Operating Manual

Baseband Signal Analyzer

R&S® FMU36
1303.3500.02

Printed in Germany

ROHDE & SCHWARZ
Test and Measurement Division

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Tabbed Divider

ROHDE&SCHWARZ
EC Certificate of Conformity

CE

Certificate No.: 2006-76

This is to certify that:

Equipment type	Stock No.	Designation
FMU36	1303.3500.02	Baseband Signal Analyzer

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:

EN 61010-1 : 2001
EN 55011 : 1998 + A1 : 1999 + A2 : 2002, Klasse B
EN 61326 : 1997 + A1 : 1998 + A2 : 2001 + A3 : 2003
EN 61000-3-2 : 2000 + A2 : 2005
EN 61000-3-3 : 1995 + A1 : 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 2006

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Contents of Manuals for Baseband Signal Analyzer R&S FMU

Operating Manual R&S FMU

The operating manual describes the following models and options of baseband signal analyzer ' R&S FMU:

- R&S FMU36

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 R&S FMU via the menus and via remote control. Typical measurement tasks for the R&S FMU 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:

The data sheet	informs about guaranteed specifications and characteristics of the instrument.
Chapter 1	see Quick Start Guide chapter 1 and 2 (describes the control elements and connectors on the front and rear panel as well as all procedures required for putting the R&S FMU into operation and integration into a test system.)
Chapter 2	gives an introduction to typical measurement tasks of the R&S FMU 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 R&S FMU 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 R&S FMU, 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 R&S FMU.
Chapter 8	describes preventive maintenance and the characteristics of the instrument's interfaces.
Chapter 8	gives a list of error messages that the R&S FMU 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 R&S FMU by exchanging modules.

1 Putting into Operation

For details refer to the Quick Start Guide chapters 1, "Front and Rear Panel", and 2, "Preparing for Use".

Contents - Chapter 2 "Getting Started"

2 Getting Started

Chapter 2 explains how to operate the R&S FMU using typical measurements as examples. This chapter is split up in two parts, basic spectrum measuremnts and measurements on modulated signals. 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 R&S FMU 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 R&S FMU – *PRESET key"*. Examples of more basic character are provided in the Quick Start Guide, chapter 5, as an introduction.

Basic Spectrum Measurements

Though the R&S FMU is a baseband signal analyzer, it can also perform basic spectrum measurements up to 36 MHz. Measuring the frequency and level of a signal is one of the most common purposes for the use of a spectrum analyzer. On the R&S FMU, spectrum measurements can be performed usign the FFT mode. For unknown signals, the FFT default settings (PRESET) are a good starting point for the measurement.
In general, modulated signals can be connected to either the I or Q baseband input of the R&S FMU, whereas baseband signals usually require two connections, one each for the I and Q component.
If the input impedance is set to 50 Ω, the total incident power at either input port may not exceed 30 dBm (= 1 W). Power attenuators can be used to measure stronger signals. With the input impedance set to 1 MΩ, the maximum voltage at the input ports is 5 V. Exceeding these limits can destroy attenuators or amplifiers.

Setting the Input Impedance and Signal Source

The following examples are all performed with the input impedance set to 50 Ω.

1. *Set the input impedance to 50 Ω*

    ➢ Press FFT hotkey.

    ➢ Press *SIGNAL SOURCE*.

    ➢ Press *I/Q INPUT* until 50 Ω is selected.

In the default state (PRESET key) the input impedance is set to 50 Ω.

Unlike spectrum analyzers, the R&S FMU can not only display positive frequencies but also the negative part of the spectrum in its FFT frequency domain. This is necessary as complex signals may have a non-symmetric spectrum.
Depending on the choice made for the I/Q path (complex or either I or Q path), the spectrum is displayed in full for a complex signal, or only positive frequencies are displayed for I or Q path only.

In the following examples for all spectrum measurements, the selection I path (I ONLY) shall be used.
In the default state (PRESET key) the baseband input is set up for complex signals (I+jQ).

2. *Select real input signal on the I port*

    ➢ Press the FFT hotkey.

    ➢ Press the SIGNAL SOURCE softkey.

    ➢ Press the softkey I/Q PATH and select I ONLY.

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.
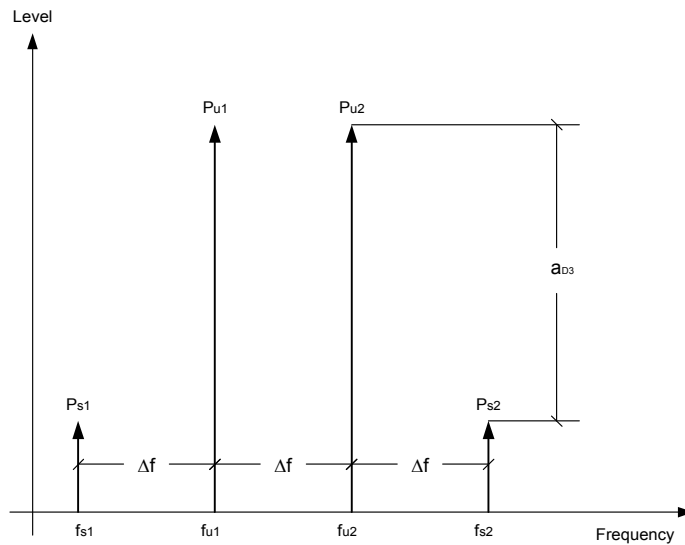
Fig. 2-1 3rd order intermodulation products

Example: f_{u1} = 10 MHz, f_{u2} = 10.03 MHz
                 f_{s1} = 2 · f_{u1} - f_{u2} = 2 · 10 MHz – 10.03 MHz = 9.97 MHz
                 f_{s2} = 2 · f_{u2} - f_{u1} = 2 · 10.03 MHz – 10 MHz = 10.06 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. 2-2 shows how the levels of the useful signals and the 3rd order intermodulation products are related.
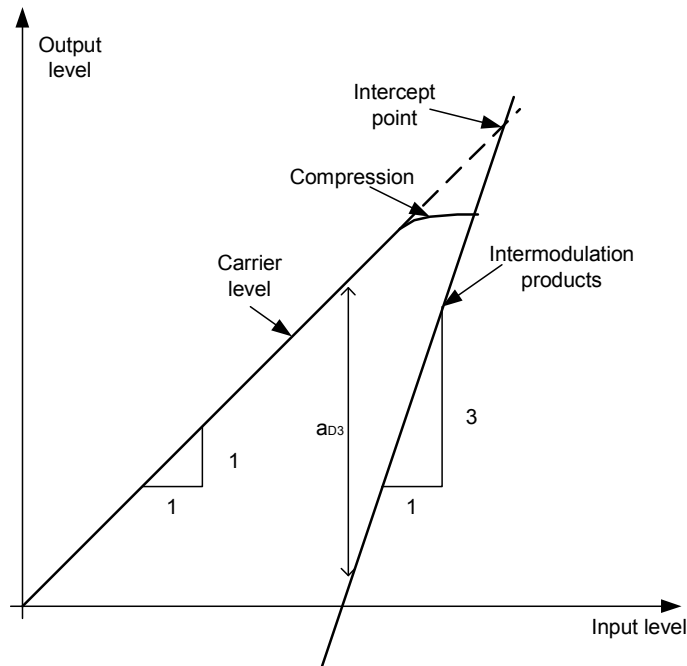
Fig. 2-2   Level of the 3rd order intermodulation products as a function of the level of the useful signals

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 R&S FMU's intrinsic intermodulation

Test setup:
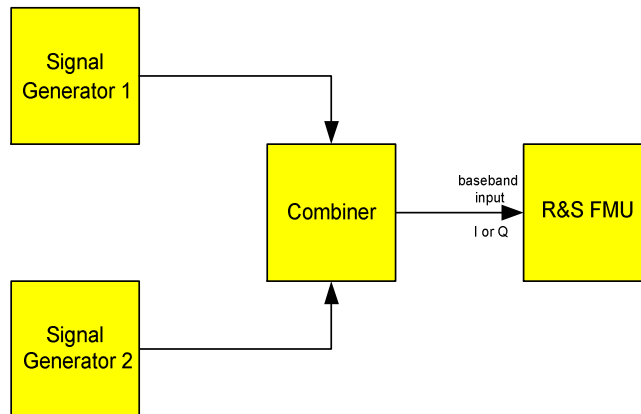
In order to measure the intermodulation performance of the R&S FMU the test signal must be largely free of intermodulation. To avoid intermodulation inside the signal generators, use a 3 dB power combiner (for example Mini Circuits ZFSC-2 series) instead of a common 6 dB splitter. Also the automatic level control (ALC) of the signal generators must be switched off. Recommended signals generators are R&S SMIQs.

Signal generator settings (e.g. R&S SMIQ):

	Level	Frequency
Signal Generator 1	+7 dBm ALC off	21.35 MHz
Signal Generator 2	+7 dBm ALC off	21.45 MHz

Measurement using the R&S FMU:

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

   ➢ Press the *PRESET* key.
   The R&S FMU is in the its default state.

2. *Set center frequency to 21.4 MHz and the frequency span to 900 kHz.*

   ➢ Press the *FREQ* key and enter 21.4 MHz.

   ➢ Press the *SPAN* key and enter 900 kHz.

3. *Set the reference level to +10 dBm.*

   ➢ Press the *AMPT* key and enter *10 dBm*.
   The input attenuator setting is coupled to the reference level setting. The attenuator is automatically set to 0 dB with a reference level setting of +10dBm.

4. *Set the resolution bandwidth to 500 Hz.*

   ➢ Press the *BW* key.

   ➢ Press the *RES BW MANUAL* softkey and enter *500 Hz.*
   By reducing the bandwidth, the noise is 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 NEXT key.

> ➢ Press the *TOI* softkey.

The R&S FMU activates four markers. Two markers are positioned on the wanted signals and two on the intermodulation products. The 3rd order intercept is calculated from the level difference between the wanted signals and the intermodulation products. It is then displayed on the screen:
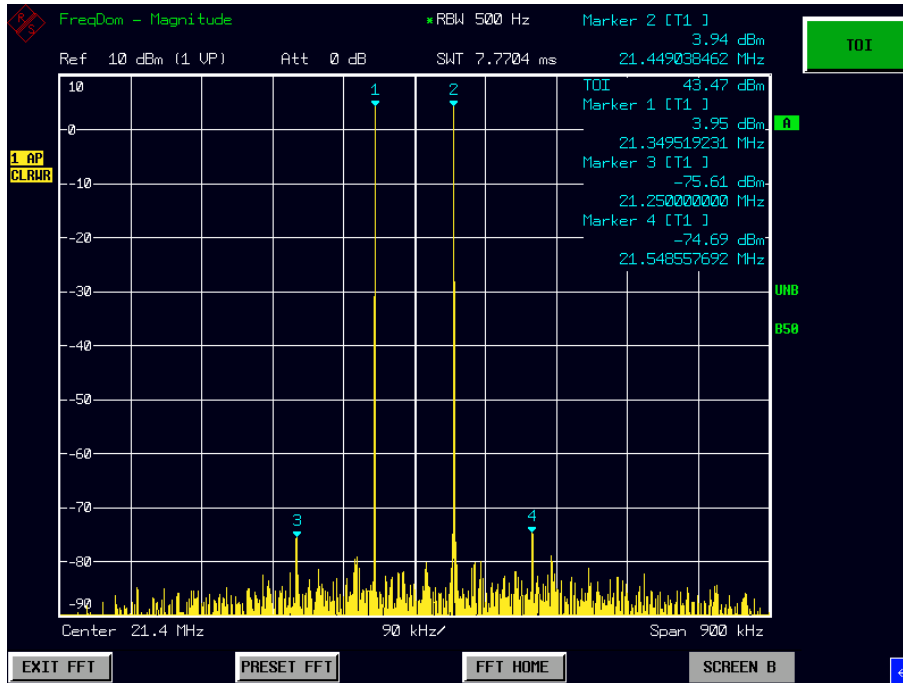
Fig. 2-3   Result of intrinsic intermodulation measurement on the R&S FMU. The 3rd order intercept (TOI) is displayed at the top right corner of the grid

Calculation method:
The method used by the R&S FMU to calculate the intercept point takes the average wanted signal level P_{uw} 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 = ½ d_3 + Pu_w

The level of the intrinsic intermodulation products depends on the level of the useful signals at the input amplifier. When the input attenuation is added, the level is reduced and the intermodulation ratio is increased. With an additional attenuation of 5 dB, the levels of the intermodulation products are reduced by 10 dB.

6. *Increasing input attenuation to 5 dB by setting the reference level to +15 dBm to reduce intermodulation products.*

> ➢ Press the AMPT key and enter 15 dBm.
> The attenuator setting is coupled to the reference level setting. The attenuator is automatically set to 5dB with a reference level of 15 dBm.
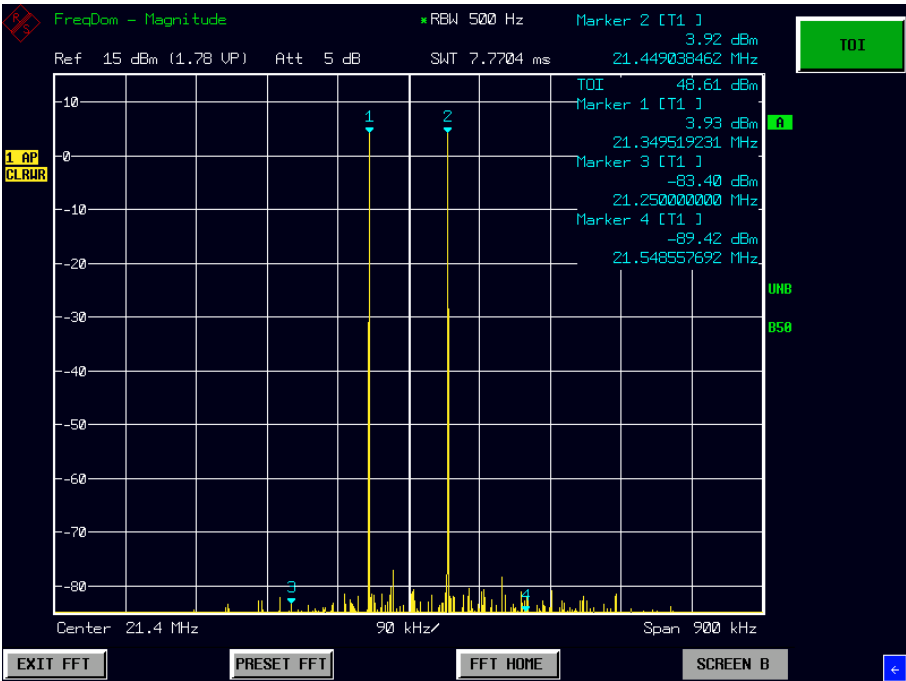
Fig. 2-4   If the baseband input attenuation is increased, the R&S FMU's intrinsic
intermodulation products are reduced. In the shown example the intermodulation
products disappear below the noise floor of the signal genarators.

Measuring Signals in the Vicinity of Noise

The minimum signal level a signal 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 signal analyzer.

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

Impact of the reference level setting

If the reference level is changed, the R&S FMU changes the gain and the input attenuation so that the voltage at the A/D converter is always the same for signal levels corresponding to the reference level. This ensures that the dynamic range of 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 amplifier makes a substantial contribution to the total noise figure of the R&S FMU. Fig. 2-5 below shows the change in the displayed noise depending on the set reference level.
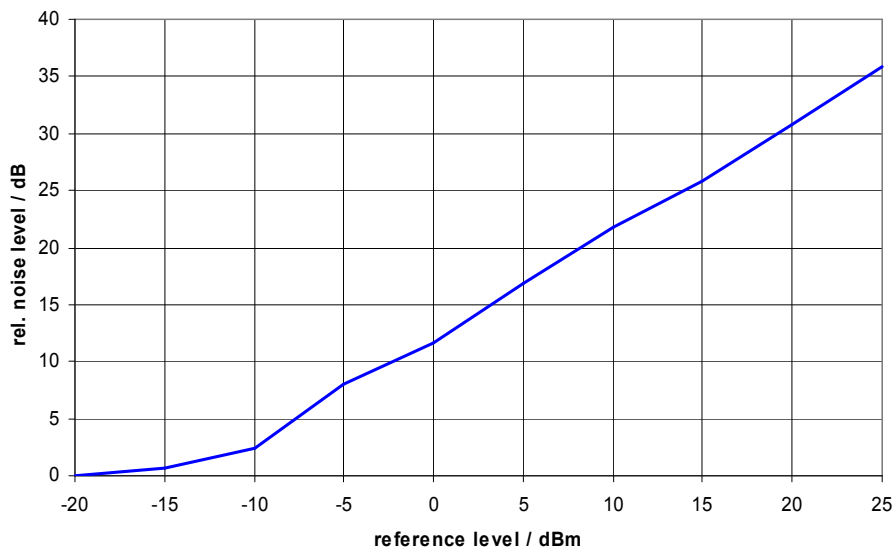
Fig. 2-5   Change in displayed noise as a function of the selected reference level

Impact of the resolution bandwidth

The sensitivity of a signal analyzer also depends directly on the selected bandwidth. The highest sensitivity is obtained for the smallest bandwidth (for the R&S FMU: 0.5 Hz). If the bandwidth is increased, the reduction in sensitivity is proportional to the change in bandwidth. 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 10 dB.

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 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 R&S FMU has the following detectors:

Maximum peak detector

If the max. peak detector is selected, the largest noise display is obtained, since the spectrum analyzer displays the highest value of the baseband input in the frequency range assigned to a pixel at each pixel in the trace. In the time domain, 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 baseband input 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.

Inn the time domain 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 signal 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 baseband input 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. In the time domain, 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 values contribute to the RMS value measurement. The trace is, therefore, smoothed. In the frequency domain, the level of sinewave signals is only displayed correctly if the selected span / resolution bandwidth ratio is less than 200 (RBW). At a resolution bandwidth of 1 kHz, this means that the frequency display range (SPAN) must not exceed 200 kHz.

Average detector

For each pixel of the trace, the average detector outputs the average value of the linear baseband input 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 span / resolution bandwidth ratio is less than 200 (RBW).

Measurement example – Measuring a sinewave signal at low S/N ratios

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

Test setup:
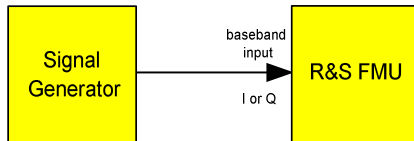
Settings on the signal generator (e.g. R&S SMIQ):
Frequency: 10 MHz
Level: -60 dBm

Measurement using R&S FMU:

1. Set the spectrum analyzer to its default state.

> ➢ Press the *PRESET* key.
   The R&S FMU is in its default state.

2. Set the center frequency to 10 MHz and the frequency span to 10 MHz.

> ➢ Press the *FREQ* key and enter *10 MHz*.

> ➢ Press the *SPAN* key and enter *10* MHz.

3. Set the reference level to 25 dBm to attenuate the input signal and to increase the intrinsic noise.

> ➢ Press the *AMPT* key.

> ➢ Press the *REF LEVEL* softkey and enter *25 dBm*.
   The high input attenuation reduces the signal level which can no longer be detected in noise.
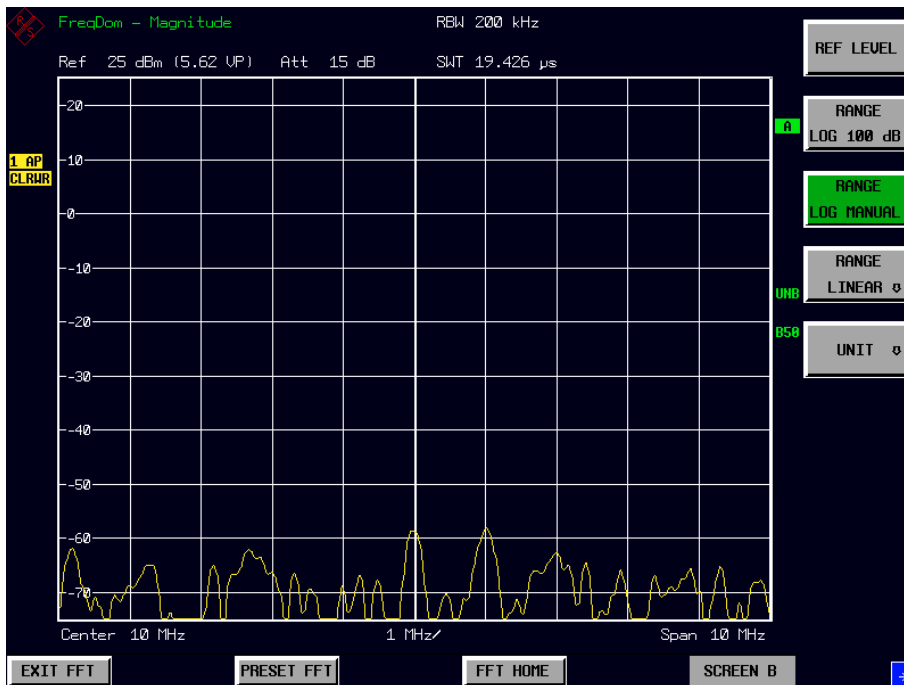
Fig. 2-6   Sinewave signal with low S/N ratio. The signal is completely swamped by the intrinsic noise of the spectrum analyzer.

4. 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 R&S FMU automatically switches on the sample detector. The signal, therefore, can be more clearly distinguished from noise.
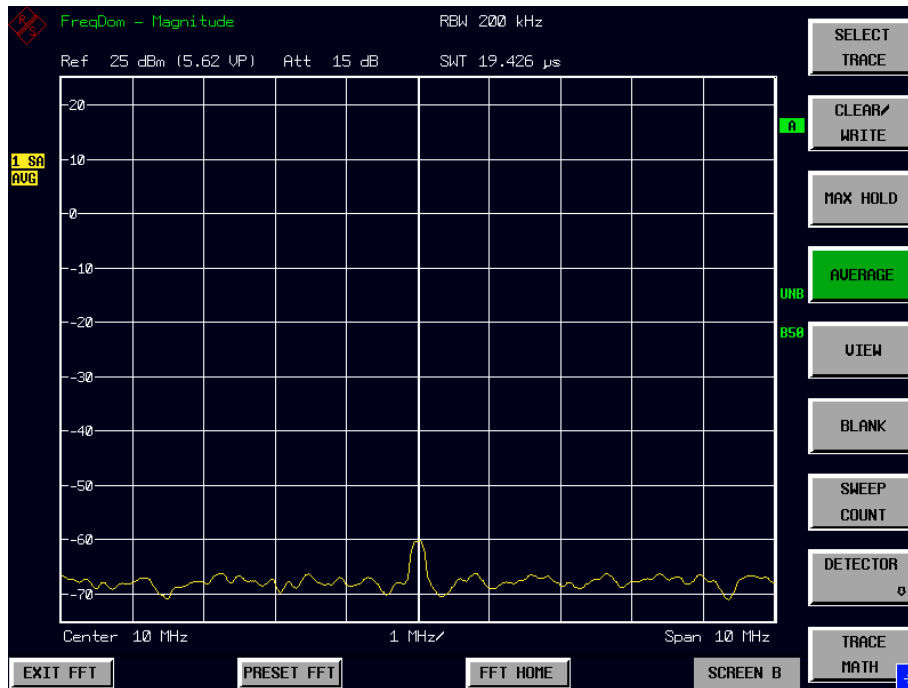
Fig. 2-7   Sinewave signal with low S/N ratio if the trace is averaged.

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

> ➢ Press the *BW* key.

> ➢ Press the *RES BW MANUAL* softkey and enter *20 kHz*.
> The displayed noise is reduced by approx. 10 dB. The signal, therefore, emerges from noise by about 10 dB.
> The noise floor is outside the displayed level range. In order to display the noise, the level range must be set to 120 dB.

> ➢ Press the AMPT key.

> ➢ Press the *RANGE LOG MANUAL* softkey and enter 1*20 dB*.
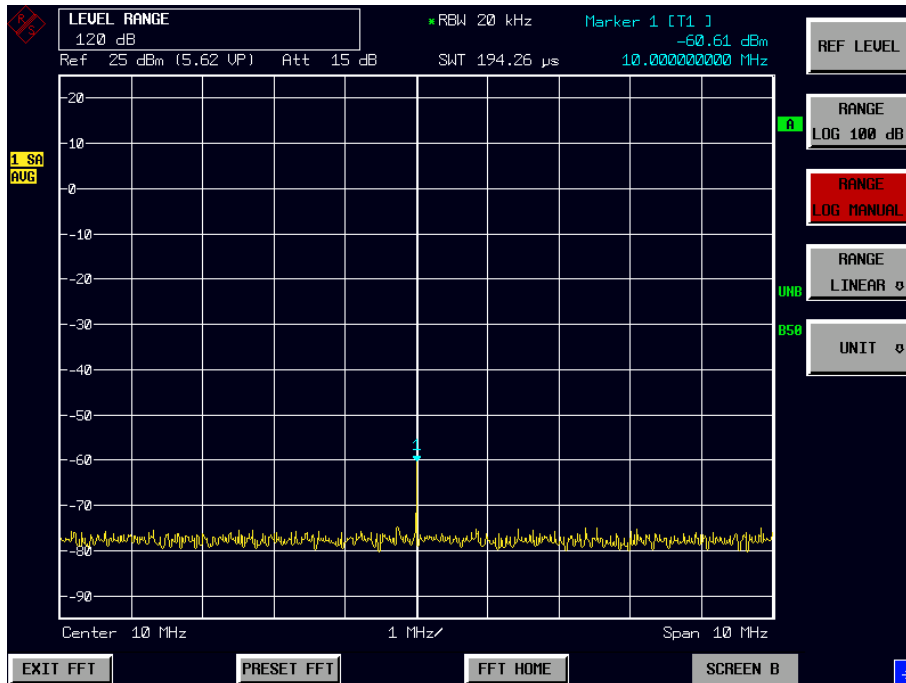
Fig. 2-8   Sinewave signal at a smaller resolution bandwidth

Measurements in the Frequency Domain

Measurement example – Spectrum of a GSM signal in the complex baseband

Test setup:
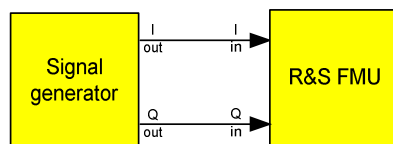
Settings on the signal generator (e.g. R&S SMIQ or R&S SMU)
  Frequency: not relevant, because the baseband output is used
  Level: not relevant, because the baseband output is used
  Modulation: GSM standard; PRBS data is used

The I baseband output of the signal generator is connected to the I baseband input of the R&S FMU. The Q baseband output of the signal generator is connected to the Q baseband input of the R&S FMU.

1. ***Set the R&S FMU to its default state:***

    ➤ Press the *PRESET* key.

2. ***Change to the FFT Analyzer:***

    ➤ Press the *FFT* hotkey.

3. ***Configure the baseband input:***

    ➤ Press the SIGNAL SOURCE softkey.

    ➤ Select the appropriate input impedance using the I/Q INPUT softkey (usually 50 Ω, depends on the signal generator).

    ➤ Use the *BALANCED* softkey to set the measurement mode (balanced / referenced to ground to match the signal generator's output).

4. ***Set the span to 1 MHz:***

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

5. ***Set the resolution bandwidth to 10 kHz:***

    ➤ Press the *FREQ* key, then the *RES BW MANUAL* softkey and enter 10 kHz.

6. *Switch on averaging:*

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

You can see the typical spectrum of a GSM signal (see Fig. 2-9). The center frequency is 0 Hz. Positive and also negative frequencies are shown. This is meaningful, because the spectrum of a complex input signal is in most cases not symmetrical to 0 Hz.
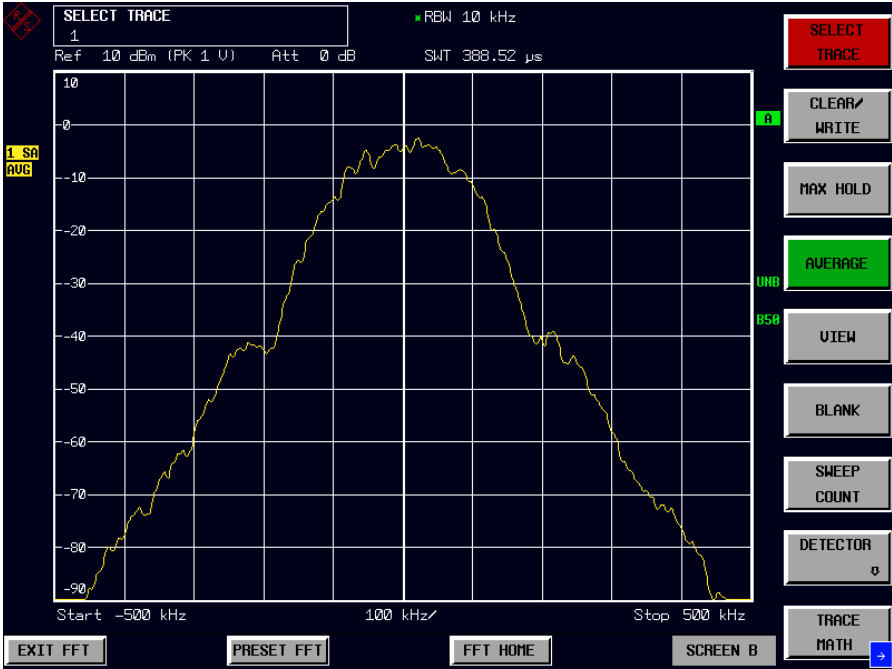
Fig. 2-9   Typical spectrum of a GSM signal (PRBS data is used)

We want to generate a complex rotating phasor now.

1. Switch the signal generator to bit pattern "11111..." or "00000....":
    ➢ Operator interactions depend on the signal generator used.
       Important: Differential coding must be used.

2. Use the marker to measure the frequency and the level of the rotating phasor:
    ➢ Press the *MKR* ⇒ key, then the *PEAK* softkey.

    You can see (Fig. 2-10) the spectrum of a complex rotating phasor. Its frequency is a quarter of
    the GSM symbol frequency of 270.833 kHz (=67.708 kHz). You can read the frequency and the
    level of the rotating phasor in the marker information field.

    A complex rotating phasor is defined as:
    $$s(t) = e^{j \cdot \varpi \cdot t} = \cos(\varpi \cdot t) + j \cdot \sin(\varpi \cdot t)$$
    with a positive or negative ω, which determines the direction of rotation and the frequency.
    The above formula can be rewritten as:
    $$\sin(\varpi \cdot t) = \frac{1}{2 \cdot j} \cdot (e^{j \cdot \varpi \cdot t} - e^{-j \cdot \varpi \cdot t})$$
    and
    $$\cos(\varpi \cdot t) = \frac{1}{2} \cdot (e^{j \cdot \varpi \cdot t} + e^{-j \cdot \varpi \cdot t})$$

    A sine or cosine can be split into two complex rotating phasors. We will need this fact later.
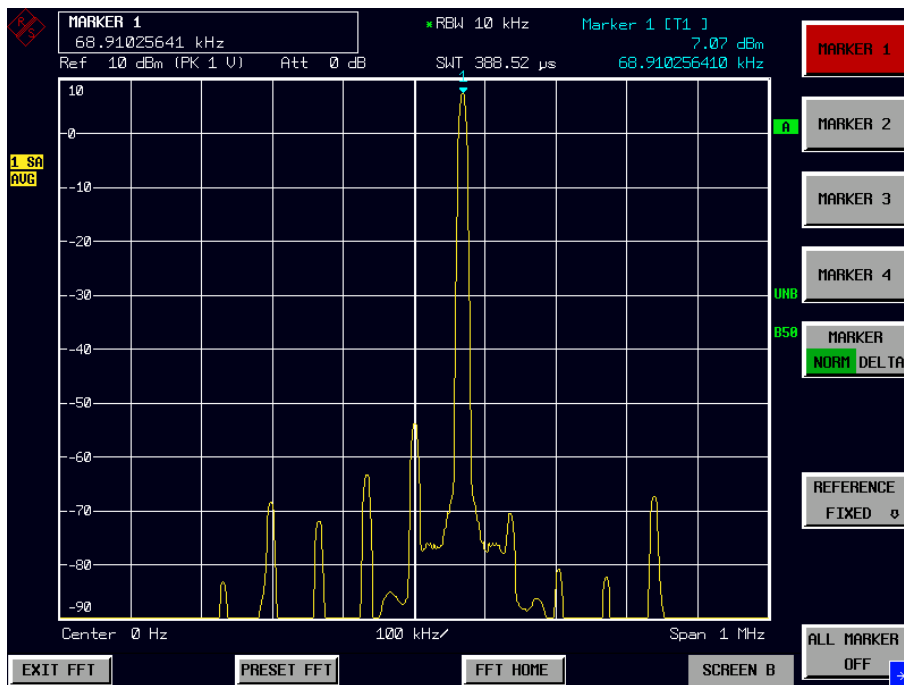
Fig. 2-10   Spectrum with pattern "11111..." or "00000..." used.

> Note: In the spectrum you can see a small DC offset around 0 Hz and a few harmonics at multiples of
> 67.708 kHz.

We now want to generate a complex rotating phasor with the opposite direction of rotation:

1. Switch the signal generator to alternating bit pattern "10101..."
   - Operator interactions depend on the signal generator used.
   Important: Differential coding must be used.

2. Use the marker to measure the frequency and the level of the rotating phasor:
   - Press the *MKR* ⇒ key, then the *PEAK* softkey.

   Now you can see (Fig. 2-11) the spectrum of the same complex rotating phasor, but with the opposite direction of rotation. The level measured by the marker stays the same.
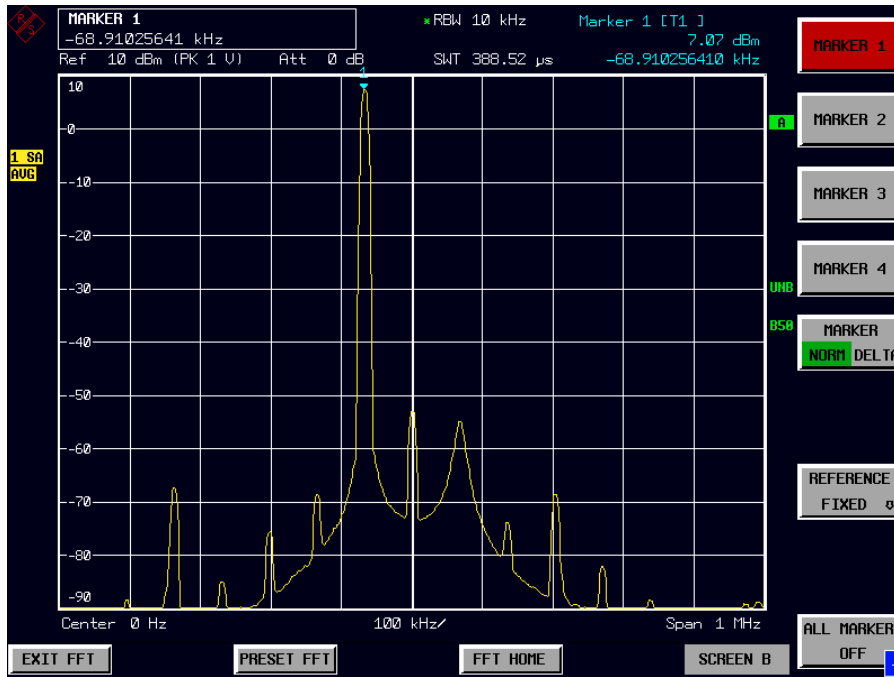
Fig. 2-11   Spectrum with pattern "101010..." used.

We now want to switch from a complex to a real input signal:

1. Use the signal generator's I output as a real signal

    ➢ Disconnect the cable from the Q input of the R&S FMU.
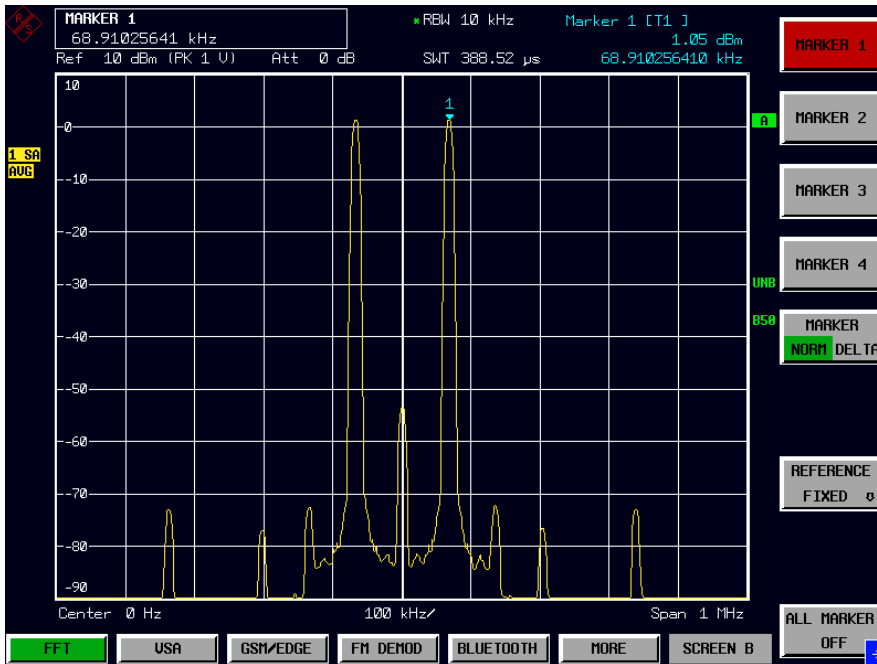
Fig. 2-12   Spectrum after disconnecting the Q signal. Misconfiguration of the FFT analyzer!

You can see (Fig. 2-12) the complex spectrum of a real carrier. The level of the carrier measured by the marker is 6 dB lower now. This is because half of the input power is now missing (one cable disconnected). Due to the complex FFT, the remaining power is additionally split into equal shares on a rotating phasor with a negative frequency and another one with a positive frequency.

Expressed mathematically: $\cos(\varpi \cdot t) = \frac{1}{2} \cdot (e^{j \cdot \varpi \cdot t} + e^{-j \cdot \varpi \cdot t})$

Conclusion: When measuring real signals, you should not use the configuration *I+j*Q*.

We configure the R&S FMU to get the correct spectrum of the signal applied to the I input:

1. Switch to real input signals:

    ➢ Press the *FFT HOME* hotkey, then *SIGNAL SOURCE*, then *IQ PATH*, then *I ONLY*

2. Use the marker to measure the frequency and the level of the rotating phasor:

    ➢ Press the *MKR* ⇒ key, then the *PEAK* softkey.

    The FFT analyzer omits the range of negative frequencies due to the selection of real input
    signals. The correct level is now shown in the range of positive frequencies (see Fig. 2-13).
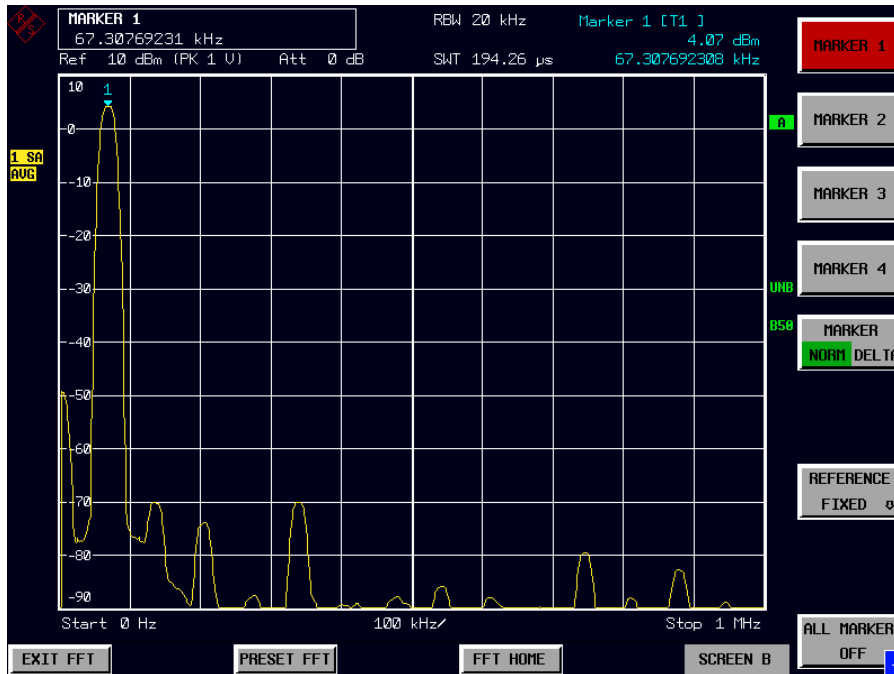
Fig. 2-13   Spectrum after switching to real input signals.

Measurement example – Function of the RECALC Softkey

This measurement example shall demonstrate the application possibilities of the RECALC function. We are using it in this example to measure the phase difference between the sine oscillations at the I and Q inputs. As in the previous example, a complex phasor is used as the input signal.

Test setup:
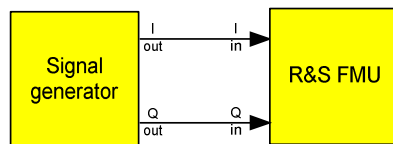
Settings on the signal generator (e.g. R&S SMIQ or R&S SMU)

Frequency:	not relevant, because the baseband output is used
Level:	not relevant, because the baseband output is used
Modulation:	GSM standard; "1111..." or "0000...." pattern is used

The I baseband output of the signal generator is connected to the I baseband input of the R&S FMU. The Q baseband output of the signal generator is connected to the Q baseband input of the R&S FMU.

1. Set the R&S FMU to its default state:
  ➢ Press the *PRESET* key.

2. Change to the FFT analyzer:
  ➢ Press the *FFT* hotkey.

3. Activate the "Capture Both Domains" mode:
  ➢ Press the *CAPTURE BOTH DOM* softkey.

4. Configure the baseband input:
  ➢ Press the *SIGNAL SOURCE* softkey.
  ➢ Select the appropriate input impedance using the *I/Q INPUT* softkey (usually 50 Ω, depends on the signal generator).
  ➢ Use the *BALANCED* softkey to set the measurement mode (balanced / referenced to ground to match the signal generator's output).

5. Initiate capturing of data:
  ➢ Press the *SWEEP* key*,* then the *SINGLE SWEEP* softkey.

  The memory was now filled completely with sampled data of the signals applied to the I and Q inputs (because the CAPTURE BOTH DOMAINS softkey was active).
  All following measurements of this measurement example are completely based on this data, since the *RECALC* softkey will be used each time. You could already disconnect both cables now or connect a new device under test.

  We already know the frequency of the rotating phasor from the previous measurement example. It is 270.8333 kHz / 4 = 67.708 kHz.

6. Set the span to 200 Hz and the center frequency to 67.708 kHz and start a recalculation

  ➢ Press the SPAN key and enter 200 Hz.

  ➢ Press the FREQ key and enter 67.708 kHz.

  ➢ Press the SWEEP key

  ➢ Press the *RECALC* softkey

7. *Switch on the phase information:*

➢ Press the *FFT HOME* hotkey, then *FREQUENCY DOMAIN*, then the *MAGNITUDE PHASE* softkey.

.

8. *Measure the phase of the signal applied to the I input:*

➢ Press the *FFT HOME* hotkey, then *SIGNAL SOURCE*, then the *IQ PATH* softkey,
then the *I-ONLY* softkey.

➢ Press the *SWEEP* key

➢ Press the *RECALC* softkey

➢ Press the *MKR* key. Then enter 67.708 kHz.

In the marker information field you can read the phase of the sine wave applied to the I input (see Fig. 2-14).
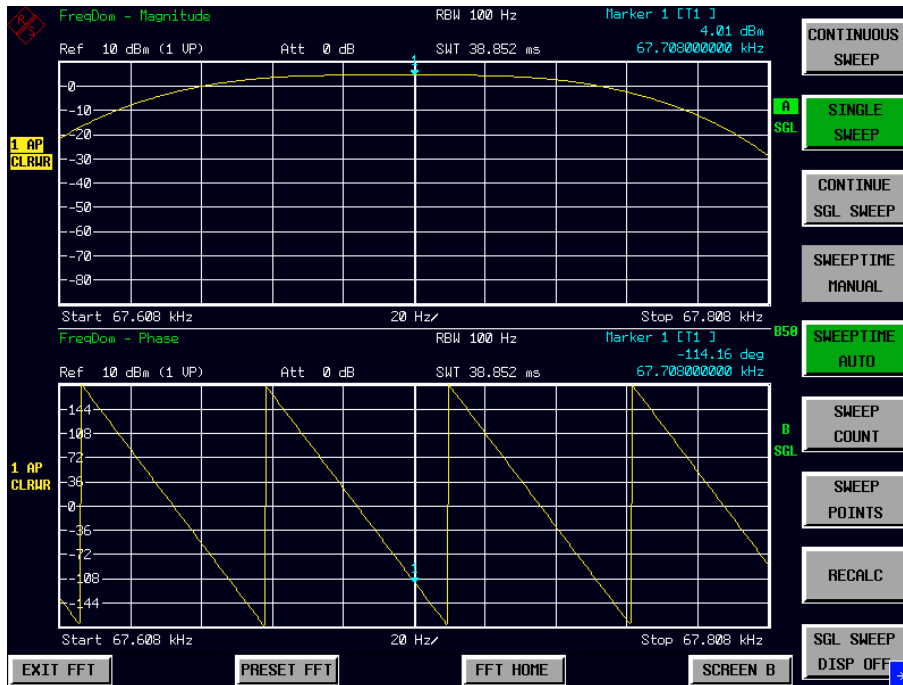
Fig. 2-14   Example of the measurement of the phase of the sine wave applied to the I input.

9. ***Measure the phase of the signal applied to the Q input:***
   ➢ Press the *FFT HOME* hotkey, then *SIGNAL SOURCE*, then the *IQ PATH* softkey, then the *Q-ONLY* softkey.
   ➢ Press the *SWEEP* key
   ➢ Press the *RECALC* softkey
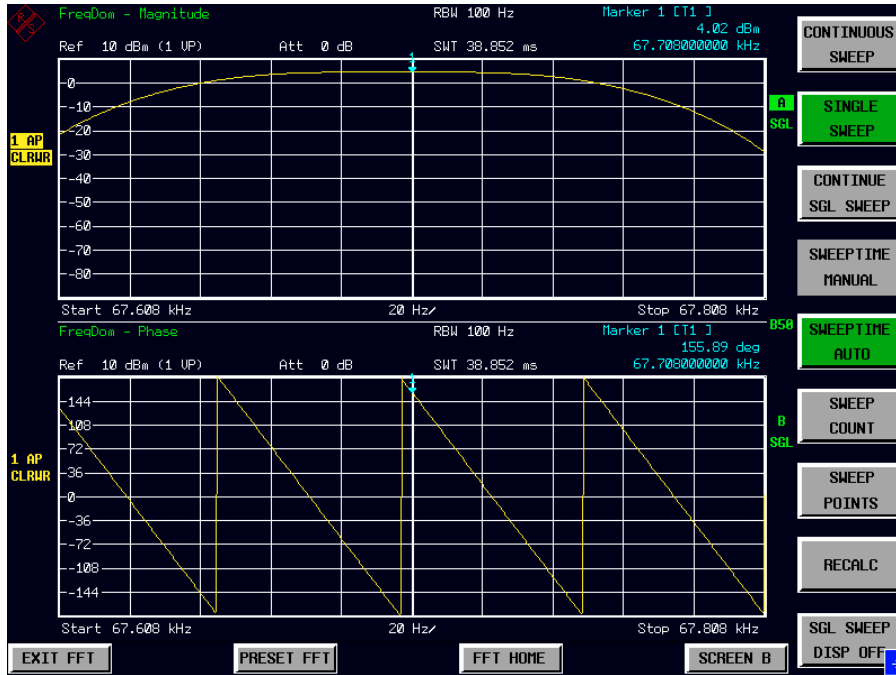
Fig. 2-15   Example of the measurement of the phase of the sine wave applied to the Q input.

In the marker information field you can read the phase of the sine wave applied to the Q input (see Fig. 2-15).

The phase difference between the I and the Q input is 155.89˚ - (-114.16˚) = 270.05˚ = -89.95˚.

Now we want to observe both signals in the time domain:

1. Switch to time domain. Show both signals simultaneously:
   ➢ Press the *FFT HOME* hotkey, then *SIGNAL SOURCE*, then the *I+j*Q* softkey.
   ➢ Press the *FFT HOME* hotkey, then *TIME DOMAIN*, then the *VOLTAGE* softkey.

2. Switch off the mixer and set up the sweep time:
   ➢ Press the *FREQ* key, then enter 0 Hz.
   ➢ Press the *SWEEP* key, then enter 20 µs.
   ➢ Press the *RECALC* soft key

3. Search for the maximum of the signal applied to the I input:
   ➢ Press the *MKR* key. The marker searches for the maximum of the trace of the I input automatically. The other marker is automatically moved synchronously on the trace of the Q input.

At the found maximum of the I signal, you can see (Fig. 2-16) a zero crossing of the sine wave applied to the Q input. The phase difference is therefore again about -90°.

> *Note:*   *This measurement in the time domain does not reach the accuracy of the previous one in the frequency domain. It should only show that you can also switch between time domain and frequency domain when using CAPTURE BOTH DOMAINS and RECALC.*
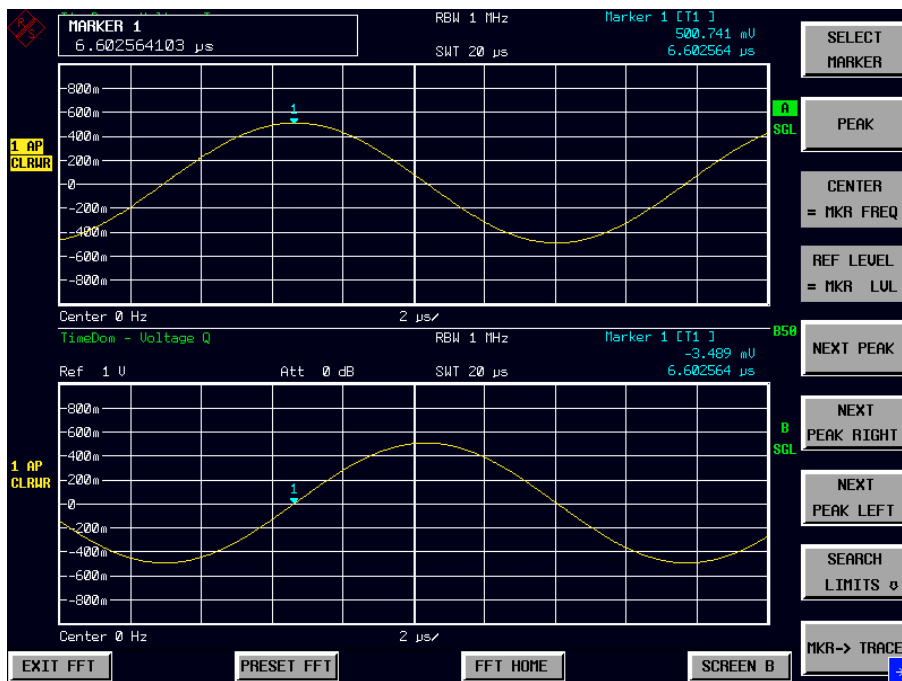
Fig. 2-16   Both signals shown simultaneously in the time domain.

Noise Measurements

Noise measurements play an important role in signal analysis. Noise for example 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 R&S FMU 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 R&S FMU

The frequency of interest is 100 kHz.

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

   ➢ Press the *PRESET* key.
   The R&S FMU is in its default state.

2. *Set the center frequency to 98 kHz and the span to 10 kHz.*

   ➢ Press the *FREQ* key and enter *98 kHz*.

   ➢ Press the *SPAN* key and enter *10 kHz*.

3. *Set the reference level to the most sensitive value*

   ➢ Press the *AMPT* key.

   ➢ Press the *REF LEVEL* softkey and enter *-20 dBm*.

4. *Set the display range 140 dB*

   ➢ Press the *AMPT* key.

   ➢ Press the *RANGE LOG MANUAL* softkey and enter *140 dB*.

5. *Switch on the noise marker function.*

   ➢ Press the *MKR FCTN* key**.**

   ➢ Press the *NOISE MEAS* softkey and enter *100 kHz.*
   The R&S FMU displays the noise power density at 100 kHz in dBm/Hz (dBm in 1Hz bandwidth).

   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.

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

> ➢ Press the *TRACE* key.

> ➢ Press the *AVERAGE* softkey.
> The R&S FMU performs sliding averaging over 10 traces from consecutive sweeps. The measurement result becomes more stable.
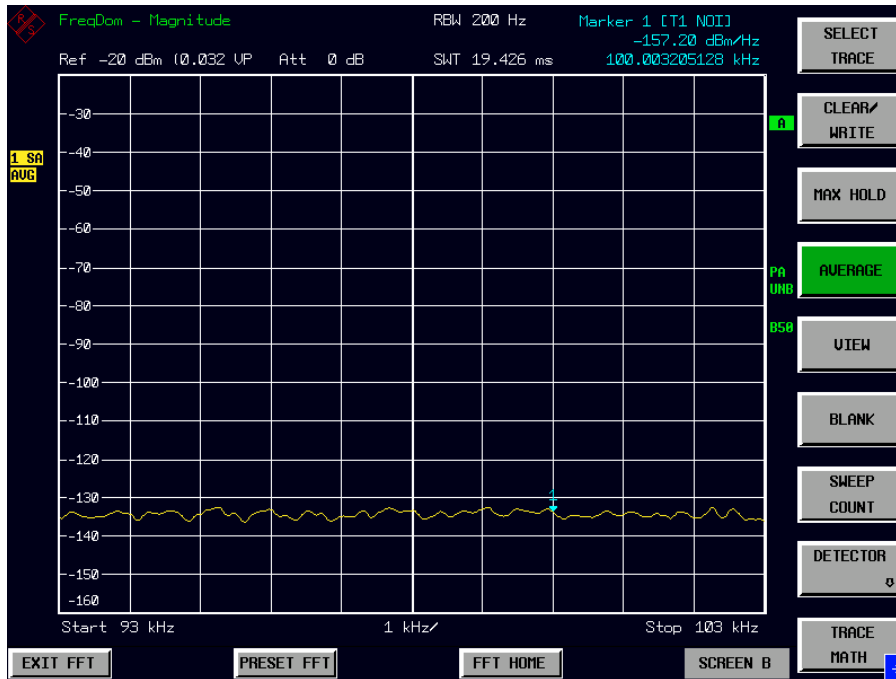
Fig. 2-17   Measurement of the intrinsic noise power density of the R&S FMU

Conversion to other reference bandwidths

The result of the noise measurement is normalized to 1 Hz bandwidth. Using the Noise Marker yields therefore a result, which is bandwidth independent.
If the noise power is read out using a standard marker, the conversion can be done manually. This is done by subtracting 10 * log (BW) of the measurement result, BW being the resolution bandwidth.

Example:

A noise power of -120 dBm measured with a resolution bandwidth of 1 kHz shall be converted to 1 Hz normalized noise power.
$P_{[Noise]}$ = -120 - 10 * log (1000) = -120 -30 = -150 dBm/Hz

Calculation method:

The following method is used to calculate the noise power:

If the noise marker is switched on, the R&S FMU automatically activates the sample detector.

To calculate the noise, the R&S FMU 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 averaging over 17 pixels.

Since 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 R&S FMU, 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). RBW is the equivalent noise power bandwidth of the selected resolution filter.

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. The R&S FMU 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).

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

Determining the noise figure:

The noise figure of an amplifier can be obtained from the noise power measured at the amplifier's output. 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 D UT in dB

Noise figure of the R&S FMU:

The R&S FMU displays the noise power density at the baseband input connector. Internal gain is already included in the result. The noise figure (NF) of the R&S FMU is obtained as follows from the displayed noise power P_{noise}:

NF = P_{noise} + 174

Example: The measured internal noise power of the R&S FMU is found to be –157.2 dBm / Hz. The noise figure of the R&S FMU is obtained as follows

NF = -157.2 + 174 = 16.8 dB

> *Note:* If noise power is measured at the output of an amplifier, for example, the sum of the internal noise power of the R&S FMU 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.
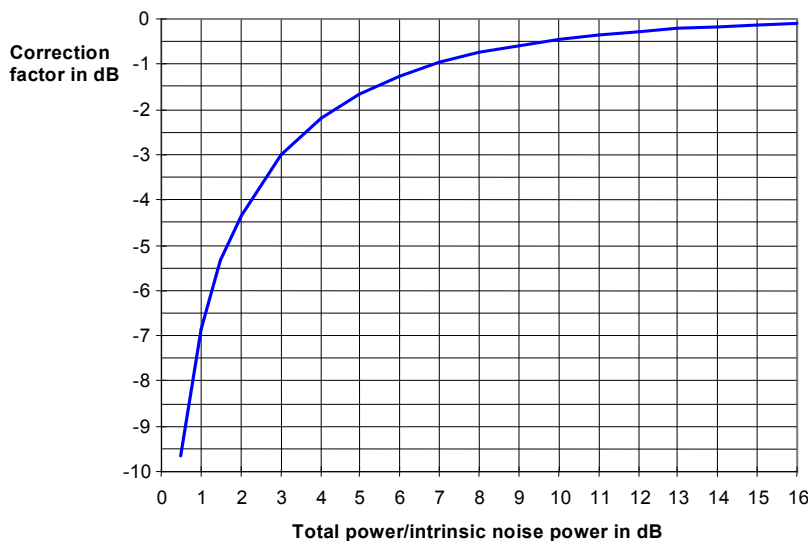
Fig. 2-18   Correction factor for measured noise power as a function of the ratio of total power to the intrinsic noise power of the spectrum analyzer.

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 R&S FMU with the channel power function

The frequency band of interest is centered at 10 MHz, the channel bandwidth is 1.23 MHz.

Test setup:

The baseband input of the R&S FMU remains open-circuited or is terminated with 50 Ω.

Measurement with the R&S FMU:

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

   ➢ Press the *PRESET* key.
   The R&S FMU is in its default state.

2. *Set the center frequency to 10 MHz and the span to 3 MHz.*

   ➢ Press the *FREQ* key and enter *10 MHz.*

   ➢ Press the *SPAN* key and enter 3 *MHz*.

3. *To obtain maximum sensitivity, set the reference level to -20 dBm.*

   ➢ Press the *AMPT* key.

   ➢ Press the *REF LEVEL* softkey and enter *-20 dBm*.

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

   ➢ Press the *MEAS* key.

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

   ➢ Press the *CP/ACP CONFIG* ⬦ softkey.
    The R&S FMU enters the submenu for configuring the channel.

   ➢ Press the *CHANNEL BANDWIDTH* softkey.

   ➢ Confirm the TX channel using the *ENTER* button and enter *1.23 MHz*.
   The R&S FMU displays the 1.23 MHz channel as two vertical lines which are symmetrical to the center frequency.

   ➢ Press the *ADJUST SETTINGS* softkey.
   The settings for the frequency span, the bandwidth (RBW) and the detector are automatically set to the optimum values required for the measurement.
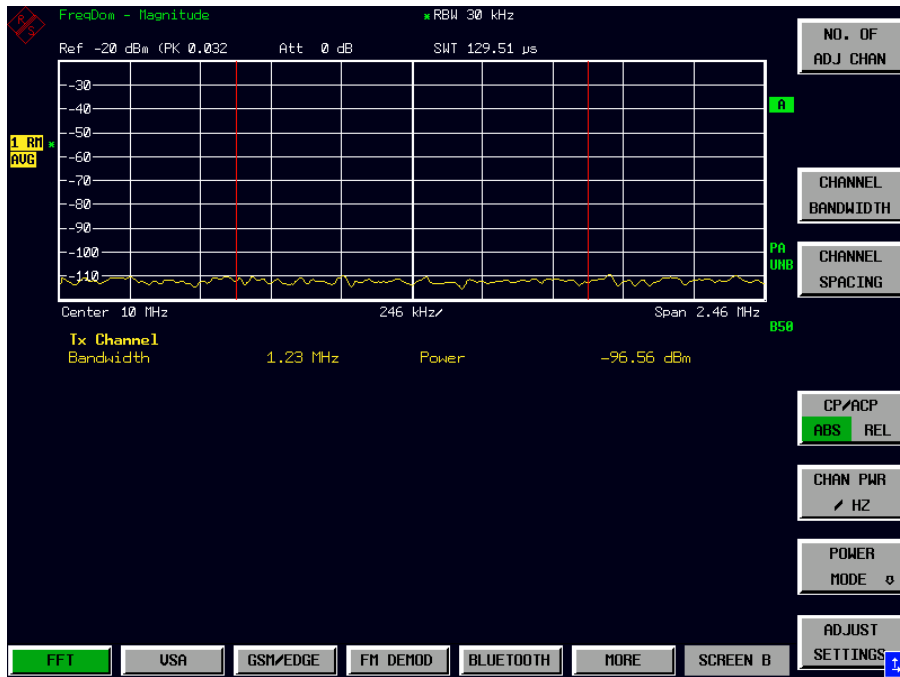
Fig. 2-19 Measurement of the R&S FMU's intrinsic noise power in a 1.23 MHz channel bandwidth.

5. *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 R&S FMU 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.

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 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 voltage and power. The R&S FMU automatically uses the RMS detector when the channel power measurement is switched on.

Repeatability

Repeatability can be estimated from the following diagram:
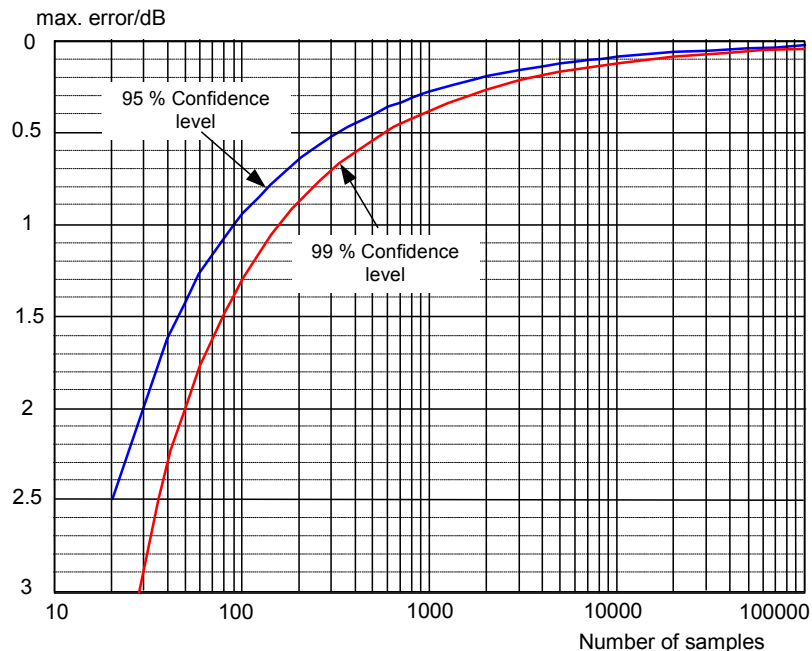
Fig. 2-20   Repeatability of channel power measurements as a function of the number of samples used for power calculation

The curves in Fig. 2-20 indicate the repeatability obtained with a probability of 95% and 99% depending on the number of samples used.

The repeatability depends on the averaging effect when summing up the noise powers within the channel bandwidth. Since only uncorrelated samples cause averaging, the number of samples is <u>not</u> equal to the number of pixels! 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} = Channel Bandwidth / RBW

Example:

At a resolution bandwidth of 10 kHz and a channel bandwidth of 1 MHz, 100 uncorrelated samples are obtained. For the channel power measurement, a repeatability of 1.3 dB with a confidence level of 99% is the estimate that can be derived from Fig. 2-20.

Averaging

To increase the stability of measurement results, the trace average mode can be used. With the trace set to average, sweep count sets the number of sweeps that are averaged. In sweep continuous mode, a sliding average is calculated over 10 sweeps, if sweep count is 0. For sweep count equalling 1, averaging is switched off, as the number of sweeps is set to 1.

The repeatability is improved by a factor of $\sqrt{N_{avg}}$ with N_{avg} = sweep count (number of averages).

Example:
The repeatability (without averaging) is estimated from Fig. 2-20 to be 1.3 dB. With trace averaging with sweep count set to 100, the repeatability is improved by a factor of $\sqrt{100}$ =10. The repeatability after 100 averages is 0.13 dB.

Measuring Phase Noise

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

Measurement Example - Measuring the phase noise of a signal generator

The phase noise at 10 kHz carrier offset shall be measured.

Test setup:
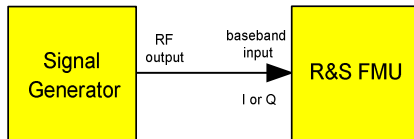
Settings on the signal generator (e.g. R&S SMIQ):
Frequency: 10 MHz
Level: 0 dBm

Measurement using R&S FMU:

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

   ➢ Press the *PRESET* key.
     The R&S FMU is in its default state.

2. *Set the center frequency to 10 MHz and the span to 50 kHz.*

   ➢ Press the *FREQ* key and enter *10 MHz*.

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

3. *Enable phase noise measurement*

   ➢ Press the *MKR FCNT* key.

   ➢ Press the *PHASE NOISE* ⇩ softkey.
     The R&S FMU 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.

4. *Set 10 kHz frequency offset for determining phase noise.*

   ➢ Enter *10 kHz*.
     The R&S FMU 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]).

5. *Stabilize the measurement result by activating trace averaging.*

> ➢ Press the *TRACE* key.

> ➢ Press the *AVERAGE* softkey.
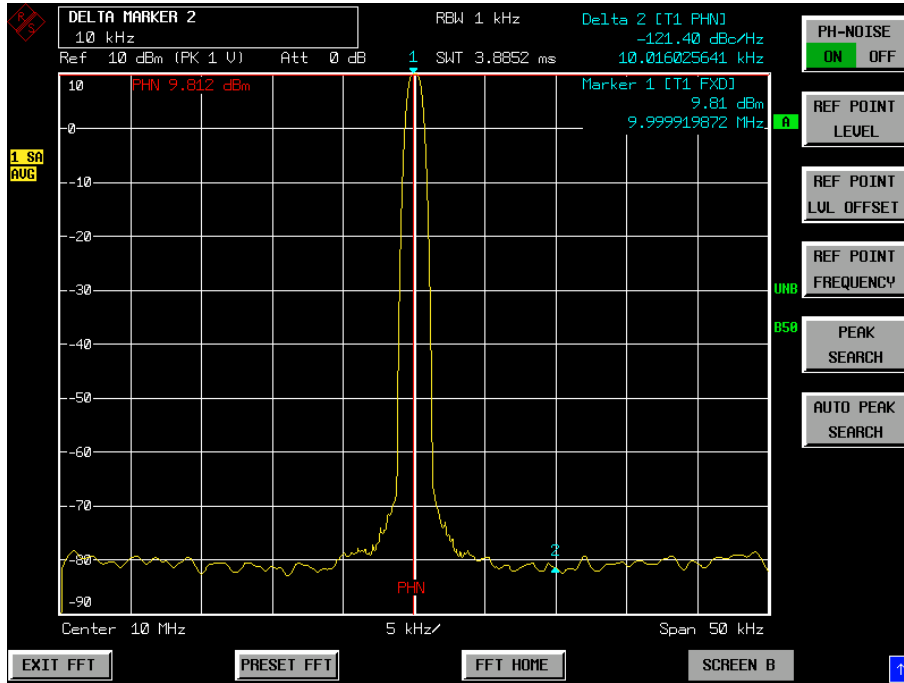
Fig. 2-21   Measuring phase noise with the phase-noise marker function

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

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 R&S FMU 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 < 0.3 dB and a relative measurement uncertainty of < 0.1 dB (each with a confidence level of 95%), the R&S FMU comes close to being a true power meter.

The R&S FMU utilizes the IBW method (**I**ntegration **B**and**w**idth Method) for measuring channel and adjacent channel power. 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.

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

Power measurements

Measurement Example - ACPR measurement on an IS95 CDMA Signal

Test setup:
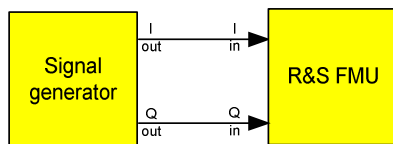
Settings on the signal generator (e.g. R&S SMIQ):
Modulation: CDMA IS 95

Measurement with the R&S FMU:

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

   ➢ Press the *PRESET* key.
   The R&S FMU is in its default state.

2. *Make sure I and Q path are activated*
   ➢ Press the *FFT* key.
   ➢ Press the *SIGNAL SOURCE* softkey.
   ➢ Press the *I/Q PATH* softkey and select *I+j*Q*.

3. *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 R&S FMU sets the channel configuration according to the IS95 standard for mobile stations with 2 adjacent channels above and below the transmit channel. The baseband 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 and detector are selected automatically to give correct results.
   The repeatability of the results in the adjacent channels is very poor. The resolution bandwidth equals the adjacent channel bandwidth, consequently only one uncorrelated sample is obtained. To get stable results - especially in the adjacent channels, which are narrow in comparison with the transmission channel – the R&S FMU automatically uses trace averaging with sweep count = 20.
   Note that the channel power for this baseband measurement is only a characteristic number for the I/Q output of the generator or DUT.
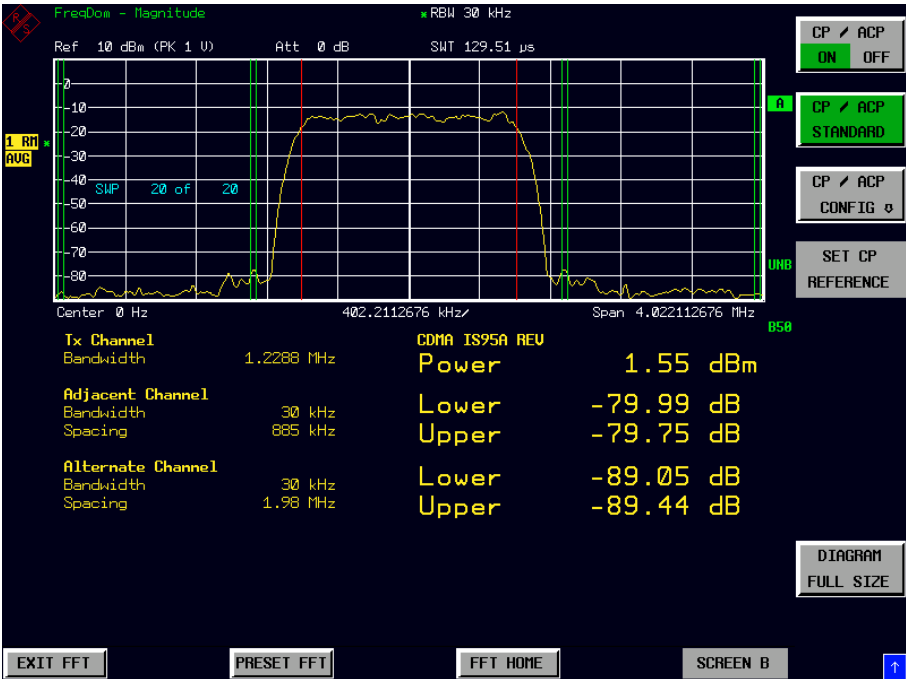
Fig. 2-22   Adjacent channel power measurement on a CDMA IS95 signal

Measuring the S/N Ratio of Burst Signals

The R&S FMU has easy-to-operate functions for measuring power during a given time interval.

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 R&S FMU, 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 – Time domain analysis of an 8PSK signal

Test setup:
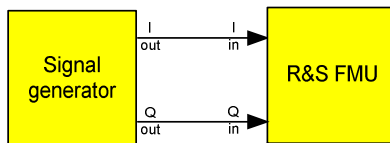
Settings on the signal generator (e.g. R&S SMIQ):
Modulation: 8PSK
Data Source: Data List: 000 001 010 011 100 101 110 111
Filter: Rectangular
Symbol Rate: 10 000 sym/s

Measurement with the R&S FMU:

1. Set the spectrum analyzer to its default state.

  ➢ Press the *PRESET* key.
    The R&S FMU is in its default state.

2. Make sure I and Q path are activated

  ➢ Press the FFT key.

  ➢ Press the SIGNAL SOURCE softkey.

  ➢ Press the I/Q PATH softkey and select I+j*Q.

3. Switch to Time Domain

  ➢ Press the *FFT* key

  ➢ Press the *TIME DOMAIN* softkey.

  ➢ Press the *VOLTAGE* softkey.

4. Adjust the sweep time and setup the trigger

  ➢ Press the *SWEEP* key and enter *800 µs.*

  ➢ Press the *TRIG* key.

  ➢ Press the *I LEVEL* softkey and enter *0.4 V*.
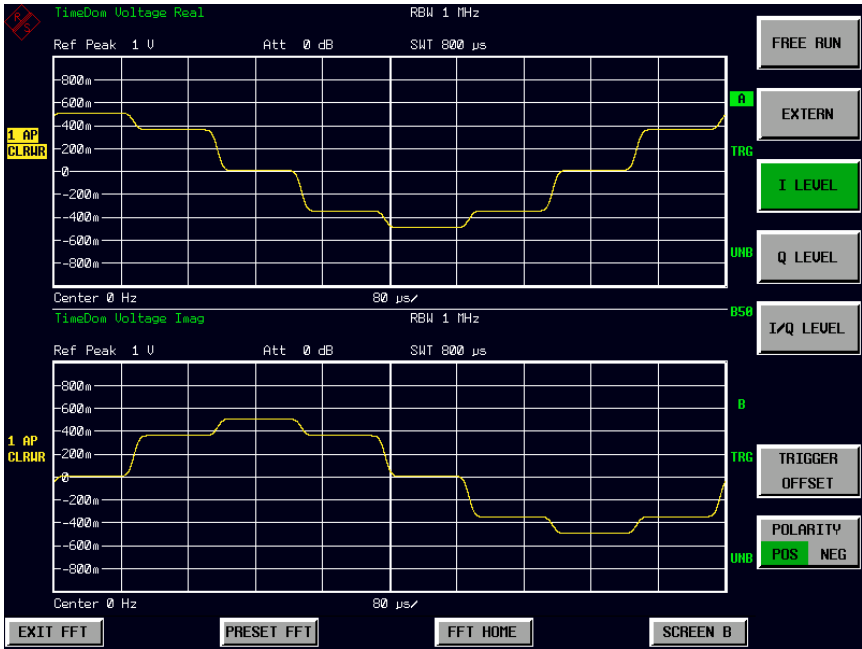
Fig. 2-23   Real and imaginary part of an 8PSK vector rotating counter-clockwise

Fig. 2-23 shows the counter-clockwise rotating 8PSK vector. It starts from the I-axis, as the trigger was set to the maximum I level. The necessary trigger level may vary depending on the I/Q output of the signal generator.

Contents - Chapter 3 " "Menu Overview"

3 Menu Overview

The following section gives a graphical overview of the R&S FMU 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.

FFT Analyzer

FREQ Key

Span > 0,
Frequency
Domain

Zerospan,
Time Domain

SPAN Key

AMPT Key

REF LEVEL	REF LEVEL POSITION	AUTOSCALE	dBm	RANGE LINEAR %
RANGE LOG 100 dB	REF LEVEL OFFSET		dBmV	RANGE LINEAR dB
RANGE LOG MANUAL	PHASE SETTINGS	Y-AXIS /DIV	dBµV	
RANGE LINEAR		Y-AXIS REF VALUE	dBµA	Y-AXIS /DIV
UNIT		Y-AXIS REF POS	dBpW	Y-AXIS REF VALUE
		PHASE OFFSET		Y-AXIS REF POS
		PHASE RAD DEG	VOLT	
		PHASEWRAP ON OFF	AMPERE	
			WATT	

MKR Key

```
┌──────┐  ┌──────┐                                                                              ┌──────────────┐
│ FREQ │  │ SPAN │          ┌──────────┐        ┌──────────┐     ┌──────────┐                   │  REF FXD     │
└──────┘  └──────┘    ══>   │ MARKER 1 │        │MKR->TRACE│     │          │          ══>      │ON      OFF   │
┌──────┐  ┌──────┐          └──────────┘        └──────────┘     └──────────┘                   └──────────────┘
│ MKR  │  │ MKR·▶│          ┌──────────┐        ┌──────────┐     ┌──────────┐                   ┌──────────────┐
└──────┘  └──────┘          │ MARKER 2 │        │LINK MKR1 │     │          │                   │ REF POINT    │
  🖐                         └──────────┘        │AND DELTA1│     └──────────┘                   │   LEVEL      │
                                                 └──────────┘                                   └──────────────┘
                            ┌──────────┐        ┌──────────┐     ┌──────────┐                   ┌──────────────┐
                            │ MARKER 3 │        │          │     │          │                   │ REF POINT    │
                            └──────────┘        └──────────┘     └──────────┘                   │ LVL OFFSET   │
                            ┌──────────┐        ┌──────────┐     ┌──────────┐                   └──────────────┘
                            │ MARKER 4 │        │          │     │          │                   ┌──────────────┐
                            └──────────┘        └──────────┘     └──────────┘                   │ REF POINT    │
                            ┌──────────┐        ┌──────────┐     ┌──────────┐                   │ FREQUENCY    │
                            │  MARKER  │        │          │     │          │                   └──────────────┘
                            │NORM DELTA│        └──────────┘     └──────────┘                   ┌──────────────┐
                            └──────────┘                                                        │ REF POINT    │
                            ┌──────────┐        ┌──────────┐     ┌──────────┐                   │   TIME       │
                            │          │        │          │     │          │                   └──────────────┘
                            └──────────┘        └──────────┘     └──────────┘                   ┌──────────────┐
                                                                                               │   PEAK       │
                            ┌──────────┐        ┌──────────┐     ┌──────────┐                   │  SEARCH      │
                            │REFERENCE │        │          │     │ MKR FILE │                   └──────────────┘
                            │ FIXED ⬇  │        └──────────┘     │ EXPORT   │                   ┌──────────────┐
                            └──────────┘                         └──────────┘                   │              │
                            ┌──────────┐        ┌──────────┐     ┌──────────┐                   └──────────────┘
                            │          │        │          │     │DECIM SEP │                   ┌──────────────┐
                            └──────────┘        └──────────┘     │ .      , │                   │              │
                            ┌──────────┐        ┌──────────┐     └──────────┘                   └──────────────┘
                            │ALL MARKER│        │          │     ┌──────────┐                   ┌──────────────┐
                            │  OFF     │        └──────────┘     │          │                   │              │
                            └──────────┘                         └──────────┘                   └──────────────┘
                              ⇨                    ⇦                ⇦                               ⇧
```

MKR-> Key

SPAN	AMPL
MKR▶	MKR FCTN

SELECT MARKER		AUTO MAX PEAK
PEAK	MIN	AUTO MIN PEAK
CENTER =MKR FREQ	NEXT MIN	
REF LEVEL =MKR LVL	NEXT MIN RIGHT	
NEXT PEAK	NEXT MIN LEFT	
NEXT PEAK RIGHT		
NEXT PEAK LEFT	EXCLUDE DC	
SEARCH LIMITS		
MRK->TRACE	PEAK EXCURSION	

LEFT LIMIT
RIGHT LIMIT
THRESHOLD
SEARCH LIM OFF

MKR FCTN Key

```
┌──────┐  ┌──────┐         ┌──────────┐                    ┌──────────┐                    ┌──────────┐
│ SPAN │  │ AMPT │   ───▶  │ SELECT   │         ┌──────────▶│ PH NOISE │
└──────┘  └──────┘         │ MARKER   │         │           │ ON   OFF │
┌──────┐  ┌──────┐         ├──────────┤         │           ├──────────┤
│ MKR▶ │  │ MKR  │         │ PEAK     │         │           │REF POINT │
└──────┘  │ FCTN │         │          │         │           │ LEVEL    │
          └──────┘         ├──────────┤         │           ├──────────┤
                           │NOISE MEAS│         │           │REF POINT │
                           ├──────────┤         │           │LVL OFFSET│
                           │ PHASE    │         │           ├──────────┤
                           │ NOISE  ▼ │─────┐   │           │REF POINT │
                           ├──────────┤     │   │           │FREQUENCY │
                           │          │     │   │           ├──────────┤
                           ├──────────┤     │   │           │ PEAK     │
                           │ N DB DOWN│     │   │           │ SEARCH   │
                           ├──────────┤     │   │           ├──────────┤
                           │ PEAK     │     │   │           │AUTO PEAK │
                           │ LIST   ▼ │──┐  │   │           │ SEARCH   │
                           ├──────────┤  │  │   │           └──────────┘
                           │          │  │  │   │
                           ├──────────┤  │  │   │
                           │ MRK->TRACE│ │  │   │
                           └──────────┘  │  │   │
```

NEW SEARCH	
SORT MODE FREQ LEVEL	
PEAK EXCURSION	
LEFT LIMIT	
RIGHT LIMIT	
THRESHOLD	
PEAK LIST OFF ⇧	

BW Key

```
┌─────────────────────┐
│  BW    SWEEP        │ ⟹  ┌──────────┐        ┌──────────┐    ┌──────────┐
│                     │    │ RES BW   │        │          │    │          │
│                     │    │ MANUAL   │        │          │    │          │
│  M      TRIG        │    └──────────┘        └──────────┘    └──────────┘
└─────────────────────┘
                           ┌──────────┐        ┌──────────┐    ┌──────────┐
                           │          │        │          │    │          │
                           └──────────┘        └──────────┘    └──────────┘

                           ┌──────────┐        ┌──────────┐    ┌──────────┐
                           │SWEEPTIME │        │          │    │          │
                           │ MANUAL   │        │          │    │          │
                           └──────────┘        └──────────┘    └──────────┘

                           ┌──────────┐        ┌──────────┐    ┌──────────┐
                           │ RESB BW  │        │          │    │          │
                           │ AUTO     │        │          │    │          │
                           └──────────┘        └──────────┘    └──────────┘

                           ┌──────────┐        ┌──────────┐    ┌──────────┐
                           │          │        │          │    │          │
                           └──────────┘        └──────────┘    └──────────┘

                           ┌──────────┐        ┌──────────┐    ┌──────────┐
                           │SWEEPTIME │        │          │    │ SPAN /RBW│
                           │ AUTO     │        │          │    │ AUTO [50]│
                           └──────────┘        └──────────┘    └──────────┘

                           ┌──────────┐        ┌──────────┐    ┌──────────┐
                           │ COUPLING │        │          │    │ SPAN /RBW│
                           │ RATIO    │        │          │    │ MANUAL   │
                           └──────────┘        └──────────┘    └──────────┘

                           ┌──────────┐        ┌──────────┐    ┌──────────┐
                           │ DEFAULT  │        │          │    │          │
                           │ COUPLING │        │          │    │          │
                           └──────────┘        └──────────┘    └──────────┘

                           ┌──────────┐        ┌──────────┐    ┌──────────┐
                           │          │        │ RES BW   │    │          │
                           │          │        │ 1-2-3-5  │    │          │
                           └──────────┘        └──────────┘    └──────────┘
```
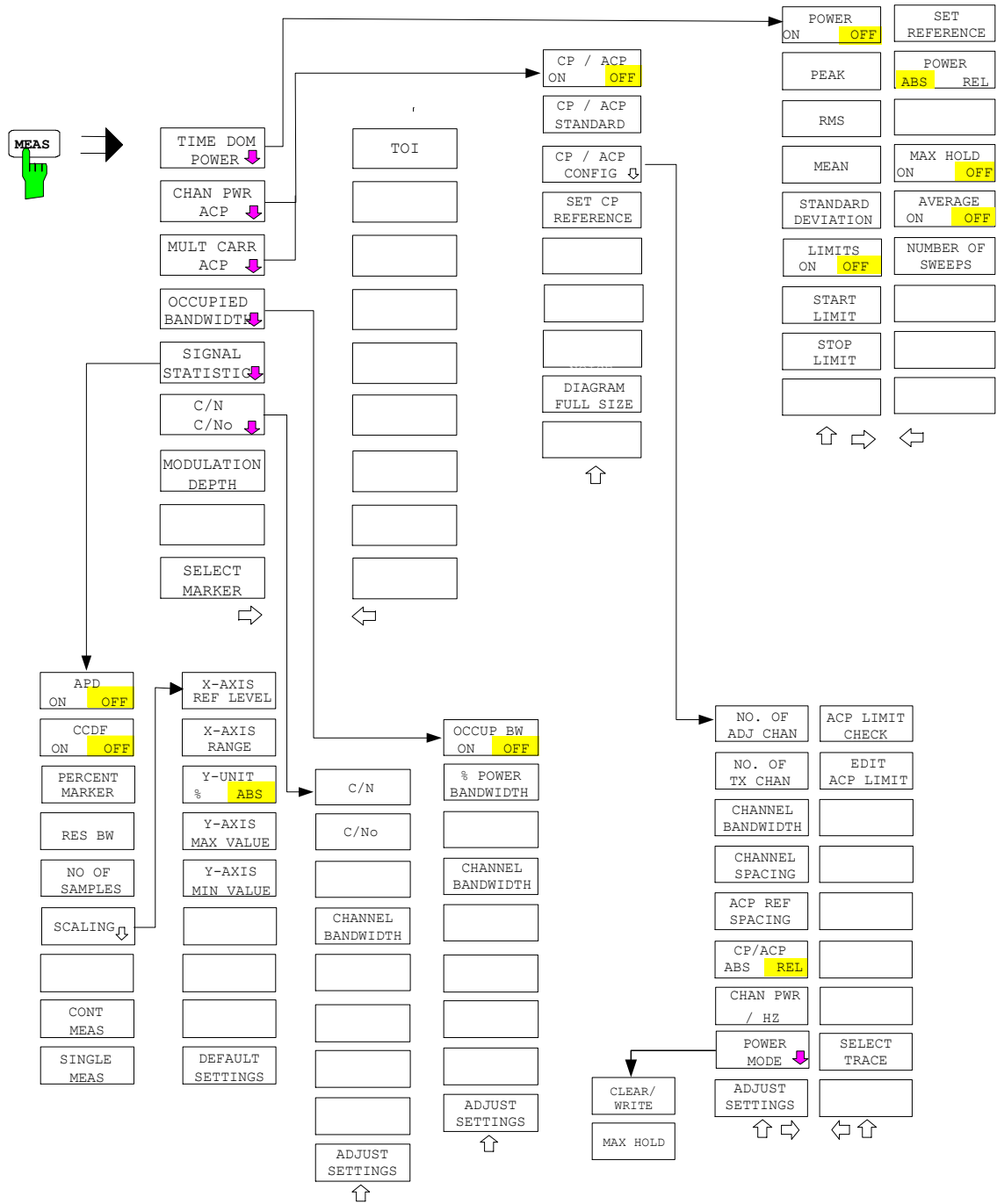
SWEEP Key

MEAS Key

TRIG Key

TRACE Key

```
TRACE  →  SELECT
          TRACE

          CLEAR/
          WRITE

          MAX HOLD

          AVERAGE

          VIEW

          BLANK

          SWEEP
          COUNT

          DETECTOR ↓

          TRACE
          MATH ↓
          ⇨
```
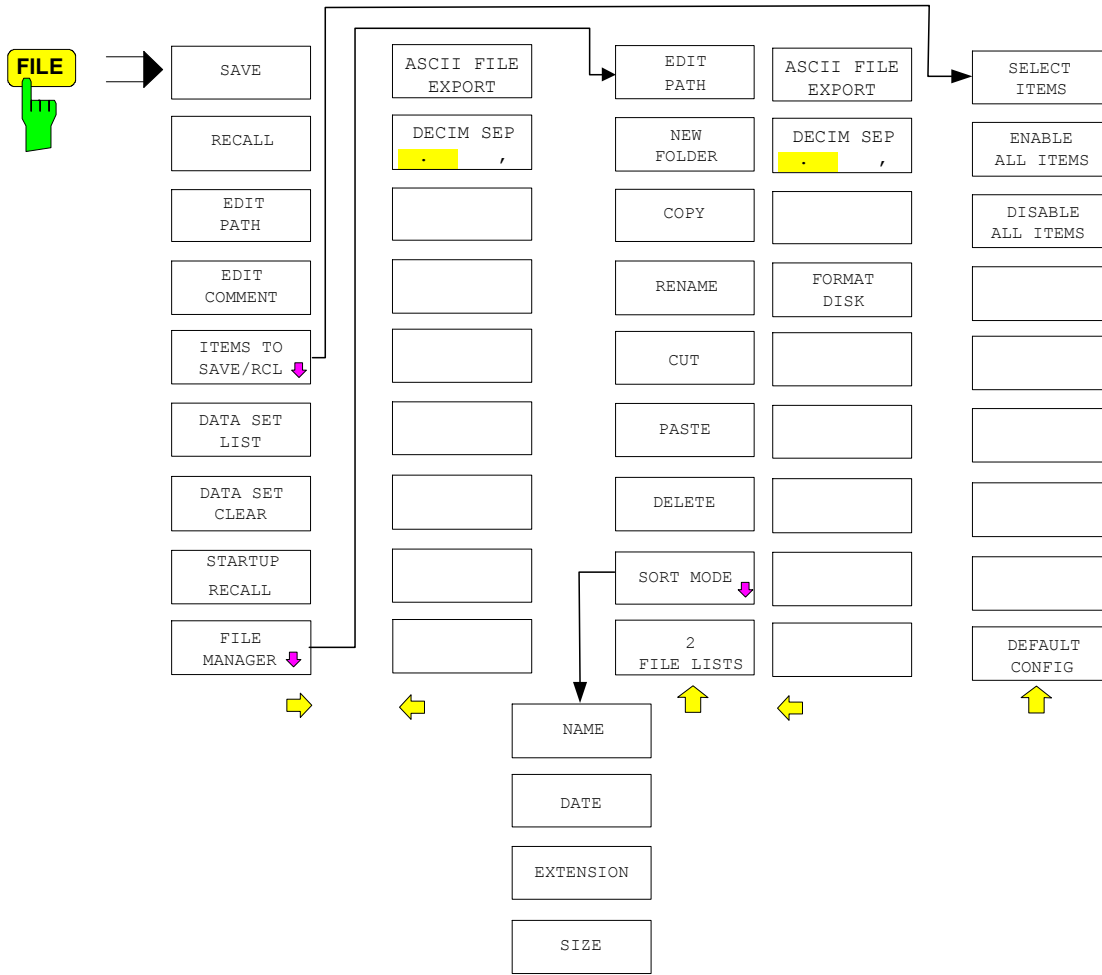
```
MIN HOLD

HOLD CONT
ON    OFF




AVG MODE
LOG   LIN



ASCII FILE
EXPORT

DECIM SEP
 .    ,

COPY
TRACE
⇦
```

```
T1-T2->T1

T1-T3->T1



TRACE
POSITION








TRACE MATH
OFF
⇧
```

```
AUTO
SELECT

DETECTOR
AUTO PEAK

DETECTOR
MAX PEAK

DETECTOR
MIN PEAK

DETECTOR
SAMPLE

DETECTOR
RMS

DETECTOR
AVERAGE



⇧
```

LINES Key

LINES →	SELECT LIMIT LINE	NAME
	NEW LIMIT LINE	VALUES
	EDIT LIMIT LINE	INSERT VALUE
	COPY LIMIT LINE	DELETE VALUE
	DELETE LIMIT LINE	SHIFT X LIMIT LINE
	X OFFSET	SHIFT Y LIMIT LINE
	Y OFFSET	
	DISPLAY LINES	SAVE LIMIT LINE
	RESTORE GSM LINES	

DISPLAY LINE 1
DISPLAY LINE 2
FREQUENCY LINE 1
FREQUENY LINE 2
TIME LINE 1
TIME LINE 2
PHASE LINE 1
PHASE LINE 2

DISP Key

LINES		SCREEN TITLE	SELECT OBJECT
DISP →	FULL SCREEN	TIME+DATE ON **OFF**	BRIGHTNESS
FILE	SPLIT SCREEN	LOGO **ON** OFF	TINT
		ANNOTATION **ON** OFF	SATURATION
		DATA ENTRY OPAQUE	
		DEFAULT COLORS 1	PREDEFINED COLORS
		DEFAULT COLORS 2	
	CONFIG DISPLAY	DISPLAY PWR SAVE	

FILE Key

```
FILE  →  ┌─────────┐      ┌─────────┐      ┌─────────┐   ┌─────────┐   ┌─────────┐
         │  SAVE   │      │ ASCII   │      │  EDIT   │   │ ASCII   │   │ SELECT  │
         │         │      │ FILE    │      │  PATH   │   │ FILE    │   │ ITEMS   │
         │         │      │ EXPORT  │      │         │   │ EXPORT  │   │         │
         ├─────────┤      ├─────────┤      ├─────────┤   ├─────────┤   ├─────────┤
         │ RECALL  │      │ DECIM   │      │  NEW    │   │ DECIM   │   │ ENABLE  │
         │         │      │ SEP     │      │ FOLDER  │   │ SEP     │   │ ALL     │
         │         │      │  .   ,  │      │         │   │  .   ,  │   │ ITEMS   │
         ├─────────┤      ├─────────┤      ├─────────┤   ├─────────┤   ├─────────┤
         │  EDIT   │      │         │      │  COPY   │   │         │   │ DISABLE │
         │  PATH   │      │         │      │         │   │         │   │ ALL     │
         │         │      │         │      │         │   │         │   │ ITEMS   │
         ├─────────┤      ├─────────┤      ├─────────┤   ├─────────┤   ├─────────┤
         │  EDIT   │      │         │      │ RENAME  │   │ FORMAT  │   │         │
         │ COMMENT │      │         │      │         │   │ DISK    │   │         │
         ├─────────┤      ├─────────┤      ├─────────┤   ├─────────┤   ├─────────┤
         │ ITEMS TO│      │         │      │  CUT    │   │         │   │         │
         │ SAVE/RCL│      │         │      │         │   │         │   │         │
         ├─────────┤      ├─────────┤      ├─────────┤   ├─────────┤   ├─────────┤
         │ DATA SET│      │         │      │ PASTE   │   │         │   │         │
         │  LIST   │      │         │      │         │   │         │   │         │
         ├─────────┤      ├─────────┤      ├─────────┤   ├─────────┤   ├─────────┤
         │ DATA SET│      │         │      │ DELETE  │   │         │   │         │
         │  CLEAR  │      │         │      │         │   │         │   │         │
         ├─────────┤      ├─────────┤      ├─────────┤   ├─────────┤   ├─────────┤
         │ STARTUP │      │         │      │  SORT   │   │         │   │         │
         │ RECALL  │      │         │      │  MODE   │   │         │   │         │
         ├─────────┤      ├─────────┤      ├─────────┤   ├─────────┤   ├─────────┤
         │  FILE   │      │         │      │   2     │   │         │   │ DEFAULT │
         │ MANAGER │      │         │      │ FILE    │   │         │   │ CONFIG  │
         │         │      │         │      │ LISTS   │   │         │   │         │
         └─────────┘      └─────────┘      └─────────┘   └─────────┘   └─────────┘

                                          ┌─────────┐
                                          │  NAME   │
                                          ├─────────┤
                                          │  DATE   │
                                          ├─────────┤
                                          │EXTENSION│
                                          ├─────────┤
                                          │  SIZE   │
                                          └─────────┘
```

CAL Key

CAL / **SETUP**	PROBE CAL	PROBE DATA SELECT	PROBE DATA SELECT	
	PROBE CORR ON OFF	SORT BY NAME DATE	SORT BY NAME DATE	
	PROBE CAL RESULTS	PROBE CAL START	PROBE DATA RENAME	
	CAL TOTAL	PROBE COMP ON OFF	PROBE DATA DELETE	
	CAL ABORT	GAIN&OFFS ON OFF	PROBE DATA DELETE ALL	
	CAL CORR ON OFF	FREQ RESP ON OFF		I + J*Q
	CAL RESULTS	IQ PATH (I ONLY)	PROBE CAL DC	I ONLY
	PAGE UP	IQ INPUT 50Ω 1MΩ	PROBE CAL PULSE	Q ONLY
	PAGE DOWN	BALANCED ON OFF	PROBE CAL COMP	

SETUP Key

SETUP

REFERENCE
INT   EXT

SIGNAL
SOURCE

GENERAL
SETUP

SYSTEM
INFO

SERVICE

FIRMWARE
UPDATE

FIRMWARE
UPDATE

RESTORE
FIRMWARE

UPDATE
PATH

BASEBAND
ANALOG

I/Q INPUT
50Ω   1MΩ

BALANCED
ON   OFF

LOW PASS
36 MHz

DITHER
ON   OFF

I+j*Q

I ONLY

Q ONLY

GPIB
ADDRESS

ID STRING
FACTORY

ID STRING
USER

SELFTEST

SELFTEST
RESULTS

ENTER
PASSWORD

HARDWARE
INFO

STATISTICS

SYSTEM
MESSAGES

CLEAR ALL
MESSAGES

GPIB

COM
INTERFACE

TIME +
DATE

CONFIGURE
NETWORK

NETWORK
LOGIN

OPTIONS

SOFT
FRONTPANEL

INSTALL
OPTION

REMOVE
OPTION

HCOPY Key

Hotkey Menu

| EXIT FFT | | PRESET FFT | | FFT HOME | | SCREEN B |

LOCAL Menu

LOCAL

Contents - Chapter 4 "Instrument Functions"

4 Instrument Functions

The baseband input is used for direct measurement of complex baseband signals (normally modulation signals) or IF signals .

Measurements in both the time domain and frequency domain are possible.

Alternatively you can also extract data: To do so, the R&S FMU digitizes the analog input signals at a user-selectable sampling rate.
The samples can be transferred via IEC/IEEE bus or LAN interface to an external computer for analysis. They are not displayed (Baseband IQ Data Grabbing).

Note: *Baseband IQ data grabbing denotes the following:*
               The TRACE:IQ subsystem (see chapter 6.1) is used by an external computer via IEC/IEEE bus or LAN interface. That is, the R&S FMU digitizes the signals applied at the baseband input, then filters, decimates and transfers them to the external computer, where they are further processed by a program (e.g. Matlab) to be written by the customer. No results are displayed by the R&S FMU.
               The user must explicitly select the sampling rate (thereby automatically selecting the filter bandwidth) and the data length.

Functional Description

Block Diagram

Baseband Input
functional block diagram (simplified)
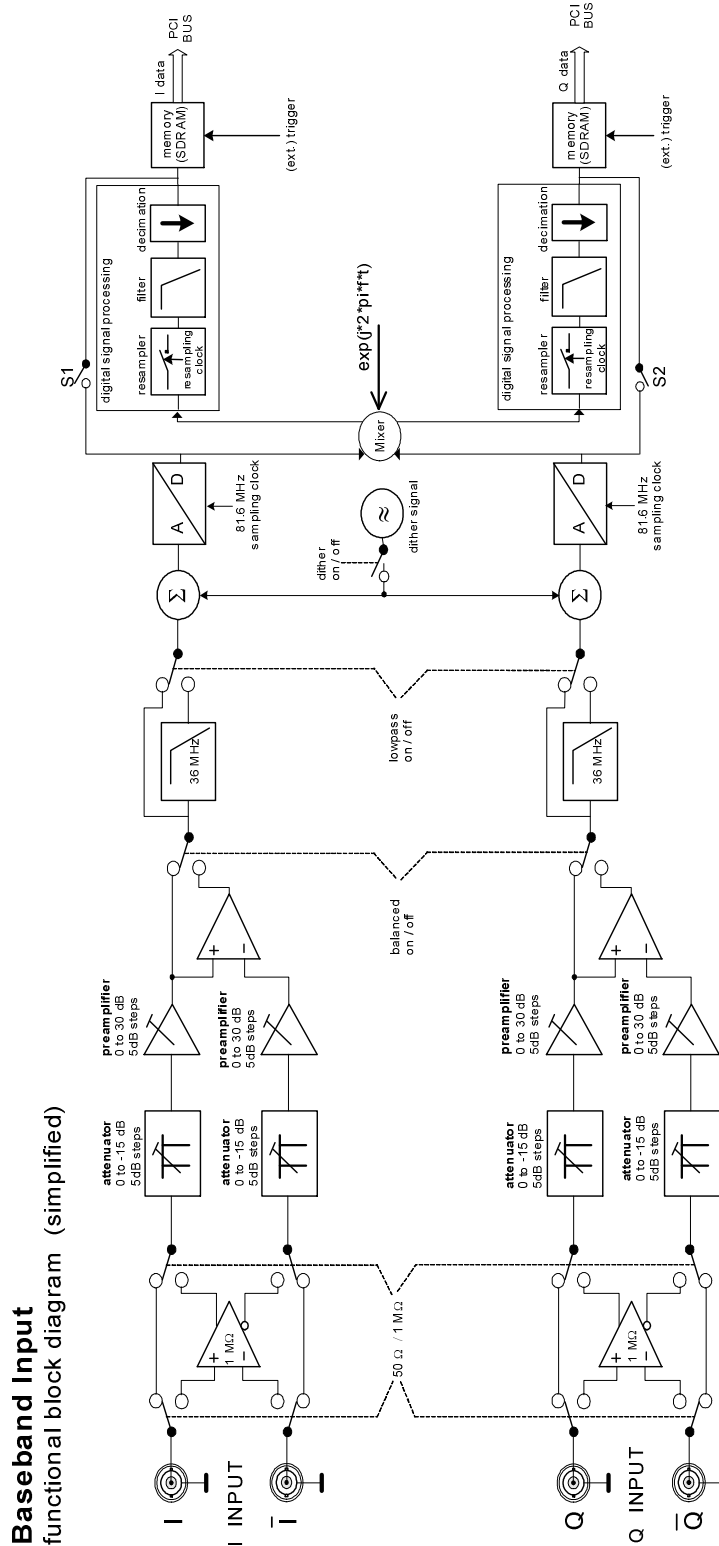
DUT Connection

The device under test, e.g. a complex modulation source, is connected to baseband inputs I and Q . By definition, I is the real part (**i**n phase) and Q the imaginary part (**q**uadrature phase).

A real signal source, like the IF output of a device under test, is connected to the baseband input I.

Differential sources are connected to baseband inputs I / $\overline{\text{I}}$ and Q / $\overline{\text{Q}}$ respectively, while the inverted signal being connected to $\overline{\text{I}}$ and $\overline{\text{Q}}$ resp.

At the **BALANCED OFF** position only the I / Q input is through-connected and at the **BALANCED ON** position the difference between the I - $\overline{\text{I}}$ and Q - $\overline{\text{Q}}$ inputs is through-connected for further processing.

Attenuator and Preamplifier

There is an attenuator to –15 dB at the input. This means that higher input voltages are attenuated to <1 V so that the A/D converter is not overloaded. Voltages of ±1 V can be measured at the 0 dB position. In sensitive measurement ranges, a preamplifier to +30 dB ensures adequate drive level of the A/D converter and thus a low noise figure.

The attenuator and preamplifier settings are permanently coupled to the setting of the **REFERENCE LEVEL** and not user accessible.

RANGE	5.62 V	3.16 V	1.78 V	1 V	562 mV	316 mV	178 mV	100 mV	56.2 mV	31.6 mV
Attenuator	-15 dB	-10 dB	-5 dB	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB
Preamplifier	0 dB	0 dB	0 dB	0 dB	+5 dB	+10 dB	+15 dB	+20 dB	+25 dB	+30 dB

The attenuator and preamplifier have an impedance of 50 Ω. The switchable **1 MΩ input** is reached by inserting a high-impedance 1:1 amplifier directly behind the input sockets. In this instance the maximum measurement range is 1.78 V.

Antialiasing Filter

An analog anti-aliasing filter follows with a cutoff frequency of 36MHz. It is active by default and can be switched off. With **LOWPASS ON / OFF** the amplitude and group delay flatness is specified up to 30 MHz / 36 MHz.

Dithering

If required, a dither signal can be added to the test signal, **DITHER ON/OFF**. This improves the linearity of the A/D converter at low drive levels.

A to D conversion

The test signal (with dither signal if necessary) is sampled by a 14 bit A/D converter with 81.6 MHz.
The anti-aliasing filter is optimized for this fixed ADC sampling rate.

Sampling rate and bandwidth

The user must specify the output sampling rate when data is extracted. It is user-definable but must be between 400 Hz and 100 MHz.

With the FFT Analyzer, the user never selects the output sampling rate directly but always indirectly using other parameters (span, RBW, etc). The firmware always selects the appropriate output sampling rate.

In both cases, the sampling rate is not changed at the A/D converter but by means of digital signal processing using a resampler and subsequent integer decimation. Digital filters limit the signal before decimation to the bandwidth which can still be displayed without aliasing at the output sampling rate.

If the sampling rate is set too low for the test signal, the bandwidth of the signal is limited; but this does not result in aliasing (folding back of high frequencies to the useful band).

The bandwidths available for the given sampling rate are specified in the following table. Reference is made to the useful bandwidth, without limitation of the data (flat response of the digital filters).
This table is only relevant if data is extracted (Baseband IQ Data Grabbing).

With the FFT Analyzer, the sampling rate is calculated by the firmware. In this case, the interdependencies from Chapter "FFT Analyzer" must be observed.

Table 4-1   Available bandwiths

Sampling rate		Max. flat bandwidth I and Q in each case
from	to	
100 MHz	>81.6 MHz	0.343 sampling rate but ≤ 30 MHz for Lowpass = ON
81.6 MHz	>40.8 MHz	0.441 sampling rate but ≤ 30 MHz for Lowpass = ON
40.8 MHz	>20.4 MHz	0.34 sampling rate
20.4 MHz	400 Hz	0.4 sampling rate

These bandwidths apply to I and Q, and are therefore the equivalent lowpass filter bandwidths.
The complex signal formed by I and Q is a bandpass signal having a center frequency of zero.
The bandpass filter bandwidth is twice the size of the lowpass filter bandwidth shown in the table.
The **maximum bandpass filter bandwidth** is therefore **72 MHz** (with sampling rate 81.6 MHz, Lowpass = OFF).

Sample length and format
When data is extracted, the samples (I/Q data) are written with the selected sampling rate to a 16 Mword memory (16 Mword for both I and Q). The number of measurement values (samples) to be acquired is user-selectable.
The FFT Analyzer, however, selects the data volume automatically such that the data volume is always just large enough for the requirements of the user-selected measurement task. The "Capture both domains" mode is an exception; here the complete memory volume of 16 Mwords is filled.

If data is extracted, the acquisition and output of I/Q samples are controlled using the commands of the **TRACe:IQ subsystem**.
In this case the measurement results are output in list form, with the list of I data and the list of Q data immediately following each other in the output buffer. You can use the FORMAT command to choose between binary output (32 bit IEEE 754 floating-point numbers) and output in ASCII format
For further details, refer to chapter 6 onwards.

Digital Down Converter for Low Carrier Frequency (IF)

The R&S FMU is capable of mixing signals from low carrier frequencies (e.g. low IF signals) into the complex baseband. The maximum allowed center frequency range is -35 MHz to +35 MHz. Both real-valued and complex-valued signals are supported.
The baseband signal is sampled, mixed from desired center frequency into the complex baseband and resampled to the requested output sampling rate.

Limitation of center frequency range depending on signal bandwidth for real-valued signals:
Center frequency and sampling rate are adjustable independently, though there are some restrictions to observe:
The lower limit of the center frequency depends on the sideband suppression that is needed for a particular measurement application. To avoid overlapping of the two sidebands of a real-valued signal, the theoretical lower limit of the intermediate frequency is **half the signal bandwidth**.
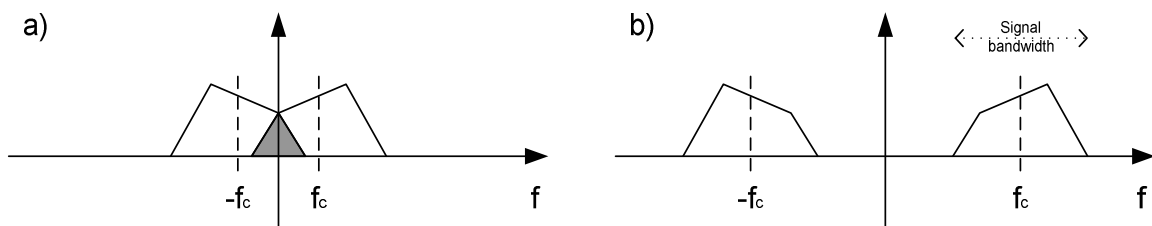

Fig. 4-1   Dependency between signal bandwidth and carrier frequency

The carrier frequency f_c in Fig. 4-1 - a) is lower than half the signal bandwidth, resulting in sideband overlap. The carrier frequency f_c in Fig. 4-1 - b) is high enough to separate the two sidebands.

