ROHDE & SCHWARZ

Test and Measurement
Division

Operating Manual

SPECTRUM ANALYZER

R&S FSP3
1093.4495.03

R&S FSP7
1093.4495.07

R&S FSP13
1093.4495.13

R&S FSP30
1093.4495.30/.39

R&S FSP40
1093.4495.40

Volume 1
This Operating Manual consists of 2 volumes

Printed in the Federal
Republic of Germany

Dear Customer,

throughout this operating manual, the abbreviation FSP is used for your Spectrum Analyzer R&S FSP.

Tabbed Divider Overview

Volume 1

Data Sheet

Safety Instructions
Certificate of Quality
EU Certificate of Conformity
List of R&S Representatives

Manuals for Spectrum Analyzer FSP

Tabbed Divider

Volume 2

Data Sheet

Safety Instructions

Manuals for Spectrum Analyzer FSP

Tabbed Divider

ROHDE&SCHWARZ
EC Certificate of Conformity

$C\,E$

Certificate No.: 99049

This is to certify that:

Equipment type	Stock No.	Designation
FSP3	1093.4495.03	Spectrum Analyzer
FSP7	1093.4495.07	
FSP13	1093.4495.13	
FSP30	1093.4495.30/.39	
FSP40	1093.4495.40	
FSP-B3	1129.6491.02	Audio Modulator AM/FM
FSP-B4	1129.6740.02	OCXO 10 MHz
FSP-B6	1129.8594.02	TV-Trigger
FSP-B9	1129.6991.02	Tracking Generator
FSP-B10	1129.7246.02	External Generator Control
FSP-B15	1155.1006.02	Pulse Calibrator
FSP-B16	1129.8042.02	Lan Interface 10/1000 Base T
FSP-B17	1129.8794.02	On-Line IQ Interface
FSP-B20	1155.1606.02	Extended Environmental Spec
FSP-B25	1129.7746.02	Electronic Attenuator
FSP-B30	1155.1158.02	DC Power Supply
FSP-B31	1155.1258.02	NIMH Battery Pack and Charger
FSP-B32	1155.1506.02	Spare Battery Pack (NIMH)

complies with the provisions of the Directive of the Council of the European Union on the approximation of the laws of the Member States

- relating to electrical equipment for use within defined voltage limits
  (73/23/EEC revised by 93/68/EEC)

- relating to electromagnetic compatibility
  (89/336/EEC revised by 91/263/EEC, 92/31/EEC, 93/68/EEC)

Conformity is proven by compliance with the following standards:

EN61010-1 : 1993 + A2 : 1995
EN55011 : 1998 + A1 : 1999
EN61326 : 1997 + A1 : 1998 + A2 : 2001

For the assessment of electromagnetic compatibility, the limits of radio interference for Class B equipment as well as the immunity to interference for operation in industry have been used as a basis.

Affixing the EC conformity mark as from 1999

ROHDE & SCHWARZ GmbH & Co. KG
Mühldorfstr. 15, D-81671 München

Munich, 2002-07-25   Central Quality Management FS-QZ / Becker

Safety Instructions

This unit has been designed and tested in accordance with the EC Certificate of Conformity and has left the manufacturer's plant in a condition fully complying with safety standards.

To maintain this condition and to ensure safe operation, the user must observe all instructions and warnings given in this operating manual.

Safety-related symbols used on equipment and documentation from R&S:

Observe operating instructions	Weight indication for units >18 kg	PE terminal	Ground terminal	Danger! Shock hazard	Warning! Hot surfaces	Ground	Attention! Electrostatic sensitive devices require special care

1. The unit may be used only in the operating conditions and positions specified by the manufacturer. Unless otherwise agreed, the following applies to R&S products:

   IP degree of protection 2X, pollution severity 2 overvoltage category 2, only for indoor use, altitude max. 2000 m.

   The unit may be operated only from supply networks fused with max. 16 A.

   Unless specified otherwise in the data sheet, a tolerance of $\pm10\%$ shall apply to the nominal voltage and of $\pm5\%$ to the nominal frequency.

2. For measurements in circuits with voltages V_{rms} > 30 V, suitable measures should be taken to avoid any hazards.

   (using, for example, appropriate measuring equipment, fusing, current limiting, electrical separation, insulation).

3. If the unit is to be permanently wired, the PE terminal of the unit must first be connected to the PE conductor on site before any other connections are made. Installation and cabling of the unit to be performed only by qualified technical personnel.

4. For permanently installed units without built-in fuses, circuit breakers or similar protective devices, the supply circuit must be fused such as to provide suitable protection for the users and equipment.

5. Prior to switching on the unit, it must be ensured that the nominal voltage set on the unit matches the nominal voltage of the AC supply network.

   If a different voltage is to be set, the power fuse of the unit may have to be changed accordingly.

6. Units of protection class I with disconnectible AC supply cable and appliance connector may be operated only from a power socket with earthing contact and with the PE conductor connected.

7. It is not permissible to interrupt the PE conductor intentionally, neither in the incoming cable nor on the unit itself as this may cause the unit to become electrically hazardous.

   Any extension lines or multiple socket outlets used must be checked for compliance with relevant safety standards at regular intervals.

8. If the unit has no power switch for disconnection from the AC supply, the plug of the connecting cable is regarded as the disconnecting device. In such cases it must be ensured that the power plug is easily reachable and accessible at all times (length of connecting cable approx. 2 m). Functional or electronic switches are not suitable for providing disconnection from the AC supply.

   If units without power switches are integrated in racks or systems, a disconnecting device must be provided at system level.

9. Applicable local or national safety regulations and rules for the prevention of accidents must be observed in all work performed.

   Prior to performing any work on the unit or opening the unit, the latter must be disconnected from the supply network.

   Any adjustments, replacements of parts, maintenance or repair may be carried out only by authorized R&S technical personnel.

   Only original parts may be used for replacing parts relevant to safety (eg power switches, power transformers, fuses). A safety test must be performed after each replacement of parts relevant to safety.

   (visual inspection, PE conductor test, insulation-resistance, leakage-current measurement, functional test).

Safety Instructions

10. Ensure that the connections with information technology equipment comply with IEC950 / EN60950.

11. Lithium batteries must not be exposed to high temperatures or fire.

    Keep batteries away from children.

    If the battery is replaced improperly, there is danger of explosion. Only replace the battery by R&S type (see spare part list).

    Lithium batteries are suitable for environmentally-friendly disposal or specialized recycling. Dispose them into appropriate containers, only.

    Do not short-circuit the battery.

12. Equipment returned or sent in for repair must be packed in the original packing or in packing with electrostatic and mechanical protection.

13. Electrostatics via the connectors may damage the equipment. For the safe handling and operation of the equipment, appropriate measures against electrostatics should be implemented.

14. The outside of the instrument is suitably cleaned using a soft, lint-free dustcloth. Never use solvents such as thinners, acetone and similar things, as they may damage the front panel labeling or plastic parts.

15. Any additional safety instructions given in this manual are also to be observed.

Contents of Manuals for Spectrum Analyzer FSP

Operating Manual FSP

The operating manual describes the following models and options of spectrum analyzer FSP:
- FSP3   9 kHz to 3 GHz
- FSP7   9 kHz to 7 GHz
- FSP13   9 kHz to 13.6 GHz
- FSP30   9 kHz to 30 GHz
- FSP40   9 kHz to 40 GHz

- Option FSP B3   audio demodulator
- Option FSP-B4   OCXO - reference oscillator
- Option FSP-B9   tracking generator
- Option FSP-B10   external generator control
- Option FSP-B15   pulse calibrator
- Option FSP-B16   LAN interface
- Option FSP-B25   electronic attenuator

This operating manual contains information about the technical data of the instrument, the setup functions and about how to put the instrument into operation. It informs about the operating concept and controls as well as about the operation of the FSP via the menus and via remote control. Typical measurement tasks for the FSP are explained using the functions offered by the menus and a selection of program examples.

Additionally the operating manual includes information about maintenance of the instrument and about error detection listing the error messages which may be output by the instrument. It is subdivided into 9 chapters:

Chapter 1	describes the control elements and connectors on the front and rear panel as well as all procedures required for putting the FSP into operation and integration into a test system.
Chapter 2	gives an introduction to typical measurement tasks of the FSP which are explained step by step.
Chapter 3	describes the operating principles, the structure of the graphical interface and offers a menu overview.
Chapter 4	forms a reference for manual control of the FSP and contains a detailed description of all instrument functions and their application. The chapter also lists the remote control command corresponding to each instrument function.
Chapter 5	describes the basics for programming the FSP, command processing and the status reporting system.
Chapter 6	lists all the remote-control commands defined for the instrument. At the end of the chapter a alphabetical list of commands and a table of softkeys with command assignment is given.
Chapter 7	contains program examples for a number of typical applications of the FSP.
Chapter 8	describes preventive maintenance and the characteristics of the instrument's interfaces.
Chapter 8	gives a list of error messages that the FSP may generate.
Chapter 9	contains a list of error messages.
Chapter 10	contains an index for the operating manual.

Service Manual - Instrument

The service manual - instrument informs on how to check compliance with rated specifications, on instrument function, repair, troubleshooting and fault elimination. It contains all information required for the maintenance of FSP by exchanging modules.

Spectrum Analyzer FSP40

9 kHz to 40 GHz

Specifications

Specifications Spectrum Analyzer R&S FSP40

Specifications apply under the follwoing conditions:

15 minutes warm-up time at ambient temperature, specified environmental conditions met, calibartion cycle adhered to, and total calibration performed.

Data without tolerances: typical values only. Data designed „nominal" apply to design parameters and are not tested.

Data designed „ = xx dB) are shown as standard deviation.

Data specified in here are data for R&S FSP40, which deviate from R&S FSP data. Data of other FSP models are included for comparison. Data not specified here: please see data sheet Spectrum Analyzer R&S FSP, PD 757.5137.24

	FSP3	FSP7	FSP13	FSP30	FSP40
Frequency					
Frequency range	9 kHz to 3 GHz	9 kHz to 7 GHz	9 kHz to 13.6 GHz	9 kHz to 30 GHz	9 kHz to 40 GHz
Freqeuncy span	0 Hz, 10 Hz to 3 GHz	0 Hz, 10 Hz to 7 GHz	0 Hz, 10 Hz to 13 GHz	0 Hz, 10 Hz to 30 GHz	0 Hz, 10 Hz to 40 GHz
Level					
Maximum input level					
DC voltage	50 V		0 V		
Intermodulation					
3rd-order-intermodulation					
Intermodulation-free dynamic range, level 2 • -30 dBm, Δf > 5 • RBW or 10 kHz, whichever the greater value					
20 MHz to 200 MHz	> 70 dBc, TOI > 5 dBm				
20 MHz to 3 GHz	> 74 dBc, TOI > 7 dBm (typ. 10 dBm)				
3 GHz to 7 GHz	-	> 80 dBc , TOI > 10 dBm (typ. 15 dBm)			
7 GHz to 13,6 GHz	-	-	> 80 dBc, IP3 > 10 dBm		
13,6 GHz to 30 GHz	-	-	-	> 76 dBc, IP3 > 8 dBm	> 80 dBc, IP3 > 10dBm
30 GHz to 40 GHz	-	-	-	-	> 80 dBc, IP3 > 10dBm
Second harmonic intercept					
< 100 MHz	typ. 25 dBm				
100 MHz to3 GHz	typ. 35 dBm				
3 GHz to 7 GHz	-	typ. 45 dBm			
7 GHz to 13,6 GHz	-	-	typ. 45 dBm		
13,6 GHz to 30 GHz	-	-	-	typ. 45 dBm	
30 GHz to 40 GHz	-	-	-	-	typ. 45 dBm
Displayed average noise level					
(0 dB RF-attenuation, RBW 10 Hz, VBW 1 Hz, 20 averages, trace average, Span 0 Hz, termination 50 Ω)					
9 kHz	< -95 dBm				
100 kHz	< -100 dBm				
1 MHz	< -120 dBm, typ. –125 dBm				
10 MHz to 1 GHz	< -142 dBm, typ. 145 dBm	< -140 dBm, typ. –145 dBm			
1 GHz to 3 GHz	< -140 dBm, typ. –145 dBm	< -138 dBm, typ. –143 dBm			
3 GHz to 7 GHz	-	< -138 dBm, typ. –143 dBm	< -135 dBm, typ. –140 dBm		< - 135 dBm
7 GHz to 13,6 GHz	-	-	< -132 dBm, typ. –138 dBm		< -132 dBm
13,6 GHz to 22 GHz	-	-	-	< -120 dBm, typ. –130 dBm	
22 GHz to 30 GHz	-	-	-	< -115 dBm, typ. –123 dBm	

	FSP3	FSP7	FSP13	FSP30	FSP40
13,6 GHz to 20 GHz	-	-	-	-	< - 120 dBm
20 GHz to 30 GHz	-	-	-	-	< - 120 dBm
30 GHz to 40 GHz	-	-	-	-	< -112 dBm
Max. uncertainty of level measurement					
Frequency response					
< 50 kHz	< + 0,5 / - 1,0 dB				
50 kHz to 3 GHz	< 0,5 dB (σ = 0,17 dB)				
3 GHz to 7 GHz	-	< 2 dB,(σ = 0,0,7			
3 GHz to 13,6 GHz				< 2,5 dB [1]	
13,6 GHz to 30 GHz				< 3 dB [1]	
30 GHz to 40 GHz					< 4 dB 1)
Inputs and outputs (frontpanel)					
RF input	N female, 50 Ω			Testport system 50 Ω, Nfemale, 3,5 mm-female	Testport system 50 Ω, N female, K-female

[1]) RF attenuation 10 dB, Sweeptimet > 1s / 1 GHz

Ordering Information

Spectrum Analyzer 9 kHz to 40 GHz   FSP40   1093.4495.40

Options and Recommended extras

See data sheet FSP, PD 757.5137.24

ROHDE & SCHWARZ

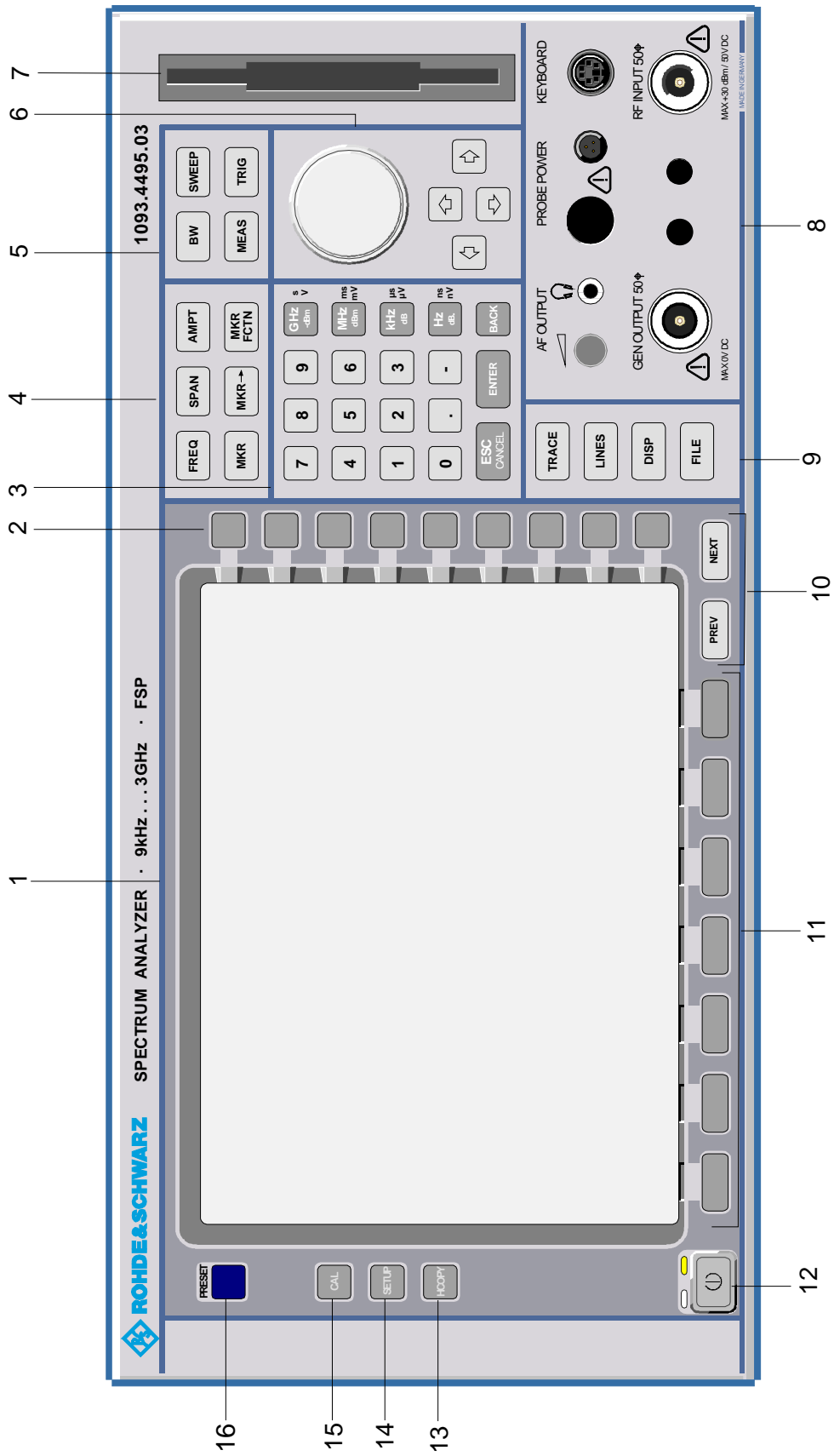# Contents - Chapter 1 " Preparing for Operation "

Fig. 1-1   Front View

1   Preparing for Operation

Chapter 1 describes the controls and connectors of the Spectrum Analyzer FSP by means of the front and rear view. Then follows all the information that is necessary to put the instrument into operation and connect it to the AC supply and to external devices.

A more detailed description of the hardware connectors and interfaces can be found in chapter 8. Chapter 2 provides an introduction into the operation of the FSP by means of typical examples of configuration and measurement; for the description of the concept for manual operation and an overview of menus refer to chapter 3.

For a systematic explanation of all menus, functions and parameters and background information refer to the reference part in chapter 4.

For remote control of the FSP refer to the general description of the SCPI commands, the instrument model, the status reporting system, and command description in chapter 5 and 6.

Description of Front and Rear Panel Views

Front View

1		
	Display Screen	see Chapter 3
2		
	Softkeys	see Chapter 3
3		

	data input	see Chapter 3
	0...9 input numbers	
	. input decimal point	
	– change sign	
	ESC – close input field (for uncompleted or	
	CANCEL already closed inputs, the original	
	entry is kept)	
	– erase the current entry in input field	
	(beginning of an input)	
	– close message window (status, error	
	and warning messages)	
	ENTER close the data input.	
	BACK – erase last character input for	
	uncompleted input	
	– restore previous input (undo)	
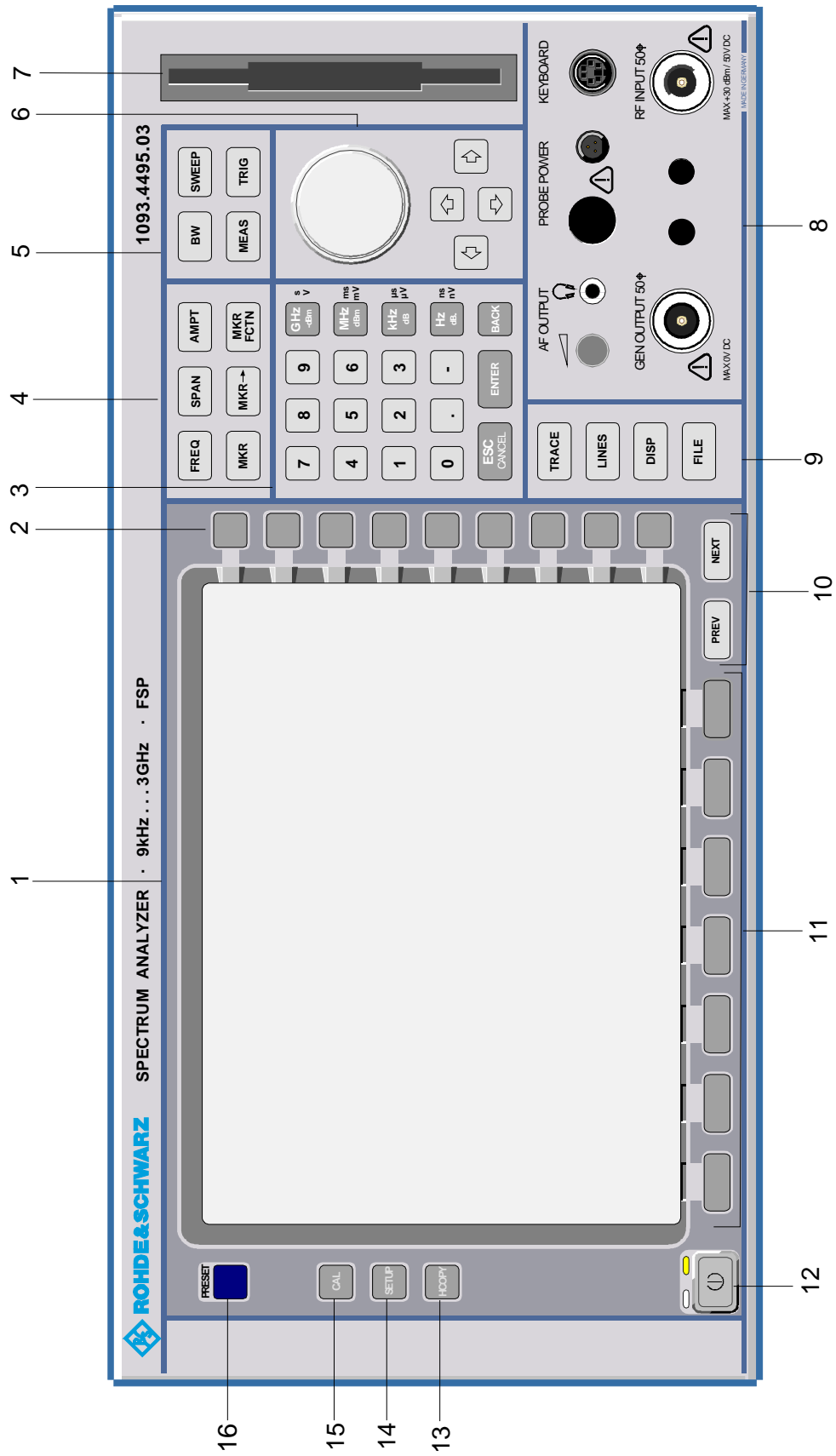
Fig. 1-1   Front View

	data input	see Chapter 3
	GHz s The units keys close the data	
	-dBm V input and define the multipli-	
	cation factor for each basic unit.	
	MHz ms For dimension-less or	
	dBm mV alphanumeric inputs, the units	
	keys have weight 1.	
	kHz µs They behave, in this case, like the	
	dB µV ENTER key.	
	Hz ns	
	dB.. nV	

4

	FREQ Set frequency axis	see Chapter 4
	SPAN Set span	
	AMPT Set level indication and configure	
	RF input.	
	MKR Select and set standard marker and delta	
	marker functions.	
	MKR-> Change instrument settings via markers	
	MKR Select further marker and delta	
	FCTN marker functions	

5

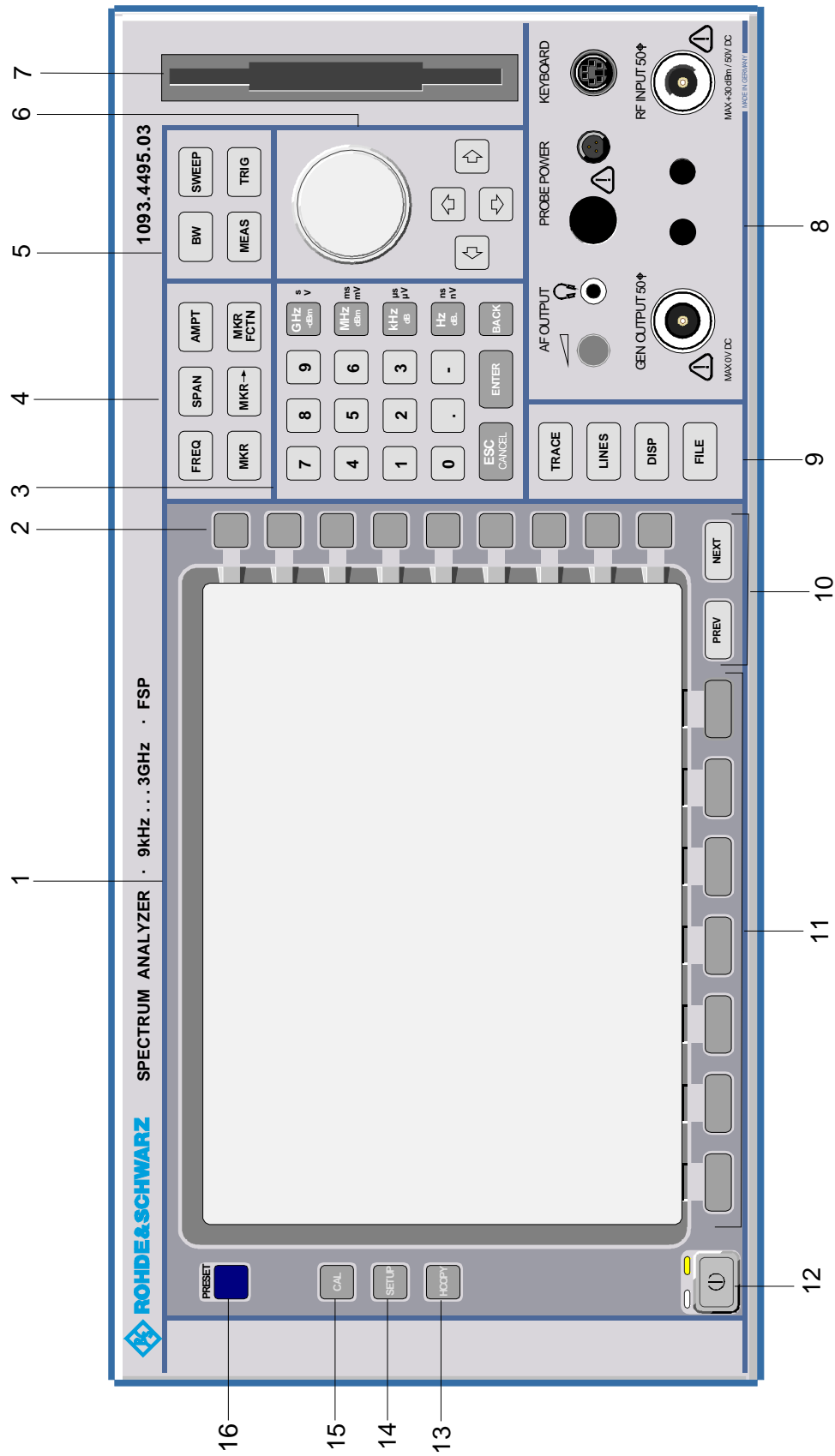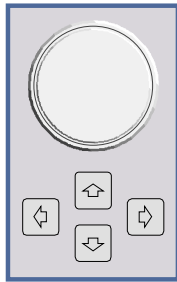|		
	BW – Set resolution bandwidth,	see Chapter 4
	video bandwidth and sweep time,	
	– Set coupling of these	
	parameters	
	SWEEP Select sweep	
	MEAS Select and set power measurements	
	TRIG Set trigger sources	

Fig. 1-1 Front View

6
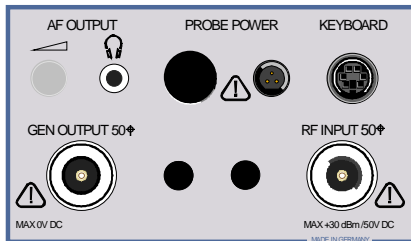
Key group for entering data and for cursor movement   see Chapter 3

Cursor keys – Move the cursor within the input
fields and tables.
– Vary the input value.
– Define the direction of movement
for the roll-key.

Roll-key – Vary input values.
– Move markers and limits.
– Select letters in the help line editor.
– Move cursor in the tables
– Close data input (ENTER)

7

3 1/2" diskette drive; 1.44 MByte

8

AF OUTPUT (only with option FSP-B3)   see Chapter 8
Volume control

Head phone
connector

PROBE POWER   Power supply and
coded socket
(+15 V/ -12 V) for
accessories

KEYBOARD   Connector for an
external keyboard

RF INPUT   RF input   see Chapter 8

Caution:

*The maximum DC voltage is
50 V, the maximum power is
1 W ($\hat{=}$ 30 dBm) at $\geq$ 10 dB
attenuation.*

9

TRACE Select and activate traces and detectors   see Chapter 4
LINES Set limit lines
DISP Configure display
FILE – Save and recall instrument data
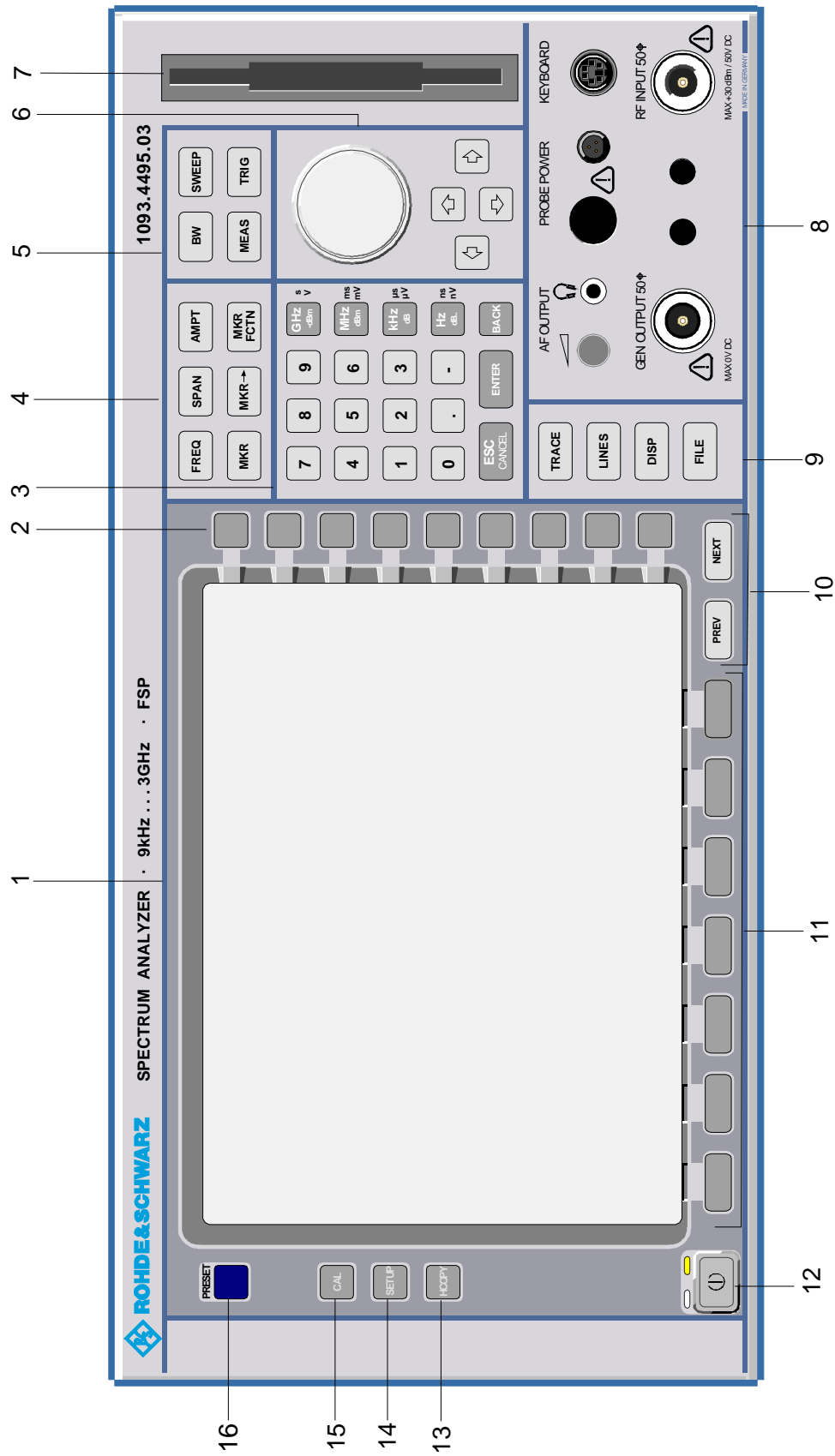– Configuration of memory media and data

Fig. 1-1   Front View

10		
PREV NEXT	Menu-change keys NEXT Change to side menu PREV Call main menu	see Chapter 3

11		
	Hotkeys	see Chapter 3

12		
	ON/STANDBY switch	see Chapter 1

13		
HCOPY	Configure and start a print job	see Chapters 1 and 4

14		
SETUP	Define general configuration	see Chapter 4

15		
CAL	Record correction data	see Chapter 4

16		
PRESET	Call default settings	see Chapter 4
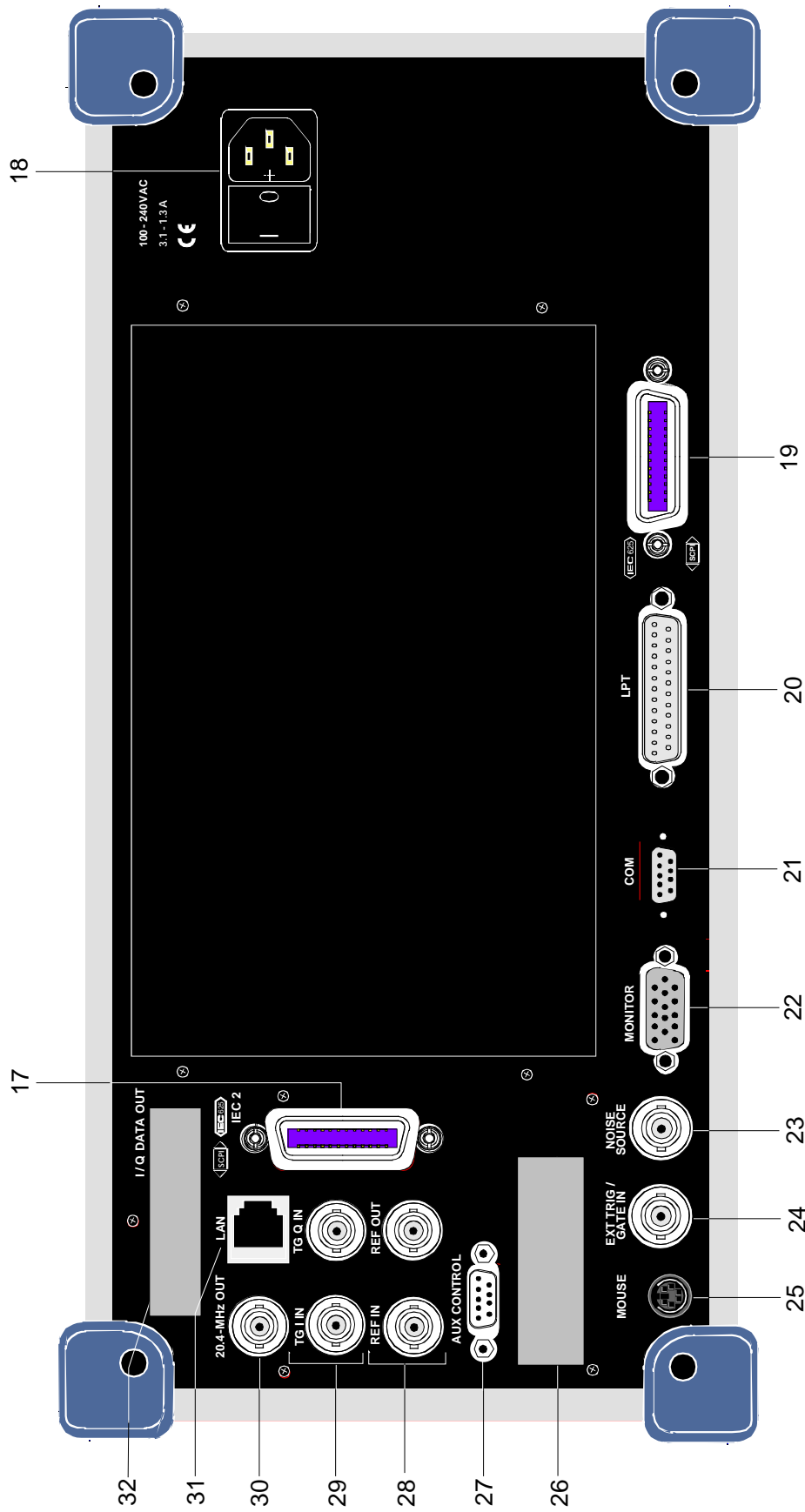
Fig. 1-1   Rear View

Rear View

17		
	Reserved for options	see Chapter 8
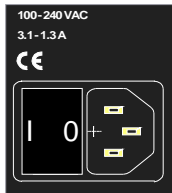
18		
	Power switch and AC power connector	see Chapter 1
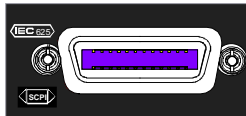
19		
	IEC/IEEE bus-connector	see Chapter 8
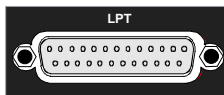
20		
	Parallel interface connector (printer connector)	see Chapter 8

21		
	Connector for a serial interface (9-pin socket; COM)	see Chapter 8

22		
	Connector for an external monitor	see Chapter 8

23		
	Output connector for an external noise source	see Chapter 8
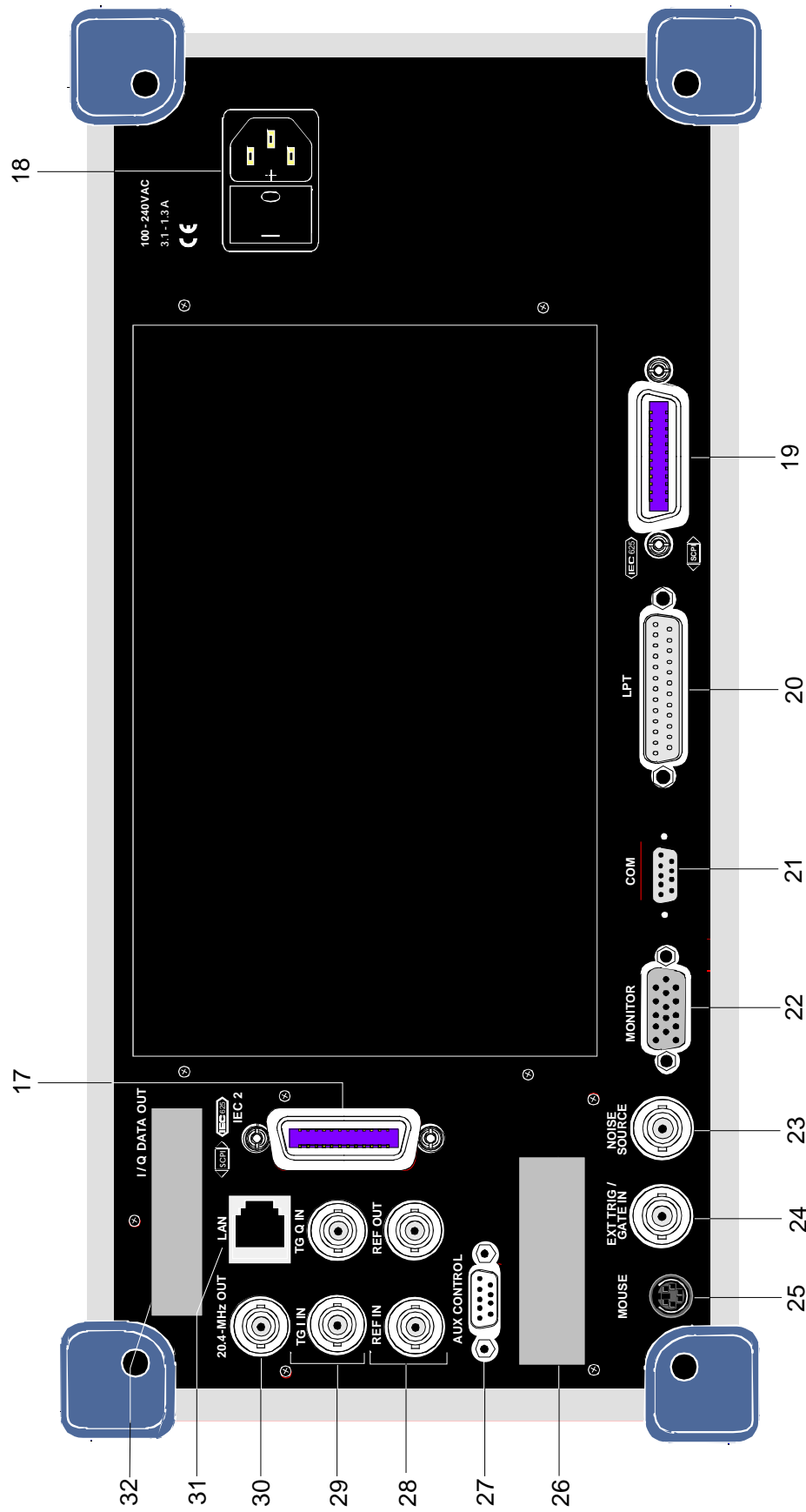
Fig. 1-2   Rear View

24		
EXT TRIG / GATE IN	Input connector for an external trigger or an external gate signal	see Chapter 8

25		
MOUSE	Connector for a PS/2 mouse	see Chapter 8

26		
	Reserved for options	

27		
AUX CONTROL	Connector to control an external generator ((only with option FSP-B10)	
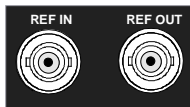
28		
REF IN REF OUT	REF IN Input connector for an external reference (10 MHz)	see Chapter 4
	REF OUT Output connector for an internal reference (10 MHz)	
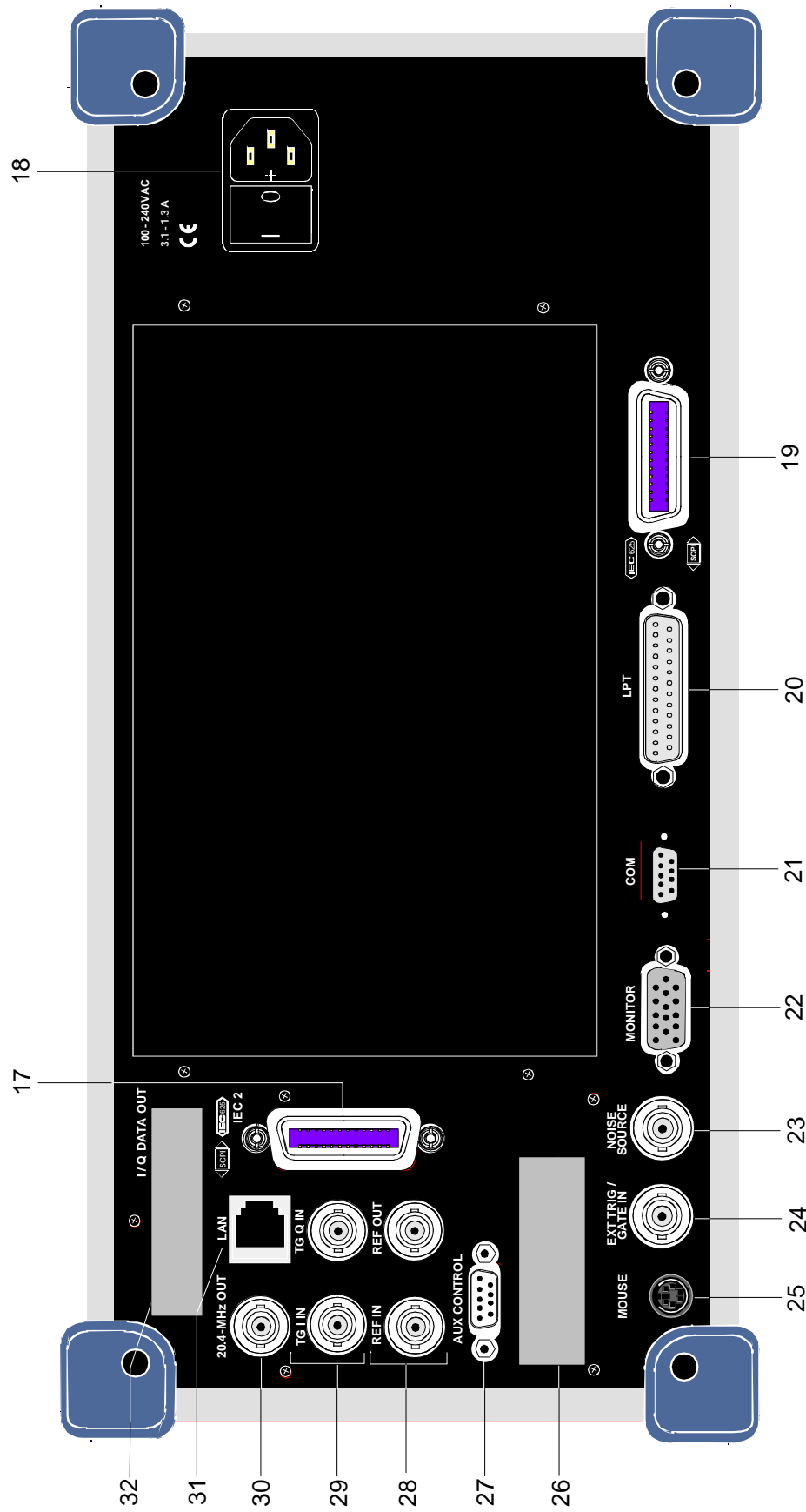
Bild 1-2   Rear View

29
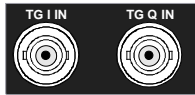
	TG IN	Signal input connector for external modulation of Tracking Generator (option FSP-B9)
	TG Q IN	Signal input connector for external modulation of Tracking Generator (option FSP-B9)

30

Output connector for 20.4 MHz IF

(replaced by CCVS IN OUT if option FSP-B6 is built in)   see Chapter 8

Selectable CCVS input/output

(only if option FSP-B6 is built in)   see Chapter 4 and 8

31

LAN Interface (option FSP-B16)   see Chapter 4

32

Reserved for options

Getting Started with the Instrument

The following section describes how to activate the instrument and how to connect external devices like e.g. printer and monitor.

Chapter 2 explains the operation of the instrument using simple measurement examples.

***Important note:***

Before turning the instrument on, care should be taken that the following conditions are fulfilled:

- *instrument cover is in place and tightened by the corresponding screws,*
- *fan openings are free from obstructions,*
- *signal levels at the input connectors are all within specified limits,*
- *signal outputs are connected correctly and not overloaded.*

   ***Ignoring these conditions may cause damage to the instrument** .*

Preparing the Instrument for Operation
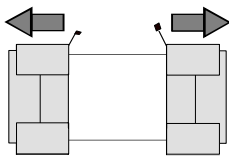
remove protective caps

- ➢ Take the instrument out of the shipping box and check whether the items listed in the packing list and in the lists of accessories are all included.
- ➢ Remove the two protective caps from the front and rear of the FSP and carefully check the instrument for damage.
- ➢ Should the instrument be damaged, immediately notify the transportation company that shipped the instrument to you and keep the box and packing material.
- ➢ For further transport or shipment of the FSP the original packing should also be used. It is recommended to keep at least the two protective caps for front and rear side in order to prevent damage to the controls and connectors.

Setting Up the Instrument

Standalone Operation

The instrument is designed for use under general laboratory conditions. The ambient conditions required at the operational site are as follows:
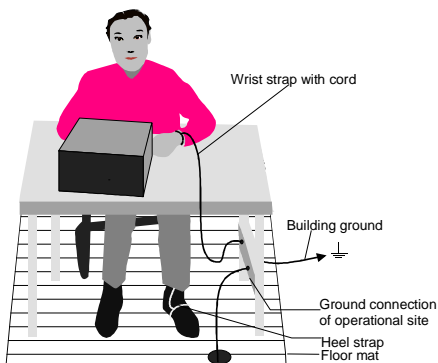
- The ambient temperature must be in the range indicated in the data sheet.
- All fan openings must be unobstructed and the air flow at the rear panel and at the side-panel perforations must not be obstructed. The distance to the wall should be at least 10 cm.
- The mounting surface should be flat.
- In order to avoid damage of electronic components of the device under test due to electrostatic discharge on manual touch, protection of the operational site against electrostatic discharge is recommended.

Safety Instruction for Instruments with Tiltable Feet

Warning

The feet must be fully folded in or out. Only in this way can the stability of the instrument be guaranteed and reliable operation be ensured. With the feet out, the total load for the feet must not exceed 500 N (own weight and additional units put onto the instrument). These units must be secured against slipping (e.g. by locking the feet of the unit at the top side of the enclosure).

<500N
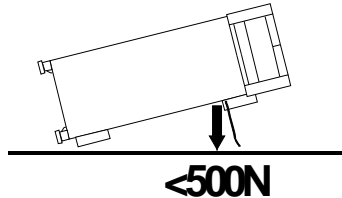
When shifting the instrument with the feet out, the feet might collapse and fold in. To avoid injuries, the instrument must therefore not be shifted with the feet out.
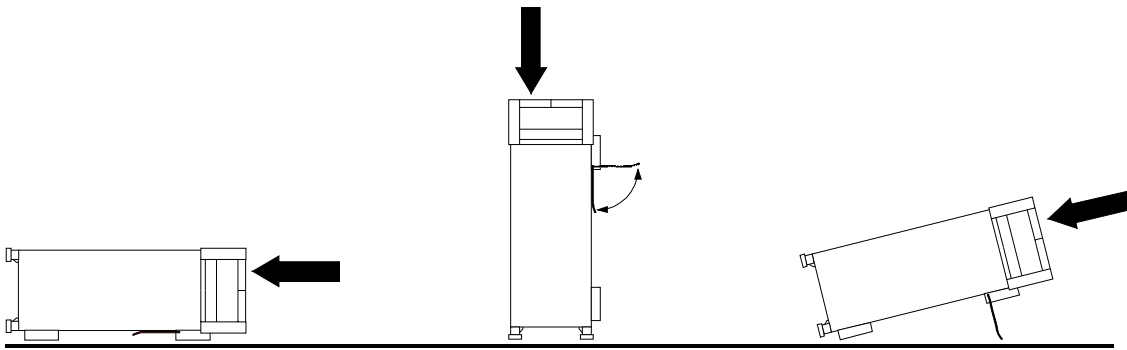
The instrument can be operated in any position.

Rackmounting

Important Note:

For rack installation, ensure that the air flow at the side-panel perforations and the air exhaust at the rear panel are not obstructed.

The instrument may be mounted in a 19" rack by using a rack adapter kit (Order No. see data sheet). The installation instructions are included in the adapter kit.

EMI Protection Measures

In order to avoid electromagnetic interference (EMI), the instrument may be operated only when all covers are correctly in place. Only adequately shielded signal and control cables may be used (see recommended accessories).

Connecting the Instrument to the AC Supply

The FSP is equipped with an AC voltage selection feature and will automatically adapt itself to the applied AC voltage (range: 100 to 240 V AC, 40 to 400 Hz). External voltage selection or adaptation of the fuses are not necessary. The AC power connector is located on the rear panel (see below).
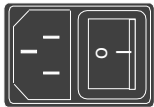
Power connector

➢ Connect the instrument to the AC power source using the AC power cable delivered with the instrument.

As the instrument is designed according to the regulations for safety class EN61010, it must be connected to a power outlet with earthing contact.

Switching the Instrument On/Off

Caution:

Do not power down during booting. *Such a switch-off may lead to corruption of the hard disk files.*

AC power switch on the rear panel

Power switch Power connector
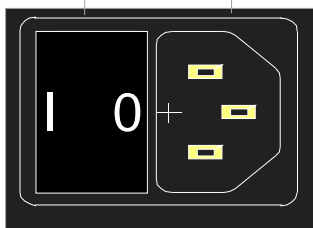
Power switch

Position I = ON

In the I position, the instrument is in standby mode or in operation, depending on the position of the ON/STANDBY key at the front of the instrument.

Note:
The AC power switch may remain ON continuously. Switching to OFF is only required when the instrument must be completely removed from the AC power source.

Position O = OFF

The 0 position implies an all-pole disconnection of the instrument from the AC power source.

ON/STANDBY switch on the front panel

ON   STANDBY

Standby switch

The ON/STANDBY switch activates two different operating modes indicated by coloured LEDs:

Operation ON - ON/STANDBY is depressed

The green LED (ON) is illuminated. The instrument is ready for operation. All modules within the instrument are supplied with power.

STANDBY - ON/STANDBY switch is not pressed.

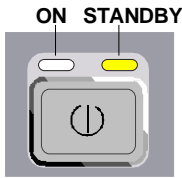The yellow LED (STANDBY) is illuminated. Only the power supply is supplied with power and the quartz oven is maintained at normal operating temperature.

Caution:

In standby mode, the AC power voltage is present within the instrument

Switching On the Instrument

➢ In order to switch on the FSP, set the power switch on the rear panel to position I.

➢ Set the FSP to operating mode by pressing the *ON/STANDBY* key on the front panel. The green LED must be illuminated.

Startup Menu and Booting

After switching on the instrument, a message indicating the installed BIOS version (e.g. Analyzer BIOS Rev. 1.2) appears on the screen for a few seconds.

Subsequently Windows NT is booted first and after that the instrument firmware will boot. As soon as the boot process is finished the instrument will start measuring. The settings used will be the one that was active when the instrument was previously switched off, provided no other device configuration than *FACTORY* had been selected with *STARTUP RECALL* in the *FILE* menu.

Switching Off the FSP

➢ Switch the ON/STANDBY key on the front panel to standby mode by pressing it once.

The FSP will write the current instrument settings to disk before performing a Windows NT shutdown. At the end of the shutdown procedure the power supply will be switched to STANDBY mode.

The yellow LED must be illuminated.

Only when removing the FSP completely from the AC power source:

➢ Set the power switch at the rear panel to position 0.

Power-Save Mode

Display:

The FSP offers the possibility of switching on a power-save mode for the screen display. The screen is blanked out if no entry is made on the front panel (key, softkey or hotkey and rollkey) during the selected response time.

In order to switch on the power-save mode:

 1. Call the *DISPLAY - CONFIG DISPLAY* submenu to configure the screen display:
    ➢ Press *DISP* key
    ➢ Press *CONFIG DISPLAY* softkey

 2. Activate the save mode
    ➢ Press *DISPLAY PWR SAVE* softkey.
      The softkey is highlighted in colour, thus indicating that the power-save mode is on. At the same time the data entry for the delay time is opened.

 3. Define the delay time
    ➢ Enter the required response time in minutes and confirm the entry using the *ENTER* key.
      The screen will be blanked out after the selected time period has elapsed.

Hard disk:

A power-save mode is preset for the built-in hard disk which is automatically closed down 15 minutes after the last access.

Recalling the Most Recent Instrument Settings

The FSP is equipped with a battery-powered read/write memory (CMOS-RAM) where instrument settings are saved at power-off. After each power-on, the FSP is reloaded with the operational parameters which were active just prior to the last power-off (STANDBY or AC power OFF) or were set with STARTUP RECALL (see Chapter 4 "Saving and Recalling Data Sets").
A lithium battery is used to supply power to the CMOS-RAM. As soon as the battery is discharged (expected life time is approx. 5 years), any data stored in CMOS-RAM will be lost. In this case, the factory standard setup is loaded at power-on. For changing batteries please contact your local service representative.

Functional Test

After turning on the AC power, the FSP will display the following message on the display screen:

> Rohde & Schwarz GmbH & Co. KG
> Analyzer BIOS   Vx.y

After appearance of the above message, a selftest of the digital hardware is performed. Subsequently, the Windows NT controller boots and the measurement screen will appear.

The system self-alignment is activated via *CAL* key, *CAL TOTAL* softkey. The individual results of the self-alignment (PASSED / FAILED) can be displayed in the *CAL* menu (*CAL RESULTS).*
With the aid of the built-in selftest functions (*SETUP* key, *SERVICE, SELFTEST* soft keys), the functional integrity of the instrument can be verified and/or defective modules can be localized.

Windows NT

> ⚠ ***Caution:***
>
> *The drivers and programs used under Windows NT are adapted to the measuring instrument. In order to prevent the instrument functions from damage, the settings should only be modified as described below. Existing software may only be modified using update software released by Rohde&Schwarz. Additionally only programs authorized by Rohde&Schwarz for use on the* FSP *may be run on the instrument.*
>
> ***Do not power down during booting.*** *Such a switch-off may lead to corruption of the hard disk files.*

The instrument runs under the operating system Windows NT. The computer can be used to install and configure device drivers that were authorized by Rohde&Schwarz. Any further use of the computer function is only allowed under the conditions described in this operating manual.

Login

Windows NT requires a login process, during which the user is asked for identification by entering his name and password. As a factory default the instrument is configured for *Auto Login*, i.e. the login is performed automatically and in the background. The user name used for this is "instrument" and the password is also "instrument" (in small letters).

Administrator level

The NT user account used for the autologin function has administrator access rights.

After a software installation that requires administrator rights (e.g. the installation of new printer drivers), Service Pack 5 of Windows NT has to be re-installed. The necessity to re-install the service pack is indicated in the corresponding operating manual chapters. The installation of the Service Pack is described in the section "Installing Windows NT Software".

**Calling the Windows NT start menu**

The Windows NT start menu is called using the key combination <CTRL> <ESC>. It is possible to access the required submenus from the start menu by means of the mouse or the cursor keys. In order to return to the measurement screen the button "R&S Analyzer Interface" in the Windows NT task bar can be used.

Connecting an External Keyboard

> **Caution:**
> *The keyboard may only be connected when the instrument is switched off (STANDBY). Otherwise, correct operation of the keyboard cannot be guaranteed.*

The FSP offers a 6-contact PS/2-connector KEYBOARD on the instrument's front panel for the connection of an external PC. It is recommended to use the PSP-Z2 keyboard (Order No. 1091.4100.02, English). This keyboard is equipped with a trackball for mouse control.
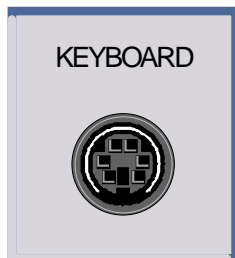
KEYBOARD

During measurement operations, the keyboard simplifies the input of commentary text, file names, etc.

The section "Instrument Interfaces" in Chapter 8 contains the interface description of the connector.

After connection of the keyboard and subsequent power-on, the keyboard will be automatically recognized. The default language used is "US keyboard". Special settings such as repetition rate etc can be performed in the Windows NT menu START - SETTINGS - CONTROL PANEL - KEYBOARD.
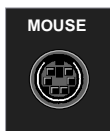
Connecting a Mouse

> **Caution:**
> *The mouse may only be connected when the instrument is switched off (STANDBY). Otherwise, correct operation of the mouse and instrument cannot be guaranteed.*

In order to ease up operation of Windows NT, the FSP provides an option for connecting a mouse to the PS/2 mouse connector (MOUSE) at the rear panel of the instrument.
The mouse type supported is "Microsoft mouse". It is available as option PS-B1 (Order No. 1006.6359.02).

Note. *The recommended keyboard PSP-Z2 is equipped with a trackball for mouse control. Connecting an additional mouse will cause interface conflicts and lead to malfunctions of the instrument.*

The section "Instrument Interfaces" in Chapter 8 contains the interface description of the connector.

After connection and subsequent power-on the mouse is automatically recognized. Special settings such as mouse cursor speed etc, can be performed in the Windows NT menu START - SETTINGS - CONTROL PANEL - MOUSE.
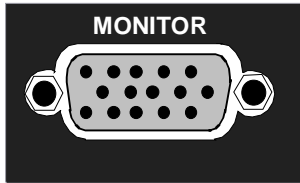
Connecting an External Monitor

> *Caution:*
> *The monitor may only be connected when the instrument is switched off (STANDBY). Otherwise, the monitor may be damaged.*
>
> *Do not modify the screen driver (display type) and display configuration since this will severely affect instrument operation.*

The instrument is equipped with a rear-panel connector MONITOR for the connection of an external monitor.

After connecting the external monitor the instrument needs to be rebooted in order to recognize the monitor. After that the measurement screen is displayed on both the external monitor and the instrument. Further settings are not necessary.
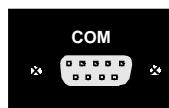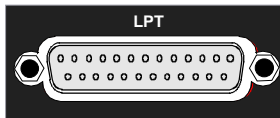
Connecting a Printing Device

> ⚠️ ***Caution:***
> *The printing device may be connected only when the instrument is switched off (STANDBY)*

Note: *When installing printer drivers that are not pre-installed on the instrument, the operator is requested to insert the disk with the new driver into drive A.*
After installation the Service Pack needs to be re-installed (see section "Installing Windows NT Software")

The instrument is prepared for connecting printing devices to two different interfaces in order to create hard copies of the display screen. The *DEVICE* table in menu *HCOPY – DEVICE1/2* indicates the available selection of installed printing devices (see also Chapter 4, section "Documentation of Test Results").

The interface connectors are located on the rear panel:

Chapter 8 contains the interface descriptions of the connectors.

After connection of the printing device to the appropriate interface connector, the interface needs to be configured, the printer driver has to be installed and assigned to an interface.

1. Connecting keyboard and mouse

For the installation and configuration of printer drivers on the FSP, it is necessary to connect a keyboard to the front panel and a PS/2 mouse to the rear panel (only in case of using a keyboard without trackball, see sections "Connecting a Mouse" and "Connecting a Keyboard").

2. Switching to Windows NT start menu and opening the system control

The combination of keys <CTRL><ESC> is used to switch to the Windows NT start menu. The system control panel is then opened in the NT start menu using the sequence SETTINGS - CONTROL PANEL.

3. Configuration of the interface

LPT   Interface LPT needs no configuration.

COM   The COM interface must first be assigned to the operating system (owner = OS) in menu SETUP - GENERAL SETUP. The configuration of the serial interface can then be performed either in the Windows NT menu START - SETTINGS - CONTROL PANEL - PORTS or in the FSP SETUP - GENERAL SETUP menu. The parameters *Baud Rate*, *Data Bits*, *Parity, Stop Bits, Flow Control* determine the transmission parameters of the interface. They must correspond to the specifications of the printing device (see the operating manual for the printer).

> *Note:*   *The settings made for the serial interface in the menu SETUP - GENERAL SETUP overwrite the settings in the NT menu.*
> *However, settings in the Windows NT menu do not overwrite those of the SETUP menu. This means that the settings are only valid as long as the interface is assigned to the operating system.*

4. Selection and installation of the printer driver

The selection and installation of the printer driver, the assignment to the interface and the setting of most of the printer-specific parameters (e.g. paper size) is performed under Windows NT in the START - SETTINGS - PRINTER menu.

5. Configuration of the connected output device

The configuration of the connected output device and the assignment to the interface takes place in the *HCOPY DEVICE1/2* menu (see in Chapter 4, the section "Measurement Documentation"). The instrument supports the configuration of up to two output devices (DEVICE1 and DEVICE2), one of which must be activated for printing.

- The parameter *DEVICE* determines which output device is to be used.

- The parameter *PRINT TO FILE* determines if the output is in the form of a file.

- The parameter *ORIENTATION* sets the page format to horizontal or vertical (portrait).

Selecting the type of printer automatically sets the parameters *PRINT TO FILE* and *ORIENTATION* to values which correspond to a standard operating mode with this output device. Other printer-dependent parameters such as *FORMFEED*, *PAPERFEED* etc, can be modified under Windows NT in the printer properties window (START/SETTINGS/PRINTER/SETTINGS/....).

Table 1-1 shows the standard factory settings for the two output devices.

The factory settings for DEVICE 1 correspond to output format "WMF" (Windows Metafile); printing is performed in a file. WMF is a common format which is used for the import of hardcopies (e.g. measurement windows) in other Windows applications that support this format (e.g. WinWord).

The factory settings for DEVICE 2 are "Clipboard". In this setting the printout is copied to the Windows NT clipboard. Most of Windows applications support the clipboard. The clipboard contents can be directly inserted into a document via EDIT - PASTE.

Table 1-1   Factory settings for *DEVICE 1 a*nd *DEVICE 2* in the *HCOPY* menu.

Setting	Selection in the configuration table	*DEVICE 1* Settings	*DEVICE 2* Settings
Output Device	DEVICE/LANGUAGE	WINDOWS METAFILE	CLIPBOARD
Output	PRINT TO FILE	YES	---
Page Orientation	ORIENTATION	---	---

In the following example, a HP DeskJet 660C printer is connected to the LPT interface and configured as *DEVICE2* for hardcopies of the screen contents.

Switch off the FSP.

Connect the printer to interface LPT.

Switch on both FSP and printer.

Select the printer driver under Windows NT

➢ Press key combination <CTRL> <ESC>

The Windows NT start menu is displayed.
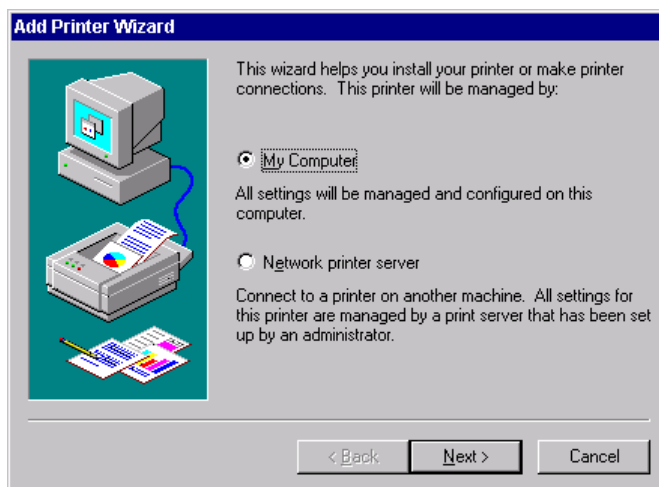
➢ In the Start menu press "Setting" and then "Printers".
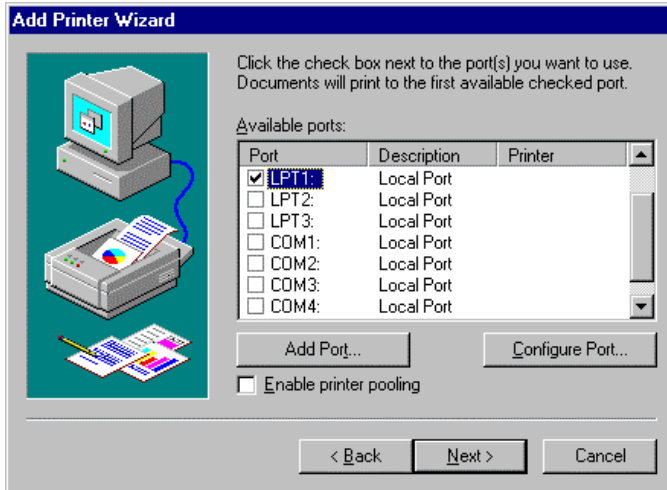
The printer window is opened.

➢ Double-click symbol "Add Printer".

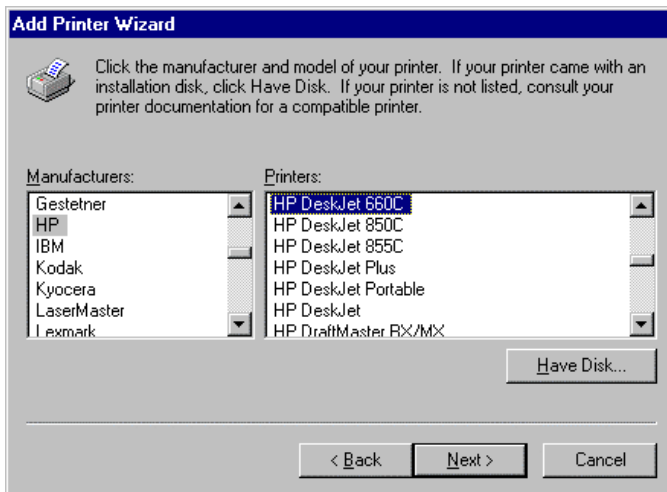The "Add Printer Wizard" window is opened. This window leads through the following printer driver installation.

➢ Click "My computer" and then "Next".

The available printer ports are displayed.

➢ Select LPT1.

The selection is marked by a tick.

➢ Click "Next".

The available printer drivers are displayed. The left-hand selection table indicates the manufacturers and the right-hand one the available printer drivers.

➢ Mark "HP" in selection table "Manufacturers" and "HP DeskJet 660C" in selection table "Printers".

Note:
If the required type of output device is not included in the list, the driver has not yet been installed. In this case click on button "HAVE DISK". A message box requesting to insert a disk with the corresponding printer driver will be displayed. Insert the disk, press OK and select the required printer driver. After installation, Service Pack 5 must be re-installed (see section "Installing Windows NT Software").

➢ Click "Next".

The entry field for the printer name is displayed.
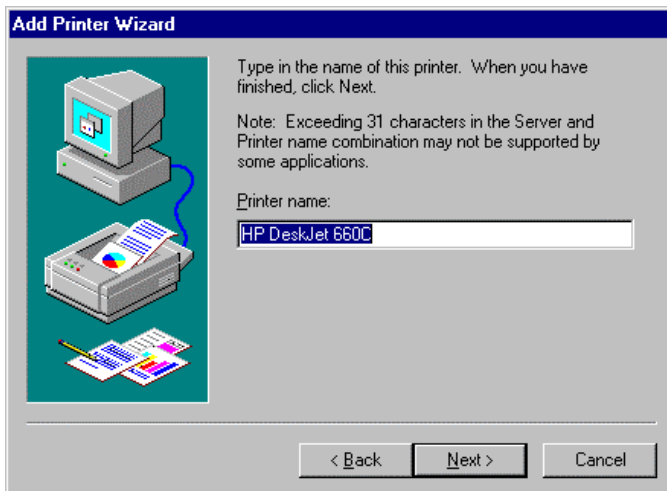
➢ The printer name can be modified in the entry field "Printer name" (max. 60 characters).

If one or more printers are already installed, a query is displayed in this window to ask if the printer last installed as default printer should be selected for the Windows NT applications (Do you want your Windows-based programs to use this printer as default printer?). The default selection is "No".
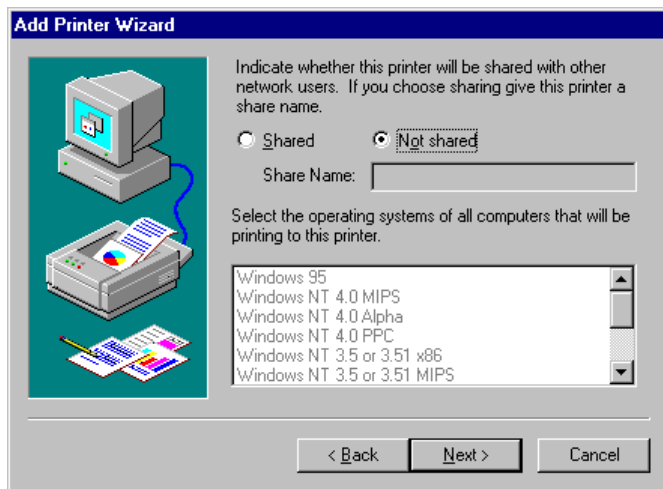
➢ Click "Next".

A query is displayed for providing the printer in the network. This query is irrelevant when installing a local printer. The default selection is "Not shared".

➢ Click "Next".

The window for starting a test page print is displayed. The test page is helpful for checking if the installation was successful.

➢ Click "Yes" (recommended).

➢ Click "Finish".

A test page is printed if the installation was successful.
If the test page is not printed or not printed completely, the Windows NT online help offers troubleshooting instructions under the topic "Printer Troubleshooting".

Note:
*If a prompt for the printer driver path appears after pressing "Finish", the Service Pack must be re-installed after this printer installation (see Chapter 1, section "Installing Windows NT Software").*

Now the instrument needs to be configured for creating hardcopies of the measurement screen using this printer.
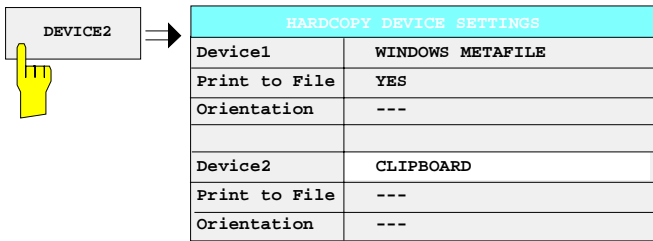
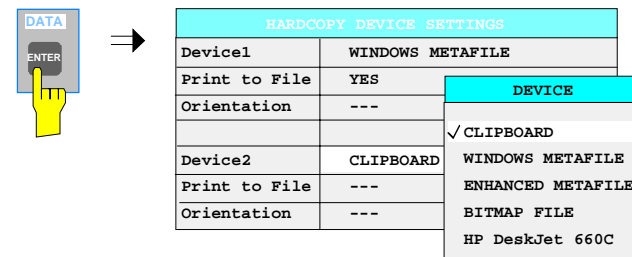***Configuring HP DeskJet 660C.***

➢ Click button "R&S Analyzer Interface".
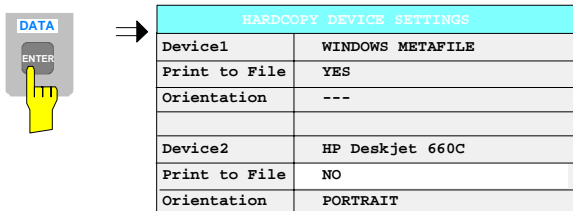
The measurement screen is displayed.

➢ Press the *HCOPY* key.
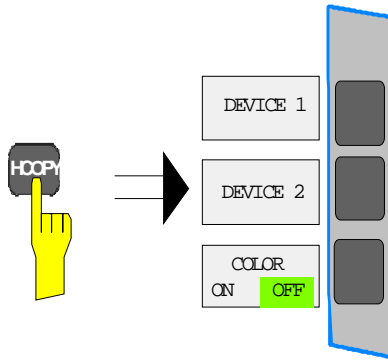
The *HCOPY* menu is opened.

| DEVICE 1 |
| DEVICE 2 |
| COLOR ON OFF |

➢ Press softkey *DEVICE2*.

DEVICE 2 is activated as printing device.

The *HARDCOPY DEVICE SETTINGS*-table is opened and the current settings of the two output devices are displayed. The current selection in line DEVICE2 is highlighted by the selection bar.

HARDCOPY DEVICE SETTINGS	
Device1	WINDOWS METAFILE
Print to File	YES
Orientation	---
Device2	CLIPBOARD
Print to File	---
Orientation	---

➢ Press the *ENTER* key.

The selection box *DEVICE* is displayed on the screen. The current selection is marked by a tick.

HARDCOPY DEVICE SETTINGS	
Device1	WINDOWS METAFILE
Print to File	YES
Orientation	---
Device2	CLIPBOARD
Print to File	---
Orientation	---

DEVICE
✓ CLIPBOARD
WINDOWS METAFILE
ENHANCED METAFILE
BITMAP FILE
HP DeskJet 660C

➢ Press cursor key [↻] until the entry *HP DeskJet 660C* is highlighted by the selection bar.

➢ Press the *ENTER* key.

The selection box *DEVICE* is closed and *HP DeskJet 660C* is entered in line *DEVICE2*.

| HARDCOPY DEVICE SETTINGS	
Device1	WINDOWS METAFILE
Print to File	YES
Orientation	---
Device2	HP Deskjet 660C
Print to File	NO
Orientation	PORTRAIT

Note:
The selection of the printer type automatically sets the parameters PRINT TO FILE and ORIENTATION to values which correspond to a standard mode with this output device. Other printer-dependent parameters such as PAPERSIZE, can be modified under Windows NT in the printer properties window (START / SETTINGS / PRINTER / SETTINGS).

```
PRINT
SCREEN
```
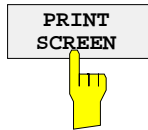
Start print of measurement results

➢ Press Softkey *PRINT SCREEN* to start the print job.

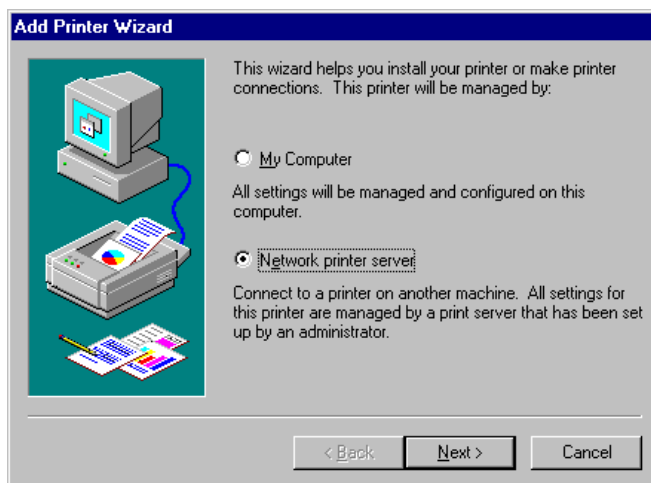# Installation of a Network Printer (with Option FSP-B16 only)
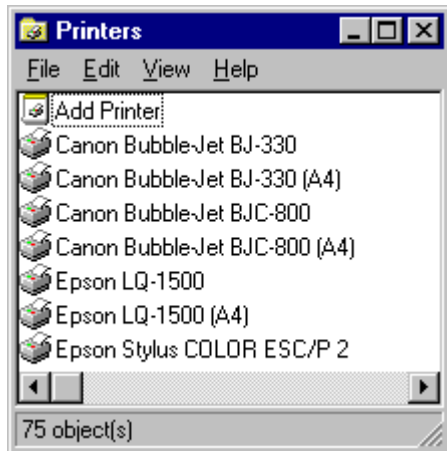
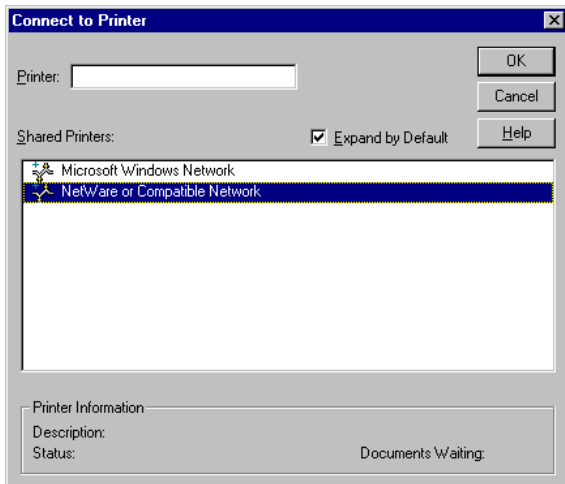After opening the "Printers" dialog window proceed with the installation as follows:

➢ Double-click the "Add Printer" line.

The "Add Printer Wizard" window is opened. This window guides the user through the printer driver installation.

➢ Click "Network printer server" and then "Next".

A list of selectable printers is displayed.

➢ Mark the desired printer and select it with OK.

➢ Confirm the following request for the installation of a suitable printer driver with OK.

The list of printer drivers is displayed. The manufacturers are listed in the window at the left, the available printer drivers at the right.
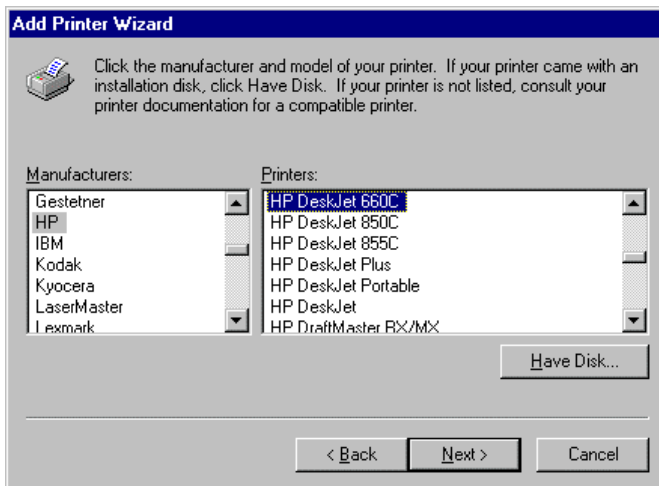
➢ Select the manufacturer in the "Manufacturers" window and then the printer driver in the "Printers" window.

Note:
If the required type of output device is not included in the list, the driver has not yet been installed. In this case click on button "HAVE DISK". A message box requesting to insert a disk with the corresponding printer driver will be displayed. Insert the disk, press OK and select the required printer driver. After installation, Service Pack 5 must be re-installed (see section "Installing Windows NT Software").

➢ Click "Next"

If one or more printers are already installed, a prompt is displayed in this window to ask if the printer last installed as default printer should be selected for the Windows NT applications ("Do you want your Windows-based programs to use this printer as default printer?"). The default selection is "No".
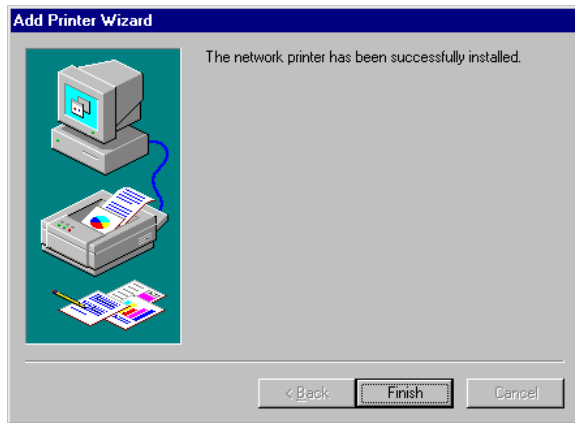
> ➢ Start the printer driver installation with "Finish".

Note:
If a prompt for the printer driver path appears after pressing "Finish", the Service Pack must be re-installed after this printer installation (see Chapter 1, section "Installing Windows NT Software").

Finally, the instrument has to be configured for printout with this printer using the DEVICE 1 and DEVICE 2 softkeys in the hardcopy menu.

Installing Windows NT Software

Authorized Windows NT Software for the Instrument

The driver software and the system settings of Windows NT are adapted to the measurement functions of the instrument. Correct operation of the instrument can therefore only be guaranteed if the software and hardware used is authorized or supplied by Rohde & Schwarz.

The following program packages have been successfully tested for compatibility with the instrument's software:

➢ FS-K3 – software for measuring the noise factor and gain

➢ FS-K4 – software for measuring the phase noise

➢ Symantec PCAnywhere – for remote control via soft front panel

➢ VNC – for remote control via soft front panel

➢ FileShredder – for deleting files from the hard disk

➢ Symantec Norton AntiVirus – software for protection against viruses

The use of other software or hardware may cause failures in the functions of the FSP.
A current list of the software authorized for use on the FSP can be obtained from your nearest Rohde&Schwarz agency (see list of addresses).

After installing software of other manufacturers from a disk, it is necessary to reinstall the Windows NT Service Pack 5, unless the instrument is equipped with the B20 option.

Reinstallation of Service Pack 5

Notes:

➢ *It is not necessary to install the Service Pack 5 if the instrument is equipped with the B20 option, since in this case the service pack files are installed automatically.*

➢ *If the service pack is not installed although there is no B20 option, the following error message will be displayed: "At least one service or driver failed during system startup..."*
   In this case, the network installation is not fully operational.
   To prevent faults, it is therefore indispensable to reinstall the service pack (see chapter 1, section "Computer Function – Installing the Windows NT Software").
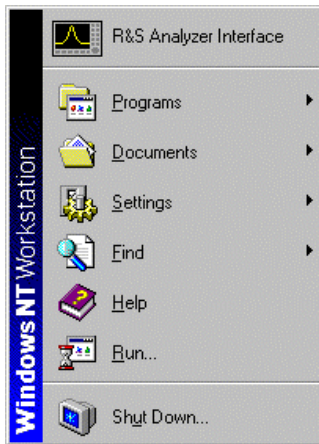
➢ Open the *Windows NT* start menu by pressing <CTRL><ESC>.

➢ Select "RUN".

➢ Enter the command:
c:\sp\sp5i386 <ENTER>

The installation of the service pack begins, the archive file being unpacked.
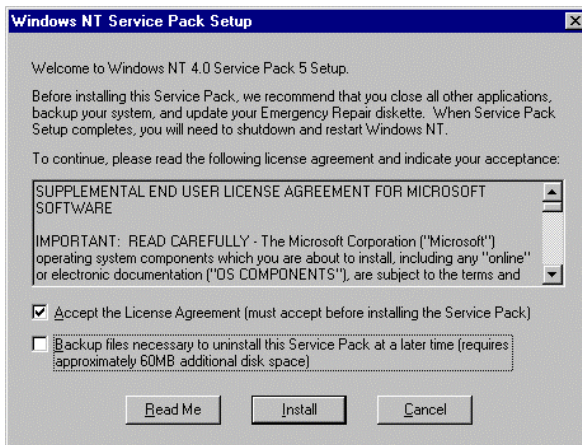
➢ Check the box "Accept the License Agreement...".
➢ Uncheck the box "Backup files necessary..." and then click "Install".

The service pack files are installed. **Installation takes approx. 5 minutes.**
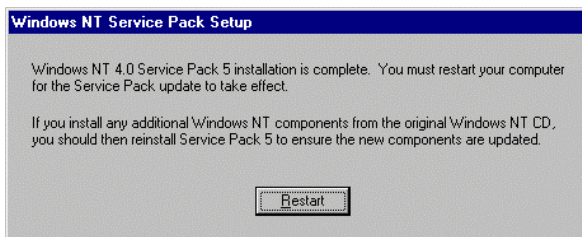
After installation has been completed, you are requested to restart the instrument.

➢ Click the "Restart" button.

The instrument restarts.

Contents - Chapter 2 "Getting Started"

2 Getting Started

Chapter 2 explains how to operate the FSP using typical measurements as examples. Chapter 3 describes the basic operating steps such as selecting the menus and setting parameters, and explains the screen structure and displayed function indicators.
Chapter 4 describes all the menus and FSP functions.

All of the following examples are based on the standard settings of the analyzer. These are set with the *PRESET* key. A complete listing of the standard settings can be found in chapter 4, section "Preset settings of the FSP – *PRESET key"*.

Level and Frequency Measurements

Measuring the frequency and level of a signal is one of the most common purposes for the use of a spectrum analyzer. For unknown signals, the spectrum analyzer default settings (PRESET) are a good starting point for the measurement.
If signal levels at the RF input are expected to be above 30 dBm (= 1 W), a power attenuator must be connected to the RF input of the spectrum analyzer. Please note that the total powar of all applied signals must be taken into account concerning this limit. If a power attenuator is not used, signal levels above 30 dBm can destroy the RF attenuator or the input mixer.

Measurement Example 1 – Measuring Frequency and Level using Markers

It is easy to measure the level and frequency of a sinewave carrier with the marker function. At the marker position, the FSP indicates the signal's amplitude and frequency. The accuracy of the frequency measurement is determined by the FSP reference frequency, the resolution of the marker frequency display and the resolution of the screen.

In the example, the frequency of the 128-MHz internal reference generator is displayed using the marker.

1. *Set the spectrum analyzer to its default settings.*

   ➢ Press the *PRESET* key.

2. *Connect the test signal to the RF INPUT on the instrument front panel.*

3. *Switch on the internal reference generator.*

   ➢ Press the *SETUP* key.
     The *SETUP* menu opens.

   ➢ Press the *SERVICE soft*key.
     The *SETUP - SERVICE* menu opens.

   ➢ Press the *INPUT CAL soft*key.
     The internal reference generator is turned on.
     The FSP's RF input is turned off.

4. *Set the center frequency to 128 MHz.*

   ➢ Press the *FREQ* key.

   ➢ The entry field for the center frequency is displayed on the screen.

   ➢ Enter *128* from the numeric keypad and terminate the entry with the *MHz* key.

5. **Reduce the measurement frequency range (SPAN) to 1 MHz.**

   ➢ Press the *SPAN* key.

   ➢ Enter *1* from the numeric keypad and terminate the entry with the *MHz* key.

   > *Note:*   *If the SPAN is changed, the resolution bandwidth (RES BW), the video bandwidth (VIDEO BW) and the sweep time (SWEEP TIME) are also set to new values because they are defined as coupled functions in the standard PRESET settings.*

6. **Measure the level and frequency using the marker and read off the results from the screen.**

   ➢ Press the MKR key.
   The marker is switched on and automatically jumps to the trace peak.

   > *Note:*   *When a marker is switched on for the first time, it automatically performs the PEAK SEARCH function (as in this example).*
   > *If a marker is already active, the PEAK softkey in the MKR-> menu must be pressed in order to set the currently active marker onto the displayed signal maximum.*

   The level and frequency indicated by the marker are displayed in the marker info field at the upper edge of the screen. These are the measurement results.

   ```
   Marker 1 [T1]
            -30.00 dBm
     128.00000000 MHz
   ```

   The info-field header indicates the number of the marker (MARKER 1) and the number of the trace on which the marker is positioned ([T1] = Trace 1).

   Increasing the Frequency Resolution During a Frequency Measurement with a Marker

   The frequency resolution of the marker is determined by the pixel resolution of the trace. The FSP uses 501 pixels for a trace, i.e. at a frequency span of 1 MHz each pixel corresponds to a frequency range of approx. 2 kHz. This gives a maximum error of 1 kHz.
   To increase the pixel resolution of the trace, the frequency span has to be reduced.

7. **Reduce the frequency span to 10 kHz.**

   ➢ Press the *SPAN* key.

   ➢ Enter *10* from the numeric keypad and terminate the entry with the *kHz* key.

   > *Note:*   *If the SPAN is changed, the resolution bandwidth (RES BW), the video bandwidth (VIDEO BW) and the sweep time (SWEEP TIME) are also set to new values because they are defined as coupled functions in the standard PRESET settings.*

   The internal reference signal is measured with a span of 10 kHz. The pixel resolution of the trace is now approx. 20 Hz (10 kHz span / 501 pixel), i.e. the accuracy of the marker frequency display is increased to approx. 10 Hz.

8. **Switch on the RF input again for normal operation of the analyzer.**

   ➢ Press the *PRESET* key <u>or</u> press the *SETUP* key and the *SERVICE* softkey.

   ➢ Press the *INPUT RF* softkey.
   The internal signal path of the FSP is switched back to the RF input in order to resume normal operation.

Measurement Example 2 – Measuring Frequency with the Frequency Counter

With the internal frequency counter, frequencies can be measured more accurately than with the marker. The frequency sweep is stopped at the marker position and the FSP measures the frequency of the corresponding signal. If an analog bandwidth (≥300 kHz) is used, the frequency is measured by counting the zero-crossings of the last IF. With digital resolution bandwidths (10 Hz to 100 kHz), the frequency measurement is performed in the IQ baseband by a special approximation algorithm.

The resolution range for the frequency measurement is 0.1 Hz to 10 kHz. At bandwidths ≥300 kHz, the time required for the FSP to perform the frequency measurement is dependent on the selected counter resolution (1/(frequency resolution in Hz)). The digital frequency approximation takes about 30 ms to perform a frequency measurement irrespective of the selected resolution.
The frequency measurement accuracy is determined by the reference frequency of the FSP and the selected counter resolution.

In the example, the frequency of the 128-MHz internal reference generator is displayed with the marker.

1. **Set the spectrum analyzer to the default settings.**

   ➢ Press the *PRESET* key.
   The FSP is in its default state.

2. **Switch on internal reference generator**

   ➢ Press the *SETUP* key.

   ➢ Press the softkeys *SERVICE - INPUT CAL*.
   The internal 128 MHz reference generator is now on. The FSP's RF input is turned off.

3. **Set the center frequency and the frequency span**

   ➢ Press the *FREQ* key and enter *128 MHz*.
   The FSP center frequency is set to 128 MHz.

   ➢ Press the *SPAN* softkey and enter *1 MHz*.
   The FSP frequency span is set to 1 MHz.

4. **Switch on the marker**

   ➢ Press the *MKR* key.
   The marker is switched on and set to the signal maximum. The level and the frequency at the marker are displayed in the marker-info field.

5. **Switch on the frequency counter.**

   ➢ Press the *SIGNAL COUNT* softkey in the marker menu.
   The frequency count is displayed in the marker field at the top of the screen along with the set resolution (1 kHz is the default setting).
   The sweep stops at the marker position and the FSP measures the frequency of the corresponding signal. The frequency is output in the marker info field. To distinguish the signal count result from the normal marker frequency display, the marker is labeled with CNT.

6. Set the resolution of the frequency counter to 1 Hz.

➢ Press the *NEXT* key.

➢ Press the *CNT RESOL 1 Hz* softkey.
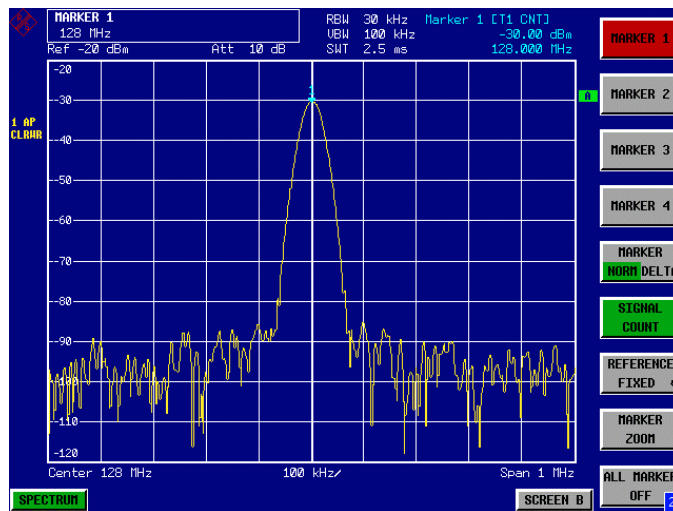
Fig. 2-1   Frequency measurement with a frequency counter

> ***Note:***   *The frequency measurement with the integral frequency counter only gives correct results for RF sinewaves or discrete spectral lines. To meet the specified measurement accuracy, the marker should be more than 25 dB above noise.*

7. Switch on the RF input again for normal operation of the analyzer.

➢ Press the *PRESET* key <u>or</u> press the *SETUP* key and the *SERVICE* softkey.

➢ Press the *INPUT RF* softkey.
The internal signal path of the FSP is switched back to the RF input in order to resume normal operation.

> **Hint**:   For bandwidths between 300 kHz and 10 MHz, the FSP uses a frequency counter at an IF of 20.4 MHz. The time for measuring the frequency is, therefore, inversely proportional to the selected resolution, i.e. at a resolution of 1 Hz a gate time of 1 second is required for the counter. For digital bandwidths below 300 kHz, the frequency is measured in the baseband by digital frequency approximation. The time required for measuring the frequency is approx. 30 ms irrespective of the selected resolution.
> When measuring the frequency of a sinewave carrier at a high resolution it is, therefore, best to set a resolution bandwidth of 100 kHz or less. The measurement time will then be reduced to a minimum.

Measurement of Harmonics

Measuring the harmonics of a signal is a frequent problem which can be solved best by means of a spectrum analyzer. In general, every signal contains harmonics which are larger than others. Harmonics are particularly critical regarding high-power transmitters such as transceivers because large harmonics can interfere with other radio services.

Harmonics are produced by nonlinear characteristics. They can often be reduced by lowpass filters. Since the spectrum analyzer has a nonlinear characteristic, e.g. in its first mixer, measures must be taken to ensure that harmonics produced in the analyzer do not cause spurious results. If necessary, the fundamental wave must be selectively attenuated with respect to the other harmonics with a highpass filter.

When harmonics are being measured, the obtainable dynamic range depends on the K2 intercept of the spectrum analyzer. The K2 intercept is the virtual input level at the RF input mixer at which the level of the 2nd harmonic becomes equal to the level of the fundamental wave. In practice, however, applying a level of this magnitude would damage the mixer. Nevertheless the available dynamic range for measuring the harmonic distance of a DUT can be calculated relatively easily using the second harmonic intercept.

As shown in Fig. 2-2, the level of the 2nd harmonic is reduced by 20 dB if the level of the fundamental wave is reduced by 10 dB.
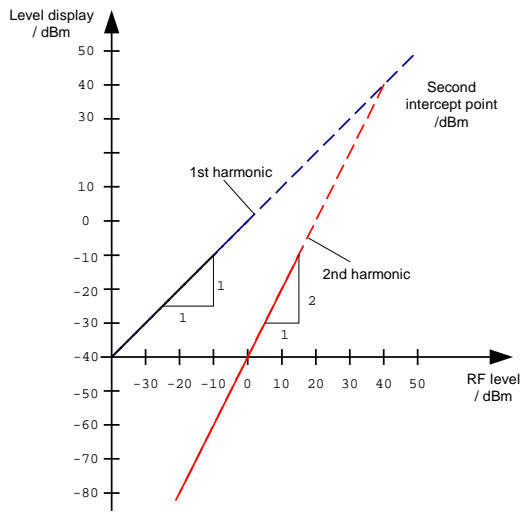
Fig. 2-2   Extrapolation of the 1st and 2nd harmonics to the second harmonic intercept at 40 dBm

The following formula for the obtainable harmonic distortion d_2 in dB is derived from the straight-line equations and the given intercept point:

$$d_2 = S.H.I - P_I \tag{1}$$

d_2 =   harmonic distortion
P_I =   mixer level/dBm
S.H.I.   =   second harmonic intercept

Note: *The mixer level is the applied RF level minus the set RF attenuation.*

The formula for the internally generated level P_1 at the 2nd harmonic in dBm is:

$$P_1 = 2 \cdot P_I - S.H.I. \tag{2}$$

The lower measurement limit for the harmonic is the noise floor of the spectrum analyzer. The harmonic of the measured DUT should – if sufficiently averaged by means of a video filter – be at least 4 dB above the noise floor so that the measurement error due to the input noise is less than 1 dB.

The following rules for measuring high harmonic ratios can be derived:

1. Select the smallest possible IF bandwidth for a minimal noise floor.
2. Select an RF attenuation which is high enough to just measure the harmonic ratio.

The maximum harmonic distortion is obtained if the level of the harmonic equals the intrinsic noise level of the receiver. The level applied to the mixer, according to (2), is:

$$P_I = \frac{P_{noise} / dBm + IP2}{2}$$

At a resolution bandwidth of 10 Hz (noise level -143 dBm, S.H.I. = 40 dBm), this level is –51.5 dBm. According to (1) a maximum measurable harmonic distortion of 91.5 dB minus a minimum S/N ratio of 4 dB is obtained.

Hint:	If the harmonic emerges from noise sufficiently (approx. >15 dB), it is easy to check (by changing the RF attenuation) whether the harmonics originate from the DUT or are generated internally by the spectrum analyzer. If a harmonic originates from the DUT , its level remains constant if the RF attenuation is increased by 10 dB. Only the displayed noise is increased by 10 dB due to the additional attenuation. If the harmonic is exclusively generated by the spectrum analyzer, the level of the harmonic is reduced by 20 dB or is lost in noise. If both – the DUT and the spectrum analyzer – contribute to the harmonic, the reduction in the harmonic level is correspondingly smaller.

Measuring Harmonics with Frequency Sweeps

There are advantages in performing harmonic measurements with a single frequency sweep, provided that the harmonic distance is in a way that a resolution bandwidth can be selected which is wide enough to give an acceptably short sweep time.

Measurement Example – Measuring the distance between fundamental wave and the 2nd and 3rd harmonics of the internal reference signal

1. Set the spectrum analyzer to the default settings.

➢ Press the *PRESET* key.
The FSP is in its default state.

2. Switch on the internal reference generator

➢ Press the *SETUP* key.
Press the softkeys *SERVICE - INPUT CAL*.
The internal 128 MHz reference generator is now on. The FSP's RF input is switched off.

3. Set the start frequency to 100 MHz and the stop frequency to 400 MHz

➢ Press the *FREQ* key.

➢ Press the *START* softkey and enter *100 MHz*.

➢ Press the *STOP* softkey and enter *400 MHz*.
The FSP displays the fundamental and the 2nd and 3rd harmonics of the input signal.

4. Set the RF attenuation to 0 dB to obtain maximum sensitivity

➢ Press the *AMPT* key.

➢ Press the *RF ATTEN MANUAL* softkey and enter *0 dB*.

5. Reduce the video bandwidth to average (suppress) noise.

➢ Press the *BW* key.

➢ Press the *COUPLING RATIO* softkey.

➢ Select *RBW/VBW NOISE [10*] using the cursor keys.

The video bandwidth (VBW) will now always be set to a value which is 10 times smaller than the resolution bandwidth (RBW).

6. Switch on the marker

➢ Press the *MKR* key.
Marker 1 is switched on and is positioned on the signal maximum (fundamental wave at 128 MHz). The level and the frequency of the marker are displayed in the marker info field.

7. *Switch on the delta marker and measure the harmonic distance*

➢ Press the *MARKER 2* softkey in the marker menu.
Marker 2 is activated as a delta marker (Delta 2 [T1]). It appears automatically on the largest harmonic of the signal. The frequency and level, related to marker 1, are indicated in the marker field at the top of the screen.

➢ Press the *MARKER 3* softkey in the marker menu.
Marker 3 is activated as a delta marker (Delta 3 [T1]). It appears automatically on the next largest harmonic of the signal. The frequency and level, related to marker 1 on the fundamental wave, are displayed in the marker info field at the top of the screen (see Fig. 2-3).
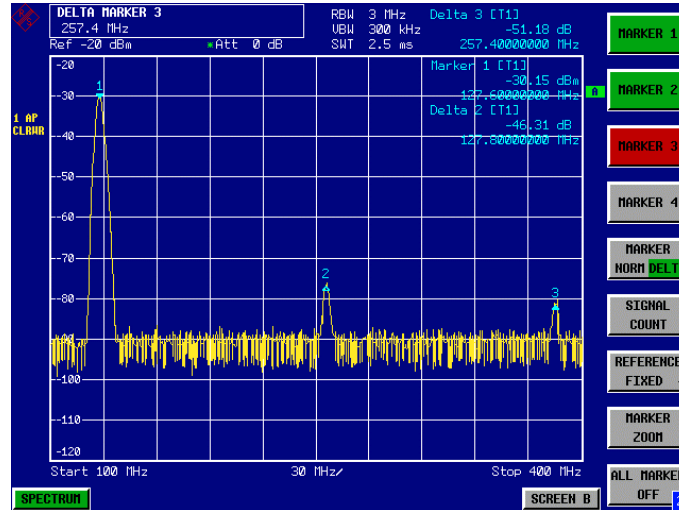
Fig. 2-3   Measuring the harmonic distance of the internal reference generator. Delta marker 2 [T1] and Delta marker 3 [T1] indicate the distance between the fundamental wave and the 2nd and 3rd harmonics.

In order to make the harmonics grow out of the noise, the following things can be done:

• Reducing the video bandwidth

• Averaging the trace

• Reducing the resolution bandwidth

The noise of the analyzer or the DUT (depending on which one is higher) is suppressed by reducing the video bandwidth and by averaging the trace. Especially for low S/N ratios, the measurement uncertainty is reduced using the two averaging methods since the signal under test is also freed from noise.

8. *Reduce noise by reducing the video bandwidth*

➢ Press the *BW* key.

➢ Press the *VIDEO BW MANUAL* softkey.

➢ Reduce the video bandwidth, e.g. to 10 kHz, using the spinwheel (turn knob counterclockwise), or enter *10 kHz.*

The noise is clearly smoothed and the sweep time is increased to 25 ms, i.e. the measurement lasts longer. The displayed video bandwidth is marked with an asterisk (*VBW) to indicate that it is no longer coupled to the resolution bandwidth (see Fig. 2-4).
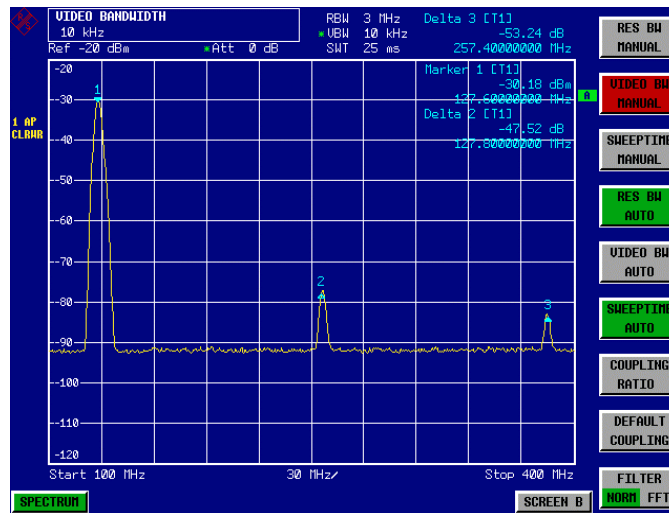
Fig. 2-4   Suppression of noise during harmonic measurement by reducing video bandwidth

9. Coupling the video bandwidth to the resolution bandwidth again.

➢ Press the *VIDEO BW AUTO* softkey.

10. Reduce noise by averaging the trace

➢ Press the *TRACE* key.

➢ Press the *AVERAGE* softkey.
The noise component of the trace is smoothed by averaging 10 consecutive traces.
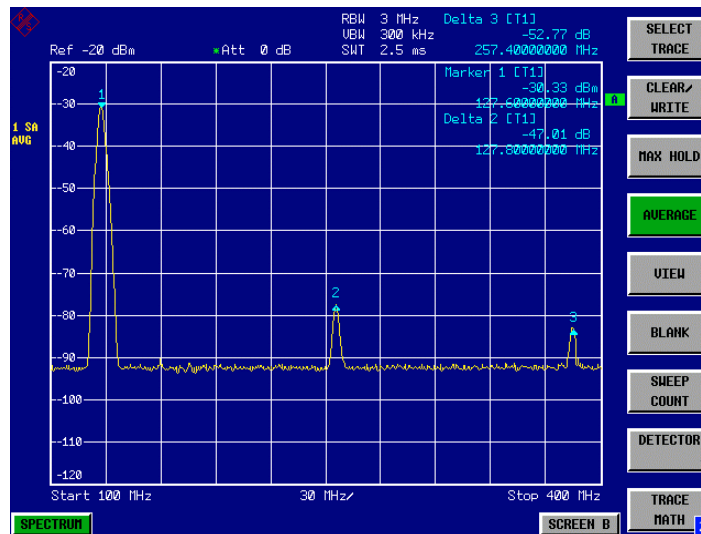
Fig. 2-5   Suppression of noise during harmonic measurements by averaging the trace

11. Switch off trace averaging again.

➢ Press the *CLEAR/WRITE* softkey.

12. Reduce noise by reducing the measurement bandwidth.

If the resolution bandwidth is decreased, noise is reduced proportionally, i.e. if the resolution bandwidth is reduced by a factor of 10, the noise is also reduced by the same factor (corresponds to 10 dB). The amplitude of a sinusoidal signal is not changed by reducing the resolution bandwidth.

13. Set the resolution bandwidth to 10 kHz.

➢ Press the *BW* key.

