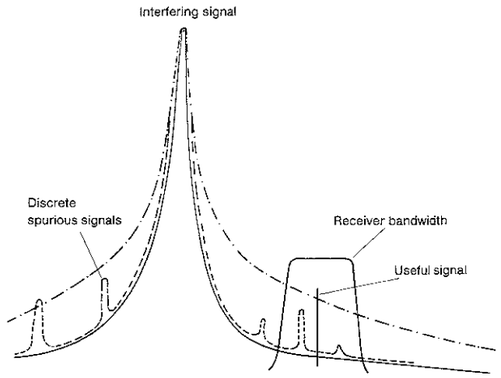
The **fast setting times** make the SMPD suitable for applications in automatic test systems and also fulfill the requirements for testing mobile phones of cellular radio networks. The short frequency setting times are matched by a level setting time of 25 ms.

Multisignal measurements These mainly include two-signal measurements for determining the receiver response to interfering signals. One of the signal sources generates the useful signal in the receive channel, while the other one simulates the interfering signal outside the receive channel. In the test assembly shown below the Radiocommunication Tester CMT provides the useful signal and the Signal Generator SMPD the interfering signal.

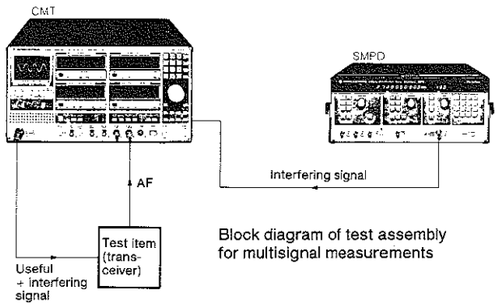
Irrespective whether these two-signal measurements involve selectivity tests on AM SSB receivers (e.g. desensitization) or FM radiotelephone receivers (e.g. dynamic adjacent-channel selectivity or suppression of spurious responses), the interfering signal source must in any case comply with the high demands on spectral purity (see diagram on the right).

An interfering signal source with excessive SSB phase noise or insufficient suppression of discrete spurious signals degrades the measurement of the receiver characteristics. The SINAD value used as a criterion is then determined by the high noise level of the interfering source and not by the noise of the receiver. Discrete spurious signals of the interfering source with too high level simulate a receive frequency when passing through the receive channel.

The Signal Generator SMPD with its excellent spectral purity meets all requirements for any kind of multisignal measurement. All modern radiotelephone test assemblies from Rohde & Schwarz are equipped with a signal combiner for non-reactive combination of the useful and interfering signal with defined attenuation and free from input distortion.

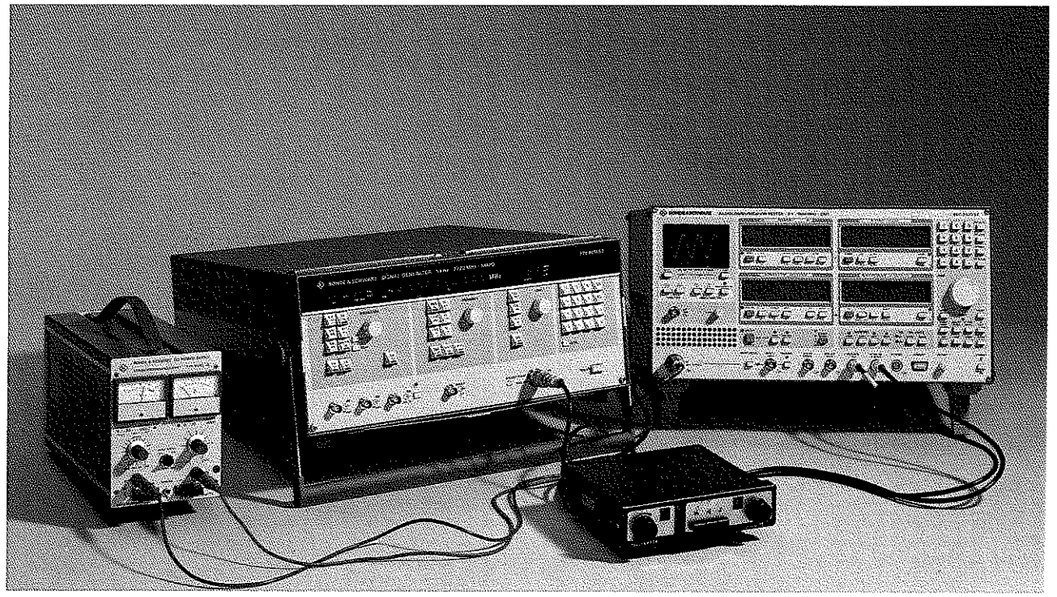


Effect of spectral purity of interfering signal on multisignal measurements:
dash-dotted: signal generator unsuitable because SSB phase noise too high;
dashed: signal generator unsuitable because discrete spurious signals too high;
blue: suitable signal generator with low SSB phase noise **and** low discrete spurious signals



Block diagram of test assembly for multisignal measurements

Test assembly with Signal Generator SMPD and Radiocommunication Tester CMT for multisignal measurements



Frequency

Range	5 kHz to 2720 MHz
Resolution up to 1000 MHz	0.1 Hz
up to 2720 MHz	1 Hz
Error referred to reference frequency at $f_{carrier}$ > 21.25 MHz	< 5 × 10⁻⁸
≤ 21.25 MHz	< 0.8 mHz
Reference frequency	from internal temperature-controlled crystal oscillator or external source 10 MHz, output: > 0.2 V_{rms} into 50 Ω, sine or squarewave signal or TTL levels
Internal crystal oscillator Crystal aging	< 2 × 10⁻⁹/day (after 100 days of operation)
Temperature effect	< 5 × 10⁻⁹/°C
Warmup time	15 min
External control	10 MHz ±100 Hz

Frequency setting time to within	1 × 10⁻⁸	2 × 10⁻⁹	
	150 Hz	3 Hz	at f_c > 21.25 MHz
			at f_c ≤ 21.25 MHz
Standard programming mode (after reception of last character via IEC bus)	< 18 ms	< 50 ms	
Fast programming mode (incl. IEC-bus transfer time)	7 ms	40 ms	

Output level

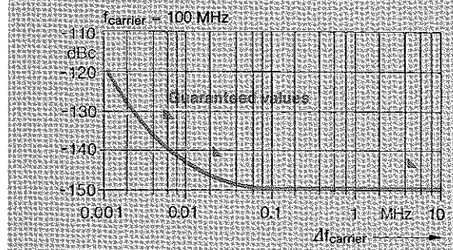
Range with CW and FM	−143 to +13 dBm (0.016 µV to 1 V into 50 Ω)
with AM	max. 7 to 12.9 dBm, depending on modulation depth
Resolution log	0.1 dB
lin	0.1% to 1%
Frequency response flatness 50 kHz to 1360 MHz	< 2 dB
to 2720 MHz	< 2.5 dB
to 10 kHz	typ. −1 dB
to 5 kHz	typ. −3 dB

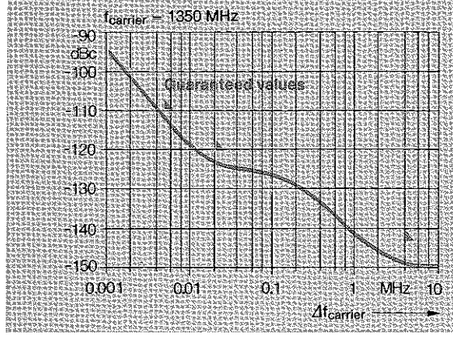
Total error[1]	50 kHz to 1360 MHz	50 kHz to 2720 MHz
from +13 to −20 dBm	< ±1.5 dB	< ±2 dB
20 to 127 dBm	< ±1.8 dB	< ±2.5 dB
Frequency response flatness with pulse modulation	< 3 dB	500 to 2720 MHz
Total error with pulse modulation	< ±3.5 dB	500 to 2720 MHz
Source impedance	50 Ω	

VSWR	50 kHz to < 680 MHz	680 to < 1360 MHz	1360 to 2720 MHz
Output level ≤ −2 dBm	< 1.2	< 1.35	< 1.8
> −2 dBm	< 1.4	< 1.6	< 1.8
VSWR with pulse modulation Output level ≤ −2 dBm	< 1.2	< 1.35	< 1.8
> −2 dBm	< 1.4	< 1.6	< 1.8

Level switch-off (LEV MIN)	switchover to minimum output level; Z_{out} remains 50 Ω
Switching time for level variations (after reception of last character via IEC bus)	25 ms

Typical values of SSB phase noise in dBc (1 Hz) (CW with special function RCL 07)





Spectral purity

Harmonics for P_{out} ≤ 10 dBm	< −30 dBc, typ. −35 dBc[2][3]
P_{out} = 12 dBm	< −25 dBc, typ. −30 dBc[3]
(without special function 07)	
Subharmonics	< −40 dBc at $f_{carrier}$ ≥ 1360 MHz
Nonharmonics from 50 kHz to 2720 MHz (at ≥ 1 kHz offset from carrier)	
at $f_{carrier}$ ≤ 21.25 MHz	< −80 dBc
21.25 < $f_{carrier}$ < 680 MHz	< −90 dBc, typ. −100 dBc
680 ≤ $f_{carrier}$ < 1360 MHz	< −84 dBc
1360 ≤ $f_{carrier}$ ≤ 2720 MHz	< −78 dBc

Noise, referred to 1 Hz bandwidth

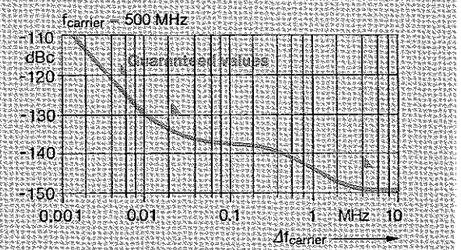
	Offset from carrier	Carrier frequency 20	100	500	1350	2720 MHz
SSB phase noise	5 kHz	< −130	< −134	< −120	< −111	< −105 dBc
	20 kHz	< −138	< −143	< −130	< −121	< −115 dBc
Broadband noise[1]	> 4 MHz	< −140	< −145	< −145	< −145	< −135 dBc

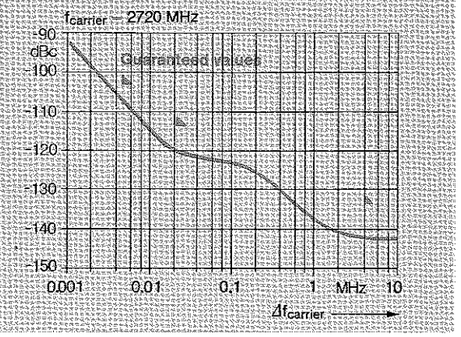
The values specified for broadband noise are valid with special function RCL 07 switched on; without RCL 07, the values are increased by 3 dB, in AM mode by 7 dB.

Modulation generator

Frequency range	10 Hz to 100 kHz
Resolution up to 10 kHz	1 Hz
above 10 kHz	10 Hz
Frequency error	< 1 Hz (in addition to relative error of reference frequency)
Frequency response flatness	< 0.1 dB
Level at rear output	1 V_{rms} into 600 Ω, Z_{out} = 10 Ω
Distortion	< 0.1%
Harmonics	typ. < −65 dBc
Nonharmonics	typ. < −65 dBc
Phase-continuous frequency change:	
Switching time (after reception of last character via IEC bus)	< 10 ms

[1] Valid if special function RCL 94 (non-interrupting level variation) is not effective.
[2] In the frequency range 50 kHz to 2720 MHz.
[3] At 10 kHz typ. −30 dBc.



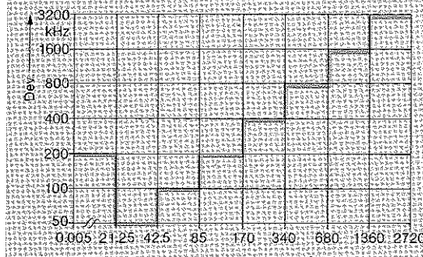


Amplitude modulation

Modes	internal, external, external DC-coupled for level control with external probe
Modulation frequency, internal	10 Hz to 50 kHz
external	DC or 10 Hz to 50 kHz
Modulation frequency response flatness up to 10 kHz	< 0.4 dB[1]), typ. 0.1 dB
up to 50 kHz	< 1.0 dB[1])
Modulation depth	0.1 to 99%
Resolution	up to 10%: 0.1%; up to 99%: 1%
Setting error at 1 kHz/≤ 80% up to 500 MHz	< 3% of set value
above 500 MHz	< 6% ±1% absolute value[1])
Incidental φM, peak value up to 680 MHz	< 0.1 rad
up to 1360 MHz	< 0.15 rad at 1 kHz and m = 30%
up to 2720 MHz	< 0.3 rad
Modulation distortion[1]) at $f_{carrier}$ < 1360 MHz	up to 30% AM / up to 80% AM
f_{mod} DC to 1 kHz	< 1% / < 1.5%
DC to 10 kHz	< 1.5% / < 3%
at $f_{carrier}$ ≥ 1360 MHz f_{mod} DC to 1 kHz	< 2% / < 3%
DC to 10 kHz	< 3% / < 5%
Modulation input AC-coupled	1 V_{rms}
DC-coupled	0 to −2.82 V for a linear level reduction by 35 dB
Input impedance	600 Ω

Frequency modulation

Modes	internal, external, AC, DC; preemphasis 50 µs, 75 µs
Modulation frequency, internal	10 Hz to 100 kHz
external	DC or 10 Hz to 125 kHz
Modulation frequency response flatness internal, 10 Hz to 100 kHz	< 0.2 dB
40 Hz to 15 kHz	< 0.1 dB
external, 10 Hz to 125 kHz	< 0.1 dB
Maximum adjustable deviation	see diagram



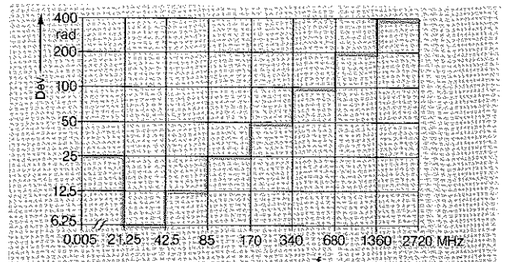
Maximum adjustable deviation as a function of carrier frequency

Resolution of deviation setting	< 1% of set value or 10 Hz
Deviation error (at f_{mod} = 1 kHz)	< 3% of set value or 20 Hz (40 Hz for $f_{carrier}$ ≥ 1360 MHz)
Modulation distortion at 50% of maximum deviation	< 0.1% at 1 kHz (< 1% at preemphasis, internal); < 0.3% at 20 kHz
with stereo (40 kHz deviation, $f_{carrier}$ < 21.25 MHz or 85 to 120 MHz)	< 0.1% at 1 kHz
Stereo crosstalk (conditions same as above)	> 45 dB down from 40 Hz to 15 kHz, typ. 56 dB from 500 Hz to 10 kHz
Unweighted signal-to-noise ratio (30 Hz to 20 kHz, rms) Stereo (40 kHz deviation, 50 µs, $f_{carrier}$ < 21.25 MHz or 85 to 120 MHz)	> 80 dB
Mono (conditions same as above)	> 82 dB
Preemphasis (switch-selected)	50 µs, 75 µs
Additional deviation error	< 2%
Incidental AM at f_{mod} = 1 kHz and 40 kHz deviation	< 0.1%
Accuracy of carrier frequency with FM DC Frequency error when switching to FM DC	< 1% of set positive deviation
	< 1 × 10⁻⁸ for $f_{carrier}$ > 21.25 MHz, < 155 Hz for $f_{carrier}$ ≤ 21.25 MHz
Recalibration	each time FM AC or FM OFF is selected
Modulation input AC-coupled	1 V_{rms}
DC-coupled	1.41 V_p, yielding set deviation
Input impedance	600 Ω

Phase modulation

Modes	internal and external
Modulation range	10 Hz to 8 kHz
Maximum adjustable deviation	see diagram

[1]) Valid if special function RCL 94 (non-interrupting level variation) is not effective.