In practice, the intermediate frequency must be increased for lower sideband crosstalk (limited filter edge steepness). All spectral components of the opposite sideband must be above the decimation filter stop band frequency. Thus, the center frequency must be higher than **0.5 x (stop band frequency + 0.5 x signal bandwidth)**. The stop band frequency depends on the desired output sampling rate and is specified in the following table:

Table 4-2   Stop band frequency of equivalent lowpass filter

Sampling rate from	to	Stop band frequency of equivalent lowpass filter
100 MHz	>81.6 MHz	0.54 sampling rate
81.6 MHz	>40.8 MHz	0.55 sampling rate
40.8 MHz	>20.4 MHz	0.42 sampling rate
20.4 MHz	400 Hz	0.53 sampling rate

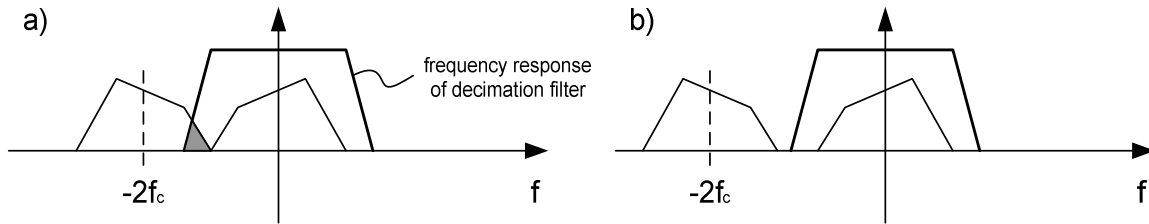**Real-valued signals shifted to complex baseband**

Fig. 4-2   Real-valued signals shifted to complex baseband

In the signal shown in Fig. 4-2 - a) an unwanted part of the opposite sideband remains after decimation filtering, while figure Fig. 4-2 - b) depicts a decimation filtered signal free from sideband crosstalk.

Signal bandwidth dependency on the maximum baseband input bandwidth

The upper limit of the carrier frequency is specified by the available baseband input bandwidth. The entire signal spectrum must fit into the baseband input bandwidth, so the carrier frequency may not exceed

± 0.5 x (baseband input bandwidth – signal bandwidth)
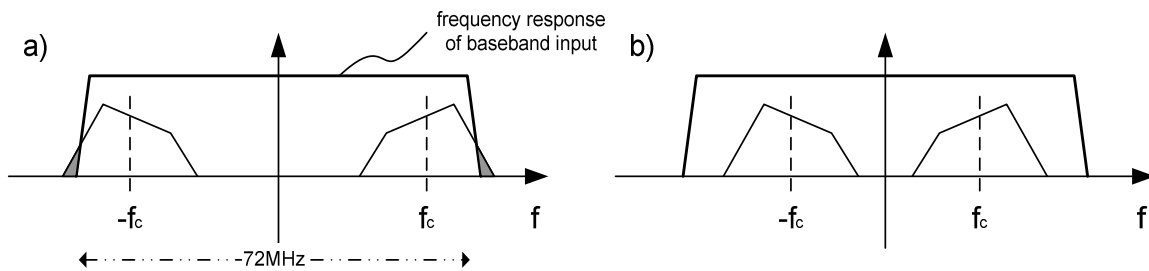

Fig. 4-3   Signal bandwidth dependency on the maximum baseband input bandwidth

In Fig. 4-3 - a) signal spectrum is cut, because it exceeds the baseband input bandwidth. Fig. 4-3 - b) shows a signal fitting entirely into the baseband input bandwidth.

Signal bandwidth limitation for real-valued input signals:
A theoretical upper bandwidth limit for an input signal on the lowest possible intermediate frequency (= 0.5 x signal bandwidth) is defined by **the half of the baseband input**.

Level display

When extracting data (I/Q data grabbing) the I/Q data specifies the voltages at the I/Q inputs at the sampling instants in volts.

In the Time Domain Voltage display of the FFT Analyzer, the I/Q voltages versus time are displayed.

In the Time Domain Magnitude or Frequency Domain Magnitude display, the result is displayed as RMS value (e.g.. RMS value of voltage or power in dBm).

Examples of the Frequency Domain Magnitude display:

Input Signal	Selected I/Q Input Mode	
	I only	I + j*Q
cw signal, 0 dBm, freq. = f at input I	signal at freq. = f 0 dBm	signal at freq. = +f , -3 dBm signal at freq. = -f , -3 dBm
cw signal, 0 dBm, freq. = f, phase 0° at input I cw signal, 0 dBm, freq. = f, phase -90° at input Q		signal at freq. = +f , +3 dBm
cw signal, 0 dBm, freq. = f, phase 0° at input I cw signal, 0 dBm, freq. = f, phase +90° at input Q		signal at freq. = -f , +3 dBm

Error correction

The R&S FMU automatically corrects all important parameters of the baseband input provided that a valid total calibration has been performed (total calibration status passed).

Baseband input parameters corrected after total calibration

Offset: Compensated for by means of a D/A converter before the A/D converters. This ensures that the measurement range of the A/D converters is retained even at high offset voltages (at high gain).

Gain: Digitally corrected by a RAM with a correction table (lookup table) downstream of the A/D converters.

Frequency response: Constant amplitude and group delay (linear phase) over the frequency are achieved by means of digital compensation filters.

Phase difference: The delay difference (and thus the phase difference) between I and Q is compensated for by means of digital filters.

Trigger offset: The different propagation delays (depending on the sampling rate and filters in the signal path) are automatically corrected so that the time reference between the test signal and an external trigger signal is retained.

FFT Analyzer

Overview

The FFT Analyzer provides a convenient way of analyzing the signals at the analog baseband input in both the time domain and the frequency domain. This does not require an external computer. The R&S FMU is used to process the data and to display the results.

In contrast to usual spectrum analyzers, the FFT Analyzer does not determine the spectrum using the sweep principle but instead by performing a FFT (Fast Fourier Transform) on the input data. For this reason, some parameter interdependencies are completely different. There are also a number of new setting options, such as the window functions.

In the FFT Analyzer, a distinction is made between the two operating modes *Time Domain* and *Frequency Domain*. They differ with respect to signal processing and the internal parameter interdependencies.

Operating principle of the FFT Analyzer

This chapter contains a brief description of the signal processing steps for the two operating modes of the FFT Analyzer.

The processing sequence depends on the following parameters:

- Is the Time Domain or Frequency Domain mode active?

- Which input signal am I expecting?
    - I+j*Q mode: Signals at the I and Q input are regarded as components of a complex signal.
    - I ONLY mode: A signal at the I input is regarded as a single, real signal. A signal at the Q input is ignored.
    - Q ONLY mode: A signal at the Q input is regarded as a single, real signal. A signal at the I input is ignored.

- Is the *CAPTURE BOTH DOMAINS* mode active?
  This mode allows measurements with completely different configurations to be performed repeatedly using data which needs to be acquired once only. Initial acquisition of the data must, however, be performed directly to the memory. In the first step, the samples of both the I and Q input are always recorded regardless of the input signal setting.

- How large is the span in the *Frequency Domain* mode?
  If the span is larger than 27.5 MHz, initial acquisition of the data must once again be performed directly to the memory.

The input signals are processed in the following sequence corresponding to the functional block diagram on page 4.2:

1. Provision of the appropriate input impedance (50 Ω or 1 MΩ).

2. Attenuation of signal depending on the REFERENCE LEVEL. Both inputs do, however, always experience the same level of attenuation.

3. Amplification of signal depending on the REFERENCE LEVEL. Both inputs do, however, always experience the same level of gain.

4. Adaptation of the measurement mode (balanced / referenced to ground). Has the same effect on both inputs.

5. Activation of analog anti-aliasing filter or not. Has the same effect on both inputs.

6. Possible addition of shaped dither signal.

7. Sampling of both paths at constant 81.6 MHz.

8. The I and Q samples are then written directly to the memory, but only if this is necessary. Bypassing of switch S1 and S2 using the signal processing block.

9. The samples from both the I and Q input are passed on to the mixer. They either come from the current data acquisition process (i.e. directly from the two A/D converters) or are read out of the two memories if the samples were written directly to these memories beforehand, e.g. because the CAPTURE BOTH DOMAINS mode is active.
Reading out of the raw data and all subsequent signal processing steps can also be triggered by a manual or automatic RECALC process. Signal processing starts here for every RECALC process.

10. The samples pass through the complex mixer. The mixer has a complex input and output. Depending on the IQ PATH setting, the mixer performs the following internal processes:
    - *I + J*Q* mode: The samples from the I input are passed on to the real part of the mixer input and the samples from the Q input to the imaginary part.
    - *I ONLY* mode: The samples from the I input are passed on to the real part of the mixer input. The samples from the Q input are discarded. The imaginary part of the mixer input is instead set to zero.
    - *Q ONLY* mode: The samples from the Q input are passed on to the real part of the mixer input. The samples from the I input are discarded. The imaginary part of the mixer input is instead set to zero.

11. The resulting real or complex signal at the mixer input is multiplied in the mixer by a complex rotating phasor. This causes a shift in the frequency domain which is directly proportional to the rotational frequency of the rotating phasor. The rotational frequency can also be 0 Hz; there is then no shift. The rotational frequency is calculated automatically by the firmware on the basis of the measurement settings. The output signal of the mixer is normally complex. If the input signal was real and has not been mixed, it remains real.

The next processing steps are different for the two operating modes *Time Domain* and *Frequency Domain*.

Operating principle in the *Time Domain* mode

The resampler processing block is not active in the *Time Domain* mode.

An identical digital lowpass filter in both signal paths allows only low-frequency signal components to pass. However, these signal components had a completely different frequency position prior to mixing. The mixing process should have shifted the frequency domain of interest to the range around 0 Hz. It is not attenuated by the filter.
In the *Time Domain* mode, the filter always has a Gaussian characteristic. Its bandpass filter bandwidth (twice the cutoff frequency) corresponds to the *RESOLUTION BANDWIDTH* (*RBW*) selected by the user.
The filter also performs integer decimation. With small filter bandwidths, the effect of decimation may be greater than with large filter bandwidths. The output sampling rate for small and medium *RBWs* is always approx. 20 times that of the selected *RBW*; with very large *RBWs* the output sampling rate drops to approx. twice that of the selected *RBW*.

The two filtered signals are then stored in the memory The output sampling rate of the signal processing block determines the period during which the memory is completely full. As a result, the maximum observation time in the *Time Domain* mode usually depends on the selected *RBW*. If, however, *CAPTURE BOTH DOMAINS* and *SINGLE SWEEP* are active, the acquisition time is always max. 0.16 seconds (16 Mwords / 81.6 MHz minus settling time) irrespective of the RBW since the data is initially recorded in the memory without decimation. See Chapter "Setting the bandwidths and sweep time – BW key", softkey *SWT MANUAL".*

The data is then read out of the memory for analysis. This cannot be performed until data acquisition and processing has been completed. The result trace is therefore not continuously plotted on the display in the case of long observation times. Instead, the trace only appears after the observation time has elapsed. With very large data volumes (i.e. large *RBW* and/or long observation time), the data is read out in blocks and, as a result, the trace is plotted bit by bit.

The read-out measurement data can be analyzed in a number of different ways:

- *MAGNITUDE* diagram: The magnitude of the measurement data is plotted over time.

- *VOLTAGE* diagram: The real and imaginary part of the read-out measurement data is plotted. If the mixer was not active, this corresponds to the operating principle of a digital single-channel or dual-channel storage oscilloscope. If, however, the mixer was active, the information contained in this diagram will not be conclusive.

Note: *The upper and lower diagram display the real part and the imaginary part of the selected complex or real input signal AFTER the input signal has passed through the signal processing modules. The two diagrams DO NOT normally represent the I and Q inputs.*

A Gaussian filter is always used for Time Domain measurements. The user-definable window functions from the Frequency Domain mode are completely irrelevant here.

Operating principle in the *Frequency Domain* mode

The resampler processing block is active in the *Frequency Domain* mode. It performs fractional resampling of the sampling rate. Combined with the subsequent integer decimation in the digital filters, this allows the output sampling rate to be varied steplessly over a very broad range.

An identical digital lowpass filter (approximately rectangular in form) in both signal paths removes high-frequency signal components. Only slightly more than the span selected by the user is allowed through unchanged. The mixing process should have shifted the center of the selected span to the frequency 0 Hz. This permits the largest possible decimation (here integer decimation) to be performed following filtering, i.e. the sampling rate is reduced.

The two filtered signals are then stored in the memory. The output sampling rate of the signal processing block determines the period during which the memory is completely full. This gives rise to the interdependencies and minimum/maximum values described in chapter "Setting the bandwidths and sweep time – BW key". Other values apply in the *CAPTURE BOTH DOMAINS* mode since the acquisition time is max. 0.16 seconds (16 Mwords / 81.6 MHz minus settling time). In this mode, data is always initially recorded in the memory without decimation.

The samples are then read out of the memory. They are multiplied using the selected window function. A complex FFT transforms the data from the time domain to the frequency domain.

The FFT results can be analyzed in a number of different ways:

- *MAGNITUDE* diagram: Only the magnitude of the FFT results is displayed.

- *MAGNITUDE PHASE* diagram: The upper diagram corresponds to the upper *MAGNITUDE* diagram. The phase information is, however, also displayed in the lower diagram. The phase trace only provides conclusive information if a single measurement (*SINGLE SWEEP*) was performed, or if a periodic signal is analyzed in the CONTINUOUS SWEEP using a trigger.

- *REAL IMAG* diagram: The real and imaginary parts of the FFT results are displayed on a linear scale. These can also be negative. This diagram is generally of little relevance. As with the *MAGNITUDE PHASE* diagram, a single measurement should be performed or, alternatively, a trigger should be used.

General Operation

The following diagrams explain which settings must be made to allow the hardware to process the input signals correctly. The operating principle is the same for all operating modes; configuration, however, takes place at different locations.

The configurations for the baseband inputs are kept separate for the following operating modes:

- Baseband IQ Data Grabbing (extraction of data by means of IEC/IEEE bus or LAN interface, TRACE:IQ)

- FFT Analyzer

- every option which can use the baseband inputs

For configuration, the **FFT Analyzer** provides:

- a separate submenu

- or, alternatively, the submenu which can be called up using the SIGNAL SOURCE softkey in the SETUP menu.

All **options** which can use the baseband inputs provide the following for configuration:

- the submenu, which can be called up using the SIGNAL SOURCE softkey in the SETUP menu.

Please also refer to the operating manual for the respective option.

Note: *Both paths (I and Q) are always taken into consideration when data is extracted. The possibility of ignoring a path is only available in the FFT Analyzer (IQ PATH softkey).*
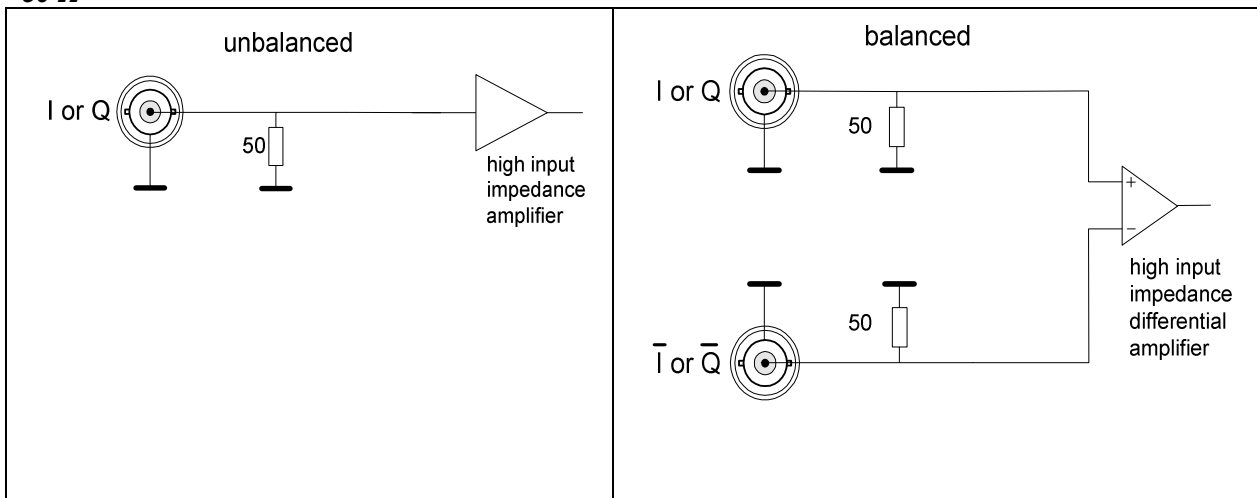
Settings of the Baseband Inputs

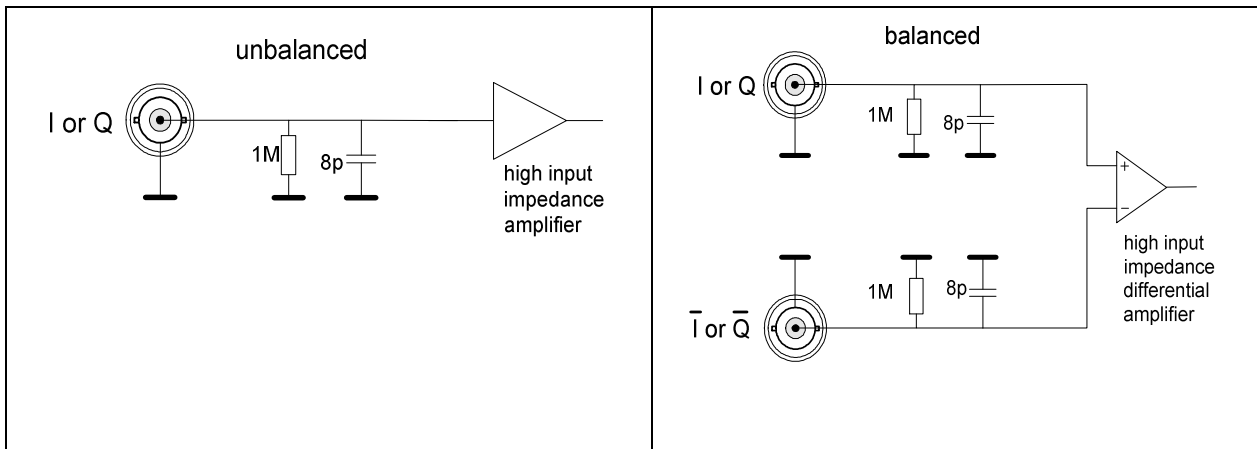### Input impedance

IEC/IEEE bus command: `INP:IQ:IMP LOW │ HIGH`

LOW corresponds to 50 Ω; HIGH corresponds to 1 MΩ.
The default setting is 50 Ω.

Equivalent input circuit

50 Ω

1 MΩ

Note: *It should be remembered that at the 50 Ω setting there is always a 50 Ω DC path to ground, even when the input is switched to BALANCED.*
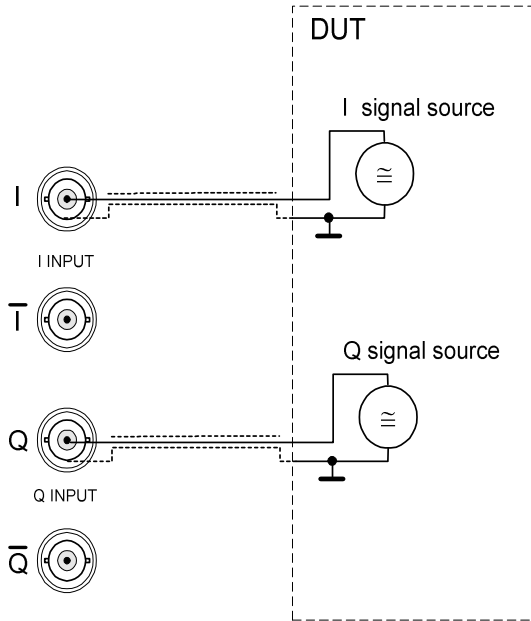
Measurement mode

IEC/IEEE bus command: `INP:IQ:BAL ON |OFF`

Used to toggle the measurement mode between balanced (BALANCED ON) and referenced to ground (BALANCED OFF).
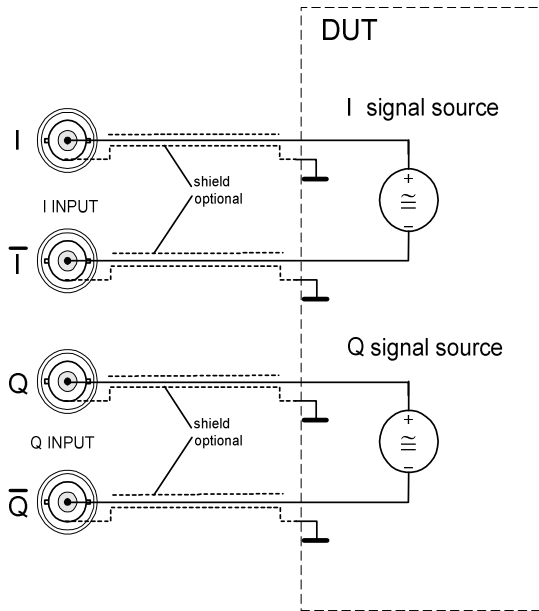The default setting is OFF.

Connecting the signal sources (device under test)

BALANCED OFF

The connection to ground is run via the shield of the coaxial cable.

BALANCED ON

A connection to ground is not necessary.

Lowpass Filter

IEC/IEEE bus command: `IQ:LPAS ON |OFF`

Used to switch the anti-aliasing filters upstream of the A/D converters on and off (cutoff frequency 36 MHz).
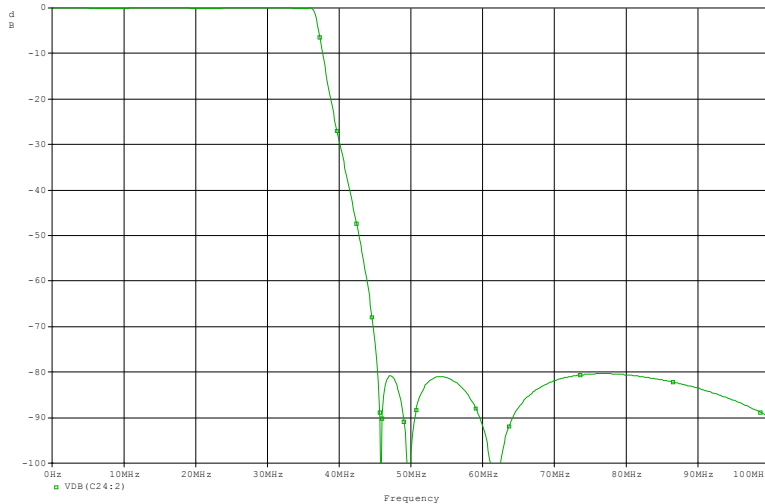The default setting is ON.

Fig. 4-4   Anti-aliasing lowpass filter, typical frequency response

Note:
- The filter prevents frequencies above the usable frequency range (>36 MHz) from being mixed into the usable frequency range (DC to 36 MHz) as a result of sampling (sampling frequency 81.6 MHz). It should therefore always be switched on. It should bear in mind that, for example, harmonics and other spurious emissions of the device under test might be in the disallowed frequency range.

- Amplitude response and phase response (or group delay) of the filter are compensated for up to 30 MHz.

- With the filter switched off, amplitude response and phase response (or group delay) of the filter are compensated for up to 36 MHz. This setting is only recommended if the higher bandwidth is required. In this case, it is important to ensure that the spectrum of the device under test has adequately decayed >45.6 MHz since these spectral components appear in the useful band <= 36 MHz.

Dithering

IEC/IEEE bus command: `IQ:DITH ON |OFF`

Used to switch the dither signal on and off. The dither signal is added to the signal to be measured before the A to D conversion.
The default setting is OFF.

The dither signal distinctly improves the linearity of the A/D converter at low signal levels (low drive level at the A/D converter) and thus the accuracy of the level displayed.

Note: *The dither signal is necessary only if the total AC voltage applied to the input (up to 36 MHz) is more than 46 dB less than the set REFERENCE LEVEL. The DC component is not taken into account.*

The dither signal has no effect with signals applied having levels higher than measurement range –46 dB. A disadvantage, however, is that it might have to be removed from the spectrum as a result of post-processing (filters).
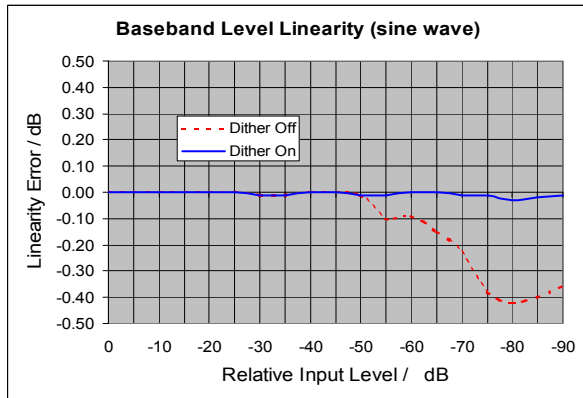

Fig. 4-5   Typical linearity error with and without dither signal

Characteristics of the dither signal:

Band-limited noise, center frequency 38.93 MHz (in the I/Q spectrum), 3 dB bandwidth approx. 2 MHz, peak voltage 7 %, rms 1 % of measurement range of A/D converter.
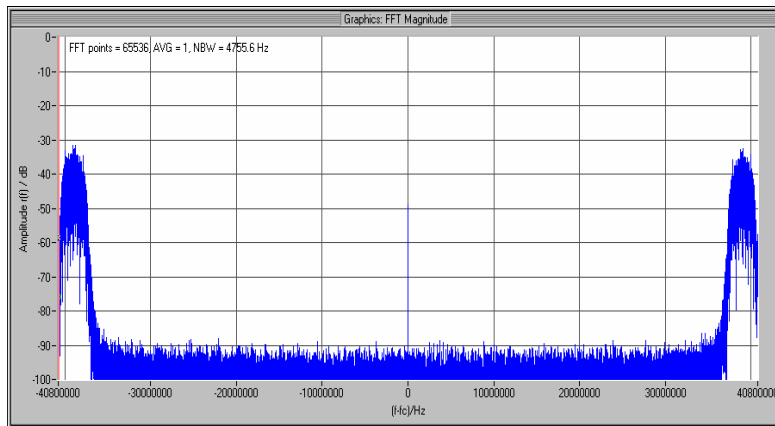
Fig. 4-6   Dither signal, spectrum (complex FFT of I/Q data)

The entire spectrum is outside the usable frequency range (>36 MHz) and can therefore be removed by means of digital filters without affecting the useful signal. If data is extracted by means of IEC/IEEE bus or LAN interface, at lower sampling rates (<40.8 MHz) the dither signal will already have been removed by the internal digital filters and therefore no longer appears in the I/Q data.

In the FFT Analyzer the dither signal is almost completely removed by the internal digital filters.

Measurement range

IEC/IEEE bus command: `VOLT:IQ:RANG 5.62|3.16|1.78|1|0.562|0.316 ...`

The unit for input is volts.

The default setting is 1 V.

The measurement range specifies the measurable peak voltage, at the I and Q inputs in each case.
For example, voltages between –1 V and +1 V can be measured with a setting of 1 V.
With the BALANCED ON setting, the measurement range defines the measurable differential voltage.

The measurement range can be changed in steps of 5 dB.
Permissible settings:

0.0316 V
0.0562 V
0.1 V
0.178 V
0.316 V
0.562 V
1 V
1.78 V
3.16 V only with IMPEDANCE LOW (50 Ω)
5.62 V only with IMPEDANCE LOW (50 Ω)

Headroom: Typically 3 dB (with dither 2 dB) higher voltages can still be measured. The A/D
                   converter is overloaded when the headroom is exceeded, then the overload display
                   appears: *OVLD*.

The measurement range depends on the REFERENCE LEVEL. By setting the REFERENCE LEVEL,
the same or the next higher measurement range is selected automatically.

Using Probes

As a special feature, the R&S FMU allows you to perform measurements using high-impedance probes, since the input impedance can be switched to 1 MΩ.

|	
10:1 probes	Conventional 10 MΩ/10:1 oscilloscope probes can be used if their compensation range includes 8 pF. Appropriate probes are available as an accessory (R&S FMU-Z1, order no. 1409.7508.00).
1:1 probes	You can also measure with 1:1 probes. But due to their high input capacitance of typ. 50 pF, these probes are only suitable for frequencies up to approx. 6 MHz. However, the 1:1 probes are only advantageous with weak signals (approx. <180 mV peak voltage), since they attain a higher signal-to-noise ratio in the R&S FMU than 10:1 probes.
Automatic probe detection	All modern probes have a coding pin. This pin is connected to ground via a resistor. A certain resistance value is assigned to a variety of attenuation factors (examples: 1:1, 2:1, 10:1, 100:1). By means of this resistance coding, the R&S FMU detects a connected probe and automatically takes into account the respective attenuation factor in the display. The attenuation factors must be between 1:1 and 100:1. Example: A measurement range of 1 V is set on the R&S FMU. A 10:1 probe is connected. The measurement range automatically changes to 10 V.
Automatic switchover to 1 MΩ	As soon as a probe is connected, the R&S FMU automatically switches the input impedance to 1 MΩ, since passive probes cannot be operated at a 50 Ω input. The automatic switchover thus simplifies operation. When you remove the probe, the 1 MΩ setting is maintained.
Preset	The blue PRESET key resets the instrument to the default state without taking connected probes into account. The default state of the baseband input is I + j*Q, unbalanced, input impedance 50 Ω. Probe calibration is switched off. The PRESET FFT key in the hot key bar has the same effect as the PRESET key, as long as no probes are connected. If probes are connected, the following settings remain unchanged: I/Q path (I only, Q only, I+j*Q) Balanced ON/OFF Input impedance 1 MΩ An active probe calibration is not switched off.

Connecting the Probes

Before connecting the probes, it is advisable to carry out the following configuration as desired:

I/Q path (I only, Q only, I+j*Q)
Balanced ON/OFF

By doing so, the active inputs are defined. Active inputs are indicated by illuminated LEDs.

Note! **Probes with identical attenuation factor must be connected on all active inputs.**

If more than one input is active, the following message will appear after the first probe has been connected:
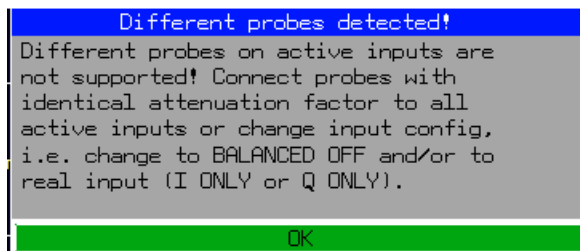
As soon as you have connected probes on all active inputs, the message will disappear automatically. If the configuration (e.g. Balanced = OFF) is not to be set correctly until after the probes have been connected, then you must first acknowledge this message by pressing ESC or ENTER.

Measuring with Probes

Usually, you have 50 Ω interfaces at instrument outputs (e.g. I/Q output of a signal generator). In development, it is often necessary to measure within printed boards – i.e. at spots that do not support 50 Ω. For this purpose, you can switch the R&S FMU to 1 MΩ input impedance. If you use a coaxial cable (e.g. BNC cable) for connecting the DUT, this cable will put considerable strain on the measuring point due to its capacitance (typ. 100 pF/m). This will lead to incorrect measurement results. Due to the high impedance (10 MΩ // 10 pF) of high-quality probes (such as the R&S FMU-Z1), you can perform virtually distortion-free measurements. Owing to their fine probe tip, adaptation is also much easier than with a cable.

Calibrating Probes

In principle, a connected probe leads to a larger measurement uncertainty. The tolerance of the attenuation factor is usually specified, allowing you to at least calculate the resulting measurement uncertainty. Although it is practically impossible to make a quantitative statement with respect to the frequency response, this is no problem for the R&S FMU. The R&S FMU is able to measure all errors of the probe and mathematically correct them afterwards. For this purpose, the probe is connected to the calibration source of the R&S FMU and automatically calibrated by pressing a button. For safe adaptation, you should make sure to use a BNC adapter. The R&S FMU-Z1 probes are supplied with a BNC adapter.

Probe calibration is explained in detail in the description of the *PROBE CAL* menu. The following gives you an overview of the procedure.

It is presumed that the I/Q input is set as desired and that all probes have been connected appropriately.

The *PROBE CAL* menu provides the following options:

- Gain & Offset   This function measures the probe attenuation and then mathematically corrects it. In connection with the probe, the DC offset of the input gain is compensated to zero.

- Frequency Response   This function measures the frequency response of the overall system (probe, amplifier, filter, etc) and then compensates it with a digital filter.

- Probe Compensation   The R&S FMU provides a 1 kHz squarewave signal that allows you to adjust the probe to the input capacitance of the R&S FMU. It is the same procedure as usual with oscilloscopes. The R&S FMU automatically sets a time domain display that matches the signal so that you only have to make the adjustment.
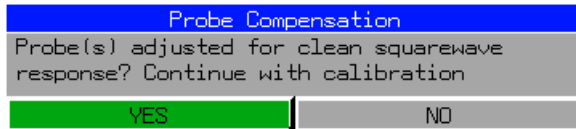
In the default setting, all three functions are active.

Probe Calibration Procedure

After pressing the *PROBE CAL START* softkey, you are requested to connect the probes to the calibration source (PROBE CAL BNC connector).

```
Probe Connection
Probe(s) I connected?
  YES          NO
```

After pressing the *ENTER* key, calibration is started. The first step (if selected) is the probe compensation.

```
Probe Compensation
Probe(s) adjusted for clean squarewave
response? Continue with calibration
      YES                NO
```

After the probe has been adjusted, the calibration is continued by pressing the *ENTER* key.

If more than one probe is to be calibrated, then this procedure, beginning with the request to connect this probe, is repeated for each probe.

Finally, after all probes have been calibrated the following message will appear:

```
Calibration Completed
Calibration passed. Save Data?
    YES            NO
```

If you acknowledge this message with YES, the calibration data will be saved to the hard disk as a file and can be reactivated at any time.
However, if you acknowledge with NO, the data will only be available in the memory. After each step that renders the data invalid (e.g. disconnecting a probe, changing the Balanced ON /OFF configuration), the calibration data is lost.

Taking the data into account (Probe Correction = ON) is automatically switched on after the calibration or after a saved file has been loaded.

Operation Menu

All functions of the baseband signal 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. Configuring the FFT Analyzer – softkeys *FREQUENCY DOMAIN, TIME DOMAIN, SIGNAL SOURCE*

4. Setting the measurement parameters - keys *FREQ*, *SPAN*, *AMPT*, *BW*, *SWEEP*, *TRIG*, *TRACE*, *CAL*

5. 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.

R&S FMU Initial Configuration – PRESET Key

PRESET
C

Using the *PRESET* key, the R&S FMU can be set to a predefined initial state.

Notes: *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 R&S FMU to enter its initial state according to the following table:

Table 4-3   Initial State of R&S FMU

Parameter   Settings

Parameter	Settings
Mode	FFT Mode
Capture domain	Frequency domain magnitude
Center frequency	0 Hz
Center frequency step size	0.1 * center frequency
Span	72 MHz
Reference level	+10 dBm (peak 1.0 V)
Level range	100 dB log
Level unit	dBm
Sweep time	3.8852 µs
Resolution bandwidth	auto (1 MHz)
Span / RBW	auto (50)
Sweep	continuous
Trigger	free run
Trace 1	clr write
Trace 2/3	blank
Detector	auto select (auto peak)
Trace math	off
Frequency offset	0 Hz
Reference level offset	0 dB
Reference level position	100 %
Grid	abs
Cal correction	on
Probe correction	off
Display	Full screen, active screen A
Type of signal at baseband input (IQ Path)	I+jQ
I/Q Input Impedance	50 Ohm
Balanced Input	Off
Lowpass 36 MHz	On
Dither	Off
Sweep count	0
Sweep points	625

The *PRESET* key also sets all other applications (e.g. VSA) to their default state.
The *PRESET FFT* key (in the hotkey bar) only sets the FFT Analyzer to a predefined default state.

IEC/IEEE bus command: `SENS:FFT:PRES`

Selecting the Operating Mode – HOTKEY bar

The R&S FMU has seven keys ("hotkeys") below the display to allow fast selection of the various operating modes. These keys may have different functions depending on the available instrument options.
The illustration below shows how the hotkey bar may look if the instrument is in the *FFT mode (Preset setting).*

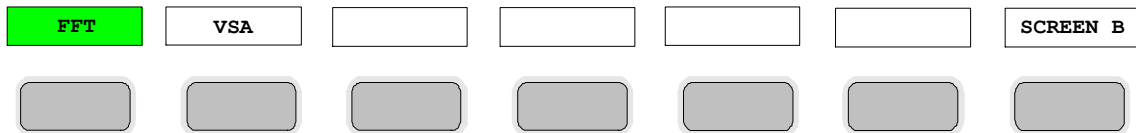| EXIT FFT		PRESET FFT		FFT HOME		SCREEN B
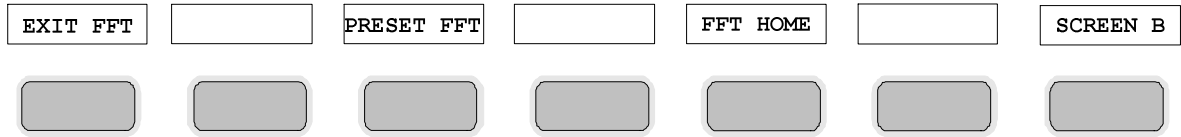
The *EXIT FFT* hotkey enables the R&S FMU main hotkey bar that allows the selection of different operation modes.

IEC/IEEE bus command: `INST:SEL <other>`
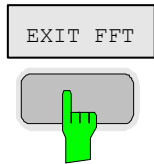
The main hotkey bar allows the activation of another operation mode.

FFT	VSA					SCREEN B

The *PRESET FFT* hotkey sets the FFT Analyzer to a predefined state.
IEC/IEEE bus command: SENS:FFT:PRES
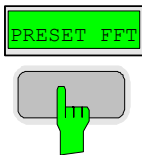
The *HOME FFT* hotkey opens the main menu of the FFT Analyzer.
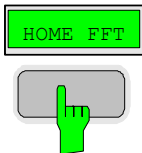
Real split-screen mode is not possible with the R&S FMU. Although there are measurements with a split screen, these measurements cannot display the results of two completely independent measurements. The SCREEN A / SCREEN B hotkey can only be used in measurements that automatically display split-screen diagrams. Marker operations and the configuration of the diagram axes can be switched between the upper diagram (SCREEN A) and the lower one (SCREEN B) with this hotkey.

IEC/IEEE-bus command: `DISP:WIND<1|2>:SEL`

The meaning of the other keys is described in the chapter describing the various options.

Return to manual control – LOCAL Menu
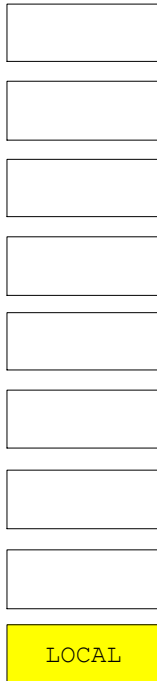
The menu LOCAL is displayed on switching the instrument to remote control mode.

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.*

Operation of the FFT Analyzer

Overview of menus

FFT HOME		FREQUENCY DOMAIN		MAGNITUDE
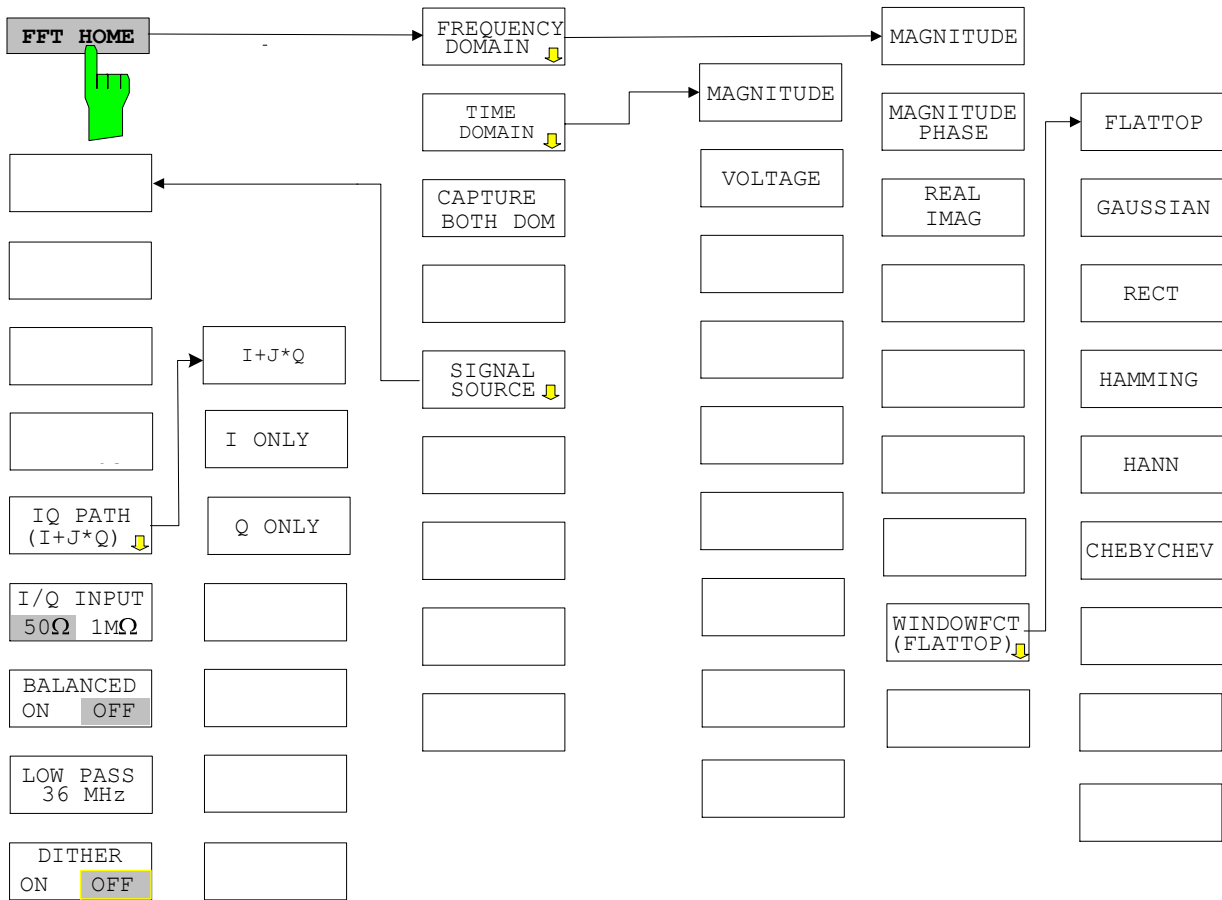
Main menu of the FFT Analyzer

This softkey main menu appears on the right-hand side of the display immediately after the *FFT Analyzer* mode is started or whenever the *HOME FFT* hotkey is pressed.
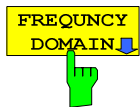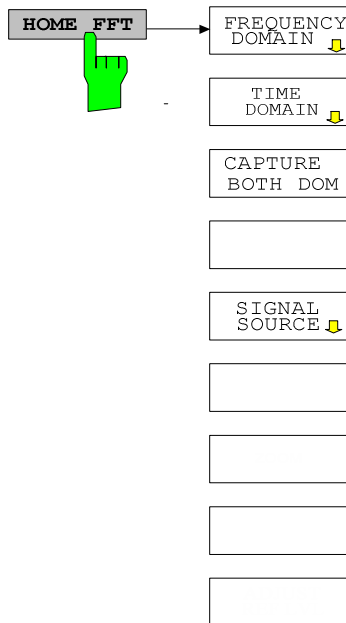
The *FREQUENCY DOMAIN* softkey opens a submenu in which various types of spectrum measurements can be selected. The softkey activates the *Frequency Domain* mode and deactivates the *Time Domain* mode.

Note: The Frequency Domain mode can also be activated by entering a SPAN larger than 0 Hz (see chapter "Setting the frequency span – SPAN ")

IEC/IEEE bus command: `SENS:FREQ:SPAN 10MHz`
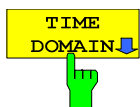
The *TIME DOMAIN* softkey opens a submenu in which various types of time-domain measurements can be selected.
The softkey activates the *Time Domain* mode and deactivates the *Frequency Domain* mode.

Note: The Time Domain mode can also be activated by entering a SPAN of 0 Hz (see Chapter "Setting the frequency span – SPAN ").

IEC/IEEE bus command: `SENS:FREQ:SPAN 0Hz`
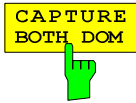
CAPTURE BOTH DOM

The *CAPTURE BOTH DOM* softkey (short for "capture both domains") has a toggle function. Function active: In single sweep mode, the entire I/Q data memory is always filled with unfiltered raw data first. By using the *RECALC* and *RECALC AUTO* softkeys in the *SWEEP* menu, this data can then be analyzed as often as required using different instrument settings. This is possible in both the time and frequency domain, hence the name of the softkey.

Function not active: Data acquisition is optimized for the currently selected measurement task. This means that the observation time is only as long as necessary. As a result, measurements are generally performed more quickly, unless the measurement settings force data to be written directly to the memory. If the function is not active and the data rate can be reduced prior to writing the data to the memory, this will permit a longer observation time and a better frequency resolution.

IEC/IEEE bus command: SENS:FFT:CAPT ON
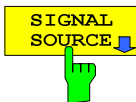
SIGNAL SOURCE

The *SIGNAL SOURCE* softkey opens a submenu in which the properties of the input signal and the way in which the signal is to be processed can be defined.

IEC/IEEE bus command: -

Frequency Domain submenu of the FFT Analyzer

This submenu appears when the *FREQUENCY DOMAIN* softkey in the main menu of the FFT Analyzer is pressed.

FREQUENCY DOMAIN → **MAGNITUDE** → **FLATTOP**

MAGNITUDE PHASE

REAL IMAG

GAUSSIAN

RECT-ANGULAR

HAMMING

HANN

CHEBYCHEV

WINDOWFCT (FLATTOP)
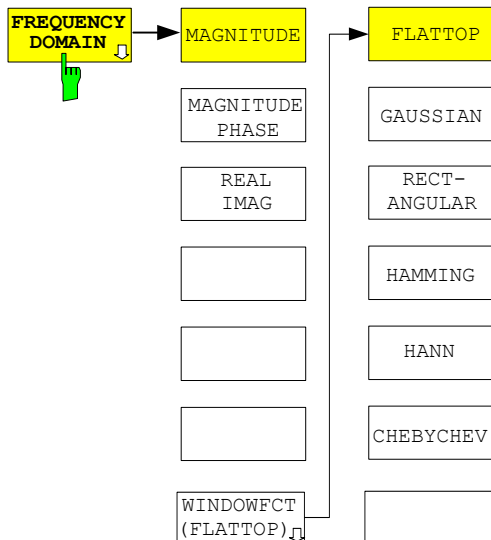
The first three softkeys are used to select the display mode for the measured spectrum. The softkey changes color when selected. Pressing a different softkey toggles the selection.

The displayed spectrum range depends primarily on the parameters *SPAN* / *CENTER FREQUENCY* and *START FREQUENCY* / *STOP FREQUENCY*. The frequency resolution is determined using the parameter *RESOLUTION BANDWIDTH* (*RBW*). The selected window function determines the filter shape and the shape factor. The window function and the RBW together determine the data acquisition time (i.e. *SWEEP TIME*) which is automatically selected internally.

MAGNITUDE

If the *MAGNITUDE* softkey is selected, only the magnitude of the spectrum is displayed as the result.

IEC/IEEE bus command: CALC:FORM MAGN

MAGNITUDE PHASE

If the *MAGNITUDE PHASE* softkey is selected, the magnitude of the spectrum and its phase information are displayed as the result.

Note: *This option should only be selected for single measurements or when using a trigger with periodic signals.*

It should be noted that scaling of the phase information can be controlled using a special submenu (*PHASE SETTINGS*) opened with the *AMPT* key.

IEC/IEEE bus command: `CALC:FORM MPH`
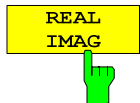
REAL IMAG

If the *REAL IMAG* softkey is selected, the real and imaginary parts of the spectrum are displayed as the result. The results are displayed on a linear scale.

Note: *This option should only be selected for single measurements or when using a trigger with periodic signals.*

A number of measurements (e.g. from the menu opened with the *MEAS* key) are not permitted in this display mode.

IEC/IEEE bus command: `CALC:FORM RIM`

WINDOWFCT (FLATTOP) → FLATTOP, GAUSSIAN, RECT, HAMMING, HANN, CHEBYCHEV

The *WINDOWFCT* softkey (short for "window function") opens a submenu in which the window function for the FFT input data can be selected. The input data for the FFT is multiplied by the selected window function. This suppresses leakage effects (but not in the case of the rectangular window).

The softkey also indicates the type of window function currently active.

Note: *The window function is completely irrelevant in the Time Domain mode.*

Selecting a different window function changes the filter shape of the resolution filter, e.g.:

- shape factor: ratio of –60 dB bandwidth to –3 dB bandwidth
- sidelobe fall-off
- attenuation of highest sidelobe

The equivalent noise bandwidth remains constant when the window function is changed. This is achieved by adapting the acquisition time.

Important: *In the FFT Analyzer, the equivalent noise bandwidth is used as the entry for RESOLUTION BANDWIDTH.*
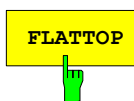
FLATTOP

The *FLATTOP* softkey selects a "flattop" window function. It provides optimum amplitude accuracy. It is therefore the default setting. It is also suitable for measurements with a wide dynamic range because the sidelobes are attenuated very effectively.

IEC/IEEE bus command: `SENS:WIND:TYPE FLAT`

GAUSSIAN

The *GAUSSIAN* softkey selects a "Gaussian" window function.
It is also suitable for measurements with a wide dynamic range because the sidelobes are attenuated very effectively.

IEC/IEEE bus command: `SENS:WIND:TYPE EXP`
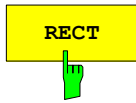
RECT

The *RECT* softkey selects a "rectangular" window function. The input data is then not weighted differently but instead remains unchanged. This type of window function is also referred to as "boxcar window" or "transient window".
It should be used for brief transient signals (no data is lost).
It should be used in cases where only frequency resolution is an important factor.
It is otherwise unsuitable since leakage is not suppressed.

IEC/IEEE bus command: `SENS:WIND:TYPE RECT`

HAMMING

The *HAMMING* softkey selects a "Hamming" window function.

Note: It is not suitable for measurements with a wide dynamic range.

IEC/IEEE bus command: `SENS:WIND:TYPE HAMM`

HANN

The *HANN* softkey selects a "Hann" window function (sometimes also referred to as "Hanning").
It is sometimes used for measurements on noise-like signals.

IEC/IEEE bus command: `SENS:WIND:TYPE HANN`

CHEBYCHEV

The *CHEBYCHEV* softkey selects a "Chebychev" window function. It is also suitable for measurements with a wide dynamic range because the sidelobes are attenuated very effectively.

IEC/IEEE bus command: `SENS:WIND:TYPE CHEB`

Table 4-4   Window function data

	ENBW (bins)	BW_{3dB} (bins)	BW_{3dB} / ENBW	BW_{6dB} (bins)	BW_{6dB} / ENBW	Shape factor $=BW_{60dB}/BW_{3dB}$	Highest sidelobe (dB)	sidelobe fall off (dB / decade)
Flattop	3.89	3.85	0.99	4.73	1.22	2.4	-90	0
Hann	1.50	1.45	0.97	2.02	1.35	9.1	-31.5	60
Hamming	1.36	1.32	0.97	1.83	1.35	70.7	-42.6	20
Rectangular	1.00	0.89	0.89	1.21	1.21	707	-13.3	20
Gaussian	2.26	2.13	0.94	3.00	1.32	4.4	-87.6	20
Chebychev	2.03	1.95	0.96	2.72	1.34	3.84	-110	0

Explanation of the table values:

- The equivalent noise bandwidth of a filter is the bandwidth which an ideal, rectangular filter would need to have to allow the same power to pass if white noise is applied at the input.
- The value BW_{3dB} / ENBW indicates the factor by which the measured 3 dB bandwidth is smaller than the selected RBW (which is defined by the equivalent noise bandwidth).
  If, for example, a Hann window and an RBW of 10 kHz are used, a 3 dB bandwidth of approx. 9.7 kHz will be measured with the *N DB DOWN* measurement.
- The values of the highest sidelobe and of the sidelobe fall-off are important if measurements are to be performed with the widest possible dynamic range. The flattop, Gaussian and Chebychev windows are ideal for such measurements. The flattop and Chebychev windows have sidelobes with more or less constant attenuation.
- The shape factor is a measure of the shape of a window or filter. It is defined as the ratio of 60 dB bandwidth to 3 dB bandwidth. Small values are to be aimed for. The rectangular window and Hamming window do not perform well here.

Interdependency between observation time and window function:

In the FFT Analyzer, the equivalent noise bandwidth is used as the entry for *RESOLUTION BANDWIDTH (RBW)*. This is because the FFT has an equivalent noise bandwidth of exactly one bin if the rectangular window function is used. The frequency resolution of the FFT for this window is 1 Hz if the observation time is 1 second. RBW and observation time (here referred to as *SWEEPTIME SWT*, although no sweep principle is actually applied) are reciprocal.

The equation $\Delta f = RBW = \dfrac{1}{SWT}$ applies in the case of a rectangular window.

However, leakage effects occur which make the rectangular window unusable for the majority of applications. If a window function is then used to reduce these leakage effects, the data is slowly attenuated toward zero at the beginning and end of the observation time. The effective observation time drops as a result and the frequency resolution in turn becomes poorer. The *FFT* then has a noise bandwidth which is one relative equivalent noise bandwidth larger than if a rectangular window of the same length is used.

$$ENBW_{rel}(window) = \frac{ENBW(window)}{ENBW(rectangular)}$$

This problem can be solved by increasing the observation time by multiplying it by the relative equivalent noise bandwidth ENBW$_{rel}$ of the window function:

The equations $SWT = \dfrac{ENBW_{rel}}{RBW}$ and $RBW = \dfrac{ENBW_{rel}}{SWT}$ apply for all windows.

Changing the window function therefore changes the observation time. However, changing the SPAN does not change the observation time.

Time Domain submenu of the FFT Analyzer

This submenu appears when the *TIME DOMAIN* softkey in the main menu of the FFT Analyzer is pressed.
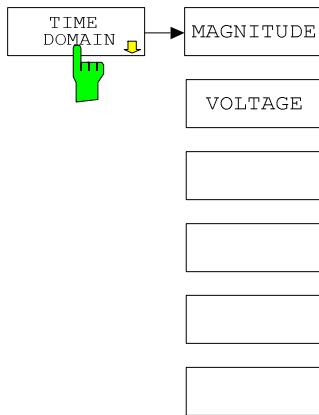
In this menu the time domain display mode can be selected.

If the *MAGNITUDE* softkey is selected, the magnitude of the input signal (which may be offset with respect to frequency and then filtered by lowpass filters) over time is displayed as the result.
Using the *IQ PATH* softkey (in the *SIGNAL SOURCE* menu), it is possible to decide whether both paths or just one path of the baseband input is to be through-connected.

IEC/IEEE bus command: `CALC:FORM MAGN`
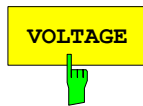
If the *VOLTAGE* softkey is selected, the real and imaginary parts of the input signal (which may be offset with respect to frequency and then filtered by lowpass filters) over time are displayed as the result. The diagram is split into two parts and shows the real and imaginary part on a linear scale.

If no mixing takes place *(CENTER FREQUENCY* = 0 Hz), the following applies:

*   With *IQ PATH = I + j*Q*: The real part and imaginary part of the result corresponds to the voltage characteristic at the I input and Q input.

*   With *IQ PATH = I ONLY*: The real part of the result corresponds to the voltage characteristic at the I input. The imaginary part is zero.

*   With *IQ PATH = Q ONLY*: The real part of the result corresponds to the voltage characteristic at the Q input. The imaginary part is zero.

A number of measurements (e.g. from the menu opened with the *MEAS* key) are not permitted in this display mode.

IEC/IEEE bus command: `CALC:FORM VOLT`

SIGNAL SOURCE submenu of the FFT Analyzer

This submenu appears when the *SIGNAL SOURCE* softkey in the main menu of the FFT Analyzer is pressed.
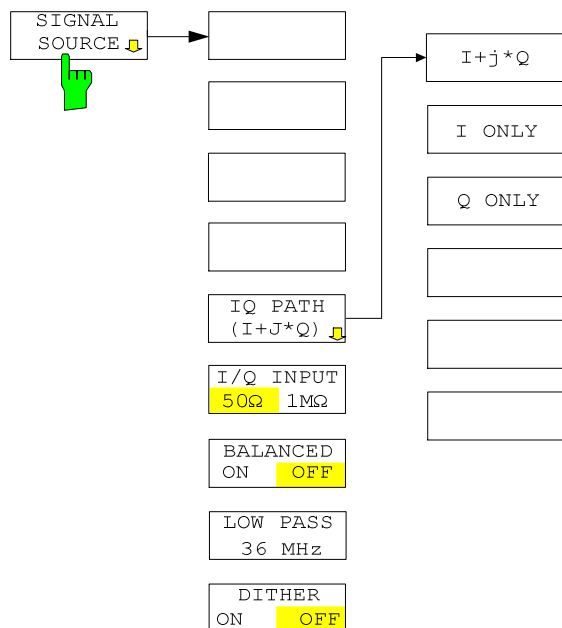
```
┌──────────┐        ┌──────────┐            ┌──────────┐
│ SIGNAL   │───────▶│          │       ┌───▶│  I+j*Q   │
│ SOURCE   │        │          │       │    └──────────┘
└──────────┘        └──────────┘       │    ┌──────────┐
                    ┌──────────┐       │    │  I ONLY  │
                    │          │       │    └──────────┘
                    └──────────┘       │    ┌──────────┐
                    ┌──────────┐       │    │  Q ONLY  │
                    │          │       │    └──────────┘
                    └──────────┘       │    ┌──────────┐
                    ┌──────────┐       │    │          │
                    │          │       │    └──────────┘
                    └──────────┘       │    ┌──────────┐
                    ┌──────────┐       │    │          │
                    │ IQ PATH  │───────┘    └──────────┘
                    │ (I+J*Q)  │            ┌──────────┐
                    └──────────┘            │          │
                    ┌──────────┐            └──────────┘
                    │ I/Q INPUT│
                    │ 50Ω  1MΩ │
                    └──────────┘
                    ┌──────────┐
                    │ BALANCED │
                    │ ON   OFF │
                    └──────────┘
                    ┌──────────┐
                    │ LOW PASS │
                    │  36 MHz  │
                    └──────────┘
                    ┌──────────┐
                    │ DITHER   │
                    │ ON   OFF │
                    └──────────┘
```

The way in which the FFT Analyzer is to process the input signals can be defined in this menu.
A similar menu for configuring the baseband input can also be opened by pressing the *SETUP* hardkey.

IQ PATH

The *IQ PATH* softkey opens a submenu. The way in which the two input paths are to be interpreted can be defined in this submenu.
Only one state can be active at a time in the submenu. The color of one of the three softkeys in the submenu changes to indicate which one is active. The *IQ PATH* softkey also indicates the selected function.

I+J*Q

The *I+J*Q* softkey causes the FFT Analyzer to regard the signals at the I and Q input as components of a complex signal. This is the standard setting for the analysis of signals with complex modulation.

IEC/IEEE bus command: `INP:IQ:TYPE IJQ`

I ONLY

The *I ONLY* softkey causes the FFT Analyzer to regard the signal at the I input as a single, real signal. The signal at the Q input is ignored.
This setting should be selected if, for example, a signal at a low intermediate frequency is connected to the I input.

IEC/IEEE bus command: `INP:IQ:TYPE I`

Q ONLY

The *Q ONLY* softkey causes the FFT Analyzer to regard the signal at the Q input as a single, real signal. The signal at the I input is ignored.
This setting should be selected if, for example, a signal at a low intermediate frequency is connected to the Q input.

IEC/IEEE bus command: `INP:IQ:TYPE Q`

I/Q INPUT
50Ω 1MΩ

The *IQ INPUT 50Ω / 1MΩ* softkey is used to toggle the input impedance of the baseband inputs. The setting has the same effect on both inputs.

The IEC/IEEE bus command uses the keywords *LOW / HIGH* for 50Ω / 1MΩ.

Caution: Toggling the input impedance has no effect on the power level indicated in the FFT Analyzer. It is always assumed that the measured voltage is applied to a 50 Ω resistor.

IEC/IEEE bus command: `INP:IQ:IMP LOW`

BALANCED
ON **OFF**

The *BALANCED ON / OFF* softkey is used to toggle the measurement mode of the baseband inputs.
ON switches to balanced inputs; *OFF* switches to ground-referenced inputs. The setting has the same effect on both inputs.

IEC/IEEE bus command: `INP:IQ:BAL:STAT ON`

LOWPASS
36MHZ

The *LOWPASS 36MHZ* softkey is used to toggle the analog anti-aliasing lowpass filters of the baseband inputs. The setting has the same effect on both inputs. The softkey changes colour when the lowpass is switched ON.

IEC/IEEE bus command: `SENS:IQ:LPAS:STAT ON`

DITHER
ON **OFF**

The *DITHER ON / OFF* softkey is used to add a shaped dither signal to both inputs.

IEC/IEEE bus command: `SENS:IQ:DITH:STAT ON`

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.
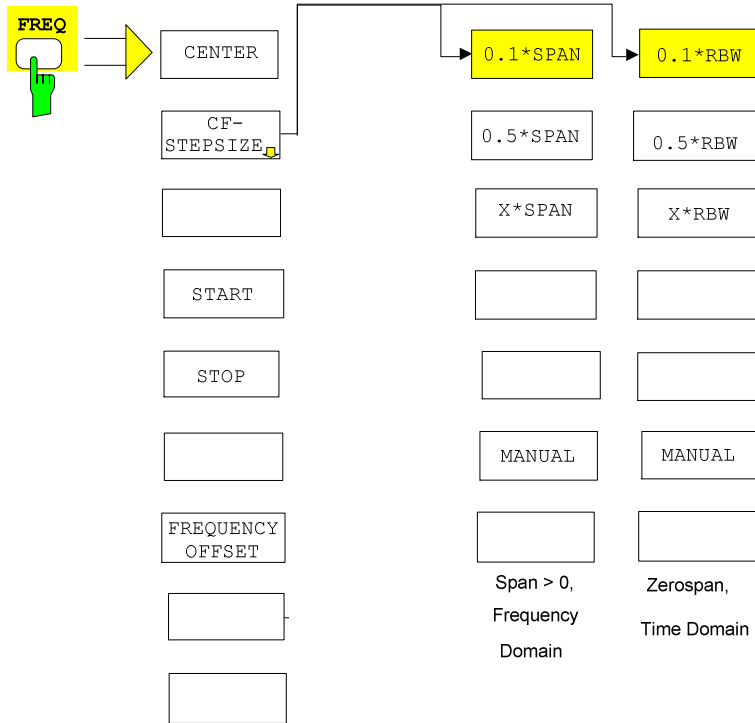
The *CENTER* softkey opens a window in which the center frequency can be entered.

The permissible entry ranges for the center frequency are as follows:

For the frequency domain (Frequency Domain, Span > 0):

- For *IQ PATH = I + jQ* (complex signal):
  $-36\ \text{MHz} + \text{Minspan}/2 \le f_{center} \le +36\ \text{MHz} - \text{Minspan}/2$

- For *IQ PATH = I ONLY* or *IQ PATH = Q ONLY* (real signal)
  $\text{Minspan}/2 \le f_{center} \le +36\ \text{MHz} - \text{Minspan}/2$

For the time domain (Time Domain, Span = 0):

- For *IQ PATH = I + jQ* (complex signal):
  $-36\ \text{MHz} \le f_{center} \le 36\ \text{MHz}$

- For *IQ PATH = I ONLY* or *IQ PATH = Q ONLY* (real signal)
  $0\ \text{Hz} \le f_{center} \le 36\ \text{MHz}$

- f_{center} Center frequency

- Minspan   Smallest selectable span: 10 Hz

IEC/IEEE bus command: `FREQ:CENT 10MHz`
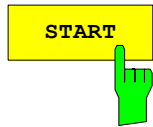
START

The *START* softkey activates manual entry of the start frequency.
The permissible entry ranges for the start frequency are as follows:

For the frequency domain (Frequency Domain, Span > 0):

- For IQ PATH = I + jQ (complex signal):
  -36 MHz $\leq$ fstart $\leq +36$ MHz - Minspan

- For IQ PATH = I ONLY or IQ PATH = Q ONLY (real signal)
  $0 \leq$ fstart $\leq +36$ MHz - Minspan

For the time domain (Time Domain, Span = 0):

- For IQ PATH = I + jQ (complex signal):
  -36 MHz $\leq$ fstart ≤ 36 MHz

- For IQ PATH = I ONLY or IQ PATH = Q ONLY (real signal)
  0 Hz $\leq$ fstart ≤ 36 MHz

If the entered start frequency is greater than the stop frequency, the stop frequency is set to start frequency + minspan.

f_{start} Start frequency
Minspan   Smallest selectable span: 10 Hz
IEC/IEEE bus command: `FREQ:STAR 2MHz`
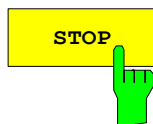
STOP

The *STOP* softkey activates entry of the stop frequency.

The permissible entry ranges for the stop frequency are as follows:

For the frequency domain (Frequency Domain, Span > 0):

- For *IQ PATH = I + jQ* (complex signal):
  -36 MHz + Minspan $\leq f_{stop} \leq +36$ MHz

- For *IQ PATH = I ONLY* or *IQ PATH = Q ONLY* (real signal)
  Minspan $\leq f_{stop} \leq +36$ MHz

  For the time domain (Time Domain, Span = 0):

- For *IQ PATH = I + jQ* (complex signal):
  -36 MHz $\leq f_{stop} \leq 36$ MHz

- For *IQ PATH = I ONLY* or *IQ PATH = Q ONLY* (real signal)
  0 Hz $\leq f_{stop} \leq 36$ MHz

If the entered stop frequency is less than the start frequency, the start frequency is set to stop frequency - minspan.

f_{stop} Stop frequency
Minspan   Smallest selectable span > 0 Hz (10 Hz)

IEC/IEEE bus command: `FREQ:STOP 20MHz`
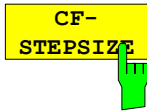
CF-STEPSIZE

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:
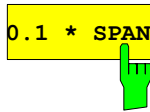
0.1 * SPAN

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
```
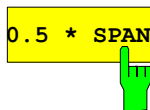
0.5 * SPAN

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
```
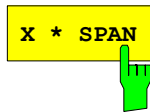
X * SPAN

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
```
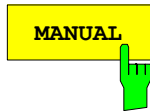
MANUAL

The *MANUAL* softkey activates the window for entering a fixed step size.

IEC/IEEE-bus command: `FREQ:CENT:STEP 120MHz`

Softkeys in time domain:
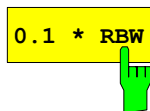
0.1 * RBW

The *0.1 * RBW* softkey sets the step size for the center frequency entry to 10% of the resolution bandwidth.

*0.1 * RBW* corresponds to the default setting.

IEC/IEEE-bus command:
```
FREQ:CENT:STEP:LINK RBW
FREQ:CENT:STEP:LINK:FACT 10PCT
```
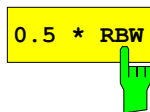
0.5 * RBW

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
```
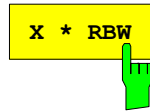
X * RBW

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
```
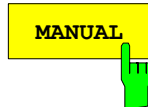
MANUAL

The *MANUAL* softkey activates the window for entering a fixed step size.

IEC/IEEE-bus command:
```
FREQ:CENT:STEP 120MHz
```
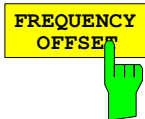
FREQUENCY OFFSET

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`

Setting the frequency span – SPAN Key

SPAN

SPAN
MANUAL

SWEEPTIME
MANUAL

FULL SPAN

ZEROSPAN

LAST SPAN
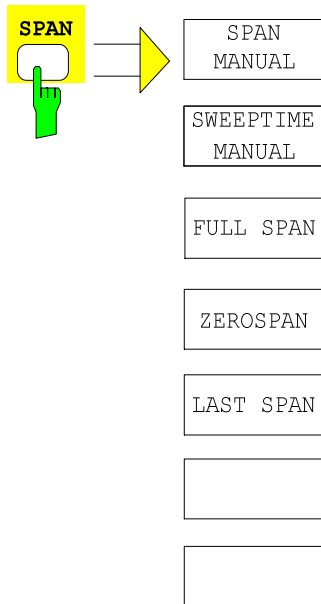
The *SPAN* key opens a menu which contains the various options for setting the frequency span (Frequency Domain mode).
In the frequency domain (Span > 0), entry of the span (*SPAN MANUAL* softkey) is activated automatically. In the time domain (Span = 0), entry of the sweep time (*SWEEPTIME MANUAL* softkey) is activated automatically.
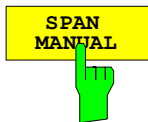
SPAN
MANUAL

The *SPAN MANUAL* softkey activates manual entry of the frequency span, whereby the center frequency is kept constant wherever possible. *CENTER FREQUENCY* is adapted automatically only if the new span projects beyond the permissible ranges. This is indicated on the display.

For the frequency domain (Frequency Domain, Span > 0), the permissible entry range for the frequency span is:

- For *IQ PATH = I + jQ* (complex signal):
  Minspan < f_{span} ≤ 72 MHz

- For *IQ PATH = I ONLY* or *IQ PATH = Q ONLY* (real signal)
  Minspan < f_{span} ≤ 36 MHz

Entering a span of 0 Hz activates the *Time Domain* mode. In this mode, 0 Hz is the only permissible value for *SPAN.*
Entering a span > 0 Hz activates the *Frequency Domain* mode.

f_{span}	Frequency span (Span)
Minspan	Smallest selectable span (10 Hz)

IEC/IEEE bus command: `FREQ:SPAN 2MHz`

SWEEPTIME
MANUAL

The *SWEEPTIME MANUAL* softkey activates manual entry of the sweep time in the *Time Domain* mode (Span = 0). If the span is greater than 0, the softkey is not available as the observation time is selected internally by the firmware.

The softkey with the same label in the submenu opened by pressing the SWEEP hardkey has the same functionality. See Table 4-5 for the permissible values of the SWEEPTIME parameter.

IEC/IEEE bus command: `SWE:TIME 1ms`
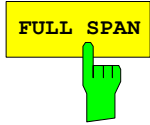
FULL SPAN

The *FULL SPAN* softkey sets the frequency span to the largest possible span in the FFT Analyzer. If the *Time Domain* mode is currently active, the mode also switches over to *Frequency Domain*.

The span and center frequency are then as follows:

- For *IQ PATH = I + jQ* (complex signal):
  SPAN = 72 MHz, i.e. –36 MHz to +36 MHz.
  CENTER FREQUENCY = 0 Hz

- For *IQ PATH = I ONLY* or *IQ PATH = Q ONLY* (real signal):
  SPAN = 36 MHz, i.e. from 0 Hz to +36 MHz
  CENTER FREQUENCY = 18 MHz

IEC/IEEE bus command: `FREQ:SPAN:FULL`
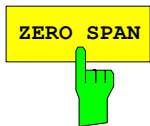
ZERO SPAN

The *ZERO SPAN* softkey sets the frequency span to 0 Hz. As a result, the mode of the FFT Analyzer changes to *Time Domain*.
The x-axis becomes the time axis, whereby the gridlines each correspond to 1/10 of the current sweep time (*SWT*).

IEC/IEEE bus command: `FREQ:SPAN 0Hz`

LAST SPAN

If the frequency span has been changed, pressing the *LAST SPAN* softkey restores the previous setting on the instrument. In this way, it is possible to switch between an overview measurement (*FULL SPAN*) and a detailed measurement (manually selected center frequency and span).

Note: *The last span value is restored if and only if the span is > 0, i.e. the time domain is not selected automatically.*

IEC/IEEE bus command: –

Setting the level display and configuring the diagrams – AMPT key

The *AMPT* key opens a submenu in which the reference level (*REF LEVEL*) and various properties of the result diagrams can be configured. *REF LEVEL* can be entered immediately since the entry dialog is opened automatically as soon as the *AMPT* key is pressed.

Note.   *With the analog baseband input, the reference level should not be specified as the RMS power but rather as the applied peak voltages.*
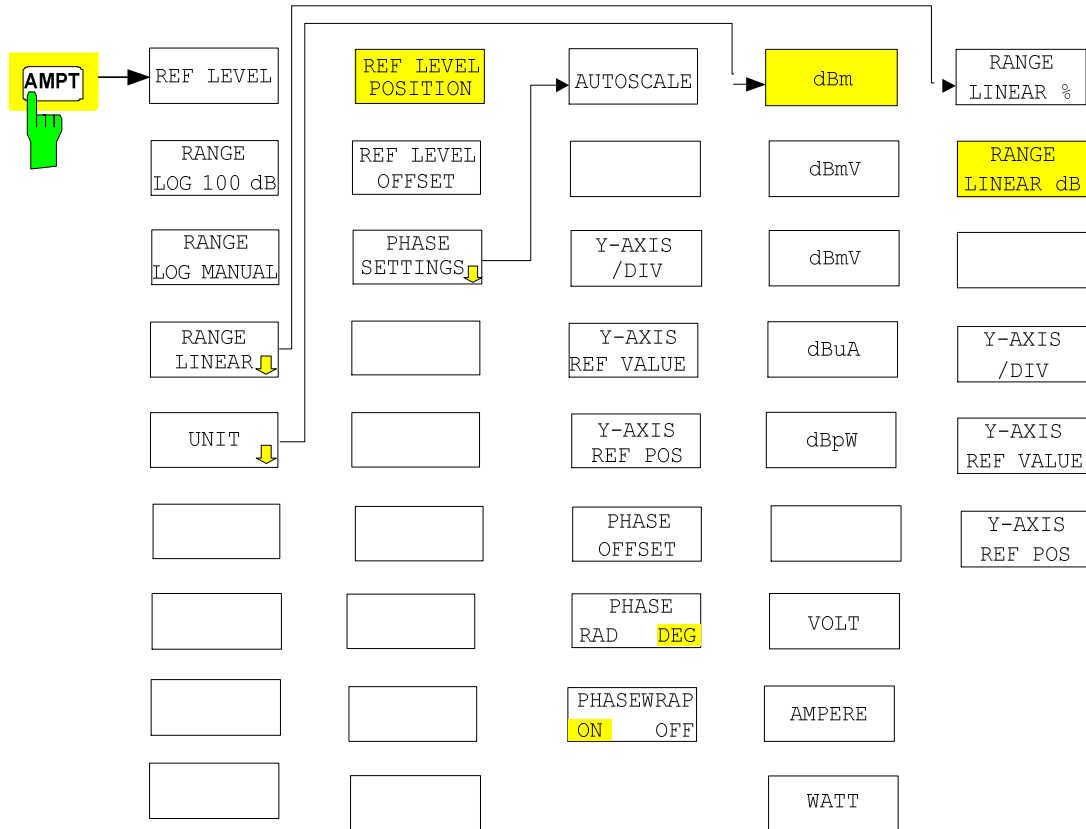
The *REF LEVEL* softkey allows the reference level to be input in the currently active unit (dBm, dBµV, etc).

The upper limit in dBm is
+15 dBm with IMPEDANCE HIGH (1 MΩ)
+25 dBm with IMPEDANCE LOW (50 Ω)
(other units corresponding)

IEC/IEEE-bus command: `DISP:WIND:TRAC:Y:RLEV –20dBm`
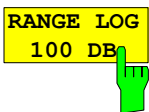
The *RANGE LOG 100 dB* softkey sets the level display range to 100 dB.

IEC/IEEE bus command: `DISP:WIND:TRAC:Y:SPAC LOG`
                          `DISP:WIND:TRAC:Y 100DB`
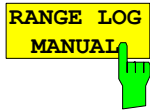
RANGE LOG MANUAL

The *RANGE LOG MANUAL* softkey activates manual entry of the level display range. Display ranges from 10 to 200 dB in 10 dB steps are permitted. Invalid entries are rounded to the nearest permissible value.

The default setting is 100 dB.

IEC/IEEE bus command: DISP:WIND:TRAC:Y:SPAC LOG
                          DISP:WIND:TRAC:Y 120DB
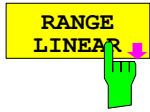
RANGE LINEAR

The *RANGE LINEAR* softkey switches the display range of the analyzer over to linear scaling and opens the submenu for selecting % or dB as the diagram labeling. The display in % is selected the first time the display range is switched over to linear scaling (see *RANGE LINEAR dB* softkey).

IEC/IEEE bus command: DISP:WIND:TRAC:Y:SPAC LIN
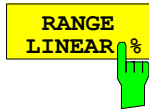
RANGE LINEAR %

The *RANGE LINEAR %* softkey switches the display range of the analyzer to linear scaling. The horizontal gridlines are labeled in %. The grid has decadic division. Markers are displayed in the selected unit and delta markers in % referred to the voltage value at the position of marker 1.

IEC/IEEE bus command: DISP:WIND:TRAC:Y:SPAC LIN
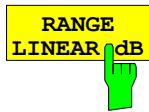
RANGE LINEAR dB

The *RANGE LINEAR dB* softkey switches the display range of the analyzer to linear scaling. The horizontal gridlines are labeled in dB.
Markers are displayed in the selected unit and delta markers in dB referred to the power at the position of marker 1.

IEC/IEEE bus command: DISP:WIND:TRAC:Y:SPAC LDB
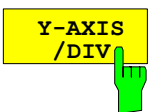
Y-AXIS /DIV

With linear scaling, the *Y-AXIS/DIV* softkey is used to determine the value range which is to correspond to the distance between two horizontal gridlines. The entire displayed value range is therefore equivalent to 10 times the selected value.

The softkey is only available in the following display modes:

- REAL IMAG in the Frequency Domain mode

- VOLTAGE in the Time Domain mode

The setting always affects both subdiagrams in the same way.

IEC/IEEE bus command: DISP:WIND:TRAC:Y:PDIV 10

Y-AXIS REF-VALUE

The *Y-AXIS REF-VALUE* softkey determines the reference value of the diagram at the reference position. The gridlines are arranged on the basis of this reference value.

The softkey is only available in the following display modes:

- REAL IMAG in the Frequency Domain mode

- VOLTAGE in the Time Domain mode

The setting always affects both subdiagrams in the same way.

IEC/IEEE bus command: DISP:WIND:TRAC:T:RVAL 1

Y-AXIS REF-POS

The *Y-AXIS REF-POS* softkey is used to control the location of the reference position within the grid from 0% to 100%. The default value is 50%.

The softkey is only available in the following display modes:

- REAL IMAG in the Frequency Domain mode
- VOLTAGE in the Time Domain mode

The setting always affects both subdiagrams in the same way.

IEC/IEEE bus command: `DISP:WIND:TRAC:Y: RPOS`

UNIT

dBm
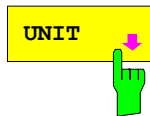
dBmV

dBµV

dBµA

dBpW

VOLT

AMPERE

WATT

The *UNIT* softkey opens a submenu in which the desired unit for the level axis can be selected.

In the default setting, the level is displayed over 1 milliwatt (= dBm). The input impedance, which is ALWAYS assumed to be 50 Ω, can be used for conversion to other units. As a result, it is possible to convert the units dBm, dBmV, dBµV, dBµA, dBpW, V, A and W directly.

IEC/IEEE bus command: `CALC:UNIT:POW DBM`

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:RPOS 100PCT`

REF LEVEL OFFSET

The *REF LEVEL OFFSET* softkey activates entry of an arithmetic level offset. This is added to the measured level irrespective of the selected unit. The y-axis scaling is changed accordingly.
The setting range is ±200 dB in 0.1 dB steps.

IEC/IEEE bus command: `DISP:WIND:TRAC:RLEV:OFFS –10dB`
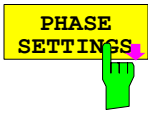
PHASE SETTINGS

The *PHASE SETTINGS* softkey opens a submenu in which the scaling of the phase diagram can be configured. The softkey and the submenu are therefore only available for the *MAGNITUDE PHASE* measurement in the *Frequency Domain* mode.

Note: *The AUTOSCALE, PHASE OFFSET, PHASE RAD/DEG and PHASEWRAP ON/OFF softkeys always affect the phase diagram. The other softkeys of this submenu can have an effect on either the upper or lower diagram, depending on the position of the SCREEN A/B hotkey.*

AUTOSCALE

The *AUTOSCALE* softkey performs one-off scaling of the phase diagram so that the current trace fully utilizes the value range.

IEC/IEEE bus command:
                    DISP:WIND2:TRAC:Y:SCAL:AUTO ONCE
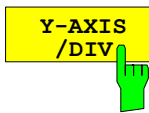
Y-AXIS /DIV

The *Y-AXIS/DIV* softkey is used to determine the value range which is to correspond to the distance between two horizontal gridlines. The entire displayed value range is therefore equivalent to 10 times the selected value. With manual entry, the unit selected using the *PHASE RAD / PHASE DEG* softkey applies (only for the phase diagram).

IEC/IEEE bus command:
                    DISP:WIND2:TRAC:Y:PDIV 10DEG

Y-AXIS REF-VALUE

The *Y-AXIS REF-VALUE* softkey determines the reference value of the diagram at the reference position. The gridlines are arranged on the basis of this reference value. The unit selected using the *PHASE RAD / PHASE DEG* softkey applies (only for the phase diagram).

IEC/IEEE bus command:
                    DISP:WIND2:TRAC:Y:RVAL 20DEG

Y-AXIS REF-POS

The *Y-AXIS REF-POS* softkey is used to control the location of the reference position within the grid from 0% to 100%. The default value is 50%.

IEC/IEEE bus command:
                    DISP:WIND2:TRAC:Y:RPOS 50

PHASE OFFSET

The *PHASE OFFSET* softkey determines a constant phase value which is added to the overall phase trace. This allows a test point to be assigned to a desired phase value.
The unit selected using the *PHASE RAD / PHASE DEG* softkey applies.

IEC/IEEE bus command: SENS:CORR:OFFS:PHAS 10DEG
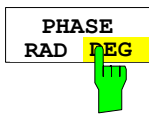
PHASE RAD DEG

The *PHASE RAD / PHASE DEG* softkey switches the unit of the phase trace between radians and degrees.

IEC/IEEE bus command: CALC:UNIT:ANGL RAD
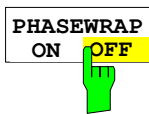
PHASEWRAP ON OFF

The *PHASEWRAP ON / PHASEWRAP OFF* softkey activates/deactivates the phase trace limitation to the value range between –180º and +180º / -pi to +pi.

IEC/IEEE bus command: CALC2:FORM PHAS
                       CALC2:FORM UPHAS

Setting the Bandwidths and Sweep Time – BW Key

The *BW* key opens a menu in which the resolution bandwidth (*RBW*) and sweep time (*SWT*) which determine the measurement are set. The *RBW* can be coupled to the span (stop frequency minus start frequency, *SPAN*) or can be freely defined by the user. The automatic coupling is set by pressing the *RES BW AUTO* softkey. The coupling ratio is selected using the *COUPLING RATIO* softkey.

The *RES BW MANUAL* softkey activates direct entry of the RBW. There is then no coupling to the SPAN.

In the Time Domain mode, Gaussian shaped digital filters are used as the resolution filters .

An FFT with preselectable windowing of the data is used in the *Frequency Domain* mode. The resolution bandwidths can be selected both in the usual steps and in fine intermediate steps (*RES BW 1-2-3-5* softkey).

The FFT Analyzer does not support video filters (*VBW*). The averaging of consecutive traces can be used instead.
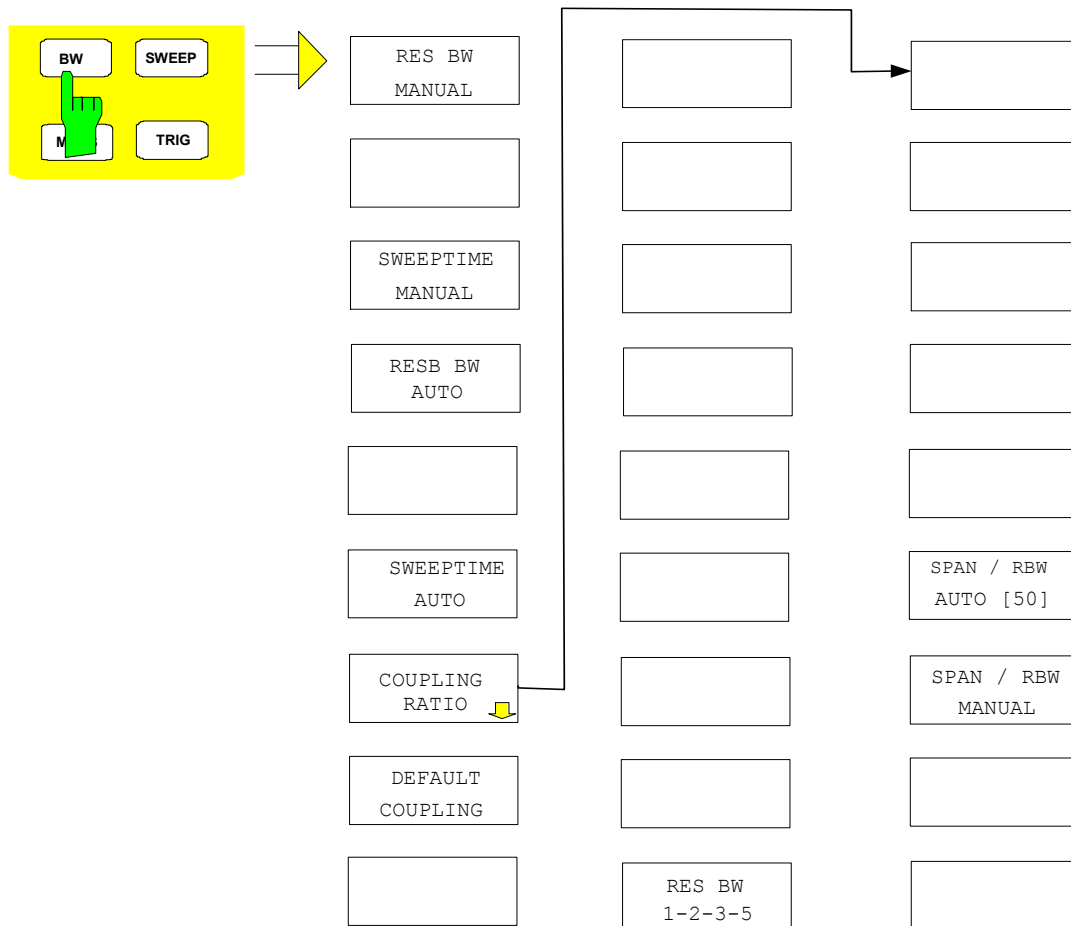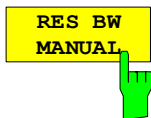
RES BW MANUAL

The *RES BW MANUAL* softkey activates manual entry of the resolution bandwidth.

The following applies in the *Frequency Domain* mode:

- The resolution bandwidth can be set in steps of 1, 2, 3, 5 and 10 or in steps of 0.1 Hz, depending on the setting of the *RBW 1-2-3-5* softkey. The nominal values for the resolution bandwidths are the equivalent noise bandwidths of the resolution filters and NOT the 3 dB bandwidths.

- The largest possible RBW is always 20 MHz.

- For *CAPTURE BOTH DOMAINS* active and/or a span greater than 27.5 MHz, the smallest possible RBW is 25 Hz, or rounded up to 30 Hz.

- Otherwise the smallest attainable RBW is equal to 0.1 Hz times the relative ENBW of the set window function, depending on the position of *RES BW 1-2-3-5,* rounded up or not. For the relative ENBW, see Table 4-5.

- Also applicable, however, is a maximum ratio of the span to RBW, which cannot be exceeded. Ratios that are too extreme can be rejected by the firmware.

The following applies in the *Time Domain* mode:

- The resolution bandwidth can always be selected in steps of 1, 2, 3, 5 and 10 between 10 Hz and 20 MHz (s. Table 4-5). The nominal values for the resolution bandwidths are the 3 dB bandwidths of the Gaussian shaped filters.

If necessary, the *RBW* is rounded to the nearest possible value when the *Frequency Domain* mode is switched over to the *Time Domain* mode.

When bandwidths are entered manually, the value is always rounded to the nearest possible bandwidth; if bandwidths are entered using the rotary knob or the UP/DOWN keys, the value is scrolled up and down in steps.

A green asterisk (*) appears on the display field to indicate that the resolution bandwidth has been entered manually.

IEC/IEEE bus command: `BAND 1MHz`

SWEEPTIME MANUAL

The *SWEEPTIME MANUAL* softkey activates manual entry of the sweep time. It is only available in the *Time Domain* mode.
In the *Frequency Domain* mode, the sweep time is preset by selecting the window function and frequency resolution. It is therefore not possible to change the sweep time.

In time domain mode (Span = 0 Hz), the sweep times (which may range from 1 µs to max. 16000 s) can be selected in steps of max. 5% of the sweep time. When sweep times are entered manually, the FFT Analyzer always rounds to the nearest possible sweep time; if sweep times are entered using the rotary knob or the UP/DOWN keys, the FFT Analyzer scrolls the sweep time up and down in steps.
Refer also to Table 4-5 for the sweep times. In the FFT Analyzer, the maximum sweep time depends on the selected *RESOLUTION BANDWIDTH* and the *CAPTURE BOTH DOMAINS* function.

IEC/IEEE bus command: `SWE:TIME 10ms`

Table 4-5   Maximum sweep times for the Time Domain mode

Maximum SWEEPTIME for *Time Domain*	*CAPTURE BOTH DOMAIN S = OFF*	*CAPTURE BOTH DOMAINS = ON*
RBW = 10Hz	16000.0000 s	Not available
RBW = 20Hz	16000.0000 s	
RBW = 30Hz	16000.0000 s	0.1600s
RBW = 50Hz	16000.0000 s	
RBW = 100Hz	8000.0000 s	
RBW = 200Hz	4000.0000 s	
RBW = 300Hz	2500.0000 s	
RBW = 500Hz	1600.0000 s	
RBW = 1KHz	800.0000 s	
RBW = 2KHz	400.0000 s	
RBW = 3KHz	250.0000 s	
RBW = 5KHz	160.0000 s	
RBW = 10KHz	80.0000 s	
RBW = 20KHz	40.0000 s	
RBW = 30KHz	25.0000 s	
RBW = 50KHz	16.0000 s	
RBW = 100KHz	8.6000 s	
RBW = 200KHz	4.5000 s	
RBW = 300KHz	2.8000 s	
RBW = 500KHz	1.6000 s	
RBW = 1MHz	0.8000 s	
RBW = 2MHz	0.6000 s	
RBW = 3MHz	0.6000 s	
RBW = 5MHz	0.4000 s	
RBW = 10MHz	0.4000 s	
RBW = 20MHz	0.4000 s	

Caution: *Very large volumes of data will be recorded if the values for both RBW and SWEEPTIME are large. The trace will then be plotted block by block.*
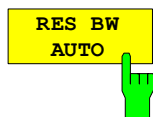
RES BW AUTO

The *RES BW AUTO* softkey is only available in the frequency domain (Span > 0 Hz). The softkey is not visible in the time domain.

It couples the resolution bandwidth to the selected frequency span (*SPAN*). If the frequency span is changed, the resolution bandwidth is adjusted automatically.

Automatic coupling of the resolution bandwidth to the frequency span is always recommended if a resolution bandwidth setting is desired which is suitable for the measurement task and in proportion to the selected span.

The coupling ratio is set in the *COUPLING RATIO* submenu.

IEC/IEEE bus command: BAND:AUTO ON

SWEEPTIME AUTO

The *SWEEPTIME AUTO* softkey is only available in the frequency domain (*SPAN* > 0 Hz) and is always selected there because it is not possible to select the *SWEEPTIME* manually.
The softkey is not visible in the time domain because the *SWEEPTIME* can only be selected manually.
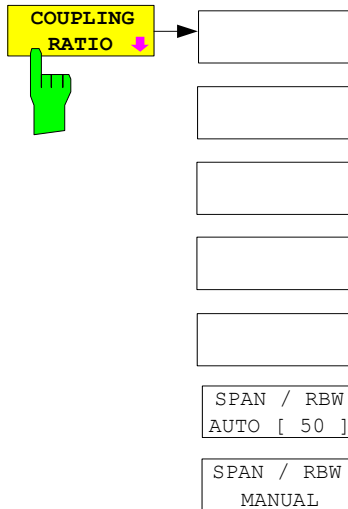
COUPLING
RATIO ⬇

The *COUPLING RATIO* softkey opens a submenu in which the coupling ratio of *SPAN* and *RBW* can be selected.

In the default state, i.e. when the *COUPLING RATIO* softkey is not active (not highlighted), the ratio of span to resolution bandwidth (SPAN/RBW) is 50 (corresponds to *SPAN / RBW AUTO [50]*).

SPAN / RBW
AUTO [50]

SPAN / RBW
MANUAL
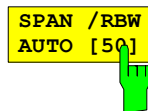
SPAN /RBW
AUTO [50]

The *SPAN/RBW AUTO* softkey sets the following coupling ratio:
Resolution bandwidth = Frequency span/50

This coupling ratio corresponds to the default setting.

IEC/IEEE bus command: `BAND:RAT 0.02`

The setting is only effective if *RBW AUTO* is active.
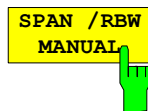
SPAN /RBW
MANUAL

The *SPAN/RBW MANUAL* softkey activates entry of the coupling ratio of frequency span and resolution bandwidth.

The ratio of frequency span to resolution bandwidth can be set between 1 and 10000.

IEC/IEEE bus command: `BAND:RAT 0.1`

t is only possible to select this softkey if *RBW AUTO* is active.
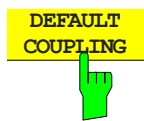
DEFAULT
COUPLING

The *DEFAULT COUPLING* softkey sets all coupling functions to their default state (*AUTO*); in the FFT Analyzer this only applies to *SPAN/RBW*. In addition, the *SPAN/RBW* ratio in the *COUPLING RATIO* submenu is set to 50.

IEC/IEEE bus command: `BAND:AUTO ON`

BW – NEXT menu:
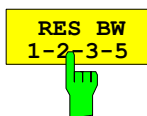
RES BW
1-2-3-5

The *RES BW 1-2-3-5* softkey is only available in the *Frequency Domain* mode. When activated, the *RESOLUTION BANDWIDTH* can only be changed in steps of 1, 2, 3, 5 and 10 (which is also always the case in the *Time Domain* mode).
However, this softkey is also used to activate manual entry of freely selected bandwidths in the *Frequency Domain* mode. The values must then be entered by means of the *RES BW MANUAL* softkey, or are derived from the SPAN if the automatic coupling function is activated. If the values are in the permissible range, they are rounded to 0.1 Hz and accepted.

If the system is switched back to the mode with the bandwidth steps or to the *Time Domain* mode, the *RESOLUTION BANDWIDTH* is rounded to the nearest permissible value.

IEC/IEEE bus command: `SENS:BWID:RESO:STEP:MODE LIN`
                     `SENS:BAND:RESO:STEP:MODE L1235`

Setting the Sweep – SWEEP Key

The SWEEP key is used to select the frequency sweep type.

Note: The term "sweep" is used here (and also at other points in the description of the FFT Analyzer) although no "sweep" principle is performed in a frequency analysis. The term is based on the *Spectrum Analysis* mode of conventional analyzers.

The sweep time used for the FFT is also shown at the top of the screen in the middle of the display (e.g. as "SWT = 10 ms"). This is, however, not the time required for a complete measurement process. If *CAPTURE BOTH DOMAINS* is active, data acquisition is initially performed for 0.16 seconds for a SINGLE SWEEP and then only a small proportion of the data is usually used for calculating the FFT. The overall measurement process is made up of the times for data acquisition, for filtering and decimation of the data, for calculation of the FFT and for displaying the results.

However, the displayed *SWEEPTIME* only indicates which time domain is covered by the input data of the FFT.

SWEEP menu
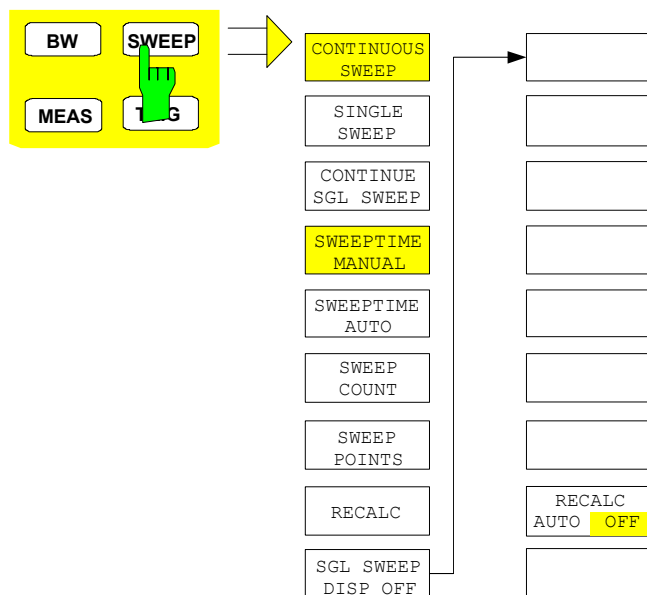
The *SWEEP* key opens a menu in which the frequency sweep (sweep mode) is configured.

The *CONTINUOUS SWEEP, SINGLE SWEEP* and *SGL SWEEP DISP OFF* softkeys are selection switches. Only one of these switches can be active at any one time.

The *CONTINUOUS SWEEP* softkey activates the continuous sweep mode, which means that the sweep takes place continuously according to the trigger mode set.

CONTINUOUS SWEEP is the default setting of R&S FMU*.*

IEC/IEEE-bus command: `INIT:CONT ON`
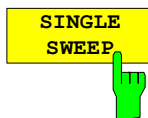
The *SINGLE SWEEP* softkey starts n sweeps after triggering. The number of sweeps is determined by the *SWEEP COUNT* softkey.

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`
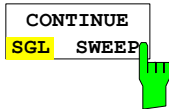
CONTINUE SGL SWEEP

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
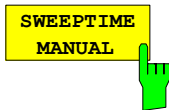
SWEEPTIME MANUAL

The *SWEEPTIME MANUAL* softkey activates the window for entering the sweep time manually (for details see BW menu) in Time Domain.

IEC/IEEE-bus command: SWE:TIME 10s
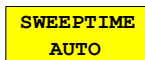
SWEEPTIME AUTO

The *SWEEPTIME AUTO* softkey indicates the automatic selection of the sweep time (for details see BW menu) in Frequency Domain.

IEC/IEEE-bus command: --

SWEEP COUNT

The *SWEEP COUNT* softkey activates the window for the entry of the number of sweeps to be performed by R&S FMU 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*]

R&S FMU 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, R&S FMU 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: 155, 313, 625 (default), 1251, 1999, 2501, 5001, 10001, 20001, 30001

Note:
The autopeak detector will be disabled while the number of points per sweep is ≠ 625.

IEC/IEEE-bus command: SWE:POIN 625

Te *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`
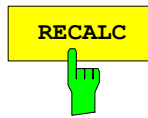
The *RECALC* softkey is deactivated and cannot be used if the *CAPTURE BOTH DOMAINS* measurement mode is not active.
The *RECALC* softkey can only be operated if the *CAPTURE BOTH DOMAINS* measurement mode is active, the FFT Analyzer is in the *SINGLE SWEEP* mode and measurement data has already been acquired.
The data stored in the memory (always sampled for 0.16 s at 81.6 MHz) is reanalyzed according to the current instrument settings each time the *RECALC* softkey is pressed. Data acquisition is not performed again. Any trigger settings, e.g. *EXTERN* or *I/Q LEVEL*, are ignored, i.e. reanalysis is performed immediately.

The instrument settings which can be adjusted are, for example:

- Time Domain / Frequency Domain

- measurement display mode (MAGNITUDE, VOLTAGE, etc)

- RBW, SPAN, WINDOWFCT, CENTER FREQUENCY, SWEEPTIME

- type of detector

- IQ PATH: I + jQ, I ONLY, Q ONLY
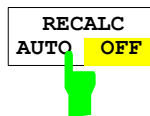
The *RECALC AUTO* / *RECALC OFF* softkey is deactivated and cannot be used if the *CAPTURE BOTH DOMAINS* measurement mode is not active.

If the softkey is set to *OFF*, the *RECALC* softkey must be pressed each time recorded data is to be analyzed using modified measurement settings.

If, however, the softkey is set to *AUTO*, the firmware automatically triggers a *RECALC* whenever the adjustable parameters are changed manually.

However, as soon as one of the critical parameters has been changed (see the description of the *RECALC* softkey), the automatic *RECALC* is not performed and, like the *RECALC* softkey, the *RECALC AUTO / OFF* softkey is also temporarily deactivated.

Triggering the Sweep – TRIG Key

The *TRIG* key opens a menu for setting the various trigger sources and selecting the polarity of the trigger. The associated softkeys are highlighted to indicate that the trigger mode is active.

The enhancement label **TRG** is displayed on the screen to indicate that a trigger mode other than *FREE RUN* is set.

TRIGGER menu

TRIG

FREE RUN
EXTERN
I LEVEL
Q LEVEL
I/Q LEVEL
TRIGGER OFFSET
POLARITY POS NEG
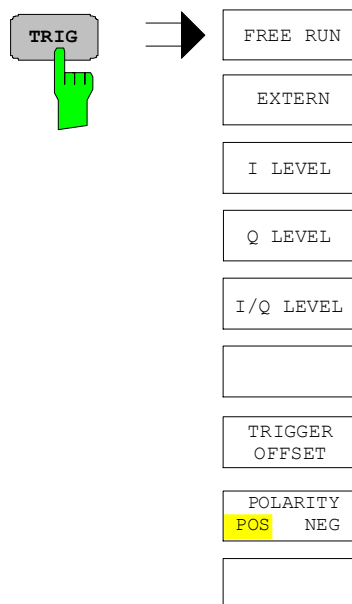
FREE RUN

The *FREE RUN* softkey activates the free-running measurement, i.e. there is no explicit triggering of the start of measurements. When one measurement has been completed, another is started immediately.

FREE RUN is the default setting of the FFT Analyzer.

IEC/IEEE bus command: `TRIG:SOUR IMM`
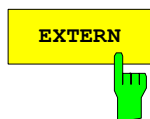
EXTERN

The *EXTERN* softkey activates triggering by means of a TTL signal at the *EXT TRIGGER* input socket on the rear panel of the instrument.
The external trigger level can be adjusted in the range from 0.5 V to 3.5 V. The default value is 1.4 V.

IEC/IEEE bus command: `TRIG:SOUR EXT <numeric_value>`

I LEVEL

The *I LEVEL* softkey activates triggering to the voltage of the I signal (real part of the signal) and determines the trigger threshold in volts. Sample acquisition starts when the value exceeds (positive polarity) or drops below (negative polarity) the selected threshold.
The *I LEVEL* softkey is only available in the Time Domain Voltage mode.
Triggering is performed on the real part after the complex signal processing as displayed in the upper diagram. This is the voltage at the I input only if center frequency is set to 0. The bandwidth is ½ * RBW.

IEC/IEEE bus command: `TRIG:LEV:IONL 0.1V`
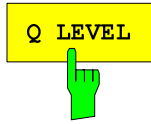
Q LEVEL

The *Q LEVEL* softkey activates triggering to the voltage of the Q signal (imaginary part of the signal) and determines the trigger threshold in volts. Sample acquisition starts when the value exceeds (positive polarity) or drops below (negative polarity) the selected threshold.
The *Q Level* softkey is only available in the Time Domain Voltage mode.
The imaginary part of the signal is triggered after the complex signal processing as displayed in the upper diagramThis is the voltage at the Q input only if center frequency is set to 0. The bandwidth is ½ * RBW.

IEC/IEEE bus command: `TRIG:LEV:QONL 0.1V`
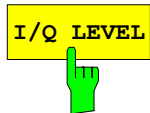
I/Q LEVEL

The *I/Q LEVEL* softkey activates triggering to the <u>magnitude</u> of the I/Q signal and determines the trigger threshold in volts. Sample acquisition starts when the value exceeds (positive polarity) or drops below (negative polarity) the selected threshold.

Here too, the *IQ PATH* setting is taken into account, which means the I or Q input may be ignored.
The following applies to the bandwidth within which the magnitude of the I/Q signal is measured:

- *With CAPTURE BOTH DOMAINS* inactive:
  - Frequency domain measurement: the bandwidth is slightly smaller than the set span, but no more than about 19 MHz
  - Time domain measurement: the bandwidth is the set RBW

- *With CAPTURE BOTH DOMAINS* active:
  - Frequency domain measurement: the bandwidth is always about 19 MHz
  - Time domain measurement: the bandwidth is the set RBW

The bandwidth is symmetric around the set center frequency.

IEC/IEEE bus command: `TRIG:LEV:IFP 0.7`

TRIGGER OFFSET

The *TRIGGER OFFSET* softkey activates entry of a time offset between the trigger signal and the start of the sweep.

Triggering is delayed (entry > 0) or advanced (entry < 0) by the entered time relative to the trigger signal. The time can be entered in the value range –100 ms to 50 s (default: 0 s).

IEC/IEEE bus command: `TRIG:HOLD  10US`

POLARITY POS NEG

The *POLARITY POS/NEG* softkey determines the polarity of the trigger slope.

Measurement starts after a positive or a negative slope of the trigger signal. The selected setting is highlighted accordingly.
The setting applies to all trigger types except *FREE RUN*.

The default setting is *POLARITY POS*.

IEC/IEEE bus command: `TRIG:SLOP POS`

Selection and Setting of Traces – TRACE Key

The R&S FMU is capable of displaying up to three different traces at a time in a diagram. A trace consists of a maximum of 625 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 and AVERAGE)

TRACE menu
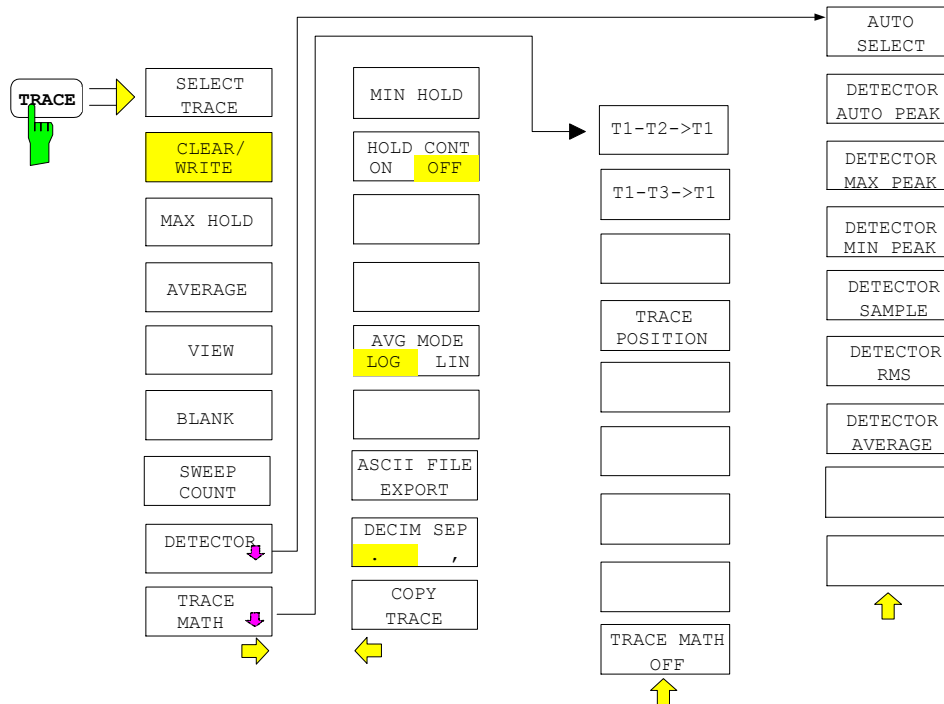
The *TRACE* key opens a menu offering the setting options for the selected trace.

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 R&S FMU.

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.

SELECT TRACE

The *SELECT TRACE* softkey activates the entry for the active trace (1, 2, 3).

IEC/IEEE-bus command -- (selected via numeric suffix of `:TRACe`)
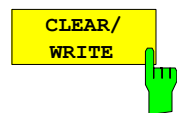
CLEAR/ WRITE

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, R&S FMUFMU clears the selected trace memory and starts the measurement anew.

IEC/IEEE-bus command `DISP:WIND:TRAC:MODE WRIT`
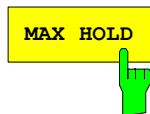
MAX HOLD

The *MAX HOLD* softkey activates the max peak detector.
R&S FMU 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`
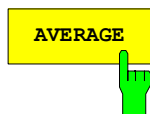
AVERAGE

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 R&S FMU, 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:

$$TRACE = \frac{9 * TRACE + \text{meas. value}}{10}$$

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:

$$Trace_n = \frac{1}{n}\left[\sum_{i=1}^{n-1}(T_i) + \text{meas.value}_n\right]$$

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:

$$TRACE = \frac{(N\text{-}1) * TRACE_{old} + \text{meas. value}}{N}$$

where
Trace = new trace
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".
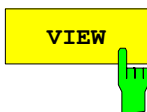
VIEW	The *VIEW* softkey freezes the current contents of the trace memory and displays it.

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, R&S FMU 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`
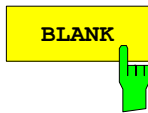
BLANK

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 32767 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"
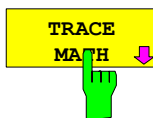
TRACE MATH

See following Section "Mathematical Functions for Traces"

TRACE - NEXT menu
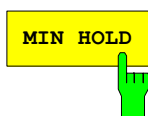
MIN HOLD

The *MIN HOLD softkey* activates the min peak detector. R&S FMU 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`
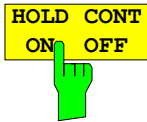
HOLD CONT
ON OFF

The *HOLD CONT* softkey defines whether the traces in min hold and max hold mode are reset after some specific parameter changes.

OFF   The traces are reset after some definite parameter changes (default)

ON   This mechanism is switched off.

In general, parameter changes require a restart of the measurement before results are evaluated (e. g. with markers). For those changes that are known to require a new measurement (e. g. modification of the span), the trace is automatically reset so that erroneous evaluations of previous results are avoided.

This mechanism can be switched off for those exceptional cases where the described behavior is unwelcome.

IEC/IEEE-bus command:
`:DISP:WIND:TRAC:MODE:HCON ON|OFF`

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 offsetting 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.

Amplitude

Amplitude distribution
(without averaging)

2.5 dB

Amplitude distribution
(after averaging)

Probability distribution
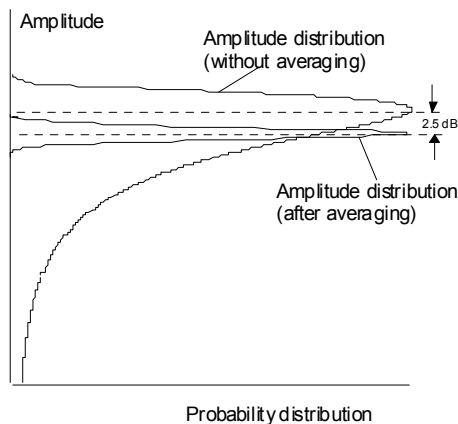
This low average value is usually corrected in noise power measurements by a +2.5 dB addition.
The R&S FMU offers the selection of linear averaging. The trace data are delogarithmized prior to averaging, then averaged and logarithmized again for display on the screen. The average value is always correctly 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;R&S FMU36;	Instrument model
	Version;1.00;	Firmware version
	Date;01.Jul 2006;	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/stop of the display range.
	Start;10000;Hz	Unit:
	Stop;100000;Hz	Hz for span > 0, s for span = 0,
		dBm/dB for statistics measurements
	Ref.Level;-20;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)
		Display range in in y direction. Unit: dB with x axis LOG,
	Level Range;100;dB	% with x axis LIN
	RBW;100000;Hz	Resolution 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
	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; 625;	Number of test points
		Measured values:
	10000;-10.3;-15.7	<x value>, <y1>, <y2>
	10180;-11.5;-16.9	<y2> being available only with detector AUTOPEAK and
	10360;-12.0;-17.4	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 R&S FMU 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 625 pixels of the display thus represents 1/625 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 625 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. 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.
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).

TRACE-DETECTOR submenu
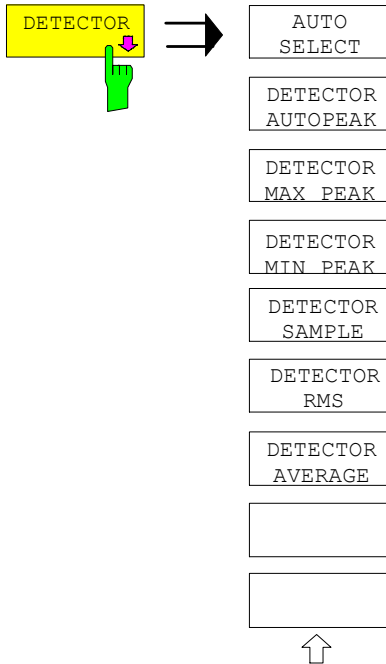
The *DETECTOR* softkey opens a submenu for selecting the detector for the selected trace. The softkey is highlighted if the detector is not selected with *AUTO SELECT*.

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).
With split-screen FFT Analyzer diagrams, the selected detector always applies to both diagrams.
The softkeys for the detectors are mutually exclusive selection keys.
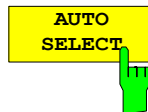
The *AUTO SELECT* softkey (= default setting) selects the optimum detector for the set display mode of the trace (Clear/Write, Max Hold and Min Hold) .

Trace display	Detector
Clear/Write	Auto Peak
Average	Sample
Max Hold	Max Peak
Min Hold	Min 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

IEC/IEEE-bus command `DET:AUTO ON`

DETECTOR AUTOPEAK

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.

IEC/IEEE-bus command `DET NEG`
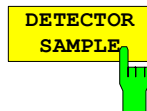
DETECTOR SAMPLE

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.

IEC/IEEE-bus command `DET SAMP`
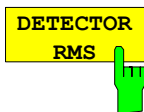
DETECTOR RMS

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 in the time domain (see TRACE AVERAGE).

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`

Mathematical Functions for Traces

TRACE 1-TRACE MATH submenu:

```
            TRACE MATH
┌──────────┐  ┌──────────┐
│  TRACE   │  │ T1-T2->T1│
│  MATH  ▽ │→ └──────────┘
└──────────┘
  👆         ┌──────────┐
            │ T1-T3->T1│
            └──────────┘

            ┌──────────┐
            │          │
            └──────────┘

            ┌──────────┐
            │  TRACE   │
            │ POSITION │
            └──────────┘

            ┌──────────┐
            │          │
            └──────────┘

            ┌──────────┐
            │          │
            └──────────┘

            ┌──────────┐
            │          │
            └──────────┘

            ┌──────────┐
            │          │
            └──────────┘

            ┌──────────┐
            │TRACE MATH│
            │   OFF    │
            └──────────┘
                 ⬆
```
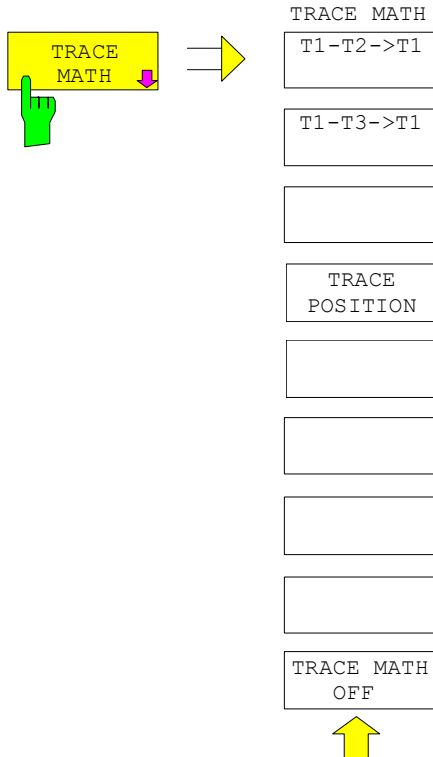
The *TRACE MATH* softkey opens a submenu in which the difference between the selected trace to trace 1 is calculated. The softkey is highlighted if a math function is activated.

TRACE MATH

T1-T2->T1

T1-T3->T1

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)

TRACE POSITION

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

TRACE MATH OFF

The *TRACE MATH OFF* softkey switches the math function off.

IEC/IEEE-bus command CALC:MATH:STAT OFF

Correction Data Acquisition of R&S FMU – CAL Key

The R&S FMU obtains its high measurement accuracy through its inbuilt 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 R&S FMU . 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.

Due to its 1 MΩ input impedance, the R&S FMU is ideally suited for measurements performed with high-impedance probes. The calibration signal source can be switched to the *PROBE CAL* and

PROBE $\overline{CAL}$ BNC connectors. Probes plugged into these connectors can be calibrated so that the high measurement accuracy of the R&S FMU is directly transferred to the tip of the probe.

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 and probe calibration.
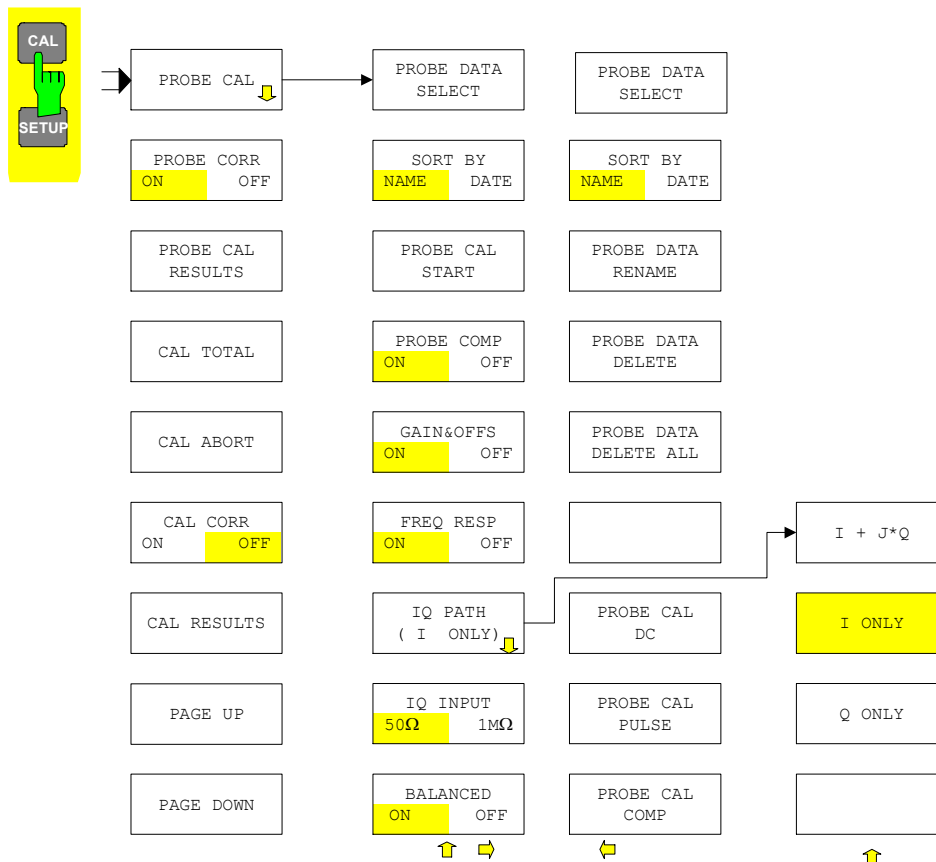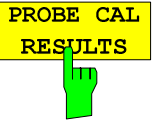
PROBE CAL

The *PROBE CAL* softkey opens a submenu for setting and performing of probe calibrations (see page 4.68).

PROBE CORR ON OFF

The *PROBE CORR ON/OFF* softkey switches the probe calibration data on/off.

When set to ON, the enhancement label **PRB** is displayed on the screen to indicate that Probe Correction Data are used.

IEC/IEEE-bus command: `PROB:STAT ON`

PROBE CAL RESULTS

The PROBE *CAL RESULTS* softkey calls the PROBE *CALIBRATION RESULTS* table, which shows the correction data found during calibration.

Es werden die Kalibrierwerte angezeigt die gerade benutzt werden. Es können die Werte aus der zuletzt durchgeführten Probe Kalibrierung sein, oder gespeicherte Daten aus einer früheren Kalibrierung (siehe hierzu softkey *PROBE DATA SELECT*).

The *CALIBRATION RESULTS* table contains the following information:
– list of found correction values
- status of each alignement process

The status has the following meaning:
PASSED   calibration successful without any restrictions
FAILED   deviations of correction value too large, no correction was possible. The found correction data are not valid.