➢ Press the *RES BW MANUAL* softkey and enter *10 kHz*.
The noise is reduced by approx. 25 dB compared to the previous setting. Since the video bandwidth is coupled to the resolution bandwidth, it is reduced to 1 kHz – the same proportional reduction as the resolution bandwidth. The sweep time is therefore increased to 60 seconds.

14. Reset the resolution bandwidth again (coupling to span).

➢ Press the *RES BW AUTO* softkey.

If you want to stop the harmonics measurement on the internal reference generator at this point, switch the FSP's RF input on again with the following key sequence.

➢ Press the *SETUP* key and the softkey sequence *SERVICE - INPUT RF* or press the *PRESET* key.

High-Sensitivity Harmonics Measurements

If harmonics have very small levels, the resolution bandwidth required to measure them must be reduced considerably. The sweep time is, therefore, also increased considerably. In this case, the measurement of individual harmonics is carried out with the spectrum analyzer set to a small span. Only the frequency range around the harmonics will then be measured with a small resolution bandwidth.

Measurement Example

1. Set the spectrum analyzer to its default settings.

➢ Press the *PRESET* key.
The FSP is in its default state.

2. Switch on the internal reference generator.

➢ Press the *SETUP* key.

➢ Press the softkeys *SERVICE - INPUT CAL*.
The internal 128 MHz reference generator is now on. The FSP's RF input is switched off.

3. Set the center frequency to 128 MHz and the span to 100 kHz.

➢ Press the *FREQ* key.
The frequency menu opens.

➢ Enter *128* in the entry field from the numeric keypad and terminate with the *MHz* key.

➢ Press the *SPAN* key.

➢ Enter *100* in the entry filed from the numeric keypad and terminate with the *kHz* key.
The FSP displays the reference signal with a span of 100 kHz and resolution bandwidth of 3 kHz.

4. Switching on the marker.

➢ Press the *MKR* key.
The marker is positioned on the trace maximum.

5. Set the measured signal frequency and the measured level as reference values

➢ Press the *REFERENCE FIXED* softkey.

➢ The position of the marker becomes the reference point. The reference point level is indicated by a horizontal line, the reference point frequency with a vertical line. At the same time, the delta 2 marker is switched on at the marker position.
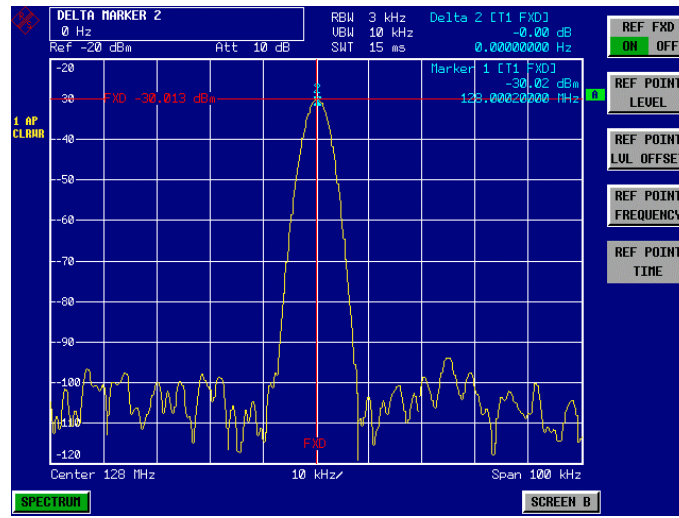
Fig. 2-6   Fundamental wave and the frequency and level reference point

6. Make the step size for the center frequency equal to the signal frequency

➢ Press the *FREQ* key.
The frequency menu opens.

➢ Press the *CF STEPSIZE* softkey and press the *=MARKER* softkey in the submenu.
The step size for the center frequency is now equal to the marker frequency.

7. Set the center frequency to the 2nd harmonic of the signal

➢ Press the *FREQ* key.
The frequency menu open. s

➢ Press the up cursor key (below the spinwheel) once.
The FSP's center frequency is set to the 2nd harmonic.

8. Place the delta marker on the 2nd harmonic.

➢ Press the *MKR →* key.

➢ Press the *PEAK* softkey.
The delta marker jumps to the maximum of the 2nd harmonic. The displayed level result is relative to the reference point level (= fundamental wave level).
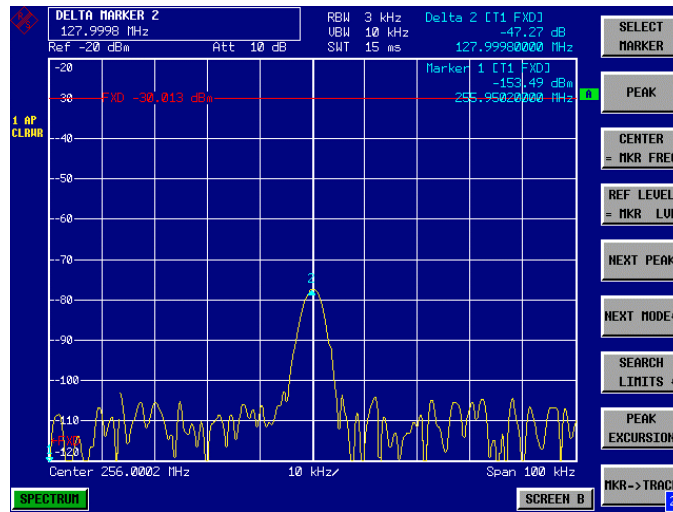
Fig. 2-7   Measuring the level difference between the fundamental wave (= reference point level) and the 2nd harmonic

The other harmonics are measured with steps 6 and 7, the center frequency being incremented or decremented in steps of 128 MHz using the up or down cursor key.

Measuring the Spectra of complex Signals

Separating Signals by Selecting an Appropriate Resolution Bandwidth

One basic characteristics of the spectrum analyzer is that it can separate the spectral components of a composite signal. The resolution with which the individual components are separated is determined by the resolution bandwidth. If the resolution bandwidth is too large, spectral components may no longer be distinct, i.e. they are displayed as a single component.

An RF sinewave signal is displayed on the screen of the spectrum analyzer with the passband characteristics of the set resolution filter (RBW). It is the 3 dB bandwidth of the filter that is displayed.

Two signals with the same amplitude can be resolved if the resolution bandwidth is less than or equal to the signals' frequency difference. If the resolution bandwidth and the frequency difference are equal, a 3 dB level dip can be seen in the middle between the two signals. The smaller the resolution bandwidth, the deeper the level dip and the better the signal resolution.

If there are large level differences between signals, the resolution is determined by selectivity as well as by the resolution bandwidth that has been selected. The measure of selectivity used for spectrum analyzers is the ratio of the 60 dB bandwidth to the 3 dB bandwidth (= shape factor).

For the FSP, the shape factor for bandwidths up to 100 kHz is < 5 and for larger bandwidths < 15, i.e. the 60 dB bandwidth of the 30 kHz filter is < 150 kHz and that of the 300 kHz filter is < 4.5 MHz. Although the 3 dB bandwidths only differ by a factor of 10, the 60 dB bandwidths differ by a factor of 30.

The higher spectral resolution with smaller bandwidths has to be traded off against longer sweep times for the same span. The sweep time required to allow the resolution filters to settle during a sweep at all signal levels and frequencies to be displayed is given by the following formula.

$$\text{SWT} = k \bullet \text{Span/RBW}^2 \tag{1}$$

SWT	=	max. sweep time for correct measurement
k	=	factor depending on type of resolution filter
		= 2.5 for analog IF filter ($\geq$300 kHz)
		= 1 for digital IF filters ($\leq$ 100 kHz)
Span	=	frequency display range
RBW	=	resolution bandwidth

If the resolution bandwidth is reduced by a factor of 3, the sweep time is increased by a factor of 9.

> **Note:**   *The impact of the video bandwidth on the sweep time is not taken into account in (1). For the formula to be valid, the video bandwidth must be $\geq$ 3 x the resolution bandwidth.*

For bandwidths > 300 kHz, the FSP uses 4pole, single-section filters. They require a k factor of 2.5 to settle during the frequency sweep. Digital filters with a Gaussian characteristic are used below a bandwidth of 300 kHz (up to 100 kHz). These filters settle at a k factor of 1, i.e. the sweep time is 2.5 times shorter than with conventional 4 or 5 pole, single-section filters.

FFT filters can be used for resolution bandwidths up to 30 kHz. Like digital filters, they have a shape factor of less than 5 up to 30 kHz. For FFT filters, however, the sweep time is given by the following formula:

$$\text{SWT} = k \cdot \text{span/RBW} \tag{2}$$

i.e. if the resolution bandwidth is reduced by a factor of 3, the sweep time is increased by a factor of 3 only

Measurement Example - Resolving two signals with a level of –30 dBm each and a frequency difference of 30 kHz

Example:
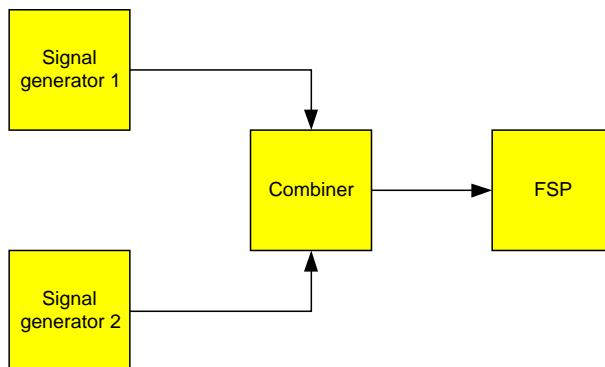
Fig. 2-8   Test setup for generating two signals

Signal generator settings (e.g. SMIQ):

	Level	Frequency
Signal generator 1	-30 dBm	100.00 MHz
Signal generator 2	-30 dBm	100.03 MHz

FSP measurement sequence:

1.   Set the spectrum analyzer to its default settings.

➢ Press the *PRESET* key.
  The FSP is in its default state.

2.   Set the center frequency to 100.015 MHz and the frequency span to 300 kHz.

➢ Press the *FREQ* key and enter *100.015 MHz*.

➢ Press the *SPAN* key and enter *300 kHz*.

3.   Set the resolution bandwidth is to 30 kHz and the video bandwidth to 1 kHz.

➢ Press the *BW* key.

➢ Press the *RES BW MANUAL* softkey and enter *30 kHz*.

➢ Press the *VIDEO BW MANUAL* softkey and enter *1 kHz*.

➢ The two signals are clearly separated by a 3 dB level dip in the middle of the screen.

Note:	The video bandwidth is set to 1 kHz to clearly display the level dip in the middle between the two signals. At larger video bandwidths, the video voltage which arises from envelope detection is not sufficiently suppressed. Therefore, additional voltages occur between the two signals and can be seen on the trace.

Fig. 2-9   Measurement of two RF sinewave signals with the same level using a resolution
              bandwidth which corresponds to the frequency difference of the signals.

Note: *The level dip is only exactly in the middle of the screen if the generator frequencies
             exactly correspond with the frequency display of FSP. To ensure this, the generators
             and the FSP must have their frequencies synchronized.*

4. Set the resolution bandwidth to 100 kHz.

➢ Press the *RES BW MANUAL* softkey and enter *100 kHz*.
   The two generator signals can no longer be clearly distinguished.
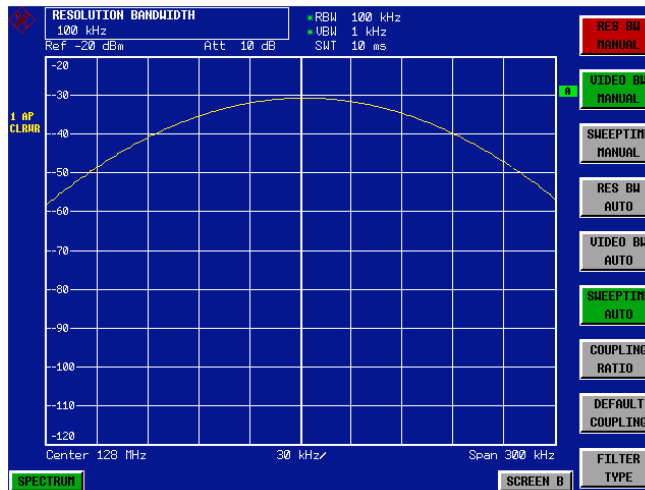
Fig. 2-10   Measurement on two RF sinewave signals with the same level using a resolution
              bandwidth which is greater than their frequency difference.

The resolution bandwidth (RBW) can be reduced again by turning the spinwheel counterclockwise
to obtain a higher frequency resolution.

5.　Set the resolution bandwidth to 1 kHz.

➢ Turn the spinwheel counterclockwise until a bandwidth of 1 kHz is displayed.
　The two generator signals are displayed at high resolution. The sweep time increases
　considerably (600 ms) because it increases by 1/ RBW$^{2.}$ The noise floor also goes down at small
　resolution bandwidths (10 dB per bandwidth factor of 10).
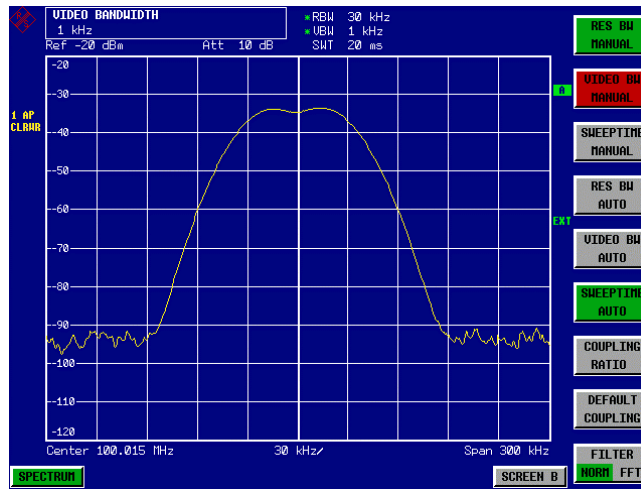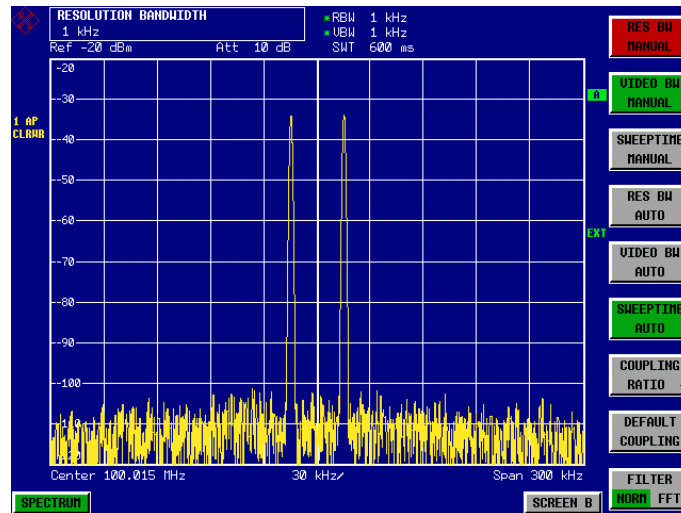

Fig. 2-11　　Measurement on two RF sinewave signals with the same level using a resolution
　　　　　　bandwidth (1 kHz) which is far below their frequency difference.

6.　Switch on the FFT bandwidths.

➢ Set the *FILTER* softkey to *FFT*.
　IF filtering is now carried out with the FFT algorithm. The sweep time is considerably reduced
　from 600 ms to 15 ms (factor of 40). The update rate of the display is increased in almost the
　same proportion.
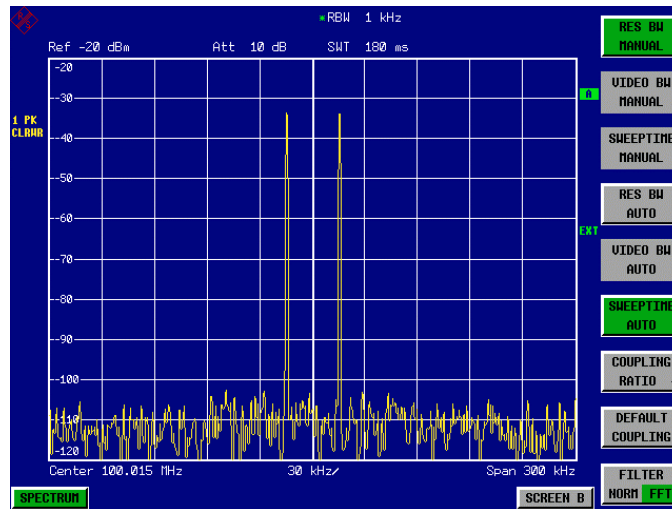
Fig. 2-12　　 Measurement with FFT filters gives a considerably shorter sweep time and a higher
　　　　　　refresh rate.

Intermodulation Measurements

If several signals are applied to a DUT with non-linear characteristics, unwanted mixing products are generated – mostly by active components such as amplifiers or mixers. The products created by 3rd order intermodulation are particularly troublesome as they have frequencies close to the useful signals and, compared with other products, are closest in level to the useful signals. The fundamental wave of one signal is mixed with the 2nd harmonic of the other signal.

$$f_{s1} = 2 \cdot f_{u1} - f_{u2} \tag{1}$$

$$f_{s2} = 2 \cdot f_{u2} - f_{u1} \tag{2}$$

where f_{s1} and f_{s2} are the frequencies of the intermodulation products and f_{u1} and f_{u2} the frequencies of the useful signals.

The following diagram shows the position of the intermodulation products in the frequency domain.
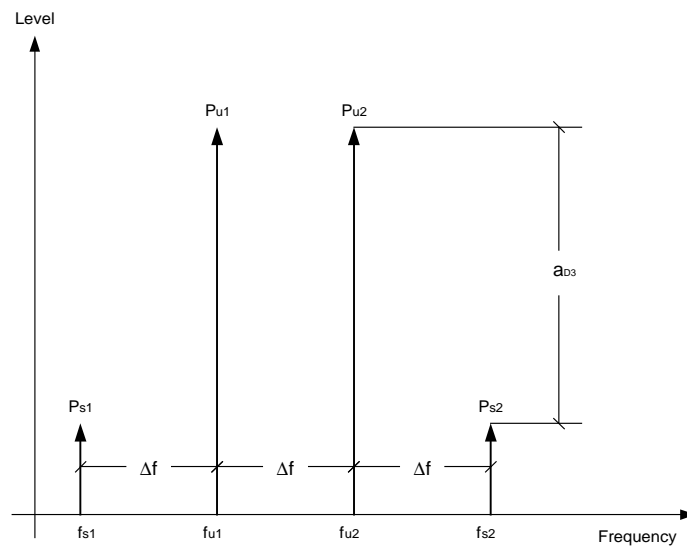
Fig. 2-13 3rd order intermodulation products

Example: $f_{u1} = 100$ MHz, $f_{u2} = 100.03$ MHz
$f_{s1} = 2 \cdot f_{u1} - f_{u2} = 2 \cdot 100$ MHz $-$ 100.03 MHz $=$ 99.97 MHz
$f_{s2} = 2 \cdot f_{u2} - f_{u1} = 2 \cdot 100.03$ MHz $-$ 100 MHz $=$ 100.06 MHz

The level of the intermodulation products depends on the level of the useful signals. If the level of the two useful signals is increased by 1 dB, the level of the intermodulation products is increased by 3 dB. The intermodulation distance d_3 is, therefore, reduced by 2 dB. Fig. 2-14 shows how the levels of the useful signals and the 3rd order intermodulation products are related.
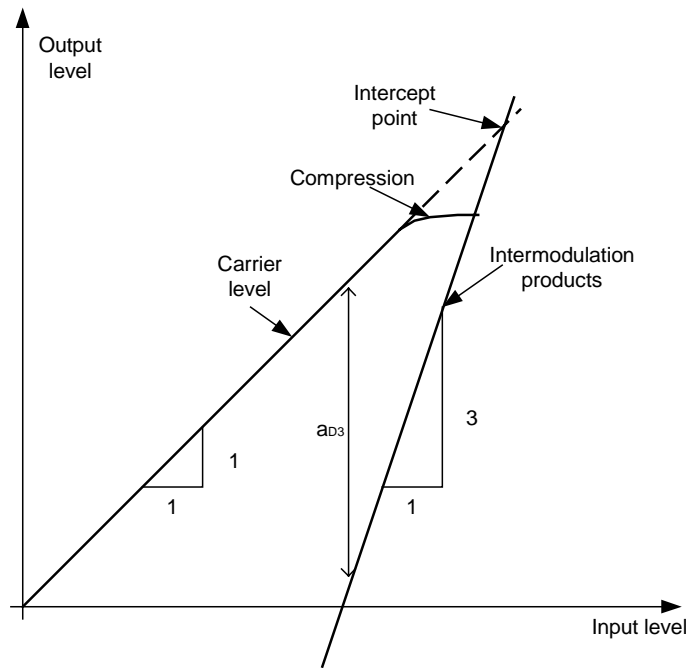
Fig. 2-14   Level of the 3rd order intermodulation products as a function of the level of the useful signals

The behavior of the signals can explained using an amplifier as an example. The change in the level of the useful signals at the output of the amplifier is proportional to the level change at the input of the amplifier as long as the amplifier is operating in linear range. If the level at the amplifier input is changed by 1 dB, there is a 1 dB level change at the amplifier output. At a certain input level, the amplifier enters saturation. The level at the amplifier output does not increase with increasing input level.

The level of the 3rd order intermodulation products increases 3 times faster than the level of the useful signals. The 3rd order intercept is the virtual level at which the level of the useful signals and the level of the spurious products are identical, i.e. the intersection of the two straight lines. This level cannot be measured directly as the amplifier goes into saturation or is damaged before this level is reached.

The 3rd order intercept can be calculated from the known slopes of the lines, the intermodulation distance d_2 and the level of the useful signals.

$$TOI = a_{D3} / 2 + P_n \tag{3}$$

with TOI (Third Order Intercept) being the 3rd order intercept in dBm and P_n the level of a carrier in dBm.

With an intermodulation distance of 60 dB and an input level, P_w, of −20 dBm, the following 3rd order intercept is obtained:

TOI = 60 dBm / 2 + (-20 dBm) = 10 dBm.

Measurement Example – Measuring the FSP's intrinsic intermodulation distance

To measure the intrinsic intermodulation distance, use the test setup in Fig. 2-8.

Signal generator settings (e.g. SMIQ):

	Level	Frequency
Signal generator 1	-10 dBm	999.9 MHz
Signal generator 2	-10 dBm	1000.1 MHz

Measurement using the FSP:

1. *Set the spectrum analyzer to its default settings.*

   ➢ Press the *PRESET* key.
     The FSP is in its default state.

2. *Set center frequency to 1 GHz and the frequency span to 1 MHz.*

   ➢ Press the *FREQ* key and enter 1 GHz.

   ➢ Press the *SPAN* key and enter 1 MHz.

3. *Set the reference level to –10 dBm and RF attenuation to 0 dB.*

   ➢ Press the *AMPT* key and enter *-10 dBm*.

   ➢ Press the *RF ATTEN MANUAL* softkey and enter 0 dB.
     By reducing the RF attenuation to 0 dB, the level to the FSP input mixer is increased. Therefore,
     3rd order intermodulation products are displayed.

4. *Set the resolution bandwidth to 10 kHz.*

   ➢ Press the *BW* key.

   ➢ Press the *RES BW MANUAL* softkey and enter *10 kHz*.
     By reducing the bandwidth, the noise is further reduced and the intermodulation products can be
     clearly seen.

5. *Measuring intermodulation by means of the 3rd order intercept measurement function*

   ➢ Press the *MEAS* key.

   ➢ Press the *TOI* softkey.
     The FSP activates four markers for measuring the intermodulation distance. Two markers are
     positioned on the useful signals and two on the intermodulation products. The 3rd order intercept
     is calculated from the level difference between the useful signals and the intermodulation
     products. It is then displayed on the screen:
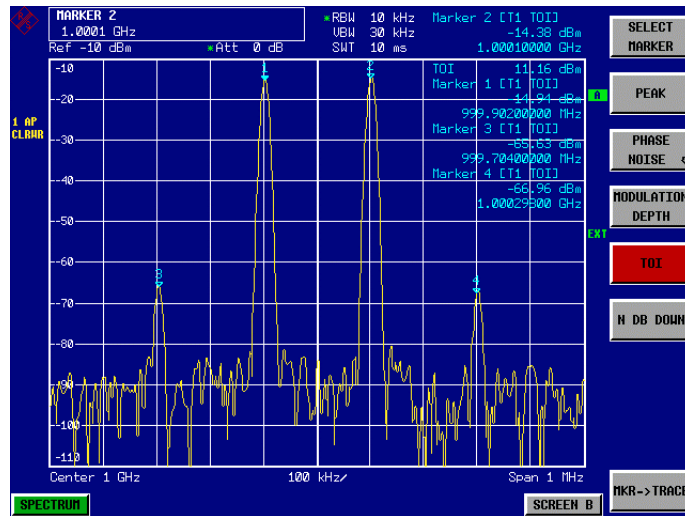
Fig. 2-15   Result of intrinsic intermodulation measurement on the FSP. The 3rd order intercept (TOI) is displayed at the top right corner of the grid

The level of a spectrum analyzer's intrinsic intermodulation products depends on the RF level of the useful signals at the input mixer. When the RF attenuation is added, the mixer level is reduced and the intermodulation distance is increased. With an additional RF attenuation of 10 dB, the levels of the intermodulation products are reduced by 20 dB. The noise level is, however, increased by 10 dB.

6.   *Increasing RF attenuation to 10 dB to reduce intermodulation products.*

➢ Press the *AMPT* key.

➢ Press the *RF ATTEN MANUAL* softkey and enter *10 dB*.
   The FSP's intrinsic intermodulation products disappear below the noise floor.

Fig. 2-16   If the RF attenuation is increased, the FSP's intrinsic intermodulation products disappear below the noise floor.

Calculation method:

The method used by the FSP to calculate the intercept point takes the average useful signal level P_u in dBm and calculates the intermodulation d_3 in dB as a function of the average value of the levels of the two intermodulation products. The third order intercept (TOI) is then calculated as follows:
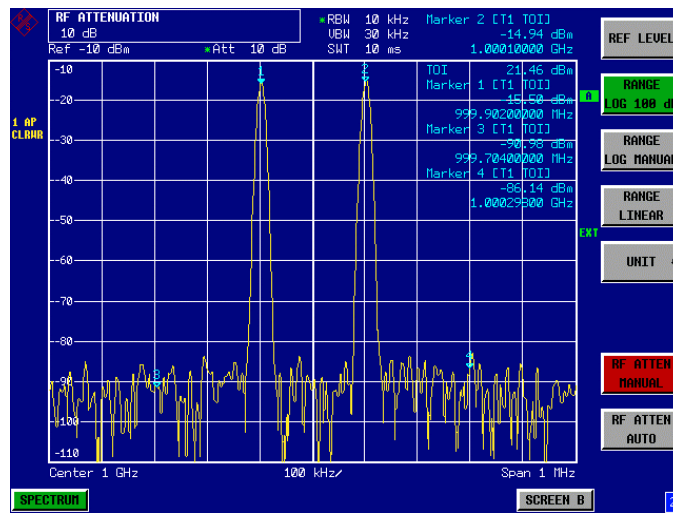
$$TOI/dBm = \frac{1}{2} d_3 + Pu$$

Intermodulation- free dynamic range

The **Intermodulation – free dynamic range** , i.e. the level range in which no internal intermodulation products are generated if two-tone signals are measured, is determined by the 3rd order intercept point, the phase noise and the thermal noise of the spectrum analyzer. At high signal levels, the range is determined by intermodulation products. At low signal levels, intermodulation products disappear below the noise floor, i.e. the noise floor and the phase noise of the spectrum analyzer determine the range. The noise floor and the phase noise depend on the resolution bandwidth that has been selected. At the smallest resolution bandwidth, the noise floor and phase noise are at a minimum and so the maximum range is obtained. However, a large increase in sweep time is required for small resolution bandwidths. It is, therefore, best to select the largest resolution bandwidth possible to obtain the range that is required. Since phase noise decreases as the carrier-offset increases, its influence decreases with increasing frequency offset from the useful signals.

The following diagrams illustrate the intermodulation-free dynamic range as a function of the selected bandwidth and of the level at the input mixer (= signal level – set RF attenuation) at different useful signal offsets.

Distortion free Dynamic Range
(1 MHz carrier offset)

Fig. 2-17   Intermodulation-free range of the FSP3 as a function of level at the input mixer and the set resolution bandwidth (useful signal offset = 1 MHz, DANL = -155 dBm /Hz, TOI = 12 dBm; typ. values at 2 GHz)

The optimum mixer level, i.e. the level at which the intermodulation distance is at its maximum, depends on the bandwidth. At a resolution bandwidth of 10 Hz, it is approx. –42 dBm and at 10 kHz increases to approx. -32 dBm.

Phase noise has a considerable influence on the intermodulation-free range at carrier offsets between 10 and 100 kHz (Fig. 2-18). At greater bandwidths, the influence of the phase noise is greater than it would be with small bandwidths. The optimum mixer level at the bandwidths under consideration becomes almost independent of bandwidth and is approx. –40 dBm.

Distortion free Dynamic Range

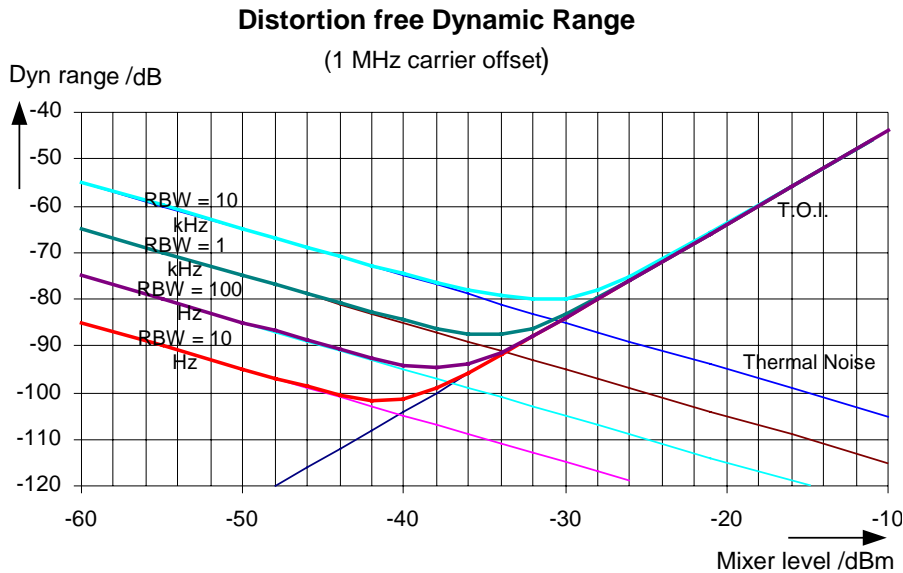(10 to 100 kHz carrier offset)
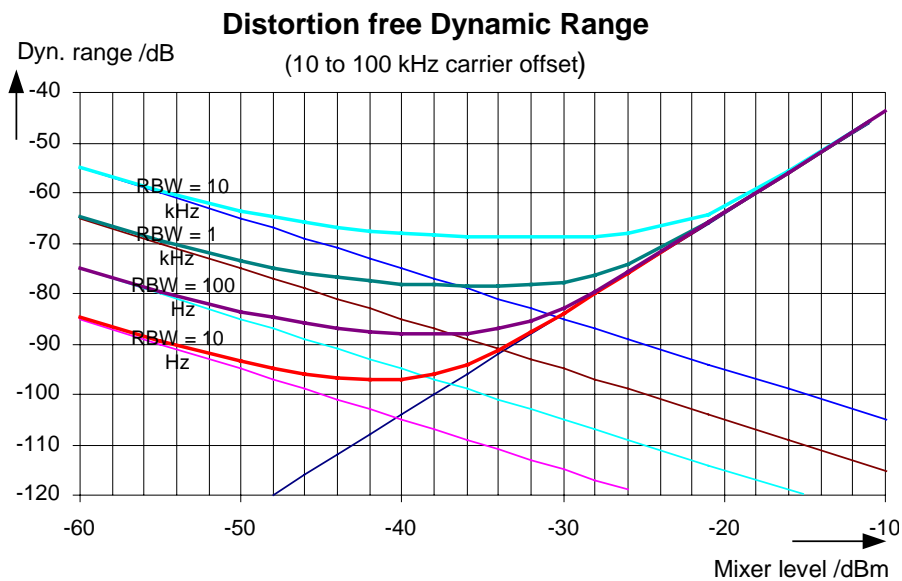
Fig. 2-18   Intermodulation-free dynamic range of the FSP3 as a function of level at the input mixer and of the selected resolution bandwidth (useful signal offset = 10 to 100 kHz, DANL = -155 dBm /Hz, TOI = 12 dBm; typ. values at 2 GHz).

Hint:	If the intermodulation products of a DUT with a very high dynamic range are to be measured and the resolution bandwidth to be used is therefore very small, it is best to measure the levels of the useful signals and those of the intermodulation products separately using a small span. The measurement time will be reduced– in particular if the offset of the useful signals is large. To find signals reliably when frequency span is small, it is best to synchronize the signal sources and the FSP.

Measuring Signals in the Vicinity of Noise

The minimum signal level a spectrum analyzer can measure is limited by its intrinsic noise. Small signals can be swamped by noise and therefore cannot be measured. For signals that are just above the intrinsic noise, the accuracy of the level measurement is influenced by the intrinsic noise of the spectrum analyzer.

The displayed noise level of a spectrum analyzer depends on its noise figure, the selected RF attenuation, the selected reference level, the selected resolution and video bandwidth and the detector. The effect of the different parameters is explained in the following.

Impact of the RF attenuation setting

The sensitivity of a spectrum analyzer is directly influenced by the selected RF attenuation. The highest sensitivity is obtained at a RF attenuation of 0 dB. The FSP's RF attenuation can be set in 10 dB steps up to 70 dB (5 dB steps up to 75 dB with option *Electronic Attenuator* FSP-B25. Each additional 10 dB step reduces the FSP's sensitivity by 10 dB, i.e. the displayed noise is increased by 10 dB.

Impact of the reference level setting

If the reference level is changed, the FSP changes the gain on the last IF so that the voltage at the logarithmic amplifier and the A/D converter is always the same for signal levels corresponding to the reference level. This ensures that the dynamic range of the log amp or the A/D converter is fully utilized. Therefore, the total gain of the signal path is low at high reference levels and the noise figure of the IF amplifier makes a substantial contribution to the total noise figure of the FSP. Fig. 2-(21) below shows the change in the displayed noise depending on the set reference level at 10 kHz and 300 kHz resolution bandwidth. With digital bandwidths ($\leq$ 100 kHz) the noise increases sharply at high reference levels because of the dynamic range of the A/D converter.
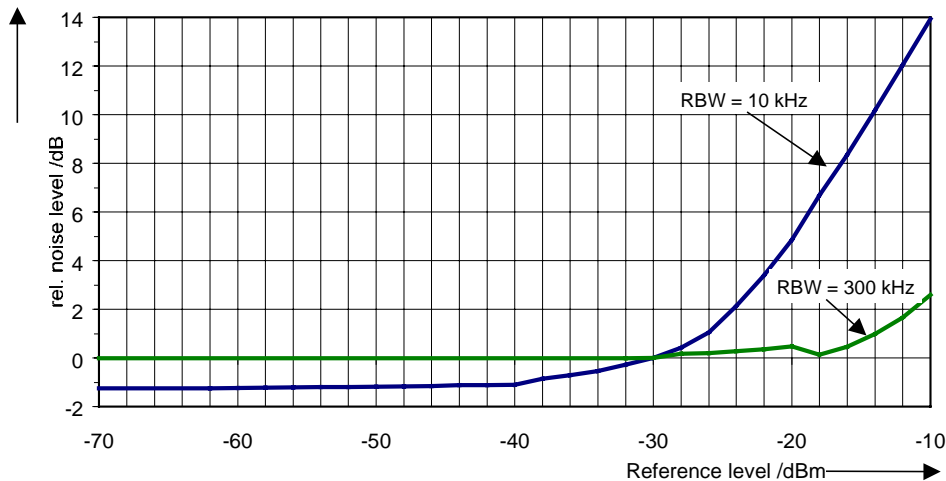
Fig. 2-19   Change in displayed noise as a function of the selected reference level at bandwidths of 10 kHz and 300 kHz (-30 dBm reference level)

Impact of the resolution bandwidth

The sensitivity of a spectrum analyzer also directly depends on the selected bandwidth. The highest sensitivity is obtained at the smallest bandwidth (for the FSP: 10 Hz, for FFT filtering: 1 Hz). If the bandwidth is increased, the reduction in sensitivity is proportional to the change in bandwidth. The FSP has bandwidth settings in 1, 3, 10 sequence. Increasing the bandwidth by a factor of 3 increases the displayed noise by approx. 5 dB (4.77 dB precisely). If the bandwidth is increased by a factor of 10, the displayed noise increases by a factor of 10, i.e. 10 dB. Because of the way the resolution filters are

designed, the sensitivity of spectrum analyzers often depends on the selected resolution bandwidth. In data sheets, the displayed average noise level is often indicated for the smallest available bandwidth (for the FSP: 10 Hz). The extra sensitivity obtained if the bandwidth is reduced may therefore deviate from the values indicated above. The following table illustrates typical deviations from the noise figure for a resolution bandwidth of 10 kHz which is used as a reference value (= 0 dB).
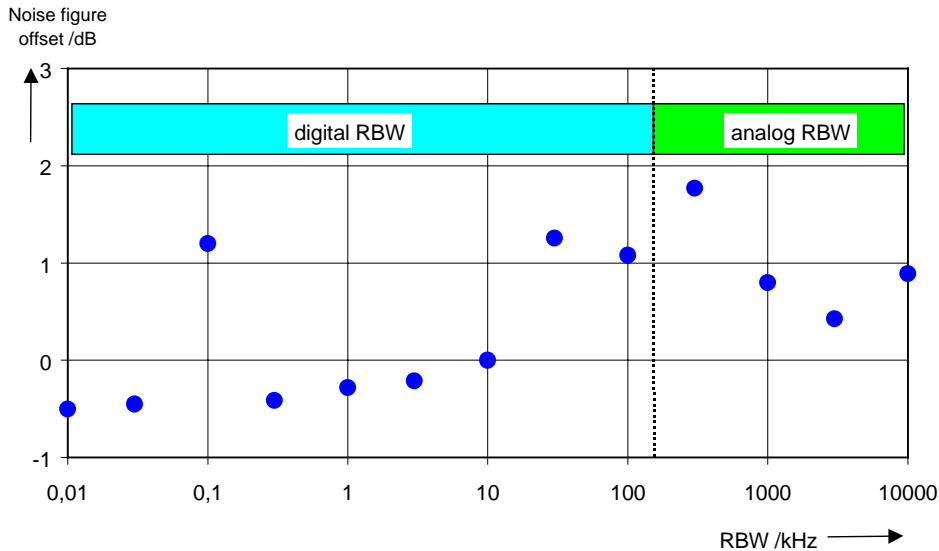
Fig. 2-20   Change in FSP noise figure at various bandwidths. The reference bandwidth is 10 kHz

Impact of the video bandwidth
The displayed noise of a spectrum analyzer is also influenced by the selected video bandwidth. If the video bandwidth is considerably smaller than the resolution bandwidth, noise spikes are suppressed, i.e. the trace becomes much smoother. The level of a sinewave signal is not influenced by the video bandwidth. A sinewave signal can therefore be freed from noise by using a video bandwidth that is small compared with the resolution bandwidth, and thus be measured more accurately.

Impact of the detector
Noise is evaluated differently by the different detectors. The noise display is therefore influenced by the choice of detector. Sinewave signals are weighted in the same way by all detectors, i.e. the level display for a sinewave RF signal does not depend on the selected detector, provided that the signal-to-noise ratio is high enough. The measurement accuracy for signals in the vicinity of intrinsic spectrum analyzer noise is also influenced by the detector which has been selected. The FSP has the following detectors:

Maximum peak detector
If the max. peak detector s selected, the largest noise display is obtained, since the spectrum analyzer displays the highest value of the IF envelope in the frequency range assigned to a pixel at each pixel in the trace. With longer sweep times, the trace indicates higher noise levels since the probability of obtaining a high noise amplitude increases with the dwell time on a pixel. For short sweep times, the display approaches that of the sample detector since the dwell time on a pixel is only sufficient to obtain an instantaneous value.

Minimum peak detector
The min. peak detector indicates the minimum voltage of the IF envelope in the frequency range assigned to a pixel at each pixel in the trace. The noise is strongly suppressed by the minimum peak detector since the lowest noise amplitude that occurs is displayed for each test point. If the signal-to-noise ratio is low, the minimum of the noise overlaying the signal is displayed too low.
At longer sweep times, the trace shows smaller noise levels since the probability of obtaining a low noise amplitude increases with the dwell time on a pixel. For short sweep times, the display approaches that of the sample detector since the dwell time on a pixel is only sufficient to obtain an instantaneous value.

Autopeak detector
The Autopeak detector displays the maximum and minimum peak value at the same time. Both values are measured and their levels are displayed on the screen joint by a vertical line.

Sample detector
The sample detector samples the logarithm of the IF envelope for each pixel of the trace only once and displays the resulting value. If the frequency span of the spectrum analyzer is considerably higher than the resolution bandwidth (span/RBW >500), there is no guarantee that useful signals will be detected. They are lost due to undersampling. This does not happen with noise because in this case it is not the instantaneous amplitude that is relevant but only the probability distribution.

RMS detector
For each pixel of the trace, the RMS detector outputs the RMS value of the IF envelope for the frequency range assigned to each test point. It therefore measures noise power. The display for small signals is, however, the sum of signal power and noise power. For short sweep times, i.e. if only one uncorrelated sample value contributes to the RMS value measurement, the RMS detector is equivalent to the sample detector. If the sweep time is longer, more and more uncorrelated RMS values contribute to the RMS value measurement. The trace is, therefore, smoothed. The level of sinewave signals is only displayed correctly if the selected resolution bandwidth (RBW) is at least as wide as the frequency range which corresponds to a pixel in the trace. At a resolution bandwidth of 1 MHz, this means that the maximum frequency display range is 501 MHz.

Average detector
For each pixel of the trace, the average detector outputs the average value of the linear IF envelope for the frequency range assigned to each test point. It therefore measures the linear average noise. The level of sinewave signals is only displayed correctly if the selected resolution bandwidth (RBW) is at least as wide as the frequency range which corresponds to a pixel in the trace. At a resolution bandwidth of 1 MHz, this means the maximum frequency display range is 501 MHz.

Quasi peak detector
The quasi peak detector is a peak detector for EMI measurements with defined charge and discharge times. These times are defined in CISPR 16, the standard for equipment used to measure EMI emissions.

Measurement example – Measuring the level of the internal reference generator at low S/N ratios

The example shows the different factors influencing the S/N ratio.

1.   ***Set the spectrum analyzer to its default state.***

     ➢ Press the *PRESET* key.
        The FSP is in its default state.

2.   ***Switch on the internal reference generator***

     ➢ Press the *SETUP* key.

     ➢ Press the softkeys *SERVICE - INPUT CAL*.
        The internal 128 MHz reference generator is on.
        The FSP's RF input is off.

3.   ***Set the center frequency to 128 MHz and the frequency span to 100 MHz.***

     ➢ Press the *FREQ* key and enter *128 MHz*.

     ➢ Press the *SPAN* key and enter *100* MHz.

4. Set the RF attenuation to 60 dB to attenuate the input signal or to increase the intrinsic noise.

➢ Press the *AMPT* key.

➢ Press the *RF ATTEN MANUAL* softkey and enter *60 dB*.
The RF attenuation indicator is marked with an asterisk (*Att 60 dB) to show that it is no longer coupled to the reference level. The high input attenuation reduces the reference signal which can no longer be detected in noise.
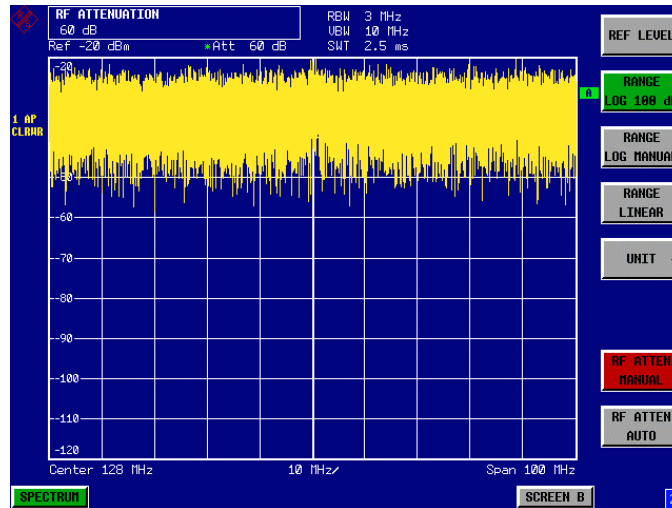

Fig. 2-21   Sinewave signal with low S/N ratio. The signal is measured with the autopeak detector and is completely swamped by the intrinsic noise of the spectrum analyzer.

5. To suppress noise spikes the trace can be averaged.

➢ Press the *TRACE* key.

➢ Press the *AVERAGE* softkey.
The traces of consecutive sweeps are averaged. To perform averaging, the FSP automatically switches on the sample detector. The RF signal, therefore, can be more clearly distinguished from noise.
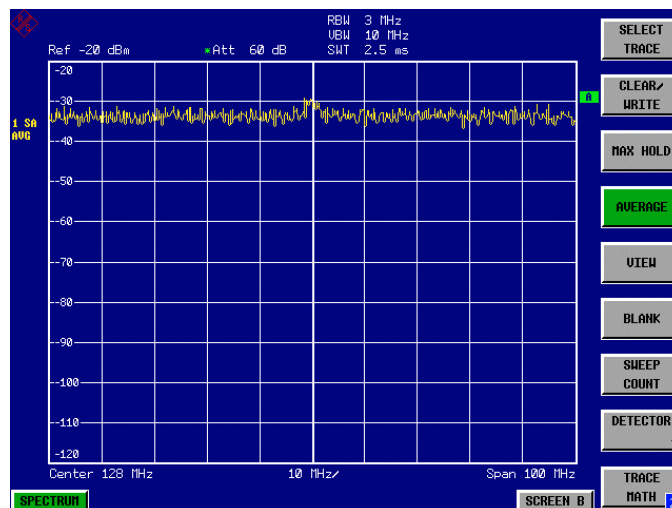

Fig. 2-22   RF sinewave signal with low S/N ratio if the trace is averaged.

6. *Instead of trace averaging, a video filter that is narrower than the resolution bandwidth can be selected.*

➢ Press the *CLEAR/WRITE* softkey in the trace menu.

➢ Press the *BW* key.

➢ Press the *VIDEO BW MANUAL* softkey and enter *10 kHz*.
The RF signal can be more clearly distinguished from noise.
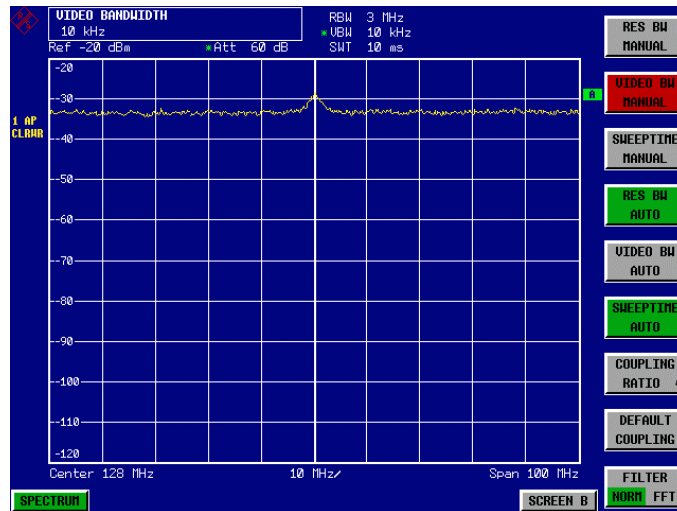

Fig. 2-23   RF sinewave signal with low S/N ratio if a smaller video bandwidth is selected.

7. *By reducing the resolution bandwidth by a factor of 10, the noise is reduced by 10 dB.*

➢ Press the *RES BW MANUAL* softkey and enter *300 kHz*.
The displayed noise is reduced by approx. 10 dB. The signal, therefore, emerges from noise by about 10 dB. Compared to the previous setting, the video bandwidth has remained the same, i.e. it has increased relative to the smaller resolution bandwidth. The averaging effect is, therefore, reduced by the video bandwidth. The trace will be noisier.
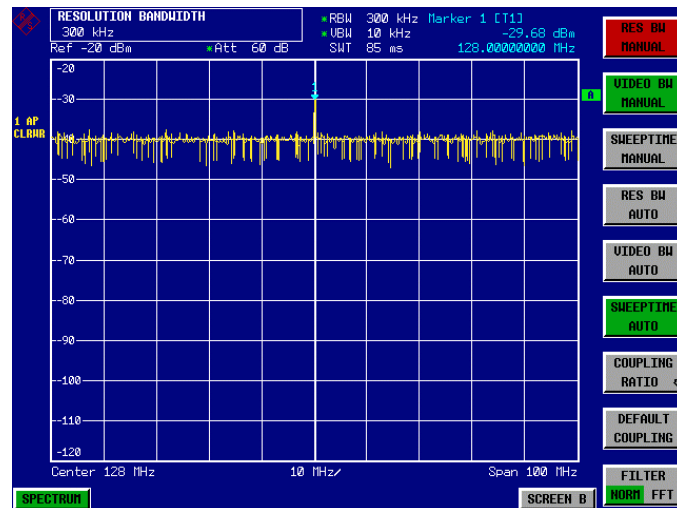

Fig. 2-24   Reference signal at a smaller resolution bandwidth

Noise Measurements

Noise measurements play an important role in spectrum analysis. Noise e.g. affects the sensitivity of radiocommunication systems and their components.

Noise power is specified either as the total power in the transmission channel or as the power referred to a bandwidth of 1 Hz. The sources of noise are, for example, amplifier noise or noise generated by oscillators used for the frequency conversion of useful signals in receivers or transmitters. The noise at the output of an amplifier is determined by its noise figure and gain.

The noise of an oscillator is determined by phase noise near the oscillator frequency and by thermal noise of the active elements far from the oscillator frequency. Phase noise can mask weak signals near the oscillator frequency and make them impossible to detect.

Measuring noise power density

To measure noise power referred to a bandwidth of 1 Hz at a certain frequency, the FSP has an easy-to-use marker function. This marker function calculates the noise power density from the measured marker level.

Measurement example – Measuring the intrinsic noise power density of the FSP at 1 GHz and calculating the FSP's noise figure.

1. *Set the spectrum analyzer to its default state.*

    ➢ Press the *PRESET* key.
    The FSP is in its default state.

2. *Set the center frequency to 1 GHz and the span to 1 MHz.*

    ➢ Press the *FREQ* key and enter *1 GHz*.

    ➢ Press the *SPAN* key and enter *1 MHz*.

3. *Switch on the marker and set the marker frequency to 1 GHz.*

    ➢ Press the *MKR* key and enter *1 GHz*.

4. *Switch   on the noise marker function.*

    ➢ Press the *NOISE MARKER* softkey.
    The FSP displays the noise power at 1 GHz in dBm (1Hz).

    Since noise is random, a sufficiently long measurement time has to be selected to obtain stable measurement results. This can be achieved by averaging the trace or by selecting a very small video bandwidth relative to the resolution bandwidth.

5. *The measurement result is stabilized by averaging the trace*

    ➢ Press the *TRACE* key.

    ➢ Press the *AVERAGE* softkey.
    The FSP performs sliding averaging over 10 traces from consecutive sweeps. The measurement result becomes more stable.

Conversion to other reference bandwidths

The result of the noise measurement can be referred to other bandwidths by simple conversion. This is done by adding 10 · log (BW) to the measurement result, BW being the new reference bandwidth.

Example:

A noise power of −150 dBm (1 Hz) is to be referred to a bandwidth of 1 kHz.
$P_{[1kHz]}$ = -150 + 10 * log (1000) = -150 +30 = -120 dBm(1 kHz)

Calculation method:

The following method is used to calculate the noise power:

If the noise marker is switched on, the FSP automatically activates the sample detector. The video bandwidth is set to 1/10 of the selected resolution bandwidth (RBW).

To calculate the noise, the FSP takes an average over 17 adjacent pixels (the pixel on which the marker is positioned and 8 pixels to the left, 8 pixels to the right of the marker). The measurement result is stabilized by video filtering and averaging over 17 pixels.

Since both video filtering and averaging over 17 trace points is performed in the log display mode, the result would be 2.51 dB too low (difference between logarithmic noise average and noise power). The FSP, therefore, corrects the noise figure by 2.51 dB.

To standardize the measurement result to a bandwidth of 1 Hz, the result is also corrected by −10 * log (RBW_{noise}), with RBW_{noise} being the power bandwidth of the selected resolution filter (RBW).

Detector selection

The noise power density is measured in the default setting with the sample detector and using averaging. Other detectors that can be used to perform a measurement giving true results are the average detector or the RMS detector. If the average detector is used, the linear video voltage is averaged and displayed as a pixel. If the RMS detector is used, the squared video voltage is averaged and displayed as a pixel. The averaging time depends on the selected sweep time (=SWT/501). An increase in the sweep time gives a longer averaging time per pixel and thus stabilizes the measurement result. The FSP automatically corrects the measurement result of the noise marker display depending on the selected detector (+1.05 dB for the average detector, 0 dB for the RMS detector). It is assumed that the video bandwidth is set to at least three times the resolution bandwidth. While the average or RMS detector is being switched on, the FSP sets the video bandwidth to a suitable value.

The Pos Peak, Neg Peak, Auto Peak and Quasi Peak detectors are not suitable for measuring noise power density.

Determining the noise figure:

The noise figure of amplifiers or of the FSP alone can be obtained from the noise power display. Based on the known thermal noise power of a 50 Ω resistor at room temperature (-174 dBm (1Hz)) and the measured noise power P_{noise} the noise figure (NF) is obtained as follows:

NF = P_{noise} + 174 – g,
where g = gain of DUT in dB

Example: The measured internal noise power of the FSP at an attenuation of 0 dB is found to be –153 dBm/1 Hz. The noise figure of the FSP is obtained as follows

NF = -153 + 174 = 19 dB

|	
Note:	If noise power is measured at the output of an amplifier, for example, the sum of the internal noise power and the noise power at the output of the DUT is measured. The noise power of the DUT can be obtained by subtracting the internal noise power from the total power (subtraction of linear noise powers). By means of the following diagram, the noise level of the DUT can be estimated from the level difference between the total and the internal noise level.
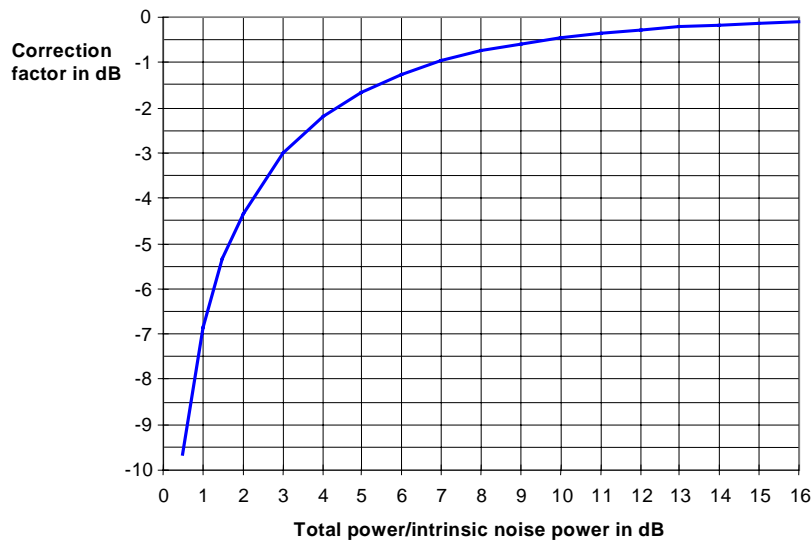
Fig. 2-25   Correction factor for measured noise power as a function of the ratio of total power to the intrinsic noise power of the spectrum analyzer.

Measurement of Noise Power within a Transmission Channel

Noise in any bandwidth can be measured with the channel power measurement functions. Thus the noise power in a communication channel can be determined, for example. If the noise spectrum within the channel bandwidth is flat, the noise marker from the previous example can be used to determine the noise power in the channel by considering the channel bandwidth. If, however, phase noise and noise that normally increases towards the carrier is dominant in the channel to be measured, or if there are discrete spurious signals in the channel, the channel power measurement method must be used to obtain correct measurement results.

Measurement Example – Measuring the intrinsic noise of the FSP at 1 GHz in a 1.23 MHz channel bandwidth with the channel power function

Test setup:

The RF input of the FSP remains open-circuited or is terminated with 50 Ω.

Measurement with the FSP:

1. ***Set the spectrum analyzer to its default state.***

    ➢ Press the *PRESET* key.
    The FSP is in its default state.

2. ***Set the center frequency to 1 GHz and the span to 1 MHz.***

    ➢ Press the *FREQ* key and enter *1 GHz.*

    ➢ Press the *SPAN* key and enter *2 MHz*.

3. ***To obtain maximum sensitivity, set RF attenuation on the FSP to 0 dB.***

    ➢ Press the *AMPT* key.

    ➢ Press the *RF ATTEN MANUAL* softkey and enter *0 dB*.

4. ***Switch on and configure the channel power measurement.***

    ➢ Press the *MEAS* key.

    ➢ Press the *CHAN POWER / ACP* softkey.
    The FSP activates the channel or adjacent channel power measurement according to the currently set configuration.

    ➢ Press the *CP/ACP CONFIG* ⇩ softkey.
    The FSP enters the submenu for configuring the channel.

    ➢ Press the *CHANNEL BANDWIDTH* softkey and enter *1.23 MHz*.
    The FSP displays the 1.23 MHz channel as two vertical lines which are symmetrical to the center frequency.

    ➢ Press the *PREV* key.
    The FSP returns to the main menu for channel and adjacent channel power measurement.

    ➢ Press the *ADJUST SETTINGS* softkey.
    The settings for the frequency span, the bandwidth (RBW and VBW) and the detector are automatically set to the optimum values required for the measurement.
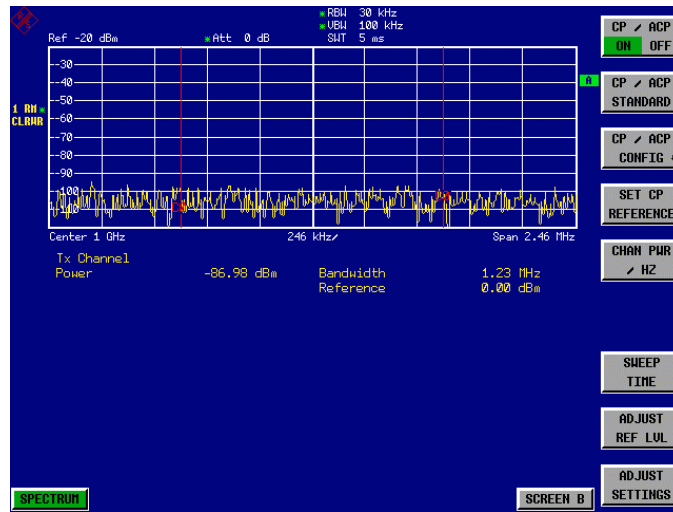
Fig. 2-26 Measurement of the FSP's intrinsic noise power in a 1.23 MHz channel bandwidth.

5. *Stabilizing the measurement result by increasing the sweep time*

➢ Press the *SWEEP TIME* softkey and enter *1 s.*
 By increasing the sweep time to 1 s, the trace becomes much smoother thanks to the RMS detector and the channel power measurement display is much more stable.

6. *Referring the measured channel power to a bandwidth of 1 Hz*

➢ Press the *CHAN PWR / Hz* softkey.
The channel power is referred to a bandwidth of 1 Hz. The measurement is corrected by -10 * log (ChanBW), with ChanBW being the channel bandwidth that was selected.

Method of calculating the channel power

When measuring the channel power, the FSP integrates the linear power which corresponds to the levels of the pixels within the selected channel. The analyzer uses a resolution bandwidth which is far smaller than the channel bandwidth. When sweeping over the channel, the channel filter is formed by the passband characteristics of the resolution bandwidth (see Fig. 2-27).
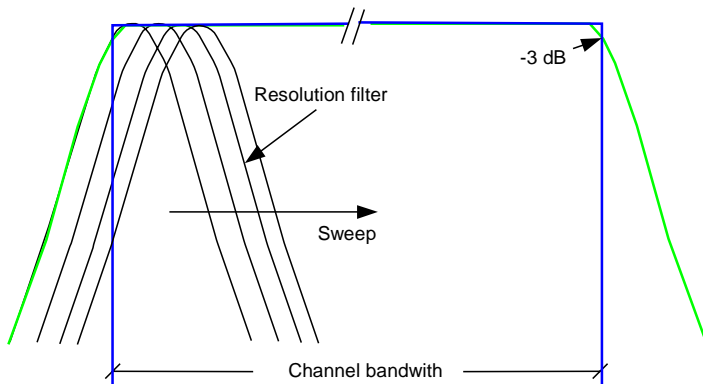

Fig. 2-27   Approximating the channel filter by sweeping with a small resolution bandwidth

The following steps are performed:

- The linear power of all the trace pixels within the channel is calculated.

$$P_i = 10^{(L_i/10)}$$

where P_i = power of the trace pixel i

              L_i = displayed level of trace point i

- The powers of all trace pixels within the channel are summed up and the sum is divided by the number of trace pixels in the channel.

- The result is multiplied by the quotient of the selected channel bandwidth and the noise bandwidth of the resolution filter (RBW).

Since the power calculation is performed by integrating the trace within the channel bandwidth, this method is also called the IBW method (**I**ntegration **B**and**w**idth method).

Bandwidth selection (RBW)

For channel power measurements, the resolution bandwidth (RBW) must be small compared to the channel bandwidth, so that the channel bandwidth can be defined precisely. If the resolution bandwidth which has been selected is too wide, this may have a negative effect on the selectivity of the simulated channel filter and result in the power in the adjacent channel being added to the power in the transmit channel. A resolution bandwidth equal to 1% to 3% of the channel bandwidth should, therefore, be selected. If the resolution bandwidth is too small, the required sweep time becomes too long and the measurement time increases considerably.

Detector selection

Since the power of the trace is measured within the channel bandwidth, only the sample detector and RMS detector can be used. These detectors provide measured values that make it possible to calculate the real power. The peak detectors (Pos Peak, Neg Peak and Auto Peak) are not suitable for noise power measurements as no correlation can be established between the peak value of the video voltage and power.

With the **sample detector,** a value (sample) of the IF envelope voltage is displayed at each trace pixel. Since the frequency spans are very large compared with the resolution bandwidth (span/RBW >501), sinewave signals present in the noise might be lost, i.e. they are not displayed. This is not important for pure noise signals, however, since a single sample in itself is not important - it is the probability distribution of all measured values that counts. The number of samples for power calculation is limited to the number of trace pixels (501 for the FSP).

Note:	To increase the repeatability of measurements, averaging is often carried out over several traces (**AVERAGE** softkey in the **TRACE** menu). This gives spurious results for channel power measurements (max. –2.51 dB for ideal averaging). Trace averaging should, therefore, be avoided.

With the **RMS detector,** the whole IF envelope is used to calculate the power for each trace pixel. The IF envelope is digitized using a sampling frequency which is at least five times the resolution bandwidth which has been selected. Based on the sample values, the power is calculated for each trace pixel using the following formula:

$$P_{RMS} = \sqrt{\frac{1}{N} \cdot \sum_{i=1}^{N} s_i^2}$$

s_i = linear digitized video voltage at the output of the A/D converter
N = number of A/D converter values per pixel of the trace

P_{RMS} = power represented by a trace pixel

When the power has been calculated, the power units are converted into decibels and the value is displayed as a trace pixel.

The number of A/D converter values, N, used to calculate the power, is defined by the sweep time. The time per trace pixel for power measurements is directly proportional to the selected sweep time. The RMS detector uses far more samples for power measurement than the sample detector, especially if the sweep time is increased. The measurement uncertainty can be reduced considerably. In the default setting, the FSP therefore uses the RMS detector to measure the channel power.

For both detectors (sample and RMS), the video bandwidth (VBW) must at least be three times the resolution bandwidth, so that the peak values of the video voltage are not cut off by the video filter. At smaller video bandwidths, the video signal is averaged and the power readout will be too small.

Sweep time selection

If the sample detector is used, it is best to select the smallest sweep time possible for a given span and resolution bandwidth. The minimum time is obtained if the setting is coupled. This means that the time per measurement is minimal. Extending the measurement time does not have any advantages as the number of samples for calculating the power is defined by the number of trace pixels in the channel.

When using the RMS detector, the repeatability of the measurement results can be influenced by the selection of sweep times. Repeatability is increased at longer sweep times.
Repeatability can be estimated from the following diagram:
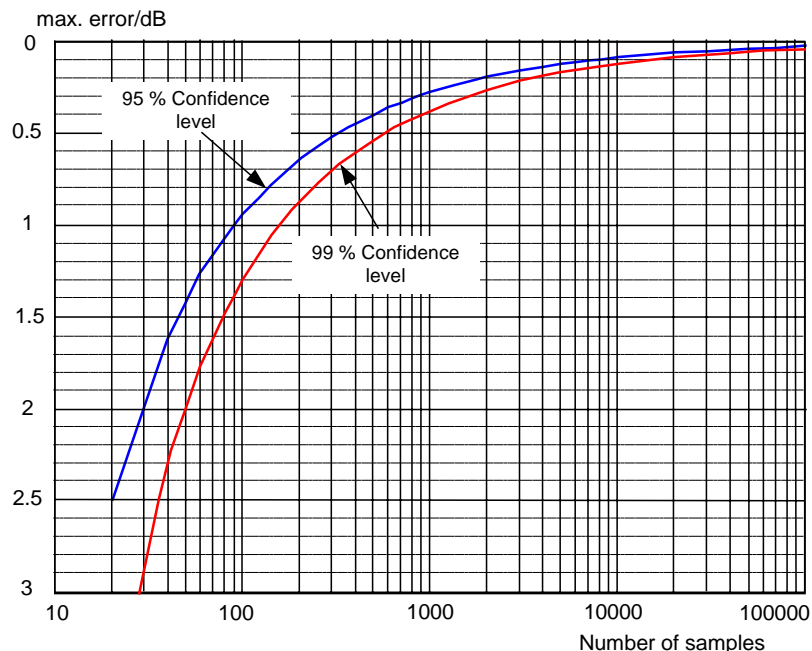

Fig. 2-28   Repeatability of channel power measurements as a function of the number of samples used for power calculation

The curves in Fig. 2-28 indicates the repeatability obtained with a probability of 95% and 99% depending on the number of samples used.
The repeatability with 600 samples is ± 0.5 dB. This means that – if the sample detector and a channel bandwidth over the whole diagram (channel bandwidth = span) is used - the measured value lies within ± 0.5 dB of the true value with a probability of 99%.

If the RMS detector is used, the number of samples can be estimated as follows:

Since only uncorrelated samples contribute to the RMS value, the number of samples can be calculated from the sweep time and the resolution bandwidth.

Samples can be assumed to be uncorrelated if sampling is performed at intervals of 1/RBW. The number of uncorrelated samples (N_{decorr}) is calculated as follows:

$$N_{decorr} = SWT \cdot RBW$$

The number of uncorrelated samples per trace pixel is obtained by dividing N_{decorr} by 501 (= pixels per trace).

Example:

At a resolution bandwidth of 30 kHz and a sweep time of 100 ms, 3000 uncorrelated samples are obtained. If the channel bandwidth is equal to the frequency display range, i.e. all trace pixels are used for the channel power measurement, a repeatability of 0.2 dB with a confidence level of 99% is the estimate that can be derived from Fig. 2-28.

Measuring Phase Noise

The FSP has an easy-to-use marker function for phase noise measurements. This marker function indicates the phase noise of an RF oscillator at any carrier in dBc in a bandwidth of 1 Hz.

Measurement Example - Measuring the phase noise of a signal generator at a carrier offset of 10 kHz.

Test setup:
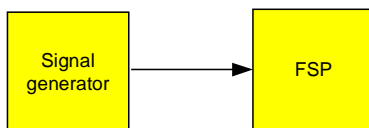
Settings on the signal generator (e.g. R&S SMIQ):
Frequency: 100 MHz
Level: 0 dBm

Measurement using FSP:

1. ***Set the spectrum analyzer to its default state***

   ➢ Press the *PRESET* key.
   FSP is in its default state.

2. ***Set the center frequency to 100 MHz and the span to 50 kHz***

   ➢ Press the *FREQ* key and enter *100 MHz*.

   ➢ Press the *SPAN* key and enter *50 kHz*.

3. ***Set the FSP's reference level to 0 dBm (=signal generator level)***

   ➢ Press the *AMPT* key and enter *0 dBm*.

4. Enable phase noise measurement

➢ Press the *MKR FCTN* key.

➢ Press the *PHASE NOISE* ⇩ softkey.
The FSP activates phase noise measurement. Marker 1 (=main marker) and marker 2 (= delta marker) are positioned on the signal maximum. The position of the marker is the reference (level and frequency) for the phase noise measurement. A horizontal line represents the level of the reference point and a vertical line the frequency of the reference point. Data entry for the delta marker is activated so that the frequency offset at which the phase noise is to be measured can be entered directly.

5. 10 kHz frequency offset for determining phase noise.

➢ Enter *10 kHz*.
The FSP displays the phase noise at a frequency offset of 10 kHz . The magnitude of the phase noise in dBc/Hz is displayed in the delta marker output field at the top right of the screen (delta 2 [T1 PHN]).

6. Stabilize the measurement result by activating trace averaging.

➢ Press the *TRACE* key.
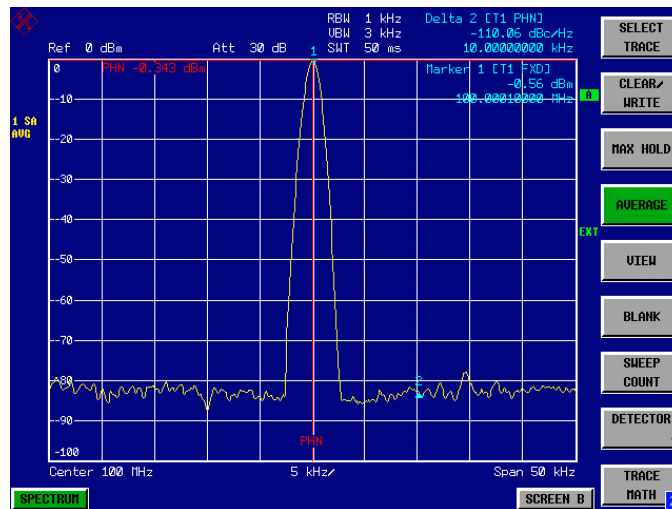
➢ Press the *AVERAGE* softkey.

Fig. 2-29   Measuring phase noise with the phase-noise marker function

The frequency offset can be varied by moving the marker with the spinwheel or by entering a new frequency offset as a number.

Measurements on Modulated Signals

If RF signals are used to transmit information, an RF carrier is modulated. Analog modulation methods such as amplitude modulation, frequency modulation and phase modulation have a long history and digital modulation methods are now used for modern systems. Measuring the power and the spectrum of modulated signals is an important task to assure transmission quality and to ensure the integrity of other radio services. This task can be performed easily with a spectrum analyzer. Modern spectrum analyzers also provide the test routines that are essential to simplify complex measurements.

Measurements on AM signals

The spectrum analyzer detects the RF input signal and displays the magnitudes of its components as a spectrum. AM modulated signals are also demodulated by this process. The AF voltage can be displayed in the time domain if the modulation sidebands are within the resolution bandwidth. In the frequency domain, the AM sidebands can be resolved with a small bandwidth and can be measured separately. This means that the modulation depth of a carrier modulated with a sinewave signal can be measured. Since the dynamic range of a spectrum analyzer is very wide, even extremely small modulation depths can be measured accurately. The FSP has a test routine which measures the modulation depth in %.

Measurement Example 1 – Displaying the AF of an AM signal in the time domain.

Test setup:
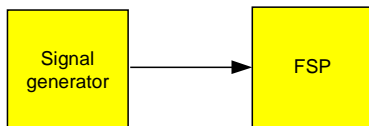
Settings on the signal generator (e.g. R&S SMIQ):
Frequency: 100 MHz
Level: 0 dBm
Modulation: 50 % AM, 1 kHz AF

Measurement with the FSP:

1. Set the spectrum analyzer to its default state

  ➢ Press the *PRESET* key.
    The FSP is in its default state.

2. Set the center frequency to 100 MHz and the span to 0 kHz

  ➢ Press the *FREQ* key and enter *100 MHz*.

  ➢ Press the *SPAN* key and enter *0 Hz*.

3. Set the reference level to +6 dBm and the display range to linear

  ➢ Press the *AMPT* key and enter *6 dBm*.

  ➢ Press the *RANGE LINEAR* softkey.

4. Use the video trigger to trigger on the AF signal in order to obtain a stationary display

➢ Press the *TRIG* key.

➢ Press the *VIDEO* softkey.
The video trigger level is set to 50% if the instrument is switched on for the first time. The trigger level is displayed as a horizontal line across the graph. The FSP displays the 1 kHz AF signal stably in the time domain.
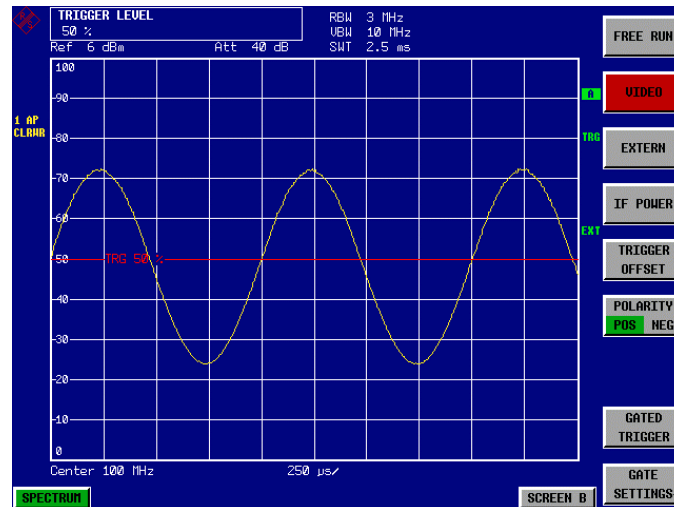

Fig. 2-30   Measuring the AF signal from a 1 kHz AM carrier

If the FSP is equipped with the AM/FM Demodulator option (FSP-B3), the AF can be monitored on the built-in loudspeaker.

5. Switch on the internal AM demodulator

➢ Press the *MKR FCTN* key.

➢ Press the *MKR DEMOD* softkey.
The FSP switches the AM demodulator on automatically.

➢ Turn up volume control.
A 1 kHz tone is output by the built-in loudspeaker.

Measurement Example 2 - Measuring the modulation depth of an AM carrier in the frequency domain.

Test setup:
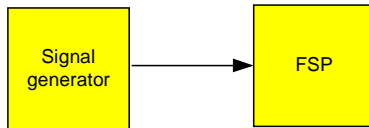
Settings on the signal generator (e.g. R&S SMIQ):
Frequency: 100 MHz
Level: -30 dBm
Modulation: 50 % AM, 1 kHz AF

Measurement with the FSP:

1. *Set the spectrum analyzer to its default state*

   ➢ Press the PRESET key.
   The FSP is in its default state.

2. *Set the center frequency to 100 MHz and the span to 0 kHz*

   ➢ Press the *FREQ* key and enter *100 MHz*.

   ➢ Press the *SPAN* key and enter *5 kHz*.

3. *Activate the marker function for AM depth measurement*

   ➢ Press the *MEAS* key.

   ➢ Press the *MODULATION DEPTH* softkey.
   The FSP automatically positions a marker on the carrier signal in the middle of the graph and one delta marker on each of the lower and upper AM sidebands. The FSP calculates the AM modulation depth from the ratios of the delta marker levels to the main marker level and outputs the numerical value in the marker info field
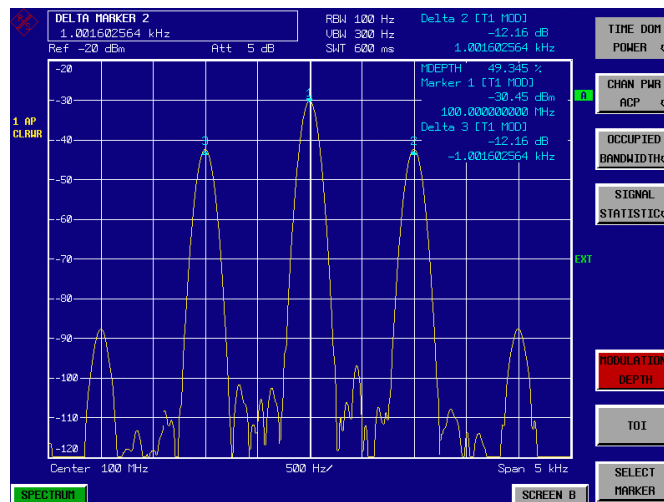

Fig. 2-31   Measurement of AM modulation depth. The modulation depth is indicated by MDEPTH. The frequency of the AF signal is indicated by the delta markers
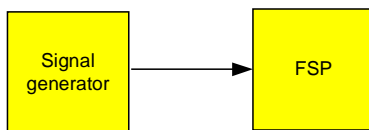
Measurements on FM Signals

Since spectrum analyzers only display the magnitude of signals by means of the envelope detector, the modulation of FM signals cannot be directly measured as is the case with AM signals. With FM signals, the voltage at the output of the envelope detector is constant as long as the frequency deviation of the signal is within the flat part of the passband characteristic of the resolution filter which has been selected. Amplitude variations can only occur if the current frequency lies on the falling edge of the filter characteristic. This effect can be used to demodulate FM signals. The center frequency of the analyzer is set in a way that the nominal frequency of the test signal is on the filter edge (below or above the center frequency). The resolution bandwidth and the frequency offset are selected in a way that the current frequency is on the linear part of the filter slope. The frequency variation of the FM signal is then transformed into an amplitude variation which can be displayed in the time domain.

The FSP's analog 4th order filters with frequencies from 300 kHz to 3 MHz have a good filter-slope linearity, if the frequency of the FSP is set to 1.2 times the filter bandwidth below or above the frequency of the transmit signal. The useful range for FM demodulation is then almost equal to the resolution bandwidth.

Measurement Example - Displaying the AF of an FM carrier

Test setup:

Settings on the signal generator (e.g. R&S SMIQ):
Frequency: 100 MHz
Level: -30 dBm
Modulation: FM 0 kHz deviation (i.e., FM = off), 1 kHz AF

Measurement with the FSP:

1. *Set the spectrum analyzer to its default state*

    ➢ Press the *PRESET* key.
      The FSP is in its default state.

2. *Set the center frequency to 99.64 MHz and the span to 300 kHz.*

    ➢ Press the *FREQ* key and enter *99.64 MHz*.

    ➢ Press the *SPAN* key and enter *300 kHz*.

3. *Set a resolution bandwidth of 300 kHz.*

    ➢ Press the *BW* key.

    ➢ Press the *RES BW MANUAL* softkey and enter *300 kHz*.

4. *Set a display range of 20 dB and shift the filter characteristics to the middle of the display.*

    ➢ Press the **AMPT** key.

    ➢ Press the *RANGE LOG MANUAL* softkey and enter *20 dB*.

    ➢ Press the **NEXT** key.

    ➢ Set the *GRID* softkey to *REL*.

➢ Press the *PREV* softkey.

➢ Using the spinwheel, shift the reference level so that the filter edge intersects the - 10 dB level line at the center frequency.

The slope of the 300 kHz filter is displayed. This corresponds to the demodulator characteristics for FM signals with a slope of approx. 5 dB/100 kHz.
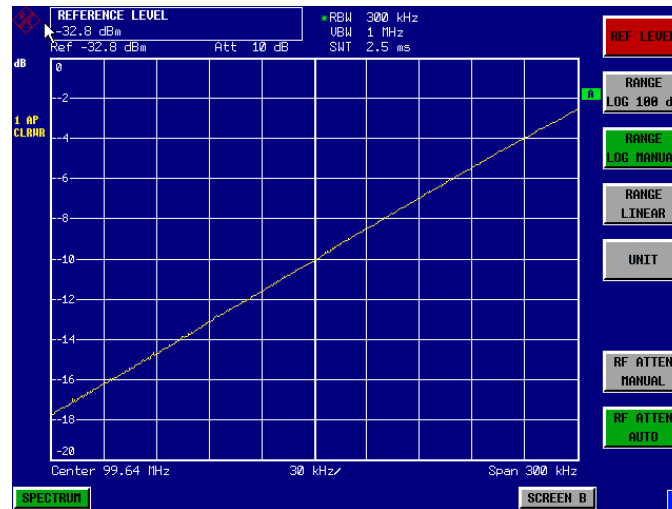

Fig. 2-32   Filter edge of a 300 kHz filter used as an FM-discriminator characteristic

5. Set an FM deviation of 100 kHz and an AF of 1 kHz on the signal generator

6. Set a frequency deviation of 0 Hz on the FSP

➢ Press the SPAN key.

➢ Press the ZERO SPAN.
The demodulated FM signal is displayed. The signal moves across the screen.

7. Creating a stable display by video triggering

➢ Press the TRIG key.

➢ Press the VIDEO softkey.
A stationary display is obtained for the FM AF signal

Result   (-10 ± 5) dB; this means that a deviation of 100 kHz is obtained if the demodulator characteristic slope is 5 dB/100 kHz
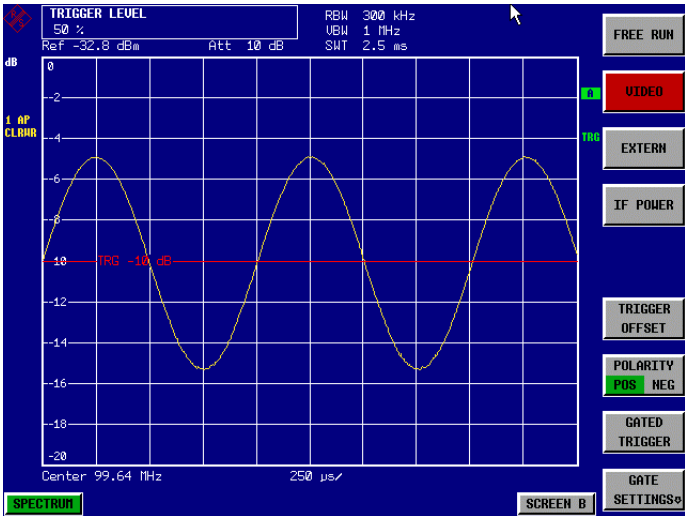
Fig. 2-33   Demodulated FM signal

Measuring Channel Power and Adjacent Channel Power

Measuring channel power and adjacent channel power is one of the most important tasks in the field of digital transmission for a spectrum analyzer with the necessary test routines. While, theoretically, channel power could be measured at highest accuracy with a power meter, its low selectivity means that it is not suitable for measuring adjacent channel power as an absolute value or relative to the transmit channel power. The power in the adjacent channels can only be measured with a selective power meter.

A spectrum analyzer cannot be classified as a true power meter, because it displays the IF envelope voltage. However, it is calibrated such as to correctly display the power of a pure sinewave signal irrespective of the selected detector. This calibration is not valid for non-sinusoidal signals. Assuming that the digitally modulated signal has a Gaussian amplitude distribution, the signal power within the selected resolution bandwidth can be obtained using correction factors. These correction factors are normally used by the spectrum analyzer's internal power measurement routines in order to determine the signal power from IF envelope measurements. These factors are valid if and only if the assumption of a Gaussian amplitude distribution is correct.
Apart from this common method, the FSP also has a true power detector, i.e. an RMS detector. It correctly displays the power of the test signal within the selected resolution bandwidth irrespective of the amplitude distribution, without additional correction factors being required. With an absolute measurement uncertainty of < 0.5 dB and a relative measurement uncertainty of < 0.2 dB (each with a confidence level of 95%), the FSP comes close to being a true power meter.

There are two possible methods for measuring channel and adjacent channel power with a spectrum analyzer:
The IBW method (**I**ntegration **B**andwidth **M**ethod) in which the spectrum analyzer measures with a resolution bandwidth that is less than the channel bandwidth and integrates the level values of the trace versus the channel bandwidth. This method is described in the section on noise measurements.

Measurement using a channel filter.
In this case, the spectrum analyzer makes measurements in the time domain using an IF filter that corresponds to the channel bandwidth. The power is measured at the output of the IF filter. Until now, this method has not been used for spectrum analyzers, because channel filters were not available and the resolution bandwidths, optimized for the sweep, did not have a sufficient selectivity. The method was reserved for special receivers optimized for a particular transmission method.

The FSP has test routines for simple channel and adjacent channel power measurements. These routines give quick results without any complex or tedious setting procedures.

Measurement Example 1 - ACPR measurement on an IS95 CDMA Signal

Test setup:
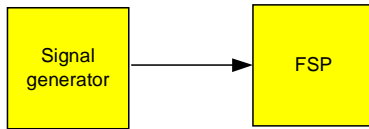
Settings on the signal generator (e.g. R&S SMIQ):
Frequency: 850 MHz
Level: 0 dBm
Modulation: CDMA IS 95

Measurement with the FSP:

1. Set the spectrum analyzer to its default state.

   ➢ Press the *PRESET* key.
     The FSP is in its default state.

2. Set the center frequency to 850 MHz and frequency deviation to 4 MHz.

   ➢ Press the *FREQ* key and enter *850 MHz*.

3. Set the reference level to +10 dBm.

   ➢ Press the *AMPT* key and enter *10 dBm*.

4. Configuring the adjacent channel power for the CDMA IS95 reverse link.

   ➢ Press the *MEAS* key.

   ➢ Press the *CHAN PWR ACP* ⇩ softkey.

   ➢ Press the *CP/ACP STANDARD* softkey.

     From the list of standards, select *CDMA IS95A REV* using the spinwheel or the cursor down key
     below the spinwheel and press *ENTER*.
     The FSP sets the channel configuration according to the IS95 standard for mobile stations with 2
     adjacent channels above and below the transmit channel. The spectrum is displayed in the upper
     part of the screen, the numeric values of the results and the channel configuration in the lower
     part of the screen. The various channels are represented by vertical lines on the graph.
     The frequency span, resolution bandwidth, video bandwidth and detector are selected
     automatically to give correct results. To obtain stable results - especially in the adjacent channels
     (30 kHz bandwidth) which are narrow in comparison with the transmission channel bandwidth
     (1.23 MHz) - the RMS detector is used.

5. *Set the optimal reference level and RF attenuation for the applied signal level.*

   ➤ Press the *ADJUST REF LVL* softkey.
   The FSP sets the optimal RF attenuation and the reference level based on the transmission channel power to obtain the maximum dynamic range. The following figure shows the result of the measurement.

Fig. 2-34   Adjacent channel power measurement on a CDMA IS95 signal

The repeatability of the results, especially in the narrow adjacent channels, strongly depends on the measurement time since the dwell time within the 30 kHz channels is only a fraction of the complete sweep time. A longer sweep time may increase the probability that the measured value converges to the true value of the adjacent channel power, but this increases measurement time.

To avoid long measurement times, the FSP measures the adjacent channel power in the time domain (FAST ACP). In the FAST ACP mode, the FSP measures the power of each channel at the defined channel bandwidth, while being tuned to the center frequency of the channel in question. The digital implementation of the resolution bandwidths makes it possible to select a filter characteristics that is precisely tailored to the signal. In case of CDMA IS95, the power in the useful channel is measured with a bandwidth of 1.23 MHz and that of the adjacent channels with a bandwidth of 30 kHz. Therefore the FSP jumps from one channel to the other and measures the power at a bandwidth of 1.23 MHz or 30 kHz using the RMS detector. The measurement time per channel is set with the sweep time. It is equal to the selected measurement time divided by the selected number of channels. The five channels from the above example and the sweep time of 100 ms give a measurement time per channel of 20 ms.

Compared to the measurement time per channel given by the span (= 5 MHz) and sweep time (= 100 ms, equal to 1.66 ms per 30 kHz channel) used in the example, this is a far longer dwell time on the adjacent channels (factor of 12). In terms of the number of uncorrelated samples this means 20000/33 µs = 606 samples per channel measurement compared to 1667/33µs = 50.5 samples per channel measurement.

Repeatability with a confidence level of 95% is increased from $\pm$ 1.4 dB to $\pm$ 0.38 dB as shown in Fig. 2-28. For the same repeatability, the sweep time would have to be set to 1.2 s with the integration method. The following figure shows the standard deviation of the results as a function of the sweep time.
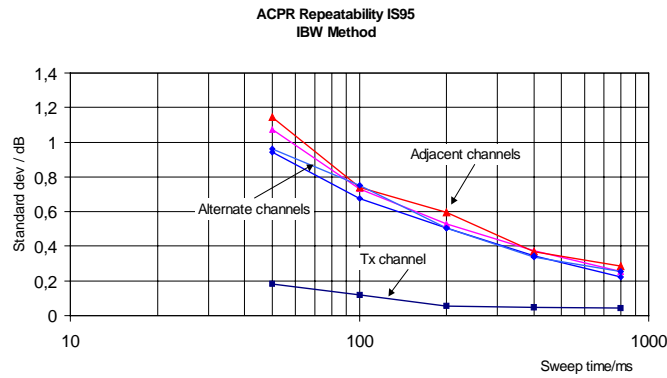
ACPR Repeatability IS95
IBW Method

Fig. 2-35   Repeatability of adjacent channel power measurement on IS95-standard signals if the integration bandwidth method is used

6.   Switch to Fast ACP to increase the repeatability of results.

➤ Press the *CP/ACP CONFIG* ⇩ softkey.

➤ Set the *FAST ACP* softkey to *ON*.
The FSP measures the power of each channel in the time domain. The trace represents power as a function of time for each channel (see Fig. 2-36). The numerical results over consecutive measurements become much more stable.
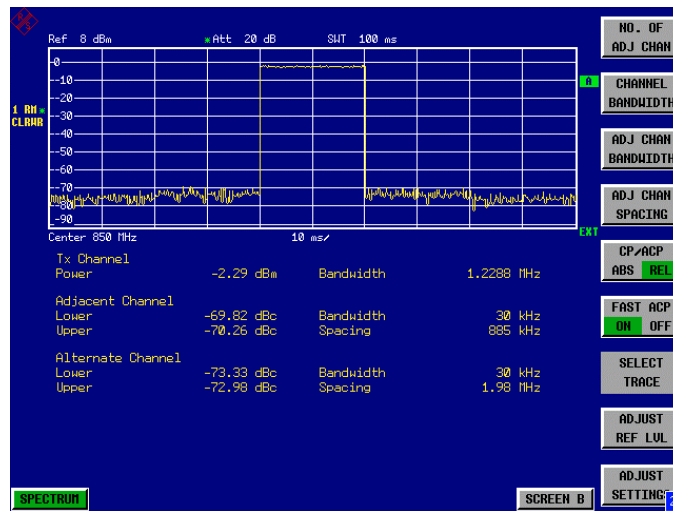
Fig. 2-36   Measuring the channel power and adjacent channel power ratio for IS95 signals in the time domain (Fast ACP)

The following figure shows the repeatability of power measurements in the transmit channel and of relative power measurements in the adjacent channels as a function of sweep time. The standard deviation of measurement results is calculated from 100 consecutive measurements as shown in Fig. 2-35. Take scaling into account if comparing power values.

ACPR IS95 Repeatability
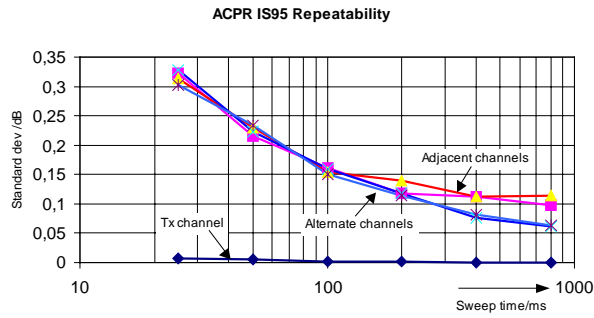
Fig. 2-37   Repeatability of adjacent channel power measurements on IS95 signals in the Fast ACP mode

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Note on adjacent channel power measurements on IS95 base-station signals:
When measuring the adjacent channel power of IS95 base-station signals, the frequency spacing of the adjacent channel to the nominal transmit channel is specified as ±750 kHz. The adjacent channels are, therefore, so close to the transmit channel that the power of the transmit signal leaks across and is also measured in the adjacent channel if the usual method using the 30 kHz resolution bandwidth is applied. The reason is the low selectivity of the 30 kHz resolution filter. The resolution bandwidth, therefore, must be reduced considerably, e.g. to 3 kHz to avoid this. This causes very long measurement times (factor of 100 between a 30 kHz and 3 kHz resolution bandwidth).
This effect is avoided with the time domain method which uses steep IF filters. The 30 kHz channel filter implemented in the FSP has a very high selectivity so that even with a ± 750 kHz spacing to the transmit channel the power of the useful modulation spectrum is not measured.

The following figure shows the passband characteristics of the 30 kHz channel filter in the FSP.
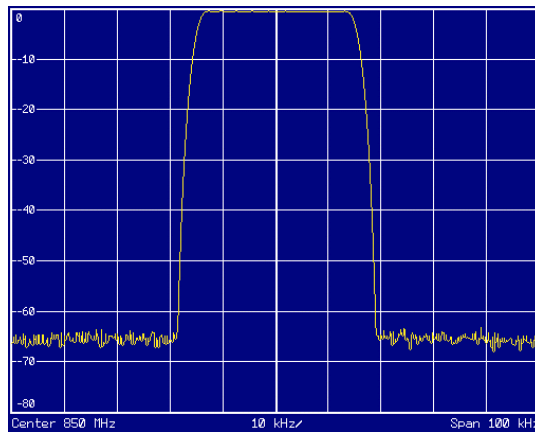
Fig. 2-38   Frequency response of the 30 kHz channel filter for measuring the power in the IS 95 adjacent channel

Measurement Example 2 – Measuring the adjacent channel power of an IS136 TDMA signal

Test setup:
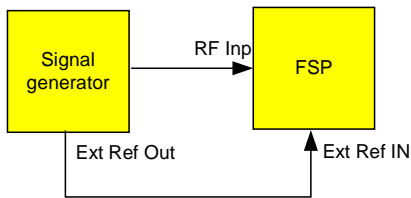
Note:	As the modulation spectrum of the IS136 signal leaks into the adjacent channel, it makes a contribution to the power in the adjacent channel. Exact tuning of the spectrum analyzer to the transmit frequency is therefore critical. If tuning is not precise, the adjacent channel power ratios in the lower and upper adjacent channels become asymmetrical. The FSP's frequency and the generator frequency are therefore synchronized.

Settings on the signal generator (e.g. R&S SMIQ):
Frequency: 850 MHz
Level: -20 dBm
Modulation: IS136/NADC

Measurement with the FSP

1. **Set the spectrum analyzer to its default state.**

   ➢ Press the *PRESET* key.
   The FSP is in its default state.

2. **Set up the FSP for synchronization to an external reference frequency.**

   ➢ Press the *SETUP* key.

   ➢ Set the *REFERENCE* softkey to *EXT*.

3. **Set the center frequency to 850 MHz-**
   Press the FREQ key and enter *850 MHz*.

4. **Configure adjacent channel power measurement for IS136 signals.**

   ➢ Press the *MEAS* key.

   ➢ Press the *CHAN PWR ACP* ⇩ softkey.

   ➢ Press the *CP/ACP STANDARD* softkey.

   ➢ Select *NADC IS136* from the list of standards and press *ENTER*.
   The FSP performs the power measurement in 5 channels (in the useful channel and in the two upper and two lower adjacent channels).

5. *Setting the optimum reference level and RF attenuation for the measurement*

   ➢ Press the *ADJUST REF LEVEL* softkey.
    The FSP sets the optimum RF attenuation and the optimum reference level on the basis of the measured channel power.

Fig. 2-39   Measuring the relative adjacent channel power of an NADC signal in each of the two adjacent channels below and above the transmit channel.

To increase repeatability - especially in the adjacent channels - the FSP's Fast ACP routine is recommended.

6. *Switching on the Fast ACP routine.*

   ➢ Press the *CP/ACP CONFIG* ⇩ softkey

   ➢ Set the *FAST ACP* softkey to *ON.*
    The FSP makes consecutive measurements on the 5 channels in the Zero Span mode using the receive filter specified in IS 136 to define the resolution bandwidth. The power in each channel is displayed on the graph as a function of time
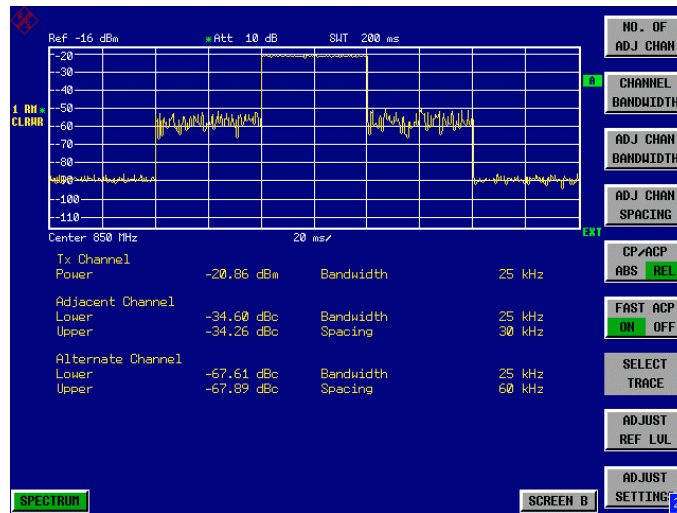
Fig. 2-40   Measuring adjacent channel power in time domain (Fast ACP)

As the resolution bandwidth is much wider than the one used for the integration method, the results are much more stable when compared at the same sweep time.

Repeatability can be influenced by the selected sweep time. The results become much more stable if long sweep times are selected. Since the amplitude distribution is different in different channels (part of the modulation spectrum falls within the first adjacent channel), the repeatability depends on the spacing of the measured channel from the transmit channel.
Fig. 2-41 below shows the standard deviation of results in the different channels as a function of the selected sweep time. The standard deviation for the various sweep times was recorded using a signal generator as a source. With real DUTs the amplitude distributions in adjacent channels may be different so that the standard deviation could differ from that shown in Fig. 2-41. To evaluate the correct measuring time for time-critical measurements at a given standard deviation, the standard deviation of the ACP values at the output of the real DUT must be determined.
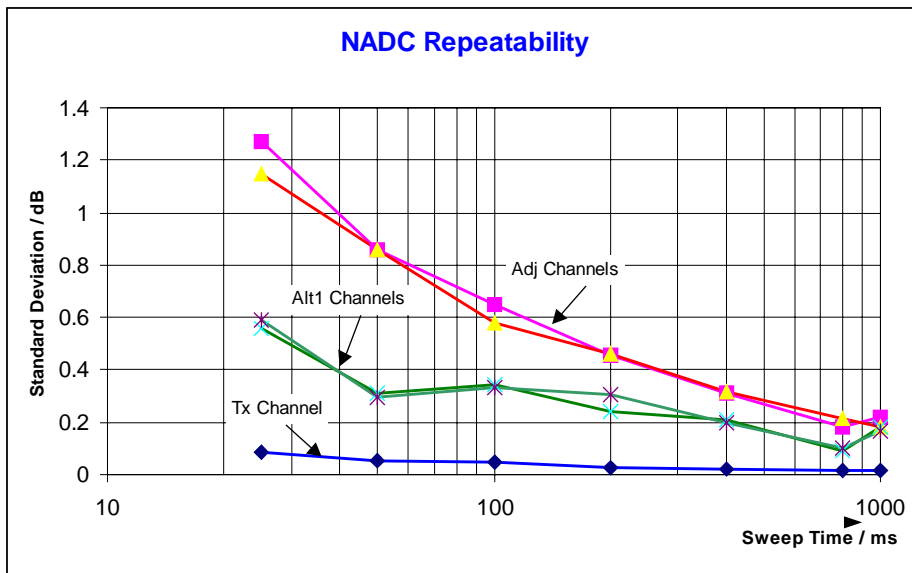
Fig. 2-41   Standard deviation of the results of Fast ACP measurement as a function of selected sweep time evaluated from 100 measurements per sweep time

Measurement Example 3 - Measuring the Modulation Spectrum in Burst Mode with the Gated Sweep Function

Since transmission systems compliant to IS136 use a TDMA method, the adjacent channel power must also be measured in burst mode. An IS136 TDMA frame is divided into 6 time slots. Two of these slots are assigned to a subscriber. This means that the ratio of transmit time to off-time for IS136 mobile phones is only 1:3 (e.g. time slots 1 and 4)

The FSP supports the measurement of the adjacent channel power in the TDMA mode with the Gated Sweep function.

Test setup with the R&S Signal Generator SMIQ:
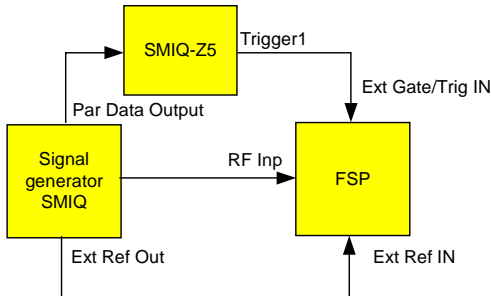
The SMIQ has to be equipped with options SMIQ-B10 or SMIQ-B20 (modulation coder) and SMIQ-B11 (data generator).

Option SMIQ-Z5 is required to trigger the FSP. This option is connected to the SMIQ's parallel output port. The BNC output Trigger 1 of the SMIQ-Z5 provides a TTL trigger signal on the rising edge of the IS136 burst, which is used to start the FSP sweep in the Gated Sweep mode.

> *Note:*   *The FSP's IF power trigger is not suitable for IS136. It triggers on every level edge of the input signal. Since the modulation of the IS136 signal causes level dips even during the transmit burst, there is no way of ensuring that the FSP is only triggered on the burst edge.*

Settings on signal generator SMIQ:

Switch the signal generator to the IS136 burst mode (time slots 1 and 4 are switched on, the other time slots are switched off).

The SMIQ is set as follows to generate the signal :
- ➢ Press the *PRESET* key.
- ➢ Press the *FREQ* key and enter 850 MHz.
- ➢ Press the *LEVE*L key and enter -20 dBm.
- ➢ Press the *RETURN* key.
- ➢ Select *DIGITAL STANDARD* using the spinwheel and press the *SELECT* key.
- ➢ Select *NADC* using the spinwheel and press the *SELECT* key.
- ➢ Press the *SELECT* key.
- ➢ Select *ON* using the spinwheel and press the *SELECT* key.
- ➢ Press the *RETURN* key.
- ➢ Keep turning the spinwheel until *SAVE/RECALL FRAME* appears in the list and select the menu item *SAVE/RECALL FRAME* using the *SELECT* key.
- ➢ The cursor is set to *GET PREDEFINED FRAME*.
- ➢ Press the *SELECT* key.

➢ Select *UP1TCH* using the spinwheel and press the *SELECT* key.

In the following operating sequence for the FSP, it is assumed that steps 1 to 6 of the previous example (example no. 2) have already been performed.

1. ***Configuring the Gated Sweep function on the FSP.***

   ➢ Press the *TRIG* key.

   ➢ Press the *GATED TRIGGER* softkey.

   ➢ Press the *EXTERN* softkey.

   ➢ Press the *GATE SETTINGS* ⇩ softkey.
   The FSP switches to time domain measurement so that the setting of the Gated Sweep parameters can be checked visually.

   ➢ Press the *ZOOM X-AXIS* softkey and enter *10 ms*.
    Exactly one TDMA burst will be displayed.

   ➢ Press the *GATE DELAY* softkey and enter *2 ms* or set the Gate Delay using the spinwheel so that the burst is reliably detected.

   ➢ Press the *GATE LENGTH* softkey and enter *5 ms* or set the vertical line for the gate length using the spinwheel so that the burst is reliably detected.
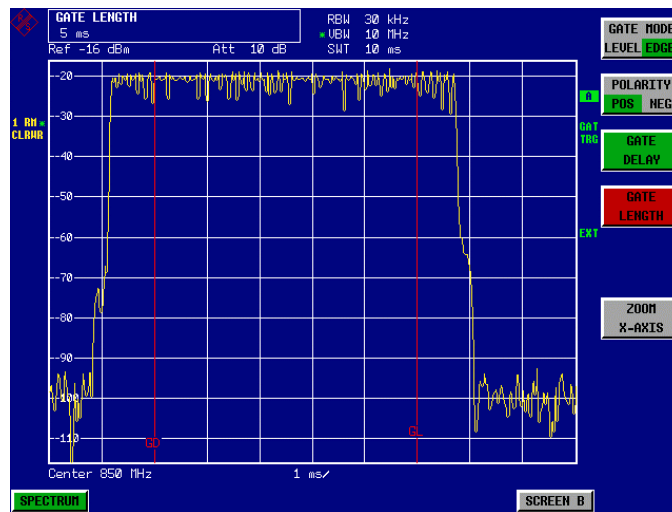
Fig. 2-42   Setting the parameters Gate Delay and Gate Length in time domain. The time interval required to measure the spectrum is indicated by two vertical lines.

   ➢ Press the *PREV* key.
   The FSP now performs the ACP measurement only during the switch-on phase of the TDMA burst. The measurement is stopped during the switch-off phase.

> **Note:** *The selected sweep time is the net sweep time, i.e. the time during which the FSP is actually measuring. The complete frame of an IS136 signal takes 40 ms. In the above example, measurement only takes place for 2x5 ms within a frame. The FSP is therefore only measuring for 25 % of the frame duration. The total measuring time is therefore four times that for the CW mode.*

Measurement Example 4 - Measuring the Transient Spectrum in Burst Mode with the Fast ACP function

In addition to the modulation spectrum or adjacent channel power from the modulation of the RF carrier, the spectrum or adjacent channel power generated by burst edges is also to be measured in TDMA systems. The spectrum is a pulse spectrum and must be measured with the peak detector. With the usual IBW method, only the power of the continuously modulated signal can be measured properly. Even if the modulation spectrum is transmitted in the TDMA mode, the measurement of the modulation spectrum will work because the burst edges are blanked out for the measurement by means of the Gated Sweep function. The spectrum analyzer performs measurements only if the modulation spectrum is continuous when the burst is on.

However, the IBW method fails for the spectrum created by the burst edges. As the measurement is carried out with resolution bandwidths that are very small compared to the signal bandwidth, a spurious amplitude distribution is obtained in the defined measurement channel because of the resolution bandwidth. The small resolution bandwidth cannot settle to the peak amplitudes of the test signal. This problem is avoided in the FSP by performing time domain measurements with the root raised cosine filter specified in the IS136 standard.

If the peak detector is used instead of the default RMS detector (which is selected when the standard is selected), the true adjacent channel power generated by the burst edges can also be measured.