Maximum adjustable deviation as a function of carrier frequency

Resolution of deviation setting	< 1% of set value or 0.01 rad
Error of deviation setting	< 5% of set value or 0.02 rad
(at f_{mod} = 1 kHz)	(0.04 rad for $f_{carrier}$ ≥ 1360 MHz)
Frequency response flatness	< 1 dB up to 3 kHz, < 3 dB up to 8 kHz
Modulation distortion at 50% of maximum deviation, internal	< 1%
external	< 0.1%

Digital sweep

Modes	single sweep up or down, periodic triangular sweep
Sweep width	freely selectable, least increment 1 Hz, log. 0.01 to 50% per step
Dwell time	normally 18 ms per step, programmable up to 5 s per step
Voltage swing at X-output	5 V (BNC female)

Pulse modulation (with option SMPD-B1)

Mode	external
Carrier frequency range	500 to 2720 MHz
Max. level	+10 dBm
ON/OFF ratio	> 80 dB
Rise/fall time (10% to 90%)	10 ns
Pulse repetition frequency	10 Hz to 1 MHz
Min. pulse width	50 ns
Video feedthrough	30 dBc
Input impedance f. ext. signal	corresponding to TTL levels, DC-coupled
Required input level	> 2.5 V (ON), < 0.5 V (OFF)

Overload protection

Protects the RF attenuator against externally applied RF (10 to 2720 MHz) or DC voltage	
Max. permissible RF power	50 W up to 1 GHz, 30 W up to 2.72 GHz
Max. permissible DC voltage	35 V
Response indication	OFF indicated on level display, service request possible via IEC bus

Remote control and data output

System	IEC 625-1 (IEEE 488)
Connector	24-contact Amphenol
Interface functions	T6, L4, SR1, RL1, DC1

General data

Rated temperature range	+5 to +45 °C
Storage temperature range	−40 to +70 °C
Power supply	115/125/220/235 V ±10%, 47 to 66 Hz (270 VA, 160 W), safety class I to VDE 0411 (IEC 348)
RF leakage	complies with requirements of VDE 0871 and MIL-STD-461A, Methods CE 03 and RE 02 (radiated and conducted interference) as well as VDE 0875 (limit values of radio interference grade K)
Mechanical resistance	shock-tested to DIN 40046, Part 7 (30 g, 11 ms) and vibration-tested to DIN 40046, Part 8 (5 to 55 Hz, 2 g), corresponds to IEC Publications 68-2-27 and 68-2-6
Dimensions, weight	470 mm × 206 mm × 485 mm, 28.5 kg

Ordering information

Order designation	► Signal Generator SMPD 376.8011.52
Accessories supplied	power cable

Recommended extras

Option Pulse Modulator	SMPD-B1 377.0914.02
19" Rack Adapter[1])	SMPD-Z9 377.1210.02
Service Kit	XPC-Z1 337.9810.02

[1]) When the 19" rack adapter is used, the total mounting height is 221 mm.

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2 Preparation for Use and Operation

Values appearing in this section are not guaranteed. The specifications in the SMPD data sheet are binding. The operating controls and indicators described below are shown in Figures 2-5 and 2-6.

2.1 Legend for Figures 2-5 and 2-6

No.	Inscription	Function
1	AF kHz	4-digit display of the frequency of the internal modulation generator.
2	FM·ΦM kHz RAD	4-digit display of frequency deviation or phase deviation. The applicable unit, kHz or RAD, is indicated by an illuminated arrow.
3	AM %	2-digit display of the modulation index.
4	VAR 50 µsec 75 µsec	The illuminated VAR indicator shows which parameter can be varied with knob 29. The 50-µsec indication lights to show the inserted pre-emphasis.
5	RF MHz	10-digit display of the high-frequency setting.
6	VAR	Three illuminated indicators to show the selected variation step.
7	LEVEL	4-digit display of the RF signal level.
8	dBm mV µV	Three illuminated arrows to show the unit of the output level.
9	TALK LISTEN REMOTE	Three illuminated arrows to show the remotely selected status with IEC-bus.
10		Display for monitoring the value entered via keyboard 11.

No.	Inscription	Function
11	7 8 9 STO 4 5 6 RCL 1 2 3 - 0 . C +	Keyboard for numerical input. Key C clears the display and permits a new input, even if the display is blinking. Key STO for storing data. Key RCL for calling stored data.
12	POWER	Power switch
13	LOC.	Button for switching from IEC-bus control to manual control.
14	LEVEL	Knob for quasi-continuous setting of the output level.
15	RF  50 Ω	RF output, N-type socket.
16	LEV dBm LEV mV LEV µV	Three keys for level input. They specify the unit for the level value entered via keyboard 11.
17	LEV MIN	Button for switching the RF level out. When the button is switched, the minimum level of -143 dBm is set and read out on the level display 7. When the button is switched again, the level value previously set is restored. The response of the overload protection is indicated by the readout OFF in the level display field. After elimination of the overvoltage, the overload protection is restored by pressing the LEV-MIN button.

No.	Inscription	Function
18	FREQUENCY	Knob for quasi-continuous RF tuning. The resolution is selected with buttons 20 and 24.
19	SWP 5 V ◄⊖	Recorder output proportional to frequency. The voltage deviation is 5 V.
20	RF MHz RF kHz RF Hz	Three buttons for frequency input. They specify the unit for the frequency value entered via keyboard 11 and change over the resolution of the frequency variation.
21	SWP/ST DOWN	Button for defining sweep and channel steps. If RESET button 23 is not lit, button 21 can be used for downward channel stepping; otherwise the button is used for defining the sweep direction.
22	SWP/ST UP	Button for defining sweep and channel steps. If RESET button 23 is not lit, button 22 can be used for upward channel stepping; otherwise the button is used for defining the sweep direction.
23	SWP RESET	Button for setting the upper and lower frequency limits. If this button is lit, the sweep direction can be specified with buttons 21 and 22. (With the RESET button not lit, buttons 21 and 22 are used for channel stepping.)
24	STEP kHz	This button is used, after a numerical value has been entered via keyboard 11, for inputting the step size, in kHz, of the sweep and single steps. If a numerical value has not been entered, the step size is set as an increment of knob 18.

No.	Inscription	Function
25	fu+/fl- MHz	Button for inputting the upper sweep frequency limit in MHz (with positive sign after the numerical value) and of the lower sweep frequency limit (with negative sign after the numerical value) after entering the numerical value on keyboard 11. If no numerical value has been entered, the indicated frequency is accepted.
26	SWP ON	Button for switching the sweep on and off.
27	AM 1 V_{RMS}	BNC socket for inputting the external AM modulation signal. If the input voltage level is too low or too high, the lower or upper segment row of the AM display 3 lights respectiveley.
28	AM EXT.	An in/out button for selecting the internal or external modulation source. This button is lit for the AM EXT setting.
29	MODULATION	Knob for varying one of the parameters indicated in display 1, 2, 3. The parameter varied is indicated by the lighting of the VAR display. The parameter to be varied is selected by button 34: AM % ΦM RAD FM kHz AF kHz without prior entry of value.
30	50 µs 75 µs	Button for switch pre-emphasis in FM operation in or out.
31	FM 1 V_{RMS}	BNC socket for inputting the external FM/ΦM signal. If the input level is too high/low, only the upper/lower segment row of the FM/ΦM display 2 lights.

No.	Inscription	Function
32	FM EXT.	In/out button for selecting the internal or external FM modulation source. The button is lit for the FM EXT setting.
33	FM DC	In/out button for selecting either FM DC or FM AC in the FM-external operating mode. The button is lit for FM DC.
34	AM % AM ON ΦM RAD. AF kHz FM kHz FM/ΦM ON	With in/out buttons AM, FM/ΦM the indicated modulation is switched in or out. The button is lit when the modulation is switched in. If the modulation is switched out, the modulation parameters remain stored and at switch-in are used again. The modulation parameters - percentage modulation, phase deviation, frequency deviation, and internal modulation frequency - are input by entering the value and then pressing one of the buttons AM % ΦM RAD FM kHz or AF kHz. For specifying a parameter to be varied with VAR button 29, the corresponding one of these buttons is operated without prior entry of a numerical value.
35	SI 1	Fuse for 220-V or 235-V supply: T1,25 115-V or 125-V supply: T1,6D
36	SI 2	Fuse for 220-V or 235-V supply: M1,25C 115-V or 125-V supply: M2,5E
37	Spare fuses	A spare fuse for each of these voltages is located behind the cover.
38		Blower case
39	EXT. 0.2 - 2 V  Ri >500 Ω	Input socket for the 10-MHz reference signal. Input impedance >500 Ω. Voltage range 0.2 to 2 volts.
40	K30	BNC connecting cable for the reference frequency.

No.	Inscription	Function
41	INT 0.5 V Ri = 50 Ω	Output socket of the internal crystal reference frequency. 50 Ω output impedance and 0.5-V signal level.
42	ADDRESS	6-way switch for setting the IEC-bus address.
43	IEC 625 IEEE 488	IEC-bus connector.
44	RF Ri = 50 Ω	Opening for mounting an RF output socket (optional).
45	Δf_Q	Trimming resistor for calibrating the internal crystal reference frequency.
46	AF 1 V_{RMS}	Output socket for the AF signal of the internal modulation generator. 10 Ω output impedance and 1 V_{rms} on 600 Ω.
47	47 - 420 Hz	AC supply connector.
48	115 V, 125 V, 220 V, 235 V,	AC supply voltage selector.
49		Button to switch on and off the pulse modulator (only with Option PM).
50	PM ⊓⊔ 0.4/2 V	Modulation input PM (only with Option PM). TTL input. With input voltages >2 V (high state) the PM is in "On" mode. A signal with the level indicated on display 7 is present on the RF output 15. For input voltages <0.8 V (low state) the output level at socket 15 is reduced by >80 dB (off state of PM).
51		LED indication of pulse modulation (only with Option PM). The LED is lit with the pulse modulator in the ON state.

2.2 Preparation for Use

The Synthesizer Generator SMPD is designed for operation with a 115-V, 125-V, 220-V, or 235-V supply voltage. It is factory set for the 220-V supply.

To convert to one of the other voltages, switches 48 (Fig. 2-1 and 2-6) are set to correspond with the markings and the appropriate fuse for the selected voltage is inserted. Spare fuses for all four supply voltages are located behind the cover 37 (Fig. 2-6).

The SMPD can be installed in any 19" rack by use of the 19" rack-mounting adapter SMPD-Z9 (Order No. 346.1210.02).

The ventilation air inlet 38 and outlet (front edge of upper cabinet cover) must be unobstructed in order to assure satisfactory ventilation.

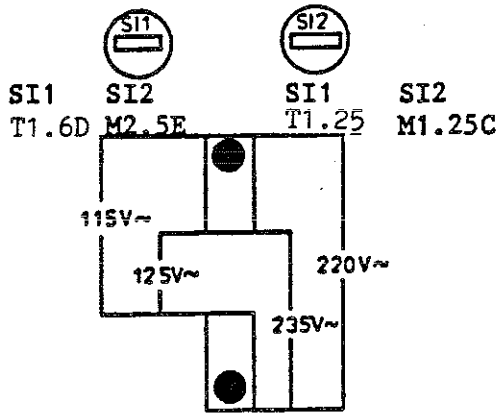


Fig. 2-1 Fuse panel

2.3 Operation

The Synthesizer Generator SMPD is set up and operated by means of pushbuttons and rotary knobs. The controls and displays are logically arranged in four groups.

The left-hand section contains the controls and display for signal modulation and two sockets for inserting AM and FM modulating signals from external sources.

The next section contains the RF display, the knob for varying the frequency, the buttons for setting the frequency and sweep and the output socket the frequency-proportional voltage for the recorder. The next section contains the level display, the level input and variation controls and the RF output socket. The section on the right contains the keyboard for entering parameter values, the indicators for remote control status, the power switch, and go-to-local button, as well as the display for monitoring the entered values.

Any settings of these controls have to be made in the following order: numerical value (optional, keyboard 11), unit, and function. Quasi-analog settings can be made with the rotary knobs.

The unit and function buttons are all non-illuminating buttons in the modulation, frequency and level sections. All illuminated buttons are of the in/out type. The variation knobs provide for varying the unit or parameter value selected by a button without prior entry of a value on the keyboard. Information as to which units or parameters are adjustable is provided by the illuminated VAR displays.

Inadmissable settings are not accepted and do not therefore change the settings of the instrument. An out-of-range input results in a blinking of the monitoring display. If a particular readout is at the same time intermittent, then the indications are to be interpreted as the newly entered value being incompatible with the value of the readout. The blinking is cleared by pressing button C (clear) or by entering a new and valid value.

All inputs possible by means of front-panel controls can also be programmed via the IEC bus. The descriptions of the individual functions include the corresponding IEC commands.

2.3.1 "On" State

After switch-on, the SMPD executes a display test and displays its IEC-bus address. During the warm-up period, which lasts a few minutes, error messages may appear in the display field 5 (see section 2.3.7). When these have ceased, the status existing at the time of switch-off is in general restored. (Exceptions to this rule are explained in section 2.3.8.4: Special Functions). If a memory error occurs, minimum values are set.

2.3.2 Frequency Setting

2.3.2.1 Input

The frequency range of the SMPD is 5 kHz to 2720 MHz. The frequency can be set by entering the desired value via keyboard 11 (Fig. 2-5) and then pressing the RF MHz, RF kHz or RF Hz button 20. Zeros at the end following the decimal point and exeeding the permitted display width is ignored. The resolution is 1 Hz (0.1 Hz in some cases, see section 2.3.8.2). The frequency is indicated on display field 5 in MHz with a decimal point.

Examples:

Keyboard 11								Buttons 20	IEC bus
		1	0	.	5			RF MHz	"1Ø.5 MH"
		1	0	0	0			RF kHz	"1ØØØ KH"
1	1	2	0	7	8			RF Hz	"112Ø78 HZ"

2.3.2.2 Variation, Channel Steps

The frequency setting can be varied either with the frequency control knob or in single steps with button 21 and 22.

The step variation of control knob 18 can be switched by means of button 20 to Hz, kHz or MHz (0.1 Hz, 100 Hz, or 100 kHz with 0.1-Hz resolution). The selected step variation is illuminated below the RF display.

Freely selectable step size:
The numerical value of the desired step size is entered in kHz via keyboard 11 and the STEP kHz button is pressed.

Control-knob variation with freely selectable step size:
When the STEP kHz button is pressed without a numerical value having first been entered, the selected step size for the control knob variation is taken as the set value. This condition is signalled by the lighting of two buttons below the RF display.

The single steps of buttons 21 and 22 are executed with the entered step size. The SWP RESET button 23 must at the same time be unlit.

Step sizes from 1 Hz (0.1 Hz) up to the largest possible step are permitted over the entire frequency range.

2.3.2.3 Frequency Addition and Subtraction

A frequency step can be added to or subtracted from the selected frequency. For this purpose, the numerical value, the sign and the unit are entered in that order.

Keyboard 11			Buttons 20	IEC bus
1	0	-	RF MHz	"1Ø- MH"
2	0	+	RF MHz	"2Ø+ MH"
	1	-	RF kHz	"1- KH"
1	1	0	+	RF Hz	"11Ø+ Hz"

2.3.2.4 Reference Frequency

The Synthesizer Generator SMPD contains a 10-MHz crystal reference oscillator from which the output frequency is derived. The reference frequency with a level of 0.5 V_{rms} is available at socket 41 on the rear panel for external control functions. In this case, the connecting cable 40 must be disconnected from socket 41 and then connected again to this socket via a three-way adapter (see Figs. 2-2 and 2-6).