```
         PROBE CALIBRATION RESULTS
OFFSET CALIBRATION
Range[V] DAC Offset I  Status  DAC Offset Q  Status
   5.6200        2102  passed          2439  passed
   3.1600        2048  passed          2247  passed
   1.7800        2023  passed          2133  passed
   1.0000        1963  passed          2028  passed
   0.5620        1971  passed          2017  passed
   0.3160        1978  passed          2004  passed
   0.1780        1979  passed          2003  passed
   0.1000        1981  passed          2002  passed



GAIN CALIBRATION
Error I                 Error Q
      0.9370                  0.9317

FREQUENCY RESPONSE CALIBRATION
PASSED
```

IEC/IEEE-bus command: `PROB:RES?`
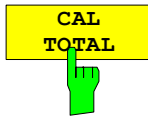
CAL TOTAL

The *CAL TOTAL* softkey starts the recording of correction data of the instrument (selfalignment process).

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?`
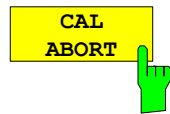
CAL ABORT

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 values
– 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
Total Calibration Status: PASSED
Rohde&Schwarz,FMU-36,900294/008,4.08b
Date (dd/mm/yyyy): 18/07/2006 Time: 08:56:14
Runtime: 00:09


Measure Baseband Board DAC Offset Unbal 50 Ohm
DAC I              Result I   DAC Q      Result Q
   1998            PASSED       2034     PASSED
   1994            PASSED       2029     PASSED
   1998            PASSED       2035     PASSED
   1992            PASSED       2032     PASSED
   1955            PASSED       2027     PASSED
   1929            PASSED       2031     PASSED
   1871            PASSED       2023     PASSED


Measure Baseband Board DAC Offset Bal 50 Ohm
DAC I              Result I   DAC Q      Result Q
   1983            PASSED       2001     PASSED
```

IEC/IEEE-bus command: `CAL:RES?`
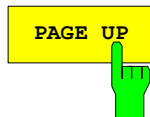
PAGE UP

The softkeys *PAGE UP* and *PAGE DOWN* scroll one page forward or backward in the *CALIBRATION RESULTS* table.

IEC/IEEE-bus command: `--`

PAGE DOWN
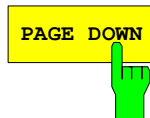
Probe Calibration

PROBE DATA
SELECT

The *PROBE DATA SELECT* softkey calls the *PROBE CALIBRATION DATA* table, which shows previously stored files that contain probe calibration values.

The *PROBE CAL DATA* table contains the following information:

– filename
- date and time of calibration
- I/Q Input configuration
- calibration options
- calibration result

PROBE CAL DATA						
FILENAME	DATE/TIME	IMP	BAL	PATH	OPTIONS	RESULT
Probe_00001_	11.07.06 13:57	1MΩ	unbal	Ionly	Freq	Passed
Probe_00003_	11.07.06 14:14	1MΩ	unbal	Ionly	Gain Freq	Passed
√Probe_00004_	11.07.06 14:17	1MΩ	unbal	Ionly	Gain Freq	Passed
Probe_00006_	11.07.06 14:28	1MΩ	unbal	Ionly	Freq	Passed

The currently active data set is indicated by a checkmark. The selection bar is set to the currently selected data set or the first entry by default. The data set is selected by marking with the selection bar (by using the rotary knob or cursor keys) and the ENTER key.

Only files that match the current configuration of the I/Q input (ímpedance, BAL/UNBAL, path e.g. I only) are displayed.

The extent of the calibration is displayed under OPTIONS:
Freq = nur Frequenzgang
Gain = nur Verstärkung/Dämpfung und Offset
Gain Freq = Frequenzgang, Verstärkung/Dämpfung und Offset

RESULT
Passed: This data set stands for a successful calilbration.
Failed: This data set stands for a failed calibration and should not be
         activated, since this may lead to incorrect measurement results.

IEC/IEEE-bus command: `PROB:CAT?`

SORT BY
NAME DATE

The *SORT BY NAME/DATE* selects the sorting criterion for the *PROBE CAL DATA* table.

IEC/IEEE-bus command: --
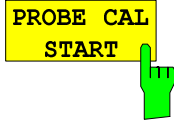
PROBE CAL
START

The *PROBE CAL START* softkey starts the probe calibration.

Important: *Before starting the probe calibration, the following must be done:*

➢ Set the calibration options (PROBE COMP, GAIN&OFFS, FREQ RESP softkeys)

➢ Set the configuration of the I/Q input (IQ PATH, I/Q INPUT, BALANCED softkeys)

➢ Connect probes at all active inputs (indicated by LEDs). The active inputs are defined by the IQ PATH and BALANCED softkeys. All probes must have the same nominal attenuation (e.g. 10:1).

Since all mentioned softkeys are available in the *PROBE CAL* menu, you can perform all presettings of the probe calibration without having to change the menu.

After starting the probe calibration, you will be requested to connect the probes to the calibration source (*PROBE CAL* and *PROBE $\overline{CAL}$* BNC connectors).

Probe Connection
Probe(s) I connected?
YES   NO
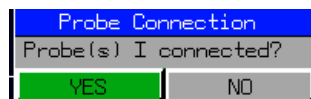
When prompted to do so, plug the I probe into the *PROBE CAL* connector (use BNC adapter) and also insert the $\overline{I}$ probe into the *PROBE $\overline{CAL}$* connector at *BALANCED = ON*.

Then calibrate the probes of the Q input in the same way.

If you acknowledge a request for probe connection with NO, the calibration will be stopped and has to be restarted, if necessary.

IEC/IEEE-bus command: CAL:PROB

PROBE COMP
ON   OFF

By using the *PROBE COMP ON/OFF* softkey, you can select the Probe Compensation option for the following probe calibration.

Probe compensation is the mechanical adjustment (trimming capacitor) of the probe to the input capacitance of the baseband input. The probe is adjusted in the same way as oscilloscopes, usually with a 1 kHz squarewave signal.

Usually it is sufficient to adjust the probes to the R&S FMU once. But then the probes must not be exchanged, not even between the different inputs, since there may be little differences in the input capacitance.
In case of doubt, you should therefore select *PROBE COMP = ON*; then you can check whether the probes have been adjusted correctly and readjust them, if necessary.

Important: *The frequency response correction (see FREQ RESP softkey) cannot correct the error that occurs due to unadjusted PROBE COMPENSATION, since a faulty adjustment of the PROBE COMPENSATION causes a step in the frequency response at approx. 1 kHz.*
Due to the high sampling rate of 81.6 MHz, the digital equalizer filter, which levels the frequency response up to 36 MHz, cannot equalize a ripple in the kHz range.

If *PROBE COMP* is set to *ON*, then after the probe calibration (*PROBE CAL*

START softkey) is started, the 1 kHz squarewave signal is switched to the *PROBE CAL / PROBE CAL* BNC connectors and a suitable time domain setup is automatically set on the R&S FMU. If you have no BNC adapter at your disposal at the moment, you can also connect the probe at the pin labeled PROBE COMPENSATION by using a terminal clamp. But then it is not possible to calibrate gain/offset or frequency response!

The R&S FMU automatically sets the scaling in such a way that the top of the squarewave signal is located at the center of the screen and is displayed with 20 mV/DIV when zoomed. When mapping the entire signal, such an exact adjustment would not be possible, since due to the pixel resolution of the screen it would be very difficult to obtain an adjustment accuracy of 1 %.

Adjust Probes to optimum square wave response (see below figures)!
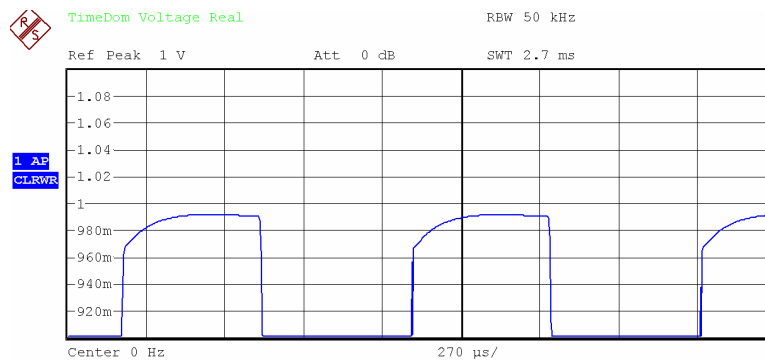
Fig. 4-7   UNDER COMPENSATED
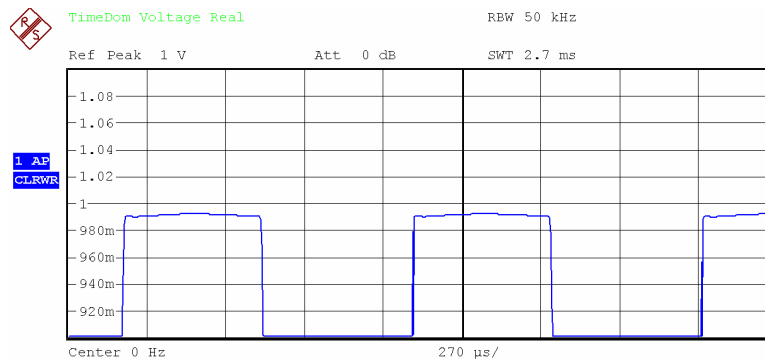
Fig. 4-8   OPTIMUM
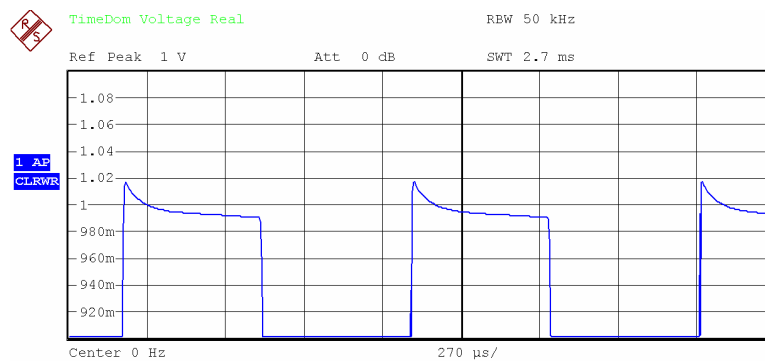
Fig. 4-9   OVER COMPENSATED

Note: *The probes can also be adjusted at any time outside the probe calibration. The 1 kHz squarewave signal is constantly applied at the pins labeled PROBE COMPENSATION. But then you must manually perform all settings that are necessary for adequate display of the signal on the R&S FMU .*

IEC/IEEE-bus command: `CAL:PROB:COMP ON`

GAIN&OFFS ON/OFF

By using the *GAIN&OFFS ON/OFF* softkey, you can select the Gain and Offset Calibration option for the subsequent probe calibration.

DC offset and gain errors (at DC) of the overall system (R&S FMU and probe) are measured and saved for later correction.

Admissible range for the gain calibration: 1 to 0.01 nominal.
The gain of the probe must not be >1 (which could be the case with an active probe). The maximum gain must not be greater than 40 dB (100:1 probe).
If the admissible range is exceeded, the status of the calibration will be FAILED.

IEC/IEEE-bus command: `CAL:PROB:GAIN ON`

FREQ RESP ON/OFF

By using the *FREQ RESP ON/OFF* softkey, you can select the Frequency Response Calibration option for the subsequent probe calibration.

The frequency response of the overall system (R&S FMU and probe) is measured and saved for later correction.

Probes that up to 36 MHz have a frequency response greater than 6 dB, cannot be calibrated. If the correctable frequency response is exceeded (>6 dB), the status of the calibration will be FAILED.

IEC/IEEE-bus command: `CAL:PROB:FRES ON`

IQ PATH (I+J*Q)

The *IQ PATH* softkey opens a submenu. The way in which the two input paths are to be interpreted can be defined in this submenu.
The color of one of the three softkeys in the submenu changes to indicate which one is active. The *IQ PATH* softkey also indicates the selected function.

I+J*Q

The *I+J*Q* softkey causes the FFT Analyzer to regard the signals at the I and Q input as components of a complex signal. This is the standard setting for the analysis of signals with complex modulation.

IEC/IEEE bus command: `:INP:IQ:TYPE IJQ`

I ONLY

The *I ONLY* softkey causes the FFT Analyzer to regard the signal at the I input as a single, real signal. The signal at the Q input is ignored.
This setting should be selected if, for example, a signal at a low intermediate frequency is connected to the I input.

IEC/IEEE bus command: `:INP:IQ:TYPE I`

Q ONLY

The *Q ONLY* softkey causes the FFT Analyzer to regard the signal at the Q input as a single, real signal. The signal at the I input is ignored.
This setting should be selected if, for example, a signal at a low intermediate frequency is connected to the Q input.

IEC/IEEE bus command: `:INP:IQ:TYPE Q`

The *IQ INPUT* *50Ω / 1MΩ* softkey is used to toggle the input impedance of the baseband inputs. The setting has the same effect on all inputs.

IEC/IEEE bus command: `:INP:IQ:IMP LOW`

The *BALANCED ON / OFF* softkey is used to toggle the measurement mode of the baseband inputs.
ON switches to balanced (differential) inputs; *OFF* switches to ground-referenced inputs. The setting has the same effect on both (I and Q) inputs.

IEC/IEEE bus command: `:INP:IQ:BAL:STAT ON`

PROBE CAL – NEXT menu:

The NEXT key opens a menu for administrating the saved probe calibration files and for manually setting the calibration signals.
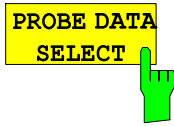
PROBE DATA SELECT

The *PROBE DATA SELECT* softkey calls the *PROBE CALIBRATION DATA* table, which shows previously stored files that contain probe calibration values. For details see *PROBE CAL* menu.

IEC/IEEE bus command: `:PROB:SEL`
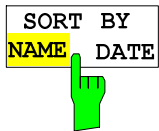
SORT BY NAME DATE

The *SORT BY NAME/DATE* softkey selects the sorting criterion for the *PROBE CAL DATA* table.

IEC/IEEE bus command: `---`
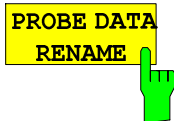
PROBE DATA RENAME

The *PROBE DATA RENAME* softkey allows you to rename the probe calibration data files.

IEC/IEEE bus command: `:PROB:MOVE`
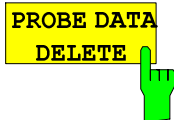
PROBE DATA DELETE

The *PROBE DATA DELETE* softkey allows you to delete a selected probe calibration data file.
The currently active file (indicated by a checkmark) cannot be deleted.

IEC/IEEE bus command: `:PROB:DEL`

PROBE DATA DELETE ALL
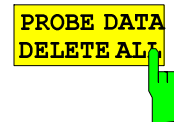
The *PROBE DATA DELETE ALL* softkey allows you to delete all probe calibration data files. The currently active file (indicated by a checkmark) is not deleted.

IEC/IEEE bus command: `---`
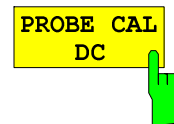
PROBE CAL DC

By using the *PROBE CAL DC* softkey, you can switch on the probe calibration source with DC voltage for service purposes (e.g. performance test). This softkey opens a selection list with voltages between 0 V and 2.4 V. The voltage is applied at the *PROBE CAL* BNC connector.
Identical negative voltage is applied at the *PROBE $\overline{CAL}$* BNC connector.

IEC/IEEE bus command: `:PROB:ADJ:DC`
                                     `:PROB:ADJ:MODE DC`
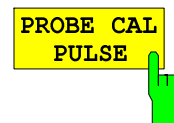
PROBE CAL PULSE

By using the *PROBE CAL PULSE* softkey, you can switch on the probe calibration source with pulse signal for service purposes (e.g. performance test). This softkey opens a selection list with frequencies between 10 kHz and 8 MHz. An 8 ns pulse ís generated with the set repetition frequency. The pulse voltage applied at the *PROBE CAL* BNC connector is positive and at the *PROBE $\overline{CAL}$* connector negative.

IEC/IEEE bus command: `:PROB:ADJ:PULS`
                                     `:PROB:ADJ:MODE PULS`
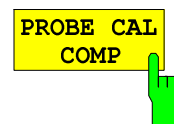
PROBE CAL COMP

By using the *PROBE CAL COMP* softkey, you can switch on the 1 kHz squarewave signal for compensating probes. The signal applied at both BNC connectors *PROBE CAL* and *PROBE $\overline{CAL}$* is positive. However, both outputs are inverted to each other.

IEC/IEEE bus command: `:PROB:ADJ:MODE COMP`

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. R&S FMU 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
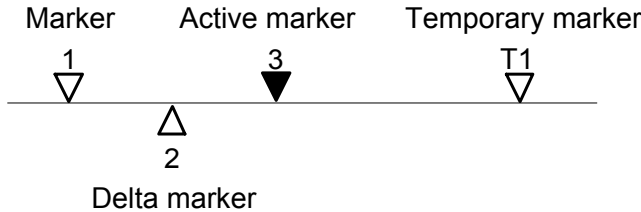
Temporary markers are used in addition to the markers and delta markers to evaluate the measurement results. They disappear when the associated function is deactivated.
The measurement results of the active marker (also called **marker values**) are displayed in the marker field. The marker info field 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
  23.4567 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 1 |
| MARKER 2 |
| MARKER 3 |
| MARKER 4 |
| MARKER NORM DELTA |
| |
| REFERENCE FIXED ⬇ |
| |
| ALL MARKER OFF ⇨ |

| MKR->TRACE |
| LINK MKR1 AND DELTA1 |
| |
| |
| |
| |
| |
| |
| ⇦ |

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| |
| |
| MKR FILE EXPORT |
| DECIM SEP . , |
| ⇦ |

| REF FXD ON OFF |
| REF POINT LEVEL |
| REF POINT LVL OFFSET |
| REF POINT FREQUENCY |
| REF POINT TIME |
| PEAK SEARCH |
| |
| |
| |
| ⇧ |

MARKER 1

•
•

MARKER 4
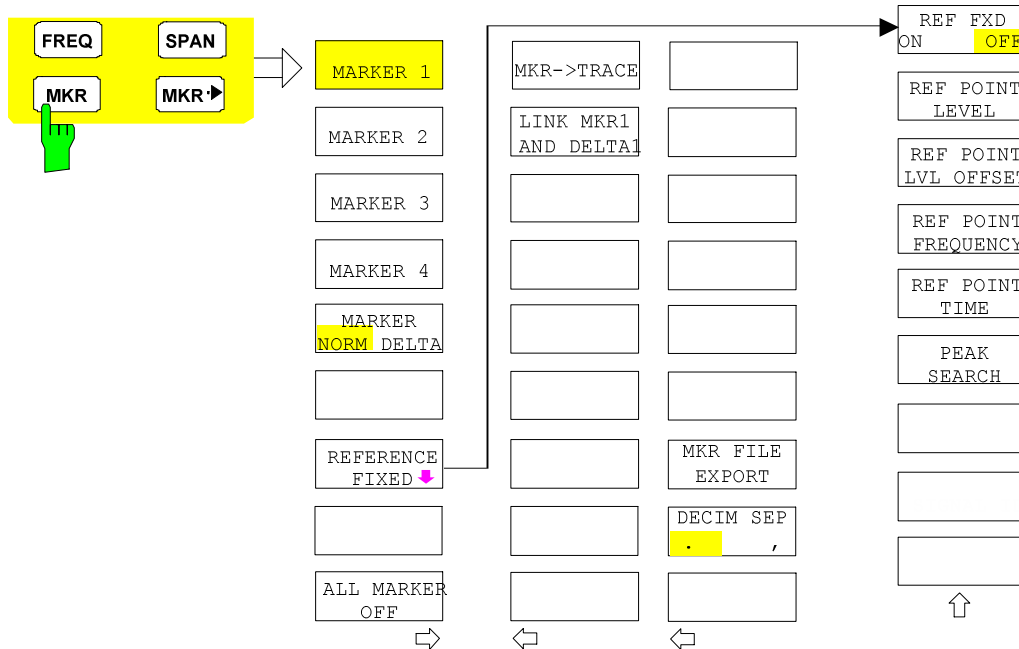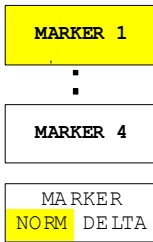
MARKER
NORM DELTA

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**]   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.

In the split-screen diagrams REAL IMAG, VOLTAGE and MAGNITUDE PHASE it is not possible to move markers separately on each trace; these markers are in fact marker pairs which are coupled to each other. The values of both markers are displayed, however. The marker always operates (search for peak, etc) in the diagram currently selected by the *SCREEN A / SCREEN B* hotkey; the other marker automatically moves in sync.

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.

LINK MKR1 AND DELTA1 With the softkey *LINK MKR1 AND DELTA1* the delta marker1 can be linked to marker1, so if the x-axis value of the marker1 is changed the delta marker1 will follow on the same x-position. The link is default off, and can be switched on.

Example for setup:

- PRESET

- TRACE | MAX HOLD

- TRACE | SELECT TRACE | 2 | AVERAGE

- MKR (Switches marker1 on)

- MARKER NORM DELTA | DELTA (Delta Marker 1 ON)

- MKR-> | MKR->TRACE | 2

- LINK MKR1 AND DELTA1

Now select the Marker1 (by switching MARKER1 from DELTA back to NORM) and when changing the x-axis value (by knob wheel or UP/DOWN keys) the delta marker1 will follow automatically.

The delta marker1 x-value can not be changed away from 0 as long as the link functionality is active.

IEC/IEEE-bus command: CALC:DELT1:LINK ON
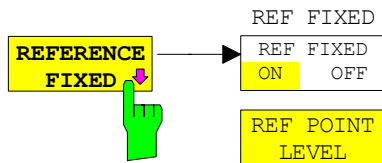
REF FIXED

REF FIXED
ON   OFF

REF POINT
LEVEL
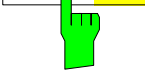
REF POINT
LVL OFFSET

REF POINT
FREQUENCY

REF POINT
TIME

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).

The *REFERENCE FIXED* softkey is available in Frequency Domain *MAGNITUDE* and Time Domain *MAGNITUDE.*

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
TIME

The *REF POINT TIME* softkey activates the entry box for the input of a reference time for the *REFERENCE FIXED* function in the time domain (span = 0 Hz).

IEC/IEEE-bus command:

                    CALC:DELT2:FUNC:FIX:RPO:X 5MS

For phase noise measurement, input of reference time is not possible.

PEAK
SEARCH

The *PEAK SEARCH* softkey sets the fixed reference value (*REFERENCE POINT*) to the peak of the trace.

Measurement example:
Small-span harmonics measurement to increase sensitivity
CW signal (eg 10 MHz, 0 dBm) with harmonics at the I input of R&S FMU.

[**PRESET**]	R&S FMU is set to the default setting.
[**CENTER**: 10 **MHz**]	The center frequency of R&S FMU is set to 10 MHz.
[**SPAN**: 1 **MHz**]	The span is set to 1 MHz.
[**AMPT**: 0 **dBm**]	The reference level is set to 0 dBm .
[**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**: 20 **MHz**]	The center frequency is set to 20 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.

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

MRK→TRACE
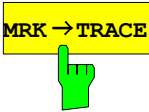
The *MKR→TRACE* softkey places the marker on a new trace. The trace is selected via a data entry field. Only those traces can be selected which are visible on the screen in the same window.

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`

MKR FILE EXPORT

The *MKR FILE EXPORT* softkey saves the data of active markers to a file < file_name >.

Example:
File content with 2 active markers in screen A:
Marker;1;T1
-25.87;dBm
19.920000000;GHz
Delta;2;T1
-21.90;dB
-5.920000000;GHz

IEC/IEEE-bus command: `:MMEM:STOR:MARK 'C:\marker.txt'"`

DECIM SEP

By means of the *DECIM SEP* softkey, one can select between a decimal point (.) and a comma (,) as decimal-point notation for the MKRI FILE EXPORT function.
Due to the possibility of selecting between different decimal-point notations, different language versions of analysis programs (such as MS Excel) can be supported.

IEC/IEEE-bus command: `:FORM:DEXP:DSEP POIN`

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)

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*:
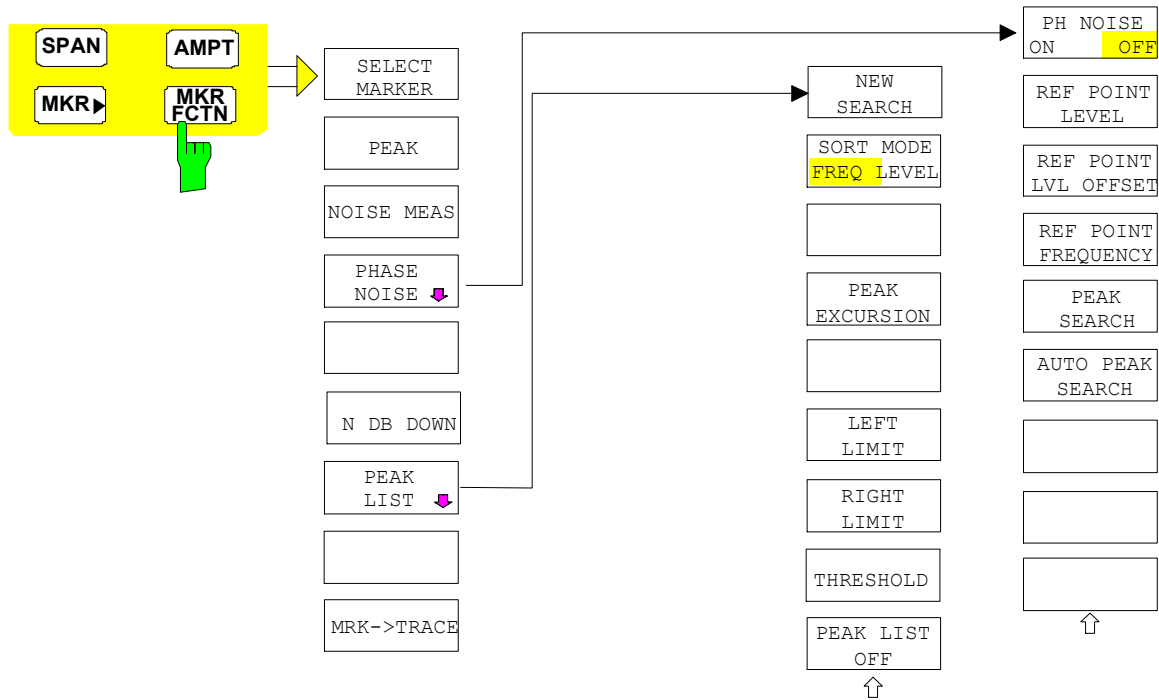
Activating the Markers

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?`
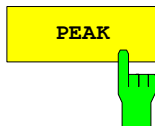
PEAK

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
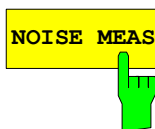
NOISE MEAS

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 magnitude mode, all points of the trace are used to determine the noise power density. When measurements are performed in the frequency domain magnitude mode, 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 logarithmic amplitude units dBm, dBpW, dBmV, dBmµV, dBµA the noise density is output in dBm/Hz, dBpW/Hz, dBmV/Hz, dBµV/Hz, dBµA/Hz, i.e. as power, voltage or current in 1 Hz bandwidth with reference to 1 mW, 1pW, 1mV, 1µV, 1µA. With linear amplitude units (V, A, W) the noise voltage density is evaluated in nV/√Hz, the noise current density in pA/√Hz or the noise power density in pW/Hz.

The following settings have to be made to ensure that the power density measurement yields correct values:

Detector: Sample or RMS

In the default setting, the R&S FMU 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 (time domain only).

The R&S FMU 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 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 R&S FMU noise

[**PRESET**]   The R&S FMU 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 R&S FMU switches the sample detector on. The power density level of inherent noise is displayed in dBm/Hz in the marker info field.

[TRACE *AVERAGE*]

With trace averaging activated, the power density reading is more stable.

Phase Noise Measurement

Menu MKR FCTN:

PHASE NOISE ⬇	→	PH NOISE ON / OFF
		REF POINT LEVEL
		REF POINT LVL OFFSET
		REF POINT FREQUENCY
		PEAK SEARCH
		AUTO PEAK SEARCH
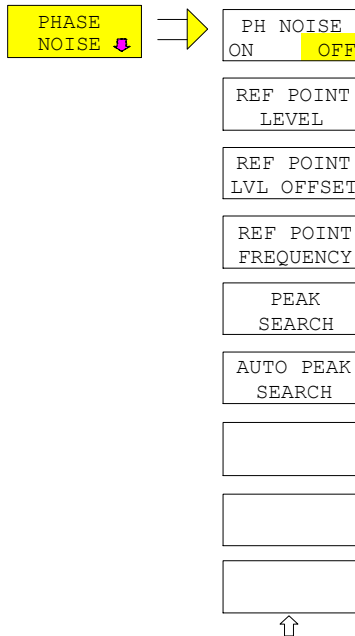
The *PHASE NOISE* softkey switches the *PHASE NOISE* function on/off. Additionally, the softkey opens the submenu for manually setting the reference point. The phase noise measurement can be switched off in the submenu.

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. Correction factors to evaluate the noise density from the marker level are automatically taken into account.

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: --
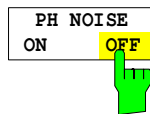
The *PH NOISE ON/OFF* softkey switches on/off the phase noise measurement. Switching on is performed by means of the *PHASE NOISE* softkey and is only necessary when the phase noise measurement has been switched off in the submenu.

IEC/IEEE-bus command: `CALC:DELT1:FUNC:PNO ON`
                      `CALC:DELT1:FUNC:PNO:RES?`
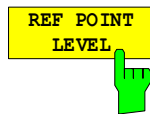
The *REF POINT LEVEL* softkey activates an entry box for the input of a reference level other than the reference marker level. The function is identical to that of the softkey with the same name in the marker menu (MKR).

IEC/IEEE-bus command:
            `CALC:DELT1:FUNC:FIX:RPO:Y -10dB`
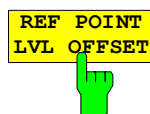
The *REF POINT LVL OFFSET* softkey activates an entry box for the input of an additional level offset for the phase noise calculation.

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`
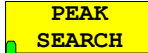
REF POINT FREQUENCY

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 10 MHz with 0 dBm level is to be measured at 8 kHz from the carrier

[**PRESET**]	The R&S FMU is set to the default setting.
[**CENTER**: 10 **MHz**]	The center frequency is set to 10 MHz.
[**SPAN**: 20 **kHz**]	The span is set to 20 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.
[*PHASE NOISE*: 8 **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. When the phase noise measurement function is enabled, the entry of the delta marker frequency is activated. It can be entered directly.
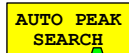
AUTO PEAK SEARCH

The phase noise *AUTO PEAK SEARCH* adds an automatic peak search action for the reference fixed marker 1 at the end of each particular sweep. This function may be used for tracking of a drifting source whilst phase noise measurement. The delta marker 2 which shows the phase noise measurement result keeps the delta frequency value. Therefore the phase noise measurement in a certain offset is valid although the source is drifting. Only when the marker 2 is reaching the border of the span the delta marker value is adjusted to be within the span. Choose a larger span in such situations.

IEC/IEEE-bus command: `CALC:DELT:FUNC:PNO:AUTO ON`

Measurement of the Filter or Signal Bandwidth

Menu *MKR FCTN*:
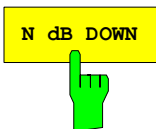
The *N dB DOWN* softkey activates the temporary markers T1 and T2 which are n dB below the active reference marker. Marker T1 is placed to the left and marker T2 at the right of the reference marker. The value n can be input in a window.

The default setting is 3 dB.

Span > 0: The frequency spacing of the two temporary markers is indicated in the marker info field.
Span = 0: The pulse width between 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.

If a negative value is entered than the markers are placed n dB above the active reference marker. This is then a n dB up function which can be used for notch filter measurements,

Note: *When the 3 dB bandwidths of the FFT-analyzer's resolution filters are measured in the Frequency Domain mode, the value that is returned is not exactly the same as the value that was set as the RESOLUTION BANDWIDTH. This is due to the fact that the equivalent noise bandwidths are entered as the RBW in the Frequency Domain mode in the FFT Analyzer.*

The function is disabled in the following display modes:

- time domain – *VOLTAGE*

- frequency domain – *REAL IMAG*

- frequency domain *MAG PHASE*

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? 'Span > 0`
                                       `CALC:MARK1:FUNC:NDBD:TIME? 'Span = 0`

Measurement of a Peak List

Menu *MKR FCTN*:

PEAK LIST	→	NEW SEARCH

SORT MODE FREQ LEVEL

PEAK EXCURSION

LEFT LIMIT

RIGHT LIMIT

THRESHOLD
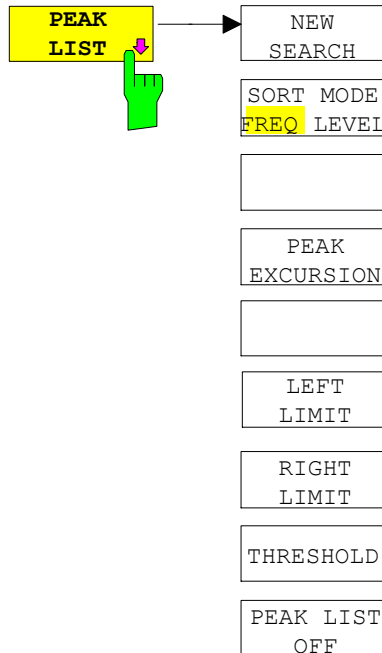
PEAK LIST OFF

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	LEVEL
1	–36.0000000000 MHz	–27.07 dBm
2	–32.8846153846 MHz	–7.18 dBm
3	–26.5384615384 MHz	–17.66 dBm
4	–11.0769230769 MHz	14.47 dBm
5	–4.7307692307 MHz	–21.53 dBm
6	–4.5000000000 MHz	–21.53 dBm
7	4.500000000 MHz	–18.85 dBm
8	11.076923076 MHz	14.61 dBm
9	17.538461538 MHz	–23.23 dBm
10	26.653846153 MHz	–19.49 dBm
11	32.884615384 MHz	–5.32 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;`
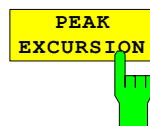
PEAK EXCURSION

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
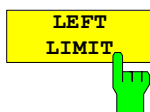
RIGHT LIMIT

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.
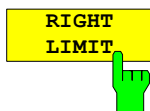
IEC/IEEE-bus commands: `CALC:MARK:X:SLIM:LEFT 1MHZ`
                                        `CALC:MARK:X:SLIM:RIGH 10MHZ`
                                        `CALC:MARK:X:SLIM ON`

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: –

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 functions for the last active marker are activated; if no marker was enabled, *MARKER 1* is activated and a peak search is performed.

MKR → menu
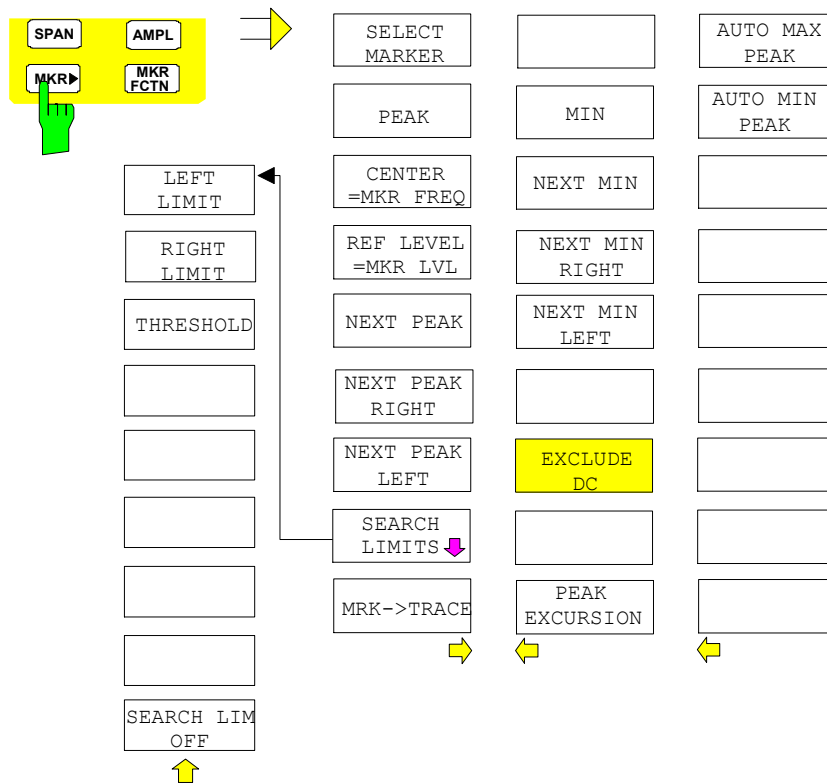
The *SELECT MARKER* softkey activates the numerical selection of the marker in the data entry field. Delta marker 1 is selected by input of ' 0 '.

IEC/IEEE-bus commands: `CALC:MARK1 ON;`
                                  `CALC:MARK1:X <value>;`
                                  `CALC:MARK1:Y?`
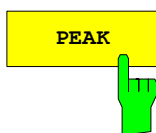
The *PEAK* softkey sets the active marker/delta marker to the peak of the trace.
If no marker is active when **MKR->** menu is called, *MARKER 1* is automatically switched on and the peak search is performed.

IEC/IEEE-bus commands: `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**]   R&S FMU 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 or the maximum frequency is not exceeded.

[*SPAN*]   The span can, for example, be reduced using the rollkey.

```
REF LEVEL
=MKR LVL
```
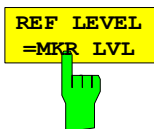
The *REF LEVEL = MKR LVL* softkey sets the reference level to the current marker level.

IEC/IEEE-bus command: CALC:MARK:FUNC:REF

Example:

A spectrum is displayed with a large span after PRESET. The reference level shall be set so that the strongest signal is exactly at refence level.

[**PRESET**]   R&S FMU is set to the default setting.

[**MKR->**]   *MARKER 1* is switched on and automatically jumps to the largest signal of the trace.

[*REF LEVEL
= MKR LVL*]   The reference level is set to the measured marker level.

```
NEXT PEAK
```

The *NEXT PEAK* softkey sets the active marker/delta marker to the next lower maximum of the selected trace.

IEC/IEEE-bus commands: CALC:MARK:MAX:NEXT
                          CALC:DELT:MAX:NEXT

```
NEXT PEAK
RIGHT
```
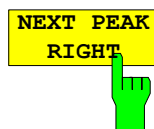
The *NEXT PEAK RIGHT* softkey sets the active marker/delta marker to the next lower maximum right of the current marker position on the selected trace.

IEC/IEEE-bus commands: CALC:MARK:MAX:RIGH
                           CALC:DELT:MAX:RIGH

```
NEXT PEAK
LEFT
```
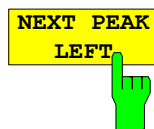
The *NEXT PEAK LEFT* softkey sets the active marker/delta marker to the next lower maximum left of the current marker position the selected trace.

IEC/IEEE-bus commands: CALC:MARK:MAX:LEFT
                           CALC:DELT:MAX:LEFT

SEARCH LIMITS	→	LEFT LIMIT
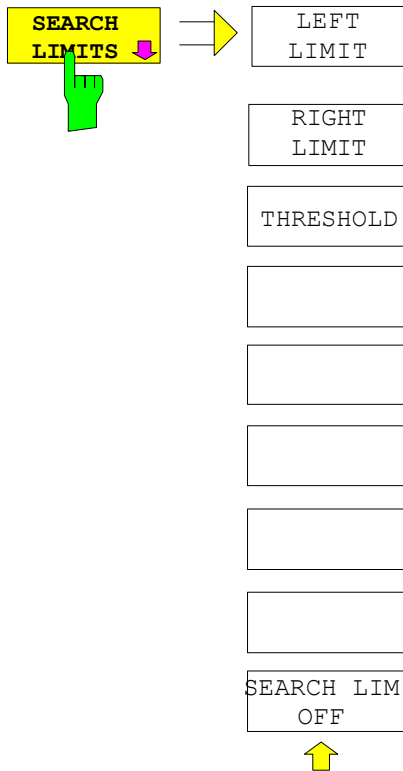
The *SEARCH LIMITS* softkey limits the search range for maximum or minimum search. The softkey switches to a submenu in which the search range limits can be set in the x and y direction.

RIGHT LIMIT

THRESHOLD

SEARCH LIM OFF

LEFT LIMIT
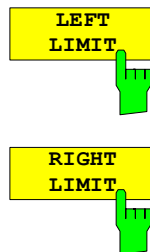
RIGHT LIMIT

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 *LEFT LIMIT* is enabled, line F1/T1 is the lower limit and the upper limit corresponds to the stop frequency. If *RIGHT LIMIT* is also enabled, it determines 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 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 commands: `CALC:THR –20dBm`
`CALC:THR ON`
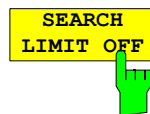
SEARCH LIMIT OFF

The *SEARCH LIMIT OFF* softkey disables all limits of the search range.

IEC/IEEE-bus commands: `CALC:MARK:X:SLIM OFF`
`CALC:THR OFF`
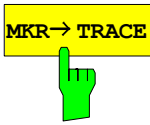
MKR→ TRACE

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.

MIN
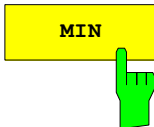
The *MIN* softkey sets the active marker/delta marker to the minimum of the selected trace.

IEC/IEEE-bus commands:　CALC:MARK:MIN
　　　　　　　　　　　　CALC:DELT:MIN
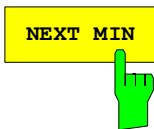
NEXT MIN

The *NEXT MIN* softkey sets the active marker/delta marker to the next higher minimum of the selected trace. The search direction is defined in the *NEXT MODE* submenu (see above).

IEC/IEEE-bus commands:　CALC:MARK:MIN:NEXT
　　　　　　　　　　　　CALC:DELT:MIN:NEXT

NEXT MIN RIGHT

The *NEXT MIN RIGHT* softkey sets the active marker/delta marker to the next higher minimum right of the current marker position on the selected trace.

IEC/IEEE-bus commands:　　CALC:MARK:MIN:RIGH
　　　　　　　　　　　　　CALC:DELT:MIN:RIGH

NEXT MIN LEFT

The *NEXT MIN LEFT* softkey sets the active marker/delta marker to the next higher minimum left of the current marker position on the selected trace.

IEC/IEEE-bus commands:　　CALC:MARK:MIN:LEFT
　　　　　　　　　　　　　CALC:DELT:MIN:LEFT
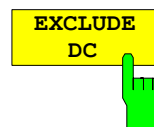
EXCLUDE DC

The *EXCLUDE DC s*oftkey limits the frequency range for the marker search functions or disables the limit.

activated　　The inherent DC component (DC offset) is represented as a signal at 0 Hz. To avoid the marker jumping to the peak at 0 Hz with the peak search function, this frequency is excluded. The minimum frequency to which the marker jumps, is ≥ 1.25 × 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
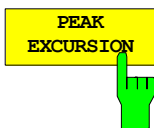
PEAK EXCURSION

The *PEAK EXCURSION* softkey enables – for level measurements – the entry of a minimum level value by which a signal must rise or fall so that it will be identified as a maximum or a minimum by the *NEXT PEAK* and *NEXT MIN* search functions.

Valid entries are from 0 dB to 80 dB; the resolution is 0.1 dB.

IEC/IEEE-bus command:　　　CALC:MARK:PEXC 10dB

The default setting for the peak excursion is 6 dB. This value is sufficient for the *NEXT PEAK* and *NEXT MIN* functions since, in this mode, the next lower maximum or next higher minimum will always be detected.

If *NEXT PEAK LEFT* or *NEXT PEAK RIGHT* is selected, these functions search for the next relative maximum left or right of the current marker position irrespective of the current signal amplitude. *Relative maximum* is understood to mean a decrease of the signal amplitude by a defined value – i.e. the peak excursion – right and left of the amplitude peak.

The 6 dB level change set as a default value may be attained already by the inherent noise of the instrument. In such a case, the R&S FMU would identify noise peaks as maxima or minima. The value entered for the *PEAK EXCURSION* should therefore be higher than the difference between the highest and the lowest value measured for the displayed inherent noise.

The following example illustrates the effect of different settings of the *PEAK EXCURSION*.
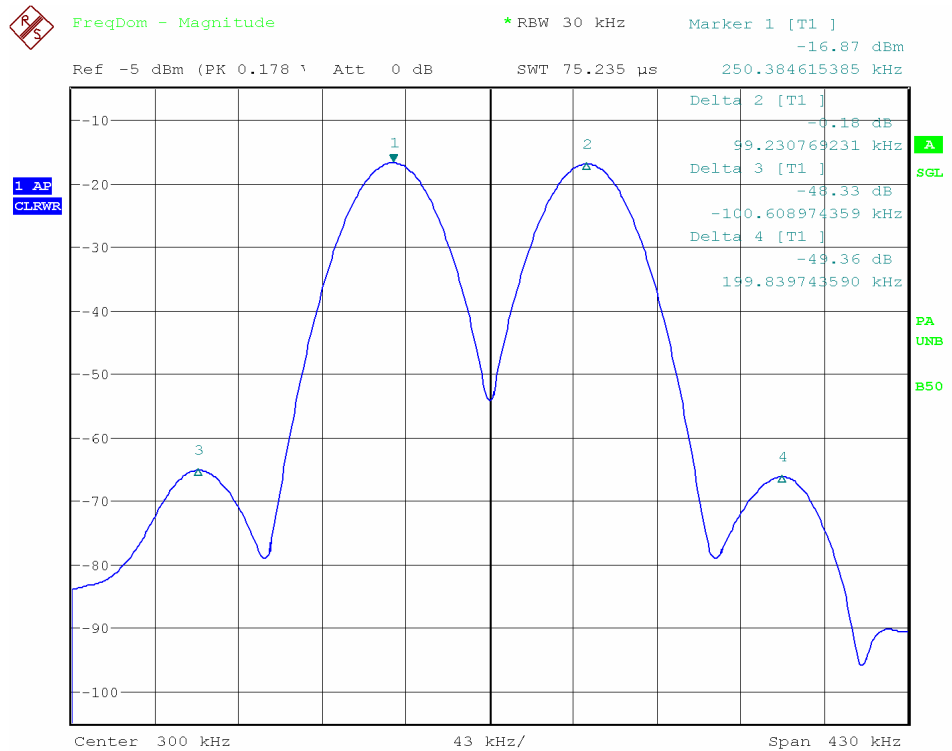
Fig. 4-10   Examples of level measurement with different settings of *PEAK EXCURSION*

The following table lists the signals as indicated by marker numbers in the diagram above, as well as the minimum of the amplitude decrease to both sides of the signal:

Table 4-6

Signal #	min. amplitude decrease to both sides of the signal
1	~36 dB
2	~36 dB
3	~14 dB
4	~13 dB

With **40 dB peak excursion**, NEXT PEAK, NEXT PEAK RIGHT and NEXT PEAK LEFT will not find any signal, as the signal level does not decrease by more than 36 dB to either side of any signal.

Order of signals detected:
PEAK:	signal 1
NEXT PEAK:	signal 1 (no further signal detected)

or

PEAK:	signal 1
NEXT PEAK LEFT:	signal 1 (no further signal detected)
NEXT PEAK RIGHT:	signal 1 (no further signal detected)

With **20 dB peak excursion**, NEXT PEAK and NEXT PEAK RIGHT will also detect signal 2, as the signal level decreases at least by 36 dB to either side of this signal, which is now greater than the peak excursion.

Order of signals detected:
PEAK:	Signal 1
NEXT PEAK:	Signal 2
NEXT PEAK:	Signal 2 (no further signal detected)

or

PEAK:	Signal 1
NEXT PEAK LEFT:	Signal 1 (no further signal detected)
NEXT PEAK RIGHT:	Signal 2
NEXT PEAK RIGHT:	Signal 2 (no further signal detected)

With **6 dB peak excursion**, all signals will be detected with NEXT PEAK and NEXT PEAK RIGHT / NEXT PEAK LEFT.
Order of signals detected:

Order of signals detected:
PEAK:	Signal 1
NEXT PEAK:	Signal 2
NEXT PEAK:	Signal 3
NEXT PEAK:	Signal 4

or

PEAK:	Signal 1
NEXT PEAK LEFT:	Signal 3
NEXT PEAK RIGHT:	Signal 1
NEXT PEAK RIGHT:	Signal 2
NEXT PEAK RIGHT.	Signal 4

AUTO MAX PEAK
AUTO MIN PEAK

AUTO MAX PEAK / *AUTO MIN PEAK* adds an automatic peak search action for Marker 1 at the end of each particular sweep. This function may be used during adjustments of a device under test to keep track of the actual peak marker position and level.
The actual marker search limit settings (*LEFT LIMIT*, *RIGHT LIMIT*, *THRESHOLD,* EXCLUDE LO) are taken into account.

IEC/IEEE-bus command: CALC1:MARK1:MAX:AUTO ON
                          CALC1:MARK1:MIN:AUTO ON

Power Measurements – MEAS Key

With its power measurement functions the R&S FMU is able to measure all the necessary parameters with high accuracy in a wide dynamic range.

A modulated carrier is almost always used for 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:

BW	SWEEP	
MEAS	TRIG	

TIME DOM POWER

CHAN PWR ACP

MULT CARR ACP

OCCUPIED BANDWIDTH

SIGNAL STATISTIC

C/N C/No

MODULATION DEPTH

SELECT MARKER

TOI
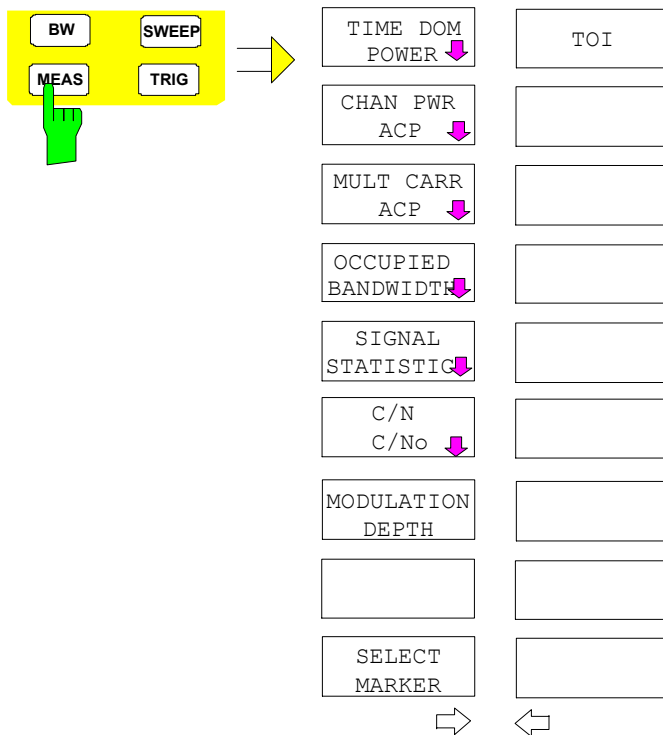
The *MEAS* key opens the menu to select and set the power measurement.

The following measurements can be selected:

- Power in the time domain (*TIME DOM POWER*)

- Channel power and adjacent-channel power in the frequency domain with a single carrier (*CHAN PWR ACP*)

- Channel power and adjacent-channel power in the frequency domain with several carriers (*MULT CARR ACP*)

- Occupied bandwidth (*OCCUPIED BANDWIDTH*)

- Carrier-to-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 R&S FMU 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*:
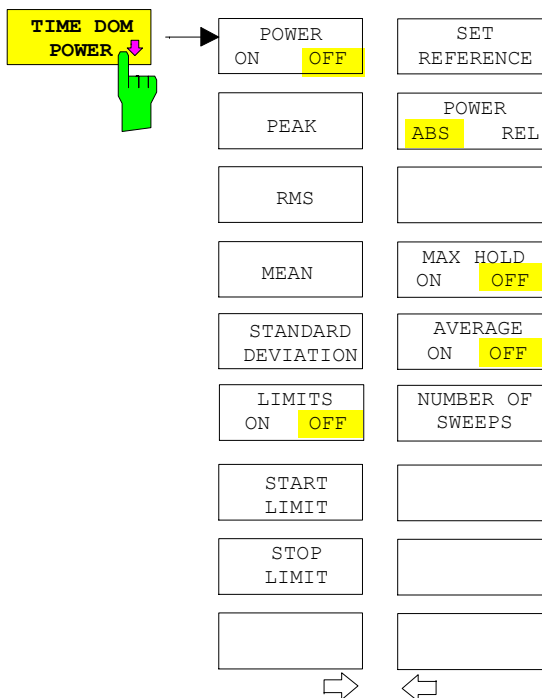
The *TIME DOM POWER* softkey activates the power measurement in the time domain and opens a submenu for configuration of the power measurement.

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 the MAGNITUDE measurement in the time domain (span=0).*
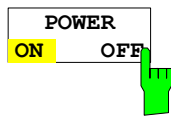
The *POWER ON/OFF* softkey switches the power measurement on and off. When entering the submenu it is *ON* since the power measurement is already switched on with the *TIME DOM POWER* softkey in the main menu.

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?
```
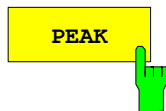
The *PEAK* softkey switches on the calculation of the peak value from the points of the displayed trace or a segment thereof.

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?
```
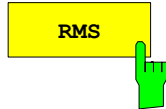
The *RMS* softkey switches on the calculation of the rms value from the points of the displayed trace or a segment of it.

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?
```
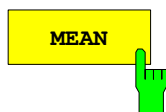
The *MEAN* softkey switches on the calculation of the mean value from the points of the displayed trace or a segment of it. The linear mean value of the equivalent voltages is calculated.

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?
```
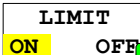
STANDARD DEIATION

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`
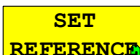
START LIMIT

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>`

STOP LIMIT

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>`
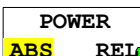
SET REFERENCE

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`

POWER ABS REL

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`
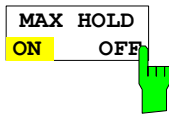
MAX HOLD
ON   OFF

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?`
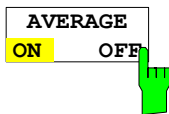
AVERAGE
ON   OFF

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?`
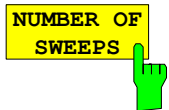
NUMBER OF
SWEEPS

The *NUMBER OF SWEEPS* softkey activates the entry of the number of sweeps for maximum or average value calculation.

SINGLE SWEEP mode	The R&S FMU 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 baseband is to be measured.

[**PRESET**]	Set the R&S FMU to the default setting.
	The center frequency is zero (baseband) in the default state.
[**SPAN**: *ZERO SPAN*]	Select time domain display (span = 0 Hz).
[**AMPT**: 5 **dBm**]	Set the reference level to 5 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**: *I/Q LEVEL*: 0.1 V]	Use the power of the complex baseband signal as trigger source.
[**MEAS**]	Call the menu for the measurement functions.
[*TIME DOM POWER*]	Select power measurement in the time domain. The R&S FMU calculates the power from the points of the whole trace. The submenu for configuration of the power measurement is opened. *RMS* is already switched on.
[*MEAN*]	Additionally switch on the *MEAN* power measurement.
[*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 radio communication system.

This configuration is defined by the nominal channel frequency (= center frequency of the R&S FMU if only one carrier is active), the channel bandwidth, the channel spacing, the adjacent-channel bandwidth and the adjacent-channel spacing. With baseband signals, the channel frequency is set to zero. The R&S FMU is able to simultaneously measure the power in up to four transmission channels and up to three adjacent channels (10 channels: 4 transmission channels, 3 lower and 3 upper adjacent channels).

The R&S FMU uses the integrated bandwidth method (IBW method) for channel and adjacent-channel power measurement, i.e. the integration of trace pixels within the bandwidth of the channel to be measured to the total power of the channel.

With the IBW method, the channel is divided into sub spectra. This is done by means of a bandwidth which is small compared to the channel bandwidth. These sub spectra are then combined by integration of the trace pixels.

The transmission channels 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. 4-11).

The results are listed in tables in the lower half of the screen.

The R&S FMU 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 on selecting the standard (e.g. NADC, TETRA or 3GPP W-CDMA).
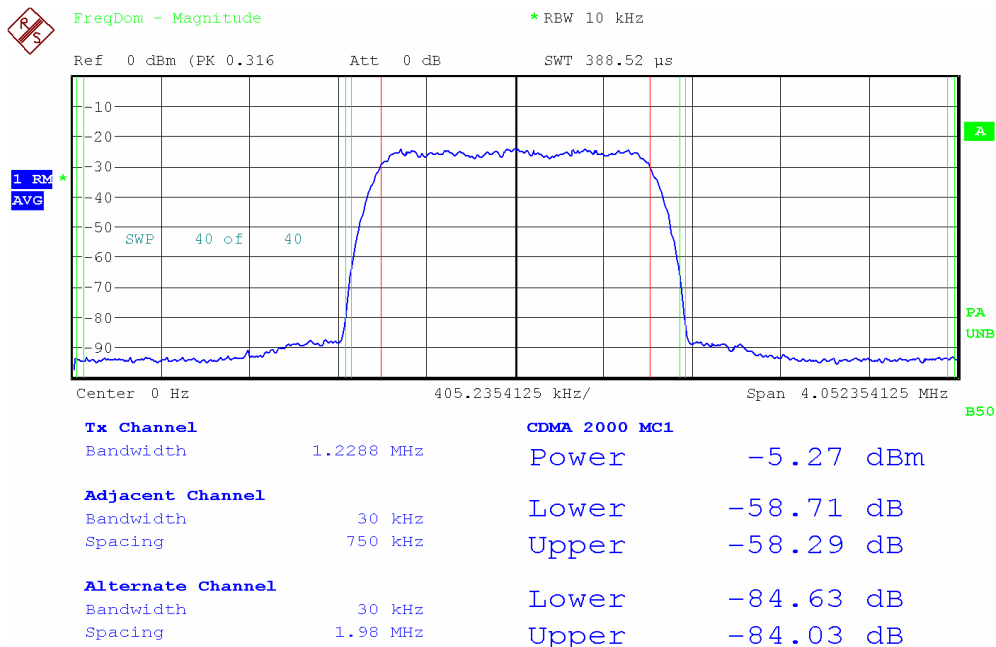
Fig. 4-11   Screen display of adjacent-channel power measurement according to CDMA2000 standard.

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 PWR ACP or the MEAS - MULT CARR ACP* menu*.*

CHAN PWR ACP		
MULT CARR ACP		

CP/ACP **ON** OFF
CP/ACP STANDARD
CP/ACP CONFIG
SET CP REFERENCE
DIAGRAM FULL SIZE

NO. OF ADJ CHAN
NO. OF TX CHAN
CHANNEL BANDWIDTH
CHANNEL SPACING
ACP REF SETTINGS
CP/ACP ABS **REL**
CHAN PWR / HZ
POWER MODE
ADJUST SETTINGS

ACP LIMIT CHECK
EDIT ACP LIMIT
SELECT TRACE
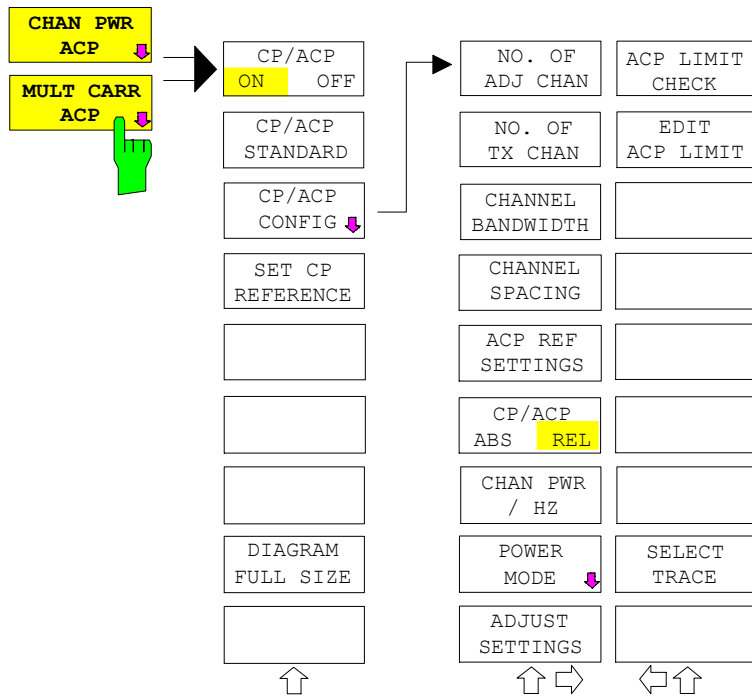
The *CHAN PWR ACP* and *MULT CARR ACP softkeys* activate channel or adjacent-channel power measurement either for a single carrier signal (*CHAN PWR ACP*) or for several carrier signals (*MULT CARR ACP*), depending on the current measurement configuration. In addition, they open a submenu for defining the parameters for channel power measurement. The softkey selected is shown in color to indicate that a channel or adjacent-channel power measurement is active.

Note: The softkeys are available only for measurements in the frequency domain(span > 0).
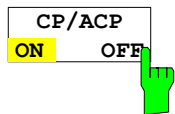
CP/ACP
ON OFF

The *CP/ACP ON/OFF* softkey switches calculation of the channel power or adjacent-channel power on and off.

The measurement is performed by integrating the powers at the display points within the specified channels (IBW method).

The powers of the adjacent channels are measured either as absolute values or as relative values referenced to the power of a transmission channel. The default setting is relative-value measurement (see *CP/ACP ABS/REL* softkey).

When multicarrier ACP measurement is activated, the number of test points is increased to ensure that adjacent-channel powers are measured with adequate accuracy.

IEC/IEEE-bus commands: `CALC:MARK:FUNC:POW:SEL CPOW|ACP|MCAC`
`CALC:MARK:FUNC:POW:RES? CPOW|ACP|MCAC`
`CALC:MARK:FUNC:POW OFF`
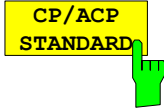
CP/ACP STANDARD

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
WLAN 802.11A
WLAN 802.11B

The standards available are listed in the table on the left.

Note: *For the R&S FMU, 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 R&S FMU 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
FAST ACP is not available if a WLAN standard is selected.

The selection of the standard influences the following parameters:

- channel spacing and adjacent-channel spacing

- channel bandwidth, adjacent-channel bandwidth, and type of filtering

- resolution bandwidth

- detector

- # of adjacent channels

Trace mathematics 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 as close as possible 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
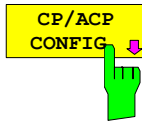
See following section "Setting the Channel Configuration"
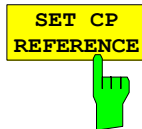
SET CP REFERENCE

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.

In adjacent-channel power measurement with one or several carrier signals, the power is always referenced to a transmission channel, i.e. no value is displayed for *CH PWR REF*.

IEC/IEEE-bus command: `POW:ACH:REF:AUTO ONCE`
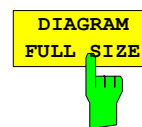
DIAGRAM FULL SIZE

The *DIAGRAM FULL SIZE* softkey switches the diagram to full screen size.

IEC/IEEE-bus command: `DISP:WIND1:SIZE LARG|SMAL`

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 neighborhood 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 is 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.

Setting the Channel Configuration

MEAS - CP/ACP CONFIG submenu:

CP/ACP CONFIG ⬇ →	NO. OF ADJ CHAN	ACP LIMIT CHECK
	NO. OF TX CHAN	EDIT ACP LIMIT
	CHANNEL BANDWIDTH	
	CHANNEL SPACING	
	ACP REF SETTINGS	
	CP/ACP ABS REL	
	CHAN PWR / HZ	
	POWER MODE ⇓	SELECT TRACE
	ADJUST SETTINGS	
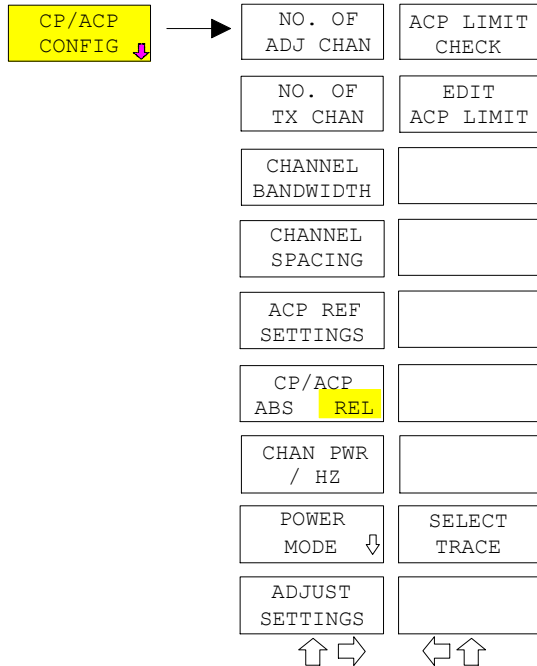
The *CP/ACP CONFIG* softkey opens a submenu for configuration of the channel power and adjacent channel power measurement independently of the offered standards.

The channel configuration includes the number of channels to be measured, the channel bandwidths (*CHANNEL BANDWIDTH*), and the channel spacings (*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.

NO. OF ADJ CHAN

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 12 can be entered.

The following measurements are performed depending on the number of the channels.

0   Only the channel powers are measured.

1   The channel powers and the power of the upper and lower adjacent channel are measured.

2   The channel powers, 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.

With higher numbers the procedure is expanded accordingly.

IEC/IEEE-bus command: `POW:ACH:ACP 1`

This increased number of adjacent channels is realized for all the relevant settings like:

ACLR LIMIT CHECK
```
:CALC:LIM:ACP:ACH:RES?
:CALC:LIM:ACP:ALT1..11:RES?
```

EDIT ACLR LIMITS
```
:CALC:LIM:ACP:ACH:STAT ON
:CALC:LIM:ACP:ACH:ABS -10dBm,-10dBm
:CALC:LIM:ACP:ACH:ABS:STAT ON
:CALC:LIM:ACP:ALT1..11 0dB,0dB
:CALC:LIM:ACP:ALT1..11:STAT ON
:CALC:LIM:ACP:ALT1..11:ABS -10dBm,-10dBm
:CALC:LIM:ACP:ALT1..11:ABS:STAT ON
```

ADJ CHAN BANDWIDTH
```
:SENS:POW:ACH:BWID:ALT1..11 30kHz
```

ADJ CHAN SPACING
```
:SENS:POW:ACH:SPAC:ALT1..11 1MHz
```
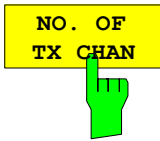
NO. OF TX CHAN

The *NO. OF TX CHAN* softkey enables the entry of the number of carrier signals to be considered in channel and adjacent-channel power measurements.

Numbers from 1 to 12 can be entered.

The softkey is available only for multicarrier ACP measurements.

IEC/IEEE-bus command: `SENS:POW:ACH:TXCH:COUN 12`
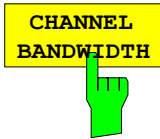
CHANNEL BANDWIDTH

The *CHANNEL BANDWIDTH* softkey opens a table for defining the channel bandwidths for the transmission channels and the adjacent channels.

ACP CHANNEL BW	
CHAN	BANDWIDTH
ADJ	14 kHz
ALT1	14 kHz
ALT2	14 kHz

The transmission-channel bandwidth is normally defined by the transmission standard. The correct bandwidth is set automatically for the selected standard (see *CP/ACP STANDARD* softkey).

The channel bandwidth limits are marked by two vertical lines right and left of the channel center frequency. It can in this way be visually checked whether the entire power of the signal under test is within the selected channel bandwidth.

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 channel spacings can be set separately by overwriting the table from top to bottom.

IEC/IEEE-bus command:
```
SENS:POW:ACH:BWID:CHAN 14kHz
SENS:POW:ACH:BWID:ACH 1kHz
SENS:POW:ACH:BWID:ALT1 14kHz
SENS:POW:ACH:BWID:ALT2 14kHz
```
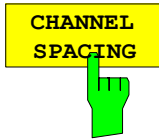
CHANNEL SPACING

The *CHANNEL SPACING* softkey opens a table for defining the channel spacings for the TX channels as well as for the adjacent channels.

Note: *The entry "TX" is only available for the multicarrier ACP measurement.*

TX channels

The spacing between every TX channels can be defined separately. Therefore a TX spacing 1-2 for the spacing between the first and the second carrier, a TX spacing 2-3 for the spacing between the second and the third carrier and so on can be defined. In order to allow a convenient setup for the system with equal TX channel spacing, the value of TX spacing 1-2 will be copied in all the spacing below after entry, the TX spacing 2-3 will be copied in all the spacing below after entry and so forth.

Note: *For different spacings a setup from top to bottom is necessary*

If the spacings are not equal the channel distribution according to the center frequency is as follows:
<u>Odd number of TX channels:</u>
The middle TX channel is centered to center frequency.
<u>Even number of TX channels:</u>
The two TX channels in the middle are used to calculate the frequency between those two channels. This frequency is aligned to the center frequency.

TX/ACP CHANNEL SPACING	
CHAN	SPACING
TX1–2	20 kHz
TX2–3	20 kHz
TX3–4	20 kHz
TX4–5	20 kHz
TX5–6	20 kHz
TX6–7	20 kHz
TX7–8	20 kHz
TX8–9	20 kHz
TX9–10	20 kHz
TX10–11	20 kHz
TX11–12	20 kHz
ADJ	20 kHz
ALT1	40 kHz
ALT2	60 kHz
ALT3	80 kHz
ALT4	100 kHz
ALT5	120 kHz
ALT6	140 kHz
ALT7	160 kHz
ALT8	180 kHz
ALT9	200 kHz
ALT10	220 kHz
ALT11	240 kHz

Adjacent channels

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 (and so on). 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:CHAN 20kHz`
`SENS:POW:ACH:SPAC:ACH 20kHz`
`SENS:POW:ACH:SPAC:ALT1 40kHz`
`SENS:POW:ACH:SPAC:ALT2 60kHz`

Note: *If the ACP or MCACP measurement is started all settings according to the standard including the channel bandwidths and channel spacings are set and can be adjusted afterwards.*
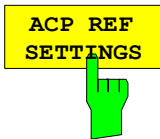
ACP REF SETTINGS

The *ACP REF SETTINGS* softkey opens a table for selecting the transmission channel to which the adjacent-channel relative power values should be referenced.

```
ACP REFERENCE CHANNEL
✓TX CHANNEL 1
 TX CHANNEL 2
 TX CHANNEL 3
 TX CHANNEL 4
 TX CHANNEL 5
 TX CHANNEL 6
 TX CHANNEL 7
 TX CHANNEL 8
 TX CHANNEL 9
 TX CHANNEL 10
 TX CHANNEL 11
 TX CHANNEL 12
 MIN POWER TX CHANNEL
 MAX POWER TX CHANNEL
 LOWEST & HIGHEST CHANNEL
```

TX CHANNEL 1 - 12	Selection of one of channels.
MIN POWER TX CHANNEL	The transmission channel with the lowest power is used as a reference channel.
MAX POWER TX CHANNEL	The transmission channel with the highest power is used as a reference channel.
LOWEST & HIGHEST CHANNEL	The outer left-hand transmission channel is the reference channel for the lower adjacent channels, the outer right-hand transmission channel that for the upper adjacent channels.

Note: *The softkey is only available for the multicarrier ACP measurement.*

IEC/IEEE-bus command: `SENS:POW:ACH:REF:TXCH:MAN 1`
`SENS:POW:ACH:REF:TXCH:AUTO MIN`

```
CP/ACP
ABS   REL
```
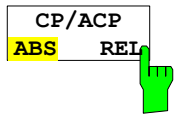
The *CP/ACP ABS/REL* softkey (channel power absolute/relative) switches between absolute and relative power measurement in the channel.

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   For adjacent-channel power measurements (*NO. OF ADJ CHAN* > 0), the level of the adjacent channels is displayed relative to the level of the transmission channel in dB.

For channel power measurements (*NO. OF ADJ CHAN* = 0) with a single carrier, the power of the 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 (R&S FMU 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
```
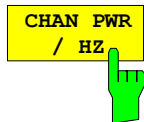
The *CHAN PWR / HZ* softkey toggles between the measurement of the total channel power and the measurement of the channel power referenced to a 1 Hz bandwidth.

The conversion factor is $10 \bullet \lg \dfrac{1}{\text{Channel Bandwidth}}$.

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`

```
POWER
MODE

CLEAR/
WRITE

MAX HOLD
```
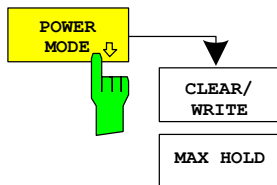
The *POWER MODE* softkey opens the submenu for selecting the power mode.

CLEAR/WRITE   In the *CLEAR/WRITE* mode the channel power and the adjacent channel powers are calculated directly from the current trace (default mode).

MAX HOLD   In *MAX HOLD* mode the power values are still derived from the current trace, but they are compared with the previous power value using a maximum algorithm. The higher value is remained.

IEC/IEEE-bus command:
        `:CALC:MARK:FUNC:POW:MODE WRIT|MAXH`

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 should cover at least all channels to be considered in a measurement.

  For channel power measurements, the frequency span is set as follows:
  (No. of transmission channels - 1) $\times$ transmission channel spacing + 2 x transmission channel bandwidth + measurement margin

  For adjacent-channel power measurements, the frequency span is set as a function of the number of transmission channels, the transmission channel spacing, the adjacent-channel spacing, and the bandwidth of one of adjacent-channels ADJ, ALT1 or ALT2, whichever is furthest away from the transmission channels:

  (No. of transmission channels - 1) $\times$ transmission channel spacing + 2 $\times$ (adjacent-channel spacing + adjacent-channel bandwidth) + measurement margin

  The measurement margin is approx. 10% of the value obtained by adding the channel spacing and the channel bandwidth.
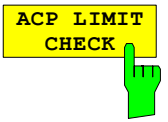
- Resolution bandwidth   RBW $\leq$ 1/40 of channel bandwidth

- Detector   RMS detector

Trace maths are switched off.
The reference level is not influenced by *ADJUST SETTINGS*.

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|MCAC|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 LIMIT | 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 R&S FMU 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`

| SELECT TRACE | The *SELECT TRACE* softkey selects the trace on which the CP/ACP measurement is to be performed. Only activated traces can be selected, i.e. traces not set to BLANK. |

IEC/IEEE-bus command: `SENS:POW:TRAC 1`

Examples:

1. Measurement of adjacent-channel power for a specific standard:

The adjacent-channel power is to be measured for a signal at baseband with 0 dBm level in line with IS136.

[**PRESET**]	Set the R&S FMU to the default setting.
	The center frequency is zero (baseband) in the default state.
[**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*: 3 **ENTER**]	Select three adjacent channels for the measurement, i.e. the adjacent channel and two alternate channels are measured.
[SPAN 100 kHz]	The span is changed manually just to demonstrate the *ADJUST SETTINGS function.*
[*ADJUST SETTINGS*]	Sets the optimum span, resolution bandwidth (RBW), and detector automatically for the measurement. The absolute channel power and the relative power of the adjacent channels are displayed on the screen.

2. Measurement with user-specific channel configuration:

Measurement of the adjacent-channel power ratio (ACPR) of an IS95 CDMA signal at baseband, level 0 dBm. Similar to example 1, the setting can be simplified by using *CP/ACP STANDARD*.

[**PRESET**]	Set the R&S FMU to the default setting.
	The center frequency is zero (baseband) in the default state.
[**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**: ⊙: 30 **kHz**]	Set the channel bandwidth to 1.23 MHz in accordance with IS 95. Set the adjacent-channel bandwidth to 30 kHz.

TX/ACP CHANNEL BW	
CHAN	BANDWIDTH
TX	1.23 MHz
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.

[*CHAN SPACING*: 750 **kHz:** ⊙: 1.98 **MHz**] ⊙: 2.65 **MHz**]	Open the list for entering the channel spacings.

ACP CHANNEL SPACING	
CHAN	SPACING
ADJ	750 kHz
ALT1	1.98 MHz
ALT2	2.65 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.

[*ADJUST SETTINGS*]	Automatically set the optimum span (= 4.02 MHz), resolution bandwidth (RBW = 30 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.

3. Measurement of signal/noise power density (C/No) of an IS95 CDMA signal (baseband, level 0 dBm)

[**PRESET**]	Set the R&S FMU to the default setting.
	The center frequency is zero (baseband) in the default state.
[**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.
[*ADJUST SETTINGS*]	Set the optimum span (= 2.46 MHz), resolution bandwidth (RBW = 30 kHz), and detector (RMS) for the measurement automatically. The absolute channel power is displayed on the screen.
[*PREV*: *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).
[**FREQ:** *CENTER*: 5 **MHz**]	Set the center frequency to 5 MHz. The R&S FMU measures the channel power at 1.23 MHz bandwidth and outputs the result in dB relative to the reference power.

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 R&S FMU.

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 frequency domain, 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 the 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*
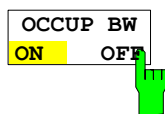
The *OCCUP BW ON/OFF* softkey switches measurement of the occupied bandwidth on or off.

IEC/IEEE-bus command: `CALC:MARK:FUNC:POW:SEL OBW`
                                     `CALC:MARK:FUNC:POW:RES? OBW`
                                     `CALC:MARK:FUNC:POW OFF`
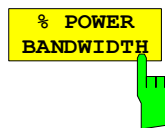
The *% POWER BANDWIDTH* softkey opens the entry of the percentage of power related to the total power in the displayed frequency range which defines the occupied bandwidth (percentage of total power).
The valid range of values is 10 % to 99.9 %.

IEC/IEEE-bus command: `SENS:POW:BWID 99PCT`
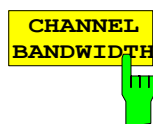
The *CHANNEL BANDWIDTH* softkey opens an input window for defining the channel bandwidth for the transmission channel. For measurements in line with a specific transmission standard, the bandwidth specified by the standard for the transmission channel must be entered.
The default setting is 14 kHz.
The specified channel bandwidth is used for optimization of the test parameters of the R&S FMU with *ADJUST SETTINGS*.

IEC/IEEE-bus command: `SENS:POW:ACH:BWID 14kHz`

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 ≤ 1/40 of channel bandwidth

- 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 as close as possible to the reference level without overloading.

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 R&S FMU 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 R&S FMU. 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)
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 R&S FMU has to be changed accordingly then.

Example:
Measurement of occupied bandwidth of a PDC signal at baseband, level 0 dBm

[**PRESET**]	Set the R&S FMU to the default setting.
	The center frequency is zero (baseband) in the default state.
[**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.
[**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.
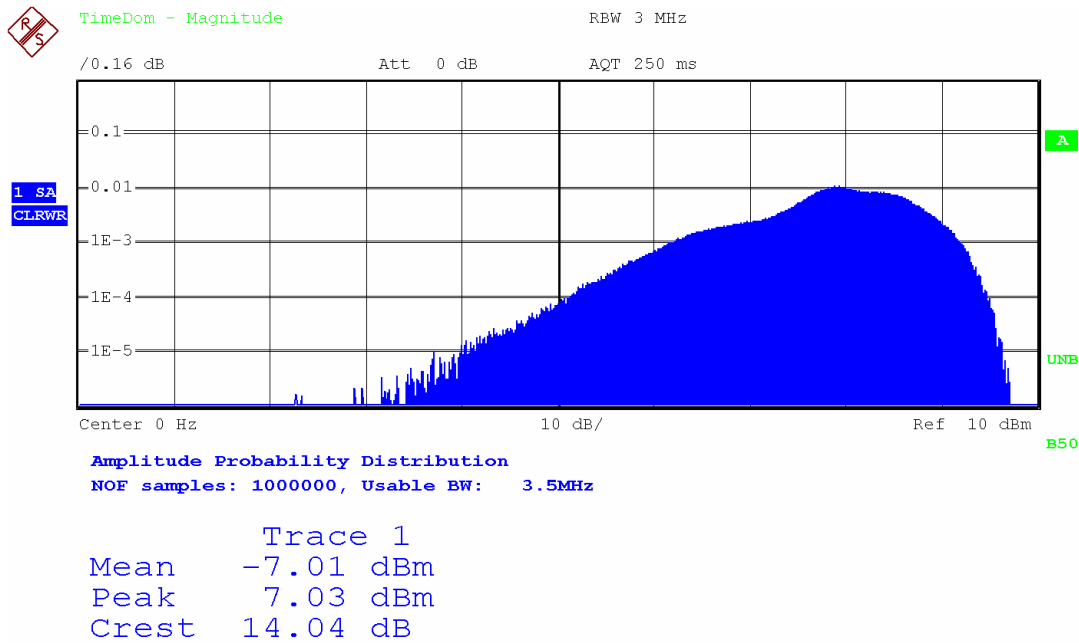
Fig. 4-12   Display of the amplitude probability distribution

```
TimeDom - Magnitude                          RBW 3 MHz

Ref  10 dBm (PK 1 V)        Att   0 dB       AQT 250 ms
```



```
Complementary Cumulative Distribution Function
NOF samples: 1000000, Usable BW:   3.5MHz

               Trace 1
    Mean     -7.01  dBm
    Peak      7.10  dBm
    Crest    14.11  dB

     10 %     4.07  dB
      1 %     8.81  dB
     .1 %    11.28  dB
     .01 %   12.88  dB
```
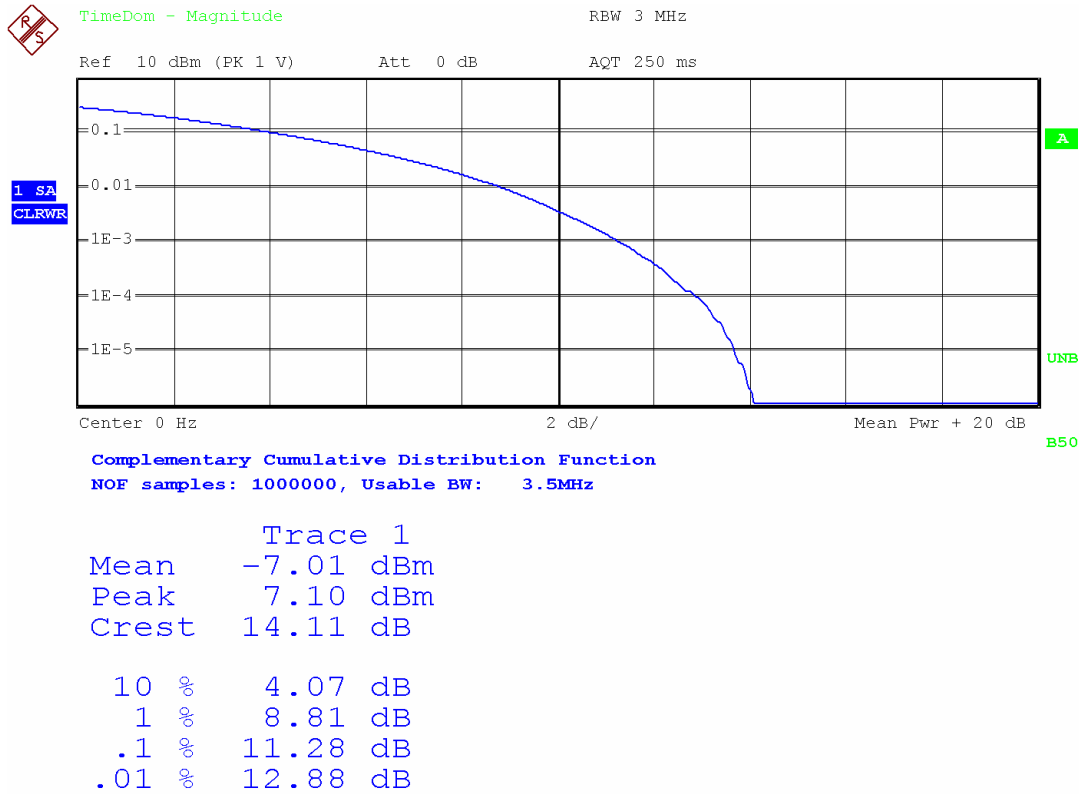
Fig. 4-13   Display of the complementary cumulative distribution function (CCDF)

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 :

SIGNAL STATISTIC	APD ON **OFF**	X-AXIS REF LEVEL
	CCDF ON **OFF**	X-AXIS RANGE
	PERCENT MARKER	Y-UNIT % ABS
	RES BW	Y-AXIS MAX VALUE
	NO OF SAMPLES	Y-AXIS MIN VALUE
	SCALING	
	CONT MEAS	
	SINGLE MEAS	DEFAULT SETTINGS
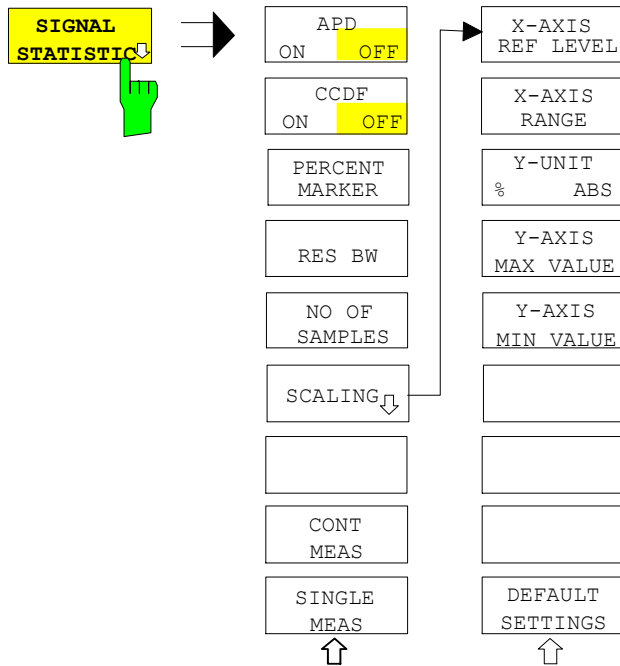
The *SIGNAL STATISTIC* softkey opens a submenu for measurement of signal statistics.

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.

The *SIGNAL STATISTIC* softkey is available only in zero span mode.

The R&S FMU measures the statistics of the signal applied to the baseband input with the resolution bandwidth set. The sample detector is used.
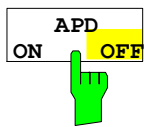
APD ON OFF

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
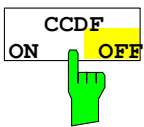
CCDF ON OFF

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
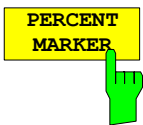
PERCENT MARKER

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%
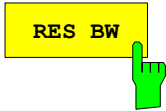
RES BW

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. The RBW can be set between 10 kHz and 60 MHz. Rectangular filters are used instead of filters with a Gaussian characteristic.

Note: *Due to the signal processing with statistic functions the actual bandwidth differs somewhat from the set resolution bandwidth (RBW). The actual bandwidth is displayed on screen additionally as "Usable BW ".*

Complementary Cumulative Distribution Function
NOF samples: 1000000, Usable BW: 3.5MHz

IEC/IEEE-bus command: `BAND 3 MHz`
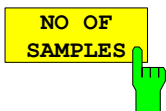
NO OF SAMPLES

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.

The measurement time is displayed on screen as "AQT" (=acquisition time).

IEC/IEEE-bus command: `CALC:STAT:NSAM <value>`

SCALING

The *SCALING* softkey opens a sub menu that allows changing the scaling parameters for both the x- and the y-axis.
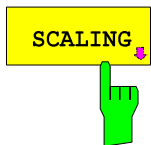
X-AXIS REF LEVEL

X-AXIS RANGE

Y-UNIT % ABS

Y-AXIS MAX VALUE

Y-AXIS MIN VALUE

DEFAULT SETTINGS

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>`
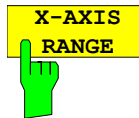
X-AXIS RANGE

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>`
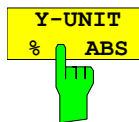
Y-UNIT % ABS

The softkey *Y-UNIT %/ABS* defines the scaling type on the y-axis. The default case are the absolute probability. This can be changed to percent values. The softkeys *Y-AXIS MIN* and *Y-AXIS MAX* are using values based on the *Y-UNIT* setting.

IEC/IEEE-bus command:
`:CALC:STAT:SCAL:Y:UNIT PCT | ABS`

The 0.1 %, 1 % and 10 % value from the CCDF measurement are shown in the bottom screen half. Those values can also queried via remote:

IEC/IEEE-bus command:
`:CALC:STAT:CCDF:X? P0_1 | P1 | P10`

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>`
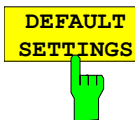
DEFAULT SETTINGS

The *DEFAULT SETTINGS* softkey resets the x- and y-axis scalings to their PRESET values.

x-axis ref level: +10 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`
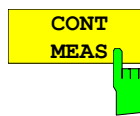
CONT MEAS

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`
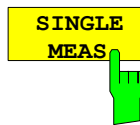
SINGLE MEAS

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 baseband signal, level 0 dBm

[**PRESET**]	Switch on preset settings.
	The center frequency is zero (baseband) in the default state.
[**SPAN**: ZERO SPAN]	Set span to 0 Hz (time domain) in order to enable statistic functions.
[**AMPT**: 10 dBm]	Set reference level to 10 dBm. The reference level must be set higher than the rms signal power by the expected crest factor.
[**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 R&S FMU 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.
[**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).
[NO OF SAMPLES: 250000]	Set the number of measurement samples to 250000.
[SINGLE MEAS]	Start the measurement sequence. At the end the resulting trace will display the CCDF for the measured 250000 samples.

Measurement of Carrier/Noise Ratio C/N and C/N$_o$

Using the carrier/noise measurement function, the R&S FMU 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. 2 x channel bandwidth.

The RMS detector is enabled when the power measurement is switched on (*TRACE-DETECTOR-RMS*).

Submenu *MEAS – C/N, C/N$_o$*:

C/N **C/No**	
	C/N
	C/No
	CHANNEL BANDWIDTH
	ADJUST SETTINGS
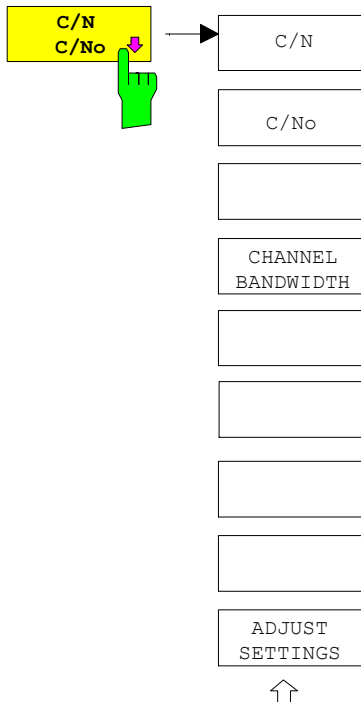
The *C/N, C/No* softkey opens the submenu for configuring the carrier/noise ratio measurement.

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).*
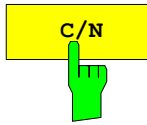
The *C/N* and *C/No* softkeys enable and disable the measurement of the carrier/noise ratio, the *C/No* measurement also being referred to a 1 Hz bandwidth.
The maximum value of the current trace is determined when the function is activated and is marked by means of the *REFERENCE FIXED* marker.
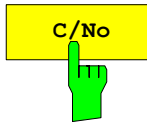
The measurements are only available in the frequency domain (span > 0). The MAGNITUDE display mode must be active.

The measurement can be performed with every window function. However, a warning is output if the measurement is started when a window function other than the flattop window is active. This is because the measurement result for the carrier might be too low if the flattop window function is not selected.

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`
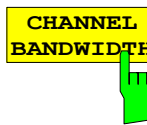
The *CHANNEL BANDWIDTH* softkey opens a window for selecting the measurement channel bandwidth.
The default setting is 14 kHz.
The specified channel bandwidth allows the optimal setting of the measurement parameters of the R&S FMU using *ADJUST SETTINGS*.

IEC/IEEE-bus command:`SENS:POW:ACH:BWID 14kHz`
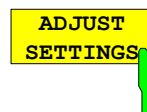
The *ADJUST SETTINGS* softkey adapts the span to the channel bandwidth selected.
For the carrier/noise ratio measurement, the span is set to:

        2 x channel bandwidth

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
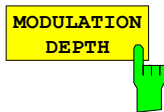
MODULATION
DEPTH

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 R&S FMU 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.

The measurements are only available in the frequency domain (span > 0). The MAGNITUDE or MAGNITUDE PHASE display mode must be active.

The measurement can be performed with every window function. However, a warning is output if the measurement is started when a window function other than the flattop window is active. This is because the measurement result for the carriers might be too low if the flattop window function is not selected.

Measurement example:

The AM modulation depth of an IF signal modulated with 1 kHz is to be measured at 10 MHz.

[**PRESET**]   The R&S FMU is set to the default setting.

[**FREQ**: 10 **MHz**]   The center frequency is set to 10 MHz.

[**SPAN**: 5 **kHz**]   The span is set to 5 kHz.

[**MEAS**: *MODULATION DEPTH*: 1 **kHz**]

The measurement of the AM modulation depth is switched on. Marker 1 is positioned at the maximum of the displayed trace.
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 device 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. 4-14 shows intermodulation products P_{I1} and P_{I2} generated by the two useful signals P_{U1} and P_{U2}.
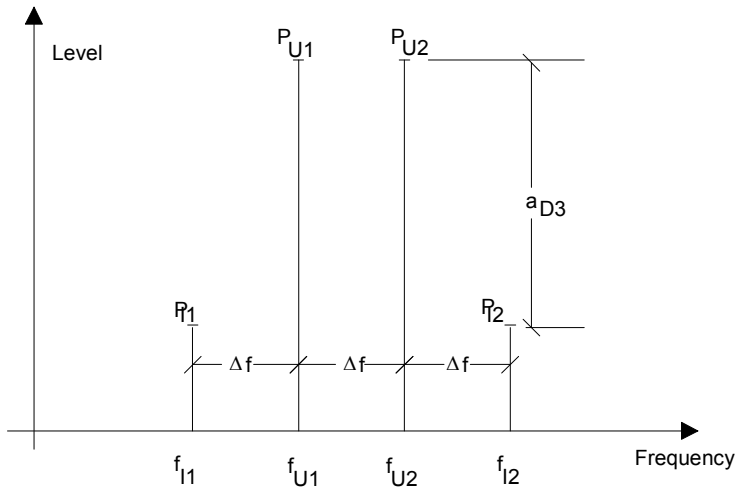
Fig. 4-14   Intermodulation products P_{U1} and P_{U2}

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}.

$$f_{i1} = 2 \times f_{u1} - f_{u2} \qquad (1)$$

$$f_{i2} = 2 \times f_{u2} - f_{u1} \qquad (2)$$

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. 4-15.
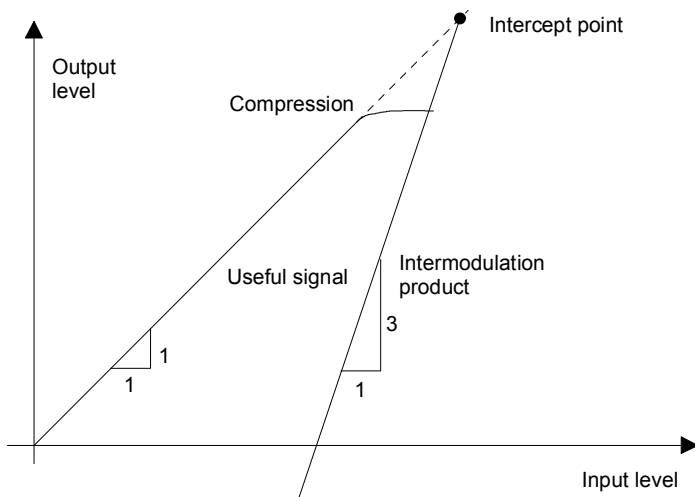
Fig. 4-15   Dependence of intermodulation level on useful signal level

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**
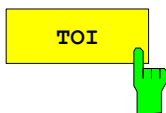
The *TOI* softkey enables the measurement of the 3rd order intercept point.

A two-tone signal with equal carrier levels is expected at the R&S FMU 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 R&S FMU calculates the third order intercept from the level spacing between normal markers and delta markers and outputs it in the marker info field.

The measurements are only available in the frequency domain (span > 0). The *MAGNITUDE* or *MAGNITUDE PHASE* display mode must be active.

The measurement can be performed with every window function. However, a warning is output if the measurement is started when a window function other than the flattop window is active. This is because the measurement result for the carriers might be too low if the flattop window function is not selected.

IEC/IEEE-bus command:
```
CALC:MARK:FUNC:TOI ON;
CALC:MARK:FUNC:TOI:RES?
```

Example:
A two-tone signal with frequencies of 10 MHz and 11 MHz is applied to the I input of the R&S FMU. The level of the two signals is 0 dBm.

[**PRESET**]   The R&S FMU is set to the default setting.

[**CENTER**: 10.5 **MHz**]   The center frequency is set to 10.5 MHz.

[**SPAN**: 3 **MHz**]   The span is set to 3 MHz.

[**AMPT**: 10 **dBm**]   The reference level is set to 10 dBm.

[**MEAS: NEXT***: TOI*]   The R&S FMU 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.

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 flash disk 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 R&S FMU 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 R&S FMU, 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.

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).
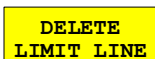
IEC/IEEE-bus command:`CALC:LIM:TRAC 1`

See following Section "Entry and Editing of Limit Lines".
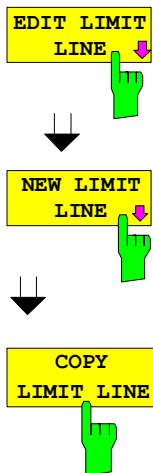
The *COPY LIMIT LINE* softkey copies the data file describing the marked limit line and saves it under a new name. In this way, a new limit line can be easily generated by parallel translation or editing of an existing limit line. The name can be arbitrarily chosen and input via an entry window (max. 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

A limit line is characterized by

- its name

- the assignment of domain (frequency or time)

- the scaling in absolute or relative times or frequencies

- he 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 R&S FMU 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 R&S FMU. 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

EDIT LIMIT LINE
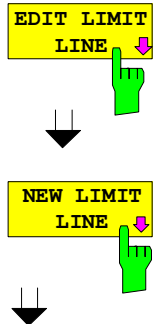
NEW LIMIT LINE

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.
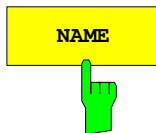
NAME

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**.**
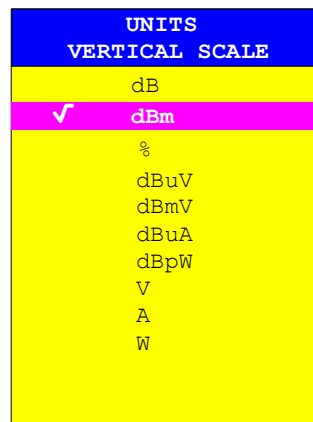
IEC/IEEE-bus command: `CALC:LIM3:UNIT DBM`

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:

```
                       RBW 300  Hz    Marker [T1]
                                      -28.4 dBm
 Ref -20 dBm   Att 0 dB    SWT 12.951 ms  20.0100 MHz
```


resulting limit

absolute threshold

relative limit line

```
 Center    20 MHz       10 kHz/        Span 100 kHz
```
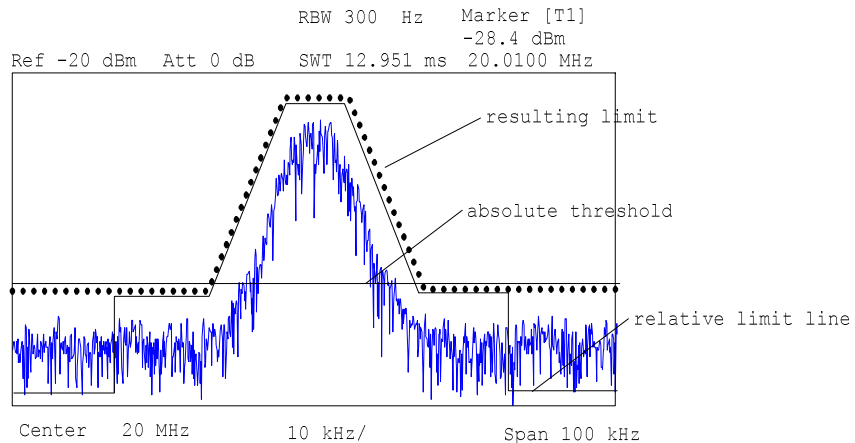
The preset value is at -200 dBm. The field is displayed if the value RELATIVE is entered in the field Y-SCALING.

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"`
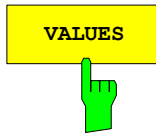
VALUES

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`
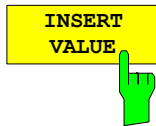
INSERT VALUE

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: `--`
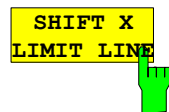
SHIFT X LIMIT LINE

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`
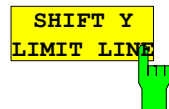
SHIFT Y LIMIT LINE

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`
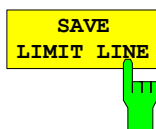
SAVE LIMIT LINE

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 R&S FMU provides two different types of display lines :

- two horizontal level lines for marking levels or phase values – Display Line 1/2, Phase 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:

D1 Display Line 1
D2 Display Line 2
F1 Frequency Line 1
F2 Frequency Line 2
T1 Time Line 1
T2 Time Line 2
P1 Phase Line 1
P2 Phase Line 2

The level lines and phase 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. *PHASE LINE 1* and *PHASE LINE 2* softkeys are only available in the frequency domain with magnitude & phase display.

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  ⇒  →   DISPLAY
LINES  ⬇            LINE 1

                   DISPLAY
                   LINE 2

                   FREQUENCY  ─┐
                   LINE 1      │   Frequency Domain
                               │   (Span > 0 Hz)
                   FREQUENCY  ─┘
                   LINE 2

                   TIME       ─┐
                   LINE 1      │   Time Domain
                               │   (Span = 0 Hz)
                   TIME       ─┘
                   LINE 2

                   PHASE      ─┐
                   LINE 1      │   Frequency Domain
                               │   Magnitude & Phase
                   PHASE      ─┘
                   LINE 2


                        ⇧
```
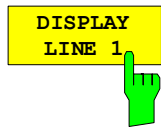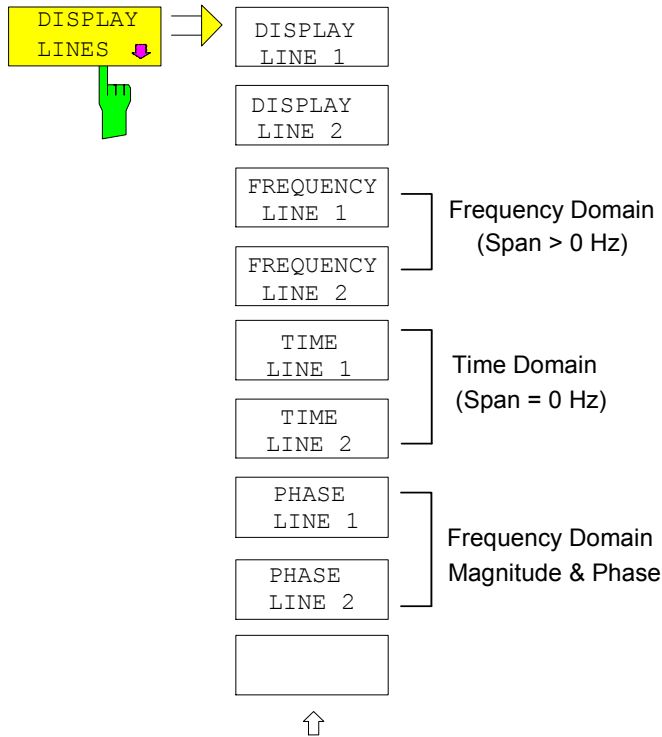
DISPLAY LINE 1   The *DISPLAY LINE 1/2* softkeys enable or disable the level lines and allow the user to enter the position of the lines.