Test setup: The test setup for this example and the settings for SMIQ are identical to those in the previous example.

Measurement with the FSP:

1. *Set the spectrum analyzer to its default state.*

   ➢ Press the *PRESET* key.
     The FSP is in its default state.

2. *Synchronize the FSP to an external reference frequency.*

   ➢ Press the *SETUP* key.

   ➢ Set the *REFERENCE* softkey to *EXT*.

3. *Set the center frequency to 850 MHz*

   ➢ Press the *FREQ* key and enter *850 MHz*.

4. *Configure the adjacent channel power measurement for IS136 signals in Fast ACP mode.*

   ➢ Press the *MEAS* key.

   ➢ Press the *CHAN PWR ACP* ⇩ softkey.

   ➢ Press the *CP/ACP STANDARD* softkey.

   ➢ Select *NADC IS136* from the list of standards and press *ENTER*.

   ➢ Press the *CP/ACP CONFIG* ⇩ softkey.

   ➢ Set the *FAST ACP* softkey to *ON*.
     The FSP performs the power measurement in 5 channels (in the useful channel and in the two upper and lower adjacent channels).

5. *Set the optimum reference level and RF attenuation for the measurement.*

   ➢ Press the *ADJUST REF LEVEL* softkey.
     The FSP sets the optimum RF attenuation and the optimum reference level on the basis of the measured channel power.

6. *Select the peak detector and increase the sweep time to 10 s.*

> ➢ Press the *TRACE* key.

> ➢ Press the *DETECTOR* softkey.

> ➢ Press the *PEAK* softkey.

> ➢ Press the *SWEEP* key.

> ➢ Press the *SWEEP TIME* softkey and enter *10 s*.
> The FSP measures the adjacent channel power generated by the burst edges and the modulation.
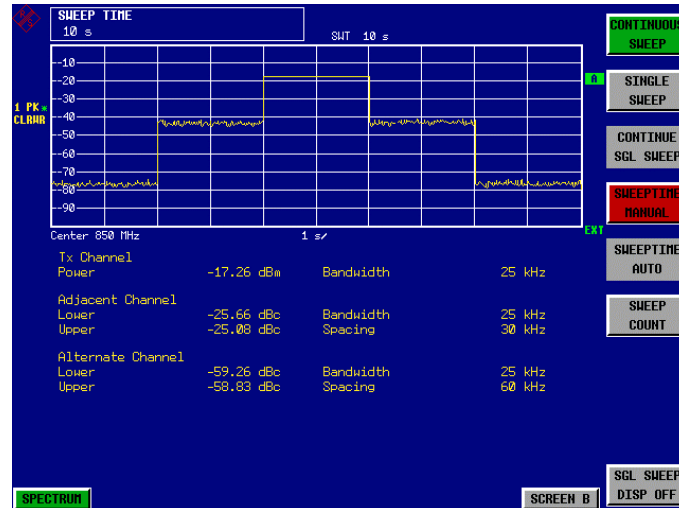

Fig. 2-43   Adjacent channel power due to modulation spectrum and transient spectrum

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Note: *The peak power display depends on the selected sweep time. The longer the sweep time, the higher the probability of measuring the highest peak amplitude of the signal.*
With shorter sweep times, level dips can be seen in the time domain traces. These level dips come from the burst characterics of the signal. The numerical results, however, indicate the peak amplitudes during the measurement in the corresponding channel.

Measurement Example 5 - Measuring adjacent channel power of a W-CDMA uplink signal

Test setup:
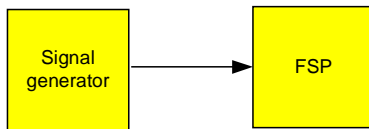
Settings on the signal generator (e.g. R&S SMIQ):
Frequency: 1950 MHz
Level: 4 dBm
Modulation: W-CDMA Reverse Link (NTT-DoCoMo, 4.096 Mcps)

Measurement with the FSP:

1. ***Set the spectrum analyzer to its default state.***

   ➤ Press the *PRESET* key.
   The FSP is in its default state.

2. ***Set the center frequency to 1950 MHz.***

   ➤ Press the *FREQ* key and enter *1950 MHz*.

3. ***Switch on the ACP measurement for W-CDMA.***

   ➤ Press the *MEAS* key.

   ➤ Press the *CHAN PWR ACP* ⇩ softkey.

   ➤ Press the *CP/ACP STANDARD* softkey.

   ➤ From the list of standards, select *W-CDMA 4.096 REV* using the spinwheel or the cursor down key below the spinwheel and press *ENTER*.
   The FSP sets the channel configuration to the W-CDMA standard (NTT-DoCoMo and ARIB, 4.096 Mcps) for mobiles with two adjacent channels above and below the transmit channel. The frequency span, the resolution and video bandwidth and the detector are automatically set to the correct values. The spectrum is displayed in the upper part of the screen and the channel power, the level ratios of the adjacent channel powers and the channel configuration in the lower part of the screen. The individual channels are displayed as vertical lines on the graph.

4. ***Set the optimum reference level and the RF attenuation for the applied signal level.***

   ➤ Press the *ADJUST REF LEVEL* softkey.
   The FSP sets the optimum RF attenuation and the reference level for the power in the transmission channel to obtain the maximum dynamic range. The following figure shows the result of the measurement:
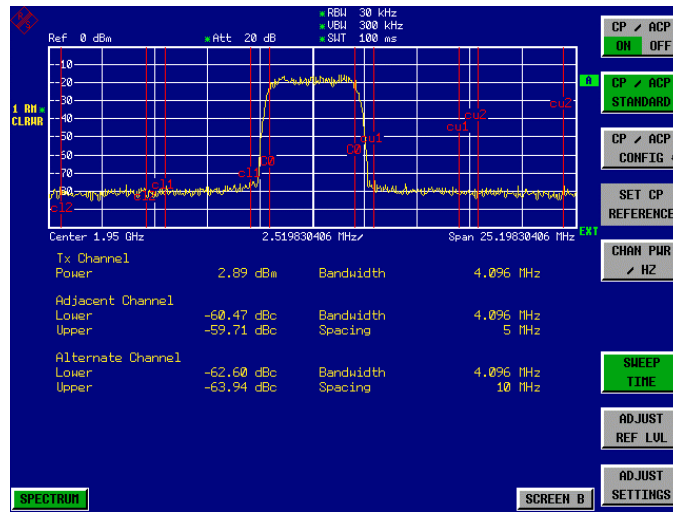
Fig. 2-44   Measuring the relative adjacent channel power on a W-CDMA uplink signal

5.   *Measuring adjacent channel power with the Fast ACP method.*

> Press the *CP/ACP CONFIG ⇩* softkey.

> Set *FAST ACP* softkey to *ON*.

> Press the ADJUST REF LVL softkey.
> The FSP measures the power of the individual channels in the time domain. A root raised cosine filter with the parameters $\alpha = 0.22$ and chip rate 4.096 Mcps (= receive filter for W-CDMA) is used as the channel filter.
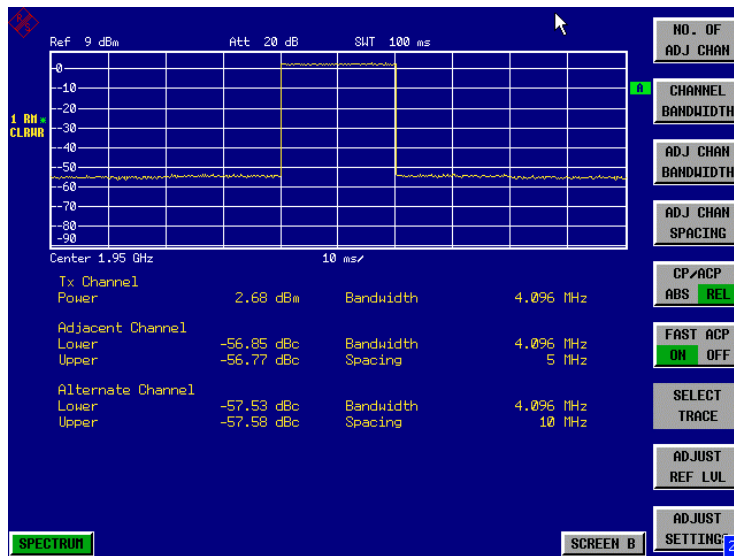

Fig. 2-45   Measuring the adjacent channel power of a W-CDMA signal with the Fast ACP method

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Note: *With W-CDMA, the FSP's dynamic range for adjacent channel measurements is limited by the 12-bit A/D converter. The greatest dynamic range is, therefore, obtained with the IBW method.*

Optimum Level Setting for ACP Measurements on W-CDMA Signals

The dynamic range for ACPR measurements is limited by the thermal noise floor, the phase noise and the intermodulation (spectral regrowth) of the spectrum analyzer. The power values produced by the FSP due to these factors accumulate linearly. They depend on the applied level at the input mixer. The three factors are shown in the figure below for the adjacent channel (5 MHz carrier offset)
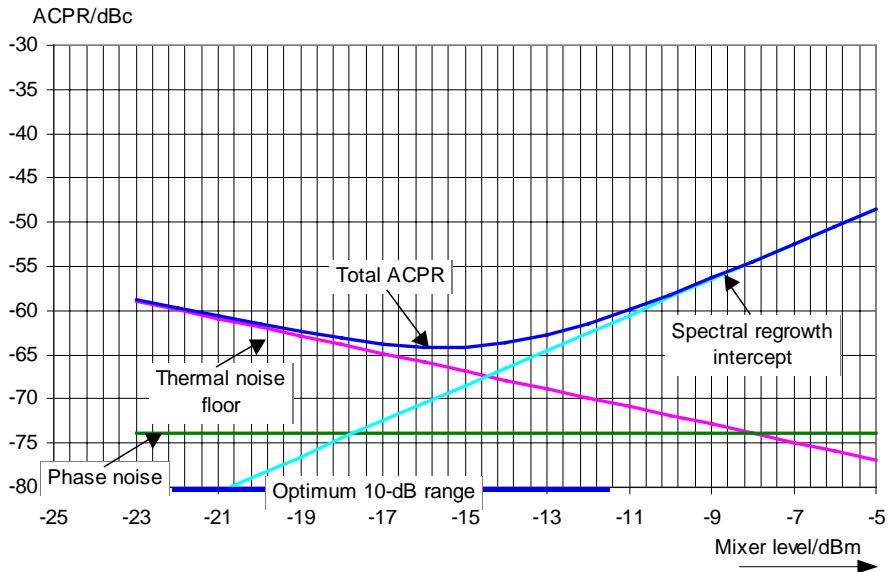
Fig. 2-46   The FSP's dynamic range for adjacent channel power measurements on W-CDMA uplink signals is a function of the mixer level.

The level of the W-CDMA signal at the input mixer is shown on the horizontal axis, i.e. the measured signal level minus the selected RF attenuation. The individual components which contribute to the power in the adjacent channel and the resulting relative level (total ACPR) in the adjacent channel are displayed on the vertical axis. The optimum mixer level is –16 dBm. The relative adjacent channel power (ACPR) at an optimum mixer level is –64 dBc. Since, at a given signal level, the mixer level is set in 10 dB steps with the 10 dB RF attenuator, the optimum 10 dB range is shown in the figure: it spreads from –11 dBm to –21 dBm. The obtainable dynamic range in this range is 60 dB.

To set the attenuation parameter manually, the following method is recommended:

- Set the RF attenuation so that the mixer level (= measured channel power – RF attenuation) is between -11 dBm and -21 dBm.

- Set the reference level so that it is 20 dB less than the RF attenuation which has been set.

This method is automated with the FSP's ADJUST REF LEVEL function. Especially in remote control mode, e.g. in production environments, it is best to correctly set the attenuation parameters prior to the measurement, as the time required for automatic setting can be saved.

Note: *To measure the FSP's intrinsic dynamic range for W-CDMA adjacent channel power measurements, a filter which suppresses the adjacent channel power is required at the output of the transmitter. A SAW filter with a bandwidth of 4 MHz, for example, can be used.*

Amplitude distribution measurements

If modulation types that do not have a constant envelope in the time domain are used, the transmitter has to handle peak amplitudes that are greater than the average power. This includes all modulation types that involve amplitude modulation -QPSK for example. CDMA transmission modes in particular may have power peaks that are large compared to the average power.

For signals of this kind, the transmitter must provide large reserves for the peak power to prevent signal compression and thus an increase of the bit error rate at the receiver.
The peak power, or the crest factor of a signal is therefore an important transmitter design criterion. The crest factor is defined as the peak power / mean power ratio or, logarithmically, as the peak level minus the average level of the signal.

To reduce power consumption and cut costs, transmitters are not designed for the largest power that could ever occur, but for a power that has a specified probability of being exceeded (e.g. 0.01%). .

To measure the amplitude distribution, the FSP has simple measurement functions to determine both the APD[1] = Amplitude Probability Distribution and CCDF = Complementary Cumulative Distribution Function.

In the APD display mode, the probability of occurrence of a certain level is plotted against the level.
In the CCDF display mode, the probability that the mean signal power will be exceeded is shown in percent.

Measurement Example – Measuring the APD and CCDF of white noise generated by the FSP

1. Set the spectrum analyzer to its default state.

  ➢ Press the *PRESET* key.
    The FSP is in its default state.

2. Configure the FSP for APD measurement

  ➢ Press the *AMPT* key and enter **-***60 dBm*.
    The FSP's intrinsic noise is displayed at the top of the screen.

  ➢ Press the *MEAS* key.

  ➢ Press the *SIGNAL STATISTIC* ⇩ softkey.

  ➢ Set the *APD* softkey to *ON*.
    The FSP sets the frequency span to 0 Hz and measures the amplitude probability distribution (APD). The number of uncorrelated level measurements used for the measurement is 100000. The mean power and the peak power are displayed in dBm. The crest factor (peak power – mean power) is output as well (see Fig. 2-47).

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[1] In the literature, APD is also used for the probability of amplitude violation. This is the complimentary function to the APD function of FSP. The term PDF (=Probability Density Function) which is frequently used in the literature corresponds to the APD function of FSP.
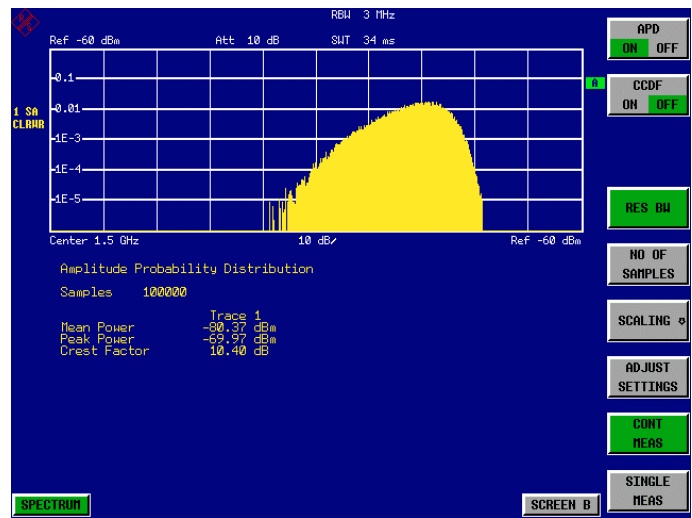
Fig. 2-47   Amplitude probability distribution of white noise

3. **Switch to the CCDF display mode.**

    ➢ Set the *CCDF* softkey to *ON*
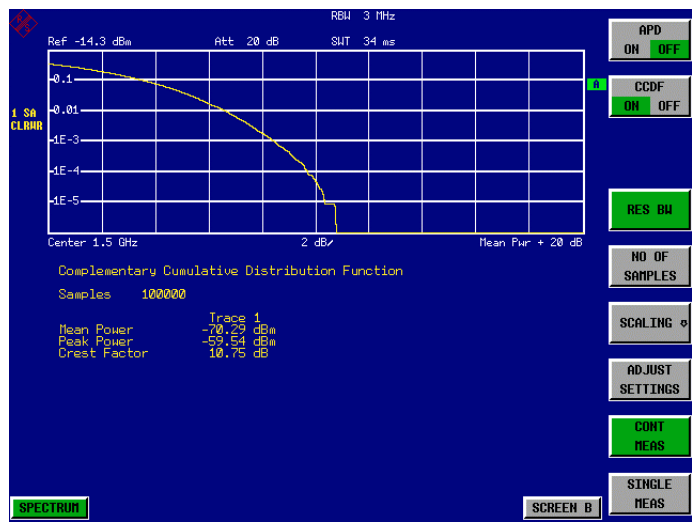   The APD measurement is switched off and the CCDF display mode is switched on.

Fig. 2-48   The CCDF of white noise

The CCDF trace indicates the probability that a level will exceed the mean power. The level above the mean power is plotted along the X axis of the graph.The origin of the axis corresponds to the mean power level. The probability that a level will be exceeded is plotted along the Y axis.

4. Bandwidth selection

If the amplitude distribution is measured, the resolution bandwidth must be set in a way that the complete spectrum of the signal to be measured falls within the bandwidth. This is the only way of ensuring that all the amplitudes will pass through the IF filter without being distorted. If the selected resolution bandwidth is too small for a digitally modulated signal, the amplitude distribution at the output of the IF filter becomes a Gaussian distribution according to the central limit theorem and so corresponds to a white noise signal. The true amplitude distribution of the signal therefore cannot be determined.

A video bandwidth which is large in comparison to the resolution bandwidth ($\geq$ 3 x RBW) must be selected. This ensures that the amplitude peaks of the signal are not smoothed by the lowpass effect of the video filter. The video bandwidth is set automatically during statistics measurements.

Since the video bandwidth of the FSP is limited to 10 MHz, lowpass filtering occurs during measurements with a resolution bandwidth of 10 MHz. Additional band-limiting occurs at a resolution bandwidth of 10 MHz due to the lowpass filtering at the output of the log amplifier. The latter limits the video signal to a bandwidth of 8 MHz in order to obtain sufficient suppression of the 20.4 MHz IF. The level range of the signal amplitudes, e.g. during APD white-noise measurements, is smaller. For broadband-modulated signals such as W-CDMA signals, the effect depends on the bandwidth occupied by the signal. At a signal bandwidth of 4 MHz, the amplitude distribution can be measured correctly with the effective video bandwidth.

5. Selecting the number of samples

For statistics measurements with the FSP, the number of samples $N_{Samples}$ is entered for statistical evaluation instead of the sweep time. Since only statistically independent samples contribute to statistics, the measurement or sweep time is calculated automatically. It is indicated on the FSP display. The samples are statistically independent if the time difference is at least 1/RBW. The sweep time SWT is, therefore, expressed as follows:

$$SWT = N_{Samples} / RBW$$

Time Domain Measurements

 With TDMA radiocommunication systems (e.g. GSM or IS136), the transmission quality is determined not only by the spectral characteristics, but also by the time domain characteristics. Since several users share the same frequency, a time slot is assigned to the each user. Unimpaired operation can only be ensured if each user adheres to his assigned time slot.

In this case, both the power during the transmit phase and the time characteristics such as duration of the TDMA burst as well as rise and fall time of the burst are relevant.

Power measurements

The FSP has easy-to-operate functions for measuring power during a given time interval.

Measurement Example – Measuring the power of a GSM burst during the switch-on phase

Test setup:
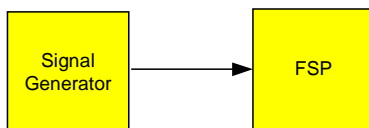
Settings on the signal generator (e.g. R&S SMIQ):
Frequency: 100 MHz
Level: 0 dBm
Modulation: GSM, one time slot is switched on

Measurement using the FSP:

1. Set the spectrum analyzer to its default state.

> Press the *PRESET* key.
  The FSP is in its default state.

2. Set the center frequency to 100 MHz, the span to 0 Hz and the resolution bandwidth to 1 MHz.

> Press the *FREQ* key and enter *100 MHz*.

> Press the *SPAN* key and enter *0 Hz* or press the *ZEROSPAN* softkey.

3. Set the FSP reference level to 10 dBm (= signal generator level +10 dB).

> Press the *AMPT* key and enter *10 dBm*.

4. Set the sweep time to 1 ms

> Press the *SWEEP* key and enter 1 ms.
  The FSP shows the GSM burst running across the display.

5. *Trigger on the rising edge of the burst using the video trigger.*

   ➤ Press the *TRIG* key.

   ➤ Press the *VIDEO* softkey and enter *70%*.
   The FSP displays a stable curve with the GSM burst at the beginning of the trace. The trigger
   level is shown as a horizontal line labeled with the absolute level for the trigger threshold.

6. *Configure the power measurement in the time domain.*

   ➤ Press the *MEAS* key.

   ➤ Press the *TIME DOM POWER* ⇩ softkey.

   ➤ Set the *LIMITS* softkey to *ON*.

   ➤ Press the *START LIMIT* softkey.

   ➤ Place the vertical line on the start of the burst by turning the spinwheel clockwise.

   ➤ Press the *STOP LIMIT* softkey.

   ➤ Place the second vertical line on the end of the burst by turning the spinwheel counterclockwise.
   The FSP displays the mean power during the switch-on phase of the burst (see Fig. 2-49).
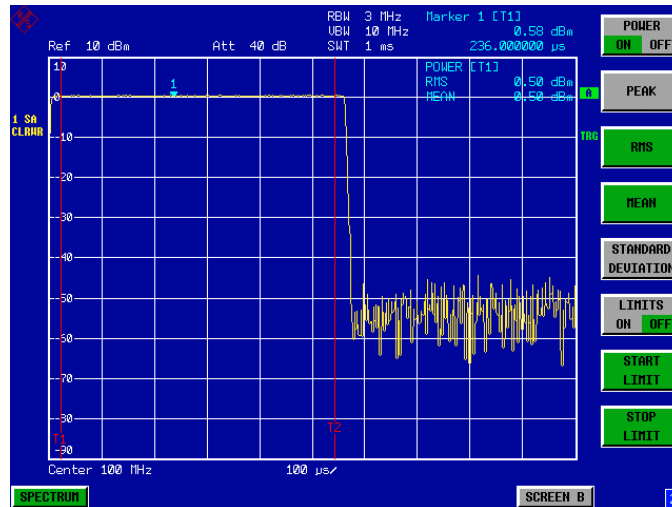
Fig. 2-49   Measuring mean power during the switch-on phase of a GSM burst

Power Ramping Measurement for Burst Signals

Since the FSP has a high time resolution at 0 Hz span, the edges of the TDMA burst can be measured accurately. The use of the trigger offset makes it possible to shift the edges onto the screen.

Measurement Example – Measurements on GSM burst edges using a high time resolution

Test setup:
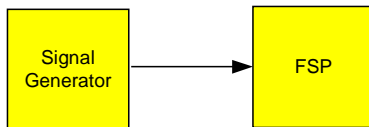
Settings on the signal generator (e.g. R&S SMIQ):
Frequency: 100 MHz
Level: 0 dBm
Modulation: GSM, one time slot is switched on

Measurement using the FSP

The settings of the example above are used to measure GSM burst power during the switch-on phase.

1. ***Switch off power measurement.***

    ➢ Press the *MEAS* key.

    ➢ Press the *TIME DOM POWER* ⇩ softkey.

    ➢ In the submenu, set the *POWER* softkey to *OFF*.

2. ***Increase the time resolution to 100 µs.***

    ➢ Press the *SWEEP* key and enter *100 µs*.

3. ***Shift the rising edge of the GSM burst to the middle of the screen using the trigger offset.***

    ➢ Press the *TRIG* key.

    ➢ Press the *TRIGGER OFFSET* softkey.

    ➢ Set the trigger offset by turning the spinwheel (counterclockwise) until the burst edge is in the middle of the screen or enter **-**50 µs.
    The FSP displays the rising edge of the GSM burst (see Fig. 2-50)
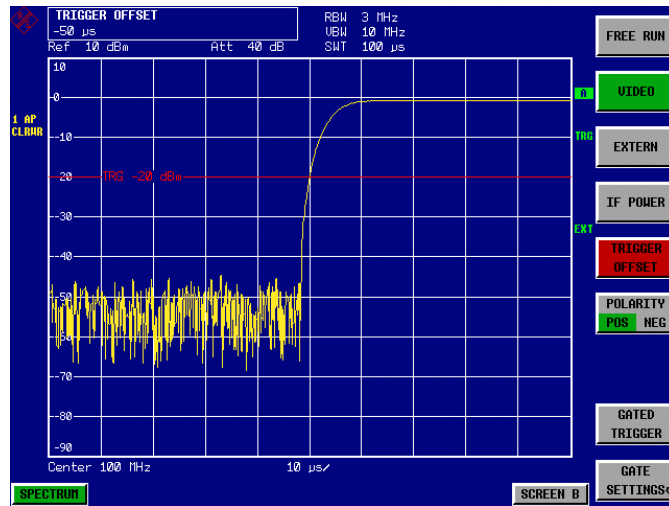
Fig. 2-50   Rising edge of GSM burst at high time-resolution.

4. *Shift the falling edge of burst to the middle of the screen using the trigger offset.*

➢ Set the *POLARITY* softkey to *NEG*.
The FSP displays the falling edge of the GSM burst (see Fig. 2-51)
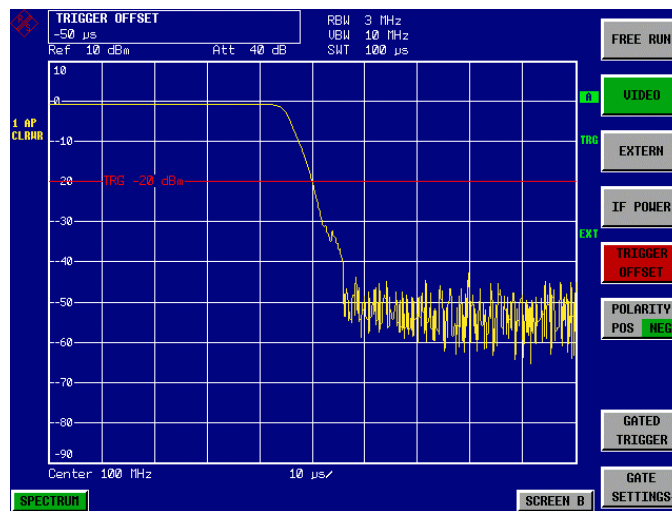
Fig. 2-51   Falling edge of GSM burst at high time resolution

Measuring the S/N Ratio of Burst Signals

For TDMA transmission methods, the S/N ratio or the switch-off range can be measured by comparing the powers during the switch-on and switch-off phase of the transmission burst. The FSP, therefore, has a function to perform absolute and relative power measurements in the time domain. The measurement is carried out as follows, using a GSM burst as an example.

Measurement Example - S/N ratio of a GSM signal

Test setup:
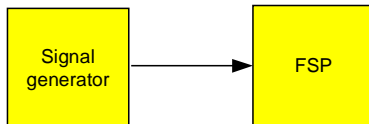
```
┌───────────┐          ┌───────────┐
│  Signal   │          │           │
│ generator │─────────▶│    FSP    │
│           │          │           │
└───────────┘          └───────────┘
```

Settings on the signal generator (e.g. R&S SMIQ):
Frequency: 100 MHz
Level: 0 dBm
Modulation: GSM, one time slot is switched on

Measurement using the FSP

1. *Set the spectrum analyzer to its default state.*

   ➢ Press the *PRESET* key.
     The FSP is in its default state.

2. *Set the center frequency to 100 MHz, the span to 0 Hz and the resolution bandwidth to 1 MHz.*

   ➢ Press the *FREQ* key and enter *100 MHz*.

   ➢ Press the *SPAN* key and enter *0 Hz*
     or

   ➢ press the *ZEROSPAN* softkey.

   ➢ Press the *BW* key and enter *1 MHz*.

3. *Set the reference level of the FSP to 0 dBm (= signal generator level) and the RF attenuation to 10 dB for maximum sensitivity.*

   ➢ Press the **AMPT** key and enter 0 **dBm**.

   ➢ Press the *RF ATTEN MANUAL* softkey and enter *10 dB*.

4. *Set the sweep time to 2 ms.*

   ➢ Press the *SWEEP* key and enter *2 ms*.
     The FSP displays the GSM burst running across the display.

5. **Trigger on the rising edge of the burst using the video trigger and shift beginning of burst to the middle of the screen.**

➢ Press the TRIG key.

➢ Press the VIDEO softkey and enter 70%.
The FSP displays a stable image with the GSM burst at the start of the trace.

➢ Press the TRIGGER OFFSET softkey and enter -1 ms.
The FSP displays the GSM burst in the right half of the graph.

6. **Configure the power measurement in the time domain.**

➢ Press the MEAS key.

➢ Press the TIME DOM POWER ⇩ softkey.

➢ Set the LIMITS softkey to ON.

➢ Press the *START LIMIT* softkey.

➢ Place the vertical line on the start of the burst using the spinwheel.

➢ Press the *STOP LIMIT* softkey.

➢ Place the second vertical line on the end of the burst using the spinwheel. .
The FSP displays the power during the switch-on phase of the burst.
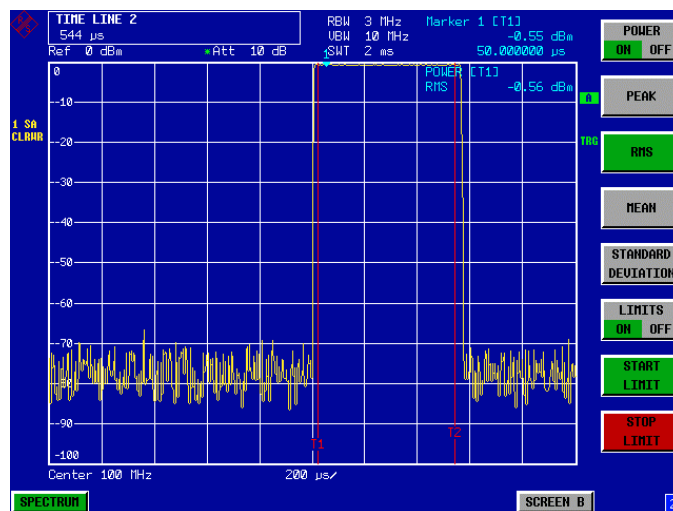
Fig. 2-52   Measuring power during the switch-on phase of the burst

7. **Define the measured power as the reference and switch on relative power measurement.**

➢ Press the *NEXT* key.
The side menu for setting the power measurement is opened.

➢ Set the *POWER ABS/REL* softkey to *REL*.

➢ The power relative to the power during the switch-on phase of the burst is displayed.

➢ Press the *SET REFERENCE* softkey.
The measured power of the GSM burst is defined as the reference.

8.   *Measure the power during the switch-off phase of the burst.*

➢ Press the *TRIG* key.

➢ Set the *POLARITY POS/NEG* softkey to *NEG*.
The FSP triggers on the falling edge of the burst. The burst is then shifted to the left half of the screen. The power is measured in the switch-off phase. The start of the burst is shifted to the middle of the screen and the power is measured during the switch-off phase relative to the reference power (= burst power).
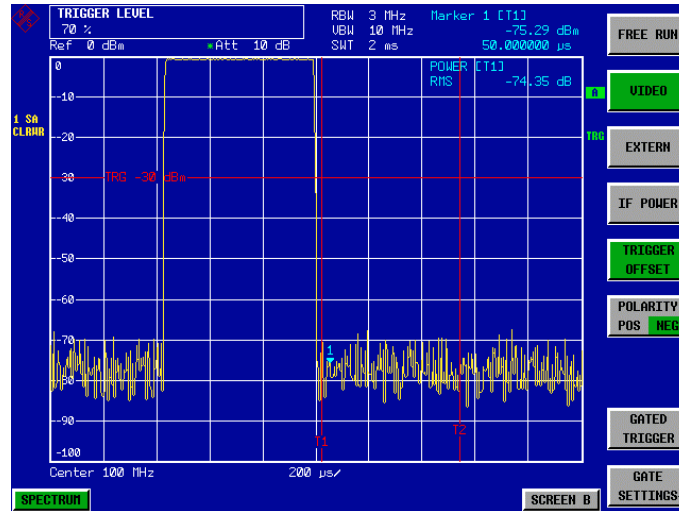
Fig. 2-53   Measuring the S/N ratio of the GSM burst signal in the time domain

Contents - Chapter 3 "Manual Operation"

3 Manual Operation

Chapter 3 provides an overview of the operating concept and the basic steps of manual operation of the FSP. This includes a description of the screen, of the control of menus and of the setting of parameters. An overview of the menus will be listed at the end of this chapter.

The functions of the menus are described in dtail in Chapter 4. Chapter 2 contains a short introduction on step-by-step simple measurements. The remote control of the instrument is described in Chapters 5, 6 and 7.

The operation of the FSP is menu-controlled via keys, hotkeys and softkeys. The setting of the instrument and test parameters in the menus is made either directly via softkeys or by entry of values in entry fields and by selection in tables. The operating mode and the screen mode is selected via the hotkeys.
If required, data entry windows and tables are superimposed on the screen.

The Screen

The screen informs continuously on the results and parameters of the selected measuring functions. It shows the assignment of the softkeys and menus, which are required for setting the measuring parameters. The display of test results, the softkey labeling and the type of menu depend on the selected measuring function.
The screen is subdivided into three areas:
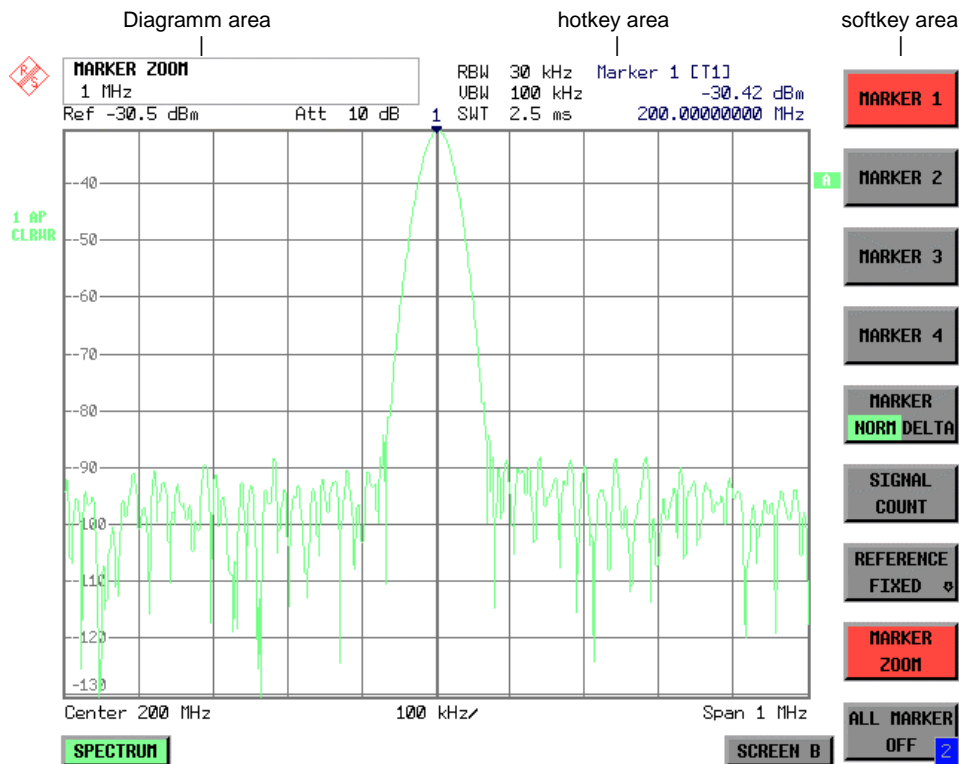
Fig. 3-1   Subdivision of screen

Diagram area   This area contains the measuring diagrams and other measured-value information as well as the parameters and status information which are important for analysis of the results.
In addition, message fields, entry windows and tables may be shown in this area.

Softkey area   This area contains the instrument functions which can be selected via the softkeys. The softkey area is not superimposed by other graphics.

Hotkey area   This area contains the available operating modes and screen modes. The hotkey area is not superimposed by other graphics.

Diagram Area
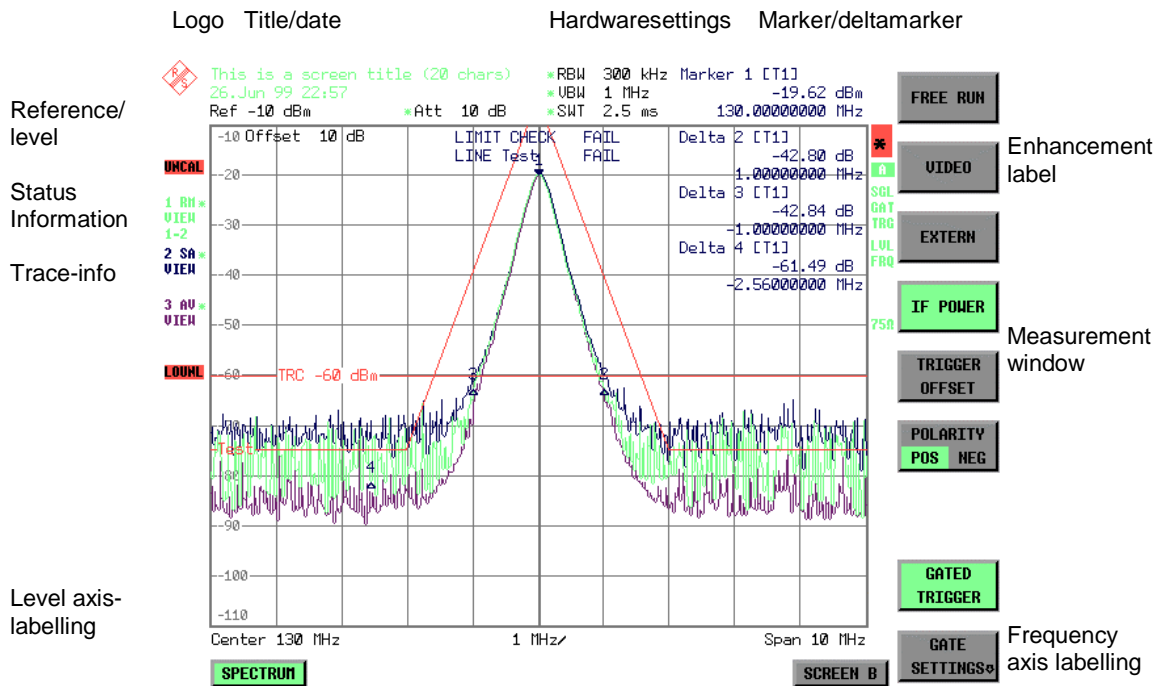
Fig. 3-2   Subdivision of the FSP screen in analyzer mode (without measuring diagram)
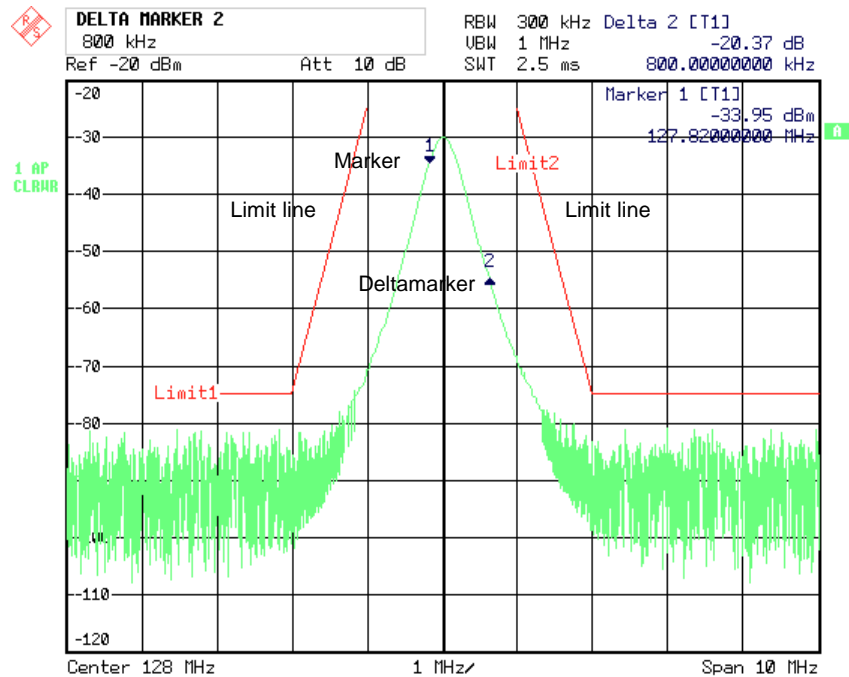
Fig.3-3   Measuring diagram

Indications in the Diagram Area

The following graphic elements are displayed in the diagram area:

General indications   Indication of the logo

    Logo

    Screen title   Indication of selected screen title

    Date / time   Indication of date and time

Hardware settings

    Ref   Indication of the reference level

    Offset   Indication of the offset of reference level.

    Att   Indication of the set RF attenuation.

    EATT   Indication of the set RF attenuation with electronic attenation (only with option Electronic Attenuaror, FSP-B25).

    RBW   Indication of the set resolution bandwidth.
If the bandwidth does not correspond to the value of the automatic coupling, a green asterisk "*" is prefixed to the field.

    VBW   Indication of the set video bandwidth.
If the bandwidth does not correspond to the value of the automatic coupling, a green asterisk "*" is prefixed to the field.

    SWT   Indication of the set sweep time.
If the sweep time does not correspond to the value of the automatic coupling an asterisk "*" is prefixed to the field. The colour of the asterisk turns red as soon as the sweep time falls below the value of the automatic coupling.

Marker/deltamarker	This label displays the position of the last selected marker or deltamarker in the x and y-directions and the marker/deltamarker index. The square brackets contain the curve which the marker is assigned to and the active measuring function of the marker indicated. The measuring function of the markers in the second field is indicated by the following abbreviations:

FXD reference fixed active

PHN phase noise measurement active

CNT frequency counter active

TRK signal track active

NOI noise measurement active

MOD measurement of AM modulation depth active

TOI TOI measurement active (3rd order intercept)

Limit check	Indication of the result of the limit check.
X-axis labelling	Display of the x-scaling.

`10 MHz/DIV`   The distance between two grid lines is displayed in this label.

`Center 1.2345678901234 GHz`

The set center frequency or start frequency is displayed in this label depending on whether the keys FREQ/SPAN or the softkeys START/STOP were last pressed.

`Start 1.2345678901234 GHz`

If span = 0 Hz, the center frequency is always displayed.

`Span 1.2345678901234 GHz`

The set frequency range (*SPAN*) or the stop frequency is displayed, depending on whether the keys FREQ/SPAN or the softkeys START/STOP were last pressed.

`Stop 1.2345678901234 GHz`

`Trigger 1.234 ms`

If span = 0 Hz, the trigger moment (*PRETRIGGER*) is displayed.

Status information	The status information on the left side of the diagram hint at irregularity (e.g. UNCAL)
UNCAL	"UNCAL" is indicated under the following circumstances:

- correction data are switched off (menu CAL, CAL CORR OFF).
  - ⇒ switch on CAL CORR ON or PRESET

- no valid correction data. This may occur after a cold start of the instrument following a firmware update.
  - ⇒ record correction data

OVLD / IFOVL	OVLD is indicated when the input mixer is overloaded.

⇒   Increase input attenuation

IFOVL is indicated when overload occurs in the IF signal path after the input mixer.

⇒   Increase reference level

MSG / LOUNL	MSG is indicated if a failure has occurred which impair correct measurement. The exact error message can be queried in the menu *SETUP SERVICE INFO*. The display disappears after the cause for the error has been eliminated.

LOUNL is indicated when an error occurs in the frequency processing of the instrument.

OVEN	OVEN is indicated when the crystal oscillator (option FSP-B4) has not yet reached its operating temperature. This indication vanishes after a few minutes after switch on.

Trace info: Every active measurement curve (trace ≠ BLANK) is allocated a trace info of two or three lines at the left of the diagram. The trace info has the same colour as the measurement curve.

\<n\> \<detector\> \<*\>
\<mode\>
\<trace math\>

Example:

```
1 PK *
CLRWR
1-2
```

n	=	trace number (**1 ... 3**)

detector	=	selected detector
	AP:	AUTOPEAK detector
	PK:	MAX PEAK detector
	MI:	MIN PEAK detector
	SA:	SAMPLE detector
	AV:	AVERAGE detector
	RM:	RMS detector
	QP:	QUASIPEAK detector

*	=	indicates that the selected detector does not correspond to that of the automatic coupling.

mode	=	indication of sweep mode
	CLRWR:	CLEAR/WRITE
	MAXH:	MAX HOLD
	MINH:	MIN HOLD
	AVG:	AVERAGE
	VIEW:	VIEW

Trace math	=	trace math active
	1 - 2	trace 1 - trace 2
	1 - 3:	trace 1 - trace 3

Instrument settings
(Enhancement Labels)   Indication of user instrument settings which influence the measuring result and which are not immediately obvious when viewing the measured values.

	*	The current instrument setting does not correspond to the one which applied when one of the displayed curves had been stored. This occurs under the following circumstances:

- The instrument setting is modified while a measurement is being performed.
- The instrument setting is modified in SINGLE SWEEP mode subsequent to the end of the sweep and no new sweep is started.
- The instrument setting is modified after setting the trace to VIEW.

The display is retained until the cause is eliminated by the user. I.e., either a new sweep is started (SINGLE SWEEP mode), or the trace of interest is switched to BLANK.

A / B	Identification for screen A / B. When screen A / B is activated for the entry of test parameters, this label is highlighted.
SGL	The sweep is set to SINGLE SWEEP .
GAT	The frequency sweep is controlled via the *EXT TRIG/GATE* input of the instrument.
TRG	The instrument is not triggered in *FREE RUN* mode.
LVL	A level offset ≠ 0 dB has been set.
FRQ	A frequency offset ≠ 0 Hz has been set.
PRN	A printer output is active.
75 Ω	The input impedance of the instrument is set to 75 Ω.
EXT	The instrument is configured for operation with external reference
PA	The RF preamplification is switched on (option FSP-B25)

Entry fields:

Entry window	The data entry window is superimposed in the left upper corner of the diagram area, if required. It covers the display of the title and the time. The field is used to enter numeric or alphanumeric device parameters.
Tables	The tables are superimposed in the diagram area, if required. Sie dienen der Anzeige und Konfiguration von Geräteparametern.

Message windows:

Message field	Message fields provide notes on measurements, e.g. results of the limit check (PASS/FAIL). These notes are no error messages, which are indicated as system messages.
	They can be masked out by pressing the *ESC* key.
System messages	System messages indicate warnings and error messages.

Message without action field:
These system messages contain only arbitrary information. They hint at events which are of interest for the user but do not affect the measurement or functioning of the instrument.

They are deleted either automatically after a predefined time has passed (3 seconds) or upon any keystroke or mouse click.

Message with action field:
These system messages require a decision to be taken by the user. They are not deleted until any action has been selected. Deletion of the message initiates the action selected and appropriate measures to be taken. The action field consists of one (OK), two (OK/CANCEL) or three (arbitrary) buttons.
The user may select one of the buttons using the cursor keys and initiate the associated action by means of the unit keys. The ESC key is used to acknowledge the message without releasing any action.

Traces:

1 to 3	Up to 3 traces in each measurement diagram can be displayed simultaneously.
Limit lines	Limit lines are used to mark level curves or spectral distributions which must not be exceeded or dropped below.

The FSP provides two display modes:

- Full Screen: 1 window, the measurement is performed in the active diagram.
- Split Screen: 2 windows, the measurements are performed in both diagrams.

Full Screen

In the full-screen mode, the settings and measurements are performed in the active visible window. All indications on the screen refer to this window. The designation (SCREEN A or SCREEN B) is inserted as enhancement label A or B on the right diagram margin.
Switching between the windows is by means of *SCREEN A/B* hotkey. The current measurement is terminated when its window is blanked out.
Switching from split-screen to full-screen mode is performed in menu *DISP*.

Split Screen

In Split Screen mode, the screen is divided into two halves.
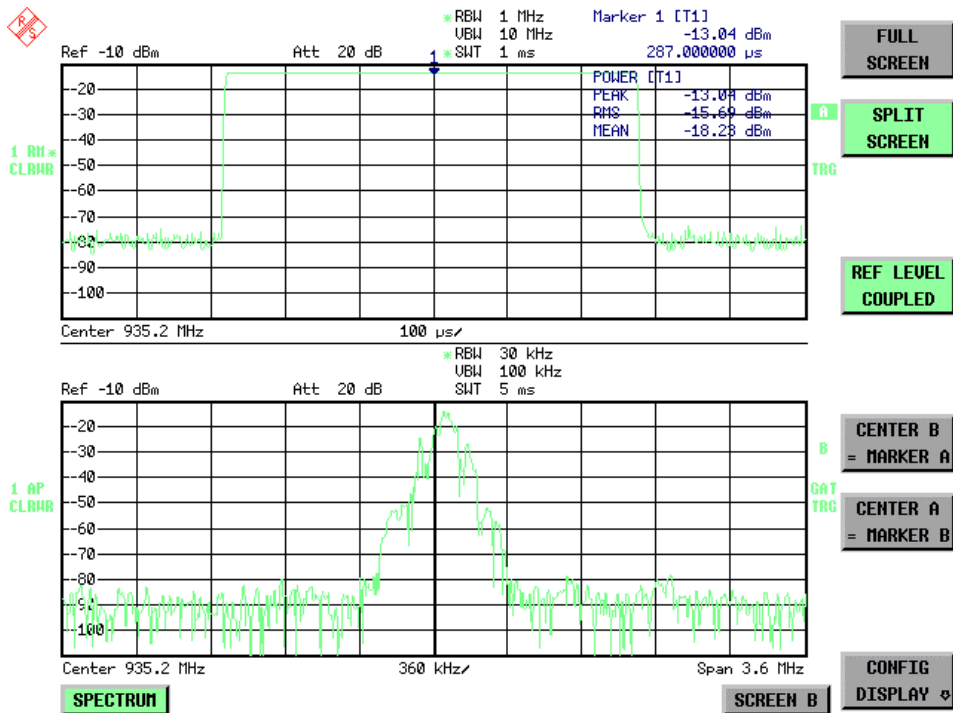
Fig.3-4   Subdivision of the screen in Split Screen mode

The upper half is assigned Screen A, the lower one Screen B. The settings for measurement can be selected independently for both screens. E.g., a spectrum may be displayed in Screen A and a time amplitude in the time range is displayed in Screen B.
The indications which are valid only for one window appear in the margin of the associated diagram. Indications which are valid for the two windows are displayed between the diagrams.
The window for entry of the measuring parameters or the marker operation is selected using the *SCREEN A/B* hotkey. The measurements are simultaneously performed in the two windows irrespective of the currently active one.
Switching from full-screen to split-screen mode is performed in menu *DISP*.

Softkey Area

The softkeys are assigned to the nine keys on the right side of the display
The setup of the softkey area is independent of the operating mode. It consists of the following graphic
elements:
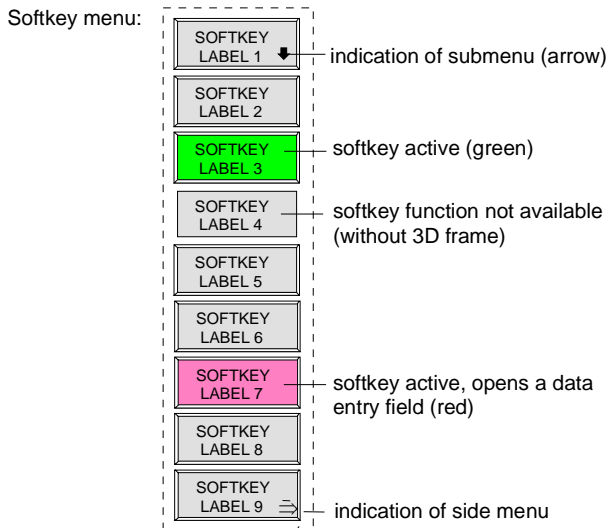
Fig.3-5   Setup of the softkey area

The softkeys have different functions depending on the instrument state. Therefore, their labeling can be
varied. The labeling of all softkeys which call a submenu includes a ⇓ arrow.
The function and current state of the softkeys is indicated in the label by different texts and colors. The
color assignment is factory-set as follows:

Table 3-1   Factory-set color assignment of soft keys

Softkey color	Meaning
gray	Softkey switched off
green	Softkey switched on
red	Softkey switched on and data entry active

These colors can be changed by the user as desired in the *DISP - CONFIG DISPLAY* menu.

A softkey is switched on or off by pressing the respective hardkey (see following section "Setting the
Parameters").

Softkeys are masked out, too, if the functionality which they represent is not available. A distinction has
to be made between two cases:

• If an instrument function depends on an option, and if this option is not fitted, the associated softkey is
  masked out,.

• If the instrument function is not available temporarily due to specific settings, the softkey is displayed
  without the 3D frame.

The label "▶" on the right lower corner of the softkey area indicates that a side menu is available. The
side menu is called by pressing the *NEXT* key.

Hotkey Area

Hotkeys are allocated to the eight keys on the bottom margin of the screen. They change between modes and the active diagrams.
The menu only shows the hotkeys which are actually used:

SPECTRUM						SCREEN B
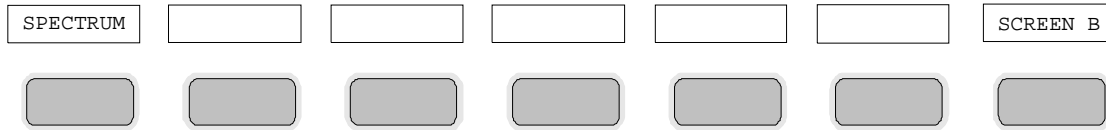
A keystroke activates the associated hotkey. An activated hotkey changes its frame:
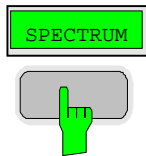
Calling and Changing the Menus

The operation of the FSP is menu-controlled via keys and softkeys. Various softkey menus are displayed depending on the instrument status. The individual menus constitute the so-called menu tree. The top menu (the root of the menu tree) is always called by means of a keystroke. Arrows at the lower edge of the softkey area indicate whether a supplementary menu can be entered or not.
Softkeys with an arrow allow for branching into further menus (so-called submenus): The field "➔" at the lower right side of the softkey area indicates that this menu has a side menu.

The menu change keys on the front panel below the softkey area allow for switching between the main menu and the side menus and submenus.

NEXT   The *NEXT* key calls the side menu.

PREV   The *PREVIOUS* key returns to the next higher menu.

Several menus provide for automatic change, i.e., return to the next higher menu is caused automatically after pressing a softkey.

Selection of a submenu is always effected via a softkey.
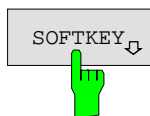
SOFTKEY⇩   The labeling of all softkeys which call a submenu includes a ⇓ arrow.

Setting Parameters

Parameters are set either by simple selection (selection parameters) or by (alpha)numeric entries in data entry windows or tables.

The numeric keypad on the front panel, an external keyboard (optional), a roll-key and the cursor keys are provided for the entry of instrument parameters in an entry window or in a table.

The external keyboard is optional. If it is not fitted, the help line editor is called automatically for entry of alphanumeric parameters. The help line editor provides for selection of individual letters and a number of special characters which are copied into the actual entry window.

Numeric Keypad

The numeric keypad is provided for entry of numeric parameters. It contains the following keys:

* Number keys 0 to 9

* Decimal point
  Inserts a decimal point "." at the cursor position.

* Sign key
  Changes the sign of the mantissa or exponent of a numeric parameter.
  A "-" is inserted at the cursor position in case of an alphanumeric parameter.

* Unit keys (*GHz/-dBm*, *MHz/dBm*, *kHz/dB* and *Hz/dB*)
  – Provide the numeric value entered with the selected unit and terminate the entry.
    The unit keys are all assigned the value "1" for dimensionless quantities or for level entries (e.g., in dB). The unit keys thus assume the function of an *ENTER* key. The same applies for an alphanumeric entry.
  – Open and close the selection windows of tables.

* *BACK* key
  – Deletes the character left to the cursor with numeric entry.
  – Allows for toggling between the current and the previous values subsequent or prior to entry (UNDO function).

* *ESC/CANCEL* key
  – Aborts the entry before it has been terminated. The previous value is restored.
  – Closes the entry field after termination of input.
  – Closes system messages.

* *ENTER* key
  – Terminates the input of dimensionless quantities. The new value is set.

  Note: *The ENTER keys assumes the function of the Hz key for frequency input, and the function of the µs(kHz) key for time input.*

Roll-key and Cursor Keys

The roll-key and the cursor keys are arranged besides the numeric keypad.

The roll-key has various functions:

- With numeric entry, the instrument parameter is incremented (turning clockwise) or decremented (turning counterclockwise) at a defined step size.

- In tables, the roll-key can be used to shift the cursor horizontally or vertically when no entry window is open. The direction (horizontal/ vertical) is switched over using the cursor keys.

- The roll-key is used with the help-line editor to select the individual letters.

- It can be used to shift markers, display lines, limit lines etc.

- Pressing the roll-key terminates the input of parameters.
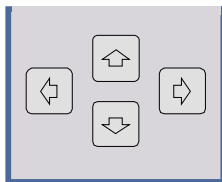
In tables, the cursor keys are used to shift the cursor between the lines and columns of the table.

The keys ⬅ and ➡ are used to shift the cursor inside the entry window to reach a particular position in the string.

The keys ⬆ and ⬇

– increase or decrease the value of a parameter for numeric input .
– switch between editing line and help line editor for alphanumeric input.

Selection and Setting of Parameters via Keys or Softkeys

The selection of parameters and their settings is effected by means of a key, a softkey or in a table depending on the hierarchical level of the menu they are assigned to. Selection and setting of parameters in tables is described in section "Selection and Setting of Parameters in Tables" .

Selection via key

Most keys of the FSP are used to enter menus where the selection and the settings are made. Few settings can be made directly by means of a keystroke, only.

Example: Call up of preset settings

➢ Press *PRESET* key

The FSP is brought into a predefined initial state.

Selection via softkey

In most cases the selection is made by pressing the respective softkey. There are various alternatives of making the selection:

1. The softkey is active or inactive.

Example: Switching on/off the frequency counter

➢ Press *MKR* key.

➢ Press *SIGNAL COUNT* softkey.

Each time the softkey is pressed, the marker info list is switched on or off. If the softkey is active (= marker info list on), it is illuminated.
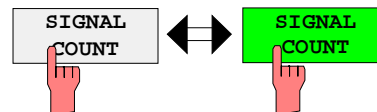
2. The softkey acts like a toggle switch, each pressing changes the active selection.

Example: Selection of the reference (internal or external)

➢ Press *SETUP* key.

➢ Press *GENERAL SETUP* softkey, the *GENERAL SETUP* submenu is opened.

➢ Press *REFERENCE INT/EXT* softkey.

With each pressing, the checkmark on the softkey changes from INT (internal reference) to EXT (external reference) and vice versa. When in the active setting the softkey menu item is illuminated.
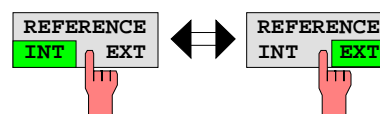
3. Various softkeys act like selection switches. Only one softkey may be active at a time.

Example: sweep setting

➢ Press *SWEEP* key.

➢ Press *CONTINOUS SWEEP* softkey.

The continuous sweep is thus set. The *CONTINOUS SWEEP* softkey is colored (factory-set: green). The second alternative, a series of n sweeps according to the trigger definition, can be selected via the *SINGLE SWEEP* softkey in the same menu. Only one of the two softkeys can be active at a time, the softkeys thus act like selection switches.
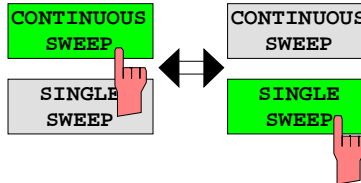
4. The softkey is used to select the parameter, the setting is made in an alphanumeric data entry window.

Example: SWEEP COUNT parameter

➢ Press *SWEEP* key

➢ Press *SWEEP COUNT* softkey.

The window for entering the number of sweeps for the SINGLE SWEEP mode is opened. The softkey is colored (factory-set: red). (Data entry is described in the next section).
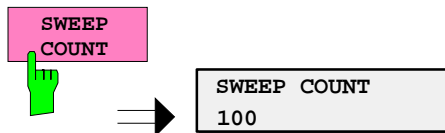
SWEEP COUNT
100

4. The softkey is used to select the parameter, the setting is made in an (alpha)numeric data entry window. The softkey function is switched on. To switch off the function, the softkey has to be pressed again.

Example: parameter MARKER

➢ Press *MRK* key.

➢ Press *MARKER 1* softkey.

The window for entering the marker frequency is opened. The softkey is colored (factory set: red).
Marker1 is switched on and the peak search is started.

➢ Press *MARKER 2* softkey.

The entry window for the marker frequency of marker 2 is opened. The softkey is colored (red), marker 2 is switched on, and the *MARKER 1* softkey turns green.
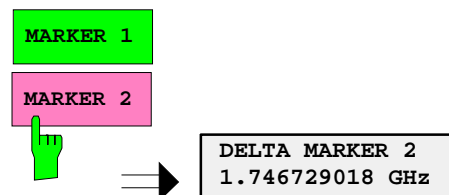
➢ Press *MARKER 1* softkey again.

Marker 1 is switched off.

5. The softkey selects the parameter, the setting is made in a selection table.

Example: Selection of the sorting criteria of a file list

➢ Press *FILE* key.

➢ Press *FILE MANAGER* softkey.

➢ Press *SORT MODE* softkey.

A selection table is displayed. The softkey is colored (factory-set: red). (operation see below).
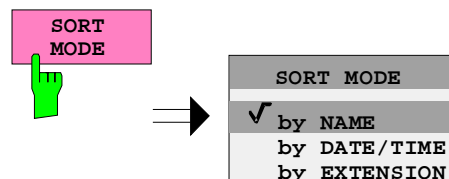
Editing of Numeric Parameters

The entry of numeric values is always made in a data entry window, which is displayed automatically after selection of the parameter.

```
┌─────────────────────────────────────┐
│         START FREQUENCY             │ ──── Head line with
├─────────────────────────────────────┤      parameter name
│ 10.2457535 GHz                      │ ──── Editing line with
├─────────────────────────────────────┤      parameter value and unit
│ START FREQUENCY OUT OF RANGE        │ ──── Status and message line
└─────────────────────────────────────┘
```
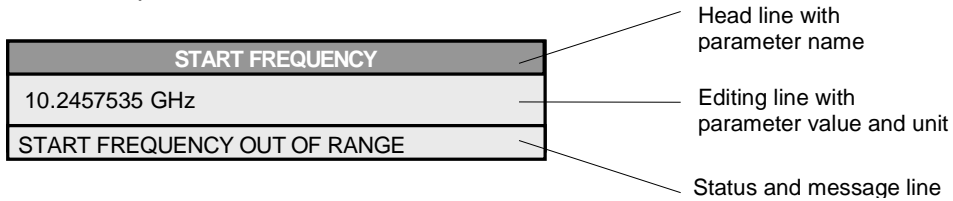
The headline indicates the name of the instrument parameter, which has been selected. The entry is made in the editing line. Subsequent to calling the entry window, the current parameter value including the unit is displayed left-justified in the editing line. Status and error messages which refer to the current entry are displayed in the third and (optionally) fourth line.

Note: *Entry windows may be represented transparent (cf. DISPLAY - CONFIG DISPLAY menu)*

Entry of a numeric value   ➢ Call data entry window (cf. selection of parameters)
                                        The editing line indicates the current value

                                      Example: center frequency (frequency-sweep mode)
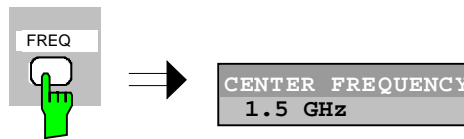
                   Entry via number keys   ➢ Enter required value via number keys.

                                      Example:
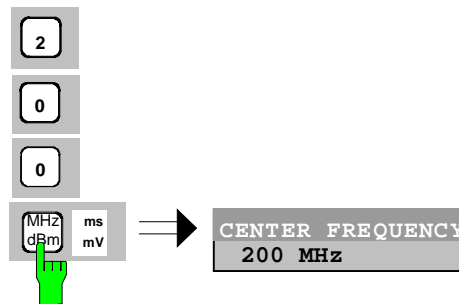
                   Entry via cursor keys   ➢ Cursor ⬆ or ⬇ until obtaining the required value.

                                      Example:
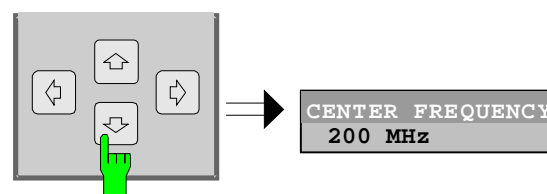
Entry via roll-key   ➢ Rotate the roll-key until reaching the required value.

The variation step size increases with increasing rotational speed.

Turning the roll-key clockwise increases the value, turning it counterclockwise decreases the value.

Example:

CENTER FREQUENCY
1.75 GHz
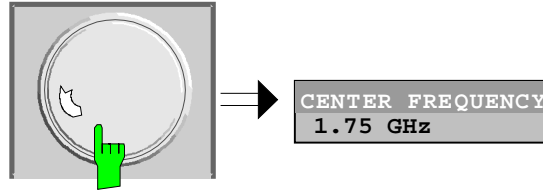
Note: *When the value is modified by means of the roll-key or the cursor keys the new value is immediately set.*

Terminating the entry   ➢ Press one of the unit keys

The unit is entered in the entry window and the new setting is accepted by the instrument.

For dimensionless quantities:

➢ Press the ENTER key or the roll-key

The new setting is accepted by the instrument.

A few data entry windows close automatically whereas others like the entry window for the start frequency remain open even after termination of the entry. They can be closed by pressing the *ESC* key.

If an error occurs, a corresponding error message is displayed in the status line of the entry window, e.g., "Out of range", "Value adjusted", etc. In this case, the new value is not accepted for the instrument setting.

Example:

CENTER FREQUENCY
0 Hz
out of range
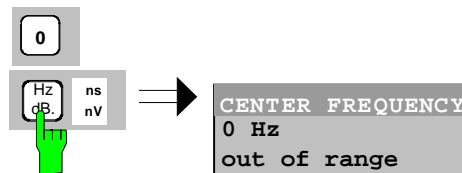
Correcting the entry

Deleting an entry   ➢ Position the cursor beside the digit which is to be deleted using the cursor keys ⬖ or ⬗ .

➢ Press the *BACK* key. The entry left to the cursor is deleted.

➢ Enter new numbers. The number is inserted to the left of the cursor, the other numbers are shifted right.

Restoring the original value   ➤ Press the *BACK* key

For numerous parameters, the data administration of the instrument stores the previously valid parameter value in addition to the current value. The BACK key can be used to toggle between these two values. This applies for terminated entries as long as the data entry window is displayed.

Aborting the entry   ➤ Press *ESC* key

The original parameter value is restored. The new entry is deleted.

➤ Press *ESC* key again

The entry window is closed, the original value remains active.

or

➤ Press any key or any softkey (even the softkey which has opened the entry window).

The entry is aborted and the entry window is closed. The original value remains active.

Entry of Alphanumeric Parameter

A help-line editor or an external keyboard (optional) are provided for the entry of alphanumeric instrument parameters.
The roll-key and the exponent key have no function with alphanumeric entry. All unit keys assume the function of an ENTER key.

The entry is always made in a data entry window which is displayed automatically upon selection of the parameter. The editing line comprises 60 characters. Up to 256 characters may be entered. If a text exceeds 60 characters the contents is shifted automatically 20 characters left or right when the left or right margin of the editing line is touched by the cursor.

Editing with External Keyboard
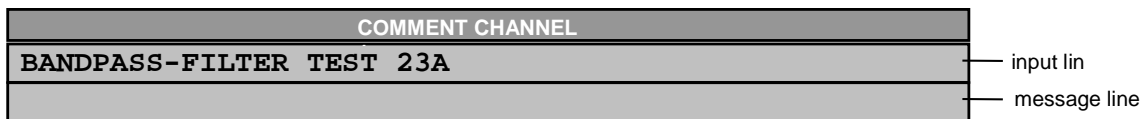
COMMENT CHANNEL
BANDPASS-FILTER TEST 23A   —— input lin
—— message line

Entry of text
> Select parameter.
  The data entry is active automatically upon calling the data entry window. The cursor is positioned at the beginning of the previous entry.

> Press the required character on the keyboard.
  The character is inserted prior to the cursor.

> Enter further characters

Correcting the entry
> Delete the entry using the *DELETE* key or *BACKSPACE* key.

Terminating the entry
> Press the *ENTER* key of the external keyboard
  The data entry window is closed and the new value is accepted for the instrument.

Aborting the entry
> Press the **ESC** key on the front panel

or

> any softkey.

  The data entry window is closed, the original value is retained.

Editing with Help Line Editor

If the external keyboard is not fitted, the help line editor is called automatically with entry of alphanumeric parameters. The help line editor is an extension of the alphanumeric entry window. It contains the complete alphabet with uppercase and lowercase letters as well as special characters in two lines of 52 characters, each. Individual letters and a series of special characters can be selected in the help line editor and copied into the entry line.

```
               CALIBRATION FILE
 C:\MEASDATA\STANDARD.CAL                              ──── input line

                                                      ──── message line

 ABCDEFGHIJKLMNOPQRSTUVWXYZÄÖÜ!?"$%/(){[]}\+*#~'-_=.:
 abcdefghijklmnopqrstuvwxyzäöüß,;<>|@µ²³^°1234567890   ──── help line editor
```
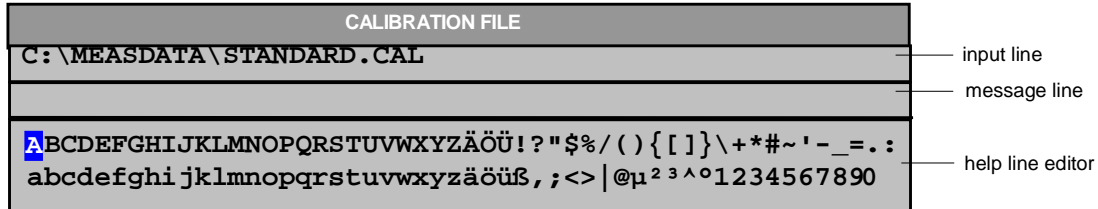
The cursor keys ⬆ or ⬇ toggle between entry in the editing line and selection in the help line editor.

Entry of text	➢ Select parameter. The data entry is active automatically upon calling the data entry window. The cursor is positioned on the left in the editing line.
	➢ Position the cursor in the help line editor using the cursor key. ⬇ The cursor marks the first letter of the editor.
	➢ Locate the cursor on the character which is to be entered into the editing line using the cursor keys ◁ or ▷ or the roll-key.
	➢ Press the *ENTER* key or the roll-key The character is entered in the editing line.
Correcting the entry	➢ Locate the cursor in the editing line using the cursor key ⬆.
	➢ Position the cursor after the character which is to be deleted using the cursor keys ◁ and ▷.
	➢ Press the *BACK* key. The entry left to the cursor is deleted.
Terminating the entry	➢ Locate the cursor in the editing line using the cursor key ⬆.
	➢ Press any unit key or the roll-key. The data entry window is closed, the new entry is accepted by the instrument.
Aborting the entry	➢ Press the *CLR* key. The data entry window is closed, the previous entry is retained.

Selection and Setting of Parameters via Tables

The FSP uses numerous tables for display and configuration of instrument parameters.

The tables differ considerably in the number of lines, columns and inscriptions. The basic steps of operation for the selection and setting of parameters are, however, the same for all tables. Shown below is the typical entry of parameters into a table.

Note:

Most of the tables are coupled to a softkey menu which provides further functions for editing table entries such as deletion of tables, copying of lines or columns, marking of table elements, restoring default states.

The definition of individual tables and the operation of particular editing functions can be looked up in the description of the corresponding softkey menu.

1. Activating the table

- If the menu has only one table, the latter is activated automatically subsequent to calling this menu in most cases and the marking cursor is positioned to the top field of the left column.

- If the menu contains various tables, the table of interest must be selected using the softkey which is labeled with the title of the table.

2. Selection of the parameter

marking cursor

LIMIT LINES					
NAME	COMPATIBLE	LIMIT CHECK	TRACE		MARGIN
GSM22UP	√	off	1		0 dB
√ LP1GHz		on	2	▼	0 dB
√ LP1GHz	√	off	1		0 dB
MIL461A		off	2		-10 dB

Selection of the parameter (or the setting) is made using the marking cursor.

➢ Press the cursor keys to move to the wanted field.

   or

➢ Rotate the roll-key until the wanted field is marked. The cursor keys are used to specify the direction of the roll-key movement (horizontal or vertical)

When shifting the cursor, elements may be skipped which can not be edited. Table elements, which can not be selected are indicated by a different color.

> Press the *ENTER* key or the roll-key.
> The parameter/the setting has been selected.

The selected parameter can be edited the way described below:

3. Editing the marked parameter

LIMIT LINES				
NAME	COMPATIBLE	LIMIT CHECK	TRACE	MARGIN
GSM22UP	√	off	1	0 dB
√ LP1GHz		on	2	0 dB
√ LP1GHz	√	off	1	0 dB
▲ MIL461A		off	2	-10 dB

checkmark

TRACE
1
√ 2
3

MARGIN
-10 dB

a) Toggling between two states

If an element of a table can be switched on and off only, the unit keys are used to toggle between these two states.

> Press one of the unit keys.
> The table element is switched on and provided with a checkmark. (√).

> Press one of the unit keys once more.
> The table element is switched off.

or

> Press one of the unit keys.
> The table element is switched on, "on" is displayed.

> Press one of the unit keys once more.
> The table element is switched off, "off" is displayed

b) Opening a data entry window

If a table entry consists of an (alpha-) numeric value, selection of the latter causes the corresponding entry window to be opened.

Note: *For numeric or alphanumeric instrument para-meters, the editing operation may be started by entering any number or letter on the front panel or on the external keyboard. In this case, the data entry window is opened automatically.*

c) Opening a selection table

If a table entry may have various states (e.g., colors from a color pallet, fixed filter bandwidths, etc.), a table indicating all possible states is displayed with selection. The current state is and marked by a checkmark and by the cursor.

➢ Set the cursor to the desired setting.

➢ Press one of the unit keys.
The setting is switched on and marked (√). The selection table closes and the value is transferred to the original table. The cursor is positioned automatically on the next table element.

Abortion of entry

➢ Press the *ESC* key.

The current entry/selection is aborted and the original setting is restored.

Scrolling

Some tables contain more entries than can be displayed on one screen page. In this case, a **scrollbar** is displayed at the right margin of the table, whose slider shows the current position in the text.

➢ Actuate the *PAGE UP* or *PAGE DOWN* softkeys.

The table is paged forward or back by one page.

➢ Press cursor key ⬆ or ⬇ .

The table is scrolled up or down by one line.

Menu Overview

The following section gives a graphical overview of the FSP menus. Side menus are marked by an arrow directed to the left/right, submenus by an arrow showing upwards.
The menus appear in the order corresponding to the arrangement of keys on the front panel. The available hotkeys and the LOCAL menu appearing during the remote control of the instrument are also displayed.

The functions of menus are described in detail in Chapter 4. The IEC/IEEE-bus command associated with each softkey is indicated. In addition, the softkey list at the of Chapter 6 gives the assignment of IEC/IEEE-bus commands to softkeys.

FREQUENCY Key

SPAN Key

```
┌──────┐        ┌──────────┐
│ SPAN │ ═════▶ │   SPAN   │
└──────┘        │  MANUAL  │
    ╖           └──────────┘
                ┌──────────┐
                │ SWEEPTIME│
                │  MANUAL  │
                └──────────┘
                ┌──────────┐
                │ FULL SPAN│
                └──────────┘
                ┌──────────┐
                │ ZERO SPAN│
                └──────────┘
                ┌──────────┐
                │ LAST SPAN│
                └──────────┘
                ┌──────────┐
                │          │
                └──────────┘
                ┌──────────┐
                │          │
                └──────────┘
                ┌──────────┐
                │          │
                └──────────┘
                ┌──────────┐
                │          │
                └──────────┘
```

AMPT Key

AMPT	→	REF LEVEL		REF LEVEL POSITION

RANGE LOG 100 dB		REF LEVEL OFFSET

RANGE LOG MANUAL		

RANGE LINEAR		GRID ABS REL

UNIT ⇩		

		EL ATTEN AUTO	Option FSP-B25

RF ATTEN MANUAL		EL ATTEN MANUAL	Option FSP-B25

RF ATTEN AUTO		EL ATTEN OFF	Option FSP-B25

		RF INPUT 50Ω 75Ω

⇨ ⇦

dBm

dBmV

dBµV

dBµA

dBpW

VOLT

AMPERE

WATT

⇧

MKR Key

```
MKR  ─────▶   ┌──────────┐        ┌──────────┐
              │ MARKER 1 │        │ MKR->TRACE│
              └──────────┘        └──────────┘

              ┌──────────┐        ┌──────────┐
              │ MARKER 2 │        │          │
              └──────────┘        └──────────┘

              ┌──────────┐        ┌──────────┐
              │ MARKER 3 │        │          │
              └──────────┘        └──────────┘

              ┌──────────┐        ┌──────────┐
              │ MARKER 4 │        │ CNT RESOL│
              └──────────┘        │  10 kHz  │
                                  └──────────┘
              ┌──────────┐        ┌──────────┐
              │ MARKER   │        │ CNT RESOL│
              │ NORM DELTA│       │   1 kHz  │
              └──────────┘        └──────────┘

              ┌──────────┐        ┌──────────┐
              │ SIGNAL   │        │ CNT RESOL│
              │ COUNT    │        │  100 Hz  │
              └──────────┘        └──────────┘

              ┌──────────┐        ┌──────────┐
              │ REFERENCE│        │ CNT RESOL│
              │ FIXED  ⇩ │        │  10 Hz   │
              └──────────┘        └──────────┘

              ┌──────────┐        ┌──────────┐
              │ MARKER   │        │ CNT RESOL│
              │ ZOOM     │        │   1 Hz   │
              └──────────┘        └──────────┘

              ┌──────────┐        ┌──────────┐
              │ ALL MARKER│       │ CNT RESOL│
              │ OFF      │        │  0.1 Hz  │
              └──────────┘        └──────────┘
                  ⇨                    ⇦
```

```
                         ┌──────────┐
                         │ REF FXD  │
                         │ ON   OFF │
                         └──────────┘

                         ┌──────────┐
                         │ REF POINT│
                         │  LEVEL   │
                         └──────────┘

                         ┌──────────┐
                         │ REF POINT│
                         │ LVL OFFSET│
                         └──────────┘

                         ┌──────────┐
                         │ REF POINT│
                         │ FREQUENCY│
                         └──────────┘

                         ┌──────────┐
                         │ REF POINT│
                         │  TIME    │
                         └──────────┘

                         ┌──────────┐
                         │ PEAK     │
                         │ SEARCH   │
                         └──────────┘

                         ┌──────────┐
                         │          │
                         └──────────┘

                         ┌──────────┐
                         │          │
                         └──────────┘

                         ┌──────────┐
                         │          │
                         └──────────┘
                            ⇧
```

MKR-> Key

```
  MKR▸  →    SELECT              MKR -> CF
            MARKER              STEPSIZE

            PEAK                   MIN               ABSOLUTE
                                                     PEAK/MIN
            CENTER
            =MKR FREQ           NEXT MIN             SEARCH
                                                     NEXT LEFT
            REF LEVEL
            =MKR LVL            NEXT MODE             SEARCH
                                   ⇩                 NEXT RIGHT
            NEXT PEAK



            NEXT MODE
               ⇩


            SEARCH
            LIMITS ⇩

            PEAK                EXCLUDE
            EXCURSION             LO

            MRK->TRACE
               ⇨                  ⇦                    ⇧


                                LEFT
                                LIMIT

                                RIGHT
                                LIMIT

                                THRESHOLD






                                SEARCH LIM
                                  OFF
                                  ⇧⇧
```

MKR FCTN Key

```
 ┌──────┐         ┌──────────┐                                                          ┌──────────┐
 │ MKR  │    ───▶ │  SELECT  │                                                          │ PH NOISE │
 │ FCTN │         │  MARKER  │                                                          │ ON   OFF │
 └──────┘         └──────────┘                                                          └──────────┘
                  ┌──────────┐                              ┌──────────┐                ┌──────────┐
                  │   PEAK   │                              │   NEW    │                │REF POINT │
                  │          │                              │  SEARCH  │                │  LEVEL   │
                  └──────────┘                              └──────────┘                └──────────┘
                  ┌──────────┐                              ┌──────────┐                ┌──────────┐
                  │NOISE MEAS│                              │SORT MODE │                │REF POINT │
                  └──────────┘           ┌──────────┐       │FREQ LEVEL│                │LVL OFFSET│
                  ┌──────────┐           │MKR DEMOD │       └──────────┘                └──────────┘
                  │  PHASE   │           │ ON   OFF │       ┌──────────┐                ┌──────────┐
                  │ NOISE ⬇  │           └──────────┘       │          │                │REF POINT │
                  └──────────┘           ┌──────────┐       └──────────┘                │FREQUENCY │
                  ┌──────────┐           │    AM    │       ┌──────────┐                └──────────┘
                  │          │           └──────────┘       │   PEAK   │                ┌──────────┐
                  └──────────┘           ┌──────────┐       │ EXCURSION│                │   PEAK   │
                  ┌──────────┐           │    FM    │       └──────────┘                │  SEARCH  │
                  │ N DB DOWN│           └──────────┘       ┌──────────┐                └──────────┘
                  └──────────┘           ┌──────────┐       │          │                ┌──────────┐
                  ┌──────────┐           │          │       └──────────┘                │          │
                  │  PEAK    │           └──────────┘       ┌──────────┐                └──────────┘
                  │  LIST ⬇  │           ┌──────────┐       │   LEFT   │                ┌──────────┐
                  └──────────┘           │   MKR    │       │  LIMIT   │                │          │
                  ┌──────────┐           │STOP TIME │       └──────────┘                └──────────┘
                  │  MARKER  │           └──────────┘       ┌──────────┐                ┌──────────┐
                  │ DEMOD ⬇  │           ┌──────────┐       │  RIGHT   │                │          │
                  └──────────┘           │   CONT   │       │  LIMIT   │                └──────────┘
                  ┌──────────┐           │  DEMOD   │       └──────────┘                     ⇧
                  │MRK->TRACE│           └──────────┘       ┌──────────┐
                  └──────────┘           ┌──────────┐       │THRESHOLD │
                                         │          │       └──────────┘
                                         └──────────┘       ┌──────────┐
                                         ┌──────────┐       │ PEAK LIST│
                                         │          │       │   OFF    │
                                         └──────────┘       └──────────┘
                                              ⇧                   ⇧
```

MEAS Key

BW Key

BW →	RES BW MANUAL		RBW/VBW SINE [1/3]
	VIDEO BW MANUAL		RBW/VBW PULSE [.1]
	SWEEPTIME MANUAL	VBW MODE LIN LOG	RBW/VBW NOISE [10]
	RES BW AUTO		RBW/VBW MANUAL
	VIDEO BW AUTO		
	SWEEPTIME AUTO		SPAN/RBW AUTO [50]
	COUPLING RATIO ⇩		SPAN/RBW MANUAL
	DEFAULT COUPLING		
	FILTER TYPE		

SWEEP Key

```
┌────────┐        ┌──────────────┐
│ SWEEP  │ ──────▶│  CONTINUOUS  │
└────────┘        │    SWEEP     │
                  └──────────────┘
                  ┌──────────────┐
                  │   SINGLE     │
                  │    SWEEP     │
                  └──────────────┘
                  ┌──────────────┐
                  │  CONTINUE    │
                  │  SGL SWEEP   │
                  └──────────────┘
                  ┌──────────────┐
                  │  SWEEPTIME   │
                  │   MANUAL     │
                  └──────────────┘
                  ┌──────────────┐
                  │  SWEEPTIME   │
                  │    AUTO      │
                  └──────────────┘
                  ┌──────────────┐
                  │   SWEEP      │
                  │   COUNT      │
                  └──────────────┘
                  ┌──────────────┐
                  │   SWEEP      │
                  │   POINTS     │
                  └──────────────┘
                  ┌──────────────┐
                  │              │
                  └──────────────┘
                  ┌──────────────┐
                  │  SGL SWEEP   │
                  │  DISP OFF    │
                  └──────────────┘
```

TRIG Key

		Option FSP-B6	Option FSP-B6	
TRIG	FREE RUN	TV TRIG SETTINGS	TV TRIGGER ON **OFF**	GATE MODE LEVEL **EDGE**
	VIDEO		VERT SYNC	POLARITY **POS** NEG
	EXTERN		VERT SYNC ODD FIELD	GATE DELAY
	IF POWER		VERT SYNC EVEN FIELD	GATE LENGTH
Option FSP-B6	RF POWER		HOR SYNC	
	TRIGGER OFFSET			SWEEPTIME
	POLARITY **POS** NEG		VIDEO POL POS **NEG**	
	GATED TRIGGER		LINES **625** 525	
	GATE SETTINGS		CCVS **INT** EXT	PRINT SCREEN

TRACE Key

LINES Key

DISP Key

FILE Key

```
┌──────┐         ┌──────────┐
│ FILE │ ───────▶│   SAVE   │
└──────┘         └──────────┘

                 ┌──────────┐
                 │  RECALL  │
                 └──────────┘

                 ┌──────────┐
                 │   EDIT   │
                 │ COMMENT  │
                 └──────────┘

                 ┌──────────┐                              ┌──────────┐
                 │ ITEMS TO │ ────────────────────────────▶│  SELECT  │
                 │SAVE/RCL ⇩│                              │  ITEMS   │
                 └──────────┘                              └──────────┘

                 ┌──────────┐                              ┌──────────┐
                 │ DATA SET │                              │  ENABLE  │
                 │   LIST   │                              │ALL ITEMS │
                 └──────────┘                              └──────────┘

                 ┌──────────┐                              ┌──────────┐
                 │ DATA SET │                              │ DISABLE  │
                 │  CLEAR   │                              │ALL ITEMS │
                 └──────────┘                              └──────────┘

                 ┌──────────┐     ┌──────────┐             ┌──────────┐
                 │ DATA SET │     │   EDIT   │             │          │
                 │CLEAR ALL │     │   PATH   │             │          │
                 └──────────┘     └──────────┘             └──────────┘

                 ┌──────────┐     ┌──────────┐             ┌──────────┐
                 │ STARTUP  │     │   MAKE   │             │          │
                 │  RECALL  │     │DIRECTORY │             │          │
                 └──────────┘     └──────────┘             └──────────┘

                 ┌──────────┐     ┌──────────┐             ┌──────────┐
                 │   FILE   │ ───▶│  FORMAT  │             │          │
                 │MANAGER ⇩ │     │   DISK   │             │          │
                 └──────────┘     └──────────┘             └──────────┘

                                  ┌──────────┐             ┌──────────┐
                                  │  RENAME  │             │          │
                                  └──────────┘             └──────────┘

                                  ┌──────────┐             ┌──────────┐
                                  │   SORT   │             │ DEFAULT  │
                                  │   MODE   │             │  CONFIG  │
                                  └──────────┘             └──────────┘
                                                                ⇧
                                  ┌──────────┐
                                  │   COPY   │
                                  └──────────┘

                                  ┌──────────┐
                                  │  DELETE  │
                                  └──────────┘

                                  ┌──────────┐
                                  │          │
                                  └──────────┘

                                  ┌──────────┐
                                  │          │
                                  └──────────┘
                                       ⇧⇧
```

CAL Key

CAL	→	CAL TOTAL
		CAL ABORT
		CAL CORR ON OFF
		CAL RESULTS
		PAGE UP
		PAGE DOWN

SETUP Key

HCOPY Key

Hotkey Menu

SPECTRUM						SCREEN B

LOCAL Menu

LOCAL

Menu Overview Network Mode

Menu Overview Option Ext. Generator Control

```
NETWORK  →  ┌──────────┐        ┌──────────┐        ┌──────────┐
 👆         │          │        │   CAL    │        │ EXT SRC  │
            └──────────┘   →    │  TRANS   │   →    │ ON   OFF │
            ┌──────────┐        ├──────────┤        ├──────────┤
            │          │        │ CAL REFL │        │  SELECT  │
            └──────────┘        │  SHORT   │        │GENERATOR │
            ┌──────────┐        ├──────────┤        ├──────────┤
            │          │        │ CAL REFL │        │FREQUENCY │
            └──────────┘        │  OPEN    │        │  SWEEP   │
            ┌──────────┐        ├──────────┤        ├──────────┤
            │ SOURCE   │        │NORMALIZE │        │          │
            │ CAL  ⬇   │        ├──────────┤        └──────────┘
            └──────────┘        │REF VALUE │        ┌──────────┐
            ┌──────────┐        │ POSITION │        │          │
            │          │        ├──────────┤        └──────────┘
            └──────────┘        │REF VALUE │        ┌──────────┐
            ┌──────────┐        ├──────────┤        │          │
            │          │        │ RECALL   │        └──────────┘
            └──────────┘        ├──────────┤        ┌──────────┐
            ┌──────────┐        │          │        │          │
            │          │        └──────────┘        └──────────┘
            └──────────┘        ┌──────────┐        ┌──────────┐
            ┌──────────┐        │          │        │          │
            │ EXT      │        └──────────┘        └──────────┘
            │ SOURCE⬇  │              ⬆                   ⬆
            └──────────┘
            ┌──────────┐
            │          │
            └──────────┘
```

Contents - Chapter 4 "Instrument Functions"

4 Instrument Functions

All functions of the spectrum analyzer and their application are explained in detail in this chapter. The sequence of the described menu groups depends on the procedure selected for the configuration and start of a measurement:

1. Resetting the instrument - *PRESET* key

2. Setting the mode – hotkey bar and *LOCAL* key

3. Setting the measurement parameters - keys *FREQ, SPAN, AMPT, BW, SWEEP, TRIG, TRACE, CAL*

4. Selecting and configuring the measurement function - keys *MKR, MKR->, MKR FCTN, MEAS, LINES*

The instrument functions for general settings, printout and data management are described at the end of this chapter – keys *DISP, SETUP, FILE* and *HCOPY*.

The different softkeys of a menu are described from top to bottom and from the left to the right side menu. The submenus are marked by an indentation or displayed in a separate section. The whole path (key - softkey - ...) is indicated in the line above the menu display.

An overview of the menus is given in chapter 3 which also contains the description of the operating concept.

The IEC/IEEE-bus commands (if any) are indicated for each softkey. For a fast overview a list of softkeys with the associated IEC/IEEE-bus commands is given at the end of Chapter 6.

An index at the end of the handbook serves as further help for the user.

FSP Initial Configuration – *PRESET* Key
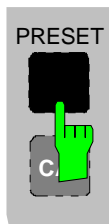
Using the *PRESET* key, the FSP can be set to a predefined initial state.

Notes: *The settings are selected in a way that the RF input is always protected against overload, provided that the applied signal levels are in the allowed range for the instrument.*

The initial instrument state set by the PRESET key can be adapted to arbitrary applications using the STARTUP RECALL function. With this function the STARTUP RECALL dataset is loaded upon pressing the PRESET key. For further information refer to section "Saving and Recalling Data Sets".

Pressing the *PRESET* key causes the FSP to enter its initial state according to the following table:

Table 4-1   Initial State of FSP

Parameter	Settings
Mode	Spectrum
Center frequency)	1,5 GHz / 3,5 GHz / 6,8 GHz / 15 GHz / 20 GHz (FSP-3/-7/-13/-30/-40)
Center frequency step size	0.1 * center frequency
Span	3 GHz / 7 GHz / 13.6 GHz / 30 GHz / 40 GHz (FSP-3/-7/-13/-30/-40)
RF attenuation	auto (10 dB)
Reference level	-20 dBm
Level range	100 dB log
Level unit	dBm
Sweep time	auto
Resolution bandwidth	auto (3 MHz)
Video bandwidth	auto (10 MHz)
FFT filters	off
Span / RBW	50
RBW / VBW	0.33
Sweep	cont
Trigger	free run
Trace 1	clr write
Trace 2/3	blank
Detector	auto peak
Trace math	off
Frequency offset	0 Hz
Reference level offset	0 dB
Reference level position	100 %
Grid	abs
Cal correction	on
Noise source	off
Input	RF
Display	Full screen, active screen A
Tracking generator (only with option FSP-B9)	off
External generator 1/2 (only with option -B10)	off
Preamplifier (only with option -B25)	off
El. Attenuation (only with option -B25)	off

Mode Selection – *HOTKEY* Bar

For fast mode selection FSP has seven keys (the so-called *HOTKEY*s) which can be allocated depending on the options installed on the instrument.
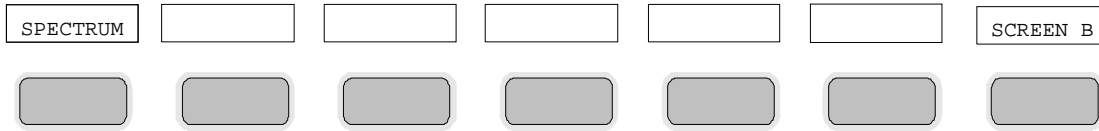
Two keys are reserved for the basic model:
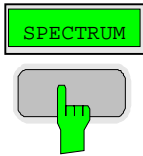
The *SPECTRUM* hotkey sets FSP to spectrum analysis mode.

The spectrum analysis mode is the basic setting of FSP.

IEC/IEEE-bus command: INST:SEL SAN
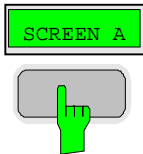
With the *SCREEN A / SCREEN B* hotkey two different settings can be selected on the FSP in the FULL SCREEN mode.

In the SPLIT SCREEN mode the key switches between active diagram A and B.

The key designation indicates the diagram which has been activated by means of the key.

The currently active window is marked by **A** or **B** on the right of the diagram.

IEC/IEEE-bus command: DISP:WIND<1|2>:SEL

The meaning of the other keys is described in the operating manuals of the various options.

Return to Manual Control – *LOCAL* Menu
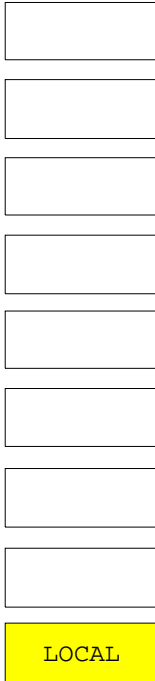
The menu LOCAL is displayed on switching the instrument to remote control mode.

At the same time, the *HOTKEY* bar is blanked out and all keys are disabled except the *PRESET* key. The diagram, traces and display fields are then blanked out (they can be activated using the remote control command `SYSTem:DISPlay:UPDate ON`).

The menu contains only one softkey, the *LOCAL* key. The *LOCAL* key switches the instrument from remote to manual control, with the assumption that the remote controller has not previously set the LOCAL LOCKOUT function.

A change in the control mode consists of:

- **Enabling the Front Panel Keys**
  Returning to manual mode enables all inactive keys and turns on the hotkey menu. The soft key menu which is displayed is the main menu of the current mode.

  Inserting the measurement diagrams
  The blanked diagrams, traces and display fields are inserted.

- **Generating the message OPERATION COMPLETE**
  If, at the time of pressing the *LOCAL* softkey, the synchronisation mechanism via *OPC, *OPC? or *WAI is active, the currently running measurement procedure is aborted and synchronisation is achieved by setting the corresponding bits in the registers of the status reporting system.

- **Setting Bit 6 (User Request) of the Event Status Register**
  With a corresponding configuration of the status reporting system, this bit immediately causes the generation of a service request (*SRQ*) which is used to inform the control software that the user wishes to return to front-panel control. This information can be used, e.g., to interrupt the control program so that the user can make necessary manual corrections to instrument settings. This bit is set each time the *LOCAL* softkey is pressed.

Note: If the LOCAL LOCKOUT function is active in the remote control mode, the front-panel PRESET key is also disabled. The LOCAL LOCKOUT state is left as soon as the process controller de-activates the REN line or the IEC/IEEE-bus cable is disconnected from the instrument.

LOCAL

Spectrum Analyzer Mode

The analyzer mode is activated by pressing hotkey *SPECTRUM* (see also Section 'Mode Selection')
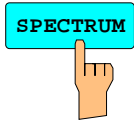
The *SPECTRUM* hotkey selects the *ANALYZER* mode.

This mode is the default setting of the FSP.

The functions provided correspond to those of a conventional spectrum analyzer. The analyzer measures the frequency spectrum of the test signal over the selected frequency range with the selected resolution and sweep time, or, for a fixed frequency, displays the waveform of the video signal.

Note: *If two displays (screen A and screen B) are opened after switch-on of signal analysis, the analyzer mode is only set for the display activated for entry (marked at the top right corner of diagram). For the other display, the previous settings remain valid.*
Data acquisition and display of measured values is sequential: first in the upper and then in the lower display.

Frequency and Span Selection – *FREQ* Key

The *FREQ* key is used to specify the frequency axis of the active display window. The frequency axis can be defined either by the start and stop frequency or by the center frequency and the span (*SPAN* key). With two windows (*SPLIT SCREEN)* displayed at the same time, the input data always refer to the window selected in the *SYSTEM-DISPLAY* menu.
After pressing one of the *CENTER*, *START* or *STOP* softkeys*,* the value of the corresponding parameter can be defined in an input window.

FREQ menu:

```
                              Span <> 0         Span = 0
```
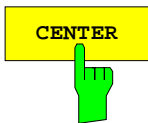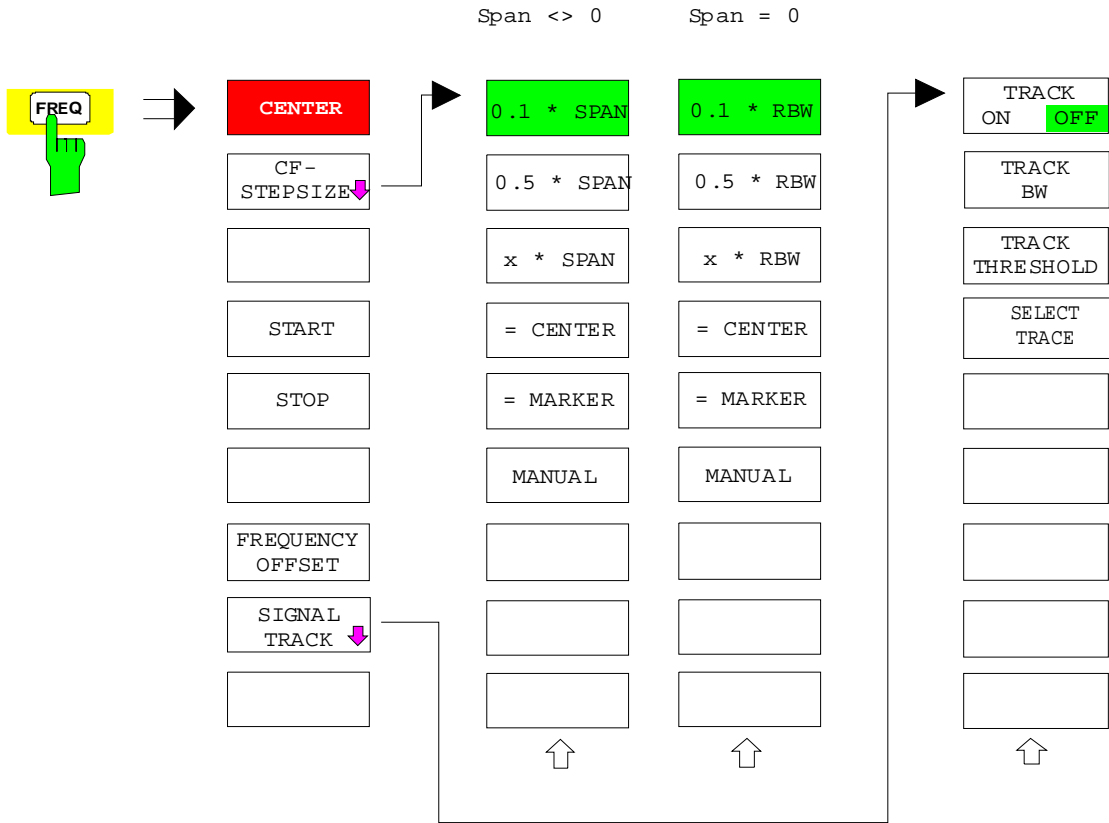

The *CENTER* softkey opens the window for manually entering the center frequency.

The allowed range of values for the center frequency is:

for the frequency domain (span >0):

$$\text{minspan} / 2 \le f_{center} \le f_{max} - \text{minspan} / 2$$

and for the time domain (span = 0):

$$0 \text{ Hz} \le f_{center} \le f_{max}$$

f_{center}	center frequency
minspan	smallest selectable span > 0 Hz (10 Hz)
f_{max}	max. frequency

IEC/IEEE-bus command: `FREQ:CENT 100MHz`
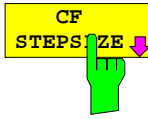
CF STEPSIZE

The CF *STEPSIZE* softkey opens a submenu for setting the step size of the center frequency. The step size can be coupled to the span (frequency domain) or the resolution bandwidth (time domain) or it can be manually set to a fixed value. The softkeys are mutually exclusive selection keys.

The softkeys are presented according to the selected domain (frequency or time).

Softkeys in frequency domain:

AUTO 0.1 * SPAN
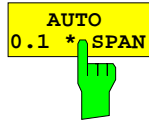
The *0.1 * SPAN* softkey sets the step size for the center frequency entry to 10% of the span.

IEC/IEEE-bus command:
```
FREQ:CENT:STEP:LINK SPAN
FREQ:CENT:STEP:LINK:FACT 10PCT
```

AUTO 0.5 * SPAN
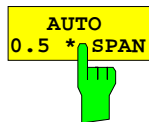
The *0.5 * SPAN* softkey sets the step size for the center frequency entry to 50% of the span.

IEC/IEEE-bus command:
```
FREQ:CENT:STEP:LINK SPAN
FREQ:CENT:STEP:LINK:FACT 50PCT
```

AUTO X * SPAN

The *X * SPAN* softkey allows the factor defining the center frequency step size to be entered as % of the span.

IEC/IEEE-bus command:
```
FREQ:CENT:STEP:LINK SPAN
FREQ:CENT:STEP:LINK:FACT 20PCT
```

= CENTER

The *= CENTER* softkey sets the step size coupling to *MANUAL* and the step size to the value of the center frequency. This function is especially useful during measurements of the signal harmonic content because by entering the center frequency each stroke of the *STEP* key selects the center frequency of another harmonic.

IEC/IEEE-bus command: --

= MARKER

The *= MARKER* softkey sets the step size coupling to *MANUAL* and the step size to the value of the marker. This function is especially useful during measurements of the signal harmonic content at the marker position because by entering the center frequency each stroke of the *STEP* key selects the center frequency of another harmonic.

IEC/IEEE-bus command: --

MANUAL

The *MANUAL* softkey activates the window for entering a fixed step size.

IEC/IEEE-bus command: `FREQ:CENT:STEP 120MHz`

Softkeys in time domain:
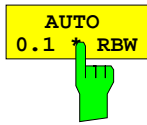
The *0.1 * RBW* softkey sets the step size for the center frequency entry to 10% of the resolution bandwidth.

AUTO 0.1 * RBW corresponds to the default setting.

IEC/IEEE-bus command:
```
FREQ:CENT:STEP:LINK RBW
FREQ:CENT:STEP:LINK:FACT 10PCT
```
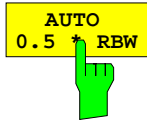
The *0.5 * RBW* softkey sets the step size for the center frequency entry to 50% of the resolution bandwidth.

IEC/IEEE-bus command:
```
FREQ:CENT:STEP:LINK RBW
FREQ:CENT:STEP:LINK:FACT 50PCT
```
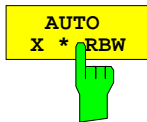
The *X * RBW* softkey allows the factor defining the center frequency step size to be entered as % of the resolution bandwidth.

Values between 1 and 100% in steps of 1% are allowed. The default setting is 10%.

IEC/IEEE-bus command:
```
FREQ:CENT:STEP:LINK RBW
FREQ:CENT:STEP:LINK:FACT 20PCT
```
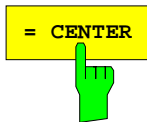
The *= CENTER* softkey sets the step size coupling to *MANUAL* and the step size to the value of the center frequency. This function is especially useful during measurements of the signal harmonic content because by entering the center frequency each stroke of the *STEP* key selects the center frequency of another harmonic.

IEC/IEEE-bus command: --

The *= MARKER* softkey sets the step size coupling to *MANUAL* and the step size to the value of the marker. This function is especially useful during measurements of the signal harmonic content at the marker position because by entering the center frequency each stroke of the *STEP* key selects the center frequency of another harmonic.

IEC/IEEE-bus command: --
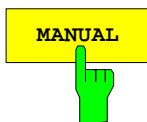
The *MANUAL* softkey activates the window for entering a fixed step size.

IEC/IEEE-bus command:
```
FREQ:CENT:STEP 120MHz
```
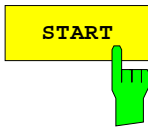
START

The *START* softkey activates the window for manually entering the start frequency.

The allowed range of values for the start frequency is:

$0 \text{ Hz} \leq f_{start} \leq f_{max} - \text{minspan}$

f_{start}	start frequency
minspan	smallest selectable span (10 Hz)
f_{max}	max. frequency

IEC/IEEE-bus command: FREQ:STAR 20MHz
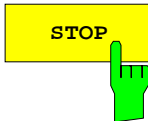
STOP

The *STOP* softkey activates the window for entering the .

The allowed range of values for the stop frequency is:

$\text{minspan} \leq f_{stop} \leq f_{max}$

f_{stop}	stop frequency
minspan	smallest selectable span (10 Hz)
f_{max}	max. frequency

IEC/IEEE-bus command: FREQ:STOP 2000MHz
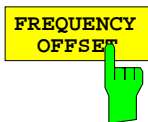
FREQUENCY OFFSET

The *FREQUENCY OFFSET* softkey activates the window for entering an arithmetical frequency offset which is added to the frequency axis labelling. The allowed range of values for the offset is -100 GHz to 100 GHz. The default setting is 0 Hz.

IEC/IEEE-bus command: FREQ:OFFS 10 MHz

SIGNAL TRACK

The *SIGNAL TRACK* softkey switches on the tracking of a signal near the center frequency. The signal is tracked as long it is in the search bandwidth around the center frequency defined with *TRACK BW* and above the level threshold defined with *TRACK THRESHOLD*.

For that purpose, the maximum signal is searched (*PEAK SEARCH)* on the screen and the center frequency set to this signal (*MARKER ->CENTER)* after each frequency sweep within the search bandwidth.

If the signal falls below the level threshold or jumps out of the search bandwidth around the center frequency, the center frequency is not varied until a signal is in the search bandwidth above the level threshold. This can be achieved by manually modifying the center frequency, for example.

On switching on, the softkey is highlighted and the search bandwidth and the threshold value are marked on the diagram by two vertical lines and one horizontal line. All these lines are allocated the designation TRK.