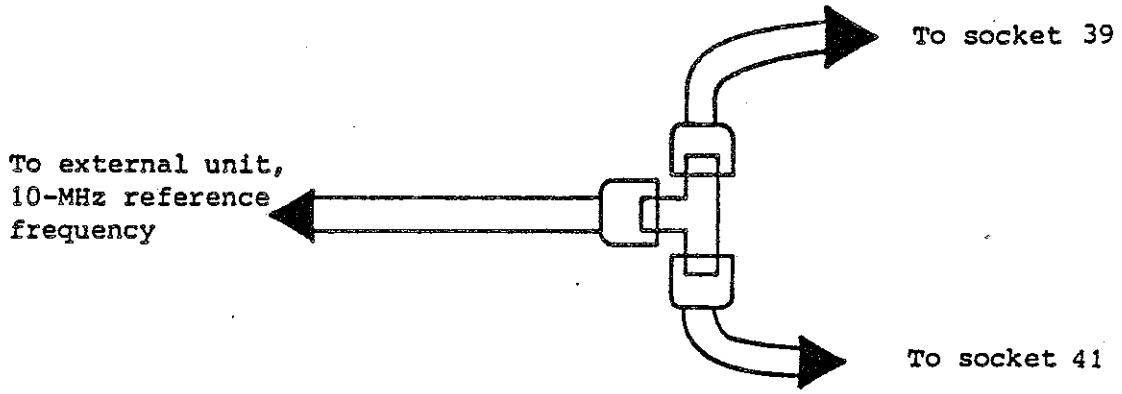


Fig. 2-2 Feeding an external unit

The SMPD can also be operated with an external reference frequency of 10 MHz. For this purpose, cable 40 must be disconnected from BNC socket 39 and a signal (sinewave or squarewave) fed into this socket at a level in the range 0.2 to 2 V_{rms} (Z_{out}= 500 Ω).

2.3.3 Sweep Operation

2.3.3.1 Setting the Frequency Limits and Step Size

Before switching on the sweep, the upper and lower frequency limits and the step size must be defined. For setting the sweep limits, first enter the numerical value and than the negative sign for the lower limit and the positive sign for the upper limit. The entries are terminated with the fu+/fl- MHz button 25.

Examples:

Keyboard 11	Button 25	IEC bus
1 0 . 5 -	fu+/fl- MHz	"1Ø.5 FL"
2 1 0 . 4 4 +	fu+/fl- MHz	"21Ø.44 FU"
5 0 0 +	fu+/fl- MHz	"5ØØ FU"
2 0 -	fu+/fl- MHz	"2Ø FL"

The displayed frequency can also be defined as upper or lower frequency limit by pressing the + or - button and then the fu+/fl-MHz button 25.

Examples:

	Keyboard 11	Button 25	IEC bus
"Indication"	-	fu+/fl- MHz	"FL"
"Indication"	+	fu+/fl- MHz	"FU"

To set the step size, the numerical value is first entered and then the STEP kHz button 24 is pressed.

Examples:

Keyboard 11	Button 24	IEC bus
2 0 0 . 5	STEP kHz	"2ØØ/.5SK"
1 0 0 0 0 . 4	STEP kHz	"1ØØØØ.4SK"

The two limits can only be entered in MHz and the step size only in kHz. The step size is also the size of the channel step.

A logarithmic sweep can be set by means of special function RCL 04 (see section 2.3.8.4). The numerical value entered before the STEP kHz button 24 is pressed then defines the step size in percent of the instantaneous frequency per step.

2.3.3.2 Setting the Operating Mode

Three operating modes are provided for the sweep:

a) Single sweep from the lower to the upper frequency limit,

b) Periodic sweep between the frequency limits swept by a triangular function,

c) Single sweep from the upper to the lower frequency limit.

The mode can be selected in the reset state (SWP RESET button 23 lit) or during the sweep (SWP ON button 26 lit) with SWP/ST UP button 22 and SWP/ST DOWN button 21.

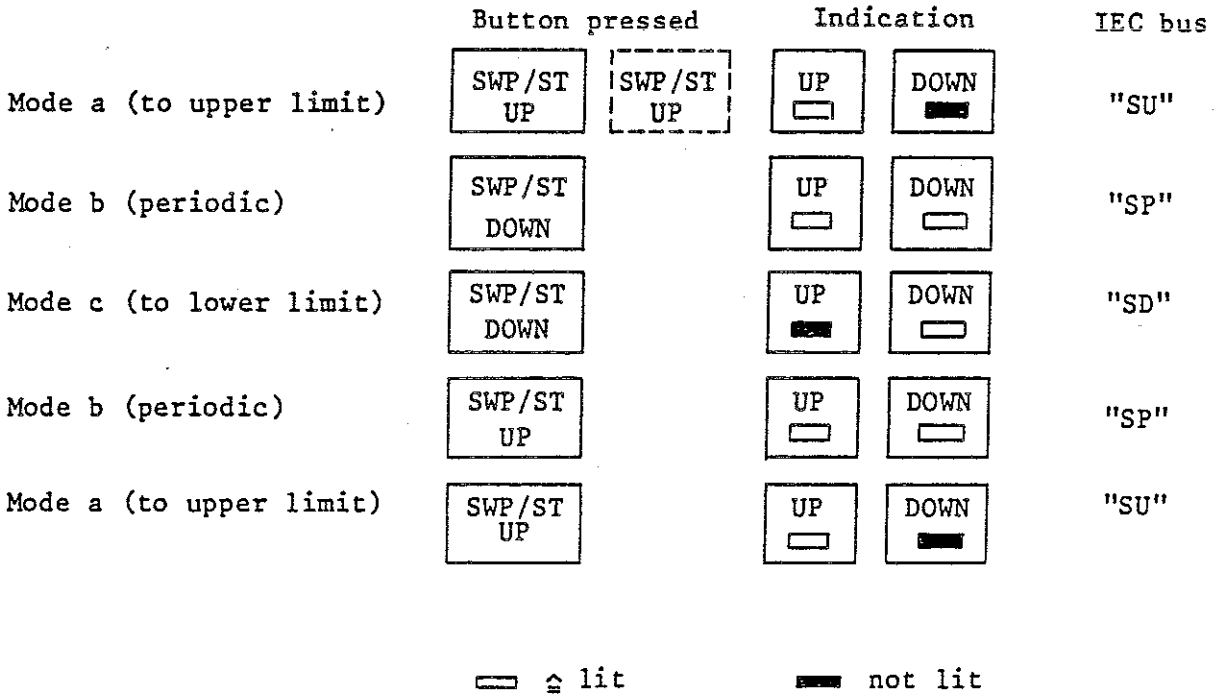
It is possible to change from mode a (button 22 lit) to mode b by pressing button 21 (buttons 22 and 21 lit) and then to mode c by pressing button 21 again (button 21 lit).

Return to mode a is also effected via mode b by pressing button 22 twice.

It is not possible to change from mode a directly to mode c.

Examples:

SWP RESET button 23 or SWP ON button 26 lit:



2.3.3.3 Initial State, Checking

The frequency can be set to the start frequency of the sweep with SWP RESET button 23. In mode a (upwards) and mode b (periodic), the start frequency is the lower frequency limit, in mode c (downwards), it is the upper frequency limit. The RESET state is indicated by the RESET button being lit. This state can be cancelled by pressing either the RESET button again, or the SWP ON button 26, or by turning knob 18.

In the RESET state, the frequency limits (cannot be called in the other states) may be checked. The step size can be checked in the normal state (RESET button not lit) by initiating a channel step with button 22 or 21 (see 2.3.2.2).

2.3.3.4 Start, Stop, Interrupt

The sweep can be started with the SWP ON button 26 (Fig. 2-5) when the instantaneous frequency is within the sweep limits. If this is not the case, the display blinks and will then be cleared by pressing key C of keyboard 11 - with no change in settings - or with SWP RESET button 23, which also sets the start frequency of the sweep. During the entire sweep operation, SWP ON button 26 is lit and SWP RESET button 23 is unlit.

The sweep can be interrupted and restarted at any point with SWP ON button 26. Pressing the SWP RESET button 23 stops the sweep and returns the instrument to the start frequency (see 2.3.3.3).

Examples:

	Indication	Buttons 26, 23	New indication	IEC bus
Start	SWP ON ■	SWP ON	SWP ON □	"S1"
Interrupt	SWP ON □	SWP ON	SWP ON ■	"SØ"
Stop/ basic setting	SWP RESET ■	SWP RESET	SWP RESET □	"R1"

□ ≙ button lit ■ button not lit

2.3.3.5 Recording with an XY Recorder

The following procedures are recommended for recording frequency responses with an XY recorder:

1. Program the frequency limits and the step size (2.3.3.1). If no special function is involved, the SMPD sets a new frequency about every 20 ms. 100 steps take about 2 seconds.

2. Calibrate the X-axis of the recorder with the stylus lifted off the paper and set the frequency limits in the RESET state as described in section 2.3.3.3. Socket 19 delivers a deflection voltage of 0 V at the lower frequency limit and +5 V at the upper frequency limit.

   For calibrating the Y-axis, vary the frequency with knob 18 (e.g. for finding a maximum). During this procedure, the X deflection voltage tracks and then stops at the corresponding sweep limit. The RESET state is thus cancelled and has to be restored (by pressing the SWP RESET button 23 again) in order to select the desired operating mode (2.3.3.2).

3. In the RESET state (SWP RESET button 23 lit), lower the recording stylus and start the sweep execution with the SWP ON button 26.

   For the logarithmic sweep (special function RCL 04, 2.3.8.4), logarithmic paper is recommended to provide a calibrated frequency axis.

4. Interrupts and new starts from the same point can be carried out with the SWP ON button 26. If the sweep is interrupted (SWP ON button not lit), a setting can be sought with knob 18 whereby the recorder tracks (note the variation step size selected for the knob 18).

5. Lift the stylus when the sweep is completed. Switch on the RESET state before a new sweep is initiated.

2.3.4 Output Level Setting

2.3.4.1 Level Entry

The permissible level-entry range is as follows:
13 dBm to -143 dBm or 1000 mV to 0.016 µV.
All values apply for a 50-Ω load.

With Option "Pulse Modulator" and switched-in pulse modulation, the level-entry range is limited to +10 dBm to -143 dBm.

The output level is set by entering the desired numerical value via keyboard 11 (Fig. 2-5). The unit is then specified by pressing the LEV dBm, LEV mV or LEV µV button 16 and thus initiating the setting. The microprocessor selects the unit mV or µV best suited for the display (e.g. an input of 10,000 µV results in an indication of 10 mV). The level that has been input is indicated on display 7. The indicated level can be converted to µV, mV or dBm by pressing the corresponding button 16. The illuminated arrow 8 on display 7 indicates the selected unit.

Examples:

	Keyboard 11	Buttons 16	IEC bus
Level 10.54	1 0 . 5 4	LEV mV	"10.54 MV"
Level 8.5 dBm	8 . 5	LEV dBm	"8.5 DB"
Level 23.1 µV	2 3 . 1	LEV µV	"23.1 UV"
Indication in dBm		LEV dBm	"DB"
		LEV mV	"MV"
Indication in mV/µV		LEV µV	"UV"

2.3.4.2 Output Level Addition or Subtraction

A level step can be added to or subtracted from the selected level. This level step can be entered in µV, mV or dBm. The result is displayed in the selected unit of the level. The level step is executed by entering the numerical value via keyboard 11 (Fig. 2-5), then the sign and finally the unit.

Examples:

Keyboard 11	Buttons 16	IEC bus	Indication before and after level step	
			Before	After
Reduce level by 1.5 dB 1 . 5 −	LEV dBm	"1.5-DB"	100 mV	84.0 mV
Increase level by 2.1 dB 2 . 1 +	LEV dBm	"2.1+DB"	10 dBm	12.1 dBm
Reduce level by 10 mV 1 0 −	LEV mV	"1Ø-MV"	100 mV	90.0 mV
Increase level by 3.7 µV 3 . 7 +	LEV µV	"3.7+UV"	-87 dBm	-84.3 dBm

2.3.4.3 Variation

The level can be varied quasi-continuously with knob 14 (Fig. 2-5). The variation is logarithmic in dB or linear in mV/µV depending on the selected unit (indicated by arrow 8). (See 2.3.8.11 regarding non-interrupting level variation over 10-dB range.)

For variation with programmable step size please refer to section 2.3.8.5.

The level limit values cannot be exceeded, i.e. the level remains at the minimum or maximum value even if the knob is turned further.

2.3.4.4 LEV MIN button

The RF level can be set to its minimum value, -143 dBm by pressing the LEV MIN button 17 (Fig. 2-5). By pressing this button again, the original level is set.

In case of overloading the RF output by an external signal, the overload protection (available as an option) responds. This response is indicated by the appearance of the word OFF in the level display field. The overload protection can be restored by pressing the LEV MIN button.

2.3.5 Modulation

2.3.5.1 Modulation Generator

The internal modulation generator is a synthesizer with a frequency range of 10 Hz to 100 kHz. Its frequency is set by entering the value via keyboard 11 and pressing the AF kHz button 34. The resolution is 1 Hz up to 10 kHz output and 10 Hz for the higher frequencies. If the AF kHz button is pressed without a value first having been entered on the keyboard 11, the frequency can be set with knob 29. The AF signal is available on socket 46 on the rear panel of the instrument at a level of 1 V_{rms}.

If the modulation is switched off or provided from an external source, the modulation generator is switched off. If the AF voltage is nevertheless required at socket 46, switch-off of the generator may be prevented by use of the special function RCL 91 (see also 2.3.8.8).

Example:	Keyboard 11					Button 34	IEC bus
	[1]	[6]	[.]	[1]	[6]	[AF kHz]	"16.16 NK"

2.3.5.2 Amplitude Modulation

The amplitude modulation can be adjusted to between 0.1 and 99%. The resolution is 0.1% up to 10% modulation and 1% beyond that. The percentage modulation is entered by keying its numerical value via keyboard 11 and pressing the AM % button 34. If this button is pressed without a value first having been entered on the keyboard, the degree of modulation can be varied by means of knob 29.

The amplitude modulation may be switched in and out with the AM ON button 34, the switched-in condition being indicated by the LED of the button. When the AM is switched out, the display also goes out. Switch-over from internal to external operation is effected by means of the AM EXT button 28. This button is lit when external operation is set.

Example:	Keyboard 11		Button 34	IEC bus
	[7]	[6]	[AM%]	"76 AP"

2.3.5.3 External Level Control

By means of the special function RCL 93 (see also 2.3.8.10), the input circuit for the external modulation is dc-coupled and the modulation-index setting thus disabled. The letters LC appear in the display. If the AM socket 27 is not used, the indicated level is maintained. A negative input voltage reduces the output voltage proportionally; -1.41 V results in 50% of the displayed value and with -2.82 V, the maximum attenuation of about 35 dB is reached.

This operating mode is switched out by pressing the AM EXT button or by means of special RCL 00 (see 2.3.8).

2.3.5.4 Frequency Modulation

The frequency deviation is input by means of the FM kHz button 34 after the numerical value has first been entered via keyboard 11. The input range is from 0.01 to 3200 kHz. The maximum deviation depends on the carrier frequency in each case (see Part 1).

If the FM kHz button is pressed without a value first having been entered via the keyboard 11, the frequency deviation can be varied by means of knob 29. Frequency and phase modulation are selected with the FM/ϕM button 34. The lighting of the LED in this button indicates the modulation mode switched in. An illuminated arrow in the display indicates the selected modulation mode even when the modulation is switched out.

Internal or external modulation is selected by the FM EXT button 32, which lights when external modulation is selected. For two-tone modulation, special function RCL 92 (see also 2.3.8.9) provides for mixing the internal AF signal with the externally supplied signal. The frequency deviation generated by the internal signal is displayed. To this is added the deviation generated by the external signal. With 1 V_{rms} on socket 31, the combined deviation is twice the value of the indication. This operating mode can be switched out by pressing the FM EXT button or by use of special function RCL 00.

In case of external modulation, dc-coupling can be switched in with the FM DC button 33. At switchover, the instantaneous control voltage of the modulation oscillator is held fixed in synchronous operation, so that the frequency deviation is a minimum ($<1 \times 10^{-6}$). By briefly deselecting the FM or by switching to AC operation, this calibration can be updated at any time.

50-µs and 75-µs preemphasis can be switched in with button 30, and switched out again by pressing the button a second time. Illuminated indicators in the display field show the switching state.

2.3.5.5 Phase Modulation

Phase deviations of 0.01 to 400 radians, depending on the carrier frequency can be set with ΦM RAD (see Part 1). For this, the modulation frequency must lie between 10 Hz and 8 kHz. If the ΦM RAD button is pressed without prior entry of a value, the phase deviation can be set with knob 29. The phase modulation can be switched in and out with the FM/ΦM button, which lights when the modulation is switched in. External modulation may be selected (as with FM modulation) with the FM EXT button.