The level lines mark the selected level in the measurement window.
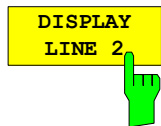
DISPLAY LINE 2   IEC/IEEE-bus command: `CALC:DLIN:STAT ON`
                                            `CALC:DLIN -20dBm`
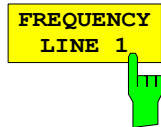
FREQUENCY LINE 1   The *FREQUENCY LINE 1/2* softkeys enable or disable the frequency lines 1/2 and allow the user to enter the position of the lines.

The frequency lines mark the selected frequencies in the measurement window.
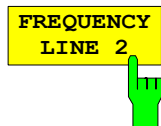
FREQUENCY LINE 2   *Note:*   *The two softkeys cannot be used in the time domain (span = 0).*

IEC/IEEE-bus command: `CALC:FLIN:STAT ON`
                        `CALC:FLIN 120MHz`
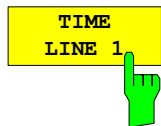
TIME LINE 1   The *TIME LINE 1/2* softkeys enable or disable the time lines 1/ and allow the user to enter the position of the lines.

The time lines mark the selected times or define search ranges (see section "Marker Functions ").
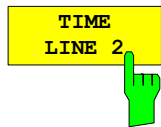
TIME LINE 2   *Note:*   *The two softkeys cannot be used in the frequency domain (span > 0).*

IEC/IEEE-bus command: `CALC:TLIN:STAT ON`
                        `CALC:TLIN 10ms`

PHASE
LINE 1

PHASE
LINE 2

The *PHASE LINE 1/2* softkeys activate/deactivate phase lines 1/2 and activate entry of the line position.

The phase lines mark the selected phases in the measurement window.

Entries are made in the currently selected phase unit.

The line is adapted automatically if the unit is changed using the *PHASE RAD/DEG* softkey in the *AMPT* menu.

The line will, however, not be adapted automatically if the phase offset is changed using the *PHASE OFFSET* softkey in the *AMPT* menu.
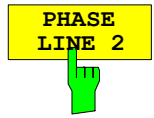
Note: *The softkeys are only available in the frequency domain for the MAGNITUDE PHASE measurement.*

IEC/IEEE bus command: `CALC:PLIN1:STAT ON`
`CALC:PLIN1 120DEG`
`CALC:PLIN2:STAT ON`
`CALC:PLIN2 140deg`

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 R&S FMU either in a full-screen window or in two overlapping windows. The two windows are called diagram A and diagram B.
In the FFT Analyzer, two measurement windows are not designed to be completely decoupled from each other, i.e. they are not intended to behave like two completely independent instruments (*SPLIT SCREEN* operation).
Although there are measurements with a split screen, they draw their data from the same measurement.

New settings 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.

The *DISP* key opens the menu for configuring the screen display and selecting the active diagram in SPLIT SCREEN mode.
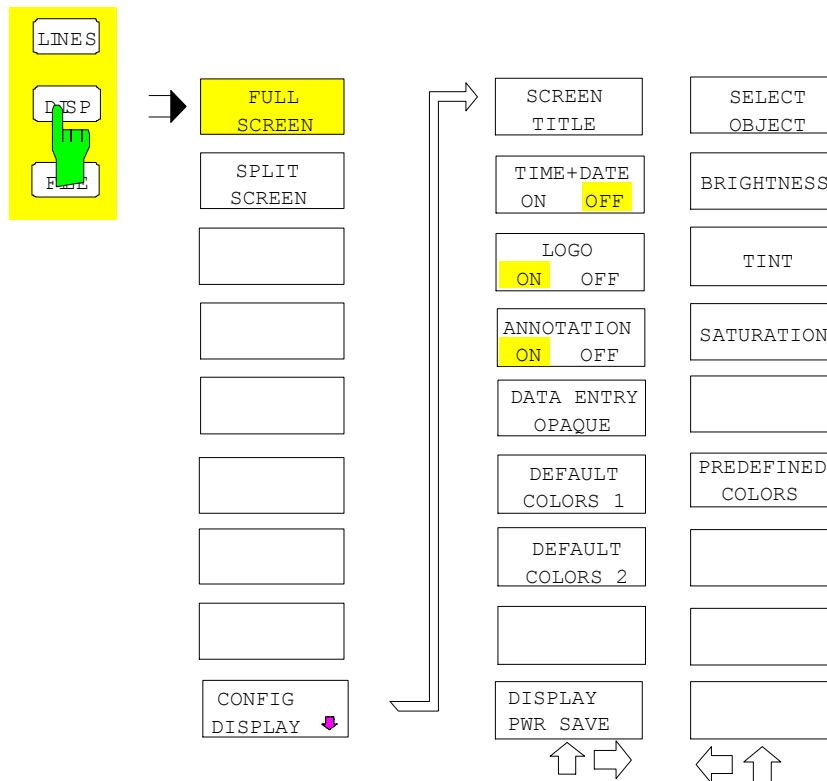
In the FFT Analyzer the full screen or split screen display is coupled to the measurement mode and not selectable by the user.

Full Screen:	Frequency Domain Magnitude
	Time Domain Magnitude

Split Screen:	Frequency Domain Magnitude&Phase, Real&Imag
	Time Domain Voltage

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	
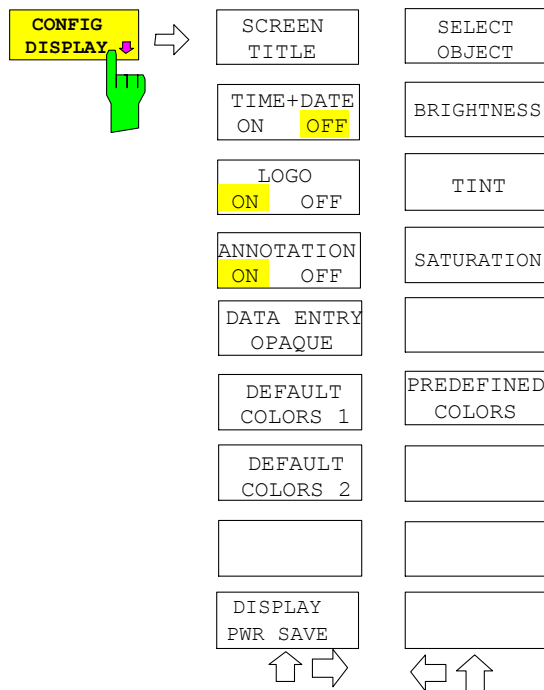
The CONFIG DISPLAY softkey opens a submenu allowing additional display items to be added to the screen. In addition, the display power-save mode (*DISPLAY PWR SAVE*) and the colors of the display elements can be set here.
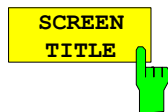
The *SCREEN TITLE* softkey activates the entry of a title for the active diagram A or B. It switches on or off a title that is already input. The length of the title is limited to max. 20 characters.

IEC/IEEE-bus command: DISP:WIND1:TEXT 'Noise Meas'
                          DISP:WIND1:TEXT:STATe ON
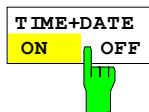
The *TIME+DATE ON/OFF* softkey switches on or off the display of date and time above the diagram.

IEC/IEEE-bus command: DISP:TIME OFF

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
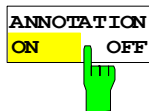
The *ANNOTATION ON/OFF* softkey switches the displaying of frequency information on the screen on and off.

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
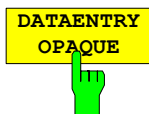
The *DATAENTRY OPAQUE* softkey sets the data entry windows to opaque. This means that entry windows are underlayed with the background color for tables.

IEC/IEEE-bus command: --

DEFAULT COLORS 1
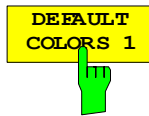
DEFAULT COLORS 2

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.
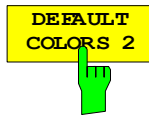
IEC/IEEE-bus command: `DISP:CMAP:DEF1`
                                      `DISP:CMAP:DEF2`

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 function to respond. After the elapse of this time the display is completely switched off, i.e. 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`
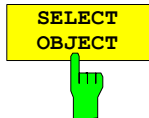
SELECT OBJECT

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>`

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 display 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:CMAP1 to 26:PDEF <color>`

Instrument Setup and Interface Configuration – SETUP Key

The *SETUP* key opens the menu for configuration of the R&S FMU:
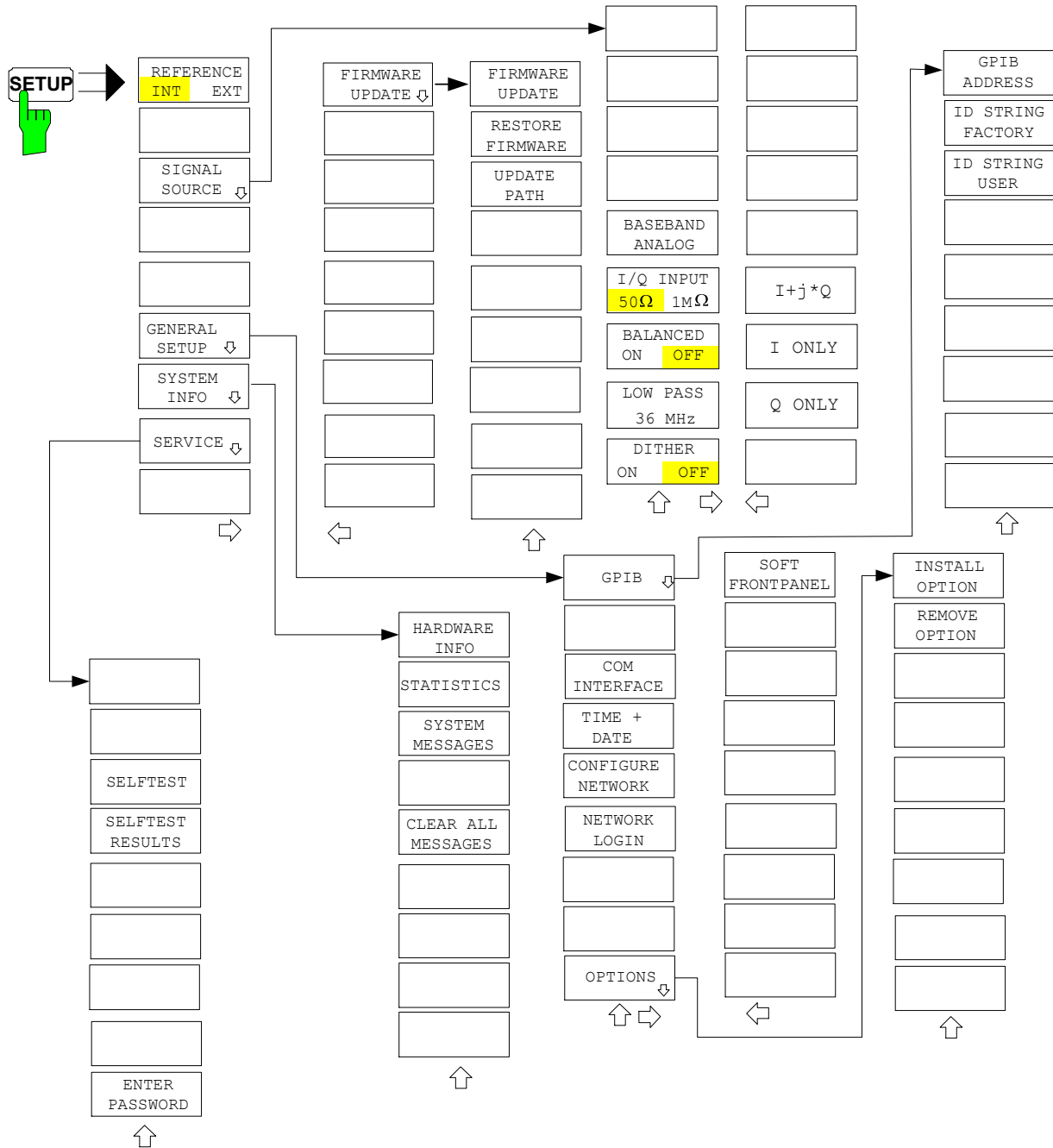
The following settings can be modified here:

- The *REFERENCE INT/EXT* softkey determines the source of the reference

- The *SIGNAL SOURCE* softkey opens a submenu for the baseband input settings

- 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.

External Reference

The R&S FMU 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 R&S FMU.
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 R&S FMU are synchronized to the external reference frequency.

SETUP menu:
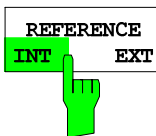
The *REFERENCE INT / EXT* softkey switches between the internal and external reference.
If the external reference is selected, also the frequency of the external reference is adjustable between 1 MHz and 20 MHz.
The default value is 10 MHz.
These reference settings are not changed if a preset occurs to maintain the specific setup of a test system.

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`
                                    `ROSC:EXT:FREQ <numeric value>`

SIGNAL SOURCE Submenu

This submenu appears when the *SIGNAL SOURCE* softkey is pressed.

```
SIGNAL
SOURCE ⇩ ──→  ┌──────┐  ┌──────┐
              │      │  │      │
              └──────┘  └──────┘
              ┌──────┐  ┌──────┐
              │      │  │      │
              └──────┘  └──────┘
              ┌──────┐  ┌──────┐
              │      │  │      │
              └──────┘  └──────┘
              ┌──────┐  ┌──────┐
              │      │  │      │
              └──────┘  └──────┘
              ┌──────────┐  ┌──────┐
              │ BASEBAND │  │      │
              │  ANALOG  │  └──────┘
              └──────────┘
              ┌──────────┐  ┌──────────┐
              │ I/Q INPUT│  │  I+j*Q   │
              │ 50Ω  1MΩ │  └──────────┘
              └──────────┘
              ┌──────────┐  ┌──────────┐
              │ BALANCED │  │  I ONLY  │
              │ ON  OFF  │  └──────────┘
              └──────────┘
              ┌──────────┐  ┌──────────┐
              │ LOW PASS │  │  Q ONLY  │
              │  36 MHz  │  └──────────┘
              └──────────┘
              ┌──────────┐  ┌──────────┐
              │ DITHER   │  │          │
              │ ON  OFF  │  └──────────┘
              └──────────┘

              ⇧   ⇨   ⇦
```

The way in which the FFT Analyzer is to process the input signals can be defined in this menu.
A similar menu for configuring the baseband input can also be opened by pressing the *FFT HOME* hotkey.

I/Q INPUT 50Ω 1MΩ — The *IQ INPUT 50Ω / 1MΩ* softkey is used to toggle the input impedance of the baseband inputs. The setting has the same effect on both inputs.

The IEC/IEEE bus command uses the keywords *LOW / HIGH* for 50Ω / 1MΩ.

Caution: *Toggling the input impedance has no effect on the power level indicated in the FFT Analyzer. It is always assumed that the measured voltage is applied to a 50 Ω resistor.*

IEC/IEEE bus command: INP:IQ:IMP LOW

BALANCED ON OFF — The *BALANCED ON / OFF* softkey is used to toggle the measurement mode of the baseband inputs.
ON switches to balanced inputs; *OFF* switches to ground-referenced inputs. The setting has the same effect on both inputs.

IEC/IEEE bus command: INP:IQ:BAL:STAT ON

LOWPASS 36MHZ — The *LOWPASS 36MHZ* softkey is used to toggle the analog anti-aliasing lowpass filters of the baseband inputs. The setting has the same effect on both inputs. The softkey changes colour when the lowpass is switched ON.

IEC/IEEE bus command: SENS:IQ:LPAS:STAT ON

The *DITHER ON / OFF* softkey is used to add a shaped dither signal to both inputs.

IEC/IEEE bus command: `SENS:IQ:DITH:STAT ON`

The *I+J*Q* softkey causes the FFT Analyzer to regard the signals at the I and Q input as components of a complex signal. This is the standard setting for the analysis of signals with complex modulation.

IEC/IEEE bus command: `INP:IQ:TYPE IJQ`

The *I ONLY* softkey causes the FFT Analyzer to regard the signal at the I input as a single, real signal. The signal at the Q input is ignored.
This setting should be selected if, for example, a signal at a low intermediate frequency is connected to the I input.

IEC/IEEE bus command: `INP:IQ:TYPE I`

The *Q ONLY* softkey causes the FFT Analyzer to regard the signal at the Q input as a single, real signal. The signal at the I input is ignored.
This setting should be selected if, for example, a signal at a low intermediate frequency is connected to the Q input.

IEC/IEEE bus command: `INP:IQ:TYPE Q`

Programming the Interface Configuration and Time Setup

The *GENERAL SETUP* softkey opens a submenu 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:
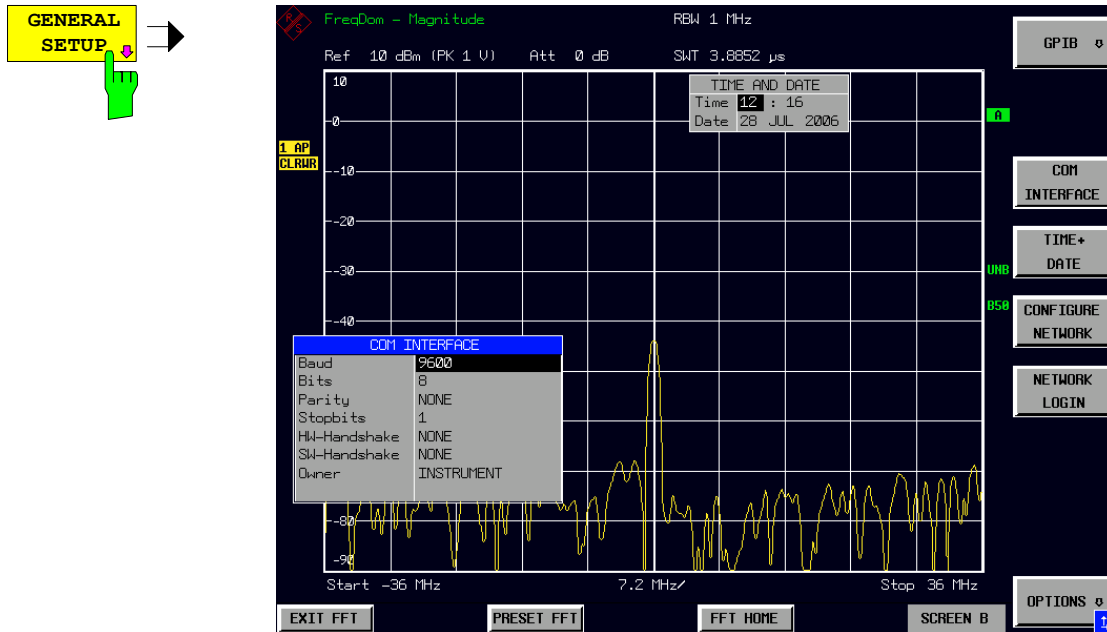
Selecting the IEC/IEEE-Bus Address

SETUP - GENERAL SETUP menu:
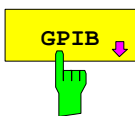
The *GPIB* softkey opens a submenu for setting the parameters of the remote-control interface.

IEC/IEEE-bus command: --
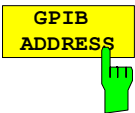
The *GPIB ADDRESS* softkey enables the entry of the IEC/IEEE-bus address.

Valid addresses are 0 through 30. The default address is 20.

IEC/IEEE-bus command: SYST:COMM:GPIB:ADDR 20

The *ID STRING FACTORY* softkey selects the default response to the *IDN? query.

IEC/IEEE-bus command: --

The *ID STRING USER* softkey opens an editor for entering a user-defined response to the *IDN? query.
Max. length of output string: 36 characters

IEC/IEEE-bus command: --

Serial Interface Configuration

SETUP-GENERAL SETUP submenu:

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

Baud – **Data transmission rate**
The R&S FMU supports baud rates between 110 and 19200 baud. The default setting is 9600 baud.

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).

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:
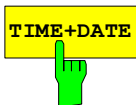
TIME+DATE

The *TIME+DATE* softkey activates the entry of time and date for the internal realtime clock.

```
 TIME AND DATE
Time 12 : 30
Date 11 MAR 2002
```
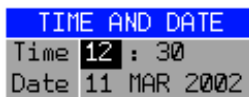
Every number can be edited separately by highlighting it and pressing enter to get into editing mode. After editing the corresponding number another press on enter will save the changes.

IEC/IEEE-bus command: `SYST:TIME 21,59`
                      `SYST:DATE 1999,10,01`

Configuration of Network Settings R&S FMU

The instrument can be connected to an Ethernet LAN (local area network) by means of the LAN Interface R&S FMU. 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 R&S FMU'.

SETUP - GENERAL SETUP - menu:
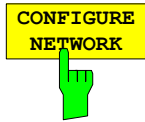
CONFIGURE
NETWORK

The *CONFIGURE NETWORK* softkey opens the dialog box with the network settings.
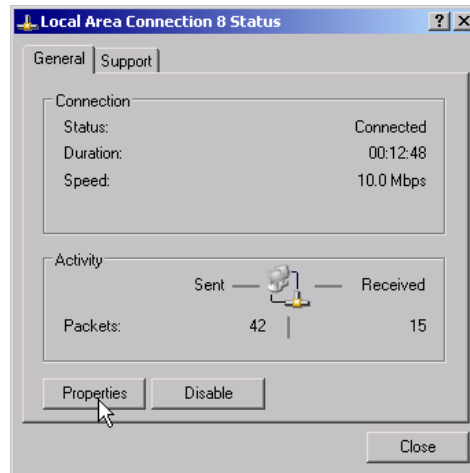
The softkey is used to modify an existing network configuration after the corresponding tabs are selected (see subsection "Configuration of Already Installed Network Protocols" in the section "LAN Interface").

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 R&S FMU

IEC/IEEE-bus command: –
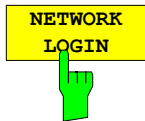
NETWORK
LOGIN

The *NETWORK LOGIN* softkey opens the dialog box with the auto login settings.
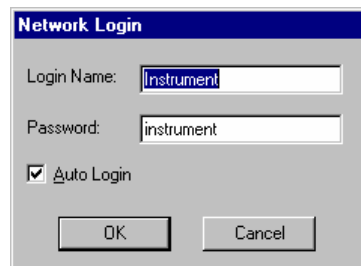
When a network is installed, the preset user name 'Instrument' and the password 'instrument' can be adapted to a new user (see section 'Defining Users' in the LAN interface manual).
With the 'Auto Login' option active, an automatic registration is performed during booting with the specified user name and password. Otherwise the Windows XP 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.*

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:
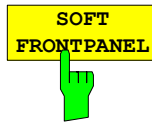
SOFT FRONTPANEL	The *SOFT FRONTPANEL* softkey switches the display of the front-panel keys on and off.

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, such as, for instance, the remote desktop of Windows XP, and the screen contents are transferred to the controller via remote link (see the section "LAN Interface - Remote Desktop under Windows XP).
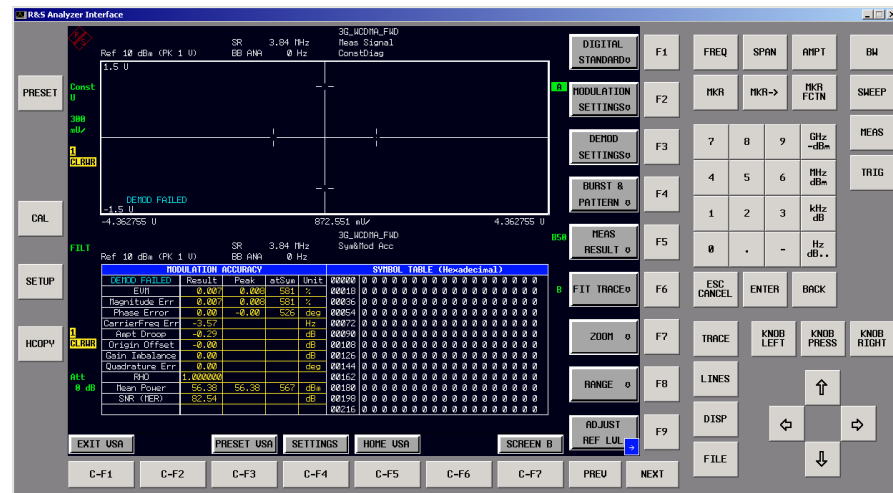
Note: *Display resolution:*

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 INFO	→	HARDWARE INFO
		STATISTICS
		SYSTEM MESSAGES
		CLEAR ALL MESSAGES

⇧

Display of Module Data

SETUP SYSTEM INFO submenu:
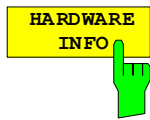
HARDWARE
INFO

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	HWC	REV	SUB REV
WBDET	100838/005	1130.3086	05	00	05	02
CPU-Board	060306/223	1091.3104	00	00	20	01
MOTHERBOARD	100009/005	1302.7082	05	00	03	00
FMU	900001/002	1303.3500	02	00	00	00
LAN Interface	000000/000	0000.0000	00	00	00	00
BASEBANDINPUT	100342/003	1130.3686	03	00	03	11
CLOCK GEN	000654/321	1303.3800	01	00	00	00

Display of Device Statistics

SETUP SYSTEM INFO submenu:
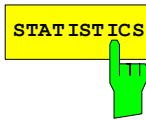
STATISTICS

The *STATISTICS* softkey opens the table *STATISTICS*. This table contains the model information, serial number, firmware version, and specifications version of the basic device. Additional the operating time of the instrument, the power-on cycles as well as attenuator switching cycles are displayed.

```
         FIRMWARE VERSIONS - STATISTICS
Model                       FMU-36
Serial #                    900001/002

Firmware Rev.               4.08c CP001
BIOS Rev.                   V5.1-16-3
Specifications Version      --.--
Memory Size                 512 MB

Operating Time (hours)      100000
Power On Cycles             387

Baseband Cycles
  S 1                       26
  S 2                       12
  S 3                       24
  S 4                       22
  S 5                       40
  S 6                       28
  S 7                       40
  S 8                       64
  S 9                       88
  S10                       40
  S11                       16
  S12                       260
  S13                       6
```

IEC/IEEE-bus command: --

For new delivered devices the specifications version (document of the hardware properties) is shown. For already delivered device dashes (--.--) are displayed.

Display of System Messages

SETUP SYSTEM INFO submenu:
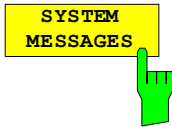
<table>
<tr><td>SYSTEM
MESSAGES</td><td>The *SYSTEM MESSAGES* softkey opens a submenu including a table in which the generated system messages are displayed in the order of their occurrence. The most recent messages are placed at the top of the list.
The following information is available:</td></tr>
</table>

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 MESSAGES		
NO	MESSAGE	COMP.	DATE/TIME
107	Reference is Unlocked	DCON	07.MAR.02; 14:03:19
110	Error 110 size of block too big. Block id 10616	CDS	07.MAR.02; 10:38:45
110	Checksum error RF attenuator Block id 10616	CDS	07.MAR.02; 10:38:45

IEC/IEEE-bus command: `SYST:ERR?`

<table>
<tr><td>CLEAR ALL
MESSAGES</td><td>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?`</td></tr>
</table>

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 R&S FMU.*
> *Therefore, many of the functions can only be used after entering a password. They are described in the instrument service manual.*

SETUP menu:

SERVICE	

👆

SELFTEST
SELFTEST RESULTS
ENTER PASSWORD ⇧⇨
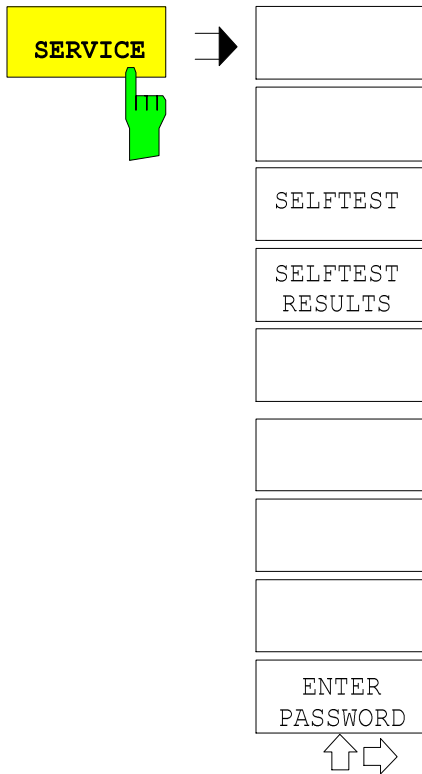
The *SERVICE* softkey opens a submenu for selection of the service function.

General Service Functions

SETUP SERVICE submenu:

ENTER PASSWORD

The *ENTER PASSWORD* softkey allows the entry of a password.

The R&S FMU 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"`

Selftest

SETUP SERVICE submenu:

SELFTEST

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?`

SELFTEST RESULTS

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.

IEC/IEEE-bus command: `DIAG:SERV:STE:RES?`
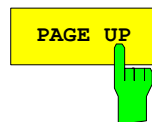
PAGE UP

PAGE DOWN

The *PAGE UP* or *PAGE DOWN* softkey sets the *SELFTEST RESULTS* table to the next or previous page.

IEC/IEEE-bus command `--`
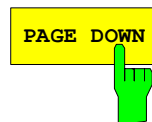
Hardware Adjustment

Some of the R&S FMU 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 and SAVE CHANGES can only be accessed after entering a password.

Firmware Update

The installation of a new firmware version can be performed using a USB Memorystick. The installation program is called in the *SETUP* menu.

SETUP side menu:
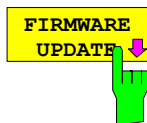
FIRMWARE UPDATE   The *FIRMWARE UPDATE* softkey opens the subdirectory for installing/deinstalling new firmware versions.

IEC/IEEE-bus command: --
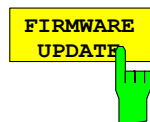
FIRMWARE UPDATE   The *FIRMWARE UPDATE* softkey starts the installation program and leads the user through the remaining steps of the update

IEC/IEEE-bus command: --

The firmware update is started as follows:

Connect your memory stick and

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: --

UPDATE PATH   The *UPDATE PATH* softkey is used to select the drive and directories under which the archive files for the firmware update are stored.

The firmware update can thus also be performed via network drives or USB-CD-ROM drives.

IEC/IEEE-bus command: `"SYST:FIRM:UPD'D:\USER\FWUPDATE'"`

Saving and Recalling Data Sets – FILE Key

Overview

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 R&S FMU 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)

The configuration of the softkeys in the menu is shown in the following figure:
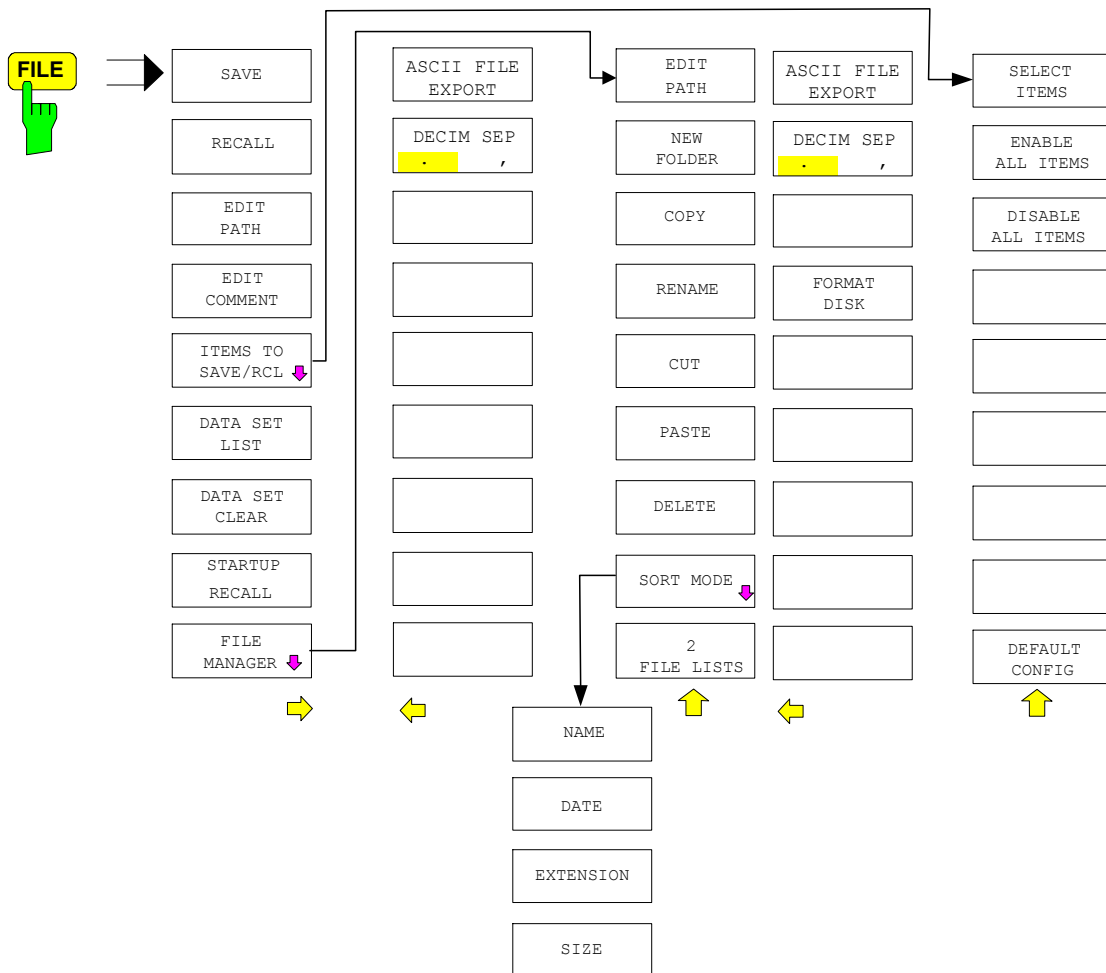
Storing a Device Configuration

Storing a Complete Device Configuration

The following steps are required to store a complete device configuration:

➢ Press the *FILE* key and then press the *SAVE softkey*.
   The selection box for the device configuration will be opened:
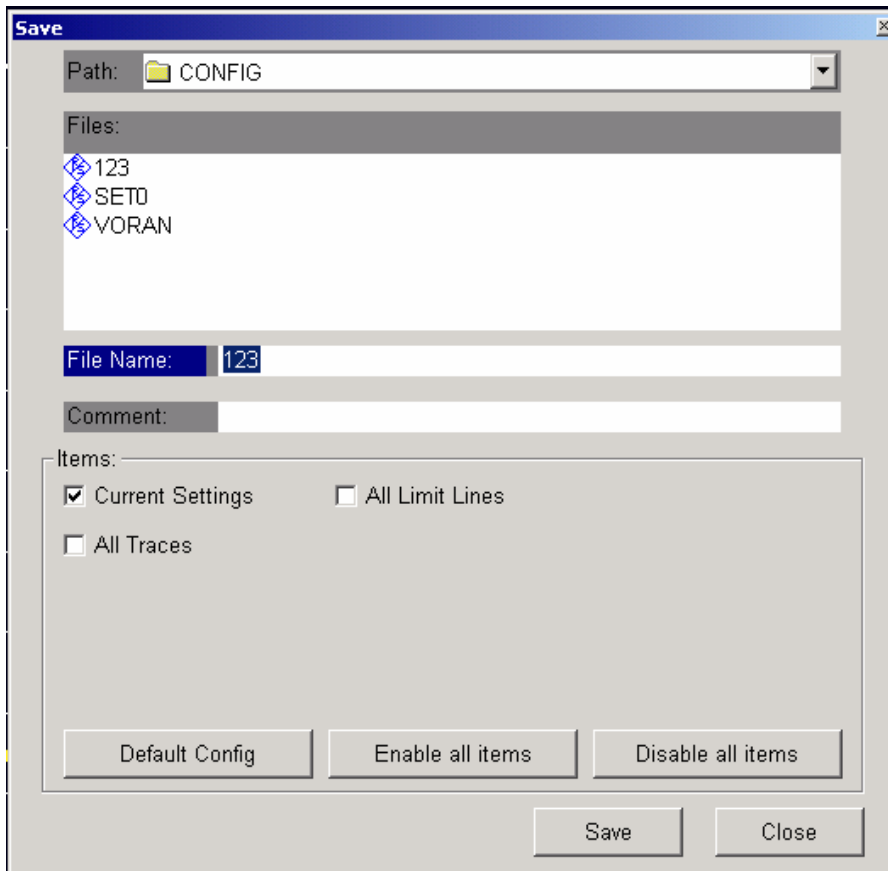
➢ Enter the name of the data set to be stored (in the simplest case, a digit from 0 to 9) and press
   ENTER. The data set will be stored and the dialog window closed.
   The name of the data set may comprise letters and digits; if required, the desired directory may
   precede the name of the data set (the directory will then automatically be used for further SAVE and
   RECALL processes).
   The help line editor, which can be opened by pressing the *Cursor Down* 🔽 key, is available for
   entering file names via the front-panel keypad.
   For further information on the operation of this editor, refer to the Quick Start Guide, chapter 4,
   "Basic Operation".

How to enter comments, change the path for the file to be stored and select the data set from a list is
described under the associated softkeys *EDIT COMMENT, EDIT PATH* and *DATA SET LIST*.

The default path for the device configuration is D:\USER\CONFIG. The file names of the data sets have
the extension . FMU.

Storing Parts of a Device Configuration

To store part of a data set (e.g. "All Traces"), the partial data set has to be selected beforehand. The following steps are required:

➢ Press the FILE key and then the SAVE softkey.

➢ Press the ITEMS TO SAVE/RCL softkey. The entry focus moves to the first entry in the   Items field.

➢ Use the spinwheel to move the entry focus to the desired entry in the Items field and select the partial data set by pressing the spinwheel or ENTER. The selection of already highlighted partial data sets can be cancelled by pressing the spinwheel / ENTER again.
Softkeys *ENABLE ALL ITEMS / DISABLE ALL ITEMS* are also available to select all partial data sets or to cancel the selection.

➢ Move the entry focus to the field *File Name* using the spinwheel and activate the text entry by pressing the spinwheel.

➢ Enter file names and store the data set with *ENTER*.

Loading a Data Set:

A data set may be loaded in two different ways:

1. **Direct entry of data set name:**
   ➢ Press the *FILE* key and then press the *RECALL* softkey.
   ➢ Enter the name of the data set to be stored (in the simplest case, a digit from 0 to 9) and press *ENTER*. The data set will be loaded.
   The name of the data set may comprise letters and digits; if required, the desired directory may precede the name of the data set (the directory will then automatically be used for further SAVE and RECALL processes).
   The help line editor, which can be opened by pressing the *Cursor Down* ⬇ key, is available for entering file names via the front-panel keypad.

   For further information on the operation of this editor, refer to the Quick Start Guide, chapter 4, "Basic Operation".

2. **Selection of data set via a selection list:**
   ➢ Press the *FILE* key and then press the *RECALL* softkey.
   ➢ Press the *ITEMS TO SAVE/RCL* softkey*.*
   The list of available data sets will be selected:
   ➢ Select the data set to be loaded with the spinwheel and confirm twice with *ENTER*. The data set will be loaded.

If the path for the device configuration is to be changed, this is done via the *EDIT PATH* softkey*.*
When loading device data, the settings of the unloaded partial data sets will remain unchanged. The R&S FMU recognizes which parts the loaded data set has and ignores selected but unavailable partial data sets.

Automatic Loading of a Data Set during Booting

When the R&S FMU is delivered, it will load the device setting last activated when the unit was switched off (provided that the unit was switched off via the *STANDBY* switch at the front panel, see section 1 "Putting the Device Into Operation").

Moreover, the R&S FMU is also able to automatically load a user-defined data set. The following operating steps are required:

➢ Press the FILE key and then press the RECALL softkey.

➢ Press the STARTUP RECALL softkey.
  The list of available data sets will be selected:
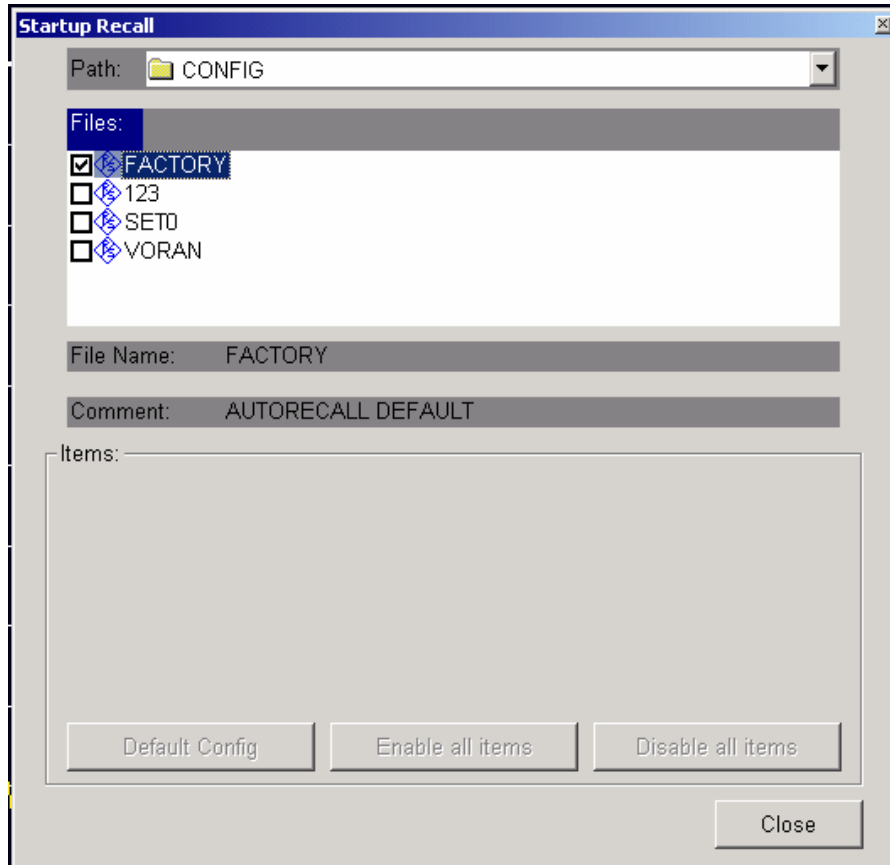
➢ Select the data set to be loaded using the spinwheel and mark with *ENTER*.

> ***Notes:***   1. *The selected data set will also be loaded when pressing the PRESET key.*
>   2. *The entry FACTORY will load the last setting that was activated prior to switch-off when the unit is started after delivery.*

➢ Close the dialog window by pressing *ESC* twice.

If the path is to be changed for the device configuration, this is done via the *EDIT PATH* softkey.

Copying Data Sets to Disk

The saved files of the data sets can be copied from one storage medium (e.g. drive D:) to another storage medium (e.g. drive E:) or to another directory using the functions found in the *FILE MANAGER* submenu. The file extension .FMU must not be changed.

Description of the Individual Softkeys
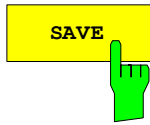
SAVE	The *SAVE* softkey opens the dialog window for entering the data set to be stored.
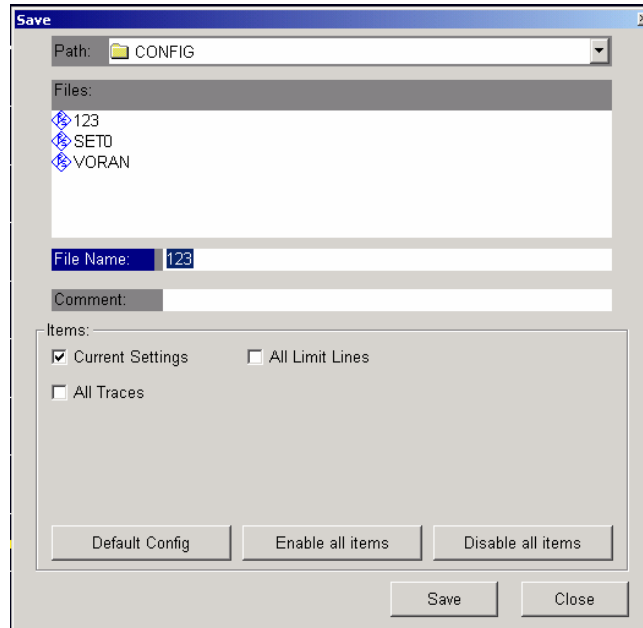
The *SAVE* table contains the entry fields for editing the data set:

Path	Directory in which the data set is stored.
Files	List of data sets already stored.
File Name	Name of data set. The name can be entered with or without drive name and directory; the drive name and directory, if available, will then appear in the PATH field. The extension of the data name is ignored.
Comment	Comment regarding the data set.
Items	Selection of settings to be stored.

IEC/IEEE command: `MMEM:STOR:STAT 1,"a:\test02"`

RECALL

👆
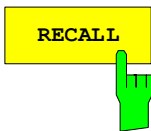
The *RECALL* softkey activates the dialog window to enter the data set to be loaded.
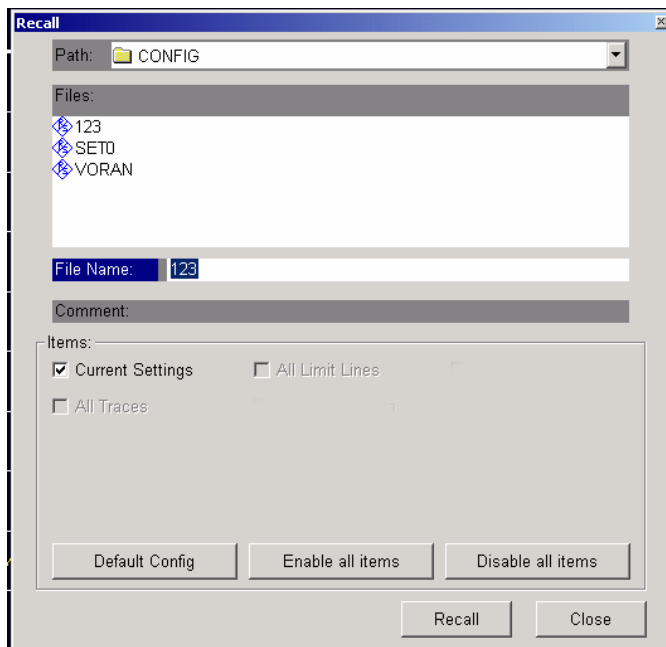
The *RECALL* table shows the current settings regarding the data set:

Path	Directory in which the data set is stored.
Files	List of stored data sets
File Name	Name of data set. The name can be entered with or without drive name and directory. The drive name and directory will then appear in the Path field. A potential extension of the file name is ignored.
Comment	Comment regarding data set.

IEC/IEEE command: `MMEM:LOAD:STAT 1,"a:\test02"`

EDIT PATH

The *EDIT PATH* softkey activates the entry of a path name for the device configuration to be stored/to be loaded:
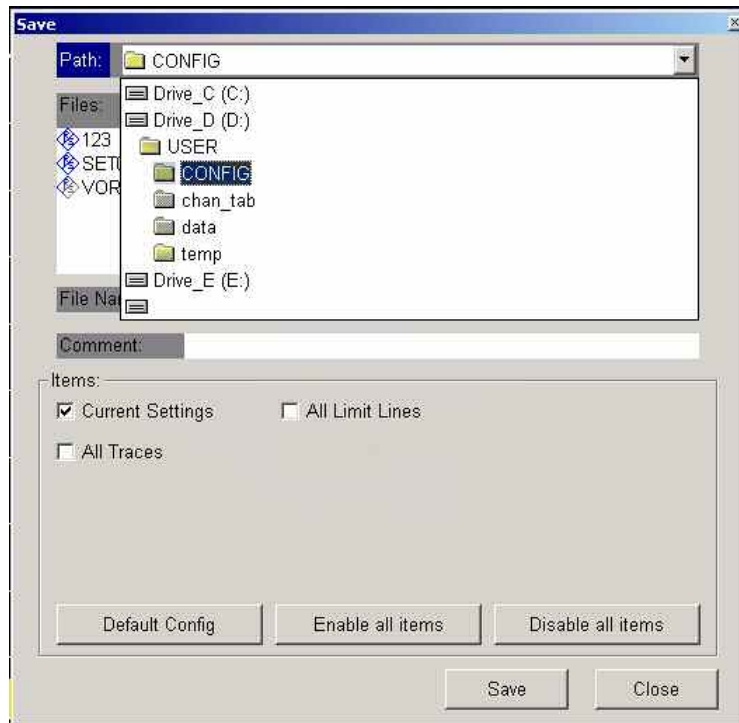
The desired directory is selected with the spinwheel or the *CURSOR UP / DOWN* key and is confirmed by pressing the spinwheel or the *ENTER* key.

Subdirectories are opened by the *CURSOR RIGHT* ⟧ key and closed with the *CURSOR LEFT* ⟧ key.

IEC/IEEE-bus command   –
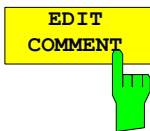
EDIT COMMENT

The *EDIT COMMENT* softkey activates the entry of commentary concerning the current data set. The help line editor is opened with *CURSOR DOWN*.
A total of 60 characters are available for this purpose.

> *Note:*
> *For further information on how to enter the comment text via the front panel of the unit, see the section '"Entering Text using the Help Line Editor".*

IEC/IEEE command: MMEM:COMM "Setup for GSM measurement"

The *SEL ITEMS TO SAVE/RCL* softkey opens a submenu for selecting the data subsets.

FILE - ITEMS TO SAVE/RCL submenu:

The Dialog *SaveL* table offers the following selectable data subsets in the *Items* field:

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 colour settings
- configuration for hardcopy output

All Limit Lines   all limit lines
All Traces   all traces which are not blanked
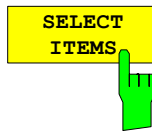
The *SELECT ITEMS* softkey moves the selection bar to the first line, left column of the *Items* field. An entry is selected. Position the entry focus to the corresponding partial data set using the cursor keys and then press the *ENTER* key in the desired line. The selection is cleared by pressing the 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`
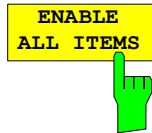
The *ENABLE ALL ITEMS* softkey marks all partial data sets.

IEC/IEEE command: `MMEM:SEL:ALL`
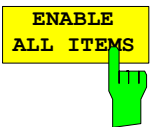
The *ENABLE ALL ITEMS* softkey marks all partial data sets.

IEC/IEEE-bus command `MMEM:SEL:ALL`
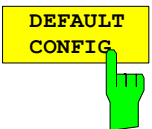
The *DEFAULT CONFIG* softkey establishes the default selection of the data subset to be saved and outputs *DEFAULT* in the *ITEMS* field of the *SAVE/RECALL DATA SET* table.

IEC/IEEE command: `MMEM:SEL:DEF`
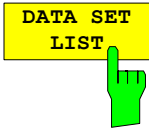
DATA SET LIST

The *DATA SET LIST* softkey sets the entry focus to the list *Files* of all available data sets. In addition, the *DATA SET CLEAR* softkey are displayed.

The list *Files* lists all data sets which are stored in the selected directory.

The *Comment* and *Items* fields in the *DATA SET CONTENTS* column indicate the saved data subsets and the comment for the currently selected data set.

IEC/IEEE command: ---
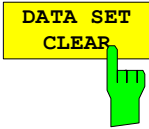
DATA SET CLEAR

The *DATA SET CLEAR* softkey deletes the selected data set

IEC/IEEE command: `MMEM:CLE:STAT 1, "test03"`
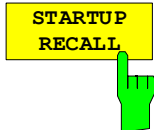
STARTUP RECALL

The *STARTUP RECALL* softkey activates the selection of a data set which is automatically loaded when the instrument is powered on and after *PRESET*. For this purpose the Dialog *Startup Recall* is opened (analogously to *DATA SET LIST).*
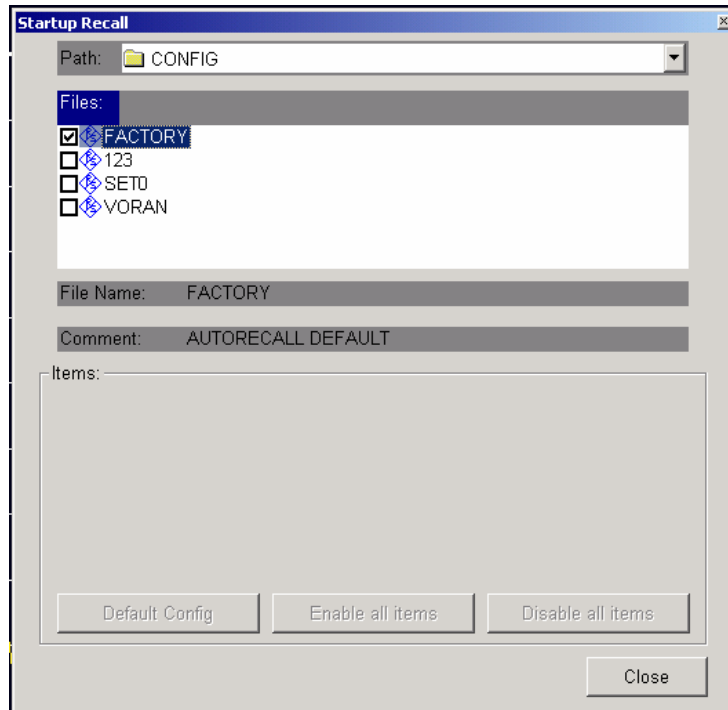
The field *Files* lists all data sets stored in the selected directory. The currently selected data set is checked.
In addition to the data sets stored by the user, the data set *FACTORY*, which specifies the settings of the instrument before it was last switched off (Standby), is always present (when unit is delivered).

To select a data set, the entry focus is set to the corresponding entry by means of the spinwheel and the data set is activated by pressing the spinwheel or the *ENTER* key.

If a data set other than *FACTORY* is chosen, this data set will be loaded when the unit is switched on or after pressing the *PRESET* key. Any settings can be assigned to the *PRESET* key.

IEC/IEEE command: `MMEM:LOAD:AUTO 1,"D:\user\config\test02"`

Operating Concept of File Managers

The *FILE MANAGER* softkey opens a menu for managing storage media and files.

FILE - FILE MANAGER submenu:
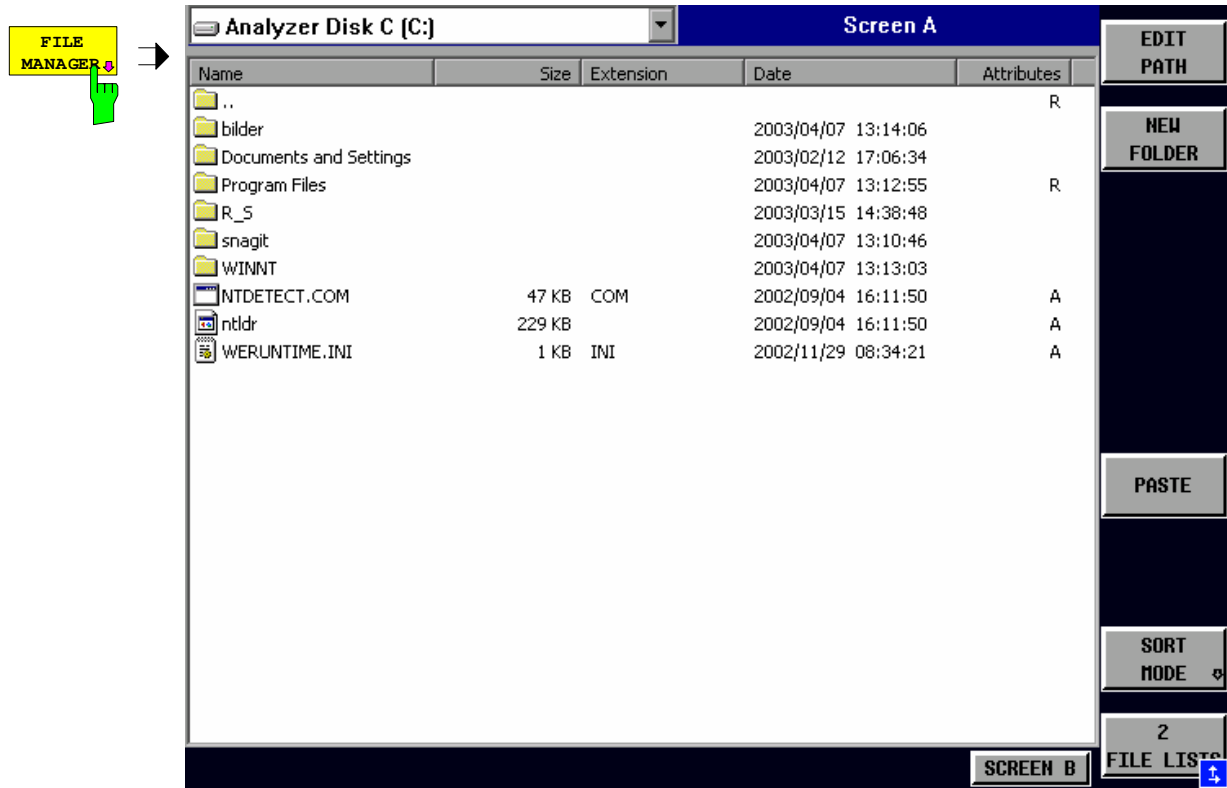
The designation and the letter of the current drive are displayed in the upper left corner of the File Manager dialog.

The table below shows the files of the current directory and potential subdirectories.

A file or a directory in the table is selected via cursor keys. The *ENTER* key is used to switch from one subdirectory to another.
The softkeys *COPY, RENAME, CUT and DELETE* are only visible if the entry focus is set to a file and not to a directory.

The dots ".." open up the next higher directory.
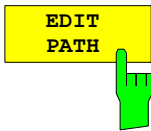
EDIT
PATH

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.
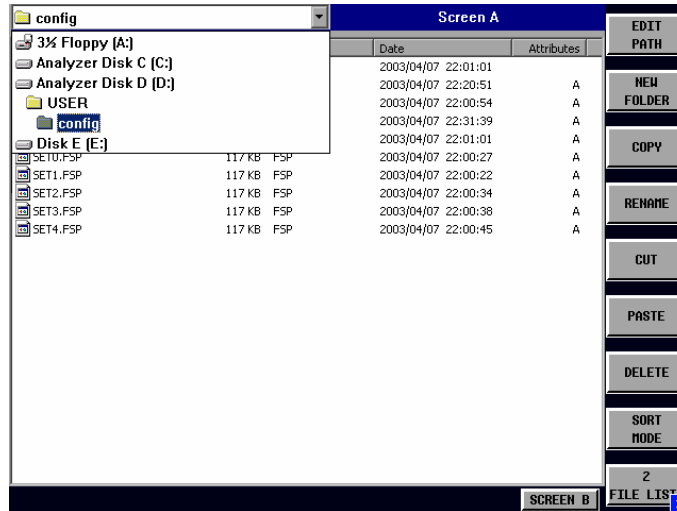
Use *CURSOR UP / DOWN* to select a drive and confirm your selection with *ENTER*.
Open subdirectories by using *CURSOR RIGHT*, and use *CURSOR LEFT* to close them again.
When you have found the subdirectory you looked for, mark it with *ENTER*.

IEC/IEEE command: `MMEM:MSIS "a:"`
                       `MMEM:CDIR "D:\user "`

NEW
FOLDER
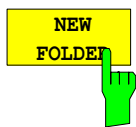
The *NEW FOLDER* softkey creates subdirectories.

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"`
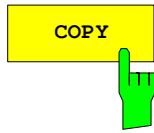
COPY

The *COPY* softkey opens the help line editor to enter the target directory for a copying process. The file is also copied into the clipboard and can be copied into a different directory at a later time by means of *PASTE.*

config				Screen A		EDIT PATH
Name	Size	Extension	Date		Attributes	
..			2003/04/07 22:01:01			NEW FOLDER
1.FSP	117 KB	FSP	2003/04/07 22:20:51		A	
2.FSP	117 KB	FSP	2003/04/07 22:00:54		A	
3.FSP	117 KB	FSP	2003/04/07 22:31:39		A	COPY
4.FSP	117 KB	FSP	2003/04/07 22:01:01		A	
SET0.FSP	117 KB	FSP	2003/04/07 22:00:27		A	
SET1.FSP	117 KB	FSP	2003/04/07 22:00:22		A	RENAME
SET2.FSP	117 KB	FSP	2003/04/07 22:00:34		A	
SET3.FSP					A	
SET4.FSP					A	CUT

```
A  B  C  D  E  F  G  H  I  J  K  L  M      1  2  3  4  5  6  7  8  9  0
N  O  P  Q  R  S  T  U  V  W  X  Y  Z      :  \  .  /  '  *  +  -  =  ,
a  b  c  d  e  f  g  h  i  j  k  l  m      <  >  (  )  {  }  [  ]  #  ~
n  o  p  q  r  s  t  u  v  w  x  y  z      '  @  ;  |  ?  !  "  €  $  %
              SPACE                        «  »    BACK        EXIT
```

PASTE

DELETE

SORT MODE

2 FILE LISTS

SCREEN B

Files can also be copied to a different storage medium by indicating a certain drive letter (e.g. D:). The selected files or directories will be copied after terminating the entry with the ENTER key.

IEC/IEEE-bus command   `MMEM:COPY "D:\user\set.cfg","a:"`
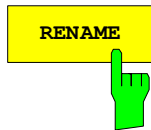
RENAME

The *RENAME* softkey opens the help line editor to rename a file or a directory (analogously to the *COPY* softkey).

 IEC/IEEE command: `MMEM:MOVE "test02.cfg","set2.cfg"`

CUT
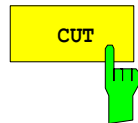
The *CUT* softkey shifts the selected file into the clipboard from where it can be copied into a different directory at a later time by means of *PASTE*.

Note:
The file in the output directory will only be deleted if the *PASTE* softkey has been pressed.

IEC/IEEE-bus command   –
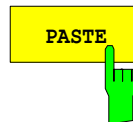
PASTE

The *PASTE* softkey copies files from the clipboard to the current directory. The directory is changed by means of the cursor keys and subsequent pressing of *ENTER* or via the *EDIT PATH* softkey.

IEC/IEEE-bus command   –
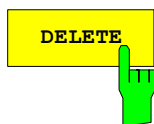
DELETE

The *DELETE* softkey deletes the selected file.
A confirmation query is displayed to avoid unintentional deletion of files.

IEC/IEEE-bus command   `MMEM:DEL "test01.hcp"`
                                  `MMEM:RDIR "D:\user\test"`
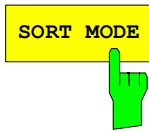
SORT MODE

The *SORT MODE* softkey opens the submenu to select the sorting mode for the displayed files.

config			Screen A	
Name	Size	Extension	Date	Attributes
..			2003/04/07 22:47:33	
autolog.txt	2 KB	txt	2000/09/27 12:14:28	A
1.FSP	117 KB	FSP	2003/04/07 22:20:51	A
2.FSP	117 KB	FSP	2003/04/07 22:00:54	A
3.FSP	117 KB	FSP	2003/04/07 22:31:39	A
4.FSP	117 KB	FSP	2003/04/07 22:01:01	A
SET0.FSP	117 KB	FSP	2003/04/07 22:00:27	A
SET1.FSP	117 KB	FSP	2003/04/07 22:00:22	A
SET2.FSP	117 KB	FSP	2003/04/07 22:00:34	A
SET3.FSP	117 KB	FSP	2003/04/07 22:00:38	A
SET4.FSP	117 KB	FSP	2003/04/07 22:00:45	A

NAME

DATE

EXTENSION

SIZE

SCREEN B

Directory names are located at the top of the list after the entry for the next higher directory level ("..").

IEC/IEEE command: ––
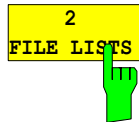
2 FILE LISTS

The *2 FILE LISTS* softkey opens a second window for the File Manager. The entry focus can be moved between the two windows by means of hotkeys *SCREEN A* and *SCREEN B*.
Files can thus very easily be copied and shifted from one directory to the other.

Note:
The second file list can also be opened in the Full Screen mode via hotkey *SCREEN B or SCREEN A*.

IEC/IEEE-bus command   –

FILE - NEXT menu:

ASCII FILE EXPORT

The *ASCII FILE EXPORT* softkey stores the active trace in ASCII format to a disk.

IEC/IEEE-bus command: FORM ASC;
                          MMEM:STOR:TRAC 1,'TRACE.DAT'

The file consists of a header, which contains important scaling parameters, and a data section, which contains the trace data.

The file header data comes in three columns separated by semicolons (;).
It has the following contents:
        parameter name; numerical value; default unit

The data section starts with the keyword "Trace <n>", where <n> designates the number of the trace to be stored. This is followed by the measured data in columns separated by semicolons (;).

This format can be read by spreadsheet programs such as MS Excel. A semicolon (;) is to be defined as a separator between the cells of a table.

Note: *Analysis programs may come in different language versions that require different notations of the decimal point. By means of the DECIM SEP softkey, a decimal point (.) or a comma (,) can be selected as decimal-point notation.*

For a detailed description of the ASCII file format, refer to section "Selection and Setting of Traces – TRACE Key", ASCII FILE EXPORT softkey.
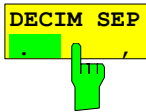
DECIM SEP

By means of the *DECIM SEP* softkey, one can select between a decimal point (.) and a comma (,) as decimal-point notation for the ASCII FILE EXPORT function.
Due to the possibility of selecting between different decimal-point notations, different language versions of analysis programs (such as MS Excel) can be supported.

IEC/IEEE-bus command: FORM:DEXP:DSEP POIN

Measurement Documentation – HCOPY Key

The installation and configuration of printers is described in the Quick Start Guide.

HCOPY menu:

```
                   ┌──────────┐   ┌──────────┐              ┌──────────┐   ┌──────────┐
                   │  PRINT   │   │ INSTALL  │              │  COLOR   │   │  SELECT  │
         ┌──────┐  │  SCREEN  │   │ PRINTER  │              │ ON   OFF │   │  OBJECT  │
         │HCOPY │  ├──────────┤   ├──────────┤              ├──────────┤   ├──────────┤
         └──────┘  │  PRINT   │   │          │              │  SCREEN  │   │BRIGHTNESS│
                   │  TRACE   │   │          │              │ COLORSET │   │          │
                   ├──────────┤   ├──────────┤              ├──────────┤   ├──────────┤
                   │  PRINT   │   │          │              │OPTIMIZED │   │   TINT   │
                   │  TABLE   │   │          │              │  COLORS  │   │          │
                   ├──────────┤   ├──────────┤              ├──────────┤   ├──────────┤
                   │          │   │          │              │   USER   │   │SATURATION│
                   │          │   │          │              │ DEFINED  │   │          │
                   ├──────────┤   ├──────────┤              ├──────────┤   ├──────────┤
                   │  DEVICE  │   │          │              │          │   │          │
                   │  SETUP   │   │          │              │          │   │          │
                   ├──────────┤   ├──────────┤              ├──────────┤   ├──────────┤
                   │  DEVICE  │   │          │              │          │   │PREDEFINED│
                   │  1   2   │   │          │              │          │   │  COLORS  │
                   ├──────────┤   ├──────────┤              ├──────────┤   ├──────────┤
                   │  COLORS  │   │          │              │          │   │          │
                   │          │   │          │              │          │   │          │
                   ├──────────┤   ├──────────┤              ├──────────┤   ├──────────┤
                   │ COMMENT  │   │          │              │          │   │  SET TO  │
                   │          │   │          │              │          │   │ DEFAULT  │
                   └──────────┘   └──────────┘              └──────────┘   └──────────┘
```
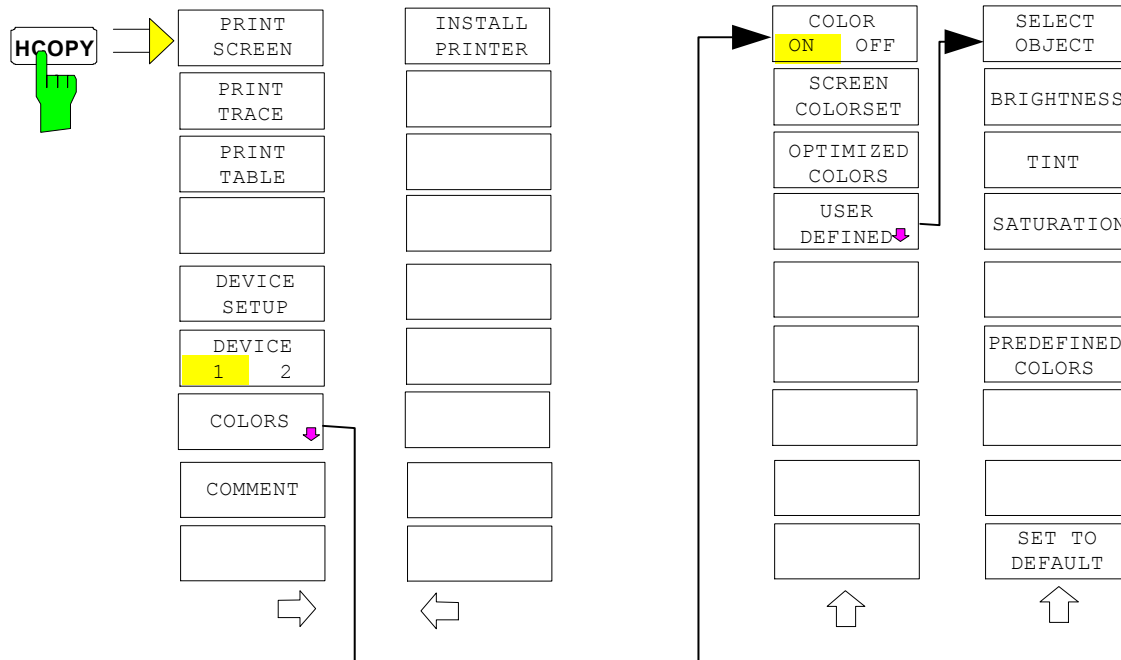
Pressing one of the softkeys *PRINT, SCREEN, PRINT TRACE or PRINT TABL*E in the *HCOPY* menu initiates the print job. The printer parameters defined in the *DEVICE SETTINGS* menu are used for setting up the printer configuration. All of the display items to be printed are written to the printer buffer. 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.

The *PRINT TRACE* function allows individual traces to be printed. With *PRINT TABLE,* tables can be printed.

The DEVICE 1 and 2 softkeys are used for selecting and configuring the output interface.

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 *PRINT...* softkeys, the file name to which the output data is to be written is requested. An entry field is then opened for entering the file name.

The *COLORS* submenu allows switchover between black-and-white and colour printouts (default), provided that the printer connected can produce colour printouts. In addition, the colours are set in this submenu.

- SCREEN   Output in screen colours.
- OPTIMIZED (default) Instead of light colours, dark colours 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 colours 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 colours can be selected, too.*

   2.   *Upon activation of the submenu, the colour display is switched over to the selected printout colours. When the menu is quit, the original colour 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.
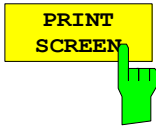
PRINT SCREEN

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
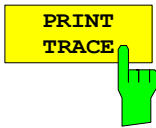
PRINT TRACE

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
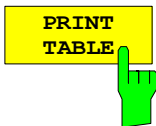
PRINT TABLE

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
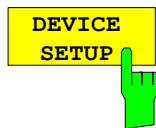
DEVICE SETUP

The *DEVICE SETUP* softkey opens the dialog where the file format and the printer can be selected (see section "Selecting Printer, Clipboard and File Formats").

IEC/IEEE-bus commands: HCOP:DEV:LANG GDI;
                         SYST:COMM:PRIN:ENUM:FIRS?;
                         SYST:COMM:PRIN:ENUM:NEXT?;
                         SYST:COMM:PRIN:SEL <Printer>;
                         HCOP:PAGE:ORI PORT;
                         HCOP:DEST "SYST:COMM:PRIN";
                         HCOP:DEST "SYST:COMM:MMEM"
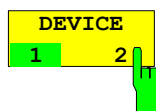
DEVICE 1 2

The analyzer is able to manage two hardcopy settings independently of each other. They are selected via the *DEVICE 1 / 2* softkey, which displays also the associated setting if the *DEVICE SETUP* dialog is open.
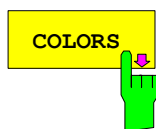
IEC/IEEE-bus command: --

COLORS

The *COLORS* softkey gives access to the submenu where the colours for the printout can be selected (see section *"Selecting Printer Colours")*.

IEC/IEEE-bus command: –
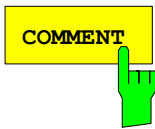
COMMENT

The *COMMENT* 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 diagram area. The comment text appears on the hardcopy, but not on the display screen.

If a comment should not be printed, it must be cleared.
If the instrument is reset by a click on the PRESET key, all entered comments are cleared.

Note:

The COMMENT softkey opens the auxiliary line editor where the desired letters can be entered in the text field by means of spinwheel and cursor keys.

After clicking the *COMMENT* softkey, the auxiliary line editor can be reached with the ⬇ key. Pressing the spinwheel or the *ENTER* key inserts the selected characters in the text line.

After editing is completed, return to the text line with the ⬆ key and confirm the comment text with *ENTER*.

If the entered comment should be aborted, quit the auxiliary line editor with *ESC*.

Important:

Only after the auxiliary line editor has been closed with *ESC* can the softkeys and hardkeys be operated again.

A detailed description of the auxiliary line editor can be found in section " Entering a Text with the Auxiliary Line Editor ".

IEC/IEEE-bus command: `HCOP:ITEM:WIND2:TEXT 'Comment'`

HCOPY NEXT menu:

INSTALL
PRINTER

A certain number of printer drivers is already installed on the R&S FMU.
The *INSTALL PRINTER* softkey opens the *Printers and Faxes* dialog where more printer drivers can be installed.
For details refer to sections "Installation of Plug&Play Printers" and "Installation of Non-Plug&Play Printers".

IEC/IEC-bus command: –

Selecting Printer, Clipboard and File Formats
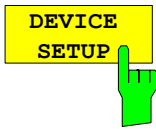
DEVICE SETUP

The *DEVICE SETUP* softkey opens the selection dialog for file format and printer.
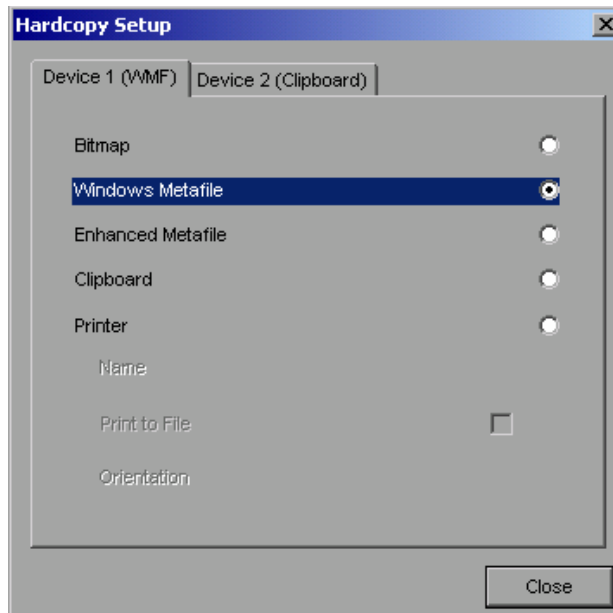
Navigation in the dialog is possible by turning the spinwheel; selection of an item is confirmed by pressing the spinwheel or the *ENTER* key.

The dialog is closed with ESC (alternatively, the *Close* button can be selected with the spinwheel and the dialog can be closed by pressing the spinwheel or with *ENTER)*.

File formats

A file format is selected by turning the spinwheel ◯ and then confirmed by pressing the spinwheel or the *ENTER* key.

The following file formats can be selected:

BITMAP	BMP format (non-compressed)
WINDOWS METAFILE	Vector format, supported as of Windows 3.1
ENHANCED METAFILE	Vector format, supported as of Windows 95/98/ME/NT/XP

When a file format is selected, printing to a file is automatic. The file name is queried when the *PRINT SCREEN, PRINT TRACE* and *PRINT TABLE* softkeys are pressed.

Clipboard

A clipboard is also selected with the spinwheel ◯ and then confirmed by pressing the spinwheel or *ENTER* key.

After the *PRINT SCREEN, PRINT TRACE* or *PRINT TABLE* softkey has been pressed, printout is routed to the clipboard. With the aid of the "Process - Insert" function, the information in the clipboard can then be pasted into other programs, e.g. *Paint*, and subsequently processed.

Printer

A printer (also a preconfigured network printer) is selected by selecting *Printer* with the spinwheel ⬭ and then confirmed by pressing the spinwheel or the *ENTER* key.

After confirmation, the entries under *Name, Print to File* and *Orientation* are available for selection with the spinwheel.
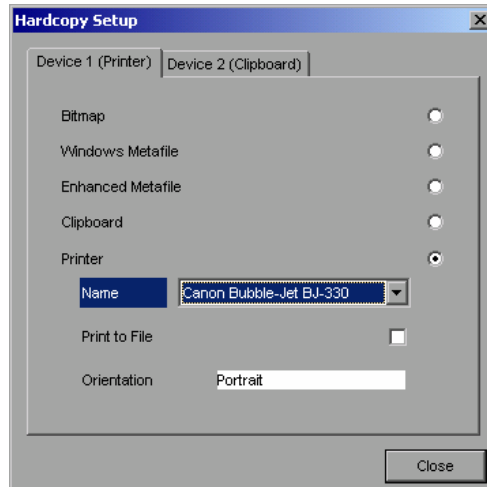
To select the printer type, select *Name* and open the selection list by pressing the spinwheel or *ENTER.*
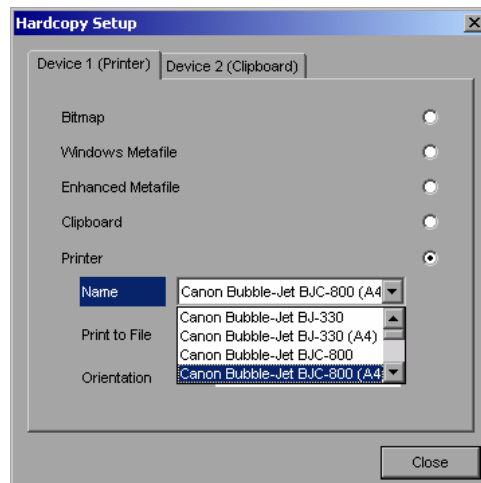
Select the desired printer (in the example "Cannon Bubble-Jet BJC800 (A4") from the list by means of the spinwheel and confirm by pressing the spinwheel or *ENTER*. This closes the list and the cursor is placed on the *Name* field again.

Printing to a file is also possible. In this case select Print to File with the spinwheel and activate or deactivate the associated list by pressing the spinwheel or the *ENTER* key.

The printing format is selected under *Orientation.* In this case, too, pressing the spinwheel or *ENTER* opens the selection list.
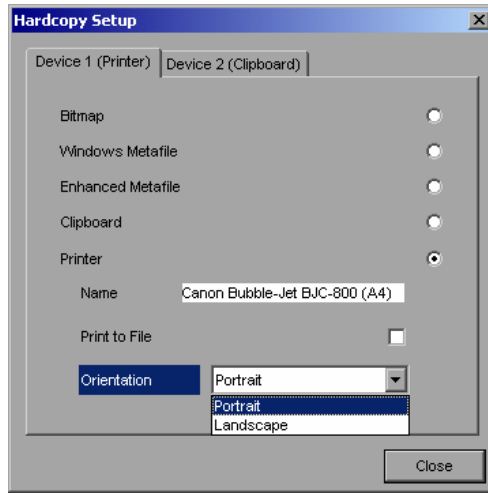
The desired format (here *Portrait*) is selected in the list with the spinwheel and confirmed by pressing the spinwheel or *ENTER*. This closes the list and the cursor is placed again on the *Orientation* field.

The dialog is then closed with *ESC* or by clicking the *Close* button.

Note: *The installation of new printer types is described in sections "Local Printer" and "Configuring a Network Printer"*

Selecting Alternative Printer Configurations

The analyzer is capable of managing two independent hardcopy settings. This, for instance, permits fast switchover between printing to a file or by a printer.
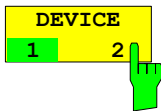
A selection is made with the *DEVICE 1 / 2* softkey which also shows settings when the *DEVICE SETUP* dialog is open.
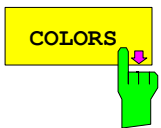
IEC/IEEE-bus command: --

Selecting Printer Colours

The *COLORS* softkey gives access to the submenu where the colours for the printout can be selected. To facilitate colour selection, the selected colour combination is displayed when the menu is entered. The previous colours are restored when the menu is exited.

IEC/IEEE-bus command: –
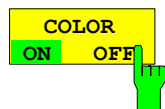
The *COLOR ON OFF* softkey switches over from colour output to black-and-white output. All colour-highlighted areas are printed in white and all colour lines in black. This improves the contrast on the printout. The default setting is COLOR ON.

IEC/IEEE-bus command: HCOP:DEV:COL ON
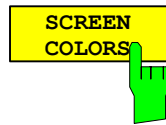
SCREEN
COLORS

The *SCREEN COLORS* softkey selects the current screen colours 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 colour setting for the printout to improve the visibility of the colours on the hardcopy.
Trace 1 is blue, trace 2 black, trace 3 green, and the markers are turquoise.
The other colours correspond to the display colours 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`
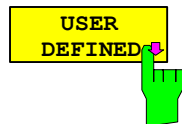
USER
DEFINED

The *USER DEFINED* softkey opens a submenu for user-defined colour selection (see submenu *USER DEFINED COLORS*).

IEC/IEEE-bus command: `HCOP:CMAP:DEF3`
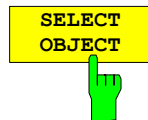
SELECT
OBJECT

The *SELECT OBJECT* softkey allows picture elements to be selected to change their colour setting. After selection, the *PREDEFINED COLORS*, *BRIGHTNESS*, *TINT* and *SATURATION* softkeys enable the user to change the colours or brightness, the hue and the colour 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
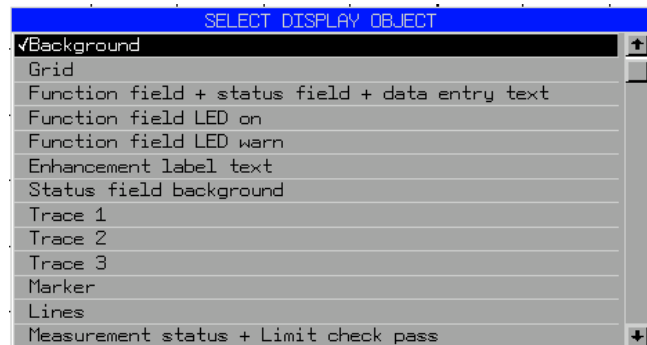
IEC/IEEE-bus command: –

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>`
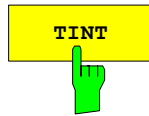
TINT

The *TINT* softkey serves for determining the hue of the element selected. The percentage entered refers to a continuous colour 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 colours for the displayed elements can be selected:

```
       COLORS
BLACK
BLUE
BROWN
GREEN
CYAN
RED
MAGENTA
YELLOW
WHITE
DARKGRAY
LIGHTGRAY
LIGHTBLUE
LIGHTGREEN
LIGHTCYAN
LIGHTRED
LIGHTMAGENTA
```

IEC/IEEE-bus command:
```
HCOP:CMAP1 ... 26:PDEF <color>
```

SET TO DEFAULT

The *SET TO DEFAULT* softkey reactivates the default colour setting (= *OPTIMIZED COLORS)*.

IEC/IEEE-bus command: –

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5 Remote Control - Basics

In this chapter you'll find:

- instructions on how to put the R&S FMU into operation via remote control,
- a general introduction to remote control of programmable instruments. This includes the description of the command structure and syntax according to the SCPI standard, the description of command execution and of the status registers,
- diagrams and tables describing the status registers used in the R&S FMU.

In chapter 6, all remote control functions are described in detail. The subsystems are listed by alphabetical order according to SCPI. All commands and their parameters are listed by alphabetical order in the command list at the end of chapter 6.

Program examples for the R&S FMU can be found in chapter 7.

The remote control interfaces and their interface functions are described in Chapter 8.

Introduction

The instrument is equipped with an IEC-bus interface according to standard IEC 625.1/IEEE 488.2and a RS-232 interface. The connectors are located at the rear of the instrument and permit to connect a controller for remote control. In addition, the instrument can be remotely controlled in a local area network (LAN interface).

The instrument supports the SCPI:version 1997.0 (Standard Commands for Programmable Instruments). The SCPI standard is based on standard IEEE 488.2 and aims at the standardization of device-specific commands, error handling and the status registers (see Section "SCPI Introduction").
The tutorial "Automatic Measurement Control – A tutorial on SCPI and IEEE 488.2" from John M. Pieper (R&S order number 0002.3536.00) offers detailed information on concepts and definitions of SCPI. For remote control in a network, information will be found in the relevant section, "Remote Control in a Network (RSIB Interface)".

This section assumes basic knowledge of IEC/IEEE bus programming and operation of the controller. A description of the interface commands can be obtained from the relevant manuals.

The requirements of the SCPI standard placed on command syntax, error handling and configuration of the status registers are explained in detail in the following sections. Tables provide a fast overview of the bit assignment in the status registers. The tables are supplemented by a comprehensive description of the status registers.

The program examples for IEC-bus programming are all written in VISUAL BASIC.

Getting Started

The short and simple operating sequence given below permits fast putting into operation of the instrument and setting of its basic functions. As a prerequisite, the IEC/IEEE-bus address, which is factory-set to 20, must not have been changed.

1. Connect instrument and controller using IEC/IEEE-bus cable.

2. Write and start the following program on the controller:

```
CALL IBFIND("DEV1", analyzer%)              'Open port to the instrument
CALL IBPAD(analyzer%, 20)                   'Inform controller about instrument address
CALL IBWRT(analyzer%, '*RST;*CLS')          "Reset instrument

CALL IBWRT(analyzer%, 'FREQ:CENT 10MHz')    ' Set center frequency to 10 MHz
CALL IBWRT(analyzer%, 'FREQ:SPAN 1MHz')     ' Set span to 1 MHz
CALL IBWRT(analyzer%, 'DISP:TRAC:Y:RLEV 1V')
                                            ' Set reference level to 1 Volt Peak
```

The instrument now performs a measurement in the frequency range of 9.5 MHz to 10.5 MHz .

3. To return to manual control, press the *LOCAL* key at the front panel

Starting Remote Control Operation

On power-on, the instrument is always in the manual operating state ("LOCAL" state) and can be operated via the front panel.
It is switched to remote control ("REMOTE" state)

IEC/IEEE-bus   as soon as it receives an addressed command from a controller.

RSIB, VXI-11   if it is controlled in a network, as soon as it receives a command from a controller.
RS-232   as soon as it receives the command "@REM" from a controller.

During remote control, operation via the front panel is disabled. The instrument remains in the remote state until it is reset to the manual state via the front panel or via remote control interfaces. Switching from manual operation to remote control and vice versa does not affect the remaining instrument settings.

Display Contents during Remote Control

During remote control, only the LOCAL softkey appears, with which it is possible to return to manual operation. In addition a softkey DISP UPD ON/OFF allows to enable or blank out the display of diagrams and results. It is OFF by default to obtain optimum performance during remote control operation. The remote command for this operation is "`SYSTem:DISPlay:UPDate ON | OFF`".

During program execution it is recommended to activate the display of results by means of "`SYSTem:DISPlay:UPDate ON`" so that it is possible to follow the changes in the device settings and the recorded measurement curves on the screen.

Note: *If the instrument is exclusively operated in remote control, it is recommended to switch on the power-save mode (POWER SAVE). In this mode, the required display is completely switched off after a preset time.*

Remote Control via IEC/IEEE Bus

Setting the Device Address

In order to operate the instrument via the IEC-bus, it must be addressed using the set IEC/IEEE bus address. The IEC/IEEE bus address of the instrument is factory-set to 20. It can be changed manually in the *SETUP - GENERAL SETUP* menu or via IEC bus. Addresses 0 to 30 are permissible.

Manually:

> ➢ Call *SETUP - GENERAL SETUP* menu

> ➢ Enter desired address in table *GPIB-ADDRESS*

> ➢ Terminate input using the *ENTER* key

Via IEC/IEEE bus:

```
CALL IBFIND("DEV1", analyzer%)                   'Open port to the instrument
CALL IBPAD(analyzer%, 20)                        'Inform controller about old address
CALL IBWRT(analyzer%, "SYST:COMM:GPIB:ADDR 18")  'Set instrument to new address
CALL IBPAD(analyzer%, 18)                        'Inform controller about new address
```

Return to Manual Operation

Return to manual operation is possible via the front panel or the IEC/IEEE bus.

Manually: ➢ Press the *LOCAL* softkey or the *PRESET* key

> **Notes:** – *Before the transition, command processing must be completed as otherwise transition to remote control is performed immediately.*
>
> – *The keys can be disabled by the universal command LLO (see Chapter 8, IEC/IEEE-Bus Interface – Interface Messages) in order to prevent unintentional transition. In this case, transition to manual mode is only possible via the IEC/IEEE bus.*
>
> – *The keys can be enabled again by deactivating the REN line of the IEC/IEEE bus (see Chapter 8, IEC/IEEE-Bus Interface – Bus Lines).*

Via IEC bus: ...
```
CALL IBLOC(analyzer%)       'Set instrument to manual operation
```
...

Remote Control via RS-232-Interface

Setting the Transmission Parameters

To enable an error-free and correct data transmission, the parameters of the unit and the controller should have the same setting.
Parameters can be manually changed in menu *SETUP-GENERAL SETUP* in table *COM PORT* or via remote control using the command `SYSTem:COMMunicate:SERial:....`

The transmission parameters of the COM interface are factory-set to the following values:
    baudrate = 9600, data bits = 8, stop bits = 1, parity = NONE and owner = INSTRUMENT.
For remote control operation, the interface should be allocated to the operating system (owner = OS) so that the control characters including @ can be recognized by the interface.

Manually: Setting the COM interface

> ➢ Call *SETUP-GENERAL SETUP* menu

> ➢ Select desired baudrate, bits, stopbit, parity in table *COM PORT.*

> ➢ Set owner to OS in table *COM PORT.*

> ➢ Terminate input using the *ENTER* key.

Return to Manual Operation

Return to manual operation is possible via the front panel or via RS-232 interface.

Manually: ➢ Press the *LOCAL* softkey or the *PRESET* key.

> *Notes:*

> – *Before the transition, command processing must be completed as otherwise transition to remote control is performed immediately*

> – *The keys can be enabled again by sending the control string "@LOC" via RS-232 (see Chapter 8, S-232-C Interface - Control Commands).*

Via RS-232:   ...
                             `v24puts(port,"@LOC");`   Set instrument to manual operation..
                             ...

Limitations

The following limitations apply if the unit is remote-controlled via the RS-232-C interface:

– No interface messages, only control strings (see interface description in Chapter 8, *RS-232-C Interface – Control Commands*).

– Only the Common Commands *OPC? can be used for command synchronization, *WAI and *OPC are not available.

– Block data cannot be transmitted.

Remote Control in a Network (RSIB Interface)

Setting the Device Address

For control of the instrument in a network, it must be accessed using the preselected IP address. The IP address of the instrument (device address) is defined in the network configuration.

Setting the IP address:

> ➢ Call *SETUP - GENERAL SETUP* – CONFIGURE NETWORK menu.

> ➢ Select "Protocols" tab.

> ➢ Set IP address for TCP/IP protocol under "Properties" (see section on option R&S FSU-B16).

Return to Manual Operation

Return to manual operation can be made manually via the front panel or remotely via the RSIB interface.

Manually: ➢ Press *LOCAL* softkey or *PRESET* key.

                                      Note:

                                      – *Make sure that the execution of commands is completed prior to switchover since otherwise the instrument will switch back to remote control immediately.*

Via RSIB interface: ...
```
CALL RSDLLibloc(analyzer%, ibsta%, iberr%, ibcntl&)'Set
device to manual control
...
```

Messages

The messages transferred via the data lines of the IEC bus (see Chapter 8, IEC/IEEE-Bus Interface) can be divided into two groups:

– **interface messages and**
– **device messages.**

IEC/IEEE-Bus Interface Messages

Interface messages are transferred on the data lines of the IEC bus, the "ATN" control line being active. They are used for communication between controller and instrument and can only be sent by a controller which has the IEC/IEEE bus control. Interface commands can be subdivided into

– **universal commands and**
– **addressed commands.**

Universal commands act on all devices connected to the IEC/IEEE bus without previous addressing, addressed commands only act on devices previously addressed as listeners. The interface messages relevant to the instrument are listed in Chapter 8, IEC/IEEE-Bus Interface – Interface Functions.

Device Messages (Commands and Device Responses)

Device messages are transferred on the data lines of the IEC bus, the "ATN" control line not being active. ASCII code is used.
A distinction is made according to the direction in which they are sent on the IEC/IEEE bus:

– **Commands** are messages the controller sends to the instrument. They operate the device functions and request informations.
The commands are subdivided according to two criteria::

1. According to the effect they have on the instrument:

Setting commands cause instrument settings such as reset of the instrument or setting the center frequency.

Queries cause data to be provided for output on the IEC/IEEE bus, e.g. for identification of the device or polling the marker.

2. According to their definition in standard IEEE 488.2:

Common Commands are exactly defined as to their function and notation in standard IEEE 488.2. They refer to functions such as management of the standar-dized status registers, reset and selftest.

Device-specific commands refer to functions depending on the features of the instrument such as frequency setting. A majority of these commands has also been standardized by the SCPI committee (cf. Section "SCPI Introduction")).

– **Device responses** are messages the instrument sends to the controller after a query. They can contain measurement results, instrument settings and information on the instrument status (cf. Section "Responses to Queries").

Structure and syntax of the device messages are described in the following Section.

Structure and Syntax of the Device Messages

SCPI Introduction

SCPI (Standard Commands for Programmable Instruments) describes a standard command set for programming instruments, irrespective of the type of instrument or manufacturer. The goal of the SCPI consortium is to standardize the device-specific commands to a large extent. For this purpose, a model was developed which defines the same functions inside a device or for different devices. Command systems were generated which are assigned to these functions. Thus it is possible to address the same functions with identical commands. The command systems are of a hierarchical structure.
Fig. 5-1 illustrates this tree structure using a section of command system SENSe, which controls the device-specific settings, that do not refer to the signal characteristics of the measurement signal.
SCPI is based on standard IEEE 488.2, i.e. it uses the same syntactic basic elements as well as the common commands defined in this standard. Part of the syntax of the device responses is defined with greater restrictions than in standard IEEE 488.2 (see Section "Responses to Queries").

Structure of a Command

The commands consist of a so-called header and, in most cases, one or more parameters. Header and parameter are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). The headers may consist of several key words. Queries are formed by directly appending a question mark to the header.

Note: *The commands used in the following examples are not in every case implemented in the instrument.*

Common commands   Common commands consist of a header preceded by an asterisk "*" and one or several parameters, if any.

Examples: `*RST`   RESET, resets the device
`*ESE 253`   EVENT STATUS ENABLE, sets the bits of the event status enable register
`*ESR?`   EVENT STATUS QUERY, queries the contents of the event status register.

Device-specific commands

Hierarchy**:**   Device-specific commands are of hierarchical structure (see Fig. 5-1). The different levels are represented by combined headers. Headers of the highest level (root level) have only one key word. This key word denotes a complete command system.

Example: `SENSe`   This key word denotes the command system `SENSe`.

For commands of lower levels, the complete path has to be specified, starting on the left with the highest level, the individual key words being separated by a colon ":".

Example: `SENSe:FREQuency:SPAN 10MHZ`

This command lies in the third level of the SENSe system. It set the frequency span.
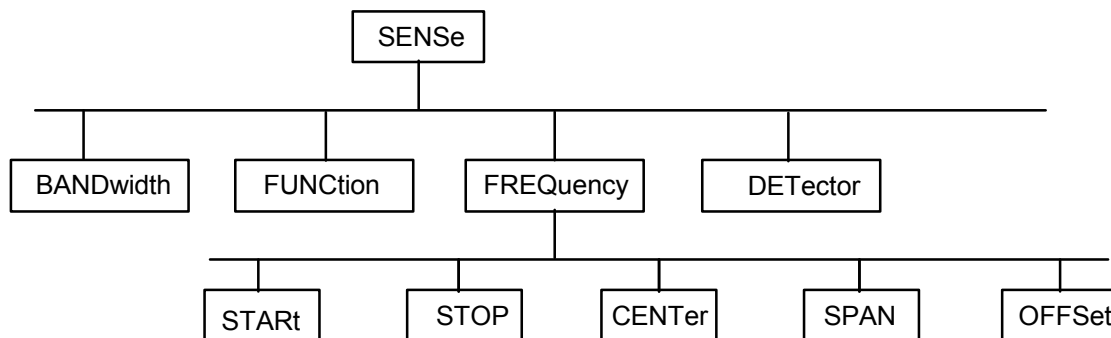
Fig. 5-1   Tree structure the SCPI command systems using the SENSe system by way of example

Some key words occur in several levels within one command system. Their effect depends on the structure of the command, that is to say, at which position in the header of a command they are inserted.

Example: `SOURce:FM:POLarity NORMal`
This command contains key word POLarity in the third command level. It defines the polarity between modulator and modulation signal.

`SOURce:FM:EXTernal:POLarity NORMal`
This command contains key word POLarity in the fourth command level. It defines the polarity between modulation voltage and the resulting direction of the modulation only for the external signal source indicated.

Optional key words: Some command systems permit certain key words to be optionally inserted into the header or omitted. These key words are marked by square brackets in the description. The full command length must be recognized by the instrument for reasons of compatibility with the SCPI standard. Some commands are considerably shortened by these optional key words.

Example: `[SENSe]:BANDwidth[:RESolution]:AUTO`
This command couples the resolution bandwidth of the instrument to other parameters. The following command has the same effect:
`BANDwidth:AUTO`

Note: *An optional key word must not be omitted if its effect is specified in detail by a numeric suffix.*

Long and short form: The key words feature a long form and a short form. Either the short form or the long form can be entered, other abbreviations are not permissible.

Beispiel: `STATus:QUEStionable:ENABle 1= STAT:QUES:ENAB 1`

Note: *The short form is marked by upper-case letters, the long form corresponds to the complete word. Upper-case and lower-case notation only serve the above purpose, the instrument itself does not make any difference between upper-case and lower-case letters.*

Parameter: The parameter must be separated from the header by a "white space". If several parameters are specified in a command, they are separated by a comma ",". A few queries permit the parameters MINimum, MAXimum and DEFault to be entered. For a description of the types of parameter, refer to Section "Parameters".

Example: `SENSe:FREQuency:STOP? MAXimum`   Response: 3.5E9
This query requests the maximal value for the stop frequency.

Numeric suffix: If a device features several functions or features of the same kind, e.g. inputs, the desired function can be selected by a suffix added to the command. Entries without suffix are interpreted like entries with the suffix 1.

Example:. `SYSTem:COMMunicate:SERial2:BAUD 9600`
This command sets the baudrate of a second serial interface.

Structure of a Command Line

A command line may consist of one or several commands. It is terminated by a <New Line>, a <New Line> with EOI or an EOI together with the last data byte. The IEC/IEEE driver of the controller usually produces automatically an EOI together with the last data byte.

Several commands in a command line are separated by a semicolon ";". If the next command belongs to a different command system, the semicolon is followed by a colon.

Example:
```
CALL IBWRT(analyzer%,"INPut:IQ:BALanced OFF;:SENSe:FREQuency:CENTer 10MHz ")
```

> This command line contains two commands. The first one is part of the SENSe command system and is used to determine the center frequency of the instrument. The second one is part of the INPut command system and sets the input signal attenuation.