At the same time a submenu is opened in which the search bandwidth, the threshold value and the trace can be modified for the maximum search.

The softkey is only available in the frequency domain (span >0).

IEC/IEEE-bus command: `CALC:MARK:FUNC:STR OFF`

TRACK ON/OFF

The *TRACK ON/OFF* softkey switches on and off signal tracking.

IEC/IEEE-bus command: `CALC:MARK:FUNC:STR OFF`

TRACK BW

The *TRACK BW* softkey defines the search bandwidth for signal tracking. The frequency range is symmetrical with respect to the center frequency.

IEC/IEEE-bus command:
`CALC:MARK:FUNC:STR:BAND 10KHZ`

TRACK THRESHOLD

The *TRACK THRESHOLD* softkey defines the threshold value for signal detection. The value is always entered as an absolute level value.

IEC/IEEE-bus command:
`CALC:MARK:FUNC:STR:THR -70DBM`
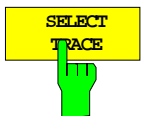
SELECT TRACE

The *SELECT TRACE* softkey selects the trace on which signal tracking is to be performed.

IEC/IEEE-bus command:
`CALC:MARK:FUNC:STR:TRAC 1`

Setting the Frequency Span – *SPAN Key*

SPAN menu
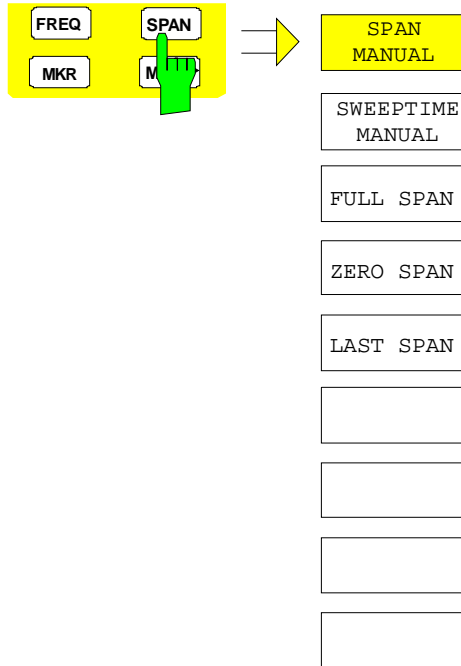
The *SPAN* key opens a menu which offers various options for setting the span.
The entry of the span (*SPAN MANUAL* softkey) is automatically active for span > 0 Hz.
For span = 0 Hz the entry for sweep time (*SWEEPTIME MANUAL*) is automatically active.
With two windows (*SPLIT SCREEN)* displayed at the same time, the input data always refer to the window selected with hotkey *SCREEN A/B*.
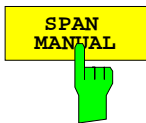
The *SPAN MANUAL* softkey activates the window for manually entering the frequency span. The center frequency is kept constant.

The allowed range of span values is:

for the time domain (span = 0):   0 Hz

and for the frequency domain (span >0):   minspan $\leq f_{span} \leq f_{max}$

f_{span} frequency span

minspan   smallest selectable span (10 Hz)

f_{max} max. frequency

IEC/IEEE-bus command   FREQ:SPAN 2GHz

The *SWEEPTIME MANUAL* softkey activates the window for entering the sweep time manually with Span = 0 Hz. The softkey is not available for Span > 0 Hz.

IEC/IEEE-bus command: SWE:TIME 10s
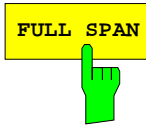
FULL SPAN

The *FULL SPAN* softkey sets the span to the full frequency range of FSP.

IEC/IEEE-bus command   `FREQ:SPAN:FULL`
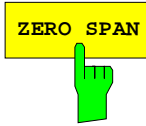
ZERO SPAN

The *ZERO SPAN* softkey sets the span to 0 Hz. The x axis becomes the time axis with the grid lines corresponding to 1/10 of the current sweep time (SWT).

IEC/IEEE-bus command   `FREQ:SPAN 0Hz`
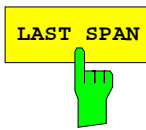
LAST SPAN

After changing the span setting the *LAST SPAN* softkey activates the previous setting. With this function a fast change between overview measurement (*FULL SPAN*) and detailed measurement (manually set center frequency and span) is possible.

Note: *Only values > 0 Hz are restored, i.e. a transition between time and frequency domain is not possible.*

IEC/IEEE-bus command   `---`

Level Display Setting and RF Input Configuration – *AMPT Key*

The *AMPT* key is used to set the reference level, the maximum level and the display range of the active window as well as the input impedance and the input attenuation of the RF input.

The *AMPT* key opens a menu for setting the reference level and the input attenuation of the active window. The data entry for the reference level (*REF LEVEL* softkey) is opened automatically.

Further settings regarding level display and attenuation can be made in this menu.
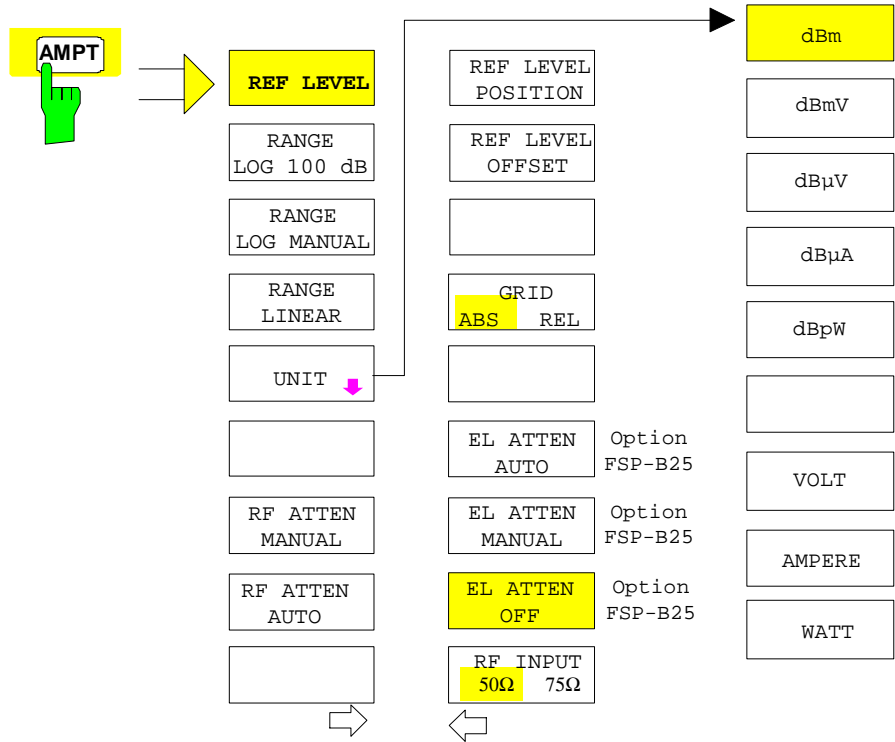
The *REF LEVEL* softkey allows the reference level to be input in the currently active unit (dBm, dBµV, etc).

IEC/IEEE-bus command: `DISP:WIND:TRAC:Y:RLEV –60dBm`
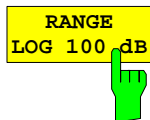
The *RANGE LOG 100 dB* softkey sets the level display range to 100 dB.

IEC/IEEE-bus command: `DISP:WIND:TRAC:Y:SPAC LOG`
                                                `DISP:WIND:TRAC:Y 100DB`

RANGE LOG MANUAL

The *RANGE LOG MANUAL* softkey activates the manual entry of the level display range. Display ranges from 10 to 200 dB are allowed in 10 dB steps. Inputs which are not allowed are rounded to the next valid value.

The default setting is 100 dB.

IEC/IEEE-bus command: `DISP:WIND:TRAC:Y:SPAC LOG`
`DISP:WIND:TRAC:Y 120DB`
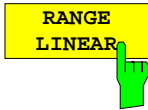
RANGE LINEAR

The *RANGE LINEAR* softkey switches the display range of the analyzer to linear scaling. The horizontal lines are labelled in %. The grid has a decadic scaling.

IEC/IEEE-bus command: `DISP:WIND:TRAC:Y:SPAC LIN`

UNIT

dBm
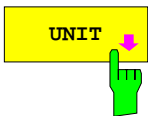
dBmV

dBµV

dBµA

dBpW

VOLT

AMPERE

WATT

The *UNIT* softkey opens a sub menu allowing to select the unit for the level axis.

The default setting is dBm.

In general, the spectrum analyzer measures the signal voltage at the RF input. The level display is calibrated in rms values of an unmodulated sinewave signal. In the default state, the level is displayed at a power of 1 mW (= dBm). Via the known input resistance of 50 Ω or 75Ω , conversion to other units is possible. The units dBm, dBmV, dBµV, dBµA, dBpW, V, A and W are directly convertible.

IEC/IEEE-bus command: `CALC:UNIT:POW DBM`
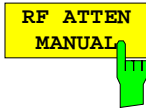
RF ATTEN
MANUAL

The *RF ATTEN MANUAL* softkey allows the attenuation to be entered irrespective of the reference level.

The attenuation can be set in 10 dB steps between 0 and 70 dB (in 5 dB steps between 0 and 75 dB if option FSP-B25, *Electronic Attenuator*, is fitted). Other entries will be rounded to the next lower integer value..

If the defined reference level cannot be set for the given RF attenuation, the reference level will be adjusted accordingly and the warning "Limit reached" will be output.

Note: *The 0-dB value can be entered only via the numeric keypad in order to protect the input mixer against occasional overload.*

IEC/IEEE-bus command: `INP:ATT 40 DB`

RF ATTEN
AUTO

The *RF ATTEN AUTO* softkey sets the RF attenuation automatically as a function of the selected reference level.
This ensures that the optimum RF attenuation desired by the user is always used.

RF ATTEN AUTO is the default setting.

IEC/IEEE-bus command: `INP:ATT:AUTO ON`

AMPT – NEXT menu:

> **REF LEVEL POSITION**

The *REF LEVEL POSITION* softkey allows the reference level position to be entered.

The setting range is from -200 to +200%, 0% corresponding to the lower and 100% to the upper limit of the diagram.

IEC/IEEE-bus command: `DISP:WIND:TRAC:Y:RPOS 100PCT`

> **REF LEVEL OFFSET**

The *REF LEVEL OFFSET* softkey allows the arithmetic level offset to be entered. This offset is added to the measured level irrespective of the selected unit. The scaling of the Y axis is changed accordingly.

The setting range is ±200 dB in 0.1 dB steps.

IEC/IEEE-bus command: `DISP:WIND:TRAC:Y:RLEV:OFFS –10dB`
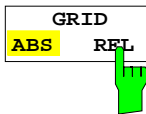
> **GRID**
> **ABS   REL**

The *GRID ABS/REL* softkey switches between absolute and relative scaling of the level axis.

G*RID ABS* is the default setting.

ABS　The labelling of the level lines refers to the absolute value of the reference level.

REL　The upper line of the grid is always at 0 dB.
　　　The scaling is in dB whereas the reference level is always
　　　in the set unit (dBm, dBμV,..).

For setting *RANGE LINEAR* (linear scaling, labelling of axes in %) the softkey is not displayed since the unit % itself implies a relative scale.

IEC/IEEE-bus command: `DISP:WIND:TRAC:Y:MODE ABS`
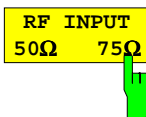
> **RF INPUT**
> **50Ω   75Ω**

The *RF INPUT 50 Ω / 75 Ω* softkey switches the input impedance of the instrument between 50 Ω (= default setting) and 75 Ω.

The setting 75 Ω should be used if the input impedance (50 Ω) is transformed to 75 Ω using the corresponding adapter unit of type RAZ (= 25 Ω in series to the input impedance of the analyzer). The correction value used for the adaption is 1.76 dB = 10 log (75Ω / 50Ω).

All levels specified in this operating manual refer to the default setting of the instrument (50 Ω).

IEC/IEEE-bus command: `INP:IMP 50OHM`

Electronic Attenuator

Besides the mechanical attenuator at the RF input, the FSP also offers an electronic attenuation setting (option *ELECTRONIC ATTENUATOR* FSP-*B25*). The attenuation range is 0 to 30 dB, with the default attenuation being preset by the mechanical attenuator.
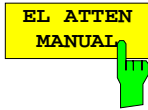
EL ATTEN MANUAL

The *EL ATTEN MANUAL* softkey switches the electronic attenuator on and allows the attenuation of the electronic attenuator to be set.

The attenuation can be varied in 5 dB steps from 0 to 30 dB. Other entries are rounded to the next lower integer value

If the defined reference level cannot be set for the given RF attenuation, the reference level will be adjusted accordingly and the warning "Limit reached" will be output.

IEC/IEEE-bus command: `INP:EATT:AUTO OFF`
                               `INP:EATT 10 DB`

This function is only available with option *ELECTRONIC ATTENUATOR FSP-B25*.

EL ATTEN AUTO

The *EL ATTEN AUTO* softkey switches the electronic attenuator on and automatically sets its attenuation to 0 dB.
The allowed setting range of the reference level ranges from the current reference level on switching on the electronic attenuator to over 30 dB. If a reference level is set outside the allowed 30-dB range, setting is performed by means of the mechanical attenuator. From this new reference level to over 30 dB the setting is again performed with the electronic attenuator.

IEC/IEEE-bus command: `INP:EATT:AUTO ON`

This function is only available with option *ELECTRONIC ATTENUATOR FSP-B25*.

EL ATTEN OFF

The *EL ATTEN OFF* softkey switches the electronic attenuator off.

IEC/IEEE-bus command: `INP:EATT:STAT OFF`

This function is only available with option *ELECTRONIC ATTENUATOR FSP-B25*.

Setting the Bandwidths and Sweep Time – *BW* Key

The *BW* key calls a menu for setting the resolution bandwidth (*RBW*), video bandwidth (*VBW*) and sweep time (*SWT*) for the frequency sweep. The parameters may be coupled dependent on the span (stop minus start frequency) or freely set by the user. When working with a split screen display, the settings always refer to the active window.

The FSP offers resolution bandwidths from 10 Hz to 10 MHz in 1, 3, 10 steps:
Resolution bandwidths up to 100 kHz are realized using digital bandpasses with Gaussian characteristics. As far as the attenuation characteristic is concerned they behave like analog filters but have a much higher measurement speed than comparable analog filters. This is due to the fact that the transient response can be compensated as a result of an accurately defined filter behaviour.

Bandwidths above 100 kHz are realized using decoupled 4-circuit LC filters.

As an alternative to the analog filters, FFT filters are available for the bandwidths between 1 Hz and 30 kHz. When working with bandwidths up to 30 kHz, the FFT algorithm offers considerably higher measurement speeds with all the other settings remaining the same. The reason is that with analog filters the sweep time required for a particular span is proportional to $(Span/RBW^2)$. When using the FFT algorithm, however, the sweep time is proportional to $(Span/RBW)$.

The video bandwidths are available in 1, 3, 10 steps between 1 Hz and 10 MHz. They can be set in accordance with the resolution bandwidth.

The video filters serve for smoothing the displayed trace. Video bandwidths that are small compared to the resolution bandwidth average out noise peaks and pulsed signals, so that only the signal average is displayed. If pulsed signals are to be measured, it is recommended to use a video bandwidth that is large compared to the resolution bandwidth (VBW $\geq$ 10 x RBW) for the amplitudes of pulses to be measured correctly.

Note: *For analog and digital filters, the FSP has overload reserves of different magnitude above the reference level. Due to the LO breakthrough the overload display OVLD responds with digital filters with RBW < 100 kHz,   as soon as the start frequency is selected <6 * resolution bandwidth, for RBW = 100 kHz, as soon as the start frequency is below 3 MHz.*

BW menu:
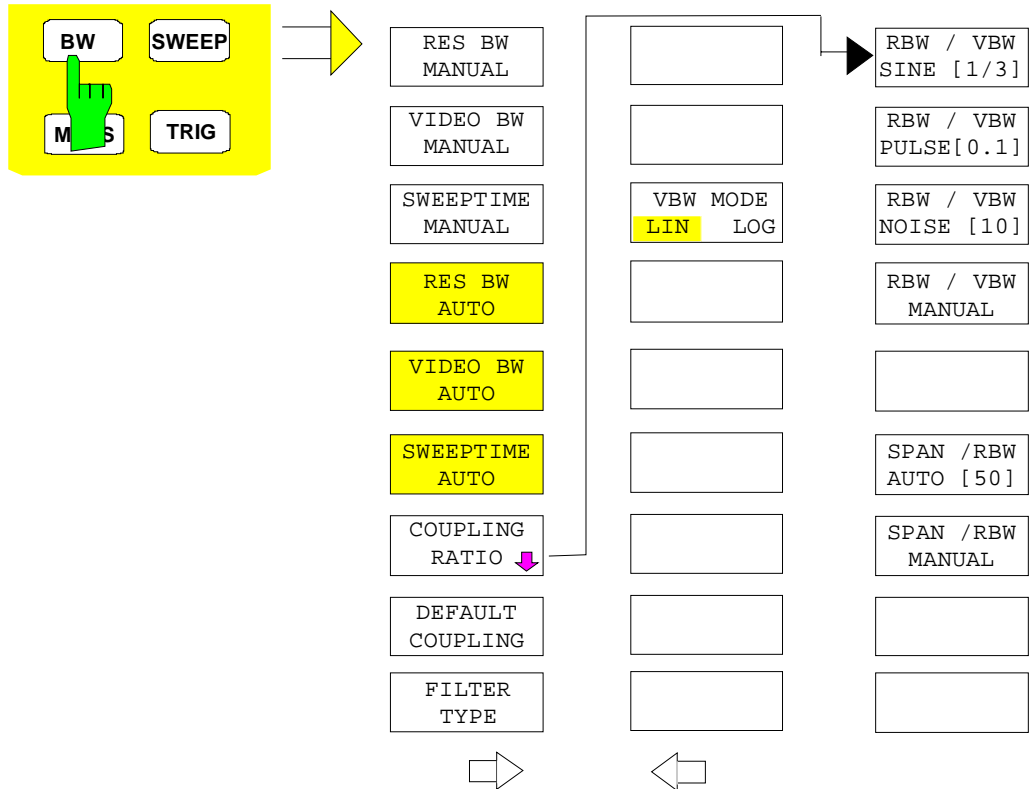
The *BW* key opens a menu for setting the resolution bandwidth, the video bandwidth, the sweep time and their couplings.

The .. *BW AUTO* softkeys are used to couple the functions. The coupling ratios are selected by means of the *COUPLING RATIO* softkey.

The .. *BW MANUAL* softkeys allow a parameter to be entered. This parameter is not coupled to the other parameters.

Note: *With the ... BW AUTO softkeys the resolution bandwidth, the video bandwidth and the sweep time can be entered separately for the frequency domain (span > 0 Hz) and the time domain (span = 0 Hz).*
             But with ...BW MANUAL softkeys the selected values apply to both the frequency and time domain.

```
  RES BW
  MANUAL
```
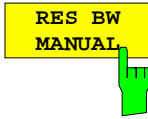
The *RES BW MANUAL* softkey activates the manual data entry for the resolution bandwidth.

The resolution bandwidth can be selected in 1/3/10 steps in the range between 10 Hz and 10 MHz. The nominal resolution bandwidth is the 3 dB bandwidth.

When FFT filters are used, the lower limit of the bandwidth is 1 Hz. FFT filters may be used with bandwidths up to 30 kHz.

For numeric inputs, the values are always rounded to the nearest possible bandwidth. For rollkey or UP/DOWN key inputs, the bandwidth is adjusted in steps either upwards or downwards.

For filter type CHANNEL or RRC the bandwidth is selected from the list of available channel filters given at the end of this chapter. For data entry, the cursor keys ↑ and ↓ scroll through this list.

The manual input mode of the resolution bandwidth is indicated by a green terisk (*) on the display.

IEC/IEEE-bus command: BAND:AUTO OFF;
                                 BAND 1MHz

```
 VIDEO BW
  MANUAL
```
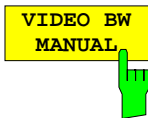
The *VIDEO BW MANUAL* softkey activates the manual data entry for the video bandwidth.

The video bandwidth can be selected in 1/3/10 steps in the range between 1 Hz and 10 MHz.
For numeric inputs, the values are always rounded to the nearest possible allowed bandwidth. For rollkey or UP/DOWN key inputs, the bandwidth is adjusted in steps either downwards or upwards.
The manual input mode of the video bandwidth is indicated by a green terisk (*) on the display.

IEC/IEEE-bus command: BAND:VID:AUTO OFF;
                                 BAND:VID 10 kHz
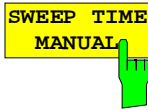
SWEEP TIME MANUAL

The *SWEEPTIME MANUAL* softkey activates the manual data entry for the sweep time. At the same time, the coupling of the sweep time is cancelled. Other couplings (*VIDEO BW, RES BW*) remain effective.

In the frequency domain (span > 0 Hz) and for resolution bandwidths above 1 kHz, the allowed sweep times for spans > 3.2 kHz range from 2.5 ms through to 16000 s. With spans below 3.2 kHz, the maximum allowed sweep time is reduced to 5 s * span/Hz.
If FFT filters are used, the sweep time is fixed by the span and the bandwidth and therefore cannot be set.
In time domain (span = 0 Hz), the range of sweep times is 1 μs to 16000 s is selectable in steps of max. 5% of the sweep time. For numeric inputs, rounding is made to the nearest possible sweep time. For rollkey or UP/DOWN key inputs, the sweep time is adjusted in steps either downwards or upwards.

The manual input mode of the sweep time is indicated by a green asterisk (*) on the display. If the selected sweep time is too short for the selected bandwidth and span, level measurement errors will occur. This happens because the available settling time for the resolution or video filters is too short. In this case, the FSP outputs *UNCAL* on the display and marks the indicated sweep time with a red asterisk (*).

IEC/IEEE-bus command: `SWE:TIME:AUTO OFF;`
                                `SWE:TIME 10s`
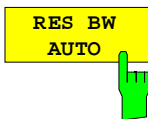
RES BW AUTO

The *RES BW AUTO* softkey couples the resolution bandwidth to the selected span. Changing the span causes automatic adjustment of the resolution bandwidth.

Automatic coupling of resolution bandwidth to span is always recommended when a favourable setting of the resolution bandwidth in relation to the selected span is desired for the measurement under request.

The coupling ratio is set in the *COUPLING RATIO* submenu.

The *RES BW AUTO* softkey is only available in the frequency domain (span > 0 Hz). The softkey is blanked in the time domain.

IEC/IEEE-bus command: `BAND:AUTO ON`
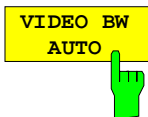
VIDEO BW AUTO

The *VIDEO BW AUTO* softkey couples the video bandwidth to the resolution bandwidth. If the resolution bandwidth is changed, the video bandwidth is automatically adjusted.

The coupling of the video bandwidth is always recommended when the minimum sweep time is required for a selected resolution bandwidth. Narrower video bandwidths require longer sweep times due to the longer settling time. Wider bandwidths reduce the signal/noise ratio.

The coupling ratio is set in the *COUPLING RATIO* submenu.

The coupling of the video bandwidth to the resolution filter is also permitted for the time domain display (span = 0).

IEC/IEEE-bus command: `BAND:VID:AUTO ON`
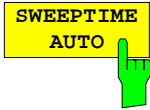
SWEEPTIME AUTO

The *SWEEPTIME AUTO* softkey couples the sweep time to the span, video bandwidth (VBW) and resolution bandwidth (RBW). The sweep time is automatically adjusted on any change in span, resolution bandwidth or video bandwidth.

The softkey is only available in the frequency domain (span >0 Hz). It is blanked in the time domain.

The FSP always selects the shortest sweep time possible without falsifying the signal. The maximum level error compared to using a longer sweep time is < 0.1 dB. If additional bandwidth and level errors are to be avoided, the sweep time is to be set to three times the time offered in coupled mode.

IEC/IEEE-bus command: SWE:TIME:AUTO ON

COUPLING RATIO

RBW / VBW SINE [1/3]

RBW / VBW PULSE [.1]

RBW / VBW NOISE [10]

RBW / VBW MANUAL

SPAN / RBW AUTO [50]

SPAN / RBW MANUAL
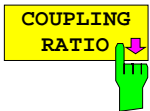
The *COUPLING RATIO* softkey opens a sub menu for selection of the coupling ratios.

When the default setting is active, i.e. the *COUPLING RATIO* softkey is deactivated (not highlighted), the ratio span/resolution bandwidth (SPAN/RBW) is 50 (this corresponds to SPAN / RBW AUTO [50]) and the ratio resolution bandwidth/video bandwidth (RBW/VBW) is 0.33 (this corresponds to RBW / VBW SINE [1/3]).

If the ratio RBW/VBW or SPAN/RBW is different from the default setting, the *COUPLING RATIO* softkey is highlighted.

The softkeys RBW/VBW... are selection keys. Only one softkey can be enabled at any one time. The softkeys are only effective for the *VBW AUTO* selection in the main menu.

The softkeys SPAN/RBW... are also selection keys. They are only effective for the *RBW AUTO* selection in the main menu.

RBW / VBW SINE [1/3]

The *RBW/VBW SINE [1/3]* softkey sets the following coupling ratio:
video bandwidth = 3 x resolution bandwidth.

This is the default setting for the coupling ratio resolution bandwidth/video bandwidth.

This is the coupling ratio recommended if sinusoidal signals are to be measured.

IEC/IEEE-bus command   BAND:VID:RAT 3

This setting is only effective for the *VBW AUTO* selection in the main menu.
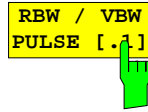
RBW / VBW PULSE [.1]

The *RBW/VBW PULSE [.1]* softkey sets the following coupling ratio:

video bandwidth = 10 x resolution bandwidth or
video bandwidth = 10 MHz (= max. VBW).

This coupling ratio is recommended whenever the amplitudes of pulsed signals are to be measured correctly. The IF filter is exclusively responsible for pulse shaping. No additional evaluation is performed by the video filter.

IEC/IEEE-bus command   `BAND:VID:RAT 10`

This setting is only effective for the *VBW AUTO* selection in the main menu.
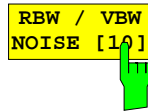
RBW / VBW NOISE [10]

The *RBW/VBW NOISE [10]* softkey sets the following coupling ratio:

video bandwidth = resolution bandwidth/10

At this coupling ratio, noise and pulsed signals are suppressed in the video domain. For noise signals, the average value is displayed.

IEC/IEEE-bus command   `BAND:VID:RAT 0.1`

This setting is only effective for the *VBW AUTO* selection in the main menu.
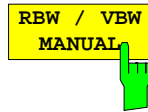
RBW / VBW MANUAL

The *RBW/VBW MANUAL* softkey activates the manual input of the coupling ratio.

The resolution bandwidth/video bandwidth ratio can be set in the range 0.001 to 1000.

IEC/IEEE-bus command   `BAND:VID:RAT 10`

This setting is only effective for the *VBW AUTO* selection in the main menu.
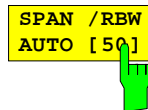
SPAN /RBW AUTO [50]

The *SPAN/RBW AUTO [50]* softkey sets the following coupling ratio:

resolution bandwidth = span/50

This coupling ratio is the default setting of the FSP

IEC/IEEE-bus command   `BAND:RAT 0.02`

This setting is only effective for the *RBW AUTO* selection in the main menu.
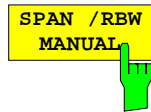
SPAN /RBW
MANUAL

The *SPAN/RBW MANUAL* softkey activates the manual input of the coupling ratio.

The span / resolution bandwidth ratio can be set in the range 1 to 10000.

IEC/IEEE-bus command   `BAND:RAT 0.1`

This setting is only effective for the *RBW AUTO* selection in the main menu.
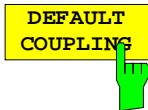
DEFAULT
COUPLING

The *DEFAULT COUPLING* softkey sets all coupled functions to the default state (*AUTO)*. In addition, the ratio *RBW/VBW* is set to *SINE [1/3]* and the ratio *SPAN/RBW* to 50 in the *COUPLING RATIO* submenu (default setting, *COUPLING RATIO* softkey not highlighted).

IEC/IEEE-bus command
```
BAND:AUTO ON
BAND:VID:AUTO ON
SWE:TIME:AUTO ON
```
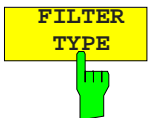
FILTER
TYPE

The *FILTER TYPE* softkey opens the selection list for different filter types. In the range up to 30 kHz digital band filters with Gaussian characteristic and filtering with FFT algorithm can be selected.

FILTER TYPE
√ NORMAL
FFT
CHANNEL
RRC
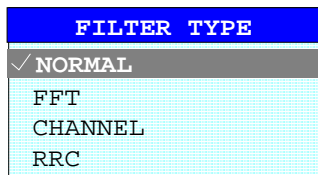
NORMAL   For resolution bandwidths up to 100 kHz digital bandpasses are used.

FFT   An FFT is performed. For that purpose, the filtered IF signal is digitized and then transformed into the spectral domain via FFT. The transformation range depends on the selected filter bandwidths and can be set between 4 kHz to 50 kHz. If the span is larger than the transformation range, several transformations are performed and the results are appended to each other in the spectral domain.
If the span is smaller than the transformation range, the measurement results are interpolated when the number of measurement points provided by the FFT is smaller than the number of display points in x-direction (501). A flattop window serves as a window in the time domain so that high amplitude precision with good selection is achieved.

A flat-top window serves as a window in the time domain so that high amplitude accuracy as well as good selection are achieved.

Sweep time	Defined by the selected bandwidth and span (reason: FFT filtering is a block transformation). It cannot be changed (softkey deactivated).
Detector	Sample detector and peak detector are available. Peak detector is active when AUTO SELECT is selected.
Video bandwidth	Not defined in case of FFT; therefore cannot be set (softkeys deactivated).

Compared to bandpasses, FFT filters lead to significantly reduced sweep times. For a span of 50 kHz and a bandwidth of 100 Hz, for instance, the sweep time is reduced from 5 s to 40 ms. FFT filters are particularly suitable for stationary signals (sinusoidal signals or signals that are continuously modulated in time). For burst signals (TDMA) or pulsed signals, normal filters are preferable.

Note:

As soon as the FFT filters are active (RBW ≤ 30 kHz) the sweep time display field (SWT) is replaced by the acquisition time (AQT) display field.

FFT is a block transformation so the result depends on the time relation between the data set to be transformed and the burst or pulsed signal. A gated sweep measurement for TDMA signals is therefore not provided if FFT filters are used.

When the tracking generator (option FSP-B9) is used as signal source for the DUT, filtering with the FFT algorithm is not useful. The selection FFT is thus not available if the tracking generator is switched on..

Additionally, a number of especially steep-edged channel filters are available for power measurement since firmware version 1.10.

A distinction is made between the following filter types:

CHANNEL = general, steep-edged channel filters

RRC = filters with root-raised cosine characteristic
      (RRC = Root Raised Cosine)

When selecting these filter types, the automatic coupling of the resolution bandwidth to the span is not available. The filters are selected via the *RES BW* softkey.

A list of all available channel filters with their associated applications can be found at the end of this chapter.

IEC/IEEE-bus command: `BAND:TYPE NORM`

List of available channel filters

The channel filters included in the following table are can be activated via the *FILTER TYPE* softkey and are then available as resolution filters (softkey *RES* available for firmware version 1.10 or higher. They *BW*).

Note:
For filters of type RRC (Root Raised Cosine), the filter bandwidth indicated describes the sampling rate of the filter.
For all other filters (CFILter) the filter bandwidth is the 3 dB bandwidth.

Filter Bandwidth		Filter Type	Application
100	Hz	CFILter	
200	Hz	CFILter	A0
300	Hz	CFILter	
500	Hz	CFILter	
1	kHz	CFILter	
1.5	kHz	CFILter	
2	kHz	CFILter	
2.4	kHz	CFILter	SSB
2.7	kHz	CFILter	
3	kHz	CFILter	
3.4	kHz	CFILter	
4	kHz	CFILter	DAB, Satellite
4.5	kHz	CFILter	
5	kHz	CFILter	
6	kHz	CFILter	
8.5	kHz	CFILter	ETS300 113 (12.5 kHz channels)
9	kHz	CFILter	AM Radio
10	kHz	CFILter	
12.5	kHz	CFILter	CDMAone
14	kHz	CFILter	ETS300 113 (20 kHz channels)
15	kHz	CFILter	
16	kHz	CFILter	ETS300 113 (25 kHz channels)
18	kHz, α=0.35	RRC	TETRA
20	kHz	CFILter	
21	kHz	CFILter	PDC
24.3	kHz, α=0.35	RRC	IS 136
25	kHz	CFILter	
30	kHz	CFILter	CDPD, CDMAone
50	kHz	CFILter	
100	kHz	CFILter	
150	kHz	CFILter	FM Radio
192	kHz	CFILter	PHS
200	kHz	CFILter	
300	kHz	CFILter	
500	kHz	CFILter	J.83 (8-VSB DVB, USA)
1.0	MHz	CFILter	CDMAone
1.2288	MHz	CFILter	CDMAone
1.5	MHz	CFILter	DAB
2.0	MHz *)	CFILter	
3.0	MHz *)	CFILter	
3.84	MHz, α=0.22 *)	RRC	W-CDMA 3GPP
4.096	MHz, α=0.22 *)	RRC	W-CDMA NTT DOCoMo
5.0	MHz *)	CFILter	

*) This filter is avaible with modification index > 2 of the IF filter module (see softkey SETUP - SYSTEM INFO - HARDWARE INFO).
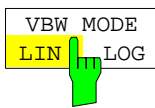
VBW MODE
LIN   LOG

The *VBW MODE LIN/LOG* softkey determines the position of the video filter in the signal path for resolution bandwidths ≤ 100 kHz:

➢ If LINear is selected, the video filter will be in front of the logarithmic amplifier (default).
➢ If LOGarithmic is selected, the video filter will be behind the logarithmic amplifier.

The essential difference between the two operating modes relates to the settling in the case of falling signal edges:

With LINear, the falling signal edge will be "flatter" than with LOGarithmic.
This is due to the conversion from linear power to logarithmic level units: a reduction of the linear power by 50% reduces the logarithmic signal level by only 3 dB.

IEC/IEEE-bus-command: `BAND:VID:TYPE LIN`

Sweep Settings – *SWEEP* Key

The SWEEP key serves for configuring the sweep mode.

SWEEP menu
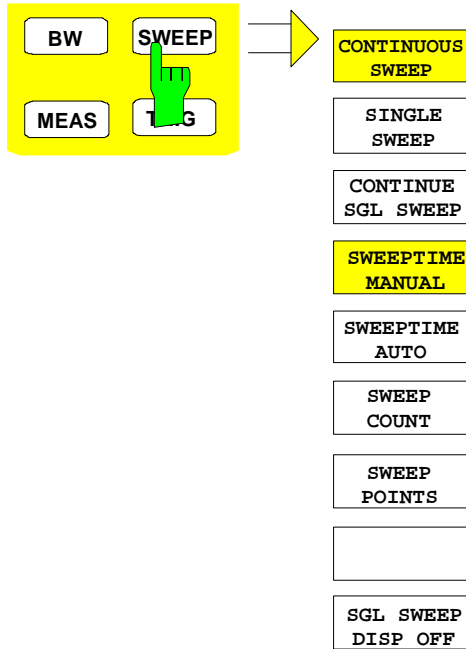
The *SWEEP* key calls a menu in which the sweep mode is defined. In split-screen mode, the entries made are valid for the active window only.

The *CONTINUOUS SWEEP, SINGLE SWEEP* and *SGL SWEEP DISP OFF* softkeys are mutually exclusive selection keys.
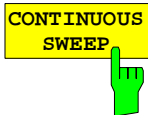
The *CONTINUOUS SWEEP* softkey activates the continuous sweep mode, which means that the sweep takes place continuously according to the trigger mode set.

When working in the split-screen mode and with different settings in the two windows, screen A is swept first, followed by screen B. When the softkey is pressed, the sweep is restarted.

CONTINUOUS SWEEP is the default setting of FSP*.*

IEC/IEEE-bus command: INIT:CONT ON
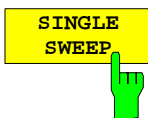
The *SINGLE SWEEP* softkey starts n sweeps after triggering. The number of sweeps is determined by the *SWEEP COUNT* softkey.

When working in the split-screen mode, the frequency ranges of the two windows are swept one after the other.

If a trace is swept using *TRACE AVERAGE* or *MAXHOLD,* the value set via the SWEEP COUNT softkey determines the number of sweeps. If 0 has been entered, one sweep is performed.

IEC/IEEE-bus command: INIT:CONT OFF
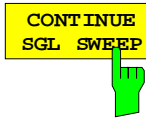
CONTINUE
SGL SWEEP

The *CONTINUE SGL SWEEP* softkey repeats the number of sweeps set under *SWEEP COUNT,* however without first deleting the trace.

This is particularly of interest when using the functions *TRACE AVERAGE* and *MAXHOLD*, if previously recorded measurement results are to be taken into consideration for averaging / maximum search.

If *SGL SWEEP DISP OFF* is active, the screen is switched off also during repeated sweeps.

IEC/IEEE-bus command: INIT:CONM
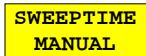
SWEEPTIME
MANUAL

The *SWEEPTIME MANUAL* softkey activates the window for entering the sweep time manually (see also BW menu).

IEC/IEEE-bus command: SWE:TIME 10s
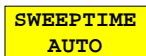
SWEEPTIME
AUTO

The *SWEEPTIME AUTO* softkey activates the automatic selection of the sweep time as a function of the bandwidth of the resolution and video filters (see also BW menu).

IEC/IEEE-bus command: SWE:TIME:AUTO ON
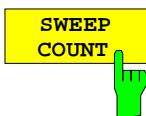
SWEEP
COUNT

The *SWEEP COUNT* softkey activates the window for the entry of the number of sweeps to be performed by FSP after a single sweep has been started. If Trace Average, Max Hold or Min Hold is activated, this also determines the number of averaging or maximum search procedures.

Example:
[**TRACE1**: *MAX HOLD*]
[**SWEEP**: *SWEEP COUNT*: {10} **ENTER**]
[*SINGLE SWEEP*]

FSP performs the Max Hold function over 10 sweeps.

The permissible range for the sweep count is 0 to 32767. For sweep count = 0 or 1, one sweep is performed. For trace averaging in the continuous-sweep mode, FSP performs running averaging over 10 sweeps if sweep count = 0; if sweep count = 1, no averaging is performed.

The sweep count is valid for all the traces in a diagram.

Note: *The number of sweeps set in the TRACE menu is the same as that in the SWEEP menu.*
           If SINGLE SWEEP is selected, the measurement stops after the selected number of sweeps has been performed.

IEC/IEEE-bus command: SWE:COUN 64
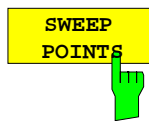
SWEEP POINTS

The *SWEEP POINTS* softkey selects the number of measurement samples acquired during a sweep.

The following numbers of points per sweep are available:
125, 251, 501 (default), 1001, 2001, 4001, 8001

Note:
The autopeak detector will be disabled while the number of points per sweep is ≠ 501.

IEC/IEEE-bus command: SWE:POIN 501

SGL SWEEP DISP OFF

The *SGL SWEEP DISP OFF* softkey deactivates the display while a single sweep is being performed. Once the sweep has been completed, the trace is shown.

IEC/IEEE-bus command: INIT:DISP OFF;:INIT

Triggering the Sweep– *TRIG* Key

The *TRIG* key opens a menu for selection of the various trigger sources, trigger polarity and external gate function. The active trigger mode is indicated by highlighting the corresponding softkey.

For video trigger, a trigger threshold can be entered, which is represented in the diagram as a horizontal line.

To indicate that a trigger mode other than *FREE RUN* has been set, the enhancement label **TRG** is displayed on the screen. If two windows are displayed, TRG appears next to the appropriate window.

The option *TV and RF Trigger* (FSP-B6) adds a number of trigger functions for the analysis of TV signals to this menu (see section Option FSP-B6 **–** TV and RF Trigger, page 4.38).

TRIGGER menu
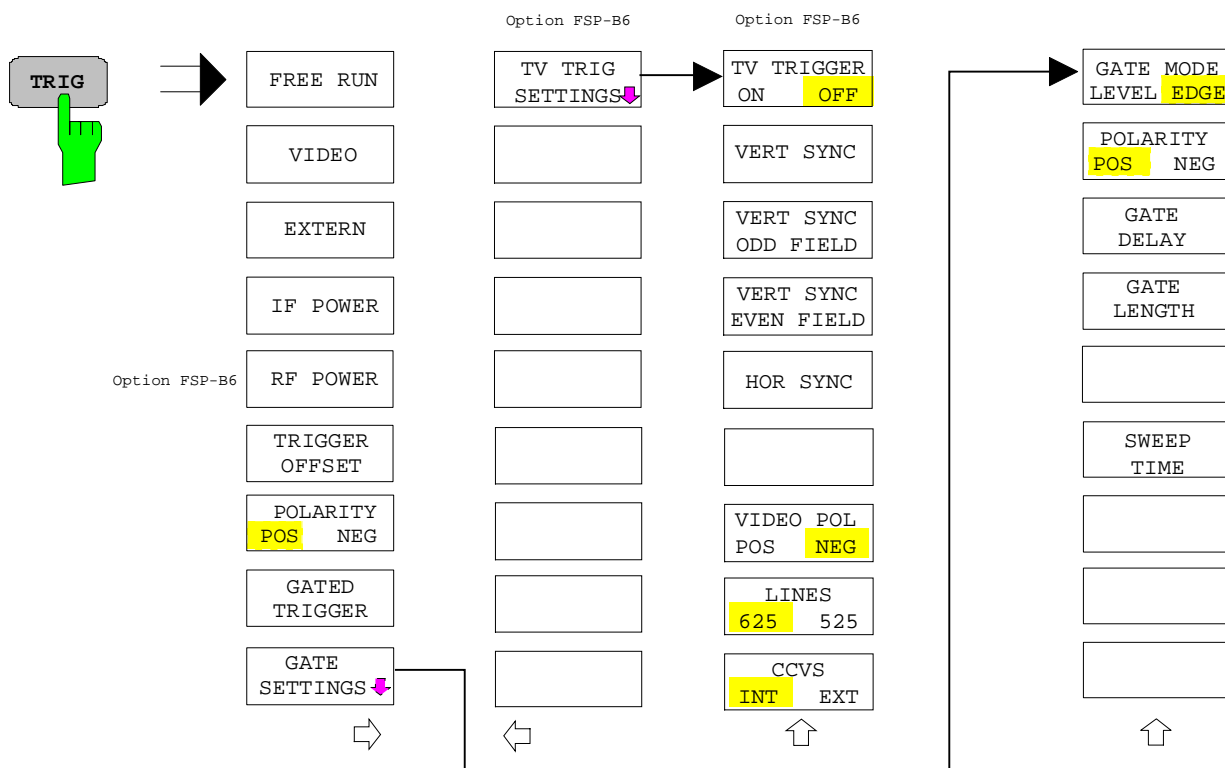
The *FREE RUN* softkey activates the free-run sweep mode, i.e. start of a sweep is not triggered. Once a measurement is completed, another is started immediately.

FREE RUN is the default setting of FSP.

IEC/IEEE-bus command: 　　　TRIG:SOUR　IMM
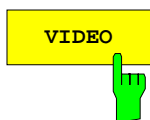
The *VIDEO* softkey activates triggering through the displayed voltage.

For the video triggering mode, a horizontal trigger line is shown in the diagram. It may be used to set the trigger threshold between 0% and 100% of the overall diagram height.

IEC/IEEE-bus command: 　　　TRIG:SOUR　VID
　　　　　　　　　　　　　　　　TRIG:LEV:VID 50 PCT
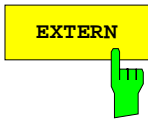
EXTERN

The *EXTERN* softkey activates triggering via a TTL signal at the input connector *EXT TRIGGER/GATE* on the rear panel.

IEC/IEEE-bus command: TRIG:SOUR EXT
                                               SWE:EGAT:SOUR EXT
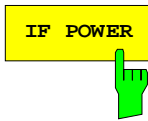
IF POWER

The *IF POWER* softkey activates triggering of the measurement via signals which are outside the measurement channel.

For this purpose, the FSP uses a level detector at the second intermediate frequency. can be selected in a range between –30 dBm and -10 dBm at the input mixer. The resulting trigger level at the RF input is calculated via the following formula:

$$Mixerlevel_{min} + RFAtt - \Pr eampGain \leq Input\ Signal \leq Mixerlevel_{max} + RFAtt - \Pr eampGain$$

The bandwidth at the intermediate frequency is 10 MHz. The FSP is triggered as soon as the trigger threshold is exceeded within a 5 MHz range around the selected frequency (= start frequency in the frequency sweep).

Thus, the measurement of spurious emissions, e.g. for pulsed carriers, is possible even when the carrier lies outside the selected frequency span.

IEC/IEEE-bus command: TRIG:SOUR IFP
                                               SWE:EGAT:SOUR IFP

RF POWER
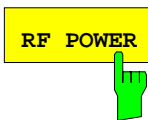
See following section Option FSP-B6 – TV and RF Trigger, page 4.38.
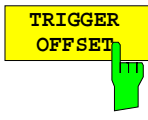
TRIGGER OFFSET

The *TRIGGER OFFSET* softkey activates the window for entering the time offset between the trigger signal and the start of the sweep.

Triggering is delayed by the entered time with respect to the trigger signal (time entered > 0) or is started earlier (time entered < 0). The time may be entered in multiples of 125 ns in the range -100 s to 100 s (default 0 s).

Note: *A negative offset (pretrigger) can be set in the time domain only (SPAN = 0 Hz) provided GATED TRIGGER is not active in that domain.*
The maximum allowed range and the maximum resolution of the pretrigger is limited by the set sweep time:
max. range = - 499/500 x sweep time
max. resolution = sweep time/500.
Pretriggering is not possible when the rms or the average detector is activated

As a common input signal is used for both trigger and gate when selecting *EXTERN* and *IF POWER,* changes to the gate delay will affect the trigger delay *(TRIGGER OFFSET)* as well.

IEC/IEEE-bus command: TRIG:HOLD 10US
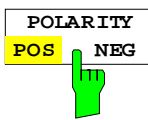
POLARITY POS NEG

The *POLARITY POS/NEG* softkey selects the polarity of the trigger source.

The sweep starts after a positive or negative edge of the trigger signal. The selected setting is highlighted.

The selection is valid for all trigger modes with the exception of *FREE RUN*; in the gate mode, it also applies to the gate polarity.

The default setting is *POLARITY POS.*

IEC/IEEE-bus command: TRIG:SLOP POS

By using a gate in sweep mode and stopping the measurement while the gate signal is inactive, the spectrum for pulsed RF carriers can be displayed without the superposition of frequency components generated during switching. Similarly, the spectrum can also be examined for an inactive carrier. The sweep can be controlled by an external gate or by the internal power trigger.
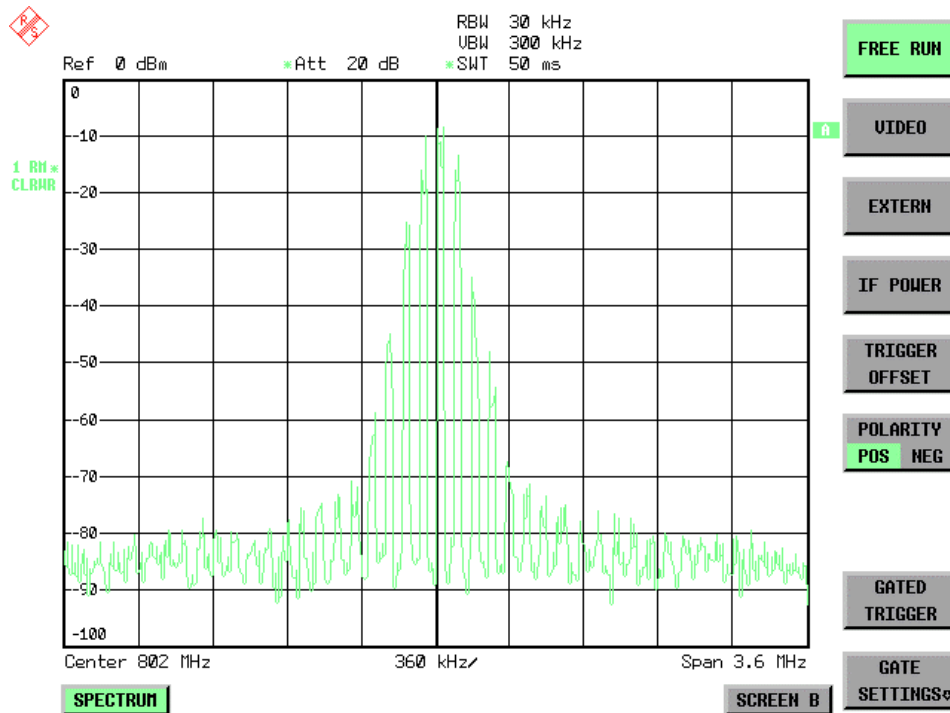
Fig. 4-1 Pulsed signal GATE OFF
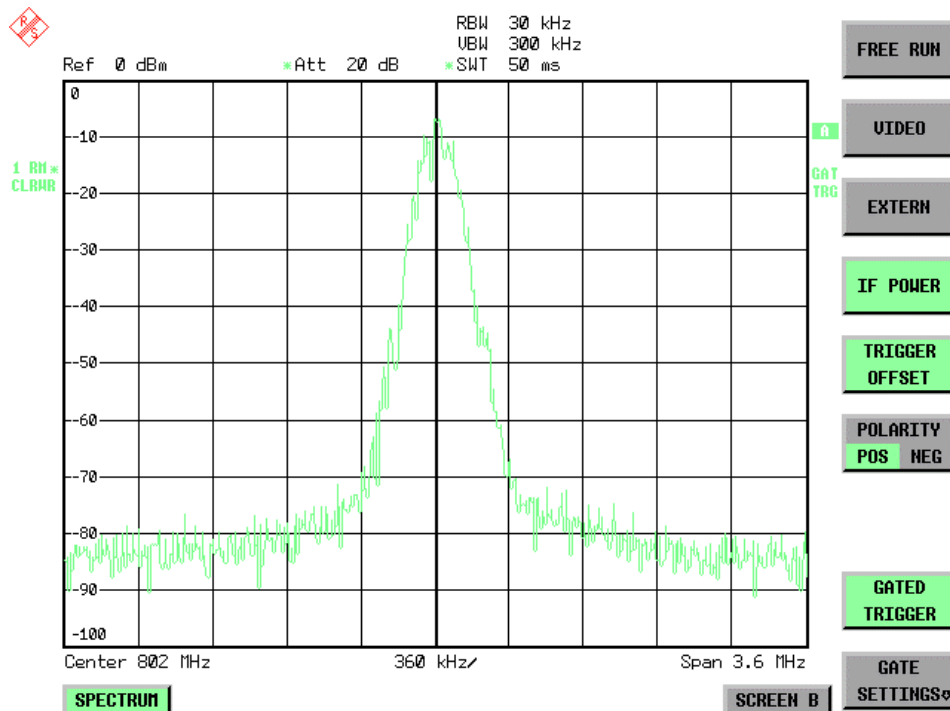
Fig. 4-2   TDMA signal with GATE ON

The gated-sweep mode is activated by the *GATED TRIGGER* softkey. The setting of the mode takes place in the *GATE SETTINGS* submenu.
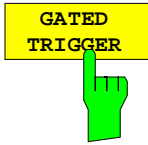
GATED
TRIGGER

The *GATED TRIGGER* softkey switches the sweep mode with gate on and off.

When gate is switched on, a gate signal applied to the rear panel connector *EXT TRIGGER/GATE* or the internal IF power detector controls the sweep of the analyzer. This selection is made via the *EXTERN* and *IF POWER* softkeys for trigger and gate.
The length of the gate signal defines when the sweep is to be interrupted. Here a differentiation is made between edge-triggered and level-triggered modes: in case of edge triggering the gate length can be set via the *GATE LENGTH* softkey, while in case of level triggering the gate length depends on the length of the gate signal.
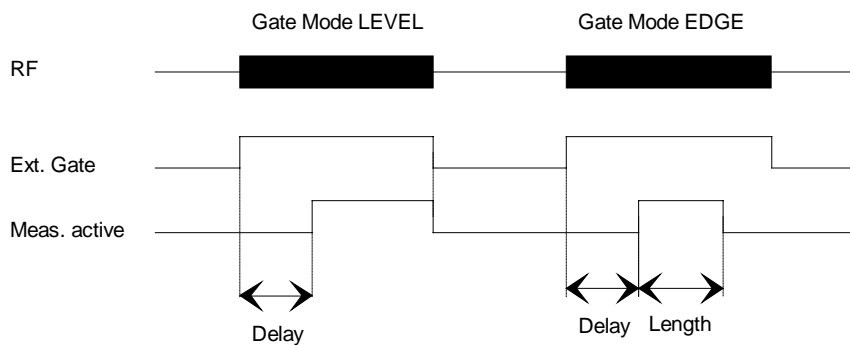
Fig.4-3 Timing diagram for GATE, GATE DELAY and GATE LENGTH

This softkey requires the *EXTERN* or *IF POWER* trigger mode. If a different mode is active, IF POWER is automatically selected.

Gated-sweep operation is also possible in the time domain. This enables - e.g. in burst signals - level variations of individual slots to be displayed versus time.

To indicate that a gate is used for the sweep, the enhancement label **GAT** is displayed on the screen. This label appears to the right of the window for which the gate is configured.

IEC/IEEE-bus command: SWE:EGAT ON
                         SWE:EGAT:SOUR IFP
                         or:
                         SWE:EGAT:SOUR EXT

```
┌─────────────┐
│    GATE     │ ──→
│ SETTINGS▼   │
└─────────────┘
     ╓
```

```
┌─────────────┐
│  GATE MODE  │
│ LEVEL EDGE  │
└─────────────┘
┌─────────────┐
│  POLARITY   │
│  POS   NEG  │
└─────────────┘
┌─────────────┐
│    GATE     │
│   DELAY     │
└─────────────┘
┌─────────────┐
│    GATE     │
│   LENGTH    │
└─────────────┘
┌─────────────┐
│             │
└─────────────┘
┌─────────────┐
│  SWEEPTIME  │
└─────────────┘
┌─────────────┐
│             │
└─────────────┘
┌─────────────┐
│             │
└─────────────┘
┌─────────────┐
│   PRINT     │
│   SCREEN    │
└─────────────┘
       ⇧
```
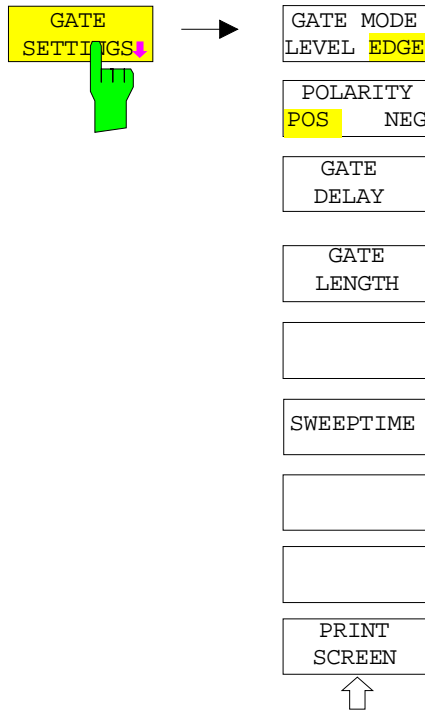
The *GATE SETTINGS* softkey calls a submenu for making all the settings required for gated-sweep operation.

At the same time, a transition is made to the time domain (span = 0) and the time parameters *GATE DELAY* and *GATE LENGTH* are represented as vertical lines. This allows the required gate time parameters to be set easily.

For highly accurate setting of gate delay and gate length, the x axis can be altered using the *ZOOM x-AXIS* softkey in a way that the signal range concerned (e.g. one full burst) is displayed.

Then the sampling time and duration can be set by *GATE DELAY* and *GATE LENGTH* in a way that the desired portion of the signal is shown.

When quitting the submenu, the program will return to the frequency domain provided it was active before. The original span is restored so the desired measurement can now be performed with the accurately set gate.

IEC/IEEE-bus command: --

```
┌─────────────┐
│  GATE MODE  │
│ LEVEL EDGE  │
└─────────────┘
      ╓
```
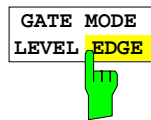
The *GATE MODE LEVEL/EDGE* softkey selects the trigger mode. Gated sweep is possible in the level-triggered as well as in the edge-triggered mode.

If level triggering is selected, the *GATE LENGTH* softkey becomes inactive and cannot be operated.

IEC/IEEE-bus command: SWE:EGAT:TYPE   EDGE

```
┌─────────────┐
│  POLARITY   │
│  POS   NEG  │
└─────────────┘
      ╓
```
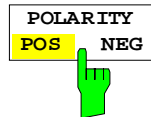
The *POLARITY POS/NEG* softkey controls the polarity of the *EXT TRIGGER/GATE* control line.

In case of level triggering the sweep is stopped by *POLARITY POS* and a logic ´0´ signal; the signal ´1´ will restart the sweep after the *GATE DELAY* time has elapsed.

In case of edge triggering the sweep is continued on a ´0´ to ´1´ transition for the duration of *GATE LENGTH* after a delay (*GATE DELAY)* has elapsed.

Changing the polarity automatically implies a transition of the trigger-edge polarity (*POLARITY* softkey in the higher menu).

IEC/IEEE-bus command: SWE:EGAT:POL   POS
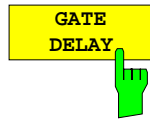
GATE DELAY

The *GATE DELAY* softkey activates the window for setting the delay time between the gate signal and the continuation of the sweep.

This may be useful for taking into account a delay between the gate signal and the stabilization of an RF carrier for example.

As gate delay, values between 125 ns and 100 s may be set. The position of the delay on the time axis in relation to the sweep is indicated by the line labelled **GD**.

As there is a common input signal for trigger and gate if *EXTERN* or *IF POWER* is selected, changes to the gate delay will affect the trigger delay (*TRIGGER OFFSET*) as well.

IEC/IEEE-bus command: SWE:EGAT:HOLD   1US
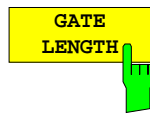
GATE LENGTH

The *GATE LENGTH* softkey activates the window for setting the sweep duration of FSP in the edge-triggered mode.

Values between 125 ns and 100 s may be set for the gate length. The length of the gate in relation to the sweep is indicated by the line labelled **GL.**

This softkey is only available if *GATE MODE EDGE* (edge triggering) has been selected.

IEC/IEEE-bus command: SWE:EGAT:LENG   100US
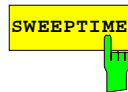
SWEEPTIME

The *SWEEP TIME* softkey enables the user to change the time axis to obtain a higher resolution for positioning gate delay and gate length.
When this is to be done, the sweep time temporarily changes; the original value is restored when the menu is quit.

IEC/IEEE-bus command: --
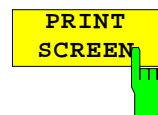
PRINT SCREEN

The *PRINT SCREEN* softkey allows the gate settings to be output on a printer.

IEC/IEEE-bus command: --

Measurement example:

The modulation spectrum of a GSM or PCS1900 signal is to be measured using the gated-sweep function. The signal is generated by a Signal Generator SME03 whose RF output is directly connected to the RF input of FSP.

Settings on SME03:

FREQ: 802 MHz
    Level: 0 dBm: Return
    Digital Mod: Select: GMSK: Select
    Source: Select: PRBS: Select: Return
    Level Attenuation: Select: 60 dB: Return

The SME03 supplies a GMSK-modulated TDMA signal (GSM).

Settings on FSP**:**

Conventions: **[KEY]**   Menu called by this key. All information between the brackets refers to
                              this menu.
                 {Number}   Numeric value to be entered for the parameter on hand.
                 SOFTKEY   Softkey to be used for making a selection or entering a value.

[PRESET]
[FREQ: *CENTER* {802} **MHz]**
[SPAN   {3.6} **MHz]**
[AMPT: *REF LEVEL* {0} **dBm**: *RF ATTEN MANUAL*: {10} **dB]**
[BW: *RES BW MANUAL*: {30} **kHz]**
[TRACE :   *TRACE 1   DETECTOR*: *RMS***]**
[SWEEP: *SWEEPTIME MANUAL*: {50} **ms]**
[TRIG: *EXTERN*
                 GATED TRIGGER;
                 GATE SETTINGS: *GATE MODE EDGE; POLARITY POS*
                 SWEEPTIME MANUAL {1} **ms**: *GATE DELAY* {300} **µs**:
                 GATE LENGTH: {250} **µs]**

The following figure shows the screen display for setting gate parameters. The vertical lines for gate
delay (GD) and gate length (GL) can be adjusted to the burst signal by entering numeric values or by
means of the rollkey.
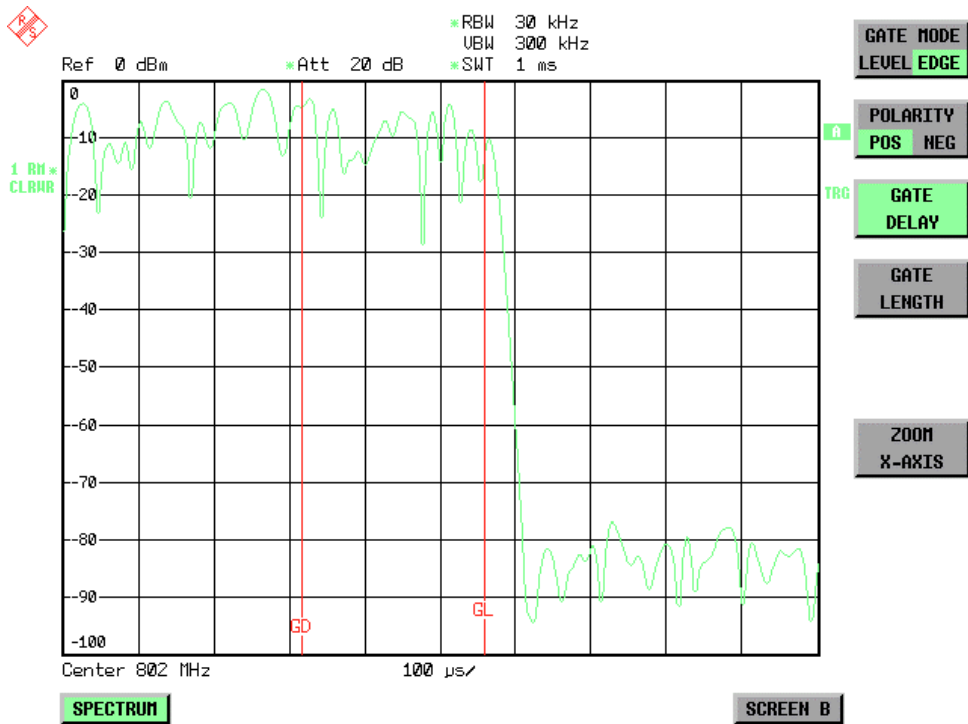
Fig.4-4   Setting GATE DELAY and GATE LENGTH in time domain by means of lines GD and GL

On quitting the *GATE SETTINGS* menu, FSP returns to the previous screen.

Option FSP-B6 − TV and RF Trigger

The option TV and RF Trigger, FSP-B6, enables the FSP to trigger on TV signals or on the presence of a RF carrier outside the resolution bandwidth.

For this purpose, the hardware board is equipped with a TV demodulator, which produces the trigger signals necessary for the analysis of TV signals. In addition to the pure trigger function, the board also creates a demodulated CCVS video signal for operation of external TV monitors. Apart from using the internal IF for creating the trigger signals, the FSP can also make use of an externally supplied CCVS signal; the corresponding connector is placed at the rear panel of the instrument.

In order to display different sections of a TV video signal, the FSP derives several trigger signals from the video signals. This allows triggering as well on the frame repetition as on each line of the TV video signal.

Additionally, the option includes a broadband RF detector (bandwidth = 80 MHz), which allows triggering within a 40 MHz range around the selected frequency (= start frequency in the frequency sweep). Thus, the measurement of spurious emissions, e.g. for pulsed carriers, is possible even when the carrier lies outside the selected frequency span. This RF power trigger can be used as long as the RF signal at the input mixer is in the range of -10 dBm to –50 dBm. The resulting range for the input signal at the RF input connector can be calculated using the following formula:

$$Mixerlevel_{\min} + RFAtt - \Pr eampGain \ \leq \ Input\ Signal \ \leq \ Mixerlevel_{\max} + RFAtt - \Pr eampGain$$

The RF Power Trigger can be selected and configured in the trigger menu (*TRIG*) using the softkey *RF POWER*::
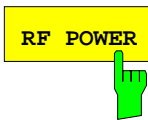
The *RF POWER* softkey activates triggering of the measurement via signals which are outside the measurement channel.

The FSP uses a level detector at the first IF. The detector's threshold can be selected from values between –50 dBm and -10 dBm at the input mixer. The range of the input signal to which the trigger responds is calculated using the following formula.

$$Mixerlevel_{\min} + RFAtt - \Pr eampGain \ \leq \ Input\ Signal \ \leq \ Mixerlevel_{\max} + RFAtt - \Pr eampGain$$

The bandwidth at the IF is 80 MHz. Triggering starts when the trigger threshold is exceeded in a range of 40 MHz around the frequency selected (= start frequency for frequency sweep). This allows spurious emissions, e.g. with pulsed carriers, to be measured, even if the carrier itself is outside the frequency display range.

IEC/IEEE-bus command:
```
TRIG:SOUR   RFP
SWE:EGAT:SOUR   RFP
```

The configuration menu for TV trigger settings can be reached with key sequence *TRIG – NEXT – TV TRIG SETTINGS:*

TV TRIG SETTINGS

The *TV TRIG SETTINGS* softkey switches the TV trigger on and opens a submenu for configuration of the TV signal parameters.

Note: *Triggering on TV signals is only possible in time domain (span = 0 Hz). Therefore the softkey TV TRIG SETTINGS is without function in frequency domain.*

IEC/IEEE-bus command: `TRIG:SOUR  TV`
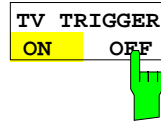
TV TRIGGER ON   OFF

The *TV TRIGGER ON/OFF* softkey switches the TV Trigger on or off. When switching off the TV trigger the selected trigger source will be *FREE RUN.*

IEC/IEEE-bus command: `SENS:TV  ON │ OFF`
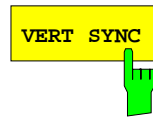
VERT SYNC

The *VERT SYNC* softkey configures the trigger for the vertical sync signal. The FSP triggers on the frame repetition without distinction between the two fields.

IEC/IEEE-bus command: `TRIG:VID:FIEL:SEL ALL`

VERT SYNC ODD FIELD

The softkeys *VERT SYNC ODD FIELD* and *VERT SYNC EVEN FIELD* configure the trigger for the vertical sync signal of the first or second field.

VERT SYNC EVEN FIELD

IEC/IEEE-bus command:
            `TRIG:VID:FIEL:SEL EVEN │ ODD`
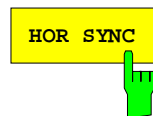
HOR SYNC

The *HOR SYNC* softkey configures the trigger for the horizontal sync signal and opens the data entry field for selection of the corresponding line.

The trigger can be set on any line number, which can be in the range of 1 to 525 or 1 to 625, depending on the line system. The maximum possible line number will be selected if the active range is exceeded.

In order to trigger on test line 17 according to CCIR 473-4, for example, the line value has to be set to 17. This is the default setting after switching on the TV trigger.

IEC/IEEE-bus command: `TRIG:VID:LINE:NUM 17`

```
VIDEO POL
POS    NEG
```

The *VIDEO POL POS / NEG* softkey selects the polarity of the video signal.

Positive video polarity is to be selected e.g. for standard L signals, negative video polarity for signals according to the standards B/G/I/M (colour standard PAL or NTSC). Default setting is *VIDEO POL NEG*.

IEC/IEEE-bus command: `TRIG:VID:SSIG:POL NEG`

```
LINES
625    525
```
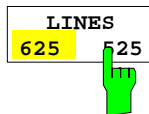
The *LINES 625 / 525* softkey selects the line system currently in use.

Default setting is *625 LINES*.

IEC/IEEE-bus command: `TRIG:VID:FORM:LPFR 625`

```
CCVS
INT    EXT
```
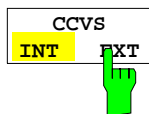
The *CCVS INT / EXT* softkey selects the input channel for the TV trigger input signal. An external CCVS signal can be supplied via the corresponding connector at the rear panel of the instrument.

IEC/IEEE-bus command: `SENS:TV:CCVS INT`

Selection and Setting of Traces – *TRACE* Key

The FSP is capable of displaying up to three different traces at a time in a diagram. A trace consists of a maximum of 501 pixels on the horizontal axis (frequency or time). If more measured values than pixels are available, several measured values are combined in one pixel.
The traces are selected using the *SELECT TRACE* softkey in the menu of the *TRACE* key*.*

The traces can individually be activated for a measurement or frozen after completion of a measurement. Traces that are not activated are blanked.

The display mode can be selected for each trace. Traces can be overwritten in each measurement (CLEAR/WRITE mode), averaged over several measurements (AVERAGE mode), or a maximum or minimum value can be determined from several measurements and displayed (MAX HOLD or MIN HOLD).
Individual detectors can be selected for the various traces. The autopeak detector displays maximum and minimum values connected by a vertical line. The max peak detector and min peak detector display the maximum and minimum value of the level within a pixel. The sample detector displays the instantaneous value of the level at a pixel. The rms detector displays the power (rms value) of the measured values within a pixel, the average detector the average value.

Selection of Trace Function

The trace functions are subdivided as follows:

- Display mode of trace (CLEAR/WRITE, VIEW and BLANK)

- Evaluation of the trace as a whole (AVERAGE, MAX HOLD and MIN HOLD)

- Evaluation of individual pixels of a trace (AUTOPEAK, MAX PEAK, MIN PEAK, SAMPLE, RMS, AVERAGE and QUASIPEAK)

TRACE menu
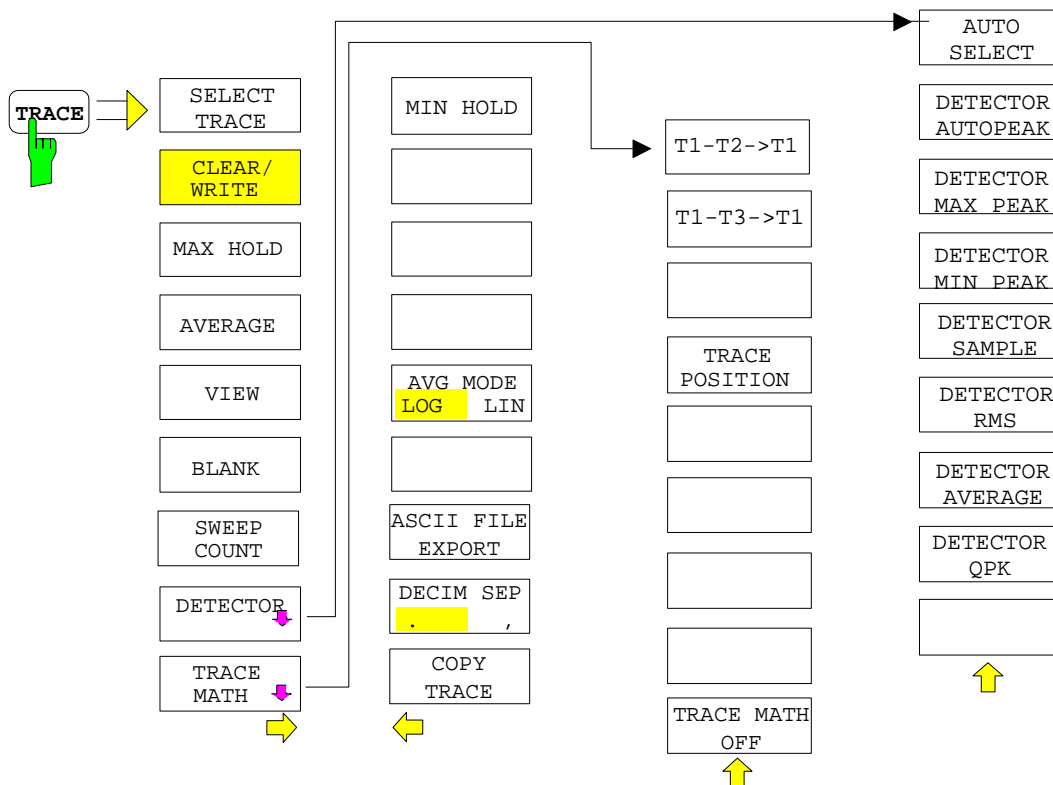
The *TRACE* key opens a menu offering the setting options for the selected trace.

In this menu, the mode of representing the measured data in the frequency or time domain in the 501 pixels of the display is determined. Upon start of the measurement, each trace can be displayed either completely new or based on the previous results.

In this menu, the mode of representing the measured data in the frequency or time domain in the 501 pixels of the display is determined. Upon start of the measurement, each trace can be displayed either completely new or based on the previous results.

Traces can be displayed, blanked and copied. Traces can also be corrected with the aid of mathematical functions.

The measurement detector for the individual display modes can be selected directly by the user or set automatically by FSP.

The default setting is trace 1 in the overwrite mode (*CLEAR / WRITE)*, the other traces 2 and 3 are switched off (*BLANK*).

The *CLEAR/WRITE, MAX HOLD, MIN HOLD, AVERAGE, VIEW* and *BLANK* softkeys are mutually exclusive selection keys.

<table>
<tr><td>SELECT
TRACE</td><td>The *SELECT TRACE* softkey activates the entry for the active trace (1, 2, 3).

IEC/IEEE-bus command -- (selected via numeric suffix of :TRACe)</td></tr>
</table>
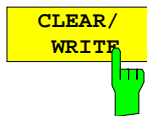
<table>
<tr><td>CLEAR/
WRITE</td><td>The *CLEAR/WRITE* softkey activates the overwrite mode for the collected measured values, ie the trace is overwritten by each sweep.

In the *CLEAR/WRITE* display mode all the available detectors can be selected. In the default mode the autopeak detector (setting *AUTO*) is selected.

Each time the *CLEAR/WRITE* softkey is actuated, FSP clears the selected trace memory and starts the measurement anew.

IEC/IEEE-bus command   DISP:WIND:TRAC:MODE WRIT</td></tr>
</table>
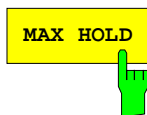
<table>
<tr><td>MAX HOLD</td><td>The *MAX HOLD* softkey activates the max peak detector.
FSP saves the sweep result in the trace memory only if the new value is greater than the previous one.

The detector is automatically set to *MAX PEAK*. The maximum value of a signal can thus be determined over several sweeps.

This is especially useful with modulated or impulsive signals. The signal spectrum is filled up upon each sweep until all signal components are detected in a kind of envelope.

Pressing the *MAX HOLD* softkey again clears the trace memory and restarts the max hold mode.

IEC/IEEE-bus command   DISP:WIND:TRAC:MODE MAXH</td></tr>
</table>
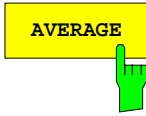
AVERAGE

The *AVERAGE* softkey activates the trace averaging function. The average is formed over several sweeps. Averaging can be performed with any of the detectors available. If the detector is automatically selected by FSP, the sample detector is used.

Depending on the setting of AVG MODE LOG / LIN, the logarithmic level values or the measured power/voltage values are averaged.

Averaging is restarted every time the *AVERAGE* softkey is pressed. The trace memory is always cleared.

IEC/IEEE-bus command   `DISP:WIND:TRAC:MODE AVER`

Description of averaging

Averaging is carried out over the pixels derived from the measurement samples. Several measured values may be combined in a pixel. This means that with linear level display the average is formed over linear amplitude values and with logarithmic level display over levels. For this reason the trace must be measured again when changing between *LIN* and *LOG* display mode. The settings *CONT/SINGLE SWEEP* and running averaging apply to the average display analogously.

There are two methods for calculating the average. For a sweep count = 0 , a running average is calculated according to the following formula:

$$\mathrm{TRACE} = \frac{9 * \mathrm{TRACE} + \text{ meas. value}}{10}$$

Due to the weighting between the new measured value and the trace average, past values have practically no influence on the displayed trace after about ten sweeps. With this setting, signal noise is effectively reduced without need for restarting the averaging process after a change of the signal.

If the sweep count is >1, averaging takes place over the selected number of sweeps. In this case the displayed trace is determined during averaging according to the following formula:

$$\mathrm{Trace}_n = \frac{1}{n}\left[\sum_{i=1}^{n-1} (T_i) + \text{meas.value}_n \right]$$

where n is the number of the current sweep (n = 2 ... SWEEP COUNT). No averaging is carried out for the first sweep but the measured value is stored in the trace memory. With increasing n, the displayed trace is increasingly smoothed since there are more single sweeps for averaging.

After the selected number of sweeps the average trace is saved in the trace memory. Until this number of sweeps is reached, a preliminary average is displayed.

After completion of averaging, ie when the averaging length defined by *SWEEP COUNT* is attained, a running averaging is continued with *CONTINUOUS SWEEP* according to the following formula:

$$\mathrm{Trace} = \frac{(N-1)\cdot \mathrm{Trace_{old}} + \text{meas.value}}{N}$$
where
Trace = new trace
$\mathrm{Trace_{old}}$ = old trace
N   = SWEEP COUNT

The display "Sweep N of N" does not change any more until a new start is triggered.

In the *SINGLE SWEEP* mode, the number of sweeps is triggered with *SWEEP START*. The sweeps are stopped when the selected number of sweeps is attained. The number of the current sweep and the total number of sweeps are shown on the display: "Sweep 3 of 200".
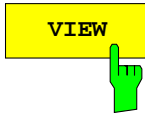
VIEW

The *VIEW* softkey freezes the current contents of the trace memory and displays it.

If a trace is frozen by *VIEW*, the instrument settings can be changed without the displayed trace being modified (exception: level display range and reference level, see below). The fact that the trace and the current instrument setting do not agree any more is indicated by an enhancement label "*" at the right edge of the grid.

If in the *VIEW* display mode the level display range (*RANGE*) or the reference level (*REF LEVEL*) are changed, FSP automatically adapts the measured data to the changed display range. This allows an amplitude zoom to be made after the measurement in order to show details of the trace.

IEC/IEEE-bus command   DISP:WIND:TRAC:MODE VIEW
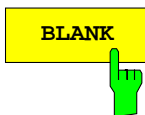
BLANK

The *BLANK* softkey activates the blanking of the trace on the screen.

IEC/IEEE-bus command   DISP:WIND:TRAC OFF

SWEEP COUNT

The *SWEEP COUNT* softkey activates the entry of the number of sweeps used for averaging. The allowed range of values is 0 to 30000 and the following should be observed:

- Sweep Count = 0 means running averaging

- Sweep Count = 1 means no averaging being carried out

- Sweep Count > 1 means averaging over the selected number of sweeps; in the continuous sweep mode averaging is performed until the set number of sweeps is attained and is then continued as running averaging.

The default setting is running averaging (Sweep Count = 0). The number of sweeps used for averaging is the same for all active traces in the selected diagram.

Note: *The setting of the sweep count in the trace menu is equivalent to the setting in the sweep menu.*

IEC/IEEE-bus command   SWE:COUN 64

DETECTOR

See following Section "Selection of Detector"

TRACE MATH

See following Section "Mathematical Functions for Traces"

TRACE - NEXT menu
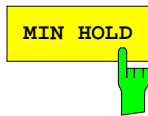
MIN HOLD

The *MIN HOLD softkey* activates the min peak detector. FSP saves for each sweep the smallest of the previously stored/currently measured values in the trace memory. The detector is automatically set to *MIN PEAK*. In this way, the minimum value of a signal can be determined over several sweeps.

This function is useful eg for making an unmodulated carrier in a composite signal visible. Noise, interference signals or modulated signals are suppressed by the min hold function whereas a CW signal is recognized by its constant level.

Pressing the *MIN HOLD* softkey again clears the trace memory and restarts the min hold function.

IEC/IEEE-bus command   `DISP:WIND:TRAC:MODE MINH`

AVG MODE
LOG   LIN

The *AVG MODE LOG/LIN* softkey selects logarithmic or linear averaging for the logarithmic level display mode.

At the same time the difference calculation is switched between linear and logarithmic in submenu *TRACE MATH*.

IEC/IEEE-bus command `CALC:MATH:AVER:MODE LIN`

With logarithmic averaging, the dB values of the display voltage are averaged or substracted from each other with trace mathematical functions. With linear averaging the level values in dB are converted into linear voltages or powers prior to averaging. Voltage or power values are averaged or offset against each other and reconverted into level values.

For stationary signals the two methods yield the same result.

Logarithmic averaging or difference calculation is recommended if sinewave signals are to be clearly visible against noise since with this type of averaging noise suppression is improved while the sinewave signals remain unchanged.

For noise or pseudo-noise signals the positive peak amplitudes are decreased in logarithmic averaging due the characteristic involved and the negative peak values are increased relative to the average value. If the distorted amplitude distribution is averaged, a value is obtained that is smaller than the actual average value. The difference is -2.5 dB.

Probability distribution
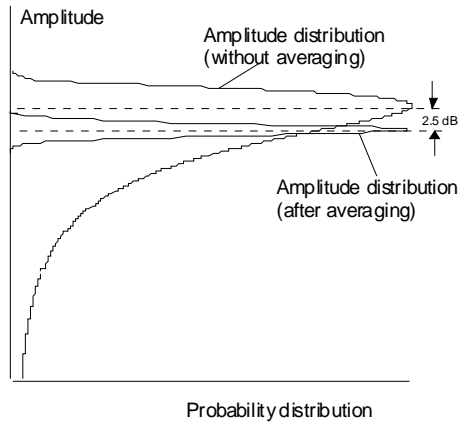
This low average value is usually corrected in noise power measurements by a 2.5 dB factor. Therefore the FSP offers the selection of linear averaging. The trace data are delogarithmized prior to averaging, then averaged and logarithmized again for display on the screen. The average value is always correctly displayed irrespective of the signal characteristic.

ASCII FILE EXPORT

The *ASCII FILE EXPORT* softkey stores the active trace in ASCII format on a floppy disk.

IEC/IEEE command   `FORM ASC;`
                               `MMEM:STOR:TRAC 1,'TRACE.DAT'`

The file consists of the header containing important scaling parameters and a data section containing the trace data.

The data of the file header consist of three columns, each separated by a semicolon:
parameter name; numeric value; basic unit

The data section starts with the keyword " Trace <n> " (<n> = number of stored trace), followed by the measured data in one or several columns (depending on measurement) which are also separated by a semicolon.
This format can be read in from spreadsheet calculation programs, eg MS-Excel. It is necessary to define ';' as a separator.

Note: *Different language versions of evaluation programs may require a different handling of the decimal point. It is therefore possible to select between separators '.' (decimal point) and ',' (comma) using softkey DECIM SEP.*

Example:

	File contents	Description
File header	Type;FSP3;	Instrument model
	Version;1.00;	Firmware version
	Date;01.Jul 1999;	Date of data set storage
	Mode;Spectrum;	Instrument mode
	Center Freq;55000;Hz	Center frequency
	Freq Offset;0;Hz	Frequency offset
	Span;90000;Hz	Frequency range (0 Hz with zero span and statistics measurements)
	x-Axis;LIN;	Scaling of x axis linear (LIN) or logarithmic (LOG)
	Start;10000;Hz Stop;100000;Hz	Start/stop of the display range. Unit: Hz for span > 0, s for span = 0, dBm/dB for statistics measurements
	Ref.Level;-30;dBm	Reference level
	Level Offset;0;dB	Level offset
	Ref Position;75;%	Position of reference level referred to diagram limits (0% = lower edge)
	y-Axis;LOG;	Scaling of y axis linear (LIN) or logarithmic (LOG)
	Level Range;100;dB	Display range in in y direction. Unit: dB with x axis LOG, % with x axis LIN
	RF Att;20;dB	Input attenuation
	El Att;0;dB	Input attenuation of el. attenuator (only with Option FSP-B25)
	RBW;100000;Hz	Resolution bandwidth
	VBW;30000;Hz	Video bandwidth
	SWT;0.005;s	Sweep time
	Trace Mode;AVERAGE;	Display mode of trace: CLR/WRITE,AVERAGE,MAXHOLD,MINHOLD
	Detector;SAMPLE;	Detector set: AUTOPEAK,MAXPEAK,MINPEAK,AVERAGE, RMS,SAMPLE,QUASIPEAK
	Sweep Count;20;	Number of sweeps set
Data section of the file	Trace 1:;;	Selected trace
	x-Unit;Hz;	Unit of x values: Hz with span > 0; s with span = 0; dBm/dB with statistics measurements
	y-Unit;dBm;	Unit of y values: dB*/V/A/W depending on the selected unit with y axis LOG or % with y axis LIN
	Values;501;	Number of test points
		Measured values:
	10000;-10.3;-15.7	<x value>, <y1>, <y2>
	10180;-11.5;-16.9 10360;-12.0;-17.4 ...;...;	<y2> being available only with detector AUTOPEAK and containing in this case the smallest of the two measured values for a test point.
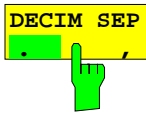
DECIM SEP

The *DECIM SEP* softkey selects the decimal separator between '.' (decimal point) and ',' (comma) with floating-point numerals for the function ASCII FILE EXPORT.

With the selection of the decimal separator different language versions of evaluation programs (eg MS-Excel) can be supported.

IEC/IEEE-bus command   `FORM:DEXP:DSEP POIN`
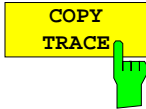
COPY TRACE

The *COPY TRACE* softkey copies the screen contents of the current trace into another trace memory. The desired memory is selected by entering the number 1, 2 or 3.

Upon copying, the contents of the selected memory is overwritten and the new contents displayed in view mode.

IEC/IEEE-bus command   `TRAC:COPY TRACE1,TRACE2`

Selection of Detector

The detectors of the FSP are implemented as pure digital devices. The detectors available are the peak detectors which determine the maximum and/or the minimum value from a number of samples, the rms detector which measures the power within a pixel, the average, the quasipeak and the sample detector. The sample detector routes through the sampled data without any modification or performs a data reduction by suppressing measured values that cannot be displayed.
The peak detectors compare the current level value with the maximum or minimum level from the previously sampled data. When the number of samples defined by the instrument setting is reached, the samples are combined in displayable pixels. Each of the 501 pixels of the display thus represents 1/501 of the sweep range and contains all single measurements (frequency samples) in this subrange in compressed form. For each trace display mode an optimized detector is selected automatically. Since peak detectors and sample detector are connected in parallel, a single sweep is sufficient for collecting all detector values for 3 traces.

Peak detectors
(*MAX PEAK* and *MIN PEAK*)

Peak detectors are implemented by digital comparators. They determine the largest of all positive (max peak) or the smallest of all negative (min peak) peak values of the levels measured at the individual frequencies which are displayed in one of the 501 pixels. This procedure is repeated for each pixel so that for wide frequency spans and despite the limited resolution of the display a large number of measurements can be taken into consideration for the display of the spectrum..

Autopeak detector

The *AUTOPEAK* detector combines the two peak detectors. The max peak detector and the min peak detector simultaneously determine the maximum and the minimum level within a displayed testpoint and display it as a single measured value. The maximum and minimum levels within a frequency point are connected by a vertical line.

Sample detector

The *SAMPLE* detector routes through the sampled data without any further evaluation and either displays them directly or, for reasons of speed in case of short sweep times, first writes them into a memory and processes them subsequently.
There is no data reduction, ie no summing up of measured values of neighbouring frequencies or time samples. If during a frequency sweep more measured values are obtained than can be displayed, measured values will be lost. This means that discrete signals might be lost.
The sample detector therefore can only be recommended for a span-to-resolution bandwidth ratio of up to approx. 250 in order to ensure that no signal will be suppressed (example: span 1 MHz, -> min. bandwidth 5 kHz).

RMS detector

The RMS detector forms the rms value of the measured values within a pixel.

To this effect, FSP uses the linear voltage after envelope detection. The sampled linear values are squared, summed and the sum is divided by the number of samples (= root mean square). For logarithmic display the logarithm is formed from the square sum. For linear display the root mean square value is displayed. Each pixel thus corresponds to the power of the measured values summed up in the pixel.

The rms detector supplies the power of the signal irrespective of the waveform (CW carrier, modulated carrier, white noise or impulsive signal). Correction factors as needed for other detectors for measuring the power of the different signal classes are not required.

Average detector

The average detector forms the average value of the measured values within a pixel.

To this effect, FSP uses the linear voltage after envelope detection. The sampled linear values are summed up and the sum is divided by the number of samples (= linear average value). For logarithmic display the logarithm is formed from the average value. For linear display the average value is displayed. Each pixel thus corresponds to the average of the measured values summed up in the pixel.

The average detector supplies the average value of the signal irrespective of the waveform (CW carrier, modulated carrier, white noise or impulsive signal).

Quasipeak detector

The quasipeak detector similates the behaviour of an analog voltmeter by evaluating the measured values in a pixel.

The quasipeak detector is especially designed for the requirements of EMC measurements and is used for evaluating pulse-shaped spurious.

Note: *During a frequency sweep, FSP increments the 1st local oscillator in steps that are smaller than approximately 1/10 of the bandwidth. This is to ensure that the signal level is correctly measured. For narrow bandwidths and wide frequency spans a very large number of measured values is thus obtained. The number of frequency steps, however, always is a multiple of 501 (= number of pixels that can be displayed). With the sample detector selected, only every n^{th} value is displayed. The value of n depends on the number of measured values, ie on the frequency span, the resolution bandwidth and the measurement rate.*

TRACE-DETECTOR submenu

DETECTOR	→	AUTO SELECT
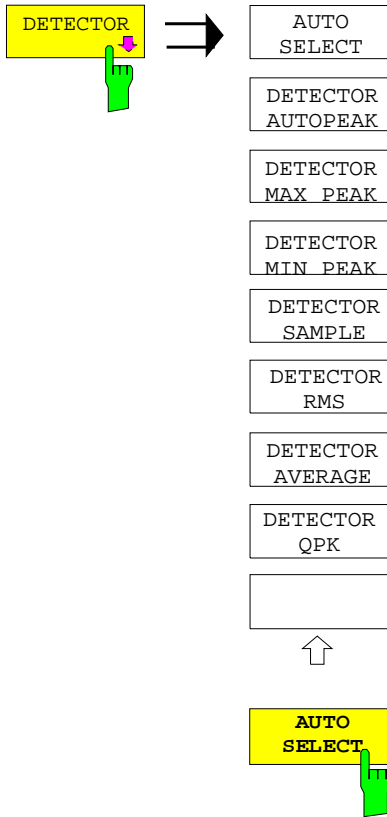
The *DETECTOR* softkey opens a submenu for selecting the detector for the selected trace. The softkey is highlighted if the detector is not selected with *AUTO SELECT*.

The detector can be selected independently for each trace. The *AUTO SELECT* mode selects the optimum detector for each display mode of the trace (Clear/Write, Max Hold or Min Hold).

The softkeys for the detectors are mutually exclusive selection keys.

Submenu items:
- AUTO SELECT
- DETECTOR AUTOPEAK
- DETECTOR MAX PEAK
- DETECTOR MIN PEAK
- DETECTOR SAMPLE
- DETECTOR RMS
- DETECTOR AVERAGE
- DETECTOR QPK

AUTO SELECT

The *AUTO SELECT* softkey (= default setting) selects the optimum detector for the set display mode of the trace (Clear/Write, Max Hold and Min Hold) and the selected filter mode (bandpass/FFT).

Trace display	Detector (bandpass)	Detector (FFT)
Clear/Write	Auto Peak	Max Peak
Average	Sample	Sample
Max Hold	Max Peak	Max Peak
Min Hold	Min Peak	Max Peak

The detector activated for the specific trace is identified in the respective trace display field as follows:

Detector	
Auto Peak	AP
Max Peak	PK
Min Peak	MI
Average	AV
RMS	RM
Sample	SA
Quasipeak	QP

IEC/IEEE-bus command   DET:AUTO ON

DETECTOR AUTO PEAK

The *DETECTOR AUTOPEAK* softkey activates the autopeak detector.

IEC/IEEE-bus command   DET APE
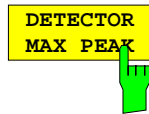
**DETECTOR
MAX PEAK**

The *DETECTOR MAX PEAK softkey* activates the max peak detector. It is recommended for measurement of impulsive signals.

IEC/IEEE-bus command   DET POS
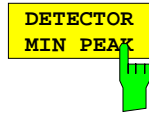
**DETECTOR
MIN PEAK**

The *DETECTOR MIN PEAK* softkey activates the min peak detector. Weak sinewave signals become clearly visible in noise using this detector. In case of a composite signal made up of sinewave and impulsive signals, the impulsive signals are suppressed.

IEC/IEEE-bus command   DET NEG
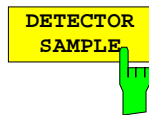
**DETECTOR
SAMPLE**

The *DETECTOR SAMPLE* softkey activates the sample detector.

It is used for measuring uncorrelated signals such as noise. The power can be determined with the aid of fixed correction factors for evaluation and the logarithmic function.

IEC/IEEE-bus command   DET SAMP
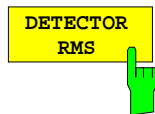
**DETECTOR
RMS**

The *DETECTOR RMS* softkey activates the rms detector.

The rms detector supplies the power of the signal independent of the waveform. For this effect the root mean square of all sampled level values is formed during the sweep of a pixel. The sweep time thus determines the number of averaged values and with increasing sweep time better averaging is obtained. The rms detector is thus an alternative for averaging over several sweeps (see TRACE AVERAGE).

Since the video bandwidth must be at least 10 times the resolution bandwidth (RBW) to ensure that video filtering does not invalidate the rms values of the signal, this ratio is set automatically upon activating the detector.

IEC/IEEE-bus command   DET RMS
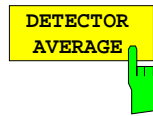
> **DETECTOR AVERAGE**

The *DETECTOR AVERAGE* softkey activates the average detector.

In contrast to the rms detector, the average detector supplies the linear average of all sampled level values during the sweep of a pixel.
The same relations as for the rms detector apply (see above).

IEC/IEEE-bus command   DET AVER
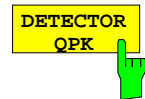
> **DETECTOR QPK**

The *DETECTOR QPK* softkey activates the quasipeak detector.

This detector evaluates the sampled level values during the sweep of a pixel like an analog voltmeter.
On switching the quasipeak detector on the video bandwidth is automatically set to 10 MHz so as to exclude the influence of the video filter on the signal evaluation.

IEC/IEEE-bus command   DET QPE

Mathematical Functions for Traces

TRACE 1-TRACE MATH submenu:
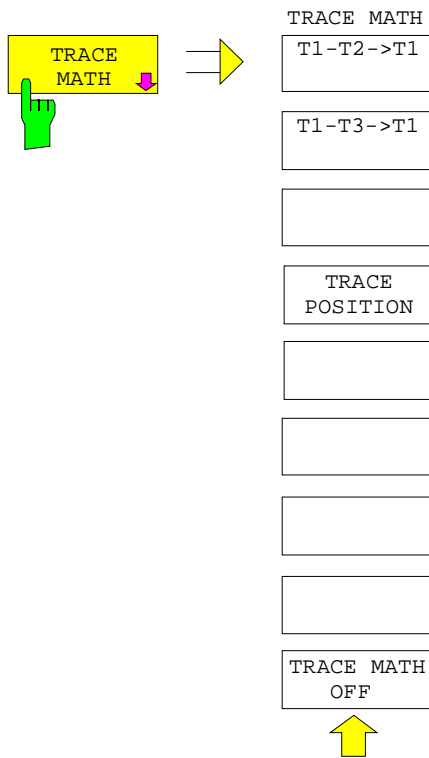
The *TRACE MATH* softkey opens a submenu in which the difference between the selected trace to trace 1 is calculated. The softkey is highlighted if a math function is activated.
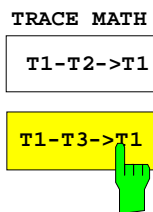
The *T1-T2* and *T1-T3* softkeys subtract the corresponding traces. The result displayed is referred to the zero point defined by *TRACE POSITION*.

To indicate that the trace has been obtained by subtraction, the difference "1 - 2" or "1 - 3" is indicated on the trace info of trace 1 and in the *TRACE* main menu the *TRACE MATH* softkey is highlighted.

IEC/IEEE-bus command   CALC:MATH (TRACE1-TRACE2)
                                CALC:MATH (TRACE1-TRACE3)

The *TRACE POSITION* softkey activates the entry of the trace position for 0 difference. The position is stated in % of the diagram height.
The range of values extends from -100% to +200%

IEC/IEEE-bus command   DISP:MATH:POS 50PCT
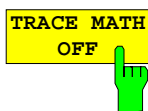
The *TRACE MATH OFF* softkey switches the math function off.

IEC/IEEE-bus command   CALC:MATH:STAT OFF

Recording the Correction Data of FSP – *CAL* Key

The FSP obtains its high measurement accuracy through its inbuitl self-alignment method.

The correction data and characteristics required for the alignment are determined by comparison of the results at different settings with the known characteristics of the high-precision calibration signal source of FSP at 128 MHz. The correction data are then available in the instrument as a file and can be displayed by means of the *CAL RESULTS* softkey.

For service purposes the use of correction data can be deactivated by means of the *CAL CORR ON/OFF* softkey. If the correction data recording is aborted, the last complete correction data set is restored.

Note: *The term "Calibration" formerly used for the integrated self alignment was often mistaken for the "true" calibration of the instrument at the test set in production and in service. It is therefore no longer used although it appears in the abbreviated form in the name of keys ("CAL...").*

CAL menu:
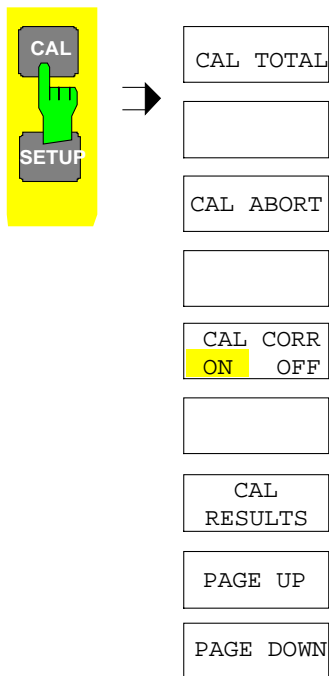
The *CAL* key opens a menu with the available functions for recording, displaying and activating the data for self alignment.

The *CAL TOTAL* softkey starts the recording of correction data of the instrument.

If the correction data recording has failed or if the correction values are deactivated (*CAL CORR = OFF* softkey), the status field indicates

UNCAL.

IEC/IEEE-bus command: `*CAL?`

The *CAL ABORT* softkey interrupts the recording of correction data and restores the last complete correction data set.

IEC/IEEE-bus command: `CAL:ABOR`

```
CAL CORR
ON   OFF
```
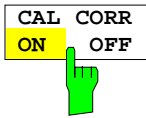
The *CAL CORR ON/OFF* softkey switches the calibration data on/off.

ON   The status message depends upon the results of the total calibration.

OFF   The message *UNCAL* appears in the status line.

IEC/IEEE-bus command: `CAL:STAT ON`

```
CAL
RESULTS
```

The *CAL RESULTS* softkey calls the *CALIBRATION RESULTS* table, which shows the correction data found during calibration.

The *CALIBRATION RESULTS* table contains the following information:

– date and time of last record of correction valuesKorrekturwertaufnahme
– overall results of correction value record
– list of found correction values according to function/module

The results have the following meaning:

PASSED   calibration successful without any restrictions

CHECK   deviation of correction value larger than expected, correction could however be performed

FAILED   deviations of correction value too large, no correction was possible. The found correction data are not valid.

ABORTED   calibration aborted

```
          CALIBRATION RESULTS

    Calibration: PASSED
    Date:        05.Jun 1999 16:24:54

    Total GAIN Adjust          PASSED
    Calibration of IF Filters  PASSED
    Bandwidth:
    Filter   Cal Val [Hz] DAC Val State

    100kHz   1.804e+03    3698    PASSED
    300kHz   8.417e+03    3516    PASSED
      1MHz   2.806e+04    2881    PASSED
      3MHz   1.804e+03    3698    PASSED
     10MHz   8.417e+03    3516    PASSED
```

IEC/IEEE-bus command: `CAL:RES?`

```
PAGE UP
```
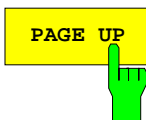
The softkeys *PAGE UP* and *PAGE DOWN* scroll one page forward or backward in the *CALIBRATION RESULTS* table. They have no function when the table is closed.

```
PAGE DOWN
```
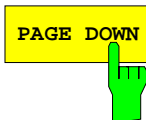
IEC/IEEE-bus command: `--`

Markers and Delta Markers – *MKR* Key

The markers are used for marking points on traces, reading out measurement results and for quickly selecting a display section. FSP provides four markers per display window. All markers can be used either as markers or delta markers. The availability of marker functions depends on whether the measurement is performed in the frequency, time or level domain.

The marker that can be moved by the user is defined in the following as the **active marker**.

Examples of marker display:

Marker   Active marker   Temporary marker

1   3   T1
▽   ▼   ▽
        △
        2
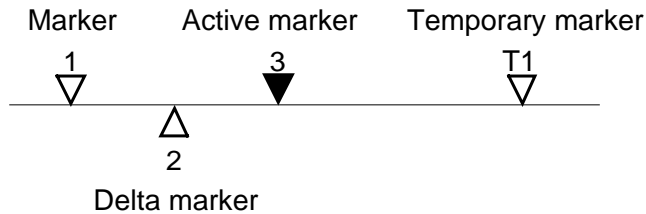
        Delta marker

Temporary markers are used in addition to the markers and delta markers to evaluate the measurement results. They disappear when the associated function is deactivated.

The measurement results of the active marker (also called **marker values**) are displayed in the marker field. The marker info field at the upper right of the display shows the marker location (here, frequency), the level and the currently selected trace [T1].

```
MARKER 1  [T1]
  -27.5 dBm
 123.4567 MHz
```

The *MKR* key calls a menu that contains all marker and delta marker standard functions. If no marker is active, *MARKER 1* will be enabled and a peak search on the trace carried out. Otherwise, the data entry for the marker activated last is opened.

MKR menu:

| FREQ | SPAN |
| MKR | MKR ▸ |

MARKER
| MARKER 1 |
| MARKER 2 |
| MARKER 3 |
| MARKER 4 |
| MARKER NORM DELTA |
| SIGNAL COUNT |
| REFERENCE FIXED ⌐ |
| MARKER ZOOM |
| ALL MARKER OFF |
⇨

MARKER
| MKR->TRACE |
| |
| |
| CNT RESOL 10 kHz |
| CNT RESOL 1 kHz |
| CNT RESOL 100 Hz |
| CNT RESOL 10 Hz |
| CNT RESOL 1 Hz |
| CNT RESOL 0.1 Hz |
⇦

| REF FIXED REF FXD ON OFF |
| REF POINT LEVEL |
| REF POINT LVL OFFSET |
| REF POINT FREQUENCY |
| REF POINT TIME |
| PEAK SEARCH |
| |
| |
| |
⇧

MARKER 1

⋮

MARKER 4

MARKER NORM DELTA

The *MARKER 1/2/3/4* .softkey selects the corresponding marker and activates it.

MARKER 1 is always the normal marker. After they have been switched on, *MARKERS 2 to 4* are delta markers that refer to *MARKER 1*. These markers can be converted into markers with absolute value display by means of the *MARKER NORM DELTA* softkey. When *MARKER 1* is the active marker, pressing the M*ARKER NORM DELTA* softkey switches on an additional delta marker.

Pressing the *MARKER 1 to 4* softkey again switches off the selected marker.

Example:

[**PRESET**]	FSP is set to the default setting.
[**MKR**]	On calling the menu, *MARKER 1* is switched on ('1' highlighted in the softkey) and positioned on the maximum value of the trace. It is a normal marker and the *MARKER NORMAL* softkey is highlighted.
[*MARKER 2*]	*MARKER 2* is switched on ('2' highlighted in the softkey). It is automatically defined as a delta marker on switching on so the *DELTA* is is highlighted on softkey *MARKER NORM DELTA*. The frequency and level of *MARKER 2* with reference to *MARKER 1* are output in the marker info field.
[*MARKER NORM DELTA*]	The *MARKER NORM DELTA* softkey is highlighted. *MARKER 2* becomes a normal marker. The frequency and level of *MARKER 2* are output as absolute values in the marker info field.
[*MARKER 2*]	*MARKER 2* is switched off. *MARKER 1* is the active marker for entry. The frequency and level of *MARKER 1* are output in the marker info field.

IEC/IEEE-bus command:
```
CALC:MARK ON;
CALC:MARK:X <value>;
CALC:MARK:Y?

CALC:DELT ON;
CALC:DELT:MODE ABS|REL
CALC:DELT:X <value>;
CALC:DELT:X:REL?
CALC:DELT:Y?
```

When several traces are being displayed, the marker is set to the maximum value (peak) of the active trace which has the lowest number (1 to 3). In case a marker is already located there, it will be set to the frequency of the next lowest level (next peak).

When the split-screen display mode is active, the marker will be placed in the active window. A marker can only be enabled when at least one trace in the corresponding window is visible.

If a trace is turned off, the corresponding markers and marker functions are also deactivated. If the trace is switched on again (*VIEW*, *CLR/WRITE*;..), the markers along with coupled functions will be restored to their original positions provided the markers have not been used on another trace.

MRK →TRACE

The *MKR→TRACE* softkey places the marker on a new trace. The trace is selected via a data entry field. Only those traces can be selected which are visible on the screen in the same window.

Example:
Three traces are presented on the screen. The marker is always on Trace 1 on switching on.

[*MKR ->TRACE]*
   "2"<ENTER>   The marker jumps to Trace 2 but remains on the previous frequency or time.

[*MKR ->TRACE]*
   "3"<ENTER>   The marker jumps to Trace 3. '

IEC/IEEE-bus command: `CALC:MARK1:TRAC 1`
                                  `CALC:DELT:TRAC 1`

Frequency Measurement with the Frequency Counter

In order to accurately determine the frequency of a signal, FSP is equipped with a frequency counter which measures the frequency of the RF signal at the intermediate frequency. Using the measured IF, FSP calculates the frequency of the RF input signal by applying the known frequency conversion factors.

The frequency measurement error depends only upon the accuracy of the frequency standard used (external or internal reference). Although FSP always operates synchronously irrespective of the set span, the frequency counter delivers a more exact result than a measurement performed with a marker. This is due to the following:

- The marker measures only the position of the pixel on the trace and infers the frequency of the signal from this value. The trace, however, contains only a limited number of pixels. Depending upon the selected span, each pixel may contain many measurement values, which therefore limits the frequency resolution.