Examples:	Keyboard	IEC bus
	[1] [0] [FM kHz]	"1Ø FK"
	[FM EXT.] [FM DC]	"PEFD"
	[FM ON]	"P1" (FM on) "PØ" (FM off)
	[6] [.] [6] [ΦM RAD.]	"6.6 PR"

2.3.6 Data Storage

All settings of the instrument can be stored. If the instrument is switched off, the data is maintained for up to six weeks. The SMPD provides for the storage of five complete instrument settings and, in addition, a setting each for RF frequency, level, sweep, AM, FM, ΦM, and AF of the internal modulation generator. The complete instrument settings are stored by pressing the STO key and one of the number keys 1 to 5 on the keyboard 11 (Fig. 2-5).

Examples:	Keyboard	IEC bus
	STO 1	"ST 1"
	STO 5	"ST 5"

If, after pressing the STO key, one of the units buttons is pressed before the number key is pressed, only the values of the parameters belonging to this unit are stored.

With the storing of the modulation settings, the operating modes such as INT/EXT and DC/AC are also stored.

Examples:	Keyboard	IEC bus
Store frequency	STO RF MHz 1	"ST MH 1"
	STO RF Hz 5	"ST HZ 5"
Store level	STO LEV dBm 1	"ST DB 1"
Store AM index	STO AM% 2	"ST AP 2"

The entire sweep data can be stored by use of the fu+/fl-MHz button 25. In addition to the frequency limits and the step size, the dwell time (section 2.3.8.3: Special function RCL 03) and the logarithmic operating mode (section 2.3.8.4: Special function RCL 04) are stored.

Example:	Keyboard			IEC bus
	STO	fu+/fl- MHz	1	"ST FS 1"

All stored values can be reactivated with the RCL key of keyboard 11. The syntax is the same as for the STO commands, except that the RCL key replaces the STO key.

All recalled data are checked for syntax to avoid incorrect settings resulting from memory faults. Errors are indicated on the RF display 5 with the word ERROR for half a second and the smallest value for the setting is output.

Examples:	Keyboard			IEC bus
	RCL		1	"RC 1"
	RCL	LEV dBm	1	"RC DB 1"

2.3.7 Self-test

The SMPD has a self-checking program for the most important modules. If one of them fails, the current displays go out and in the RF display appears one of the digits from 1 to 6. These have the following meaning (in a fully warmed-up instrument):

1 Fault in Y7 (SMPC buffer)

2 Fault in Y5 (Interpolation synthesizer II)

3 Fault in Y6 (Interpolation synthesizer III)

4 Fault in Y12 (AM modulator + ALC)

5 Fault in Y10 (Oscillator control)

6 Fault in Y2 (FM stage)

Arising from one error, several errors may concurrently occur. The error messages 1, 2, 3, 5 can appear on the power-up of a unit in cold state for up to 5 minutes. The error messages will disappear as soon as the warm-up of the temperature-regulated reference oscillator is completed and the normal frequency accuracy is attained.

The self-test is automatically carried out approximately every 20 seconds. For troubleshooting it can be suppressed by means of the special function RCL 09. When switching on the special function RCL 00, the self-test is immediately carried out. Indication of the error messages is switched off by pressing any button and only reappears after another 20 seconds if the error is still present.

2.3.8 Special Functions

The special functions are initiated by pressing the RCL key and two digit keys on keyboard 11 (Fig. 2-5):

RCL 00 Clearing of all special functions, immediate self-test.

RCL 01 0.1-Hz resolution (for frequencies below 1000 MHz).

RCL 02 1-Hz resolution (normal state).

RCL 03 Permits the input of an additional dwell time in ms per step of a sweep with the STEP kHz button 24 and the input of a step size in dB for the level control knob by means of LEV dBm button 16 (applies only to one input).

RCL 04 Produces a logarithmic sweep and a logarithmic variation of knob 18.

RCL 05 Restores the linear sweep and linear variation of knob 18. (Normal state)

RCL 06 Switching the level control knob for programmable stop size.

RCL 07 Limits the range of electronic level adjustment for measurements requiring a maximum wideband S/N ratio.

RCL 08 Restores the normal range of electronic level adjustment, which ensures improved harmonic distortion for levels below 10 dBm. (Normal state)

RCL 09 Switches off the self-checking program to permit servicing of the instrument.

RCL 91 The internal modulation generator remains in operation even though the modulation is switched out. The AF signal is available on the rear-panel socket 46. This function is cleared by use of special function RCL 00.

RCL 92 Provides for two-tone modulation in FM and ΦM. One signal source is the internal modulation generator, the second source is an external generator. This operating mode can be cleared by pressing the FM EXT button or by use of special function RCL 00.

RCL 93 Provides for external level control (ALC) via the AM modulation input, which is dc-coupled for this operating mode. This mode is cleared by pressing the AM EXT button or by use of special function RCL 00.

RCL 94 Provides a continuous level variation of 10 dB.

RCL 95 Restores the normal functioning of the level setting, in which the mechanical attenuation switches in 2-dB steps.

RCL 96 Disables the three variation knobs.

RCL 97 Restores the normal functioning of the variation knobs.

RCL 98 Switches off the buffer oscillator also in the case of CW and small FM deviations.

RCL 99 Resets RCL 98.

The special functions RCL 03, RCL 06, RCL 07 and RCL 09 are cleared when the instrument is switched off (and also in case of an AC supply failure).

2.3.8.1 Clearing all Special Functions (RCL 00)

RCL 00 clears all special functions and restores the normal state; in addition, a self-test is carried out.

2.3.8.2 Frequency Resolution (RCL 01, RCL 02)

RCL 01 switches on the 0.1-Hz resolution, which permits any frequency below 1000 MHz to be set with a resolution of 0.1 Hz. The decimal point of the display is shifted one digit to the left. If the 1000-MHz value is exceeded while a new setting is made, the SMPD switches automatically to 1-Hz resolution and the decimal point is shifted to the right by one digit. If the frequency falls below 1000 MHz, the 0.1-Hz resolution is automatically restored. The last digit is set to zero. It is possible by means of the variation knob to set the variation in steps of 0.1 Hz, 100 Hz and 100 kHz.

The 0.1-Hz resolution is cancelled by entering the function RCL 02. The 1-Hz resolution is then valid over the whole frequency range.

Examples:

Resolution	Keyboard 11	IEC bus
0.1 Hz	RCL 0 1	"RCØ1"
1 Hz	RCL 0 2	"RCØ2"

2.3.8.3 Dwell Time during Sweep Operation Step Size of Level Variation (RCL 03)

After entering RCL 03, an additional dwell time per frequency step in ms can be input with the STEP kHz button 24.

The range of settable values is 0 to 5000 ms. When this range is exceeded, the display blinks (cleared by pressing key C on keyboard 11 or entering new value). This function applies only to a single input of dwell time which can be switched off by inputting "RCL 03 0 STEP kHz". The dwell time can also be cleared by special function RCL 00 or by switching off the AC supply (or by AC supply failure). When a complete data set or a sweep-data set (section 2.3.6) is stored, the selected dwell time is also stored.

Example:

An additional dwell time of 80 ms (resulting in a period of about 100 ms per step):

Keyboard						IEC bus
RCL	0	3	8	0	STEP kHz	"RCØ38ØSK" or "8Ø DT"

The step size of the level control knob is programmed in dB when entering a numerical value after RCL 03 and then pressing the LEV dBm button 16 (see also section 2.3.8.5).

2.3.8.4 Logarithmic Sweep and Logarithmic Variation (RCL 04, RCL 05)

Special function RCL 04 affects the sweep, channel-step buttons 21 and 22 and knob 18. This function is indicated by all three VAR indicators lighting up.

In this operating mode, any numerical value entered before pressing the STEP kHz button 24 is interpreted as a relative frequency variation per step in %. For reasons of programming, the microprocessor selects the nearest processable lower value from the series 0.01, 0.02, 0.04, 0.09, 0.19, 0.39, 0.78, 1.56, 3.12, 6.25, 12.5, 25, 50%/step (rounded values).

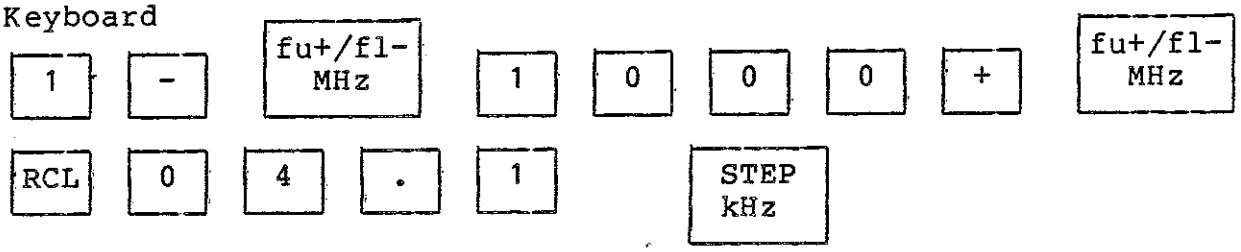
These relative variations apply to the sweep step size, the channel steps, and the variation step size of knob 18. Output socket 19 delivers an output voltage proportional to the number of steps. Hence this voltage is also proportional to the logarithm of the frequency. Wideband measurements over the entire frequency range of the SMPD are possible with a logarithmic frequency scale. Plottings with an XY recorder can be made on logarithmic paper.

The normal state can be restored by entering function RCL 05 without changing any other special functions. The linear state can also be restored by means of RCL 00. The function is retained even if the AC supply is switched off or fails. When a complete setting or a sweep-data set (section 2.3.6) is stored, the special function is also stored.

Example:

Logarithmic sweep from 1 MHz to 1000 MHz with a frequency variation of approx. 0.1% per step:

Keyboard



IEC bus
"1 FL 1ØØØ FU RC Ø4.1 SK"

2.3.8.5 Programmable Step Size of Level Rotary Knob (RCL 06)

The special function RCL 06 permits the step size of the level rotary knob to be switched to programmable dB steps (with level indication in dBm). Programming takes place via the following entry:

(Example of 3-dB steps)

The normal step size can be restored by pressing one of the LEV buttons. This special function is stored together with the complete settings and is cancelled by RCL 00 or disconnection of the AC supply.

2.3.8.6 Largest Wideband S/N Ratio (RCL 07, RCL 08)

These special functions affect the distribution of the level settings between the electronic and the electromechanical attenuators. In the normal state, the output amplifier is only driven to 10 dBm for levels below 10 dBm, thus lowering the harmonic distortion. Function RCL 07 permits full utilization of the output amplifier so that it can be driven up to 13 dBm even in the case of small levels. The electronic level setting then only covers the ranges between the 2-dB steps of the electromechanical attenuator. This improves the wideband S/N ratio but slightly deteriorates the harmonic distortion.

The input of RCL 08 restores the normal state without changing any other special functions.

When complete settings are stored (section 2.3.6), the special function RCL 07 is also stored. It is cleared by RCL 00 or by switching off the AC supply (or by AC supply failure).

2.3.8.7 Switching off the Self-checking Facility (RCL 09)

This special function is designed for servicing and permits uninterrupted front-panel operation when troubleshooting. RCL 09 suppresses the error messages on the display (see 2.3.7).

This function cannot be stored. It is cleared by RCL 00 or by switching off the AC supply (or by AC supply failure).

2.3.8.8 AF Signal without Modulation (RCL 91)

In normal functioning, the internal modulation generator is switched on only when internal modulation is switched in. Special function RCL 91 provides for the internal modulation generator remaining permanently switched on. The AF signal is available on rear-panel socket 46. The frequency of the AF signal is in the usual way adjustable for modulation via the keyboard or the variation knob. This function is cleared by means of RCL 00.

2.3.8.9 Two-signal Modulation in FM/ΦM (RCL 92)

Normal functioning permits switching in either an internally or an externally generated modulation signal. Special function RCL 92 provides for two-signal modulation in which the internally generated AF signal is mixed with an externally supplied signal. The deviation produced by the internal signal is displayed. To this is added the deviation produced by the external signal. With a signal of 1 V_{rms} on socket 31, the combined deviation is double the value displayed. The two-signal modulation can be switched in or out with the FM/ΦM button. This operating mode can be cleared by pressing the FM EXT button or by use of special function RCL 00.

2.3.8.10 External Level Control (ALC) (RCL 93)

Special function RCL 93 results in the input for external AM modulation being DC-coupled and the modulation-index setting being disabled. In the display, the letters LC (level control) appear. If there is no input on AM socket 27, the indicated RF level is maintained. A negative input reduces the level, -1.41 V producing an attenuation of 6 dB, and with -2.82 V, the maximum attenuation of about 35 dB is reached. This operating mode is cleared by pressing the AM EXT button or by use of special function RCL 00.

2.3.8.11 Non-interrupting Level Variation (RCL 94, RCL 95)

In normal functioning, the level is set by a mechanical attenuator set providing attenuation in discrete 2-dB steps.

When RCL 94 is activated, an electronic attenuation circuit is used over a dynamic range of 10 dB in place of the mechanical unit. The 10-dB range of non-interrupted level adjustment extends initially from the level set at the time of entering the RCL 94 function to the 10-dB lower level. If this 10-dB range is exceeded in either direction, the mechanical attenuator is set to a new level and the new 10-dB range of non-interrupting level variation extends from this level to the 10-dB lower level.

Every time that function RCL 94 is entered, the 10-dB range is redefined as described above.

The input monitoring display 10 indicates the position of the level within the 10-dB dynamic range. The lighting of all ten segments of the segment row signifies that the level is within 1 dB of the upper boundary of the range. When only one segment is lit, the level is within 1 dB of the lower boundary.

The level readout in the level display 7 always shows the correct value.

Special funtion RCL 95 restores normal functioning of the level setting, in which the level is set in 2-dB intervals by the mechanical attenuator set.

2.3.8.12 Disabling the Rotary Knobs (RCL 96, RCL 97)

The special function RCL 96 disables the rotary knobs in order to prevent any inadvertent variation of the settings. The VAR indicators are not lit. The rotary knobs are reactivated by RCL 97 and RCL 00. This special function is maintained when the unit is switched off and on again and is stored together with the complete settings.

2.3.8.13 Switching off the Buffer Oscillator (RCL 98, RCL 99)

The special function RCL 98 is designed to switch off the buffer oscillator (Y7, refer to 4.1.1) also in the CW mode and in the case of small FM deviations. The results is a reduction of the SSB noise up to approximately 300-Hz spacing from the carrier and of the microphonic sensitivity. With spacings exceeding this value, an increase of the SSB noise level by up to 10 dB is caused. RCL 99 restores the normal state.

RCL 98 is stored together with the instrument settings (refer to 2.3.6). It is cleared by RCL 00 and by power off (AC supply failure).

2.3.9 Options and Accessories

2.3.9.1 Option: Overload Protection SMPD-B2

The Option Overload Protection SMPD-B2 protects the RF attenuator against excessive RF and DC voltages at the output socket 15. The protective circuit is effective for RF frequencies to 1000 MHz up to a power of 50 W, over 1000 MHz up to 30 W and for DC voltages up to 35 V. The responding of the SMPD-B2 is signalled by the message OFF in the level display field 7. In remote-control operation, a service request message can be output. The protective circuit can be reset with the LEV MIN button 17 or the remote-control command "F1".

The option impairs to a slight degree of the frequency characteristic and output reflection factor.

2.3.9.2 Option Pulse Modulator SMPD-B1

With the Option Pulse Modulator it is possible to pulse modulate via socket 50 the SMPD output signal in the carrier-frequency range from 500 MHz to 2720 MHz.

Switching on the pulse modulator is carried out either with PM button (49) or with remote-control command U1. Switching off is initiated by re-pressing PM button (49) or by the remote-control command UØ. The switch-on state of the pulse modulator is shown by LED 51.

For input voltages <0.8 V (TTL low state) the modulator reduces the RF level by >80 dB.