If the successive commands belong to the same system, having one or several levels in common, the command line can be abbreviated. For that purpose, the second command after the semicolon starts with the level that lies below the common levels (see also Fig. 5-1). The colon following the semicolon must be omitted in this case.

Example:
```
CALL IBWRT(analyzer%, "SENSe:FREQuency:STARt 1E6;:SENSe:FREQuency:STOP 10E6")
```

> This command line is represented in its full length and contains two commands separated from each other by the semicolon. Both commands are part of the SENSe command system, subsystem FREQuency, i.e. they have two common levels.
> When abbreviating the command line, the second command begins with the level below SENSe:FREQuency. The colon after the semicolon is omitted.

> The abbreviated form of the command line reads as follows:

```
CALL IBWRT(analyzer%,  "SENSe:FREQuency:STARt 1E6;STOP 10E6")
```

However, a new command line always begins with the complete path.

Example:
```
CALL IBWRT(analyzer, "SENSe:FREQuency:STARt 1E6")
CALL IBWRT(analyzer%, "SENSe:FREQuency:STOP 10E6")
```

Responses to Queries

A query is defined for each setting command unless explicitly specified otherwise. It is formed by adding a question mark to the associated setting command. According to SCPI, the responses to queries are partly subject to stricter rules than in standard IEEE 488.2.

1. The requested parameter is transmitted without header.
   Example: `INPut:IQ:IMPedance?`
   Response: `LOW`

2. Maximum values, minimum values and all further quantities, which are requested via a special text parameter are returned as numerical values.
   Example: `SENSe:FREQuency:STOP? MAX`   Response: `36E6`

3. Numerical values are output without a unit. Physical quantities are referred to the basic units or to the units set using the Unit command.
   Example: `SENSe:FREQuency:CENTer?`   Response: `1E6` for 1 MHz

4. Truth values <Boolean values> are returned as 0 (for OFF) and 1 (for ON).
   Example: `INPut:IQ:BALanced:STATe?`   Response: 0 for OFF

5. Text (character data) is returned in a short form (see also Section 3.5.5).
   Example: `SYSTem:COMMunicate:SERial:CONTrol:RTS?` Response(for standard): `STAN`

Parameters

Most commands require a parameter to be specified. The parameters must be separated from the header by a "white space". Permissible parameters are numerical values, Boolean parameters, text, character strings and block data. The type of parameter required for the respective command and the permissible range of values are specified in the command description

Numerical values   Numerical values can be entered in any form, i.e. with sign, decimal point and exponent. Values exceeding the resolution of the instrument are rounded up or down. The mantissa may comprise up to 255 characters, the exponent must lie inside the value range -32000 to 32000. The exponent is introduced by an "E" or "e". Entry of the exponent alone is not permissible. In the case of physical quantities, the unit can be entered. Permissible unit prefixes are G (giga), MA (mega), MOHM and MHZ are also permissible), K (kilo), M (milli), U (micro) and N (nano). It the unit is missing, the basic unit is used.

Example:
`SENSe:FREQuency:STOP 15MHz = SENSe:FREQuency:STOP 15E6`

Special numerical   The texts MINimum, MAXimum, DEFault, UP and DOWN are interpreted as valuesspecial numerical values.

In the case of a query, the numerical value is provided.

Example: Setting command: `SENSe:FREQuency:STOP MAXimum`
Query: `SENSe:FREQuency:STOP?`   Response: `36E6`

MIN/MAX   MINimum and MAXimum denote the minimum and maximum value.

DEF   DEFault denotes a preset value which has been stored in the EPROM. This value conforms to the default setting, as it is called by the *RST command

UP/DOWN   UP, DOWN increases or reduces the numerical value by one step. The step width can be specified via an allocated step command (see annex C, List of Commands) for each parameter which can be set via UP, DOWN.

INF/NINF   INFinity, Negative INFinity (NINF) Negative INFinity (NINF) represent the numerical values -9.9E37 or 9.9E37, respectively. INF and NINF are only sent as device reponses.

NAN   Not A Number (NAN) represents the value 9.91E37. NAN is only sent as device response. This value is not defined. Possible causes are the division of zero by zero, the subtraction of infinite from infinite and the representation of missing values.

Boolean Parameters   Boolean parameters represent two states. The ON state (logically true) is represented by ON or a numerical value unequal to 0. The OFF state (logically untrue) is represented by OFF or the numerical value 0. 0 or 1 is provided in a query.

Example: Setting command: `DISPlay:WINDow:STATe ON`
Query: `DISPlay:WINDow:STATe?`   Response: `1`

Text

Text parameters observe the syntactic rules for key words, i.e. they can be entered using a short or long form. Like any parameter, they have to be separated from the header by a white space. In the case of a query, the short form of the text is provided.

Example: Setting command: `SENSe:DETector APEak   GROund`
          Query: `SENSe:DETector?          ` Response `APE`

Strings

Strings must always be entered in quotation marks (' or ").

Example: DISPlay:`WINDow:TEXT "Text Example"`   or
          DISPlay: `WINDow:TEXT 'Example'`

Block data

Block data are a transmission format which is suitable for the transmission of large amounts of data. A command using a block data parameter has the following structure:

Example: `HEADer:HEADer #45168xxxxxxxx`

ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. In the example the 4 following digits indicate the length to be 5168 bytes. The data bytes follow. During the transmission of these data bytes all End or other control signs are ignored until all bytes are transmitted.

Overview of Syntax Elements

The following survey offers an overview of the syntax elements.

| : | The colon separates the key words of a command. In a command line the colon after the separating semicolon marks the uppermost command level. |

| ; | The semicolon separates two commands of a command line. It does not alter the path. |

| , | The comma separates several parameters of a command. |

| ? | The question mark forms a query. |

| * | The asterix marks a common command. |

| " | Quotation marks introduce a string and terminate it. |

| # | The double dagger (#) introduces block data |

| | A "white space (ASCII-Code 0 to 9, 11 to 32 decimal, e.g.blank) separates header and parameter. |

Instrument Model and Command Processing

The instrument model shown in Fig. 5-2 has been made viewed from the standpoint of the servicing of IEC-bus commands. The individual components work independently of each other and simultaneously. They communicate by means of so-called "messages".
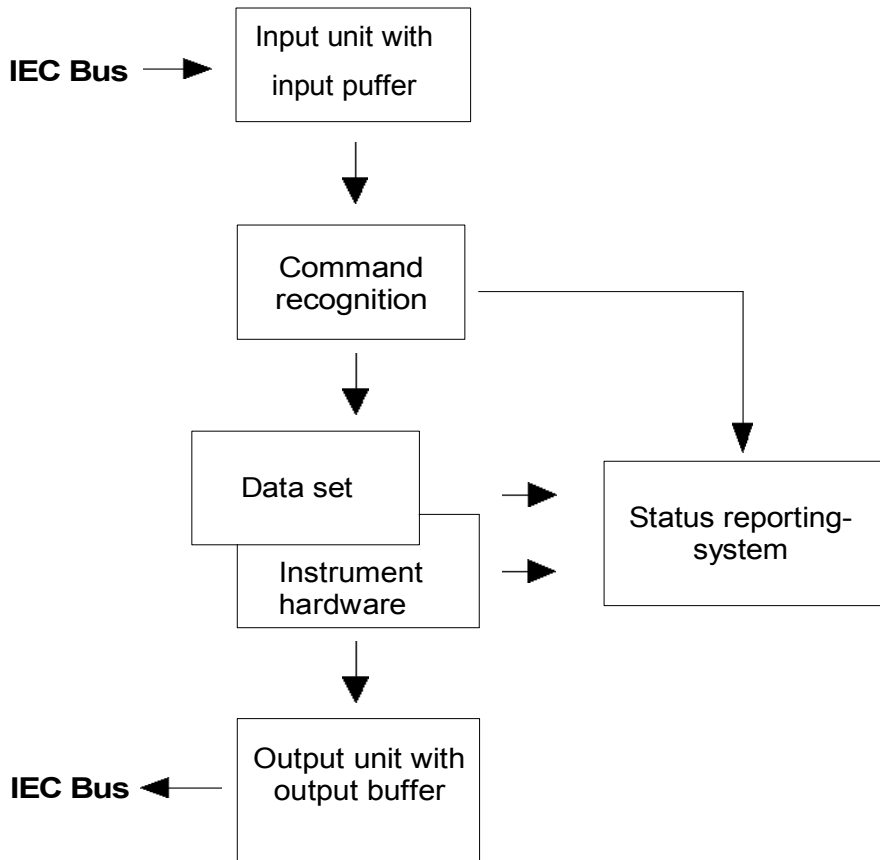
Fig. 5-2   Instrument model in the case of remote control by means of the IEC bus

Input Unit

The input unit receives commands character by character from the IEC bus and collects them in the input buffer. The input unit sends a message to the command recognition as soon as the input buffer is full or as soon as it receives a delimiter, <PROGRAM MESSAGE TERMINATOR>, as defined in IEEE 488.2, or the interface message DCL.
If the input buffer is full, the IEC-bus traffic is stopped and the data received up to then are processed. Subsequently the IEC-bus traffic is continued. If, however, the buffer is not yet full when receiving the delimiter, the input unit can already receive the next command during command recognition and execution. The receipt of a DCL clears the input buffer and immediately initiates a message to the command recognition.

Command Recognition

The command recognition analyses the data received from the input unit. It proceeds in the order in which it receives the data. Only a DCL is serviced with priority, a GET (Group Execute Trigger), e.g., is only executed after the commands received before as well. Each recognized command is immediately transferred to the instrument data base but without being executed there at once.

Syntactical errors in the command are recognized in the command recognition and supplied to the status reporting system. The rest of a command line after a syntax error is analysed further if possible and serviced.

If the command recognition recognizes a delimiter (<PROGRAM MESSAGE SEPARATOR> or <PROGRAM MESSAGE TERMINATOR>) or a DCL, it requests the instrument data base to set the commands in the instrument hardware as well now. Subsequently it is immediately prepared to process commands again. This means for the command servicing that further commands can already be serviced while the hardware is still being set ("overlapping execution").

Instrument Data Base and Instrument Hardware

Here the expression "instrument hardware" denotes the part of the instrument fulfilling the actual instrument function - signal generation, measurement etc. The controller is not included.

The instrument data base is a detailed reproduction of the instrument hardware in the software.

IEC-bus setting commands lead to an alteration in the data set. The data base management enters the new values (e.g. frequency) into the data base, however, only passes them on to the hardware when requested by the command recognition.

The data are only checked for their compatibility among each other and with the instrument hardware immediately before they are transmitted to the instrument hardware. If the detection is made that an execution is not possible, an "execution error" is signalled to the status reporting system. The alteration of the data base are cancelled, the instrument hardware is not reset.

IEC-bus queries induce the data base management to send the desired data to the output unit.

Status Reporting System

The status reporting system collects information on the instrument state and makes it available to the output unit on request. The exact structure and function are described in Section 3.8

Output Unit

The output unit collects the information requested by the controller, which it receives from the data base management. It processes it according to the SCPI rules and makes it available in the output buffer. If the instrument is addressed as a talker without the output buffer containing data or awaiting data from the data base management, the output unit sends error message "Query UNTERMINATED" to the status reporting system. No data are sent on the IEC bus, the controller waits until it has reached its time limit. This behaviour is specified by SCPI.

Command Sequence and Command Synchronization

What has been said above makes clear that all commands can potentially be carried out overlapping.

In order to prevent an overlapping execution of commands, one of commands *OPC, *OPC? or *WAI must be used. All three commands cause a certain action only to be carried out after the hardware has been set and has settled. By a suitable programming, the controller can be forced to wait for the respective action to occur (cf. Table 5-1).

Table 5-1   Synchronisation using *OPC, *OPC? and *WAI

Command	Action after the hardware has settled	Programming the controller
*OPC	Setting the opteration-complete bit in the ESR	- Setting bit 0 in the ESE - Setting bit 5 in the SRE - Waiting for service request (SRQ)
*OPC?	Writing a "1" into the output buffer	Addressing the instrument as a talker
*WAI	Continuing the IEC-bus handshake	Sending the next command

An example as to command synchronization can be found in Chapter "Program Examples".

For a couple of commands the synchronization to the end of command execution is mandatory in order to obtain the desired result. The affected commands require either more than one measurement in order to accomplish the desired instrument setting (eg autorange functions), or they require a longer period of time for execution. If a new command is received during execution of the corresponding function this may either lead to either an aborted measurement or to invalid measurement data.

The following list includes the commands, for which a synchronization via *OPC, *OPC? or *WAI is mandatory:

Table 5-2   Commands with mandatory synchronization (Overlapping Commands)

Command	Purpose
INIT	start measurement
INIT:CONM	continue measurement
CALC:STAT:SCAL:AUTO ONCE	optimize level settings for signal statistic measurement functions
[SENS:]POW:ACH:PRES:RLEV	optimize level settings for adjacent channel power measurements

Status Reporting System

The status reporting system (cf. Fig. 5-4) stores all information on the present operating state of the instrument, e.g. that the instrument presently carries out a calibration and on errors which have occurred. This information is stored in the status registers and in the error queue. The status registers and the error queue can be queried via IEC bus.

The information is of a hierarchical structure. The register status byte (STB) defined in IEEE 488.2 and its associated mask register service request enable (SRE) form the uppermost level. The STB receives its information from the standard event status register (ESR) which is also defined in IEEE 488.2 with the associated mask register standard event status enable (ESE) and registers STATus:OPERation and STATus:QUEStionable which are defined by SCPI and contain detailed information on the instrument.

The IST flag ("Individual STatus") and the parallel poll enable register (PPE) allocated to it are also part of the status reporting system. The IST flag, like the SRQ, combines the entire instrument status in a single bit. The PPE fulfills the same function for the IST flag as the SRE for the service request.

The output buffer contains the messages the instrument returns to the controller. It is not part of the status reporting system but determines the value of the MAV bit in the STB and thus is represented in Fig. 5-4.

Structure of an SCPI Status Register

Each SCPI register consists of 5 parts which each have a width of 16 bits and have different functions (cf. Fig. 5-3). The individual bits are independent of each other, i.e. each hardware status is assigned a bit number which is valid for all five parts. For example, bit 3 of the STATus:OPERation register is assigned to the hardware status "wait for trigger" in all five parts. Bit 15 (the most significant bit) is set to zero for all parts. Thus the contents of the register parts can be processed by the controller as positive integer.
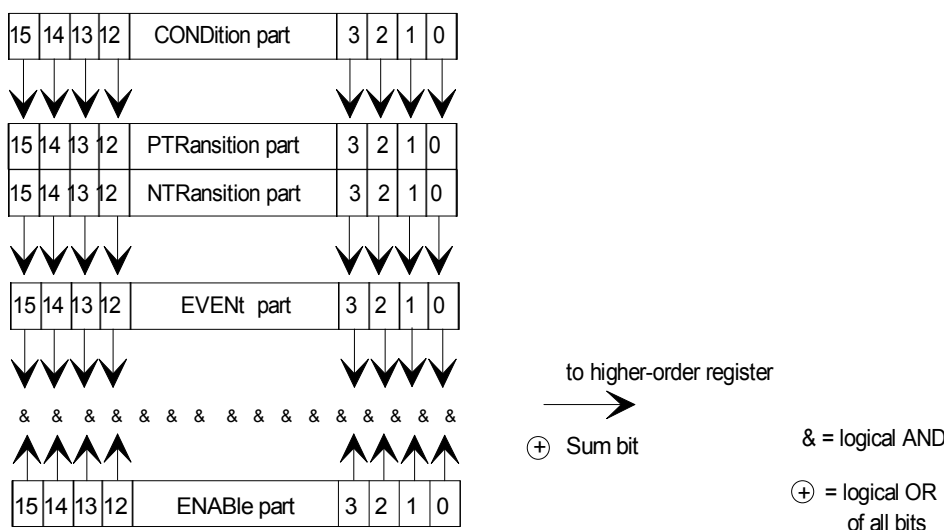
Fig. 5-3   The status-register model

CONDition part   The CONDition part is directly written into by the hardware or the sum bit of the next lower register. Its contents reflects the current instrument status. This register part can only be read, but not written into or cleared. Its contents is not affected by reading.

PTRansition part   The Positive-TRansition part acts as an edge detector. When a bit of the CONDition part is changed from 0 to 1, the associated PTR bit decides whether the EVENt bit is set to 1.
PTR bit =1: the EVENt bit is set.
PTR bit =0: the EVENt bit is not set.
This part can be written into and read at will. Its contents is not affected by reading.

NTRansition part   The Negative-TRansition part also acts as an edge detector. When a bit of the CONDition part is changed from 1 to 0, the associated NTR bit decides whether the EVENt bit is set to 1.
NTR-Bit = 1: the EVENt bit is set.
NTR-Bit = 0: the EVENt bit is not set.
This part can be written into and read at will. Its contents is not affected by reading.

With these two edge register parts the user can define which state transition of the condition part (none, 0 to 1, 1 to 0 or both) is stored in the EVENt part.

EVENt part   The EVENt part indicates whether an event has occurred since the last reading, it is the "memory" of the condition part. It only indicates events passed on by the edge filters. It is permanently updated by the instrument. This part can only be read by the user. During reading, its contents is set to zero. In linguistic usage this part is often equated with the entire register.

ENABle part   The ENABle part determines whether the associated EVENt bit contributes to the sum bit (cf. below). Each bit of the EVENt part is ANDed with the associated ENABle bit (symbol '&'). The results of all logical operations of this part are passed on to the sum bit via an OR function (symbol '+').
ENABle-Bit = 0:   the associated EVENt bit does not contribute to the sum bit
ENABle-Bit = 1: if the associated EVENT bit is "1", the sum bit is set to "1" as well.
This part can be written into and read by the user at will. Its contents is not affected by reading.

Sum bit   As indicated above, the sum bit is obtained from the EVENt and ENABle part for each register. The result is then entered into a bit of the CONDition part of the higher-order register.
The instrument automatically generates the sum bit for each register. Thus an event, e.g. a PLL that has not locked, can lead to a service request throughout all levels of the hierarchy.

Note: *The service request enable register SRE defined in IEEE 488.2 can be taken as ENABle part of the STB if the STB is structured according to SCPI. By analogy, the ESE can be taken as the ENABle part of the ESR.*

Overview of the Status Registers

& = logic   AND

⊕ = logic   OR
     of all bits

	STATus:OPERation
15	not used
14	
13	
12	
11	
10	
9	
8	HCOPy in progress
7	
6	
5	
4	
3	
2	
1	
0	CALibrating

	STATus:QUEStionable:ACPLimit
15	not used
14	
13	ALT2 LOWer FAIL (screen B)
12	ALT2 UPPer FAIL (screen B)
11	ALT1 LOWer FAIL (screen B)
10	ALT1 UPPer FAIL (screen B)
9	ADJ LOWer FAIL (screen B)
8	ADJ UPPer FAIL (screen B)
7	
6	
5	ALT2 LOWer FAIL (screen A)
4	ALT2 UPPer FAIL (screen A)
3	ALT1 LOWer FAIL (screen A)
2	ALT1 UPPer FAIL (screen A)
1	ADJ LOWer FAIL (screen A)
0	ADJ UPPer FAIL (screen A)

	STATus:QUEStionable:SYNC
15	not used
14	
13	
12	I Probe Adjust
11	Q Probe Adjust
10	
9	
8	
7	
6	
5	
4	
3	CARRier overload
2	No carrier
1	SYNC not found
0	BURSt not found

SRQ

	SRE		STB
-&-	7		7
-&-	6	RQS/MSS	6
-&-	5	ESB	5
-&-	4	MAV	4
-&-	3		3
-&-	2		2
	1		1
	0		0

SRE   **STB**

	PPE
-&-	
-&-	
-&-	
-&-	
-&-	
-&-	

PPE

IST flag

	STATus:QUEStionable
15	not used
14	
13	
12	ACPLimit
11	SYNC
10	LMARgin
9	LIMit
8	CALibration (= UNCAL)
7	
6	
5	FREQuency
4	TEMPerature
3	POWer
2	
1	
0	

STATus:QUEStionable:LMARgin <1|2>

Screen A   Screen B

Screen A		Screen B
15	not used	15
14		14
13		13
12		12
11		11
10		10
9		9
8		8
7	LMARgin 8 FAIL	7
6	LMARgin 7 FAIL	6
5	LMARgin 6 FAIL	5
4	LMARgin 5 FAIL	4
3	LMARgin 4 FAIL	3
2	LMARgin 3 FAIL	2
1	LMARgin 2 FAIL	1
0	LMARgin 1 FAIL	0

Screen A   Screen B

STATus:QUEStionable:LIMit<1|2>

Screen A		Screen B
15	not used	15
14		14
13		13
12		12
11		11
10		10
9		9
8		8
7	LIMit 8 FAIL	7
6	LIMit 7 FAIL	6
5	LIMit 6 FAIL	5
4	LIMit 5 FAIL	4
3	LIMit 4 FAIL	3
2	LIMit 3 FAIL	2
1	LIMit 2 FAIL	1
0	LIMit 1 FAIL	0

	ESE	ESR
-&-	7	Power on
-&-	6	User Request
-&-	5	Command Error
-&-	4	Execution Error
-&-	3	Device Dependent Error
-&-	2	Query Error
-&-	1	
-&-	0	Operation Complete

Error/event   Output
queue   buffer   ESE   ESR

	STATus:QUEStionable:FREQuency
15	not used
14	
13	
12	
11	
10	
9	CLock UNLocked (screen B)
8	
7	
6	
5	
4	
3	
2	
1	CLock UNLocked (screen A)
0	OVEN COLD

	STATus:QUEStionable:POWer
15	not used
14	
13	
12	
11	
10	
9	
8	
7	
6	
5	
4	
3	
2	Baseband Overload
1	
0	

Fig. 5-4   Overview of the status registers

Description of the Status Registers

Status Byte (STB) and Service Request Enable Register (SRE)

The STB is already defined in IEEE 488.2. It provides a rough overview of the instrument status by collecting the pieces of information of the lower registers. It can thus be compared with the CONDition part of an SCPI register and assumes the highest level within the SCPI hierarchy. A special feature is that bit 6 acts as the sum bit of the remaining bits of the status byte.
The STATUS BYTE is read out using the command "*STB?" or a serial poll.

The STB implies the SRE. It corresponds to the ENABle part of the SCPI registers as to its function. Each bit of the STB is assigned a bit in the SRE. Bit 6 of the SRE is ignored. If a bit is set in the SRE and the associated bit in the STB changes from 0 to 1, a Service Request (SRQ) is generated on the IEC bus, which triggers an interrupt in the controller if this is appropriately configured and can be further processed there.
The SRE can be set using command "*SRE" and read using "*SRE?".

Table 5-3 Meaning of the bits in the status byte

Bit No.	Meaning
2	**Error Queue not empty** The bit is set when an entry is made in the error queue. If this bit is enabled by the SRE, each entry of the error queue generates a Service Request. Thus an error can be recognized and specified in greater detail by polling the error queue. The poll provides an informative error message. This procedure is to be recommended since it considerably reduces the problems involved with IEC-bus control.
3	**QUEStionable status sum bit** The bit is set if an EVENt bit is set in the QUEStionable: status register and the associated ENABle bit is set to 1. A set bit indicates a questionable instrument status, which can be specified in greater detail by polling the QUEStionable status register.
4	**MAV bit** (message available) The bit is set if a message is available in the output buffer which can be read. This bit can be used to enable data to be automatically read from the instrument to the controller (cf. Chapter 7, program examples).
5	**ESB bit** Sum bit of the event status register. It is set if one of the bits in the event status register is set and enabled in the event status enable register. Setting of this bit implies an error or an event which can be specified in greater detail by polling the event status register.
6	**MSS bit** (master status summary bit) The bit is set if the instrument triggers a service request. This is the case if one of the other bits of this registers is set together with its mask bit in the service request enable register SRE.
7	**OPERation status register sum bit** The bit is set if an EVENt bit is set in the OPERation-Status register and the associated ENABle bit is set to 1. A set bit indicates that the instrument is just performing an action. The type of action can be determined by polling the OPERation-status register.

IST Flag and Parallel Poll Enable Register (PPE)

By analogy with the SRQ, the IST flag combines the entire status information in a single bit. It can be queried by means of a parallel poll (cf. Section 3.8.4.3) or using command "*IST?".

The parallel poll enable register (PPE) determines which bits of the STB contribute to the IST flag. The bits of the STB are ANDed with the corresponding bits of the PPE, with bit 6 being used as well in contrast to the SRE. The Ist flag results from the ORing of all results. The PPE can be set using commands "*PRE" and read using command "*PRE?".

Event-Status Register (ESR) and Event-Status-Enable Register (ESE)

The ESR is already defined in IEEE 488.2. It can be compared with the EVENt part of an SCPI register. The event status register can be read out using command "*ESR?".
The ESE is the associated ENABle part. It can be set using command "*ESE" and read using command "*ESE?".

Table 5-4   Meaning of the bits in the event status register

Bit No.	Meaning
0	**Operation Complete** This bit is set on receipt of the command *OPC exactly when all previous commands have been executed.
1	This bit is not used
2	**Query Error** This bit is set if either the controller wants to read data from the instrument without having send a query, or if it does not fetch requested data and sends new instructions to the instrument instead. The cause is often a query which is faulty and hence cannot be executed.
3	**Device-dependent Error** This bit is set if a device-dependent error occurs. An error message with a number between -300 and -399 or a positive error number, which denotes the error in greater detail, is entered into the error queue (cf. Chapter 9, Error Messages).
4	**Execution Error** This bit is set if a received command is syntactically correct, however, cannot be performed for other reasons. An error message with a number between -200 and -300, which denotes the error in greater detail, is entered into the error queue (cf. Chapter 9, Error Messages).
5	**Command Error** This bit is set if a command which is undefined or syntactically incorrect is received. An error message with a number between -100 and -200, which denotes the error in greater detail, is entered into the error queue (cf. Chapter 9 "Error Messages").
6	**User Request** This bit is set on pressing the *LOCAL* key.
7	**Power On** (supply voltage on) This bit is set on switching on the instrument.

STATus:OPERation Register

In the CONDition part, this register contains information on which actions the instrument is being executing or, in the EVENt part, information on which actions the instrument has executed since the last reading. It can be read using commands "STATus:OPERation:CONDition?" or "STATus :OPERation[:EVENt]?".

Table 5-5   Meaning of the bits in the STATus.OPERation register

Bit No.	Meaning
0	**CALibrating** This bit is set as long as the instrument is performing a calibration.
1 to 7	These bits are not used
8	**HardCOPy in progress** This bit is set while the instrument is printing a hardcopy.
9	These bits are not used
10 to 14	These bits are not used
15	This bit is always 0

STATus:QUEStionable Register

This register comprises information about indefinite states which may occur if the unit is operated without meeting the specifications. It can be queried by commands `STATus:QUEStionable:CONDition?` and `STATus:QUEStionable[:EVENt]?`.

Table 5-6   Meaning of bits in STATus:QUEStionable register

Bit No.	Meaning
0 to 2	These bits are not used
3	**POWer** This bit is set if a questionable power occurs (cf. also section "STATus:QUEStionable:POWer Register")
4	**TEMPerature** This bit is set if a questionable temperature occurs.
5	**FREQuency** The bit is set if a frequency is questionable (cf. section "STATus:QUEStionable:FREQuency Register")
6 to 7	These bits are not used
8	**CALibration** The bit is set if a measurement is performed uncalibrated ($\triangleq$ label "UNCAL")
9	**LIMit** (device-specific) This bit is set if a limit value is violated (see also section STATus:QUEStionable:LIMit Register)
10	**LMARgin** (device-specific) This bit is set if a margin is violated (see also section STATus:QUEStionable:LMARgin Register)
11	**SYNC** (device-dependent) This bit is set if, in measurements or premeasurements in GSM MS mode, synchronization to midamble fails or no burst is found. This bit is also set if, in premeasurements in GSM MS mode, the result differs too strongly from the expected value (see also "STATus:QUEStionable:SYNC Register").
12	**ACPLimit** (device-specific) This bit is set if a limit for the adjacent channel power measurement is violated (see also section "STATus:QUEStionable:ACPLimit Register")
13 to 14	These bits are not used
15	This bit is always 0.

STATus:QUEStionable:ACPLimit Register

This register comprises information about the observance of limits during adjacent power measurements. It can be queried with commands `'STATus:QUEStionable:ACPLimit :CONDition?'` and `'STATus:QUEStionable:ACPLimit[:EVENt]?'`

Table 5-7   Meaning of bits in STATus:QUEStionable:ACPLimit register

Bit No.	Meaning
0	**ADJ UPPer FAIL(Screen A)** This bit is set if in screen A. the limit is exceeded in the upper adjacent channel
1	**ADJ LOWer FAIL (Screen A)** This bit is set if in screen A the limit is exceeded in the lower adjacent channel.
2	**ALT1 UPPer FAIL (Screen A)** This bit is set if in screen A the limit is exceeded in the upper 1st alternate channel.
3	**ALT1 LOWer FAIL (Screen A)** This bit is set if in screen A the limit is exceeded in the lower 1st alternate channel.
4	**ALT2 UPPer FAIL (Screen A)** This bit is set if in screen A the limit is exceeded in the upper 2nd alternate channel.
5	**ALT2 LOWer FAIL (Screen A)** This bit is set if in screen A the limit is exceeded in the lower 2nd alternate channel.
6 to 7	not used
8	**ADJ UPPer FAIL (Screen B)** This bit is set if in screen B the limit is exceeded in the upper adjacent channel.
9	**ADJ LOWer FAIL (Screen B)** This bit is set if in screen B the limit is exceeded in the lower adjacent channel.
10	**ALT1 UPPer FAIL (Screen B)** This bit is set if in screen B the limit is exceeded in the upper 1st alternate channel.
11	**ALT1 LOWer FAIL (Screen B)** This bit is set if in screen B the limit is exceeded in the lower 1st alternate channel.
12	**ALT2 UPPer FAIL (Screen B)** This bit is set if in screen B the limit is exceeded in the upper 2nd alternate channel.
13	**ALT2 LOWer FAIL (Screen B)** This bit is set if in screen B the limit is exceeded in the lower 2nd alternate channel.
14	not used
15	This bit is always set to 0.

STATus:QUEStionable:FREQuency Register

This register comprises information aboutthe reference and local oscillator.
It can be queried with commands STATus:QUEStionable:FREQuency:CONDition? and "STATus
:QUEStionable:FREQuency[:EVENt]?.

Table 5-8   Meaning of bits in STATus:QUEStionable:FREQuency register

Bit No.	Meaning
0	**OVEN COLD** This bit is set if the reference oscillator has not yet attained its operating temperature. 'OCXO' will then be displayed.
1	**Clock UNLocked** (Screen A) This bit is set if the local oscillator no longer locks. 'CLUNL will then be displayed.
2 to 8	not used
9	**Clock UNLocked** (Screen B) This bit is set if the local oscillator no longer locks.' CLUNL' will then be displayed.
10 to 14	not used
15	This bit is always 0.

STATus:QUEStionable:LIMit<1|2> Register

This register comprises information about the observance of limit lines in the corresponding measurement window (LIMit 1 corresponds to Screen A, LIMit 2 to Screen B). It can be queried with commands `STATus:QUEStionable:LIMit<1|2>:CONDition?` and `STATus:QUEStionable:LIMit<1|2>[:EVENt]?`.

Table 5-9   Meaning of bits in STATus:QUEStionable:LIMit<1|2> register

Bit No.	Meaning
0	**LIMit 1 FAIL** This bit is set if limit line 1 is violated.
1	**LIMit 2 FAIL** This bit is set if limit line 2 is violated.
2	**LIMit 3 FAIL** This bit is set if limit line 3 is violated.
3	**LIMit 4 FAIL** This bit is set if limit line 4 is violated.
4	**LIMit 5 FAIL** This bit is set if limit line 5 is violated.
5	**LIMit 6 FAIL** This bit is set if limit line 6 is violated.
6	**LIMit 7 FAIL** This bit is set if limit line 7 is violated.
7	**LIMit 8 FAIL** This bit is set if limit line 8 is violated.
8 to 14	not used
15	This bit is always 0.

STATus:QUEStionable:LMARgin<1|2> Register

This register comprises information about the observance of limit margins in the corresponding measurement window (LMARgin1 corresponds to Screen A, LMARgin2 corresponds to Screen B). It can be queried with commands `STATus:QUEStionable:LMARgin<1|2>:CONDition?` and `"STATus :QUEStionable:LMARgin<1|2>[:EVENt]?`.

Table 5-10   Meaning of bits in STATus:QUEStionable:LMARgin<1|2> register

Bit No.	Meaning
0	**LMARgin 1 FAIL** This bit is set if limit margin 1 is violated.
1	**LMARgin 2 FAIL** This bit is set if limit margin 2 is violated.
2	**LMARgin 3 FAIL** This bit is set if limit margin 3 is violated.
3	**LMARgin 4 FAIL** This bit is set if limit margin 4 is violated.
4	**LMARgin 5 FAIL** This bit is set if limit margin 5 is violated.
5	**LMARgin 6 FAIL** This bit is set if limit margin 1 is violated.
6	**LMARgin 7 FAIL** This bit is set if limit margin 7 is violated.
7	**LMARgin 8 FAIL** This bit is set if limit margin 8 is violated.
8 to 14	not used
15	This bit is always 0.

STATus:QUEStionable:POWer Register

This register comprises all information about possible overloads of the unit.
It can be queried with commands `STATus:QUEStionable:POWer:CONDition?` and "`STATus:QUEStionable:POWer[:EVENt]?`.

Table 5-11   Meaning of bits in STATus:QUEStionable:POWer register

Bit No.	Meaning
0	not used
1	not usednot used
2	**Baseband Verload** This bit is set if thebaseband signal path is overloaded. 'OVLD' will then be displayed.
3 to 14	not used
15	This bit is always 0.

STATus:QUEStionable:SYNC Register

This register is used only with GSM MS mode. It contains information about sync and bursts not found, and about premeasurement results exceeding or falling short of expected values.
The bits can be queried with commands "STATus:QUEStionable:SYNC:CONDition?" and "STATus:QUEStionable:SYNC[:EVENt]?".

Table 5-12   Meaning of bits in STATus:QUEstionable:SYNC register

Bit No.	Meaning
0	**BURSt not found (screen A)** This bit is set if no burst is found in the measurements/premeasurements for phase/frequency error (PFE) or carrier power versus time (PVT) in GSM MS mode. If a burst is found in these measurements/premeasurements, the bit is reset.
1	**SYNC not found (screen A)** This bit is set if the synchronization sequence (training sequence) of the midamble is not found in the measurements/premeasurements for phase/frequency error (PFE) or carrier power versus time (PVT) in GSM MS mode. If the synchronization sequence (training sequence) of the midamble is found in these measurements/premeasurements, the bit is reset.
2	**No carrier (screen A)** This bit is set if, in GSM MS mode, the level value determined in the premeasurements for carrier power versus time (PVT) and spectrum due to modulation is too low. The bit is reset at the beginning of the premeasurement (see also Chapter 2, description of the named premeasurements).
3	**Carrier overload (screen A)** This bit is set if, in GSM MS mode, the level value determined in the premeasurements for carrier versus time (PVT) and spectrum due to modulation is too high. The bit is reset at the beginning of the premeasurement (see also Chapter 2, description of the named premeasurements).
4-11	Not used.
12	**I Probe Adjust** This bit is set during probe calibration when the probe connected with **Input I** has to be manually adjusted. After the manual adjustment is finished, the probe calibration process will continue with INIT:CONM.
13	**Q Probe Adjust** This bit is set during probe calibration when the probe connected with **Input Q** has to be manually adjusted. After the manual adjustment is finished, the probe calibration process will continue with INIT:CONM.
14	Not used.
15	This bit is always 0.

Application of the Status Reporting Systems

In order to be able to effectively use the status reporting system, the information contained there must be transmitted to the controller and further processed there. There are several methods which are represented in the following. Detailed program examples are to be found in chapter 7, Program Examples.

Service Request, Making Use of the Hierarchy Structure

Under certain circumstances, the instrument can send a service request (SRQ) to the controller. Usually this service request initiates an interrupt at the controller, to which the control program can react with corresponding actions. As evident from Fig. 5-4, an SRQ is always initiated if one or several of bits 2, 3, 4, 5 or 7 of the status byte are set and enabled in the SRE. Each of these bits combines the information of a further register, the error queue or the output buffer. The corresponding setting of the ENABle parts of the status registers can achieve that arbitrary bits in an arbitrary status register initiate an SRQ. In order to make use of the possibilities of the service request, all bits should be set to "1" in enable registers SRE and ESE.

Examples (cf. Fig. 5-4 and chapter 7, Program Examples, as well):

Use of command "*OPC" to generate an SRQ at the end of a sweep.

  ➢ `CALL IBWRT(analyzer%, "*ESE 1")` Set bit 0 in the ESE (Operation Complete)
  ➢ `CALL IBWRT(analyzer%, "*SRE 32")` Set bit 5 in the SRE (ESB)?

   After its settings have been completed, the instrument generates an SRQ.

The SRQ is the only possibility for the instrument to become active on its own. Each controller program should set the instrument in a way that a service request is initiated in the case of malfunction. The program should react appropriately to the service request. A detailed example for a service request routine is to be found in chapter 7, Program Examples.

Serial Poll

In a serial poll, just as with command "*STB", the status byte of an instrument is queried. However, the query is realized via interface messages and is thus clearly faster. The serial-poll method has already been defined in IEEE 488.1 and used to be the only standard possibility for different instruments to poll the status byte. The method also works with instruments which do not adhere to SCPI or IEEE 488.2.

The VISUAL BASIC command for executing a serial poll is "IBRSP()". Serial poll is mainly used to obtain a fast overview of the state of several instruments connected to the IEC bus.

Parallel Poll

In a parallel poll, up to eight instruments are simultaneously requested by the controller by means of a single command to transmit 1 bit of information each on the data lines, i.e., to set the data line allocated to each instrument to logically "0" or "1". By analogy to the SRE register which determines under which conditions an SRQ is generated, there is a parallel poll enable register (PPE) which is ANDed with the STB bit by bit as well considering bit 6. The results are ORed, the result is then sent (possibly inverted) as a response in the parallel poll of the controller. The result can also be queried without parallel poll by means of command "*IST".

The instrument first has to be set for the parallel poll using quick-BASIC command "IBPPC()". This command allocates a data line to the instrument and determines whether the response is to be inverted. The parallel poll itself is executed using "IBRPP()".

The parallel-poll method is mainly used in order to quickly find out after an SRQ which instrument has sent the service request if there are many instruments connected to the IEC bus. To this effect, SRE and PPE must be set to the same value. A detailed example as to the parallel poll is to be found in chapter 7, Program Examples.

Query by Means of Commands

Each part of every status register can be read by means of queries. The individual commands are indicated in the detailed description of the registers in Section 3.8.3. What is returned is always a number which represents the bit pattern of the register queried. Evaluating this number is effected by the controller program.

Queries are usually used after an SRQ in order to obtain more detailed information on the cause of the SRQ.

Error-Queue Query

Each error state in the instrument leads to an entry in the error queue. The entries of the error queue are detailed plain-text error messages which can be looked at in the ERROR menu via manual control or queried via the IEC bus using command "SYSTem:ERRor?". Each call of "SYSTem:ERRor?" provides an entry from the error queue. If no error messages are stored there any more, the instrument responds with 0, "No error".

The error queue should be queried after every SRQ in the controller program as the entries describe the cause of an error more precisely than the status registers. Especially in the test phase of a controller program the error queue should be queried regularly since faulty commands from the controller to the instrument are recorded there as well.

Resetting Values of the Status Reporting System

Table 5-13 comprises the different commands and events causing the status reporting system to be reset. None of the commands, except for *RST and SYSTem:PRESet influences the functional instrument settings. In particular, DCL does not change the instrument settings.

Table 5-13Resettting instrument functions

Event	Switching on supply voltage		DCL,SDC	*RST or SYSTem:PRESet	STATus:PRESet	*CLS
	Power-On-Status-Clear		(Device Clear, Selected Device Clear)			
Effect	0	1				
Clear STB,ESR	—	yes	—	—	—	yes
Clear SRE,ESE	—	yes	—	—	—	—
Clear PPE	—	yes	—	—	—	—
Clear EVENTt parts of the registers	—	yes	—	—	—	yes
Clear Enable parts of all OPERation and QUEStionable registers, Fill Enable parts of all other registers with "1".	—	yes	—	—	yes	—
Fill PTRansition parts with "1" , Clear NTRansition parts	—	yes	—	—	yes	—
Clear error queue	yes	yes	—	—	—	yes
Clear output buffer	yes	yes	yes	1)	1)	1)
Clear command processing and input buffer	yes	yes	yes	—	—	—

1) Every command being the first in a command line, i.e., immediately following a <PROGRAM MESSAGE TERMINATOR> clears the output buffer.

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6   Remote Control - Description of Commands

Notation

In the following sections, all commands implemented in the instrument are first listed in tables and then described in detail, arranged according to the command subsystems. The notation is adapted to the SCPI standard. The SCPI conformity information is included in the individual description of the commands.

Table of Commands

Command: In the command column, the table provides an overview of the commands and their hierarchical arrangement (see indentations).

Parameter: The parameter column indicates the requested parameters together with their specified range.

Unit: The unit column indicates the basic unit of the physical parameters.

Comment: In the comment column an indication is made on:
 – whether the command does not have a query form,
 – whether the command has only one query form
 – whether the command is implemented only with a certain option of the instrument

Indentations   The different levels of the SCPI command hierarchy are represented in the table by means of indentations to the right. The lower the level, the further the indentation to the right. Please note that the complete notation of the command always includes the higher levels as well.

Example: `SENSe:FREQuency:CENTer` is represented in the table as follows:

`SENSe`	first level
`:FREQuency`	second level
`:CENTer`	third level

Individual description   The individual description contains the complete notation of the command. An example for each command, the *RST value and the SCPI information are included as well.

Note: *The baseband analysis (FFT) mode is implemented in the basic unit. For the other modes, the corresponding options are required.*

Upper/lower case notation Upper/lower case letters are used to mark the long or short form of the key words of a command in the description (see Chapter 5). The instrument itself does not distinguish between upper and lower case letters.

Special characters | A selection of key words with an identical effect exists for several commands. These keywords are indicated in the same line; they are separated by a vertical stroke. Only one of these keywords needs to be included in the header of the command. The effect of the command is independent of which of the keywords is used.

Example: `SENSe:FREQuency:CW|:FIXed`

> The two following commands with identical meaning can be created. They set the frequency of the fid frequency signal to 1 kHz:

`SENSe:FREQuency:CW 1E3` = `SENSe:FREQuency:FIXed 1E3`

A vertical stroke in parameter indications marks alternative possibilities in the sense of "or". The effect of the command is different, depending on which parameter is used.

Example: Selection of the parameters for the command

> `DISPlay:FORMat   FULL | SPLit`

> If parameter FULL is selected, full screen is displayed, in the case of SPLit, split screen is displayed.

[ ] Key words in square brackets can be omitted when composing the header (cf. Chapter 5, Optional Keywords). The full command length must be accepted by the instrument for reasons of compatibility with the SCPI standards.
Parameters in square brackets can be incorporated optionally in the command or omitted as well.

{ } Parameters in braces can be incorporated optionally in the command, either not at all, once or several times.

Description of parameters Due to the standardization, the parameter section of SCPI commands consists always of the same syntactical elements. SCPI has therefore specified a series of definitions, which are used in the tables of commands. In the tables, these established definitions are indicated in angled brackets (< to >) and will be briefly explained in the following (see also Chapter 5, Section "Parameters").

<Boolean> This keyword refers to parameters which can adopt two states, "on" and "off". The "off" state may either be indicated by the keyword **OFF** or by the numeric value 0, the "on" state is indicated by **ON** or any numeric value other than zero. Parameter queries are always returned the numeric value 0 or 1.

<numeric_value>

<num>　　　　　　These keywords mark parameters which may be entered as numeric values or be set using specific keywords (character data).

The following keywords given below are permitted:

MINimum　　This keyword sets the parameter to the smallest possible value.

MAXimum　　This keyword sets the parameter to the largest possible value.

DEFault　　This keyword is used to reset the parameter to its default value.

UP　　　　This keyword increments the parameter value.

DOWN　　　This keyword decrements the parameter value.

The numeric values associated to MAXimum/MINimum/DEFault can be queried by adding the corresponding keywords to the command. They must be entered following the quotation mark.

Example: `SENSe:FREQuency:CENTer? MAXimum`

returns the maximum possible numeric value of the center frequency as result.

<arbitrary block program data>

　　　　　　This keyword is provided for commands the parameters of which consist of a binary data block.

Common Commands

The common commands are taken from the IEEE 488.2 (IEC 625-2) standard. A particular command has the same effect on different devices. The headers of these commands consist of an asterisk "*" followed by three letters. Many common commands refer to the status reporting system which is described in detail in Chapter 5.

Command	Parameter	Function	Comment
*CAL?		Calibration Query	query only
*CLS		Clear Status	no query
*ESE	0 to 255	Event Status Enable	
*ESR?		Standard Event Status Query	query only
*IDN?		Identification Query	query only
*IST?		Individual Status Query	query only
*OPC		Operation Complete	
*OPT?		Option Identification Query	query only
*PCB	0 to 30	Pass Control Back	no query
*PRE	0 to 255	Parallel Poll Register Enable	
*PSC	0 | 1	Power On Status Clear	
*RST		Reset	no query
*SRE	0 to 255	Service Request Enable	
*STB?		Status Byte Query	query only
*TRG		Trigger	no query
*TST?		Self Test Query	query only
*WAI		Wait to continue	no query

*CAL?

>   **CALIBRATION QUERY** initiates a calibration of the instrument and subsequently queries the calibration status. Any responses > 0 indicate errors.

*CLS

>   **CLEAR STATUS** sets the status byte (STB), the standard event register (ESR) and the EVENt-part of the QUEStionable and the OPERation register to zero. The command does not alter the mask and transition parts of the registers. It clears the output buffer.

*ESE 0 to 255

>   **EVENT STATUS ENABLE** sets the event status enable register to the value indicated. The query form *ESE? returns the contents of the event status enable register in decimal form.

*ESR?

>   **STANDARD EVENT STATUS QUERY** returns the contents of the event status register in decimal form (0 to 255) and subsequently sets the register to zero.

*IDN?

>   **IDENTIFICATION QUERY** queries the instrument identification.
>   Example: " Rohde&Schwarz, R&S FMU-36, 123456/789, 4.08"
>   R&S FMU-36   = Device name
>   123456/789 = Serial number of the instrument
>   4.08   = Firmware version number

*IST?

>   **INDIVIDUAL STATUS QUERY** returns the contents of the IST flag in decimal form (0 | 1). The IST flag is the status bit which is sent during a parallel poll (cf. Chapter 5).

*OPC

>   **OPERATION COMPLETE** sets bit 0 in the event status register when all preceding commands have been ecuted. This bit can be used to initiate a service request (cf. Chapter 5).

*OPC?

>   **OPERATION COMPLETE QUERY** writes message "1" into the output buffer as soon as all preceding commands have been ecuted (cf. Chapter 5).

*OPT?

OPTION IDENTIFICATION QUERY queries the options included in the instrument and returns a list of the options installed. The options are separated from each other by means of commas.

Position	Option	
1		reserved
2	B4	OCXO
3		reserved
4		reserved
5		reserved
6		reserved
7		reserved
8		reserved
9		reserved
11		reserved
10		reserved
11 to 12		reserved
13		reserved
14		LAN Interface
15 to 18		reserved
19		reserved
20 to 22		reserved
23		reserved
24	FS-K74	HSDPA BTS
25		reserved
26	FS-K76	SCDMA BTS
27		reserved
28		reserved
29		reserved
30	FS-K5	GSM-GSM/EDGE
31		reserved
32	FS-K7	FM Demodulator
33	FS-K8	Application Firmware Bluetooth® Transmitter Measurement
34		reserved
35	FS-K72	WCDMA 3G FDD BTS
36	FS-K73	WCDMA 3G FDD UE
37		reserved
38	FS-K82	CDMA2000 Downlink
39	FS-K83	CDMA2000 Uplink
40	FS-K84	1xEV-DO Downlink
41	FS-K85	1xEV-DOUpnlink
42		reserved
43	FSQ-K90	W-Lan 802.11a reserved
44	FSQ-K91	W-Lan 802.11b/g reserved
45	FSQ-K92	W-Lan 802.16 reserved
46		reserved
47		reserved
48		reserved
49	FSQ-K70	Vector signal analysis
50 to 51		reserved

Example:
0,B4,0,0,0,0,0,B10,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,K70,0,0

*PCB 0 to 30

　　PASS CONTROL BACK indicates the controller address which the IEC-bus control is to be returned to after termination of the triggered action.

*PRE 0 to 255

　　PARALLEL POLL REGISTER ENABLE sets the parallel poll enable register to the indicated value. The query form *PRE? returns the contents of the parallel poll enable register in decimal form.

*PSC 0 | 1

　　POWER ON STATUS CLEAR determines whether the contents of the ENABle registers are preserved or reset during power-up.

　　*PSC = 0　　causes the contents of the status registers to be preserved. Thus a service request can be generated when switching on the instrument, if the status registers ESE and SRE are suitably configured.

　　*PSC $\neq$ 0　　'Resets the registers.

　　The query form *PSC? reads out the contents of the power-on-status-clear flag. The response can be 0 or 1.

*RST

　　RESET sets the instrument to a defined default status. The command essentially corresponds to pressing the *PRESET* key. The default setting is indicated in the description of the commands.

*SRE 0 to 255

　　SERVICE REQUEST ENABLE sets the service request enable register to the indicated value. Bit 6 (MSS mask bit) remains 0. This command determines under which conditions a service request is generated. The query form *SRE? reads the contents of the service request enable register in decimal form. Bit 6 is always 0.

*STB?

　　READ STATUS BYTE QUERY reads out the contents of the status byte in decimal form.

*TRG

　　TRIGGER initiates all actions in the currently active test screen expecting a trigger event. This command corresponds to `INITiate:IMMediate` (cf. Section "TRIGger Subsystem").

*TST?

　　SELF TEST QUERY initiates the selftest of the instrument and outputs an error code in decimal form (0 = no error).

*WAI

　　WAIT-to-CONTINUE permits servicing of subsequent commands only after all preceding commands have been ecuted and all signals have settled (cf. Chapter 5 and "*OPC" as well).

ABORt Subsystem

The ABORt subsystem contains the commands for aborting triggered actions. An action can be triggered again immediately after being aborted. All commands trigger events, and therefore they have no *RST value.

Command	Parameters
ABORt	

ABORt

This command aborts a current measurement and resets the trigger system

Example: `"ABOR;INIT:IMM"`

Characteristics: ***RST value:**   0
SCPI: conforming

CALCulate Subsystem

The CALCulate subsystem contains commands for converting instrument data, transforming and carrying out corrections. These functions are carried out subsequent to data acquistion, i.e. following the SENSe subsystem.

The numeric suffix is used in CALCulate to make the distinction between the two measurement windows SCREEN A and SCREEN B:

CALCulate1 = Screen A
CALCulate2 = Screen B.

For commands without suffix, screen A is selected automatically.

Full Screen	The settings are valid for the measurement window selected with the numeric suffix. They become effective as soon as the corresponding measurement window has been selected as active measurement window using the command `DISPLay[:WINDow<1|2>]:SELect`. Triggering measurements and querying measured values is possible only in the active measurement window.
Split Screen	The settings are valid for the measurement window selected by means of the numeric suffix and become effective immediately.
Notes:	*All GSM measurements are performed in screen A. Therefore, commands carrying a numerical suffix selecting the screen should start either with the numerical suffix 1 (i.e.* `CALCulate1`*) or without a numerical suffix (i.e.* `CALCulate`*).*

CALCulate:DELTamarker Subsystem

The CALCulate:DELTamarker subsystem controls the delta-marker functions in the instrument. The measurement windows are selected via CALCulate1 (screen A) or 2 (screen B).

Command	Parameters
CALCulate<1|2>:DELTamarker<1 to 4>:AOFF	
CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:FIXed:RPOint:MAXimum[:PEAK]	!<numeric_value>
CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:FIXed:RPOint:X	<numeric_value>
CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:FIXed:RPOint:Y	
CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:FIXed:RPOint:Y:OFFSet	<numeric_value>
CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:FIXed[:STATe]	ON | OFF
CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:PNOise:AUTO	ON | OFF
CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:PNOise:RESult?	
CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:PNOise[:STATe]	ON | OFF
CALCulate<1|2>:DELTamarker<1 to 4>:LINK	ON | OFF
CALCulate<1|2>:DELTamarker<1 to 4>:MAXimum:LEFT	
CALCulate<1|2>:DELTamarker<1 to 4>:MAXimum:NEXT	
CALCulate<1|2>:DELTamarker<1 to 4>:MAXimum[:PEAK]	
CALCulate<1|2>:DELTamarker<1 to 4>:MAXimum:RIGHt	
CALCulate<1|2>:DELTamarker<1 to 4>:MINimum:LEFT	
CALCulate<1|2>:DELTamarker<1 to 4>:MINimum:NEXT	
CALCulate<1|2>:DELTamarker<1 to 4>:MINimum[:PEAK]	
CALCulate<1|2>:DELTamarker<1 to 4>:MINimum:RIGHt	
CALCulate<1|2>:DELTamarker<1 to 4>:MODE	ABSolute | RELative
CALCulate<1|2>:DELTamarker<1 to 4>[:STATe]	ON | OFF
CALCulate<1|2>:DELTamarker<1 to 4>:TRACe	1 to 3
CALCulate<1|2>:DELTamarker<1 to 4>:X	0 to MAX (frequency | sweep time)
CALCulate<1|2>:DELTamarker<1 to 4>:X:RELative?	
CALCulate<1|2>:DELTamarker<1 to 4>:Y?	

CALCulate<1|2>:DELTamarker<1 to 4>:AOFF

> This command switches off all active delta markers in the selected measurement window (screen A or screen B).
>
> **Example:**   `"CALC2:DELT:AOFF"`   'Switches off all delta markers in screen B.
>
> **Characteristics:**   *RST value: -
>   SCPI: device-specific
>
> This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:FIXed:RPOint:MAXimum[:PEAK] <numeric_value>

This command sets the reference point level for all delta markers in the selected measurement window for a measurement with fid reference point (CALC:DELT:FUNC:FIX:STAT ON) to the peak of the selected trace.
For phase-noise measurements (CALCulate:DELTamarker:FUNCtion:PNOise:STATe ON), the command defines a new reference point level for delta marker 2 in the selected measurement window.

Example: "CALC:DELT:FUNC:FIX:RPO:MAX"

Characteristics: *RST value: -
                      SCPI: device-specific

CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:FIXed:RPOint:X <numeric_value>

This command defines a new reference frequency (span > 0) or time (span = 0) for all delta markers in the selected measurement window for a measurement with fid reference value (CALCulate:DELTamarker:FUNCtion:FIXed:STATe ON).
For phase-noise measurements (CALCulate:DELTamarker:FUNCtion:PNOise:STATe ON), the command defines a new reference frequency or time for delta marker 2 in the selected measurement window.

Example: "CALC:DELT:FUNC:FIX:RPO:X 12MHz"   'Sets the reference frequency in
                                                             'screen A to 12 MHz.

Characteristics: *RST value: - (FUNction:FIXed[:STATe] is set to OFF)
                      SCPI: device-specific

CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:FIXed:RPOint:Y <numeric_value>

This command defines a new reference point level for all delta markers in the selected measurement window for a measurement with fid reference point.
(CALCulate:DELTamarker:FUNCtion:FIXed:STATe ON).
For phase-noise measurements (CALCulate:DELTamarker:FUNCtion:PNOise:STATe ON), the command defines a new reference point level for delta marker 2 in the selected measurement window.

Example: "CALC:DELT:FUNC:FIX:RPO:Y –10dBm"   'Sets the reference point level for
                                                             'delta markers in screen A to -10
                                                             'dBm.

Characteristics: *RST value: - (FUNction:FIXed[:STATe] is set to OFF)
                      SCPI: device-specific

CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:FIXed:RPOint:Y:OFFSet <numeric_value>

This command defines an additional level offset for the measurement with fid reference value (CALCulate:DELTamarker:FUNCtion:FIXed:STATe ON). For this measurement, the offset is included in the display of all delta markers of the selected measurement window.
For phase-noise measurements (CALCulate:DELTamarker:FUNCtion:PNOise:STATe ON), the command defines an additional level offset which is included in the display of delta marker 2 in the selected measurement window.

Example: "CALC:DELT:FUNC:FIX:RPO:Y:OFFS 10dB"
                      'Sets the level offset for the measurement with fid reference
                      'value or the phase-noise measurement in screen A to 10 dB.

Characteristics: *RST value: 0 dB
                      SCPI: device-specific

CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:FIXed[:STATe]   ON | OFF

This command switches the relative measurement to a fid reference value on or off.   Marker 1 will be activated previously and a peak search will be performed, if necessary. If marker 1 is activated, its position becomes the reference point for the measurement. The reference point can then be modified with commands `CALCulate:DELTamarker:FUNCtion:FIXed:RPOint:X` and `to :RPOint:Y` independently of the position of marker 1 and of a trace. It is valid for all delta markers in the selected measurement window as long as the function is active.

Example:	`"CALC:DELT:FUNC:FIX ON"`	'Switches on the measurement with fid 'reference value for all delta markers in 'screen B.
	`"CALC:DELT:FUNC:FIX:RPO:X 14 MHZ"`	'Sets the reference frequency 'in screen A to 14 MHz.
	`"CALC:DELT:FUNC:FIX:RPO:Y 30 DBM"`	'Sets the reference level in 'screen A to +30 dBm

Characteristics:	*RST value:	OFF
	SCPI:	device-specific.

CALCultate<1|2>:DELTamarker<1…4>:FUNCtion:PNOise:AUTO   ON | OFF

This command activates an automatic peak search for the phase-noise measurement.

Example:	`"CALC:DELT:FUNC:PNO 1"`	'Switches on the phase-noise measurement.
	`"CALC:DELT:FUNC:PNO:AUTO 1"`	Activates the automatic peak search.

Characteristics:	*RST value:	OFF
	SCPI:	device-specific.

CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:PNOise:RESult?

This command queries the result of the phase-noise measurement in the selected measurement window.The measurement will be switched on, if necessary.

Example:	`"CALC:DELT:FUNC:PNO:RES?"`	'Outputs the result of phase-noise 'measurement of the selected delta marker in 'screen A.

Characteristics:	*RST value:	-
	SCPI:	device-specific

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:PNOise[:STATe] ON | OFF

This command switches on or off the phase-noise measurement with all active delta markers in the selected measurement window. The correction values for the bandwidth and the log amplifier are taken into account in the measurement.
Marker 1 will be activated, if necessary, and a peak search will be performed. If marker 1 is activated, its position becomes the reference point for the measurement.
The reference point can then be modified with commands `CALCulate:DELTamarker` `:FUNCtion:FIXed:RPOint:X` and ` to :RPOint:Y` independently of the position of marker 1 and of a trace (the same commands used for the measurement with fid reference point).
The numeric suffix <1 to 4> with `DELTamarker` is not relevant for this command.

Note: *This command is not available during GSM measurements.*

Example:	`"CALC:DELT:FUNC:PNO ON"`	'Switches on the phase-noise measurement 'with all delta markers in screen A.
	`"CALC:DELT:FUNC:FIX:RPO:X 12 MHZ"`	'Sets the reference frequency 'to '12 MHz.
	`"CALC:DELT:FUNC:FIX:RPO:Y 10 DBM"`	'Sets the reference level to +10 dBm

| **Characteristics:** | *RST value: | OFF |
| | SCPI: | device-specific |

CALCulate<1|2>:DELTamarker<1 to 4>:LINK ON | OFF

This command switches on and off the delta marker when delta marker 1 is selected. The corresponding marker becomes the delta marker when delta marker 2 to 4 is selected. If the corresponding marker is not activated, it will be activated and positioned on the maximum of the measurement curve.
If no numeric suffix is indicated, delta marker 1 is selected automatically.

| **Example:** | `"CALC:DELT3 ON"` | 'Switches marker 3 in screen A to delta marker mode. |

| **Characteristics:** | *RST value: | OFF |
| | SCPI: | device-specific |

CALCulate<1|2>:DELTamarker<1 to 4>:MAXimum:LEFT

This command positions the delta marker to the next smaller maximum value to the left of the current value (i.e. descending X values). The corresponding delta marker will be activated first, if necessary.

| **Example:** | `"CALC:DELT:MAX:LEFT"` | 'Sets delta marker 1 in screen A to the next smaller 'maximum value to the left of the 'current value. |

| **Characteristics:** | *RST value: | - |
| | SCPI: | device-specific |

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:DELTamarker<1 to 4>:MAXimum:NEXT

This command positions the delta marker to the next smaller maximum value on the measured curve. The corresponding delta marker will be activated first, if necessary.

| **Example:** | `"CALC1:DELT2:MAX:NEXT"` | 'Sets delta marker 2 in screen A to the next 'smaller maximum value. |

| **Characteristics:** | *RST value: | - |
| | SCPI: | device-specific |

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:DELTamarker<1 to 4>:MAXimum[:PEAK]

This command positions the delta marker to the current maximum value on the measured curve. If necessary, the corresponding delta marker will be activated first.

Example:　　　　　"CALC2:DELT3:MAX"　　　　　'Sets delta marker 3 in screen B to the
　　　　　　　　　　　　　　　　　　　　　　　　　　　'maximum value of the associated trace.

Characteristics:　　*RST value:　　　-
　　　　　　　　　　　SCPI:　　　　　　　device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:DELTamarker<1 to 4>:MAXimum:RIGHt

This command positions the delta marker to the next smaller maximum value to the right of the current value (i.e. ascending X values).
The corresponding delta marker is activated first, if necessary.

Example:　　　　　"CALC2:DELT:MAX:RIGH"　　　'Sets delta marker 1 in screen B to the next
　　　　　　　　　　　　　　　　　　　　　　　　　　　'smaller maximum value to the right of the
　　　　　　　　　　　　　　　　　　　　　　　　　　　'current value.

Characteristics:　　*RST value:　　　-
　　　　　　　　　　　SCPI:　　　　　　　device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:DELTamarker<1 to 4>:MINimum:LEFT

This command positions the delta marker to the next higher minimum value to the left of the current value (i.e. descending X values). The corresponding delta marker will be activated first, if necessary.

Example:　　　　　"CALC:DELT:MIN:LEFT"　　　　'Sets delta marker 1 in screen A to the next
　　　　　　　　　　　　　　　　　　　　　　　　　　　'higher minimum to the left of the current
　　　　　　　　　　　　　　　　　　　　　　　　　　　'value.

Characteristics:　　*RST value:　　　-
　　　　　　　　　　　SCPI:　　　　　　　device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:DELTamarker<1 to 4>:MINimum:NEXT

This command positions the delta marker to the next higher minimum value of the measured curve. The corresponding delta marker will be activated first, if necessary.

Example:　　　　　"CALC1:DELT2:MIN:NEXT"　　　'Sets delta marker 2 in screen A to the next
　　　　　　　　　　　　　　　　　　　　　　　　　　　higher minimum value.

Characteristics:　　*RST value:　　　-
　　　　　　　　　　　SCPI:　　　　　　　device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:DELTamarker<1 to 4>:MINimum[:PEAK]

This command positions the delta marker to the current minimum value on the measured curve. The corresponding delta marker will be activated first, if necessary.

Example: `"CALC2:DELT3:MIN"`   'Sets delta marker 3 in screen B to the 'minimum value of the associated trace.

Characteristics: *RST value: -
                      SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:DELTamarker<1 to 4>:MINimum:RIGHt

This command positions the delta marker to the next higher minimum value to the right of the current value (i.e. ascending X values). The corresponding delta marker will be activated first, if necessary.

Example: `"CALC2:DELT:MIN:RIGH"`   'Sets delta marker 1 in screen B to the next 'higher minimum value to the right of the current value.

Characteristics: *RST value: -
                      SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:DELTamarker<1 to 4>:MODE ABSolute | RELative

This command switches between relative and absolute frequency input of the delta marker (or time with span = 0). It affects all delta markers independent of the measurement window.

Example: `"CALC:DELT:MODE ABS"`   'Switches the frequency/time indication for all delta markers to absolute values.
                      `"CALC:DELT:MODE REL"`   'Switches the frequency/time indication for all 'delta markers to relative to marker 1.

Characteristics: *RST value: REL
                      SCPI: device-specific

CALCulate<1|2>:DELTamarker<1 to 4>[:STATe] ON | OFF

This command switches on and off the delta marker when delta marker 1 is selected. The corresponding marker becomes the delta marker when delta marker 2 to 4 is selected. If the corresponding marker is not activated, it will be activated and positioned on the maximum of the measurement curve.
If no numeric suffix is indicated, delta marker 1 is selected automatically.

Example: `"CALC:DELT3 ON"`   'Switches marker 3 in screen A to delta marker mode.

Characteristics: *RST value: OFF
                      SCPI: device-specific

CALCulate<1|2>:DELTamarker<1 to 4>:TRACe 1 to 3

This command assigns the selected delta marker to the indicated measurement curve in the indicated measurement window. The selected measurement curve must be active, i.e. its state must be different from "BLANK".

Example: `"CALC:DELT3:TRAC 2"`   'Assigns deltamarker 3 to trace 2 in screen A.
                      `"CALC:DELT:TRAC 3"`   'Assigns deltamarker 1 to trace 3 in screen B.

Characteristics: *RST value: -
                      SCPI: device-specific

CALCulate<1|2>:DELTamarker<1 to 4>:X   0 to MAX (frequency | sweep time)

This command positions the selected delta marker in the indicated measurement window to the indicated frequency (span > 0), time (span = 0) or level (APD measurement = ON or CCDFmeasurement = ON). The input is in absolute values or relative to marker 1 depending on the command `CALCulate:DELTamarker:MODE`. If Reference Fid measurement (`CALCulate:DELTamarker:FUNCtion:FIXed:STATe ON`) is active, relative values refer to the reference position are entered. The query always returns absolute values.

Example:	`"CALC:DELT:MOD  REL"`	'Switches the input for all delta markers to 'relative to marker 1.
	`"CALC:DELT2:X  10.7MHz"`	'Positions delta marker 2 in screen A '10.7 MHz to the right of marker 1.
	`"CALC2:DELT:X?"`	'Outputs the absolute frequency/time of delta 'marker 1 in screen B
	`"CALC2:DELT:X:REL?"`	'Outputs the relative frequency/time/level of 'delta marker 1 in screen B
Characteristics:	*RST value: -	
	SCPI: device-specific	

CALCulate<1|2>:DELTamarker<1 to 4>:X:RELative?

This command queries the frequency (span > 0) or time (span = 0) of the selected delta marker relative to marker 1 or to the reference position (for `CALCulate:DELTamarker:FUNCtion:FIXed:STATe ON`). The command activates the corresponding delta marker, if necessary.

Example:	`"CALC:DELT3:X:REL?"`	'Outputs the frequency of delta marker 3 in 'screen B relative to marker 1 or relative to the 'reference position.
Characteristics:	*RST value: -	
	SCPI: device-specific	

CALCulate<1|2>:DELTamarker<1 to 4>:Y?

This command queries the measured value of the selected delta marker in the indicated measurement window. The corresponding delta marker will be activated, if necessary. The output is always a relative value referred to marker 1 or to the reference position (reference fid active).

To obtain a valid query result, a complete sweep with synchronization to the sweep end must be performed between the activation of the delta marker and the query of the y value. This is only possible in single sweep mode.

Depending on the unit defined with `CALC:UNIT` or on the activated measuring functions, the query result is output in the units below:

- DBM | DBPW | DBUV | DBMV | DBUA: Output unit DB
- WATT | VOLT | AMPere: Output unit W | V | A
- Statistics function (APD or CCDF) on: Dimensionless output

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"CALC:DELT2 ON"`	'Switches on delta marker 2 in screen A.
	`"INIT;*WAI"`	'Starts a sweep and waits for its end.
	`"CALC:DELT2:Y?"`	'Outputs measurement value of delta marker 2 in 'screen A.
Characteristics:	*RST value: -	
	SCPI: device-specific	

CALCulate:FORMat subsystem

The CALCulate:FORMat subsystem determines the postprocessing and conversion of measured data. The measurement window is selected via CALCulate1 (SCREEN A) or CALCulate2 (SCREEN B).

Command	Parameters
CALCulate<1|2>::FORMat	MAGNitude | PHASe | UPHase | RIMag | MPHase | VOLTage

:CALCulate<1|2>:FORMat   MAGNitude | PHASe | UPHase | RIMag | MPHase | VOLTage

This command defines the display of traces.
The availability of the parameters depends on the FREQUENCY DOMAIN/TIME DOMAIN setting

MAGNitude	Display of magnitude.
	This parameter is available in both the frequency and time domains.
RIMag	Display of real and imaginary component of spectrum.
	This parameter is available only in the frequency domain.
MPHase	Display of magnitude and phase of spectrum.
	This parameter is available only in the frequency domain.
VOLTage	Display of voltage.
	This parameter is available only in the time domain.
PHASe	Display of phase with limitation to ±180 deg or . ± π (PHASE WRAP).
	This parameter is available only in the phase diagram.
UPHASe	Display of phase without limitation to ±180 deg or . ± π (PHASE UNWRAP).
	This parameter is available only in the phase diagram.

Example: `":CALC:FORM MPH"`   Display of magnitude/phase diagram

Characteristics: *RST value: MAGNitude
                       SCPI: conforms to standard

CALCulate:LIMit Subsystem

The CALCulate:LIMit subsystem consists of the limit lines and the corresponding limit checks. Limit lines can be defined as upper or lower limit lines. The individual Y values of the limit lines correspond to the values of the X axis (CONTrol). The number of X and Y values must be identical.

8 limit lines can be active at the same time (marked by LIMIT1 to LIMIT8) in screen A and/or screen B. The measurement windows is selected via CALCulate 1 (screen A) or 2 (screen B).

The limit check can be switched on separately for each measurement screen and limit line. WINDow1 corresponds to screen A, WINDow2 to screen B.

Each limit line can be assigned a name (max. 8 letters) under which the line is stored in the instrument. An explanatory comment can also be given for each line (max. 40 characters).

Example (analyzer mode):
Definition and use of a new limit line 5 for trace 2 in screen A and trace 1 in screen B with the following features:

- upper limit line
- absolute X axis in the frequency domain
- 5 ref. values:12 MHz/-40 dB, 13 MHz/-40 dB, 14 MHz/-20 dB, 15 MHz/-40 dB, 16 MHz/-40 dB
- relative Y axis with unit dB
- absolute threshold value at -35 dBm
- no safety margin

Definition of the line:

1. Defining the name: `CALC:LIM5:NAME 'TEST1'`
2. Entering the comment: `CALC:LIM5:COMM 'Upper limit line'`
3. Associated trace in screen A: `CALC1:LIM5:TRAC 2`
4. Associated trace in screen B: `CALC2:LIM5:TRAC 1`
5. Defining the X axis range: `CALC:LIM5:CONT:DOM FREQ`
6. Defining the X axis scaling: `CALC:LIM5:CONT:MODE ABS`
7. Defining the Y axis unit: `CALC:LIM5:UNIT DB`
8. Defining the Y axis scaling: `CALC:LIM5:UPP:MODE REL`
9. Defining the X axis values: `CALC:LIM5:CONT 12MHZ, 13MHZ, 14MHZ, 15MHZ, 16MHZ`
10. Defining the y values: `CALC:LIM5:UPP -40, -40, -30, -40, -40`
11. Defining the y threshold value: `CALC:LIM5:UPP:THR -35DBM`

The definition of the safety margin and shifting in X and/or Y direction can take place as from here (see commands below).

Switching on and evaluating the line in screen A:

1. Switching on the line in screen A: `CALC1:LIM5:UPP:STAT ON`
2. Switching on the limit check in screen A: `CALC1:LIM5:STAT ON`
3. Starting a new measurement with synchronization: `INIT;*WAI`
4. Querying the limit check result: `CALC1:LIM5:FAIL?`

Switching on and evaluating the line in screen B is performed in the same way by using `CALC2` instead of `CALC1`.

Command	Parameters
CALCulate<1|2>:LIMit<1 to 8>:CATalog?	
CALCulate<1|2>:LIMit<1 to 8>:CLEar[:IMMediate]	
CALCulate<1|2>:LIMit<1 to 8>:COMMent	<string>
CALCulate<1|2>:LIMit<1 to 8>:COPY	1 to 8 | <name>
CALCulate<1|2>:LIMit<1 to 8>:DELete	1 to 8 | <name>
CALCulate<1|2>:LIMit<1 to 8>:FAIL?	
CALCulate<1|2>:LIMit<1 to 8>:NAME	1 to 8 | <name>
CALCulate<1|2>:LIMit<1 to 8>:STATe	ON | OFF
CALCulate<1|2>:LIMit<1 to 8>:TRACe	1 to 3
CALCulate<1|2>:LIMit<1..8>:UNIT	DBM | DBPW | WATT | DBUV | DBMV | VOLT | DBUA | AMPere | DB | DEG | RAD | S | HZ | PCT | UNITLESS

CALCulate:LIMit:CATalog?

This command reads out the names of all limit lines stored on the hard disk.

Example: "CALC:LIM:CAT?"

Feature: *RST value: -
                    SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:CLEar[:IMMediate]

This command deletes the result of the current limit check for all limit lines in the selected measurement window.

Example: "CALC:LIM:CLE"   'Deletes the result of the limit check in screen A

Characteristics: *RST value: -
                      SCPI: conforming

This command is an event and therefore has no *RST value.

CALCulate<1|2>:LIMit<1 to 8>:COMMent <string>

This command defines a comment for the limit line selected (max. 40 characters). The comment is independent from the measurement window.

Example: "CALC:LIM5:COMM 'Upper limit for spectrum'"
                                                      'Defines the comment for limit line 5.

Characteristics: *RST value: blank comment
                      SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:COPY   1 to 8 | <name>

This command copies one limit line onto another one. It is independent of the measurement window. The name of the limit line may consist of max 8 characters.

Parameter: 1 to 8 ::= number of the new limit line or:
                   <name> ::= name of the new limit line given as a string

Example: `"CALC:LIM1:COPY 2"`   'Copies limit line 1 to line 2.

                   `"CALC:LIM1:COPY 'GSM2'"`   'Copies limit line 1 to a new line named
                                                    "GSM2'.

Characteristics: *RST value: --
                   SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:LIMit<1 to 8>:DELete

This command deletes the selected limit line. The command is independent of the measurement window.

Example: `"CALC:LIM1:DEL"`   'Deletes limit line 1.

Characteristics: *RST value: --
                   SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:LIMit<1 to 8>:FAIL?

This command queries the result of the limit check of the limit line indicated in the selected measurement window. It should be noted that a complete sweep must have been performed for obtaining a valid result. A synchronization with *OPC, *OPC? or *WAI should therefore be provided. The result of the limit check responds with 0 for PASS, 1 for FAIL, and 2 for MARGIN.

Example: `"INIT;*WAI"`   'Starts a new sweep and waits for its end.
                   `"CALC2:LIM3:FAIL?"`   'Queries the result of the check for limit
                                                    'line 3 in screen B.

Characteristics: *RST value: -
                   SCPI: conforming

CALCulate<1|2>:LIMit<1 to 8>:NAME   <name of limit line>

This command assigns a name to a limit line numbered 1 to 8. If it does not exist already, a limit line with this name is created. The command is independent of the measurement window.

The name of the limit line may contain a maximum of 8 characters.

Example: `"CALC:LIM1:NAME 'GSM1'"`   'Assigns the name 'GSM1' to limit line 1.

Characteristics: *RST value: 'REM1' to 'REM8' for lines 1 to 8
                   SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:STATe   ON | OFF

This command switches on or off the limit check for the selected limit line in the selected measurement window.

The result of the limit check can be queried with `CALCulate:LIMit<1 to 8>:FAIL?`.

Example:	`"CALC:LIM:STAT ON"`	'Switches on the limit check for limit line 1 in 'screen A.
	`"CALC2:LIM:STAT OFF"`	'Switches off the limit check for limit line 1 in 'screen B.
	`"CALC:LIM1:NAME 'TEST_1'"`	'define name for limit line 1
	`"CALC:LIM1:DEL'"`	'delete previous limit line TEST_1
	`"CALC:LIM1:COMM"`	'Upper Limit Example' '"
	`"CALC:LIM1:TRAC 1"`	
	`"CALC:LIM1:CONT:DOM:FREQ"`	
	`"CALC:LIM1:CONT:MODE ABS "`	
	`"CALC:LIM1:UNIT DB"`	
	`"CALC:LIM1:UPP:MODE REL "`	
	`"CALC:LIM1:CONT 10.0MHZ, 12.0MHz, 12.5MHZ, 13.0MHZ",13.5MHZ, 14.0MHZ, 16MHZ`	
	`"CALC:LIM1:UPP  -70, -40, -40, -20, -40, -40, -70"`	
	`"CALC:LIM1:UPP:STAT ON"`	

Characteristics:	*RST value:	OFF
	SCPI:	conforming

CALCulate<1|2>:LIMit<1 to 8>:TRACe   1 to 3

This command assigns a limit line to a trace in the indicated measurement window.

Examples:	`"CALC:LIM2:TRAC 3"`	'Assigns limit line 2 to trace 3 in screen A.
	`"CALC2:LIM2:TRAC 1"`	'Assigns limit line 2 to trace 1 in screen B at the same time.

Characteristics:	*RST value:	1
	SCPI:	device-specific

CALCulate<1|2>:LIMit<1 to 8>:UNIT DBM | DBPW | WATT | DBUV | DBMV | VOLT |DBUA | AMPere | DB | DBT | DBUV_M | DBMV_M

This command defines the unit of the selected limit line.

The definition is valid independently of the measurement window.

Upon selection of the unit DB the limit line is automatically switched to the relative mode. For units different from DB the limit line is automatically switched to absolute mode.The permissible unit depends on the following:

- The selection TIME DOMAIN / FREQUENCY DOMAIN
- The selected result display (MAGNITUDE, MAGNITUDE/PHASE, REAL/IMAG or MAGNITUDE, VOLTAGE)
- The display unit set with :DISP:WIND:TRAC:Y:UNIT

Example:	`"CALC:LIM4:UNIT DBUV"`	'Sets the unit of limit line 4 to dBµV.

Characteristics:	*RST value:	DBM
	SCPI:	device-specific

CALCulate:LIMit:ACPower Subsystem

The CALCulate:LIMit:ACPower subsystem defines the limit check for adjacent channel power measurement.

Command	Parameters
CALCulate<1|2>:LIMit<1 to 8>:ACPower:ACHannel:ABSolute	-200 to 200 DBM, -200 to 200 DBM
CALCulate<1|2>:LIMit<1 to 8>:ACPower:ACHannel:ABSolute:STATe	ON	OFF
CALCulate<1|2>:LIMit<1 to 8>:ACPower:ACHannel[:RELative]	0 to 100 dB, 0 to 100 dB
CALCulate<1|2>:LIMit<1 to 8>:ACPower:ACHannel[:RELative]:STATe	ON	OFF
CALCulate<1|2>:LIMit<1 to 8>:ACPower:ACHannel:RESult?	
CALCulate<1|2>:LIMit<1 to 8>:ACPower:ALTernate<1 to 11>:ABSolute	-200 to 200 DBM, -200 to 200 DBM
CALCulate<1|2>:LIMit<1 to 8>:ACPower:ALTernate<1 to 11>:ABSolute:RESult?	
CALCulate<1|2>:LIMit<1 to 8>:ACPower:ALTernate<1 to 11>:ABSolute:STATe	ON	OFF
CALCulate<1|2>:LIMit<1 to 8>:ACPower:ALTernate<1 to 11>[:RELative]	0 to 100 DB, 0 to 100 DB
CALCulate<1|2>:LIMit<1 to 8>:ACPower:ALTernate<1 to 11>[:RELative]:STATe	ON	OFF
CALCulate<1|2>:LIMit<1 to 8>:ACPower[:STATe]	ON	OFF

CALCulate<1|2>:LIMit<1 to 8>:ACPower:ACHannel:ABSolute   -200DBM to 200DBM, -200 to 200DBM

This command defines the absolute limit value for the lower/upper adjacent channel during adjacent-channel power measurement (Adjacent Channel Power) in the selected measurement window.
It should be noted that the absolute limit value has no effect on the limit check as soon as it is below the relative limit value defined with CALCulate:LIMit:ACPower:ACHannel:RELative. This mechanism allows automatic checking of the absolute basic values of adjacent channel power as defined in mobile radio standards.
The numeric suffis <1 to 8> with LIMit are irrelevant for this command. The numeric suffix 2 with CALCulate is not allowed.

Parameter: The first value is the limit for the lower and the upper adjacent channel. The second limit value is ignored but must be indicated for reasons of compatibility with the FSE family.

Example: "CALC:LIM:ACP:ACH:ABS -35DBM, -35DBM"
'Sets the absolute limit value in 'screen A for the power in the lower 'and upper adjacent channel to '-35 dBm.

Characteristics: *RST value: -200DBM
SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:ACPower:ACHannel:ABSolute:STATe   ON | OFF

This command activates the limit check for the adjacent channel when adjacent-channel power measurement (Adjacent Channel Power) is performed. Before the command, the limit check for the channel/adjacent-channel measurement must be globally switched on using `CALC:LIM:ACP ON`. The result can be queried with `CALCulate:LIMit:ACPower:ACHannel:RESult?`. It should be noted that a complete measurement must be performed between switching on the limit check and the result query, since otherwise no valid results are available.
The numeric suffis <1 to 8> with LIMit are irrelevant for this command. The numeric suffix 2 with CALCulate is not allowed.

Example:	`"CALC:LIM:ACP:ACH 30DB, 30DB"`	
		'Sets the relative limit value in screen A for 'the power in the lower and upper adjacent 'channel to 30 dB below the channel power.
	`"CALC:LIM:ACP:ACH:ABS -35DBM, -35DBM"`	
		'Sets the absolute limit value in screen A 'for the power in the lower and upper 'adjacent channel to -35 dBm.
	`"CALC:LIM:ACP ON"`	'Switches on globally the limit check for the 'channel/adjacent channel measurement in 'screen A.
	`"CALC:LIM:ACP:ACH:REL:STAT ON"`	
		'Switches on the check of the relative limit 'values for adjacent channels in screen A.
	`"CALC:LIM:ACP:ACH:ABS:STAT ON"`	
		'Switches on the check of absolute limit 'values for the adjacent channels in screen 'A.
	`"INIT;*WAI"`	'Starts a new measurement and waits for 'the sweep end.
	`"CALC:LIM:ACP:ACH:RES?"`	'Queries the limit check result in the 'adjacent channels in screen A.

Characteristics: *RST value: OFF
                            SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:ACPower:ACHannel[:RELative]   0 to 100dB, 0 to 100dB

This command defines the relative limit of the upper/lower adjacent channel for adjacent channel power measurements in the selected measurement window. The reference value for the relative limit value is the measured channel power.
It should be noted that the relative limit value has no effect on the limit check as soon as it is below the absolute limit value defined with `CALCulate:LIMit:ACPower:ACHannel:ABSolute`. This mechanism allows automatic checking of the absolute basic values of adjacent channel power as defined in mobile radio standards.
The numeric suffis <1 to 8> with LIMit are irrelevant for this command. The numeric suffix 2 with CALCulate is not allowed.

Parameter:	The first numeric value is the limit for the upper (lower) adjacent channel. The second value is ignored but must be indicated for reasons of compatibility with the FSE family.	
Example:	`"CALC:LIM:ACP:ACH 30DB, 30DB"`	'Sets the relative limit value in 'screen A for the power in the lower 'and upper adjacent channel to '30 dB below the channel power.

Characteristics: *RST value: 0 dB
                            SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:ACPower:ACHannel[:RELative]:STATe   ON | OFF

This command activates the limit check for the relative limit value of the adjacent channel when adjacent channel power measurement is performed. Before the command, the limit check must be activated using `CALCulate:LIMit:ACPower:STATe ON`.
The result can be queried with `CALCulate:LIMit:ACPower:ACHannel:RESult?`. It should be noted that a complete measurement must be performed between switching on the limit check and the result query, since otherwise no valid results are available.
The numeric suffis <1 to 8> with LIMit are irrelevant for this command. The numeric suffix 2 with CALCulate is not allowed.

Example:	`"CALC:LIM:ACP:ACH 30DB,30DB"`	'Sets the relative limit value in screen A for 'the power in the lower and upper adjacent 'channel to 30 dB below the channel 'power.
	`"CALC:LIM:ACP:ACH:ABS -35DBM, -35DBM"`	'Sets the absolute limit value in screen A 'for the power in the lower and upper 'adjacent channel to -35 dBm.
	`"CALC:LIM:ACP ON"`	'Switches on globally the limit check for the 'channel/adjacent channel measurement in 'screen A.
	`"CALC:LIM:ACP:ACH:REL:STAT ON"`	'Switches on the check of the relative limit values for adjacent channels in 'screen A.
	`"CALC:LIM:ACP:ACH:ABS:STAT ON"`	'Switches on the check of absolute 'limit values for the adjacent channels in 'screen A.
	`"INIT;*WAI"`	'Starts a new measurement and waits for 'the sweep end.
	`"CALC:LIM:ACP:ACH:RES?"`	'Queries the limit check result in the 'adjacent channels in screen A.
Characteristics:	*RST value: OFF	
	SCPI: device-specific	

CALCulate<1|2>:LIMit<1 to 8>:ACPower:ACHannel:RESult?

This command queries the result of the limit check for the upper/lower adjacent channel in the selected measurement window when adjacent channel power measurement is performed.

If the power measurement of the adjacent channel is switched off, the command produces a query error.
The numeric suffis <1 to 8> with LIMit are irrelevant for this command. The numeric suffix 2 with CALCulate is not allowed.

Parameter:	The result is returned in the form <result>, <result> where <result> = PASSED | FAILED, and where the first returned value denotes the lower, the second denotes the upper adjacent channel.

Example: `"CALC:LIM:ACP:ACH 30DB, 30DB"`
'Sets the relative limit value in screen A for the
'power in the lower and upper adjacent
'channel to 30 dB below the channel power.

`"CALC:LIM:ACP:ACH:ABS -35DBM, -35DBM"`
Sets the absolute limit value in screen A
'for the power in the lower and upper
'adjacent channel to -35 dB.

`"CALC:LIM:ACP ON"`   'Switches on globally the limit check for the
'channel/adjacent channel measurement in
'screen A.

`"CALC:LIM:ACP:ACH:STAT ON"` 'Switches on the limit check for the adjacent
'channels in screen A.

`"INIT;*WAI"`   'Starts a new measurement and waits for the
'sweep end.

`"CALC:LIM:ACP:ACH:RES?"`   'Queries the limit check result in the adjacent
'channels in screen A.

Characteristics: *RST value: --
SCPI: device-specific

This command is a query and therefore has no *RST value.

CALCulate<1|2>:LIMit<1 to 8>:ACPower:ALTernate<1 to 11>[:RELative] 0 to 100dB, 0 to 100dB.

This command defines the limit for the alternate adjacent channels in the selected measurement window for adjacent channel power measurements. The reference value for the relative limit value is the measured channel power.

The numeric suffix after ALTernate<1 to 11> denotes the alternate channel. The numeric suffis <1 to 8> with LIMit are irrelevant for this command. The numeric suffix 2 with CALCulate is not allowed.

It should be noted that the relative limit value has no effect on the limit check as soon as it is below the absolute limit defined with CALCulate:LIMit:ACPower:ALTernate<1 to 11>:ABSolute. This mechanism allows automatic checking of the absolute basic values of adjacent channel power as defined in mobile radio standards.

Parameter:	The first value is the limit for the lower and the upper alternate adjacent channel. The second limit value is ignored but must be indicated for reasons of compatibility with the FSE family.
Example:	"CALC:LIM:ACP:ALT2 30DB, 30DB" 'Sets the relative limit value in 'screen A for the power in the lower 'and upper alternate adjacent 'channel to 30 dB below the channel 'power.

Characteristics: *RST value: 0DB
                 SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:ACPower:ALTernate<1 to 11>[:RELative]:STATe ON | OFF

This command activates the limit check for the alternate adjacent channels in the selected measurement window for adjacent channel power measurements. Before the command, the limit check must be activated using CALCulate:LIMit:ACPower:STATe ON.

The numeric suffix after ALTernate<1 to 11> denotes the alternate channel. The numeric suffis <1 to 8> with LIMit are irrelevant for this command. The numeric suffix 2 with CALCulate is not allowed.

The result can be queried with CALCulate:LIMit:ACPower:ALTernate<1 to 11>:RESult?. It should be noted that a complete measurement must be performed between switching on the limit check and the result query, since otherwise no valid results are obtained.

Example:	"CALC:LIM:ACP:ALT2 30DB, 30DB"
	'Sets the relative limit value in screen A for the 'power in the lower and upper second alternate 'adjacent channel to 30 dB below the channel 'power.
	"CALC:LIM:ACP:ALT2:ABS -35DBM, -35DBM"
	'Sets the absolute limit value in screen A for the 'power in the lower and upper second alternate 'adjacent channel to -35 dBm.
	"CALC:LIM:ACP ON" 'Switches on globally the limit check for the 'channel/adjacent channel measurement in 'screen A.
	"CALC:LIM:ACP:ACH:REL:STAT ON"
	'Switches on the check of the relative limit 'values for the alternate adjacent channels in 'screen A.
	"CALC:LIM:ACP:ACH:ABS:STAT ON"
	'Switches on the check of absolute limit values 'for the alternate adjacent channels in screen A.
	"INIT;*WAI" 'Starts a new measurement and waits for the 'sweep end.
	"CALC:LIM:ACP:ACH:RES?" 'Queries the limit check result in the second 'alternate adjacent channels in screen A.

Characteristics: *RST value: OFF
SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:ACPower:ALTernate<1 to 11>:ABSolute   -200DBM   to   200DBM,
-200DBM to .200DBM

This command defines the absolute limit value for the lower/upper alternate adjacent channel power measurement (Adjacent Channel Power) in the selected measurement window.

The numeric suffix after ALTernate<1 to 11> denotes the alternate channel. The numeric suffis <1 to 8> with LIMit are irrelevant for this command. The numeric suffix 2 with CALCulate is not allowed.

It should be noted that the absolute limit value for the limit check has no effect as soon as it is below the relative limit value defined with CALCulate:LIMit:ACPower:ALTernate<1 to 11>:RELative. This mechanism allows automatic checking of the absolute basic values defined in mobile radio standards for the power in adjacent channels.

Parameter:	The first value is the limit for the lower and the upper alternate adjacent channel. The second limit value is ignored but must be indicated for reasons of compatibility with the FSE family.
Example:	"CALC:LIM:ACP:ALT2:ABS –35DBM, –35DBM"
	'Sets the absolute limit value in 'screen A for the power in the lower 'and upper second alternate 'adjacent channel to -35 dBm.
Characteristics:	*RST value: -200DBM
	SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:ACPower:ALTernate<1 to 11>:RESult?

This command queries the result of the limit check for the alternate adjacent channels in the selected measurement window for adjacent channel power measurements.

The numeric suffix after ALTernate<1 to 11> denotes the alternate channel. The numeric suffis <1 to 8> with LIMit are irrelevant for this command. The numeric suffix 2 with CALCulate is not allowed.

If the power measurement of the adjacent channel is switched off, the command produces a query error.

Parameter:	The result is returned in the form <result>, <result> where <result> = PASSED | FAILED and where the first (second) returned value denotes the lower (upper) alternate adjacent channel.
Example:	`"CALC:LIM:ACP:ALT2 30DB, 30DB"`
	'Sets the relative limit value in screen A for the 'power in the lower and upper second alternate 'adjacent channel to 30 dB below the channel 'power.
	`"CALC:LIM:ACP:ALT2:ABS -35DBM, -35DBM"`
	'Sets the absolute limit value in screen A for the 'power in the lower and upper second alternate 'adjacent channel to -35 dBm.
	`"CALC:LIM:ACP ON"` 'Switches on globally the limit check for the 'channel/adjacent channel measurement in 'screen A.
	`"CALC:LIM:ACP:ALT:STAT ON"`
	'Switches on the limit check for the adjacent 'channels in screen A.
	`"INIT;*WAI"` 'Starts a new measurement and waits for the 'sweep end.
	`"CALC:LIM:ACP:ALT:RES?"` 'Queries the limit check result in the second 'alternate adjacent channels in screen A.
Characteristics:	*RST value: --
	SCPI: device-specific

This command is a query and therefore has no *RST value.

CALCulate<1|2>:LIMit<1 to 8>:ACPower:ALTernate<1 to 11>:ABSolute:STATe ON | OFF

This command activates the limit check for the alternate adjacent channels in the selected measurement window for adjacent channel power measurement (Adjacent Channel Power).

Before the command, the limit check must be globally switched on for the channel/adjacent channel power with the command `CALCulate:LIMit:ACPower:STATe ON`.

The numeric suffix after ALTernate<1 to 11> denotes the alternate channel. The numeric suffis <1 to 8> with LIMit are irrelevant for this command. The numeric suffix 2 with CALCulate is not allowed.

The result can be queried with `CALCulate:LIMit:ACPower:ALTernate<1 to 11>:RESult?`. It should be noted that a complete measurement must be performed between switching on the limit check and the result query, since otherwise no valid results are available.

Example:	`"CALC:LIM:ACP:ALT2 30DB, 30DB"`
	'Sets the relative limit value in screen A for the power in the lower and upper second alternate 'adjacent channel to 30 dB below the channel 'power.
	`"CALC:LIM:ACP:ALT2:ABS -35DBM, -35DBM"`
	'Sets the absolute limit value in screen A for the 'power in the lower and upper second alternate 'adjacent channel to -35 dBm.
	`"CALC:LIM:ACP ON"` 'Switches on globally the limit check for the 'channel/adjacent channel measurement in 'screen A.
	`"CALC:LIM:ACP:ACH:REL:STAT ON"`
	Switches on the check of the relative limit values for the alternative adjacent channels in 'screen A.
	`"CALC:LIM:ACP:ACH:ABS:STAT ON"`
	'Switches on the check of absolute limit values 'for the alternative adjacent channels in screen 'A.
	`"INIT;*WAI"` 'Starts a new measurement and waits for the 'sweep end.
	`"CALC:LIM:ACP:ACH:RES?"` 'Queries the limit check result in the second 'alternate adjacent channels in screen A.
Characteristics:	*RST value: OFF SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:ACPower[:STATe]   ON | OFF

This command switches on and off the limit check for adjacent channel power measurements in the selected measurement window. The commands `CALCulate:LIMit:ACPower:ACHannel:STATe` or `CALCulate:LIMit:ACPower:ALTernate:STATe` must be used in addition to specify whether the limit check is to be performed for the upper/lower adjacent channel or for the alternate adjacent channels. The numeric suffis <1 to 8> with LIMit are irrelevant for this command. The numeric suffix 2 with CALCulate is not allowed.

Example:	`"CALC:LIM:ACP ON"` 'Switches on the ACP limit check in screen A.
Characteristics:	*RST value: OFF SCPI: device-specific

CALCulate:LIMit:CONTrol Subsystem

The CALCulate:LIMit:CONTrol subsystem defines the x axis (CONTrol-axis).

Command	Parameters
CALCulate<1|2>:LIMit<1 to 8>:CONTrol[:DATA]	<numeric_value>,<numeric_value>..
CALCulate<1|2>:LIMit<1 to 8>:CONTrol:DOMain	FREQuency | TIME
CALCulate<1|2>:LIMit<1 to 8>:CONTrol:MODE	RELative | ABSolute
CALCulate<1|2>:LIMit<1 to 8>:CONTrol:OFFset	<numeric_value>
CALCulate<1|2>:LIMit<1 to 8>:CONTrol:SHIFt	<numeric_value>
CALCulate<1|2>:LIMit<1 to 8>:CONTrol:SPACing	LINear | LOGarithmic

CALCulate<1|2>:LIMit<1 to 8>:CONTrol[:DATA]   <numeric_value>,<numeric_value>..

This command defines the X axis values (frequencies or times) of the upper or lower limit lines. The values are defined independently of the measurement window.

Example: "CALC:LIM2:CONT 1MHz,3MHz,10MHz, 15MHz,30MHz"

                                                       'Defines 5 reference values for the X axis of 'limit line 2

                       "CALC:LIM2:CONT?"   'Outputs the reference values for the X axis of 'limit line 2 separated by a comma.

Characteristics: *RST value: - (LIMit:STATe is set to OFF)
                             SCPI: conforming

CALCulate<1|2>:LIMit<1 to 8>:CONTrol:DOMain   FREQuency | TIME

This command defines the frequency or time domain for the x axis values.

Example: "CALC:LIM2:CONT:DOM TIME"   'Defines the time domain for the X axis of limit 'line 2.

Characteristics: *RST value: FREQuency
                             SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:CONTrol:MODE   RELative | ABSolute

This command selects the relative or absolute scaling for the X axis of the selected limit line. The definition is independent of the measurement window.

Example: "CALC:LIM2:CONT:MODE REL"   'Defines the X axis of limit line 2 as relatively 'scaled.

Characteristics: *RST value: ABSolute
                             SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:CONTrol:OFFSet   <numeric_value>

This command defines an offset for the X axis value of the selected relative limit line in the frequency or time domain.

The unit of values depends on the frequency or time domain of the X axis, i.e. it is `HZ` with `CALC:LIM:CONT:DOM FREQ and S with CALC:LIM:CONT:DOM TIME`.

Example: `"CALC:LIM2:CONT:OFFS 100us"`   'Sets the X offset for limit line 2 (defined in 'the time domain) to 100µs.

Characteristics: *RST value: 0
                    SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:CONTrol:SHIFt   <numeric_value>

This command moves a limit line by the indicated value in x direction. In contrast to `CALC:LIM:CONT:OFFS`, the line is shifted by modifying the individual x values and not by means of an additive offset. The shift is independent of the measurement window.

Example: `"CALC:LIM2:CONT:SHIF 50KHZ"`   'Shifts all reference values of limit line 2 by '50 kHz.

Characteristics: *RST value: --
                    SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:LIMit<1 to 8>:CONTrol:SPACing LINear | LOGarithmic

This command selects linear or logarithmic interpolation for the calculation of limit lines from frequency points.

Example: `"CALC:LIM:CONT:SPAC LIN"`

Characteristics: *RST value: LIN
                    SCPI: device-specific

CALCulate:LIMit:LOWer Subsystem

The CALCulate:LIMit:LOWer subsystem defines the lower limit line.

Command	Parameters
CALCulate<1|2>:LIMit<1 to 8>:LOWer[:DATA]	<numeric_value>
CALCulate<1|2>:LIMit<1 to 8>:LOWer:MARGin	<numeric_value>
CALCulate<1|2>:LIMit<1 to 8>:LOWer:MODE	RELative | ABSolute
CALCulate<1|2>:LIMit<1 to 8>:LOWer:OFFset	<numeric_value>
CALCulate<1|2>:LIMit<1 to 8>:LOWer:SHIFt	<numeric_value>
CALCulate<1|2>:LIMit<1 to 8>:LOWer:SPACing	LINear | LOGarithmic
CALCulate<1|2>:LIMit<1 to 8>:LOWer:STATe	ON | OFF
CALCulate<1|2>:LIMit<1 to 8>:LOWer:THReshold	<numeric_value>

CALCulate<1|2>:LIMit<1 to 8>:LOWer[:DATA]   <numeric_value>,<numeric_value>..

This command defines the values for the selected lower limit line independently of the measurement window.
The unit must be identical with the unit selected by CALC:LIM:UNIT. If no unit is indicated, the unit defined with CALC:LIM:UNIT is automatically used.
If the measured values are smaller than the LOWer limit line, the limit check signals errors.

The permissible unit depends on the following:

- The selected TIME DOMAIN / FREQUENCY DOMAIN

- The selected result display (MAGNITUDE, MAGNITUDE/PHASE, REAL/IMAG or MAGNITUDE, VOLTAGE)

- The display unit set with:DISP:WIND:TRAC:Y:UNIT

Example: "CALC:LIM2:LOW -30,-40,-10,-40,-30"

                                              'Defines 5 lower limit values for limit line 2 in 'the preset unit.

                   "CALC:LIM2:LOW?"   'Outputs the lower limit values of limit line 2 'separated by a comma.

Characteristics: *RST value: - (LIMit:STATe is set to OFF)
                           SCPI: conforming

CALCulate<1|2>:LIMit<1 to 8>:LOWer:MARGin   <numeric_value>

This command defines a margin to a lower limit line, at which out-of-limit values are signaled (if the limit check is active), but not handled as a violation of the limit value. The margin is independent of the measurement window.

Example: "CALC:LIM:LOW:MARG 10dB"

Characteristics: *RST value: 0
                           SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:LOWer:MODE   RELative | ABSolute

This command selects the relative or absolute scaling for the Y axis of the selected lower limit line. The setting is independent of the measurement window.

Selecting RELative causes the unit to be switched to DB.

Example: `"CALC:LIM:LOW:MODE REL"`   'Defines the Y axis of limit line 2 as relative 'scaled.

Characteristics: *RST value: ABSolute
                       SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:LOWer:OFFSet   <numeric_value>

This command defines an offset for the Y axis of the selected relative lower limit line. In contrast to `CALC:LIM:LOW:SHIFt`, the line is not shifted by modifying the individual Y values but by means of an additive offset. The offset is independent of the measurement window.

Example: `"CALC:LIM2:LOW:OFFS 3dB"`   'Shifts limit line 2 in the corresponding 'measurement windows by 3 dB upwards.

Characteristics: *RST value: 0
                       SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:LOWer:SHIFt   <numeric_value>

This command shifts a limit line by the indicated value in Y direction. In contrast to `CALC:LIM:LOW:OFFS`, the line is shifted by modifying the individual Y values but not by means of an additive offset. The shift is independent of the measurement window.

Example: `"CALC:LIM3:LOW:SHIF 20DB"`   'Shifts all Y values of limit line 3 by 20 dB.

Characteristics: *RST value: --
                       SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:LIMit<1 to 8>:LOWer:SPACing   LINear | LOGarithmic

This command selects linear or logarithmic interpolation for the lower limit line.

Example: `"CALC:LIM:LOW:SPAC LIN"`

Characteristics: *RST value: LIN
                       SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:LOWer:STATe   ON | OFF

This command switches on or off the indicated limit line in the selected measurement window. The limit check is activated separately with `CALC:LIM:STAT ON`.

In analyzer mode, the result of the limit check can be queried with `CALCulate:LIMit<1 to 8>:FAIL?`.

Example:	`"CALC:LIM4:LOW:STAT ON"`	'Switches on limit line 4 (lower limit) in 'screen A.
	`"CALC2:LIM4:LOW:STAT ON"`	'Switches on limit line 4 (lower limit) also in 'screen B.

Characteristics:	*RST value:	OFF
	SCPI:	conforming

CALCulate<1|2>:LIMit<1 to 8>:LOWer:THReshold   <numeric_value>

This command defines an absolute threshold value for limit lines with relative Y axis scaling independently of the measurement window. The absolute threshold value is used in the limit check as soon as it exceeds the relative limit value.

The unit must correspond to the unit selected with `CALC:LIM:UNIT` (except dB which is not allowed). If no unit is indicated, the unit defined with `CALC:LIM:UNIT` is automatically used (exception: dBm instead of dB).

Example:	`"CALC:LIM2:LOW:THR -35DBM"`	'Defines an absolute threshold value 'for limit line 2.

Characteristics:	*RST value:	-200 dBm
	SCPI:	device-specific

CALCulate:LIMit:UPPer Subsystem

The CALCulate:LIMit:UPPer subsystem defines the upper limit line.

Command	Parameters
CALCulate<1|2>:LIMit<1 to 8>:UPPer[:DATA]	<num_value>,<num_value>..
CALCulate<1|2>:LIMit<1 to 8>:UPPer:MARGin	<numeric_value>
CALCulate<1|2>:LIMit<1 to 8>:UPPer:MODE	RELative | ABSolute
CALCulate<1|2>:LIMit<1 to 8>:UPPer:OFFset	<numeric_value>
CALCulate<1|2>:LIMit<1 to 8>:UPPer:SHIFt	<numeric_value>
CALCulate<1|2>:LIMit<1 to 8>:UPPer:SPACing	LINear | LOGarithmic
CALCulate<1|2>:LIMit<1 to 8>:UPPer:STATe	ON | OFF
CALCulate<1|2>:LIMit<1 to 8>:UPPer:THReshold	<numeric value>

CALCulate<1|2>:LIMit<1 to 8>:UPPer[:DATA]   <numeric_value>,<numeric_value>..

This command defines the values for the upper limit lines independently of the measurement window.
The number of values for the CONTrol axis and for the corresponding UPPer and/or LOWer limit line have to be identical. Otherwise default values are entered for missing values or not necessary values are deleted.
The unit must be identical with the unit selected by CALC:LIM:UNIT. If no unit is indicated, the unit defined with CALC:LIM:UNIT is automatically used.

Example: "CALC:LIM2:UPP –10,0,0,–10,–5"   'Defines 5 upper limit values for limit
'line 2 in the preset unit.

"CALC:LIM2:UPP?"   'Outputs the upper limit values for limit
'line 2 separated by a comma.

Characteristics: *RST value: - (LIMit:STATe is set to OFF)
SCPI: conforming

CALCulate<1|2>:LIMit<1 to 8>:UPPer:MARGin   <numeric_value>

This command defines a margin to an upper limit line, at which out-of-limit values are signaled (if the limit check is active), but not handled as a violation of the limit value. The margin is independent of the measurement window.

Example: "CALC:LIM2:UPP:MARG 10dB"   'Defines the margin of limit line 2 to 10
'dB below the limit value.

Characteristics: *RST value: 0
SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:UPPer:MODE   RELative | ABSolute

This command selects the relative or absolute scaling for the Y axis of the selected upper limit line. The setting is independent of the measurement window.
Selecting RELative causes the unit to be switched to DB.

Example: "CALC:LIM2:UPP:MODE REL"   'Defines the Y axis of limit line 2 as
'relative scaled.

Characteristics: *RST value: ABSolute
SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:UPPer:OFFSet   <numeric_value>

This command defines an offset for the Y axis of the selected relative upper limit line. In contrast to `CALC:LIM:UPP:SHIFt`, the line is not shifted by modifying the individual Y values but by means of an additive offset. The offset is independent of the measurement window.

Example: `"CALC:LIM2:UPP:OFFS 3dB"`   'Shifts limit line 2 by 3 dB upwards in the
                                                                         'corresponding measurement windows.

Characteristics: *RST value: 0
                                    SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:UPPer:SHIFt   <numeric_value>

This command moves a limit line by the indicated value in Y direction. In contrast to `CALC:LIM:UPP:OFFS`, the line is shifted by modifying the individual Y values and not by means of an additive offset. The shift is independent of the measurement window.

Example: `"CALC:LIM3:UPP:SHIF 20DB"`   'Shifts all Y values of limit line 3 by 20 dB.

Characteristics: *RST value: --
                                    SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:LIMit<1 to 8>:UPPer:SPACing   LINear | LOGarithmic

This command selects linear or logarithmic interpolation for the upper limit line.

Example: `"CALC:LIM:UPP:SPAC LIN"`

Characteristics: *RST value: LIN
                                    SCPI: device-specific

CALCulate<1|2>:LIMit<1 to 8>:UPPer:STATe   ON | OFF

This command switches on or off the indicated limit line in the selected measurement window. The limit check is activated separately with `CALC:LIM:STAT ON`.

Example: `"CALC1:LIM4:UPP:STAT ON"`   'Switches on limit line 4 (upper limit) in
                                                                         'screen A.
                           `"CALC2:LIM4:UPP:STAT ON"`   'Switches on limit line 4 (upper limit) in
                                                                         'screen B.

Characteristics: *RST value: OFF
                                    SCPI: conforming

CALCulate<1|2>:LIMit<1 to 8>:UPPer:THReshold   <numeric_value>

This command defines an absolute threshold value for limit lines with relative Y axis scaling independently of the measurement window. The absolute threshold value is used in the limit check as soon as it exceeds the relative limit value.
The unit must correspond to the unit selected with `CALC:LIM:UNIT` (except dB which is not possible). If no unit is indicated, the unit defined with `CALC:LIM:UNIT` is automatically used (exception: dBm instead of dB).
The units DEG, RAD, S, HZ, PCT are not available in the *SPECTRUM* mode.