- The resolution with which the frequency can be measured is proportional to the measurement time. For this reason, the bandwidth is normally made as wide as possible and the sweep time as short as possible. This results in a loss of frequency resolution.

For the measurement with the frequency counter, the sweep is stopped at the reference marker, the frequency is counted with the desired resolution and then the sweep is allowed to continue.

```
SIGNAL
COUNT
```
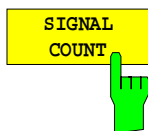
The *SIGNAL COUNT* softkey switches the frequency counter on/off.

The frequency is counted at the position of the reference marker (*MARKER* 1). The sweep stops at the reference marker until the frequency counter has delivered a result. The time required for a frequency measurement depends on the selected frequency resolution. The resolution is set in the side menu.

If no marker is enabled when the *SIGNAL COUNT* softkey is pressed, *MARKER 1* is switched on and set at the largest signal.

In addition, the *SIGNAL COUNT* function is displayed in the marker info field on the screen with [Tx CNT].

```
MARKER 1 [T1 CNT]
    -27.5 dBm
  23.4567891 MHz
```

Switching the *SIGNAL COUNT* function off is accomplished by pressing the softkey again.

IEC/IEEE-bus command: CALC:MARK1:COUN ON;
                             CALC:MARK:COUN:FREQ?

MARKER NEXT menu

The resolution of the frequency counter is set in the *NEXT* menu of the MARKER menu. FSP offers counter resolutions between 0.1 Hz and 10 kHz.

```
    MARKER
CNT RESOL
 10 kHz

CNT RESOL
  1 kHz

CNT RESOL
 100 Hz

CNT RESOL
  10 Hz

CNT RESOL
  1 Hz

CNT RESOL
 0.1 Hz
```
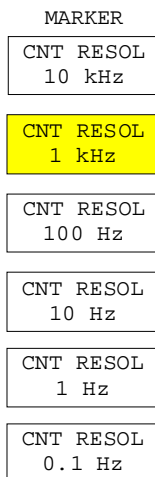
The *CNT RESOL ...* softkeys select the counter resolution. They are selection switches, i.e. only one of the can be active at any one time.
The marker stop time, ie the frequency measurement time, depends on the selected resolution.

IEC/IEEE-bus command: CALC:MARK1:COUN:RES <value>

Measurement example:
The frequency of a CW signal is to be determined by means of the frequency counter with a resolution of 10 Hz.

[**PRESET**]   FSP is set to the default setting.

[**MARKER**]   *MARKER 1* is switched on and set to the maximum value of the displayed spectrum.

[*SIGNAL
 COUNT*]   The frequency counter is switched on. FSP counts the frequency of the signal at the marker position with a resolution of 1 kHz. The counted frequency is indicated in the marker info field.

[*NEXT*]   Changes to the submenu for setting the counter resolution.

[*CNT RESOL
 10 Hz*]   The frequency counter resolution is increased to 10 Hz.

REF FIXED

REF FIXED	
ON	OFF

REF POINT
LEVEL

REF POINT
LVL OFFSET

REF POINT
FREQUENCY

REF POINT
TIME

PEAK
SEARCH
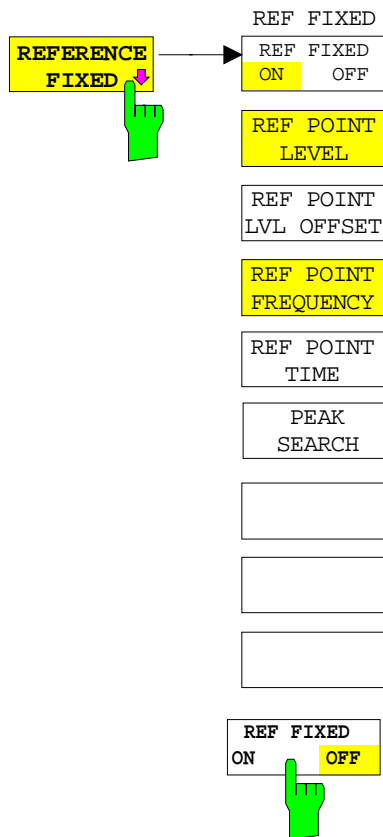
The *REFERENCE FIXED* softkey defines the level and the frequency or time of *MARKER 1* as a reference for one or several delta markers. The measured values for one or several markers displayed in the marker info field are derived from this reference point instead of the current values of the reference marker (*MARKER* 1).

On actuating the softkey, reference fixed is switched on and thus, the level value and the frequency, time or x-level value of *MARKER 1* immediately become the reference point.

Additionally, the *REFERENCE FIXED* softkey opens the submenu where it is possible to determine manually a reference point with level and frequency, time or x-axis level, to define a level offset or deactivate the reference point.

The *REFERENCE FIXED* function is useful for the measurement of the harmonic suppression at small span (fundamental not represented).

REF FIXED	
ON	**OFF**

The *REF FXD ON/OFF* softkey switches on or off the relative measurement to a fixed reference value (*REFERENCE POINT*) independent of the trace.

IEC/IEEE-bus command: `CALC:DELT2:FUNC:FIX ON`
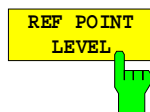
REF POINT
LEVEL

The *REF POINT LEVEL* softkey enters a reference level independent of the reference marker level. All relative level values of the delta markers refer to this reference level.

IEC/IEEE-bus command:
`CALC:DELT2:FUNC:FIX:RPO:Y –10dBm`

REF POINT
LVL OFFSET

The *REF POINT LVL OFFSET* softkey specifies a level offset relevant to the reference level. The relative level values of the delta markers refer to the reference point level plus the level offset.

The level offset is set to 0 dB on enabling the *REFERENCE FIXED* or *PHASE NOISE* function.

IEC/IEEE-bus command:
`CALC:DELT2:FUNC:FIX:RPO:Y:OFFS 0dB`

REF POINT
FREQUENCY

With the *REF POINT FREQUENCY* softkey a reference frequency can be manually activated for the delta markers when the *REFERENCE FIXED* or *PHASE NOISE* function is used.

IEC/IEEE-bus command:
`CALC:DELT2:FUNC:FIX:RPO:X 10.7MHz`
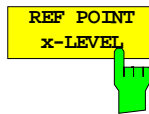
| REF POINT x-LEVEL | The *REF POINT x-LEVEL* softkey activates the entry box for the input of a reference level on the x-axis for the *REFERENCE FIXED* function when the power sweep is active. |

IEC/IEEE-bus command:
                    `CALC:DELT2:FUNC:FIX:RPO:X -5DBM`

| PEAK SEARCH | The *PEAK SEARCH* sets the reference point level for all delta markers to the peak of the selected trace when the *REFERENCE FIXED* function is used. |

IEC/IEEE-bus command: `CALC:DELT:FUNC:FIX:RPO:MAX`

Measurement example:
Small-span harmonics measurement to increase sensitivity
CW signal (eg 100 MHz, 0 dBm) with harmonics at the RF input of FSP.

[**PRESET**]	FSP is set to the default setting.
[**CENTER**: 100 **MHz**]	The center frequency of FSP is set to 100 MHz.
[**SPAN**: 1 **MHz**]	The span is set to 1 MHz.
[**AMPL**: 3 **dBm**]	The reference level is set to 3 dBm (3 dB above the expected RF level).
[**MKR**]	*MARKER* 1 is switched on ('1' highlighted in the softkey) and set to the signal peak.
[*MARKER 2*]	*MARKER 2* is switched on and automatically defined as the delta marker (*DELTA* is highlighted on *MARKER NORM DELTA* softkey).
[*REFERENCE FIXED*]	The frequency and level of *MARKER 1* are a reference for the delta marker.
[**CENTER**: 200 **MHz**]	The center frequency is set to 200 MHz (= frequency of the 2nd harmonic). The reference level may have to be reduced to see the 2nd harmonic from the noise. This does not affect the reference level set with *REFERENCE FIXED*.
[**MKR->**: *PEAK*]	The delta marker jumps to the 2nd harmonic of the signal. The level spacing of the harmonic to the fundamental is displayed in the marker info field.
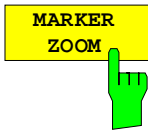
MARKER ZOOM

The *MARKER ZOOM* softkey expands the area around MARKER 1. With the zoom function, more details of the spectrum can be seen. The desired display range can be defined in an entry window.

The following sweep is stopped at the position of the reference marker. The frequency of the signal is counted and the measured frequency becomes the new center frequency. The zoomed display range is then configured and the new settings are used by FSP for further measurements.

As long as switching to the new frequency display range has not yet taken place, pressing the softkey will abort the procedure.

If *MARKER 1* is not active when the softkey is pressed, it is automatically activated and set to the highest peak in the window.

If an instrument setting is changed after selection of *MARKER ZOOM*, the function is aborted.

The *MARKER ZOOM* softkey is only available in the frequency domain (span > 0).

IEC/IEEE-bus command: CALC:MARK1:FUNC:ZOOM 1kHz

ALL MARKER OFF

The *ALL MARKER OFF* softkey switches off all markers (reference and delta markers). It also switches off all functions and displays associated with the markers/delta markers.

IEC/IEEE-bus command: CALC:MARK:AOFF

Marker Functions – *MKR FCTN* Key

The MKR FCTN menu offers further measurements with the markers:

- Measurement of noise density (*NOISE MEAS* softkey)
- Measurement of phase noise (*PHASE NOISE* softkey)
- Measurement of filter or signal bandwidth (*N DB DOWN* softkey)
- Activating of AF demodulation (*MARKER DEMOD* softkey)

On calling the menu, the entry for the last active marker is activated (*SELECT MARKER* softkey); if no marker is activated, marker 1 is activated and a maximum search (*PEAK* softkey) is performed. The marker can be set to the desired trace by means of *MKR -> TRACE* softkey.

Menu *MKR FCTN*:
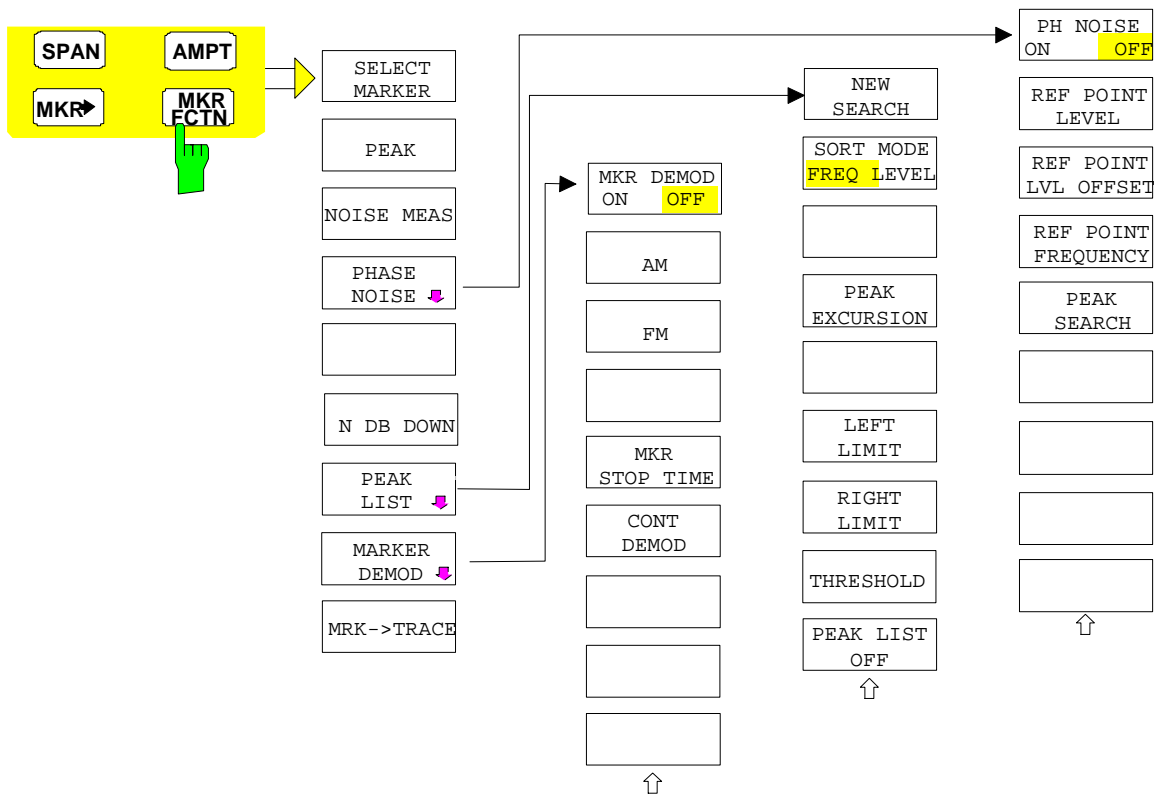
Activating the Markers

Menu *MKR FCTN*:
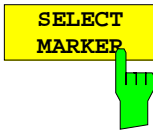
> **SELECT MARKER**

The *SELECT MARKER* softkey activates the numerical selection of the marker in the data entry field. Delta marker 1 is selected by input of ' 0 '.
If the marker is switched off, then it is switched on and can be moved later on.

IEC/IEEE-bus command: `CALC:MARK1 ON;`
                        `CALC:MARK1:X <value>;`
                        `CALC:MARK1:Y?`
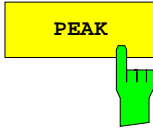
> **PEAK**

The *PEAK* softkey sets the active marker/delta marker to the peak of the trace.

IEC/IEEE-bus command: `CALC:MARK1:MAX`
                        `CALC:DELT1:MAX`

Measurement of Noise Density
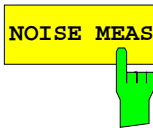
> **NOISE MEAS**

The *NOISE MEAS* softkey switches the noise measurement for the active marker on or off. The corresponding marker becomes the *NORMAL* marker.

During noise measurement, the noise power density is measured at the position of the marker. In the time domain mode, all points of the trace are used to determine the noise power density. When measurements are performed in the frequency domain, two points to the right and left of the marker are used for the measurement to obtain a stable result.
The noise power density is indicated in the marker field. With a logarithmic amplitude units (dBm, dBmV, dBmμV, dBμA) the noise power density is output in dBm/Hz i.e. as level in 1 Hz bandwidth with reference to 1 mW. With linear amplitude units (V, A, W) the noise voltage density is evaluated in μV/√Hz, the noise current density in μA/√Hz or the noise power density in μW/Hz.

The following settings have to be made to ensure that the power density measurement yields correct values:

Detector: Sample or RMS

Video bandwidth:
    ≤ 0.1 x resolution bandwidth with sample detector
              (corresponds to RBW / VBW NOISE)
    ≥ 3 x resolution bandwidth with RMS detector
              (corresponds to RBW / VBW SINE)

In the default setting, the FSP uses the sample detector for the noise function.

With the sample detector, the trace can additionally be set to AVERAGE to stabilize the measured values. With RMS detector used, trace averaging must not be used since in this case it produces too low noise levels which cannot be corrected. Instead, the sweep time can be increased to obtain stable measurement results.

The FSP uses the following correction factors to evaluate the noise density from the marker level:

- Since the noise power is indicated with reference to 1 Hz bandwidth, the bandwidth correction value is deducted from the marker level. It is 10 x lg (1 Hz/BW_{Noise}), where BW_{Noise} is the noise or power bandwidth of the set resolution filter (RBW).

Sample detector:

- As a result of video filter averaging and trace averaging, 1.05 dB is added to the marker level. This is the difference between the average value and the RMS value of white noise.

- With a logarithmic level axis, 1.45 dB is added additionally. Logarithmic averaging is thus fully taken into account which yields a value that is 1.45 dB lower than that of linear averaging.

RMS detector:

- With the exception of bandwidth correction, no further corrections are required for the RMS detector since it already indicates the power with every point of the trace.

To allow a more stable noise display the adjacent (symmetric to the measurement frequency) points of the trace are averaged.

In time domain mode, the measured values are averaged versus time (after a sweep).

IEC/IEEE-bus command: `CALC:MARK:FUNC:NOIS ON;`
                                         `CALC:MARK:FUNC:NOIS:RES?`

Example: Measurement of inherent FSP noise

[**PRESET**]   The FSP is set to default setting.

[**MARKER**]   Marker 1 is switched on and set to the maximum value of the displayed spectrum. Set marker to desired frequency using the rotary knob.

[*NOISE*]   The FSP switches the sample detector on and sets the video bandwidth to 300 kHz (0.1 x RBW). The power density level of inherent noise is displayed in dBm/Hz in the marker info field.

Note: *The FSP noise figure can be calculated from the measured power density level. It is calculated by deducting the set RF attenuation (RF Att) from the displayed noise level. 174 is to be added to the result to obtain the FSP noise figure.*

Phase Noise Measurement

Menu MKR FCTN:

PHASE NOISE
ON   OFF

REF POINT
LEVEL

REF POINT
LVL OFFSET

REF POINT
FREQUENCY

PEAK
SEARCH
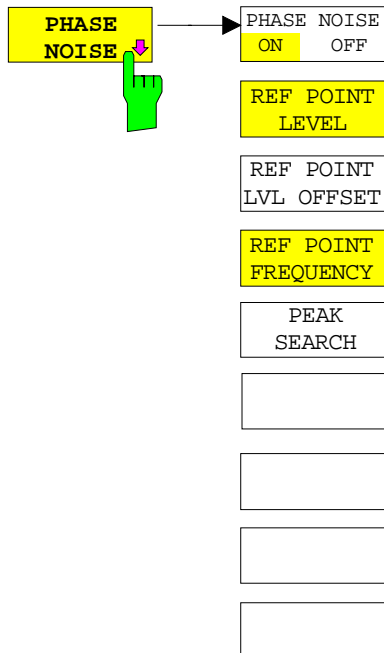
The *PHASE NOISE* softkey switches the *PHASE NOISE* function on/off. Additionally, the softkey opens the submenu for manually setting the reference point. The phase noise measurement can be switched off in the submenu.

MARKER 1 (= reference marker) is used as a reference for the phase noise measurement. The frequency and level of the reference marker are used as fixed reference values, i.e. the *REFERENCE FIXED* function is activated. After switching on the phase noise measurement the reference level or the center frequency can thus be set in a way that the carrier is outside the displayed frequency range, or, for example, a notch filter is switched on to suppress the carrier.

A noise power density measurement is carried out with the delta marker or delta markers. This measurement corresponds to the NOISE function in the *MARKER* menu (MKR). The result of the phase noise measurement is the difference in level between the reference point and the noise power density.

The following possibilities can be selected on switching on *PHASE NOISE*:

1. No marker enabled:

[**MKR FCTN**]	*MARKER 1* is enabled and set to peak.
[*PHASE NOISE*]	*MARKER 1* becomes the reference marker, *MARKER 2* the delta marker; frequency = frequency of the reference marker. The delta marker is the active marker, i.e. it can be moved with the rollkey or adjusted by entering numerals. The *PHASE NOISE* function is switched on and the measured value is output.

2. Markers are enabled:

[**MKR FCTN**]	The previous marker configuration remains unchanged.
[*PHASE NOISE*]	*MARKER* 1 becomes the reference marker. If other markers are enabled, they become delta markers and measure the phase noise at their respective positions.

If further markers are enabled during the phase noise measurement, they automatically become delta markers and measure the phase noise at their respective positions.

When the phase noise measurement is switched off, the marker configuration remains unchanged and the delta markers measure the relative level to the reference marker (*MARKER 1*).

The *PHASE NOISE* function measures the noise power at the delta markers referred to 1 Hz bandwidth. The sample detector is automatically used and the video bandwidth set to 0.1 times the resolution bandwidth (RBW). The two settings are taken into account in the correction values used for the noise power measurement.

To obtain stable results, two pixels on the right and the left of the respective delta marker position are taken for the measurement. The procedure for determining the noise power is identical to the method used for the noise power measurement (see NOISE softkey). The measured noise level referred to 1 Hz bandwidth is subtracted from the carrier level at the reference marker (*MARKER 1*). The measured values are displayed in the delta marker field in dBc/Hz (= spacing in dB of the noise power from the carrier level in 1 Hz bandwidth).

If several delta markers are enabled, only the value read by the active marker is shown in the marker field. If several delta markers are active, their measurement results are shown in the marker info field.

The reference value for the phase noise measurement can be defined with *REF POINT LEVEL*, *REF POINT FREQUENCY* and *REF POINT LVL OFFSET* to differ from that of the reference marker.

IEC/IEEE-bus command: `--`
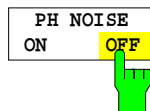
PH NOISE ON OFF

The *PH NOISE ON/OFF* softkey switches on/off the phase noise measurement. Switching on is performed by means of the *PHASE NOISE* softkey and is only necessary when the phase noise measurement has been switched off in the submenu.

IEC/IEEE-bus command: `CALC:DELT1:FUNC:PNO ON`
                          `CALC:DELT1:FUNC:PNO:RES?`
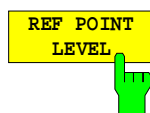
REF POINT LEVEL

The *REF POINT LEVEL* softkey activates an entry box for the input of a reference level other than the reference marker level. The function is identical to that of the softkey with the same name in the marker menu (MKR).

IEC/IEEE-bus command:
                 `CALC:DELT1:FUNC:FIX:RPO:Y -10dB`

REF POINT LVL OFFSET

The *REF POINT LVL OFFSET* softkey activates an entry box for the input of an additional level offset for the phase noise calculation.

This level offset is set to 0 dB on when the *REFERENCE FIXED* or *PHASE NOISE* function is enabled.

IEC/IEEE-bus command:
                 `CALC:DELT:FUNC:FIX:RPO:Y:OFFS 10dB`

REF POINT
FREQUENCY
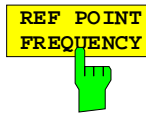
The *REF POINT FREQUENCY* softkey activates an entry box for the manual input of a reference frequency for the *REFERENCE FIXED* or *PHASE NOISE* function.

IEC/IEEE-bus command:
```
CALC:DELT1:FUNC:FIX:RPO:X 10.7MHz
```

PEAK
SEARCH

The *PEAK SEARCH* sets the reference point level for delta marker 2 in the selected measurement window to the peak of the selected trace.

IEC/IEEE-bus command: `CALC:DELT:FUNC:FIX:RPO:MAX`

Measurement example:

The phase noise of a CW signal at 100 MHz with 0 dBm level is to be measured at 800 kHz from the carrier

[**PRESET**]	The FSP is set to the default setting.
[**CENTER**: 100 **MHz**]	The center frequency is set to 100 MHz.
[**SPAN**: 2 **MHz**]	The span is set to 2 MHz.
[**AMPT**: 0 **dBm**]	The reference level is set to 0 dBm.
[**MKR FCTN**]	*MARKER 1* is switched on and positioned at the maximum of the displayed trace.
[*PHASE NOISE*: 800 **kHz**]	The phase noise measurement is switched on. The delta marker is positioned on the main marker and the measured phase noise value is displayed in the marker info field. The sample detector is used and the video bandwidth is set to 3 x RBW. When the phase noise measurement function is enabled, the entry of the delta marker frequency is activated. It can be entered directly.

Measurement of the Filter or Signal Bandwidth

Menu *MKR FCTN*:
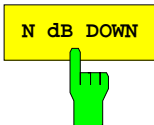
N dB DOWN

The *N dB DOWN* softkey activates the temporary markers T1 and T2 which are n dB below the active reference marker. Marker T1 is placed to the left and marker T2 at the right of the reference marker. The value n can be input in a window.

The default setting is 3 dB.

The frequency spacing of the two temporary markers is indicated in the marker info field.
If, for example, it is not possible to form the frequency spacing for the n dB value because of the noise display, dashes are indicated instead of a measured value.

IEC/IEEE-bus command:
```
CALC:MARK1:FUNC:NDBD:STAT ON
CALC:MARK1:FUNC:NDBD 3dB
CALC:MARK1:FUNC:NDBD:RES?
CALC:MARK1:FUNC:NDBD:FREQ?
```

Measurement of a Peak List

Menu *MKR FCTN*:

```
PEAK              NEW
LIST            SEARCH

             SORT MODE
             FREQ LEVEL


              PEAK
            EXCURSION


              LEFT
              LIMIT

             RIGHT
             LIMIT

            THRESHOLD

            PEAK LIST
               OFF
```
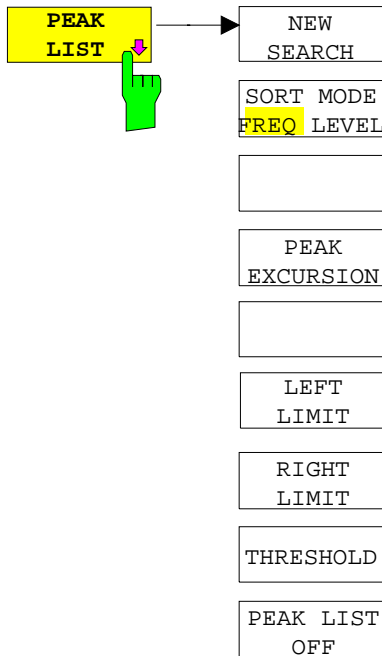
The *PEAK LIST* softkey allows the peak values of the trace to be determined and entered in a list with 50 entries max. The order of the entries is defined by the *SORT MODE*:

FREQ   sorting in ascending order of frequency values (see screenshot); if span = 0, the entries are sorted in ascending order of time values

LEVEL   sorting according to level

PEAK LIST		
#	FREQUENCY	POWER
1	794.871794871 MHz	-55.37 dBm
2	2.397435897 GHz	-74.70 dBm
3	4.012820512 GHz	-38.00 dBm
4	5.615384615 GHz	-26.04 dBm
5	6.435897435 GHz	-38.02 dBm
6	7.217948717 GHz	-55.39 dBm

The search range can be restricted by means of the *LEFT LIMIT, RIGHT LIMIT* and *THRESHOLD* softkeys. The definition of the peak values can be modified using the *PEAK EXCURSION* softkey. The *MKR->TRACE* softkey in the main menu is used to select the trace for searching peak values.

Opening the list performs a single search at the end of the sweep. The *NEW SEARCH* softkey triggers a new sweep, determines the peak values of the trace at the end of the sweep and enters them in the list.

Use the *PEAK LIST OFF* key to delete the list from the screen.

IEC/IEEE-bus commands: `INIT:CONT OFF;`
`CALC:MARK:TRAC 1;`
`CALC:MARK:FUNC:FPE:SORT X;`
`INIT;*WAI;`
`CALC:MARK:FUNC:FPE 10;`
`CALC:MARK:FUNC:FPE:COUN?;`
`CALC:MARK:FUNC:FPE:Y?;`
`CALC:MARK:FUNC:FPE:X?`

| NEW SEARCH |

The *NEW SEARCH* softkey starts a new peak search and enters the results in the peak list.

IEC/IEEE-bus commands:
```
INIT;*WAI;
CALC:MARK:FUNC:FPE 10;
CALC:MARK:FUNC:FPE:COUN?;
CALC:MARK:FUNC:FPE:Y?;
CALC:MARK:FUNC:FPE:X?
```

| SORT MODE FREQ LEVEL |

The *SORT MODE FREQ/LEVEL* softkey defines the position of the peak values in the list:

FREQ   sorting in ascending order of frequency values (time values if span = 0)
LEVEL   sorting according to level

IEC/IEEE-bus command: `CALC:MARK:FUNC:FPE:SORT X;`
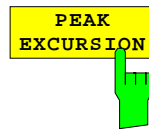
| PEAK EXCURSION |

With level measurements, the *PEAK EXCURSION* softkey allows the minimum amount to be entered by which a signal must decrease or increase in order to be recognized as a maximum by the peak search function.

Values between 0 dB and 80 dB may be entered, the resolution being 0.1 dB

IEC/IEEE-bus command: `CALC:MARK:PEXC 6dB`

| LEFT LIMIT |

| RIGHT LIMIT |
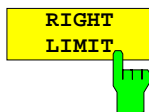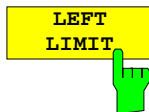
The *LEFT LIMIT* and *RIGHT LIMIT* softkeys define the vertical lines F1/F2 in the frequency domain (span > 0) and T1/T2 in the time domain (span = 0) between which the search is carried out.
If only one line is active, the F1/T1 line is used as the lower limit; the upper limit is the stop frequency. If F2/T2 is also active, it defines the upper limit.

IEC/IEEE-bus commands:
```
CALC:MARK:X:SLIM:LEFT 1MHZ
CALC:MARK:X:SLIM:RIGH 10MHZ
CALC:MARK:X:SLIM ON
```

| THRESHOLD |

The *THRESHOLD* softkey defines a horizontal threshold line which represents the lower limit of the peak search level range.

IEC/IEEE-bus command:
```
CALC:THR –20dBm
CALC:THR ON
```

| PEAK LIST OFF |

The *PEAK LIST OFF* softkey switches off the table with the search results.

IEC/IEEE-bus command: –

AF Demodulation

The FSP provides demodulators for AM and FM signals when equipped with the AF demodulator option (FSP-B3). With these demodulators, a displayed signal can be identified acoustically through the use of the internal loudspeaker or with headphones. The frequency at which the demodulation is enabled is coupled to the markers. The sweep stops at the frequency determined by the active marker for the selected time and the RF signal is demodulated. During a measurement in the time domain (span = 0 Hz) the demodulation is continuously on.

The threshold line (*MKR->SEARCH LIMITS:THRESHOLD*) performs a squelch function in the demodulator. If the threshold is set, the FSP LF demodulation is switched on only when the signal to be demodulated exceeds the set threshold.

Menu *MKR FCTN*:
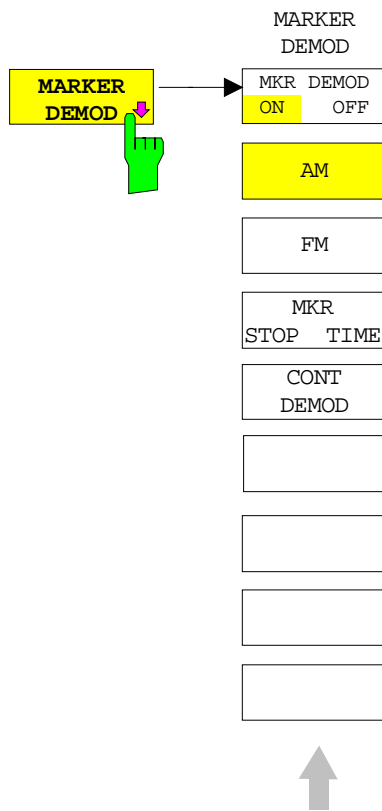
The *MARKER DEMOD* softkey switches on the audio demodulator and calls a submenu in which the demodulation mode and the duration of the demodulation can be selected.

IEC/IEEE-bus command: `CALC:MARK1:FUNC:DEM ON`
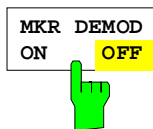
The *MKR DEMOD ON/OFF* softkey switches the demodulation on/off.

In the frequency range (span >0), the frequency scan is stopped at the frequency of the active marker with demodulation switched on – provided that the level is above the threshold line - and the signal is demodulated during the given stop time.

In the time domain (span = 0) demodulation is continuous, i.e. not only active at the marker position.

IEC/IEEE-bus command: `CALC:MARK1:FUNC:DEM ON`

AM

FM
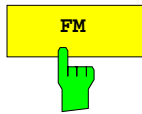
The softkeys *AM and FM* are selector switches one of which only may be active at a time. They set the desired demodulation mode FM or AM. Default setting is AM.

IEC/IEEE-bus command: `CALC:MARK1:FUNC:DEM:SEL AM`
　　　　　　　　　　　　　　`CALC:MARK1:FUNC:DEM:SEL FM`

MKR
STOP TIME

The *MKR STOP TIME* softkey defines the stop time for demodulation at the marker(s).
The FSP interrupts the frequency sweep at the marker position and activates the demodulation for the duration of the stop time (see also *MKR DEMOD ON/OFF*).
In the time domain (span = 0) the demodulation is continuously active irrespective of the stop time set.

IEC/IEEE-bus command: `CALC:MARK1:FUNC:DEM:HOLD 3s`
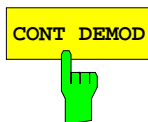
CONT DEMOD

The *CONT DEMOD* softkey switches on the continuous demodulation in the frequency domain. If the sweep time is long enough, the set frequency range can be monitored acoustically.

IEC/IEEE-bus command: `CALC:MARK1:FUNC:DEM:CONT ON`

Selecting the Trace

Menu *MKR FCTN*:

MRK →TRACE

The *MKR→TRACE* softkey sets the active marker to different traces. Only those traces can be selected which are visible on the screen in the same window.

The function of the softkey is identical to that of the softkey with the same name in the MKR-> menu.

Example:
Three traces are displayed on the screen. The marker is always on Trace 1 on switching on.

[*MKR ->TRACE*]
　　"1"<ENTER>　　The marker jumps to Trace 2, but remains at the previous frequency or time.

[*MKR ->TRACE*]
　　"3"<ENTER>　　The marker jumps to Trace 3.

IEC/IEEE-bus command:　`CALC:MARK:TRAC 2`

Change of Settings via Markers – *MKR* ⇒ Key

The *MKR* → menu offers functions through which instrument parameters can be changed with the aid of the currently active marker. The functions can be used on markers and delta markers.

On opening the menu, the entry for the last active marker is activated; if no marker was enabled, *MARKER 1* is activated and a peak search is performed.

MKR → menu
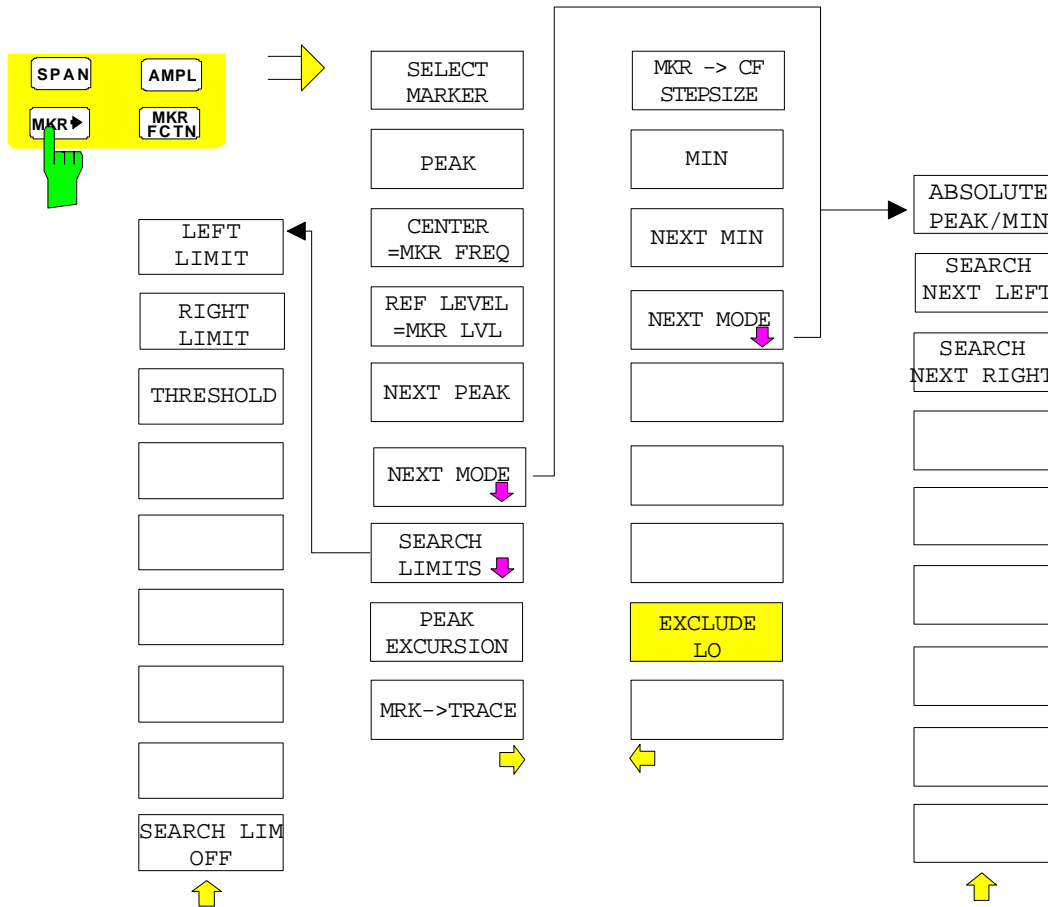
The *SELECT MARKER* softkey activates the numerical selection of the marker in the data entry field. Delta marker 1 is selected by input of ' 0 '.

IEC/IEEE-bus command: CALC:MARK1 ON;
                       CALC:MARK1:X <value>;
                       CALC:MARK1:Y?
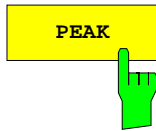
PEAK

The *PEAK* softkey sets the active marker or delta marker to the peak of the trace.

If no marker is active when **MKR->** menu is called, *MARKER 1* is automatically switched on and the peak search is performed.

IEC/IEEE-bus command: `CALC:MARK:MAX`
                          `CALC:DELT:MAX`

CENTER =MKR FREQ

The *CENTER = MKR FREQ* softkey sets the center frequency to the current marker or delta marker frequency.

A signal can thus be set to the center of the frequency display range, for example, so that it can then be examined in detail with a smaller span.

The softkey is not available in the time domain (zero span).

IEC/IEEE-bus command: `CALC:MARK:FUNC:CENT`

Example:

A spectrum is displayed with a large span after PRESET. A signal off the center is to be examined in detail:

[**PRESET**]   FSP is set to the default setting.

[**MKR->**]   *MARKER 1* is switched on and automatically jumps to the largest signal of the trace.

[*CENTER =MKR FREQ*]   The center frequency is set to the marker frequency. The span is adapted in such a way that the minimum frequency (= 0 Hz) or the maximum frequency is not exceeded.

[*SPAN*]   The span can, for example, be reduced using the rollkey.

REF LEVEL =MKR LVL

The *REF LEVEL = MKR LVL* softkey sets the reference level to the current marker level.

IEC/IEEE-bus command: `CALC:MARK:FUNC:REF`

Example:

A spectrum is displayed with a large span after PRESET. A signal off the center is to be examined in detail:

[**PRESET**]   FSP is set to the default setting.

[**MKR->**]   *MARKER 1* is switched on and automatically jumps to the largest signal of the trace.

[*CENTER =MKR FREQ*]   The center frequency is set to the marker frequency. The span is adapted in such a way that the minimum frequency (= 0 Hz) or the maximum frequency is not exceeded.

[*REF LEVEL = MKR LVL*]   The reference level is set to the measured marker level.

[**SPAN**]   The span can, for example, be reduced using the rollkey.

NEXT PEAK

The *NEXT PEAK* softkey sets the active marker/delta marker to the next lower peak value on the trace. The search direction is defined in the *NEXT MODE* submenu (see below).

IEC/IEEE-bus command: `CALC:MARK:MAX:NEXT`
                          `CALC:DELT:MAX:NEXT`

NEXT MODE → ABSOLUTE PEAK/MIN

SEARCH NEXT LEFT

SEARCH NEXT RIGHT
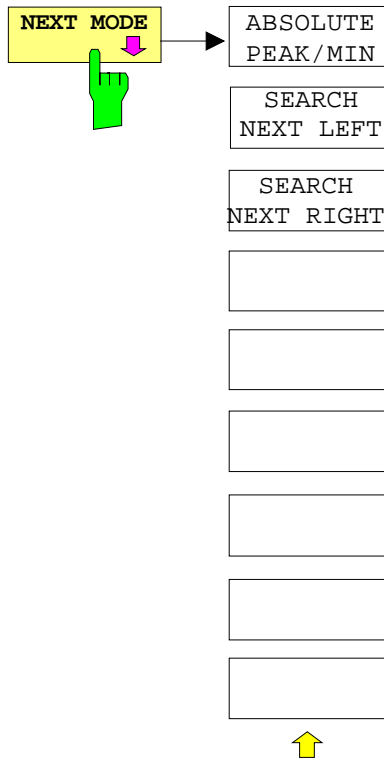
The *NEXT MODE* softkey opens a sub menu for definition of the search direction for *NEXT PEAK and NEXT MIN.*

The softkeys are selection switches, ie only one of them can be active at any one time.
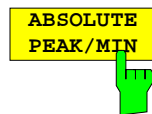
ABSOLUTE PEAK/MIN

The *ABSOLUTE PEAK/MIN* softkey defines that the next higher maximum or minimum is searched for on the whole trace.

IEC-Bus-Befehle: CALC:MARK:MAX:NEXT
                        CALC:DELT:MAX:NEXT
                        CALC:MARK:MIN:NEXT
                        CALC:DELT:MIN:NEXT

SEARCH NEXT LEFT

The *SEARCH NEXT LEFT* softkey defines that the next higher maximum or minimum on the left of the active marker is searched for, ie only frequencies or time values smaller than the current marker frequency or time are taken into account.

IEC-Bus-Befehle: CALC:MARK:MAX:LEFT
                        CALC:DELT:MAX:LEFT
                        CALC:MARK:MIN:LEFT
                        CALC:DELT:MIN:LEFT

SEARCH NEXT RIGHT

The *SEARCH NEXT RIGHT* softkey defines that the the next higher maximum or minimum on the right of the active marker is searched for, ie only frequencies or time values higher than the current marker frequency or time are taken into account.

IEC-Bus-Befehle: CALC:MARK:MAX:RIGH
                        CALC:DELT:MAX:RIGH
                        CALC:MARK:MIN:RIGH
                        CALC:DELT:MIN:RIGH
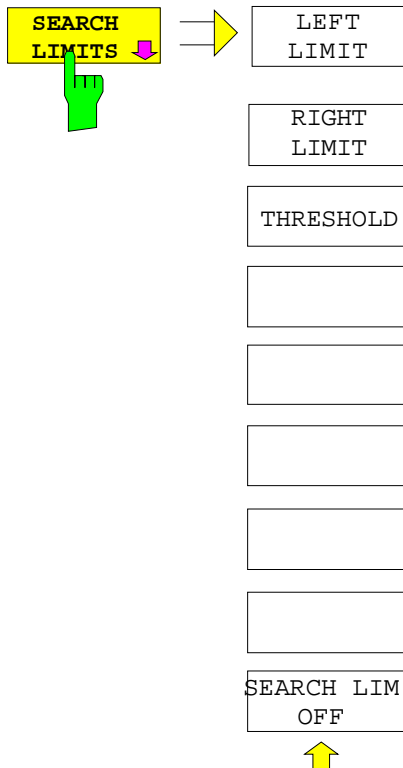
The *SEARCH LIMITS* softkey limits the search range for maximum or minimum search. The softkey switches to a submenu in which the search range limits can be set in the x and y direction.
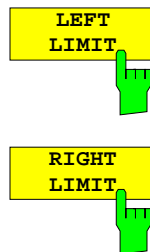
The *LEFT LIMIT* und *RIGHT LIMIT* softkeys define the two vertical lines F1 and F2 in the frequency domain (span > 0) and T1 / T2 in the time domain (span = 0). The search is performed between these lines in the frequency and time domain
If only one line is enabled, line F1/T1 is the lower limit and the upper limit corresponds to the stop frequency. If F2/T2 is also enabled, it determines the upper limit.

IEC/IEEE-bus command: `CALC:MARK:X:SLIM:LEFT 1MHZ`
`CALC:MARK:X:SLIM:RIGH 10MHZ`
`CALC:MARK:X:SLIM ON`

The *THRESHOLD* softkey defines the threshold line.
The threshold line represents a limit for the level range of the max. search at the lower end and that of the min. search at the upper end.

IEC/IEEE-bus command: `CALC:THR -20dBm`
`CALC:THR ON`
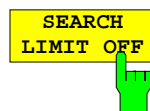
The *SEARCH LIMIT OFF* softkey disables all limits of the search range.

IEC/IEEE-bus command: `CALC:MARK:X:SLIM OFF`
`CALC:THR OFF`
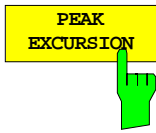
PEAK EXCURSION

The *PEAK EXCURSION* softkey activates an entry box for selecting the minimum amount by which a signal level must decrease/increase before it is recognized by the *NEXT PEAK* and *NEXT MIN* search functions as a maximum or minimum.

Input values from 0 to 80 dB are allowed, the resolution being 0.1 dB.

IEC/IEEE-bus command: `CALC:MARK:PEXC 10dB`

The peak excursion is preset to 6 dB. This is sufficient for the *NEXT PEAK* (or *NEXT MIN*) functions in the *NEXT MODE ABS* setting as always the next smaller (or larger) signal is searched for.

In the *SEARCH NEXT LEFT* or *SEARCH NEXT RIGHT* setting, functions *NEXT PEAK* and *NEXT MIN* search for the next relative maximum or minimum on the right or left of the current marker position irrespective of the instantaneous signal amplitude. A relative maximum is given when the signal amplitude on both sides of the maximum is reduced by a certain amount, ie the peak excursion.

The preset 6 dB level change can already be reached by the noise indication of the FSP. Noise maxima are identified as peaks. In this case, *PEAK EXCURSION* has to be selected with a higher value than the difference between the highest and lowest noise indication values.

The following example shows the effect of different *PEAK EXCURSION* settings.
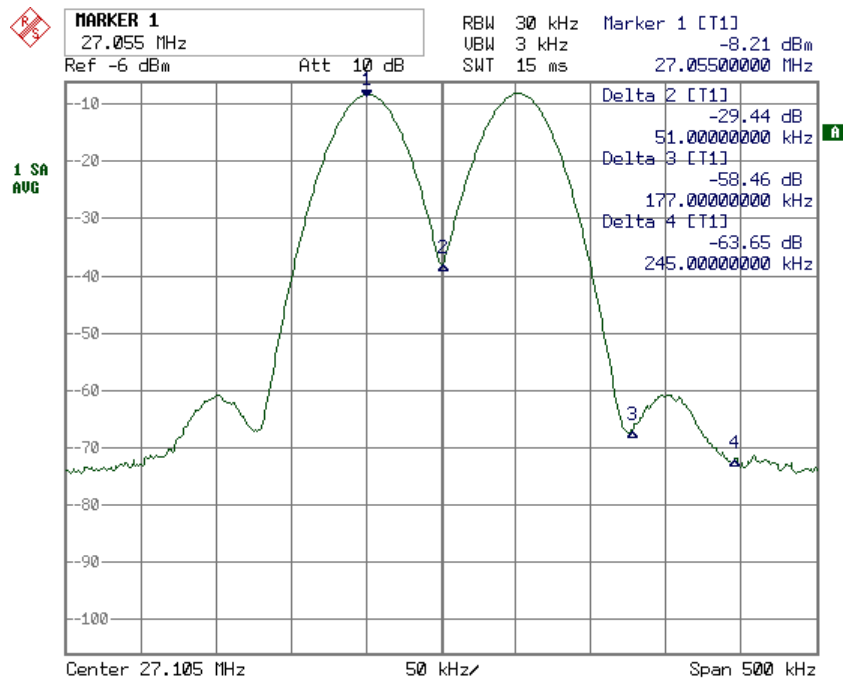
Fig. 4-5   Example for level measurements at different peak excursion settings

Maximum relative level change of the measured signals:
 Signal 2:   42 dB
 Signal 3   30 dB
 Signal 4:   46 dB

The setting **Peak Excursion 40 dB** causes signals 2 and 4 to be detected with *NEXT PEAK* or *NEXT PEAK RIGHT*. Signal 3 is not detected since it only decreases by 30 dB before the level rises again.

Order of signals found:
 PEAK: Signal 1
 NEXT PEAK: Signal 2
 NEXT PEAK: Signal 4
or
 PEAK: Signal 1
 NEXT PEAK RIGHT: Signal 2
 NEXT PEAK RIGHT: Signal 4

The setting **Peak Excursion 20 dB** causes signal 3 to be detected as well since its highest level change of 30 dB is now higher than the set peak excursion.

Order of signals found:
 PEAK: Signal 1
 NEXT PEAK: Signal 2
 NEXT PEAK: Signal 4
 NEXT PEAK: Signal 3
or
 PEAK: Signal 1
 NEXT PEAK RIGHT: Signal 2
 NEXT PEAK RIGHT: Signal 3
 NEXT PEAK RIGHT: Signal 4

The setting **Peak Excursion 6 dB** detects all the signals, *NEXT PEAK RIGHT* does not work as required.

Order of signals found:
 PEAK: Signal 1
 NEXT PEAK: Signal 2
 NEXT PEAK: Signal 4
 NEXT PEAK: Signal 3
or
 PEAK: Signal 1
 NEXT PEAK RIGHT: Marker in noise between signal 1 and signal 2
 NEXT PEAK RIGHT: Marker in noise between signal 1 and signal 2
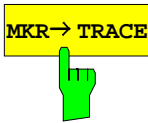
MKR→ TRACE

The *MKR→TRACE* softkey sets the active marker to a new trace. If only one trace is available on the screen, the softkey does not appear. If several traces are available on the screen, only these are offered.

IEC/IEEE-bus command: CALC:MARK:TRAC 2

Example:

Three traces are displayed on the screen. The marker is always on Trace 1 after switching on.

[*MKR ->TRACE] "2" <ENTER>*	The marker jumps to Trace 2 but remains at the previous frequency or time.
[*MKR ->TRACE*] "3" *<ENTER>*	The marker jumps to Trace 3.

MKR->CF STEPSIZE

The *MKR→CF STEPSIZE* softkey sets the step size for the center frequency variation to the current marker frequency, and also sets step size adaptation to *MANUAL*. *CF STEPSIZE* remains at this value until the center frequency entry mode in the STEP menu is switched from *MANUAL* to *AUTO* again.

The *MKR→CF STEPSIZE* function is, above all, useful in the measurement of harmonics with large dynamic range (narrow bandwidth and narrow span).

The softkey is not available in the time domain (span = 0 Hz).

IEC/IEEE-bus command: CALC:MARK:FUNC:CST

Example:

The harmonics levels of a CW carrier are to be measured at 100 MHz.

[**PRESET**]	FSP is set to the default setting.
[**CENTER**: 100 **MHz**]	FSP sets the center frequency to 100 MHz. The span is set to 200 MHz.
[**SPAN**: 1 **MHz**]	The span is set to 100 MHz.
[**MKR->**]	*MARKER 1* is switched on and set to the maximum value of the signal.
[**NEXT**]	FSP switches to the submenu.
[*MKR->CF STEPSIZE*]	The step size of the center frequency setting equals the marker frequency (100 MHz).
[**CENTER**]	The center frequency entry mode is activated.
[**Right key**]	The center frequency is set to 200 MHz. The first harmonic of the test signal is displayed.
[**MKR->:** *PEAK*]	The marker is set to the harmonic and the level of the latter is output in the marker info field.

MIN
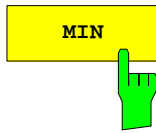
The *MIN* softkey sets the active marker to the minimum value on the corresponding trace.

IEC/IEEE-bus command: CALC:MARK:MIN
CALC:DELT:MIN
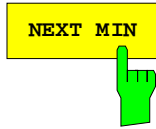
NEXT MIN

The *NEXT MIN* softkey sets the active marker to the next higher minimum value on the corresponding trace. The search direction is defined in the *NEXT MODE* submenu (see above).

IEC/IEEE-bus command: CALC:MARK:MIN:NEXT
CALC:DELT:MIN:NEXT
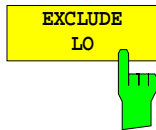
EXCLUDE LO

The *EXCLUDE LO s*oftkey limits the frequency range for the marker search functions or disables the limit.

activated   Because of the feedthrough of the first local oscillator to the first intermediate frequency at the input mixer, the LO is represented as a signal at 0 Hz. To avoid the marker jumping to the LO at 0 Hz with the peak function when setting the display range, this frequency is excluded. The minimum frequency to which the marker jumps, is $\geq 6 \times$ resolution bandwidth (RBW).

deactivated No restriction to the search range. The frequency 0 Hz is included in the marker search functions.

IEC/IEEE-bus command: CALC:MARK:LOEX ON

Power Measurements – Hardkey *MEAS*

With its power measurement functions the FSP is able to measure all the necessary parameters with high accuracy in a wide dynamic range.

A modulated carrier is almost always used (except e.g. SSB-AM) for high-frequency transmission of information. Due to the information modulated upon the carrier, the latter covers a spectrum which is defined by the modulation, the transmission data rate and the signal filtering. Within a transmission band each carrier is assigned a channel taking into account these parameters. In order to ensure error-free transmission, each transmitter must be conforming to the specified parameters. These include among others:

- the output power,

- the occupied bandwidth, i.e. the bandwidth which must contain a defined percentage of the power and

- the power dissipation allowed in the adjacent channels.

Additionally the menu contains functions to determine the modulation depth of AM modulated signals and to measure the 3rd order intercept point.

The measurements and the corresponding settings are selected in the *MEAS* menu.

MEAS menu:
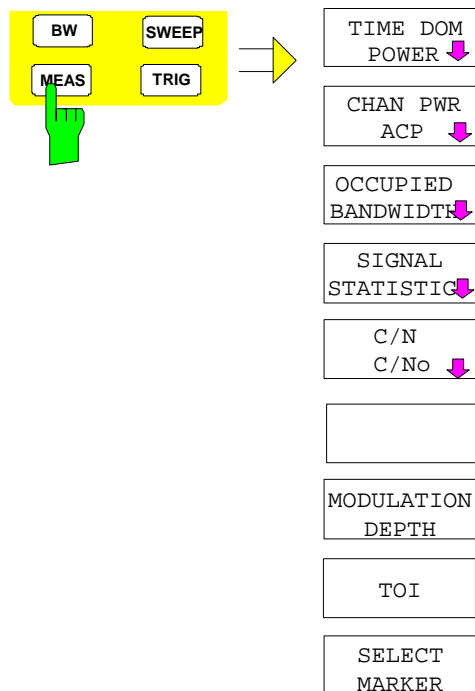
The *MEAS* key opens the menu to select and set the power measurement.

The following measurements can be selected:
- Power in time domain (*TIME DOM POWER*)
- Channel power and adjacent-channel power in frequency domain (*CHAN PWR /ACP*)
- Occupied bandwidth (*OCCUPIED BANDWIDTH*)
- Carrier/noise ratio (*C/N, C/No*)
- Amplitude probability distribution (*SIGNAL STATISTICS*)
- Modulation depth (*MODULATION DEPTH*)
- 3rd order intercept (*TOI*)

The above measurements are carried out alternatively.

Power Measurement in Time Domain

With the aid of the power measurement function the FSP determines the power of the signal in the time domain (SPAN = 0 Hz) by summing up the power at the individual pixels and dividing the result by the number of pixels. In this way it is possible to measure for example the power of TDMA signals during transmission or during the muting phase. Both the mean power and the rms power can be measured by means of the individual power values.
 The result is displayed in the marker info field.

The measured values are updated after each sweep or averaged over a user-defined number of sweeps (*AVERAGE ON/OFF* and *NUMBER OF SWEEPS*) in order to determine e.g. the mean power over several bursts. For determination of the peak value (*MAX HOLD ON*) the maximum value from several sweeps is displayed.

Example:
Marker info field for: *MEAN* selected, *AVERAGE ON* and *MAX HOLD ON*:

```
MEAN HOLD        -2.33 dBm
MEAN AV          -2.39 dBm
```

If both the on and off phase of a burst signal are displayed, the measurement range can be limited to the transmission or to the muting phase with the aid of vertical lines. The ratio between signal and noise power of a TDMA signal for instance can be measured by using a measurement as a reference value and after that varying the measurement range.

Upon switching on power measurement the sample detector is activated (*TRACE-DETECTOR-SAMPLE)*.

Submenu *MEAS - TIME DOM POWER*:
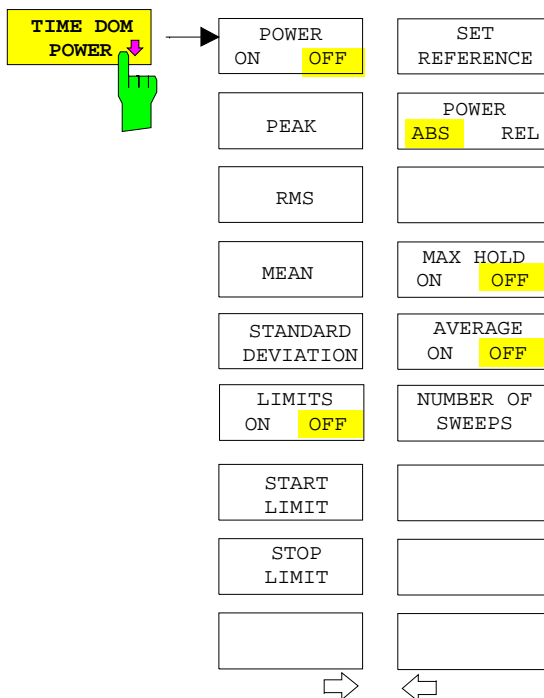
The *TIME DOM POWER* softkey activates the power measurement in the time domain and opens a submenu for configuration of the power measurement.

The submenu allows selection of the type of power measurement (rms or mean power), the settings for max hold and averaging as well as the definition of limits.

The power evaluation range can be limited by input of limit values.

Note: This softkey is only available in time domain (SPAN = 0).

The *POWER ON/OFF* softkey switches the power measurement on and off. When entering the submenu it is *ON* since the power measurement is already switched on with the *TIME DOM POWER* softkey in the main menu.

Note: *The measurement is performed on the trace on which marker 1 is placed. To evaluate another trace, marker 1 should be set on another trace using the SELECT TRACE softkey in menu MKR.*

IEC/IEEE-bus command: CALC:MARK:FUNC:SUMM:PPE ON
                          CALC:MARK:FUNC:SUMM:PPE:RES?
                          CALC:MARK:FUNC:SUMM:RMS ON
                          CALC:MARK:FUNC:SUMM:RMS:RES?
                          CALC:MARK:FUNC:SUMM:MEAN ON
                          CALC:MARK:FUNC:SUMM:MEAN:RES?
                          CALC:MARK:FUNC:SUMM:SDEV ON
                          CALC:MARK:FUNC:SUMM:SDEV:RES?

The *PEAK* softkey switches on the calculation of the peak value from the points of the displayed trace or a segment thereof.

For the maximum peak, the largest peak value obtained since the activation of *MAX HOLD ON* is displayed.

With *AVERAGE ON*, the peak values of a trace are averaged over several sweeps and displayed.

The number of sweeps over which the average or the maximum value is calculated is set with the *NUMBER OF SWEEPS* softkey.

IEC/IEEE-bus command: CALC:MARK:FUNC:SUMM:PPE ON
                          CALC:MARK:FUNC:SUMM:PPE:RES?

The *RMS* softkey switches on the calculation of the rms value from the points of the displayed trace or a segment of it.

For the maximum peak, the largest rms value obtained since the activation of *MAX HOLD ON* is displayed.

With *AVERAGE ON*, the rms values of a trace are averaged over several sweeps and displayed.

The number of sweeps over which the average or the maximum value is calculated is set with the *NUMBER OF SWEEPS* softkey.

IEC/IEEE-bus command: CALC:MARK:FUNC:SUMM:RMS   ON
                          CALC:MARK:FUNC:SUMM:RMS:RES?

MEAN

The *MEAN* softkey switches on the calculation of the mean value from the points of the displayed trace or a segment of it. The linear mean value of the equivalent voltages is calculated.

This can be used for instance to measure the mean power during a GSM burst.

For the maximum peak, the largest mean value obtained since the activation of *MAX HOLD ON* is displayed.

With *AVERAGE ON*, the mean values of a trace are averaged over several sweeps and displayed.

The number of sweeps over which the average or the maximum value is calculated is set with the *NUMBER OF SWEEPS* softkey.

IEC/IEEE-bus command: `CALC:MARK:FUNC:SUMM:MEAN ON`
                         `CALC:MARK:FUNC:SUMM:MEAN:RES?`

STANDARD DEVIATION
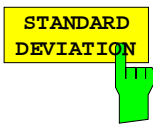
The *STANDARD DEVIATION* softkey switches on the calculation of the standard deviation of trace points from the mean value and outputs them as measured value. The measurement of the mean power is automatically switched on at the same time.

For the maximum peak, the largest standard deviation obtained since the activation of *MAX HOLD ON* is displayed.

With *AVERAGE ON*, the standard deviations of a trace are averaged over several sweeps and displayed.

The number of sweeps over which the average or the maximum value is calculated is set with the *NUMBER OF SWEEPS* softkey.

IEC/IEEE-bus command: `CALC:MARK:FUNC:SUMM:SDEV ON`
                         `CALC:MARK:FUNC:SUMM:SDEV:RES?`
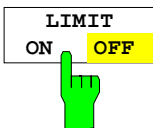
LIMIT ON OFF

The *LIMIT ON/OFF* softkey selects the limited (*ON*) or non-limited (*OFF*) evaluation range.

The evaluation range is defined by the *START LIMIT* and *STOP LIMIT* softkeys. If *LIMIT = ON*, signals are only searched between the two lines.

If only one limit line is switched on, time line 1 is the lower limit and the upper limit corresponds to the stop frequency. If time line 2 is also switched on, it defines the upper limit.

If no limit line is switched on, the evaluation range is not limited.

The default setting is *LIMIT = OFF*.

IEC/IEEE-bus command: `CALC:MARK:X:SLIM OFF`
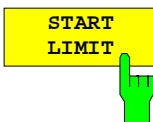
START LIMIT

The *START LIMIT* softkey activates the entry of the lower limit of the evaluation range.

IEC/IEEE-bus command: `CALC:MARK:X:SLIM:LEFT <value>`
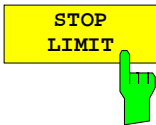
The *STOP LIMIT* softkey activates the entry of the upper limit of the evaluation range.

IEC/IEEE-bus command: `CALC:MARK:X:SLIM:RIGH <value>`
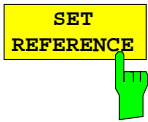
The *SET REFERENCE* softkey sets the power values currently measured as reference values for the calculation of the mean value (*MEAN)* and the rms value (*RMS).* The reference values are used to perform relative measurements.

If the calculation of the mean value (*MEAN)* and rms value (*RMS)* is not switched on, 0 dBm is used as a reference value.

If the average value (*AVERAGE)* or maximum value (*MAX HOLD*) is calculated over several sweeps, the current value is the measured value summed up at the actual time.

IEC/IEEE-bus command: `CALC:MARK:FUNC:SUMM:REF:AUTO ONCE`
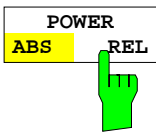
The *POWER ABS/REL* softkey selects the absolute power measurement (default setting) or relative power measurement. The reference value for the relative power is defined by *SET REFERENCE*.

The value 0 dBm is used if the reference value is not defined.

IEC/IEEE-bus command: `CALC:MARK:FUNC:SUMM:MODE ABS`
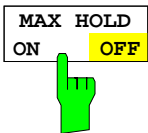
The *MAX HOLD ON/OFF* softkey switches the display of the maximum peak obtained from measurements at successive sweeps on and off.

The displayed maximum peak is only updated at the end of a sweep if a higher value has occurred.

The maximum value can be reset by switching the *MAX HOLD ON / OFF* softkey off and on again.

IEC/IEEE-bus command: `CALC:MARK:FUNC:SUMM:PHOL ON`
                                       `CALC:MARK:FUNC:SUMM:PPE:PHOL:RES?`
                                       `CALC:MARK:FUNC:SUMM:RMS:PHOL:RES?`
                                       `CALC:MARK:FUNC:SUMM:MEAN:PHOL:RES?`
                                       `CALC:MARK:FUNC:SUMM:SDEV:PHOL:RES?`
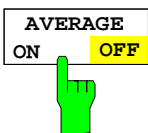
The *AVERAGE ON/OFF* softkey switches averaging over successive sweep measurements on and off.

The measured values can be reset by switching the *AVERAGE ON / OFF* softkey off and on again.

IEC/IEEE-bus command: `CALC:MARK:FUNC:SUMM:AVER ON`
                                       `CALC:MARK:FUNC:SUMM:PPE:AVER:RES?`
                                       `CALC:MARK:FUNC:SUMM:RMS:AVER:RES?`
                                       `CALC:MARK:FUNC:SUMM:MEAN:AVER:RES?`
                                       `CALC:MARK:FUNC:SUMM:SDEV:AVER:RES?`
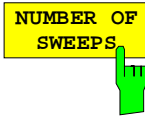
NUMBER OF SWEEPS	The *NUMBER OF SWEEPS* softkey activates the entry of the number of sweeps for maximum or average value calculation.

SINGLE SWEEP mode	The FSP performs sweeps until the selected number of sweeps is reached and stops then.
CONTINUOUS SWEEP mode	Averaging is carried out until the selected number of sweeps is reached. After that, averaging is performed in continuous mode. and is then continued as running averaging. Calculation of the maximum peak (*MAX HOLD*) is performed continuously irrespective of the selected number of sweeps.

The valid range values is 0 to 32767.

Depending on the specified number of sweeps, averaging is carried out according to the following rules:

NUMBER OF SWEEPS = 0	Continuous averaging is carried out over 10 measured values.
NUMBER OF SWEEPS = 1	No averaging is carried out.
NUMBER OF SWEEPS > 1	Averaging is carried out over the set number of measured values.

Note: *This setting is equivalent to the setting of the sweep count in the TRACE menu.*

IEC/IEEE-bus command: SWE:COUN <value>

Example:

The mean power of a GSM burst with 0 dBm nominal power at 800 MHz is to be measured.

[**PRESET**]	Set the FSP to the default setting.
[**FREQ:** *CENTER*: 800 **MHz**]	Set the center frequency to 800 MHz.
[**SPAN**: *ZERO SPAN*]	Select time domain display (span = 0 Hz).
[**AMPT**: 0 **dBm**]	Set the reference level to 0 dBm.
[**BW**: *RES BW MANUAL*: 30 **kHz**]	Set the resolution bandwidth to 30 kHz in line with the requirements of the GSM standard.
[**SWEEP**: *SWEEPTIME MANUAL* 600 µs]	Set the sweep time to 600 µs.
[**TRIG**: *VIDEO*: 50 **%**]	Use the video signal as trigger source.
[**MEAS**]	Call the menu for the measurement functions.
[*TIME DOM POWER*]	Select power measurement in the time domain. The FSP calculates the mean power from the points of the whole trace. The submenu for configuration of the power measurement is opened. *MEAN* is already switched on.
[*LIMITS ON*]	Activate the limitation of the time domain of the power measurement .
[*START LIMIT*: 250 **µs**]	Set the start of the power measurement at 250 µs.
[*STOP LIMIT*: 500 **µs**]	Set the end of the power measurement at 500 µs.

Note: *The GSM specifications require the power to be measured between 50% and 90% of the TDMA burst. The time limits set above approximately correspond to the required time domain.*

Channel and Adjacent-Channel Power Measurements

For all channel and adjacent-channel power measurements a specified channel configuration is assumed which is for instance based on a specific radiocommunication system.
This configuration is defined by the nominal channel frequency (= center frequency of the FSP), channel bandwidth, adjacent-channel bandwidth and adjacent-channel spacing. The FSP is able to simultaneously measure the power in up to three adjacent channels (7 channels: transmission channel, 3 lower and 3 upper adjacent channels).
It offers two methods for channel and adjacent-channel power measurement:

- The integrated bandwidth method (IBW method), i.e. the integration of trace pixels within the bandwidth of the channel to be measured to the total power of the channel,

- The measurement in time domain (Fast ACP) by means of steep resolution filters simulating the channel.

The two measurements yield the same results. The measurement in time domain can be performed much faster since the complete signal is measured within a channel at the same time. With the IBW method, the channel is divided into subspectra. This is done by means of a bandwidth which is small compared to the channel bandwidth. These subspectra are then combined by integration of the trace pixels.

With the IBW method, the transmission channel or adjacent channels are marked by vertical lines at a distance of half the channel bandwidth to the left and to the right of the corresponding channel center frequency. (see Fig. 4-6).
In the time-domain method, the power trace in the different channels is shown. (see Fig. 4-7).
For both methods, the results are listed in tables in the lower half of the screen.
The FSP offers predefined standard settings which can be selected from a table for the common mobile radio standards. Thus, channel configuration is performed automatically without the need to enter the corresponding parameters manually.
For some standards, the channel power and the adjacent-channel power are to be weighted by means of a root-raised cosine filter corresponding to a receive filter. This type of filtering is switched on automatically for both methods on selecting the standard (e.g. NADC, TETRA or 3GPP W-CDMA).
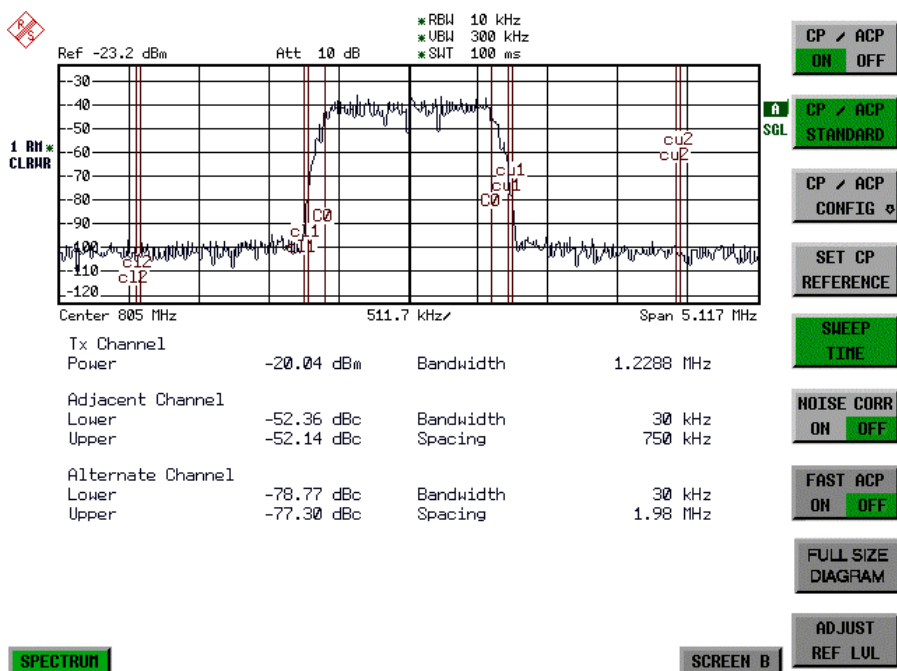
Fig. 4-6   Screen display of adjacent-channel power measurement using the IBW method
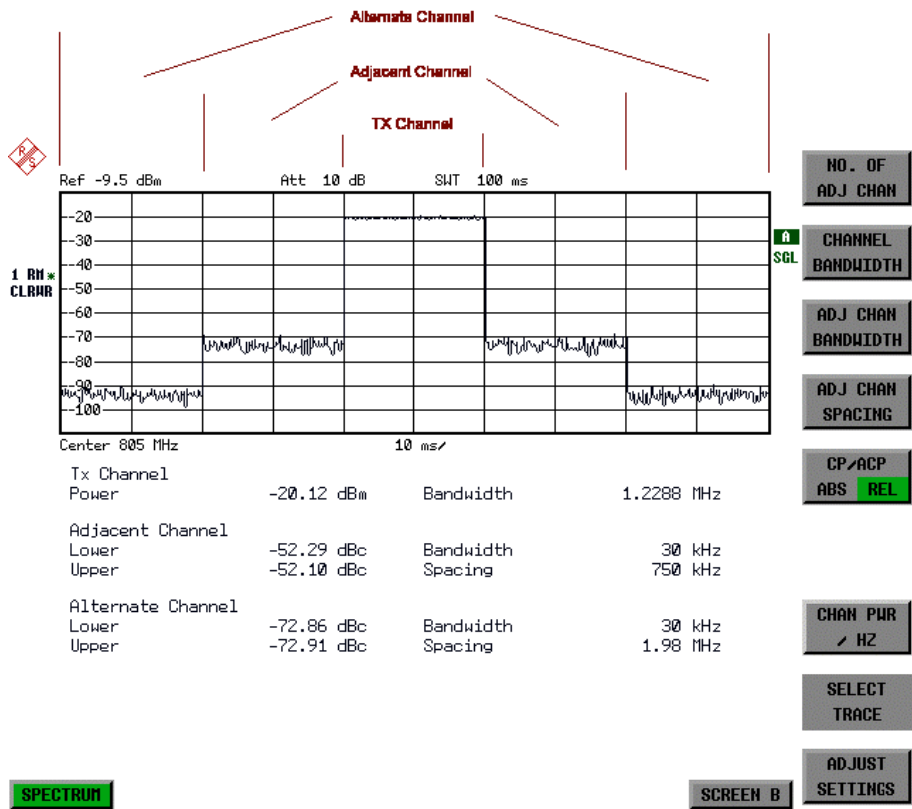
Fig. 4-7   Screen display of adjacent-channel power measurement using the time-domain method

Limit values for the adjacent-channel power can be defined for the measurement. If limit checking is switched on, a pass/fail information indicating that the power has been exceeded is displayed during the measurement in the table in the lower half of the screen.

Note: *With the CP/ACP measurement switched on the functions SPLIT SCREEN and FULL SCREEN are inhibited.*

The channel configuration is defined in the *MEAS CHAN POWER/ACP* menu*.*

CHAN POWER /ACP		CP/ACP ON OFF		NO. OF ADJ CHAN	ACP LIMIT CHECK
		CP/ACP STANDARD		CHANNEL BANDWIDTH	EDIT ACP LIMIT
		CP/ACP CONFIG		ADJ CHAN BANDWIDTH	
		SET CP REFERENCE		ADJ CHAN SPACING	
		SWEEP TIME		CP/ACP ABS REL	
		NOISE CORR ON OFF			
		FAST ACP ON OFF		CHAN PWR / HZ	
		FULL SIZE DIAGRAM		SELECT TRACE	
		ADJUST REF LVL		ADJUST SETTINGS	
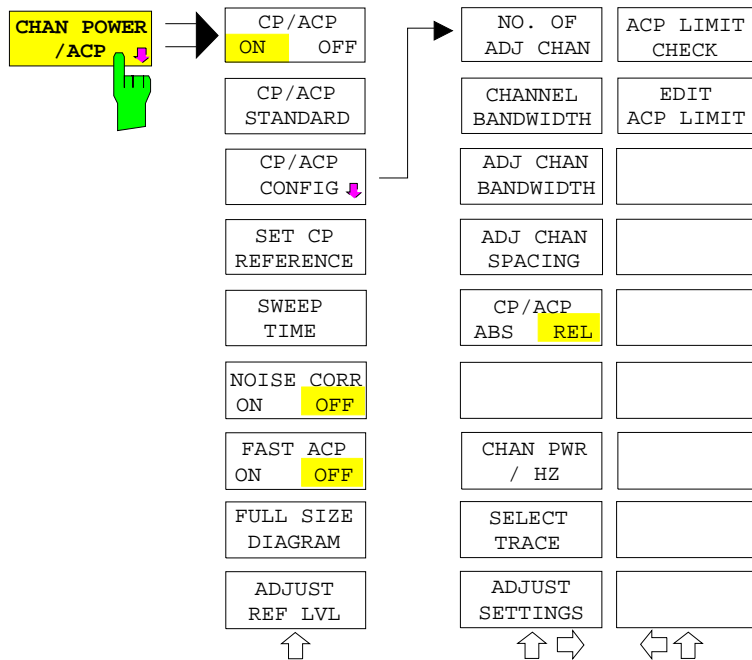
The *CHAN POWER /ACP* softkey switches on the channel power measurement or adjacent-channel power measurement according to the current configuration. At the same time it opens the submenu for defining the channel power measurement. The softkey is highlighted to show that channel or adjacent-channel power measurement is on.

Note: This softkey can only be operated in frequency domain (SPAN > 0).
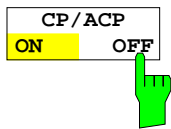
CP/ACP
ON   OFF

The *CP/ACP ON/OFF* softkey switches the calculation of the channel power or adjacent-channel power on or off.

With default settings the measurement is performed by integrating the powers at the display points within the specified channels (IBW method).

The adjacent-channel power can be either absolute or relative related to the transmission channel power. The default setting is relative measurement (see softkey *CP/ACP ABS/ REL*).

IEC/IEEE-bus command: CALC:MARK:FUNC:POW:SEL CPOW│ACP
CALC:MARK:FUNC:POW:RES? CPOW│ACP
CALC:MARK:FUNC:POW OFF
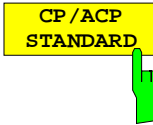
**CP/ACP
STANDARD**

The *CP/ACP STANDARD* softkey opens a table for the selection of the settings according to predefined standards. The test parameters for the channel and adjacent-channel measurements are set according to the mobile radio standard.

ACP STANDARD
✓NONE
NADC IS136
TETRA
PDC
PHS
CDPD
CDMA IS95A FWD
CDMA IS95A REV
CDMA IS95C Class 0 FWD
CDMA IS95C Class 0 REV
CDMA J-STD008 FWD
CDMA J-STD008 REV
CDMA IS95C Class 1 FWD
CDMA IS95C Class 1 REV
W-CDMA 4.096 FWD
W-CDMA 4.096 REV
W-CDMA 3GPP FWD
W-CDMA 3GPP REV
CDMA 2000 DS
CDMA 2000 MC1
CDMA 2000 MC3
TD-SCDMA

The standards available are listed in the table on the left.

Note: *For the FSP, the channel spacing is defined as the distance between the center frequency of the adjacent channel and the center frequency of the transmission channel. The definition of the adjacent-channel spacing in standards IS95 B and C, IS97 B and C and IS98 B and C is different. These standards define the adjacent-channel spacing from the center of the transmission channel to the closest border of the adjacent channel. This definition is also used for the FSP when the following standard settings are selected:*
CDMA IS95 Class 0 FWD
CDMA IS95 Class 0 REV
CDMA IS95 Class 1 FWD
CDMA IS95 Class 1 REV

The selection of the standard influences the following parameters:
- channel spacing
- channel bandwidth and type of filtering
- resolution bandwidth
- video bandwidth
- detector
- # of adjacent channels

Trace mathematics and trace averaging are switched off.
The reference level is not influenced by the selection of a standard. To achieve an optimum dynamic range, the reference level has to be set in a way that places the signal maximum close to the reference level without forcing an overload message.

The default setting is CP/*ACP STANDARD NONE*.

IEC/IEEE-bus command: `CALC:MARK:FUNC:POW:PRES <standard>`
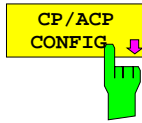
CP/ACP CONFIG	See following section "Setting the Channel Configuration"
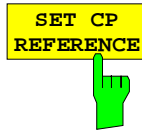
SET CP REFERENCE

With channel power measurement activated, the *SET CP REFERENCE* softkey defines the currently measured channel power as the reference value. The reference value is displayed in the *CH PWR REF* field; the default value is 0 dBm.

During the adjacent-channel power measurement the power in the transmission channel becomes the reference value. The display *CH PWR REF* is not required.

IEC/IEEE-bus command: POW:ACH:REF:AUTO ONCE
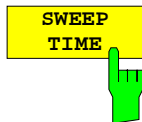
SWEEP TIME

The *SWEEP TIME* softkey activates the entry of the sweep time. With the RMS detector, a longer sweep time increases the stability of the measurement results.
The function of the softkey is identical to the softkey *SWEEP TIME MANUAL* in the menu *BW*.

IEC/IEEE-bus command: SWE:TIM <value>
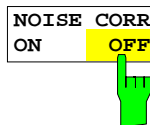
NOISE CORR ON   OFF

If the *NOISE CORR ON/OFF* softkey is activated, the results will be corrected by the instrument's inherent noise, which increases the dynamic range.
When the function is switched on, a reference measurement of the instrument's inherent noise is carried out. The noise power measured is then subtracted from the power in the channel that is being examined.
The inherent noise of the instrument depends on the selected center frequency, resolution bandwidth and level setting. Therefore, the correction function is disabled whenever one of these parameters is changed. A disable message is displayed on the screen.
To enable the correction function in conjunction with the changed setting, press the softkey once more. A new reference measurement is carried out.

IEC/IEEE-bus command: SENS:POW:NCOR ON
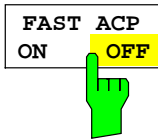
**FAST ACP
ON   OFF**

The *FAST ACP* softkey switches between the IBW method (*FAST ACP OFF*) and the time domain method (*FAST ACP ON*).

With *FAST ACP ON* the power measurement is performed in the different channels in time domain. The FSP sets the center frequency consecutively to the different channel center frequencies and measures the power with the selected measurement time (= sweep time/number of channels). The RBW filter suitable for the selected standard and frequency offset are automatically used (e.g. root raised cos with IS 136). The list of available channel filters is included in section "Setting of Bandwidths and Sweep Time – *BW key"*.

The RMS detector is used for obtaining correct power measurement results. Therefore this requires no software correction factors.

The measured values are displayed in a table, the power in the useful channel being displayed in dBm and the power in the adjacent channels in dBm (CP/ACP ABS) or dB (CP/ACP REL).

The sweep time is selected depending on the desired reproducibility of results. Reproducibility increases with sweep time since power measurement is then performed over a longer time period.

As a general approach, it can be assumed that approx. 500 non-correlated measured values are required for a reproducibility of 0.5 dB (99% of the measurements are within 0.5 dB of the true measured value). This holds true for white noise. The measured values are considered as non-correlated when their time interval corresponds to the reciprocal of the measured bandwidth.

With IS 136 the measurement bandwidth is approx. 25 kHz, i.e. measured values at an interval of 40 µs are considered as noncorrelated. A measurement time of 20 ms is thus required per channel for 1000 measured values. This is the default sweep time which the FSP sets in coupled mode. Approx. 5000 measured values are required for a reproducibility of 0.1 dB (99%), i.e. the measurement time is to be increased to 200 ms.

IEC/IEEE-bus command   SENS:POW:HSP ON
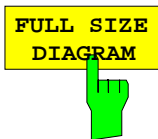
**FULL SIZE
DIAGRAM**

The *FULL SIZE DIAGRAM* softkey switches the diagram to full screen size.

IEC-Bus-Befehl: –
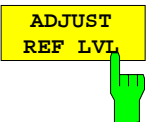
**ADJUST
REF LVL**

The *ADJUST REF LVL* softkey adjusts the reference level of the FSP to the measured channel power. This ensures that the settings of the RF attenuation and the reference level are optimally adjusted to the signal level without overloading the FSP or limiting the dynamic range by a too small S/N ratio.
Since the measurement bandwidth for channel power measurements is significantly lower than the signal bandwidth, the signal path may be overloaded although the trace is still significantly below the reference level.

IEC/IEEE-bus command: SENS:POW:ACH:PRES:RLEV

For manual setting of the test parameters different from the settings made with *ADJUST SETTINGS* the following should be observed:

Frequency span   The frequency span must at least cover the channels to be measured plus a measurement margin of 10%.
                             For channel power measurement, the span is 1.1 x channel bandwidth.
                             Note:
                             If the frequency span is large in comparison with the channel bandwidth (or the adjacent-channel bandwidths) being examined, only a few points on the trace are available per channel. This reduces the accuracy of the

waveform calculation for the channel filter used, which has a negative effect on the measurement accuracy.
We therefore strongly recommend that the formulas mentioned be taken into consideration when selecting the frequency span.

Resolution bandwidth (RBW)

To ensure both an acceptable measurement speed and the required selection (to suppress spectral components outside the channel to be measured, especially of the adjacent channels), the resolution bandwidth must not be selected too small or too large. As a general approach, the resolution bandwidth is to be set to values between 1% and 4% of the channel bandwidth.
A larger resolution bandwidth can be selected if the spectrum within the channel to be measured and around it has a flat characteristic. In the standard setting, e.g. for standard IS95A REV at an adjacent channel bandwidth of 30 kHz, a resolution bandwidth of 30 kHz is used. This yields correct results since the spectrum in the neighbourhood of the adjacent channels normally has a constant level. For standard NADC/IS136 this is not possible for example, since the spectrum of the transmit signal penetrates into the adjacent channels and a too large resolution bandwidth causes a too low selection of the channel filter. The adjacent-channel power would thus be measured too high.

With the exception of the IS95 CDMA standards, the *ADJUST SETTINGS* softkey sets the resolution bandwidth (RBW) as a function of the channel bandwidth:

RBW $\leq$ 1/40 of channel bandwidth.

The maximum possible resolution bandwidth (with respect to the requirement RBW $\leq$ 1/40) resulting from the available RBW steps (1, 3) is selected .

Video bandwidth (VBW)

For a correct power measurement, the video signal must not be limited in bandwidth. A restricted bandwidth of the logarithmic video signal would cause signal averaging and thus result in a too low indication of the power (-2.51 dB at very low video bandwidths). The video bandwidth should therefore be selected at least three times the resolution bandwidth.

The *ADJUST SETTINGS* softkey sets the video bandwidth (VBW) as a function of the channel bandwidth as follows:

VBW $\geq 3 \times$ RBW.

The smallest possible VBW with regard to the available step size will be selected.

Detector

The *ADJUST SETTINGS* softkey selects the RMS detector.
The RMS detector is selected since it correctly indicates the power irrespective of the characteristics of the signal to be measured. In principle, the sample detector would be possible as well. Due to the limited number of trace pixels used to calculate the power in the channel, the sample detector would yield less stable results. Averaging, which is often performed to stabilize the measurement results, leads to a too low level indication and should therefore be avoided. The reduction in the displayed power depends on the number of averages and the signal characteristics in the channel to be measured.

Setting the Channel Configuration

MEAS - CP/ACP CONFIG submenu:
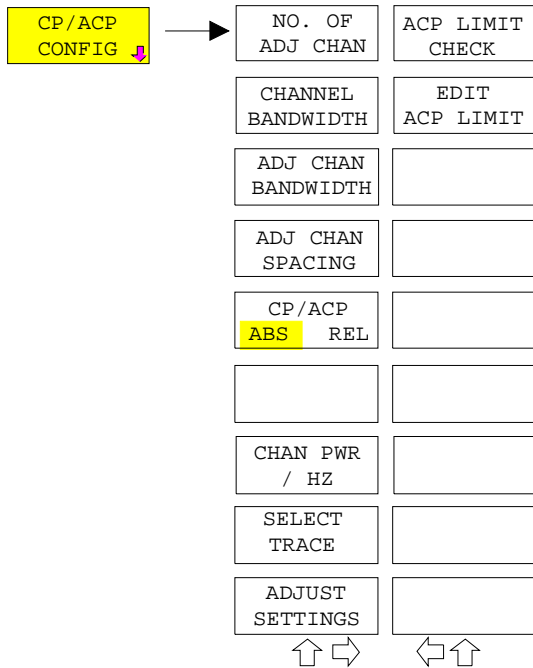
The *CP/ACP CONFIG* softkey opens a submenu for configuration of the channel power and adjacent channel power measurement independent from the offered standards.

The channel configuration consists of the number of adjacent channels to be measured, the channel bandwidth (*CHANNEL BANDWIDTH*), the bandwidth of the adjacent channels (*ADJ CHANNEL BANDWIDTH*) and the distance of the adjacent channels from the center frequency of the transmission channel (*ADJ CHANNEL SPACING*).

Limit values can additionally be specified for the adjacent-channel power (*ACP LIMIT CHECK* and *EDIT ACP LIMITS*) which are checked for compliance during the measurement.
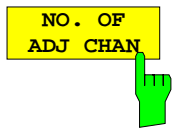
The *NO. OF ADJ CHAN* softkey activates the entry of the number ±n of adjacent channels to be considered in the adjacent-channel power measurement.
Numbers from 0 to 3 can be entered.

The following measurements are performed depending on the number of the channels.

0   Only the channel power is measured.

1   The channel power and the power of the upper and lower adjacent channel are measured.

2   The channel power, the power of the upper and lower adjacent channel and of the next higher and lower channel (alternate channel 1) are measured.

3   The channel power, the power of the upper and lower adjacent channel, the power of the next higher and lower channel (alternate channel 1) and of the next but one higher and lower adjacent channel (alternate channel 2) are measured.

IEC/IEEE-bus command: POW:ACH:ACP 1

CHANNEL BANDWIDTH

The *CHANNEL BANDWIDTH* softkey activates the entry of the channel bandwidth for the transmission channel.

The useful channel bandwidth is generally defined by the transmission method. It is automatically adjusted correctly on measurements according to a given standard (see *CP/ACP STANDARD* softkey).

When measuring according to the IBW method (*FAST ACP OFF)* the channel bandwidth is displayed by two vertical lines to the left and right of the screen center. It can thus be visually checked whether the whole power of the signal to be measured is within the selected channel bandwidth.

With the time domain method (*FAST ACP ON)* the measurement is performed in zero span. The channel limits are not marked in this case. The FSP offers all available channel filters for selection of the channel bandwidth. Deviating channel bandwidths cannot be set. If deviating channel bandwidths are required, the IBW method should be used.

The list of available channel filters is included in section "Setting of Bandwidths and Sweep Time – *BW key"*.

The default setting is 14 kHz.

IEC/IEEE-bus command: `SENS:POW:ACH:BWID 14kHz`

ADJ CHAN BANDWIDTH

The ADJ *CHAN BANDWIDTH* softkey opens a table for defining the channel bandwidths for the adjacent channels.

ACP CHANNEL BW	
CHAN	BANDWIDTH
ADJ	14 kHz
ALT1	14 kHz
ALT2	14 kHz

When measuring according to the IBW method (FAST ACP OFF) the bandwidths of the different adjacent channels are to be entered numerically. Since all adjacent channels often have the same bandwidth, the other channels Alt1 and Alt2 are set to the bandwidth of the adjacent channel on entering the adjacent-channel bandwidth (ADJ). Thus only one value needs to be entered in case of equal adjacent channel bandwidths. The same holds true for the ALT2 channels (alternate channels 2) when the bandwidth of the ALT1 channel (alternate channel 1) is entered.

Note: *The bandwidths can be selected independent from each other by overwriting the table from top to bottom.*

With the time domain method (FAST ACP ON), the adjacent-channel bandwidths are selected from the list of available channel filters. For deviating adjacent-channel bandwidths the IBW method should be used.

IEC/IEEE-bus command: `SENS:POW:ACH:BWID:ACH 1kHz`
                                   `SENS:POW:ACH:BWID:ALT1 14kHz`
                                   `SENS:POW:ACH:BWID:ALT2 14kHz`

```
ADJ CHAN
 SPACING
```
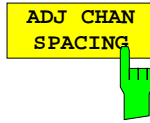
The ADJ *CHAN SPACING* softkey opens a table for defining the channel spacings.

ACP CHANNEL SPACING	
CHAN	SPACING
ADJ	20 kHz
ALT1	40 kHz
ALT2	60 kHz

Since all the adjacent channels often have the same distance to each other, the entry of the adjacent-channel spacing (ADJ) causes channel spacing ALT1 to be set to twice and channel spacing ALT2 to three times the adjacent-channel spacing. Thus only one value needs to be entered in case of equal channel spacing. The same holds true for the ALT2 channels when the bandwidth of the ALT1 channel is entered.

Note: *The channel spacings can be set separately by overwriting the table from top to bottom.*

IEC/IEEE-bus command: `SENS:POW:ACH:SPAC:ACH 20kHz`
`SENS:POW:ACH:SPAC:ALT1 40kHz`
`SENS:POW:ACH:SPAC:ALT2 60kHz`

```
CP/ACP
ABS   REL
```
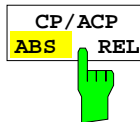
The *CP/ACP ABS/REL* softkey (channel power absolute/relative) switches between absolute and relative power measurement in the channel.

CP/ACP ABS   The absolute power in the transmission channel and in the adjacent channels is displayed in the unit of the Y axis, e.g. in dBm, dBµV.

CP/ACP REL   In case of adjacent-channel power measurement (*NO. OF ADJ CHAN* > 0) the level of the adjacent channels is displayed relative to the level of the transmission channel in dBc.

In case of channel power measurement (*NO. OF ADJ CHAN* = 0) the power of a transmission channel is displayed relative to the power of a reference channel defined by *SET CP REFERENCE*. This means:

1. Declare the power of the currently measured channel as the reference value, using the *SET CP REFERENCE* softkey.

2. Select the channel of interest by varying the channel frequency (FSP center frequency).

With linear scaling of the Y axis, the power of the new channel relative to the reference channel (CP/CP_{ref}) is displayed. With dB scaling, the logarithmic ratio $10 \lg (CP/CP_{ref})$ is displayed.

The relative channel power measurement can thus also be used for universal adjacent-channel power measurements. Each channel can be measured individually.

IEC/IEEE-bus command: `SENS:POW:ACH:MODE ABS`
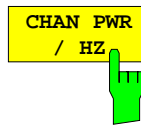
CHAN PWR / HZ

The *CHAN PWR / HZ* softkey toggles between the measurement of the total channel power and the measurement of the channel power referenced to a 1-Hz bandwidth.

The conversion factor is $10 \cdot \lg \dfrac{1}{\text{Channel} \cdot \text{Bandwidth}}$.

By means of this function it is possible e.g. to measure the signal/noise power density or use the additional functions *CP/ACP REL* and *SET CP REFERENCE* to obtain the signal to noise ratio.

IEC/IEEE-bus command:
        `CALC:MARK:FUNC:POW:RES:PHZ ON|OFF`
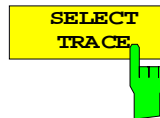
SELECT TRACE

The *SELECT TRACE* softkey selects the trace, on which the CP/ACP measurement is performed. Only traces can be selected, which are switched on (= not set to BLANK).

IEC/IEEE-bus command: `SENS:POW:TRAC 1`
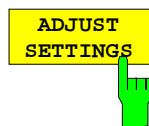
ADJUST SETTINGS

The *ADJUST SETTINGS* softkey automatically optimizes the instrument settings for the selected power measurement (see below).

All instrument settings relevant for a power measurement within a specific frequency range (channel bandwidth) are optimized for the selected channel configuration (channel bandwidth, channel spacing):

- Frequency span:

  The frequency span has to cover at least all channels to be considered.
  When measuring the channel power,
  2 x channel bandwidth + measurement margin
  is set as span.
  The setting of the span during adjacent-channel power measurement is dependent on the channel spacing and channel bandwidth of the adjacent channel ADJ, ALT1 or ALT2 with the largest distance from the transmission channel.

  $2 \times$ (channel spacing + channel bandwidth) + measurement margin
  The measurement margin is approx. 10% of the value obtained by adding channel spacing and channel bandwidth.

- Resolution bandwidth   RBW $\leq$ 1/40 of channel bandwidth
- Video bandwidth   VBW $\geq 3 \times$ RBW
- Detector   RMS detector

Trace math and trace averaging functions are switched off.
The reference level is not influenced by *ADJUST SETTINGS*. It can be separately adjusted with *ADJUST REF LVL*.

The adjustment is carried out only once; if necessary, the instrument settings can be changed later.

IEC/IEEE-bus command:
        `SENS:POW:ACH:PRES ACP|CPOW|OBW`
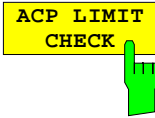
ACP LIMIT CHECK

The *ACP LIMIT CHECK* softkey switches the limit check for the ACP measurement on and off.

IEC/IEEE-bus command:
```
CALC:LIM:ACP ON
CALC:LIM:ACP:ACH:RES?
CALC:LIM:ACP:ALT:RES?
```
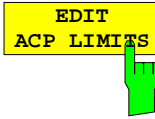
EDIT ACP LIMITS

The *EDIT ACP LIMITS* softkey opens a table for defining the limits for the ACP measurement.

ACP LIMITS				
CHAN	RELATIVE LIMIT CHECK		ABSOLUTE LIMIT CHECK	
	VALUE	ON	VALUE	ON
ADJ	-45 dB	√		
ALT1	-60 dB	√		
ALT2				

The following rules apply for the limits:

- A separate limit can be defined for each adjacent channel. The limit applies to both the upper and the lower adjacent channel.

- A relative and/or absolute limit can be defined. The check of both limit values can be activated independently.

- The FSP checks adherence to the limits irrespective of whether the limits are absolute or relative or whether the measurement is carried out with absolute or relative levels. If both limits are active and if the higher of both limit values is exceeded, the measured value is marked accordingly.

Note: *Measured values exceeding the limit are marked by a preceding asterisk.*

IEC/IEEE-bus command:
```
CALC:LIM:ACP ON
CALC:LIM:ACP:ACH 0dB,0dB
CALC:LIM:ACP:ACH:STAT ON
CALC:LIM:ACP:ACH:ABS –10dBm,-10dBm
CALC:LIM:ACP:ACH:ABS:STAT ON
CALC:LIM:ACP:ALT1 0dB,0dB
CALC:LIM:ACP:ALT1:STAT ON
CALC:LIM:ACP:ALT1:ABS –10dBm,-10dBm
CALC:LIM:ACP:ALT1:ABS:STAT ON
CALC:LIM:ACP:ALT2 0dB,0dB
CALC:LIM:ACP:ALT2:STAT ON
CALC:LIM:ACP:ALT2:ABS –10dBm,-10dBm
CALC:LIM:ACP:ALT2:ABS:STAT ON
```

Examples:

1. Measurement of adjacent-channel power for a specific standard:

The adjacent-channel power is to be measured for a signal at 800 MHz with 0 dBm level in line with IS136.

[**PRESET**]	Set the FSP to the default setting.
[**FREQ**: *CENTER*: 800 **MHz**]	Set the center frequency to 800 MHz.
[**AMPT**: 0 **dBm**]	Set the reference level to 0 dBm.
[**MEAS**]	Call the menu for the measurement functions.
[*CHAN PWR / ACP*]	Select the channel and adjacent-channel power measurement function. The measurement is performed with the default settings or a previously defined setting. The submenu for setting the desired new configuration is opened.
[*CP/ACP STANDARD*: select IS136: **ENTER**]	Select the NADC (IS136) standard.
[*CP/ACP CONFIG*]	Call the submenu for configuration of the adjacent-channel power measurement.
[*NO. OF ADJ CHAN*: 2 **ENTER**]	Select two adjacent channels for the measurement, i.e. the adjacent channel and the alternate channel are measured.
PREV	Change to the main menu for channel power measurement.
[*ADJUST SETTINGS*]	Set the optimum span, resolution bandwidth (RBW), video bandwidth (VBW) and detector automatically for the measurement. The absolute channel power and the relative power of the adjacent channels are displayed on the screen.
[*ADJUST REF LVL*]	Set the reference level equal to the channel power measured.

2. Measurement with user-specific channel configuration:

Measurement of the adjacent-channel power ratio (ACPR) of an IS95 CDMA signal at 800 MHz, level 0 dBm. Similar to example 1, the setting can be simplified by using *CP/ACP STANDARD*.

[**PRESET**]	Set the FSP to the default setting.
[**FREQ**: *CENTER*: 800 **MHz**]	Set the center frequency to 800 MHz.
[**AMPT**: 0 **dBm**]	Set the reference level to 0 dBm.
[**MEAS**]	Call the menu for the measurement functions.
[*CHAN PWR / ACP*]	Select the channel and adjacent-channel power measurement function. The measurement is carried out with the default settings or a previously defined setting. The submenu for setting the desired new configuration is opened.
[*CP/ACP CONFIG*]	Call the submenu for defining the channel configuration.
[*NO. OF ADJ CHAN*: 2 **ENTER**]	Select two adjacent channels for the measurement, i.e. the adjacent channel and the alternate channel are measured.
[*CHANNEL BANDWIDTH*: 1.23 **MHz**]	Set the channel bandwidth to 1.23 MHz according to IS95.
[*ADJ CHAN BANDWIDTH:* 30 **kHz**]	Open the list for setting the bandwidth of the adjacent channels.

ACP CHANNEL BW	
CHAN	BANDWIDTH
ADJ	30 kHz
ALT1	30 kHz
ALT2	30 kHz

Upon entry of 30 kHz for the adjacent channel the alternate channels are also set to 30 kHz.

[*ADJ CHAN SPACING*: 885 **kHz:** ⬇ : 1.98 **MHz**]	Open the list for entering the adjacent-channel spacings.

ACP CHANNEL SPACING	
CHAN	SPACING
ADJ	885 kHz
ALT1	1.98 MHz
ALT2	2.97 MHz

Upon entry of 885 kHz for the adjacent channel the channels ALT1 and ALT2 are set to 1770 kHz and 2655 kHz. Upon entry of 1.98 MHz for the alternate channel 1 the alternate channel 2 is set to 2.97 MHz.

PREV	Go to the main menu for channel power measurement.
[*ADJUST SETTINGS*]	Automatically set the optimum span (= 5 MHz), resolution bandwidth (RBW = 30 kHz), video bandwidth (VBW = 300 kHz) and detector (RMS) for the measurement. The absolute channel power and the relative power of the adjacent channels and alternate channels are displayed on the screen.
[*ADJUST REF LVL*]	Set the reference level equal to the channel power measured.

3. **Measurement of signal/noise power density (C/No) of an IS95 CDMA signal (frequency 800 MHz, level 0 dBm)**

[**PRESET**]	Set the FSP to the default setting.
[**FREQ:** *CENTER*: 800 **MHz**]	Set the center frequency to 800 MHz.
[**AMPT**: 0 **dBm**]	Set the reference level to 0 dBm.
MEAS]	Call the menu for the measurement functions.
[*CHAN PWR / ACP*]	Select the channel and adjacent-channel power measurement. The measurement is performed with the default setting or a previously defined setting. The submenu for setting the desired new configuration is opened.
[*CP/ACP CONFIG*]	Call the submenu for defining the channel configuration.
[*NO. OF ADJ CHAN*: 0 **ENTER**]	Do not select an adjacent channel for the measurement, i.e. the measurement is carried out in one channel only.
[*CHANNEL BANDWIDTH*: 1.23 **MHz**]	Set the channel bandwidth to 1.23 MHz in line with IS95.
PREV	Go to the main menu for channel power measurement
[*ADJUST SETTINGS*]	Set the optimum span (= 5 MHz), resolution bandwidth (RBW = 30 kHz), video bandwidth (VBW = 300 kHz) and detector (RMS) for the measurement automatically. The absolute channel power and the relative power of the adjacent channels and alternate channels are displayed on the screen.
[*ADJUST REF LVL*]	Set the reference level equal to the channel power measured.
[*SET CP REFERENCE*]	Set the measured channel power as a reference for the subsequent measurements.
[*CP/ACP ABS / REL*]	Select relative measurement related to the reference power set with *SET REFERENCE* (result 0 dB).
[*CHAN PWR / HZ*]	Select power measurement related to 1 Hz bandwidth (result -60.9 dB).
[**FREQ:** *CENTER*: 805 **MHz**]	Set the center frequency to 805 MHz. The FSP measures the channel power at 1.23 MHz bandwidth and outputs the result in dB relative to the reference power and 1 Hz bandwidth.

Measurement of Occupied Bandwidth

An important characteristics of a modulated signal is its occupied bandwidth. In a radio communications system for instance the occupied bandwidth must be limited to enable distortion-free transmission in adjacent channels. The occupied bandwidth is defined as the bandwidth containing a defined percentage of the total transmitted power. A percentage between 10% and 99.9% can be set on the FSP.

MEAS OCCUPIED BANDWIDTH menu:
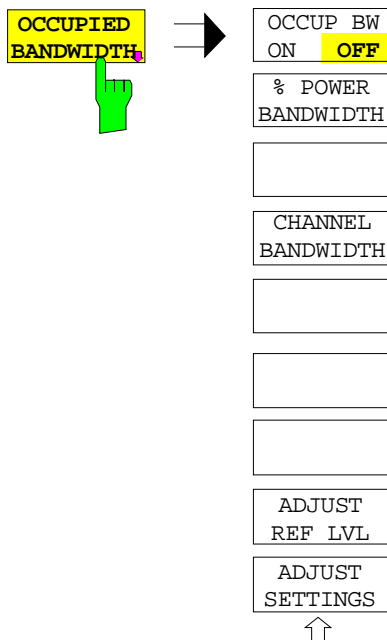
The *OCCUPIED BANDWIDTH* softkey activates measurement of the occupied bandwidth according to the current configuration and opens the submenu for configuring the measurement. The softkey is available only in frequency domain (span > 0) and is highlighted when the measurement is switched on.

In the spectrum display mode, this measurement determines the bandwidth that contains a predefined percentage of the power of the displayed frequency range (*% POWER BANDWIDTH* softkey). The occupied bandwidth is output in the marker display field and marked on the trace by temporary markers.

Note: - *The softkey is only available in frequency domain (span > 0).*
               - *The measurement is performed on the trace with marker 1. In order to evaluate another trace, marker 1 must be placed on another trace by means of SELECT TRACE in the MKR menu*
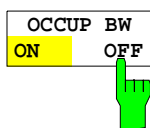
The *OCCUP BW ON/OFF* softkey switches measurement of the occupied bandwidth on or off.

IEC/IEEE-bus command: `CALC:MARK:FUNC:POW:SEL OBW`
                                    `CALC:MARK:FUNC:POW:RES? OBW`
                                    `CALC:MARK:FUNC:POW OFF`
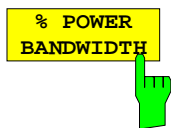
The *% POWER BANDWIDTH* softkey opens the entry of the percentage of power related to the total power in the displayed frequency range which defines the occupied bandwidth (percentage of total power).
The valid range of values is 10% to 99.9%.

IEC/IEEE-bus command: `SENS:POW:BWID 99PCT`
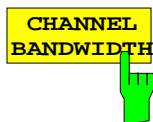
The *CHANNEL BANDWIDTH* softkey opens an input window for defining the channel bandwidth for the transmission channel. For measurements in line with a specific transmission standard, the bandwidth specified by the standard for the transmission channel must be entered.
The default setting is 14 kHz.
The specified channel bandwidth is used for optimization of the test parameters of the FSP with *ADJUST SETTINGS*.

IEC/IEEE-bus command: `SENS:POW:ACH:BWID 14kHz`
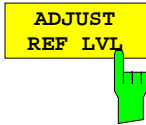
ADJUST
REF LVL

The *ADJUST REF LVL* softkey adjusts the reference level of the FSP to the measured total power of the signal. The softkey is activated after the first sweep with the measurement of the occupied bandwidth has been completed and the total power of the signal is thus known.

Adjusting the reference level ensures that the signal path of the FSP will not be overloaded and the dynamic range not limited by too low a reference level.

Since the measurement bandwidth for channel power measurements is significantly lower than the signal bandwidth, the signal path may be overloaded although the trace is distinctly below the reference level. If the measured channel power is equal to the reference level, the signal path cannot be overloaded.

IEC/IEEE-bus command: SENS:POW:ACH:PRES:RLEV
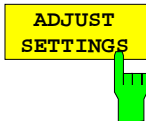
ADJUST
SETTINGS

The *ADJUST SETTINGS* softkey optimizes the instrument settings for the measurement of the occupied bandwidth according to the specified channel bandwidth.

All instrument settings relevant for power measurement within a specific frequency range, such as

- frequency span   3 x channel bandwidth
- resolution bandwidth   RBW $\leq$ 1/40 of channel bandwidth
- video bandwidth   VBW $\geq 3 \times$ RBW
- detector   RMS

are optimized.

The reference level is not influenced by *ADJUST SETTINGS*. For an optimum dynamic range it should be selected in a way that the signal maximum is close to the reference level.