For input voltages >2 V (TTL high state) the RF level, referred to a load of 50 Ω, is present on socket 15.

The input voltage applied to the modulation input should not exceed or fall below the permissible voltage range of 0 to +5 V.

Referred to a load of 50 Ω and with the pulse modulation switched on, the maximum settable RF level is limited to +10 dBm.

2.3.9.3 Accessories

The 19" Rack-mounting Adapter XPC-Z9 and Service Kit XPC-Z1 are available as accessories.

2.4 IEC-bus Control

The standard SMPD model is equipped with a remote-control facility. The selected data is transmitted in a byte-serial bus system with an interface conforming to the IEC 625-1 (formerly IEC 66.22), IEEE 488-1975, and DIN IEC 66.22 standards. The connection to the IEC bus is made through the rear-panel IEC-625-bus socket 43 (Fig. 2-6).

2.4.1 Interface

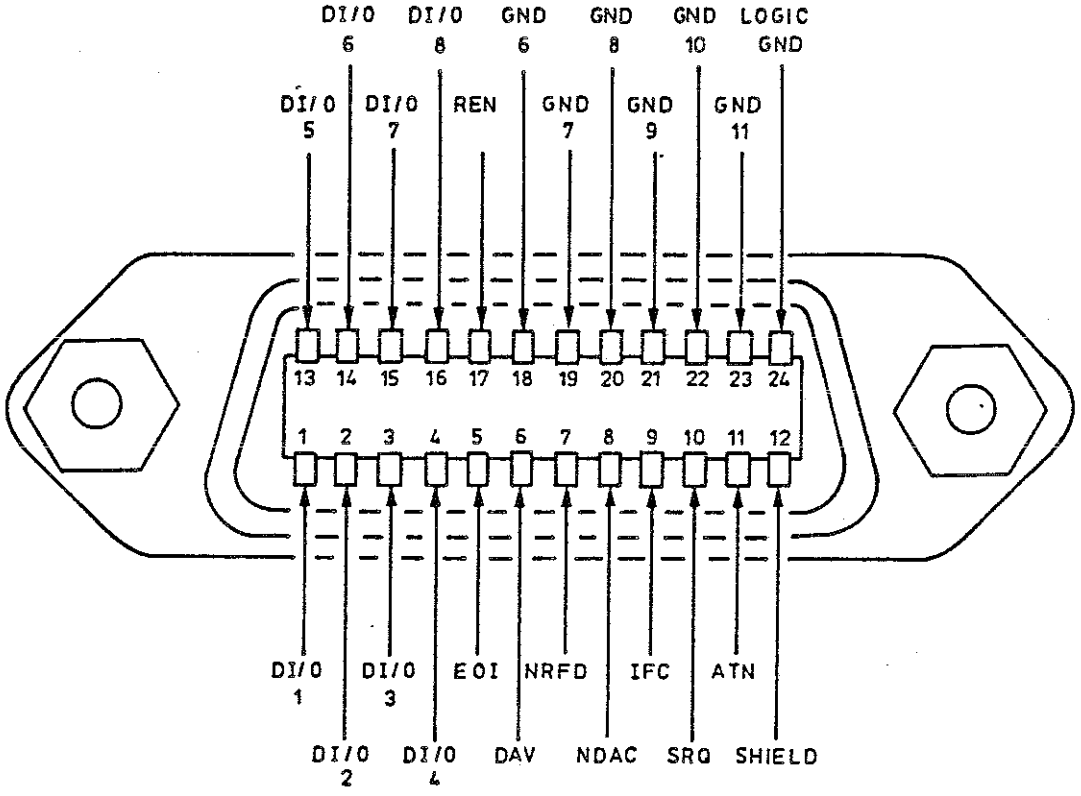


Fig. 2-3 Pin assignment

The Americal standard IEEE 488-1975 specifies a connector differing from that of the IEC standard. The SMPD is equipped with the more frequently used 24-way connector of the IEEE 488-1975 standard. Connection to units equipped with the 25-way IEC-standard connector can easily be made by use of an adapter. The control function and data transmission are the same for both connectors.

The standardized interface contains three groups of bus lines:

1. Data bus, consisting of 8 lines: DI/O 1 to DI/O 8.
   Data transmission is bit-parallel and byte-serial. The characters are transmitted in the ISO 7-bit code (corresponding to the ASCII code). DI/O 1 is the least significant and DI/O 8 the most significant bit.

2. Control bus, consisting of 5 lines:
   This bus transmits the following control functions:

ATN (attention)	becomes active LOW during transmission of an address to other units.
REC (remote enable)	for switching the SMPD to remote control.
SRQ (service request)	permits a device of the system to request a service call from the controller.
IFC (interface clear)	activated to set the devices of the system to a predefined state.
EOI (end or identify)	for identifying the end of a data transmission and for inquiry after a service request.

3. Handshake bus, consisting of 3 lines:
   This bus controls the data transmission sequence.

NRFD (not ready for data)	active LOW on this line informs the controller that a device of the system is not ready to accept data.
DAV (data valid)	activated by controller shortly after a new data byte has been placed on the data bus.
NDAC (not data accepted)	kept LOW by a device of the system until it has accepted the data on the data bus.

The data-output commands differ somewhat for the different calculator manufacturers. Examples are given in Table 2-2 for the outputting of certain parameter settings in the case of the most frequently used desktop calculators. These examples all use 13 as the SMPD address.

2.4.1.1 Address Setting

The required switch positions are shown in Table 2-1. The SMPD is set at the factory to decimal address 13.

The address is taken over only when the SMPD is switched on and in case of DCL (device clear).

Table 2-1

ASCII character		Binary address					Decimal equivalent
Listen address	Talk address	Address switch A5	A4	A3	A2	A1	
(SPACE)	@	0	0	0	0	0	0
!	A	0	0	0	0	1	1
"	B	0	0	0	1	0	2
#	C	0	0	0	1	1	3
$	D	0	0	1	0	0	4
%	E	0	0	1	0	1	5
&	F	0	0	1	1	0	6
'	G	0	0	1	1	1	7
(	H	0	1	0	0	0	8
)	I	0	1	0	0	1	9
*	J	0	1	0	1	0	10
+	K	0	1	0	1	1	11
, comma	L	0	1	1	0	0	12
-	M	0	1	1	0	1	13
.	N	0	1	1	1	0	14
/	O	0	1	1	1	1	15
0	P	1	0	0	0	0	16
1	Q	1	0	0	0	1	17
2	R	1	0	0	1	0	18
3	S	1	0	0	1	1	19
4	T	1	0	1	0	0	20
5	U	1	0	1	0	1	21
6	V	1	0	1	1	0	22
7	W	1	0	1	1	1	23
8	X	1	1	0	0	0	24
9	Y	1	1	0	0	1	25
:	Z	1	1	0	1	0	26
;		1	1	0	1	1	27
<		1	1	1	0	0	28
=		1	1	1	0	1	29
>		1	1	1	1	0	30

	R&S PPC	Tektronix* 4051/4052	hp 9825	hp 9835	Commodore PET 2001/3001
Set up Listener		---	---	---	Open1,13
Frequency 123.5 MHz	IECOUT13,"123.5MH"	PRINT@13:"123.5MH"	wrt713,"123.5MH"	OUTPUT713;"123.5MH"	PRINT#1,"123.5MH"
Frequency as Variable	LET F=123.5 IECOUT13,STR$(F)+"MH"	LET F=123.5 PRINT@13:F;"MH"	F=123.5 wrt713,F,"MH"	LET F=123.5 OUTPUT713;F;"MH"	LET F=123.5 PRINT#1,STR$(F);"MH"
Level -24.8 dBm	IECOUT13,"-24.8DB"	PRINT@13:"-24.8DB"	wrt713,"-24.8DB"	OUTPUT713;"-24.8DB"	PRINT#1,"-24.8DB"
Set lower frequ. sweep limit 100 MHz	IECOUT13,"100FL"	PRINT@13:"100FL"	wrt713,"100FL"	OUTPUT713;"100FL"	PRINT#1,"100FL"
RF OFF	IECOUT13,"FØ"	PRINT@13:"FØ"	wrt713,"FØ"	OUTPUT713;"FØ"	PRINT#1,"FØ"
Talker Call up SMPD Frequency	IECOUT13,"RF" IECIN13,A$	PRINT@13:"RF" INPUT@13:A$	wrt713,"RF" red713,A$	OUTPUT713;"RF" ENTER713;A$	PRINT#1,"RF" INPUT#1,A$

* For use with desktop computer Tektronix 4051, connect bus line REN (pin 17) to earth (pin 18). This can be made with a shorting plug.

Table 2-2

	R&S PPC	Tektronix 4051/4052	hp 9825	hp 9835/9845	Commodore PET 2001/3001
Go to Local	IECGTL (for addressed unit)	WBYTE@45,1:	lcl713	LOCAL713 or LOCAL7	not possible
Local Lockout	IECLLO (for all units)	WBYTE@45,17: or WBYTE 17:	llo7 (for all units)	LOCAL LOCKOUT7 (for all units)	" - "
Remote	IECLAD13	WBYTE@45:	rem713 or rem7	REMOTE713 or REMOTE7	only together with a command output
Selected Device Clear	IECSDC (listener responds to addressed units)	WBYTE@45,4:	clr713	RESET713	not possible

Table 2-3

2.4.2 Remote-control Commands

2.4.2.1 SMPD as Listener

Setting commands consist of data (optional) and an easily remembered two-digit combination designating the unit and/or function and serving also as a delimiter. Storage commands and special functions are terminated with digits.

All characters can be used as separators except digits, the decimal point, mathematical signs and the letters used in commands. If the resolution of the data entered is greater than that of the SMPD, the unusable digits are ignored.

With "immediate command execution" (normal operation afer DEVICE CLEAR or command "DØ"), every recognized command is immediately executed and the transfer via the IEC bus is inhibited for the time of the execution.

With "command execution after the delimiter" (command D1), up to 50 characters are stored and are only processed when the transfer is terminated. The transfer time is thus reduced. The computing time must now also be taken into account. If more than 50 characters are transmitted in one string, and transmission after the 50th character is inhibited until the characters so far transferred have been processed.

Function	Data	Command
Set carrier frequency in MHz kHz Hz	up to 10 places, decimal point (DP)	MH KH HZ
Set level in dBm mV µV	up to 4 places, DP -"- -"-	DB MV UV
Switch RF output off on	- -	FØ F1 *
Sweep programming: Upper frequency limit in MHz Lower frequency limit in MHz Step size in kHz Single sweep upwards, Set start frequency Single sweep downwards, Set start frequency	 up to 10 places, DP -"- -"- - -	 FU FL SK SU SD

Function	Data	Command
Periodic sweep (triangle function) Set start frequency (= lower frequency limit)	-	SP
Switch in basic setting (Reset)	-	R1
Switch out basic setting	-	RØ *
Start sweep	-	S1
Interrupt sweep	-	SØ *
Additional dwell time per step of sweep in ms	Whole number from Ø to 5ØØØ	DT
Single frequency steps (channel steps): Precondition: No sweep being executed (SØ) and no basic sweep setting (RØ)		
Step size in kHz	up to 10 places, DP	SK
Single step upwards	-	UP
Single step downwards	-	DO
Set AF generator in kHz	up to 4 places, DP	NK
Frequency modulation, phase modulation		
Set deviation in kHz	up to 4 places, DP	FK
Set deviation in radians	up to 3 places, DP	PR
Switch in FM/ΦM	-	P1
Switch out FM/ΦM	-	PØ *
Internal FM/ΦM	-	PI *
External FM/ΦM	-	PE
Internal + external FM/ΦM	-	PM
FM AC	-	FA *
FM DC	-	FD
Preemphasis in FM: out	-	TØ *
50 µs	-	T1
75 µs	-	T2
Amplitude modulation:		
Set modulation index in %	up to 2 places, DP	AP
AM in	-	A1
AM out	-	AØ *
AM internal	-	AI *
AM external	-	AE
External level control	-	LC
Immediate command execution	-	DØ *
Command execution after delimiter	-	D1
Service request: enabled	-	X1
disabled	-	XØ *

Function	Data	Command
Talker functions:		
Output carrier frequency	-	RF
Output level	-	RL
Define delimiter		
Only EOI line active	-	ZØ *
NL and EOI active	-	Z1
ETX and EOI active	-	Z2
ETB and EOI active	-	Z3
CR + NL and EOI active	-	Z4
Only NL	-	Z5
ETX	-	Z6
ETB	-	Z7
CR + NL	-	Z8
Store setting data:		
Store set instrument status	n: 1 - 5	ST n
Store carrier frequency	(whole numbers)	STMH n STKH n STHZ n
Store level		STDB n
Store AM data		STAP n
Store FM data		STFK n
Store ΦM data		STPR n
Store AF frequency		STNK n
Store sweep data		STFS n
Call setting data: As for store, but with RC replacing ST.		
Switch in special functions	nn: special function number	RCnn
Clear all special functions and perform self-test	-	RCØØ *

With built-in Option SMPD-B1:

Function	Data	Command
Pulse modulation: ON	-	U1
OFF	-	UØ

* These settings are made with "Device clear".
Setting data assume minimum value with "Device clear".

2.4.2.1.1 Times of Transfer and Execution

The values specified below are given as guidelines for program writing.

With "immediate command execution" (DØ), the NRFD line is low after every identified command.

Function	low time
Frequency setting	28 ms
Normal level setting	10 ms
Level setting with RCL 94	12 ms
Setting of AM depth	15 ms
Setting of FM deviation	17 ms
Frequency setting on modulation generator	8 ms

The rate of transfer is 0.8 ms per character (1.25 kbyte/s) when data are transmitted and 0.4 ms per character (2.5 kbyte/s) in the case of commands.

With "command execution after the delimiter" (D1), the rate of transfer is always 0.4 ms per character (2.5 kbyte/s). During the above times of execution, further unit can be driven in this operating mode.

2.4.2.2 SMPD as Talker

When the command "RF" is received, the SMPD stores the selected carrier frequency and when "RL" is received, the selected level, in a buffer. If the SMPD is then addressed as a talker, it outputs the stored value.

The carrier frequency is always output in Hz. Leading and end zeros are suppressed. The unit (Hz) is output along with the value.

The level is output as it appears in the display, and with it the unit, DB, MV or UV.

The delimiter is defined in the programm (see the Table of Commands).

Examples: Output	Value
57Ø37ØØØHZ	57.037 MHz
2133971.6HZ	2.1339716 MHz
51Ø79.8HZ	51.0798 kHz
-1Ø1.3DB	-101.3 dB
99.ØMV	99.0 mV
.Ø16UV	0.016 µV

2.4.2.3 Service Request

If the controller enables a service request with the X1 command, the SMPD reports various input errors, the end of a sweep and errors arising in the self-check, by activating the SRQ line. The status byte output at the end of the subsequent serial poll has the following meaning:

Status byte (dec. equiv.)	Meaning
65	Input error
66	Input outside acceptable range
68	Attempted sweep start at a frequency outside the sweep range
70	Storage error
71	IEC-bus failure
72	End of sweep
74	Error message ..... 1 (see 2.3.7)
75	" 2
76	" 3
77	" 4
78	" 5
79	" 6
80	Activation of overload protection (Option SMPD-B2)

After switch-on of the instrument, the Service Request is always disabled; the enabling command "X1" is not stored.

Following error messages (status byte 74 to 79), the Service Request is disabled.