Example: `"CALC:LIM2:UPP:THR -35DBM"`   'Defines an absolute threshold value for
                                                                         'limit line 2.

Characteristics: *RST value: -200 dBm
                                    SCPI: device-specific

CALCulate:MARKer Subsystem

The CALCulate:MARKer subsystem checks the marker functions in the instrument. The measurement windows are assigned to CALCulate 1 (screen A) or 2 (screen B).

For measurements using two windows (MAGNITUDE/PHASE, REAL/IMAG, VOLTAGE), a second marker in the other window follows the first marker. Switching a marker on and off and positioning it thus applies to both windows in this case.

Command	Parameters
CALCulate<1|2>:MARKer<1 to 4>:AOFF	
CALCulate<1|2>:MARKer<1 to 4>:LOEXclude	ON | OFF
CALCulate<1|2>:MARKer<1 to 4>:MAXimum:AUTO	ON | OFF
CALCulate<1|2>:MARKer<1 to 4>:MAXimum:LEFT	
CALCulate<1|2>:MARKer<1 to 4>:MAXimum:NEXT	
CALCulate<1|2>:MARKer<1 to 4>:MAXimum[:PEAK]	
CALCulate<1|2>:MARKer<1 to 4>:MAXimum:RIGHt	
CALCulate<1|2>:MARKer<1 to 4>: MINimum:AUTO	ON | OFF
CALCulate<1|2>:MARKer<1 to 4>:MINimum:LEFT	
CALCulate<1|2>:MARKer<1 to 4>:MINimum:NEXT	
CALCulate<1|2>:MARKer<1 to 4>:MINimum[:PEAK]	
CALCulate<1|2>:MARKer<1 to 4>:MINimum:RIGHt	
CALCulate<1|2>:MARKer<1 to 4>:PEXCursion	<numeric_value>
CALCulate<1|2>:MARKer<1 to 4>[:STATe]	ON | OFF
CALCulate<1|2>:MARKer<1 to 4>:TRACe	1 to 3
CALCulate<1|2>:MARKer<1 to 4>:X	0 to MAX (frequency | sweep time)
CALCulate<1|2>:MARKer<1 to 4>:X:SLIMits:LEFT	0 to MAX (frequency|sweep time)
CALCulate<1|2>:MARKer<1 to 4>:X:SLIMits:RIGHt	0 to MAX (frequency|sweep time)
CALCulate<1|2>:MARKer<1 to 4>:X:SLIMits[:STATe]	ON | OFF
CALCulate<1|2>:MARKer<1 to 4>:Y?	
CALCulate<1|2>:MARKer<1 to 4>:Y:PERCent	0 to 100 %

CALCulate<1|2>:MARKer<1 to 4>:AOFF

This command switches off all active markers in the selected measurement window. All delta markers and active marker/delta marker measurement functions are switched off. The numeric suffix in CALCulate<1|2> is irrelevant.

Example: `"CALC:MARK:AOFF"`   'Switches off all markers.

Characteristics: *RST value: -
SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1...4>:LOEXclude ON | OFF

> This command switches the suppression of the DC component on or off during maximum search. This function is available only in the frequency domain display.
> This setting is valid for all markers and delta markers in all measurement windows. The numeric suffix under CALCulate<1|2> and the numeric suffix under MARKer<1...4> are irrelevant.

> **Example:**   `"CALC:MARK:LOEX OFF"`

> **Characteristics:**   *RST value: ON
>   SCPI: device-specific

CALCulate<1|2>:MARKer<1...4>:MAXimum:AUTO ON | OFF

> This command switches an automatic maximum peak search for marker 1 at the end of each particular sweep on and off. The actual marker search limit settings (*LEFT LIMIT*, *RIGHT LIMIT*, *THRESHOLD,* EXCLUDE LO) are taken into account.
> The numeric suffix at MARKer<1..4> is irrelevant.

> **Example:**   `"CALC:MARK:MAX:AUTO ON"`'activates the auto search function
>   for marker 1

> **Characteristics:**   *RST value   OFF
>   SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:MAXimum:LEFT

> This command positions the marker to the next smaller maximum value to the left of the current value (i.e. in descending X values) on the trace in the selected measurement window. For measurements using two windows (MAGNITUDE/PHASE, REAL/IMAG, VOLTAGE), the corresponding marker of the other window is moved to the same X position.

> *Note:*   *If no next smaller maximum value is found on the trace (level spacing to adjacent values < peak excursion), an ecution error (error code: -200) is produced.*

> **Example:**   `"CALC:MARK2:MAX:LEFT"`   'Positions marker 2 in screen A to the next
>   'lower maximum value to the left of the current
>   'value.

> **Characteristics:**   *RST value: -
>   SCPI: device-specific

> This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1 to 4>:MAXimum:NEXT

> This command positions the marker to the next smaller maximum value of the corresponding trace in the selected measurement window. For measurements using two windows (MAGNITUDE/PHASE, REAL/IMAG, VOLTAGE), the corresponding marker of the other window is moved to the same X position.

> *Note:*   *If no next smaller maximum value is found on the trace (level spacing to adjacent values < peak excursion), an ecution error (error code: -200) is produced.*

> **Example:**   `"CALC:MARK2:MAX:NEXT"`   'Positions marker 2 in screen A to the next
>   'lower maximum value.

> **Characteristics:**   *RST value: -
>   SCPI: device-specific

> This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1 to 4>:MAXimum[:PEAK]

This command positions the marker to the current maximum value of the corresponding trace in the selected measurement window. The corresponding marker is activated first or switched to the marker mode. For measurements using two windows (MAGNITUDE/PHASE, REAL/IMAG, VOLTAGE), the corresponding marker of the other window is moved to the same X position.

Note: *If no maximum value is found on the trace (level spacing to adjacent values < peak excursion), an ecution error (error code: -200) is produced.*

Example: `"CALC:MARK2:MAX"`   'Positions marker 2 in screen A to the maximum value of 'the trace.

Characteristics: *RST value: -
                       SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1 to 4>:MAXimum:RIGHt

This command positions the marker to the next smaller maximum value to the right of the current value (i.e. in ascending X values) on the corresponding trace in the selected measurement window. For measurements using two windows (MAGNITUDE/PHASE, REAL/IMAG, VOLTAGE), the corresponding marker of the other window is moved to the same X position.

Note: *If no next smaller maximum value is found on the trace (level spacing to adjacent values < peak excursion), an ecution error (error code: -200) is produced.*

Example: `"CALC:MARK2:MAX:RIGH"`   'Positions marker 2 in screen A to the next 'lower maximum value to the right of the 'current value.

Characteristics: *RST value: -
                       SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1...4>:MINimum:AUTO ON | OFF

This command switches an automatic minimum peak search for marker 1 at the end of each particular sweep on and off. The actual marker search limit settings (*LEFT LIMIT*, *RIGHT LIMIT*, *THRESHOLD,* EXCLUDE LO) are taken into account.

The numeric suffix at MARKer<1..4> is irrelevant.

Example: `"CALC:MARK:MIN:AUTO ON"`'activates the auto search function
                                           for marker 1

Characteristics: *RST value   OFF
                       SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:MINimum:LEFT

This command positions the marker to the next higher minimum value to the left of the current value (i.e. in descending X direction) on the corresponding trace in the selected measurement window. For measurements using two windows (MAGNITUDE/PHASE, REAL/IMAG, VOLTAGE), the corresponding marker of the other window is moved to the same X position.

Note: *If no next higher minimum value is found on the trace (level spacing to adjacent values < peak excursion), an ecution error (error code: -200) is produced.*

Example: `"CALC:MARK2:MIN:LEFT"` 'Positions marker 2 in screen A to the next 'higher minimum value to the left of the 'current value.

Characteristics: *RST value: -
SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1 to 4>:MINimum:NEXT

This command positions the marker to the next higher minimum value of the corresponding trace in the selected measurement window. For measurements using two windows (MAGNITUDE/PHASE, REAL/IMAG, VOLTAGE), the corresponding marker of the other window is moved to the same X position.

Note: *If no next higher minimum value is found on the trace (level spacing to adjacent values < peak excursion), an ecution error (error code: -200) is produced.*

Example: `"CALC:MARK2:MIN:NEXT"` 'Positions marker 2 in screen A to the next 'higher maximum value.

Characteristics: *RST value: -
SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1 to 4>:MINimum[:PEAK]

This command positions the marker to the current minimum value of the corresponding trace in the selected measurement window. The corresponding marker is activated first or switched to marker mode, if necessary.For measurements using two windows (MAGNITUDE/PHASE, REAL/IMAG, VOLTAGE), the corresponding marker of the other window is moved to the same X position.

Note: *If no minimum value is found on the trace (level spacing to adjacent values < peak excursion), an ecution error (error code: -200) is produced.*

Example: `"CALC:MARK2:MIN"` 'Positions marker 2 in screen A to the minimum value of 'the trace.

Characteristics: *RST value: -
SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1 to 4>:MINimum:RIGHt

This command positions the marker to the next higher minimum value to the right of the current value (i.e. in ascending X direction) on the corresponding trace in the selected measurement window. For measurements using two windows (MAGNITUDE/PHASE, REAL/IMAG, VOLTAGE), the corresponding marker of the other window is moved to the same X position.

Note: *If no next higher minimum value is found on the trace (level spacing to adjacent values < peak excursion), an ecution error (error code: -200) is produced.*

Example: `"CALC:MARK2:MIN:RIGH"`   'Positions marker 2 in screen A to the next 'higher minimum value to the right of the 'current value.

Characteristics: *RST value: -
                        SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1 to 4>:PEXCursion   <numeric_value>

This command defines the peak excursion., i.e. the spacing below a trace maximum which must be attained before a new maximum is recognized, or the spacing above a trace minimum which must be attained before a new minimum is recognized. The set value is valid for all markers and delta markers. The unit depends on the selected operating mode. The numeric suffix in MARKer<1 to 4> is irrelevant.

Example: `"CALC:MARK:PEXC 10dB"`   'Defines peak excursion 10 dB in 'SPECTRUM mode

                 `"CALC:MARK:PEXC 100 HZ"`   Defines peak excursion 100 Hz in 'FM DEMOD mode

Characteristics: *RST value: 6dB
                        SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>[:STATe]   ON | OFF

This command switches on or off the currently selected marker. If no indication is made, marker 1 is selected automatically. If marker 2, 3 or 4 is selected and used as a delta marker, it is switched to marker mode. The numeric suffix in CALCulate<1|2> is irrelevant.

Example: `"CALC:MARK3 ON"`   'Switches marker 3 on or to marker mode.

Characteristics: *RST value: OFF
                        SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:TRACe   1 to 3

This command assigns the selected marker (1 to 4) to the indicated measurement curve in the selected measurement window. The corresponding trace must be active, i.e. its status must be different from "BLANK". The numeric suffix in CALCulate<1|2> is irrelevant.

If necessary the corresponding marker is switched on prior to the assignment.

Example: `"CALC:MARK3:TRAC 2"`   'Assigns marker 3 to trace 2.

Characteristics: *RST value   -
                        SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:X   0 to MAX (frequency | sweep time)

This command positions the selected marker to the indicated frequency (frequency domain, span > 0), time (time domain, span = 0) or level (APD measurement or CCDF measurement ON). If marker 2, 3 or 4 is selected and used as delta marker, it is switched to marker mode. The numeric suffix in CALCulate<1|2> is irrelevant.

Example: `"CALC1:MARK2:X 10.7MHz"`   'Positions marker 2 to frequency '10.7 MHz.

Characteristics: *RST value: -
                            SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:X:SLIMits[:STATe]   ON | OFF

This command switches between a limited (ON) and unlimited (OFF) search range in the selected measurement window. The function is independent of the selection of a marker, i.e. the numeric suffix MARKer<1 to 4> is irrelevant.
If the time domain power measurement is active, this command limits the evaluation range on the trace.

Example: `"CALC:MARK:X:SLIM ON"`   'Switches on search limitation in screen A.

Characteristics: *RST value: OFF
                            SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:X:SLIMits:LEFT   0 to MAX (frequency | sweep time)

This command sets the left limit of the search range for markers and delta markers in the selected measurement window. Depending on the x axis domain the indicated value defines a frequency (span > 0) or time (span = 0). The function is independent of the selection of a marker, i.e. the numeric suffix in MARKer<1 to 4> is irrelevant.
If the time domain power measurement is active, this command limits the evaluation range to the trace.

Note: *The function is only available if the search limit for marker and delta marker is switched on* `(CALC:MARK:X:SLIM ON).`

Example: `"CALC:MARK:X:SLIM ON"`   'Switches the search limit function on for screen A.

                         `"CALC:MARK:X:SLIM:LEFT 10MHz"`   'Sets the left limit of the search range in screen A to 10 MHz.

Characteristics: *RST value: - (is set to the left diagram border on switching on search limits)
                            SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:X:SLIMits:RIGHt   0 to MAX (frequency | sweep time)

This command sets the right limit of the search range for markers and delta markers in the selected measurement window. Depending on the x axis domain the indicated value defines a frequency (span > 0) or time (span = 0). The function is independent of the selection of a marker, i.e. the numeric suffix in MARKer<1 to 4> is irrelevant.
If the time domain power measurement is active, this command limits the evaluation range to the trace.

Note: *The function is only available if the search limit for marker and delta marker is switched on*
                (CALC:MARK:X:SLIM ON).

Example: "CALC:MARK:X:SLIM ON"   'Switches the search limit function on
                                                      'for screen A.

                        "CALC:MARK:X:SLIM:RIGH 20MHz"   'Sets the right limit of the search range
                                                        'in screen A to 20 MHz.

Characteristics: *RST value: - is set to the right diagram border on switching on search
                                                  limits)
                   SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:Y?

This command queries the measured value of the selected marker in the selected measurement window. The corresponding marker is activated before or switched to marker mode, if necessary.
To obtain a valid query result, a complete sweep with synchronization to the sweep end must be performed between the activation of the marker and the query of the y value. This is only possible in single sweep mode.
The query result is output in the unit determined with CALCulate:UNIT.
In the default setting, the output is made depending on the unit determined with CALC:UNIT.

Example: "INIT:CONT OFF"   'Switches to single-sweep mode.
                        "CALC:MARK2 ON"   'Switches marker 2.
                        "INIT;*WAI"   'Starts a sweep and waits for the end.
                        "CALC:MARK2:Y?"   'Outputs the measured value of marker 2 in screen A.

Characteristics: *RST value: -
                   SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:Y:PERCent   0 to100 %

This command positions the selected marker in the selected window to the given probability. If marker 2, 3 or 4 is selected and used as a delta marker, it is switched to marker mode. Only numeric suffix 1 in CALCulate<1|2> is allowed.

Note: *The command is only available with the CCDF measurement switched on.*
               The associated level value can be determined with the CALC:MARK:X? command.

Example: "CALC1:MARK:Y:PERC 95PCT"   'Positions marker 1 to a 'probability of 95 %.

Characteristics: *RST value: -
                   SCPI: device-specific

CALCulate:MARKer:FUNCtion Subsystem

The measurement window is selected by CALCulate 1 (screen A) or 2 (screen B).

Command	Parameters
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:CENTer	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:FPEaks:COUNt?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:FPEaks[:IMMediate]	<numeric value>
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:FPEaks:SORT	X	Y
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:FPEaks:X?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:FPEaks:Y?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:MDEPth:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:MDEPth[:STATe]	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NDBDown	<numeric_value>
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NDBDown:FREQuency?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NDBDown:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NDBDown:STATe	ON	OFF
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NDBDown:TIME?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NOISe:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NOISe[:STATe]	ON	OFF
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:TOI:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:TOI[:STATe]	ON	OFF

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:CENTer

This command sets the center frequency of the selected measurement window equal to the frequency of the indicated marker.

If marker 2, 3 or 4 is selected and used as delta marker, it is switched to the marker mode.

This function is available for measurement result MAGNITUDE in frequency domain.

Example: `"CALC:MARK2:FUNC:CENT"`   'Sets the center frequency of screen A to the frequency of marker 2.

Characteristics: *RST value: -
                     SCPI: device-specific

This command is an "event" and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:FPEaks:COUNt?

This query reads out the number of maxima found during the search. If no search for maxima has been performed, 0 is returned.

This function is available for measurement result MAGNITUDE in frequency domain or time domain.

Example: `"CALC:MARK:FUNC:FPE 3"` 'searches the 3 highest maxima for trace 1

                     `"CALC:MARK:FUNC:FPE:COUN?"` 'queries the number of maxima found

Characteristics: *RST value: --
                     SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:FPEaks[:IMMediate] <numeric_value>

This command searches the selected trace for the indicated number of maxima. The results are entered in a list and can be queried with commands `CALC:MARK:FUNC:FPEaks:X?` and `CALC:MARK:FUNC:FPEaks:Y?`. The number of maxima found can be queried with `CALC:MARK:FUNC:FPEaks:COUNt?`. The trace to be examined is selected with `CALC:MARK:TRACe`. The order of the results in the list can be defined with `CALC:MARK:FUNC:FPEaks:SORT`.
This function is available for measurement result MAGNITUDE in frequency domain or time domain.

Note: *The number of maxima found depends on the waveform and value set for the Peak Excursion parameter (CALC:MARK:PEXC), however, a maximum number of 50 maxima are determined. Only the signals which exceed their surrounding values at least by the value indicated by the peak excursion parameter will be recognized as maxima. Therefore, the number of maxima found is not automatically the same as the number of maxima desired.*

Example: `"INIT:CONT OFF"`   'switches to single-sweep mode

`"INIT;*WAI"`   'starts measurement and synchronizes to 'end

`"CALC:MARK:TRAC 1"`   ' sets marker 1 in screen A to trace 1

`"CALC:MARK:FUNC:FPE:SORT X"`   ' sets the sort mode to increasing X values

`"CALC:MARK:FUNC:FPE 3"`   ' searches the 3 highest maxima for trace 1

`"CALC:MARK:FUNC:COUN?"`   ' queries the number of maxima found

`"CALC:MARK:FUNC:Y?"`   ' queries the level of maxima found

`"CALC:MARK:FUNC:X?"`   ' queries the frequencies (span <> 0) or
'time (span = 0) of maxima found.

Characteristics: *RST value: --
SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:FPEaks:SORT X | Y

This command sets the sort mode for the search for maxima:

X   the maxima are sorted in the list of responses according to increasing X values
Y   the maxima are sorted in the list of responses according to decreasing Y values

This function is available for measurement result MAGNITUDE in frequency domain or time domain.

Example: `"CALC:MARK:FUNC:FPE:SORT Y"` 'sets the sort mode to decreasing y values.

Characteristics: *RST value: --
SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:FPEaks:X?

This query reads out the list of X values of the maxima found. The number of available values can be queried with `CALC:MARK:FUNC:FPEaks:COUNt?`.
With sort mode X, the X values are in increasing order; with sort mode Y the order corresponds to the decreasing order of the Y values.
This function is available for measurement result MAGNITUDE in frequency domain or time domain.

Example: `"CALC:MARK:FUNC:FPE:SORT Y"`   'sets the sort mode to decreasing y values
                             `"CALC:MARK:FUNC:FPE 3"`   'searches the 3 highest maxima for trace 1
                             `"CALC:MARK:FUNC:FPE:COUN?"`   'queries the number of maxima found
                             `"CALC:MARK:FPE:FUNC:X?"`   'queries the frequencies (span <> 0) or.
                                                                   ' time (span = 0) of the maxima found.

Returned values:
                            `"107.5E3,153.8E3,187.9E3"` 'frequencies in increasing order
                            `"2.05E-3,2.37E-3, 3.71e-3"` 'times in increasing order

Characteristics: *RST value: --
                            SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:FPEaks:Y?

This query reads out the list of X values of the maxima found. The number of available values can be queried with `CALC:MARK:FUNC:FPEaks:COUNt?`.
With sort mode X, the X values are in increasing order; with sort mode Y the order corresponds to the decreasing order of the Y values.
This function is available for measurement result MAGNITUDE in frequency domain or time domain.

Example: `"CALC:MARK:FUNC:FPE:SORT Y"`   'sets the sort mode to decreasing y values
                             `"CALC:MARK:FUNC:FPE 3"`   'searches the 3 highest maxima for trace 1
                             `"CALC:MARK:FUNC:FPE:COUN?"`   'queries the number of maxima found
                             `"CALC:MARK:FUNC:FPE:Y?"`   'queries the levels of the maxima found.

Return value:
                            `"-37.5,-58.3,-59.6"` 'level in decreasing order

Characteristics: *RST value: --
                            SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:MDEPth:RESult?

This command queries the AM modulation depth in the indicated measurement window.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in frequency domain. The numeric suffix <1 to 4> of :MARKer is irrelevant for this command.

Example: `"INIT:CONT OFF"`   'Switches to single-sweep mode.
                             `"CALC:MARK:X 10MHZ"`   'Sets the reference marker (marker 1) to
                                                               'the carrier signal at 10 MHz.
                             `"CALC:MARK:FUNC:MDEP ON"`   'Switches on the modulation depth
                                                               'measurement in screen A.
                             `"INIT;*WAI"`   'Starts a sweep and waits for the end.
                             `"CALC:MARK:FUNC:MDEP:RES?"` 'Outputs the measured value of screen A.

Characteristics: *RST value: -
                            SCPI: device-specific

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:MDEPth[:STATe]

This command switches on the measurement of the AM modulation depth. An AM-modulated carrier is required on the screen for correct operation. If necessary, marker 1 is previously activated and set to the largest signal available.

The level value of marker 1 is regarded as the carrier level. On activating the function, marker 2 and marker 3 are automatically set as delta markers symmetrically to the carrier to the adjacent maxima of the trace.

If the position of delta marker 2 is changed, delta marker 3 is moved symmetrically with respect to the reference marker (marker 1). If the position of delta marker 3 is changed, fine adjustment can be performed independently of delta marker 2.

The R&S FMU calculates the power at the marker positions from the measured levels.

The AM modulation depth is calculated from the ratio of power values at the reference marker and the delta markers. If the two AM sidebands differ in power, the average value of the two power values is used for calculating the AM modulation depth.

This function is available for measurement result MAGNITUDE in frequency domain. The numeric suffix <1 to 4> of :MARKer is irrelevant with this command.

Example:	`"CALC:MARK:X 10MHZ"`	'Sets the reference marker (marker 1) to 'the carrier signal at 10 MHz
	`"CALC:MARK:FUNC:MDEP ON"`	'Switches on the modulation depth 'measurement in screen A.
	`"CALC:DELT2:X 10KHZ"`	'Sets delta markers 2 and 3 to the signals 'at 10 kHz from the carrier signal
	`"CALC:DELT3:X 9.999KHZ"`	'Corrects the position of delta marker 3 'relative to delta marker 2.

Characteristics: *RST value: OFF
SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NDBDown   <numeric_value>

This command defines the level spacing of the two delta markers to the right and left of marker 1 in the selected measurement window. Marker 1 is always used as the reference marker. The numeric suffix <1 to 4> is irrelevant for this command.
The temporary markers T1 and T2 are positioned by n dB below the active reference marker. The frequency spacing of these markers can be queried with `CALCulate:MARKer:FUNCtion:NDBDown:RESult?`.
This function is available for measurement result MAGNITUDE in frequency domain or time domain.

Example: `"CALC:MARK:FUNC:NDBD 3dB"`'Sets the level spacing in screen A to 3 dB.

Characteristics: *RST value: 6dB
SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NDBDown:FREQuency?

This command queries the two frequencies of the N-dB-down marker in the selected measurement window. The numeric suffix <1 to 4> is irrelevant for this command. The two frequency values are separated by comma and output in ascending order.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in frequency domain or time domain.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"CALC:MARK:FUNC:NDBD ON"`	'Switches on the n-dB-down function in 'screen A.
	`"INIT;*WAI"`	'Starts a sweep and waits for the end.
	`"CALC:MARK:FUNC:NDBD:FREQ?"`	'Outputs the frequencies of the temporary 'markers in screen A.

Characteristics:	*RST value:	-
	SCPI:	device-specific

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NDBDown:RESult?

This command queries the frequency spacing (bandwidth) of the N-dB-down markers in the selected measurement window. The numeric suffix <1 to 4> is irrelevant for this command.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value in order to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in frequency domain or time domain.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"CALC:MARK:FUNC:NDBD ON"`	'Switches on the n-dB-down function in 'screen A.
	`"INIT;*WAI"`	'Starts a sweep and waits for the end.
	`"CALC:MARK:FUNC:NDBD:RES?"`	'Outputs the measured value of screen A.

Characteristics:	*RST value:	-
	SCPI:	device-specific

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NDBDown:STATe   ON | OFF

This command switches the "N dB Down" function on or off in the selected measurement window. Marker 1 is activated first, if necessary. The numeric suffix <1 to 4> is irrelevant for this command.
This function is available for measurement result MAGNITUDE in frequency domain or time domain.

Example:	`"CALC:MARK:FUNC:NDBD:STAT ON"`	'Switches on the N-dB-down function in 'screen A.

Characteristics:	*RST value:	OFF
	SCPI:	device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NDBDown:TIME?

This command queries the two time values of the "N dB Down" markers in the specified measurement window. The suffix <1 to 4> has no meaning with this command. The two time values are output in ascending order, separated by commas.
To obtain a valid query response, a complete sweep with synchronization to the sweep end must have been performed in between activating the function and querying the measurement results. This is possible only in single-sweep mode.This function is available for measurement result MAGNITUDE in frequency domain or time domain.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"CALC:MARK:FUNC:NDBD ON"`	'Switches on the "N dB Down" function in 'screen A.
	`"INIT;*WAI"`	'Starts a sweep and waits for the end.
	`"CALC:MARK:FUNC:NDBD:TIME?"`	'Outputs the time values of the temporary markers in screen A.

Characteristics:	*RST value:	-
	SCPI:	device-specific

This command is a query only and thus has no *RST value

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NOISe:RESult?

This command queries the result of the noise measurement.
A complete sweep with synchronization to the sweep end must be performed between switching on the function and querying the measured value in order to obtain a valid query result. This is only possible in single sweep mode.

This function is available for measurement result MAGNITUDE in frequency domain or time domain.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"CALC:MARK2 ON"`	'Switches on marker 2 in screen A.
	`"CALC:MARK:FUNC:NOIS ON"`	'Switches on noise measurement in screen A.
	`"INIT;*WAI"`	'Starts a sweep and waits for the end.
	`"CALC:MARK2:NOIS:RES?"`	'Outputs the noise result of marker 2 in 'screen A.

Characteristics:	*RST value:	-
	SCPI:	device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:NOISe[:STATe]   ON | OFF

This command switches the noise measurement on or off for all markers of the indicated measurement window. The noise power density is measured at the position of the markers. The result can be queried with `CALCulate:MARKer:FUNCtion:NOISe:RESult?`.
This function is available for measurement result MAGNITUDE in frequency domain or time domain.

Example:	`"CALC1:MARK:FUNC:NOIS ON"`	'Switches on the noise measurement for 'screen A.

Characteristics:	*RST value:	OFF
	SCPI:	device-specific
Mode:	A, GSM/EDGE	

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:TOI:RESult?

This command queries the third-order intercept point measurement in the indicated measurement window.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in frequency domain. The numeric suffix <1 to 4> of :MARKer is irrelevant of this command.

Example:	"INIT:CONT OFF"	'Switches to single-sweep mode.
	"CALC:MARK:FUNC:TOI ON"	'Switches the intercept measurement in 'screen A.
	"INIT;*WAI"	'Starts a sweep and waits for the end.
	"CALC:MARK:FUNC:TOI:RES?"	'Outputs the measured value of screen A.

| **Characteristics:** | *RST value: | - |
| | SCPI: | device-specific |

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:TOI[:STATe] ON | OFF

This command initiates the measurement of the third-order intercept point.
A two-tone signal with equal carrier levels is expected at the RF input of the instrument. Marker 1 and marker 2 (both normal markers) are set to the maximum of the two signals. Delta marker 3 and delta marker 4 are positioned to the intermodulation products. The delta markers can be modified sperately afterwards with the commands CALCulate:DELTamarker3:X and CALCulate:DELTamarker4:X.
The third-order intercept is calculated from the level spacing between the normal markers and the delta markers.
This function is available for measurement result MAGNITUDE in frequency domain. The numeric suffix <1 to 4> of :MARKer is irrelevant for this command.

| **Example:** | "CALC:MARK:FUNC:TOI ON" | 'Switches on the measurement of the third-order intercept in screen A. |

| **Characteristics:** | *RST value: | OFF |
| | SCPI: | device-specific |

CALCulate:MARKer:FUNCtion:POWer Subsystem

The CALCulate:MARKer:FUNCtion:POWER subsystem contains the commands for control of power measurement.

Command	Parameters
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:POWer:MODE	WRITe | MAXHold
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:POWer:PRESet	NADC | TETRA | PDC | PHS | CDPD | FWCDma | RWCDma | F8CDma | R8CDma | F19Cdma | R19Cdma | FW3Gppcdma | RW3Gppcdma | D2CDma | S2CDma | M2CDma | FIS95A | RIS95A | FIS95C0 | RIS95C0 | FJ008 | RJ008 | FIS95C1 | RIS95C1 | TCDMa | NONE | AWLan | BWLan
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:POWer:RESult?	ACPower | CPOWer | MCACpower | OBANdwidth | OBWidth | CN | CN0
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:POWer:RESult:PHZ?	ON | OFF
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:POWer:SELect	ACPower | MCACpower | CPOWer | OBANdwidth | OBWidth | CN | CN0
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:POWer[:STATe]	OFF

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:POWer:MODE   WRITe | MAXHold

This command selects the Clear Write or Maxhold for Channel Power values.
This function is available for measurement result MAGNITUDE in frequency domain.

Example: "CALC:MARK:FUNC:POW:MODE MAXH"   'Maxhold für Channel Power Werte

Characteristics: *RST-Wert: WRITe
                        SCPI: gerätespezifisch

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:POWer:PRESet NADC | TETRA | PDC | PHS | CDPD | FWCDma | RWCDma | F8CDma | R8CDma | F19Cdma | R19Cdma | FW3Gppcdma | RW3Gppcdma | D2CDma | S2CDma | M2CDma | FIS95A | RIS95A | FIS95C0 | RIS95C0 | FJ008 | RJ008 | FIS95C1 | RIS95C1 | TCDMa | NONE | AWLan | BWLan

This command selects the power measurement setting for a standard in the indicated measurement window and previously switches on the corresponding measurement, if required. The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of MARKer is irrelevant.

This function is available for measurement result MAGNITUDE in frequency domain.

The configuration for a standard comprises of the parameters weighting filter, channel bandwidth and spacing, resolution and video bandwidth, as well as detector and sweep count.

Meaning of the CDMA standard abbreviations:

FIS95A, F8CDma	CDMA IS95A forward
RIS95A, R8CDma	CDMA IS95A reverse
FJ008, F19CDma	CDMA J-STD008 forward
RJ008, R19CDma	CDMA J-STD008 reverse
FIS95C0	CDMA IS95C Class 0 forward
RIS95C0	CDMA IS95C Class 0 reverse
FIS95C1	CDMA IS95C Class 1 forward
RIS95C1	CDMA IS95C Class 1 reverse
FWCDma	W-CDMA 4.096 MHz forward
RWCDma	W-CDMA 4.096 MHz reverse
FW3Gppcdma	W-CDMA 3.84 MHz forward
RW3Gppcdma	W-CDMA 3.84 MHz reverse
D2CDma	CDMA 2000 direct sequence
S2CDma	CDMA 2000 MC1 multi carrier with 1 carrier
M2CDma	CDMA 2000 MC3 multi carrier with 3 carriers
TCDMa	TD-SCDMA
AWLan	WLAN 802.11a
BWLan	WLAN 802.11b
WIMax	WiMAX
WIBro	WiBro

Notes: *The settings for standards IS95A and C differ as far as the calculation method of channel spacings is concerned. For IS95A and J-STD008 the spacing is calculated from the center of the main channel to the center of the corresponding adjacent channel, for IS95C from the center of the main channel to the nearest border of the adjacent channel.*

Example: `"CALC:MARK:FUNC:POW:PRES NADC"`   'Selects the standard setting for 'NADC

Characteristics: *RST value: -
                SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:POWer:RESult? ACPower | CPOWer | MCACpower | OBANdwidth | OBWidth | CN | CN0

This command queries the result of the power measurement performed in the selected window. If necessary, the measurement is switched on prior to the query.

The channel spacings and channel bandwidths are configured in the `SENSe:POWer:ACHannel` subsystem.

To obtain a valid result, a complete sweep with synchronization to the end of the sweep must be performed before a query is output. Synchronization is possible only in the single-sweep mode.

This function is available for measurement result MAGNITUDE in frequency domain. In addition the occupied bandwidth measurement is available in MAGNITUDE/PHASE, too.

Parameters:

ACPower: Adjacent-channel power measurement

Results are output in the following sequence, separated by commas:
1. Power of transmission channel
2. Power of lower adjacent channel
3. Power of upper adjacent channel
4. Power of lower alternate channel 1
5. Power of upper alternate channel 1
6. Power of lower alternate channel 2
7. Power of upper alternate channel 2

The number of measured values returned depends on the number of adjacent/alternate channels selected with `SENSe:POWer:ACHannel:ACPairs`.
With logarithmic scaling (RANGE LOG), the power is output in the currently selected level unit; with linear scaling (RANGE LIN dB or LIN %), the power is output in W. If `SENSe:POWer:ACHannel:MODE REL` is selected, the adjacent/alternate-channel power is output in dB.

CPOWer   Channel power measurement

With logarithmic scaling (RANGE LOG), the channel power is output in the currently selected level unit; with linear scaling (RANGE LIN dB or LIN %), the channel power is output in W.

MCACpower: Channel/adjacent-channel power measurement with several carrier signals

Results are output in the following sequence, separated by commas:
1. Power of carrier signal 1
2. Power of carrier signal 2
3. Power of carrier signal 3
4. Power of carrier signal 4
5. Total power of all carrier signals
6. Power of lower adjacent channel
7. Power of upper adjacent channel
8. Power of lower alternate channel 1
9. Power of upper alternate channel 1
10. Power of lower alternate channel 2
11. Power of upper alternate channel 2

The number of measured values returned depends on the number of carrier signals and adjacent/alternate channels selected with `SENSe:POWer:ACHannel:TXCHannel:COUNt` and `SENSe:POWer:ACHannel:ACPairs`.

If only one carrier signal is measured, the total value of all carrier signals will not be output.

With logarithmic scaling (RANGE LOG), the power is output in dBm; with linear scaling (RANGE LIN dB or LIN %), the power is output in W. If `SENSe:POWer:ACHannel:MODE REL` is selected, the adjacent/alternate-channel power is output in dB.

OBANdwidth | OBWidth   Measurement of occupied bandwidth
The occupied bandwidth in Hz is returned.

CN   Measurement of carrier-to-noise ratio
The carrier-to-noise ratio in dB is returned.

CN0   Measurement of carrier-to-noise ratio referenced to 1 Hz bandwidth.
The carrier-to-noise ratio in dB/Hz is returned.

Example of channel/adjacent-channel power measurement:

`"SENS:POW:ACH:ACP 3"`	'Sets the number of adjacent/alternate channels to 3.
`"SENS:POW:ACH:BAND 30KHZ"`	'Sets the bandwidth of the transmission channel to 30 kHz.
`"SENS:POW:ACH:BAND:ACH 40KHZ"`	'Sets the bandwidth of each adjacent channel to 40 kHz.
`"SENS:POW:ACH:BAND:ALT1 50KHZ"`	'Sets the bandwidth of each alternate channel to 50 kHz.
`"SENS:POW:ACH:BAND:ALT2 60KHZ"`	'Sets the bandwidth of alternate channel 2 to 60 kHz.
`"SENS:POW:ACH:SPAC 30KHZ"`	'Sets the spacing between the transmission channel and the adjacent channel to 30 kHz, the spacing between the transmission channel and alternate channel 1 to 60 kHz, and the spacing between the transmission channel and alternate channel 2 to 90 kHz.
`"SENS:POW:ACH:SPAC:ALT1 100KHZ"`	'Sets the spacing between the transmission channel and alternate channel 1 to 100 kHz, and the spacing between the transmission channel and alternate channel 2 to 150 kHz.
`"SENS:POW:ACH:SPAC:ALT2 140KHZ"`	'Sets the spacing between the transmission channel and alternate channel 2 to 140 kHz.
`"SENS:POW:ACH:MODE ABS"`	'Switches on absolute power measurement.
`"CALC:MARK:FUNC:POW:SEL ACP"`	'Switches on the adjacent-channel power measurement.
`"INIT:CONT OFF"`	'Switches over to single-sweep mode.
`"INIT;*WAI"`	'Starts a sweep and waits for the end of the sweep.
`"CALC:MARK:FUNC:POW:RES? ACP"`	'Queries the result of adjacent-channel power measurement.
`"SENS:POW:ACH:REF:AUTO ONCE"`	'Defines the measured channel power as the reference value for relative power measurements.

If the **channel power only** is to be measured, all commands relating to adjacent/alternate channel bandwidth and channel spacings are omitted. The number of adjacent/alternate channels is set to 0 with `SENS2:POW:ACH:ACP 0`.

Example of occupied bandwidth measurement:

`"SENS1:POW:BAND 90PCT"  '`	'Defines 90 % as the percentage of the power to be contained in the bandwidth range to be measured.
`"INIT:CONT OFF"`	'Switches over to single-sweep mode.
`"INIT;*WAI"  '`	'Starts a sweep and waits for the end of the sweep.
`"CALC1:MARK:FUNC:POW:RES? OBW"`	'Queries the occupied bandwidth measured in screen A.

Characteristics: *RST value: -
                       SCPI: device-specific

This command is a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:POWer:RESult:PHZ ON | OFF

This command switches the query response of the power measurement results in the indicated measurement window between output of absolute values (OFF) and output referred to the measurement bandwidth (ON).
The measurement results are output with `CALCulate:MARKer:FUNCtion:POWer:RESult?`
This function is available for measurement result MAGNITUDE in frequency domain.

Parameter: ON: Results output referred to measurement bandwidth.
OFF: Results output in absolute values.

Example of channel/adjacent channel measurement:

`"SENS:POW:ACH:ACP 3"`	'Sets the number of adjacent channels to 3.
`"SENS:POW:ACH:BAND 30KHZ"`	'Sets the bandwidth of the main channel to 30 kHz.
`"SENS:POW:ACH:BAND:ACH 40KHZ"`	'Sets the bandwidth of all adjacent 'channels to 40 kHz.
`"SENS:POW:ACH:BAND:ALT1 50KHZ"`	'Sets the bandwidth of all alternate 'adjacent channels to 50 kHz.
`"SENS:POW:ACH:BAND:ALT2 60KHZ"`	'Sets the bandwidth of alternate adjacent 'channel 2 to 60 kHz.
`"SENS:POW:ACH:SPAC 30KHZ"`	'Sets the spacing between channel and 'adjacent channel as well as between all 'adjacent channels to 30 kHz.
`"SENS:POW:ACH:SPAC:ALT1 40KHZ"`	'Sets the spacing between adjacent 'channel and alternate adjacent channel as 'well as between all alternate adjacent 'channels to 40 kHz.
`"SENS:POW:ACH:SPAC:ALT2 50KHZ"`	'Sets the spacing between alternate 'adjacent channel 1 and alternate adjacent 'channel 2 to 50 kHz.
`"SENS:POW:ACH:MODE ABS"`	'Switches on absolute power 'measurement.
`"CALC:MARK:FUNC:POW:SEL ACP"`	'Switches the adjacent channel power 'measurement on.
`"INIT:CONT OFF"`	'Switches to single-sweep mode.
`"INIT;*WAI"`	'Starts a sweep and waits for the end.
`"CALC:MARK:FUNC:POW:RES:PHZ ON"`	'Output of results referred to the channel 'bandwidth.
`"CALC:MARK:FUNC:POW:RES? ACP"`	'Queries the result of the adjacent channel 'power measurement referred 'to the channel bandwidth.

If only the **channel power** is to be measured, all commands for defining the bandwidths of adjacent channels as well as the channel spacings are not necessary. The number of adjacent channels is set to 0 with `SENS:POW:ACH:ACP 0`.

Characteristics: *RST value: -
SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:POWer:SELect ACPower | CPOWer | MCACpower |
OBANdwidth | OBWidth | CN | CN0

This command selects – and switches on – one of the above types of power measurement in the
selected measurement window. This function is independent of the selected marker, i.e. the
numerical suffix <1 to 4> appended to MARKer has no effect.
The channel spacings and channel bandwidths are configured in the `SENSe:POWer:ACHannel`
subsystem.
Please note the following:
If CPOWer is selected, the number of adjacent channels (command:
`[SENSe:]POWer:ACHannel:ACPairs`) is set to 0. If ACPower is selected, the number of adjacent
channels is set to 1, unless adjacent-channel power measurement is switched on already.
With respect to the above two settings, the behaviour of the R&S FMU differs from that of the FSE
family.

Note: *The channel/adjacent-channel power measurement is performed for the trace selected with*
                `SENSe:POWer:TRACe 1|2|3`.
                This command is not available during an active GSM measurement.

The occupied bandwidth measurement is performed for the trace on which marker 1 is positioned.
To select another trace for the measurement, marker 1 is to be positioned on the desired trace by
means of `CALC:MARK:TRAC 1|2|3`.

Parameters:	ACPower	Adjacent-channel power measurement with a single carrier signal
	CPOWer	Channel power measurement with a single carrier signal (equivalent to adjacent-channel power measurement with *NO. OF ADJ CHAN* = 0)
	MCACpower	Channel/adjacent-channel power measurement with several carrier signals
	OBANdwidth | OBWidth	Measurement of occupied bandwidth
	CN	Measurement of carrier-to-noise ratio
	CN0	Measurement of carrier-to-noise ratio referenced to 1Hz bandwidth

This function is available for measurement result MAGNITUDE in frequency domain. In addition the
occupied bandwidth measurement is available in MAGNITUDE/PHASE, too.

Example:	`"CALC:MARK:FUNC:POW:SEL ACP"`	'Switches on adjacent-channel power measurement.

Characteristics:	*RST value:	-
	SCPI:	device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:POWer[:STATe]   OFF

This command switches off the power measurement in the selected measurement window.
This function is available for measurement result MAGNITUDE in frequency domain.

Example:	`"CALC:MARK:FUNC:POW OFF"`	'Switches off the power measurement.

Characteristics:	*RST value:	-
	SCPI:	device-specific

This command is an event and therefore has no *RST value.

CALCulate:MARKer:FUNCtion:SUMMary Subsystem

This subsystem contains the commands for controlling the time domain power functions.

Command	Parameters
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:AOFF	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:AVERage	ON | OFF
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:MEAN:AVERage:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:MEAN:PHOLd:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:MEAN:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:MEAN[:STATe]	ON | OFF
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:MODE	ABSolute | RELative
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:MSUMmary?	<time offset of first pulse>, <measurement time>, <period>, < # of pulses to measure>
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:PPEak:AVERage:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:PPEak:PHOLd:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:PPEak:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:PPEak[:STATe]	ON | OFF
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:PHOLd	ON | OFF
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:REFerence:AUTO	ONCE
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:RMS:AVERage:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:RMS:PHOLd:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:RMS:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:RMS[:STATe]	ON | OFF
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:SDEV:AVERage:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:SDEV:PHOLd:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:SDEViation:RESult?	
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:SDEViation[:STATe]	ON | OFF
CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:STATe	ON | OFF

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:AOFF

This command switches off all time domain measurements in the selected measurement window.The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of :MARKer is irrelevant.
This function is available for measurement result MAGNITUDE in time domain.

Example: "CALC:MARK:FUNC:SUMM:AOFF"   'Switches off the time domain power
                                                                                       'measurement functions.

Characteristics: *RST value: _
                               SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:AVERage ON | OFF

This command switches on or off averaging for the active time domain power measurement in the indicated window. The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
Averaging is reset by switching it off and on again.
The number of results required for the calculation of average is defined with
`[SENSe<1|2>:]AVERage:COUNt`.
It should be noted that synchronization to the end of averaging is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in time domain.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"CALC:MARK:FUNC:SUMM:AVER ON"`	'Switches on the calculation of.
	`"AVER:COUN 200"`	'Sets the measurement counter to 200.
	`"INIT;*WAI"`	'Starts a sweep and waits for the end.

Characteristics:	*RST value:	OFF
	SCPI:	device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:MEAN:AVERage:RESult?

This command queries the result of the measurement of the averaged mean value in the selected measurement window. The query is only possible if averaging has been activated previously using
`CALCulate<1|2>:MARKer<1 to 4>:FUNCtion: SUMMary:AVERage`.
The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in time domain.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"CALC:MARK:FUNC:SUMM:MEAN ON"`	'Switches on the function.
	`"CALC:MARK:FUNC:SUMM:AVER ON"`	'Switches on the average value
		'calculation.
	`"INIT;*WAI"`	'Starts a sweep and waits for
		'the end.
	`"CALC:MARK:FUNC:SUMM:MEAN:AVER:RES?"`	'Outputs the result.

Characteristics:	*RST- value:	-
	SCPI:	device-specific

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:MEAN:PHOLd:RESult?

This command queries the result of the measurement of the mean value with active peak hold in the selected measurement window. The query is only possible if the peak hold function has been switched on previously using `CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary: PHOLd`.
The query is possible only if the peak hold function is active. The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in time domain.

Example: `"INIT:CONT OFF"`   'Switches to single-sweep mode
                           `"CALC:MARK:FUNC:SUMM:MEAN ON"`   'Switches on the function
                           `"CALC:MARK:FUNC:SUMM:PHOL ON"`   'Switches on the peak value
                                                                      'measurement.
                           `"INIT;*WAI"`   'Starts a sweep and waits for the end
                           `"CALC:MARK:FUNC:SUMM:MEAN:PHOL:RES?"` 'Outputs the result.

Characteristics: *RST- value: -
                                   SCPI: device-specific

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:MEAN:RESult?

This command queries the result of the measurement of the mean value in the selected measurement window. The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in time domain.

Example: `"INIT:CONT OFF"`   'Switches to single-sweep mode.
                           `"CALC:MARK:FUNC:SUMM:MEAN ON"`   'Switches on the function.
                           `"INIT;*WAI"`   'Starts a sweep and waits for the end.
                           `"CALC:MARK:FUNC:SUMM:MEAN:RES?"` 'Outputs the result.

Characteristics: *RST- value: -
                                   SCPI: device-specific

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:MEAN[:STATe] ON | OFF

This command switches on or off the measurement of the mean value in the selected measurement window.
The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
This function is available for measurement result MAGNITUDE in time domain.

Note: *The measurement is performed on the trace on which marker 1 is positioned. In order to evaluate another trace, marker 1 must be positioned on another trace with* `CALC:MARK:TRAC 1|2|3.`

Example: `"CALC:MARK:FUNC:SUMM:MEAN ON"`   'Switches on the function.

Characteristics: *RST value: OFF
                                   SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:MODE ABSolute | RELative

This command selects absolute or relative time domain power measurement in the indicated measurement window. The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.

The reference power for relative measurement is defined with `CALCulate:MARKer:FUNCtion :SUMMary:REFerence:AUTO ONCE`. If the reference power is not defined, the value 0 dBm is used.

This function is available for measurement result MAGNITUDE in time domain.

Example:	`"CALC:MARK:FUNC:SUMM:MODE REL"`	'Switches the time domain power 'measurement to relative.

Characteristics:	*RST value:	ABSolute
	SCPI:	device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:MSUMmary?   <time offset of first pulse>, <measurement time>, <period>, < # of pulses to measure>

The commands of this subsystem are used to determine the power of a sequence of signal pulses having the same interval, as are typical for the slots of a GSM signal, for example. The number of pulses to be measured as well as the measurement time and the period can be set. To define the position of the first pulse in the trace, a suitable offset can be entered.

The evaluation is performed on the measurement data of a previously recorded trace. The data recorded during the set measurement time is combined to a measured value for each pulse according to the detector specified and the indicated number of results is output as a list.
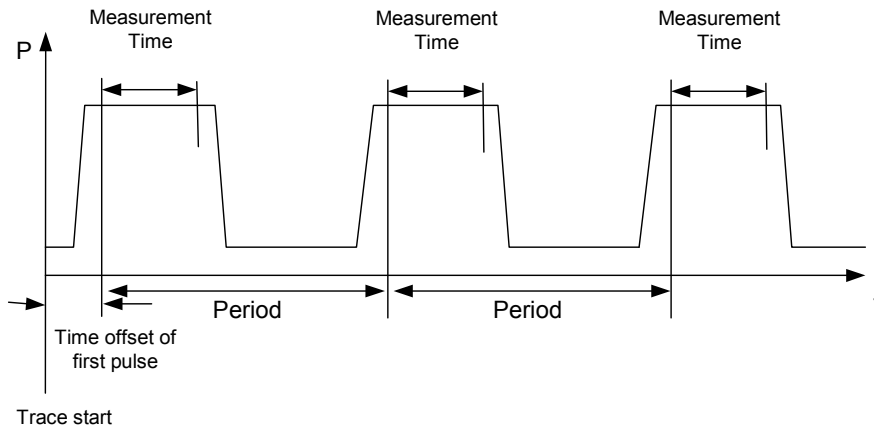
TRACE 1 of the selected screen is always used by the function. The suffix of MARKer will be ignored.

This function is available for measurement result MAGNITUDE in time domain.

Example:	`"DISP:WIND:TRAC:Y:RLEV –10dBm"`	'Sets the reference level to 10 dBm
	`"FREQ:CENT 18MHz;SPAN 0Hz"`	'Sets the receive frequency to 18 MHz 'and the span to 0 Hz (time domain)
	`"BAND:RES 1MHz"`	'Sets the resolution bandwidth to 1 MHz `"DET RMS"`'Sets the RMS detector
	`"TRIG:SOUR EXT "`	'Selects the trigger source EXTern
	`"SWE:TIME 50ms"`	'Sets the sweep time to 50 ms
	`"INIT;*WAI"`	'Starts the measurement with synchronization
	`"CALC:MARK:FUNC:MSUM? 50US,450US,576.9US,8"`	
		'Queries 8 bursts with an offset of 50 μs, a 'test time of 450 μs and a period of 576.9 μs

Characteristics:	*RST value:-	
	SCPI:device-specific	

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:PHOLd ON | OFF

This command switches on or off the peak-hold function for the active time domain power measurement in the indicated measurement window. The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
The peak-hold function is reset by switching it off and on again.
This function is available for measurement result MAGNITUDE in time domain.

Example: `"CALC:MARK:FUNC:SUMM:PHOL ON"` 'Switches on the function.

Characteristics: *RST value: OFF
                        SCPI: device-specific

The peak-hold function is reset by switching off and on, again.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:PPEak:AVERage:RESult?

This command is used to query the result of the measurement of the averaged positive peak value in the selected measurement window. The query is only possible if averaging has been activated previously using `CALCulate<1|2>:MARKer<1 to 4>:FUNCtion: SUMMary:AVERage`.
The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> in MARKer is irrelevant.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in time domain.

Example: `"INIT:CONT OFF"`   'Switches to single-sweep mode.
                       `"CALC:MARK:FUNC:SUMM:PPE ON"`   'Switches on the function.
                       `"CALC:MARK:FUNC:SUMM:AVER ON"`   'Switches on the calculation of average.
                       `"INIT;*WAI"`   'Starts a sweep and waits for the end.
                       `"CALC:MARK:FUNC:SUMM:PPE:AVER:RES?"`   'Outputs the result.

Characteristics: *RST value: -
                        SCPI: device-specific

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:PPEak:PHOLd:RESult?

This command is used to query the result of the measurement of the positive peak value with active peak hold function. The query is only possible if the peak hold function has been activated previously using `CALCulate<1|2>:MARKer<1 to 4>: FUNCtion:SUMMary:PHOLd`.
The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.

This function is available for measurement result MAGNITUDE in time domain.

Example: `"INIT:CONT OFF"`   'Switches to single-sweep mode.
                       `"CALC:MARK:FUNC:SUMM:PPE ON"`   'Switches on the function.
                       `"CALC:MARK:FUNC:SUMM:PHOL ON"`   'Switches on the measurement of the
                                                            'peak value.
                       `"INIT;*WAI"`   'Starts a sweep and waits for the end.
                       `"CALC:MARK:FUNC:SUMM:PPE:PHOL:RES?"`   'Outputs the result.

Characteristics: *RST value: -
                        SCPI: device-specific

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:PPEak:RESult?

This command is used to query the result of the measurement of the positive peak value in the selected measurement window. The measurement may have to be switched on previously.
The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of MARKer is irrelevant.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in time domain.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"CALC:MARK:FUNC:SUMM:PPE ON"`	'Switches on the function.
	`"INIT;*WAI"`	'Starts a sweep and waits for the end.
	`"CALC:MARK:FUNC:SUMM:PPE:RES?"`	'Outputs the result.

| **Characteristics:** | *RST value: | - |
| | SCPI: | device-specific |

Mode: A-T, MS

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:PPEak[:STATe] ON | OFF

This command switches on or off the measurement of the positive peak value in the selected measurement window.
The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of MARKer is irrelevant.
This function is available for measurement result MAGNITUDE in time domain.

| **Example:** | `"CALC:MARK:FUNC:SUMM:PPE ON"` 'Switches on the function in screen A. |

| **Characteristics:** | *RST value: | OFF |
| | SCPI: | device-specific |

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:REFerence:AUTO ONCE

With this command the currently measured average value (`..:SUMMary:MEAN`) and RMS value (`..:SUMMary:RMS`) are declared as reference values for relative measurements in the indicated measurement window. The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
If the measurement of RMS value and average is not activated, the reference value 0 dBm is used.
If the function `to :SUMMary:AVERage` or `to :SUMMary:PHOLd` is switched on, the current value is the accumulated measurement value at the time considered.
This function is available for measurement result MAGNITUDE in time domain.

Example:	`"CALC:MARK:FUNC:SUMM:REF:AUTO ONCE"`
	' Takes the currently measured power in
	' screen A as reference value for the relative
	' time domain power measurement.

| **Characteristics:** | *RST value: | - |
| | SCPI: | device-specific |

This command is an event and therefore has no *RST value and no query.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:RMS:AVERage:RESult?

This command queries the result of the measurement of the averaged RMS value in the selected measurement window. The query is only possible if averaging has been activated previously using `CALCulate<1|2>:MARKer<1 to 4>:FUNCtion: SUMMary:AVERage`.
The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in time domain.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"CALC:MARK:FUNC:SUMM:RMS ON"`	'Switches on the function.
	`"CALC:MARK:FUNC:SUMM:AVER ON"`	Switches on the average value
		'calculation.
	`"INIT;*WAI"`	'Starts a sweep and waits for the end.
	`"CALC:MARK:FUNC:SUMM:RMS:AVER:RES?"`	'Outputs the result.

Characteristics: *RST- value: -
                      SCPI: device-specific
This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:RMS:PHOLd:RESult?

This command queries the result of the measurement of the RMS value with active peak hold in the selected measurement window. The query is only possible only if the peak hold function has been activated previously using `CALCulate<1|2>:MARKer<1 to 4>: FUNCtion:SUMMary:PHOLd`.
The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in time domain.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"CALC:MARK:FUNC:SUMM:RMS ON"`	'Switches on the function.
	`"CALC:MARK:FUNC:SUMM:PHOL ON"`	'Switches on the peak value
		'measurement.
	`"INIT;*WAI"`	'Starts a sweep and waits for the end.
	`"CALC:MARK:FUNC:SUMM:RMS:PHOL:RES?"`	'Outputs the result.

Characteristics: *RST- value: -
                      SCPI: device-specific
This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:RMS:RESult?

This command queries the result of the measurement of the RMS power value in the selected measurement window.
The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in time domain.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"CALC:MARK:FUNC:SUMM:RMS ON"`	'Switches on the function.
	`"INIT;*WAI"`	'Starts a sweep and waits for the end.
	`"CALC:MARK:FUNC:SUMM:RMS:RES?"`	'Outputs the result.

| **Characteristics:** | *RST- value: | - |
| | SCPI: | device-specific |

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:RMS[:STATe] ON | OFF

This command switches on or off the measurement of the effective (RMS) power in the selected measurement window. If necessary the function is switched on previously.
The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
This function is available for measurement result MAGNITUDE in time domain.

| **Example:** | `"CALC:MARK:FUNC:SUM:RMS ON"` | 'Switches on the function. |

| **Characteristics:** | *RST value: | OFF |
| | SCPI: | device-specific |

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:SDEViation:AVERage:RESult?

This command queries the result of the averaged standard deviation determined in several sweeps in the selected measurement window. The query is possible only if averaging is active. The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of `:MARKer` is irrelevant.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in time domain.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"CALC:MARK:FUNC:SUMM:SDEV ON"`	'Switches on the function.
	`"CALC:MARK:FUNC:SUMM:AVER ON"`	'Switches on the calculation of average.
	`"INIT;*WAI"`	'Starts a sweep and waits for the end.
	`"CALC:MARK:FUNC:SUMM:MEAN:SDEV:RES?"`	'Outputs the result.

| **Characteristics:** | *RST value: | - |
| | SCPI: | device-specific |

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:SDEViation:PHOLd:RESult?

This command queries the maximum standard deviation value determined in several sweeps in the selected measurement window. The query is possible only if the peak hold function is active.
The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of :MARKer is irrelevant.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in time domain.

Example:	"INIT:CONT OFF"	'Switches to single-sweep mode.
	"CALC:MARK:FUNC:SUMM:SDEV ON"	'Switches on the function.
	"CALC:MARK:FUNC:SUMM:PHOL ON"	'Switches on the peak value
		'measurement.
	"INIT;*WAI"	'Starts a sweep and waits for the end.
	"CALC:MARK:FUNC:SUMM:SDEV:PHOL:RES?"	'Outputs the result.

Characteristics: *RST value: -
SCPI: device-specific

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:SDEViation:RESult?

This command queries the results of the standard deviation measurement. The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of :MARKer is irrelevant.
A complete sweep with synchronization to sweep end must be performed between switching on the function and querying the measured value to obtain a valid query result. This is only possible in single sweep mode.
This function is available for measurement result MAGNITUDE in time domain.

Example:	"INIT:CONT OFF"	'Switches to single-sweep mode.
	"CALC:MARK:FUNC:SUMM:SDEV ON"	'Switches on the function.
	"INIT;*WAI"	'Starts a sweep and waits for the end.
	"CALC:MARK:FUNC:SUMM:SDEV:RES?"	'Outputs the result.

Characteristics: *RST value: -
SCPI: device-specific

This command is only a query and therefore has no *RST value.

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary:SDEViation[:STATe] ON | OFF

This command switches on or off the measurement of the standard deviation in the selected measurement window.The function is independent of the marker selection, i.e. the numeric suffix <1 to 4> of :MARKer is irrelevant.
On switching on the measurement, the mean power measurement is switched on as well.
This function is available for measurement result MAGNITUDE in time domain.

Example:	"CALC:MARK:FUNC:SUMM:SDEV ON"	'Switches on the measurement of
		'the standard deviation.

Characteristics: *RST value: OFF
SCPI: device-specific

CALCulate<1|2>:MARKer<1 to 4>:FUNCtion:SUMMary[:STATe]   ON | OFF

This command switches on or off the previously selected time domain power measurements. Thus one or several measurements can be first selected and then switched on and off together with `CALC:MARK:FUNC:SUMMary:STATe`.
The function is independent of the marker selection, i.e. the suffix of MARKer is irrelevant. As default the complete trace is taken into account. The calculation range can be reduced by using CALC:MARK:X:SLIM sub-system.

This function is available for measurement result MAGNITUDE in time domain.

Example: `"CALC:MARK:FUNC:SUMM:STAT ON"`

Characteristics: *RST value: OFF
                    SCPI: device-specific

CALCulate:MATH Subsystem

The CALCulate:MATH subsystem allows to process data from the SENSe-subsystem in numeric expressions. The measurement windows are selected by CALCulate1 (screen A) or CALCulate2 (screen B).

Command	Parameters
CALCulate<1|2>:MATH[:EXPRession][:DEFine]	<expr>
CALCulate<1|2>:MATH:MODE	LINear | LOGarithmic
CALCulate<1|2>:MATH:POSition	-100PCT to 200PCT
CALCulate<1|2>:MATH:STATe	ON | OFF

CALCulate<1|2>:MATH[:EXPRession][:DEFine] <expr>

This command defines the mathematical expression for relating traces to trace1.
The zero point of the result display can be defined with CALC:MATH:POS. Command CALCulate:MATH:STATe switches the mathematical relation of traces on or off .

Parameter: <expr>::= 'OP1 - OP2'
                         OP1 ::= TRACE1
                         OP2 ::= TRACE2 | TRACE3

Example: "CALC1:MATH (TRACE1 – TRACE2)"   'Selects the subtraction of trace 1
                                                        'from trace 2 in screen A.
                   "CALC2:MATH (TRACE1 – TRACE3)"   'Selects the subtraction of trace 1
                                                        'from trace 3 in screen B.

Characteristics: *RST value: -
                      SCPI: conforming

CALCulate<1|2>:MATH:MODE LINear | LOGarithmic

This command selects linear or logarithmic calculation of the mathematical functions related to the traces. The calculation of the average is one of the affected functions. The setting is valid for all measurement windows, i.e. the numeric suffix <1|2> of CALCulate is irrelevant.

Example: "CALC:MATH:MODE LIN"   'Switches on the linear calculation.

Characteristics: *RST value: LOG
                      SCPI: device-specific

CALCulate<1|2>:MATH:POSition -100PCT to 200PCT

This command defines the position of the result of the trace mathematics in the selected measurement window. The indication is in % of the screen height, with 100 % corresponding to the upper diagram border.

Example: "CALC:MATH:POS 50PCT"   'Sets the position in screen A to the
                                              'horizontal diagram center.

Characteristics: *RST value: 50 %
                      SCPI: device-specific

CALCulate<1|2>:MATH:STATe   ON | OFF

This command switches the mathematical relation of traces on or off.

Example:	`"CALC:MATH:STAT ON"`	'Switches on the trace mathematics in 'screen A.

Characteristics:	*RST value:	OFF
	SCPI:	conforming

CALCulate:PLINe Subsystem

The CALCulate:PLINe subsystem controls the display lines in the phase diagram in the FFT Analyzer mode. The measurement window is selected via CALCulate1 (SCREEN A) or CALCulate2 (SCREEN B).

COMMAND	PARAMETER
CALCulate<1|2>:PLINe<1|2>	-36000 to 36000 DEG | RAD
CALCulate<1|2>::STATe	ON | OFF

CALCulate<1|2>:PLINe<1|2> -36000 to 36000 DEG | RAD

This command defines the position of the display lines in the phase diagram (phase line).
The lines mark the specified phases in the measurement window. Phase lines are available only in the frequency domain of the magnitude/phase display when the FFT Analyzer mode is active.

Example: `"CALC2:PLIN2 10 DEG"`

Characteristics: *RST value: - (STATe to OFF)
SCPI: device-specific

CALCulate<1|2>:PLINe<1|2>:STATe ON | OFF

This command switches the display lines in the phase diagram on or off. Phase lines are available only in the frequency domain of the magnitude/phase display when the FFT Analyzer mode is active.

Example: `"CALC2:PLIN2:STAT ON"`

Characteristics: *RST value: OFF
SCPI: device-specific

CALCulate:STATistics Subsystem

The CALCulate:STATistics subsystem controls the statistical measurement functions in the instrument. The measurement window cannot be selected with these functions. The numeric suffix in CALCulate is therefore ignored.

Command	Parameters
CALCulate:STATistics:APD[:STATe]	ON | OFF
CALCulate:STATistics:CCDF[:STATe]	ON | OFF
CALCulate:STATistics:CCDF:X<1 to 3>?	P0_1|P1|P10
CALCulate:STATistics:NSAMples	100 to 1E9
CALCulate:STATistics:PRESet	
CALCulate:STATistics:Result<1 to 3>?	MEAN|PEAK|CFACtor|ALL
CALCulate:STATistics:SCALe:AUTO	ONCE
CALCulate:STATistics:SCALe**:**X:RLEVel	0.0316 V to 5.63 V
CALCulate:STATistics: SCALe**:**X:RANGe	1 dB to 200 dB
CALCulate:STATistics:SCALe**:**Y:UNIT	PCT|ABS
CALCulate:STATistics:SCALe**:**Y:UPPer	-1E-8 to 1.0
CALCulate:STATistics: SCALe**:**Y:LOWer	-1E-9 to 0.1

CALCulate:STATistics:APD[:STATe] ON | OFF

This command switches on or off the measurement of amplitude distribution (APD). On activating this function, the CCDF measurement is switched off.
This function is available for measurement result MAGNITUDE in time domain.

Example: "CALC:STAT:APD ON"   'Switches on the APD measurement.

Characteristics: *RST value: OFF
                        SCPI: device-specific

CALCulate:STATistics:CCDF[:STATe] ON | OFF

This command switches on or off the measurement of the complementary cumulative distribution function (CCDF). On activating this function, the APD measurement is switched off.
This function is available for measurement result MAGNITUDE in time domain.

Example: "CALC:STAT:CCDF ON"   'Switches on the CCDF measurement.

Characteristics: *RST value: OFF
                        SCPI: device-specific

CALCulate:STATistics:CCDF:X<1 to 3>?   P0_01 | P0_1 | P1 | P10

This command reads out the level values for the probabilities 0.1 %, 1 % and 10 %. The trace is selected by means of the numeric suffix <1 to 3>.
This function is available for measurement result MAGNITUDE in time domain.

Parameters:	The desired result is selected by means of the following parameters:
	P0_01 Level value for 0.01 % probability
	P0_1 Level value for 0.1% probability
	P1 Level value for 1 % probability
	P10 Level value for 10 % probability

Example: `"CALC:STAT:CCDF:X? P1"`   'Reads out the level values for 1 % probability.

Characteristics: *RST value: --
                         SCPI: device-specific

CALCulate:STATistics:NSAMples   100   to   1E9

This command sets the number of measurement points to be acquired for the statistical measurement functions.
This function is available for measurement result MAGNITUDE in time domain.

Example: `"CALC:STAT:NSAM 500"`   'Sets the number of measurement points to be
                                                             'acquired to 500.

Characteristics: *RST value: 100000
                         SCPI: device-specific

CALCulate:STATistics:PRESet

This command resets the scaling of the X and Y as in a statistical measurement. The following values are set:

X axis ref level: -1 volt peak
X axis range APD: 100 dB
X axis range CCDF: 20 dB

Y axis upper limit: 1.0
Y axis lower limit: 1E-6

This function is available for measurement result MAGNITUDE in time domain.

Example: `"CALC:STAT:PRES"`   'Resets the scaling for statistical functions

Characteristics: *RST value: --
                         SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate:STATistics:RESult<1 to 3>? MEAN | PEAK | CFACtor | ALL

This command reads out the results of statistical measurements of a recorded trace. The trace is selected with the numeric suffix <1 to 3> attached to RESult.

Parameter:	The required result is selected via the following parameters:	
	MEAN	Average (=RMS) power in dBm measured during the measurement time.
	PEAK	Peak power in dBm measured during the measurement time.
	CFACtor	Determined CREST factor (= ratio of peak power to average power) in dB.
	ALL	Results of all three measurements mentioned before, separated by commas: <mean power>,<peak power>,<crest factor>

This function is available for measurement result MAGNITUDE in time domain.

Example: "CALC:STAT:RES2? ALL"   'Reads out the three measurement results of
                                                        'trace 2. Example of answer string:
                                                        '5.56,19.25,13.69
                                                        'i.e. mean power: 5.56 dBm, peak power 19.25
                                                        'dBm, CREST factor 13.69 dB

Characteristics: *RST value: --
                                 SCPI: device-specific

CALCulate:STATistics:SCALe:AUTO ONCE

This command optimizes the level setting of the instrument depending on the measured peak power, in order to obtain maximum instrument sensitivity.

To obtain maximum resolution, the level range is set as a function of the measured spacing between peak power and the minimum power for the APD measurement and of the spacing between peak power and mean power for the CCDF measurement. In addition, the probability scale for the number of test points is adapted.

This function is available for measurement result MAGNITUDE in time domain.

Note: *Subsequent commands have to be synchronized with *WAI, *OPC or *OPC? to the end of the autorange process which would otherwise be aborted.*

Example: "CALC:STAT:SCAL:AUTO ONCE;*WAI"   'Adapts the level setting for
                                                                           'statistical measurements.

Characteristics: *RST value: --
                                 SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALCulate:STATistics:SCALe:X:RLEVel 0.0316 V to 5.62 V

This command defines the reference level in volt peak for the X axis of the measurement diagram. The setting is identical to the reference level setting using the command DISPlay:WINDow:TRACe:Y: RLEVel.

With the reference level offset <> 0 the indicated value range of the reference level is modified by the offset.

This function is available for measurement result MAGNITUDE in time domain.

Example: "CALC:STAT:SCAL:X:RLEV 1.78V"

Characteristics: *RST value: 1.0 volt peak
                                 SCPI: device-specific

CALCulate:STATistics:SCALe:X:RANGe 1dB to 200dB

This command defines the level range for the X axis of the measurement diagram. The setting is identical to the level range setting defined with the command `DISPlay:WINDow:TRACe:Y:SCALe`.

This function is available for measurement result MAGNITUDE in time domain.

Example: `"CALC:STAT:SCAL:X:RANG 20dB"`

Characteristics: *RST value: 100dB
SCPI: device-specific

CALCulate:STATistics:SCALe:Y:UNIT PCT | ABS

This command toggles the scaling of Y axis between percentage und absolute.

This function is available for measurement result MAGNITUDE in time domain.

Example: `"CALC:STAT:SCAL:Y:UNIT PCT"` 'toggle to percentage

Characteristics: *RST value ABS
SCPI: device-specific

CALCulate:STATistics:SCALe:Y:UPPer 1E-8 to 1.0

This command defines the upper limit for the Y axis of the diagram in statitistical measurements. Since probabilities are specified on the Y axis, the entered numerical values are dimensionless.

This function is available for measurement result MAGNITUDE in time domain.

Example: `"CALC:STAT:Y:UPP 0.01"`

Characteristics: *RST value: 1.0
SCPI: device-specific

CALCulate:STATistics:SCALe:Y:LOWer 1E-9 to 0.1

This command defines the lower limit for the Y axis of the diagram in statistical measurements. Since probabilities are specified on the Y axis, the entered numerical values are dimensionless.

This function is available for measurement result MAGNITUDE in time domain.

Example: `"CALC:STAT:SCAL:Y:LOW 0.001"`

Characteristics: *RST value: 1E-6
SCPI: device-specific

CALCulate:THReshold Subsystem

The CALCulate:THReshold subsystem controls the threshold value for the maximum/minimum search of markers. The measurement windows are selected by CALCulate 1 (screen A) or 2 (screen B).

Command	Parameters
CALCulate<1|2>:DLINe<1|2>	MINimum to MAXimum
CALCulate<1|2>:DLINe<1|2>:STATe	ON | OFF
CALCulate<1|2>:FLINe<1|2>	-fmax to +fmax
CALCulate<1|2>:FLINe<1|2>:STATe	ON | OFF
CALCulate<1|2>:THReshold	MINimum to MAXimum
CALCulate<1|2>:THReshold:STATe	ON | OFF
CALCulate<1|2>:TLINe<1|2>	0 to 1000s
CALCulate<1|2>:TLINe<1|2>:STATe	ON | OFF

CALCulate<1|2>:DLINe<1|2>   MINimum .. MAXimum (depending on current unit)

This command defines the position of Display Line 1 or 2. These lines enable the user to mark any levels in the diagram. The unit depends on the setting made with `CALC:UNIT`" and the selected measurement result of the window.

Example: `"CALC:DLIN –20dBm"`

Characteristics: *RST value: - (STATe to OFF)
                     SCPI: device-specific

CALCulate<1|2>:DLINe<1|2>:STATe   ON | OFF

This command switches Display Line 1 or 2 (level lines) on or off.

Example: `"CALC:DLIN2:STAT OFF"`

Characteristics: *RST value: OFF
                     SCPI: device-specific

CALCulate<1|2>:FLINe<1|2> $-f_{max}$ to $+f_{max}$

This command defines the position of the frequency lines.

The frequency lines mark the frequencies specified in the measurement window. Frequency lines are only available in frequency domain.

Example: `"CALC:FLIN2 12MHz"`

Characteristics: *RST value: - (STATe to OFF)
                     SCPI: device-specific

CALCulate<1|2>:FLINe<1|2>:STATe   ON | OFF

This command switches the frequency line on or off. Frequency lines are only available in frequency domain.

Example: `"CALC:FLIN2:STAT ON"`

Characteristics: *RST value: OFF
                     SCPI: device-specific

CALCulate<1|2>:THReshold   MINimum to MAXimum (depending on current unit)

This command defines the threshold value for the maximum/minimum search of markers with marker search functions MAX PEAK, NEXT PEAK, etc in the selected measurement window. The associated display line is automatically switched on.

Example: "CALC:THR -82DBM"   'Sets the threshold value for screen A to -82 dBm.

Characteristics: *RST value: - (STATe to OFF)
                       SCPI: device-specific

CALCulate<1|2>:THReshold:STATe   ON | OFF

This command switches on or off the threshold line in the selected measurement window. The unit depends on the setting performed with CALC:UNIT and the selected measurement result of the window.

Example: "CALC2:THR:STAT ON"   'Switches on the threshold line in screen B.

Characteristics: *RST value: OFF
                       SCPI: device-specific

CALCulate<1|2>:TLINe<1|2>   0 to 1000s

This command defines the position of the time lines.

The time lines mark the times specified in the measurement window. Time lines are only available in time domain.

Example: "CALC:TLIN 10ms"

Characteristics: *RST value: - (STATe auf OFF)
                       SCPI: device-specific

CALCulate<1|2>:TLINe<1|2>:STATe ON | OFF

This command switches the time line on or off. Time lines are only available in time domain.

Example: "CALC:TLIN2:STAT ON"

Characteristics: *RST value: OFF
                       SCPI: device-specific

CALCulate:UNIT subsystem

The CALCulate:UNIT subsystem defines the units of the phase in the FFT Analyzer mode.

Command	Parameters
CALCulate<1|2>:UNIT:ANGLe	DEG	RAD

CALCulate<1|2>: UNIT:ANGLe DEG | RAD

This command selects the unit of the phase in the magnitude/phase diagram.

Example: "CALC2:UNIT:ANGL RAD"

Characteristics: *RST value: DEG
SCPI: device-specific

CALibration Subsystem

The commands of the CALibration subsystem determine the data for system error correction in the instrument.

Command	Parameters
CALibration:ABORt	
CALibration[:ALL]	
CALibration:PROBe:COMPensation	ON | OFF
CALibration:PROBe:FRESponse	ON | OFF
CALibration:PROBe:GAIN	ON | OFF
CALibration:PROBe[:STARt]	<file_name>
CALibration:RESult?	
CALibration:STATe	ON | OFF

CALibration:ABORt

This command aborts the acquisition of correction data and restores the last complete correction data set.

Example: `"CAL:ABOR"`

Characteristics: *RST value: -
                           SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALibration[:ALL]?

This command initiates the acquisition of system error correction data. A "0" is returned if the acquisition was successful.

Note: *During the acquisition of correction data the instrument does not accept any remote control commands, except*
         *RST
         CALibration:ABORt

In order to recognize when the acquisition of correction data is completed, the MAV bit in the status byte can be used. If the associated bit is set in the Service Request Enable Register, the instrument generates a service request after the acquisition of correction data has been completed.

Example: `"*CLS"`   `'` Resets the status management.
                     `"*SRE 16"`   `'` Enables MAV bit in the Service Request Enable Register.
                     `"*CAL?"`   `'` Starts the correction data recording and then a service
                                                               `'`request is generated.

Characteristics: *RST value: -
                           SCPI: conforming

CALibration:PROBe:COMPensation ON | OFF

This command switches the manual probe adjustment as part of the probe calibration process on or off. If active the probe calibration process is interrupted and the bits 12/13 of the STATus:QUEStionable:SYNC register will signal the required manual operation. The calibration process has to be continued by "INIT:CONM" afterwards.

Example: `"CAL:PROB:COMP ON"` ' manual probe compensation will be requested
' during probe calibration process.

Characteristics: *RST value: -
SCPI: device-specific

CALibration:PROBe:FRESponse ON | OFF

This command switches the gain error compensation on or off.

Example: `"CAL:PROB:FRES OFF"` ' frequency response calibration off

Characteristics: *RST value: -
SCPI: device-specific

CALibration:PROBe:GAIN ON | OFF

This command switches the gain error compensation on or off.

Example: `"CAL:PROB:GAIN ON"` ' gain compensation active

Characteristics: *RST value: -
SCPI: device-specific

CALibration:PROBe[:STARt] <file_name>

This command starts a probe calibration using the specified file name to generate a probe data set at the end of the calibration process. During the probe calibration process, manual operations may be required (see -chapter 4, softkey PROBE CAL START). The Status Questionable Sync Register bits 12 and 13 are set if related user operation has to take place. After adjusting the probes of input I or Q, the calibration process has to be continued by the command "INIT:CONM". The probe data set is automatically activated and can be switched off again using the SENS:PROBE:STATE ON | OFF command.

Example:	`"INP:IQ:TYPE IQ"`	' complex input path I + j*Q used
	`"INP:IQ:IMP HIGH"`	' impedance 1 MΩ
	`"INP:IQ:BAL OFF"`	' unbalanced input
	`"CAL:PROB:COMP ON"`	' activates the manual probe adjust
	`"CAL:PROB:GAIN ON"`	' activates the gain error compensation
		' calibration
	`"CAL:PROB:FRES:GAIN ON"`	' activates the frequency response calibration
	`"CAL:PROB 'probe_1';*OPC"`	' starts the calibration and creates probe
		' data set probe_1
		" now wait for questionable sync register
	now wait until STAT QUES SYNC Bit 12=1	
		' now manually adjust probe I, when finished:
	`"INIT:CONM"`	' continue probe cal
	now wait until STAT QUES SYNC Bit 12=1	
		' now manually adjust probe Q, when finished:
	`"INIT:CONM"`	' continue probe cal
	now wait until OPC=1	' calibration is finished
		' probe data set is created

Characteristics: *RST value: -
SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

CALibration:RESult?

This command outputs the results of the correction data acquisition. The lines of the result table (see section "Recording the correction data of R&S FMU – *CAL* key") are output as string data separated by commas:
```
"Total Calibration Status: PASSED","Date (dd/mm/yyyy): 24/04/2006",
"Time: 16:24:54","Runtime:00:06"
```

Example: `"CAL:RES?"`

Characteristics: *RST value: --
SCPI: device-specific

CALibration:STATe ON | OFF

This command determines whether the current calibration data are taken into account by the instrument (ON) or not (OFF).

Example: `"CAL:STAT OFF"` 'Sets up the instrument to ignore the calibration data.

Characteristics: *RST value: -
SCPI: conforming

DIAGnostic Subsystem

The DIAGnostic subsystem contains the commands which support instrument diagnostics for maintenance, service and repair. In accordance with the SCPI standard, all of these commands are device-specific.

The measurement windows are selected by DIAGnostic1 (screen A) or DIAGnostic2 (screen B) .

Command	Parameters
DIAGnostic<1|2>:SERVice:HWINfo?	
DIAGnostic<1	2>:SERVice:IQ:CALibration:DESTination	IHIGh	ILOW	QHIGh	QLOW
DIAGnostic<1	2>:SERVice:IQ:CALibration:DC	0	0.1	0.178	0.316	0.562	1.0
DIAGnostic<1|2>:SERVice:IQ:CALibration**:**PULSe:PRATe	10 kHz	62.5 kHz	80 kHz	100 kHz	102.4 kHz	200 kHz	500 kHz	1 MHz	2 MHz	4 MHz
DIAGnostic<1	2>:SERVice:IQ:INPut	IQ	GND	CALDc	CALPulse
DIAGnostic<1|2>:SERVice:SFUNction	<string>
DIAGnostic<1|2>:SERVice:STESt:RESult?	

DIAGnostic<1|2>:SERVice:HWINfo?

This command queries the contents of the module info table. Table lines are output as string data and are separated by commas.

"<component 1>|<serial #>|<order #>|<model>|<HWC>|<rev>|<sub rev>",
"<component 2>|<serial #>|<order #>|<model>|<HWC>|<rev>|<sub rev>", to

The individual columns of the table are separated from each other by '|'.
The numeric suffix <1|2> is ignored with this command.

Example: "DIAG:SERV:HWIN?"

Result (shortened):

"WBDET|100553/005|1130.3086|05|00|04|13",
" CLOCK GEN|000654/321|1303.3800|01|00|00|00",
 to

Characteristics: *RST value: --
                      SCPI: device-specific

DIAGnostic<1|2>:SERVice:IQ:CALibration:DESTination IHIGh | ILOW | QHIGh | QLOW

The calibration signals (DC Cal signal and Pulse Cal signal) can only be switched to one input at a time. This command switches the calibration signal to the I or Q path.
High selects the positive and low the negative input. The negative input is only connected through at the Balanced setting. The calibration signals are always positive. An inverted signal therefore appears in the output data during feeding into the negative input (Low).
The DC Cal signal voltage is set using the command diag:serv:iq:cal:dc, and the frequency of the Pulse Cal signal is set using the command diag:serv:iq:cal:puls:prat.

IHIGh   Feed the calibration signal into the positive I path
ILOW   Feed the calibration signal into the negative I path
QHIGh   Feed the calibration signal into the positive Q path
QLOW   Feed the calibration signal into the negative Q path

The numeric suffix <1|2> has no meaning with this command.

Example: "DIAG:SERV:IQ:CAL:DEST QHIG"

Characteristics: *RST value: IHIGh
                      SCPI: device-specific

DIAGnostic<1|2>:SERVice:IQ:CALibration:DC 0 | 0.1 | 0.178 | 0.316 | 0.562 | 1.0

This command selects the voltage for the DC Cal signal in Volt.

The numeric suffix <1|2> has no meaning with this command.

Example: "DIAG:SERV:IQ:CAL:DC 0.316"

Characteristics: *RST value: 0
                      SCPI: device-specific

DIAGnostic<1|2>:SERVice:IQ:CALibration:PULSe:PRATe 10KHz | 62.5KHz | 80KHz | 100KHz | 102.4KHz | 200KHz | 500KHz | 1MHz | 2MHz | 4MHz

This command sets the frequency of the Pulse Cal signal.
The numeric suffix <1|2> has no meaning with this command.

Example: "DIAG:SERV:IQ:CAL:PULS:PRAT 80KHZ"

Characteristics: *RST value: 62.5 kHz
                      SCPI: device-specific

DIAGnostic<1|2>:SERVice:IQ:INPut IQ | GND | CALDc | CALPulse

This command selects the baseband signal source.

IQ   The female I and Q connectors of the R&S FMU are the baseband signal sources.
GND   The baseband inputs are internally connected to ground.
CALDc   The baseband signal source is the DC Cal signal. The voltage of this signal can be set with diag:serv:iq:cal:dc.
CALPulse   The baseband signal source is the Pulse Cal signal. The frequency of this signal can be set with diag:serv:iq:prat.

The numeric suffix <1|2> has no meaning with this command.

Example: "DIAG:SERV:IQ:INP CALD"

Characteristics: *RST value: IQ
                      SCPI: device-specific

DIAGnostic<1|2>:SERVice:SFUNction <string>

This command activates a service function which can be selected by indicating the five parameters: function group number, board number, function number, parameter 1 and parameter 2 (see service manual). The contents of the parameter string is identical to the code to be entered in the data entry field of manual operation.
The entry of a service function is accepted only if the system password Level 1 or Level 2 has been entered previously (command: `SYSTem:SECurity`).
The numeric suffix <1|2> is ignored with this command.

Example: `"DIAG:SERV:SFUN '2.0.2.12.1'"`

Characteristics: *RST value: -
                           SCPI: device-specific

DIAGnostic<1|2>:SERVice:STESt:RESult?

This command reads the results of the selftest out of the instrument. The lines of the result table are output as string data separated by commas:

```
"Total Selftest Status: PASSED","Date (dd/mm/yyyy): 09/07/1999
TIME: 16:24:54","Runtime: 00:06"," to
```

The numeric suffix <1|2> is ignored with this command.

Example: `"DIAG:SERV:STES:RES?"`

Characteristics: *RST value: --
                           SCPI: device-specific

DISPlay Subsystem

The DISPLay subsystem controls the selection and presentation of textual and graphic information as well as of measurement data on the display.
The measurement windows are selected by WINDow1 (screen A) or WINDow2 (screen B) .

Command	Parameters
DISPlay:ANNotation:FREQuency	ON	OFF
DISPlay:CMAP<1 to 26>:DEFault<1|2>	
DISPlay:CMAP<1 to 26>:HSL	<hue>,<sat>,<lum>
DISPlay:CMAP<1 to 26>:PDEFined	<color>
DISPlay:FORmat?	query only
DISPlay:LOGO	ON	OFF
DISPlay:PSAVe:HOLDoff	0 to 60
DISPlay:PSAVe[:STATe]	ON	OFF
DISPlay[:WINDow<1|2>]:ACTive?	
DISPlay[:WINDow<1|2>]:SELect	
DISPlay[:WINDow<1	2>]:SIZE	LARGe	SMALl
DISPlay[:WINDow<1|2>]:TEXT[:DATA]	<string>
DISPlay[:WINDow<1	2>]:TEXT:STATe	ON	OFF
DISPlay[:WINDow<1	2>]:TIME	ON	OFF
DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:MODE	WRITe	VIEW	AVERage	MAXHold	MINHold
DISPlay[:WINDow<1	2>]:TRACe<1 to 3>:MODE:HCONtinuous	ON	OFF
DISPlay[:WINDow<1	2>]:TRACE<1 to 3>[:STATe]	ON	OFF
DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:Y[:SCALe]	10dB to 200dB
DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:Y[:SCALe]:AUTO	ONCE
DISPlay[:WINDow<1	2>]:TRACe<1 to 3>:Y[:SCALe]:MODE	ABSolute	RELative
DISPlay[:WINDow<1|2>]:TRACE<1 to 3>:Y[:SCALe]:PDIVision	<numeric_value>
DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:Y[:SCALe]:RLEVel	<numeric_value>
DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:Y[:SCALe]:RLEVel:OFFSet	−200dB to 200dB
DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:Y[:SCALe]:RPOSition	0 to 100 PCT
DISPlay[:WINDow<1|2>]:TRACE<1 to 3>:Y[:SCALe]:RVALue	<numeric_value>
DISPlay[:WINDow<1	2>]:TRACe<1 to 3>:Y:SPACing	LINear	LOGarithmic	PERCent

DISPlay:ANNotation:FREQuency ON | OFF

This command switches the X axis annotation on or off.

Example:　　　　"DISP:ANN:FREQ OFF"

Characteristics:　*RST value:　　ON
　　　　　　　　　　SCPI:　　　　conforming

DISPlay:CMAP<1 to 26>:DEFault<1|2>

This command resets the screen colors of all display items to their default settings. Two default settings DEFault1 and DEFault2 are available. The numeric suffix of CMAP is irrelevant.

Example: `"DISP:CMAP:DEF2"`   'Selects default setting 2 for setting the colors.

Characteristics: *RST value: --
                              SCPI: conforming

This command is an event and therefore has no query and no *RST value .

DISPlay:CMAP<1 to 26>:HSL   <hue>,<sat>,<lum>

This command defines the color table of the instrument.

Each numeric suffix of CMAP is assigned one or several graphical elements which can be modified by varying the corresponding color setting. The following assignment applies:

CMAP1	Background
CMAP2	Grid
CMAP3	Function field + status field + data entry text
CMAP4	Function field LED on
CMAP5	Function field LED warn
CMAP6	Enhancement label text
CMAP7	Status field background
CMAP8	Trace 1
CMAP9	Trace 2
CMAP10	Trace 3
CMAP11	Marker
CMAP12	Lines
CMAP13	Measurement status + limit check pass
CMAP14	Limit check fail
CMAP15	Table + softkey background
CMAP16	Table + softkey text
CMAP17	Table selected field text
CMAP18	Table selected field background
CMAP19	Table + data entry field opaq titlebar
CMAP20	Data entry field opaq text
CMAP21	Data entry field opaq background
CMAP22	3D shade bright part
CMAP23	3D shade dark part
CMAP24	Softkey state on
CMAP25	Softkey state data entry
CMAP26	Logo

Parameter: hue = TINT
                              sat = SATURATION
                              lum = BRIGHTNESS

                              The value range is 0 to 1 for all parameters.

Example: `"DISP:CMAP2:HSL 0.3,0.8,1.0"`   Changes the grid color.

Characteristics: *RST value: --
                              SCPI: conforming

The values set are not changed by *RST.

DISPlay:CMAP<1 to 26>:PDEFined BLACk | BLUE | BROWn | GREen | CYAN | RED | MAGenta | YELLow | WHITe | DGRAy | LGRAy | LBLUe | LGREen | LCYan | LRED | LMAGenta

This command defines the color table of the instrument using predefined color values. Each numeric suffix of CMAP is assigned one or several graphical elements which can be modified by varying the corresponding color setting. The same assignment as for `DISPlay:CMAP<1 to 26>:HSL` applies.

Example: `"DISP:CMAP2:PDEF GRE"`

Characteristics: *RST value: --
SCPI: conforming

The values set are not changed by *RST.

DISPlay:FORMat?

This command returns the state of the result display (FULL SCREEN or SPLIT SCREEN). The number of windows depends on the selected measurement result.

Return value: SING FULL SCREENfor Magnitude
SPL SPLIT SCREENfor Magnitude/Phase, Real/Imag, Voltage

In split screen display the active measurement window can be selected with `DISPlay:WINDow<1|2>:SELect`.

Example: `"DISP:FORM? "` 'returns the current state SPL or SING.

Characteristics: *RST value: -
SCPI: device-specific

This command is a query only and thus has no *RST value

DISPlay:LOGO ON | OFF

This command switches the company logo on the screen on or off.

Example: `"DISP:LOGO OFF"`

Characteristics: *RST value: ON
SCPI: device-specific

DISPlay:PSAVe:HOLDoff 1 to 60

This command sets the hold off time for the power-save mode of the display. The available value range is 1 to 60 minutes, the resolution 1 minute. The entry is dimensionless.

Example: `"DISP:PSAV:HOLD 30"`

Characteristics: *RST value: 15
SCPI: device-specific

DISPlay:PSAVe[:STATe] ON | OFF

This command switches on or off the power-save mode of the display. With the power-save mode activated the display including backlight is completely switched off after the elapse of the response time (see command `DISPlay:PSAVe:HOLDoff`).

Note: *This mode is recommended for preserving the display especially if the instrument is exclusively operated via remote control.*

Example: `"DISP:PSAVe ON"` 'Switches on the power-save mode.

Characteristics: *RST value: OFF
SCPI: device-specific

DISPlay[:WINDow<1|2>]:ACTive?

This command returns the active measurement window. The numeric response has following meaning:

1	Screen A
2	Screen B
3	Screen C
4	Screen D

The numeric suffix at WINDow<1|2> is irrelevant.

Example: `"DISP:WIND:ACT?` 'returns the active window

Characteristics: ***RST value:** **-**
SCPI: device-specific

DISPlay[:WINDow<1|2>]:SELect

This command selects the active measurement window. WINDow1 corresponds to SCREEN A, WINDow2 to SCREEN B.

The selection of the active window for result queries is irrelevant.

Example: `"DISP:WIND2:SEL` 'Selects SCREEN B as active measurement window.

Characteristics: *RST value: SCREEN A active
SCPI: device-specific

This command is an event and therefore has no query.

DISPlay[:WINDow<1|2>]:SIZE LARGe | SMALl

This command switches the measurement window for channel and adjacent-channel power measurements to full screen or half screen. Only "1" is allowed as a numerical suffix.

Example: `"DISP:WIND1:SIZE LARG"` ' Switches the measurement window to
' full screen.

Characteristics: *RST value: SMALl
SCPI: device-specific

DISPlay[:WINDow<1|2>]:TEXT[:DATA] <string>

This command defines a comment (max. 20 characters) which can be displayed on the screen in the selected measurement window.

Example: `"DISP:WIND2:TEXT 'Noise Measurement'"`
'Defines the title for screen B

Characteristics: *RST value: "" (empty)
SCPI: conforming

DISPlay[:WINDow<1|2>]:TEXT:STATe ON | OFF

This command switches on or off the display of the comment (screen title) in the selected measurement window.

Example: `"DISP:TEXT:STAT ON"` 'Switches on the title of screen B.

Characteristics: *RST value: OFF
SCPI: conforming

DISPlay[:WINDow<1|2>]:TIME ON | OFF

This command switches on or off the screen display of date and time. The numeric suffix in WINDow<1| 2> is irrelevant.

Example: `"DISP:TIME ON"`

Characteristics: *RST value: OFF
SCPI: device-specific

DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:MODE WRITe | VIEW | AVERage | MAXHold | MINHold

This command defines the type of display and the evaluation of the traces in the selected measurement window. WRITE corresponds to the Clr/Write mode of manual operation. The trace is switched off (= BLANK in manual operation) with `DISP:WIND:TRAC:STAT OFF`.
The number of measurements for AVERage, MAXHold and MINHold is defined with the command `SENSe:AVERage:COUNt` or `SENSe:SWEep:COUN`t. It should be noted that synchronization to the end of the indicated number of measurements is only possible in single sweep mode.
If calculation of average values is active, selection between logarithmic and linear averaging is possible. For more detail see command `SENSe:AVERage:TYPE`.

Example: `"INIT:CONT OFF"`   Switching to single-sweep mode.
`"SWE:COUN 16"`   'Sets the number of measurements to 16.
`"DISP:WIND1:TRAC3:MODE MAXH"`   'Switches on the calculation of the for
                                           'trace 3 in screen A.
`"INIT;*WAI"`   'Starts the measurement and waits for the end of the
                                           '16 sweeps.

Characteristics: *RST value: WRITe for TRACe1, STATe OFF for TRACe2/3
SCPI: device-specific

DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:MODE:HCONtinuous ON | OFF

This command specifies whether or not the traces with peak or minimum value detection are reset after specific parameter changes.
Usually the measurement must be restarted after a parameter change, before an evaluation of the measurement results is performed (e.g. with a marker). In cases in which a change causes a compulsory new measurement, the trace is automatically reset in order to prevent erroneous measurements of previous measurement results (e.g. when the span changes). For applications in which this behavior is not desired, this mechanism can be switched off.

OFF   The traces are reset after specific parameter changes.
ON   The reset mechanism is switched off.

Example: `"DISP:WIND1:TRAC3:MODE:HCON ON"` The reset mechanism is switched off
                                                  for measurement window 1.

Characteristics: *RST value: OFF
SCPI: device-specific

DISPlay[:WINDow<1|2>]:TRACE<1 to 3>[:STATe] ON | OFF

This command switches on or off the display of the corresponding trace in the selected measurement window.

Example: `"DISP:WIND1:TRAC3 ON"`

Characteristics: *RST value: ON for TRACe1, OFF for TRACe2 to 4
SCPI: conforming

DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:Y[:SCALe]   10dB to 200dB

This command defines the display range of the Y axis (level axis) in the selected measurement window for MAGNITUDE with logarithmic scaling (`DISP:TRAC:Y:SPAC  LOG`).
For linear scaling, (`DISP:TRAC:Y:SPAC  LIN | PERC`) the display range is fid and cannot be modified. The numeric suffix in TRACe<1 to 3> is irrelevant.

Example: "`DISP:TRAC:Y 110dB`"

Characteristics: *RST value: 100dB
                      SCPI: device-specific

DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y[:SCALe]:AUTO   ONCE

This command adapts the diagram limits to the current measurement results. The value range depends on the selected display.

Example: "`:DISP:WIND2:TRAC:Y:SCAL:AUTO ONCE`"

Characteristics: *RST value: ---
                      SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:Y[:SCALe]:MODE   ABSolute | RELative

This command defines the scale type of the Y axis (absolute or relative) in the selected measurement window for MAGNITUDE.
When `SYSTem:DISPlay` is set to `OFF,` this command has no immediate effect on the screen. The numeric suffix in TRACe<1 to 3> is irrelevant.

Example: "`DISP:TRAC:Y:MODE REL`"

Characteristics: *RST value: ABS
                      SCPI: device-specific

DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y[:SCALe]:PDIVision   <numeric_value>

This command defines the scaling of the y-axis.

Example: "`:DISP:WIND2:TRAC:Y:PDIV 20deg`" 'Sets the scaling of the y-axis to 20 deg/ DIV

Characteristics: *RST value: --
                      SCPI: device-specific

The numeric suffix under TRACe <1...3> is irrelevant.

DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:Y[:SCALe]:RLEVel   –<numeric_value>

This command defines the reference level.The value range of the baseband input depends on the input impedance. The measurement range is defined as the measurable peak voltage (positive and negative).The setting can also be made with SENS:VOLT:IQ:RANG:UPP.

Input impedance	Value range / Volt (5 dB steps)
Low (50 Ω)	0.0316; 0.0562; 0.1; 0.178 ; 0.316; 0.562; 1; 1.78; 3.16; 5.62
High (1 MΩ or 1KΩ)	0.0316; 0.0562; 0.1; 0.178 ; 0.316; 0.562; 1; 1.78

With the reference level offset <> 0 the indicated value range of the reference level is modified by the offset.
The numeric suffix at WINDow<1...2> and the numeric suffix at TRACe<1...3> are irrelevant.

Example: "DISP:WIND1:TRAC:Y:RLEV 0.1"'sets the reference level to
                                                   0.1 volt peak

Characteristics: *RST value: 1 volt peak
                       SCPI: conforming

DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:Y[:SCALe]:RLEVel:OFFSet   –200 dB to 200 dB

This command defines the offset of the reference level.
The numeric suffix at WINDow<1...2> and the numeric suffix at TRACe<1...3> are irrelevant.

Example: "DISP:TRAC:Y:RLEV:OFFS –10dB"

Characteristics: *RST value: 0dB
                       SCPI: conforming

DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y[:SCALe]:RPOSition 0 to 100 PCT

This command defines the position of the reference value for the y-axis. It is available for MAGNITUDE/PHASE (screen B), REAL/IMAG, VOLTAGE.
The numeric suffix at TRACe<1...3> is irrelevant.

Example: ":DISP:WIND2:TRAC:Y:RPOS 30PCT"'shifts the reference value to 30 %

Characteristics: *RST value: --
                       SCPI: device specific

DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y[:SCALe]:RVALue   <numeric_value>

This command defines the reference value for the y-axis of the measurement diagram. It is available for MAGNITUDE/PHASE (screen B), REAL/IMAG, VOLTAGE.
The numeric suffix at TRACe<1...3> is irrelevant.

Example: ":DISP:WIND2:TRAC:Y:RVAL 10deg"'sets the reference value to 10 deg

Characteristics: *RST value: 0
                       SCPI: device specific

DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:Y:SPACing   LINear | LOGarithmic| LDB

This command toggles between linear and logarithmic display in the MAGNITUDE window.On a linear scale, switchover between the unit % (command DISP:WIND:TRAC:Y:SPAC LIN) and the unit dB (command DISP:WIND:TRAC:Y:SPAC LDB) is also possible.
The numeric suffix in TRACe<1 to 3> is irrelevant.

Example: "DISP:TRAC:Y:SPAC LIN"

Characteristics: *RST value: LOGarithmic
                       SCPI: conforming

FORMat Subsystem

The FORMat subsystem specifies the data format of the data transmitted from and to the instrument.

Command	Parameters
FORMat[:DATA]	ASCii | REAL | UINT [,8 | 32]
FORMat:DEXPort:DSEParator	POINt|COMMa

FORMat[:DATA] ASCii | REAL| UINT [, 8 | 32]

This command specifies the data format for the data transmitted from the instrument to the control PC.

The data format is either ASCII or one of the formats REAL . ASCII data are transmitted in plain text, separated by commas. REAL data are transmitted as 32-bit IEEE 754 floating-point numbers in the "definite length block format".

The FORMat command is valid for the transmission of trace data. The data format of trace data received by the instrument is automatically recognized, regardless of the format which is programmed.

Note: Incorrect format setting will result in numerical conversion, which may lead to incorrect results.

Example: `"FORM REAL,32"`
                      `"FORM ASC"`
                      `"FORM UINT,8"`

Characteristics: *RST value: ASCII
                      SCPI: conforming

FORMat:DEXPort:DSEParator POINt | COMMA

This command defines which decimal separator (decimal point or comma) is to be used for outputting measurement data to the file in ASCII format. Different languages of evaluation programs (e.g. MS-Excel) can thus be supported.

Example: `"FORM:DEXP:DSEP POIN`   'Sets the decimal point as separator.

Characteristics: *RST value: -- (factory setting is POINt; *RST does not affect setting)
                      SCPI: device-specific

HCOPy Subsystem

The HCOPy subsystem controls the output of display information for documentation purposes on output devices or files. The instrument allows two independent printer configurations which can be set separately with the numeric suffix <1|2>.

Command	Parameters
HCOPy:ABORt	
HCOPy:CMAP<1 to 26>:DEFault	1|2|3
HCOPy:CMAP<1 to 26>:HSL	<hue>,<sat>,<lum>
HCOPy:CMAP<1 to 26>:PDEFined	<color>
HCOPy:DESTination<1	2>	MMEM'	'SYST:COMM:PRIN'	'SYST:COMM:CLIP'
HCOPy:DEVice:COLor	ON	OFF
HCOPy:DEVice:LANGuage<1|2>	GDI	WMF	EWMF	BMP
HCOPy[:IMMediate]	
HCOPy:ITEM:WINDow<1	2>:TABle:STATe	ON	OFF
HCOPy:ITEM:WINDow<1|2>:TEXT	<string>
HCOPy:ITEM:WINDow<1	2>:TRACe:STATe	ON	OFF
HCOPy:PAGE:ORIentation<1	2>	LANDscape	PORTrait

HCOPy:ABORt

This command aborts a running hardcopy output.

Example: `"HCOP:ABOR"`

Characteristics: *RST value: -
SCPI: conforming

This command is an event and therefore has no *RST value and no query.

HCOPy:CMAP<1 to 26>:DEFault 1|2|3

This command resets the colors for a hardcopy to the selected default settings. DEFault1(SCREEN COLORS, but background white), DEFault2 (OPTIMIZED COLOR SET) and DEFault3 (USER DEFINED). The numeric suffix in CMAP is not significant.

Example: `"HCOP:CMAP:DEF2"` 'selects OPTIMIZED COLOR SET for the color settings of a hardcopy.

Characteristics: *RST value: --
SCPI: conforming

This command is an event and therefore has no query and no *RST value.

HCOPy:CMAP<1 to 26>:HSL <hue>,<sat>,<lum>

This command defines the color table in USER DEFINED COLORS mode.
To each numeric suffix of CMAP is assigned one or several picture elements which can be modified by varying the corresponding color setting. The following assignment applies:

CMAP1   Background
CMAP2   Grid
CMAP3   Function field + status field + data entry text
CMAP4   Function field LED on
CMAP5   Function field LED warn
CMAP6   Enhancement label text
CMAP7   Status field background
CMAP8   Trace 1
CMAP9   Trace 2
CMAP10 Trace 3
CMAP11 Marker
CMAP12 Lines
CMAP13 Measurement status + Limit check pass
CMAP14 Limit check fail
CMAP15 Table + softkey background
CMAP16 Table + softkey text
CMAP17 Table selected field text
CMAP18 Table selected field background
CMAP19 Table + data entry field opaque titlebar
CMAP20 Data entry field opaque text
CMAP21 Data entry field opaque background
CMAP22 3D shade bright part
CMAP23 3D shade dark part
CMAP24 Softkey state on
CMAP25 Softkey state data entry
CMAP26 Logo

Parameter: hue = tint
                  sat = saturation
                  lum = brightness
                  The value range is 0 to 1 for all parameters

Example: "HCOP:CMAP2:HSL 0.3,0.8,1.0" 'changes the grid color

Characteristics: *RST value: --
                      SCPI: conforming

The values set are not changed by *RST.

HCOPy:CMAP<1 to 26>:PDEFined BLACk | BLUE | BROWn | GREen | CYAN | RED | MAGenta |
                                        YELLow | WHITe | DGRAy | LGRAy | LBLUe | LGREen | LCYan |
                                        LRED | LMAGenta

This command defines the color table in USER DEFINED COLORS using predefined color values. To each numeric suffix of CMAP is assigned one or several picture elements which can be modified by varying the corresponding color setting. The same assignment as for :HCPOy:CMAP<1 to 26>:HSL applies

Example: "HCOP:CMAP2:PDEF GRE"

Characteristics: *RST value: --
                      SCPI: conforming

The values set are not changed by *RST.

HCOPy:DESTination<1|2> <string>

This command selects the printer output medium (Disk, Printer or Clipboard) associated with configuration 1 or 2.

Note: *The type of instrument is selected with* SYSTem:COMMunicate:PRINter:SELect, *which will automatically select a default output medium. Therefore the command* HCOPy:DESTination *should always be sent* <u>after</u> *setting the device type.*

Parameter:	<string>::=	'SYST:COMM:GPIB' | 'SYST:COMM:SER 'SYST:COMM:CENT' | 'MMEM' | 'SYST:COMM:PRIN' | 'SYST:COMM:CLIP'
	'MMEM'	'Directs the hardcopy to a file. Command MMEM:NAME '<file_name> defines the file name. All formats can be 'selected for HCOPy:DEVice:LANGuage.
	'SYST:COMM:PRIN'	'Directs the hardcopy to the printer. The printer is 'selected with command 'SYSTEM:COMMunicate:PRINter:SELect. 'GDI should be selected for 'HCOPy:DEVice:LANGuage.
	'SYST:COMM:CLIP'	'Directs the hardcopy to the clipboard. EWMF should be 'selected for HCOPy:DEVice:LANGuage.
Example:	"SYST:COMM:PRIN:SEL2 'LASER on LPT1'"	'Selects the printer and output 'medium for device 2
	"HCOP:DEST2 'SYST:COMM:PRIN'"	'Selects the printer interface 'as device 2.

Characteristics: *RST value: -
                    SCPI: conforming

This command is an event and therefore has no *RST value and no query.

HCOPy:DEVice:COLor ON|OFF

This command selects between color and monochrome hardcopy of the screen.

Example: "HCOP:DEV:COL ON"

Characteristics: *RST value: OFF
                    SCPI: conforming

HCOPy:DEVice:LANGuage<1|2>   GDI | WMF | EWMF | BMP

This command determines the data format of the printout.

Parameter: GDI   Graphics Device Interface:
Default format for the output to a printer configured under Windows.
Must be selected for the output to the printer interface (`HCOPy:DEVice
'SYST:COMM:PRIN'`).
Can be used for the output to a file (`HCOPy:DEVice
'SYST:COMM:MMEM'`). The printer driver configured under Windows is
used in this case and a printer-specific file format is thus generated.

WMF   WINDOWS Metafile and Enhanced Metafile Format:
and EWMF   Data formats for output files which can be integrated in corresponding
programs for documentation purposes at a later time. WMF can only
be used for output to a file (`HCOPy:DEVice 'SYST:COMM:MMEM'`)
and EWMF also for the output to the clipboard
(`HCOPy:DEVice 'SYST:COMM:CLIP'`).

BMP   Bitmap.
Data format for output to files only (`HCOPy:DEVice
'SYST:COMM:MMEM'`).

Example: `"HCOP:DEV:LANG WMF"`

Characteristics: *RST value: -
SCPI: conforming

HCOPy[:IMMediate<1|2>]

This command starts a hardcopy output. The numeric suffix selects which printer configuration (1 or 2) is to be used for the hardcopy output. If there is no suffix, configuration 1 is automatically selected.

`HCOPy:IMM[1]`   'Starts the hardcopy output to device 1 (default).
`HCOPy:IMM2`   'Starts the output to device 2.

Example: `"HCOP"`

Characteristics: *RST value: -
SCPI: conforming

This command is an event and therefore has no *RST value and no query.

HCOPy:ITEM:ALL

This command selects the complete screen to be output.