The adjustment is carried out only once; if necessary, the instrument settings may be changed later.

IEC/IEEE-bus command: SENS:POW:PRES OBW

Measurement principle:

For example, the bandwidth containing 99% of the signal power is to be determined. The routine first calculates the total power of all displayed points of the trace. In the next step, the points from the right edge of the trace are summed up until 0.5% of the total power is reached. Auxiliary marker 1 is positioned at the corresponding frequency. Then the FSP sums up the points from the left edge of the trace until 0.5% of the power is reached. Auxiliary marker 2 is positioned at this point. 99% of the power is now between the two markers. The distance between the two frequency markers is the occupied bandwidth which is displayed in the marker info field.
A prerequisite for correct measurement is that only the signal to be measured is visible on the screen of the FSP. An additional signal would invalidate the measurement.

To ensure correct power measurement especially for noise signals and to obtain the correct occupied bandwidth, the following settings should be selected:

RBW	<< occupied bandwidth (approx. 1/20 of occupied bandwidth, for voice communication type. 300 Hz or 1 kHz)
VBW	≥ 3 x RBW
Detector	RMS or sample
Span	≥2 to 3 x occupied bandwidth

Some of the measurement specifications (e.g. PDC, RCR STD-27B) require measurement of the occupied bandwidth using a peak detector. The detector setting of the FSP has to be changed accordingly then.

Example:
Measurement of occupied bandwidth of a PDC signal at 800 MHz, level 0 dBm

[**PRESET**]	Set the FSP to the default setting.
[**FREQ**: *CENTER*: 800 MHz]	Set the center frequency to 800 MHz.
[**AMPT**: 0 dBm]	Set the reference level to 0 dBm.
[**MEAS**]	Call the menu for the measurement functions.
[*OCCUPIED BANDWIDTH*]	Select measurement of the occupied bandwidth and open the submenu for configuring the measurement.
[% POWER BANDWIDTH: 99 **%**]	Select 99% for the bandwidth to be measured.
[*CHANNEL BANDWIDTH*: 21 **kHz**]	Enter the channel bandwidth of 21 kHz specified by PDC.
[*ADJUST SETTINGS*]	Optimize the measurement parameters for the specified channel bandwidth.
	Allow for a complete frequency sweep so that the FSP can determine the total signal power.
[*ADJUST REF LVL*]	Adjust the reference level to the measured signal power.
[**TRACE**: *DETECTOR*: *DETECTOR MAX PEAK*]	PDC requires measurement of the occupied bandwidth using a peak detector. Therefore, switch on the peak detector instead of the RMS detector selected by *ADJUST SETTINGS*.

Measurement of Signal Amplitude Statistics

Digital modulated signals are similar to white noise within the transmit channel, but are different in their amplitude distribution. In order to transmit the modulated signal without distortion all amplitudes of the signal have to be transmitted linearly, e. g. from the output power amplifier. Most critical are the peak amplitude values, of course.

Degradation in transmit quality caused by a transmitter two port network is dependent on the amplitude of the peak values as well as on their probability.

The probability of amplitude values can be measured with the APD function (Amplitude Probability Distribution). During a selectable measurement time all occurring amplitude values are assigned to an amplitude range. The number of amplitude values in the specific ranges is counted and the result is displayed as a histogram. Each bar of the histogram represents the percentage of measured amplitudes within the specific amplitude range.
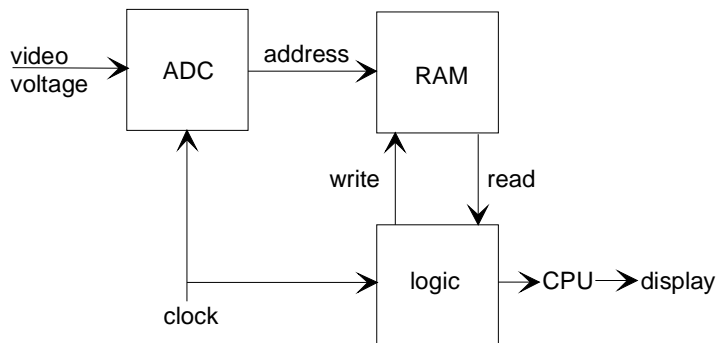
Fig. 4-8   Simplified block diagram for APD measurement
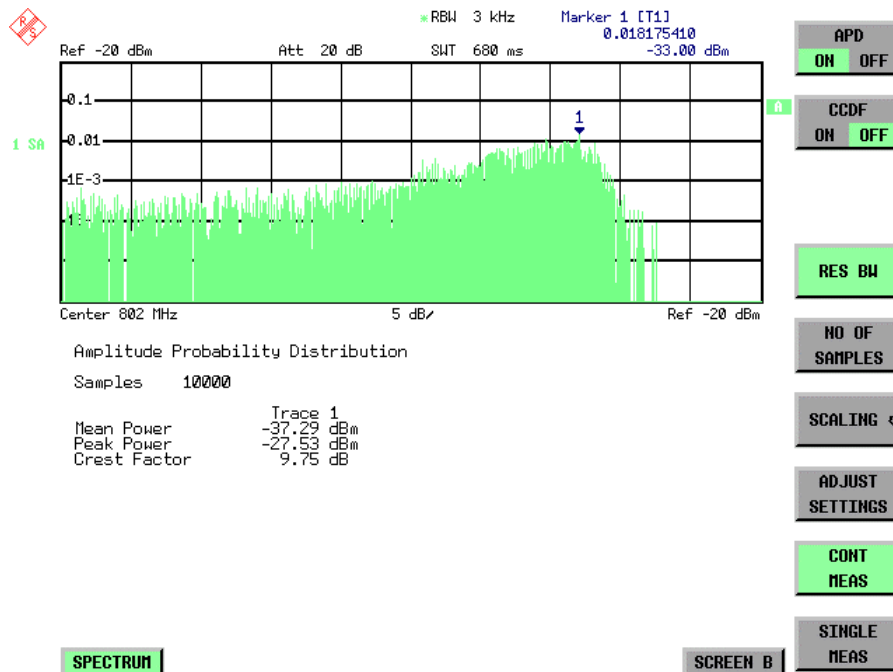
Fig. 4-9   Display of the amplitude probability distribution
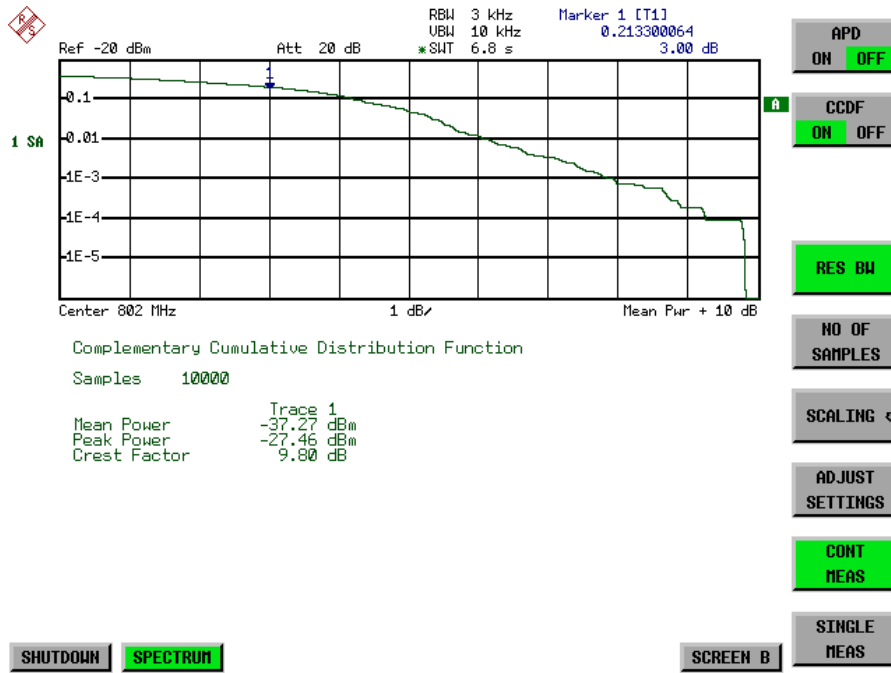
Fig. 4-10   Display of the complementary cumulative distribution function (CCDF)

Alternate to the histogram display of the APD the Complementary Cumulative Distribution Function (CCDF) can be displayed. It shows the probability of an amplitude exceeding a specific value.
For the APD function the x-axis is scaled in absolute values in dBm, whereas for the CCDF function the x-axis is scaled relative to the MEAN POWER measured.

Definitions:
Crest factor   =   peak voltage to rms
CCDF   =   complementary cumulative distribution function

Note: *During an active statistic measurement the functions FULL SCREEN, SPLIT SCREEN and selection of the active diagram via SCREEN A / SCREEN B are disabled.*

MEAS SIGNAL STATISTIC submenu :
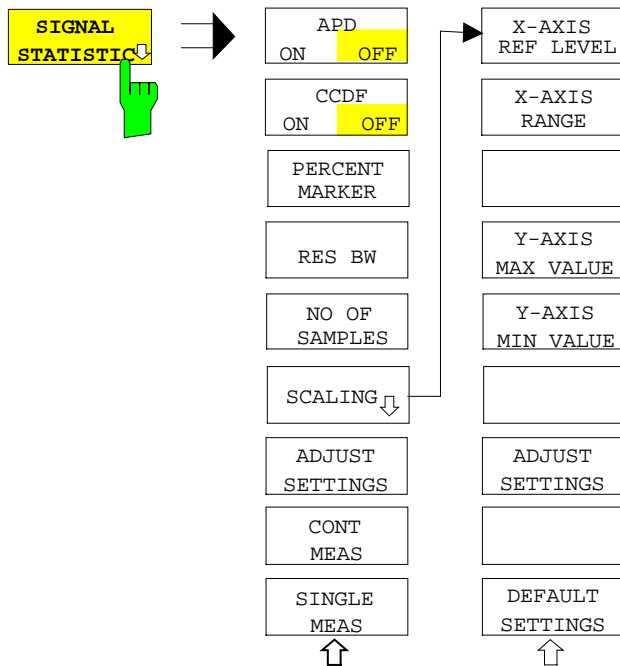
The *SIGNAL STATISTIC* softkey opens a submenu for measurement of signal statistics.

In the submenu measurement of amplitude probability density (*APD*) and complementary cumulative distribution (*CCDF*) can be selected alternately. Only one of the signal statistic functions can be switched on at a time.

In default mode all statistic functions are switched off.

With a statistic function switched on the FSP is set into zero span mode automatically.

The FSP measures the statistics of the signal applied to the RF input with the resolution bandwidth set. In order not to influence the peak amplitudes the video bandwidth is automatically set to 10 times the resolution bandwidth. The sample detector is used for detecting the video voltage.
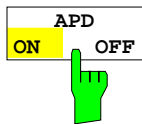
The *APD ON/OFF* softkey switches on or off the amplitude probability distribution function.
When the APD function is switched on, the CCDF function is switched off automatically.

IEC/IEEE-bus command: `CALC:STAT:APD ON`
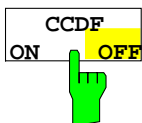
The *CCDF ON/OFF* softkey switches on or off the complementary cumulative distribution function.
When the CCDF function is switched on, the APD function is switched off automatically.

IEC/IEEE-bus command: `CALC:STAT:CCDF ON`
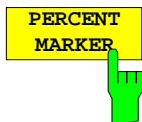
If the CCDF function is active, the *PERCENT MARKER* softkey allows to position marker 1 by entering a probability value. Thus, the power which is exceeded with a given probability can be determined very easily.
If marker 1 is in the switched-off state, it will be switched on automatically.

IEC/IEEE-bus command: `CALC:MARK:Y:PERC 0...100%`
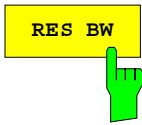
RES BW

The *RES BW* softkey sets the resolution bandwidth in the menu *STATISTIC FUNCTION* directly without switching to the corresponding menu (BW). The function of the softkey is identical to the softkey *RES BW MANUAL* in the menu *BW*.

For correct measurement of the signal statistics the resolution bandwidth has to be wider than the signal bandwidth in order to transmit the actual peaks of the signal amplitude correctly. Video bandwidth is set to 10 MHz automatically with a statistic function switched on.

IEC/IEEE-bus command: BAND 3 MHz
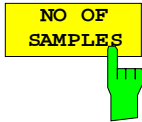
NO OF SAMPLES

The *NO OF SAMPLES* softkey sets the number of power measurements taken into account for the statistics.

Please note that the overall measurement time is influenced by the number of samples selected as well as by the resolution bandwidth set up for the measurement as the resolution bandwidth directly influences the sampling rate.

IEC/IEEE-bus command: CALC:STAT:NSAM <value>

SCALING

X-AXIS REF LEVEL
X-AXIS RANGE
Y-AXIS MAX VALUE
Y-AXIS MIN VALUE
ADJUST SETTINGS
DEFAULT SETTINGS
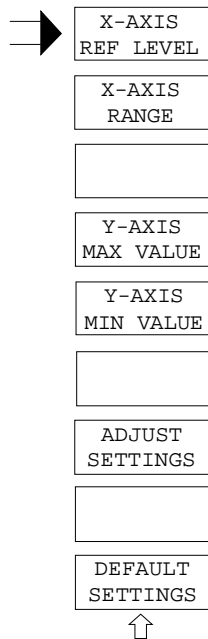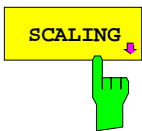
The *SCALING* softkey opens a sub menu that allows changing the scaling parameters for both the x- and the y-axis.

X-AXIS REF LEVEL

The *X-AXIS REF LEVEL* softkey changes the level settings of the instrument and sets the maximum power to be measured.

The function is identical to softkey *REF LEVEL* in menu *AMPT*.

For the *APD* function this value is mapped to the right diagram border. For the *CCDF* function there is no direct representation of this value on the diagram as the x-axis is scaled relatively to the *MEAN POWER* measured.
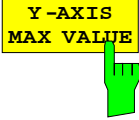
IEC/IEEE command: CALC:STAT:SCAL:X:RLEV <value>

X-AXIS RANGE

The *X-AXIS RANGE* softkey changes the level range to be covered by the statistics measurement selected.
The function is identical to softkey *RANGE LOG MANUAL* in menu *AMPT*.

IEC/IEEE command: `CALC:STAT:SCAL:X:RANG <value>`

Y-AXIS MAX VALUE

The *Y-AXIS MAX VALUE* softkey defines the upper limit of the displayed probability range.
Values on the y-axis are normalized which means that the maximum value is 1.0. As the y-axis scaling has a logarithmic axis the distance between max and min value must be at least one decade.
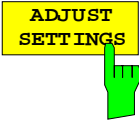
IEC/IEEE command: `CALC:STAT:SCAL:Y:UPP <value>`

Y-AXIS MIN VALUE
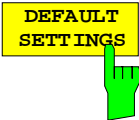
The *Y-AXIS MIN VALUE* softkey defines the lower limit of the displayed probability range.
As the y-axis scaling has a logarithmic axis the distance between max and min value must be at least one decade. Valid values are in the range 0 < value < 1.

IEC/IEEE command: `CALC:STAT:SCAL:Y:LOW <value>`

ADJUST SETTINGS

see below
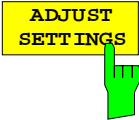
DEFAULT SETTINGS

The *DEFAULT SETTINGS* softkey resets the x- and y-axis scalings to their PRESET values.

x-axis ref level: -20 dBm
x-axis range APD: 100 dB
x-axis range CCDF: 20 dB

y-axis upper limit: 1.0
y-axis lower limit: 1E-6

IEC/IEEE-bus command: `CALC:STAT:PRES`

ADJUST SETTINGS

The *ADJUST SETTINGS* softkey optimizes the level settings of the FSP according to the measured peak power in order to gain maximum sensitivity of the instrument.
The level range is adjusted according to the measured difference between peak and minimum power for APD measurement and peak and mean power for CCDF measurement in order to obtain maximum power resolution.
Additionally the probability scale is adapted to the selected number of samples.

IEC/IEEE-bus command: `CALC:STAT:SCAL:AUTO ONCE`
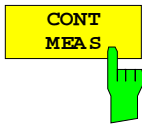
CONT MEAS	The *CONT MEAS* softkey starts collecting a new sequence of sample data and calculating the APD or CCDF curve depending on the selected measurement. The next measurement is started automatically as soon as the indicated number of samples has been reached ("<u>CONT</u>inuous <u>MEAS</u>urement").

IEC/IEEE-bus command: `INIT:CONT                ON;`
                          `INIT:IMM`
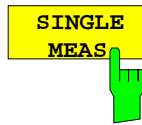
SINGLE MEAS	The *SINGLE MEAS* softkey starts collecting a new sequence of sample data and calculating the APD or CCDF curve depending on the selected measurement. At the beginning of the measurement previously obtained measurement results are discarded.

IEC/IEEE-bus command: `INIT:CONT                OFF;`
                          `INIT:IMM`

Hint for usage of the marker functions with measurement of signal statistics:

With the signal statistic measurement level always is displayed on x-axis. Y-axis always is a normalized value between 0 and 1. In contrary to use of marker in frequency or time domain marker is input in level values and the output is in percentage values.

Example:

Measurement of CCDF of a IS95 BTS signal, level 0 dBm, frequency 800 MHz

[**PRESET**]	Switch on preset settings.
[**FREQ**: *CENTER*: 800 MHz]	Set center frequency to 800 MHz.
[**AMPT**: 10 dBm]	Set reference level to 10 dBm.
[**BW**: 3 MHz]	Set resolution bandwidth to 3 MHz (resolution bandwidth shall be wider then signal bandwidth (1.25 MHz) in order to have the complete signal within the resolution bandwidth).
[**MEAS**]	Call the menu for measurement functions.
[*SIGNAL STATISTIC*]	Call the menu for signal statistics measurement.
[*CCDF ON /OFF*]	Switch on measurement of the complementary cumulative distribution function. The FSP switches to zero span mode. The power of the signal and the CCDF is calculated for the number of samples selected. With the CCDF function sample detector and video bandwidth are set automatically.
[NO OF SAMPLES: 10000]	Set the number of measurement samples to 10000.
[SINGLE MEAS]	Start the measurement sequence. At the end the resulting trace will display the CCDF for the measured 10000 samples.

Measurement of Carrier/Noise Ratio C/N and C/N$_o$

Using the carrier/noise measurement function, the FSP determines the C/N ratio which can also be shown normalized to a 1 Hz bandwidth (function *C/N$_o$*).

To determine the noise power, a channel at the set center frequency is examined. The bandwidth of the channel is fixed by means of the *CHANNEL BANDWIDTH* function.

The largest signal in the frequency span is the carrier. It is searched when the function is activated and is marked by means of the *REFERENCE FIXED* marker. The noise power of the channel is subtracted from the signal level obtained (*C/N*), and in the case of a *C/N$_o$* measurement it is referred to a 1 Hz bandwidth.

There are two methods for measuring the carrier/noise ratio:

1. The carrier is outside the channel examined:

In this case, it is sufficient to switch on the desired measurement function and to set the channel bandwidth. The carrier/noise ratio is displayed on the screen.

2. The carrier is inside the channel examined:

In this case, the measurement must be performed in two steps. First, the reference measurement is performed with the carrier being active. This is done by switching on either the C/N or the C/N$_o$ measurement and waiting for the end of the next measurement run . Then, the carrier is switched off so that only the noise of the test setup is active in the channel. The carrier/noise ratio is displayed after the subsequent measurement has been completed.

The *ADJUST SETTINGS* function facilitates the selection of the frequency span appropriate for the channel bandwidth: it automatically sets the *SPAN* to approx. 4 x channel bandwidth.

The RMS detector is enabled when the power measurement is switched on (*TRACE-DETECTOR-RMS).*

Submenu *MEAS – C/N, C/N$_o$*:
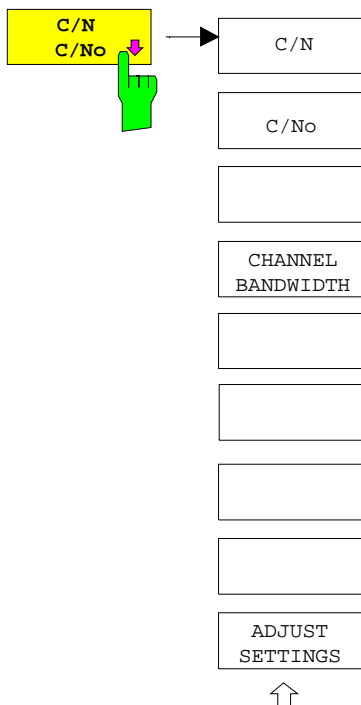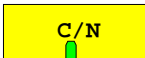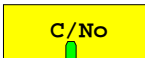
The *C/N, C/No* softkey opens the submenu for configuring the carrier/noise ratio measurement.

The user can choose between measurement without (C/N) and measurement with reference to the bandwidth (C/No). In addition, it is possible to select the bandwidth of the channel and to adapt the span.

Note:
The measurements are only available in the frequency domain (span >0).

C/N

C/No
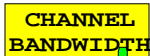
The *C/N* and *C/No* softkeys enable and disable the measurement of the carrier/noise ratio, the *C/No* measurement also being referred to a 1 Hz bandwidth.
The maximum value of the current trace is determined when the function is activated and is marked by means of the *REFERENCE FIXED* marker.

Note: *The measurement is performed on the trace where MARKER 1 is located. To measure another trace, MARKER 1 has to be shifted to the trace in question using the SELECT TRACE softkey in the MKR menu.*
If no marker is active, MARKER 1 is activated when the function is switched on.

IEC/IEEE-bus command: CALC:MARK:FUNC:POW:SEL CN
                        CALC:MARK:FUNC:POW:RES? CN
                        CALC:MARK:FUNC:POW:SEL CN0
                        CALC:MARK:FUNC:POW:RES? CN0
                        CALC:MARK:FUNC:POW OFF
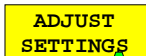
CHANNEL BANDWIDTH

The *CHANNEL BANDWIDTH* softkey opens a window for selecting the measurement channel bandwidth.
The default setting is 14 kHz.
The specified channel bandwidth allows the optimal setting of the measurement parameters of the FSP using *ADJUST SETTINGS*.

IEC/IEEE-bus command: SENS:POW:ACH:BWID 14kHz

ADJUST SETTINGS

The *ADJUST SETTINGS* softkey adapts the span to the channel bandwidth selected.
For the carrier/noise ratio measurement, the span is set to:

        4 x channel bandwidth + measurement margin

The adjustment is performed once; if necessary, the setting can be changed later on.

IEC/IEEE-bus command: SENS:POW:ACH:PRES CN │ CN0

Measurement of the AM Modulation Depth

> [!NOTE]
> **MODULATION DEPTH**

The *MODULATION DEPTH* softkey switches on the measurement of the AM modulation depth. An AM-modulated carrier is required on the screen for ensuring correct operation.

The level value of *MARKER 1* is taken as the carrier level. When this function is activated, *MARKER 2* and *MARKER 3* are automatically set symmetrically to the carrier on the adjacent peak values of the trace as delta markers and *MARKER 2* is activated for the entry.

When the position of *MARKER 2* (delta) is changed, *MARKER 3* (delta) is moved symmetrically with respect to the reference marker (*MARKER 1*).

If the data entry is activated for *MARKER 3* (*MARKER 1 2 3 4* softkey), the latter can be moved for fine adjustment irrespective of *MARKER 2*.

The FSP calculates the power at the marker positions from the measured levels. The AM modulation depth is calculated from the ratio between the power values at the reference marker and at the delta markers. When the powers of the two AM side bands are unequal, the mean value of the two power values is used for AM modulation depth calculation.

Measurement example:

The AM modulation depth of a carrier modulated with 1 kHz is to be measured at 100 MHz.

[**PRESET**]	The FSP is set to the default setting.
[**CENTER**: 100 **MHz**]	The center frequency is set to 100 MHz.
[**SPAN**: 5 **kHz**]	The span is set to 5 kHz.
[**AMPT**: 0 **dBm**]	The reference level is set to 0 dBm.
[**MKR FCTN**]	*MARKER 1* is switched on and positioned at the maximum of the displayed trace.
[*MODULATION DEPTH*: 1 **kHz**]	The measurement of the AM modulation depth is switched on. *MARKERS 2* and *3* (delta markers) are set to the adjacent peak values of the trace and are activated for the frequency entry. The AM modulation depth is output in % in the marker info field. When 1 kHz is entered, *MARKER 2* can be exactly positioned on 1 kHz and *MARKER 3* at -1 kHz from the reference marker.

IEC/IEEE-bus command: `CALC:MARK:FUNC:MDEP      ON;`
`CALC:MARK:FUNC:MDEP:RES?`

Measurement of the Third Order Intercept (TOI)

If several signals are applied to a transmission twoport with nonlinear characteristic, intermodulation products appear at its output by the sums and differences of the signals. The nonlinear characteristic produces harmonics of the useful signals which intermodulate at the characteristic. The intermodulation products of lower order have a special effect since their level is largest and they are near the useful signals. The intermodulation product of third order causes the highest interference. It is the intermodulation product generated from one of the useful signals and the 2nd harmonic of the second useful signal in case of two-tone modulation.

The frequencies of the intermodulation products are above and below the useful signals. Fig. 4-11 shows intermodulation products P_{I1} and P_{I2} generated by the two useful signals P_{U1} and P_{U2}.
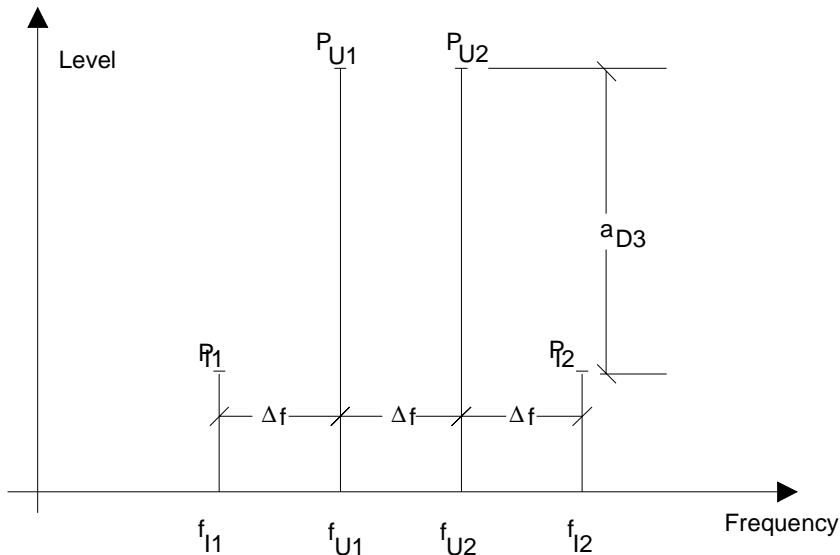
Fig. 4-11   Intermodulation products P_{U1} and P_{U2}

The intermodulation product at f_{I2} is generated by mixing the 2nd harmonic of useful signal P_{U2} and signal P_{U1}, the intermodulation product at f_{I1} by mixing the 2nd harmonic of useful signal P_{U1} and signal P_{U2}.

$$f_{i1} = 2 \times f_{u1} - f_{u2} \qquad\qquad (1)$$

$$f_{i2} = 2 \times f_{u2} - f_{u1} \qquad\qquad (2)$$

The level of the intermodulation products depends on the level of the useful signals. If the two useful signals are increased by 1 dB, the level of the intermodulation products increases by 3 dB, which means that spacing a_{D3} between intermodulation signals and useful signals is reduced by 2 dB. This is illustrated in Fig. 4-12.
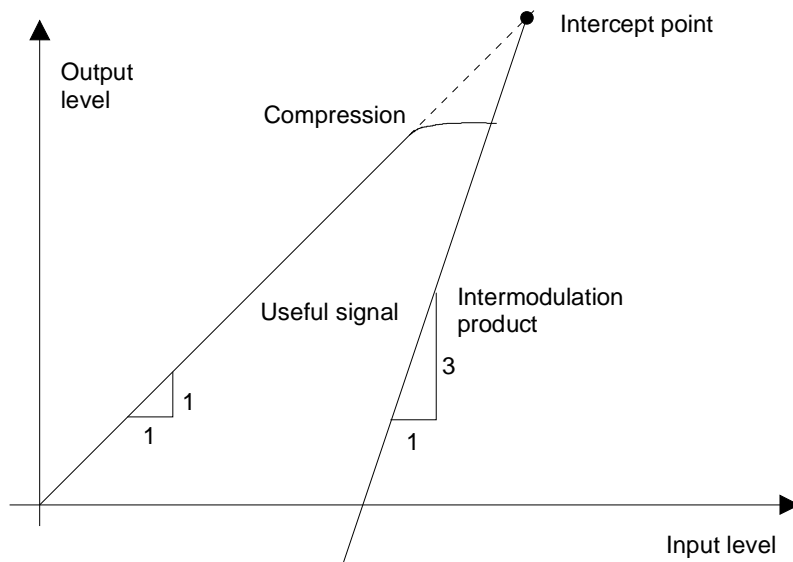
Fig. 4-12   Dependence of intermodulation level on useful signal level

The useful signals at the twoport output increase proportionally with the input level as long as the twoport is in the linear range. A level change of 1 dB at the input causes a level change of 1 dB at the output. Beyond a certain input level, the twoport goes into compression and the output level stops increasing. The intermodulation products of the third order increase three times as much as the useful signals. The intercept point is the fictitious level where the two lines intersect. It cannot be measured directly since the useful level is previously limited by the maximum twoport output power.

It can be calculated from the known line slopes and the measured spacing a_{D3} at a given level according to the following formula.

$$IP3 = \frac{a_{D3}}{2} + P_N \qquad\qquad (3)$$

The 3rd order intercept point (TOI), for example, is calculated for an intermodulation of 60 dB and an input level P_U of -20 dBm according to the following formula:

$$IP3 = \frac{60}{2} + (-20dBm) = 10dBm. \qquad (4)$$
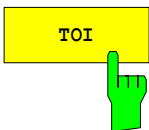
| TOI | The *TOI* softkey enables the measurement of the 3rd order intercept point. A two-tone signal with equal carrier levels is expected at the FSP input. *MARKER 1* and *MARKER 2* (both normal markers) are set to the maximum of the two signals. *MARKER 3* and *MARKER 4* (both delta markers) are placed on the intermodulation products. When the function is enabled, the frequency entry is activated for the delta markers. They can be set manually. The FSP calculates the third order intercept from the level spacing between normal markers and delta markers and outputs it in the marker info field. |

IEC/IEEE-bus command: `CALC:MARK:FUNC:TOI`   `ON;`
                                                   `CALC:MARK:FUNC:TOI:RES?`

Example:

A two-tone signal with frequencies of 100 MHz and 101 MHz is applied to the RF input of the FSP. The level of the two signals is -10 dBm.

[**PRESET**]   The FSP is set to the default setting.

[**CENTER**: 100.5 **MHz**]   The center frequency is set to 100.5 MHz.

[**SPAN**: 3 **MHz**]   The span is set to 3 MHz.

[**AMPT**: -10 **dBm**]   The reference level is set to -10 dBm.

[*MKR FCTN*]   *MARKER 1* is switched on and set to the signal peak.

[*TOI*]   The FSP sets the 4 markers to the useful signals and the intermodulation products and calculates the third order intercept. The result is output in the marker info field.
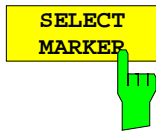
SELECT
MARKER

The *SELECT MARKER* softkey activates the selection of a marker for functions *MODULATION DEPTH* and *TOI*. Thus, the markers can be fine-adjusted for these functions.

The markers are numerically selected in a data entry field. Delta marker 1 is selected by entering '0'.

If the marker is in the switch-off state, it will be switched on and can thus be shifted.

IEC/IEEE-bus command: CALC:MARK1 ON;
                                            CALC:MARK1:X <value>;
                                            CALC:MARK1:Y?

Setup of Limit Lines and Display Lines – *LINES* Key

Limit lines are used to define amplitude curves or spectral distribution boundaries on the display screen which are not to be exceeded. They indicate, for example, the upper limits for interference radiation or spurious waves which are allowed from a unit under test (UUT). For transmission of information in TDMA (e.g. GSM), the amplitude of the bursts in a timeslot must adhere to a curve which must fall within a specified tolerance band. The lower and upper limits may each be specified by a limit line. Then, the amplitude curve can be controlled either visually or automatically for any violations of the upper or lower limits (GO/NOGO test).

The instrument supports limit lines with a maximum of 50 data points. 8 of the limit lines stored in the instrument can be used simultaneously and activated in the split-screen mode either in Screen A, Screen B or in the two windows. The number of limit lines stored in the instrument is only limited by the capacity of the flashdisk used.

For each limit line, the following characteristics must be defined:

- The name of the limit line. The limit line data are stored under this name and can be examined in the table *LIMIT LINES.*

- The domain in which the limit line is to be used. Here, a distinction is made between the time domain (span = 0 Hz) and the frequency domain (span > 0 Hz).

- The reference of the interpolation points to the X axis. The limit line may be specified either for absolute frequencies or times or for frequencies which are related to the set center frequency and times related to the time on the left edge of the diagram.

- The reference of the interpolation points to the Y axis. The limit line can be selected either for absolute levels or voltages or referred to the set maximum level (Ref Lvl). The position on the display depends on the *REF LEVEL POSITION*.

- With relative reference values for the Y axis, it is possible to enter an absolute threshold (THRESHOLD) which lowers the relative limit values (see below).

- The type of limit line (upper or lower limit). With this information and the active limit checking function (Table *LIMIT LINES*, *LIMIT CHECK ON*, the FSP checks for compliance with each limit.

- The limit line units to be used. The units of the limit line must be compatible with the level axis in the active measurement window.

- The measurement curve (trace) to which the limit line is assigned. For the FSP, this defines the curve to which the limit is to be applied when several traces are simultaneously displayed.

- For each limit line, a margin can be defined which serves as a threshold for automatic evaluation.

- In addition, commentary can be written for each limit line, e.g. a description of the application.

Display lines are exclusively used to optically mark relevant frequencies or points in time (span = 0) as well as constant level values. It is not possible to check automatically whether the marked level values have been underranged or exceeded.

Selection of Limit Lines

The *LINES* key opens the menu for fixing the limit lines and the display lines.

LINES menu

The *SELECTED LIMIT LINE* display field provides information concerning the characteristics of the marked limit lines.

In the *LIMIT LINES* table, the limit lines compatible to the settings of the active screen can be enabled.

New limit lines can be specified and edited in the *NEW LIMIT LINE and EDIT LIMIT LINE* sub-menus, respectively.

The horizontal and vertical lines of the *DISPLAY LINES* submenu mark individual levels or frequencies (span > 0) or times (span = 0) in the diagram.

The *SELECTED LIMIT LINE* table provides information about the characteristics of the marked limit line :

Name	name
Domain	frequency or time
Unit	vertical scale
X-Axis	interpolation
Limit	upper/lower limit
X-Scaling	absolute or relative frequencies/times
Y-Scaling	absolute or relative Y units
Threshold	absolute limit with relative Y units
Comment	commentary

The characteristics of the limit line are set in the *EDIT LIMIT LINE (=NEW LIMIT LINE)* sub-menu.

SELECT LIMIT LINE

The *SELECT LIMIT LINE* softkey activates the *LIMIT LINES* table and the selection bar jumps to the uppermost name in the table.

The following information is offered in the columns of the table:

Name	Enable the limit line.
Compatible	Indicates if the limit line is compatible with the measurement window of the given trace.
Limit Check	Activate automatic violation check for upper/lower limits.
Trace	Select the measurement curve to which the limit is assigned.
Margin	Define margin.

Name and Compatible - Enabling limit lines

A maximum of 8 limit lines can be enabled at any one time. In split screen mode, they may be assigned to screen A, screen B or to both screens. A check mark at the left edge of a cell indicates that this limit line is enabled.
A limit line can only be enabled when it has a check mark in the *Compatible* column, i.e. only when the horizontal display (time or frequency) and vertical scales are ***identical*** to those of the display in the measurement window.
Lines with the unit dB are compatible to all dB(..) settings of the Y axis.

If the scale of the y axis or the domain (frequency or time axis) are changed, all non-compatible limit lines are automatically switched off in order to avoid misinterpretation. The limit lines must be enabled anew when the original display is re-displayed.

IEC/IEEE-bus command: CALC:LIM3:NAME "GSM1"
                           CALC:LIM3:UPP:STAT ON
                           CALC:LIM4:LOW:STAT ON

Limit Check - **Activate automatic limit violation check**

When *LIMIT CHECK ON* is activated, a GO/NOGO test is performed in the active screen. In the center of the diagram, a display window appears which indicates the results of the limit check test:

LIMIT CHECK: PASSED   No violations of active limits.

LIMIT CHECK: FAILED   One or more active limit lines were violated. The message contains the names of the limit lines which were violated or whose margins were not complied with.

LIMIT CHECK: MARGIN   The margin of at least one active limit lines was not complied with, however, no limit line was violated. The message contains the names of the limit lines whose margins were not complied with.

The following example shows two active limit lines:

```
LIMIT CHECK: FAILED

LINE VHF_MASK: Failed
LINE UHF2MASK: Margin
```

A check for violations of limit lines takes place only if the limit line of the assigned measurement curve (trace) is enabled.
If *LIM CHECK* is set to *OFF* for all active limit lines, then the limit line check is not executed and the display window is activated.

IEC/IEEE-bus command: CALC:LIM:STAT ON
                               INIT;*WAI
                               CALC:LIM:FAIL?

Trace -   **Select the measurement curve to which the limit line is assigned.**

The selection of the measurement curve (trace) takes place in an entry window. Allowed are the integer entries 1, 2 or 3. The default setting is trace 1. If the selected limit line is not compatible with the assigned measurement curve, then the limit line is disabled (display and limit check).

IEC/IEEE-bus command: CALC:LIM:TRAC 1

NEW LIMIT LINE

See following Section "Entry and Editing of Limit Lines".

EDIT LIMIT LINE
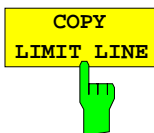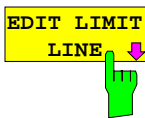
COPY LIMIT LINE

The *COPY LIMIT LINE* softkey copies the data file describing the marked limit line and saves it under a new name. In this way, a new limit line can be easily generated by parallel translation or editing of an existing limit line. The name can be arbitrarily chosen and input via an entry window (max. of 8 characters).

IEC/IEEE-bus command: `CALC:LIM3:COPY 2`   or
                                  `CALC:LIM3:COPY "GSM2"`

DELETE LIMIT LINE

The *DELETE LIMIT LINE* softkey erases the selected limit line. Before deletion, a message appears requesting confirmation.

IEC/IEEE-bus command: `CALC:LIM3:DEL`

X OFFSET

The *X OFFSET* softkey horizontally shifts a limit line, which has been specified for relative frequencies or times (X axis). The softkey opens an entry window, where the value for shifting may be entered numerically or via the rollkey.

Note: *This softkey does not have any effect on limit lines that represent absolute values for the X axis.*

IEC/IEEE-bus command: `CALC:LIM3:CONT:OFFS 10kHz`

Y OFFSET

The *Y OFFSET* softkey vertically shifts a limit line, which has relative values for the Y axis (levels or linear units such as volt). The softkey opens an entry window where the value for shifting may be entered numerically or via the rollkey.

Note: *This softkey does not have any effect on limit lines that represent absolute values for the Y axis.*

IEC/IEEE-bus command: `CALC:LIM3:LOW:OFFS 3dB`
                                    `CALC:LIM3:UPP:OFFS 3dB`

Entry and Editing of Limit Lines

```
                              RBW  3 MHz
                       EDIT LIMIT LINE TABLE
     Name:            LP1GHZ
     Domain:          FREQUENCY
     Unit:            dBm
     x-Axis:          LIN
     x-Scaling:       ABSOLUTE
     y-Scaling:       ABSOLUTE
     Limit:           UPPER
     Margin:          40 dB
     Threshold:
     Comment:         Lowpass at 1 GHz
           Frequency                      LIMIT/dBm
        0.000 Hz                  -10.0000
        1.000 GHz                 -10.0000
        1.001 GHz                 -70.0000
        3.000 GHz                 -70.0000



                    Press ENTER to edit field
     -120

     Start  0 Hz              200 MHz/            Stop  2 GHz
```

| NAME |
| VALUES |
| INSERT VALUE |
| DELETE VALUE |
| SHIFT X LIMIT LINE |
| SHIFT Y LIMIT LINE |
| SAVE LIMIT LINE |

A limit line is characterized by

- its name
- the assignment of domain (frequency or time)
- the scaling in absolute or relative times or frequencies
- the vertical unit
- the interpolation
- the vertical scaling
- the vertical threshold (only with relative vertical scaling)
- the margin
- the definition of the limit line as either upper or lower limit.
- the data points for frequency/time and level

At the time of entry, the FSP immediately checks that all limit lines are in accordance with certain guidelines. These guidelines must be observed if specified operation is to be guaranteed.

- The frequencies/times for each data point must be entered in ascending order, however, for any single frequency/time, two data points may be input (vertical segment of a limit line).

  The data points are allocated in order of ascending frequency/time. Gaps are not allowed. If gaps are desired, two separate limit lines must be defined and then both enabled.

- The entered frequencies/times need not necessarily be selectable in FSP. A limit line may also exceed the specified frequency or time domains. The minimum frequency for a data point is -200 GHz, the maximum frequency is 200 GHz. For the time domain representation, negative times may also be entered. The valid range is -1000 s to +1000 s.

- The minimum/maximum value for a limit line is -200 dB to +200 dB for the logarithmic or 10^{-20} to 10^{+20} or -99.9% to + 999.9% for the linear amplitude scales.

LINES - EDIT LIMIT LINE menu
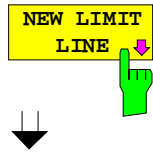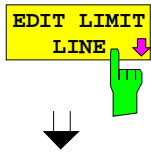
The *EDIT LIMIT LINE* and *NEW LIMIT LINE* softkeys both call the *EDIT LIMIT LINE* sub-menu used for editing limit lines. In the table heading, the characteristics of the limit line can be entered. The data points for frequency/time and level values are entered in the columns.

Name	Enter name.
Domain	Select domain.
Unit	Select units.
X-Axis	Select interpolation
Limit	Select upper and lower limit value.
X-Scaling	Entry of absolute or relative values for the X axis
Y-Scaling	Entry of absolute or relative values for the Y axis
Margin	Entry of margin.
Threshold	Entry of vertical threshold (only with relative vertical scaling)
Comment	Enter comments.
Time/Frequency	Enter time/frequency for the data points.
Limit/dBm	Enter magnitudes for the data points.

> ***Note:*** *Domain, unit, X scaling and Y scaling cannot be modified as soon as reference values have been entered in the data section of the table.*
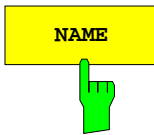
The *NAME* softkey enables the entry of characteristics in the table heading.

Name - **Enter name**

A maximum of 8 characters is permitted for each name. All names must be compatible with the MS DOS conventions for file names. The instrument stores all limit lines with the .LIM extension.

IEC/IEEE-bus command: CALC:LIM3:NAME "GSM1"

Domain - **Select time or frequency domain**

The default setting is frequency.

> ***Note:*** *A change in domain (frequency/time) is only permitted when the data point table is empty.*

IEC/IEEE-bus command: CALC:LIM3:CONT:DOM FREQ

X Axis - **Select interpolation**

Linear or logarithmic interpolation can be carried out between the frequency reference points of the table. The ENTER key toggles between LIN and LOG selection.

IEC/IEEE-bus commands   `CALC:LIM3:CONT:SPAC LIN`
                                `CALC:LIM3:UPP:SPAC LIN`
                                `CALC:LIM3:LOW:SPAC LIN`

Scaling - **selection of absolute or relative scaling**

The limit line can either be scaled in absolute (frequency or time) or relative units. Any of the unit keys may be used to toggle between *ABSOLUTE* and *RELATIVE*, the cursor must be positioned in the X *Scaling* or the *Y Scaling* line.

X-Scaling ABSOLUTE	The frequencies or times are interpreted as absolute physical units.
X-Scaling RELATIVE	In the data point table, the frequencies are referred to the currently set center frequency. In time domain mode, the left boundary of the diagram constitutes the reference.
Y-Scaling ABSOLUTE	The limit values refer to absolute levels or voltages.
Y-Scaling RELATIVE	The limit values refer to the reference level (Ref Level) or, in case a reference line is set, to the reference line. Limit values with the unit dB are always relative values.

The *RELATIVE* scaling is always suitable, if masks for bursts are to be defined in the time domain, or if masks for modulated signals are required in the frequency domain.
An X offset with half the sweep time may be entered in order to shift the mask in the time domain into the center of screen.

IEC/IEEE-bus command: `CALC:LIM3:CONT:MODE ABS`
                                `CALC:LIM3:UPP:MODE ABS`
                                `CALC:LIM3:LOW:MODE ABS`

Unit - **Select the vertical scale units for the limit line**

The selection of units takes place in a selection box. The default setting is dBm**.**

```
        UNITS
    VERTICAL SCALE
        dB
  √     dBm
        %
        dBuV
        dBmV
        dBuA
        dBpW
        V
        A
        W

```
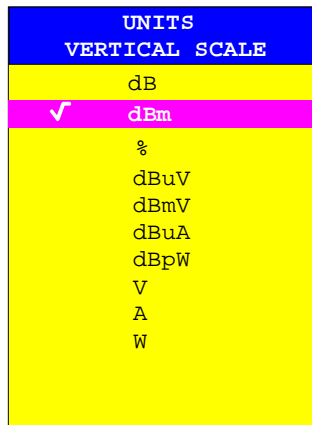
IEC/IEEE-bus command: `CALC:LIM3:UNIT DBM`

Limit - **Select upper/lower limit**

A limit line can be defined as either an upper or lower limit.

IEC/IEEE-bus command: --
(defined by key words :UPPer or :LOWer)

Margin - **Setting a margin.**

The margin is defined as the signal-level distance to the limit line . When the limit line is defined as an upper limit, the margin means that the level is below the limit line. When the limit line is defined as a lower limit, the margin means that the level is above the limit line. The default setting is 0 dB (i.e. no margin).

IEC/IEEE-bus command: CALC:LIM3:UPP:MARG 10dB
                             CALC:LIM3:LOW:MARG 10dB

Threshold – **Selection of the threshold value with relative Y scaling**

With relative Y scaling, an absolute threshold value can be defined which lowers the relative limit values. The function is useful especially for mobile radio applications provided the limit values are defined in relation to the carrier power as long as they are above an absolute limit value.

Example:
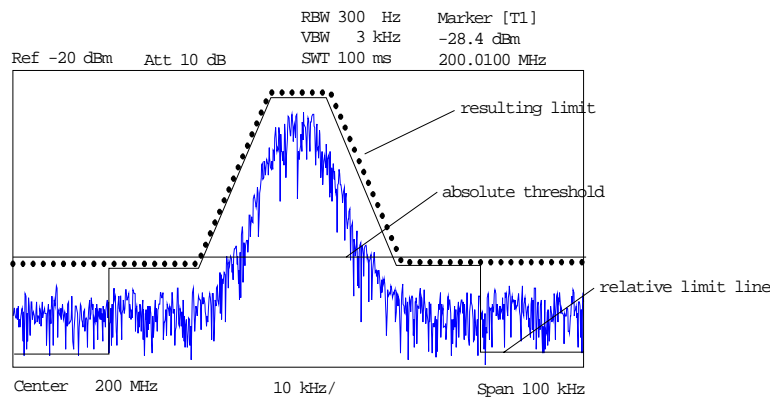
The preset value is at -200 dBm. The field is displayed if the value RELATIVE is entered in the field Y-SCALING.

IEC/IEEE-bus command: CALC:LIM3:UPP:THR –30 dBm
                             or
                             CALC:LIM3:LOW:THR –30 dBm

Comment - **Enter comments**

Comments are arbitrary, however, they must be less than 41 characters long.

IEC/IEEE-bus command: CALC:LIM3:COMM "Upper limit"
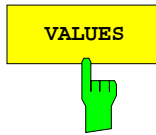
VALUES

The *VALUES* softkey activates the entry of the data points in the table columns *Time*/*Frequency* and *Limit/dB*. Which table columns appear depends upon the *Domain* selection in the table heading.

The desired frequency/time data points are entered in ascending order (two repeated frequencies/time values are permitted).

IEC/IEEE-bus command: CALC:LIM3:CONT:DATA 1MHz,3MHz,30MHz
                        CALC:LIM3:UPP:DATA -10,0,0
                        CALC:LIM3:LOW:DATA -30,-40,-40
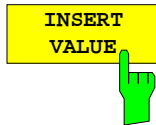
INSERT VALUE

The *INSERT VALUE* softkey creates an empty line above the current cursor position where a new data point may be entered. However, during the entry of new values, it is necessary to observe an ascending order for frequency/time.

IEC/IEEE-bus command: --
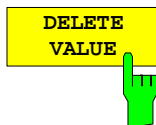
DELETE VALUE

The *DELETE VALUE* softkey erases the data point (complete line) at the cursor position. All succeeding data points are shifted down accordingly.

IEC/IEEE-bus command: --
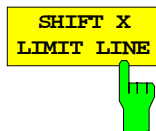
SHIFT X LIMIT LINE

The *SHIFT X LIMIT LINE* softkey calls an entry window where the complete limit line may be shifted parallel in the horizontal direction.

The shift takes place according to the horizontal scale:

– in the frequency domain in Hz, kHz, MHz or GHz

– in the time domain in ns, µs, ms or s

In this manner, a new limit line can be easily generated based upon an existing limit line which has been shifted horizontally and stored (*SAVE LIMIT LINE* softkey) under a new name (*NAME* softkey).

IEC/IEEE-bus command: CALC:LIM3:CONT:SHIF 50KHz
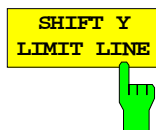
SHIFT Y LIMIT LINE

The *SHIFT Y LIMIT LINE* softkey calls an entry window where the complete limit line may be shifted parallel in the vertical direction.

The shift takes place according to the vertical scale:

– for logarithmic units, relative, in dB

– for linear units, as a factor

In this manner, a new limit line can be easily generated based upon an existing limit line which has been shifted vertically and stored (*SAVE LIMIT LINE* softkey) under a new name (*NAME* softkey).

IEC/IEEE-bus command: CALC:LIM3:CONT:UPP:SHIF 20dB
                            CALC:LIM3:CONT:LOW:SHIF 20dB
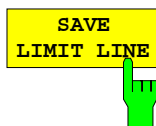
SAVE LIMIT LINE

The *SAVE LIMIT LINE* softkey stores the currently edited limit line . The name can be entered in an input window (max. 8 characters)

IEC/IEEE-bus command: --

Display Lines

Display lines help to evaluate a trace – as do markers. The function of a display line is comparable to that of a ruler that can be shifted on the trace in order to mark absolute values.

The FSP provides two different types of display lines :
- two horizontal level lines for marking levels – Display Line 1/2,

- two vertical frequency or time lines for marking frequencies or points in time – Frequency/Time Line 1/2.

Each line is identified by one of the following abbreviations at the right edge of the diagram:
D1   Display Line 1
D2   Display Line 2
F1   Frequency Line 1
F2   Frequency Line 2
T1   Time Line 1
T2   Time Line 2

The level lines are continuous horizontal lines across the entire width of a diagram and can be shifted in y direction.

The frequency or time lines are continuous vertical lines across the entire height of the diagram and can be shifted in x direction.

The *DISPLAY LINES* submenu for activating and setting the display lines appears different depending on the display mode set in the active measurement window (frequency or time domain).

If the spectrum is shown (span ≠ 0) the *TIME LINE 1* and *TIME LINE 2* softkeys are disabled, whereas in the time domain (span = 0) the *FREQUENCY LINE 1* and *FREQUENCY LINE 2* softkeys are not available.

Note: *The softkeys for setting and switching the display lines on/off work like triple switches:*
Initial situation: The line is off (softkey with gray background)

1st press: The line is switched on (softkey with red background) and the data input function is activated. The position of the display line can be selected by means of the rollkey, the step keys or a numerical entry in the appropriate field. The data input function is disabled if another function is activated. The line, however, remains switched on (softkey with green background).

2nd press.   The line is switched off (softkey with gray background).

Initial situation: The line is on (softkey with green background)

1st press: The data input function is activated (softkey with red background). The position of the display line can be selected by means of the rollkey, the step keys or a numerical entry in the appropriate field. The data input function is disabled if another function is activated. The line, however, remains switched on (softkey with green background).

2nd press.   The line is switched off (softkey with gray background).

LINES menu

DISPLAY
LINES

> DISPLAY
LINE 1

DISPLAY
LINE 2

FREQUENCY
LINE 1 ─┐
         ├─ Frequency Domain
FREQUENCY   (Span > 0 Hz)
LINE 2 ─┘

TIME
LINE 1 ─┐
         ├─ Time Domain
TIME   (Span = 0 Hz)
LINE 2 ─┘

⇧
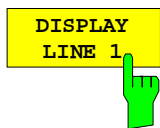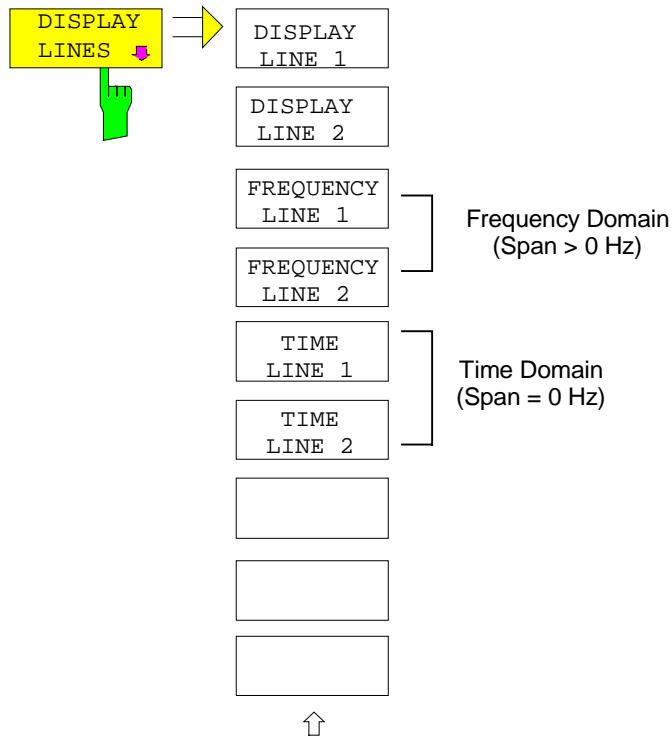
**DISPLAY
LINE 1**

The *DISPLAY LINE 1/2* softkeys enable or disable the level lines and allow the user to enter the position of the lines.

The level lines mark the selected level in the measurement window.

**DISPLAY
LINE 2**
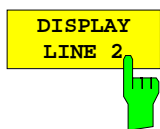
IEC/IEEE-bus command: CALC:DLIN:STAT ON
                          CALC:DLIN -20dBm
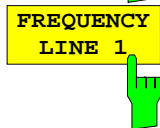
**FREQUENCY
LINE 1**

The *FREQUENCY LINE 1/2* softkeys enable or disable the frequency lines 1/2 and allow the user to enter the position of the lines.

The frequency lines mark the selected frequencies in the measurement window.

**FREQUENCY
LINE 2**
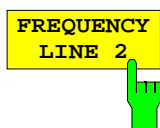
Note: *The two softkeys cannot be used in the time domain (span = 0).*

IEC/IEEE-bus command: CALC:FLIN:STAT ON
                          CALC:FLIN 120MHz

TIME LINE 1
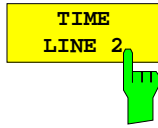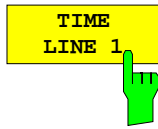
TIME LINE 2

The *TIME LINE 1/2* softkeys enable or disable the time lines 1/ and allow the user to enter the position of the lines.

The time lines mark the selected times or define search ranges (see section "Marker Functions ").

Note: *The two softkeys cannot be used in the frequency domain (span > 0).*

IEC/IEEE-bus command: `CALC:TLIN:STAT ON`
                                           `CALC:TLIN 10ms`

Configuration of Screen Display – *DISP* Key

The *DISPLAY* menu allows the configuration of the diagram display on the screen and also the selection of the display elements and colors. The *POWER SAVE* mode is also configured in this menu for the display.

The test results are displayed on the screen of the FSP either in a full-screen window or in two overlapping windows. The two windows are called diagram A and diagram B.

In the default setting, the two windows are completely decoupled from each other, ie they behave like two separate instruments. This is very useful, for example with harmonics measurements or measurements on frequency-converting DUTs, since the input signal and the output signal lie in different frequency ranges.

However, specific settings of the two windows (reference level, center frequency) can be coupled, if required, so that with *CENTER B = MARKER A* for example, the shift of the marker in diagram A causes the frequency range (zoomed in some cases) to be shifted along diagram B.

New setttings are performed in the diagram selected via hotkey SCREEN A or SCREEN B. If only one window is displayed, it is the diagram in which the measurements are performed; the diagram not displayed is not active for measurements.
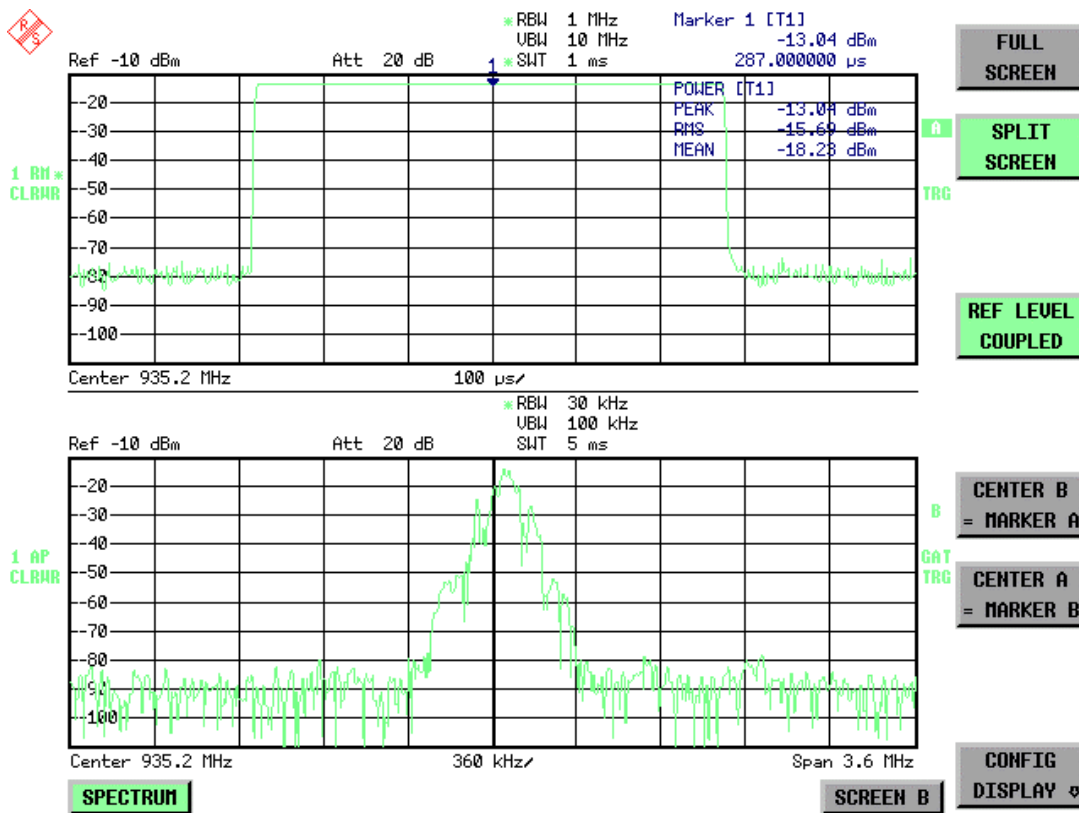
Fig. 4-15   Typical split-screen display, settings are uncoupled

The *DISP* key opens the menu for configuring the screen display and selecting the active diagram in SPLIT SCREEN mode.

LINE S		
DISP	FULL SCREEN	SCREEN TITLE
HELP	SPLIT SCREEN	TIME+DATE ON OFF
		LOGO ON OFF
	REF LEVEL COUPLED	ANNOTATION ON OFF
		DATA ENTRY OPAQUE
	CENTER B = MARKER A	DEFAULT COLORS 1
	CENTER A = MARKER B	DEFAULT COLORS 2
	CONFIG DISPLAY	DISPLAY PWR SAVE

SELECT OBJECT
BRIGHTNESS
TINT
SATURATION
PREDEFINED COLORS
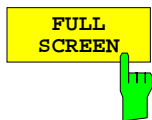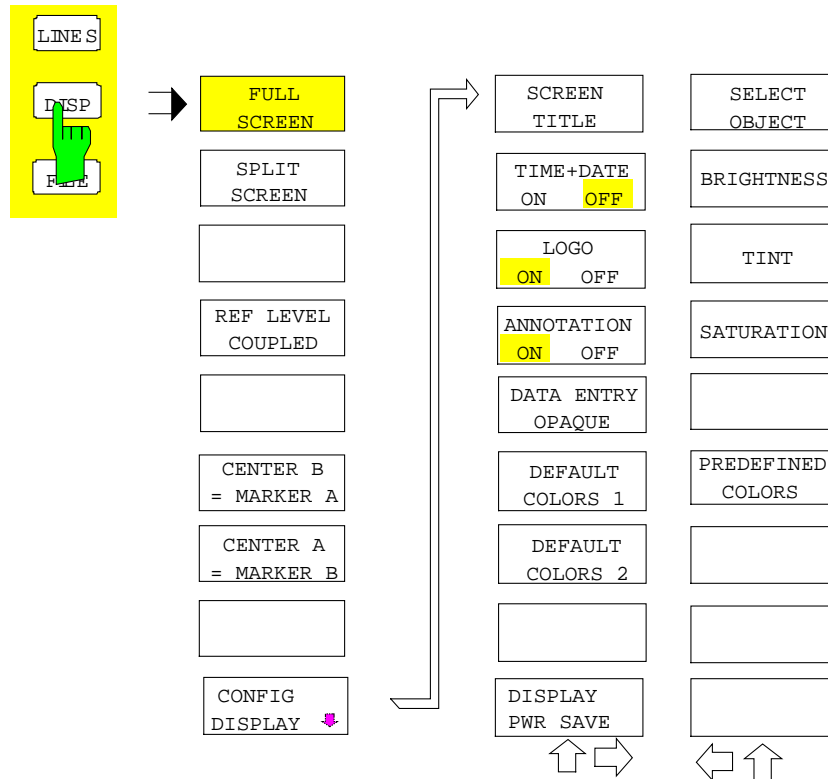
FULL SCREEN

The *FULL SCREEN* softkey selects the display of one diagram. This corresponds to the default setting of FSP.

In the *FULL SCREEN* mode it is possible to switch between two different device settings by selecting the active window (screen A or screen B).
Switching between *SCREEN A* and *SCREEN B* is performed by means of the corresponding key in the *HOTKEY bar*:

SPECTRUM						SCREEN B
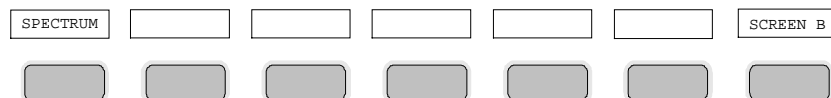
It should be noted that the measurements in the FULL SCREEN mode are performed only in the visible (active) window.

The active window is marked by **A** or **B** on the right of the diagram.

IEC/IEEE-bus command: DISP:FORM SING
                         DISP:WIND<1|2>:SEL
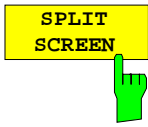
SPLIT SCREEN

The *SPLIT SCREEN* softkey selects the display of two diagrams. The upper diagram is designated *SCREEN A*, the lower diagram *SCREEN B*.

Switching between *SCREEN A* and *SCREEN B* is performed via the corresponding key in the *HOTKEY* bar. The active window is marked by highlighting fields **A** and **B** on the right of the diagram.

IEC/IEEE-bus command: DISP:FORM SPL

REF LEVEl COUPLED

The *REF LEVEL COUPLED* softkey switches the coupling of the reference level on and off. In addition to the reference level, the mixer level and input attenuation are coupled with one another.

For the level measurement, the same reference level and input attenuation must be set for the two diagrams.

IEC/IEEE-bus command   INST:COUP RLEV

CENTER B =MARKER A
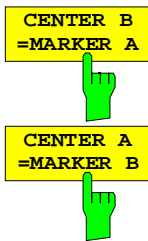
CENTER A =MARKER B

The *CENTER B = MARKER A and CENTER A = MARKER B* softkeys couple the center frequency in diagram B with the frequency of marker 1 in diagram A and the center frequency in diagram B with the frequency of marker 1 in diagram B. The two softkeys are mutually exclusive.
This coupling is useful, eg for viewing the signal at the marker position in diagram A with higher frequency resolution or in the time domain in diagram B.
If marker 1 is off, it is switched on and set to the maximum of the trace in the active diagram.

IEC/IEEE-bus command: INST:COUP CF_B
                               INST:COUP CF_A
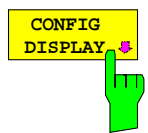
CONFIG DISPLAY

SCREEN TITLE	SELECT OBJECT
TIME+DATE ON **OFF**	BRIGHTNESS
LOGO **ON** OFF	TINT
ANNOTATION **ON** OFF	SATURATION
DATA ENTRY OPAQUE	
DEFAULT COLORS 1	PREDEFINED COLORS
DEFAULT COLORS 2	
DISPLAY PWR SAVE	

The *CONFIG DISPLAY* softkey opens a submenu allowing additional display items to be added to the screen. In addition, the display power-save mode (*DISPLAY PWR SAVE*) and the colors of the display elements can be set here.
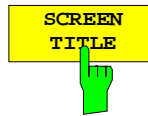
SCREEN TITLE

The *SCREEN TITLE* softkey activates the entry of a title for the active diagram A or B. It switches on or off a title that is already input. The length of the title is limited to max. 20 characters.

IEC/IEEE-bus command: `DISP:WIND1:TEXT 'Noise Meas'`
                            `DISP:WIND1:TEXT:STATe ON`
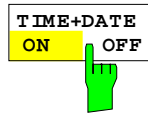
TIME+DATE ON OFF

The *TIME+DATE ON/OFF* softkey switches on or off the display of date and time above the diagram.

IEC/IEEE-bus command: `DISP:TIME OFF`
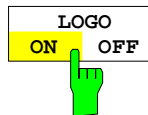
LOGO ON OFF

The *LOGO ON/OFF* softkey switches the Rohde & Schwarz company logo displayed in the upper left corner of the display screen on or off.

IEC/IEEE-bus command: `DISP:LOGO ON`
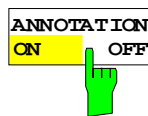
ANNOTATION ON OFF

The *ANNOTATION ON/OFF* softkey switches the displaying of frequency information on the screen on and off.

ON   Frequency information is displayed.

OFF   Frequency information is not outputted to the display. This can be used for example to protect confidential data.

IEC/IEEE-bus command: `DISP:ANN:FREQ ON`
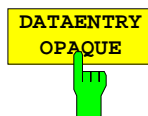
DATAENTRY OPAQUE

The *DATAENTRY OPAQUE* softkey sets the data entry windows to opaque. This means that entry windows are underlayed with the background color for tables.

IEC/IEEE-bus command: `--`

DEFAULT COLORS 1

DEFAULT COLORS 2

The *DEFAULT COLORS 1 and 2* softkey restores the default settings for brightness, color tint and color saturation for all display screen elements.
The color schemes have been selected to give optimum visibility of all picture elements at an angle of vision from above or below. *DEFAULT COLORS 1* is active in the default setting of the instrument.

IEC/IEEE-bus command: `DISP:CMAP:DEF1`
                                       `DISP:CMAP:DEF2`

DISPLAY
PWR SAVE

The *DISPLAY PWR SAVE* softkey is used to switch on/off the power-save mode for the display and to enter the time for the power-save fuction to respond. After the elapse of this time the display is completely switched off, ie including backlighting.

Note: *This mode is recommended for saving the TFT display especially when the instrument is exclusively operated in remote control.*

The power-save mode is configured as follows:
- The first keystroke activates the power-save mode and opens the editor for the response time (*POWER SAVE TIMEOUT*). The response time is entered in minutes between 1 and 6 minutes and is confirmed by *ENTER*.
- The power-save mode is deactivated by pressing the key again.

On leaving the menu with the power-save mode in the activated state, the softkey is highlighted in color on returning to the menu and opens again the editor for the response time. Pressing again the key switches off the power-save mode.

IEC/IEEE-bus command: DISP:PSAV ON
                                    DISP:PSAV:HOLD 15
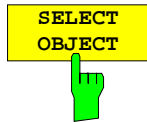
SELECT
OBJECT

The *SELECT OBJECT* softkey activates the *SELECT DISPLAY OBJECT* table, with which a graphics element can be selected. After selection, the brightness, tint and saturation of the selected element can be changed using the softkeys of the same name. The color changes by means of the *PREDEFINED COLORS* softkey can be seen immediately on the display screen.

```
             SELECT DISPLAY OBJECT
 √ Background
   Grid
   Function field + status field + data entry text
   Function field LED on
   Function field LED warn
   Enhancement label text
   Status field background
   Trace 1
   Trace 2
   Trace 3
   Marker
   Lines
   Measurement status + limit check pass
   Limit check fail
   Table + softkey text
   Table + softkey background
   Table selected field text
   Table selected field background
   Table + data entry field opaq titlebar
   Data entry field opaq text
   Data entry field opaq background
   3D shade bright part
   3D shade dark part
   Softkey state on
   Softkey state data entry
   Logo
```

BRIGHTNESS

The *BRIGHTNESS* softkey activates entry of the brightness of the selected graphics element.

Values between 0 and 100% can be entered.

IEC/IEEE-bus: `DISP:CMAP3:HSL< hue>,<sat>,<lum>`
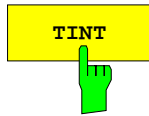
TINT

The *TINT* softkey activates the entry of the color tint of the selected element. The entered value is related to a continuous color spectrum ranging from red (0%) to blue (100%).

IEC/IEEE-bus: `DISP:CMAP3:HSL <hue>,<sat>,<lum>`

SATURATION

The *SATURATION* softkey activates the entry of the color saturation for the selected element.

The range of inputs is from 0 to 100%.

IEC/IEEE-bus: `DISP:CMAP3:HSL <hue>,<sat>,<lum>`

PREDEFINED COLORS

The *PREDEFINED COLORS* softkey activates a table, with which the predefined colors for the diplay screen elements can be selected.

```
           COLOR

  √  BLACK
     BLUE
     BROWN
     GREEN
     CYAN
     RED
     MAGENTA

     YELLOW
     WHITE
     GRAY
     LIGHT GRAY
     LIGHT BLUE
     LIGHT GREEN
     LIGHT CYAN
     LIGHT RED
     LIGHT MAGENTA
```

IEC/IEEE-bus command: `DISP:CMAP 1 to 26:PDEF <color>`

Instrument Setup and Interface Configuration – *SETUP* Key

The *SETUP* key opens the menu for configuration of the FSP:

```
                    TRANSDUCER                    INSERT
                    FACTOR                        LINE
                                                  DELETE
                                                  LINE
                    NEW      ⇩
                    EDIT     ⇩
                    DELETE
                    VIEW
                    TRANSDUCER
                                                  SAVE TRD
                                                  FACTOR
                    PAGE
                    UP
                    PAGE
                    DOWN
                      ⇧                             ⇧

                                        HARDWARE      GPIB        SOFT
                                        INFO          ADDRESS     FRONTPANEL
          REFERENCE   FIRMWARE   INPUT
SETUP ⇨   INT   EXT   UPDATE     RF      STATISTICS
          NOISE SRC   RESTORE    INPUT                COM
          ON    OFF   FIRMWARE   CAL     SYSTEM       INTERFACE
                                 SELFTEST  MESSAGES   TIME +
                                          CAL GEN     DATE
          PREAMP                 SELFTEST 128 MHZ     CONFIGURE
          ON    OFF              RESULTS  CAL GEN     NETWORK
          TRANSDUCER ⇩                    COMB        NETWORK
                                          CLEAR ALL   LOGIN
          GENERAL                         MESSAGES
          SETUP ⇩
          SYSTEM
          INFO ⇩
          SERVICE ⇩              ENTER
                                 PASSWORD
             ⇨        ⇦       ⇧⇨      ⇦        ⇧          ⇧⇨      ⇦
```

The following settings can be modified here:

- The *REFERENCE INT/EXT* softkey determines the source of the reference

- The *NOISE SRC ON/OFF* softkey switches on and off the voltage supply for an external noise source.

- The *PREAMP* softkey switches on the RF preamplifier gain.
- The *PREAMP* softkey switches on the RF preamplifier gain. This softkey is only available with option EL. ATTENUATOR (FSP-B25).

- The *TRANSDUCER* softkey opens a submenu for entering the correction characteristics for transducers.

- The *GENERAL SETUP* softkey opens a submenu for all the general settings such as IEC/IEEE-bus address, date and time as well as the configuration of the device interfaces. *FIRMWARE OPTIONS* can be installed under this menu item.

- The *SYSTEM INFO* softkey opens a submenu for displaying the hardware configuration of the instrument, the switching cycle statistics and system messages.

- The *SERVICE* softkey opens a submenu in which special device functions and system information can be selected for servicing. The password required for service functions can be entered in this submenu.

- The *SERVICE FUNCTIONS* softkey enables additional special settings for servicing and troubleshooting. It is available after entering the corresponding password under the *SERVICE* softkey.

External Reference Oscillator

The FSP can use the internal reference source or an external reference source as frequency standard from which all internal oscillators are derived. A 10 MHz crystal oscillator is used as internal reference source. In the default setting (internal reference), this frequency is available as output signal at rear-panel connector REF OUT, e.g. to synchronize other instruments to the reference of the FSP.
In the setting *REFERENCE EXT*, the connector REF IN is used as input connector for an external frequency standard. In this case all internal oscillators of the FSP are synchronized to the external reference frequency (also 10 MHz).

SETUP menu:
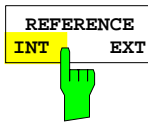
The *REFERENCE INT / EXT* softkey switches between the internal and external reference.

Note: *If the reference signal is missing when switching to external reference, the message "EXREF" appears after a while to indicate that there is no synchronization.*
                     On switching to internal reference please ensure that the external reference signal is de-activated to avoid interactions with the internal reference signal.

IEC/IEEE-bus command: `ROSC:SOUR INT`

External Noise Source

SETUP menu:
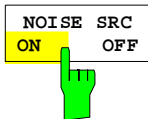
The *NOISE SRC ON/OFF* softkey switches on or off the supply voltage for an external noise source which is connected to the *NOISE SOURCE* connector on the rear panel of the instrument.

IEC/IEEE-bus command: `DIAG:SERV:NSO ON`

RF Preamplifier

To improve the noise figure, a low-noise preamplifier with variable gain at the RF input can be switched into the signal path.
SETUP menu:
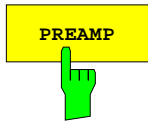
PREAMP

The *PREAMP* softkey switches the preamplifier on and activates the entry of the preamplifier gain. The preamplifier is switched off by pressing the softkey again.
The only possible value with option el. attenuator is 20 dB.

IEC/IEEE-bus command: INP:GAIN 0DB

Note: *The PREAMP softkey is only available with option EL. ATTENUATOR (*FSP-*B25) .*

Transducer

Activating Transducer Factors and Transducer Sets

The *TRANSDUCER* softkey opens a submenu enabling the user to activate or deactivate defined transducer factors, to generate new transducer factors or to edit existing ones. A table with the transducer factors defined is displayed.

As soon as a transducer is activated, the unit of the transducer is automatically used for all the level settings and outputs. The unit cannot be changed in the *AMPT* menu since the FSP and the transducer used are regarded as one measuring instrument. Only if the transducer has the unit dB, will the unit originally set on the FSP be maintained and can be changed.

If a transducer factor is active, the remark TDF appears in the Enhancement Labels column.
After all transducers have been switched off, the FSP returns to the unit that was used before a transducer was activated.

In the analyzer mode, an active transducer for a sweep is calculated once in advance for every point displayed and is added to the result of the level measurement during the sweep. If the sweep range changes, the correction values are calculated again. If several measured values are combined, only one value is taken into consideration.

If the active transducer factor is not defined for the entire sweep range, the values missing are replaced by zeroes.

SETUP menu:
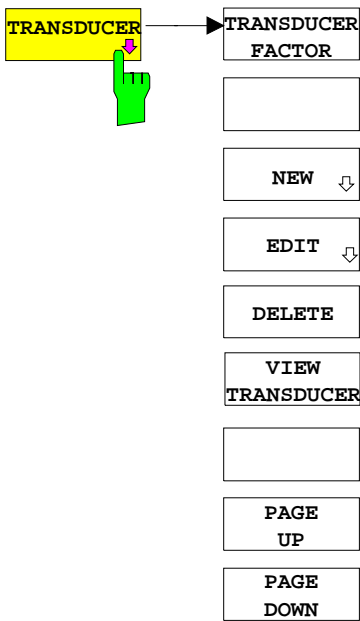
The *TRANSDUCER* softkey opens a submenu where defined transducer factors can be edited or new transducer factors can be entered. A table with the available factors is displayed, and the active transducer can be selected from this list.

TRANSDUCER FACTOR	
Name	**Unit**
√ **Cable_1**	**dB**
HK116	**dBuV/m**
HL223	**dBuV/m**

The *TRANSDUCER FACTOR* table contains all the defined factors with name and unit. If the number of transducer factors defined exceeds the number of lines available in the table, the user has to scroll through the table.

Only one factor at a time can be activated. A tick next to the name indicates that the transducer is active.
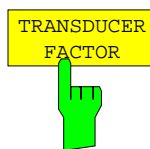
The *TRANSDUCER FACTOR* softkey places the scrollbar on the position of the active transducer factor.
If a transducer factor is not active, the scrollbar is placed on the first line of the table.

IEC/IEEE-bus command: CORR:TRAN:SEL <name>
                          CORR:TRAN ON | OFF
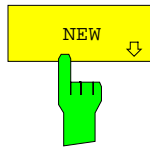
NEW ⇩

The *NEW* and *EDIT* softkeys give access to the submenu for editing and generating transducer factors.

EDIT ⇩
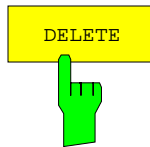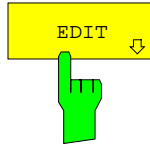
DELETE

The *DELETE* softkey deletes the factor that is marked. To prevent inadvertent deleting, the instrument outputs a confirmation query.

MESSAGE
Do you really want to delete the factor?
YES   NO

IEC/IEEE-bus command: CORR:TRAN DEL
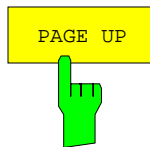
PAGE UP

The *PAGE UP* and *PAGE DOWN* softkeys are used to scroll through large tables that cannot completely be displayed on the screen.

PAGE DOWN
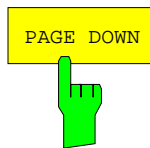
Entry and Editing of Transducer Factors

A transducer factor is characterized by the following:

- Reference values with frequency and factor (*Values*)
- Unit of the factor (*Unit*) and
- Name (*Name*) to distinguish the various factors.

During entry the FSP checks the transducer factor for compliance with specific rules that must be met to ensure correct operation.

- The frequencies for the reference values must always be entered in ascending order. Otherwise the entry will not be accepted and the following message will appear.

    Frequency Sequence!

- The frequencies entered may exceed the frequency range of the FSP since only the set frequency range is taken into account for measurements. The minimum frequency of a reference value is 0 Hz, the maximum frequency 200 GHz.

- The value range for the transducer factor is ±200 dB. If the minimum or maximum value is exceeded, the FSP outputs the following message:

    Min Level -200 dB or
    Max Level 200 dB.

- Gain has to be entered as a negative value, and attenuation as a positive value.

Note: The softkeys in the "UNIT" submenu of the AMPT key cannot be operated if the transducer is on.
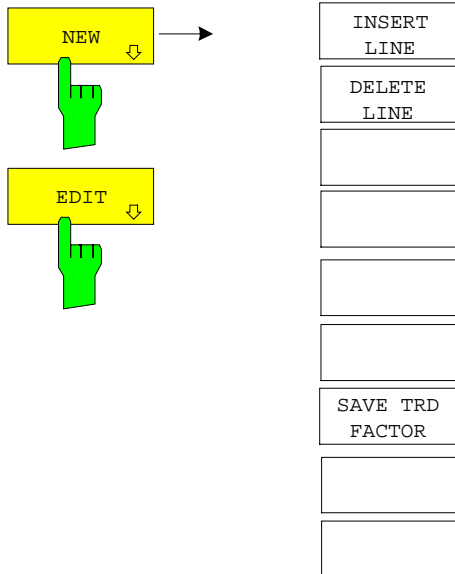
The *NEW* and *EDIT* softkeys give access to the submenu for editing and generating transducer factors.

NEW ⇩	→	INSERT LINE
		DELETE LINE
EDIT ⇩		
		SAVE TRD FACTOR

```
                          EDIT TRANSDUCER FACTOR
 Name/Unit/Interpolation:  Cable          dB            LIN
 Comment:
     FREQUENCY          TDF/dB..       FREQUENCY        TDF/dB..
    1.0000000 MHz        1.000
    1.0000000 GHz        5.500
```

Depending on the softkey selected, either the table with the data of the factor marked (softkey *EDIT*) or an empty table (softkey *NEW*) appears. This table is empty except for the following entries:

Unit: dB

Interpolation: LIN for linear frequency scaling

                 LOG for logarithmic frequency scaling

The features of the factor are entered in the header of the table, and the frequency and the transducer factor are entered in the columns.

Name	Entry of name
Unit	Selection of unit
Interpolation	Selection of interpolation
Comment	Entry of comment
FREQUENCY	Entry of frequency of reference values
TDF/dB	Entry of transducer factor.

During editing, a transducer factor remains stored in the background until the factor edited is saved with the *SAVE TRD FACTOR* softkey or until the table is closed. A factor that was edited by mistake can be restored by leaving the entry function.

Name – **Entry of name**

The name may consist of a maximum of 8 characters that have to comply with the conventions for DOS file names. The instrument automatically adds the extension .TDF to all transducer factors that are saved.

If an existing name is changed, the factor stored under the previous name is maintained and is not automatically overwritten by the new version. The old factor can be deleted later on using the *DELETE* function. This makes it possible to copy factors.

IEC/IEEE-bus command   CORR:TRAN:SEL <name>

Unit **- Selection of unit**

The unit of the transducer factor is selected from a box that is activated by pressing ENTER.

```
┌─────────────────────┐
│    FACTOR UNIT      │
├─────────────────────┤
│      dB             │
│      dBm            │
│      dBμV           │
│      dBμV/m         │
│      dBμA           │
│      dBμA/m         │
│   √  dBpW           │
│      dBpT           │
└─────────────────────┘
```
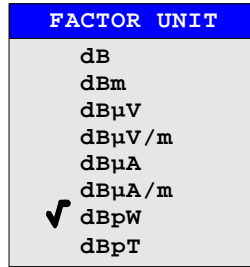
The default setting is dB.

IEC/IEEE-bus command   CORR:TRAN:UNIT <string>

Interpolation **- Selection of interpolation**

Linear or logarithmic interpolation can be performed between the frequency reference values of the table. The ENTER key allows the user to select LIN or LOG (toggle function).

IEC/IEEE-bus command   CORR:TRAN:SCAL LIN│LOG

The following diagrams show the effect that interpolation has on the calculated trace:
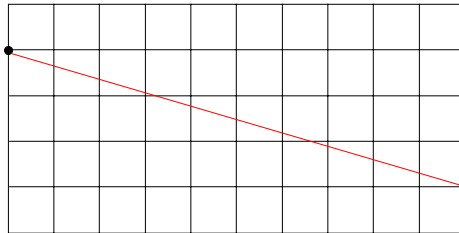
Fig. 4-1   Linear frequency axis and linear interpolation
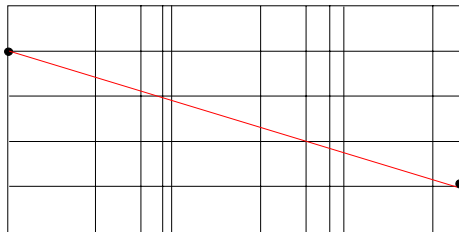
Fig. 4-2   Logarithmic frequency axis and interpolation

Comment **-** Entry of comment

Any comment with a maximum length of 50 characters can be entered.

IEC/IEEE-bus command   CORR:TRAN:COMM <string>

FREQUENCY, TDF/dB – **Entry of values**

The scrollbar marks the first reference value. The desired reference values must be entered in ascending order of frequencies. After the frequency has been entered, the scrollbar automatically goes to the associated level value.

The table can be edited after entry of the first value using the *INSERT LINE* and *DELETE LINE* softkeys. To change individual values later on, the value has to be selected and a new one entered.

IEC/IEEE-bus command   `CORR:TRAN:DATA <freq>,<level>.`
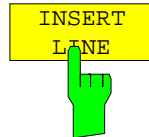
The *INSERT LINE* softkey inserts an empty line above the marked reference value. When entering a new reference value in the line, the ascending order of frequencies must be taken into consideration, however.
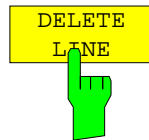
The *DELETE LINE* softkey deletes the marked reference value (complete line). The reference values that follow move one line up.

IEC/IEEE-bus command   `--`

The *SAVE TRD FACTOR* softkey saves the changed table in a file on the internal hard disk.
If there is already a transducer factor that has the same name, a confirmation query is output.
If the new factor is active, the new values become immediately valid.

IEC/IEEE-bus command - (With IEC/IEEE bus operation, the save operation is performed automatically after the definition of the reference values)

Programming the Interface Configuration and Time Setup

The *GENERAL SETUP* softkey opens a sub-menu in which the general instrument parameters can be set up. In addition to the configuration of the digital interfaces (*IECBUS, COM*), the date and time may be entered.

The current settings are displayed in tabular form on the display screen where they may be edited.

SETUP - GENERAL SETUP submenu:
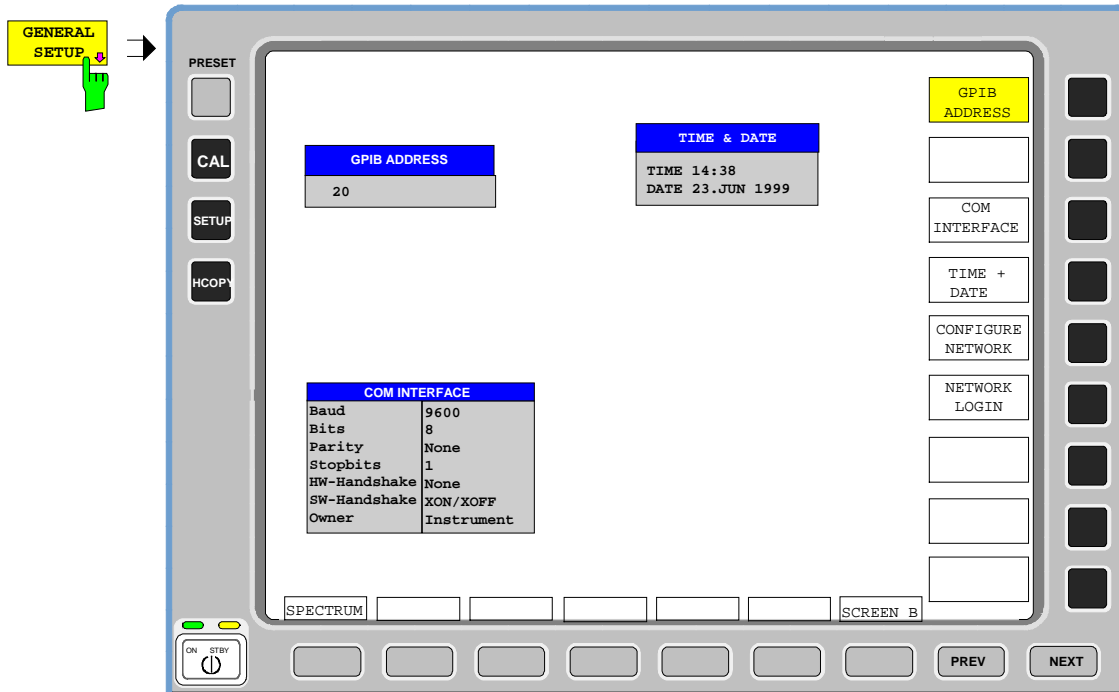
Selecting the IEC/IEEE-Bus Address

SETUP - GENERAL SETUP submenu:
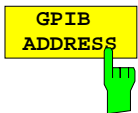
The *GPIB ADDRESS* softkey activates the entry of the IEC Bus address.

Valid addresses are 0 through 30. The default setting is address 20.

IEC/IEEE-bus command: SYST:COMM:GPIB:ADDR 20

Serial Interface Configuration

SETUP-GENERAL SETUP submenu:

COM INTERFACE

The *COM INTERFACE* softkey activates the *COM INTERFACE* table for entry of the serial interface parameters.

The following parameters can be configured in the table:

Baud rate	data transmission rate
Bits	number of data bits
Parity	bit parity check
Stop bits	number of stop bits
HW-Handshake	hardware handshake protocol
SW-Handshake	software handshake protocol
Owner	assignment to the measuring instrument or computer

COM INTERFACE	
Baud	9600
Bits	8
Parity	None
Stopbits	1
HW-Handshake	None
SW-Handshake	XON/XOFF
Owner	Instrument

Baud – Data transmission rate
The FSP supports baud rates between 110 and 19200 baud. The default setting is 9600 baud.

BAUD RATE
19200
√ 9600
4800
1200
600
300
110

IEC/IEEE-bus command: SYST:COMM:SER:BAUD 9600

Bits – Number of data bits per word
For the transmission of text without special characters, 7 bits are adequate. For binary data as well as for text with special characters, 8 bits must be selected (default setting).

BITS
√ 7
8

IEC/IEEE-bus command: SYST:COMM:SER:BITS 7

Parity – **Bit parity check**

NONE   no parity check (default setting)
EVEN   even parity check
ODD   odd parity check

```
┌─────────────┐
│   PARITY    │
├─────────────┤
│   NONE      │
│ √ EVEN      │
│   ODD       │
└─────────────┘
```

IEC/IEEE-bus command: `SYST:COMM:SER:PAR NONE`

Stop bits – **Number of stop bits**

Available are 1 and 2. The default setting is 1 stop bit.

```
┌─────────────┐
│  STOPBITS   │
├─────────────┤
│     1       │
│ √   2       │
└─────────────┘
```

IEC/IEEE-bus command: `SYST:COMM:SER:SBIT 1`

HW-Handshake – **Hardware handshake protocol**

The integrity of data transmission can be improved by the use of a hardware handshake mechanism, which effectively prevents uncontrolled transmission of data and the resulting loss of data bytes. For hardware handshake additional interface lines are used to transmit acknowledge signals with which the data transmission can be controlled and, if necessary, stopped until the receiver is ready to receive data again.

A prerequisite for using hardware handshaking is, however, that the interface lines (DTR and RTS) are connected on both transmitter and receiver. For a simple 3-wire connection, this is not the case and hardware handshake cannot be used here.

Default setting is *NONE*.

```
┌───────────────┐
│ HW-HANDSHAKE  │
├───────────────┤
│    None       │
│ √  DTR/RTS    │
└───────────────┘
```

IEC/IEEE-bus command: `SYST:COMM:SER:CONT:DTR OFF`
                                 `SYST:COMM:SER:CONT:RTS OFF`

SW-Handshake – **Software handshake protocol**

Besides the hardware handshake mechanism using interface lines, it is also possible to achieve the same effect by using a software handshake protocol. Here, control bytes are transmitted in addition to the normal data bytes. These control bytes can be used, as necessary, to stop data transmission until the receiver is ready to receive data again.

In contrast to hardware handshaking, software handshaking can be realized even for a simple 3-wire connection.

One limitation is, however, that software handshaking cannot be used for the transmission of binary data, since the control characters XON and XOFF require bit combinations that are also used for binary data transmission.

Default setting is *NONE*.

```
SW-HANDSHAKE
   None
√  XON/XOFF
```

IEC/IEEE-bus command: SYST:COMM:SER:PACE NONE

Owner – **Assignment of the interface**

The serial interface can be assigned alternatively to the measuring instrument section or to the computer section

If the interface is assigned to one section of the instrument, it is not available to the other section.

INSTRUMENT	The interface is assigned to the measuring instrument section. Outputs to the interface from the computer section are not possible will get lost.
OS	The interface is assigned to the computer section. It cannot be used by the measuring instrument section. This means that remote control of the instrument via the interface is not possible.

```
   OWNER
√  INSTRUMENT
   OS
```

IEC/IEEE-bus command: --

Setting Date and Time

SETUP-GENERAL SETUP submenu:
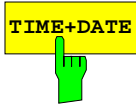
TIME+DATE

The *TIME+DATE* softkey activates the entry of time and date for the internal realtime clock.

```
     TIME AND DATE

Time  21:59
Date  01 Oct 1997
```

Time - Input of time

In the corresponding dialog box, the time is partitioned into two input fields so that hours and minutes can be entered independently.

```
            TIME
TIME    21 : 59
```

IEC/IEEE-bus command: SYST:TIME 21,59

Date - Input of Date

In the corresponding dialog box, the date is partitioned into 3 input fields so that day, month and year can be input separately.

```
            DATE
DATE    01  Oct  1999
```

For the selection of the month, pressing a unit key opens a list of abbreviations wherein the desired month can be selected.

```
    MONTH

    JAN
    FEB
    MAR
    APR
    MAY
    JUN
    JUL
    AUG
    SEP
 ✔  OCT
    NOV
    DEC
```

IEC/IEEE-bus command: SYST:DATE 1999,10,01

Configuration of Network Settings (with Option FSP-B16 only)

The instrument can be connected to an Ethernet LAN (local area network) by means of the LAN Interface Option FSP-B16. This allows data transmission via the network and the use of network printers. The network card is able to handle both 10 MHz Ethernet IEEE 802.3 and 100 MHz Ethernet IEEE 802.3u.
For more details see section 'LAN Interface - Option FSP-B16'.

SETUP - GENERAL SETUP - menu:
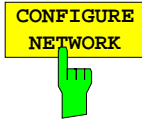
CONFIGURE NETWORK

The *CONFIGURE NETWORK* softkey opens the dialog box with the network settings.

Pressing the key for the first time installs the Windows NT network support (see section 'Installation and Configuration of the Driver for the Network Card' in the manual for LAN Interface FSP-B16) .

If the softkey is pressed again later, the existing network configuration can be changed after selecting the corresponding configuration folder. After pressing the 'Change' button the computer name and the work group on the 'Identification' folder can be adapted to network requirements.

Notes: *- A PC keyboard with trackball (or mouse instead) is required for the installation/configuration of the network support.*
            - The softkey is only available with built-in LAN interface option (FSP-B16).

IEC/IEEE-bus command: –

NETWORK
LOGIN

The *NETWORK LOGIN* softkey opens the dialog box with the auto login settings.

Network Login

Login Name: Instrument

Password: instrument

☑ Auto Login

[OK] [Cancel]
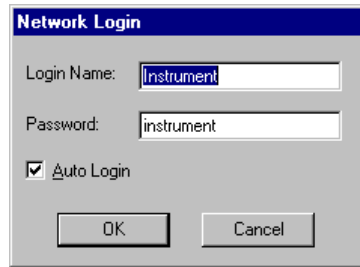
When a network is installed, the preset user name 'Instrument' and the password 'instrument' can be adapted to a new user (see section 'Defining Users' in the LAN interface manual).

With the 'Auto Login' option active, an automatic registration is performed during booting with the specified user name and password. Otherwise the Windows NT login request is displayed during booting.

Notes: - *A PC keyboard with trackball (or additional mouse instead) is required for the installation/configuration of the network support.*
- *The softkey is only available with built-in LAN interface option (FSP-B16).*

IEC/IEEE-bus command: –

Enabling Firmware Options

The *OPTIONS* softkey opens a submenu that allows license keys for firmware options to be entered. Previously installed options are displayed in a table that opens automatically.
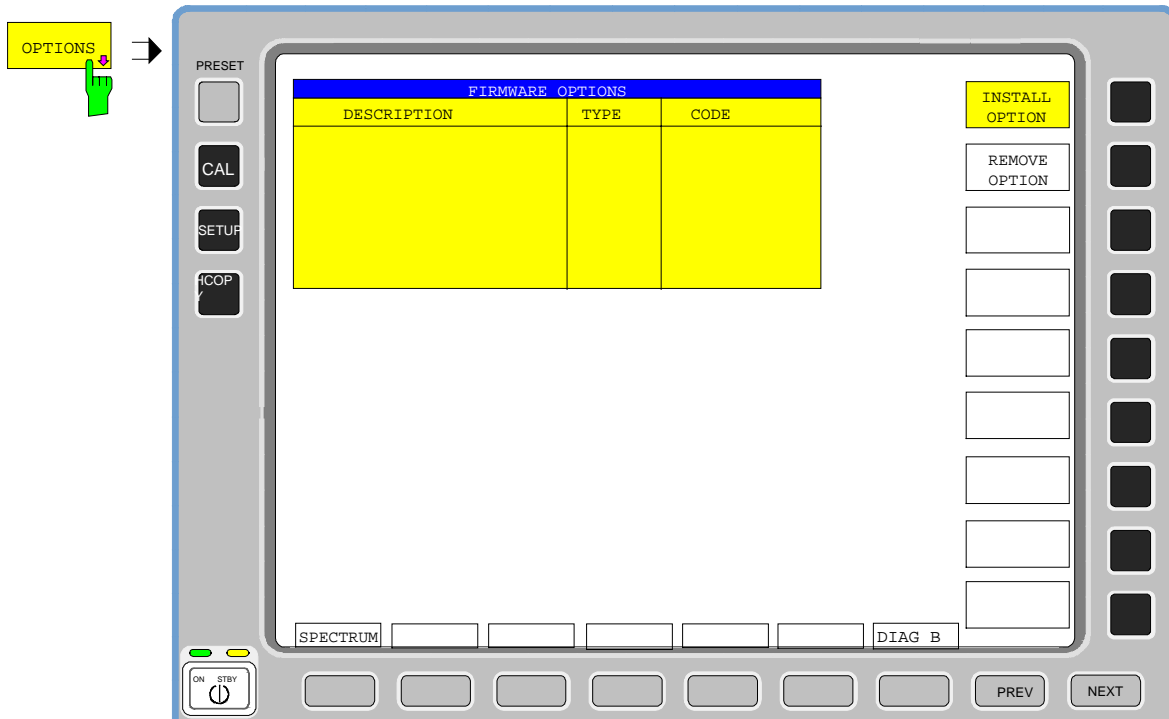
Softkey *INSTALL OPTION* opens the data entry for the license keycode of a firmware option.

On entry of a valid license key the message *OPTION KEY OK* is displayed in the status line and the firmware option appears in table *FIRMWARE OPTIONS* .

On entry of an invalid license key the message *OPTION KEY INVALID* is displayed in the status line.

IEC/IEEE-bus command: --

Softkey *REMOVE OPTION* removes all firmware options from the instruments. Execution of this function must be confirmed in a message box in order to avoid removal of the firmware options by mistake.

IEC/IEEE-bus command: --

Emulation of the Instrument Front Panel

SETUP - GENERAL SETUP – NEXT menu:
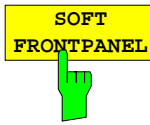
SOFT FRONTPANEL

The *SOFT FRONTPANEL* softkey switches the display of the front-panel keys on and off.

When the front-panel keys are displayed on the screen, the instrument can be controlled by clicking the respective button with the mouse. This is especially useful when the instrument in a different site is controlled via a remote-control program, like for instance PCANYWHERE, and the screen contents are transferred to the controller via remote link.
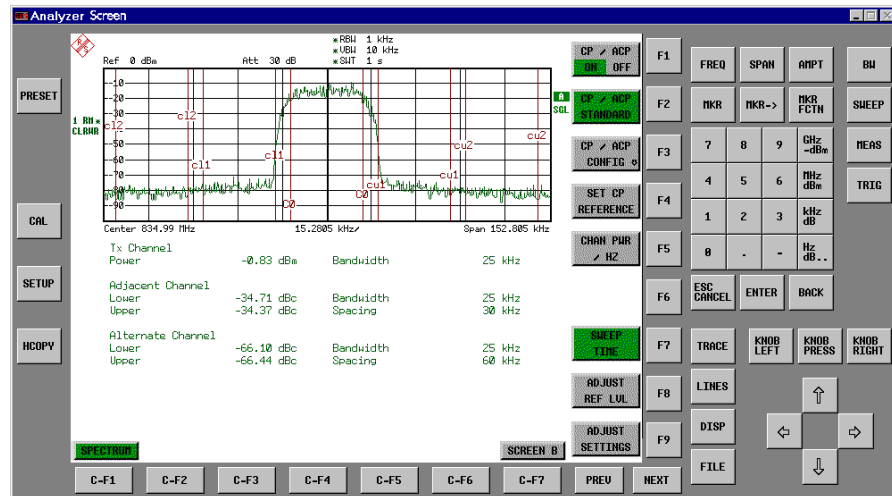
Note:

> ***Display resolution:***
>
> *When the display of the front-panel keys is switched on, the screen resolution of the instrument changes to 1024x768 pixels. Only a section of the total screen is then displayed on the LC display, which will automatically be shifted on mouse moves.*
>
> *In order to obtain a complete display of the user interface, an external monitor is to be plugged into the corresponding connector at the rear panel. Prior to performing the resolution change the user is prompted for confirmation whether the required monitor is connected.*
>
> *Switching off the front-panel display restores the original screen resolution.*
>
> ***Key assignment:***
>
> *Button labels largely correspond to those of the front-panel keys. The rotation function of the rotary knob is assigned to the 'KNOB LEFT' and 'KNOB RIGHT' buttons, the press function (<ENTER>) to 'KNOB PRESS'.*
>
> *The labels of the softkey buttons (F1 to F9) and of the hotkey buttons (C-F1 to C-F7) indicate that the keys can be operated directly by means of the corresponding function keys F1 to F9 or <CTRL>F1 to <CTRL>F7 of a PS/2 keyboard.*

IEC/IEEE-bus command: SYST:DISP:FPAN ON

System Information

The *SYSTEM INFO* softkey opens a submenu in which detailed information on module data, device statistics and system messages is displayed.

SETUP menu:

```
┌──────────┐        ┌──────────┐
│ SYSTEM   │   ───▶ │ HARDWARE │
│ INFO     │        │ INFO     │
└──────────┘        ├──────────┤
     👆             │STATISTICS│
                    ├──────────┤
                    │ SYSTEM   │
                    │ MESSAGES │
                    ├──────────┤
                    │          │
                    ├──────────┤
                    ┆CLEAR ALL ┆
                    ┆ MESSAGES ┆
                    └┄┄┄┄┄┄┄┄┄┄┘
                    ┌──────────┐
                    │          │
                    ├──────────┤
                    │          │
                    ├──────────┤
                    │          │
                    ├──────────┤
                    │          │
                    └──────────┘
                         ⇧
```
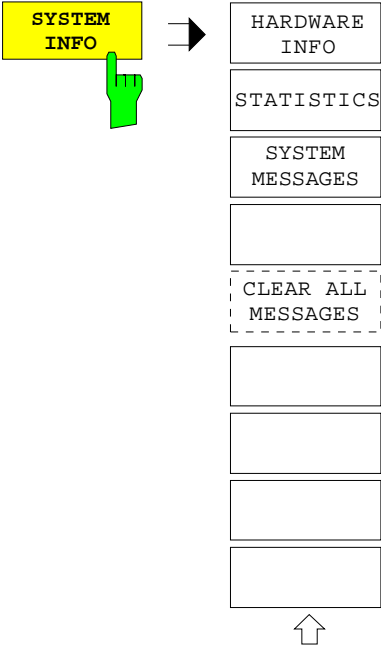
Display of Module Data

SETUP SYSTEM INFO submenu:
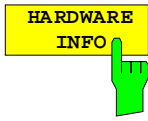
HARDWARE
INFO

The *HARDWARE INFO* softkey opens a table in which the modules (INSTALLED COMPONENTS) installed in the instrument are listed together with the corresponding hardware revisions.

Table *HARDWARE INFO* consists of six columns:

SERIAL #	serial number
COMPONENT	name of module
ORDER #	order number
MODEL	model number of the module
REV	main modification index of the module
SUB REV	secondary modification index of the module

```
                          HARDWARE INFO
        COMPONENT            SERIAL #    ORDER #   MODEL REV SUB REV
RF_ATTEN_7                  688557/005  1067.7684   00   21    00    ▲
FRONTEND1                   833387/003  1093.5540   03   07    11
FRONTEND2                   683346/053  1093.5791   03   05    12
IF-FILTER/REF               689712/002  1093.7242   02   04    04
DETECTOR                    683999/035  1093.6998   02   03    04
AF_DEMOD                    665087/002  1093.7620   02   03    03
CPU-Board                   991025/687  1091.2489   00   04    11
MOTHERBOARD                 675631/022  1093.7494   02   05    04
FSP                         833387/026  1093.4495   03   00    00
LAN Interface               821818/018  1093.9080   00   00    80
                                                                    ▼
```

> *Note:* *The screenshot lists the components of an FSP 7 with options FSP-B3 (AF demodulator) and FSP-B16 (LAN interface).*

Display of Device Statistics

SETUP SYSTEM INFO submenu:
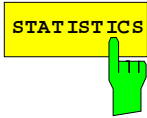
The *STATISTICS* softkey opens the table *STATISTICS*. This table contains the model information, serial number and firmware version, and a list in which the operating time of the instrument, the power-on cycles as well as attenuator switching cycles are displayed.

```
                    STATISTICS
    Model                    FSP3
    Serial #                 123456/789

    Firmware Rev             1.23
    BIOS Rev.                1.00

    Operating time (hours)   375
    Power On Cycles          786

    Attenuator Cycles
      Input RF/Cal           57
      10dB                   1786
      20dB                   1473
      40dB                   675
```

IEC/IEEE-bus command: --

Display of System Messages

SETUP SYSTEM INFO submenu:

<div style="float:left">

```
SYSTEM
MESSAGES
```
</div>
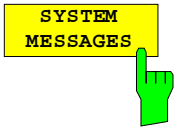
The *SYSTEM MESSAGES* softkey opens a submenu including a table in which the generated system messages are displayed in the order of their occurrence. The most recent messages are placed at the top of the list.
The following information is available:

No	Device-specific error code
MESSAGE	Brief description of the message

COMPONENT	On hardware messages:
	    name of the affected module
	On software messages:
	    if needed, the name of the affected software
	    components

DATE/TIME	Date and time of the occurrence of the message

Messages that have occurred since the last call to the *SYSTEM MESSAGES* menu are marked with an asterisk '*'.
The CLEAR ALL MESSAGES softkey is activated and allows clearing of the error buffer.