2.4.3 Programming Examples

2.4.3.1 Frequency Setting

a) 566.783567 MHz
"566.783567 MH"

b) 300.173 kHz
"3ØØ.173 KH"

c) 100 753 000 Hz
"1ØØ753ØØØ HZ"

2.4.3.2 Level Setting

a) -35.5 dBm
"-35.5 DB"

b) 200 mV
"2ØØ MV"

c) 890 µV
"89Ø UV"

2.4.3.3 Switching the RF Level

a) Switching RF-level off:
"FØ"

b) Switching RF-level in again:
"F1"

2.4.3.4 Sweep Setting

a) Set lower frequency limit (only possible in MHz):
780.5 MHz
"780.5 FL"

b) Set upper frequency limit (only possible in MHz):
900.42 MHz
"900.42 FU"

c) Set the step size (only possible in kHz):
"100 SK"

d) Select direction of sweep and switch on start frequency:

Downward sweep	Upward sweep	Periodic sweep
"SD"	"SU"	"SP"

e) Switch on the sweep start frequency:
"R1"

f)

Sweep start	Sweep stop
"S1"	"S0"

g) Logarithmic sweep of 1 MHz to 1000 MHz with 0.1% per step frequency change:
"1FL1000FURC04.1SK"

2.4.3.5 Frequency Stepping

10-MHz steps from 1000 MHz to 1040 MHz:

Step size	Initial frequency
"10000 SK"	"1000 MH"

+10 MHz	+10 MHz	+10 MHz	+10 MHz
"UP"	"UP"	"UP"	"UP"

2.4.3.6 Amplitude Modulation Setting

Set modulation frequency 22.16 kHz	"22.16 NK"
Set modulation index AM 55%	"55 AP"
Set operating mode:	
internal modulation	"AI"
external modulation	"AE"
external level control	"LC"
switch out modulation	"A0"
switch in modulation	"A1"

2.4.3.7 Frequency and Phase Modulation Setting

Set modulation frequency 3.14 kHz	"3.14 NK"
Set frequency deviation 40 kHz	"4Ø FK"
Set phase deviation 6.7 rad	"6.7 PR"
Set operating mode	
internal modulation	"PI"
external modulation	"PE"
preemphasis 50 µs	"T1"
" 75 µs	"T2"
" out	"TØ"
DC coupling in external FM	"FD"
AC coupling in external FM	"FA"
switch out modulation	"PØ"
switch in modulation	"P1"

2.4.3.8 Complete Settings

Switch off sweep and start frequency
Clear special functions
Modulation out

Carrier frequency	1230.36 MHz
Level	5.8 dBm
Modulation frequency	3.333 kHz
Amplitude modulation	30%
Frequency modulation	40 kHz

FM external, DC-coupled

"SØ RØ RCØØ AØ PØ 123Ø.36 MH 5.8 DB 3.333 NK 3Ø AP 4Ø FK PE FD".

For clarity the same command may be written with a separator.

"SØ RØ, RCØØ, AØ PØ, 1230.36 MH, 5.8 DB, 3.333 NK, 3Ø AP, 4Ø FK, PE, FD".

2.4.4 Frequency Setting without Processor Time (RAM Frequency Setting)

This mode permits the RAM storage of 34 frequency settings together with corresponding values of FM or ΦM deviation and the calling up of the stored values with the aid of short IEC-bus commands. The mode does not take up any processor time so that setting times which include the time for the transfer of characters are reduced to between 4 and 7 ms. Data stored previously with STO are thereby lost. Settings present prior to the switch-on of RAM frequency setting are however saved and are made active on leaving this mode.

2.4.4.1 Storing Setting Data

Setting data for a maximum of 34 frequencies can be stored in the normal operating state without affecting the current setting. The syntax of the IEC-bus command:

"<n> n LF Data [MH / KH / HZ] < Data [FK / PR] >"

<> optional, [] alternative, n = number, <n>n = memory location

Overranging and incorrect entries are signalled by service requests. Overloading during operation with preemphasis is not indicated, since preemphasis is not stored.

The frequency and deviation of a current setting can be stored with the command:

"<n> n LF#"

Entries under visual control and storing settings which are found with the aid of the tuning knob are possible.

2.4.4.2 Initializing for RAM Frequency Setting

Since setting data of carrier frequency and deviation can only be stored, all other parameters must be defined before switching on the RAM frequency setting. The definitions will then have validity for all called-up frequencies (see commands "DØ" and "D1").

2.4.4.3 Service Request during RAM Frequency Setting

Various modes of service request are possible also during RAM frequency setting. The service request must be defined before switching on RAM frequency setting:

"XØ" just as in normal operation, service request is inadmissible.

"X1" SRQ is raised during RAM frequency setting only in case of error messages. The decimal equivalent of the status byte is 85.

"X2" SRQ is raised on the completion of RAM frequency setting. The decimal equivalent of the status byte is in this case 84.

"X3" SRQ with decimal equivalent of 84 at the end of frequency setting and with a value of 85 with an error message.

After a service request reporting an error, RAM frequency setting is disabled.

2.4.4.4 Switching on RAM Frequency Setting

The switch-on of the mode is made with the command "Q1". The deviation and carrier frequency displays show then a -F-. Subsequently, the stored frequencies with memory location numbers "Ø1" to "34" which are to have two assigned characters can be called up. If several location numbers are to be sent in one string, specifying one or several "P" between the location numbers will generate pauses of 5 ms per "P".

2.4.4.5 Switching off RAM Frequency Setting

The command "QØ" terminates the RAM frequency setting and sets the SMPD to the state prior to the switch-on of the RAM frequency setting.

2.4.4.6 Programming Examples

a) Store frequencies:

470 MHz with 3.3 kHz deviation in location 27
"27LF47ØMH3.3FK"

470.025 MHz with 2.5 rad deviation in location 7
"7LF47Ø.Ø25MH2.5PR"

500 MHz unmodulated in location 17
"17LF5ØØMH"

Current setting in location 1
"1LF#"

b) Initialize RAM frequency setting:

External modulation, no preemphasis, AC coupled, AM off, immediate execution of command, level 10 mV

"PE TØ FA AØ DØ 1ØMV"

Internal modulation, modulation frequency 400 Hz, no preemphasis, 10% AM, external AM, level -22 dBm, command executed after delimiter, service request at end of frequency setting and on error.

"PI .4NK TØ 1ØAP AE -22DB D1 X3"

c) Switch on RAM frequency setting, set frequencies, switch off RAM frequency setting:

Switch on, call up frequency 1
"Q1 Ø1"

Call up frequencies
"17" "Ø7" "27"

Call up frequencies with pauses
"17PØ7PPP27"

Switch off RAM frequency setting
"QØ"

3 Maintenance

3.1 Required Measuring Instruments and Auxiliary Equipment

Table 3-1

Ref. No.	Instrument	Performance ratings	R&S type design. and order numb.	See section
1	Frequency counter	Range 0.05 to 1360 MHz resolution 0.1 Hz		3.2.2 3.2.4 3.2.17.10
2	RF analyzer	Range 0.1 to 3250 MHz of crystal stability dynamic range 90 dB		3.2.3 3.2.10
3	Power meter	Range 0.05 to 2720 MHz power up to 20 mW Z = 50 Ω, error <0.1 dB resolution <0.02 dB		3.2.4 3.2.5 3.2.7 3.2.8
4	Precision attenuator	Range >500 MHz attenuation 0 to 120 dB Z = 50 Ω	DPVP 214.8017..	3.2.6
5	Test receiver with frequency controller	Range 500 MHz Inherent noise <-10 dBµV	ESU 2 252.0010.. EZK 255.0010..	3.2.6
6	Directional coupler	Range 2720 MHz Z = 50 Ω		3.2.8
7	Adjustable short	Z = 50 Ω, Δ l $\geq$0.5 m		3.2.8
8	RF analyzer	Range up to 5.5 GHz Dynamic range >40 dB		3.2.9
9	Mixer	Range LO RF up to 2720 MHz ring modulator LO level: >13 dBm		3.2.11 3.2.12 3.2.16 3.2.17 3.2.18
10	Low-pass filter 200 kHz	Z = 50 Ω for f >200 kHz		3.2.11 3.2.12
11	Amplifier with impedance transformer	Range 1 kHz to 20 kHz transformer 10 dB amplifier 20 dB inherent noise <5 nV/1 Hz test bandwidth		3.2.11

Ref. No.	Instrument	Performance ratings	R&S type design. and order numb.	See section
12	AF analyzer	Range up to 20 kHz sensitivity <3 µV Z_{in} >10 kΩ		3.2.11
13	Oscillo-scope	DC to 5 MHz, 0.05 V/div		3.2.11 3.2.13
14	Signal generator	Range up to 2720 MHz low noise	SMPD 376.8011.52	3.2.11 3.2.17 3.2.18
15	Attenuation line	Z = 50 Ω 0, 10, 40 dB		3.2.12 3.2.16 3.2.17 3.2.18
16	Amplifier	Range up to 200 kHz, gain 40 dB, Z_{in} = 50 Ω, inherent noise <5 nV/Hz		3.2.12
17	Process controller	Interface acc. to IEC-625-1	PPC 343.3510.. PUC 344.8900..	3.2.14
18	Modulation analyzer	Frequency range up to 1360 MHz, AM, FM, ΦM, error <1%	FAM 334.2015.53 FAM-B2 334.4918.02 FAM-B8 334.5714.02	3.2.16 to 3.2.18
19	AF generator	Frequency range up to 125 kHz, frequency response <0.01 dB	SPN 336.3019.02	3.2.16 to 3.2.18
20	AF voltmeter	Frequency range up to 125 kHz, frequency response <0.01 dB	URE 342.1214.02	3.2.16 to 3.2.18
21	Distortion factor meter	Frequency range up to 100 kHz resolution <0.05%		3.2.15.3 3.2.17.7
22	AF counter	Frequency range up to 100 kHz, error <1 x 10^{-7}		3.2.15.1
23	Stereo coder	Stereo crosstalk attenuation	MSC2 230.9314.03	3.2.17
24	Stereo decoder	>60 dB	MSDC2 281.0514.03	3.2.17

Ref. No.	Instrument	Performance ratings	R&S type design. and order numb.	See section
25	FM/AM demodulator	Frequency range 87.5 to 108 MHz (crystal)	FAB 206.9418.52 FAB-E2 207.7019.02	3.2.17.9
26	Psophometer	Frequency range 15 Hz to 20 kHz rms rectifier	UPGS 248.0019.03	3.2.17.9

3.2 Performance Check

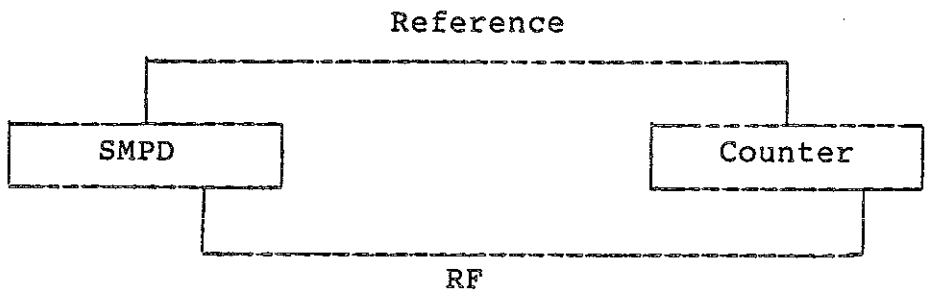
3.2.1 Displays and Keys

At switch-on all LEDs are lit up for a few seconds to see whether any of them are defective. For checking the function of the keys actuate them and read off display.

3.2.2 Frequency Setting

To check the frequency error relative to the reference frequency test PC board Y4 (see section 5) since errors of 5×10^{-12} are not detectable by counters. To perform the check as against the resolution of the counter used proceed as follows:

Test setup:

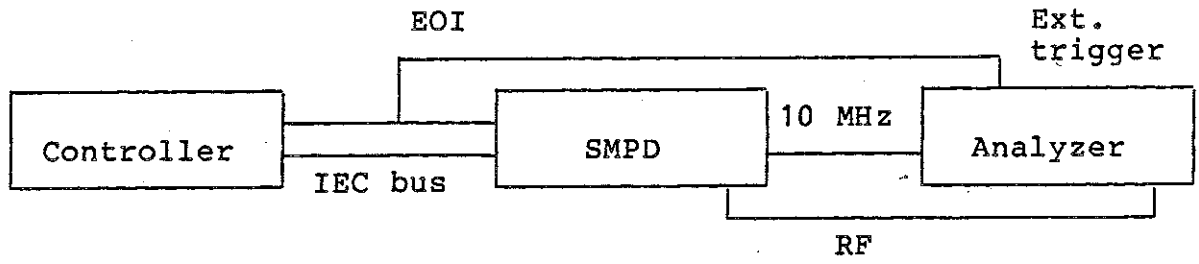


Synchronize the reference frequencies of SMPD and counter. Set level on the SMPD at which the counter operates properly. Set the frequencies to be checked. The last digit of the values read off the counter may deviate by ±1.

3.2.3 Settling Time

The settling time can be measured by means of a crystal-controlled RF analyzer with storage display which can be externally triggered by the positive-going edge of a TTL signal. The settling process is made visible with the aid of slope demodulation at 0 Hz span. Using a control computer two frequencies are set in turn on the SMPD via IEC bus. The controller must activate the EOI line only when the last data byte has been transmitted and must not transmit a delimiter. Adjust the analyzer such that one of the two frequencies is on a filter slope. If the analyzer is triggered by the positive-going edge of the EOI signal, the settling characteristic appears on the screen after the last character of the IEC-bus message has been transmitted.

Test setup:



Measurement: Synchronize the SMPD with the reference frequency from the analyzer. Connect IEC bus, trigger and RF lines. Set SMPD and analyzer to the stop frequency of the frequency step width to be measured. It will be sufficient to measure frequencies above 500 MHz, as all frequencies below 680 MHz are derived from the upper octave by dividing and mixing. Settings for the measurement are given below with an accuracy of 2×10^{-6}, with 2×10^{-8} in brackets, (if there is any difference). Set a resolution bandwidth of 10 (1) kHz and a span of 30 (3) kHz on the analyzer.

At an amplitude scale of 1 dB/Div set the reference level to 3 dB below the level to be measured. Increase the centre frequency until the filter slope is in the screen centre. Now reduce the span to 0 Hz and calibrate the scale on the screen with frequency increments of 1 kHz (100 Hz). If the test program is started and the analyzer switches to external trigger, the settling time characteristic appears on the screen. Settling time should be <18 (50) ms.

Test program for settling time (for PUC)

```
1Ø  IECTERM1
2Ø  IECDCL:HOLD5ØØ
3Ø  IECOUT13,"ØDB"
4Ø  INPUT"STARTFREQUENCY IN MHZ";F1$
5Ø  INPUT"STOPFREQUENCY IN MHZ";F2$
6Ø  IECOUT13,F1$+"MH";
7Ø  HOLD2ØØ
8Ø  IECOUT13,F2$+"MH";
9Ø  INPUT"REPETITION";W$
1ØØ IFW$="J"THEN5Ø
11Ø GOTO4Ø
```

3.2.4 Reference Frequency

Warm up unit for at least one hour. Connect calibrated frequency counter to output 41 on the rear panel. The relative frequency error should not exceed 2×10^{-9}/day and 5×10^{-9}/degree over the nominal temperature range. Connect power meter to output 41. The level should be >0.2 V_{rms}.

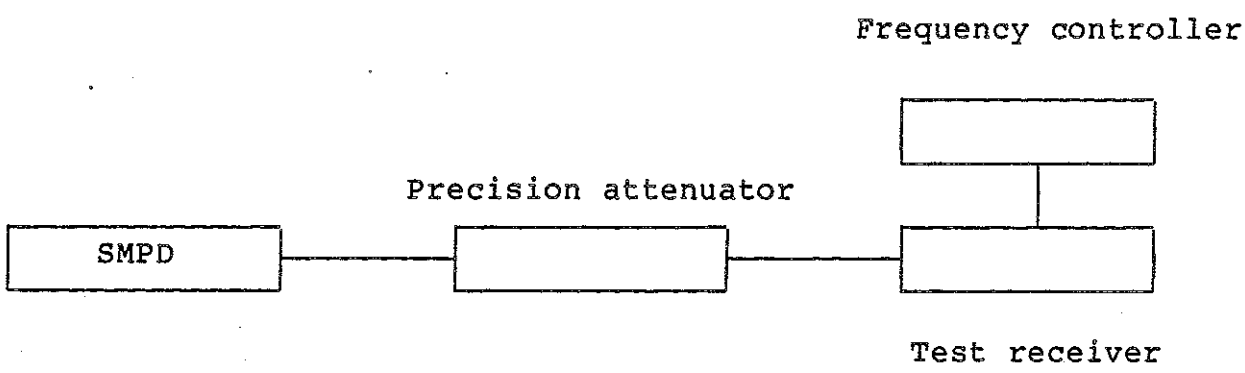
3.2.5 Output Level

Connect the power meter to the RF output 15. Settings on the SMPD: level 10 dBm, frequencies 50 kHz to 2720 MHz.