The hardcopy output is always provided with comments, title, time and date. As an alternative to the whole screen, only traces (commands '`HCOPy:ITEM:WINDow:TRACe: STATe ON`') or tables (command '`HCOPy:ITEM:WINDow:TABLe:STATe ON`') can be output.

Example: `"HCOP:ITEM:ALL"`

Characteristics: *RST value: OFF
SCPI: conforming

HCOPy:ITEM:WINDow<1|2>:TABle:STATe   ON | OFF

This command selects the output of the currently displayed tables.
The command `HCOPy:DEVice:ITEM:WINDow<1|2>:TABle:STATe   OFF` as well as command
`HCOPy:DEVice:ITEM:ALL` enable the output of the whole screen.

Example: `"HCOP:ITEM:WIND:TABL:STAT ON"`

Characteristics: *RST value: OFF
                    SCPI: device-specific

HCOPy:ITEM:WINDow<1|2>:TEXT   <string>

This command defines the comment text for measurement window 1 or 2 for printout, with a
maximum of 100 characters; line feed by means of character @).
The numeric suffix at `WINDow<1|2>` is irrelevant.

Example: `"HCOP:ITEM:WIND:TEXT 'comment'"`

Characteristics: *RST value: -
                    SCPI: device-specific

HCOPy:ITEM:WINDow<1|2>:TRACe:STATe   ON | OFF

This command selects the output of the currently displayed trace.
The command `HCOPy:ITEM:WINDow<1|2>:TRACe:STATe OFF` as well as command
`HCOPy:ITEM:ALL` enable the output of the whole screen.

Example: `"HCOP:ITEM:WIND:TRACe:STAT ON"`

Characteristics: *RST value: OFF
                    SCPI: device-specific

HCOPy:PAGE:ORIentation<1|2>   LANDscape | PORTrait

The command selects the format of the output (portrait and landscape) (hardcopy unit 1 or 2).

Note: *The command is only available provided that the output device "printer" (`HCOP:DEST 'SYST:COMM:PRIN'`) has been selected.*

Example: `"HCOP:PAGE:ORI LAND"`

Characteristics: *RST value: -
                    SCPI: conforming

INITiate Subsystem

The INITiate subsystem is used to control the init-measurement function in the selected measurement window. The numeric suffix 2 at INITiate<1|2> is not allowed.

Command	Parameters
INITiate<1|2>:CONMeas	
INITiate<1|2>:CONTinuous	ON	OFF
INITiate<1|2>:DISPlay	ON	OFF
INITiate<1|2>[:IMMediate]	

INITiate<1|2>:CONMeas

This command continues a stopped probe calibration. It is used to confirm the manual probe adjustment. It is only required if the related calibration process is switched on
Numeric suffix 2 at INITiate<1|2> is not allowed.

Example:

`"INP:IQ:TYPE IQ"`	' complex input path I + j*Q used
`"INP:IQ:IMP LOW"`	' impedance 50Ω
`"INP:IQ:BAL OFF"`	' unbalanced input
`"CAL:PROB:COMP ON"`	' activates the manual probe adjust
`"CAL:PROB:GAIN ON"`	' activates the gain error compensation
	' calibration
`"CAL:FRES:GAIN ON"`	' activates the frequency response calibration
`"CAL:PROB 'probe_1';*OPC"`	' starts the calibration and creates probe
	' data set probe_1
	" now wait for questionable sync register
now wait until STAT QUES SYNC Bit 12=1	
	' now manually adjust probe I, when finished:
`"INIT:CONM"`	' continue probe cal
now wait until STAT QUES SYNC Bit 12=1	
	' now manually adjust probe Q, when finished:
`"INIT:CONM"`	' continue probe cal
now wait unil OPC=1	' calibration is finished
	' probe data set is created

Characteristics: *RST value: -
                      SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

INITiate<1|2>:CONTinuous   ON | OFF

This command determines whether the trigger system is continuously initiated (continuous) or performs single measurements (single).
In manual operation, this setting refers to the sweep sequence (switching between continuous/single sweep).
Numeric suffix 2 at INITiate<1|2> is not allowed.

Example:

`"INIT:CONT OFF"`	'Switches the sequence to single sweep.
`"INIT:CONT ON"`	'Switches the sequence to continuous sweep.

Characteristics: *RST value: ON
                      SCPI: conforming

INITiate<1|2>:DISPlay   ON | OFF

This command configures the behavior of the display during a single sweep.
`INITiate:DISPlay OFF` means that the display is switched off during the measurement,
`INITiate:DISPlay ON` means that the display is switched on during the measurement.
The numeric suffix of INITiate is irrelevant with this command.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode
	`"INIT:DISP OFF`	'Sets the display behavior to `OFF`
	`"INIT;*WAI"`	'Starts the measurement with display
		'switched off.

| **Characteristics:** | *RST value: | ON |
| | SCPI: | device-specific |

INITiate<1|2>[:IMMediate]

The command initiates a new sweep in the indicated measurement window.
In single sweep mode, synchronization to the end of the indicated number of measurements can be achieved with the command *OPC, *OPC? or *WAI. In continuous-sweep mode, synchronization to the sweep end is not possible since the overall measurement never ends.

Example:	`"INIT:CONT OFF"`	'Switches to single-sweep mode.
	`"DISP:WIND:TRAC:MODE AVER`	'Switches on trace averaging.
	`"SWE:COUN 20"`	Setting the sweep counter to 20 sweeps.
	`"INIT;*WAI"`	'Starts the measurement and waits for the
		'end of the 20 sweeps.

| **Characteristics:** | *RST value: | - |
| | SCPI: | conforming |

This command is an event and therefore has no *RST value and no query.

INPut Subsystem

The INPut subsystem controls the input characteristics of the baseband input of the instrument. The numeric suffix at INPut<1|2> is irrelevant.

Command	Parameters
INPut<1|2>:IQ:BALanced[:STATE]	ON | OFF
INPut<1|2>:IQ:IMPedance	LOW | HIGH
INPut<1|2>:IQ:TYPE	I | Q | IQ
INPut<1|2>:SELect	AIQ

INPut<1|2>:IQ:BALanced[:STATe] ON | OFF

This command toggles the baseband inputs between balanced and unbalanced.
ON   Inputs balanced
OFF   Inputs unbalanced
The numeric suffix at INPut<1|2> is irrelevant.

Example: "INP:IQ:BAL ON"

Characteristics: *RST value: OFF
         SCPI: device-specific

INPut<1|2>:IQ:IMPedance LOW | HIGH

This command selects the impedance of the baseband inputs.
LOW   Input impedance 50 Ω
HIGH   Input impedance 1 MΩ
The numeric suffix at INPut<1|2> is irrelevant.

Example: "INP:IQ:IMP HIGH"

Characteristics: *RST value: LOW
         SCPI: device-specific

INPut<1|2>:IQ:TYPE I | Q | IQ

This command defines the input signal path used.
I Real signal   I only
Q Real signal   Q only
IQ Complex signal I + j*Q
The numeric suffix <1|2> is irrelevant with this command.

Example: "INP:IQ:TYPE IQ" 'Selection of 'I+j*Q'

Characteristics: *RST value: IQ
         SCPI: device-specific

INPut<1|2>:SELect AIQ

This command selects the analog baseband inputs.
AIQ: analog baseband input
The numeric suffix at INPut<1|2> is irrelevant.

Example: "INP:SEL AIQ"

Characteristics: *RST value: AIQ
         SCPI: device-specific

INSTrument Subsystem

The INSTrument subsystem selects the operating mode of the unit either via text parameters or fid numbers.

Command	Parameters
INSTrument<1|2>:NSELect	
INSTrument[:SELect]	FANalyzer

INSTrument:NSELect <numeric value>

This command switches between the operating modes by means of numbers.

Parameter: 22:   Baseband analysis, FFT

Example: `"INST:NSEL 22"` 'Switches the instrument to FFT.

Characteristics: *RST value: 1
                  SCPI: conforming

INSTrument[:SELect]   FANalyzer

This command switches between the operating modes by means of text parameters.

                  FANalyzer   Baseband Analyzer mode FFT

Example: `"INST FAN"`   'Switches the instrument to FFT.

Characteristics: *RST value: FANalyzer
                  SCPI: conforming

MMEMory Subsystem

The MMEMory (mass memory) subsystem provides commands which allow for access to the storage media of the instrument and for storing and loading various instrument settings.

The various drives can be addressed via the "mass storage unit specifier" <msus> using the conventional DOS syntax. The internal hard disk is addressed by "D:", the floppy disk drive by "A:".

Note: *For reasons of compatibility with the FSE instruments, addressing the hard disk by "C:" is also accepted. Since hard disk "C:" is reserved for instrument software, all read and write operations are rerouted to hard disk "D:" in normal operation (service level 0).*

The file names <file_name> are indicated as string parameters with the commands being enclosed in quotation marks. They also comply with DOS conventions.

DOS file names consist of max. 8 ASCII characters and an extension of up to three characters separated from the file name by a dot "." Both, the dot and the extension are optional. The dot is not part of the file name. DOS file names do not distinguish between uppercase and lowercase notation. All letters and digits are permitted as well as the special characters "_", "^", "$", "~", "!", "#", "%", "&", "-", "{", "}", "(", ")", "@" and "`". Reserved file names are CLOCK$, CON, AUX, COM1 to COM4, LPT1 to LPT3, NUL and PRN.

The two characters "*" and "?" have the function of so-called "wildcards", i.e., they are variables for selection of several files. The question mark "?" replaces exactly one character, the asterisk means any of the remaining characters in the file name. "*.*" thus means all files in a directory.

Command	Parameters
MMEMory:CATalog?	Path
MMEMory:CATalog:LONG?	Pfad
MMEMory:CDIRectory	directory name
MMEMory:CLear:ALL	
MMEMory:CLear:STATe	1,Path
MMEMory:COMMent	<string>
MMEMory:COPY	path, file name
MMEMory:DATA	<file name>,<block data>
MMEMory:DELete	path, file name
MMEMory:LOAD:AUTO	1,Path
MMEMory:LOAD:STATe	path, file name
MMEMory:MDIRectory	path
MMEMory:MOVE	path, file name
MMEMory:MSIS	'A:' | 'D:'
MMEMory:NAME	path, file name
MMEMory:RDIRectory	directory name
MMEMory:STORe<1|2>:TRACe	1 to 3,Path
MMEMory:SELect[:ITEM]:ALL	
MMEMory:SELect[:ITEM]:DEFault	
MMEMory:SELect[:ITEM]:HWSettings	ON | OFF
MMEMory:SELect[:ITEM]:LINes:ALL	ON | OFF
MMEMory:SELect[:ITEM]:NONE	
MMEMory:SELect[:ITEM]:TRACe[:ACTive]	ON | OFF
MMEMory:STORe<1|2>:MARKer	<file_name>
MMEMory:STORe<1|2>:STATe	path, file name

MMEMory:CATalog? <path>

This command reads the indicated directory. In accordance with DOS convention, wild card characters can be entered in order to query e.g. a list of all files of a certain type.

The path name should be in conformance with DOS conventions and may also include the drive name.

Parameter: <path>::= DOS Path name

Example: "MMEM:CAT? 'D:\USER\DATA'   'Returns the contents of the
                                                'D:\USER\DATA directory
                  "MMEM:CAT? 'D:\USER\DATA*.LOG'   'Returns all files in D:\USER\DATA
                                                'with extension ".LOG"
                  "MMEM:CAT? 'D:\USER\DATA\SPOOL?.WMF'
                                                ' Returns all files in D:\USER\DATA whose
                                              'names start with SPOOL, have 6 letters
                                              'and the extension ".WMF".

Response value: List of file names in the form of strings separated by commas, i.e.
                'SPOOL1.WMF','SPOOL2.WMF','SPOOL3.WMF'

Characteristics: *RST value: -
                     SCPI: conforming

MMEMory:CATalog:LONG? <path>

This command queries the directories and files in the given path.

Parameter:	<path>::= DOS path
Example:	"`MMEM:CAT:LONG? 'D:\USER\DATA'`'queries the contents of directory D:\USER\DATA
Return value:	<used_bytes_in_this_directory>,<free_bytes_on_this_disk>,

”<file_name>,<file_type>,<filesize_in_bytes>”,
”<file_name>,<file_type>,<filesize_in_bytes>”, …
with
<file_name>   name of file or directory
<file_type>   file type: DIR (directory), ASCii (ASCII file),
                    BINary (binary file) and STATe (file with device settings)
<filesize_in_bytes>   size of file, 0 for directories

Characteristics:	*RST value:	-
	SCPI:	conforming
Mode:	all	

MMEMory:CDIRectory <directory_name>

This command changes the current directory.
In addition to the path name, the indication of the directory may contain the drive name. The path name complies with the DOS conventions.

Parameter:	<directory_name>::= DOS path name	
Example:	"`MMEM:CDIR 'D:\USER\DATA'`"	'Returns the list of files in directory 'D:\USER\DATA.
Characteristics:	*RST value: -	
	SCPI: conforming	

MMEMory:CLEar:ALL

This command deletes all device settings in the current directory.The current directory can be selected with `MMEM:CDIR`. The default directory is D:.

Example:	"`MMEM:CLE:ALL`"	
Characteristics:	*RST value:	-
	SCPI:	device-specific
Mode:	all	

This command is an event and therefore has no *RST value and no query.

MMEMory:CLEar:STATe 1,<file_name>

This command deletes the instrument setting selected by <file_name>. All associated files on the mass memory storage are cleared. A list of the extensions used is included under `MMEMory:LOAD:STATe`. The file name includes indication of the path and may also include the drive. The path name complies with DOS conventions.

Parameter:	<file_name> ::= DOS file name without extension	
Example:	"`MMEM:CLE:STAT 1,'TEST'`"	
Characteristics:	*RST value:	-
	SCPI:	device-specific
Mode:	all	

This command is an event and therefore has no *RST value and no query.

MMEMory:COMMent   <string>

This command defines a comment (max. 60 characters) for a device setting to be stored.

Example: "MMEM:COMM 'Setup for GSM measurement'"

Characteristics: *RST value: blank comment
                      SCPI: device-specific

MMEMory:COPY   <file_source>,<file_destination>

This command copies the files indicated in <file_source> to the destination directory indicated with <file_destination> or to the destination file indicated by <file_destination> when <file_source> is just a file. The indication of the file name may include the path and the drive name. The file names and path information must be in accordance with the DOS conventions.

Parameter: <file_source>,<file_destination> ::= <file_name>
                      <file_name> ::= DOS file name

Example: "MMEM:COPY 'D:\USER\DATA\SETUP.CFG','A:'"

Characteristics: *RST value: -
                      SCPI   conforming

This command is an event and therefore has no *RST value and no query.

MMEMory:DATA   <file_name>[,<block data>]

This command writes the block data contained in <block> into the file characterized by <file_name>. The IEC/IEEE-bus delimiter must be set to EOI to obtain error-free data transfer.
The associated query command reads the indicated file from the mass memory and transfers it to the control computer via the IEC/IEEE bus. It should be noted that the buffer memory of the control computer should be large enough to store the file. The setting of the IEC/IEEE-bus delimiter is irrelevant in this case.
The command is useful for reading stored device settings or trace data from the instrument or for transferring them to the instrument.

Syntax: MMEMory:DATA <file_name>,<block data>   Data transfer from control computer
                                                              to instrument.
                      MMEMory:DATA? <file_name>   Data transfer from instrument
                                                              to control computer.
                      <file_name> selects the file to be transferred.
                      The binary data block <block> has the following structure:

- it always begins with the character '#',
- followed by a digit for the length of the length information,
- followed by the indicated number of digits as length information (number of bytes) for the binary data themselves,
- finally the binary data with the indicated number of bytes

Example: "MMEM:DATA 'TEST01.HCP',   #217This is the file"
                                                 'means:
                                                 '#2:   the next 2 characters
                                                 '   are the length indication
                                                 '17:   number of subsequent binary data
                                                 '   bytes
                                                 'This is the file:
                                                 '   17 bytes stored as binary data in the
                                                 '   file TEST01.HCP.

                      "MMEM:DATA? 'TEST01.HCP'" 'Transfers the file TEST01.HCP from the
                                                 'instrument to the control computer.

| Characteristics: | *RST value: | - |
| | SCPI: | conforming |

MMEMory:DELete   <file_name>

This command deletes the indicated files.

The indication of the file name contains the path and, optionally, the drive name. Indication of the path complies with DOS conventions.

Parameter: <file_name> ::= DOS file name

Example: `"MMEM:DEL 'TEST01.HCP'"`   'The file TEST01.HCP is deleted.

| Characteristics: | *RST value: | - |
| | SCPI: | conforming |

This command is an event and therefore has no *RST value and no query.

MMEMory:LOAD:AUTO   1,<file_name>

This command defines which device setting is automatically loaded after the device is switched on. The contents of the file are read after switching on the device and used to define the new device state. The file name includes indication of the path and may also include the drive. The path name complies with DOS conventions.

Note: *The data set defined as auto recall set will also be restored by a *RST-command.*

Parameter: <file_name> ::= DOS file name without extension;
                                     FACTORY denotes the data set previously in the
                                     instrument

Example: `"MMEM:LOAD:AUTO 1,'D:\USER\DATA\TEST'"`

| Characteristics: | *RST value: | FACTORY |
| | SCPI: | device-specific |

This command is an event and therefore has no *RST value and no query.

MMEMory:LOAD:STATe   1,<file_name>

This command loads device settings from files.The contents of the file are loaded and set as the new device state.
The file name includes indication of the path and may also include the drive name. The path name complies with DOS conventions.

Parameter: <file_name> ::= DOS file name without extension, extensions see table

Example: `"MMEM:LOAD:STAT 1,'F:TEST'"`

| Characteristics: | *RST value: | - |
| | SCPI: | conforming |

This command is an event and therefore has no *RST value and no query.

MMEMory:MDIRectory   <directory_name>

This command creates a new directory. The file name includes indication of the path and may also include the drive name. The path name complies with DOS conventions.

Parameter: <directory_name>::= DOS path name

Example: `"MMEM:MDIR 'D:\USER\DATA'"`

| Characteristics: | *RST value: | - |
| | SCPI: | device-specific |

This command is an event and therefore has no *RST value and no query.

MMEMory:MOVE   <file_source>,<file_destination>

This command renames existing files, if <file_destination> contains no path indication. Otherwise the file is moved to the indicated path and stored under the file name specified there, if any.
The file name includes indication of the path and may also include the drive. The path name complies with DOS conventions.

Parameter:	<file_source>,<file_destination> ::= <file_name>
	<file_name> ::= DOS file name

Example: `"MMEM:MOVE 'D:\TEST01.CFG','SETUP.CFG'"`
                              'Renames TEST01.CFG in SETUP.CFG
                              'in directory D:\.
`"MMEM:MOVE 'D:\TEST01.CFG','D:\USER\DATA'"`
                              'Moves TEST01.CFG from D:\ to
                              'D:\USER\DATA.
`"MMEM:MOVE 'D:\TEST01.CFG','D:\USER\DATA\SETUP.CFG'"`
                              'Moves TEST01.CFG from D:\ to
                              'D:\USER\DATA and renames the file in
                              'SETUP.CFG.

Characteristics: *RST value: -
                      SCPI: conforming
This command is an event and therefore has no *RST value and no query.

MMEMory:MSIS   <device>

This command changes to the drive indicated. The drive may be the internal hard disk D: or a memory stick F::.

Example: `"MMEM:MSIS 'F:'"`

Characteristics: *RST value: "D:'
                      SCPI: conforming

MMEMory:NAME   <file_name>

This command defines a destination file for the printout started with the command `HCOPy:IMMediate`. In this case the printer output must be routed to destination *FILE* using the command `"HCOP:DEST 'MMEM' "`.

The file name includes indication of the path and may also include the drive name. The file name and path information comply with DOS conventions.

Parameter: <file_name> ::= DOS file name

Example: `"HCOP:DEV:LANG BMP"`   Selection of data format.
              `"HCOP:DEST 'MMEM' "`   Selection of the output device
              `"MMEM:NAME 'PRINT1.BMP'"`   Selection of file name.
              `"HCOP:IMM"`   Start of the printout.

Characteristics: *RST value: -
                      SCPI: conforming

This command is an event and therefore has no *RST value and no query.

MMEMory:RDIRectory   <directory_name>

This command deletes the indicated directory. The directory name includes indication of the path and may also include the drive name. The path name complies with DOS conventions.

Parameter: <directory_name>::= DOS path name

Example: `"MMEM:RDIR 'D:\TEST'"`

Characteristics: *RST value: -
                        SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

MMEMory:SELect[:ITEM]:HWSettings   ON | OFF

This command includes the hardware settings in the list of data subsets of a device setting to be stored/loaded. The hardware settings include:
- current configuration of general device parameters (general setup)
- current setting of the measurement hardware including markers
- activated limit lines:
  A data set may include 8 limit lines at maximum in each measurement window. This number includes the activated limit lines and, if available, the de-activated limit lines last used. Therefore the combination of the non-activated restored limit lines depends on the sequence of use with the command `MMEM:LOAD`.
- user-defined color setting
- configuration for the hardcopy output

Example: `"MMEM:SEL:HWS ON"`

Characteristics: *RST value: ON
                        SCPI: device-specific

MMEMory:SELect[:ITEM]:TRACe[:ACTive]   ON | OFF

This command adds the active traces to the list of data subsets of a save/recall device setting. Active traces are all traces whose state is not blank.

Example: `"MMEM:SEL:TRAC ON"`

Characteristics: *RST value: OFF, i.e. no traces will be stored
                        SCPI: device-specific

MMEMory:SELect[:ITEM]:LINes:ALL   ON | OFF

This command adds all limit lines (activated and de-activated) to the list of device settings to be stored/loaded.The selection MMEM:SEL:LIN:ACT is thus switched off.

Example: `"MMEM:SEL:LIN:ALL ON"`

Characteristics: *RST value: ON
                        SCPI: device-specific

MMEMory:SELect[:ITEM]:ALL

This command includes all data subsets in the list device settings to be stored/loaded.

Example: `"MMEM:SEL:ALL"`

Characteristics: *RST value: --
                        SCPI: device-specific

This command is an event and therefore has no *RST value.

MMEMory:SELect[:ITEM]:NONE

This command deletes all data subsets from the list of device settings to be stored/loaded.

Example: `"MMEM:SEL:NONE"`

Characteristics: *RST value: --
                  SCPI: device-specific

This command is an event and therefore has no *RST value.

MMEMory:SELect[:ITEM]:DEFault

This command sets the default list of device settings to be stored/loaded.The latter includes:
- current configuration of general device parameters (general setup)
- current setting of the measurement hardware including markers
- activated limit lines
- user-defined color setting
- configuration for the hardcopy output

Trace data and non-used limit lines are not included.

Example: `"MMEM:SEL:DEFault"`

Characteristics: *RST value: --
                  SCPI: device-specific

This command is an event and therefore has no *RST value.

MMEMory:STORe<1|2>:MARKer <file_name>

This command saves the data of active markers to a file < file_name >.
Example for the content of a tex file contaning the data for 2 active markers in screen A:
Marker;1;T1
-25.87;dBm
19.920000000;GHz
Delta;2;T1
-21.90;dB
-5.920000000;GHz

Example: `"MMEM:STOR:MARK 'C:\marker.txt'"`
                  'Creates the file'marker.txt, with all marker data of screen A.

Characteristics: *RST-Wert: -
                  SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

MMEMory:STORe<1|2>:STATe   1,<file_name>

This command stores the current device settings in a series of files which have the indicated file name, but different extensions. The file name includes indication of the path and may also include the drive name. The path name complies with DOS conventions. The numeric suffix in STORe<1|2> is irrelevant with this command.

Parameter:	<file_name> := DOS file name without extension

Example:	"MMEM:STOR:STAT 1,'TEST'"

Characteristics: *RST value: -
                       SCPI: conforming
This command is an event and therefore has no *RST value and no query.

MMEMory:STORe<1|2>:TRACe   1 to 3,<file_name>

This command stores the selected trace (1 to 3) in the measurement window indicated by STORe<1|2> (screen A or B) in a file with ASCII format. The file format is described in chapter 4 in the TRACE menu under the *ASCII-FILE EXPORT* softkey.
The decimal separator (decimal point or comma) for floating-point numerals contained in the file is defined with the command FORMat:DEXPort:DSEParator.
The file name includes indication of the path and the drive name. Indication of the path complies with DOS conventions.

Parameter:	1 to 3	:= selected measurement curve Trace 1 to 3
	<file_name>	:= DOS file name

Example:	"MMEM:STOR2:TRAC 3,'F:\TEST.ASC'"
	'Stores trace 3 from screen B in the file
	'TEST.ASC on an USB stick.

Characteristics: *RST value: -
                       SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

SENSe Subsystem

The SENSe subsystem is organized in several subsystems. The commands of these subsystems directly control device-specific settings, they do not refer to the signal characteristics of the measurement signal.

The SENSe subsystem controls the essential parameters of the analyzer. In accordance with the SCPI standard, the keyword "SENSe" is optional for this reason, which means that it is not necessary to include the SENSe node in command sequences.

The measurement windows are selected by SENSe1 and SENSe2:

SENSe1 = Modification of screen A settings
SENSe2 = Modification of screen B settings.

Screen A is automatically selected if 1 or 2 is missing.

SENSe:AVERage Subsystem

The SENSe:AVERage subsystem calculates the average of the acquired data. A new test result is obtained from several successive measurements.

There are two types of average calculation: logarithmic and linear. In case of logarithmic average calculation (denoted with VIDeo), the average value of the measured logarithmic power is calculated and in case of linear average calculation, the linear power is averaged before the logarithm is applied.

The measurement windows are selected by SENSe1 (screen A) and SENSe2 (screen B).

Command	Parameters
[SENSe<1|2>:]AVERage:COUNt	0 to 32767
[SENSe<1|2>:]AVERage[:STATe<1 to 3>]	ON	OFF
[SENSe<1|2>:]AVERage:TYPE	VIDeo	LINear

[SENSe<1|2>:]AVERage:COUNt   0 to 32767

This command defines the number of measurements which contribute to the average value.

It should be noted that continuous averaging will be performed after the indicated number has been reached in continuous sweep mode.

In single sweep mode, the sweep is stopped as soon as the indicated number of measurements (sweeps) is reached. Synchronization to the end of the indicated number of measurements is only possible in single sweep mode.

The command `[SENSe<1|2>:]AVERage:COUNt` is the same as command `[SENSe<1|2>:]SWEep:COUNt`. In both cases, the number of measurements is defined whether the average calculation is active or not.

The number of measurements is valid for all traces in the indicated measurement window.

The numeric suffix at SENSet<1|2> is irrelevant.

Example: `"SWE:CONT OFF"`   Switching to single-sweep mode.
                             `"AVER:COUN 16"`   'Sets the number of measurements to 16.
                             `"AVER:STAT ON"`   'Switches on the calculation of average.
                             `"INIT;*WAI"`   'Starts the measurement and waits for the end of the 16 'sweeps.

Characteristics: *RST value: 0
                             SCPI: conforming

[SENSe<1|2>:]AVERage[:STATe<1 to 3>]   ON | OFF

This command switches on or off the average calculation for the selected trace (STATe<1 to 3>) in the selected measurement window. For measurement results using two windows (e.g. Magnitude/Phase), the average calculation is activated in both windows.

The numeric suffix at SENSet<1|2> is irrelevant.

Example: `"AVER OFF"`   'Switches off the average calculation for trace 1 in screen A.

                    `"SENS2:AVER:STAT3 ON"`   'Switches on the average calculation for trace 3 'in screen B.

Characteristics: *RST value: OFF
                             SCPI: conforming

[SENSe<1|2>:]AVERage:TYPE   VIDeo | LINear

This command selects the type of average function. If VIDeo is selected, the logarithmic power is averaged and, if LINear is selected, the power values are averaged before they are converted to logarithmic values.

The type of average calculation is equally set for all traces in one measurement window.

Example: "AVER:TYPE LIN"   'Switches screen A to linear average calculation.

Characteristics: *RST value: LINear
                      SCPI: device-specific

SENSe:BANDwidth Subsystem

This subsystem controls the setting of the instrument's filter bandwidths. Both groups of commands (BANDwidth and BWIDth) perform the same functions. The numeric suffix at SENSe<1|2> is irrelevant..

Command	Parameters
[SENSe<1|2>:]BANDwidth|BWIDth[:RESolution]:	10 Hz to 50 MHz
[SENSe<1|2>:]BANDwidth|BWIDth[:RESolution]:AUTO	ON	OFF
[SENSe<1|2>:]BANDwidth|BWIDth[:RESolution]:RATio	0.0001 to 1
[SENSe<1|2>:]BANDwidth|BWIDth[:RESolution]:STEP:MODE	LIN	L1235

[SENSe<1|2>:]BANDwidth|BWIDth[:RESolution] 10 Hz to 20 MHz

This command defines the analyzer's resolution bandwidth.
An FFT with preselectable windowing of the data is used in the Frequency Domain mode. The resolution bandwidths can be selected both in the usual steps and in fine intermediate steps (RES BW 1-2-3-5 softkey).
In time domain digital resolution filters of 10 Hz to 20 MHz in 1, 2, 3, 5, 10 steps are available.
In frequency domain a preselectable windowing of the data is performed. The minimum resolution bandwidth is 0.5 Hz and is dependent on the selected windowing function and the span.
If the resolution bandwidth is modified in SPECTRUM mode, the coupling to the span is automatically switched off.

Example: `"BAND 1MHz"` 'Sets the resolution bandwidth to 1 MHz

Characteristics: *RST value: - (AUTO is set to ON)
                      SCPI: conforming

[SENSe<1|2>:]BANDwidth|BWIDth[:RESolution]:AUTO   ON | OFF

This command either automatically couples the resolution bandwidth of the instrument to the span or cancels the coupling in frequency domain.
The automatic coupling adapts the resolution bandwidth to the currently set frequency span according to the relationship between frequency span and resolution bandwidth.
The ratio resolution bandwidth/span can be modified with the command
`[SENSe<1|2>:]BANDwidth[:RESolution]:RATio`.

Example: `"BAND:AUTO OFF"`   'Switches off the coupling of the resolution bandwidth to
                                            'the span (frequency domain)

Characteristics: *RST value: ON
                      SCPI: conforming

[SENSe<1|2>:]BANDwidth|BWIDth[:RESolution]:RATio   0.0001 to 1

This command defines the ratio resolution bandwidth (Hz) / span (Hz). The ratio to be entered is reciprocal to the ratio span/RBW used in manual control.

Example: `"BAND:RAT 0.1"`

Characteristics: *RST value: 0.02
                      SCPI: conforming

[SENSe<1|2>:]BANDwidth|BWIDth[:RESolution]:STEP:MODE LIN | L1235.

This command controls the rounding of the settable bandwidth in the frequency domain. With L1235, it is limited to steps of 1/2/3/5/10; with LIN, it is rounded to 0.1 Hz.

The numeric suffix <1|2> is irrelevant with this command.

Example: `"BAND:STEP:MODE L1235"`

Characteristics: *RST value: `L1235`
                SCPI: device-specific

SENSe:CORRection Subsystem

This subsystem also controls calibration and normalization during operation with the external generator control option (B10). The measurement windows are selected by SENSe1 (screen A) and SENSe2 (screen B).

Note: *The commands of this subsystem are not available during GSM measurements.*

Command	Parameters
[SENSe<1|2>:]CORRection:OFFset:PHAse	<numeric_value>

[SENSe<1|2>:]CORRection:OFFSet:PHASe <numeric_value.

This command sets a reference value for the phase display.

Example: "`CORR:OFFS:PHAS 10deg`"includes a phase offset of 10 deg

Characteristics: *RST value: 0 dB
                      SCPI: device-specific

SENSe:DETector Subsystem

The SENSe:DETector subsystem controls the acquisition of measurement data via the selection of the detector for the corresponding trace. The measurement windows are selected by SENSe1 (screen A) and SENSe2 (screen B).

Command	Parameters
[SENSe<1|2>:]DETector<1 to 3>[:FUNCtion]	APEak | NEGative | POSitive | SAMPle | RMS | AVERage
[SENSe<1|2>:]DETector<1 to 3>[:FUNCtion]:AUTO	ON | OFF

[SENSe<1|2>:]DETector<1..3>[:FUNCtion]   APEak | NEGative | POSitive | SAMPle | RMS | AVERage | QPEak

This command switches on the detector for the data acquisition in the selected trace and the indicated measurement window.

- The APEak detector (AutoPeak) displays the positive and also the negative peak value of the noise floor. If a signal is detected, only the positive peak value is displayed.

- The POSitive or NEGative detector only displays the positive or the negative peak value.

- With the Sample detector the value measured at the sampling time is displayed, whereas the RMS value of the power measured at each test point is displayed with the RMS detector.

- The AVERage detector displays the power average value at each test point.

The trace is indicated as numeric suffix in `DETector`.

Example: `"DET POS"`   'Sets the detector in screen A to "positive peak".

Characteristics: *RST value: APEak
                       SCPI: conforming

[SENSe<1|2>:]DETector<1 to 3>[:FUNCtion]:AUTO   ON | OFF

This command either couples the detector in the selected measurement window to the current trace setting or turns coupling off. The trace is selected by the numeric suffix at DETector.

Example: `"DET:AUTO OFF"`

Characteristics: *RST value: ON
                       SCPI: conforming

SENSe:FFT Subsystem

The SENSe:FFT subsystem controls the I/Q capturing. The numeric suffix at SENSe<1|2> is irrelevant.

Command	Parameters
[SENSe<1|2>:]FFT:CAPTure	ON | OFF
[SENSe<1|2>:]FFT:CAPTure:AUTO	ON | OFF
[SENSe<1|2>:]FFT:CAPTure:CALCulate	
[SENSe<1|2>:]FFT:PRESet[:DEVice]	

[SENSe<1|2>:]FFT:CAPTure ON | OFF

This command controls how data is captured. While the highest measurement speed is attained with OFF, ON and Single Sweep allow switching between the time and frequency domains even after the measurement without further data capture being necessary.

The numeric suffix <1|2> is irrelevant with this command.

Example: "FFT:CAPT ON"

Characteristics: *RST value: ON
                       SCPI: device-specific

[SENSe<1|2>:]FFT:CAPTure:AUTO ON | OFF

This command controls the automatic recalculation of measurement results after changing the instruments parameter. This function is only available for BOTH DOMAIN OFF and SINGLE SWEEP.

The numeric suffix <1|2> is irrelevant with this command.

Example: "FFT:CAPT:AUTO ON"

Characteristics: *RST value: OFF
                       SCPI: device-specific

[SENSe<1|2>:]FFT:CAPTure:CALCulate

This command restarts the analysis of captured data with new parameter settings, e.g. resolution bandwidth, window function or domain. This function is only available for BOTH DOMAIN OFF and SINGLE SWEEP."

This recalculation is automatically done, if FFT:CAPT:AUTO is switched ON.

The numeric suffix <1|2> is irrelevant with this command.

Example: "FFT:CAPT:CALC"

Characteristics: *RST value: -
                       SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

SENSe<1|2>:]FFT:PRESet[:DEVice]

This command sets the FFT Analyzer mode to the default state. This default state is nearly identical with the setting in effect after PRESET. An active probe calibration is not switched off. Connected coded power probes are taken into account.

The numeric suffix <1|2> is irrelevant with this command.

Example: `"SENS:FFT:PRES"`   'sets the instrument to the default state
                                          ' probe cal remains active

Characteristics: *RST value: --
                       SCPI: device-specific

This command is an event, so it has neither an *RST value nor a query.

SENSe:FREQuency Subsystem

The SENSe:FREQuency subsystem defines the frequency axis of the active display. The frequency axis can either be defined via the start/stop frequency or via the center frequency and span. The numeric suffix at SENSe<1|2> is irrelevant.

Command	Parameters
[SENSe<1|2>:]FREQuency:CENTer:STEP	0 to f_{max}
[SENSe<1|2>:]FREQuency:CENTer:STEP:LINK	SPAN | RBW | OFF
[SENSe<1|2>:]FREQuency:CENTer:STEP:LINK:FACTor	1 to 100 PCT
[SENSe<1|2>:]FREQuency:MODE	CW|FIXed | SWEep
[SENSe<1|2>:]FREQuency:OFFSet	<numeric_value>
[SENSe<1|2>:]FREQuency:SPAN	0 Hz to f_{max}
[SENSe<1|2>:]FREQuency:SPAN:FULL	
[SENSe<1|2>:]FREQuency:STARt	0 Hz to f_{max}
[SENSe<1|2>:]FREQuency:STOP	0 Hz to f_{max}

[SENSe<1|2>:]FREQuency:CENTer:STEP   0 to f_{max}

This command defines the step width of the center frequency.

Example: `"FREQ:CENT:STEP 1.50MHz"`

Characteristics: *RST value: - (AUTO 0.1 $\times$ SPAN is switched on)
        SCPI: conforming

[SENSe<1|2>:]FREQuency:CENTer:STEP:LINK   SPAN | RBW | OFF

This command couples the step width of the center frequency to span (span >0) or to the resolution bandwidth (span = 0) or cancels the couplings.

Parameters: SPAN = Coupling to frequency display range (for frequency domain)
       RBW = Coupling to resolution bandwidth (for time domain)
       OFF   = manual input, no coupling.

Example: `"FREQ:CENT:STEP:LINK SPAN"`

Characteristics: *RST value: SPAN
        SCPI: device-specific

[SENSe<1|2>:]FREQuency:CENTer:STEP:LINK:FACTor   1 to 100 PCT

This command couples the step width of the center frequency with a factor to the span (span >0) or to the resolution bandwidth (span = 0).

Note: *This command is not available for GSM/EDGE measurements modulation accuracy (MAC), phase/frequency error (PFE) and power versus time (PVT).*

Example: `"FREQ:CENT:STEP:LINK:FACT 20PCT"`

Characteristics: *RST value: - (AUTO $0.1 \times$ SPAN is switched on)
                   SCPI: device-specific

[SENSe<1|2>:]FREQuency:MODE   CW | FIXed | SWEep

This command switches between frequency domain (SWEep) and time domain (CW | FIXed).

For CW and FIXed, the frequency setting is via command `FREQuency:CENTer`. In the SWEep mode, the setting is via commands `FREQuency:STARt`, `STOP`, `CENTer` and `SPAN`.

Example: `"FREQ:MODE SWE"`

Characteristics: *RST value: SWEep
                   SCPI: conforming

[SENSe<1|2>:]FREQuency:OFFSet   <numeric_value>

This command defines the frequency offset of the instrument.

Example: `"FREQ:OFFS 1GHZ"`

Characteristics: *RST value: 0 Hz
                   SCPI: conforming

[SENSe<1|2>:]FREQuency:SPAN   0 to f_{max}

This command defines the frequency span in the frequency domain. A span of 0 Hz activates the time domain.

Example: `"FREQ:SPAN 1MHz"`

Characteristics: *RST value: 72 MHz
                   SCPI: conforming

[SENSe<1|2>:]FREQuency:SPAN:FULL

This command sets the frequency span in the frequency domain to its maximum.

Example: `"FREQ:SPAN:FULL"`

Characteristics: *RST value: -
                   SCPI: conforming

This command is an event and therefore has no *RST value and no query.

[SENSe<1|2>:]FREQuency:STARt $-f_{max}$ to f_{max}

This command defines the start frequency of the analyzer. This command is only available in the frequency domain. For signal path I only/Q only, only values ≥ 0 are allowed.

The automatic coupling of the frequency parameters is set to STOP FIXED.

Example: `"FREQ:STAR 20MHz"`

Characteristics: *RST value: 0
                      SCPI: conforming

[SENSe<1|2>:]FREQuency:STOP $-f_{max}$ to f_{max}

This command defines the stop frequency of the frequency domain. For signal path I only/Q only, only values > 0 are allowed.

Example: `"FREQ:STOP 20MHz"`

Characteristics: *RST value: f_{max}
                      SCPI: conforming

SENSe:I/Q Subsystem

This subsystem controls the settings for the baseband input.

Command	Parameters
[SENSe<1|2>:]IQ:DITHer[:STATe]	ON	OFF
[SENSe<1|2>:]IQ:LPASs[:STATe]	ON	OFF

[SENSe<1|2>:]IQ:DITHer[:STATe] ON | OFF

This command inserts a 2 MHz wide noise signal at 42.67 MHz into the signal path of the baseband input.

The numeric suffix at SENSe<1|2> is irrelevant.

Example: "IQ:DITH ON"

Features: *RST value: OFF
                     SCPI: device-specific

[SENSe<1|2>:]IQ:LPASs[:STATe] ON | OFF

This command switches a filter of 36 MHz into the I and Q paths of the baseband input.

The numeric suffix at SENSe<1|2> is irrelevant.

Example: "IQ:LPAS OFF"

Features: *RST value: ON
                     SCPI: device-specific

SENSe:POWer Subsystem

This subsystem controls the setting of the instrument's channel and adjacent channel power measurements. The measurement is allowed in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Note: *The maximum allowed values of the number of channels, channel spacing and channel bandwidth parameters exceed the frequency range of the R&S FMU. There is no checking concerning possible R&S FMU frequency range and valid measurement settings. If the effective sweep parameters exceed the available frequency range, the measurement results will be marked as invalid.*

Command	Parameters
[SENSe<1|2>:]POWer:ACHannel:ACPairs	0 to 12
[SENSe<1|2>:]POWer:ACHannel:BANDwidth|BWIDth:ACHannel	100 to 1000MHz
[SENSe<1|2>:]POWer:ACHannel:BANDwidth|BWIDth:ALTernate<1..11>	100 to 1000MHz
[SENSe<1|2>:]POWer:ACHannel:BANDwidth|BWIDth[:CHANnel]	100 to 1000 MHz
[SENSe<1|2>:]POWer:ACHannel:MODE	ABSolute | RELative
[SENSe<1|2>:]POWer:ACHannel:PRESet	ACPower | CPOWer | MCACpower | OBANdwidth | OBWidth | CN | CN0
[SENSe<1|2>:]POWer:ACHannel:REFerence:AUTO	ONCE
[SENSe<1|2>:]POWer:ACHannel:REFerence:TXCHannel:AUTO	MINimum | MAXimum | LHIGhest
[SENSe<1|2>:]POWer:ACHannel:REFerence:TXCHannel:MANual	1 to 12
[SENSe<1|2>:]POWer:ACHannel:SPACing:ACHannel	100 to 2000MHz
[SENSe<1|2>:]POWer:ACHannel:SPACing:ALTernate<1 to 11>	100 to 2000MHz
[SENSe<1|2>:]POWer:ACHannel:SPACing:CHANnel<1 to 11>	100 to 2000MHz
[SENSe<1|2>:]POWer:ACHannel:TXCHannel:COUNt	1 to 12
[SENSe<1|2>:]POWer:BANDwidth|BWIDth	10 to 99.9PCT
[SENSe<1|2>:]POWer:TRACe	1 to 3

[SENSe<1|2>:]POWer:ACHannel:ACPairs 0 to 12

This command sets the number of adjacent channels (upper and lower channel in pairs).The figure 0 stands for pure channel power measurement.
The command is only available in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Example: `"POW:ACH:ACP 3"` 'Sets the number of adjacent channels to 3, i.e. the 'adjacent channel and alternate adjacent channels 1 and '2 are switched on.

Characteristics: *RST value: 1
SCPI: device-specific

[SENSe<1|2>:]POWer:ACHannel:BANDwidth|BWIDth:ACHannel 100 Hz to 1000 MHz

This command defines the channel bandwidth of the adjacent channel of the radio transmission system. If the bandwidth of the adjacent channel is changed, the bandwidths of all alternate adjacent channels are automatically set to the same value.
With `SENS:POW:HSP ON` the steep-edged channel filters from the table "List of available channel filters" in Section "Setting Bandwidths and Sweep Time – Key *BW*" are available.
The command is only available in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Example:	`"POW:ACH:BWID:ACH 30kHz"`	'Sets the bandwidth of all adjacent channels to '30 kHz.

Characteristics: *RST value: 14 kHz
                              SCPI: device-specific

[SENSe<1|2>:]POWer:ACHannel:BANDwidth|BWIDth:ALTernate<1 to 11>   100 Hz to 1000 MHz

This command defines the channel bandwidth of the alternate adjacent channels of the radio transmission system. If the channel bandwidth of an alternate adjacent channel (e.g. channel no. 1) is changed, the bandwidth of all the following alternate adjacent channels (e.g. channels no. 2 to 11) is automatically set to the same value.
With `SENS:POW:HSP ON` the steep-edged channel filters from the table "List of available channel filters" in Section "Setting Bandwidths and Sweep Time – Key *BW*" are available.
The command is only available in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Example: `"POW:ACH:BWID:ALT2 30kHz"`

Characteristics: *RST value: 14 kHz
                              SCPI: device-specific

SENSe<1|2>:]POWer:ACHannel:BANDwidth|BWIDth[:CHANnel]   100 Hz to 1000 MHz

This command sets the channel bandwidth of the radio communication system.The bandwidths of adjacent channels are not influenced by this modification (in contrast to the FSE family).
With `SENS:POW:HSP ON` the steep-edged channel filters from the table "List of available channel filters" in Section "Setting Bandwidths and Sweep Time – Key *BW*" are available.
The command is only available in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Example:	`"POW:ACH:BWID 30kHz"`	'Sets the bandwidth of the TX channel to '30 kHz.

Characteristics: *RST value: 14 kHz
                              SCPI: device-specific

[SENSe<1|2>:]POWer:ACHannel:MODE   ABSolute | RELative

This command toggles between absolute and relative adjacent channel measurement.

For the relative measurement the reference value is set to the currently measured channel power by command `SENSe:POWer:ACHannel:REFerence:AUTO ONCE`.
The command is only available in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Example: `"POW:ACH:MODE REL"`

Characteristics: *RST value: ABSolute
                              SCPI: device-specific

[SENSe<1|2>:]POWer:ACHannel:PRESet ACPower | CPOWer | MCACpower | OBANdwidth | OBWidth | CN | CN0

This command adjusts the frequency span, the measurement bandwidths and the detector as required for the number of channels, the channel bandwidths and the channel spacings selected in the active power measurement. If necessary, adjacent-channel power measurement is switched on prior to the adjustment.

To obtain valid results, a complete sweep with synchronization to the end of the sweep must be performed after the adjustment. Synchronization is possible only in the single-sweep mode.

The result is queried with the command `CALCulate:MARKer:FUNCtion:POWer:RESult?`.

The command is available only for measurements in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Example:	`"POW:ACH:PRES ACP"`	'Sets the frequency span, the measurement bandwidths and the detector as required for the ACP measurement in screen A.
	`"INIT:CONT OFF"`	'Switches over to single-sweep mode.
	`"INIT;*WAI"`	'Starts a sweep and waits for the end of the sweep.
	`"CALC:MARK:FUNC:POW:RES? ACP"`	'Queries the result of the adjacent-channel power measurement.

Characteristics: *RST value: -
                     SCPI: device-specific

[SENSe<1|2>:]POWer:ACHannel:REFerence:AUTO ONCE

This command sets the reference value for the relative measurement to the currently measured channel power.

The command is only available in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed..

Example: `"POW:ACH:REF:AUTO ONCE"`

Characteristics: *RST value: -
                     SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

[SENSe<1|2>:]POWer:ACHannel:REFerence:TXCHannel:AUTO MINimum | MAXimum | LHIGhest

This command activates the automatic selection of a transmission channel to be used as a reference channel in relative adjacent-channel power measurements.

The transmission channel with the highest power, the transmission channel with the lowest power, or the transmission channel nearest to the adjacent channels can be defined as a reference channel.

The command is available only for multicarrier channel and adjacent-channel power measurements (`CALC:MARK:FUNC:POW:SEL MCAC`) in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Parameters:	MINimum	Transmission channel with the lowest power
	MAXimum	Transmission channel with the highest power
	LHIGhest	Lowermost transmission channel for the lower adjacent channels, uppermost transmission channel for the upper adjacent channels
Example:	`"POW:ACH:REF:TXCH:AUTO MAX"`	'The transmission channel with the highest power is used as a reference channel.

Characteristics: *RST value: -
                     SCPI: device-specific

[SENSe<1|2>:]POWer:ACHannel:REFerence:TXCHannel:MANual 1 to 12

This command selects a transmission channel to be used as a reference channel in relative adjacent-channel power measurements.

The command is available only for multicarrier channel and adjacent-channel power measurements (`CALC:MARK:FUNC:POW:SEL MCAC`) in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Example: `"POW:ACH:REF:TXCH:MAN 3"` 'Transmission channel 3 is used as a reference
                                              channel.

Characteristics: *RST value: 1
                     SCPI: device-specific

[SENSe<1|2>:]POWer:ACHannel:SPACing:ACHannel 100 Hz to 2000 MHz

This command defines the channel spacing of the adjacent channel to the TX channel. At the same time, the spacing of alternate adjacent channels 1 to 11 is set to the double or triple etc. of the entered value. The command is only available in frequency domain / magnitude.

Note: *The maximum values of the channel spacing/channel bandwidth parameters exceed the frequency range of the R&S FMU. There is no checking concerning valid measurement settings. If the effective sweep parameters exceed the available frequency range, the measurement results will be marked as invalid.*

The numeric suffix 2 with SENSe is not allowed.

Example: `"POW:ACH:SPAC:ACH 33kHz"` 'Sets the spacing between the carrier signal
                                             'and
                                             '- the adjacent channel to 33 kHz
                                             '- the alternate adjacent channel 1 to 66 kHz
                                             '- the alternate adjacent channel 2 to 99 kHz

Characteristics: *RST value: 14 kHz
                     SCPI: device-specific

[SENSe<1|2>:]POWer:ACHannel:SPACing:ALTernate<1 to 11> 100 Hz to 2000 MHz

This command defines the spacing between the alternate adjacent channels and the TX channel. If the spacing to an alternate adjacent channel ALTernate<k> is modified, the spacing to all the following alternate adjacent channels ALTernate<n> is set to (<n> + 1) / (<k> + 1) times the entered value. This command is only available in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Example: `"POW:ACH:SPAC:ALT1 100kHz"` 'Sets the spacing between TX channel and
                                              'alternate adjacent channel 1 to 100 kHz and
                                              'between TX channel and alternate adjacent
                                              'channel 2 to 150 kHz.

Characteristics: *RST value   40 kHz (ALT1)
                                  60 kHz (ALT2)
                                  80 kHz (ALT3)
                                  100 kHz (ALT4)
                                  120 kHz (ALT5)
                                  140 kHz (ALT6)
                                  160 kHz (ALT7)
                                  180 kHz (ALT8)
                                  200 kHz (ALT9)
                                  220 kHz (ALT10)
                                  240 kHz (ALT11)
                     SCPI: device-specific

[SENSe<1|2>:]POWer:ACHannel:SPACing:CHANnel<1 to 11>   100 Hz to 2000 MHz

This command defines the channel spacing of the carriers. At the same time the spacing of carriers with higher channel number are set to the same value. If the spacing is equal between all carriers it is sufficient to set the spacing between carrier 1 and 2 with the command
`SENS:POW:ACP:SPAC:CHAN1` or `SENS:POW:ACP:SPAC:CHAN`. If the spacing are set in ascending order individual spacing of the carriers can be set.
The command is available only in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Example: `"POW:ACH:SPAC:CHAN 25kHz"` 'Sets the spacing between all carriers to 25 kHz

                      `"POW:ACH:SPAC:CHAN2 4.8MHz"`
                                                 'sets the spacing between TX carrier 2 and 3 to 4.8 MHz.

Characteristics: *RST value: 20 kHz
                      SCPI: device-specific

[SENSe<1|2>:]POWer:ACHannel:TXCHannel:COUNt 1 to 12

This command selects the number of carrier signals.
The command is available only for multicarrier channel and adjacent-channel power measurements (`CALC:MARK:FUNC:POW:SEL MCAC`) in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Example: `"POW:ACH:TXCH:COUN 3"`

Characteristics: *RST value: 4
                      SCPI: device-specific

[SENSe<1|2>:]POWer:BANDwidth|BWIDth   10 to 99.9 PCT

This command defines the percentage of the power with respect to the total power. This value is the basis for the occupied bandwidth measurement (command: `POWer:ACHannel:PRESet OBW`).
The command is only available in frequency domain / magnitude. The numeric suffix 2 with SENSe is not allowed.

Example: `"POW:BWID 95PCT"`

Characteristics: *RST value: 99PCT
                      SCPI: device-specific

[SENSe<1|2>:]POWer:TRACe 1 to 3

This command assigns the channel/adjacent channel power measurement to the indicated trace in the selected measurement window. The corresponding trace must be active, i.e. its state must be different from blank.

Note: *The measurement of the occupied bandwidth (OBW) is performed on the trace on which marker 1 is positioned. To evaluate another trace, marker 1 must be positioned to another trace with* `CALCulate:MARKer:TRACe`*.*
           The maximum values of the channel spacing/channel bandwidth parameters exceed the frequency range of the R&S FMU. There is no checking concerning valid measurement settings. If the effective sweep parameters exceed the available frequency range, the measurement results will be marked as invalid.

The numeric suffix 2 with SENSe is not allowed.

Example: `"POW:TRAC 2"`   'Assigns the measurement in screen A to trace 2.
                      `"SENS2:POW:TRAC 3"`   'Assigns the measurement in screen B to trace 3.

Characteristics: *RST value: -
                      SCPI: device-specific

SENSe:PROBe Subsystem

This subsystem controls the probe calibration data set handling.

Command	Parameters
[SENSe<1|2>:]PROBe:ADJust:DC	0 to 2.4 V
[SENSe<1|2>:]PROBe:ADJust:MODE	DC	PULSE	COMPensation
[SENSe<1|2>:]PROBe:ADJust:PULSe	10 kHz to 8 MHz
[SENSe<1|2>:]PROBe:CATalog?	
[SENSe<1|2>:]PROBe:DELete	<probe_data_set_name>
[SENSe<1|2>:]PROBe:FAIL?	
[SENSe<1|2>:]PROBe:MOVE	<file_name>,<file_name>
[SENSe<1|2>:]PROBe:RESult?	
[SENSe<1|2>:]PROBe:SELect	<file_name>
[SENSe<1	2>:]PROBe[:STATe]	ON	OFF

[SENSe<1|2>:]PROBe:ADJust:DC   0 to 2.4V

This command sets the voltage at the Probe Cal output (0V, 10mV, 20mV, 50mV, 100mV, 200mV, 500mV, 1V, 2V, 2.4V).

The numeric suffix <1|2> is ignored with this command.

Note: *To activate the voltage at the Probe Cal output use the command* `PROBe:ADJ:MODE DC.`

Example: "`PROB:ADJ:DC 2`"   'Set the DC voltage at the Probe Cal output to 2V

"`PROB:ADJ:MODE DC`"   'Activate the DC voltage at the Probe Cal output

Characteristics: *RST value: 0
SCPI: device-specific

[SENSe<1|2>:]PROBe:ADJust:MODE   DC | PULSE | COMPensation

This command activates the DC voltage, frequency or pulse at the Prob Cal or Compensation output.

The numeric suffix <1|2> is ignored with this command.

Parameter: DC   activates DC voltage at the Prob Cal output
PULSe   activates pulse at the Prob Cal output
COMPensation   activates a 1kHz frequency at the Compensation output

Example: "`PROB:ADJ:MODE COMP`"   'Activate a 1kHz signal the Compensation output

Characteristics: *RST value: DC
SCPI: device-specific

[SENSe<1|2>:]PROBe:ADJust:PULSe   10 kHz to 8 MHz

This command sets the pulse frequenzy at the Probe Cal output (10kHz, 62.5kHz, 100kHz, 102.4kHz, 200kHz, 250kHz, 500kHz, 1MHz, 2MHz, 4MHz, 8MHz).

The numeric suffix <1|2> is ignored with this command.

Note: *To activate the pulse at the Probe Cal output use the command* `PROBe:ADJ:MODE` `PULSe.`

Example: `"PROB:ADJ:PULS 100KHZ"` 'Set the pulse frequency at the Probe Cal output to '100 kHz

                   `"PROB:ADJ:MODE PULS"`   'Activate the pulse at the Probe Cal output

Characteristics: *RST value: 102.4kHz
                   SCPI: device-specific

[SENSe<1|2>:]PROBe:CATalog?

This command queries the names of all probe data sets stored in the FMU.

The numeric suffix <1|2> is ignored with this command.

The syntax of this output format is as follows:

<1st probe data set>,<2st probe data set 2>,..,<nst probe data set>

Example: `"PROB:CAT?"` 'Query names of all probe data sets

Characteristics: *RST value: -
                   SCPI: device-specific

[SENSe<1|2>:]PROBe:DELete   <probe_data_set_name>

This command deletes the specified probe data set.

The numeric suffix <1|2> is ignored with this command.

Parameters: probe_data_set_name   name of the probe data set to delete

Example: `"PROB:DEL 'probe_1'"`   'Delete probe data set probe_1

Characteristics: *RST value: -
                   SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

[SENSe<1|2>:]PROBe:FAIL?

This command queries, if the calibration of the selected probe data set passed or failed. The response of this query is 0 for PASS and 1 for FAIL.

The numeric suffix <1|2> is ignored with this command.

Note: *The probe data set is selected with* `PROBe:SELect`*. Therefore the command* `PROBe:FAIL?` *should always be sent* <u>*after*</u> *selecting the probe data set.*

Example: `"PROB:SEL 'probe_1'"` 'Select probe data set probe_1
                   `"PROB:FAIL?"`   'Query if calibration failed

Characteristics: *RST value: -
                   SCPI: device-specific

[SENSe<1|2>:]PROBe:MOVE   <probe_data_set_source>,<probe_data_set_destination>

This command renames existing probe data sets.

The numeric suffix <1|2> is ignored with this command.

Parameters: probe_data_set_source   name of the source probe data set
                    probe_data_set_destination   name of the destination probe data set

Example: `"PROB:MOV 'probe_1', 'probe_2'"`   'Rename probe data set probe_1 to
                                                      'probe_2

Characteristics: *RST value: -
                        SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

[SENSe<1|2>:]PROBe:RESult?

This command queries the calibration result of the selected probe data set.

The numeric suffix <1|2> is ignored with this command.

Note: *The probe data set is selected with* `PROBe:SELect`*. Therefore the command*
            `PROBe:RESult?` *should always be sent <u>after</u> selecting the probe data set.*

Example: `"PROB:SEL 'probe_1'"`   'Select probe data set probe_1
                      `"PROB:RES?"`   'Query calibration results

Characteristics: *RST value: -
                        SCPI: device-specific

[SENSe<1|2>:]PROBe:SELect   <probe_data_set_name>

This command selects the specified probe data set.

The numeric suffix <1|2> is ignored with this command.

Note: *Use the command PROBe:STATe to activate the probe data set,*

Parameters: probe_data_set_name   name of the probe data set to select

Example: `"PROB:SEL 'probe_1'"`   'Select probe data set probe_1

Characteristics: *RST value: -
                        SCPI: device-specific

This command is an event and therefore has no *RST value and no query.

[SENSe<1|2>:]PROBe:STATe   ON | OFF

This command activates a selected probe data set.

The numeric suffix <1|2> is ignored with this command.

Note: *The probe data set is selected with* `PROBe:SELect`*. Therefore the command*
            `PROBe:STATe` *should always be sent <u>after</u> selecting the probe data set.*

Example: `"PROB:SEL 'probe_1'"`   'Select probe data set probe_1
                     `"PROB:STAT ON"`   'Activate probe data set probe_1

Characteristics: *RST value: OFF
                        SCPI: device-specific

SENSe:ROSCillator Subsystem

This subsystem controls the reference oscillator. The numeric suffix in SENSe is irrelevant for the commands of this subsystem.

Command	Parameters
[SENSe<1|2>:]ROSCillator:EXTernal:FREQuency	1MHz to 20MHz
[SENSe<1|2>:]ROSCillator:SOURce	INTernal	EXTernal
[SENSe<1|2>:]ROSCillator[:INTernal]:TUNe	0 to 4095
[SENSe<1|2>:]ROSCillator[:INTernal]:TUNe:SAVe	

[SENSe<1|2>:]ROSCillator:EXTernal:FREQuency   1MHz to 20MHz

This command informs the instrument on the frequency of the external reference oscillator. This frequency is used as starting point for the synchronization of the internal reference frequencies. The value of the external reference frequency (1 MHz to 20 MHz) is rounded in steps of 1 Hz.

Example: "ROSC:EXT:FREQ 5MHz"

Characteristics: *RST value: -
                     SCPI: conforming

*RST **is not** influencing this parameter.

[SENSe<1|2>:]ROSCillator:SOURce   INTernal | EXTernal

This command controls selection of the reference oscillator.

If the external reference oscillator is selected, the reference signal must be connected to the rear panel of the instrument.

Example: "ROSC:SOUR EXT"

Characteristics: *RST value: –
                     SCPI: conforming

*RST **is not** influencing this parameter.

[SENSe<1|2>:]ROSCillator[:INTernal]:TUNe   0 to 4095

This command defines the value for the tuning of the internal reference oscillator.
The reference oscillator should be tuned only if an error has been detected in the frequency accuracy check. After rebooting the instrument, the factory-set reference frequency or the previously saved reference frequency is restored.

Note: *This command is only available at service level 1.*

Example: "ROSC:TUN 128"

Characteristics: *RST value: –
                     SCPI: device-specific

[SENSe<1|2>:]ROSCillator[:INTernal]:TUNe:SAVe

This command saves the new value for the tuning of the internal reference oscillator. The factory-set value in the EEPROM is overwritten.

Note: *This command is only available at service level 1.*

Example: "ROSC:TUN:SAV"

Characteristics: *RST value: –
                     SCPI: device-specific

SENSe:SWEep Subsystem

This subsystem controls the sweep parameters. The measurement windows are selected by SENSe1 (screen A) and SENSe2 (screen B).

Command	Parameters
[SENSe<1|2>:]SWEep:COUNt	0 to 32767
[SENSe<1|2>:]SWEep:COUNt:CURRent?	
[SENSe<1|2>:]SWEep:POINts	625, 1251, 1999, 2501,5001,10001,20001,30001
[SENSe<1|2>:]SWEep:TIME	1µs to 16000s

[SENSe<1|2>:]SWEep:COUNt 0 to 32767

This command defines the number of sweeps started with single sweep, which are used for calculating the average or maximum value. In average mode, the value 0 defines a continuous averaging of measurement data over 10 sweeps.

Example: `"SWE:COUN 64"`   'Sets the number of sweeps to 64.
                       `"INIT:CONT OFF"`   'Switches to single-sweep mode.
                       `"INIT;*WAI"`   'Starts a sweep and waits for its end.

Characteristics: *RST value: 0
                           SCPI: conforming

[SENSe<1|2>:]SWEep:COUNt:CURRent?

This query command returns the current number of started sweeps. A sweep count value should be set and the device should be in single sweep mode. This command is a query and therefore has no *RST value.

Example: `"SWE:COUNt 64"`   'sets sweep count to 64
                       `"INIT:CONT OFF"`   'switches to single sweep mode
                       `"INIT"`   'starts a sweep (without waiting for the sweep end!)
                       `"SWE:COUN:CURR?"`   'queries the number of started sweeps

Characteristics: *RST value: -
                           SCPI: conforming

[SENSe<1|2>:]SWEep:POINts <numeric value>

This command defines the number of measurement points for one sweep run. Allowed numeric values are 155, 201, 313, 401, 625, 801, 1251, 1601, 1999, 2501, 5001, 10001, 20001, 30001.

Example: `"SENS:SWE:POIN 801"`

Characteristics: *RST value: 625
                           SCPI: conforming

[SENSe<1|2>:]SWEep:TIME   1µs to 16000s

This command defines the sweep time in time domain.
The available range depends on following instrument settings:

- Both Domain ON/OFF
- Resolution Bandwidth

In frequency domain, it is not possible to set the sweep time (here the acquisition time for I/Q data capturing). But the current setting can be queried.

Example: `"SWE:TIME 10s"`

Characteristics: *RST value   5 ms (for time domain)
                       SCPI: conforming

SENSe:VOLTage Subsystem

This subsystem controls the amplitude settings of the baseband input.

Command	Parameters
[SENSe<1|2>]:VOLTage:IQ:RANGe:OFFSet	−200 dB to 200 dB
[SENSe<1|2>:]:VOLTage:IQ:RANGe[:UPPer]	<numeric_value> V

[SENSe<1|2>]:VOLTage:IQ:RANGe:OFFSet −200 dB to 200 dB

   This command defines the reference level offset for the baseband input.The command
   DISP:WIND:TRAC:Y:SCAL:RLEV:OFFS can also be used.

   The numeric suffix <1|2> is irrelevant with this command.

   Example: `"VOLT:IQ:RANG:OFFS -20dB"`   'sets the reference level offset for the
                                                                ' baseband input to −20 dB

   Characteristics: *RST value: 0 dB
                         SCPI: device-specific

[SENSe<1|2>]:VOLTage:IQ:RANGe[:UPPer] <numeric_value>

   This command defines the measurement range of the baseband input. The value range depends on
   the input impedance. The measurement range defines the measurable peak voltage (positive and
   negative).

Input impedance	Range of values / Volt (5 dB steps)
Low (50 Ω)	0.0316; 0.0562; 0.1; 0.178 ; 0.316; 0.562; 1; 1.78; 3.16; 5.62
High (1 MΩ or 1 kΩ)	0.0316; 0.0562; 0.1; 0.178 ; 0.316; 0.562; 1; 1.78

   The numeric suffix <1|2> is irrelevant with this command.

   Example: `"VOLT:IQ:RANGE 0.1V"`

   Characteristics: *RST value: 1 V
                         SCPI: device-specific

SENSe:WINDow Subsystem

This subsystem controls the evaluation in the FFT Analyzer mode.

Command	Parameters
[SENSe<1|2>:]:WINDow:TYPE	FLATtop | EXPonential | HAMMing | HANNing | RECTangular | CHEBychev

SENSe<1|2>:WINDow:TYPE FLATtop | EXPonential | HAMMing | HANNing | RECTangular | CHEBychev

This command selects the type of the window function for the I/Q input data in the spectrum display (frequency domain).

Parameter: FLATtop   "Flattop" type
                         EXPonential   "Gaussian" type
                         HAMMing   "Hamming" type
                         HANNing   "Hann" type
                         RECTangular   "Rectangular" type
                         CHEBychev   "Chebychev" type

The numeric suffix <1|2> is irrelevant with this command.

Example: "WIND:TYPE CHEB"

Characteristics: *RST value: CHEB
                          SCPI: device-specific

STATus Subsystem

The STATus subsystem contains the commands for the status reporting system (see Chapter 5, Status Reporting System"). *RST does not influence the status registers.

Command	Parameters
STATus:OPERation:CONDition?	
STATus:OPERation:ENABle	0 to 65535
STATus:OPERation[:EVENt]	
STATus:OPERation:NTRansition	0 to 65535
STATus:OPERation:PTRansition	0 to 65535
STATus:PRESet	
STATus:QUEStionable:ACPLimit:CONDition?	
STATus:QUEStionable:ACPLimit:ENABle	0 to 65535
STATus:QUEStionable:ACPLimit[:EVENt]?	
STATus:QUEStionable:ACPLimit:NTRansition	0 to 65535
STATus:QUEStionable:ACPLimit:PTRansition	0 to 65535
STATus:QUEStionable:CONDition?	
STATus:QUEStionable:ENABle	0 to 65535
STATus:QUEStionable[:EVENt]?	
STATus:QUEStionable:LIMit:CONDition?	
STATus:QUEStionable:LIMit:ENABle	0 to 65535
STATus:QUEStionable:LIMit[:EVENt]?	
STATus:QUEStionable:LIMit:NTRansition	0 to 65535
STATus:QUEStionable:LIMit:PTRansition	0 to 65535
STATus:QUEStionable:LMARgin:CONDition?	
STATus:QUEStionable:LMARgin:ENABle	0 to 65535
STATus:QUEStionable:LMARgin[:EVENt]?	
STATus:QUEStionable:LMARgin:NTRansition	0 to 65535
STATus:QUEStionable:LMARgin:PTRansition	0 to 65535
STATus:QUEStionable:NTRansition	0 to 65535
STATus:QUEStionable:POWer:CONDition?	
STATus:QUEStionable:POWer:ENABle	0 to 65535
STATus:QUEStionable:POWer[:EVENt]?	
STATus:QUEStionable:POWer:NTRansition	0 to 65535
STATus:QUEStionable:POWer:PTRansition	0 to 65535
STATus:QUEStionable:PTRansition	0 to 65535
STATus:QUEStionable:SYNC:CONDition?	
STATus:QUEStionable:SYNC:ENABle	0 to 65535
STATus:QUEStionable:SYNC[:EVENt]?	
STATus:QUEStionable:SYNC:NTRansition	0 to 65535
STATus:QUEStionable:SYNC:PTRansition	0 to 65535
STATus:QUEStionable:FREQuency:CONDition?	
STATus:QUEStionable:FREQuency:ENABle	0 to 65535
STATus:QUEStionable:FREQuency[:EVENt]?	
STATus:QUEStionable:FREQuency:NTRansition	0 to 65535
STATus:QUEStionable:FREQuency:PTRansition	0 to 65535
STATus:QUEue[:NEXT]?	

STATus:OPERation:CONDition?

This command queries the CONDition section of the STATus:OPERation register. Readout does not delete the contents of the CONDition section. The value returned reflects the current hardware status.

Example: `"STAT:OPER:COND?"`

Characteristics: *RST value: –
                        SCPI: conforming

STATus:OPERation:ENABle   0 to 65535

This command sets the bits of the ENABle section of the STATus:OPERation register. The ENABle register selectively enables the individual events of the associated EVENt section for the summary bit in the status byte.

Example: `"STAT:OPER:ENAB 65535"`

Characteristics: *RST value: –
                        SCPI: conforming

STATus:OPERation[:EVENt]?

This command queries the contents of the EVENt section of the STATus:OPERation register. The contents of the EVENt section are deleted after readout.

Example: `"STAT:OPER?"`

Characteristics: *RST value: –
                        SCPI: conforming

STATus:OPERation:NTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:OPERation register from 1 to 0 for the transitions of the CONDition bit.

Example: `"STAT:OPER:NTR 65535"`

Characteristics: *RST value: –
                        SCPI: conforming

STATus:OPERation:PTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:OPERation register from 0 to 1 for the transitions of the CONDition bit.

Example: `"STAT:OPER:PTR 65535"`

Characteristics: *RST value: –
                        SCPI: conforming

STATus:PRESet

This command resets the edge detectors and ENABle parts of all registers to a defined value. All PTRansition parts are set to FFFFh, i.e. all transitions from 0 to 1 are detected. All NTRansition parts are set to 0, i.e. a transition from 1 to 0 in a CONDition bit is not detected. The ENABle part of the STATus:OPERation and STATus:QUEStionable registers are set to 0, i.e. all events in these registers are not passed on.

Example: `"STAT:PRES"`

Characteristics: *RST value: –
                      SCPI: conforming

STATus:QUEStionable:ACPLimit:CONDition?

This command queries the contents of the CONDition section of the STATus:QUEStionable:ACPLimit register. Readout does not delete the contents of the CONDition section.

Example: `"STAT:QUES:ACPL:COND?"`

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:ACPLimit:ENABle   0 to 65535

This command sets the bits of the ENABle section of the STATus:QUEStionable:ACPLimit register. The ENABle register selectively enables the individual events of the associated EVENt section for the summary bit.

Example: `"STAT:QUES:ACPL:ENAB 65535"`

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:ACPLimit[:EVENt]?

This command queries the contents of the EVENt section of the STATus:QUEStionable:ACPLimit register. Readout deletes the contents of the EVENt section.

Example: `"STAT:QUES:ACPL?"`

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:ACPLimit:NTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable: ACPLimit register from 1 to 0 for the transitions of the CONDition bit.

Example: `"STAT:QUES:ACPL:NTR 65535"`

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:ACPLimit:PTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable: ACPLimit register from 0 to 1 for the transitions of the CONDition bit.

Example: `"STAT:QUES:ACPL:PTR 65535"`

Characteristics: *RST value: –
                        SCPI: device-specific

STATus:QUEStionable:CONDition?

This command queries the CONDition section of the STATus:QUEStionable register. Readout does not delete the contents of the CONDition section.

Example: `"STAT:QUES:COND?"`

Characteristics: *RST value: –
                        SCPI: conforming

STATus:QUEStionable:ENABle   0 to 65535

This command sets the bits of the ENABle section of the STATus-QUEStionable register. The ENABle register selectively enables the individual events of the associated EVENt section for the summary bit in the status byte.

Example: `"STAT:QUES:ENAB 65535"`

Characteristics: *RST value: –
                        SCPI: conforming

STATus:QUEStionable[:EVENt]?

This command queries the contents of the EVENt section of the STATus:QUEStionable register. The contents of the EVENt section are deleted after the readout.

Example: `"STAT:QUES?"`

Characteristics: *RST value: –
                        SCPI: conforming

STATus:QUEStionable:LIMit<1|2>:CONDition?

This command queries the contents of the CONDition section of the STATus:QUEStionable:LIMit register.

Readout does not delete the contents of the CONDition section.

Example: `"STAT:QUES:LIM:COND?"`

Characteristics: *RST value: –
                        SCPI: device-specific

STATus:QUEStionable:LIMit<1|2>:ENABle   0 to 65535

This command sets the bits of the ENABle section of the STATus:QUEStionable register. The ENABle register selectively enables the individual events of the associated EVENt section for the summary bit.

Example: "STAT:QUES:ENAB 65535"

Characteristics: *RST value: –
SCPI: device-specific

STATus:QUEStionable:LIMit<1|2> [:EVENt]?

This command queries the contents of the EVENt section of the STATus:QUEStionable:LIMit register. Readout deletes the contents of the EVENt section.

Example: "STAT:QUES?"

Characteristics: *RST value: –
SCPI: device-specific

STATus:QUEStionable:LIMit<1|2>:NTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable:LIMit register from 1 to 0 for the transitions of the CONDition bit.

Example: "STAT:QUES:NTR 65535"

Characteristics: *RST value: –
SCPI: device-specific

Mode: all

STATus:QUEStionable:LIMit<1|2>:PTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable:LIMit register from 0 to 1 for the transitions of the CONDition bit.

Example: "STAT:QUES:PTR 65535"

Characteristics: *RST value: –
SCPI: device-specific

STATus:QUEStionable:LMARgin<1|2>:CONDition?

This command queries the contents of the CONDition section of the STATus:QUEStionable:LMARgin register. Readout does not delete the contents of the CONDition section.

Example: "STAT:QUES:LMAR:COND?"

Characteristics: *RST value: –
SCPI: device-specific

STATus:QUEStionable:LMARgin<1|2>:ENABle   0 to 65535

This command sets the bits of the ENABle section of the STATus:QUEStionable:LMARgin register. The ENABle register selectively enables the individual events of the associated EVENt section for the summary bit.

Example: `"STAT:QUES:LMAR:ENAB 65535"`

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:LMARgin<1|2> [:EVENt]?

This command queries the contents of the EVENt section of the STATus:QUEStionable:LMARgin register. Readout deletes the contents of the EVENt section.

Example: `"STAT:QUES:LMAR?"`

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:LMARgin<1|2>:NTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable:LMARgin register from 1 to 0 for the transitions of the CONDition bit.

Example: `"STAT:QUES:LMAR:NTR 65535"`

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:LMARgin<1|2>:PTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable:LMARgin register from 0 to 1 for the transitions of the CONDition bit.

Example: `"STAT:QUES:LMAR:PTR 65535"`

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:NTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:OPERation register from 1 to 0 for the transitions of the CONDition bit.

Example: `"STAT:QUES:NTR 65535"`

Characteristics: *RST value: –
                      SCPI: conforming

STATus:QUEStionable:POWer:CONDition?

This command queries the contents of the CONDition section of the STATus:QUEStionable:POWer register. Readout does not delete the contents of the CONDition section.

Example: `"STAT:QUES:COND?"`

Characteristics: *RST value: –
                      SCPI: conforming

STATus:QUEStionable:POWer:ENABle   0 to 65535

This command sets the bits of the ENABle section of the STATus:QUEStionable:POWer register. The ENABle register selectively enables the individual events of the associated EVENt section for the summary bit.

Example: `"STAT:QUES:ENAB 65535"`

Characteristics: *RST value: –
                     SCPI: conforming

STATus:QUEStionable:POWer[:EVENt]?

This command queries the contents of the EVENt section of the STATus:QUEStionable:POWer register. Readout deletes the contents of the EVENt section.

Example: `"STAT:QUES?"`

Characteristics: *RST value: –
                     SCPI: conforming

STATus:QUEStionable:POWer:NTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable:POWer register from 1 to 0 for the transitions of the CONDition bit.

Example: `"STAT:QUES:NTR 65535"`

Characteristics: *RST value: –
                     SCPI: conforming

STATus:QUEStionable:POWer:PTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable:POWer register from 0 to 1 for the transitions of the CONDition bit.

Example: `"STAT:QUES:PTR 65535"`

Characteristics: *RST value: –
                     SCPI: conforming

STATus:QUEStionable:PTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable register from 0 to 1 for the transitions of the CONDition bit.

Example: `"STAT:QUES:PTR 65535"`

Characteristics: *RST value: –
                     SCPI: conforming

STATus:QUEStionable:SYNC:CONDition?

This command queries the contents of the CONDition section of the STATus:QUEStionable:SYNC register. Readout does not delete the contents of the CONDition section.

Example: `"STAT:QUES:SYNC:COND?"`

Characteristics: *RST value: –
                     SCPI: device-specific

STATus:QUEStionable:SYNC:ENABle 0 to 65535

This command sets the bits of the ENABle section of the STATus:QUEStionable: SYNC register. The ENABle register selectively enables the individual events of the associated EVENt section for the sum bit in the status byte.

Example: "STAT:QUES:SYNC:ENAB 65535"

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:SYNC[:EVENt]?

This command queries the contents of the EVENt section of the STATus:QUEStionable:SYNC register. Readout deletes the contents of the EVENt section.

Example: "STAT:QUES:SYNC?"

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:SYNC:NTRansition 0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable: SYNC register from 1 to 0 for the transitions of the CONDition bit.

Example: "STAT:QUES:SYNC:NTR 65535"

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:SYNC:PTRansition 0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable: SYNC register from 0 to 1 for the transitions of the CONDition bit.

Example: "STAT:QUES:SYNC:PTR 65535"

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:FREQuency:CONDition?

This command queries the contents of the CONDition section of the STATus:QUEStionable:FREQuency register. Readout does not delete the contents of the CONDition section.

Example: "STAT:QUES:FREQ:COND?"

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:FREQuency:ENABle   0 to 65535

This command sets the bits of the ENABle section of the STATus:QUEStionable:FREQuency register. The ENABle register selectively enables the individual events of the associated EVENt section for the summary bit.

Example: `"STAT:QUES:FREQ:ENAB 65535"`

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:FREQuency[:EVENt]?

This command queries the contents of the EVENt section of the STATus:QUEStionable: FREQuency register.

Example: `"STAT:QUES:FREQ?"`

Characteristics: *RST value: –
                      SCPI: device-specific

Readout deletes the contents of the EVENt section.

STATus:QUEStionable:FREQuency:NTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable:FREQuency register from 1 to 0 for the transitions of the CONDition bit.

Example: `"STAT:QUES:FREQ:NTR 65535"`

Characteristics: *RST value: –
                      SCPI: device-specific

STATus:QUEStionable:FREQuency:PTRansition   0 to 65535

This command sets the edge detectors of all bits of the STATus:QUEStionable:FREQuency register from 0 to 1 for the transitions of the CONDition bit.

Example: `"STAT:QUES:FREQ:PTR 65535"`

Characteristics: *RST value: –
                      SCPI: device-specific

Mode: all

STATus:QUEue[:NEXT]?

This command returns the earliest entry to the error queue and deletes it.

Positive error numbers indicate device-specific errors, negative error numbers are error messages defined by SCPI (cf. Chapter 9). If the error queue is empty, the error number 0, "no error", is returned. This command is identical with the command `SYSTem:ERRor`.

Example: `"STAT:QUE?"`

Characteristics: *RST value: –
                      SCPI: conforming

SYSTem Subsystem

This subsystem contains a series of commands for general functions.

Command	Parameters
SYSTem:COMMunicate:GPIB[:SELF]:ADDRess	0 to 30
SYSTem:COMMunicate:GPIB[:SELF]:RTERminator	LFEOI | EOI
SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?	
SYSTem:COMMunicate:PRINter:ENUMerate:NEXT?	
SYSTem:COMMunicate:PRINter:SELect <1|2>	<printer_name>
SYSTem:COMMunicate:SERial:CONTrol:DTR	IBFull | OFF
SYSTem:COMMunicate:SERial:CONTrol:RTS	IBFull | OFF
SYSTem:COMMunicate:SERial[:RECeive]:BAUD	110 | 300 | 600 | 1200 | 2400 | 9600 | 19200
SYSTem:COMMunicate:SERial[:RECeive]:BITS	7 | 8
SYSTem:COMMunicate:SERial[:RECeive]:PARity[:TYPE]	EVEN | ODD | NONE
SYSTem:COMMunicate:SERial[:RECeive]:PACE	XON | NONE
SYSTem:COMMunicate:SERial[:RECeive]:SBITs	1 | 2
SYSTem:DATE	1980 to 2099, 1 to 12, 1 to 31
SYSTem:DISPlay:FPANel	ON | OFF
SYSTem:DISPlay:UPDate	ON | OFF
SYSTem:ERRor?	
SYSTem:ERRor:CLEar:ALL	
SYSTem:ERRor:LIST?	
SYSTem:FIRMware:UPDate	<path>
SYSTem:MSIZe?	MBOard | B100
SYSTem:PASSword[:CENable]	'password'
SYSTem:PRESet	
SYSTem:TIME	0 to 23, 0 to 59, 0 to 59
SYSTem:VERSion?	

SYSTem:COMMunicate:GPIB[:SELF]:ADDRess   0 to 30

This command changes the IEC/IEEE-bus address of the unit.

Example: `"SYST:COMM:GPIB:ADDR 18"`

Characteristics: *RST value: - (no influence on this parameter, factory default 20)
                       SCPI: conforming

SYSTem:COMMunicate:GPIB[:SELF]:RTERminator LFEOI | EOI

This command changes the GPIB receive terminator.
In accordance with to the standard the terminator in ASCII is <LF> and/or <EOI>. For binary data transfers (e.g. trace data) from the control computer to the instrument, the binary code (0AH) used for <LF> might be included in the binary data block, and therefore should not be interpreted as a terminator in this particular case. This can be avoided by changing the receive terminator to EOI. Output of binary data from the instrument to the control computer does not require such a terminator change.

Example: "SYST:COMM:GPIB:RTER EOI"

Characteristics: *RST value: -- (no influence on this parameter, factory default LFEOI)
SCPI: device-specific

SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?

This command queries the name of the first printer (in the list of printers) available under Windows NT. The names of other installed printers can be queried with command SYSTem:COMMunicate: PRINter:ENUMerate:NEXT?.
If no printer is configured an empty string is output.

Example: "SYST:COMM:PRIN:ENUM:FIRS?"

Characteristics: *RST value: NONE
SCPI: device-specific

SYSTem:COMMunicate:PRINter:ENUMerate:NEXT?

This command queries the name of the next printer installed under Windows NT.

The command SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?
should be sent previously to return to the beginning of the printer list and query the name of the first printer.
The names of other printers can then be queried with NEXT?. After all available printer names have been output, an empty string enclosed by quotation marks (") is output for the next query. Further queries are answered by a Query Error.

Example: "SYST:COMM:PRIN:ENUM:NEXT?"

Characteristics: *RST value: NONE
SCPI: device-specific

SYSTem:COMMunicate:PRINter:SELect <1|2> <printer_name>

This command selects one of the printers configured under Windows NT including the associated output destination.
The specified printer name must be a string as returned by the commands
SYSTem:COMMunicate :PRINter:ENUMerate:FIRSt? or
SYSTem:COMMunicate :PRINter:ENUMerate:NEXT?

Note: *Command* HCOPy:DESTination *is used to select an output medium other than the default one.*

Example: "SYST:COMM:PRIN:SEL 'LASER on LPT1'"

Characteristics: *RST value: NONE
SCPI: device-specific

SYSTem:COMMunicate:SERial:CONTrol:DTR IBFull | OFF
SYSTem:COMMunicate:SERial:CONTrol:RTS IBFull | OFF

These commands switch the hardware handshake procedure for the serial interface off (OFF) or on (IBFull).

The two commands are equivalent.

Examples: `"SYST:COMM:SER:CONT:DTR OFF"`
        `"SYST:COMM:SER:CONT:RTS IBF"`

Characteristics: *RST value: -- (no influence on this parameter, factory default OFF)
        SCPI: conforming

SYSTem:COMMunicate:SERial[:RECeive]:BAUD 110 | 300 | 600 | 1200 | 2400 | 9600 | 19200

This command sets the transmission speed for the serial interface (COM).

Example: `"SYST:COMM:SER:BAUD 2400"`

Characteristics: *RST value: -- (no influence on this parameter, factory default 9600)
        SCPI: conforming

SYSTem:COMMunicate:SERial[:RECeive]:BITS 7 | 8

This command defines the number of data bits per data word for the serial interface (COM).

Example: `"SYST:COMM:SER:BITS 7"`

Characteristics: *RST value: -- (no influence on this parameter, factory default 8)
        SCPI: conforming

SYSTem:COMMunicate:SERial[:RECeive]:PACE XON | NONE

This command switches on or off the software handshake for the serial interface.

Example: `"SYST:COMM:SER:PACE XON"`

Characteristics: *RST value: -- (no influence on this parameter, factory default NONE)
        SCPI: conforming

SYSTem:COMMunicate:SERial[:RECeive]:PARity[:TYPE] EVEN | ODD | NONE

This command defines the parity check for the serial interface (COM).

Possible values are: EVEN even parity
              ODD odd parity
              NONE no parity check.

Example: `"SYST:COMM:SER:PAR EVEN"`

Characteristics: *RST value: -- (no influence on this parameter, factory default NONE)
        SCPI: conforming

SYSTem:COMMunicate:SERial[:RECeive]:SBITs 1|2

This command defines the number of stop bits per data word for the serial interface (COM).

Example: `"SYST:COMM:SER:SBITs 2"`

Characteristics: *RST value: -- (no influence on this parameter, factory default 1)
        SCPI: conforming

SYSTem:DATE   1980 to 2099, 1 to 12, 1 to 31

This command is used to enter the date for the internal calendar.
The sequence of entry is year, month, day.

Example: `" SYST:DATE 2000,6,1"`

Characteristics: *RST value: –
                         SCPI: conforming

SYSTem:DISPlay:FPANel   ON | OFF

This command activates or deactivates the display of the front panel keys on the screen.
With the display activated, the instrument can be operated on the screen using the mouse by
pressing the corresponding buttons. This may be useful if the instrument is operated in a detached
station by means of a remote program such as PCANYWHERE.

Notes: *With the display of the front panel keys activated, the screen resolution of the unit is set to
1024x768. Thus, only a section of the whole screen is visible on the internal LCD display,
which will be moved by mouse moves.*

                *For a full display of the user interface, an external monitor has to be connected to the rear
panel.*

                When the front panel display is deactivated, the original screen resolution is restored.

Example: `"SYST:DISP:FPAN ON"`

Characteristics: *RST value: OFF
                         SCPI: device-specific

SYSTem:DISPlay:UPDate   ON | OFF

This command switches on or off the update of all display elements during remote control.

Note: *The best performance is obtained when the display output is switched off during remote
control.*

Example: `" SYST:DISP:UPD ON`

Characteristics: *RST value: OFF
                         SCPI: device specific

SYSTem:ERRor?

This command queries the earliest entry in the error queue, and deletes it after the readout.
Positive error numbers indicate device-specific errors, negative error numbers are error messages
defined by SCPI (cf. Chapter 9). If the error queue is empty, the error number 0, "no error", is
returned. This command is identical with the command `STATus:QUEue:NEXT?`. This command is a
query and therefore has no *RST value.

Example: `"SYST:ERR?"`

Characteristics: *RST value: –
                         SCPI: conforming

SYSTem:ERRor:CLEar:ALL

This command deletes all entries in the table SYSTEM MESSAGES.
This command is an event and therefore has no query and no *RST value.

Example: `"SYST:ERR:CLE:ALL?"`

Characteristics: *RST value: –
                         SCPI: device specific

SYSTem:ERRor:LIST?

This command reads all system messages and returns a list of comma separated strings. Each string corresponds to an entry in the table SYSTEM MESSAGES.
If the error list is empty, an empty string "" will be returned.
This command is a query and therefore has no *RST value.

Example: `"SYST:ERR:LIST?"`

Characteristics: *RST value: –
                   SCPI: device specific

SYSTem:FIRMware:UPDate <path>

This command starts a firmware update using the data set in the selected directory. Beforehand, the update files have to be stored in the following subdirectories using command `MMEM:DATA`:

Directory	Contents
DISK1	disc1.bin
DISK2	data3.cab
DISK3	data4.cab
DISK4	data5.cab
.	.
.	.
.	.
DISK11	data12.cab

Example: `"SYST:FIRM:UPD 'D:\USER\FWUPDATE'"`
                                        `'Starts the firmware update`
                                        `'from directory`
                                        `'D:\USER\FWUPDATE using the '`
                                        `'files of ubdirectories DISK1`
                                        `'to DISK11`

Characteristics: *RST value: –
                   SCPI: device specific

This command is an 'event' and therefore has no query and no *RST value.

SYSTem:MSIZe? MBOard

This command returns the memory size installed on related boards. This information is listed in table SETUP - SYSTEM INFO - STATISTICS.

Parameter: MBOard Mainboard

Example: `"SYST:MSIZ? MBO"`   'reads the memory size of the CPU-Board

Characteristics: *RST-Wert: -
                   SCPI: device-specific

SYSTem:PASSword[:CENable] 'password'

This command enables access to the service functions by means of the password.

Example: `"SYST:PASS 'XXXX'"`

Characteristics: *RST value: –
                   SCPI: conforming

This command is an event and therefore has no *RST value and no query.

SYSTem:PRESet

This command initiates an instrument reset.

The effect of this command corresponds to that of the *PRESET* key with manual control or to the *RST command.

Example: "SYST:PRES"

Characteristics: *RST value: –
                    SCPI: conforming

SYSTem:TIME   0 to 23, 0 to 59, 0 to 59

This command sets the internal clock. The sequence of entry is hour, minute, second.

Example: "SYST:TIME 12,30,30"

Characteristics: *RST value: –
                    SCPI: conforming

SYSTem:VERSion?

This command queries the number of the SCPI version, which is relevant for the instrument.

Example: "SYST:VERS?"

Characteristics: *RST value: –
                    SCPI: conforming

This command is a query and therefore has no *RST value.

TRACe Subsystem

The TRACe subsystem controls access to the instrument's internal trace memory.

General Trace Commands

Command	Parameters
TRACe<1|2>[:DATA]	TRACE1| TRACE2| TRACE3, <block> | <numeric_value>
TRACe<1|2>:COPY	TRACE1| TRACE2| TRACE3

TRACe<1|2>[:DATA] TRACE1 | TRACE2 | TRACE3, <block> | <numeric_value>

This command transfers trace data from the control computer to the instrument, the query reads trace data out of the instrument. The associated measurement window is selected with the numeric suffix of TRACe<1|2>.

Example: `"TRAC TRACE1,"+A$`   (A$: data list in the current format)
`"TRAC? TRACE1"`

Characteristics: *RST value: -
SCPI: conforming

Return values:

The returned values are scaled in the currently selected unit of the measurement window (magnitude: "UNIT:POW"; Phase: CALC:UNIT:ANGL").

ASCII format (FORMat ASCII):

In ASCII format, a list of values separated by commas is returned (Comma Separated Values = CSV).

The default number of measurement points is 625 and can be set by SENS:SWE:POIN.

Binary format (FORMat REAL,32):

If the transmission takes place using the binary format (REAL,32), the data are transferred in block format (Definite Length Block Data in accordance with IEEE 488.2). They are arranged in succeeding lists of 32 bit IEEE 754 floating-point numbers. General structure of return string:

#42500<meas value 1><meas value value2> to <meas value 625>

with

#4   digits of the subsequent number of data bytes (4 in the example)

2500   Number of subsequent data bytes (2500 in the example))

<meas value x>   4 byte floating point measurement values

Saving and recalling:

Saving and recalling trace data together with the device settings to/from the device-internal hard disk or to/from a floppy is controlled via the commands "`MMEMory:STORe:STATe`" and "`MMEMory:LOAD:STATe`" respectively. Trace data are selected with "`MMEMory:SELect[:ITEM]:ALL`" or "`MMEMory:SELect[:ITEM]:TRACe`". Trace data in ASCII format (ASCII FILE EXPORT) are exported with the command "`MMEM:STORe:TRACe`".

Transfer format:

The trace data are transferred in the current format (corresponding to the command FORMat ASCii|REAL). The device-internal trace memory is addressed using the trace names 'TRACE1' to 'TRACE3'.

The transfer of trace data from the control computer to the instrument takes place by indicating the trace name and then the data to be transferred. In ASCII format, these data are values separated by commas. If the transfer takes place using the format real (REAL,32), the data are transferred in block format.

The parameter of the query is the trace name TRACE1 to TRACE3, it indicates which trace memory will be read out.

The command "`MMEMory:STORe:STATe`" or "`MMEMory:LOAD:STATe`" controls the storage or loading of measured data, including the device settings, on or from the internal hard disk or floppy disk. The trace data is selected via "`MMEMory:SELect[:ITEM]:ALL`" or "`MMEMory:SELect[:ITEM]:TRACe`". The trace data in ASCII format (ASCII FILE EXPORT) is exported via the "`MMEM:STORe:TRACe`" command.

TRACe<1|2>:COPY   TRACE1| TRACE2| TRACE3|

This command copies data from one trace to another. The second operand describes the source, the first operand the destination of the data to be copied.The associated measurement window is selected with the numeric suffix of TRACe<1|2>.

Example: "`TRAC:COPY TRACE2,TRACE1`"   ' copies contents of trace 1 to trace 2

Characteristics: *RST value:
                      SCPI: conforming

TRACe:IQ Subsystem

The commands of this subsystem are used for collection of measured I/Q data. A special memory is therefore available in the instrument with 16M words for complex I/Q data. The measurement is always performed in the time domain .The mixing frequency into the complex baseband is configured by parameter center frequency (SENS:FREQ:CENT). The number of samples to be collected can be set. The sampling rate can be set in the range from 400 Hz to 100 MHz. Prior to being stored in memory or output via GPIB, the measured data is corrected by an equalizer filter in terms of frequency response.

Baseband Input
functional block diagram (simplified)

Fig. 6-1   Functional block diagram I/Q data capturing

The baseband signal is sampled by a 14 bit A/D converter with 81.6 MHz. The analog anti-aliasing filter is optimized for this fid sampling rate. The sampling rate is not changed at the A/D converter but by means of digital signal processing using a resampler and subsequent integer decimation.
The signal is first digitally down converted into the complex baseband, low pass filtered and then decimated. There is thus no aliasing despite a lower output sample rate.

If the output sampling rate is set too low (Nyquist condition), the bandwidth of the signal is limited; but this does not result in aliasing (folding back of high frequencies to the useful band).

The bandwidths available for the given sampling rate are specified in the following table. Reference is made to the useful bandwidth (flat response of the digital filters).

Table 6-1   Available useful bandwiths (0.05 dB)

| Sampling rate | | Equivalent lowpass filter bandwidth |
from	to	(useful bandwidth)
100.0 MHz	>81.6 MHz	0.343 sampling rate but ≤ 30 MHz for Lowpass ON *)
81.6 MHz	>40.8 MHz	0.441 sampling rate but ≤ 30 MHz for Lowpass ON *)
40.8 MHz	>20.4 MHz	0.34 sampling rate
20.4 MHz	400 Hz	0.4 sampling rate

*) SENS:IQ:LPAS ON | OFF)

The bandwidth listed in table Table 6-1 applies to I and Q, and is therefore the equivalent lowpass filter bandwidth.

The complex signal formed by I and Q is a bandpass signal having a center frequency of zero.
The bandpass filter bandwidth is twice the size of the lowpass filter bandwidth shown in the table.

The **maximum bandpass filter bandwidth** is therefore **72 MHz**.

An analog anti-aliasing filter with a cutoff frequency of 36 MHz is active by default and can be switched off (command SENS:IQ:LPAS ON | OFF).

Note:
- The filter prevents frequencies above the usable frequency range (>36 MHz) from being mid into the usable frequency range (DC to 36 MHz) as a result of sampling (sampling frequency 81.6 MHz). It should therefore always be switched on. It should bear in mind that, for example, harmonics and other spurious emissions of the device under test might be in the disallowed frequency range.

- Amplitude response and phase response (or group delay) of the filter are compensated for up to 30 MHz.

- With the filter switched off, amplitude response and phase response (or group delay) of the filter are compensated for up to 36 MHz. This setting is only recommended if the higher bandwidth is required. In this case, it is important to ensure that the spectrum of the device under test has adequately decayed >45.6 MHz since these spectral components appear in the useful band <= 36 MHz.

When data is extracted, the samples (I/Q data) are written with the selected sampling rate to a 16 Mword memory (16 Mword for both I and Q). The number of measurement values (samples) to be acquired is user-selectable.

Digital Down Converter for Low Carrier Frequency Using Baseband Inputs

The R&S FMU is capable of mixing signals from low carrier frequencies (e.g. low IF signals) into the complex baseband. The maximum allowed center frequency range is -35 MHz to +35 MHz. Both real-valued and complex-valued signals are supported.
The baseband signal is sampled, mid from desired center frequency into the complex baseband and resampled to the requested output sampling rate.

Limitation of center frequency range depending on signal bandwidth for real-valued signals:

Center frequency and sampling rate are adjustable independently, though there are some restrictions to observe:
The lower limit of the center frequency depends on the sideband suppression that is needed for a particular measurement application. To avoid overlapping of the two sidebands of a real-valued signal, the theoretical lower limit of the intermediate frequency is **half the signal bandwidth**.
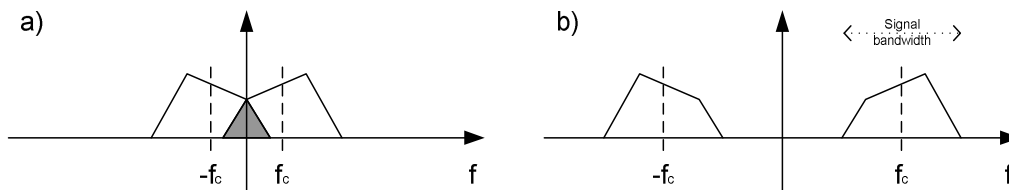
Fig. 6-2   Dependency between signal bandwidth and carrier frequency

The carrier frequency f_c in Fig. 6-2 - a) is lower than half the signal bandwidth, resulting in sideband overlap. The carrier frequency f_c in Fig. 6-2 - b) is high enough to separate the two sidebands.

In practice, the intermediate frequency must be increased for lower sideband crosstalk (limited filter edge steepness). All spectral components of the opposite sideband must be above the decimation filter stop band frequency. Thus, the center frequency must be higher than **0.5 x (stop band frequency + 0.5**

x signal bandwidth). The stop band frequency depends on the desired output sampling rate and is specified in the following table:

Table 6-2   Stop band frequency of equivalent lowpass filter

Sampling rate from	to	Stop band frequency of equivalent lowpass filter
100 MHz	>81.6 MHz	0.54 sampling rate
81.6 MHz	>40.8 MHz	0.55 sampling rate
40.8 MHz	>20.4 MHz	0.42 sampling rate
20.4 MHz	400 Hz	0.53 sampling rate

Real-valued signals shifted to complex baseband
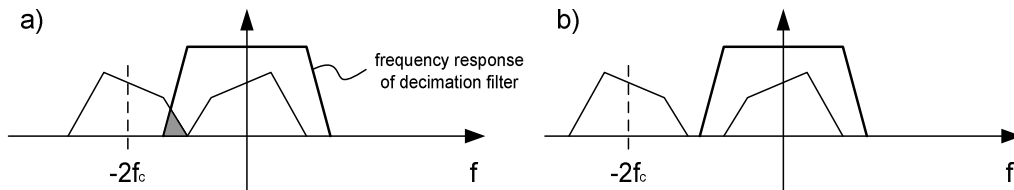
Fig. 6-3   Real-valued signals shifted to complex baseband

In the signal shown in Fig. 6-3 - a) an unwanted part of the opposite sideband remains after decimation filtering, while figure Fig. 6-3 - b) depicts a decimation filtered signal free from sideband crosstalk.

Signal bandwidth dependency on the maximum baseband input bandwidth

The upper limit of the carrier frequency is specified by the available baseband input bandwidth. The entire signal spectrum must fit into the baseband input bandwidth, so the carrier frequency may not exceed

$\pm$ 0.5 x (baseband input bandwidth – signal bandwidth)
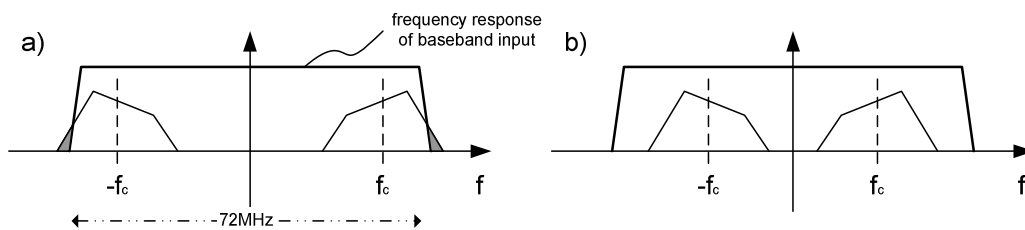
Fig. 6-4   Signal bandwidth dependency on the maximum baseband input bandwidth

In Fig. 6-4 - a) signal spectrum is cut, because it exceeds the baseband input bandwidth. Fig. 6-4 - b) shows a signal fitting entirely into the baseband input bandwidth.

Signal bandwidth limitation for real-valued input signals:
A theoretical upper bandwidth limit for an input signal on the lowest possible intermediate frequency (= 0.5 x signal bandwidth) is defined by **the half of the baseband input**.

Trigger and Measurement

With the **trigger** setting *IMMEDIATE* (corresponds to *FREE RUN*), sample acquisition begins directly following the request. The number of test points to be acquired before the trigger instant has to be set to 0.
The **trigger** setting *EXTERNAL* supports synchronization of sample acquisition with an external trigger signal. The number of test points to be acquired before the trigger instant can be set.
With the **trigger** setting *IFPOWER* (corresponds to *I/Q LEVEL*), sample acquisition begins as soon as the magnitude of the I/Q signal exceeds or falls below a selectable threshold. The number of test points to be acquired before the trigger instant can be set.

The measurement results are output in list form. You can use the FORMAT command to choose between binary output (32 bit IEEE 754 floating-point values) and output in ASCII format and to choose between block and I/Q pair mode.

The commands of this subsystem can be used in two ways:

1. Measurement and result query with one command:

    This method causes the least delay between measurement and output of the result data, but it requires the control computer to wait actively for the response data.

2. Setting up the instrument, start of the measurement via "INIT" and query of the result list at the end of the measurement:

    With this method the control computer can be used for other activities during the measurement. In this case the additional time needed for synchronization via service request must be taken into account.

Command	Parameters
TRACe<1|2>:IQ:DATA?	
TRACe<1|2>:IQ:DATA:FORMat	COMPatible | IQBLock | IQPair
TRACe<1|2>:IQ:DATA:MEMory?	!<offset sample>,<number of samples>
TRACe<1|2>:IQ:SET	< reserved1>, < reserved2>,<sampling rate>,<trigger source>,<trigger slope>,<pretrigger samples>,<# of samples>
TRACe<1|2>:IQ:SRATe	400 Hz to 100 MHz
TRACe<1|2>:IQ[:STATe]	ON | OFF

TRACe<1|2>:IQ:DATA?

This command starts a measurement with the settings defined via `TRACe:IQ:SET` and returns the list of measurement results immediately after they are corrected in terms of frequency response. The number of measurement results depends on the settings defined with `TRACe:IQ:SET`, the output format depends on the settings of the `FORMat` – subsystem.

Note: *The command requires that all response data are read out completely before the instrument accepts further commands.*

Example: `"TRAC:IQ:STAT ON"` 'Enables acquisition of I/Q data

                       `"TRAC:IQ:SET NORM,3E6,32MHz,EXT,POS,0,4096"`

                                                 'Measurement configuration:
                                                        'NORM: reserved
                                                        '3E6: reserved
                                                        'Sampling Rate:32 MHz
                                                        'Trigger Source:External
                                                        'Trigger Slope:Positive
                                                        'Pretrigger Samples:0
                                                        '# of Samples:4096

                       `"FORMat REAL,32"`   'Selects format of response data

                       `"TRAC:IQ:DATA:FORM IQP"`   'Select result as array of I/Q pairs

                       `"TRAC:IQ:DATA?"`   'Starts measurement and reads results

Return values:

The result values are scaled linear in unit *Volt* and correspond to the voltage at the baseband input of the instrument.

Note: *The format of data (all I data followed by all Q data or I/Q pairs is selectable by the TRACE:IQ:DATA:FORMAT command.*
                         With >512 k ≡ 524288 samples, the data is transmitted in logical blocks of 512k values if the default format is used. See below.

ASCII Format (FORMat ASCII):

In this case the command returns a comma separated list of the measured voltage values in floating point format (Comma Separated Values = CSV). The number of values returned is 2 * number of samples. The order of values (I1, I2,….,In,Q1,Q2,…Qn or I1,Q1,I2Q2,…In,Qn) is controlled by TRACe:IQ:DATA:FORM**at**.

Binary Format (FORMat REAL,32) with TRAC:IQ:DATA:FORM IQBLock

In this case the command returns binary data (Definite Length Block Data n accordance with IEEE 488.2), with the lists of I- and Q-data being arranged one after the other in 32 bit IEEE 754 floating point data. The scheme of the response string is as follows:

#44096<I-value1><I-value2> to <I-value512><Q-value1><Q-value2> to <Q-value512>

with

#4   digits of the subsequent number of data bytes (4 in the example)

4096   number of subsequent data bytes (*# of DataBytes*, 4096 in the example)

<I-value x>   4-Byte-Floating Point I-value; max. 512k

<Q-value y>   4-Byte-Floating Point Q-value; max. 512k

The number of I- and Q-data can be calculated as follows:

$$\# \ of \ I-Data \ = \ \# \ of \ Q-Data \ = \ \frac{\# \ of \ DataBytes}{8}$$

The offset of Q-data in the output buffer can be calculated as follows:

$$Q - Data - Offset \quad = \quad \frac{(\# \ of \ DataBytes)}{2} + LengthIndicatorDigits$$

with LengthIndicatorDigits being the number of digits of the length indicator including the '#'. In the example above (#44096 to) this results in a value of 6 for LengthIndicatorDigits and the offset for the Q-data will result in 2048 + 6 = 2054.

Binary Format (FORMat REAL,32) with TRAC:IQ:DATA:FORM IQPair

In this case the command returns binary data (Definite Length Block Data n accordance with IEEE 488.2), with the lists of I- and Q-data being arranged one after the other in 32 bit IEEE 754 floating point data. The scheme of the response string is as follows:

#44096<I-value1><Q-value1><I-value2><Q-value2> to <I-value512><Q-value512>

with

#4	digits of the subsequent number of data bytes (4 in the example)
4096	number of subsequent data bytes (*# of DataBytes*, 4096 in the example)
<I-value x>	4-byte-Floating point I-value
<Q-value x>	4-byte-Floating point Q-value

The number of I- and Q-data pairs can be calculated as follows:

$$\# \ of \ I \ / \ Q - Pairs \quad = \quad \frac{\# \ of \ DataBytes}{8}$$

Blockwise transmission with data volumes exceeding 512k words:

With > 512 k ≡ 524288 samples, the data is transmitted in logical blocks of 512k values. All transmitted blocks, except the block last transmitted, have a data length of exactly 512k words.