If the number of error messages exceeds the capacity of the error buffer, the message appearing first is "Message buffer overflow".

SYSTEM INFO			
No	MESSAGE	COMPONENT	DATE/TIME
01	No of cycles	Attenuator	05.Jan.99 10:02:00
02	VCO unlock	Frontend	05.Jan.99 10:01:30
03	Calamp range	IF Filter	05.Jan.99 10:00:50
04	3.3V: Voltage	Detector	04.Jan.99 15:58:10
05	I2C-Bus failed	CPU	04.Jan.99 15:58:05

IEC/IEEE-bus command: SYST:ERR?

<div style="float:left">

```
CLEAR ALL
MESSAGES
```
</div>

The *CLEAR ALL MESSAGES* softkey deletes all messages in the table.
The softkey is only available when table *SYSTEM INFO* is active.

IEC/IEEE-bus command: SYST:ERR?

Service Menu

The service menu offers a variety of additional functions which are used for maintenance and/or trouble shooting.

⚠ *Caution:*

The service functions are not necessary for normal measurement operation. However, incorrect use can affect correct operation and/or data integrity of the FSP.
Therefore, many of the functions can only be used after entering a password. They are described in the instrument service manual.

SETUP menu:

SERVICE	→	INPUT RF		The *SERVICE* softkey opens a submenu for selection of the service function.
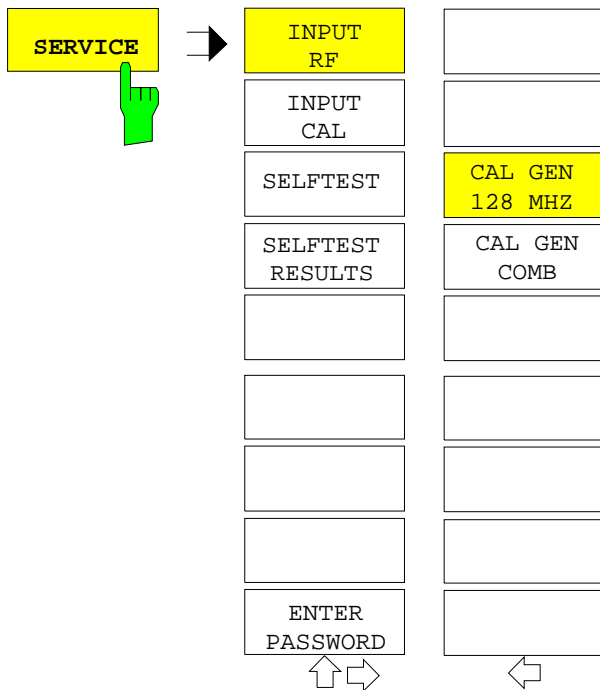
The *SERVICE* softkey opens a submenu for selection of the service function.

The *INPUT RF* and *INPUT CAL* softkeys are mutually exclusive selection switches. Only one switch can be active at any one time.

SERVICE

INPUT RF
INPUT CAL
SELFTEST
SELFTEST RESULTS

ENTER PASSWORD

CAL GEN 128 MHZ
CAL GEN COMB

General Service Functions

SETUP SERVICE submenu:
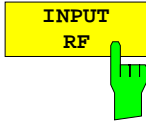
| INPUT RF |

The *INPUT RF* softkey switches the input of the FSP to the input connector (normal position).

After *PRESET*, *RECALL* or FSP power on, the *INPUT RF* is always selected.

IEC/IEEE-bus command: DIAG:SERV:INP RF
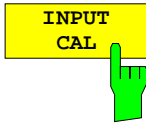
| INPUT CAL |

The *INPUT CAL* softkey switches the RF input of the FSP to the internal calibration source (128 MHz) and activates the data entry of the output level of the calibration source. Possible values are 0 dB and –30 dB.

IEC/IEEE-bus command: DIAG:SERV:INP CAL;
                               DIAG:SERV:INP:CSO 0 DBM

| ENTER PASSWORD |

The *ENTER PASSWORD* softkey allows the entry of a password.

The FSP contains a variety of service functions which, if incorrectly used, can affect correct operation of the analyzer. These functions are normally not accessible and are only usable after the entry of a password (see instrument service manual).

IEC/IEEE-bus command: SYST:PASS "Password"

SETUP SERVICE NEXT submenu:
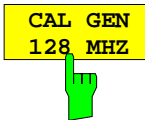
| CAL GEN 128 MHZ |

The CAL GEN 128 MHZ softkey selects a sinusoidal signal at 128 MHz as output signal for the internal calibration source. The internal pulse generator will be switched off.

Note:
The softkey is only available if the optional Broadband Calibration Source FSP-B15 is fitted.
IEC/IEEE-bus command: DIAG:SERV:INP:PULS OFF

| CAL GEN COMB |

The *CAL GEN COMB* softkey switches the internal pulse generator on and allows the pulse frequency to be entered.
The selectable pulse frequencies are 10 kHz and 62.5 kHz.

Note:
The softkey is only available if the optional Broadband Calibration Source FSP-B15 is fitted.

IEC/IEEE-bus command

Selftest

SETUP SERVICE submenu:

The *SELFTEST* softkey initiates the selftest of the instrument modules.

With this function the instrument is capable of identifying a defective module in case of failure.
During the selftest a message box appears in which the current test and its result is shown. The test sequence can be aborted by pressing ENTER ABORT.
All modules are checked consecutively and the test result (selftest PASSED or FAILED) is output in the message box.

IEC/IEEE-bus command: `*TST?`

The *SELFTEST RESULTS* softkey calls the *SELFTEST* table in which the results of the module test are displayed.
In case of failure a short description of the failed test, the defective module, the associated value range and the corresponding test results are indicated.

SELFTEST			
SELFTEST: FAILED		24.APR.1999 14:25	
		Service level: 0	
TEST	**RESULT**	**VALID RANGE**	**VALUE**
Voltages	OK		
Pretune DAC	OK		
Synthesizer	FAIL		
Frontend2 128MHz Ref unlock	FAIL	1.25V...3.5V	1.14V
Frontend1 384MHz Ref Input	OK	0.5...0.6V	0V
Signal Path	OK		

IEC/IEEE-bus command: `DIAG:SERV:STE:RES?`
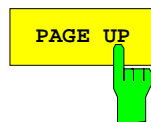
The *PAGE UP* or *PAGE DOWN* softkey sets the *SELFTEST RESULTS* table to the next or previous page.
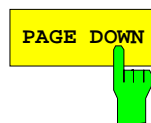
IEC/IEEE-bus command   `--`

Hardware Adjustment

Some of the FSP modules can be realigned. This realignment can become necessary after calibration due to temperature drift or aging of components (see service manual instrument).

Caution:

The realignment should be carried out by qualified personnel since the changes considerably influence the measurement accuracy of the instrument. This is the reason why the softkeys REF FREQUENCY, CAL SIGNAL POWER and SAVE CHANGES can only be accessed after entering a password.

Firmware Update

The installation of a new firmware version can be performed using the built-in diskette drive. The firmware update kit contains several diskettes.
The installation program is called in the *SETUP* menu.

SETUP side menu:

<div style="display:flex">

FIRMWARE UPDATE

</div>
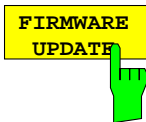
The *FIRMWARE UPDATE* softkey starts the installation program and leads the user through the remaining steps of the update

IEC/IEEE-bus command: --

The firmware update is started as follows:

Insert disk 1 into the floppy drive.

Call *SETUP* side menu via *[SETUP][NEXT]*

Start the update via *[FIRMWARE UPDATE]*

RESTORE FIRMWARE

The *RESTORE FIRMWARE* softkey restores the previous firmware version

IEC/IEEE-bus command: --

Saving and Recalling Data Sets – *FILE* Key

The *FILE* key calls the following functions:
- Storage/loading functions for storing (*SAVE*) instrument settings such as instrument configurations (measurement/display settings, etc.) and measurement results from working memory to permanent storage media, or to load (*RECALL*) stored data into working memory.
- Functions for management of storage media (*FILE MANAGER*). Included are among others functions for listing files, formatting storage media, copying, and deleting/renaming files.

The FSP is capable of internally storing complete instrument settings with instrument configurations and measurement data in the form of data sets. The respective data are stored on the internal hard disk or, if selected, on a floppy. The hard-disk and floppy-disk drives have the following names:

       floppy disk   A:
       hard disk   D: (hard disk C: is reserved for instrument software)

In addition to the saving and recalling of complete instrument settings, it is also possible to save/recall subsets of settings. Configuration data and measurement values are stored in separate files. These files have the same name as the data set but however have a different extension. A data set thus consists of several files which have the same name but different extensions (see Table 4-2). Default setting for storing the data sets is directory D:\USER\CONFIG.
When saving or loading a data set, the subsets which are to be saved or loaded can be selected in the corresponding tables. This makes it easy to reconstruct specific instrument settings beside the default setting of the instrument. When saving and loading data, data subsets are selected in table *SEL ITEMS TO SAVE/RECALL.*
The saved files of the data sets can be copied from one storage medium (e.g. drive C:) to another storage medium (e.g. drive A:) or to another directory using the functions found in the *FILE MANAGER* sub menu. File names and extensions must however not be changed. The relationship between the data subsets and the extensions is shown in Table 4-2.

Table 4-2 Relationship between extensions, contents and designations of data subsets

	Designation in the table SEL ITEMS TO SAVE/RECALL	Contents	Extension
Configuration data:	CURRENTSETTINGS	current settings of the measurement hardware and the related title, if present	.SET
		active limit lines	.LIN
		current configuration of general instrument parameters	.CFG
		configuration for hardcopy output	.HCS
		tracking generator settings (only with option tracking generator)	.TCI
Additional configuration data	ALL LIMIT LINES	all limit lines	.LIA
	SOURCE CAL DATA	Settings for source calibration (only with option tracking generator)	.TS1 .TS2
		Correction data for source calibration (only with option tracking generator)	.TC1 .TC2
Measurement results:	ALL TRACES	measurement data trace 1 to trace 3, screen A	.TR1 to TR3
		measurement data trace 1 to trace 3, screen B	.TR4 to TR6

Saving a Data Set

➢ Select the data subsets to be saved (sub-menu *ITEMS TO SAVE/RCL* (configurations, measurement and calibration data) (softkey *ITEMS TO SAVE/RCL)* .

➢ Possibly enter a comment (softkey *EDIT COMMENT*)

➢ Enter the directory in which the data set should be saved in table *SAVE DATA SET* (softkey *SAVE*).

➢ Enter the name of the data set which should be saved (softkey *SAVE*) and save the data set by pressing the *ENTER* key.

Data set names may contain both letters and numbers, in the simplest case only numbers.

If required, the desired directory can be given a prefix to the data set name (the directory is then automatically set for further SAVE and RECALL operations).

The simplest example for the input of a data set name is illustrated by the following key strokes:

        <SAVE>   <1> <units key>

Note: *If the current instrument configuration is to be stored under an existing name, a selection list is available via the DATA SET LIST softkey. The storage is performed as follows.*

      ➢ *Press a units key after selecting a data set in table DATA SET LIST*

        The name and the selection of the data subsets for the currently selected data set will be placed in the SAVE DATA SET table.

      ➢ *Press the SAVE softkey.*

        The entry field EDIT NAME with the name of the selected data set is opened.

      ➢ *Press a units key.*
        The current instrument configuration is saved as a data set under this name.

Recalling a Data Set:

The data set can be loaded in two ways:

1. **Direct entry of the data name:**

      ➢ Select data subsets which should be loaded (configurations, measurement and calibration data) with softkey *ITEMS TO SAVE/RCL* in sub menu *ITEMS TO SAVE/RCL).*

      ➢ Enter the name of the data set to be saved (softkey *RECALL*) and recall the data set by pressing the *ENTER* key*).*

        Data set names may contain both letters and numbers, in the simplest case only numbers. If required, the desired directory can be prefixed to the data set name (the directory is then automatically set for further SAVE and RECALL operations).

        The simplest example for the input of a data set name is illustrated by the following key strokes: <RECALL>   <1> <units key>

2. Selecting the data set from a selection list:

      ➢ Select from submenu *ITEMS TO SAVE/RCL* the data subsets which should be loaded (configurations, measurement and calibration data) (softkey *ITEMS TO SAVE/RCL).*

      ➢ Select the data set which should be loaded (Softkey *DATA SET LIST*) and confirm with *ENTER*. The data set is taken over in the *RECALL DATA SET* table.

      ➢ Press the RECALL softkey. The entry field for the data set name is opened and contains the desired data set.

      ➢ Initiate the loading of the selected data set by pressing the *ENTER* key.

Note: *If the set directory does not correspond to the required directory for loading, it can be changed as follows:*

> *Press the RECALL softkey.*
> *Close the entry field for the data set name with ESC.*
> *Select the PATH filed with the cursor keys.*
> *Open the entry field for the directory name with ENTER.*
> *Enter the directory name and confirm with ENTER.*

> *Then proceed with the selection list as described above.*

Any settings not restored when data subsets are loaded will remain unchanged in the instrument. During recall operations, the FSP recognises which subsets are present in the recalled data set and ignores selected data subsets that are not available.

FILE Menu

FILE menu
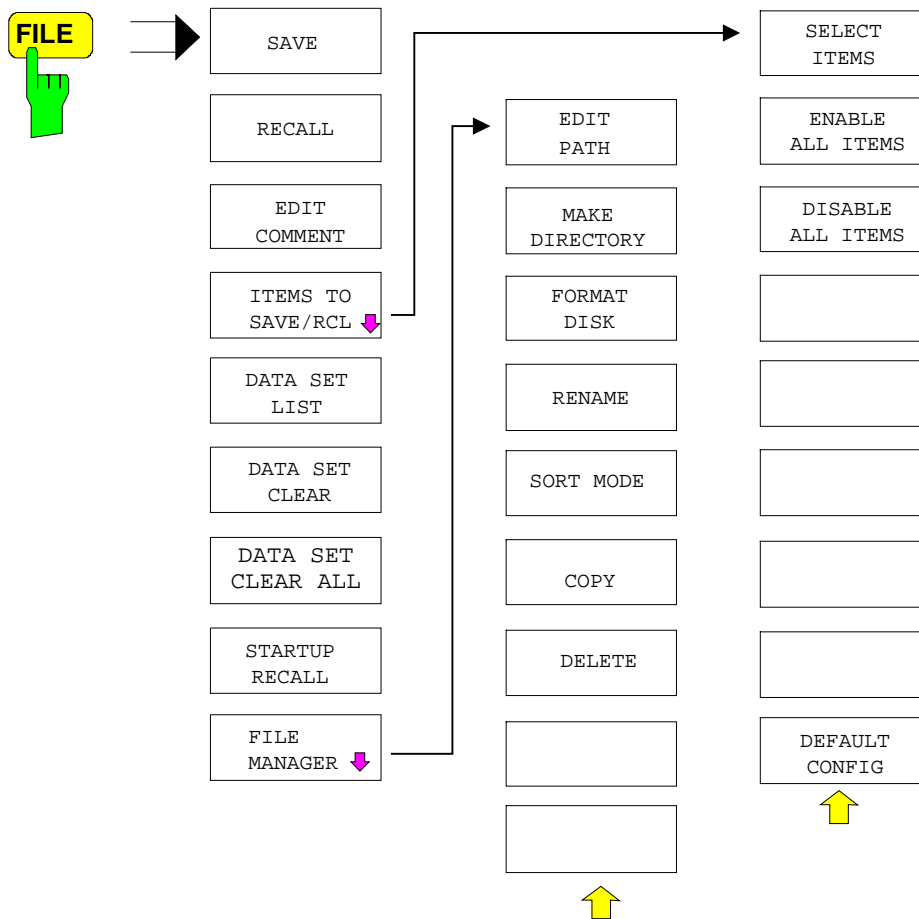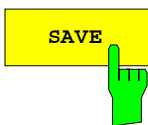
SAVE

The *SAVE* softkey activates table *SAVE DATA SET*. The data set is stored by pressing the *ENTER* key.

SAVE DATA SET		
NAME: DATASET1	PATH:D:\USER\CONFIG	ITEMS: DEFAULT
COMMENT: R...	EDIT NAME	
	DATASET1_	

The *SAVE DATA SET* table contains the entry fields for editing the data set:

Name	name of data set
	The name can be entered with or without drive name and directory; the drive name and directory, if available, are then taken over in the PATH field. The extension of the data name is ignored.
Path	directory in which the data set will be saved
Items	indicates whether the default selection of the data subset (DEFAULT) or a user-defined selection (SELECTED) will be saved
Comment	Commentary regarding the data set

IEC/IEEE command: `MMEM:STOR:STAT 1,"a:\test02"`
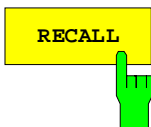
RECALL

The *RECALL* softkey activates the entry of the path in which the data set is located. The data set is recalled by pressing the *ENTER* key.

RECALL DATA SET		
NAME: DATASET1	PATH:D:\USER\CONFIG	ITEMS: DEFAULT
COMMENT: R...	EDIT NAME	
	DATASET1_	

The *RECALL DATA SET* table shows the current settings regarding the data set:

Name	name of data set
Path	directory in which the data set is located
Items	indicates whether the default selection of the data subset (DEFAULT) or a user-defined selection (SELECTED) will be recalled
Comment	Commentary regarding the data set

IEC/IEEE command: `MMEM:LOAD:STAT 1,"a:\test02"`
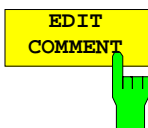
EDIT COMMENT

The *EDIT COMMENT* softkey activates the entry of commentary concerning the current data set. A total of 60 characters are available for this purpose.

IEC/IEEE command: `MMEM:COMM "Setup fuer GSM Messung"`

The *SEL ITEMS TO SAVE/RCL* softkey opens a sub-menu for selection of the data subsets.

FILE - ITEMS TO SAVE/RCL sub-menu:
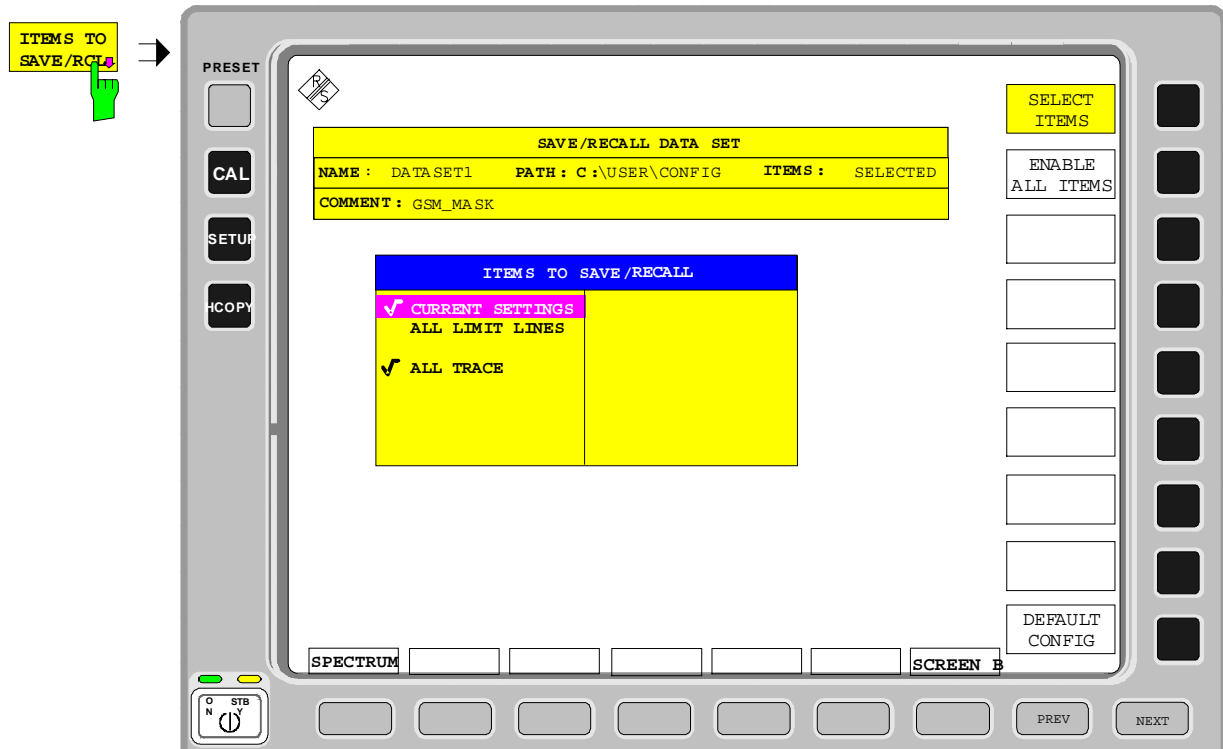
The *ITEMS TO SAVE/RECALL* table offers the following selectable data subsets:

Current Settings   these settings include:

- current configuration of general instrument parameters
- current measurement hardware settings
- active limit lines:
  A data set may contain maximum 8 limit lines for each window. It always contain the activated limit lines and the de-activated limit lines used last, if any.
  Consequently, the combination of the restored de-activated limit lines depends on the sequence of use with command MMEM:LOAD.
- user-defined color settings
- configuration for hardcopy output
- Settings of tracking generator (only with option tracking generator)
- Settings of tracking generator (only with option)

All Limit Lines   all limit lines
All Traces   all traces which are not blanked
Source Cal Data   correction data for tracking generator (only with option tracking generator)
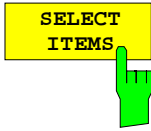
SELECT ITEMS

The *SELECT ITEMS* softkey moves the selection bar to the first line, left column of the table. An entry is selected by pressing the *ENTER* key in the desired line. The selection is cleared by pressing the key again.

IEC/IEEE command:

Current Settings:	`MMEM:SEL:HWS ON`
All Limit Lines:	`MMEM:SEL:LIN:ALL ON`
All Traces:	`MMEM:SEL:TRAC ON`
Source Cal Data:	`MMEM:SEL:SCD ON`
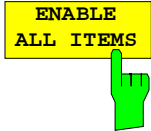
ENABLE ALL ITEMS

The *ENABLE ALL ITEMS* softkey marks all entries in the table.

IEC/IEEE command: `MMEM:SEL:ALL`
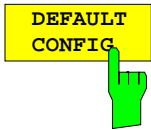
DEFAULT CONFIG

The *DEFAULT CONFIG* softkey establishes the default selection of the data subset to be saved and outputs *DEFAULT* in the *ITEMS* field of the *SAVE/RECALL DATA SET* table.

IEC/IEEE command: `MMEM:SEL:DEF`
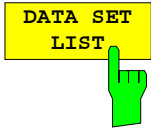
DATA SET LIST

The *DATA SET LIST* softkey opens the *DATA SET LIST/CONTENTS* table. In addition, the *DATA SET CLEAR* and *DATA SET CLEAR ALL* softkeys are displayed.

DATA SET LIST	DATA SET CONTENTS
DATASET 1	**CONTENTS**
DATASET 2	✔ CURRENT SETTINGS
DATASET 3	ALL LIMIT LINES
	✔ ALL TRACES
	SOURCE CAL DATA
	COMMENT
	GSM_MASK

The *DATA SET LIST* column lists all of the data sets which are stored in the selected directory.

The *CONTENTS* and *COMMENT* lines in the *DATA SET CONTENTS* column indicate the saved data subsets and the comment for the currently selected data set. A '-' prefixed to a data subset means that the latter is available in the instrument but that it has not been selected (see *SELECT ITEMS* softkey).

IEC/IEEE command: `---`
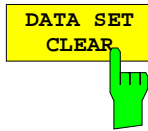
DATA SET CLEAR	The *DATA SET CLEAR* softkey deletes the selected data set
	IEC/IEEE command: `MMEM:CLE:STAT 1, "test03"`
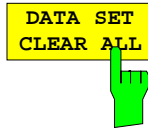
DATA SET CLEAR ALL	The *DATA SET CLEAR ALL* softkey deletes all data sets in the current directory.
	Since, in this case, all available data sets are lost, confirmation by the user is required.
	IEC/IEEE command: `MMEM:CLE:ALL`
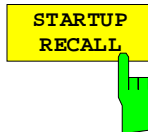
STARTUP RECALL	The *STARTUP RECALL* softkey activates the selection of a data set which is automatically loaded when the instrument is powered on. For that purpose the table *DATA SET LIST/CONTENT* is opened (analog to *DATA SET LIST)*.

DATA SET LIST	DATA SET CONTENTS
	CONTENTS
DATASET 1	✔ CURRENT SETTINGS
DATASET 2	ALL LIMIT LINES
DATASET 3	
	✔ ALL TRACES
	SOURCE CAL DATA
	COMMENT
	GSM_MASK

The *DATA SET LIST* column displays all data sets present in the selected directory.

The *CONTENTS* and *COMMENT* lines in the *STARTUP RECALL* column indicate the saved data subsets and the commentary for the currently selected data set.

In addition to the data sets stored by the user, the data set *FACTORY*, which specifies the settings of the instrument before it was last switched off (Standby), is always present.

If a data set other than *FACTORY* is chosen then, at the time of instrument power on, the available data subsets of the selected data set are recalled. The data subsets which are not present in this data set are taken from the *FACTORY* data set.

Note: *The specified data set is also loaded upon PRESET if STARTUP RECALL is active. The preset settiongs can thus be arbitrarily modified.*

IEC/IEEE command: `MMEM:LOAD:AUTO 1,"D:\user\config\test02"`

The *FILE MANAGER* softkey opens a menu for managing storage media and files.

FILE - FILE MANAGER sub-menu:

```
FILE
MANAGER
```

```
                    DRIVE MANAGEMENT
Drive: HARDDISK D:  Label:        Free Mem: 394:510.336


                    FILE MANAGEMENT
PATH:  D:\USER\CONFIG
     FILE NAME        DATE       TIME         SIZE

   ..
✓ SETTING1.DRW     10.MAY.98    10:25:10    68.175 kB
   SETTING2.DRW     15.MAY.98    13:08:27    73.283 kB
   SETTING3.DRW     17.MAY.98    08:15:21   174.315 kB
   SETTING4.DRW     28.MAY.98    17:05:42   1.236812 MB


SPECTRUM                                        SCREEN A
```

Softkeys: EDIT PATH, MAKE DIRECTORY, FORMAT DISK, RENAME, SORT MODE, COPY, DELETE

Table *Drive Management* displays the name and label of the storage medium as well as the available storage area.

Table *File Management* displays the files of the current directory and indicates if any subdirectories are present.

If a directory name is selected, the FSP automatically changes to this directory. Selection of the entry '..' moves the FSP to the next higher directory level.

Note: *It is not possible to change menus as long as a file operation is running.*

```
EDIT
PATH
```
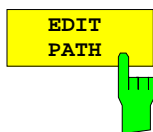
The *EDIT PATH* softkey activates the input of the directory which will be used in subsequent file operations.

The new path is included in the *FILE MANAGEMENT* table.

IEC/IEEE command: MMEM:MSIS "a:"
                     MMEM:CDIR "D:\user "
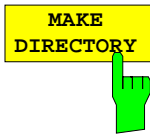
MAKE DIRECTORY

The *MAKE DIRECTORY* softkey creates directories/sub-directories. Sub-directories are recommended for sorting files on the storage medium so that the structure is easier to comprehend.

The entry of an absolute path name (e.g.; "\USER\MEAS") as well as the path relative to the current directory (e.g., "..\MEAS") is possible.

IEC/IEEE command: MMEM:MDIR "D:\user\test"
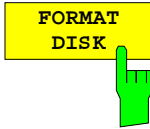
FORMAT DISK

The *FORMAT DISK* softkey formats diskettes located in drive A:.
To prevent accidental destruction of diskette data, confirmation by the user is requested.

IEC/IEEE command: MMEM:INIT "a:"
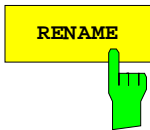
RENAME

The *RENAME* softkey activates the entry of a new name for the selected file or directory.

IEC/IEEE command: MMEM:MOVE "test02.cfg","set2.cfg"
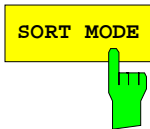
SORT MODE

The *SORT MODE* softkey activates the selection of the criteria according to which the files listed in the *FILE MANAGEMENT* table may be sorted.

SORT MODE
√ by NAME
by DATE/TIME
by EXTENSION
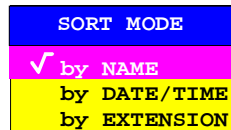
Directory names are located at the top of the list after the entry for the next higher directory level ("..").

IEC/IEEE command: --
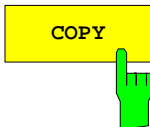
COPY

The *COPY* softkey activates the input of the destination of the copy operation.

By entering a predefined disk drive (e.g. C:), a file can also be copied to another storage medium. The files/directories selected by the cursor are copied after the input is confirmed by pressing the *ENTER* key.

IEC/IEEE command: MMEM:COPY "D:\user\set.cfg","a:"
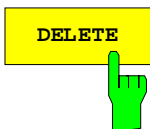
DELETE

The *DELETE* softkey deletes the selected files.
To prevent accidental deletion of data, confirmation by the user is requested.

IEC/IEEE command: MMEM:DEL "test01.hcp"
                     MMEM:RDIR "D:\user\test"

Measurement Documentation – *HCOPY* Key

Note: *The installation of additional printers is described in chapter 1, section "Installation and Configuration of Printers".*

Pressing one of the softkeys *PRINT...* in the *HCOPY* menu initiates the print job. The printer parameters defined in the *DEVICE SETTINGS* menu are used for setting up the printer configuration. All of the display items to be printed are written to the printer buffer. Since the printer runs in the background, the instrument may be operated immediately after pressing the *PRINT...* softkey.

With *PRINT SCREEN* selected, all the diagrams with traces and status displays are printed as they occur on the screen. Softkeys, open tables and data entry fields are not printed out. Function *PRINT TRACE* allows printing out individual traces. With *PRINT TABLE* tables can be printed out.

If the *PRINT TO FILE* option in the *DEVICE SETTINGS* table is selected the printout is directed to a file. Upon pressing one of the softkeys *PRINT...*, the file name to which the output data are to be written is requested. For this an entry field is opened for entering the file name.

While a print job is in progress, problems may occur in the output device. If, while printing, the output device issues a PAPER OUT message, i.e., no more paper is available, the user will be prompted by the following message

WARNING	
Paper out on device LPT	
ABORT	CONTINUE
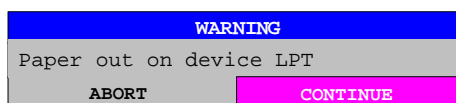
to load paper into the output device. The print job will then be either continued (CONTINUE selected) or aborted (ABORT selected).

Similar *SYSTEM MESSAGES* appear if the printer is offline, etc.

The *HARDCOPY ABORT* softkey aborts a print job in progress.

HCOPY menu:

```
              ┌──────────┐      ┌──────────┐  Option      ┌──────────┐      ┌──────────┐
              │  PRINT   │      │ INSTALL  │  FSP-B16     │  COLOR   │      │  SELECT  │
  HCOPY ─────▶│  SCREEN  │      │ PRINTER  │      ───────▶│ ON   OFF │─────▶│  OBJECT  │
              ├──────────┤      ├──────────┤              ├──────────┤      ├──────────┤
              │  PRINT   │      │          │              │  SCREEN  │      │BRIGHTNESS│
              │  TRACE   │      │          │              │  COLORS  │      │          │
              ├──────────┤      ├──────────┤              ├──────────┤      ├──────────┤
              │  PRINT   │      │          │              │OPTIMIZED │      │   TINT   │
              │  TABLE   │      │          │              │  COLORS  │      │          │
              ├──────────┤      ├──────────┤              ├──────────┤      ├──────────┤
              │ HARDCOPY │      │          │              │  USER    │      │SATURATION│
              │  ABORT   │      │          │              │ DEFINED  │──┐   │          │
              ├──────────┤      ├──────────┤              ├──────────┤  │   ├──────────┤
              │ DEVICE 1 │      │          │              │          │  │   │          │
              ├──────────┤      ├──────────┤              ├──────────┤  │   ├──────────┤
              │ DEVICE 2 │      │          │              │          │  │   │PREDEFINED│
              │          │      │          │              │          │  │   │  COLORS  │
              ├──────────┤      ├──────────┤              ├──────────┤  │   ├──────────┤
              │  COLORS  │─┐    │          │              │          │  │   │          │
              ├──────────┤ │    ├──────────┤              ├──────────┤  │   ├──────────┤
              │ COMMENT  │ │    │          │              │          │  │   │  SET TO  │
              │ SCREEN A │ │    │          │              │          │  │   │ DEFAULT  │
              ├──────────┤ │    ├──────────┤              ├──────────┤  │   └──────────┘
              │ COMMENT  │ │    │          │              │          │  │
              │ SCREEN B │ │    │          │              │          │  │
              └──────────┘ │    └──────────┘              └──────────┘  │
```
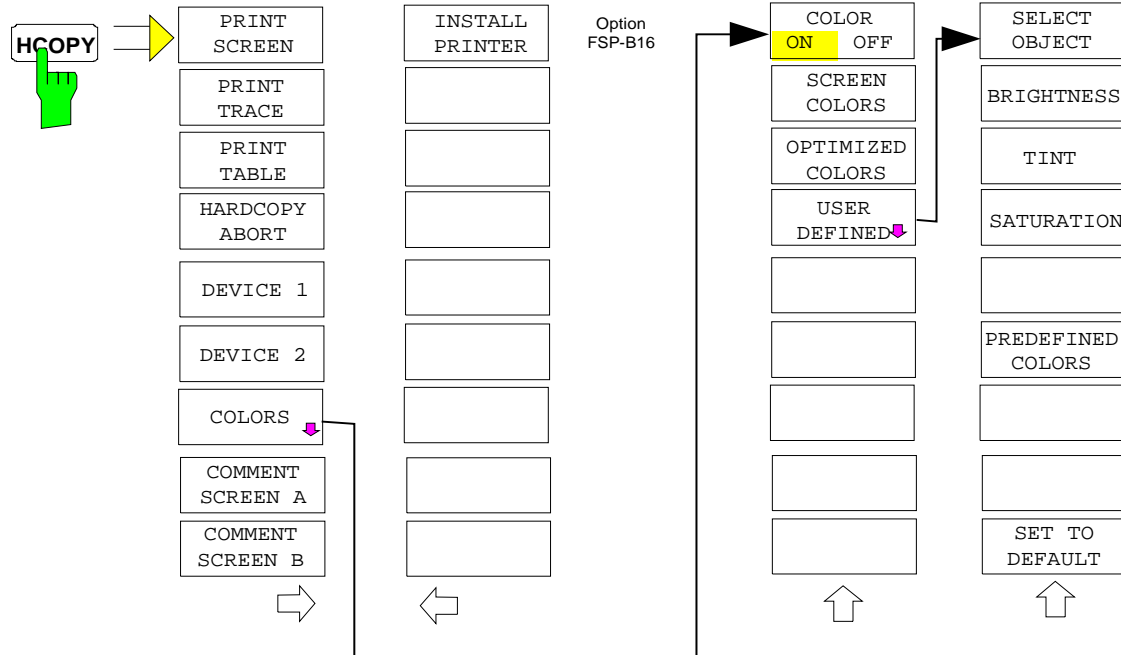
The *HCOPY* key opens the *HARDCOPY* menu for starting and configuring the printout.

The *PRINT SCREEN, PRINT TRACE and PRINT TABLE* softkeys start the desired printout. Printing can be stopped by means of HARDCOPY ABORT.

The DEVICE 1 and 2 softkeys are used for selecting and configuring the output interface.

The *COLORS* submenu allows the switchover between black-and-white and color printouts (default), provided that the printer connected can produce color printouts. In addition, the colors are set in this submenu.

- SCREEN   Output in screen colors.
- OPTIMIZED (default)   Instead of light colors, dark colors are used for traces and markers: trace 1 blue, trace 1 black, trace 3 green, markers turquoise.
- USER DEFINED   This option enables the user to change the colors at will. It provides the same setting functions as the *DISPLAY – CONFIG DISPLAY – NEXT* menu.

Notes:
1. *With SCREEN and OPTIMIZED selected, the background will always be white and the grid black. With USER DEFINED, these colors can be selected, too.*
2. *Upon activation of the submenu, the color display is switched over to the selected printout colors. When the menu is quit, the original color setting is restored.*

The *COMMENT SCREEN A* and *COMMENT SCREEN B* softkeys allow text to be added to the printout (date and time are inserted automatically).

Use the *INSTALL PRINTER* softkey to install additional printer drivers.
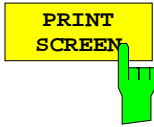
PRINT SCREEN

The *PRINT SCREEN* softkey starts the output of test results.

All the diagrams, traces, markers, marker lists, limit lines etc are printed out as long as they are displayed on the screen. All the softkeys, tables and open data entry fields are not printed out. Moreover, comments, title, date, and time are output at the bottom margin of the printout .

IEC/IEEE-bus command: `HCOP:ITEM:ALL`
                                    `HCOP:IMM`
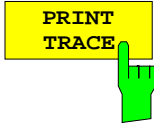
PRINT TRACE

The *PRINT TRACE* softkey starts the output of all curves visible on the display screen without auxiliary information. Specifically, <u>no</u> markers or display lines are printed.

IEC/IEEE-bus command: `HCOP:ITEM:WIND:TRAC:STAT ON`
                                    `HCOP:IMM`
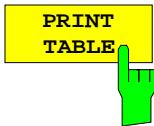
PRINT TABLE

The *PRINT TABLE* softkey starts the output of all tables and info lists visible on the display screen without the measurement diagrams and other information lying behind.

IEC/IEEE-bus command: `HCOP:ITEM:WIND:TABL:STAT ON`
                                    `HCOP:IMM`
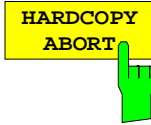
HARDCOPY ABORT

The *HARDCOPY ABORT* softkey aborts the printout.

IEC/IEEE-bus command: ABOR
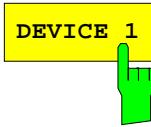
DEVICE 1

The *DEVICE 1/DEVICE 2* softkey determines the active output device.
Table *HARDCOPY DEVICE SETTINGS* is simultaneously opened for the configuration of the two possible devices. The selection bar marks the selected line of the table.
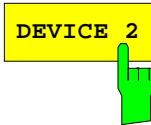
DEVICE 2

HARDCOPY DEVICE SETTINGS	
Device1	WINDOWS METAFILE
Print to File	YES
Orientation	---
Device2	CLIPBOARD
Print to File	---
Orientation	---

Device 1/2	In this lines, the selection of the output device/language for Device1 or Device2 is made.
Print to File	selects printout to file or printer
Orientation	selects the print format of the output page

Device 1/ Device 2

The selection of the output device/language for *Device 1* and *Device 2* is made in this line.

After pressing the *ENTER* key, the list of all installed printers is displayed. Three file formats and the Windows NT clipboard are also available:

CLIPBOARD	output in Windows NT clipboard.
WINDOWS METAFILE or BITMAP FILE	output in file
ENHANCED METAFILE	output in file or Windows NT clipboard.

HARDCOPY DEVICE SETTINGS	
Device1	WINDOWS METAFILE
Print to File	YES
Orientation	---
Device2	CLIPBOARD
Print to File	---
Orientation	---

DEVICE

✓ CLIPBOARD
WINDOWS METAFILE
ENHANCED METAFILE
BITMAP FILE
HP DeskJet 660C

The installation of additional printers is described in chapter 1, section "Installation and Configuration of Printers".

Notes: *Selecting the type of printer automatically sets the parameters PRINT TO FILE and ORIENTATION to values which correspond to a standard mode with this output device. Other printer-dependent parameters, such as PAPERSIZE, can be modified under Windows NT in the printer properties window (START/SETTINGS/PRINTER/ SETTINGS). For operation of Windows NT, a mouse and an external keyboard have to be connected to instrument (see also Section "Installation and Configuration of Printers")*

IEC/IEEE-bus command:
```
HCOP:DEV:LANG GDI;
SYST:COMM:PRIN:ENUM:FIRS?;
SYST:COMM:PRIN:ENUM:NEXT?;
SYST:COMM:PRIN:SEL 'HP Deskjet 660 on LPT1';
HCOP:DEST "SYST:COMM:PRIN"
```

Print to File

In this line, directing the printout to the printer (OFF) or to a file (ON) is selected. For printout to a file, the user is prompted to enter a file name on starting the print.

Selecting the type of printer automatically sets this parameter to the value which corresponds to a standard mode with this output device.

IEC/IEEE-bus command: `HCOP:DEST "SYST:COMM:PRIN" or`
                                             `HCOP:DEST "SYST:COMM:MMEM"`

Orientation

In this line, the print format of the output page is set to either vertical (= PORTRAIT) or horizontal (= LANDSCAPE).

IEC/IEEE-bus command: `HCOP:PAGE:ORI PORT`
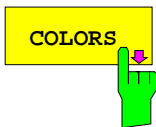
COLORS

The *COLORS* softkey gives access to the submenu where the colors for the printout can be selected (see section *"Selection of Printer Colors").*

IEC/IEEE-bus command: –

COMMENT SCREEN A

COMMENT SCREEN B

The *COMMENT SCREEN A* or *B* softkey opens an entry field in which a comment of two lines (60 characters per line) can be entered for screen A or B.
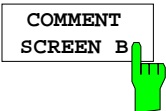
If the user enters more than 60 characters, the excess characters appear on the second line on the print-out. At any point, a manual line-feed can be forced by entering the @ character.

The comment is printed below the corresponding diagram. The comment text appears on the print-out, but does not appear on the display screen.

If a comment is not to appear on the printout, it has to be deleted.
By pressing *PRESET,* all comments will be deleted.

IEC/IEEE-bus command: `HCOP:ITEM:WIND2:TEXT 'Comment'`

HCOPY side menu:

INSTALL PRINTER

A certain number of printer drivers is already installed on the FSP.
The *INSTALL PRINTER* softkey opens the "Printers" window where further printer drivers can be installed (see section "Installation of a Local Printer" and "Installation of Network Printer").

IEC/IEC-bus command: –

Selection of Printer Colors
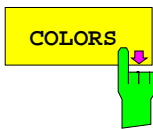
COLORS

The *COLORS* softkey gives access to the submenu where the colors for the printout can be selected. To facilitate color selection, the color combination selected is displayed when the menu is entered. The previous colors are restored when the menu is exited.

IEC/IEEE-bus command: –
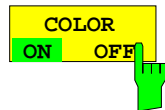
COLOR ON OFF

The *COLOR ON OFF* softkey switches over from color output to black-and-white output. All color-highlighted areas are printed in white and all color lines in black. This improves the contrast on the printout. The default setting is COLOR ON.

IEC/IEEE-bus command: HCOP:DEV:COL ON
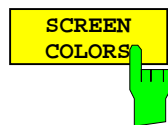
SCREEN COLORS

The *SCREEN COLORS* softkey selects the current screen colors for the printout.

Note:
The background is always printed in white and the grid in black.

IEC/IEEE-bus command: HCOP:CMAP:DEF1

OPTIMIZED COLORS

The *OPTIMIZED COLORS* softkey selects an optimized color setting for the printout to improve the visibility of the colors on the hardcopy.
Trace 1 is blue, trace 2 black, trace 3 green, and the markers are turquoise.
The other colors correspond to the display colors of the *DISP – CONFIG DISPLAY -DEFAULT COLORS 1* softkey.

Note:
The background is always printed in white and the grid in black.

IEC/IEEE-bus command: HCOP:CMAP:DEF2
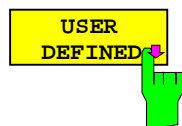
USER DEFINED

The *USER DEFINED* softkey opens a submenu for user-defined color selection (see submenu *USER DEFINED COLORS*).

IEC/IEEE-bus command: HCOP:CMAP:DEF3

```
SELECT
OBJECT
```
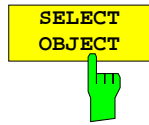
The *SELECT OBJECT* softkey allows picture elements to be selected to change their color setting. After selection the *PREDEFINED COLORS*, *BRIGHTNESS*, *TINT* and *SATURATION* softkeys enable the user to change the colors or the brightness, the hue and the color saturation of the element selected.

```
                  SELECT DISPLAY OBJECT
 √ Background
   Grid
   Function field + status field + data entry text
   Function field LED on
   Function field LED warn
   Enhancement label text
   Status field background
   Trace 1
   Trace 2
   Trace 3
   Marker
   Lines
   Measurement status + limit check pass
   Limit check fail
   Table + softkey text
   Table + softkey background
   Table selected field text
   Table selected field background
   Table + data entry field opaq titlebar
   Data entry field opaq text
   Data entry field opaq background
   3D shade bright part
   3D shade dark part
   Softkey state on
   Softkey state data entry
   Logo
```

IEC/IEEE-bus command: –

```
BRIGHTNESS
```

The *BRIGHTNESS* softkey serves for determining the brightness of the graphic element selected.

A value between 0 and 100% can be entered.

IEC/IEEE-bus command:
    HCOP:CMAP5:HSL <hue>,<sat>,<lum>

```
TINT
```
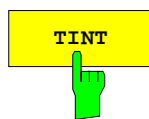
The *TINT* softkey serves for determining the hue of the element selected. The percentage entered refers to a continuous color spectrum from red (0%) to blue (100%).

IEC/IEEE-bus command:
    HCOP:CMAP5:HSL <hue>,<sat>,<lum>

SATURATION

The *SATURATION* softkey serves for determining the saturation of the element selected.

A value between 0 and 100% can be entered.

IEC/IEEE-bus command:
    HCOP:CMAP5:HSL <hue>,<sat>,<lum>

PREDEFINED COLORS

The *PREDEFINED COLORS* softkey opens a list from which predefined colors for the elements displayed can be selected:

```
        COLOR

  √ BLACK
    BLUE
    BROWN
    GREEN
    CYAN
    RED
    MAGENTA

    YELLOW
    WHITE
    GRAY
    LIGHT GRAY
    LIGHT BLUE
    LIGHT GREEN
    LIGHT CYAN
    LIGHT RED
    LIGHT MAGENTA
```

IEC/IEEE-bus command:
    HCOP:CMAP1 ... 26:PDEF <color>
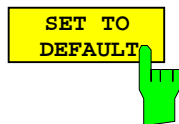
SET TO DEFAULT

The *SET TO DEFAULT* softkey reactivates the default color setting (= *OPTIMIZED COLORS*).

IEC/IEEE-bus command: –

Installation of a Local Printer

Note: *For an easy operation of the subsequent dialogs, connection of a PS/2 keyboard including trackball to the front panel is recommended. If no trackball is available, a PS/2 mouse should be connected additionally to the rear panel (see section "Connecting a Mouse" and "Connecting a Keyboard").*
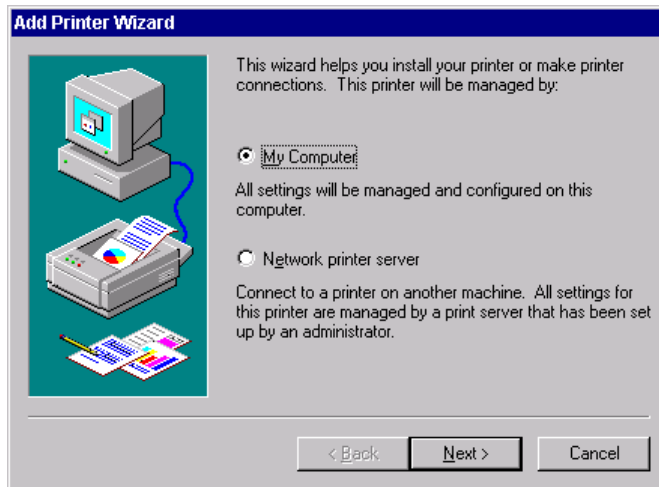
> Click on "My Computer" and then "Next".

  The selection of printer ports appears.

> Select port LPT1.

  The selection will be marked with a tick.

> Click on "Next".

  The selection of the printer drivers appears. The left table contains the manufacturers, the right on the available printer drivers.
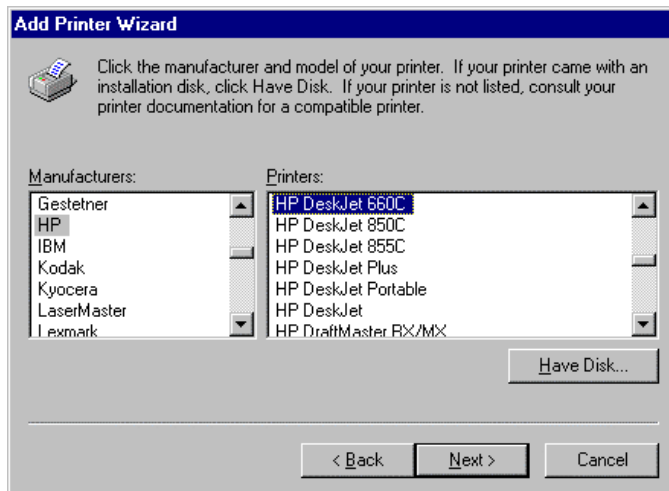
> Select the desired manufacturer and the corresponding printer driver.

Note:
If the desired printer type does not appear in the list, then the corresponding driver has not been installed on the instrument so far. In this case click on button "HAVE DISK". This will open a prompt for inserting a disk with the corresponding driver into the floppy drive. Press "OK" and select the desired printer driver.
After the installation the "Service Pack 5" must be reinstalled (see section "Installing Windows-NT software").

> Click on "Next".

  The data entry field for the printer name appears.
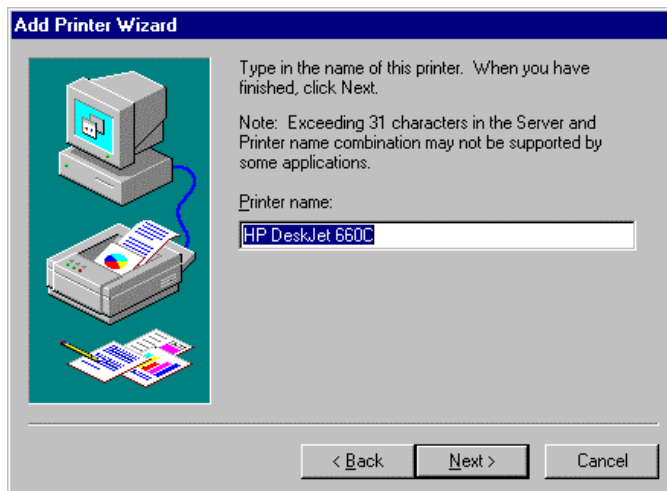
➢ The name of the printer can be modified in the edit field "Printer name" (max. 60 characters).

If there are already installed printers in the system, there will be a prompt for whether the new printer should be used as the standard printer for Windows NT applications (Do you want your Windows-based programs to use this printer as default printer?). The preselection is "No".
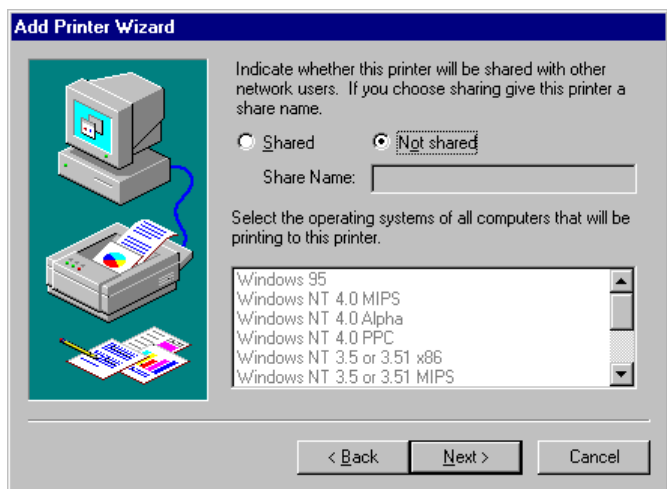
➢ Click on "Next".

A prompt will appear querying the availability of the printer in a network. This query is irrelevant for the installation of a local printer. The answer "Not shared" is preselected.

➢ Click on "Next".

The window for printing a test page appears. This allows testing whether the installation was successful.

➢ Click on "Yes (recommended)".

➢ Click on "Finish".

If the installation was successful, a test page will be printed.
If the test page is not printed or printed incorrectly, the Windows NT online help will supply additional support in chapter "Printer - Trouble Shooting".

Note:
If you are prompted to indicate the printer driver path after clicking on "Finish", the Service Pack must be reinstalled after this printer installation (see chapter 1, section "Installing Windows NT software").

Finally the instrument must be configured for printouts of the measurement screen with this printer. For details please refer to softkey *DEVICE 1* and *DEVICE 2* in the hardcopy menu.

Installation of a Network Printer (with Option FSP-B16 only)
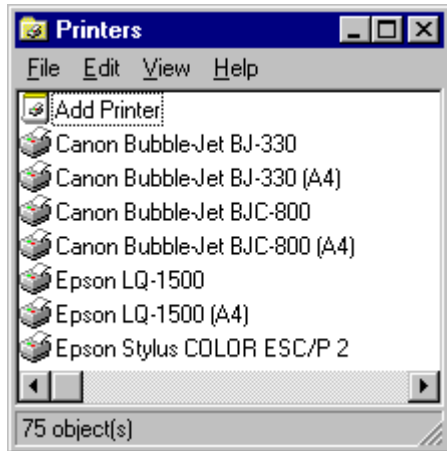
After opening the "Printer" dialog window proceed with the installation as follows:

➢ Double-click "Add Printer" line.

The "Add Printer Wizard" window is opened. This window guides the user through the printer driver installation.
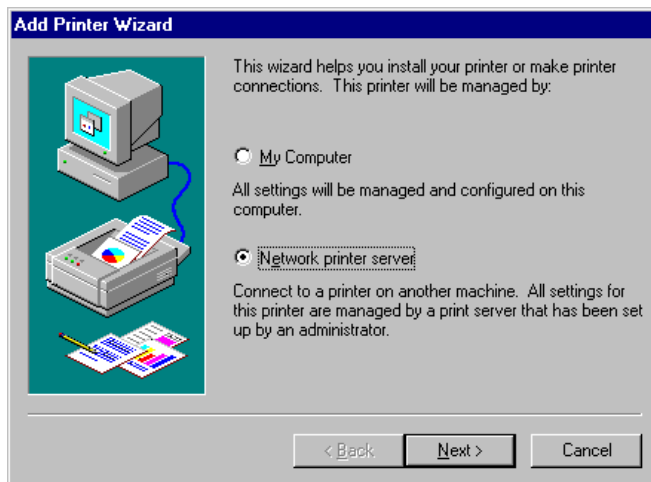
➢ Click "Network printer server" and then "Next".

A list of selectable printers is displayed.
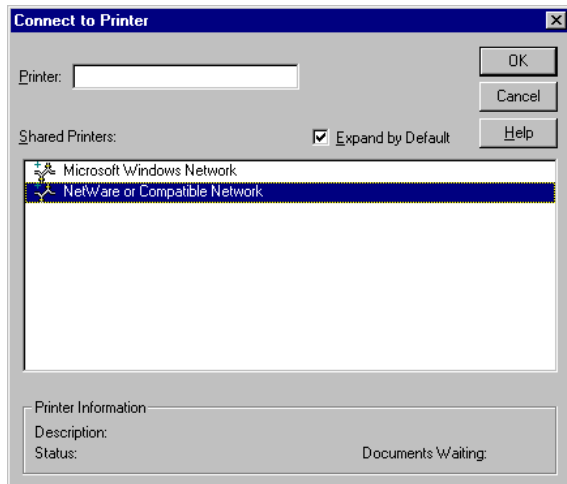
> ➢ Mark printer and select it with OK.

> ➢ Confirm the following request for the installation of a suitable printer driver with OK.

The list of printer drivers is displayed. The manufacturers are listed in the window at the left, the available printer drivers at the right.
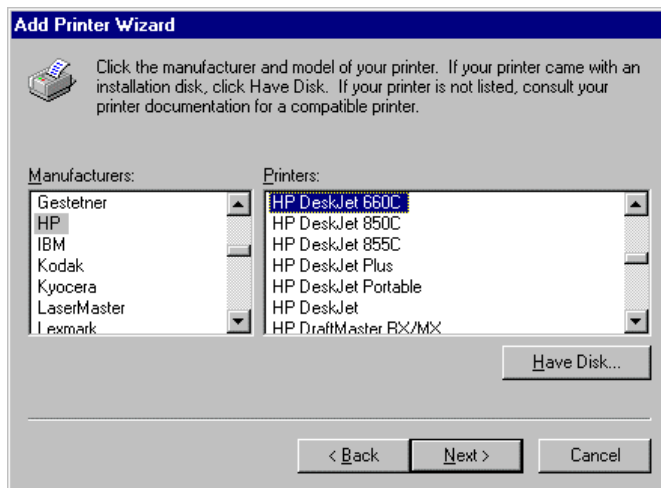
> ➢ Select the manufacturer in the "Manufacturers" window and then the printer driver in the "Printers" window.

Note:
If the desired printer type is not listed, the driver has not been installed. In this case click HAVE DISK. You are requested to insert a floppy with the respective printer driver. Subsequently press OK and select the desired driver. After this the "Service Pack 5" has to be newly installed (see chapter "Install Windows-NT Software)

> ➢ Click "Next"

If one or more printers have been installed, a query is displayed in this window, whether the printer you have just installed should be used as the standard printer for Windows NT applications. (Do you want your Windows-based programs to use this printer as default printer?). Default setting is "No".
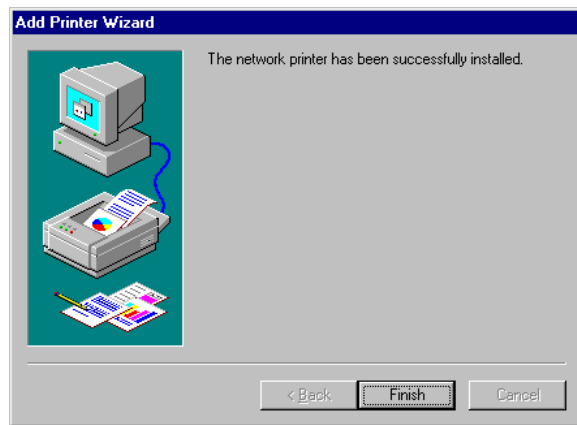
> ➢ Start the printer driver installation with "Finish".

> **Note:**
> *If after clicking on "Finish" you are requested to enter the printer driver path, the Service Pack has to be reinstalled after the printer installation (see chapter 1, Installing Windows NT Software).*

Finally the instrument must be configured for printouts of the measurement screen with this printer. For details please refer to softkey *DEVICE 1* and *DEVICE 2* in the hardcopy menu.

Tracking Generator - Option FSP-B9

During normal operation (without a frequency offset), the tracking generator emits a signal exactly at the input frequency of the FSP.

For frequency-converting measurements it is possible to set a constant frequency offset of ±150 MHz between the receive frequency of the FSP and the output signal of the tracking generator.
Moreover, an I/Q modulation or AM and FM modulation of the output signal can be provided using two analog input signals.

The output power is level-controlled and can be set in 0.1 dB steps in a range from -30 dBm to 0 dBm.

The tracking generator can be used in all operating modes. Acquisition of test setup calibration values (SOURCE CAL) and normalization using these correction values (*NORMALIZE*) is only possible in the *NETWORK* operating mode.

Note: *The RF characteristics of some DUTs is especially sensitive concerning the input VSWR. In such cases insertion of 20 dB attenuation between the DUT and the tracking generator output is highly recommended.*

The tracking generator is activated by means of the NETWORK hotkey in the hotkey bar at the bottom of the screen:

| SPECTRUM | NETWORK | | SCREEN B |

Tracking Generator Settings

The *NETWORK* hotkey opens a menu for selecting the functions of the tracking generator.
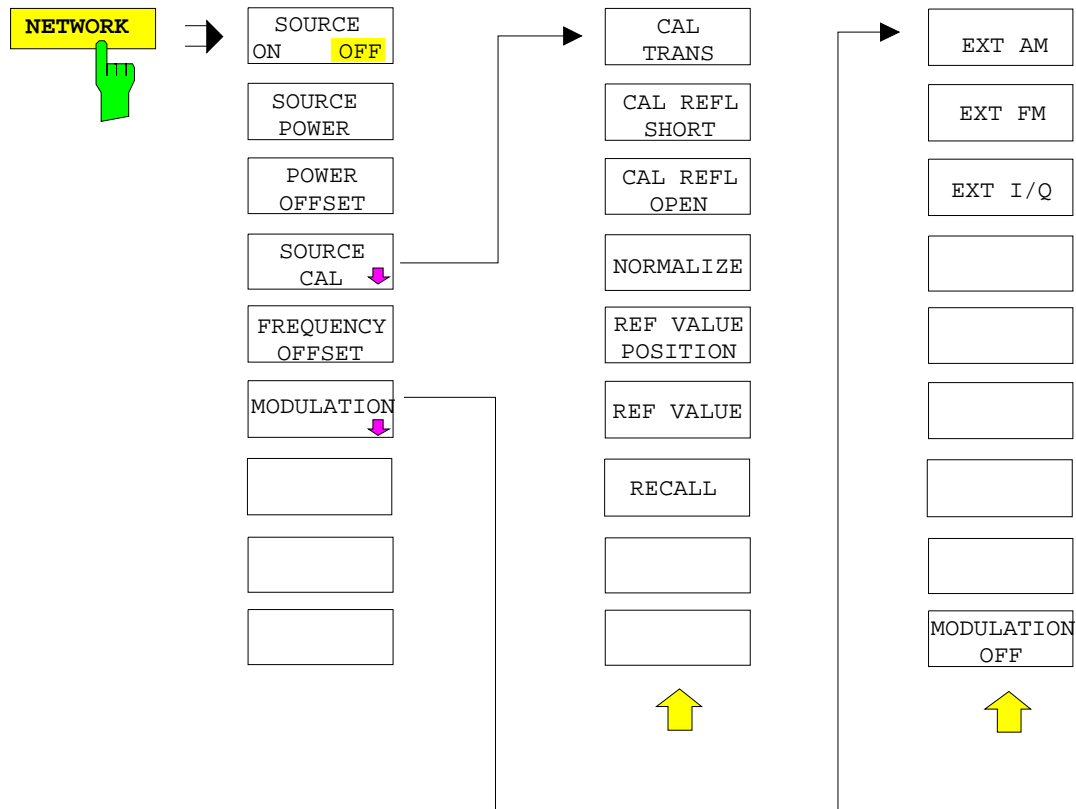
Note: *Additional softkeys are available in the displayed menus for controlling an external generator if option External Generator Control FSP-B10 is fitted. For detailed information see section 'External Generator Control Option FSP-B10'.*
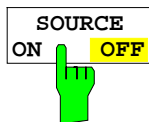
The *SOURCE ON/OFF* softkey switches the tracking generator on or off.
Default setting is *OFF*

Note:

- *When the tracking generator is switched on the maximum stop frequency is limited to 3 GHz. This upper limit is automatically reduced by a frequency offset set up for the tracking generator.*

- *In order to meet the data sheet accuracy for measurements with active tracing generetor the start frequency must be set to ≥ 3 x Resolution Bandwidth.*

- *The minimum sweeptime for measurements with data sheet accuracy is 100 ms in frequency domain (span > 0 Hz). Selecting a sweeptime below this limit will result in the sweeptime indicator field SWT being supplied with a red asterisc and the message UNCAL being displayed.*

- *FFT filters (FILTER TYPE FFT in BW menu) are not available when the tracking generator is active.*

IEC/IEEE-bus command: `OUTP:STAT ON`
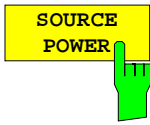
SOURCE POWER

The *SOURCE POWER* softkey allows the tracking generator output power to be selected.
The output level can be set in 0.1 dB steps from -30 dBm to 0 dBm.

If the tracking generator is off, it is automatically switched on when an output power value is entered.

The default output power is -20 dBm.

IEC/IEEE-bus command: `SOUR:POW -20dBm`
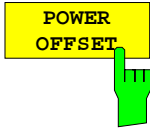
POWER OFFSET

The *POWER OFFSET* softkey allows selection of a constant level offset for the tracking generator.

With this offset for example attenuators or amplifiers at the output connector of the tracking generator can be taken into account for the displayed output power values on screen or during data entry.

The valid range is -200 dB to +200 dB in 0.1 dB steps. Positive offsets apply to an amplifier and negative offsets to an attenuator subsequent to the tracking generator.
The default setting is 0 dB. Offsets <> 0 will display the enhancement label **LVL**.

IEC/IEEE-bus command: `SOUR:POW:OFFS -10dB`

Transmission Measurement

This measurement will yield the transmission characteristics of a two-port network. The built-in tracking generator serves as a signal source. It is connected to the input connector of the DUT. The input of the FSP is fed from the output of the DUT.
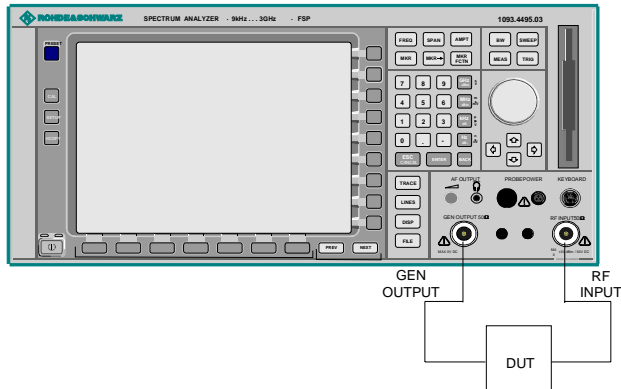
Fig. 4-16   Test setup for transmission measurement

A calibration can be carried out to compensate for the effects of the test setup (eg frequency response of connecting cables).

Calibration of Transmission Measurement

NETWORK menu:
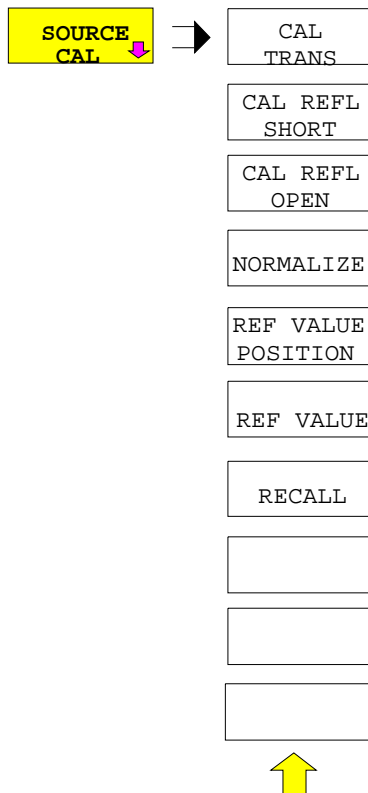
The *SOURCE CAL* softkey opens a submenu comprising of the calibration functions for the transmission and reflection measurement.

The calibration of the reflection measurement (*CAL REFL...*) and its mechanisms are described in separate sections.

To carry out a calibration for transmission measurements the whole test setup is through-connected (THRU).

CAL
TRANS
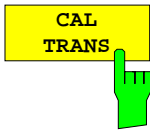
The *CAL TRANS* softkey triggers the calibration of the transmission measurement.

It starts a sweep that records a reference trace. This trace is then used to calculate the difference for the normalized values.
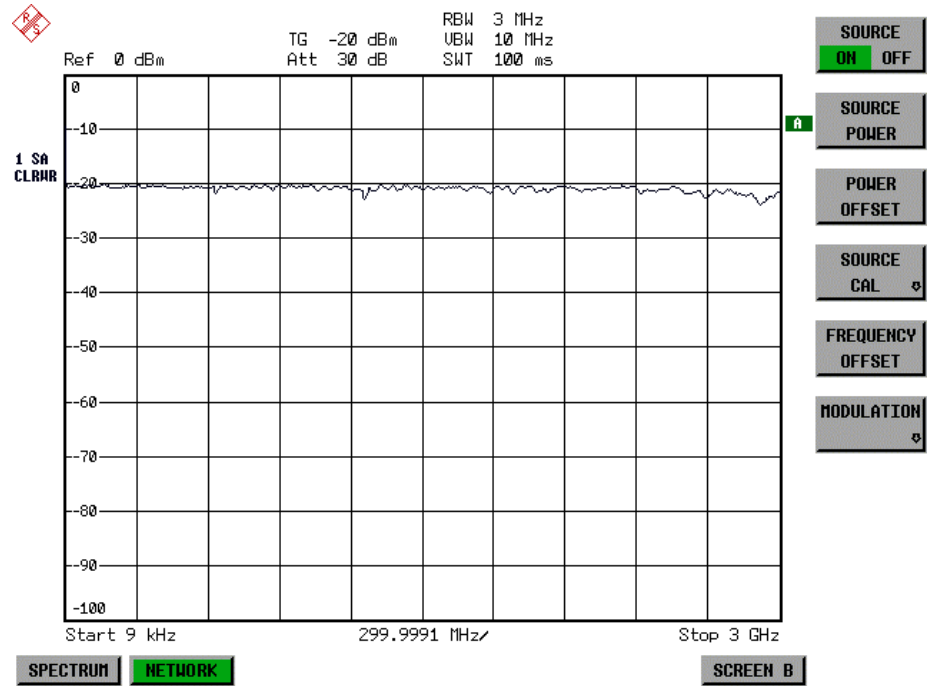
Fig.: 4-17   Calibration curve for transmission measurement

During the calibration the following message is displayed:

After the calibration the following message is displayed:
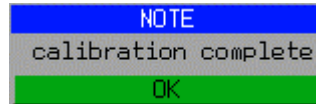
This message will be cleared automatically after approx. 3 seconds.

IEC/IEEE-bus command: CORR:METH TRAN

Normalization

NETWORK-SOURCE CAL menu:
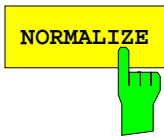
NORMALIZE

The *NORMALIZE* softkey switches the normalization on or off. The softkey is only available if the memory contains a correction trace.

It is possible to shift the relative reference point within the grid using the *REF VALUE POSITION* softkey. Thus, the trace can be shifted from the upper border of the grid to the vertical center of the grid:
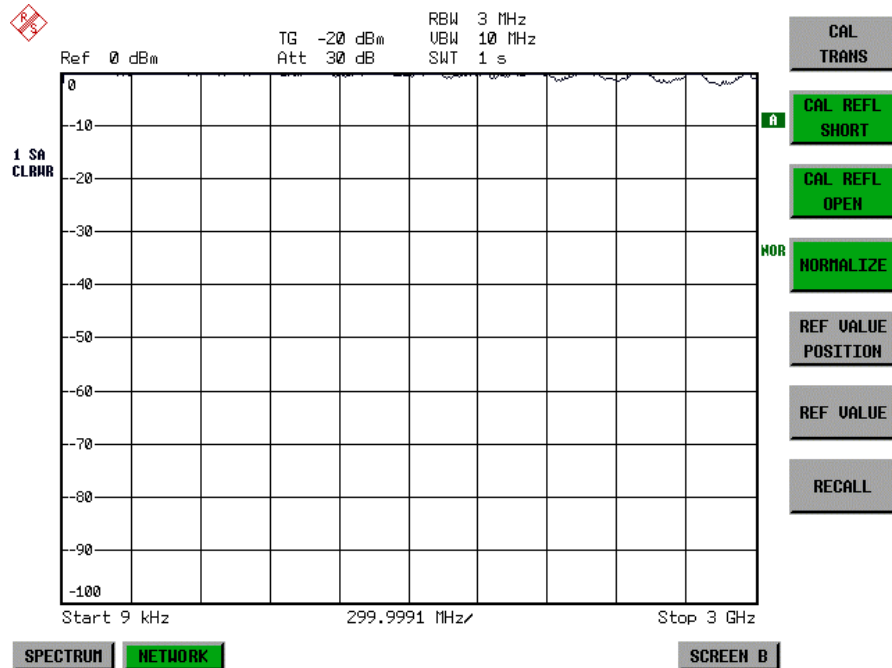
Fig.: 4-18   Normalized display

In *SPLIT SCREEN* operation, the normalization is switched on in the currently active window. Different types of normalization can be active in the two windows.

Normalization is aborted when the *NETWORK* operating mode is quit.

IEC/IEEE-bus command: CORR ON
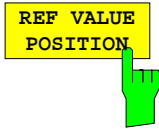
REF VALUE
POSITION

The *REF VALUE POSITION* softkey marks a reference position in the active window at which the normalization result (calculated difference with a reference trace) is displayed.

If no reference line is active, the softkey switches on a reference line and activates the input of its position. The line can be moved within the grid boundaries.
The reference line is switched off by pressing the softkey again.

The function of the reference line is explained in the section "Calibration mechanisms".
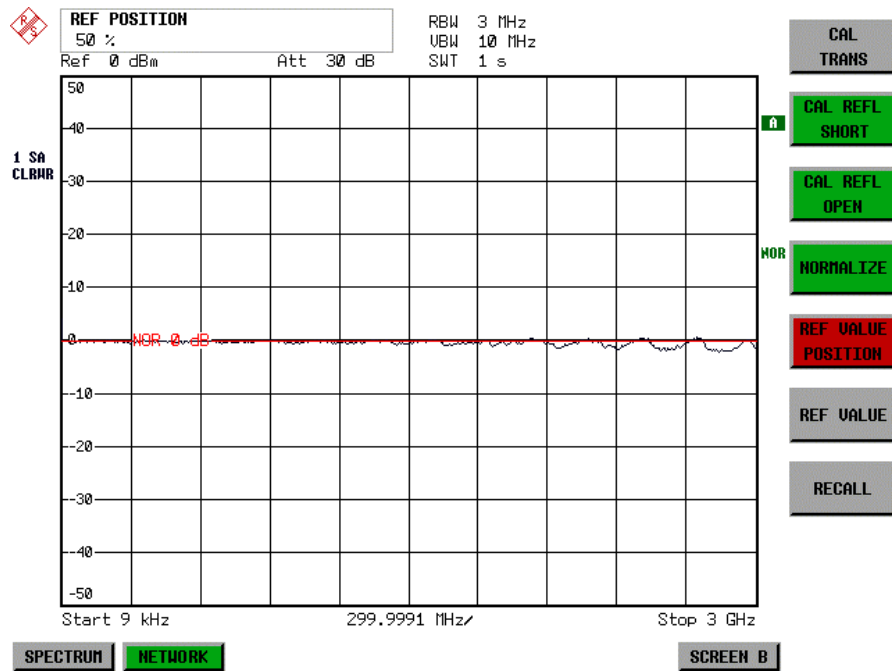
Fig.: 4-19　　Normalized measurement, shifted with *REF VALUE POSITION* 50 %

IEC/IEEE-bus command:　　`DISP:WIND:TRAC:Y:RPOS 10PCT`
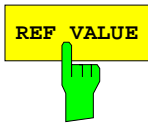
REF VALUE

The *REF VALUE* softkey activates the input of a value which is assigned to the reference line.

With default settings the reference line corresponds to a difference of 0 dB between the currently measured trace and the reference trace. Setting the *REF VALUE* to a different value helps to compensate for changes to the level conditions in the signal path after the calibration data have been recorded. If eg after a source calibration a 10 dB attenuation is inserted into the signal path between DUT and FSP input, the measurement trace will be moved by 10 dB down. Entering a *REF VALUE* of –10 dB will then result in the reference line for difference calculation being moved by 10 dB down as well. This means that the measured trace will be placed on it, as displayed in figure 4-17.

REF VALUE always refers to the active window.
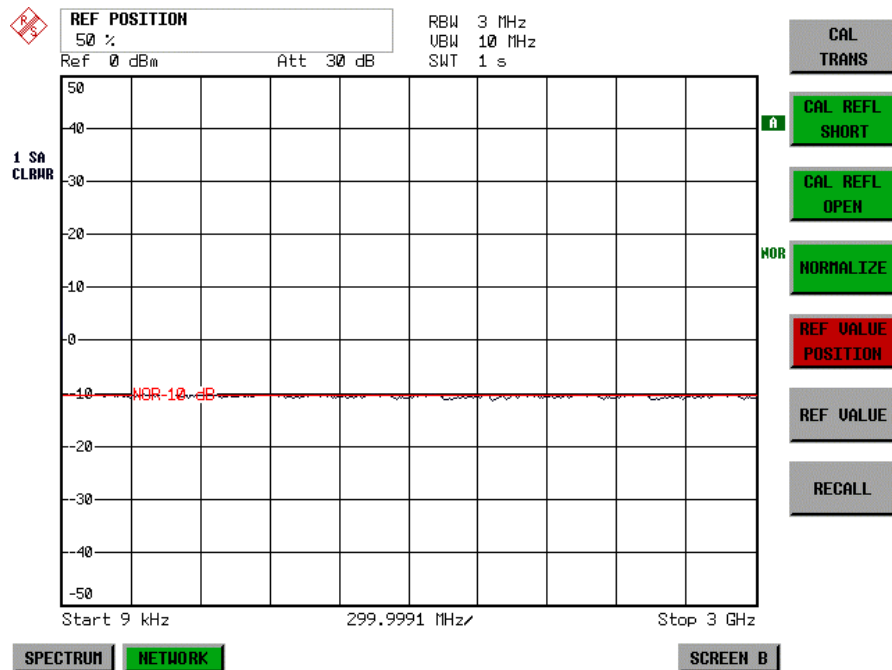
Fig.: 4-20   Measurement with REF VALUE -10 dB and REF VALUE POSITION 50%

After the reference line has been moved by entering a *REF VALUE* of –10 dB the deviation from the nominal power level can be displayed with high resolution (eg 1 dB/div). The power is still displayed in absolute values, which means that in the above example 1 dB below the nominal power (reference line) = 11 dB attenuation.
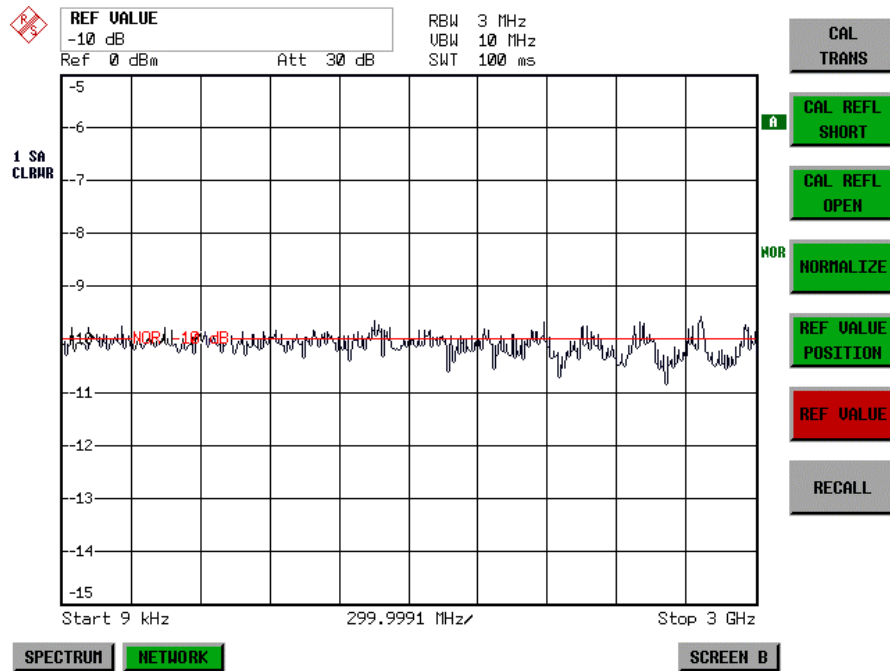
Fig.: 4-21   Measurement of a 10dB attenuator pad with 1dB/DIV

IEC/IEEE-bus command: DISP:WIND:TRAC:Y:RVAL –10dB
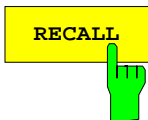
The *RECALL* softkey restores the FSP settings that were used during source calibration.
This can be useful if device settings were changed after calibration (eg center frequency, frequency deviation, reference level, etc).

The softkey is only available if:
- the NETWORK mode has been selected
- the memory contains a calibration dataset.

IEC/IEEE-bus command: CORR:REC

Reflection Measurement

Scalar reflection measurements can be carried out by means of a reflection-coefficient measurement bridge.

GEN OUTPUT   RF INPUT

Mess-
brücke

DUT
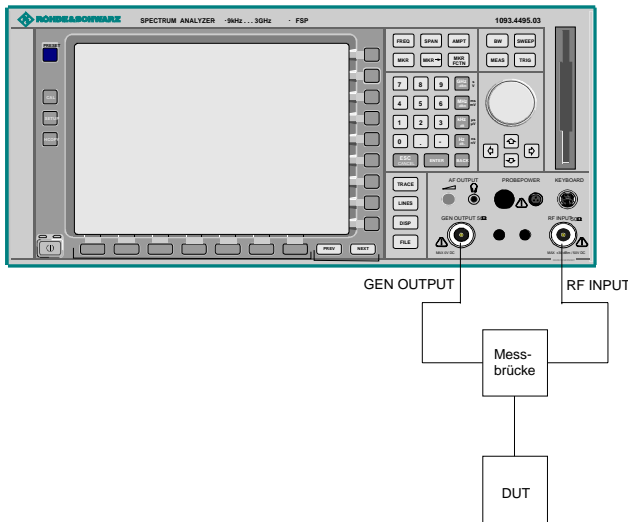
Fig.: 4-22   Test Setup for Reflection Measurement

Calibration of Reflection Measurement

The calibration mechanism for reflection measurement is basically the same as the one used for transmission measurement.

NETWORK-SOURCE CAL submenu

CAL REFL OPEN   The *CAL REFL OPEN* softkey starts the open-circuit calibration. During calibration the following message is displayed:

SOURCE CAL
in progress
ABORT
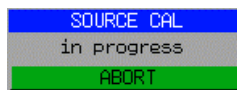
IEC/IEEE-bus command: CORR:METH REFL
CORR:COLL OPEN

CAL REFL SHORT   The *CAL REFL SHORT* softkey starts the short-circuit calibration.

If both calibrations (open circuit, short circuit) are carried out, the calibration curve is calculated by averaging the two measurements and stored in the memory. The order of the two calibration measurements is free.

After the calibration the following message is displayed:

NOTE
calibration complete
OK
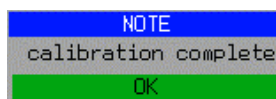
The message is cleared after approx. 3 seconds.

IEC/IEEE-bus command: CORR:METH REFL

Calibration mechanism

Calibration means a calculation of the difference between the currently measured power and a reference curve, independent of the selected type of measurement (transmission/reflection). The hardware settings used for measuring the reference curve are included in the reference dataset.

Even with normalization switched on, the device settings can be changed in a wide area without stopping the normalization. This reduces the necessity to carry out a new normalization to a minimum.

For this purpose the reference dataset (trace with 501 measured values) is stored internally as a table of 501 points (frequency/level).
Differences in level settings between the reference curve and the current device settings are taken into account automatically. If the span is reduced, a linear interpolation of the intermediate values is applied. If the span increases, the values at the left or right border of the reference dataset are extrapolated to the current start or stop frequency, ie the reference dataset is extended by constant values.
An enhancement label is used to mark the different levels of measurement accuracy. This enhancement label is displayed at the right diagram border when normalization is switched on and a deviation from the reference setting occurs. Three accuracy levels are defined:

Table 4-3   Measurement accuracy levels

Accuracy	Enhancement label	Reason/Limitation
High	NOR	No difference between reference setting and measurement
Medium	APX (approximation)	Change of the following settings: • coupling (RBW, VBW, SWT) • reference level, RF attenuation • start or stop frequency • output level of tracking generator • frequency offset of tracking generator • detector (max. peak, min. peak, sample, etc.) Change of frequency: • max. 501 points within the set sweep limits (corresponds to a doubling of the span)
-	Aborted normalization	• more than 500 extrapolated points within the current sweep limits (in case of span doubling)

Note: *At a reference level (REF LEVEL) of -10 dBm and at a tracking generator output level of the same value the FSP operates without overrange reserve, ie the FSP is in danger of being overloaded if a signal is applied whose amplitude is higher than the reference line. In this case, either the message "OVLD" for overload is displayed in the status line or the display range is exceeded (clipping of the trace at the upper diagram border = Overrange).*

Overloading can be avoided as follows:

• *Reducing the output level of the tracking generator (SOURCE POWER, NETWORK menu)*

• *Increasing the reference level (REF LEVEL, AMPT menu)*

Frequency-Converting Measurements

For frequency-converting measurements (eg on converter units) the tracking generator is able to set a constant frequency offset between the output frequency of the tracking generator and the receive frequency of the FSP. Up to an output frequency of 150 MHz the measurement can be carried out in both inverted and normal positions.
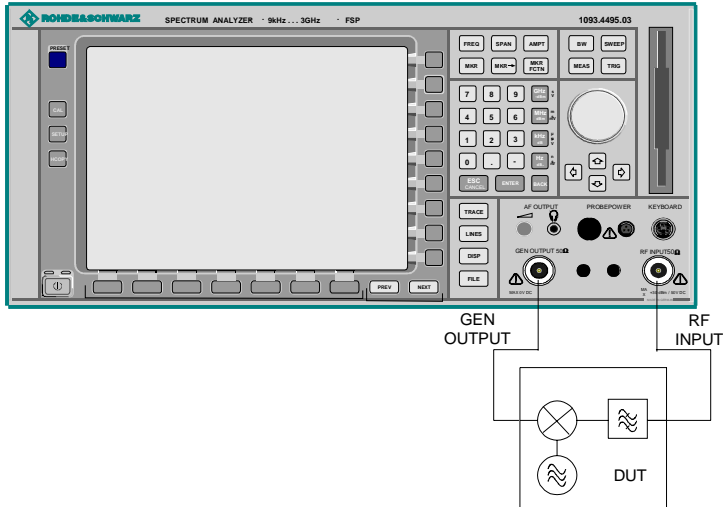
Fig.: 4-23   Test setup for frequency converting measurements
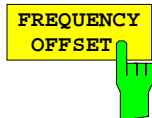
NETWORK menu

The *FREQUENCY OFFSET* softkey activates the input of the frequency offset between the output signal of the tracking generator and the input frequency of the FSP. Possible offsets are in a range of ±150 MHz in 0.1 Hz steps.

The default setting is 0 Hz. Offsets <> 0 Hz are marked with the enhancement label **FRQ**.

If a positive frequency offset is entered, the tracking generator generates an output signal above the receive frequency of the FSP. In case of a negative frequency offset it generates a signal below the receive frequency of the FSP. The output frequency of the tracking generator is calculated as follows:

Tracking generator frequency = receive frequency + frequency offset.

IEC/IEEE-bus command: `SOUR:FREQ:OFFS 50MHz`

External Modulation of the Tracking Generator

NETWORK menu:

```
          MODULATION

┌───────────┐      ┌───────────┐
│MODULATION │ ──▶  │  EXT AM   │
└───────────┘      └───────────┘

                   ┌───────────┐
                   │  EXT FM   │
                   └───────────┘

                   ┌───────────┐
                   │  EXT I/Q  │
                   └───────────┘

                   ┌───────────┐
                   │           │
                   └───────────┘

                   ┌───────────┐
                   │           │
                   └───────────┘

                   ┌───────────┐
                   │           │
                   └───────────┘

                   ┌───────────┐
                   │           │
                   └───────────┘

                   ┌───────────┐
                   │           │
                   └───────────┘

                   ┌───────────┐
                   │MODULATION │
                   │    OFF    │
                   └───────────┘
```
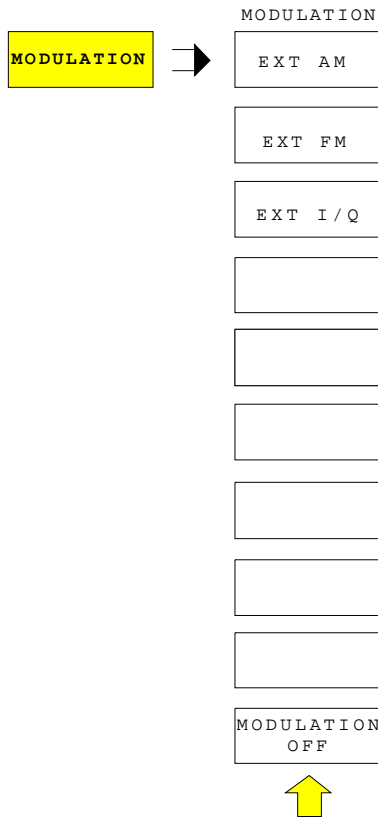
The *MODULATION* softkey opens a submenu for selecting different modulation modes.

The time characteristics of the tracking generator output signal can be influenced by means of external signals (input voltage range -1 V to +1 V).

Two BNC connectors at the rear panel are available as signal inputs. Their function changes depending on the selected modulation:

TG IN I / AM and

TG IN Q / FM

The modulation modes can be combined with each other and with the frequency offset function up to a certain degree. The following table shows which modulation modes are possible at the same time and which ones can be combined with the frequency offset function.

Table 4-4   Simultaneous modes of modulation (tracking generator)

Modulation	Frequency offset	EXT AM	EXT FM	EXT I/Q
Frequency offset		●	●	●
EXT AM	●		●	
EXT FM	●	●		
EXT I/Q	●			

● = can be combined
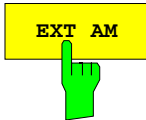
EXT AM

The *EXT AM* softkey activates an AM modulation of the tracking generator output signal.

The modulation signal is applied to the *TG IN I / AM* connector. An input voltage of 1 V corresponds to 100% amplitude modulation.

Switching on an external AM disables the following function:

– active I/Q modulation.

IEC/IEEE-bus command: `SOUR:AM:STAT ON`
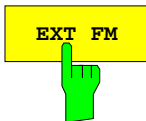
EXT FM

The *EXT FM* softkey activates the FM modulation of the tracking generator output signal.

The modulation frequency range is 1 kHz to 100 kHz, the deviation can be set in 1-decade steps in the range of 100 Hz to 10 MHz at an input voltage of 1 V. The phase deviation η should not exceed the value 100.

Phase deviation η = deviation / modulation frequency

The modulation signal is applied to the TG IN Q / FM connector.

Switching on an external FM disables the following function:

– active I/Q modulation.

IEC/IEEE-bus command: `SOUR:FM:STAT ON`
`SOUR:FM:DEV  10MHz`
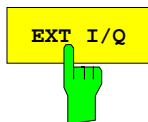
EXT I/Q

The *EXT I/Q* softkey activates the external I/Q modulation of the tracking generator.

The signals for modulation are applied to the two input connectors *TG IN I* and *TG IN Q* at the rear panel of the unit. The input voltage range is ±1 V into 50 Ω.

Switching on an external I/Q modulation disables the following functions:
– active external AM
– active external FM

Functional description of the quadrature modulator:
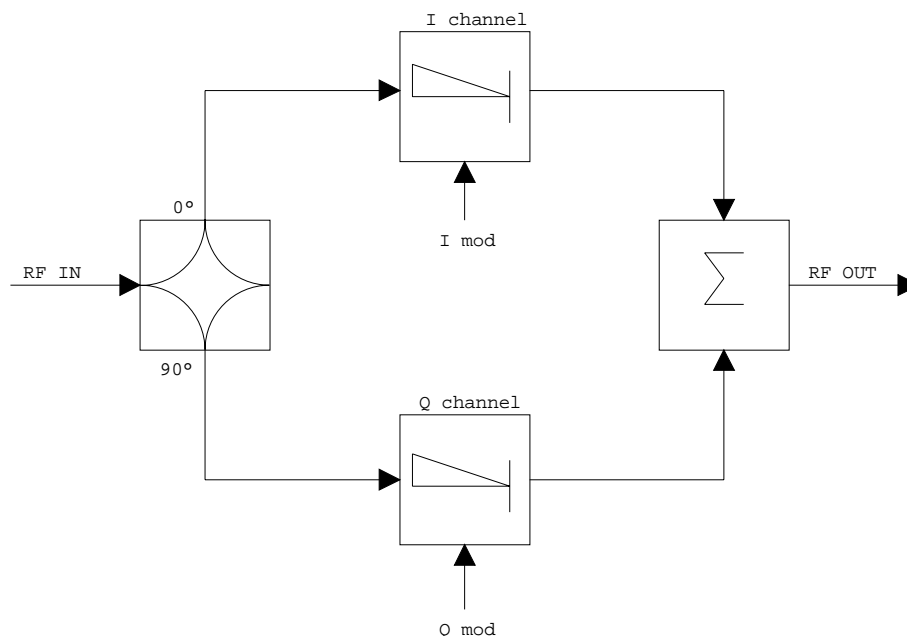
Fig.: 4-24   I/Q modulation

I/Q modulation is performed by means of the built-in quadrature modulator. The RF signal is divided into two orthogonal I and Q components (inphase and quadrature phase). Amplitude and phase are controlled in each path by the I and Q modulation signal. By adding the two components an RF output signal is generated that can be controlled in amplitude and phase.

IEC/IEEE-bus command: `SOUR:DM:STAT ON`
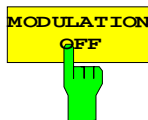
MODULATION OFF

The *MODULATION OFF* softkey switches off the modulation of the tracking generator.

IEC/IEEE-bus command: `SOUR:AM:STAT OFF`
`SOUR:FM:STAT OFF`
`SOUR:DM:STAT OFF`

Option External Generator Control - FSP-B10

The external generator control option permits to operate a number of commercially available generators as tracking generator on the FSP. Thus, scalar network analysis with the FSP is also possible outside the frequency range of the internal tracking generator when the appropriate generators are used.

The FSP also permits to set a frequency offset for frequency-converting measurements when external generators are used. For harmonics measurements or frequency-converting measurements, it is also possible to enter a factor, by which the generator frequency is increased or reduced compared with the receive frequency of the FSP. Only make sure that the resulting generator frequencies do not exceed the allowed setting range of the generator.

The settable level range also depends on the generator used.
The generator is controlled via the – optional – second IECBUS interface of the FSP (= IEC2, supplied with the option) and, with some Rohde & Schwarz generators, additionally via the TTL synchronization interface included in the AUX interface of the FSP.

Note: *The use of the TTL interface enables considerably higher measurement rates as pure IECBUS control, because the frequency stepping of the FSP is directly coupled with the frequency stepping of the generator.*

Therefore, the frequency sweep differs according to the capabilities of the generator used:

- In the case of generators without TTL interface, the generator frequency is first set for each frequency point via IECBUS, then the setting procedure has to be completed before recording of measured values is possible.

- In the case of generators with TTL interface, a list of the frequencies to be set is entered into the generator before the beginning of the first sweep. Then the sweep is started and the next frequency point selected by means of the TTL handshake line TRIGGER. The recording of measured values is only enabled when the generator signals the end of the setting procedure via the BLANK signal. This method is considerably faster than pure IECBUS control.

With the "SELECT GENERATOR" softkey, a list of the supported generators with the frequency and level range as well as the capabilities used is included.

The external generator can be used in all operating modes. Recording of test setup calibration values (*SOURCE CAL*) and normalization with the correction values (*NORMALIZE*) are only possible in the *NETWORK* mode.

Note: *In order to enhance measurement accuracy a common reference frequency should be used for both the FSP and the generator. If no independent 10 MHz reference frequency is available, it is recommended to connect the reference output of the generator with the reference input of the FSP and to enable usage of the external Reference on the FSP via SETUP – REFERENCE EXT.*

Like the internal tracking generator, the external generator is activated by means of the *NETWORK* hotkey in the hotkey bar at the screen bottom:

SPECTRUM   NETWORK   SCREEN B

External Generator Settings

The *NETWORK* hotkey opens the menu for setting the functions of the external generator.
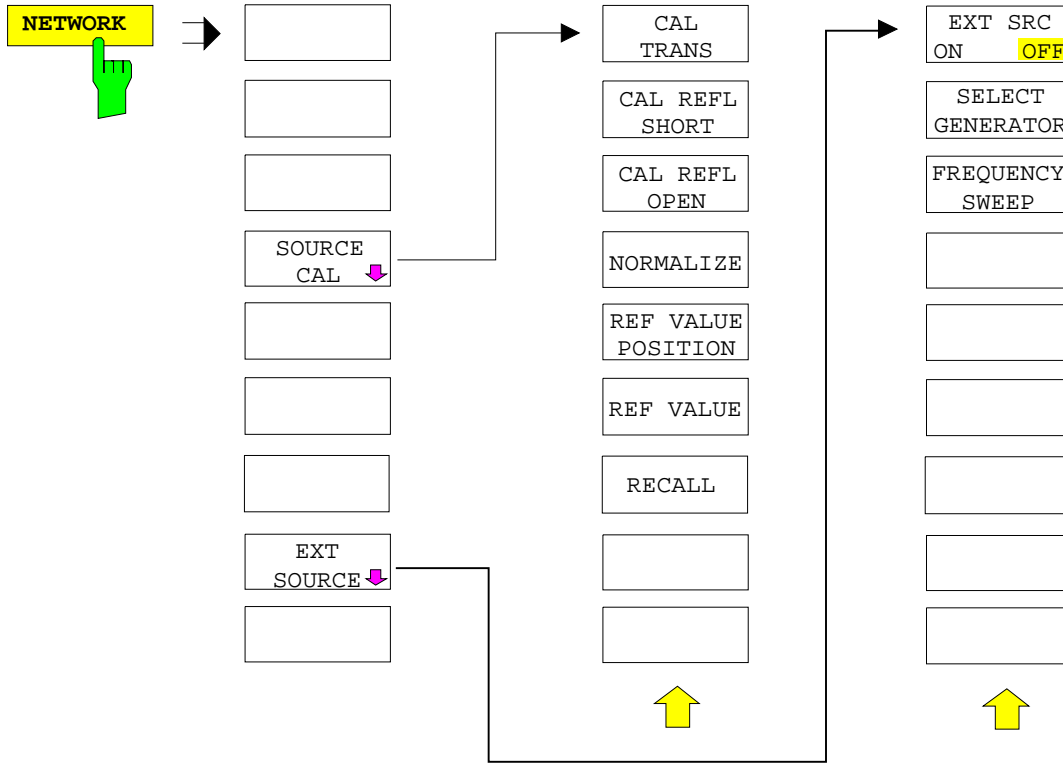
Note: *Other softkeys are available in the displayed menus for controlling the internal tracking generator when option Tracking Generator FSP-B9 is fitted. For detailed information see section "Option Tracking Generator FSP-B9".*
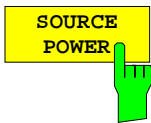
The *SOURCE POWER* softkey activates the input of the generator output level. The value range depends on the selected generator (See table of chapter "Configuration of the External Generator").

Ist neben der Option *Externe Generatorsteuerung FSP-B10* auch die Option *Mitlaufgenerator FSP-B9* installiert, so verändert der Softkey wahlweise den Ausgangspegel des internen Mitlaufgenerators oder des externen Generators, je nachdem, welcher Generator gerade eingeschaltet ist.

Die Grundeinstellung des Ausgangspegels ist -20 dBm.

IEC/IEEE-bus command: SOUR:EXT:POW –20dBm

Transmission Measurement

The transmission characteristic of a two-port network is measured . The external generator serves as a signal source. It is connected to the input connector of the DUT. The input of the analyser is fed from the output of the DUT.
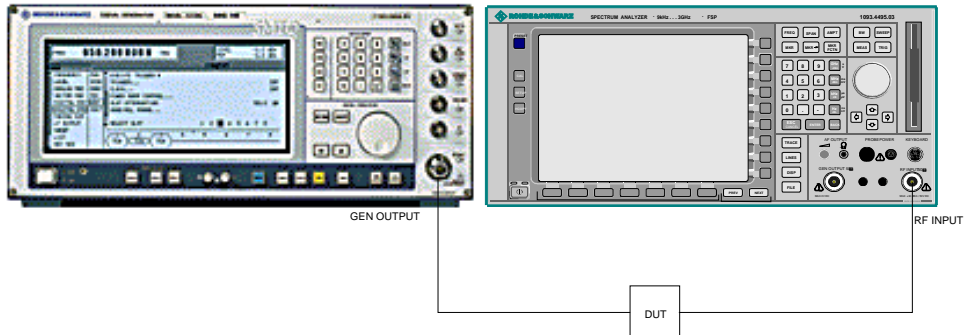
Fig. 4-27   Test setup for transmission measurement

A calibration can be carried out to compensate for the effects of the test setup (eg frequency response of connecting cables).

Calibration of Transmission Measurement

NETWORK menu:
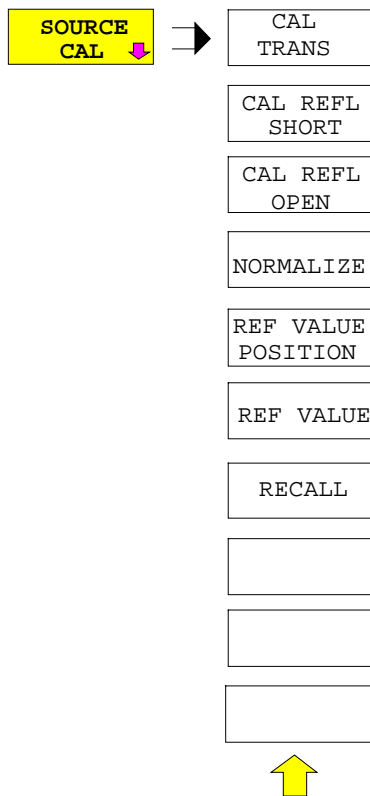
The *SOURCE CAL* softkey opens a submenu comprising the calibration functions for the transmission and reflection measurement.

The calibration of the reflection measurement (*CAL REFL...*) and its functioning are described in separate sections.

To carry out a calibration for transmission measurements the whole test setup is through-connected (THRU).

```
CAL
TRANS
```
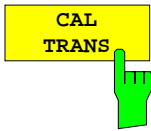
The *CAL TRANS* softkey triggers the calibration of the transmission measurement.

It starts a sweep that records a reference trace. This trace is then used to obtain the differences to the normalized values.
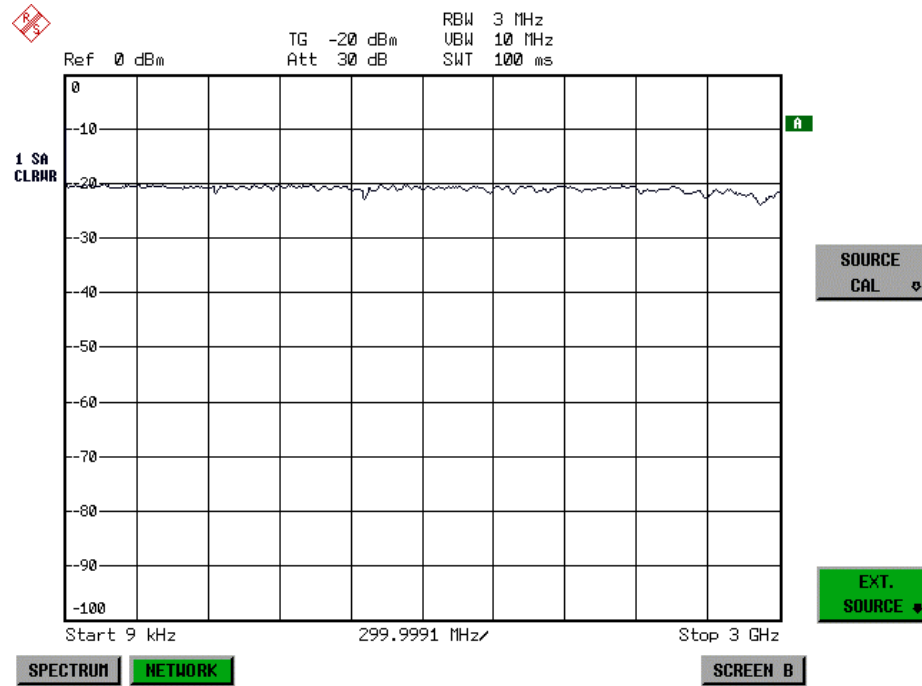
Fig. 4-28   Calibration curve for transmission measurement

During the calibration the following message is displayed:

```
SOURCE CAL
in progress
ABORT
```
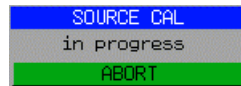
After the calibration sweep the following message is displayed:

```
NOTE
calibration complete
OK
```
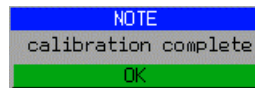
This message is cleared after approx. 3 seconds.

IEC-bus command   `CORR:METH TRAN`

Normalization:

NETWORK - SOURCE CAL menu:
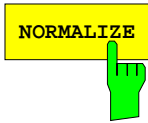
NORMALIZE

The *NORMALIZE* softkey switches normalization on or off. The softkey is only available if the memory contains a correction trace.

It is possible to shift the relative reference point within the grid using the *REF VALUE POSITION* softkey. Thus, the trace can be shifted from the top grid margin to the middle of the grid:
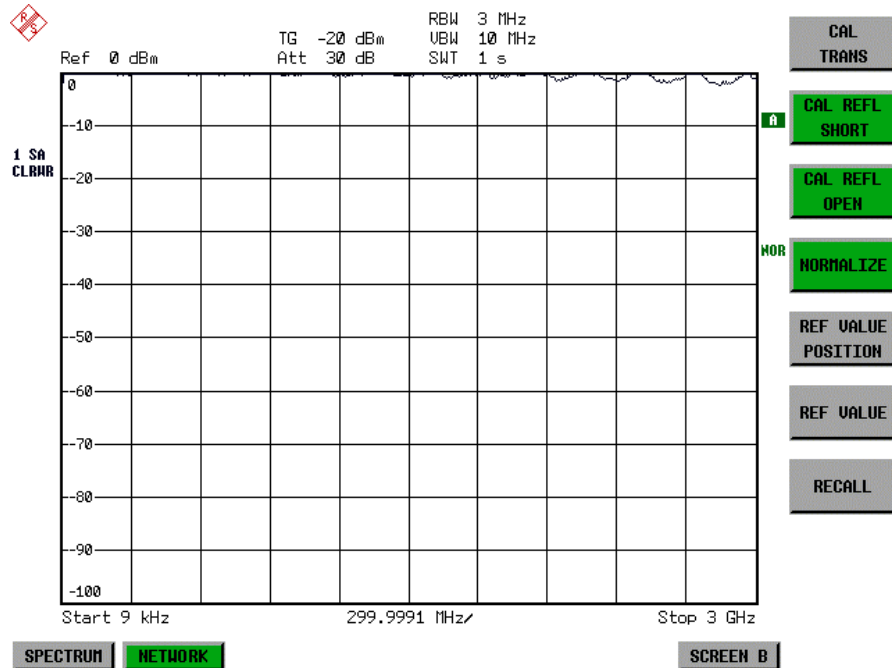
Fig. 4-29   Normalized display

In the *SPLIT SCREEN* setting, the normalization is switched on in the current window. Different normalizations can be active in the two windows.

Normalization is aborted when the *NETWORK* mode is quit.

IEC/IEEE-bus command: CORR ON
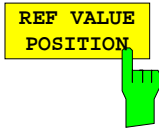
REF VALUE POSITION

The *REF VALUE POSITION* softkey (reference position) marks a reference position in the active window on which the normalization (difference formation with a reference curve) is performed.

When pressed for the first time, the softkey switches on the reference line and activates the input of its position. The line can be shifted within the grid limits.