Maximum permissible frequency response:
flat within ±1.0 dB from 50 kHz to 1360 MHz
flat within ±1.5 dB from 50 kHz to 2720 MHz

3.2.6 Precision Attenuator

Test setup:



Make sure that the connecting cables are leakage-proof.

Settings: Precision attenuator: 115 dB attenuation

SMPD: 27,1354 MHz, 8 dBm

Test receiver: 27,1354 MHz, -10 dB, linear, peak value, bandwidth 15 kHz

Frequency controller: operating mode DFC

Check: Note down level indicated on the test receiver as reference level (approx. 0 dBµV). Repeat measurements at the settings listed in Table 3-2.

Table 3-2

Level SMPD dBm	Attenuation of precision attenuator dB
6	113
4	111
0	107
-2	105
-12	95
-32	75
-52	55
-72	35
-92	15
-102	5

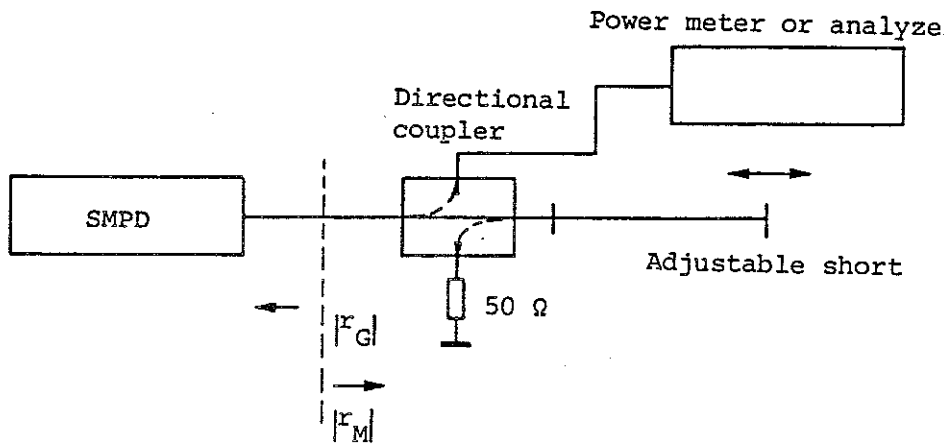
The permissible level error is ≤1.2 dB (0.5 dB typ.) with respect to 8 dBm of the reference value.

3.2.7 Level Setting

Connect power meter with a resolution of <0.02 dB to RF output 15. Settings on the SMPD: 100 MHz, 8.1 dBm, RCL 00. Read off level on power meter. Setting on the SMPD: 12.1 dBm. Read off again level on power meter. The difference between the two levels should be 4 ±0.1 dB.

3.2.8 Output Reflection Coefficient

Test setup:



Settings on the SMPD: Test frequency 300 to 2720 MHz, unmodulated

Measurement: Read off minimum and maximum levels on power meter or analyzer varying the adjustable short over its full length. Calculate the output reflection coefficient according to the following formulae:

$$|r_M| = 1 - |d_k|^2$$

$$|r| = \frac{|s| - 1}{|s| + 1}$$

$$|r_G| = \frac{|r|}{|r_M|}$$

$$|s_G| = \frac{1 + |r_G|}{1 - |r_G|}$$

r_M = reflection coefficient of the test setup

d_k = coupling attenuation of directional coupler (lin) at the test frequency

s = measured VSWR $\left(\frac{V_{max}}{V_{min}}\right)$

r = measured reflection coefficient

r_G = reflection coefficient of generator

s_G = VSWR of generator

$|s_G|$ → 1.2 (1.4) at level ≤-2 dBm (>-2 dBm) in the carrier frequency range $0.05 \leq f_{CR} < 680$ MHz

→ 1.35 (1.6) at ≤-2 dBm (>-2 dBm) and $680 \leq f_{CR} < 1360$ MHz

→ 1.8 (1.8) at ≤-2 dBm (>-2 dBm) and $1360 \leq f_{CR} < 2720$ MHz

In the pulse modulation mode, values of VSWR apply to output levels of ≤-2 dBm.

3.2.9 Harmonics

Connect RF analyzer to output socket 15. Settings on the SMPD: 10 dBm, 0.05 to 2720 MHz. The harmonic content must not exceed -30 dBc. If necessary, check whether analyzer is overdriven. Repeat check with 12 dBm. The harmonic content must not exceed -25 dBc.

3.2.10 Non-harmonic and Subharmonic Spurious Signals

Connect RF analyzer to output socket 15. Settings on the SMPD: test level 10 dBm. Preferred frequency settings and search frequencies are listed in the table below.

Table 3-3

Non-harmonics

Setting on the SMPD	Search frequency	Max. level
21 MHz	10 MHz	-80 dBc
	135 MHz	-80 dBc
	156 MHz	-80 dBc
160 MHz	25 MHz	-90 dBc
	10 MHz	-90 dBc
690 MHz	±20.294 MHz	-84 dBc
	±40.588 MHz	-84 dBc
1000 MHz	±20 MHz	-84 dBc
	±40 MHz	-84 dBc
1359 MHz	±20.283 MHz	-84 dBc
	±40.566 MHz	-84 dBc

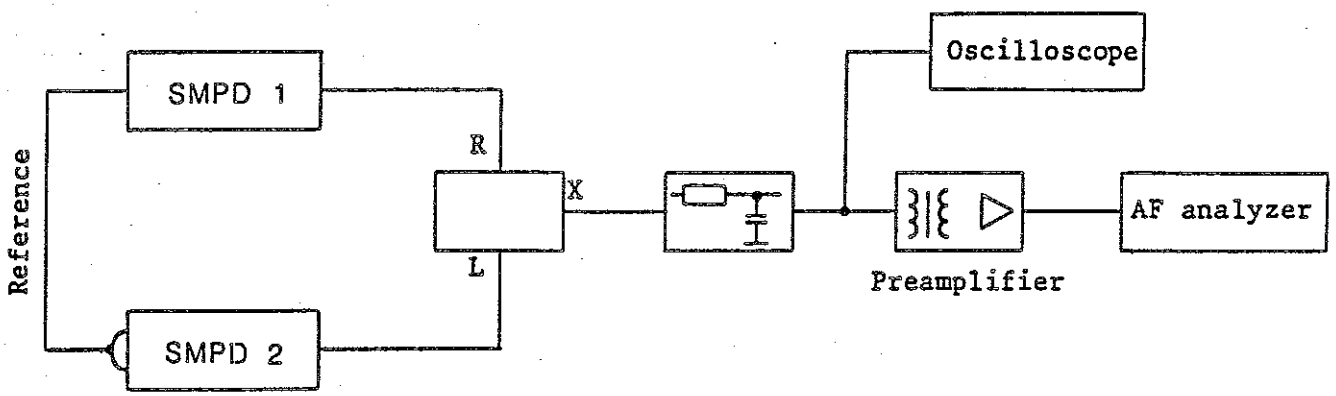
Subharmonics

Setting on the SMPD	Search frequency	Max. level
1360.1 MHz	2040.15 MHz	-40 dBc
1709.9 MHz	854.95 MHz	-40 dBc
1710 MHz	2565 MHz	-40 dBc
2149.9 MHz	1074.95 MHz	-40 dBc
2150 MHz	3225 MHz	-40 dBc
2720 MHz	1360 MHz	-40 dBc

Since the non-harmonic spurious signal rejection to be measured is beyond the performance specifications of the RF analyzers each detected non-harmonic spurious signal should be checked whether or not it is an inherent spurious product of the analyzer (identifier, level switchover).

3.2.11 SSB Phase Noise in the Vicinity of the Carrier

Test setup:



Settings: carrier frequencies according to Table 3-4
level on SMPD 1 -3 dBm
SMPD 2 7 dBm
Synchronization of reference frequencies.
Oscilloscope: DC coupling, 50 mV/div
AF analyzer: bandwidth $\leq$500 Hz, linear

Measurement: a) Read off reference values.
Adjust frequency difference of 5 kHz and 20 kHz.
Read off reference value on AF analyzer.

b) Measure noise voltages.
Set both SMPDs to carrier frequency. Enter step width of 0.001 kHz into one SMPD. Adjust beat frequency of 1 Hz using single sweep upwards. Stop at 0-axis crossing (±50 mV) on scope screen using single sweep downwards. Read off noise voltages on analyzer at 5 kHz and 20 kHz. The shape factor must be taken into consideration when using analyzers with average-value rectification.

c) Calculate relative noise level

$$a_r = 20 \log_{10} \left(\frac{u_A}{u_B \sqrt{B_r/Hz} \cdot 2 \cdot \sqrt{2}} \right)$$ where

u_A = noise voltage (rms value)

u_B = reference voltage (rms value)

B_r = noise bandwidth of analyzer

a_r = noise level in dBc referred to 1 Hz bandwidth

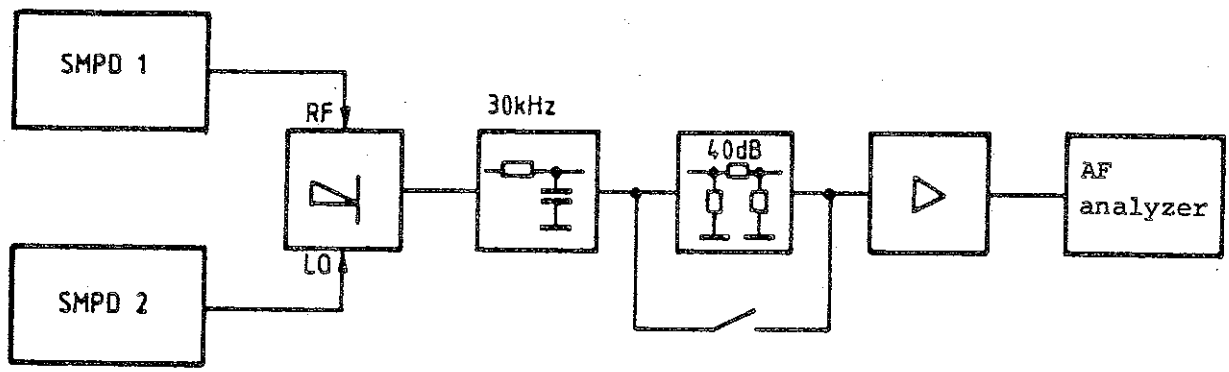
The following values must not be exceeded:

Table 3-4

Offset from carrier frequency	Carrier frequency 20	100	500	1350	2720	MHz
5 kHz	-130	-134	-120	-111	-105	dBc
20 kHz	-138	-143	-130	-121	-115	dBc

3.2.12 Broadband Noise

Test setup:



Measurement:

a) Set attenuator to 40 dB attenuation

b) Settings on SMPD1: Carrier frequency, +5.1 dBm, RCL 07
Settings on SMPD2: Frequency difference of 10 kHz as pertaining to SMPD1, +13 dBm

c) Read off reference value 10 kHz on AF analyzer

d) On SMPD2 set 5.01 MHz frequency difference to carrier frequency of unit 1; switch attenuator to 0 dB.

e) Read off noise level on analyzer and convert to 1 Hz bandwidth. Note the form factor when analyzers with average-responsive rectification are involved.

f) Determine noise level:

noise level (-dBc) =
reference value (dBm) - measurement value/1 Hz (dBm) + 43 dB

For carrier frequencies <21.25 MHz, -140 dBc, for carrier frequencies 21.25 MHz to 1360 MHz, -145 dBc and for carrier frequencies >1360 MHz, -135 dBc should not be exceeded.

3.2.13 Sweep Functions

Connect RF analyzer to RF output socket 15. Connect oscilloscope or voltmeter to the X output socket 19.

Check: Enter sweep and trigger. Check sweep on the RF analyzer. Observe voltage at the X output by means of oscilloscope or voltmeter. The voltage span for sweeping should be 5 ±0.1 V.

3.2.14 Interface Functions

Connect the SMPD to a process controller. Send the commands listed in Table 2-4 and check the execution on the display.

3.2.15 Modulation Generator

3.2.15.1 Frequency Setting

Connect AF counter to 46 (at the rear), and set modulation frequencies between 10 Hz and 100 kHz on the SMPD. The measured frequency may deviate from the setting by max. 1 Hz.

3.2.15.2 Amplitude Frequency Response

Connect AF voltmeter to 46 and vary modulation frequency of the SMPD between 10 Hz and 100 kHz. The difference between the smallest and highest measured level should be <0.1 dB. The level at 1 kHz should be 1 ±0.05 V_{rms}.

3.2.15.3 Distortion Factor

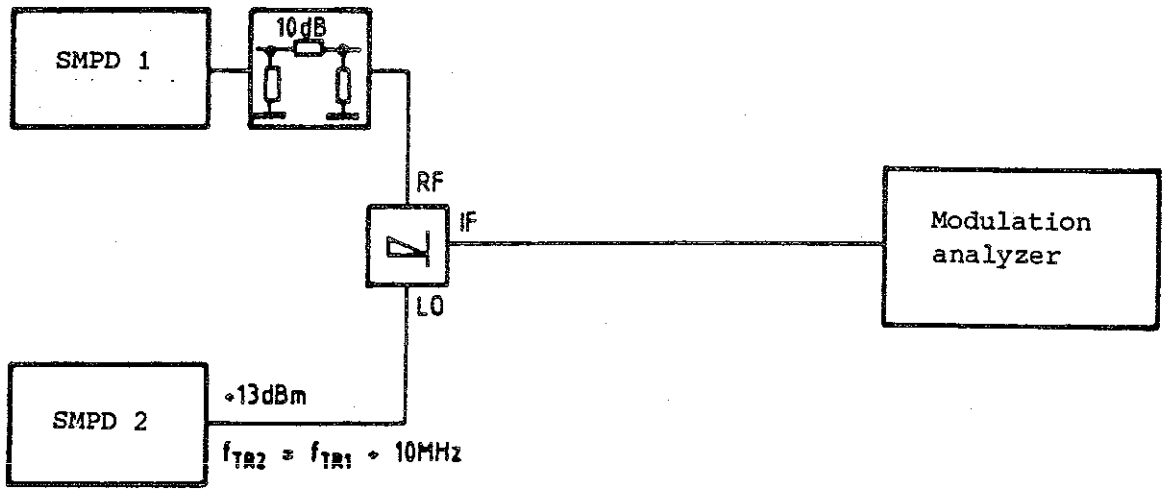
Connect distortion factor meter to 46 and vary the modulation frequency of the SMPD between 10 Hz and 100 kHz. The measured distortion factor must not exceed 0.1%.

3.2.16 Amplitude Modulation

3.2.16.1 Modulation Depth

With carrier frequencies below 1360 MHz, connect modulation analyzer to RF output BU 15. Set 1 kHz modulation frequency and 6 dBm RF level on SMPD. Measure modulation depth at various modulation frequencies and modulation depths.

For carrier frequencies exceeding 1360 MHz use the following test setup.



Recommended modulation depth: 9.9, 30, 60, 80%

Recommended carrier frequency (f_C): 1, 15, 22, 30, 60, 120, 240, 480, 680, 960, 1200, 1360, 1361, 1530, 1700, 1710, 1930, 2140, 2150, 2440, 2490 MHz

With carrier frequencies below 500 MHz, a value of 3% for f_C and 1% AM and with carrier frequencies above 500 MHz a value of 6% for f_C and 1% AM must not be exceeded.

3.2.16.2 Modulation Distortion Factor and Modulation Frequency Response

Connect modulation analyzer with distortion factor meter to RF output 15. Set a level of 0.1 dBm and a modulation depth of 30 (or 80)% on the SMPD: Measure at various carrier frequencies and modulation frequencies and modulation depth.

For carrier frequencies above 1360 MHz test setup see under 3.2.16.1.

The modulation distortion must not exceed 1.5 (3%) with modulation frequencies up to 10 kHz for carrier frequencies <1360 MHz and for carrier frequencies >1360 MHz, 3 (5%). The modulation frequency response must be <0.4 (up to 10 kHz) and <1.0 dB (up to 50 kHz).

3.2.16.3 Spurious ΦM at AM

Connect modulation analyzer to RF output 15. Set a 1-kHz modulation frequency and modulation depth of 30% on the SMPD. Measure the resulting phase modulation at various carrier frequencies.

Recommended carrier frequencies and test setup see under 3.2.16.1.

A phase modulation of <0.1 rad should be measured for carrier frequencies up to 680 MHz, <0.15 rad up to 1360 MHz and <0.3 rad for carrier frequencies >1360 MHz.

3.2.17 Frequency Modulation

3.2.17.1 Setting the Deviation

Connect modulation analyzer to RF output 15 and set a modulation frequency of 1 kHz on the SMPD. Measure at various carrier frequencies and modulation deviations.

Recommended frequencies and deviations: At 240 MHz: 0.1, 0.3, 1, 3, 10, 30, 100, 300, 400 kHz and at 30, 60, 120, 240, 480, 960 MHz: 25 kHz. The measured value must not deviate by more than 3% or 20 Hz from the settings.

For carrier frequencies >1360 MHz use test setup 3.2.16.1. Permissible deviation is in this case 3% or 40 Hz.

3.2.17.2 Modulation Distortion Factor

Connect modulation analyzer with distortion factor meter to RF output 15. Set a modulation frequency of 1 kHz on the SMPD. Measure the modulation distortion factor at the following carrier frequencies and deviations: 10 MHz, 100 kHz; 22 MHz, 22.5 kHz; 44 MHz, 50 kHz; 88 MHz, 100 kHz; 176 MHz, 200 kHz; 352 MHz, 400 kHz; 700 MHz, 800 kHz. Then use test setup 3.2.16.1 and test modulation distortion factor at 1400 MHz and at 1600 kHz deviation. The modulation factor must not exceed 0.1%. Repeat the measurement at a modulation frequency of 20 kHz. In this case the modulation distortion factor must not exceed 0.3%.

3.2.17.3 Preemphasis

Connect modulation analyzer to RF output 15. Set a carrier frequency of 100 MHz, a deviation of 40 kHz with 50 µs preemphasis on the SMPD. Measure the deviation with corresponding deemphasis on the modulation analyzer at modulation frequencies of 0.04, 0.4, 1, 5, 10, 15 kHz. Repeat the measurement with a preemphasis of 75 µs and a deviation of 25 kHz.

3.2.17.4 Internal Modulation Frequency Response

Connect modulation analyzer to RF output 15 and set a carrier frequency of 100 MHz and 100 kHz deviation on the SMPD. Vary the modulation frequency between 10 Hz and 100 kHz. The difference between the highest and the lowest measured deviation must not exceed 0.2 dB over the entire frequency range and 0.1 dB between 40 Hz and 15 kHz.

3.2.17.5 External Modulation Frequency Response

Connect modulation analyzer to RF output 15 and the AF generator to FM input 31. Adjust a carrier frequency of 100 MHz and 100 kHz deviation of the SMPD with external modulation. Set a level of 1 V_{rms} on the AF generator (check deviation indication on the SMPD), and vary the frequency between 10 Hz to 125 kHz. The difference between the highest and the lowest measured deviation must not exceed 0.1 dB in the entire frequency range.

3.2.17.6 Spurious AM at FM

Connect modulation analyzer to RF output 15. Set a modulation frequency of 1 kHz and 40 kHz FM deviation on the SMPD. Measure the resulting AM at various carrier frequencies. For carrier frequencies >1360 MHz use test setup 3.2.16.1. The measured values must not exceed 0.1%.

3.2.17.7 Stereo Modulation Distortion Factor

Connect stereo coder to FM input 31, modulation analyzer to RF output 15, stereo decoder to modulation analyzer and distortion factor meter to AF output of decoder. Set on the SMPD 10.7 or 85 to 120 MHz carrier frequency and a deviation of 40 kHz; select external modulation. Set on the coder and decoder a preemphasis and deemphasis of 50 µs. Measure the distortion factor of both channels at a modulation frequency of 1 kHz. It must not exceed 0.1%.

3.2.17.8 Stereo Crosstalk Attenuation

Test setup and setting as under 3.2.17.7, without distortion factor meter. Modulate only one channel at a time. Measure the demodulated signal of both channels. The difference of the measured values should be >56 dB with modulation frequencies from 500 Hz to 10 kHz, and >45 dB from 40 Hz to 15 kHz.

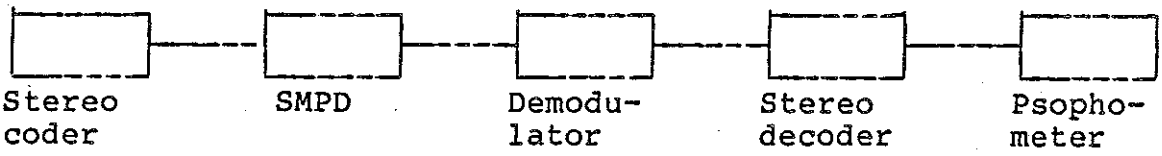
3.2.17.9 Unweighted S/N Ratio

Mono

Connect demodulator (87.5 to 108 MHz) with crystal to RF output 15 and psophometer to AF output of demodulator. Set on the SMPD: crystal frequency as carrier frequency, 0 dBm output level, 40 kHz FM deviation, 500 Hz modulation frequency and 50 µs pre-emphasis. Set a deemphasis of 50 µs on the demodulator. Select UNWEIGHTED and SLOW INDICATION on the psophometer. Measure the output level of the demodulator as reference level. Short-circuit the RF input socket 31 on the SMPD and select external FM. Read the unweighted S/N ratio on the psophometer. The difference between measured level and reference value should be >76 dB.

Stereo

Test setup



Modulate only one channel with 40 kHz deviation and a modulation frequency of 500 Hz. Select a pre- and deemphasis of 50 µs on the stereo coder and decoder respectively. Make sure that the stereo signal is to standard. Read the reference level on the psophometer. Remove stereo coder and short-circuit FM input socket 31 on the SMPD. The unweighted S/N ratio is indicated on the psophometer. The difference between measured and reference level should be ≥76 dB.

3.2.17.10 Frequency Deviation with FM, DC

Connect RF counter to RF output 15 and short-circuit FM input 31. Set on the SMPD: 20 MHz carrier frequency, 1 kHz FM deviation, external modulation and DC. Measure the output frequency when the modulation is switched on and off. The difference must not exceed 155 Hz. Set a carrier frequency of 500 MHz and repeat the measurement. The difference then must not exceed 500 Hz.

3.2.18 Phase Modulation

3.2.18.1 Setting the Deviation

If the tests of the FM deviation (acc. to 3.2.17.1) do not show any impermissible deviations, continue by testing the phase deviation at a modulation frequency of 1 kHz at the following frequencies and deviations: 4.3 MHz, 12.5 rad; 500 MHz, 50 rad; 1360 MHz, 100 rad.

The permissible variation of the set value is 5% or 0.04 rad at carrier frequencies <1360 MHz. For carrier frequencies >1360 MHz use test setup 3.2.16.1. In this case the measured value must not differ from the set deviation by more than 5% or 0.04 rad.

3.2.18.2 Modulation Distortion Factor

Connect modulation analyzer with distortion factor meter to RF output 15 and AF generator to FM input 31. Set on the SMPD: 100 MHz carrier frequency, 12.5 rad deviation and 1 kHz modulation frequency. Set on the AF generator: 1 kHz output frequency and a level of 1 V_{rms} (check deviation indication on the SMPD at external modulation).

The distortion factor of the demodulated signal must not exceed 1% with internal modulation and 0.1% with external modulation.

3.2.18.3 Modulation Frequency Response

Connect modulation analyzer to RF output 15. Set 100 MHz carrier frequency and 25 rad deviation on the SMPD. Vary the modulation frequency between 0.01 and 8 kHz. The difference between the highest and the lowest deviation must not exceed 1 dB up to 3 kHz and 3 dB up to 8 kHz.

Ref. No.	Characteristic	Measure acc. to	Min.	Actual	Max.	Unit
1	Function of keys and displays	3.2.1	-		-	
2	Frequency setting	3.2.2	-		-	
3	Switching time for f_C	3.2.3				
	to within 1×10^{-6} >21.25MHz		-		18	ms
	to within 2×10^{-8} >21.25MHz		-		50	ms
	to within 150Hz ≤21.25MHz		-		18	ms
	to within 3Hz ≤21.25MHz		-		50	ms
4	Reference frequency	3.2.4				
	Aging effect		-		2×10^{-9}	per day
	Temperature effect		-		5×10^{-9}	" degr.
5	Output level	3.2.5				
	Test level 10 dBm					
	Frequency response flatness					
	50 kHz up to 1360 MHz		-1.0		+1.0	dB
	50 kHz up to 2720 MHz		-1.5		+1.5	dB
6	Output level (attenuator error)	3.2.6	-1.2		+1.2	dB
7	Output level (error of vernier setting)	3.2.7	3.9		4.1	dB
8	Output reflection coefficient (VSWR)	3.2.8				
	Output level ≤-2 dBm:					
	$0.05 \leq f_C < 680$ MHz		-		1.2	
	$680 \leq f_C < 1360$ MHz		-		1.35	
	$1360 \leq f_C \leq 2720$ MHz		-		1.8	
	Output level >-2 dBm:					
	$0.05 \leq f_C < 680$ MHz		-		1.4	
	$680 \leq f_C < 1360$ MHz		-		1.6	
	$1360 \leq f_C \leq 2720$ MHz				1.8	
9	Harmonics at 10 dBm	3.2.9	-		-30	dBc
	at 12 dBm				-25	dBc
10	Non-harmonic spurious signals at 21 MHz	3.2.10	-		-80	dBc
	160 MHz		-		-90	dBc
	690 MHz		-		-84	dBc
	1000 MHz		-		-84	dBc
	1359 MHz		-		-84	dBc
	Sub-harmonic spurious signals for f_C >1360 MHz [$^1/_2 f_C$, $^3/_2 f_C$]		-		-40	dBc

Ref. No.	Characteristic	Measure acc. to	Min.	Actu-al	Max.	Unit
11	SSB phase noise	3.2.11				
	5 kHz from carrier					
	at 20 MHz		-		-130	dBc
	100 MHz		-		-134	dBc
	500 MHz		-		-120	dBc
	1350 MHz		-		-111	dBc
	2720 MHz		-		-105	dBc
	20 kHz from carrier					
	at 20 MHz		-		-138	dBc
	100 MHz		-		-143	dBc
	500 MHz		-		-130	dBc
	1350 MHz		-		-121	dBc
	2720 MHz		-		-115	dBc
12	Broadband noise	3.2.12				
	at 20 MHz		-		-140	dBc
	100 MHz		-		-145	dBc
	500 MHz		-		-145	dBc
	1350 MHz		-		-145	dBc
	2720 MHz		-		-135	dBc
13	Sweep function	3.2.13	4.9		5.1	V
14	Interface functions	3.2.14	-		-	
15	Frequency deviation of modulation generator	3.2.15.1	-		1	Hz
16	Amplitude frequency response and output level of modulation generator	3.2.15.2	- 0.95		0.1 1.05	dB V_{rms}
17	Distortion factor of modulation generator	3.2.15.3	-		0.1	%
18	Modulation depth AM	3.2.16.1				
	CF <500 MHz AM 9.9%		8.6		11.2	%
	30%		28.1		31.9	%
	60%		57.2		62.8	%
	80%		76.6		83.4	%
	CF >500 MHz AM 9.9%		8.4		11.5	%
	30%		27.4		32.8	%
	60%		55.8		64.6	%
	80%		74.8		85.8	%

Ref. No.	Characteristic	Measure acc. to	Min.	Actual	Max.	Unit
19	Modulation distortion factor f_C <1360 MHz [f_C >1360 MHz]	3.2.16.2				
	AM 30%, f_{mod} < 1 kHz		-		1 [2]	%
	<10 kHz		-		1.5 [3]	%
	AM 80%, < 1 kHz		-		1.5 [3]	%
	<10 kHz		-		3 [5]	%
	Modulation frequency response					
	AM f_{mod} <10 kHz		-		0.4	dB
	f_{mod} <50 kHz		-		1.0	dB
20	Spurious ΦM at AM	3.2.16.3				
	CF <680 MHz		-		0.1	rad
	CF >680 MHz		-		0.15	rad
21	Deviation setting FM	3.2.16.4				
	240 MHz 0.1 kHz		0.08		0.12	kHz
	0.3 kHz		0.28		0.32	kHz
	1 kHz		0.97		1.03	kHz
	3 kHz		2.91		3.09	kHz
	10 kHz		9.70		10.3	kHz
	30 kHz		29.1		30.9	kHz
	100 kHz		97.0		103	kHz
	300 kHz		291		309	kHz
	400 kHz		388		412	kHz
	30 MHz 25 kHz		24.25		25.75	kHz
	60 MHz 25 kHz		24.25		25.75	kHz
	120 MHz 25 kHz		24.25		25.75	kHz
	240 MHz 25 kHz		24.25		25.75	kHz
	480 MHz 25 kHz		24.25		25.75	kHz
	960 MHz 25 kHz		24.25		25.75	kHz
22	Modulation distortion factor FM	3.2.17.2				
	f_{mod} = 1 kHz		-		0.1	%
	20 kHz		-		0.3	%
23	Deviation error with preemphasis 50 µs	3.2.17.3	-		5	%
	75 µs		-		5	%
24	Int. modulation-frequency response	3.2.17.4				
	40 Hz to 15 kHz		-		0.1	dB
	10 Hz to 100 kHz		-		0.2	dB
25	Ext. modulation-frequency response	3.2.17.5				
	10 Hz to 125 kHz		-		0.1	dB
26	Spurious AM at FM	3.2.17.6	-		0.1	%

Ref. No.	Characteristic	Measure acc. to	Min.	Actual	Max.	Unit
27	Modulation distortion factor, stereo	3.2.17.7	-		0.1	%
28	Stereo crosstalk attenuation	3.2.17.8				
	10.7 MHz					
	L→R 0.5 to 10 kHz		56		-	dB
	0.04 to 15 kHz		45		-	dB
	R→L 0.5 to 10 kHz		56		-	dB
	0.04 to 15 kHz		45		-	dB
	100 MHz					
	L→R 0.5 to 10 kHz		56		-	dB
	0.04 to 15 kHz		45		-	dB
	R→L 0.5 to 10 kHz		56		-	dB
	0.04 to 15 kHz		45		-	dB
29	S/N ratio	3.2.17.9				
	mono		76		-	dB
	stereo		76		-	dB
30	Frequency deviation at FM DC 20 MHz	3.2.17.10	-		155	Hz
	500 MHz		-		500	Hz
31	Deviation setting ΦM	3.2.18.1				
	CF 240 MHz 0.1 rad		0.08		1.02	rad
	0.3 rad		0.28		0.32	rad
	1 rad		0.95		1.05	rad
	3 rad		2.85		3.15	rad
	10 rad		9.5		10.5	rad
	30 rad		28.5		31.5	rad
	50 rad		47.5		52.5	rad
	CF 30 MHz 3 rad		2.85		3.15	rad
	60 MHz 3 rad		2.85		3.15	rad
	120 MHz 3 rad		2.85		3.15	rad
	240 MHz 3 rad		2.85		3.15	rad
	480 MHz 3 rad		2.85		3.15	rad
	960 MHz 3 rad		2.85		3.15	rad
32	Modulation distortion factor ΦM	3.2.18.2				
	internal		-		1.0	%
	external		-		0.1	%
33	Modulation frequency response ΦM	3.2.18.3				
	up to 3 kHz		-		1.0	dB
	up to 8 kHz		-		3.0	dB

3.4 Routine Maintenance

Blower bearings and rotary knobs require no maintenance. After extended operation, particularly in dusty surroundings, open the instrument and remove the dust that might have accumulated.

3.5 Storage

The SMPD should be stored in a dry room. After extended storage the memory-back-up accumulator is discharged. After about 20 hours of operation it is fully recharged.