The reference line is switched off by pressing the softkey again.

The function of the reference line is explained in the section "Functioning of Calibration".
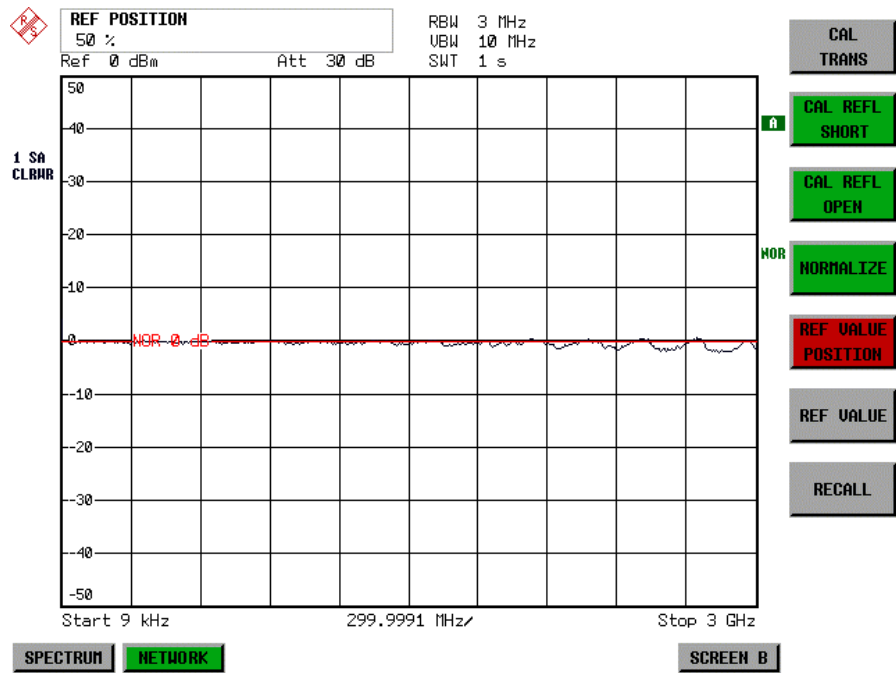
Fig. 4-30   Normalized   measurement,   shifted   with   *REF   VALUE POSITION* 50 %

IEC-bus command   `DISP:WIND:TRAC:Y:RPOS 10PCT`
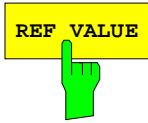
REF VALUE

The *REF VALUE* softkey activates the input of a level difference which is assigned to the reference line.

In the default setting, the reference line corresponds to a level difference of 0 dB. If e.g. a 10-dB attenuator pad is inserted between DUT and analyzer input between recording of the calibration data and normalization, the trace will be shifted down by 10 dB. By entering a *REF VALUE* of –10 dB the reference line for difference formation can also be shifted down by 10 dB so that it will again coincide with the trace (see Fig. 4-31).
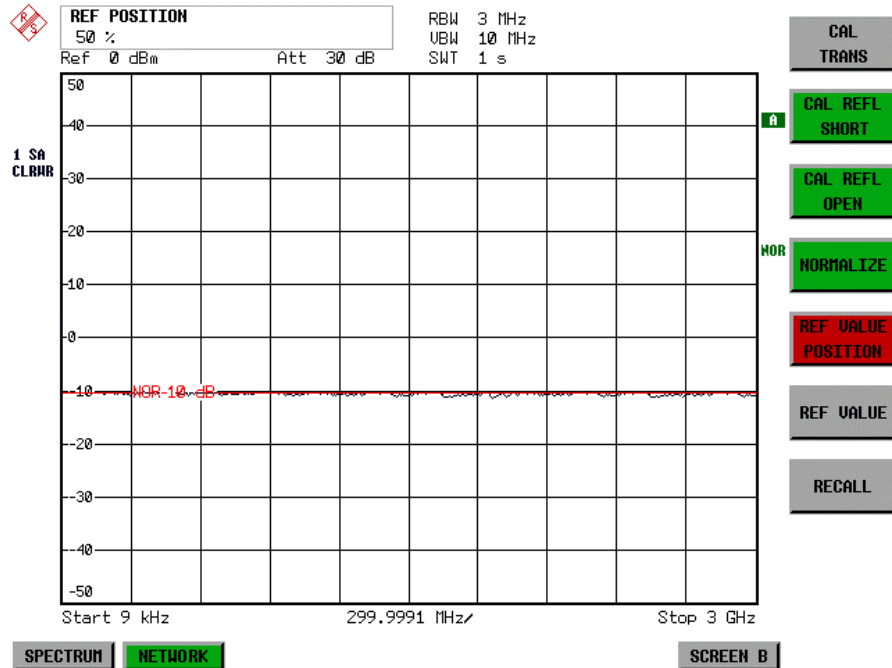
Fig. 4-31   Measurement with REF VALUE -10dB and REF VALUE POSITION 50%

After the reference line has been shifted by entering *REF VALUE* –10 dB, departures from the nominal value can be displayed with high resolution (e.g. 1 dB / Div.). The absolute measured values are still displayed, in the above example, 1 dB below nominal value (reference line) = 11 dB attenuation.
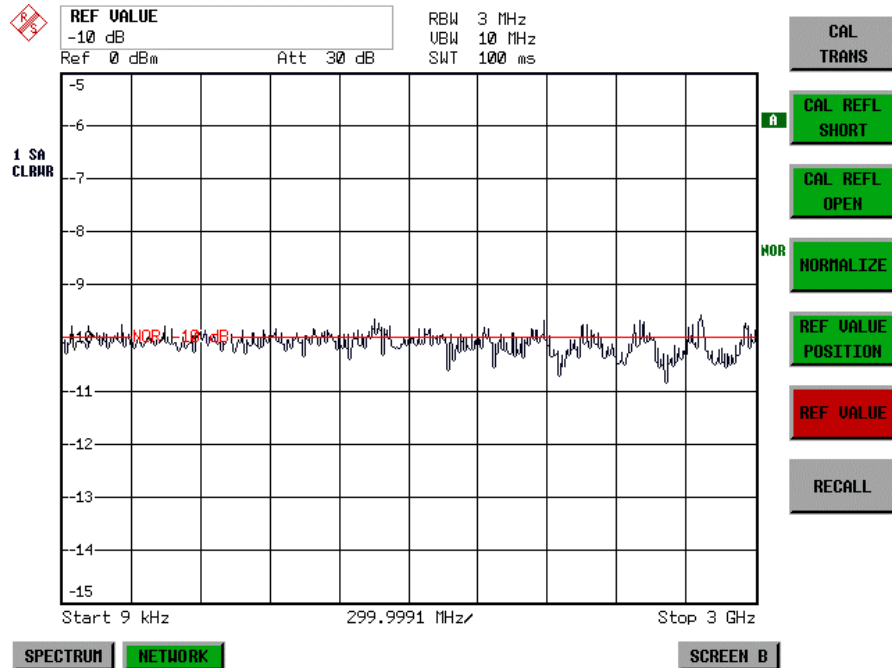
Fig. 4-32   Measurement of a 10-dB attenuator pad with 1dB/DIV

IEC-bus command   `DISP:WIND:TRAC:Y:RVAL -10dB`
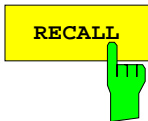
The *RECALL* softkey restores the instrument setting with which the calibration was carried out.
This can be useful if the device setting was changed after calibration (eg center frequency setting, frequency deviation, reference level, etc).

The softkey is only available if:

- the *NETWORK* mode has been selected
- the memory contains a calibration data set.

IEC/IEEE-bus command   `CORR:REC`

Reflection Measurement

Scalar reflection measurements can be carried out by means of a reflection-coefficient bridge.
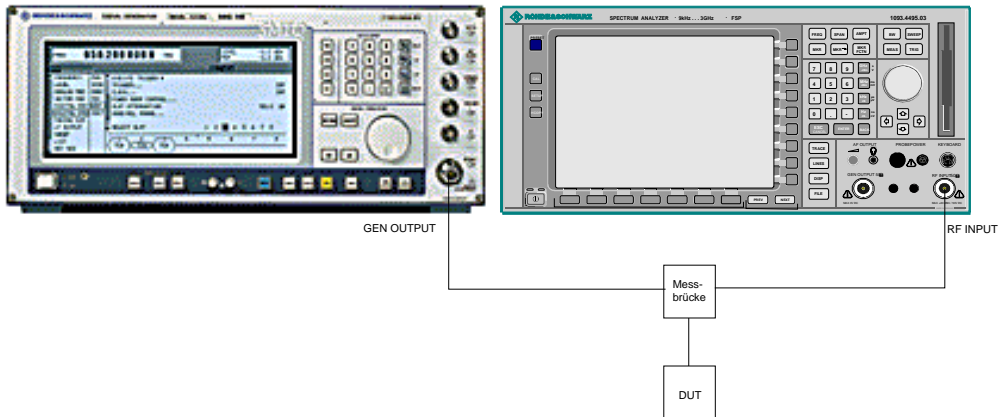
Fig. 4-33   Test setup for reflection measurement

Calibration of Reflection Measurement

The calibration mechanism essentially corresponds to that of the transmission measurement.
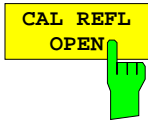
NETWORK-SOURCE CAL submenu

The *CAL REFL OPEN* softkey starts the open-circuit calibration. During calibration the following message is displayed:

IEC-bus command   CORR:METH REFL
                      CORR:COLL OPEN

The *CAL REFL SHORT* softkey starts the short-circuit calibration.

If both calibrations (open circuit, short circuit) are carried out, the calibration curve is formed by averaging the two measurements and stored in the memory. The order of measurements is optional.

After the calibration the following message is displayed:
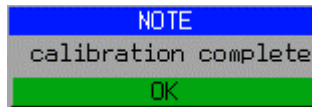
The display is cleared after approx. 3 seconds.

IEC-bus command   CORR:METH REFL
                      CORR:COLL THR

Calibration mechanism

Calibration means a calculation of the difference between the currently measured power and a reference curve, independent of the selected type of measurement (transmission/reflection). The hardware settings used for measuring the reference curve are included in the reference dataset.

Even with normalization switched on, the device settings can be changed in a wide area without stopping the normalization. This reduces the necessity to carry out a new normalization to a minimum.

For this purpose the reference dataset (trace with 501 measured values) is stored internally as a table of 501 points (frequency/level).
Differences in level settings between the reference curve and the current device settings are taken into account automatically. If the span is reduced, a linear interpolation of the intermediate values is applied. If the span increases, the values at the left or right border of the reference dataset are extrapolated to the current start or stop frequency, ie the reference dataset is extended by constant values.
An enhancement label is used to mark the different levels of measurement accuracy. This enhancement label is displayed at the right diagram border when normalization is switched on and a deviation from the reference setting occurs. Three accuracy levels are defined:

Table 4-5   Measurement accuracy levels

Accuracy	Enhancement label	Reason/Limitation
High	NOR	No difference between reference setting and measurement
Medium	APX (approximation)	Change of the following settings: • coupling (RBW, VBW, SWT) • reference level, RF attenuation • start or stop frequency • output level of tracking generator • frequency offset of tracking generator • detector (max. peak, min. peak, sample, etc.) Change of frequency: • max. 501 points within the set sweep limits (corresponds to a doubling of the span)
-	Aborted normalization	• more than 500 extrapolated points within the current sweep limits (in case of span doubling)

Note: *At a reference level (REF LEVEL) of -10 dBm and at a tracking generator output level of the same value the analyzer operates without overrange reserve, ie the analyzer is in danger of being overloaded if a signal is applied whose amplitude is higher than the reference line. In this case, either the message "OVLD" for overload is displayed in the status line or the display range is exceeded (clipping of the trace at the upper diagram border = Overrange).*

Overloading can be avoided as follows:

* *Reducing the output level of the tracking generator (SOURCE POWER, NETWORK menu)*
* *Increasing the reference level (REF LEVEL, AMPT menu)*

Frequency-converting Measurements

For frequency-converting measurements (e.g. on converters) the external generator is able to set a constant frequency offset between the output frequency of the generator and the receive frequency of the analyzer and, in addition, the generator frequency as a multiple of the analyzer.

GEN OUTPUT   RF INPUT

DUT
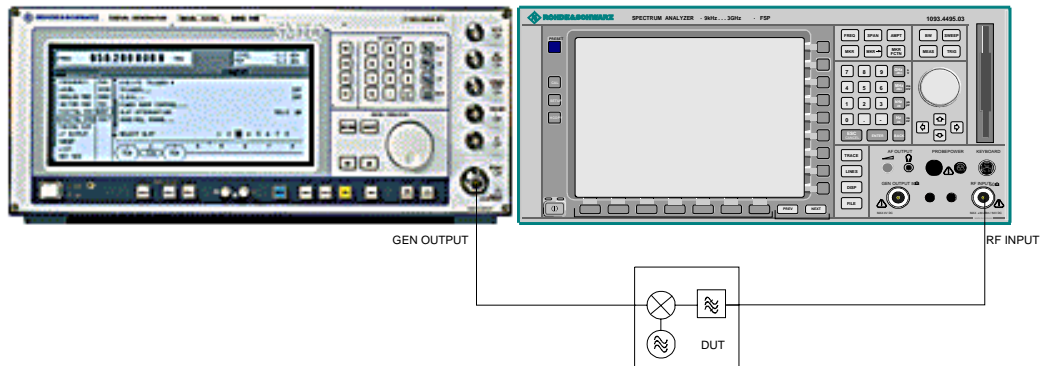
Fig. 4-34   Test setup for frequency-converting measurements
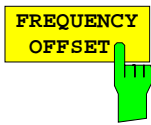
NETWORK Menü

**FREQUENCY
OFFSET**

The *FREQUENCY OFFSET* softkey activates the input of the frequency offset between the output signal of the generator and the input frequency of the analyzer. The value range depends on the selected generator.
The default setting is 0 Hz. Offsets <> 0 Hz are marked with the enhancement label **FRQ**.

If a positive frequency offset is entered, the tracking generator generates an output signal above the receive frequency of the "analyzer. In case of a negative frequency offset it generates a signal below the receive frequency of the analyzer. The output frequency of the generator is calculated as follows:

Generator frequency = receive frequency + frequency offset

IEC/IEEE-bus command: SOUR:EXT:FREQ:OFFS 1GHZ

Configuration of an External Generator

NETWORK menu:

The *EXT SOURCE* softkey opens a submenu for configuration of the external generator.
The FSP is able to manage two generators, one of which can be active at the time.

The *EXT SRC ON / OFF* softkey switches the external generator on or off.
It can only be switched on successfully if the generator has been selected by means of *SELECT GENERATOR* and configured correctly by means of *FREQUENCY SWEEP*. If one of these conditions is not fulfilled, an error message will be output.

Notes:

When switching on the external generator, the FSP *switches off the internal tracking generator and starts programming the generator settings via the IECBUS.*

At the same time, the maximum stop frequency is limited to the maximum generator frequency. This upper limit is automatically reduced by the set frequency offset of the generator and a set multiplication factor.

With the external generator switched on, the FFT filters (FILTER TYPE FFT in the menu BW) are not available.

If there is an error on the IECBUS during programming of the external generator, the generator is automatically switched off and the following error message output:

IEC-bus command   SOUR:EXT ON
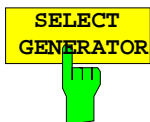
The *SELECT GENERATOR* softkey opens a table for selection of the generator and definition of IECBUS address and control interface.
The table permits configuration of two generators so that switching between two different configurations is easily possible.

SELECT GENERATOR								
SRC	TYPE	IFC	GPIB ADDR	MODE	F MIN	F MAX	P MIN	P MAX
1	SME03	TTL	28	REMOTE	5kHz	3GHz	–144dBm	16dBm
2	SMIQ03	GPIB	28	LOCAL	300kHz	3.3GHz	–140dBm	13dBm

The individual fields contain the following settings:

SRC   Index of generator selected

TYPE   The field opens the list with the available generators:
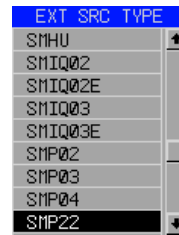
After completion of the selection, the remaining fields of the table are filled with the generator characteristics.

A list of generator types supported by the FSP is to be found at the end of section "Softkey *SELECT GENERATOR*".

IFC   This field selects the interface type of external generator 1or 2. The following types are available:

GPIB   IECBUS only, suitable for all generators of other manufacturers and some Rohde & Schwarz instruments

or

TTL   IECBUS and TTL interface for synchronization, for most of the Rohde & Schwarz generators, see table above.

The two operating modes differ in the speed of the control: Whereas, with pure IECBUS operation, each frequency to be set must be individually transferred to the generator, additional use of the TTL interface permits to program a total frequency list at once and subsequently perform the frequency stepping via TTL handshake, which is a big advantage in terms of speed.

Note:

Generators equipped with the TTL interface can also be operated with IECBUS (= GPIB) only.

Only one of the two generators can be operated with TTL interface at a time. The other generator must be configured for IECBUS (GPIB).

GPIB   IECBUS address of the respective generator. Addresses from 0 to 30
ADDR   are possible.

MODE   Operating mode of generator. The generator activated using the FREQUENCY SWEEP softkey is automatically set to remote mode (REMOTE), the other to manual mode (LOCAL).

F MIN   Frequency range of generator. Select the start and stop frequency of the
F MAX FSP in a way that the specified range is not exceeded.
If the start frequency lies below F MIN, the generator is only switched on when F MIN is reached.
If the stop frequency lies above F MAX, it is limited to F MAX when the generator is switched on using the EXT SRC ON/OFF softkey.

P MIN   Level range of generator. This field defines the allowed input range for
P MAX the *POWER* column in the *FREQUENCY SWEEP* table.

IEC-bus commands   SYST:COMM:RDEV:GEN2:TYPE 'SME02'
                           `SYST:COMM:RDEV:GEN:LINK TTL`
                           SYST:COMM:GPIB:RDEV:GEN1:ADDR 28

List of Generator Types Supported by the FSP

Generator	Interface Type	Generator Min Freq	Generator Max Freq	Generator Min Power dBm	Generator Max Power dBm
SME02	TTL	5 kHz	1.5 GHz	-144	+16
SME03	TTL	5 kHz	3.0 GHz	-144	+16
SME06	TTL	5 kHz	6.0 GHz	-144	+16
SMG	GPIB	100 kHz	1.0 GHz	-137	+13
SMGL	GPIB	9 kHz	1.0 GHz	-118	+30
SMGU	GPIB	100 kHz	2.16 GHz	-140	+13
SMH	GPIB	100 kHz	2.0 GHz	-140	+13
SMHU	GPIB	100 kHz	4.32 GHz	-140	+13
SMIQ02B	TTL	300 kHz	2.2 GHz	-144	+13
SMIQ02E	GPIB	300 kHz	2.2 GHz	-144	+13
SMIQ03B	TTL	300 kHz	3.3 GHz	-144	+13
SMIQ03E	GPIB	300 kHz	3.3 GHz	-144	+13
SMIQ04B	TTL	300 kHz	4.4 GHz	-144	+10
SMIQ06B	TTL	300 kHz	6.4 GHz	-144	+10
SML01	GPIB	9 kHz	1.1 GHz	-140	+13
SML02	GPIB	9 kHz	2.2 GHz	-140	+13
SML03	GPIB	9 kHz	3.3 GHz	-140	+13
SMR20	TTL	1 GHz	20 GHz	-130 [2]	+11 [2]
SMR20B11 [1]	TTL	10 MHz	20 GHz	-130 [2]	+13 [2]
SMR27	TTL	1 GHz	27 GHz	-130 [2]	+11 [2]
SMR27B11 [1]	TTL	10 MHz	27 GHz	-130 [2]	+12 [2]
SMR30	TTL	1 GHz	30 GHz	-130 [2]	+11 [2]
SMR30B11 [1]	TTL	10 MHz	30 GHz	-130 [2]	+12 [2]
SMR40	TTL	1 GHz	40 GHz	-130 [2]	+9 [2]
SMR40B11 [1]	TTL	10 MHz	40 GHz	-130 [2]	+12 [2]
SMR60	TTL	1 GHz	60 GHz	-130 [2]	+9 [2]
SMR60B11 [1]	TTL	10 MHz	60 GHz	-130 [2]	+12 [2]
SMP02	TTL	10 MHz	20 GHz	-130 [3]	+17 [3]
SMP03	TTL	10 MHz	27 GHz	-130 [3]	+13 [3]
SMP04	TTL	10 MHz	40 GHz	-130 [3]	+12 [3]
SMP22	TTL	10 MHz	20 GHz	-130 [3]	+20 [3]
SMT02	GPIB	5.0 kHz	1.5 GHz	-144	+13
SMT03	GPIB	5.0 kHz	3.0 GHz	-144	+13
SMT06	GPIB	5.0 kHz	6.0 GHz	-144	+13
SMV03	GPIB	9 kHz	3.3 GHz	-140	+13
SMX	GPIB	100 kHz	1.0 GHz	-137	+13
SMY01	GPIB	9 kHz	1.04 GHz	-140	+13
SMY02	GPIB	9 kHz	2.08 GHz	-140	+13
HP8340A	GPIB	10 MHz	26.5 GHz	-110	10
HP ESG-A Series 1000A, 2000A, 3000A, 4000A	GPIB	250 kHz	4 GHz	-136	20
HP ESG-D SERIES E4432B	GPIB	250 kHz	3 GHz	-136	+10

[1] Requires the option SMR-B11 to be fitted.
[2] Maximum/minimum power depends on presence of Option SMR-B15/-B17 and set frequency range.
     For more details see SMR data sheet.
[3] Maximum/minimum power depends on presence of Option SMP-B15/-B17 and set frequency range.
     For more details see SMP data sheet.

FREQUENCY SWEEP

The *FREQUENCY SWEEP* softkey opens a table for setting the generator level as well as the multiplier and the offset used to derive the generator frequency from the analyzer frequency.

This table also permits configuration of two generators so that switching between two different configurations is easily possible.

			FREQUENCY SWEEP			
		SOURCE FREQ = REC FREQ * NUM/DEN + OFFSET				
SRC	STATE	POWER[dBm]	NUM	DEN	OFFSET	RESULT
1	✓	-30dBm	1	1	0Hz	0Hz..3GHz *
2		-30dBm	1	1	0Hz	0Hz..3.2GHz

SRC   Index of selected generator

STATE   Selects the active generator. Only one generator can be active at a time. The operating mode of the active generator is set to remote control in the SELECT GENERATOR table.

POWER   Permits to enter the generator level within the limits P MIN to P MAX of the *SELECT GENERATOR* table.

NUM   Numerator,

DEN   Denominator,

OFFSET   Offset, used to derive the generator frequency from the current frequency of the FSP according to the following formula:

$$F_{Generator} = F_{Analyzer} * \frac{Numerator}{Denominator} + F_{Offset}$$

Note that the frequencies resulting from start and stop frequency of the FSP do not exceed the allowed generator range:

➢ If the start frequency lies below F MIN, the generator is only switched on when F MIN is reached.

➢ If the stop frequency lies above F MAX, the generator is switched off. When the generator is subsequently switched on using the *EXT SRC ON/OFF* softkey, the stop frequency is limited to F MAX.

➢ If the stop frequency lies below F MIN, the generator is switched off and the following error message output:

ERROR
GENERATOR RANGES EXEEDED; EXT GEN SWITCHED OFF.
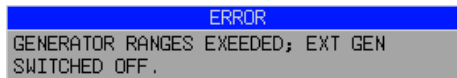
➢ In the time domain (Span = 0 Hz) the generator frequency is derived from the set receive frequency of the FSP using the calculation formula.

For the sake of clarity, the formula is also displayed in the table.

RESULT   The frequency range of the generator resulting from the calculation formula. An asterisk (*) after the upper limit indicates that the stop frequency of the FSP must be adapted when the generator is switched on in order not to exceed its maximum frequency. In the following illustration, this is true for the upper generator at a stop frequency of 3.2 GHz of the FSP, whereas the lower generator does not yet require an adaptation:

SOURCE FREQ = REC FREQ * NUM/DEN + OFFSET			
NUM	DEN	OFFSET	RESULT
1	1	0Hz	0Hz..3GHz *
1	1	0Hz	0Hz..3.2GHz

IEC-bus commands   SOUR:EXT:POW –30dBm
SOUR:EXT:FREQ:NUM 4
SOUR:EXT:FREQ:DEN 3
SOUR:EXT:FREQ:OFFS 100MHZ

Option LAN Interface – FSP-B16

Using the option FSP-B16 LAN Interface, the instrument can be connected to an Ethernet LAN (Local Area Network). Thus it is possible to transfer data via the network and use network printers. In addition, the instrument can be remote-controlled via network. The network card allows both for a 10 MHz Ethernet IEEE 802.3 and a 100 MHz Ethernet IEEE 802.3u. The selection between 10 Mbit/s and 100 Mbit/s can take place either automatically or via manual setting.

Connecting the Instrument to the Network

> **Caution:**
> *Before connecting the instrument to the network it is recommended to contact the network administrator, in particular larger LAN installations are affected. Faults in the connection may have a negative effect on the entire network.*

The instrument is connected to a network hub of the desired LAN segment via a commercially-available RJ45 cable (not supplied with the instrument) at the instrument rear panel. Since RJ45 provides no bus but a star network topology, no other precautions need to be taken for the connection.

The connection procedure does not produce any disturbances in the network traffic. Disconnection from the network is easily possible provided that there is no more data traffic from and to the instrument.

Installing the Software

The data transfer in the network takes place in data blocks, called packets. In addition to the useful data, further information on the operation, i.e. protocol data (transmitter, receiver, type of data, sequence), is transferred in the packets. For processing the protocol information, suitable drivers must be installed. For the network services (file transfer, directory services, printing in the network) a network operating system needs to be installed.

Installation and Configuration of the Driver for the Network Card

Notes:
- *The WINDOWS NT files required for the installation of network drivers, protocols or services are included in the directory "C:\I386".*

- *For the installation, a PC keyboard with trackball (or an additional mouse instead) is required.*
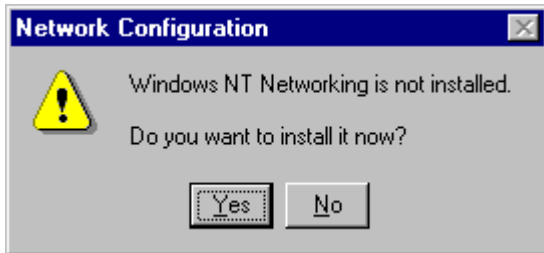
➢ Press the *SETUP* key.

  The *SETUP* menu opens.

➢ Press the *GENERAL SETUP* key.

  The *GENERAL SETUP* menu opens.

➢ Press the CONFIGURE NETWORK softkey.
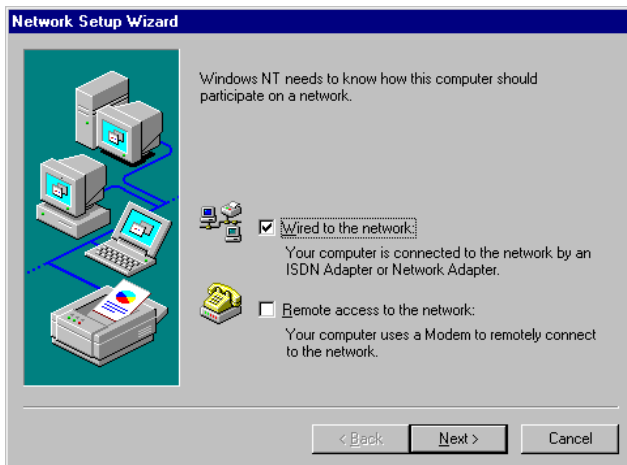
➢ Answer the prompt "Do you want to install it now?" with "Yes".

➢ Leave the default setting "Wired to the network" unchanged and confirm by means of "NEXT".
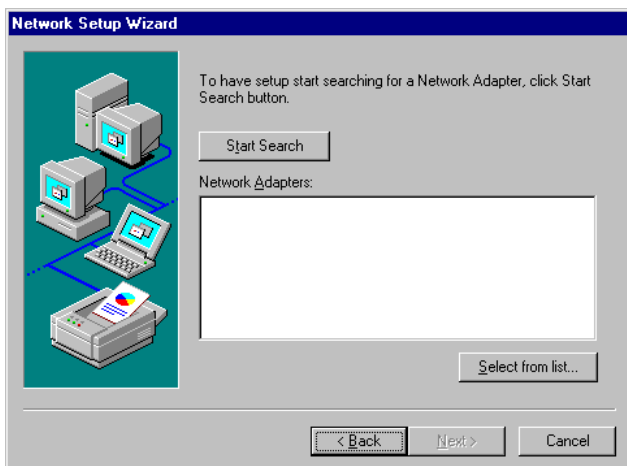
➢ To select the appropriate network card click on "Select from list".
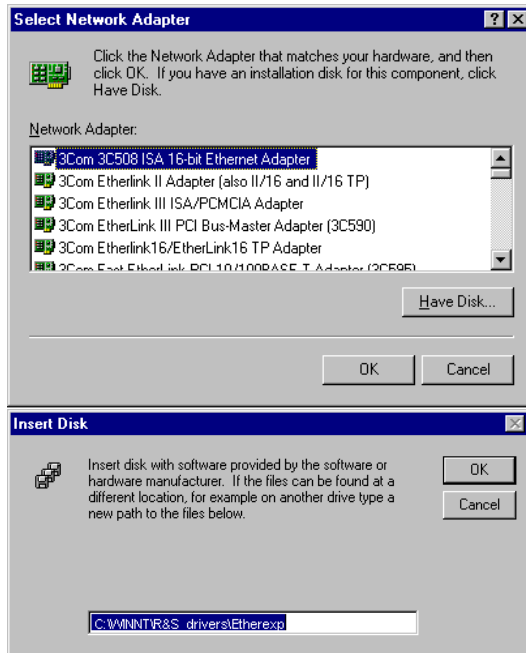
➢ Click on "Have Disk".

A prompt to enter a path name will appear.

➢ Enter the following path name:
'C:\WINNT\R&S_drivers\Etherexp' and
click on 'OK'.

Note: *If this path does not exist, enter "A:"
as a path name. Insert the driver disk
and click on "OK".*
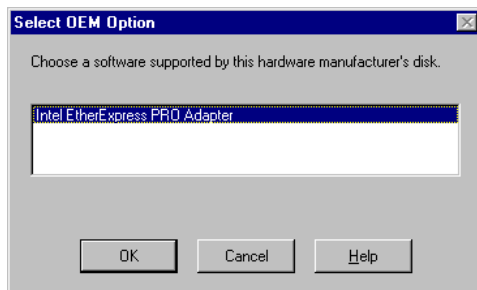
➢ Confirm 'Intel EtherExpress PRO Adapter'
with 'OK'.
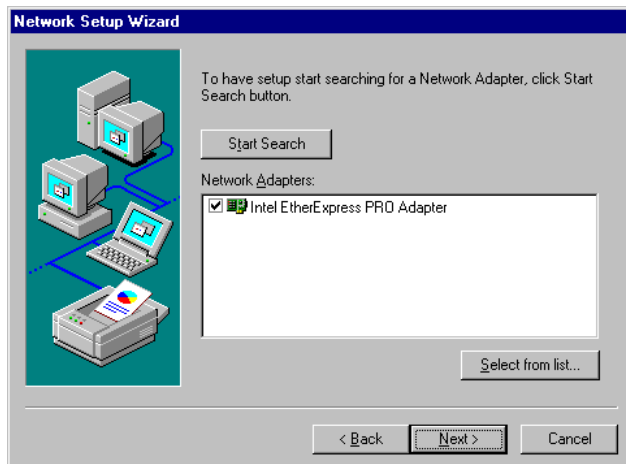
➢ Close the dialog by means of 'NEXT' after
selecting 'Intel EtherExpress PRO Adapter'
once again

Selection of the Network Protocols

Note: *The network administrator knows the protocols to be used. For the RSIB interface, the TCP/IP protocol must be installed in any case.*
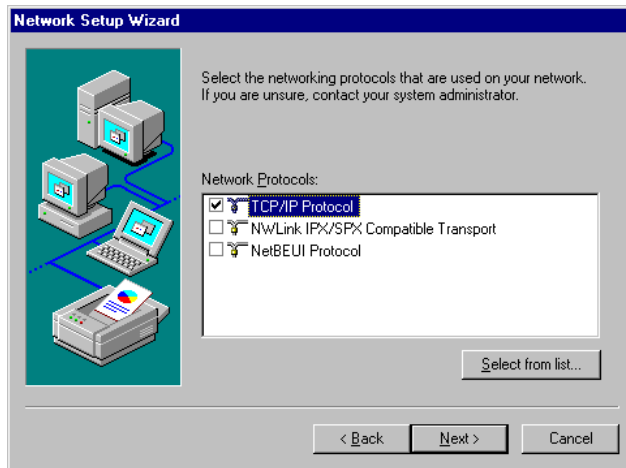
➢ Select the desired protocols and confirm using "NEXT".

Selection of the Network Services

To be able to utilize the resources in the network, it is necessary to install the respective services.

Note: The network administrator knows the services to be used.
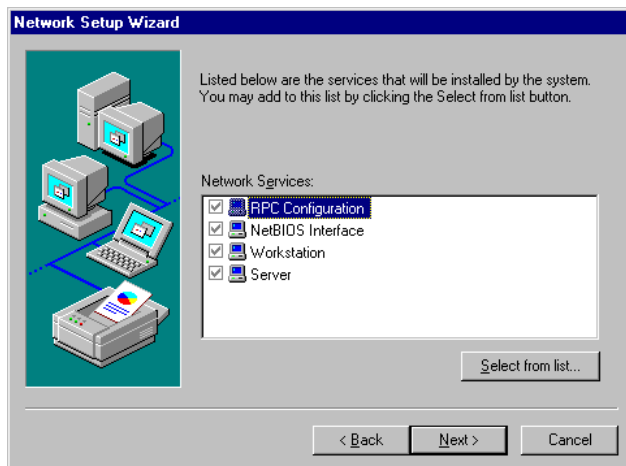
➢ During the first installation, the selected services cannot be changed.

Further services can be added after completion of the installation.

Completion of the Installation
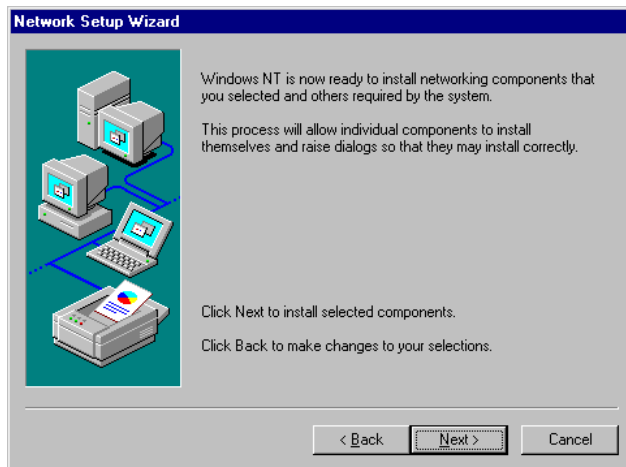
> ➢ Start the installation by clicking on "NEXT" .
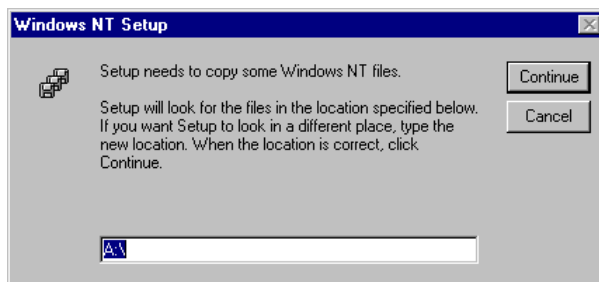
> ➢ Enter drive "C:\I386" and click on "Continue".
>
> ***Note:***
> *If the instrument is equipped with the B20 option, enter "D:\I386".*
>
> After a couple of files have been copied, there is a message indicating that the driver for the network card has been installed.
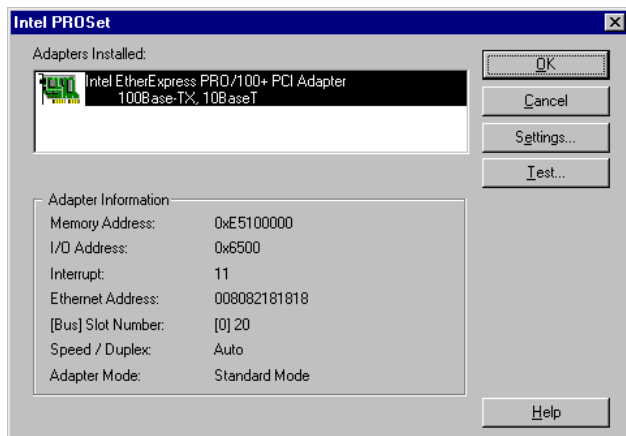
> ➢ If required, the network speed and the duplex mode can be set manually using the "Settings" button.
>
> ➢ Click on "OK".
>
> The settings are checked and processed. Missing information on the installed network protocols (e.g. the TCP/IP address) is queried.
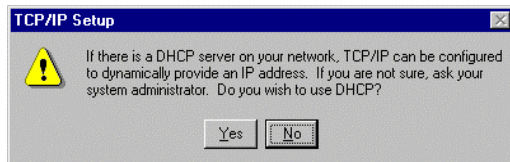
> ➤ The answer is "Yes" if the network comprises a DHCP server. In this case, you do not have to enter an IP address.
> ➤ The answer is "No" if there is no DHCP server in the network. In this case, enter the IP address assigned to the instrument. The IP address and the subnet mask are available from the network administrator.

Ask the network administrator whether a DHCP server is used.
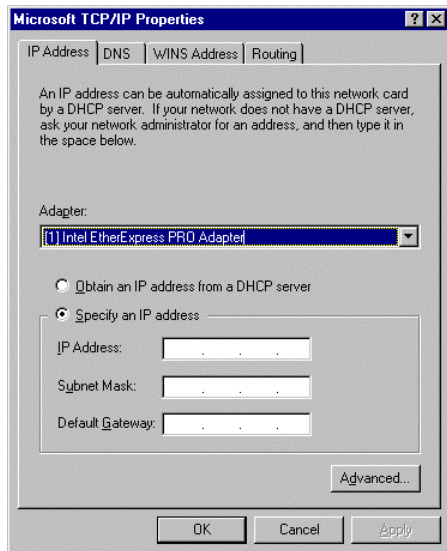
Manual entry of an IP address (not if a DHCP server is used):

> ➤ Do not change the "Adapter" setting.
> ➤ Click on "Specify an IP address".
> ➤ Enter the IP address and the subnet mask assigned to the instrument. These addresses are assigned by your network administrator.
>
> *Note:*
> *If the network card has been installed in the factory, the default settings are:*
> *IP Address 10.0.0.10*
> *and*
> *Subnet Mask 255,255,255,0.*
> ➤ Click on OK to leave the dialog.

The network bindings display opens next.
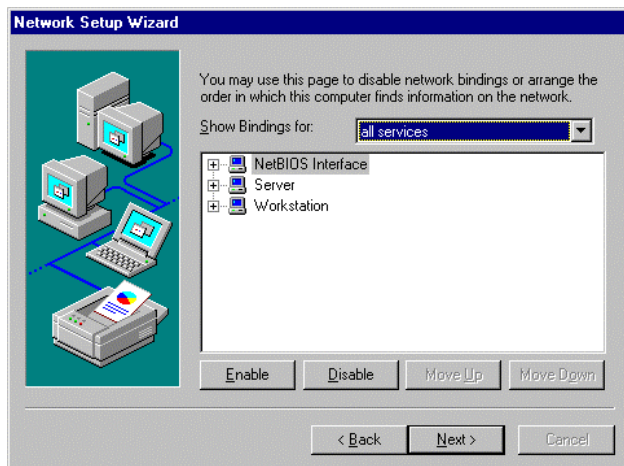
> ➤ Do **not** change the settings and click on "Next".
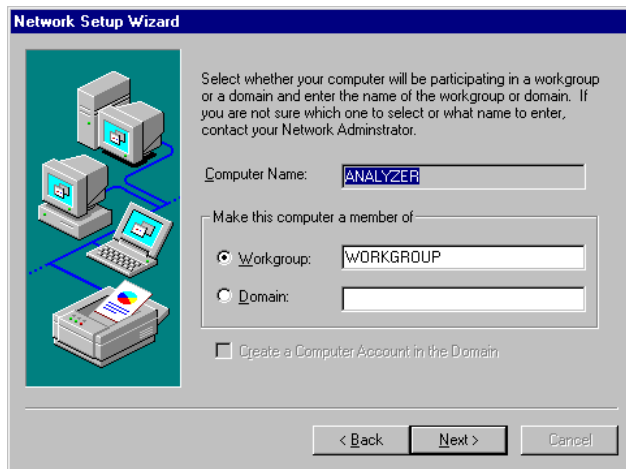
➢ The preselected computer and workgroup names "ANALYZER" and "WORKGROUP" can be confirmed using "NEXT".

Note:
In Windows networks, the computer name must be unique.
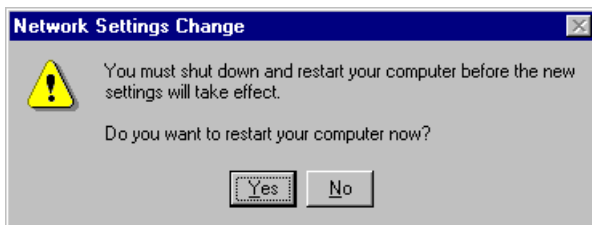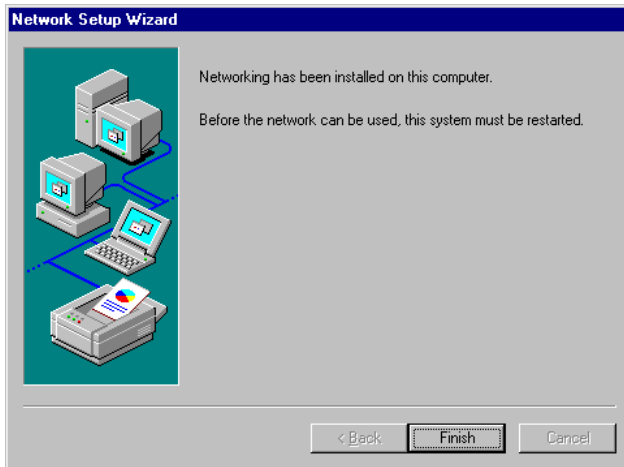
➢ Terminate the installation by clicking on "Finish".

➢ Answer the prompt "You must shutdown..." with "No", since the "Service Pack 5" of Windows NT must be reinstalled after the installation of the driver software. (see chapter 1, section "Computer Function - "Installing the Windows NT Software ")

Notes:

➢ *It is not necessary to install the Service Pack 5 if the instrument is equipped with the B20 option.*

➢ *If the service pack is not installed although there is no B20 option, the following error message will be displayed: "At least one service or driver failed during system startup..."* ***In this case, the network installation is not fully operational.***
To prevent faults, it is therefore indispensable to reinstall the service pack (see chapter 1, section "Computer Function – Installing the Windows NT Software").

Examples of Configurations

Network	Protocols	Services	Notes
NOVELL Netware	NWLink IPX/SPX Compatible Transport	Client Service for NetWare	In folder "Protocols - Properties", the frame type used in the network is to be set.
IP Networks (FTP, TELNET, WWW, GOPHER, etc)	TCP/IP Protocol	Simple TCP/IP Services	In folder "Protocols - Properties", an IP address that is unique in the network is to be set.
MICROSOFT Network	NetBEUI Protocol or TCP/IP Protocol	Workstation Server	In folder "Identification - Computer Name", a name that is unique in the network is to be entered.

Subsequent Changing of the Network Configuration (Computer Name etc)
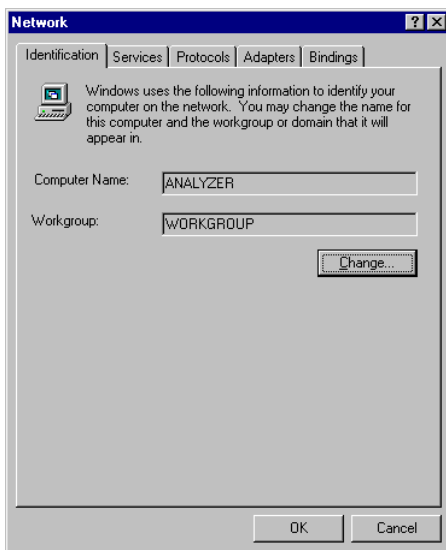
After completion of the installation, the computer name can be adapted as follows:

➢ Press the *SETUP* key.

The *SETUP* menu opens.

➢ Press softkey *GENERAL SETUP*.

The *GENERAL SETUP* menu opens.

➢ Press softkey *CONFIGURE NETWORK*.

The configuration menu "Network" for the network settings opens.

➢ Select folder "Identification".

Both entries can be changed in the submenu "Change".

The other settings can be changed after selecting the other folders. However, it is recommended to contact the network administrator before any changes.

Disabling the Autologin Mechanism

Upon delivery, the instrument is configured for automatic login into Windows NT. This mechanism must be disabled if the instrument is operated in a network, since the default user name ("instrument") and the password normally are not identical to those of the network account.

To disable the autologin mechanism, proceed as follows:

➢ Open the NT start menu by means of <CTRL><ESC>.
➢ Select the menu item "RUN". A dialog box opens.
➢ Enter the command "D:\USER\NO_AUTOLOGIN.REG" into the dialog box and confirm with <ENTER>.

The autologin mechanism is disabled. When the instrument is rebooted, a prompt for user name and password will appear before the instrument firmware is started.

Reenabling the Autologin Mechanism

To enable the autologin mechanism again, proceed as follows:

➢ Open the NT start menu by means of <CTRL><ESC>.
➢ Select the menu item "RUN". A dialog box opens.
➢ Enter the command "D:\USER\AUTOLOGIN.REG" into the dialog box and confirm with <ENTER>.

The autologin mechanism is reenabled and is active when the instrument is rebooted the next time.

Deinstallation of the Network Driver – Installation of the MS Loopback Adapter

If the instrument is to be operated without network connection for a limited or an unlimited period of time, the network card driver must be uninstalled or at least deactivated. It is not possible to uninstall the driver without installing another network driver on the analyzer, since this would impair the performance of the instrument.

For this reason, the network card driver is replaced by the "MS Loopback Adapter" (supplied with the instrument). This pseudo network driver simulates a network including network card and can, therefore, also be installed if the system does not contain a network card or if an existing network card is to be removed from the instrument.

Note:
The "MS Loopback Adapter" must be installed prior to removing the network card from the instrument. Otherwise there will be driver conflicts when the instrument is started the next time.

To install the MS Loopback Adapter, proceed as follows:
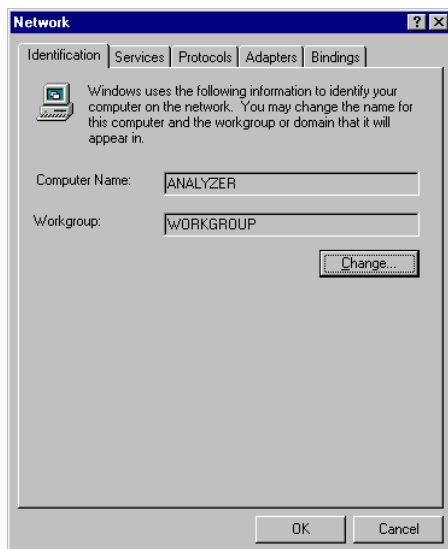
➢ Press the *SETUP* key.

    The *SETUP* menu opens.

➢ Press the *GENERAL SETUP* key.

    The *GENERAL SETUP* menu opens.

➢ Press the *CONFIGURE NETWORK* softkey.

    The configuration menu for the network settings ("Network") opens.

➢ Select the "Adapters" tab.
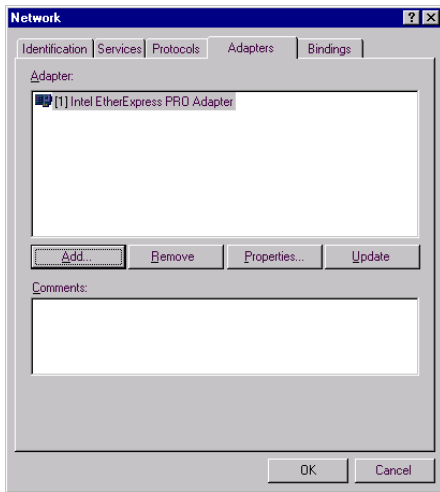
The active network driver is displayed.

➢ Click on *Add*.

The list indicating the available network drivers opens.
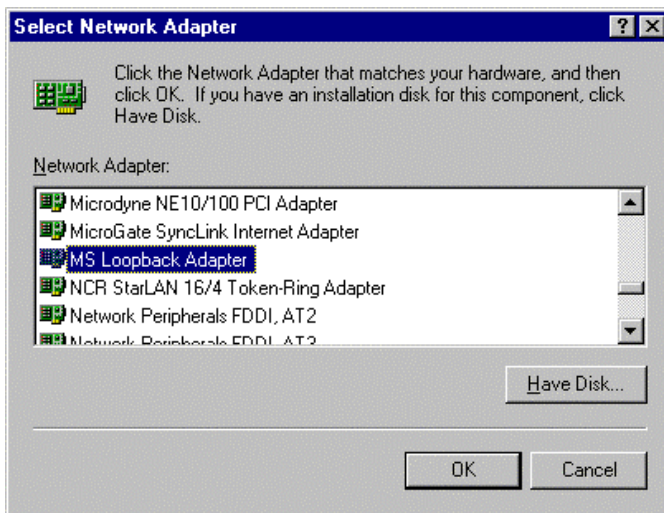
➢ Click on "MS Loopback Adapter" and confirm with "OK".

The OEM options selection appears.
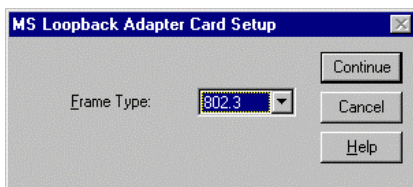
➢ Confirm "Frame Type 802.3" with "OK".
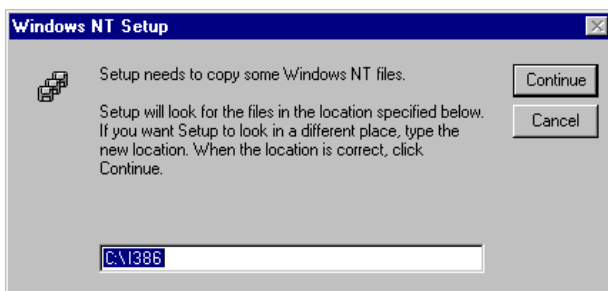
➢ Enter "C:\I386" as the drive and click on "Continue".
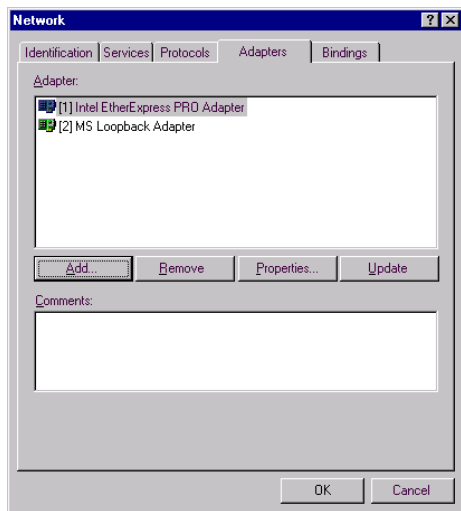
Afterwards the network drivers installed are displayed. You now have to uninstall the network driver for the network card:

➢ Select the Intel EtherExpress network driver.

➢ Click on *Remove*.

➢ Answer the confirmation query
   "This action will permanently remove the component from the system...
   Do you still wish to continue?"
   with "**YES**".

The network driver for the network card is removed.

➢ Use "Close" to leave the dialog.
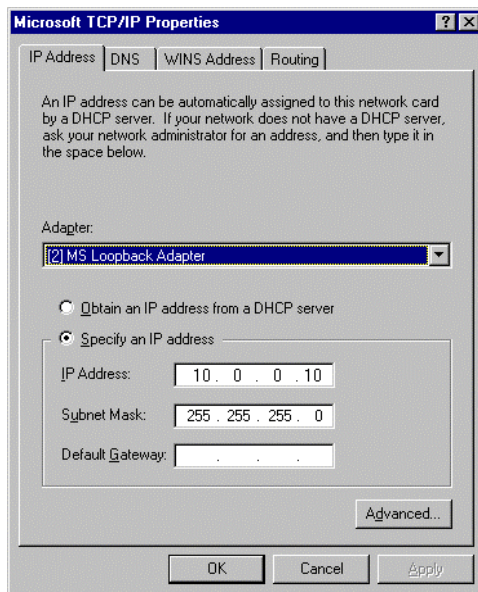
You are then requested to enter an IP address:

➢ Do not change the "Adapter" setting.
➢ Click on "Specify an IP address".
➢ Enter the following IP address and subnet mask:
   IP address: 10.0.0.10
   Subnet mask: 255.255.255.0
➢ Click on OK to leave the dialog.

 The restart request is displayed.
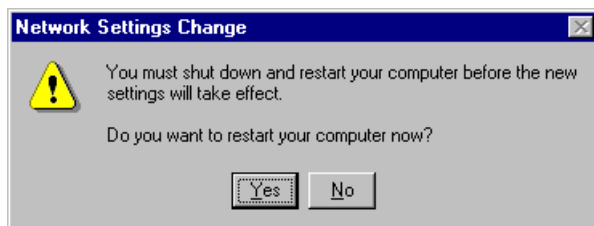
➢ Answer "You must shutdown..." with "No".

Afterwards the following steps have to be performed:

➢ To disable the start request for user and password, the autologin mechanism has to be enabled (see section "Reenabling the Autologin Mechanism") **before** the service pack is installed.

➢ The **Service Pack 5** of Windows NT must be reinstalled afterwards (see chapter 1, section "Computer Function – Installing the Windows NT Software").

➢ If the instrument is equipped with the firmware application FS-K3 (noise measurement software) or FS-K4 (phase measurement software), the modified IP address must also be entered in the configuration of these programs. See the relevant documentation for details.

Notes:

➢ *It is not necessary to install the Service Pack 5 if the instrument is equipped with the B20 option.*

➢ *If the service pack is not installed although there is no B20 option, the following error message will be displayed: "At least one service or driver failed during system startup..."* **In this case, the network installation is not fully operational.**
To prevent faults, it is therefore indispensable to reinstall the service pack (see chapter 1, section " Computer Function – Installing the Windows NT Software ").

Operating the Instrument on the Network

After the network support has been installed, it is possible to exchange data between the instrument and other computers and to use printers in the network.

A prerequisite to the network operation is the appropriate access rights for the required network resources. Resources may be file directories of other computers or also central printers.

Access rights can be obtained from the network or server administrator. In that respect it is necessary to obtain the network name of the resource as well as the corresponding access rights.

In order to avoid misuse, the resources are protected by passwords. Normally, every entitled user of the resources is assigned a user name that is also protected by a password. Resources can then be assigned to this user. It is possible to determine the type of data access, i.e. whether data can only be read or also written, as well as shared data access. Depending on the network operating system, different types of usage are possible.

NOVELL Networks

The operating system NETWARE from NOVELL is a server based system. Data cannot be exchanged between individual workstations; the data transfer takes place between the PC and a server. This server provides memory space and the connection to network printers. On a server, data are organized in directories as under DOS and mapped to the workstation as virtual drives. A virtual drive behaves like an additional hard disk on the workstation, and the data can be edited accordingly. Network printers can also be addressed like normal printers.

There are two versions of the NOVELL network operating system: bindary-based (NETWARE 3) and NDS-based (more recent versions of NETWARE). With the older version (NETWARE 3), each server manages its resources on its own and is independent. A user must be managed on each server separately. In the case of NDS-based versions, all resources in the network are managed together in the NDS (NOVELL DIRECTORY SERVICE). The user must log into the network only once and is given access to the resources according to his/her access rights. The individual resources and users are managed as objects in a hierarchical tree (NDS TREE). The position of the object in the tree is referred to as "CONTEXT" with NETWARE and must be known for access to the resources.

MICROSOFT Network

In case of a MICROSOFT network, data can be exchanged both between workstations (peer to peer) and between workstations and servers. The latter can supply access to files and connection to the printers. On a server, data are organized in directories as under DOS and mapped to the workstation as virtual drives. A virtual drive behaves like an additional hard disk on the workstation, and the data can be edited accordingly. Network printers can also be addressed like normal printers. A connection is possible to DOS, WINDOWS FOR WORKGROUPS, WINDOWS95, WINDOWS NT.

Defining Users

After the network driver software has been installed, the instrument will output an error message on the next power-on, as there is no user called "Instrument" (= user name for NT autologin) in the network. It is therefore necessary to define a common user for Windows NT and the network and to disable the autologin-mechanism subsequently.

The definition of new users in the network is done by the network administrator. For definition of a new user on the instrument, the User Manager is required:
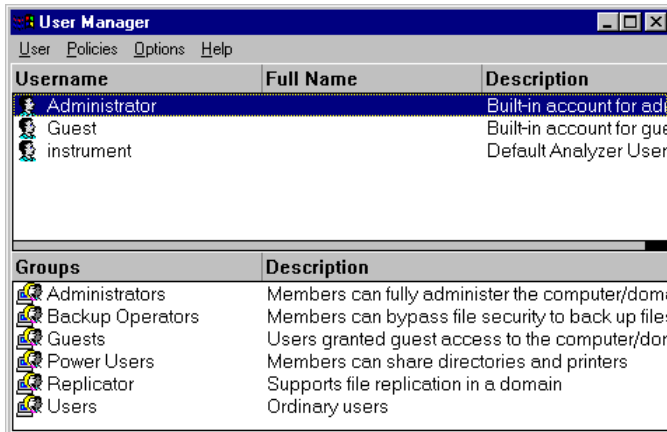
➢ Use the key combination <CTRL> <ESC> to call the Windows NT start menu.

➢ Click on "Programs", "Administrative Tools (Common)" and "User Manager" one after the other.

   The "User Manager" menu opens.

➢ Select User "instrument".

➢ Click on the "User" menu and select "Copy...".

   The menu for entering the user data will appear.
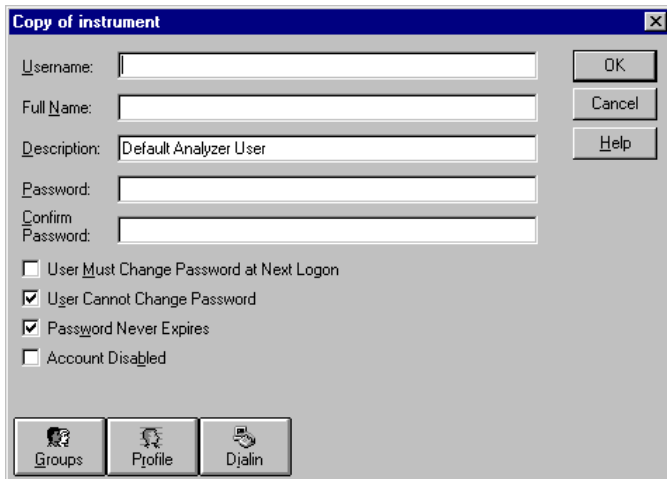
➢ Fill in the lines
   - "Username"
   - "Password and
   - "Confirm Password"

   and terminate the data entry with "OK".

   The user data must comply with the settings on the network.

Only NOVELL network:
Configure NOVELL Client

➢ Use the key combination <CTRL> <ESC> to call the Windows NT start menu.

➢ Click on "Settings", "Control Panel" and "CSNW" one after the other.

Bindary login (NOVELL 3.x)

➢ Click on "Preferred Server".

➢ Select the NOVELL server where the user is configured using "Select Preferred Server".

Client Service for NetWare

Username: Administrator

◉ Preferred Server

Current Preferred Server: <None>

Select Preferred Server: |<None>   ▾|

○ Default Tree and Context

Tree: [   ]

Context: [   ]

Print Options
☐ Add Form Feed
☑ Notify When Printed
☑ Print Banner

Login Script Options
☐ Run Login Script

[OK]
[Cancel]
[Help]
[Overview]
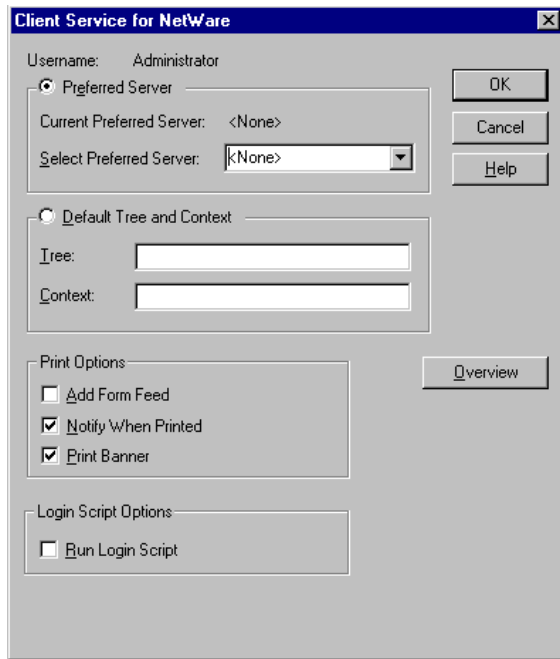
NDS login (more recent NOVELL versions)

➢ Click on "Default Tree and Context".

➢ Enter the NDS Tree under "Tree" and the hierarchical path where the user is defined under "Context".

Note: *This data can be obtained from the network administrator.*

Login in the Network

The user automatically logs into the network with the registration in the operating system. As a prerequisite, the user name and the password must be identical under Windows NT and on the network.

Disabling the Autologin Mechanism

Upon delivery, the instrument is configured for automatic login into Windows NT. This mechanism must be disabled if the instrument is operated in a network, since the default user name ("instrument") and the password normally are not identical to those of the network account.

To disable the autologin mechanism, proceed as follows:

➢ Open the NT start menu by means of <CTRL><ESC>.
➢ Select the menu item "RUN". A dialog box opens.
➢ Enter the command "D:\USER\NO_AUTOLOGIN.REG" into the dialog box and confirm with <ENTER>.

The autologin mechanism is disabled. When the instrument is rebooted, a prompt for user name and password will appear before the instrument firmware is started.

Reenabling the Autologin Mechanism

To enable the autologin mechanism again, proceed as follows:

➢ Open the NT start menu by means of <CTRL><ESC>.
➢ Select the menu item "RUN". A dialog box opens.
➢ Enter the command "D:\USER\AUTOLOGIN.REG" into the dialog box and confirm with <ENTER>.

The autologin mechanism is reenabled and is active when the instrument is rebooted the next time.

Using Network Drives
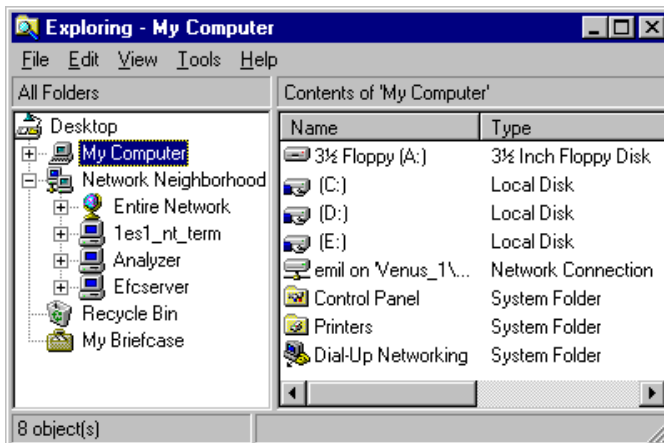
Mapping a network drive:

➢ Use the key combination <CTRL> <ESC> to call the Windows NT start menu.

➢ Click on "Programs", "Windows NT Explorer" one after the other.

➢ Click on the line "Network Neighborhood" in the overview "All Directories".

An overview of the available network drives is displayed.
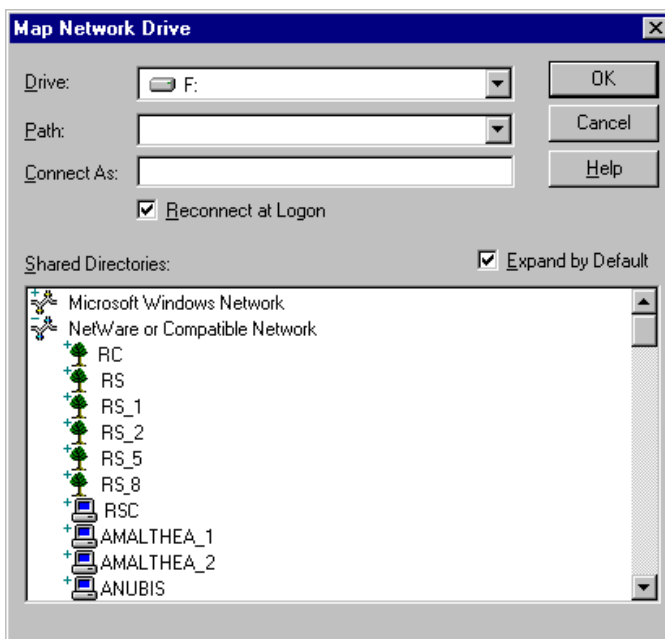
➢ Click on "Tools" and then "Map Network Drive".

The network paths available in the network are displayed in the overview "Shared Directories**:**".

➢ Mark the desired network path.
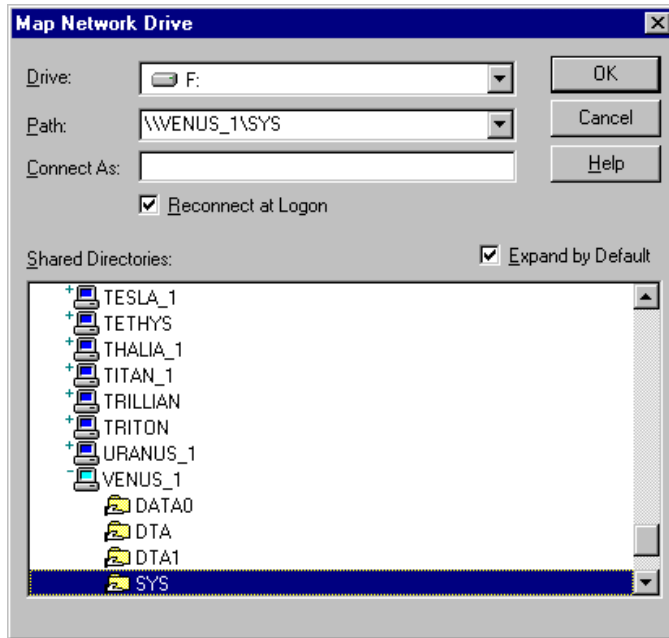
➢ Select the appropriate drive under "Drive:".

➢ Activate "Reconnect at Logon:" if the connection is to be set up automatically each time the instrument is started.

➢ Use "OK" to connect the network path with the selected drive.

   The user name and the password are queried. Then the drive will appear in the overview "All Directories" of the explorer.

Note: *Only drives in the network can be connected that the user has the appropriate access rights for.*
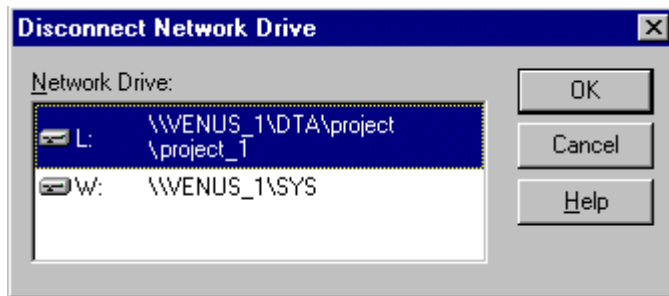
Disconnecting a network drive:

➢ Click on "Tools" in the Explorer and then "Disconnect Network Drive".

➢ Select the drive to be disconnected under "Network Drive:".

➢ Disconnect the drive using "OK". The security prompt must be answered with "Yes".

Printing on a Network Printer
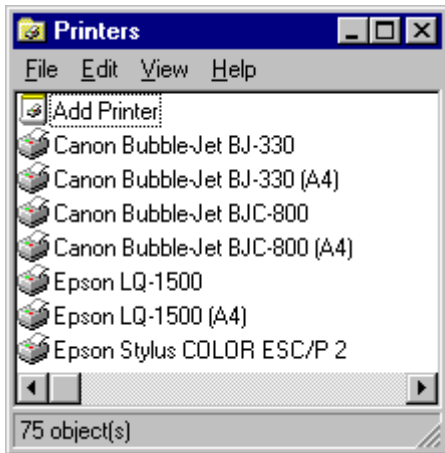
> Press the *HCOPY* key.
>
> The *HCOPY* menu opens.
>
> Press the *NEXT* key.
>
> The *HCOPY* submenu opens.
>
> Press the *INSTALL PRINTER* softkey.
>
> The printer window opens.
>
> Double-click on the line "Add Printer".
>
> The "Add Printer Wizard" window opens. It guides through the following printer driver installation.
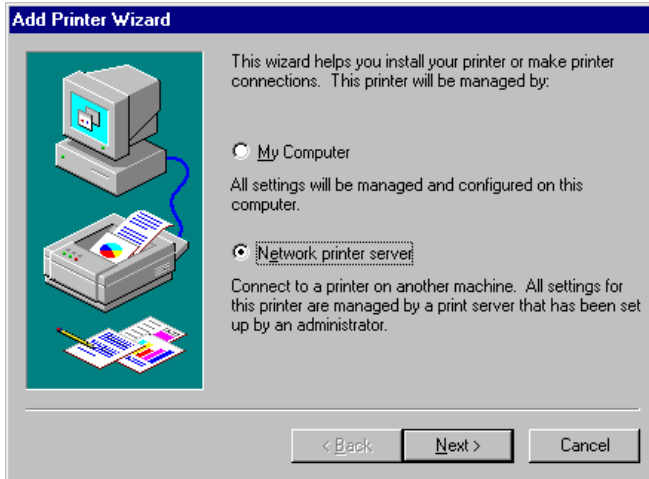
> Click on "Network Printer server" first and then on "Next".
>
> The choice of enabled printers appears.
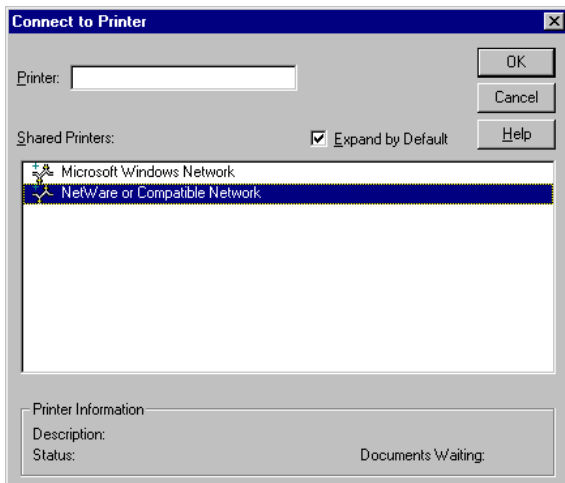
> Mark the printer and select using "OK".
>
> Confirm the following prompt to install a suitable printer driver using "OK".
>
> The choice of printer drivers appears. The left table shows the manufacturers, the right one the available printer drivers.
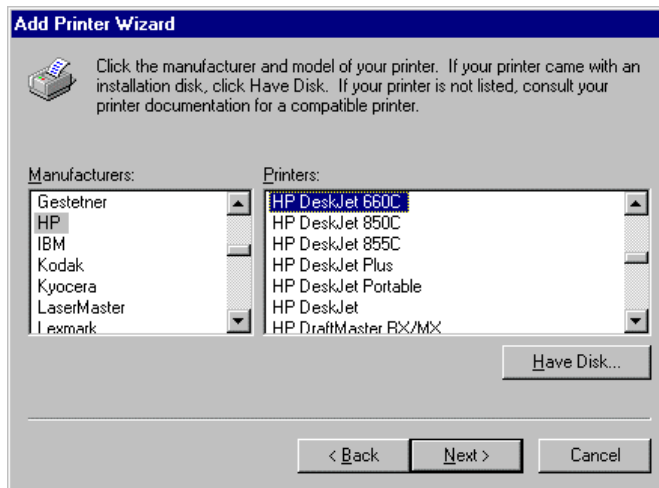
➢ Mark the manufacturer in the "Manufacturers" table and then the printer driver in the "Printers" table.

Note:
If the desired type of the output device does not appear in the list, the driver has not yet been installed on the instrument. In this case, click on the "HAVE DISK" button. A prompt appears, requesting the user to insert a disk with the respective printer driver. Then press "OK" and select the desired printer driver. After the installation, "Service Pack 5" must be reinstalled (see section "Installing the Windows NT Software")

➢ Click on "Next".

If one or more printers are already installed, this window will ask whether the just installed printer is to be selected as standard printer for the Windows NT applications (Do you want your Windows-based programs to use this printer as default printer?). "No" is set as default.

➢ Complete the installation of the printer driver by means of "Finish".

Note:
If the prompt to specify the path to the printer driver appears after clicking on "Finish", the Service Pack must be reinstalled after this printer installation (see Chapter 1, section "Computer Function - Installing the Windows NT Software").

Finally the instrument needs to be configured for use of the installed network printer using softkeys DEVICE 1 and DEVICE 2 in the Hardcopy Main Menu.

Remote Data Transfer with TCP/IP Services

The protocol TCP/IP allows the transfer of files between different computer systems. This requires a program running on the two computers that controls this data transfer. It is not necessary that the same operating or file system is used by both computers. For example, a file transfer between DOS/WINDOWS and UNIX is possible. One of the two partners must be configured as Host and the other one as Client. However, they may as well change their roles. Usually, the system which is able to perform several processes at the same time will play the host role. The file transfer program usually used under TCP/IP is FTP (File Transfer Protocol). An FTP host is installed as standard on the majority of UNIX systems.

If the TCP/IP services are installed, a terminal connection is possible using "Start" - "Programs" - "Accessories" - "Telnet" or a data transfer via FTP by means of "Start" - "Run" "ftp" - "OK". Thus all computer systems supporting these universal protocols can be addressed (UNIX, VMS, ...).

For further information please refer to the corresponding NT literature.

File Transfer via FTP

The total scope of functions and commands is described in the FTP literature. The following table therefore only contains the major functions:

Setting up the connection	Click on "Start" and then "Run" in the task bar
	The DOS command
	`FTP`
	starts the program.
	The command
	`OPEN <xx.xx.xx.xx>`
	sets up the connection.
	xx.xx.xx.xx = IP address e.g. 89.0.0.13
Data transfer	The command
	`PUT <dateiname>`
	transfers the data to the target system.
	The command
	`GET <dateiname>`
	transfers the data from the target system.
	The command
	`TYPE B`
	transfers the data in BINARY format, no conversion takes place.
	The command
	`TYPE A`
	transfers the data in ASCII format, converting control characters so that text files can also be read on the target system.
	Examples:
	`PUT C:\AUTOEXEC.BAT`
	sends the file `AUTOEXEC.BAT` to the target system.
	`LCD DATA`
	changes the current directory on the local machine to subdirectory `DATA`
	`CD SETTING`
	changes to the subdirectory `SETTING` on the target system
	dateiname= File name e.g. DATA.TXT

Changing the directories

The command
        LCD <path>
changes the directory on the local machine as with DOS.

The command
        LDIR
shows the directory contents on the local machine.

These commands refer to the file system of the FSP. If the L is omitted ahead of the commands, they apply to the target system.

RSIB Interface

The instrument is equipped with an RSIB interface as standard, which allows the instrument to be controlled by means of Visual C++ and Visual Basic programs, but also by means of the Windows applications WinWord and Excel as well as National Instruments LabView, LabWindows/CVI and Agilent VEE . The control applications run on an external computer in the network.

A Unix operating system can be installed on an external computer in addition to a Windows operating system. In this case, the control applications are created either in C or C++. The supported Unix operating systems include:

- Sun Solaris 2.6 Sparc Station
- Sun Solaris 2.6 Intel Platform
- Red Hat Linux 6.2 x86 Processors

Remote Control via RSIB Interface

Windows Environment

In order to be able to access the measuring instruments via the RSIB interface, the file `RSIB32.DLL` must be copied into the Windows `system32` directory or into the directory of the control applications. For 16-bit applications, the file `RSIB.DLL` must be additionally copied into the directories mentioned. The files RSIB.DLL and RSIB32.DLL are included on the instrument in directory D:\R_S\Instr\RSIB.

For the different programming languages there are files available that contain the declarations of the DLL functions and the definition of the error codes.

Visual Basic (16 bit):	`'RSIB.BAS'`	(D:\R_S\Instr\RSIB)
Visual Basic (32 bit):	`'RSIB32.BAS'`	(D:\R_S\Instr\RSIB)
C:/C++:	`'RSIB.H'`	(D:\R_S\Instr\RSIB)

For C/C++: programs, import libraries are additionally available.

Import library for RSIB.DLL:	`RSIB.LIB'`	(D:\R_S\Instr\RSIB)
Import library for RSIB32.DLL:	`RSIB32.LIB'`	(D:\R_S\Instr\RSIB)

The control is performed using the Visual C++ or Visual Basic programs WinWord, Excel, LabView, LabWindows/CVI or Agilent VEE. Every application that can load a DLL is able to use the RSIB interface. The programs use the IP address of the instrument or its *host name* to set up the connection.

.

Via VisualBasic: ud = RSDLLibfind ("82.1.1.200", ibsta, iberr, ibcntl)

Return to manual operation is possible via the front panel (*LOCAL* key) or via the RSIB interface:

Via RSIB: ud = RSDLLibloc (ud, ibsta, iberr, ibcntl);
                          or
                          ud = RSDLLibonl (ud, 0, ibsta, iberr, ibcntl);

Unix Environment

In order to access the measuring equipment via the RSIB interface, copy the `librsib.so.X.Y` file to a directory for which the control application has read rights. `X.Y` in the file name indicates the version number of the library, for example `1.0`.

The `librsib.so.X.Y` library is created as a *shared library*. The applications using the library need not consider its version. They simply link the library with the `lrsib` option. The following instructions have to be observed so that linking can be successfully performed and the library can be found during program execution:

File link:

- Use the operating system command *ln* to create a file with the link name `librsib.so` and pointing to `librsib.so.X.Y` in a directory for which the control application has read rights. Example:

      $ ln –s /usr/lib/librsib.so.1.0 /usr/lib/librsib.so

Linker options for creating applications:

- `-lrsib` : import library

- `-Lxxx` : path information where the import library can be found. This is where the above file link has been created. Example: `-L/usr/lib`.

Additional linker options for creating applications (only under Solaris):

- `-Rxxx`: path information where the library is searched for during the program run: `-R/usr/lib`.

Run-time environment:

- Set environment variable `LD_RUN_PATH` to the directory in which the file link has been created. This is necessary only if `librsib.so` cannot be found in the standard search path of the operating system and the `-R` linker option (only Solaris) was not specified.

For C/C++ programming, the declarations of the library functions and the definition of error codes are contained in:

C/C++:   'RSIB.H'   (D:\R_S\Instr\RSIB)

RSIB Interface Functions

This chapter lists all functions of the DLL `"RSIB.DLL" or "RSIB32.DLL"` or `"librsib.so"`, which allow to produce control applications.

Overview of Interface Functions

The library functions are adapted to the interface functions of National Instruments for GPIB programming. The functions supported by the libraries are listed in the following table.

Function	Description
RSDLLibfind()	Provides a handle for access to a device.
RSDLLibwrt()	Sends a zero-terminated string to a device.
RSDLLilwrt()	Sends a certain number of bytes to a device.
RSDLLibwrtf()	Sends the contents of a file to a device.
RSDLLibrd()	Reads data from a device into a string.
RSDLLilrd()	Reads a certain number of bytes from a device.
RSDLLibrdf()	Reads data from a device into a file.
RSDLLibtmo()	Sets timeout for RSIB functions
RSDLLibsre()	Switches a device into the local or remote state
RSDLLibloc()	Temporarily switches a device into the local state
RSDLLibeot()	Enables/disables the END message for write operations.
RSDLLibrsp()	Performs a serial poll and provides the status byte.
RSDLLibonl()	Sets the device online/offline.
RSDLLTestSrq()	Checks whether a device has generated an SRQ.
RSDLLWaitSrq()	Waits until a device generates an SRQ.
RSDLLSwapBytes	Swaps the byte sequence for binary numeric display (only required for non-Intel platforms)

Variables ibsta, iberr, ibcntl

As with the National Instrument interface, the successful execution of a command can be checked by means of the variables ibsta, iberr and ibcntl. For this purpose, all RSIB functions are assigned references to these three variables.

Status word - ibsta
The status word ibsta provides information on the status of the RSIB interface. The following bits are defined:

Bit designation	Bit	Hex code	Description
ERR	15	8000	Is set when an error has occurred on calling a function. If this bit is set, iberr contains an error code which specifies the error in greater detail.
TIMO	14	4000	Is set when a timeout has occurred on calling a function.
CMPL	8	0100	Is set if the response of the GPIB parser has been read out completely. If a parser response is read out with the function RSDLLilrd() and the length of the buffer is insufficient for the answer, the bit will be cleared.

Error variable - iberr
If the ERR bit (8000h) is set in the status word, iberr contains an error code which allows to specify the error in greater detail. Extra error codes are defined for the RSIB interface, independent of the National Instruments interface.

Error	Error code	Description
IBERR_CONNECT	2	Setup of the connection to the measuring instrument has failed.
IBERR_NO_DEVICE	3	A function of the interface has been called with an illegal device handle.
IBERR_MEM	4	No empty memory available
IBERR_TIMEOUT	5	Timeout has occurred.
IBERR_BUSY	6	The RSIB interface is blocked by a still running function.
IBERR_FILE	7	Error when reading or writing to a file.
IBERR_SEMA	8	Error upon creating or assigning a semaphore (only under Unix)

Count variable - ibcntl
The variable ibcntl is updated with the number of transferred bytes each time a read or write function is called.

Description of Interface Functions

RSDLLibfind()

The function provides a handle for access to the device with the name `udName`.

VB format:	Function RSDLLibfind (ByVal udName$, ibsta%, iberr%, ibcntl&) As Integer
C-format:	short WINAPI RSDLLibfind(char far *udName, short far *ibsta, short far *iberr, unsigned long far *ibcntl)
C format (Unix):	short RSDLLibfind(char *udName, short *ibsta, short *iberr, unsigned long *ibcntl)
Parameter:	udName IP address of device
Example:	ud = RSDLLibfind ("89.10.38.97", ibsta, iberr, ibcntl)

The function must be called prior to all other functions of the interface.

As return value, the function provides a handle that must be indicated in all functions for access to the device. If the device with the name `udName` is not found, the handle has a negative value.

RSDLLibwrt

This function sends data to the device with the handle `ud`.

VB format:	Function RSDLLibwrt (ByVal ud%, ByVal Wrt$, ibsta%, iberr%, ibcntl&) As Integer
C format:	short WINAPI RSDLLibwrt(short ud, char far *Wrt, short far *ibsta, short far *iberr, unsigned long far *ibcntl)
C format (Unix):	short RSDLLibwrt(short ud, char *Wrt, short *ibsta, short *iberr, unsigned long *ibcntl)
Parameter:	ud Device handle
	Wrt String sent to the device.
Example:	RSDLLibwrt(ud, "SENS:FREQ:STAR?", ibsta, iberr, ibcntl)

This function allows to send setting and query commands to the measuring instruments. Whether the data is interpreted as a complete command can be set using the function `RSDLLibeot()`.

RSDLLilwrt

This function sends `Cnt` bytes to a device with the handle `ud`.

VB format:	Function RSDLLilwrt (ByVal ud%, ByVal Wrt$, ByVal Cnt&, ibsta%, iberr%, ibcntl&) As Integer
C format:	short WINAPI RSDLLilwrt(short ud, char far *Wrt, unsigned long Cnt, short far *ibsta, short far *iberr, unsigned long far *ibcntl)
C format (Unix):	short RSDLLilwrt(short ud, char *Wrt, unsigned long Cnt, short *ibsta, short *iberr, unsigned long *ibcntl)
Parameter:	ud Device handle
	Wrt String sent to the GPIB parser.
	Cnt Number of bytes sent to the device.
Example:	RSDLLilwrt (ud, '......', 100, ibsta, iberr, ibcntl)

Like `RSDLLibwrt()` this function sends data to a device. The only difference is that binary data can be sent as well. The length of the data is not determined by a zero-terminated string, but by the indication of `Cnt` bytes. If the data is to be terminated with EOS (0Ah), the EOS byte must be appended to the string.

RSDLLibwrtf

This function sends the contents of a file `file$` to the device with the handle `ud`.

VB format:	`Function RSDLLibwrtf (ByVal ud%, ByVal file$, ibsta%, iberr%, ibcntl&) As Integer`
C format:	`short WINAPI RSDLLibwrt( short ud, char far *Wrt, short far *ibsta, short far *iberr, unsigned long far *ibcntl )`
C format (Unix):	`short RSDLLibwrt( short ud, char *Wrt, short *ibsta, short *iberr, unsigned long *ibcntl )`

Parameter:	`ud`	Device handle
	`file`	File the contents of which are sent to the device.
Example:	`RSDLLibwrtf(ud, "C:\db.sav", ibsta, iberr, ibcntl)`	

This function allows to send setting and query commands to the measuring instruments. Whether the data is interpreted as complete command can be set using the function `RSDLLibeot()`.

RSDLLibrd()

The function reads data from the device with the handle `ud` into the string `Rd`.

VB format:	`Function RSDLLibrd (ByVal ud%, ByVal Rd$, ibsta%, iberr%, ibcntl&) As Integer`
C format:	`short WINAPI RSDLLibrd( short ud, char far *Rd, short far *ibsta, short far *iberr, unsigned long far *ibcntl )`
C format (Unix):	`short RSDLLibrd( short ud, char *Rd, short *ibsta, short *iberr, unsigned long *ibcntl )`

Parameter:	`ud`	Device handle
	`Rd`	String into which the read data is copied.
Example:	`RSDLLibrd (ud, Rd, ibsta, iberr, ibcntl)`	

This function fetches the responses of the GPIB parser to a query.

In the case of Visual Basic programming, a string of sufficient length must be generated before. This can be done during the definition of the string or using the command `Space$()`.

Generation of a string of the length 100:
- `Dim Rd as String * 100`
- `Dim Rd as String`
  `Rd = Space$(100)`

RSDLLilrd

This function reads `Cnt` bytes from the device with the handle `ud`.

VB format:	`Function RSDLLilrd (ByVal ud%, ByVal Rd$, ByVal Cnt&, ibsta%, iberr%, ibcntl&) As Integer`
C format:	`short WINAPI RSDLLilrd( short ud, char far *Rd, unsigned long Cnt, short far *ibsta, short far *iberr, unsigned long far *ibcntl )`
C format (Unix):	`short RSDLLilrd( short ud, char *Rd, unsigned long Cnt, short *ibsta, short *iberr, unsigned long *ibcntl )`

Parameter:	`ud`	Device handle
	`cnt`	Maximum number of bytes copied from the DLL into the target string `Rd`.
Example:	`RSDLLilrd (ud, RD, 100, ibsta, iberr, ibcntl)`	

Like the function `RSDLLibrd()`, this function reads data from a device. The only difference is that in this case the maximum number of bytes to be copied into the target string `Rd` can be indicated by means of `Cnt`. This function prevents writing beyond the end of the string.

RSDLLibrdf()

Reads data from the device with the handle ud into the file file.

VB format: `Function RSDLLibrdf (ByVal ud%, ByVal file$, ibsta%, iberr%, ibcntl&) As Integer`

C format: `short WINAPI RSDLLibrd( short ud, char far *file, short far *ibsta, short far *iberr, unsigned long far *ibcntl )`

C format (Unix): `short RSDLLibrd( short ud, char *file, short *ibsta, short *iberr, unsigned long *ibcntl )`

Parameter: ud   Device handle
file   File into which the read data is written.

Example: `RSDLLibrdf (ud, "c:\db.sav", ibsta, iberr, ibcntl)`

The file name may as well include a drive or path specification.

RSDLLibtmo

This function defines the timeout for a device. The default value for the timeout is set to 5 seconds.

VB format: `Function RSDLLibtmo (ByVal ud%, ByVal tmo%, ibsta%, iberr%, ibcntl&) As Integer`

C format: `void WINAPI RSDLLibtmo( short ud, short tmo, short far *ibsta, short far *iberr, unsigned long far *ibcntl )`

C format (Unix): `short RSDLLibtmo( short ud, short tmo, short *ibsta, short *iberr, unsigned long *ibcntl )`

Parameter: ud   Device handle
tmo   Timeout in seconds

Example: `RSDLLibtmo (ud, 10, ibsta, iberr, ibcntl)`

RSDLLibsre

This function sets the device to the 'LOCAL' or 'REMOTE' state.

VB format: `Function RSDLLibsre (ByVal ud%, ByVal v%, ibsta%, iberr%, ibcntl&) As Integer`

C format: `void WINAPI RSDLLibsre( short ud, short v, short far *ibsta, short far *iberr, unsigned long far *ibcntl)`

C format (Unix): `short RSDLLibsre( short ud, short v, short *ibsta, short *iberr, unsigned long *ibcntl)`

Parameter: ud   Device handle
v   State of device

                  0 - local

                  1 - remote

Example: `RSDLLibsre (ud, 0, ibsta, iberr, ibcntl)`

RSDLLibloc

This function temporarily switches the device to the 'LOCAL' state.

VB format:	`Function RSDLLibloc (ByVal ud%, ibsta%, iberr%, ibcntl&) As Integer`
C format:	`void WINAPI RSDLLibloc( short ud, short far *ibsta, short far *iberr, unsigned long far *ibcntl)`
C format (Unix):	`short RSDLLibloc( short ud, short *ibsta, short *iberr, unsigned long *ibcntl)`
Parameter:	`ud` Device handle
Example:	`RSDLLibloc (ud, ibsta, iberr, ibcntl)`

After switchover to LOCAL state, the instrument can be manually operated via the front panel. On the next access to the instrument by means of one of the functions of the library the instrument is switched again to the REMOTE state.

RSDLLibeot

This function enables or disables the END message after write operations.

VB format:	`Function RSDLLibeot (ByVal ud%, ByVal v%, ibsta%, iberr%, ibcntl&) As Integer`
C format:	`void WINAPI RSDLLibsre( short ud, short v, short far *ibsta, short far *iberr, unsigned long far *ibcntl)`
C format (Unix):	`short RSDLLibsre( short ud, short v, short *ibsta, short *iberr, unsigned long *ibcntl)`
Parameter:	`ud` Device handle.
	`v` 0 - no END message
	1 – send END message
Example:	`RSDLLibeot (ud, 1, ibsta, iberr, ibcntl)`

If the END message is disabled, the data of a command can be sent with several successive calls of write functions. The END message must be enabled again before sending the last data block.

RSDLLibrsp

This function performs a serial poll and provides the status byte of the device.

VB format:	`Function RSDLLibrsp(ByVal ud%, spr%, ibsta%, iberr%, ibcntl&) As Integer`
C format:	`void WINAPI RSDLLibrsp( short ud, char far* spr, short far *ibsta, short far *iberr, unsigned long far *ibcntl)`
C format (Unix):	`short RSDLLibrsp( short ud, char *spr, short *ibsta, short *iberr, unsigned long *ibcntl)`
Parameter:	`ud` Device handle
	`spr` Pointer to status byte
Example:	`RSDLLibrsp(ud, spr, ibsta, iberr, ibcntl)`

RSDLLibonl

This function switches the device to 'online' or 'offline' mode. When it is switched to 'offline' mode, the interface is released and the device handle becomes invalid. By calling RSDLLibfind again, the communication is set up again.

VB format:	`Function RSDLLibonl (ByVal ud%, ByVal v%, ibsta%, iberr%,` `ibcntl&) As Integer`
C format:	`void WINAPI RSDLLibonl( short ud, short v, short far *ibsta,` `short far *iberr, unsigned long far *ibcntl)`
C format:	`short RSDLLibonl( short ud, short v, short *ibsta, short` `*iberr, unsigned long *ibcntl)`
Parameter:	ud Device handle
	v Device state
	0 - local
	1 - remote
Example:	`RSDLLibonl(ud, 0, ibsta, iberr, ibcntl)`

RSDLLTestSRQ

This function checks the status of the SRQ bit.

VB format:	`Function RSDLLTestSrq (ByVal ud%, Result%, ibsta%, iberr%,` `ibcntl&) As Integer`
C format:	`void WINAPI RSDLLTestSrq( short ud, short far *result, short` `far *ibsta, short far *iberr, unsigned long far *ibcntl)`
C format (Unix):	`short RSDLLTestSrq( short ud, short *result, short *ibsta,` `short *iberr, unsigned long *ibcntl)`
Parameter:	ud Device handle
	result Reference to an integer value in which the library returns the status of the SRQ bit.
	0 - no SRQ
	1 - SRQ active, device requests service
Example:	`RSDLLTestSrq (ud, result%, ibsta, iberr, ibcntl)`

This function corresponds to the function `RSDLLWaitSrq`. The only difference is that `RSDLLTestSRQ` immediately returns the current status of the SRQ bit, whereas `RSDLLWaitSrq` waits for an SRQ to occur.

RSDLLWaitSrq

This function waits until the device triggers an SRQ with the handle ud.

VB format: `Function RSDLLWaitSrq (ByVal ud%, Result%, ibsta%, iberr%, ibcntl&) As Integer`

C format: `void WINAPI RSDLLWaitSrq( short ud, short far *result, short far *ibsta, short far *iberr, unsigned long far *ibcntl)`

C format (Unix): `short RSDLLWaitSrq( short ud, short *result, short *ibsta, short *iberr, unsigned long *ibcntl)`

Parameter: ud   Device handle

                  result   Reference to an integer value in which the library returns the status of the SRQ bit.

                                  0 - No SRQ has occurred during the timeout

                                  1 - SRQ has occurred during the timeout

Example: `RSDLLWaitSrq( ud, result, ibsta, iberr, ibcntl );`

The function waits until one of the following two events occurs.

- The measuring instrument triggers an SRQ
- No SRQ occurs during the timeout defined with `RSDLLibtmo()`

RSDLLSwapBytes

This function changes the display of binary numbers on non-Intel platforms.

VB format: Not provided at present since it is required only on non-Intel platforms.

C format: `void WINAPI RSDLLSwapBytes( void far *pArray, const long size, const long count)`

C format (Unix): `void RSDLLSwapBytes( void *pArray, const long size, const long count)`

Parameter: pArray   Array in which modifications are made
                  size   Size of a single element in pArray
                  count   Number of elements in pArray

Example: `RSDLLSwapBytes( Buffer, sizeof(float), ibcntl/sizeof(float))`

This function swaps the display of various elements from *Big Endian* to *Little Endian* and vice versa. It is expected that a coherent storage area of elements of the same file type (size byte) is transferred to pArray. This function has no effect on Intel platforms.

Different types of processor architecture store data in different byte sequences. For example, Intel processors store data in the reverse order of Motorola processors. Comparison of byte sequences:

Byte sequence	Use in	Display in memory	Description
Big Endian	Motorola processors, network standard	Most significant byte at least significant address	The *most significant* byte is at the left end of the word.
Little Endian	Intel processors	Least significant byte at least significant address	The *most significant* byte is at the right end of the word.

Programming via the RSIB Interface

Visual Basic

Programming hints:

- Access to the functions of the RSIB.DLL

  To create Visual Basic control applications, the file RSIB.BAS must be added to a project for 16-bit Basic programs and the file RSIB32.BAS for 32-bit Basic programs (D:\R_S\INSTR\RSIB) so that the functions of the RSIB.DLL or RSIB32.DLL can be accessed.

- Generating a response buffer

  Prior to calling the functions `RSDLLibrd()` and `RSDLLilrd()`, a string of sufficient length must be generated. This is possible either by defining the string or using the command `Space$()`.
  Generating a string of the length 100:   – `Dim Response as String * 100`

                                                        – `Dim Response as String`
                                                          `Response = Space$(100)`

  If a response is to be output as a string from the measuring instrument, the appended blanks can be removed using the Visual Basic Function RTrim().

  Example:
  ```
  Response = Space$(100)
  Call RSDLLibrd(ud, Response, ibsta, iberr, ibcntl)
  Response = RTrim(Response)
  ' Output of Response
  ```

- Reading out trace data in real format

  Using the function declarations in the file RSIB.BAS or RSIB32.BAS the responses of the device can be assigned to one string only. If the data are to be read into an array with float values, the header and the useful data must be read out with separate function calls.

  Example of a header
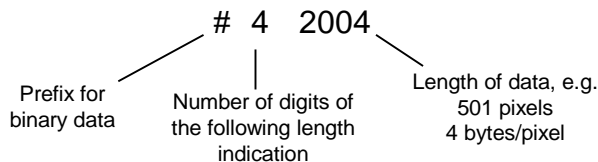
  In order to enable the trace data to be directly read into a float array, a special function declaration must be created.

  ```
  Declare Function RSDLLilrdTraceReal Lib "rsib32.dll" Alias "RSDLLilrd"
  (ByVal ud%, Rd As Single, ByVal Cnt&, ibsta%, iberr%, ibcntl&) As Integer
  ```

Example:

```
Dim ibsta As Integer          ' Status variable
Dim iberr As Integer          ' Error variable
Dim ibcntl As Long            ' Count variable
Dim ud As Integer             ' Handle for measuring instrument
Dim Result As String          ' Buffer for simple results
Dim Digits As Byte            ' Number of digits of length indication
Dim TraceBytes As Long        ' Length of trace data in bytes
Dim TraceData(501) As Single  ' Buffer for floating point
                              ' Binary data

' Set up connection to instrument
ud = RSDLLibfind("89.10.38.97", ibsta, iberr, ibcntl)

' Query trace data in real format
Call RSDLLibwrt(ud, "FORM:DATA REAL,32", ibsta, iberr, ibcntl)
Call RSDLLibwrt(ud, "TRACE? TRACE1", ibsta, iberr, ibcntl)

'Read number of digits of length indication
Result = Space$(20)
Call RSDLLilrd(ud, Result, 2, ibsta, iberr, ibcntl)
Digits = Val(Mid$(Result, 2, 1))

'Read length indication
Result = Space$(20)
Call RSDLLilrd(ud, Result, Digits, ibsta, iberr, ibcntl)
TraceBytes = Val(Left$(Result, Digits))     'and store

' Read out trace data
Call RSDLLilrdTraceReal(ud, TraceData(0), TraceBytes, ibsta, iberr,ibcntl)
```

Programming examples:

- In this example, the start frequency of the instrument is queried.

```
Dim ibsta As Integer     ' Status variable
Dim iberr As Integer     ' Error variable
Dim ibcntl As Long       ' Count variable
Dim ud As Integer        ' Handle for measuring instrument
Dim Response As String   ' Response string

' Set up connection to measuring instrument
ud = RSDLLibfind("89.10.38.97", ibsta, iberr, ibcntl)
If (ud < 0) Then
    ' Error treatment
End If

' Send query command
Call RSDLLibwrt(ud, "FREQ:START?", ibsta, iberr, ibcntl)

' Provide space for response
Response = Space$(100)

' Read response from measuring instrument
Call RSDLLibrd(ud, Response, ibsta, iberr, ibcntl)
```

- In this example, a Save/Recall of the instrument setups is performed.

```
Dim ibsta As Integer    ' Status variable
Dim iberr As Integer    ' Error variable
Dim ibcntl As Long      ' Count variable
Dim ud As Integer       ' Handle for measuring instrument
Dim Cmd As String       ' Command string

' Set up connection to measuring instrument
ud = RSDLLibfind("89.10.38.97", ibsta, iberr, ibcntl)
If (ud < 0) Then
    ' Error treatment
End If

' Request instrument settings
Cmd = "SYST:SET?"
Call RSDLLibwrt(ud, Cmd, ibsta, iberr, ibcntl)

' Store instrument response in file
Call RSDLLibrdf(ud, "C:\db.sav", ibsta, iberr, ibcntl)

' Reset instrument
Call RSDLLibwrt(ud, "*RST", ibsta, iberr, ibcntl)

' and restore the previous settings
' to this end disable the END message
Call RSDLLibeot(ud, 0, ibsta, iberr, ibcntl)
' first send off command
Call RSDLLibwrt(ud, "SYST:SET ", ibsta, iberr, ibcntl)
' enable the END message again
Call RSDLLibeot(ud, 1, ibsta, iberr, ibcntl)
' and send the data
Call RSDLLibwrtf(ud, "C:\db.sav", ibsta, iberr, ibcntl)
```

Visual Basic for Applications (Winword and Excel)

Programming hints:

The programming language Visual Basic for Applications (VBA) is supported as a macro language by various manufacturers. The programs Winword and Excel use this language for the versions Winword 97 or Excel 5.0 and higher.
For macros created with Visual Basic for Applications, the same hints are valid as for Visual Basic Applications.

Programming example:

- Using the macro `QueryMaxPeak` a single sweep with subsequent query of the maximum peak is performed. The result is entered in a Winword or Excel document.

```
Sub QueryMaxPeak()

    Dim ibsta As Integer      ' Status variable
    Dim iberr As Integer      ' Error variable
    Dim ibcntl As Long        ' transferred characters
    Dim ud As Integer         ' Unit Descriptor (handle)for instrument
    Dim Response As String    ' Response string

    ' Set up connection to measuring instrument
    ud = RSDLLibfind("89.10.38.97", ibsta, iberr, ibcntl)
    If (ud < 0) Then
      Call MsgBox("Device with address 89.10.38.97 could" & _
                  "not be found", vbExclamation)
      End
    End If

    ' Determine maximum peak in the range 1-2MHZ
    Call RSDLLibwrt(ud, "*RST", ibsta, iberr, ibcntl)
    Call RSDLLibwrt(ud, "INIT:CONT OFF", ibsta, iberr, ibcntl)
    Call RSDLLibwrt(ud, "FREQ:START 1MHZ", ibsta, iberr, ibcntl)
    Call RSDLLibwrt(ud, "FREQ:STOP 2MHZ", ibsta, iberr, ibcntl)
    Call RSDLLibwrt(ud, "INIT:IMM;*WAI", ibsta, iberr, ibcntl)
    Call RSDLLibwrt(ud, "CALC:MARK:MAX;Y?", ibsta, iberr, ibcntl)
    Response = Space$(100)
    Call RSDLLibrd(ud, Response, ibsta, iberr, ibcntl)
    Response = RTrim(Response) ' Cut off space

    ' Insert value in current document (Winword)
    Selection.InsertBefore (Response)
    Selection.Collapse (wdCollapseEnd)

    ' Terminate connection to measuring instrument
    Call RSDLLibonl(ud, 0, ibsta, iberr, ibcntl)

End Sub
```

The entry of the peak value in the Winword document can be replaced as follows for Excel:

```
    ' Insert value in current document (Excel)
    ActiveCell.FormulaR1C1 = Response
```

C / C++

Programming hints:

- Access to the functions of the RSIB32.DLL (Windows platforms)

  The functions of the `RSIB32.DLL` are declared in the header file `RSIB.H`. The DLL functions can be linked to a C/C++ program in different ways.

  1. Enter one of the supplied import libraries (`RSIB.LIB or RSIB32.LIB`) into the linker options.

  2. Load the library using the function `LoadLibrary()` during runtime and determine the function pointers of the DLL functions using `GetProcAddress()`. Before the end of the program, the `RSIB.DLL` must be unloaded again using the function `FreeLibrary()`.

  When import libraries are used, the DLL is automatically loaded immediately before the application is started. At the end of the program, the DLL is unloaded again unless it is still used by other applications.

- Access to librsib.so functions (Unix platforms)

  The functions of `librsib.so` are declared in the header file `RSIB.H`. Upper/lower case characters for file names are typically observed under Unix. The library functions are linked to a C/C++ program by entering the `-lrsib` linker option.

  The *shared library* `librsib.so` is automatically loaded on starting the application. The accessibility (for example via standard path) of the library must be ensured. Refer to the beginning of this main chapter under „Unix Environment".

- Query of strings

  If instrument responses are to be further processed as strings, a zero termination must be appended.

  Example:
  ```
  char buffer[100];
  ...
  RSDLLibrd( ud, buffer, &ibsta, &iberr, &ibcntl );
  buffer[ibcntl] = 0;
  ```

Programming example:

In the following C program example, a single sweep is started on the device with the IP address 89.10.38.97 and subsequently a marker is set to maximum level. Prior to the search for maximum, a synchronization to the end of the sweep is performed. For this purpose the command `"*OPC"` (Operation complete) is used to create a service request at the end of the sweep, for which the control program waits with the function `RSDLLWaitSrq()`. Then the maximum is determined (`"CALC:MARK:MAX"`) and the level read out (`"Y?"`).

```c
#define MAX_RESP_LEN 100

short          ibsta, iberr;
unsigned long  ibcntl;
short          ud;
short          srq;
char           MaxPegel[MAX_RESP_LEN];
char           spr;

// Determine handle for instrument
ud = RSDLLibfind( "89.10.38.97", &ibsta, &iberr, &ibcntl );

// if instrument exists
if ( ud >= 0 )
{
  // Set timeout for RSDLLWaitSrq() to 10 seconds
  RSDLLibtmo( ud, 10, &ibsta, &iberr, &ibcntl );

  // Activate SRQ generation via event status register (ESR)
  // and enable ESB bit in SRE register
  RSDLLibwrt( ud, "*ESE 1;*SRE 32", &ibsta, &iberr, &ibcntl );

  // Set single sweep, trigger sweep and use "*OPC" to cause
  // the generation of a service request at the end of the sweep
  RSDLLibwrt( ud, "INIT:CONT off;INIT;*OPC", &ibsta, &iberr, &ibcntl );

  // Wait for SRQ (end of sweep)
  RSDLLWaitSrq( ud, &srq, &ibsta, &iberr, &ibcntl );

  // Clear RQS/MSS bit
  RSDLLibrsp( ud, &spr, &ibsta, &iberr, &ibcntl );

  // if sweep is terminated
  if (srq)
  {
    // then set marker to first maximum and query the level
    RSDLLibwrt( ud, "CALC:MARK:MAX;Y?", &ibsta, &iberr, &ibcntl );
    RSDLLilrd( ud, MaxPegel, MAX_RESP_LEN, &ibsta, &iberr, &ibcntl );
    MaxPegel[ibcntl] = 0;
  }
  // End connection to instrument
  RSDLLibonl (ud, 0, &ibsta, &iberr, &ibcntl ) ;
}
else
{
  ; // Error Instrument not found
}
```

10 Index

Note: All softkeys are listed alphabetically under keyword "Softkey" with their names. The page numbers 4.xxx refer to the detailed description of the softkeys in chapter 4. Generally, the number of the page in chapter 6 containing the equivalent remote control command is given in addition.
A list of softkeys and equivalent remote control commands or command sequences is given in chapter 6, section "Table of Softkeys with IEC/IEEE-Bus Command Assignment". Chapter 6 also contains an alphabetical list of all remote control commands.