The following example shows the data structure for 1058816 I data samples and 1058816 Q data the samples. Since the block length is limited to 512k, 3 blocks are required for data transmission:

512k	(=524288)	Samples of I data of **Block 1**
512k	(=524288)	Samples of Q data of **Block 1**
512k	(=524288)	Samples of I data of **Block 2**
512k	(=524288)	Samples of Q data of **Block 2**
10k	(=10240)	Samples of I data of **Block 3**
10k	(=10240)	Samples of Q data of **Block 3**
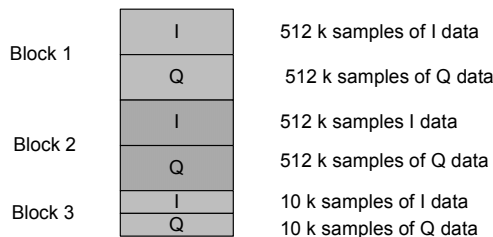
Block transfer structure for 1034k samples = 1058816 samples

Characteristics:	*RST value:	--	**Note:**
			Using the command with the *RST values for command TRAC:IQ:SET the following minimum buffer sizes for the response data are recommended:
			ASCII format:10 kBytes
			Binary format:2 kBytes
	SCPI:		device specific

TRACe<1|2>:IQ:DATA:FORMat   COMPatible | IQBLock | IQPair

This command sets the data output formatting (using the TRAC:IQ:DATA? command):

COMPatible	512k I data and 512k Q data is alternately transferred
IQBLock	First, all I and then all Q data is transferred
	Returned values: $I_1, I_2, \ldots I_n, Q_1, Q_2, Q_n$
IQPair	I/Q data is transferred in pairs
	Returned values: $I_1, Q_1, I_2, Q_2, \ldots I_n, Q_n$

Example: "TRAC:IQ:DATA:FORM IQP"

Characteristics: *RST value: COMPatible
                           SCPI: device-specific

TRACe<1|2>:IQ:DATA:MEMory? <offset samples>,<# of samples>

This command permits the readout of previously acquired (and frequency response corrected) I/Q data from the memory, with indication of the offset related to the start of measurement and with indication of the number of measurement values. Therefore a previously acquired data set can be read out in smaller portions. The maximum amount of available data depends on the settings of command TRACe:IQ:SET, the output format on the settings in the FORMat – subsystem.

<offset samples>	Offset of the values to be output, referenced to the start of the sampled data. Value range: 0 ... <# of samples> - 1, where <# of samples> is the value specified with the TRACe:IQ:SET command
<# of samples>	Value range: 1 ... <# of samples> - <offset samples> where <# of samples> is the value specified with the TRACe:IQ:SET command.

Examples: "TRAC:IQ:STAT ON"   'activates the I/Q data sampling
                         "TRAC:IQ:SET NORM,3E6,32MHz,EXT,POS,100,4096"
                                                 'configures the measurement:
      'NORM: reserved
      3E6: reserved
      'Sampling Rate:32 MHz
      'Trigger Source:External
      'Trigger Slope:Positive
      'Pretrigger Samples:100
      '# of Samples:4096

                         "INIT;*WAI"   ' starts the measurement and waits for
      ' its end

                         "FORMat REAL,32"   ' specifies the format of the response
      ' data

                         "Reading the results:

                         "TRAC:IQ:DATA:MEM? 0,2048"   'reads in 2048 I/Q values starting with
      ' the beginning of the sampling

                         "TRAC:IQ:DATA:MEM? 2048,1024"   'reads in 2048 I/Q values starting with
      ' the beginning of the sampling

                         "TRAC:IQ:DATA:MEM? 100,512"   'reads in 512 I/Q values starting with
      'the trigger time (<Pretrigger Samples>
      ' was 100))

Return values: Irrespective of the output format selected, the data is scaled linearly with 'V' as the unit and corresponds to the voltage at the baseband input of the device. The return buffer is similarly configured to the return buffer with the TRACe:IQ:DATA? command where all I data has the value 0.

Characteristics: *RST value: --
                           SCPI: device-specific

TRACe<1|2>:IQ:SET   <reserved1>,<reserved2>,<sampling rate>,<trigger source>,<trigger slope>, <pretrigger samples>,<# of samples>

This command defines the settings of the analyzer hardware for the measurement of I/Q data.
This allows setting the bandwidth of the analog filters in front of the A/D converter as well as setting the sampling rate, trigger conditions and the record length.

Note: If this command is omitted, the current analyzer settings will be used for the corresponding parameters.

<reserved1>:	NORM	reserved, the value NORM has to be used for reasons of compatibillity reasons to other instruments..
<reserved2>:	3E6	reserved for compatibility to other instruments.
<sampling rate>:	Sampling rate for the data acquisition.	
Value range:	Value range:	400 Hz to 100 MHz
<trigger mode>:	Selection of the trigger source used for the measurement.	
	Values:	IMMediate	EXTernal	IFPower
	After selecting IFPower, the trigger threshold can be set with command TRIG:LEV:IFP.	
<trigger slope>:	Used trigger slope.	
	Values:	POSitive (currently the only value supported)
<pretrigger samples>:	Number of measurement values to be recorded before the trigger point.	
	Range:	-16744447

$$(= -(2^{24}-1-512k)) \text{ to } 65023 (= 64*1024 - 512 - 1)$$

Note: Negative values correspond to a trigger delay.For <trigger mode> = IMMediate the value must be 0.

<# of samples>:	Number of measurement values to record.	
	Value range:	1 to 16776704 (=16*1024*1024 - 512)

Examples: `"TRAC:IQ:SET NORM,3E6,32MHz,EXT,POS,0,2048"`
                            'Reads 2048 I/Q-values starting at the 'trigger point.
'   NORM (reserved)
'   3E6 (reserved)
                            'Sampling Rate:32 MHz
                            'Trigger:External
                            'Slope:Positive

              `"TRAC:IQ:SET NORM,3E6,4MHz,EXT,POS,1024,512"`
                            'Reads 512 I/Q-values from 1024 'measurement points before the 'trigger point.
                            'NORM (reserved)
                            '3E6 (reserved)
                            'Sampling Rate:4 MHz
                            'Trigger:External
                            'Slope:Positive

Characteristics: *RST values: `NORM,3E6,32MHz,IMM,POS,0,128`

Note: For using these default settings with command TRAC:IQ:DATA? the following minimum buffer sizes for the response data are recommended:
ASCII format:10 kBytes
Binary format:2 kBytes

              SCPI: device specific

TRACe<1|2>:IQ:SRATe   400 Hz to 100 MHz

This command sets the sampling rate for the I/Q data acquisition. Thus the sampling rate can be modified without affecting the other settings.

Example: `TRAC:IQ:SRAT 4MHZ`

Characteristics: *RST value: 32 MHz
                      SCPI: device specific

TRACe<1|2>:IQ[:STATe]   ON | OFF

This command switches the I/Q data acquisition on or off.

Note: *The I/Q data acquisition is not compatible with other measurement functions. Therefore all other measurement functions will be switched off as soon as the I/Q measurement function is switched on. Additionally a trace display is not possible in this operating mode. Therefore all traces are set to "BLANK". Finally split screen operation will automatically be stopped.*

Example: `TRAC:IQ ON`   'Switches on I/Q data acquisition

Characteristics: *RST value: OFF
                      SCPI: device specific

TRIGger Subsystem

The TRIGger subsystem is used to synchronize instrument actions with events. It is thus possible to control and synchronize the start of a sweep. An external trigger signal can be applied to the connector at the rear panel of the instrument. A distinction is made between TRIGger1 (screen A) and TRIGger2 (screen B).

Command	Parameters
TRIGger<1|2>[:SEQuence]:HOLDoff	-100 ms to 50 s
TRIGger<1|2>[:SEQuence]:LEVel[:EXTernal]	0.5 to +3.5V
TRIGger<1|2>[:SEQuence]:LEVel:IFPower	0.001V to 7.948 V
TRIGger<1|2>[:SEQuence]:LEVel:IONLy	1.41 to +1.41 V
TRIGger<1|2>[:SEQuence]:LEVel:QONLy	1.41 to +1.41 V
TRIGger<1|2>[:SEQuence]:SLOPe	POSitive | NEGative
TRIGger<1|2>[:SEQuence]:SOURce	MMediate | EXTernal | IFPower | IONLy | QONLy

TRIGger<1|2>[:SEQuence]:HOLDoff   -100ms to 50s

This command defines the length of the trigger delay.

Triggering is delayed (entry > 0) or advanced (entry < 0) by the entered time relative to the trigger signal. The time can be entered in the value range –100 ms to 50 s (default: 0 s).

Example: "TRIG:HOLD 500us"

Characteristics: *RST value: 0s
SCPI: conforming

TRIGger<1|2>[:SEQuence]:LEVel[:EXTernal]   0.5 to +3.5V

This command sets the level of the external trigger source.

Example: "TRIG:LEV 2V"

Characteristics: *RST-Wert: 1.4 V
SCPI: gdevice-specific

TRIGger<1|2>[:SEQuence]:LEVel:IFPower   1 mV...7.948 V

This command sets the level of the I/Q level trigger source. The upper limit is dependent on current reference level and selected input impedance.

Example: "TRIG:LEV:IFP 0.1V"

Characteristics: *RST value: 0.5 V
SCPI: device-specific

TRIGger<1|2>[:SEQuence]:LEVel:IONLy   -7.9242 to +7.9242V

This command sets the level of the I level trigger source.

Example: "TRIG:LEV:IONL 0.1V"

Characteristics: *RST-Wert: 0 V
SCPI: gdevice-specific

TRIGger<1|2>[:SEQuence]:LEVel:QONLy -7.9242 to +7.9242V

This command sets the level of the Q level trigger source.

Example: "TRIG:LEV:IONL 0.1V"

Characteristics: *RST-Wert: 0 V
                      SCPI: gdevice-specific

TRIGger<1|2>[:SEQuence]:SLOPe POSitive | NEGative

This command selects the slope of the trigger signal. The selected trigger slope applies to all trigger signal sources .

Example: "TRIG:SLOP NEG"

Characteristics: *RST value: POSitive
                      SCPI: conforming

TRIGger<1|2>[:SEQuence]:SOURce IMMediate | EXTernal | IFPower | IONLy | QONLy

This command selects the trigger source for the start of a sweep.

Parameter: IMMediate = automatic triggering the next measurement at the end of the previous one. The value IMMediate corresponds to the FREE RUN setting.

                      EXTernal = the next measurement is triggered by the signal at the external trigger input.

                      IFPower   = the next measurement is triggered by the magnitude of the I/Q signal. Sample acquisition starts when the value exceeds (positive polarity) or drops below (negative polarity) the selected threshold.

                      IONLy   = the next measurement is triggerd by the magnitude of the I signal

                      QONLy   = the next measurement is triggerd by the magnitude of the Q signal

Example: "TRIG:SOUR EXT"   'Selects the external trigger input as source of the trigger 'signal

Characteristics: *RST value: IMMediate
                      SCPI: conforming

UNIT Subsystem

The UNIT subsystem is used to switch the basic unit of setting parameters. A distinction is made between UNIT1 (screen A) and UNIT2 (screen B).

Command	Parameters
UNIT<1|2>:POWer	DBM | DBPW | WATT | DBUV | DBMV | VOLT | DBUA | AMP | V | A | W

UNIT<1|2>:POWer DBM | DBPW | WATT | DBUV | DBMV | VOLT | DBUA | AMPere | V | A | W

This command selects the default unit for the selected measurement window.

Example: `"UNIT:POW DBUV"`   'Sets the power unit for screen A to dBm.

Characteristics: *RST value: DBM
                   SCPI: conforming

Table of Softkeys with IEC/IEEE-Bus Command Assignment

Hotkeys

FFT	`INSTrument[:SELect] FANalyzer` `INSTrument:NSELect 22`
EXIT FFT	`INSTrument[:SELect] <other>` `INSTrument:NSELect <other>`
PRESET FFT	`[SENSe:]FFT:PRESet`
FFT HOME	

SCREEN A/B	FULL SCREEN:	Selection of the active window: `DISPlay[:WINDow<1|2>]:SELect` The window valid for the setting is selected by the numeric. suffix in the command, eg `SENSe<1|2>`
	SPLIT SCREEN:	The two measurement windows are active. The window valid for the setting is selected by the numeric suffix in the command, eg `SENSe<1|2>`

Hotkey FFT HOME

FFT HOME

FREQUENCY DOMAIN	`[SENSe:]FREQuency:SPAN >0`
MAGNITUDE	`CALCulate:FORMat MAGNitude`
MAGNITUDE PHASE	`CALCulate:FORMat MPHase`
REAL IMAG	`CALCulate:FORMat RIMag`
WINDOW FUNCTION	
FLATTOP	`[SENSe:]WINDow[:TYPE] FLATtop`
GAUSSIAN	`[SENSe:]WINDow[:TYPE] EXPonential`
RECT ANGULAR	`[SENSe:]WINDow[:TYPE] RECTangular`
HAMMING	`[SENSe:]WINDow[:TYPE] HAMMing`
HANN	`[SENSe:]WINDow[:TYPE] HANNing`
CHEBYSHEV	`[SENSe:]WINDow[:TYPE] CHEBychev`
TIME DOMAIN	`[SENSe:]FREQuency:SPAN 0`
MAGNITUDE	`CALCulate:FORMat MAGNitude`
VOLTAGE	`CALCulate:FORMat VOLTage`
CAPTURE BOTH DOM	`[SENSe:]FFT:CAPTure ON|OFF`
SIGNAL SOURCE	
IQ PATH(I+J*Q)	
I+J*Q	`INPut:IQ:TYPE IQ`
I ONLY	`INPut:IQ:TYPE I`
Q ONLY	`INPut:IQ:TYPE Q`
I/Q INPUT 50Ω 1MΩ	`INPut:IQ:IMPedance LOW|HIGH`
BALANCED ON OFF	`INPut:IQ:BALanced[:STATe] ON|OFF`
LOW PASS 36 MHz	`[SENSe:]IQ:LPASs[:STATe] ON|OFF`
DITHER ON OFF	`[SENSe:]IQ:DITHer[:STATe] ON|OFF`

FREQ Key

| FREQ |

| CENTER | `[SENSe:]FREQuency:CENTer <num_value>`

| CF-
SREPSIZE |

     | 0.1 * SPAN | `[SENSe:]FREQuency:CENTer:STEP:LINK SPAN;`
`[SENSe:]FREQuency:CENTer:STEP:LINK:FACTor 10PCT`

     | 0.5 * SPAN | `[SENSe:]FREQuency:CENTer:STEP:LINK SPAN;`
`[SENSe:]FREQuency:CENTer:STEP:LINK:FACTor 50PCT`

     | X * SPAN | `[SENSe:]FREQuency:CENTer:STEP:LINK SPAN;`
`[SENSe:]FREQuency:CENTer:STEP:LINK:FACTor <num_value>`

     | 0.1 * RBW | `[SENSe:]FREQuency:CENTer:STEP:LINK RBW;`
`[SENSe:]FREQuency:CENTer:STEP:LINK:FACTor 10PCT`

     | 0.5 * RBW | `[SENSe:]FREQuency:CENTer:STEP:LINK RBW;`
`[SENSe:]FREQuency:CENTer:STEP:LINK:FACTor 50PCT`

     | X * RBW | `[SENSe:]FREQuency:CENTer:STEP:LINK RBW;`
`[SENSe:]FREQuency:CENTer:STEP:LINK:FACTor <num_value>`

     | MANUAL | `[SENSe:]FREQuency:CENTer:STEP <num_value>`

| START | `[SENSe:]FREQuency:STARt <num_value>`

| STOP | `[SENSe:]FREQuency:STOP <num_value>`

| FREQUENCY
OFFSET | `[SENSe:]FREQuency:OFFSet <num_value>`

SPAN Key

```
SPAN
```

```
SPAN
MANUAL
```
        `[SENSe:]FREQuency:SPAN <num_value>`

```
FULL
SPAN
```
        `[SENSe:]FREQuency:SPAN:FULL`

```
ZERO
SPAN
```
        `[SENSe:]FREQuency:SPAN 0HZ`
or
        `[SENSe:]FREQuency:MODE CW | FIXed`

```
LAST
SPAN
```
        no corresponding IEC/IEEE-bus command

AMPT Key

AMPT

REF LEVEL	`DISPlay[:WINDow<1	2>]:TRACe<1...3>:Y[:SCALe]:RLEVel`
	`                                <num_value`
RANGE LOG 100 dB	`DISPlay[:WINDow<1	2>]:TRACe<1...3>:Y:SPACing LOGarithmic;`
	`DISPlay[:WINDow<1	2>]:TRACe<1...3>:Y[:SCALe] 100 dB`

| RANGE LOG MANUAL | `DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y:SPACing  LOGarithmic;` |
| | `DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y[:SCALe]  <num_value>` |

| RANGE LINEAR | `DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y:SPACing  LINear` |

| RANGE LINEAR % | `DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y:SPACing  LINear %` |

| RANGE LINEAR dB | `DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y:SPACing  LINear dB` |

Y-AXIS /DIV	`DISPlay[:WINDow<1	2>]:TRACE<1 to 3>:Y[:SCALe]:PDIVision`
	`                                <num_value`
Y-AXIS REF VALUE	`DISPlay[:WINDow<1	2>]:TRACE<1 to 3>:Y[:SCALe]:RVALue<num_v`

| Y-AXIS REF POS | `DISPlay[:WINDow<1|2>]:TRACe<1 to 3>:Y[:SCALe]:RPOSition<nu` |

| UNIT |

| dBm | `CALCulate<1|2>:UNIT:POWer  DBM` |

| dBmV | `CALCulate<1|2>:UNIT:POWer DBMV` |

| dBµV | `CALCulate<1|2>:UNIT:POWer DBUV` |

| dBµA | `CALCulate<1|2>:UNIT:POWer DBUA` |

| dBpW | `CALCulate<1|2>:UNIT:POWer DBPW` |

| VOLT | `CALCulate<1|2>:UNIT:POWer VOLT` |

| AMPERE | `CALCulate<1|2>:UNIT:POWer AMPere` |

| WATT | `CALCulate<1|2>:UNIT:POWer  WATT` |

REF LEVEL POSITION	`DISPlay[:WINDow<1	2>]:TRACe<1...3>:Y[:SCALe]:RPOSition`
	`                                <num_value>`
REF LEVEL OFFSET	`DISPlay[:WINDow<1	2>]:TRACe<1...3>:Y[:SCALe]:RLEVel:OFFSet`
	`                                <num_value>`
PHASE SETTINGS

| AUTOSCALE | `DISP:WIND:TRAC:Y:SCALe:AUTO ONCE` |

| Y-AXIS /DIV | `DISP:WIND:Y:PDIV <numeric_value>` |

| Y-AXIS REF VALUE | `DISP:WIND:Y:RVAL <numeric_value>` |

Y-AXIS REF POS	`DISP:WIND:Y:RPOS <numeric_value>`
PHASE OFFSET	`SENSe:CORR:OFFS:PHASe <numeric_value>`
PHASE RAD DEG	`CALC:UNIT:ANGL RAD|DEG`
PHASEWRAP ON OFF	`CALC:FORM PHASe|UPHase`

MKR Key

MKR

MARKER 1..4	`CALCulate<1	2>:MARKer<1...4>[:STATe] ON	OFF;` `CALCulate<1	2>:MARKer<1...4>:X <numeric value>;` `CALCulate<1	2>:MARKer<1...4>:Y?` `CALCulate<1	2>:DELTamarker1[:STATe] ON	OFF;` `CALCulate<1	2>:DELTamarker<1...4>:X <numeric value>;` `CALCulate<1	2>:DELTamarker<1...4>:Y?`
MARKER NORM DELTA	`CALCulate<1	2>:DELTamarker<1...4>[:STATe] ON	OFF;`
REFERENCE FIXED	

REF FXD ON OFF	`CALCulate<1	2>:DELTamarker<1...4>:FUNCtion:FIXed[:STATe]` ` ON	OF`
REF POINT LEVEL	`CALCulate<1	2>:DELTamarker<1..4>:FUNCtion:FIXed:RPOint:Y` `<num_value>`
REF POINT LVL OFFSET	`CALCulate<1	2>:DELTamarker<1..4>:FUNCtion:FIXed:RPOint:Y:` `OFFSet <num_value`
REF POINT FREQUENCY	`CALCulate<1	2>:DELTamarker<1..4>:FUNCtion:FIXed:RPOint:X` ` <num_value`

or:

REF POINT TIME	`CALCulate<1	2>:DELTamarker<1..4>:FUNCtion:FIXed:RPOint:X` ` <num_value`
PEAK SEARCH	`CALCulate<1	2>:DELTamarker<1..4>:FUNCtion:FIXed:RPOint: MAX`
ALL MARKER OFF	`CALCulate<1|2>:MARKer<1...4>:AOFF` `CALCulate<1|2>:DELTamarker<1...4>:AOFF`
MKR-> TRACE	`CALCulate<1|2>:MARKer<1...4>:TRACe <num_value>` `CALCulate<1|2>:DELTamarker<1...4>:TRACe <num_value>`
LINK MKR1 AND DELTA	`CALCulate<1|2>:DELTamarker<1...4>:LINK ON	OFF`
MKR FILE EXPORT	`MMEMory:STORe<1	2>:MARKer <file_name>`
DECIM . ,	`FORMat:DEXPort:DSEParator POINt	COMMa`

MKR-> Key

MKR->	
SELECT MARKER	no corresponding IEC/IEEE-bus command
PEAK	`CALCulate<1|2>:MARKer<1...4>:MAXimum[:PEAK]`
	`CALCulate<1|2>:DELTamarker<1...4>:MAXimum[:PEAK]`
CENTER = MKR FREQ	`CALCulate<1|2>:MARKer<1...4>:FUNCtion:CENTer`
REF LEVEL = MKR LVL	`CALCulate<1|2>:MARKer<1...4>:FUNCtion:REFerence`
NEXT PEAK	`CALCulate<1|2>:MARKer<1...4>:MAXimum:NEXT`
	`CALCulate<1|2>:DELTamarker<1...4>:MAXimum:NEXT`
NEXT PEAK RIGHT	`CALCulate<1|2>:MARKer<1...4>:MAXimum:RIGHt`
	`CALCulate<1|2>:DELTamarker<1...4>:MAXimum:LEFT`
NEXT PEAK LEFT	`CALCulate<1|2>:MARKer<1...4>:MAXimum:NEXT`
	`CALCulate<1|2>:DELTamarker<1...4>:MAXimum:NEXT`
SEARCH LIMITS	
LEFT LIMIT	`CALCulate<1|2>:MARKer<1...4>:X:SLIMits[:STATe] ON	OFF`
	`CALCulate<1|2>:MARKer<1...4>:X:SLIMits:LEFT <num_value>`
RIGHT LIMIT	`CALCulate<1|2>:MARKer<1...4>:X:SLIMits[:STATe] ON	OFF`
	`CALCulate<1|2>:MARKer<1...4>:X:SLIMits:RIGHt <num_value>`
THRESHOLD	`CALCulate<1|2>:THReshold[:STATe] ON	OFF`
	`CALCulate<1|2>:THReshold <num_value>`
SEARCH LIM OFF	`CALCulate<1|2>:MARKer<1...4>:X:SLIMits[:STATe] OFF`
	`CALCulate<1|2>:THReshold[:STATe] ON	OFF`
MKR->TRACE	`CALCulate<1|2>:MARKer<1...4>:TRACe <numeric value>`
	`CALCulate<1|2>:DELTamarker<1...4>:TRACe <numeric value>`
MIN	`CALCulate<1|2>:MARKer<1...4>:MINimum[:PEAK]`
	`CALCulate<1|2>:DELTamarker<1...4>:MINimum[:PEAK]`
NEXT MIN	`CALCulate<1|2>:MARKer<1...4>:MINimum:NEXT`
	`CALCulate<1|2>:DELTamarker<1...4>:MINimum:NEXT`
NEXT MIN RIGHT	`CALCulate<1|2>:MARKer<1...4>:MINimum::RIGHt`
	`CALCulate<1|2>:DELTamarker<1...4>:MINimum::LEFT`
NEXT MIN LEFT	`CALCulate<1|2>:MARKer<1...4>:MINimum::NEXT`
	`CALCulate<1|2>:DELTamarker<1...4>:MINimum::NEXT`
EXCLUDE DC	`CALCulate<1|2>:MARKer<1...4>:LOEXclude ON	OFF`
PEAK EXCURSION	`CALCulate<1|2>:MARKer<1...4>:PEXCursion <num_value>`
AUTO MAX PEAK	`CALCulate<1|2>:MARKer<1 to 4>:MAXimum[:PEAK]`
AUTO MIN PEAK	`CALCulate<1|2>:MARKer<1 to 4>:MINimum[:PEAK]`

MKR FCTN Key

MKR FCTN

| SELECT MARKER | no corresponding IEC/IEEE-bus command |

| PEAK | CALCulate<1|2>:MARKer<1...4>:MAXimum[:PEAK]
CALCulate<1|2>:DELTamarker<1...4>:MAXimum[:PEAK] |

| NOISE MEAS | CALCulate<1|2>:MARKer<1...4>:FUNCtion:NOISe[:STATe]
ON | OFF
CALCulate<1|2>:MARKer<1...4>:FUNCtion:NOISe:RESult? |

| PHASE NOISE | |

| PH NOISE ON OFF | CALCulate<1|2>:DELTamarker<1...4>:FUNCtion:PNOise[:STATe]
ON | OF
CALCulate<1|2>:DELTamarker<1...4>:FUNCtion:PNOise:RESult? |

| REF POINT LEVEL | CALCulate<1|2>:DELTamarker<1..4>:FUNCtion:FIXed:RPOint:Y < |

| REF POINT LVL OFFSET | CALCulate<1|2>:DELTamarker<1..4>:FUNCtion:FIXed:RPOint:Y:O |

| REF POINT FREQUENCY | CALCulate<1|2>:DELTamarker<1..4>:FUNCtion:FIXed:RPOint:X
<num_value |

| PEAK SEARCH | CALCulate<1|2>:DELTamarker<1..4>:FUNCtion:FIXed:RPOint: MAX |

| AUTO PEAK SEARCH | CALCulate<1|2>:DELTamarker<1 to 4>:FUNCtion:PNOise:AUTO
ON | OF |

| N dB DOWN | CALCulate<1|2>:MARKer<1...4>:FUNCtion:NDBDown[:STATe]
ON | OF
CALCulate<1|2>:MARKer<1...4>:FUNCtion:NDBDown <num_value>
CALCulate<1|2>:MARKer<1...4>:FUNCtion:NDBDown:RESult?
CALCulate<1|2>:MARKer<1...4>:FUNCtion:NDBDown:FREQuency |

| PEAK LIST | |

| NEW SEARCH | INIT;*WAI;
CALCulate<1|2>:MARKer<1...4>:FUNCtion:FPEaks 10;
CALCulate<1|2>:MARKer<1...4>:FUNCtion:FPEaks:COUNt?;
CALCulate<1|2>:MARKer<1...4>:FUNCtion:FPEaks:Y?;
CALCulate<1|2>:MARKer<1...4>:FUNCtion:FPEaks:X?; |

| SORT MODE FREQ LEVEL | CALCulate<1|2>:MARKer<1...4>:FUNCtion:FPEaks:SORT X | Y |

| PEAK EXCURSION | CALCulate<1|2>:MARKer<1...4>:PEXCursion <num_value> |

| LEFT LIMIT | CALCulate<1|2>:MARKer<1...4>:X:SLIMits[:STATe] ON | OFF
CALCulate<1|2>:MARKer<1...4>:X:SLIMits:LEFT <num_value> |

RIGHT LIMIT	`CALCulate<1|2>:MARKer<1...4>:X:SLIMits[:STATe] ON | OFF` `CALCulate<1|2>:MARKer<1...4>:X:SLIMits:RIGHt <num_value>`
THRESHOLD	`CALCulate<1|2>:THReshold[:STATe] ON | OFF` `CALCulate<1|2>:THReshold <num_value>`
PEAK LIST OFF	no corresponding IEC/IEEE-bus command
MKR-> TRACE	`CALCulate<1|2>:MARKer<1...4>:TRACe <numeric value>` `CALCulate<1|2>:DELTamarker<1...4>:TRACe <numeric value>`

BW Key

```
┌─────────┐
│   BW    │
└─────────┘
```

RES BW MANUAL	`[SENSe:]BANDwidth|BWIDth:AUTO OFF`
	`[SENSe:]BANDwidth|BWIDth[:RESolution] <num_value>`
SWEEP TIME MANUAL	`[SENSe<1|2>:]SWEep:TIME <num_value>`
RES BW AUTO	`[SENSe:]BANDwidth|BWIDth[:RESolution]:AUTO ON`
SWEEP TIME AUTO	`[SENSe:]SWEep:TIME:AUTO ON`
COUPLING RATIO	
SPAN / RBW AUTO [50]	`[SENSe:]BANDwidth|BWIDth[:RESolution]:RATio 0.02`
SPAN / RBW MANUAL	`[SENSe:]BANDwidth|BWIDth[:RESolution]:RATio <num_value>`
DEFAULT COUPLING	`[SENSe:]BANDwidth|BWIDth[:RESolution]:AUTO ON;`
RES BW 1/2/3/5	`[SENSe:]BBANDwidth|BWIDth[:RESolution]STEP:MODE`
	`LINear|L1235`

SWEEP Key

SWEEP

CONTINUOUS SWEEP	`INITiate:CONTinuous ON`
SINGLE SWEEP	`INITiate:CONTinuous OFF;` `INITiate:IMMediate`
CONTINUE SGL SWEEP	`INITiate:CONMeasure`
SWEEP TIME MANUAL	`[SENSe:]SWEep:TIME <num_value>`
SWEEP TIME AUTO	no corresponding IEC/IEEE-bus command
SWEEP COUNT	`[SENSe:]SWEep:COUNt <num_value>`
SWEEP POINTS	`[SENSe:]SWEep:POINts <num_value>`
RECALC	`[SENSe:]FFT:CAPTure:CALCulate`
SGL SWEEP DISP OFF	`INITiate:DISPlay OFF` `INITiate:IMMediate`
RECALC AUTO OFF	`[SENSe:]FFT:CAPTure:AUTO ON|OFF`

MEAS Key

MEAS

TIME DOM
POWER

```
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:RMS[:STATe] ON
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:PPEak[:STATe]
                                                        ON
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:MEAN[:STATe]
ON
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:SDEViation
                                                [:STATe] ON
```

POWER
ON   OFF

```
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:RMS[:STATe]
                                                    ON|OFF
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:PPEak[:STATe]
                                                    ON|OFF
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:MEAN[:STATe]
                                                    ON|OFF
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:SDEViation
                                            [:STATe] ON|OFF
```

PEAK

RMS

```
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:PPEak[:STATe]
                                                    ON | OFF
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:PPEak:RESult?
CALCulate<1|2>:MARKer<1..4>:FUNCtion:SUMMary:RMS[:STATe]
                                                    ON | OFF
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:RMS:RESult?
```

MEAN

STANDARD
DEVIATION

```
CALCulate<1|2>:MARKer<1..4>:FUNCtion:SUMMary:MEAN[:STATe]
                                                    ON | OFF
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:MEAN:RESult?
CALCulate<1|2>:MARKer<1..4>:FUNCtion:SUMMary:SDEViation
                                            [:STATe] ON|OFF
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:SDEViation:
                                                    RESult?
```

LIMITS
ON   OFF

```
CALCulate<1|2>:MARKer<1...4>:SLIMits ON | OFF
```

START
LIMIT

```
CALCulate<1|2>:MARKer<1...4>:SLIMits:LEFT <num_value>
```

STOP
LIMIT

```
CALCulate<1|2>:MARKer<1...4>:SLIMits:RIGHt <num_value>
```

SET
REFERENCE

```
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:REFerence:
                                                AUTO ONCE
```

POWER
ABS   REL

```
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:MODE
                                                ABS | REL
```

MAX HOLD
ON   OFF

```
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:PHOLd
                                                ON | OFF
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:PPEak:PHOLd:
                                                RESult?
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:RMS:PHOLd:
                                                RESult?
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMar:MEAN:PHOLd:
                                                RESult?
CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:SDEViation:
                                                PHOLd:RESult?
```

AVERAGE ON OFF	`CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:AVERage` `ON	OFF` `CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:PPEak:AVERage:`          `RESult?` `CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:RMS:AVERage:RESult?` `CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMar:MEAN:AVERage:RESult?` `CALCulate<1|2>:MARKer<1...4>:FUNCtion:SUMMary:SDEViation:AVERage:RES?`
NUMBER OF SWEEPS	`[SENSe:]SWEep:COUNt <num_value>`
CHAN PWR ACP	
CP / ACP ON OFF	`CALCulate<1|2>:MARKer<1...4>:FUNCtion:POWer:SELect` `CPOWer	ACPower;` `CALCulate<1|2>:MARKer<1...4>:FUNCtion:POWer:RESult? CPOWer |` `ACPower;` `CALCulate<1|2>:MARKer<1...4>:FUNCtion:POWer[:STATe] OFF`
CP / ACP STANDARD	`CALCulate<1|2>:MARKer<1...4>:FUNCtion:POWer:PRESet <standard>`
CP / ACP CONFIG	
NO. OF ADJ CHAN	`[SENSe:]POWer:ACHannel:ACPairs <num_value>`
NO. OF TX CHAN	`[SENSe<1|2>:]POWer:ACHannel:TXCHannel:COUNt<num_value>`

CHANNEL
BANDWIDTH
	`[SENSe:]POWer:ACHannel:BANDwidth|BWIDth[:CHANnel] <num_value>`
	`[SENSe:]POWer:ACHannel:BANDwidth|BWIDth:ACHannel`
	         `<num_value>`
	`[SENSe:]POWer:ACHannel:BANDwidth|BWIDth:ALTernate`
	         `<1...11> <num_value>`

CHANNEL SPACING	`[SENSe:]POWer:ACHannel:SPACing:ACHannel <num_value>` `[SENSe:]POWer:ACHannel:SPACing:ALTernate<1...11> <num_value>`
ACP REF SETTINGS	`[SENSe:]POWer:ACHannel:REFerence:TXCHannel:MAN 1` `[SENSe:]POWer:ACHannel:REFerence:TXCHannel:Auto MIN`
CP/ACP ABS/REL	`[SENSe:]POWer:ACHannel:MODE ABSolute|RELative`
CHAN PWR /HZ	`CALCulate<1|2>:MARKer<1...4>:FUNCtion:POWer:RESult:PHZ` `ON	OFF`
POWER MODE	
CLEAR/ WRITE	`CALCulate<1|2>:MARKer:FUNCtion:POWer:MODE WRITe|MAXHold`
MAX HOLD	
ADJUST SETTINGS	`[SENSe:]POWer:ACHannel:PRESet` `ACPower|CPOWer|OBANdwidth|OBWidth`
ACP LIMIT CHECK	`CALCulate<1|2>:LIMit<1...8>:ACPower[:STATe] ON	OFF` `CALCulate<1|2>:LIMit<1...8>:ACPower:ACHannel:RESult?` `CALCulate<1|2>:LIMit<1...8>:ACPower:ALTernate<1|2>:RESult?`

EDIT ACP LIMITS	`CALCulate<1|2>:LIMit<1...8>:ACPower[:STATe] ON	OFF` `CALCulate<1|2>:LIMit<1...8>:ACPower:ACHannel[:RELative]:` ` STATe ON	OFF` `CALCulate<1|2>:LIMit<1...8>:ACPower:ACHannel[:RELative]` ` <num_val>,<num_val>` `CALCulate<1|2>:LIMit<1...8>:ACPower:ACHannel:ABSolute:STATe` ` ON	OFF` `CALCulate<1|2>:LIMit<1...8>:ACPower:ACHannel:ABSolute` ` <num_value>,<num_value>` `CALCulate<1|2>:LIMit<1...8>:ACPower:ALTernate[:RELative]` ` :STATeON	OFF` `CALCulate<1|2>:LIMit<1...8>:ACPower:ALTernate[:RELative]` ` <num_value>,<num_value>` `CALCulate<1|2>:LIMit<1...8>:ACPower:ALTernate:ABSolute:STATe` ` ON	OFF` `CALCulate<1|2>:LIMit<1...8>:ACPower:ALTernate:ABSolute` ` <num_value>,<num_value>`
SELECT TRACE	`[SENSe:]POWer:TRACe 1|2|3`
SET CP REFERENCE	`[SENSe:]POWer:ACHannel:REFerence:AUTO ONCE`
SWEEP TIME	`[SENSe:]SWEep:TIME <num_value>`
DIAGRAM FULL SIZE	`DISPlay[:WINDow<1	2>]:SIZE LARGe	SMALl`
MULT CARR ACP	
CP / ACP ON OFF	`CALCulate<1	2>:MARKer<1...4>:FUNCtion:POWer:SELect` ` CPOWer	ACPower;` `CALCulate<1	2>:MARKer<1...4>:FUNCtion:POWer:RESult?` ` CPOWer	ACPower;` `CALCulate<1	2>:MARKer<1...4>:FUNCtion:POWer[:STATe] OFF`
CP / ACP STANDARD	`CALCulate<1|2>:MARKer<1...4>:FUNCtion:POWer:PRESet` `                                        <standard>`
CP / ACP CONFIG	
NO. OF ADJ CHAN	`[SENSe:]POWer:ACHannel:ACPairs <num_value>`
NO. OF TX CHAN	`[SENSe:]POWer:ACHannel:TXCHannel:COUNt <num_value>`

CHANNEL BANDWIDTH	`[SENSe:]POWer:ACHannel:BANDwidth|BWIDth[:CHANnel]`
	`                                        <num_value>`
	`[SENSe:]POWer:ACHannel:BANDwidth|BWIDth:ACHannel`
	`                                        <num_value>`
	`[SENSe:]POWer:ACHannel:BANDwidth|BWIDth:ALTernate<1|2>`
	`                                        <num_value>`

CHANNEL SPACING	`[SENSe:]POWer:ACHannel:SPACing:CHANnel <num_value>`
	`[SENSe:]POWer:ACHannel:SPACing:ACHannel <num_value>`
	`[SENSe:]POWer:ACHannel:SPACing:ALTernate<1|2> <num_value>`

ACP REF SETTINGS	`[SENSe:]POWer:ACHannel:REFerence:TXCHannel:MAN 1` `[SENSe:]POWer:ACHannel:REFerence:TXCHannel:Auto MIN`
CP/ACP ABS REL	`[SENSe:]POWer:ACHannel:MODE ABSolute|RELative`
CHAN PWR /HZ	`CALCulate<1	2>:MARKer<1...4>:FUNCtion:POWer:RESult:PHZ` ` ON	OFF`

POWER
MODE

CLEAR/
WRITE

```
CALCulate<1|2>:MARKer:FUNCtion:POWer:MODE WRITe|MAXHold
```

MAX HOLD

ADJUST
SETTINGS

```
[SENSe:]POWer:ACHannel:PRESet
ACPower|CPOWer|MCACpower|OBANdwidth|OBWidth
```

ACP LIMIT
CHECK

```
CALCulate<1|2>:LIMit<1...8>:ACPower[:STATe] ON | OFF
CALCulate<1|2>:LIMit<1...8>:ACPower:ACHannel:RESult?
CALCulate<1|2>:LIMit<1...8>:ACPower:ALTernate<1|2>:RESult?
```

EDIT
ACP LIMITS

```
CALCulate<1|2>:LIMit<1...8>:ACPower[:STATe] ON | OFF
CALCulate<1|2>:LIMit<1...8>:ACPower:ACHannel[:RELative]:S
TATe                                          ON | OFF
CALCulate<1|2>:LIMit<1...8>:ACPower:ACHannel[:RELative]
                                  <num_val>,<num_val>
CALCulate<1|2>:LIMit<1...8>:ACPower:ACHannel:ABSolute:STATe
                                              ON | OFF
CALCulate<1|2>:LIMit<1...8>:ACPower:ACHannel:ABSolute
                              <num_value>,<num_value>
CALCulate<1|2>:LIMit<1...8>:ACPower:ALTernate[:RELative]:
STATe                                         ON | OFF
CALCulate<1|2>:LIMit<1...8>:ACPower:ALTernate[:RELative]
                              <num_value>,<num_value>
CALCulate<1|2>:LIMit<1...8>:ACPower:ALTernate:ABSolute:STAT
e                                             ON | OFF
CALCulate<1|2>:LIMit<1...8>:ACPower:ALTernate:ABSolute
                              <num_value>,<num_value>
```

SELECT
TRACE

```
[SENSe:]POWer:TRACe 1|2|3
```

SWEEP
TIME

```
[SENSe:]SWEep:TIME <num_value>
```

DIAGRAM
FULL SIZE

```
DISPlay[:WINDow<1|2>]:SIZE  LARGe | SMALl
```

OCCUPIED
BANDWIDTH

OCCUP BW
ON OFF

```
CALCulate<1|2>:MARKer<1...4>:FUNCtion:POWer:SELect
                              OBANdwidth | OBWidth
CALCulate<1|2>:MARKer<1...4>:FUNCtion:POWer:RESult?
                              OBANdwidth| OBWidth
CALCulate<1|2>:MARKer<1...4>:FUNCtion:POWer[:STATe] OFF
```

% POWER
BANDWIDTH

```
[SENSe:]POWer:BANDwidth|BWIDth <num_value>
```

CHANNEL
BANDWIDTH

```
[SENSe:]POWer:ACHannel:BANDwidth|BWIDth <num_value>
```

ADJUST
SETTINGS

```
[SENSe:]POWer:PRESet ACPower|CPOWer|OBANdwidth|OBWidth
```

```
SIGNAL
STATISTIC

        APD            CALCulate:STATistics:APD[:STATe] ON | OFF
      ON   OFF         CALCulate:STATistics:RESult<1...3>? MEAN | PEAK | CFACtor
                                                                        | ALL

       CCDF            CALCulate:STATistics:CCDF[:STATe] ON | OFF
      ON   OFF         CALCulate:STATistics:RESult<1...3>? MEAN | PEAK | CFACtor |
                                                                            ALL

     PERCENT           CALC:MARK:Y:PERC 0...100%
     MARKER

     RES BW            [SENSe:]BANDwidth[:RESolution]:AUTO OFF
                       [SENSe:]BANDwidth[:RESolution] <num_value>
      NO OF            CALCulate:STATistics:NSAMples <num_value>
     SAMPLES

     SCALING

        X-AXIS         CALCulate:STATistics:X:RLEVel <num_value>
      REF LEVEL

        X-AXIS         CALCulate:STATistics:X:RANGe  <num_value>
        RANGE

        Y-UNIT         CALCulate:STATistics:Y:SCALe:Y:UNIT PCT | ABS
       %    ABS

        Y-AXIS         CALCulate:STATistics:Y:UPPER <num_value>
      MAX VALUE

        Y-AXIS         CALCulate:STATistics:Y:LOWer <num_value>
      MIN VALUE

       ADJUST          CALCulate:STATistics:SCALe:AUTO ONCE
      SETTINGS

      DEFAULT          CALCulate:STATistics:PRESet
      SETTINGS

      COUNT            INITiate:CONTinuous ON;
      MEAS             INITiate:IMMediate

      SINGLE           INITiate:CONTinuous OFF;
      MEAS             INITiate:IMMediate
  C/NO

        C/N            CALCulate:MARKer:FUNCtion:POWer:SELect CN
                       CALCulate:MARKer:FUNCtion:POWer:RESult? CN
        C/No           CALCulate:MARKer:FUNCtion:POWer:SELect CN0
                       CALCulate:MARKer:FUNCtion:POWer:RESult? CN0
                       CALCulate:MARKer:FUNCtion:POWer OFF

      CHANNEL          [SENSe:]POWer:ACHannel:BANDwidth|BWIDth <num_value>
     BANDWIDTH

      ADJUST           [SENSe:]POWer:ACHannel:PRESet CN | CN0
     SETTINGS
MODULATION             CALCulate<1|2>:MARKer<1...4>:FUNCtion:MDEPth[:STATe]
  DEPTH                                                            ON | OF
                       CALCulate<1|2>:MARKer<1...4>:FUNCtion:MDEPth:RESult?

    SELECT             CALCulate<1|2>:MARKer<1...4>:FUNCtion:MDEPth[:STATe]
    MARKER                                                         ON | OF
                       CALCulate<1|2>:MARKer<1...4>:FUNCtion:MDEPth:RESult?

      TOI              CALCulate:MARKer:FUNCtion:TOI ON
```

TRIG Key

TRIG

| FREE RUN | `TRIGger[:SEQuence]:SOURce   IMMediate` |

| EXTERN | `TRIGger[:SEQuence]:LEVel[EXTernal] <numeric value>`
`EXTernalTRIGger[:SEQuence]:SOURce EXTernal`
`[SENSe:]SWEep:EGATe:SOURce EXTernal` |

| I LEVEL | `TRIGger<1|2>[:SEQuence]:LEVel:IONLy <numeric value>` |

| Q LEVEL | `TRIGger<1|2>[:SEQuence]:LEVel:IONLy <numeric value>` |

| I/Q LEVEL | `TRIGger<1|2>[:SEQuence]:LEVel:IFPower <numeric value>` |

| TRIGGER OFFSET | `TRIGger[:SEQuence]:HOLDoff <num_value>` |

| POLARITY POS/NEG | `TRIGger[:SEQuence]:SLOPe POSitive | NEGative or`
`[SENSe:]SWEep:EGATe:POLarity POSitive | NEGative` |

TRACE Key

TRACE		

SELECT TRACE   no corresponding IEC/IEEE-bus command

CLEAR/ WRITE   `DISPlay[:WINDow<1|2>]:TRACe<1...3>:MODE WRITe`

MAX HOLD   `DISPlay[:WINDow<1|2>]:TRACe<1...3>:MODE MAXHold`

AVERAGE   `DISPlay[:WINDow<1|2>]:TRACe<1...3>:MODE  AVERage`
or:
`[SENSe:]AVERage[:STATe<1...3>] ON`

VIEW   `DISPlay[:WINDow<1|2>]:TRACe<1...3>:MODE VIEW`

BLANK   `DISPlay[:WINDow<1|2>]:TRACe<1...3>[:STATe] OFF`

SWEEP COUNT   `[SENSe:]SWEep:COUNt <num_value>`
or:
`[SENSe:]AVERage:COUNt <num_value>`

DETECTOR

    AUTO SELECT   `[SENSe:]DETector[:FUNCtion]:AUTO   ON | OFF`

    DETECTOR AUTO PEAK   `[SENSe:]DETector[:FUNCtion] APEak`

    DETECTOR MAX PEAK   `[SENSe:]DETector[:FUNCtion] POSitive`

    DETECTOR MIN PEAK   `[SENSe:]DETector[:FUNCtion] NEGative`

    DETECTOR SAMPLE   `[SENSe:]DETector[:FUNCtion] SAMPle`

    DETECTOR RMS   `[SENSe:]DETector[:FUNCtion] RMS`

    DETECTOR AVERAGE   `[SENSe:]DETector[:FUNCtion] AVERage`

TRACE MATH

    T1-T2->T1   `CALCulate<1|2>:MATH:STATe ON`
`CALCulate<1|2>:MATH[:EXPRession][:DEFine] (TRACE1 - TRACE2)`

    T1-T3->T1   `CALCulate<1|2>:MATH:STATe ON`
`CALCulate<1|2>:MATH[:EXPRession][:DEFine] (TRACE1 - TRACE3)`

    TRACE POSITION   `CALCulate<1|2>:MATH:POSition <num_value>`

    TRACE MATH OFF   `CALCulate<1|2>:MATH:STATe OFF`

MIN HOLD   `DISPlay[:WINDow<1|2>]:TRACe<1...3>:MODE MINHold`

HOLD CONT ON OFF   `DISPlay[:WINDow<1|2>]:TRACe<1..4>:MODE:HCON ON|OFF`

AVG MODE LOG LIN	`CALCulate<1|2>:MATH:MODE LINear	LOGarithmic` `or:` `[SENSe:]AVERage:TYPE VIDeo	LINear`
ASCII FILE EXPORT	`FORMat[:DATA] ASCii` `MMEMory:STORe<1|2>:TRACe 1,'TRACE.DAT'`
DECIM SEP . ,	`FORMat:DEXPort:DSEParator POINt	COMMa`
COPY TRACE	`TRACe:COPY      TRACE1|TRACE2|TRACE3,TRACE1|TRACE2|TRACE`

LINES Key

LINES

SELECT LIMIT LINE

selection:
```
CALCulate<1|2>:LIMit<1...8>:NAME <string>;
CALCulate<1|2>:LIMit<1...8>:UPPer:STATe   ON | OFF
CALCulate<1|2>:LIMit<1...8>:LOWer:STATe ON | OFF
```
limit check:
```
CALCulate<1|2>:LIMit<1...8>:STATe ON | OFF
INITiate[:IMMediate]; WAI*
CALCulate<1|2>:LIMit<1...8>:FAIL?
```
trace assignment:
```
CALCulate<1|2>:LIMit<1...8>:TRACe 1|2|3
```

NEW LIMIT LINE

NAME

name:
```
  CALCulate<1|2>:LIMit<1...8>:NAME <string>;
```
domain:
```
  CALCulate<1|2>:LIMit<1...8>:CONTrol:DOMain
                                      FREQuency|TIME
```
scaling:
```
  CALCulate<1|2>:LIMit<1...8>:CONTrol:MODE
                                    RELative | ABSolute
  CALCulate<1|2>:LIMit<1...8>:UPPer:MODE
RELative | ABSolute
  CALCulate<1|2>:LIMit<1...8>:LOWer:MODE
                                    RELative | ABSolute
```
unit:
```
  CALCulate<1|2>:LIMit<1...8>:UNIT   DBM| DBPW| WATT|
  DBUV| VOLT|DBUA|AMPere| DB| DBUV_MHZ| DBUA_MHZ| DEG| RAD
  | S| HZ| PCT
```
margin:
```
  CALCulate<1|2>:LIMit<1...8>:UPPer:MARGin <num_value>
  CALCulate<1|2>:LIMit<1...8>:LOWer:MARGin <num_value>
```
threshold for relative y-scaling:
```
  CALCulate<1|2>:LIMit<1...8>:UPPer:THReshold
                                            <num_value>
  CALCulate<1|2>:LIMit<1...8>:LOWer:THReshold
                                            <num_value>
```
comment:
```
  CALCulate<1|2>:LIMit<1...8>:COMMent <string>
```

VALUES

```
CALCulate<1|2>:LIMit<1...8>:CONTrol[:DATA]
                      <num_value>, <num_value>..
CALCulate<1|2>:LIMit<1...8>:UPPer[:DATA]
                      <num_value>, <num_value>..
CALCulate<1|2>:LIMit<1...8>:LOWer[:DATA]
                       <num_value>,<num_value>..
```

INSERT VALUE

no corresponding IEC/IEEE-bus command

DELETE VALUE

no corresponding IEC/IEEE-bus command

SHIFT X LIMIT LINE

```
CALCulate<1|2>:LIMit<1...8>:CONTrol:SHIFt <num_value>
```

SHIFT Y LIMIT LINE	`CALCulate<1|2>:LIMit<1...8>:UPPer:SHIFt <num_value>` `CALCulate<1|2>:LIMit<1...8>:LOWer:SHIFt <num_value>`
SAVE LIMIT LINE	automatically executed during IEC/IEEE-bus operation
EDIT LIMIT LINE	s. NEW LIMIT LINE
COPY LIMIT LINE	`CALCulate<1|2>:LIMit<1...8>:COPY 1...8	<name>`
DELETE LIMIT LINE	`CALCulate<1|2>:LIMit<1...8>:DELete`
X OFFSET	`CALCulate<1|2>:LIMit<1...8>:CONTrol:OFFset <num_value>`
Y OFFSET	`CALCulate<1|2>:LIMit<1...8>:UPPer:OFFset <num_value>` `CALCulate<1|2>:LIMit<1...8>:LOWer:OFFset <num_value>`
DISPLAY LINES	
DISPLAY LINE 1	`CALCulate<1|2>:DLINe1:STATe ON|OFF` `CALCulate<1|2>:DLINe1 <num_value>`
DISPLAY LINE 2	`CALCulate<1|2>:DLINe2:STATe ON|OFF` `CALCulate<1|2>:DLINe2 <num_value>`
FREQUENCY LINE 1	`CALCulate<1|2>:FLINe1:STATe ON|OFF` `CALCulate<1|2>:FLINe1 <num_value>`
FREQUENCY LINE 2	`CALCulate<1|2>:FLINe2:STATe ON|OFF` `CALCulate<1|2>:FLINe2 <num_value>`
TIME LINE 1	`CALCulate<1|2>:TLINe1:STATe ON|OFF` `CALCulate<1|2>:TLINe1 <num_value>`
TIME LINE 2	`CALCulate<1|2>:TLINe2:STATe ON|OFF` `CALCulate<1|2>:TLINe2 <num_value>`
PHASE LINE 1	`CALCulate<1|2>:PLINe1:STATe ON|OFF` `CALCulate<1|2>:PLINe1 <num_value>`
PHASE LINE 2	`CALCulate<1|2>:PLINe2:STATe ON|OFF` `CALCulate<1|2>:PLINe2 <num_value>`

DISP Key

<div style="border:1px solid black;padding:4px;width:80px;text-align:center">**DISP**</div>

FULL SCREEN	`DISPlay:FORmat?` `DISPlay[:WINDow<1|2>]:SELect`
SPLIT SCREEN	`DISPlay:FORmat?`
CONFIG DISPLAY	
SCREEN TITLE	`DISPlay[:WINDow<1|2>]:TEXT[:DATA] <string>` `DISPlay[:WINDow<1|2>]:TEXT:STATe ON	OFF`
TIME+DATE ON OFF	`DISPlay[:WINDow<1|2>]:TIME ON	OFF`
LOGO ON OFF	`DISPlay:LOGO ON|OFF`
ANNOTATION ON OFF	`DISPlay:ANNotation:FREQuency ON|OFF`
DATAENTRY OPAQUE	no corresponding IEC/IEEE-bus command
DEFAULT COLORS 1	`DISPlay:CMAP<1...13>:DEFault1`
DEFAULT COLORS 2	`DISPlay:CMAP<1...13>:DEFault2`
DISPLAY PWR SAVE	`DISPlay:PSAVe[:STATe] ON	OFF` `DISPlay:PSAVe:HOLDoff <num_value>`
SELECT OBJECT	no corresponding IEC/IEEE-bus command
BRIGHTNESS	`DISPlay:CMAP:HSL <hue>,<sat>,<lum>`
TINT	`DISPlay:CMAP<1...13>:HSL <hue>,<sat>,<lum>`
SATURATION	`DISPlay:CMAP<1...13>:HSL <hue>,<sat>,<lum>`

PREDEFINED COLORS	`DISPlay:CMAP<1...13>:PDEFined BLACk| BLUE| BROWn| GREen|`
	`CYAN| RED| MAGenta|`
	`YELLow| WHITe| DGRAy|`
	`LGRAy| LBLUe| LGREen|`
	`LCYan| LRED| MAGenta`

FILE Key

FILE

SAVE	`MMEMory:STORe:STATe 1,<file_name>`
RECALL	`MMEMory:LOAD:STATe 1,<file_name>`
EDIT PATH	no corresponding IEC/IEEE-bus command
EDIT COMMENT	`MMEMory:COMMent <string>`
ITEMS TO SAVE/RCL	

SELECT ITEMS	`MMEMory:SELect[:ITEM]:HWSettings ON|OFF`
	`MMEMory:SELect[:ITEM]:TRACe[:ACTive] ON|OFF`
	`MMEMory:SELect[:ITEM]:LINes:ALL ON|OFF`
	`MMEMory:SELect[:ITEM]:NONE`

ENABLE ALL ITEMS	`MMEMory:SELect[:ITEM]:ALL`
DISABLE ALL ITEMS	`MMEMory:SELect[:ITEM]:NONE`
DEFAULT CONFIG	`MMEMory:SELect[:ITEM]:DEFault`
DATA SET LIST	no corresponding IEC/IEEE-bus command
DATA SET CLEAR	`MMEMory:CLEar:STATe 1,<file_name>`
STARTUP RECALL	`MMEMory:LOAD:AUTO 1,<file_name>`
FILE MANAGER	
EDIT PATH	`MMEMory:MSIS <device>` `MMEMory:CDIRectory <directory_name>`
NEW FOLDER	`MMEMory:MDIRectory <directory_name>`
COPY	`MMEMory:COPY <file_source>,<file_destination>`
RENAME	`MMEMory:MOVE <file_source>,<file_destination>`
CUT	`MMEMory:DELete <file_name>` `MMEMory:RDIRectory <directory_name>`
PASTE	no corresponding IEC/IEEE-bus command
DELETE	`MMEMory:DELete <file_name>` `MMEMory:RDIRectory <directory_name>`
SORT MODE	no corresponding IEC/IEEE-bus command
NAME	no corresponding IEC/IEEE-bus command

DATE	no corresponding IEC/IEEE-bus command
EXTENSION	no corresponding IEC/IEEE-bus command
2 FILE LISTS	no corresponding IEC/IEEE-bus command
ASCII FILE EXPORT	FORMat[:DATA] ASCii MMEMory:STORe<1|2>:TRACe 1,'TRACE.DAT'
DECIM SEP . ,	FORMat:DEXPort:DSEParator POINt | COMMa
FORMAT DISK	
ASCII FILE EXPORT	FORMat[:DATA] ASCii MMEMory:STORe<1|2>:TRACe 1,'TRACE.DAT'
DECIM SEP . ,	FORMat:DEXPort:DSEParator POINt | COMMa

CAL Key

CAL

PROBE CAL

PROBE DATA SELECT	`SENSe:PROBe:CATalog?`
	`SENSe:PROBe:DELete <file_name>`
	`SENSe:PROBe:MOVE <file_name>,<file_name>`
	`SENSe:PROBe:SELect <file_name>`

SORT BY NAME DATE	no corresponding IEC/IEEE-bus command

PROBE CAL START	`CALibration:PROBe[:STARt] <file_name>`
	`INIT:CONM`
	`STATus:QUEStionable:SYNC:CONDition (bit 12, bit 13)`

PROBE COMP ON OFF	`CALibration:PROBe:COMPensation ON	OFF`
GAIN&OFFS ON OFF	`CALibration:PROBe:GAIN ON	OFF`
FREQ RESP ON OFF	`CALibration:PROBe:FRESponse ON	OFF`
IQ PATH (I+j*Q)	
I+J*Q	`INPut:IQ:TYPE IJQ`
I ONLY	`INPut:IQ:TYPE I`
Q ONLY	`INPut:IQ:TYPE Q`
I/Q INPUT 50Ω 1MΩ	`INPut:IQ:IMPedance LOW|HIGH`
BALANCED ON OFF	`INPut:IQ:BALanced[:STATe] ON|OFF`
PROBE DATA RENAME	`[SENSe<1|2>:]PROBe:MOVE <file_name>,<file_name>`
PROBE DATA DELETE	`[SENSe<1|2>:]PROBe:DELete <probe_data_set_name>`
PROBE DATA DELETE ALL	no corresponding IEC/IEEE-bus command
PROBE CAL DC	`[SENSe<1|2>:]PROBe:ADJust:DC <numreric value>` `[SENSe<1|2>:]PROBe:ADJust:MODE DC`
PROBE CAL PULSE	`[SENSe<1|2>:]PROBe:ADJust:PULSe <numreric value>` `[SENSe<1|2>:]PROBe:ADJust:MODE PULSE`
PROBE CAL COMP	
PROBE CORR ON OFF	`SENSe:PROBe[:STATe] ON	OFF`
PROBE CALL RESULTS	no corresponding IEC/IEEE-bus command
CAL TOTAL	`CALibration[:ALL]?`

CAL ABORT	`CALibration:ABORt`
CAL CORR ON OFF	`CALibration:STATe ON	OFF`
CAL RESULTS	`CALibration:RESults?`
PAGE UP	no corresponding IEC/IEEE-bus command
PAGE DOWN	no corresponding IEC/IEEE-bus command

SETUP Key

REFERENCE INT EXT	`[SENSe:]ROSCillator:SOURce INTernal|EXTernal`
SIGNAL SOURCE	

I/Q INPUT 50Ω 1MΩ	`INPut:IQ:IMPedance LOW|HIGH`
BALANCED ON OFF	`INPut:IQ:BALanced[:STATe] ON|OFF`
LOW PASS 36MHz	`[SENSe:]IQ:LPASs[:STATe] ON|OFF`
DITHER ON OFF	`[SENSe:]IQ:DITHer[:STATe] ON|OFF`
I+J*Q	`INPut<1|2>:IQ:TYPE IQ`
I ONLY	`INPut<1|2>:IQ:TYPE I`
Q ONLY	`INPut<1|2>:IQ:TYPE Q`

GENERAL SETUP	
GPIB	
GPIB ADDRESS	`SYSTem:COMMunicate:GPIB[:SELF]:ADDRess  0...30`
ID STRING FACTORY	no corresponding IEC/IEEE-bus command
LD STRING USER	no corresponding IEC/IEEE-bus command
COM INTERFACE	`SYSTem:COMMunicate:SERial[:RECeive:]BAUD  <num_value>` `SYSTem:COMMunicate:SERial[:RECeive]:BITS 7	8` `SYSTem:COMMunicate:SERial:RECeive:PARity[:TYPE] EVEN |`                                       `ODD	NON` `SYSTem:COMMunicate:SERial[:RECeive]:SBITs 1|2` `SYSTem:COMMunicate:SERial:CONTrol:DTR IBFull	OFF` `SYSTem:COMMunicate:SERial:CONTrol:RTS IBFull	OFF` `SYSTem:COMMunicate:SERial[:RECeive]:PACE XON	NONE`
TIME+DATE	`SYSTem:TIME  0...23, 0...59, 0...59` `SYSTem:DATE  <num>,<num>,<num>`
CONFIGURE NETWORK	no corresponding IEC/IEEE-bus command
NETWORK LOGIN	no corresponding IEC/IEEE-bus command
OPTIONS	
INSTALL OPTION	no corresponding IEC/IEEE-bus command
REMOVE OPTION	no corresponding IEC/IEEE-bus command
SYSTEM INFO	
HARDWARE INFO	`DIAGnostic:SERVice:HWINfo?`
STATISTICS	no corresponding IEC/IEEE-bus command

SYSTEM MESSAGES	`SYSTem:ERRor?` `SYSTem:ERRor:LIST?`
CLEAR ALL MESSAGES	`SYSTem:ERRor?`

SERVICE

SELFTEST	`*TST?`
SELFTEST RESULTS	`DIAGnostic:SERVice:STESt:RESult?`
ENTER PASSWORD	`SYSTem:PASSword[:CENable]   <string>`

FIRMWARE UPDATE

FIRMWARE UPDATE	no corresponding IEC/IEEE-bus command
RESTORE FIRMWARE	no corresponding IEC/IEEE-bus command
UPDATE PATH	`SSYSTem:FIRMware:UPDate <path>`

HCOPY Key

HCOPY

PRINT
SCREEN

```
HCOPy:ITEM:ALL
HCOPy:IMMediate
```

for printout into file add   MMEMory:NAME <file_name>

PRINT
TRACE

```
HCOPy:ITEM:WINDow<1|2>:TRACe:STATe   ON | OFF
HCOPy:IMMediate
```

for printout into file add   MMEMory:NAME <file_name>

PRINT
TABLE

```
HCOPy:ITEM:WINDow<1|2>:TABle:STATe   ON | OFF
HCOPy:IMMediate
```

for printout into file add   MMEMory:NAME <file_name>

DEVICE
SETUP

DEVICE2
1   2

```
SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?
SYSTem:COMMunicate:PRINter:ENUMerate:NEXT?
SYSTem:COMMunicate:PRINter:SELect <string>
HCOPy:DESTination   <string>
HCOPy:DEVice:LANGuage   GDI | WMF | EWMF | BMP
HCOPy:PAGE:ORIentation<1|2>   LANDscape | PORTrait
```

COLORS

```
HCOPy:CMAP:DEFault1
```

COLOR
ON OFF

```
HCOPy:DEVice:COLor ON | OFF
```

SCREEN
COLORS

```
HCOPy:CMAP<1 to 26>:DEFault 2
```

OPTIMIZED
COLORS

```
HCOPy:CMAP<1 to 26>:DEFault 1
```

USER
DEFINE

```
HCOPy:CMAP<1 to 26>:DEFault 3
```

SELECT
OBJECT

no corresponding IEC/IEEE-bus command

BRIGHTNESS

```
HCOPy:CMAP<1 to 26>:HSL <hue>,<sat>,<lum>
```

TINT

```
HCOPy:CMAP<1 to 26>:HSL <hue>,<sat>,<lum>
```

SATURATION

```
HCOPy:CMAP<1 to 26>:HSL <hue>,<sat>,<lum>
```

PREDIFINED
COLORS

```
HCOPy:CMAP<1 to  26>:PDEFined <color>
```

SET TO
DEFAULT

no corresponding IEC/IEEE-bus command

COMMENT

```
HCOPy:ITEM:WINDow:TEXT   <string>
```

INSTALL
PRINTER

no corresponding IEC/IEEE-bus command

Contents - Chapter 7 "Remote Control - Programming Examples"

7 Remote Control - Programming Examples

The following programming examples have a hierarchical structure, i.e. subsequent examples are based on previous ones. It is thus possible to compile very easily an operational program from the modules of the given examples.

Basic Steps of IEC/IEEE-Bus Programming

The examples explain the programming of the instrument and can serve as a basis to solve more complex programming tasks.

VISUAL BASIC has been used as programming language. However, the programs can be translated into other languages.

Service Request

The service request routine requires an extended initialization of the instrument in which the relevant bits of the transition and enable registers are set.
In order to use the service request function in conjunction with a National Instruments GPIB driver, the setting "Disable Auto Serial Poll" must be changed to "yes" by means of IBCONF.

Initiate Service Request

```
REM ---- Example of initialization of the SRQ in the case of errors --------
PUBLIC SUB SetupSRQ()


CALL IBWRT(analyzer%, "*CLS")              'Reset status reporting system
CALL IBWRT(analyzer%,"*SRE 168")           'Permit service request for
                                           'STAT:OPER,STAT:QUES and ESR
                                           'register
CALL IBWRT(analyzer%,"*ESE 60")            'Set event enable bit for
                                           'command, execution, device-
                                           'dependent and query error
CALL IBWRT(analyzer%,"STAT:OPER:ENAB 32767")   'Set OPERation enable bit for
                                           'all events
CALL IBWRT(analyzer%,"STAT:OPER:PTR 32767")    'Set appropriate OPERation
                                           'Ptransition bits
CALL IBWRT(analyzer%,"STAT:QUES:ENAB 32767")   'Set questionable enable bits
                                           'for all events
CALL IBWRT(analyzer%,"STAT:QUES:PTR 32767")    'Set appropriate questionable
                                           'Ptransition bits
END SUB
REM ************************************************************************
```

Waiting for the Arrival of a Service Request

There are basically two methods of waiting for the arrival of a service request:

1. **Blocking (user inputs not possible):**
   This method is appropriate if the waiting time until the event to be signalled by an SRQ is short (shorter than the selected timeout), if no response to user inputs is required during the waiting time, and if – as the main criterion – the event is absolutely certain to occur.
   Reason:
   From the time the WaitSRQ() function is called until the occurrence of the expected event, it does not allow the program to respond to mouse clicks or key entries during the waiting time. Moreover, it causes program abort if the SRQ event does not occur within the predefined timeout period. The method is, therefore, in many cases not suitable for waiting for measurement results, especially with triggered measurements.

   The following function calls are required:

```
CALL WaitSRQ(boardID%,result%)       'Wait for service request
                                     'User inputs are not possible
                                     'during the waiting time!

IF (result% = 1) THEN CALL Srq       'If SRQ is recognized =>
                                     'subroutine for evaluation
```

2. **Non-blocking (user inputs possible):**
   This method is recommended if the waiting time until the event to be signalled by an SRQ is long (longer than the selected timeout), and user inputs should be possible during the waiting time, or if the event is not certain to occur. This method is, therefore, the preferable choice for waiting for the end of measurements, i.e. the output of results, especially in the case of triggered measurements.

   The method necessitates a waiting loop that checks the status of the SRQ line at regular intervals and returns control to the operating system during the time the expected event has not yet occurred. In this way, the system can respond to user inputs (mouse clicks, key entries) during the waiting time.

   It is advisable to employ the Hold() auxiliary function, which returns control to the operating system for a selectable waiting time (see section "Waiting Without Blocking the Keyboard or Mouse"), so enabling user inputs during the waiting time.

```
result% = 0

For i = 1 To 10                      'Abort after max. 10 loop
                                     'iterations

    CALL TestSRQ(boardID%,result%)   'Check service request line

    If (result% <> 0) Then
        CALL Srq                     'If SRQ is recognized =>
                                       'subroutine for evaluation
    Else
        Call Hold(20)                'Call hold function with
                                     '20 ms waiting time.
                                     'User inputs are possible.

    Endif

Next i

If result% = 0 Then
    PRINT "Timeout Error; Program aborted"' Output error message
    STOP                                    'Stop software
Endif
```

Waiting Without Blocking the Keyboard and Mouse

A frequent problem with remote control programs using Visual Basic is to insert waiting times without blocking the keyboard and the mouse.

If the program is to respond to user inputs also during a waiting time, control over the program events during this time must be returned to the operating system. In Visual Basic, this is done by calling the *DoEvents* function. This function causes keyboard- or mouse-triggered events to be executed by the associated elements. For example, it allows the operation of buttons and input fields while the user waits for an instrument setting to be completed.

The following programming example describes the *Hold()* function, which returns control to the operating system for the period of the waiting time selectable in milliseconds.

```
Rem *******************************************************************
Rem The waiting function below expects the transfer of the desired
Rem waiting time in milliseconds. The keyboard and the mouse remain
Rem operative during the waiting period, thus allowing desired elements
Rem to be controlled
Rem *******************************************************************
Public Sub Hold(delayTime As Single)

    Start = Timer          'Save timer count on calling the function

    Do While Timer < Start + delayTime / 1000   'Check timer count

      DoEvents             'Return control to operating system
                           'to enable control of desired elements as long as
                           'timer has not elapsed

    Loop

End Sub

Rem *******************************************************************
```

The waiting procedure is activated simply by calling *Hold(<Waiting time in milliseconds>)*.

Service Request Routine

A service request is processed in the service request routine.
Note: the variables userN% and userM% must be pre-assigned usefully!

```
REM ------------ Service request routine --------------------------------
Public SUB Srq()


ON ERROR GOTO noDevice                          'No user existing
CALL IBRSP(analyzer%, STB%)                      'Serial poll, read status byte
IF STB% > 0 THEN                                 'This instrument has bits set
                                                 'in the STB

    SRQFOUND% = 1
    IF (STB% AND 16)  > 0 THEN CALL Outputqueue
    IF (STB% AND 4)   > 0 THEN CALL ErrorQueueHandler
    IF (STB% AND 8)   > 0 THEN CALL Questionablestatus
    IF (STB% AND 128) > 0 THEN CALL Operationstatus
    IF (STB% AND 32)  > 0 THEN CALL Esrread
  END IF
noDevice:
END SUB                                          'End of SRQ routine
REM ************************************************************************
```

Reading out the status event registers, the output buffer and the error/event queue is effected in subroutines.

Reading Out the Output Buffer

```
REM -------- Subroutine for the individual STB bits ----------------------
Public SUB Outputqueue()                         'Reading the output buffer


result$ = SPACE$(100)                            'Make space for response
CALL IBRD(analyzer%, result$)
PRINT "Contents of Output Queue : "; result$
END SUB
REM ************************************************************************
```

Reading Out Error Messages

```
REM -------- Subroutine for reading the error queue ----------------------
Public SUB ErrorQueueHandler()
ERROR$ = SPACE$(100)                          'Make space for error variable
CALL IBWRT(analyzer%, "SYSTEM:ERROR?")
CALL IBRD(analyzer%, ERROR$)
PRINT "Error Description : "; ERROR$
END SUB
REM ***********************************************************************
```

Evaluation of SCPI Status Registers

```
REM ------ Subroutine for evaluating Questionable Status Register ---------
Public SUB Questionablestatus()
Ques$ = SPACE$(20)                    'Preallocate blanks to text variable
CALL IBWRT(analyzer%, "STATus:QUEStionable:EVENt?")
CALL IBRD(analyzer%, Ques$)
PRINT "Questionable Status: "; Ques$
END SUB
REM ***********************************************************************


REM ------ Subroutine for evaluating Operation Status Register -----------
Public SUB Operationstatus()
Oper$ = SPACE$(20)                    'Preallocate blanks to text variable
CALL IBWRT(analyzer%, "STATus:OPERation:EVENt?")
CALL IBRD(analyzer%, Oper$)
PRINT "Operation Status: "; Oper$
END SUB
REM ***********************************************************************
```

Evaluation of Event Status Register

```
REM ------ Subroutine for evaluating the Event Status Register ------------
Public SUB Esrread()
Esr$ = SPACE$(20)                'Preallocate blanks to text variable
CALL IBWRT(analyzer%, "*ESR?")                              'Read ESR
CALL IBRD(analyzer%, Esr$)
IF (VAL(Esr$) AND 1) > 0 THEN PRINT "Operation complete"
IF (VAL(Esr$) AND 2) > 0 THEN PRINT "Request Control"
IF (VAL(Esr$) AND 4) > 0 THEN PRINT "Query Error"
IF (VAL(Esr$) AND 8) > 0 THEN PRINT "Device dependent error"
IF (VAL(Esr$) AND 16) > 0 THEN
    PRINT "Execution Error; Program aborted"'  Output error message
    STOP                                       'Stop software
    END IF
IF (VAL(Esr$) AND 32) > 0 THEN
    PRINT "Command Error; Program aborted"'    Output error message
    STOP                                       'Stop software
    END IF
IF (VAL(Esr$) AND 64) > 0 THEN PRINT "User request"
IF (VAL(Esr$) AND 128) > 0 THEN PRINT "Power on"
END SUB
REM ********************************************************************
```

More Complex Programming Examples

Using Marker and Delta Marker

Measuring Spurious Emissions

In transmission measurements, it is often necessary to search a large frequency range for unwanted spurious emissions.

This can be done by means of the R&S FMU's LIST PEAKS function, which finds up to 50 peaks in a preselected frequency range and outputs them as a list. The search range can be defined both in terms of frequency and level, and the number of peaks to be found is selectable as well.

In the following example, the 10 highest peaks are to be found in a preselected frequency range. Only signals >-60 dBm in a range ± 400 kHz about the center frequency are of interest, so the search range is limited accordingly. The signals found are output in the order of ascending frequency.

```
REM *************************************************************************
Public Sub SpuriousSearch()


powerlist$ = Space$(1000)
freqlist$ = Space$(1000)
count$ = Space$(30)

'--------- R&S FMU default setting --------------------------------------
CALL SetupInstrument                        'Default setting

CALL IBWRT(analyzer%,"INIT:CONT OFF")       'Default setting

'--------- Definition of search range ----------------------------------
CALL IBWRT(analyzer%,"CALC:MARK:X:SLIM:STAT ON")
CALL IBWRT(analyzer%,"CALC:MARK:X:SLIM:LEFT 99.6MHz;RIGHt 100.4MHz")
                                            'Activate search limit and
                                            'set to ±400 kHz about
                                            'center frequency
CALL IBWRT(analyzer%,"CALC:THR:STAT ON")
CALL IBWRT(analyzer%,"CALC:THR -60DBM")     'Activate threshold and
                                            'set to -60 dBm

'--------- Activate search for spurious --------------------------------
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:FPE:SORT X")     'Sort according to
                                                      'frequency

CALL IBWRT(analyzer%,"INIT;*WAI")           'Perform sweep with sync

CALL IBWRT(analyzer%,"CALC:MARK:FUNC:FPE 10")         'Search for
                                                      '10 highest peaks

CALL IBWRT(analyzer%,"CALC:MARK:FUNC:FPE:COUN?")      'Call number of
                                                      'peaks, check it,
CALL IBRD(analyzer%, count$)                 'and read it in

CALL IBWRT(analyzer%,"CALC:MARK:FUNC:FPE:X?")   'Query and read

CALL IBRD(analyzer%, freqlist$)              'frequency list

CALL IBWRT(analyzer%,"CALC:MARK:FUNC:FPE:Y?")   'Query and read

CALL IBRD(analyzer%, powerlist$)             'level list

Print "# of spurious: ";count$              'Output number of results

Print "Frequencies: ";freqlist$             'Output frequency list
```

```
Print "Power: ";powerlist$                    'Output level list
```

END SUB

REM *

Shape Factor Measurement (using n dB down)

The n-dB-down function of the R&S FMU is used twice to determine the shape factor of a filter (ratio of bandwidths at 60 dB and 3 dB below the filter maximum).

The following example is again based on a signal with a level of –30 dBm at 100 MHz. The shape factor is determined for the 30 kHz resolution bandwidth. The default setting of the R&S FMU is used for measurements (SetupInstrument).

REM *

Public Sub ShapeFactor()

```
result$ = Space$(100)
```

'--------- R&S FMU default setting ---

```
CALL SetupInstrument                          'Default setting
CALL IBWRT(analyzer%,"INIT:CONT OFF")         'Single sweep
```

'--------- Set frequency ---

```
CALL IBWRT(analyzer%,"FREQ:SPAN 1MHz")        'Span
CALL IBWRT(analyzer%,"BAND:RES 30kHz")        'Resolution bandwidth
CALL IBWRT(analyzer%,"INIT;*WAI")             'Perform sweep with sync
```

'--------- Measure 60 dB value ---

```
CALL IBWRT(analyzer%,"CALC:MARK:PEXC 6DB")    'Peak excursion

CALL IBWRT(analyzer%,"CALC:MARK:STAT ON")     'Marker1 on
CALL IBWRT(analyzer%,"CALC:MARK:TRAC 1")      'Assign marker1 to trace1
CALL IBWRT(analyzer%,"CALC:MARK:MAX")         'Set marker1 to 100 MHz

CALL IBWRT(analyzer%,"CALC:MARK:FUNC:NDBD 60dB")'Read out bandwidth measured
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:NDBD:RES?")'at 60 dB
CALL IBRD(analyzer%,result$)

result60 = Val(result$)
```

'--------- Measure 3 dB Down value   ---------------------------------------

```
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:NDBD 3dB")'Read out bandwidth measured
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:NDBD:RES?")'at 60 dB
CALL IBRD(analyzer%,result$)

result3 = Val(result$)
```

'--------- Read out shape factor--

```
Print "Shapefaktor 60dB/3dB: ";result60/result3
```

END SUB

REM *

Measuring the Third Order Intercept Point

The third order intercept point (TOI) is the (virtual) level of two adjacent useful signals at which the intermodulation products of third order have the same level as the useful signals.

The intermodulation product at f_{S2} is obtained by mixing the first harmonic of the useful signal P_{N2} with signal P_{N1}, the intermodulation product at f_{S1} by mixing the first harmonic of the useful signal P_{N1} with signal P_{N2}.

$f_{s1} = 2 \times f_{n1} - f_{n2(1)}$

$f_{s2} = 2 \times f_{n2} - f_{n1(2)}$

The following example is based on two adjacent signals with a level of –30 dBm at 100 MHz and 110 MHz. The intermodulation products lie at 90 MHz and 120 MHz according to the above formula. The frequency is set so that the examined mixture products are displayed in the diagram. Otherwise, the default setting of the R&S FMU is used for measurements (SetupInstrument).

```
REM ********************************************************************

Public Sub TOI()


result$ = Space$(100)
'--------- R&S FMU default setting -----------------------------------------
---
CALL SetupStatusReg                          'Set status registers
CALL IBWRT(analyzer%,"*RST")                 'Reset instrument
CALL IBWRT(analyzer%,"INIT:CONT OFF")        'Single sweep
CALL IBWRT(analyzer%,"SYST:DISP:UPD ON")     'ON: display on
                                             'OFF: off

'--------- Set frequency ---------------------------------------------
CALL IBWRT(analyzer%,"FREQ:STARt 85MHz;STOP 125 MHz")  'Span

'--------- Set level -------------------------------------------------
CALL IBWRT(analyzer%,"DISP:WIND:TRAC:Y:RLEV –20dBm")   'Reference level

CALL IBWRT(analyzer%,"INIT;*WAI")                 'Perform sweep with sync

'--------- TOI measurement -------------------------------------------
CALL IBWRT(analyzer%,"CALC:MARK:PEXC 6DB")        'Peak excursion

CALL IBWRT(analyzer%,"CALC:MARK:FUNC:TOI ON")     'Switch on TOI measurement
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:TOI:RES?") 'and read out results
CALL IBRD(analyzer%,result$)
'--------- Read out result -------------------------------------------
Print "TOI [dBm]: ";result$

END SUB

REM ********************************************************************
```

Measuring the AM Modulation Depth

The example below is based on an AM-modulated signal at 100 MHz with the following characteristics:
- Carrier signal level: –30 dBm
- AF frequency: 100 kHz
- Modulation depth: 50 %

The default setting of the analyzer for measurements can be used for the measurements described below (SetupInstrument).

```
REM ***********************************************************************

Public Sub AMMod()


result$ = Space$(100)

CALL SetupInstrument                      'Default setting

'--------- Peak search -------------------------------------------------

CALL IBWRT(analyzer%,"INIT:CONT OFF")        'Single sweep
CALL IBWRT(analyzer%,"INIT;*WAI")            'Perform sweep with sync

CALL IBWRT(analyzer%,"CALC:MARK:PEXC 6DB")   'Peak excursion
CALL IBWRT(analyzer%,"CALC:MARK:STAT ON")    'Marker 1 on
CALL IBWRT(analyzer%,"CALC:MARK:TRAC 1")     'Assign marker1 to trace1

'--------- Measure modulation depth-------------------------------------

CALL IBWRT(analyzer%,"CALC:MARK:MAX;FUNC:MDEP ON") 'Marker to Peak;
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:MDEP:RES?")   'Measure mod. depth
CALL IBRD(analyzer%, result$)                      'Read out result

'--------- Read out result ---------------------------------------------

Print "AM Mod Depth [%]: ";result$

END SUB

REM ***********************************************************************
```

Limit Lines and Limit Test

The example below shows the definition and use of a new limit line 5 for trace 1 on screen A and trace 2 on screen B with the following characteristics:

- Upper limit line
- Absolute x axis in the frequency range
- 5 reference values: 120 MHz / -70 dB, 126 MHz/-40 dB, 127 MHz/-40 dB, 128 MHz/-10 dB, 129 MHz/-40 dB, 130 MHz/-40 dB, 136 MHz / -70 dB
- Relative y axis with unit dB
- Absolute threshold at -75 dBm
- No margin

The signal of the integrated calibration source (128 MHz, -30 dBm) is used to check the limit test.

```
REM *********************************************************************

Public Sub LimitLine()


result$ = Space$(100)

'--------- R&S FMU default setting ------------------------------------------
CALL SetupInstrument                            'Default setting

CALL IBWRT(analyzer%,"FREQUENCY:CENTER 128MHz;Span 10MHz")'Span

Call ibwrt(analyzer%,"Diag:Serv:Inp Cal;CSO -30dBm")   'Cal signal on

'--------- Definition of limit lines -------------------------------------
CALL IBWRT(analyzer%,"CALC:LIM5:NAME 'TEST1'")          'Define name
CALL IBWRT(analyzer%,"CALC:LIM5:COMM 'Upper limit'")   'Define comment

CALL IBWRT(analyzer%,"CALC1:LIM5:TRAC 1")         'Assign trace in screen A
CALL IBWRT(analyzer%,"CALC2:LIM5:TRAC 2")         'Assign trace in screen B

CALL IBWRT(analyzer%,"CALC:LIM5:CONT:DOM FREQ")'Define x axis range
CALL IBWRT(analyzer%,"CALC:LIM5:CONT:MODE ABS")'Define x axis scaling

CALL IBWRT(analyzer%,"CALC:LIM5:UNIT DB")         'Define y axis unit
CALL IBWRT(analyzer%,"CALC:LIM5:UPP:MODE REL")  'Define y axis scaling

'--------- Definition of data points and threshold -----------------------
xlimit$ = "CALC:LIM5:CONT 120MHZ,126MHZ,127MHZ,128MHZ,129MHZ,130MHZ,136MHZ"
CALL IBWRT(analyzer%, xlimit$)                    'Set values for x axis

CALL IBWRT(analyzer%,"CALC:LIM5:UPP -70,-40,-40,-20,-40,-40,-70")
                                                  'Set values for y axis



CALL IBWRT(analyzer%,"CALC:LIM5:UPP:THR -75DBM") 'Set y threshold (only
                                                  'possible for relative
                                                  'y axis)
'------------------------------------------------------------------------
'A margin or an x /y offset can be defined here.

'----------- Activate and evaluate the limit line in screen A -------------
CALL IBWRT(analyzer%,"CALC1:LIM5:UPP:STAT ON") 'Activate line 5 in screen A

CALL IBWRT(analyzer%,"CALC1:LIM5:STAT ON")       'Activate limit check in
                                                  'screen A

CALL IBWRT(analyzer%,"INIT;*WAI")                'Perform sweep with sync
```

```
CALL IBWRT(analyzer%,"CALC1:LIM5:FAIL?")        'Query result of limit
                                                'check

CALL IBRD(analyzer%, result$)                   'Result: 1 (= FAIL)
'--------- Read out result ----------------------------------------------
Print "Limit Result Line 5: ";result$


'------ Evaluate limit line in screen A by means of status register -------
CALL IBWRT(analyzer%,"*CLS")                     'Reset status register
'--------- Measure ------------------------------------------------------
CALL IBWRT(analyzer%,"INIT;*OPC")               'Perform sweep with sync
CALL WaitSRQ(boardID%,status%)                  'Wait for service request
'--------- Read out result ----------------------------------------------
IF (status% = 1) THEN
   CALL IBWRT(analyzer%,"STAT:QUES:LIM1:COND?") 'Read out STAT:QUES:LIMit
   CALL IBRD(analyzer%, result$)                'register

   IF ((Val(result$) And 16) <> 0) THEN

      Print "Limit5 failed"

   ELSE

      Print "Limit5 passed"

   END IF

END IF

END SUB

REM ***************************************************************************
```

Measuring the Channel and Adjacent Channel Power

In the following example, the channel and adjacent channel power is first measured on a signal with a level of 0 dBm at 800 MHz to IS95. Then the channel and adjacent channel power is measured on a GSM signal at 935.2 MHz with fast ACP measurement (FAST ACP).

In addition, the limit test is activated.

```
REM *************************************************************************

Public Sub ACP()

result$ = Space$(100)
'--------- R&S FMU default setting ----------------------------------------
CALL SetupStatusReg                           'Set status register
CALL IBWRT(analyzer%,"*RST")                  'Reset instrument
CALL IBWRT(analyzer%,"INIT:CONT OFF")         'Single sweep
CALL IBWRT(analyzer%,"SYST:DISP:UPD ON")      'ON: display on
                                              'OFF: off

'--------- Set frequency ----------------------------------------
CALL IBWRT(analyzer%,"FREQ:CENT 800MHz")        'Set frequency
'--------- Set level ----------------------------------------
CALL IBWRT(analyzer%,"DISP:WIND:TRAC:Y:RLEV 10dBm")    'Reference level

'--------- Example 1: Configure CP/ACP for CDMA  ---------------------------
CALL IBWRT(analyzer%,"CALC2:MARK:FUNC:POW:SEL ACP")    'ACP measurement on
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:POW:PRES F8CDMA") 'Select CDMA800 FWD
CALL IBWRT(analyzer%,"SENS:POW:ACH:ACP 2")      'Select 2 adjacent channels
CALL IBWRT(analyzer%,"SENS:POW:ACH:PRES ACP")   'Optimize settings
CALL IBWRT(analyzer%,"SENS:POW:ACH:PRES:RLEV")  'Optimize reference level
CALL IBWRT(analyzer%,"SENS:POW:ACH:MODE ABS")   'Absolute measurement
CALL IBWRT(analyzer%,"SENS:POW:HSP ON")         'Fast ACP measurement
'--------- Perform measurement and query results -------------------------
CALL IBWRT(analyzer%,"INIT;*WAI")               'Perform sweep with sync
CALL IBWRT(analyzer%,"CALC2:MARK:FUNC:POW:RES? ACP")   'Query result
CALL IBRD(analyzer%, result$)
'--------- Read out result -------------------------------------------------
Print "Result (CP, ACP low, ACP up, Alt low, Alt up): "
Print result$
```

```
'--------- Example 2: Configure CP/ACP manually for GSM  -------------------
result$ = Space$(100)
CALL IBWRT(analyzer%,"FREQ:CENT 935.2MHz")        'Set frequency
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:POW:SEL ACP")  'ACP measurement on
CALL IBWRT(analyzer%,"SENS:POW:ACH:ACP 1")          '1 adjacent channel
CALL IBWRT(analyzer%,"SENS:POW:ACH:BAND 200KHZ")     'Channel bandw. 200 kHz
CALL IBWRT(analyzer%,"SENS:POW:ACH:BAND:ACH 200KHZ")'Adjacent channel band-
                                                    'width 200 kHz
CALL IBWRT(analyzer%,"SENS:POW:ACH:SPAC 200KHZ")     'Channel spacing 200 kHz
CALL IBWRT(analyzer%,"SENS:POW:ACH:PRES ACP")   'Optimize settings
CALL IBWRT(analyzer%,"SENS:POW:ACH:PRES:RLEV")  'Optimize reference level
CALL IBWRT(analyzer%,"SENS:POW:ACH:MODE ABS")   'Absolute measurement
'--------- Start measurement and query result ----------------------------
CALL IBWRT(analyzer%,"INIT;*WAI")                 'Perform sweep with sync
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:POW:RES? ACP")    'Query result
CALL IBRD(analyzer%, result$)
'--------- Read out result -----------------------------------------------
Print "Result (CP, ACP low, ACP up): "
Print result$
'--------- Active limit check --------------------------------------------
result$ = Space$(100)
CALL IBWRT(analyzer%,"CALC:LIM:ACP:ACH 30DB, 30DB")    'Set relative limit
CALL IBWRT(analyzer%,"CALC:LIM:ACP:ACH:ABS −35DBM,−35DBM")
                                                    'Set absolute limit
CALL IBWRT(analyzer%,"CALC:LIM:ACP:ACH:STAT ON")       'Rel. limit check on
CALL IBWRT(analyzer%,"CALC:LIM:ACP:ACH:ABS:STAT ON")   'Abs. limit check on
CALL IBWRT(analyzer%,"CALC:LIM:ACP ON")                'Limit check on
'--------- Start measurement and query result ----------------------------
CALL IBWRT(analyzer%,"INIT;*WAI")                      'Perform sweep with
sync
CALL IBWRT(analyzer%,"CALC:LIM:ACP:ACH:RES?")          'Query result of
CALL IBRD(analyzer%, result$)                          'limit check
'--------- Read out result -----------------------------------------------
Print "Result Limit Check: ";result$
END SUB
REM ************************************************************************
```

Occupied Bandwidth Measurement

In the following example, the bandwidth is to be found in which 95% of the power of a GSM signal is contained. Signal frequency is 935,2 MHz; channel bandwidth is 200 kHz.

```
REM ***************************************************************************

Public Sub OBW()

result$ = Space$(100)
'--------- R&S FMU default setting ----------------------------------------
CALL SetupStatusReg                          'Set status register
CALL IBWRT(analyzer%,"*RST")                 'Reset instrument
CALL IBWRT(analyzer%,"INIT:CONT OFF")        'Single sweep
CALL IBWRT(analyzer%,"SYST:DISP:UPD ON")     'ON: display on
                                             'OFF: off

'--------- Configure R&S FMU for OBW for GSM  ------------------------------
CALL IBWRT(analyzer%,"FREQ:CENT 935.2MHz")        'Set frequency
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:POW:SEL OBW")  'OBW measurement on
CALL IBWRT(analyzer%,"SENS:POW:ACH:BAND 200KHZ")    'Channel bandw. 200 kHz
CALL IBWRT(analyzer%,"SENS:POW:BWID 95PCT")       'Percentage of power
CALL IBWRT(analyzer%,"SENS:POW:ACH:PRES OBW")     'Set frequency and
CALL IBWRT(analyzer%,"SENS:POW:ACH:PRES:RLEV")    'optimize reference level
CALL IBWRT(analyzer%,"SENS:POW:NCOR OFF")         'Noise correction
                                                  'OFF: switch off
                                                  'ON:  switch on

'--------- Perform measurement and query results --------------------------
CALL IBWRT(analyzer%,"INIT;*WAI")                 'Perform sweep with sync
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:POW:RES? OBW")    'Query result
CALL IBRD(analyzer%, result$)
Print result$
END SUB

REM ***************************************************************************
```

Time Domain Power Measurement

In the following example, the mean carrier power of a signal with 300 kHz bandwidth at 100 MHz is to be determined. In addition, the peak power, the rms value and the standard deviation are measured. To do this, the time-domain-power measurement functions are used.

```
REM ****************************************************************************

Public Sub TimeDomainPower()

result$ = Space$(100)

'--------- R&S FMU default setting ----------------------------------------

CALL SetupStatusReg                          'Set status register

CALL IBWRT(analyzer%,"*RST")                 'Reset instrument

CALL IBWRT(analyzer%,"INIT:CONT OFF")        'Single sweep

CALL IBWRT(analyzer%,"SYST:DISP:UPD ON")     'ON: display on
                                             'OFF: off

'--------- Configure R&S FMU for time domain power measurement ------------
CALL IBWRT(analyzer%,"FREQ:CENT 100MHz;SPAN 0Hz")   'Set frequency
CALL IBWRT(analyzer%,"BAND:RES 300kHz")             'Resolution bandwidth
CALL IBWRT(analyzer%,"SWE:TIME 200US")              'Sweep time

CALL IBWRT(analyzer%,"CALC:MARK:FUNC:SUMM:PPE ON")  'Peak measurement on
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:SUMM:MEAN ON") 'Mean measurement on
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:SUMM:RMS ON")  'RMS measurement on
CALL IBWRT(analyzer%,"CALC:MARK:FUNC:SUMM:SDEV ON") 'Standard deviation on

'------------------ Perform measurement and query results ----------------

CALL IBWRT(analyzer%,"INIT;*WAI")                    'Perform sweep with sync

                                                     'Query results:
query$ =           " CALC:MARK:FUNC:SUMM:PPE:RES?;"  'Peak measurement
query$ = query$ + ":CALC:MARK:FUNC:SUMM:MEAN:RES?;" 'Mean measurement
query$ = query$ + ":CALC:MARK:FUNC:SUMM:RMS:RES?;"  'RMS measurement
query$ = query$ + ":CALC:MARK:FUNC:SUMM:SDEV:RES?"  'Standard deviation
Call IBWRT(analyzer%, query$)

CALL IBRD(analyzer%, result$)

Print result$

END SUB

REM ****************************************************************************
```

Fast Power Measurement on Power Ramps

A frequent task in mobile radio tests is measurement of a DUT at various power control levels at the highest possible speed. The R&S FMU offers two test functions for this task, which can be used depending on the signal characteristics.

In the following, the two methods are presented by means of two examples.

Power Measurement with Multi-Summary Marker

The multi-summary marker function is suitable for measuring the power of a sequence of pulses with the following characteristics:

- The pulses occur at identical time intervals, which is typical of GSM transmission in slots, for example.
- The level of the first signal is reliably above threshold.
- The subsequent pulses may have any levels.

The function uses the first pulse as a trigger signal. The power of the subsequent pulses is determined exclusively via the timing pattern selected for the pulse sequence. The function is, therefore, suitable for adjustments where the DUT output power varies considerably and is not reliably above the trigger threshold.

The measurement accuracy is determined by the ratio of pulse duration to total measurement time; this should not be below 1:50.

The function always uses TRACE 1 of the selected screen.
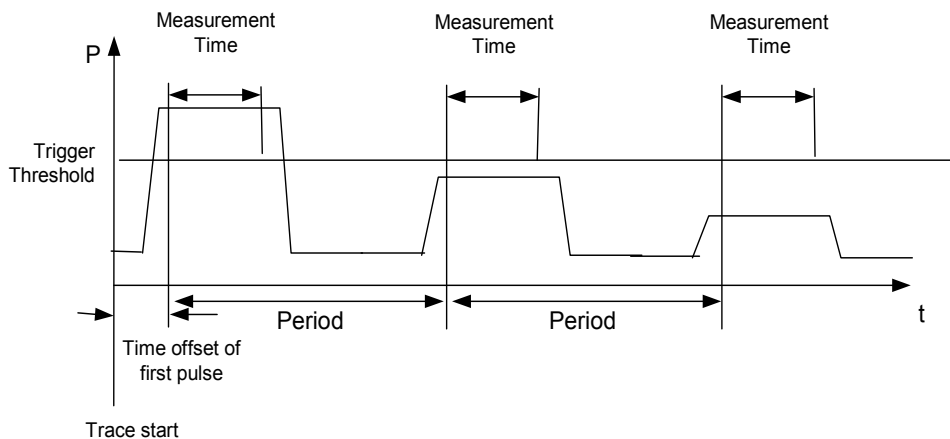
Fig. 7-1   Block diagram illustrating signal processing in analyzer

In the example below, a sequence of 8 pulses is measured with an offset of 50 µs of the first pulse, 450 µs measurement time/pulse and 576.9 µs pulse period.

```
REM ********************************************************************
Public Sub MultiSumMarker()

result$ = Space$(200)
'--------- R&S FMU default setting---------------------------------------
CALL SetupStatusReg                          'Configure status register
CALL IBWRT(analyzer%,"*RST")                 'Reset instrument
CALL IBWRT(analyzer%,"INIT:CONT OFF")        'Single sweep mode
CALL IBWRT(analyzer%,"SYST:DISP:UPD ON")     'ON:  switch display on
                                             'OFF: switch display off

'--------- Configure R&S FMU for power measurement in time domain ----------
CALL IBWRT(analyzer%,"FREQ:CENT 935.2MHz;SPAN 0Hz")   'Frequency setting

CALL IBWRT(analyzer%,"DISP:WIND:TRAC:Y:RLEV 10dBm")   'Set reference level
                                                      'to 10 dB

CALL IBWRT(analyzer%,"INP:ATT 30 dB")        'Set input attenuation
                                             'to 30 dB

CALL IBWRT(analyzer%,"BAND:RES 1MHz;VID 3MHz")  'Bandwidth setting

CALL IBWRT(analyzer%,"DET RMS")              'Select RMS detector

CALL IBWRT(analyzer%,"TRIG:SOUR VID")        'Trigger source: video
CALL IBWRT(analyzer%,"TRIG:LEV:VID 50 PCT")  'Trigger threshold: 50%

CALL IBWRT(analyzer%,"SWE:TIME 50ms")        'Sweep time ≥ 1 frame
'--------- Perform measurement and query results ------------------------
CALL IBWRT(analyzer%,"INIT;*WAI")            'Perform sweep with sync

                                             'Query results:

cmd$ = "CALC:MARK:FUNC:MSUM? "

cmd$ = cmd$ + "50US,"            'Offset of first pulse

cmd$ = cmd$ + "450US,"          'Measurement time

cmd$ = cmd$ + "576.9US,"        'Pulse period

cmd$ = cmd$ + "8"              'Number of bursts

CALL IBWRT(analyzer%,cmd$)

CALL IBRD(analyzer%, result$)                'Read results

Print result$

END SUB

REM ********************************************************************
```

Multi-Burst Power Measurement

The multi-burst power measurement function is suitable for measuring the power of a sequence of pulses with the following characteristics:

- The pulses occur at variable time intervals.
- The levels of all pulses of the sequence are reliably above the trigger threshold, or an external trigger signal is used.

The function requires one trigger event per pulse. This means that if the video trigger or the IF power trigger is used, the levels of all pulses must be above the trigger threshold.

The function is, therefore, particularly suitable for re-measuring DUTs already adjusted and whose output power is within the specified range. The measurement is optimized for minimum overhead relative to the actual measurement time.
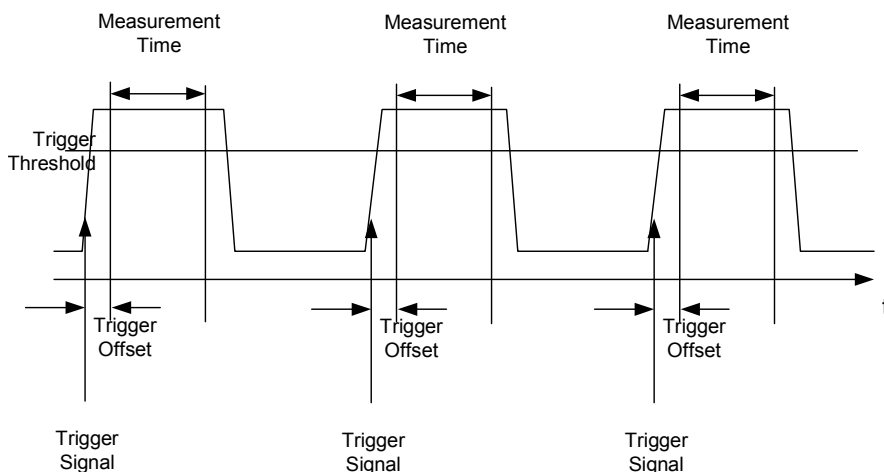
Fig. 7-2   Block diagram illustrating signal processing in analyzer

Either the root-mean-square power or the peak power is measured, depending on whether the RMS detector or the PEAK detector is selected. The function always uses TRACE 1 of the selected screen.

The following parameters are to be set for this measurement:
- Analyzer frequency
- Resolution bandwidth
- Measurement time per single pulse
- Trigger source
- Trigger threshold
- Trigger offset
- Type of power measurement (PEAK, MEAN)
- Number of pulses to be measured

During the measurement, each pulse is mapped into a pixel of the screen, i.e. any change of the trace can be detected only at the left-hand edge of the screen. Maximum measurement speed is as usual achieved with the display switched off.

In the example below, a GSM pulse sequence of 8 pulses is measured with 5 µs trigger offset, 434 µs measurement time/pulse, video trigger with 50% trigger threshold, and peak detection:

```
REM ***********************************************************************
Public Sub MultiBurstPower()

result$ = Space$(200)
'--------- R&S FMU default setting -----------------------------------------
CALL SetupStatusReg                           'Configure status register
CALL IBWRT(analyzer%,"*RST")                   'Reset instrument
CALL IBWRT(analyzer%,"INIT:CONT OFF")          'Single sweep mode
CALL IBWRT(analyzer%,"SYST:DISP:UPD OFF")      'OFF: display off
'--------- Perform measurement and query results ---------------------
cmd$ = "MPOW? "
cmd$ = cmd$ + "935.2 MHZ,"        'Center frequency
cmd$ = cmd$ + "1MHZ,"            'Resolution bandwidth
cmd$ = cmd$ + "434US,"           'Measurement time
cmd$ = cmd$ + "VID,"             'Trigger source
cmd$ = cmd$ + "50PCT,"           'Trigger threshold
cmd$ = cmd$ + "1US,"             'Trigger offset, must be > 125 ns
cmd$ = cmd$ + "PEAK,"            'Peak detector
cmd$ = cmd$ + "8"               'Number of bursts
CALL IBWRT(analyzer%, cmd$)
CALL IBRD(analyzer%, result$)               'Read results
Print result$
END SUB
REM ***********************************************************************
```

Fast Level Measurement Using Frequency Lists

A typical task for the R&S FMU is power measurement at a number of frequency points, e.g. at multiples of the fundamental (harmonics measurement), or at frequencies defined by a mobile radio standard (e.g. spectrum due to transients at ± 200 kHz, ± 400 kHz, etc about the carrier frequency of a GSM signal). In many cases, different level and/or bandwidth settings are required for the different frequency points to match the channel spacing and meet the requirements of dynamic range.

Especially for this application, the R&S FMU offers a number of remote-control functions (commands available in SENSe:LIST subsystem) that allow level measurement based on a frequency list with different instrument settings assigned to different frequencies. Not only the frequency list can be programmed, but also the measurement types (PEAK, RMS, AVG) to be performed simultaneously can be selected.

The example below describes a harmonics measurement on a dual-band amplifier. The harmonics level in general decreases as the frequency increases. To boost measurement sensitivity, therefore, the reference level is lowered by 10 dB from the third harmonic.

The following settings are used:

Reference level: 10.00 dBm up to 2nd harmonic, 0 dBm from 3rd harmonic
RF attenuation: 20 dB
Electronic attenuation: 0 dB
RBW: 1 MHz
VBW: 3 MHz
Filter type: NORMal
Measurement time: 300 μs
Trigger delay: 100 μs
Trigger: video, 45 %

Frequency	Type
935.2 MHz	GSM 900 fundamental
1805.2 MHz	GSM 1800 fundamental
1870.4 MHz	GSM 900 2nd harmonic
2805.6 MHz	GSM 900 3rd harmonic
3610.4 MHz	GSM 1800 2nd harmonic
3740.8 MHz	GSM 900 4th harmonic
5815.6 MHz	GSM 1800 3rd Harmonic

The frequencies are selected in ascending order to minimize system-inherent waiting times resulting from frequency changes.

At each frequency point the peak power and the rms power are measured. The peak power and the rms power values are stored alternately in the results memory.

```
REM ************************************************************************
Public Sub FrequencyList()

result$ = Space$(500)
'--------- R&S FMU default setting ------------------------------------------
CALL SetupStatusReg                          'Configure status register
CALL IBWRT(analyzer%,"*RST")                 'Reset instrument
CALL IBWRT(analyzer%,"INIT:CONT OFF")        'Single sweep mode
CALL IBWRT(analyzer%,"SYST:DISP:UPD OFF")    'Display off
'---------Configure R&S FMU for power measurement based on frequency list --
Call IBWRT(analyzer%, "TRIG:LEV:VID 45PCT")  'Video trigger threshold
Call IBWRT(analyzer%, "LIST:POWer:SET ON,ON,OFF,VID,POS,100us,0")
'--------- Perform measurement and query results --------------------------
cmd$ = "LIST:POWer? "
cmd$ = cmd$ + "935.2MHZ,10dBm,20dB,OFF,NORM,1MHz,3MHz,300us,0,"
cmd$ = cmd$ + "1805.2MHZ,10dBm,20dB,OFF,NORM,1MHz,3MHz,300us,0,"
cmd$ = cmd$ + "1870.4MHZ,10dBm,20dB,OFF,NORM,1MHz,3MHz,300us,0,"
cmd$ = cmd$ + "2805.6MHZ,0dBm,20dB,OFF,NORM,1MHz,3MHz,300us,0,"
cmd$ = cmd$ + "3610.4MHz,10dBm,20dB,OFF,NORM,1MHz,3MHz,300us,0,"
cmd$ = cmd$ + "3740.8MHz,0dBm,20dB,OFF,NORM,1MHz,3MHz,300us,0,"
cmd$ = cmd$ + "5815.6MHz,0dBm,20dB,OFF,NORM,1MHz,3MHz,300us,0"
Call IBWRT(analyzer%, cmd$)
Call IBRD(analyzer%, result$)
Print result$
END SUB
REM ************************************************************************
```

Level Correction of Transducers (Definition of Transducer Factors)

In more complex test systems, the frequency response of the test setup must be taken into account in all power measurements to avoid any measurement errors being introduced from sources other than the DUT.

The R&S FMU offers the possibility of defining a frequency-dependent attenuation correction factor (transducer factor).

In the example below, a factor with the following characteristics is defined:

Name: Transtest
Unit: dB
Scaling: lin
Comment: simulated cable correction

Frequency	Level
10 MHz	0 dB
100 MHz	3 dB
1 GHz	7 dB
3 GHz	10 dB

The factor is defined and can be activated as required.

```
REM ********************************************************************

Public Sub TransducerFactor()


'--------- Define transducer factor -------------------------------------

CALL IBWRT(analyzer%,"CORR:TRAN:SEL 'TRANSTEST'")
                                        'Define "Transtest"
                                        'transducer factor

CALL IBWRT(analyzer%,"CORR:TRAN:UNIT 'DB'") 'Unit 'dB'

CALL IBWRT(analyzer%,"CORR:TRAN:SCAL LIN")  'Linear frequency axis

CALL IBWRT(analyzer%,"CORR:TRAN:COMM 'Simulated cable correction'")

cmd$ = "CORR:TRAN:DATA "                 'Enter frequency and level
cmd$ = cmd$ + "10MHz, 0,"                'values. Level values without
cmd$ = cmd$ + "100MHz, 3,"               'unit!
cmd$ = cmd$ + "1GHz, 7,"
cmd$ = cmd$ + "3GHz, 10"

CALL IBWRT(analyzer%,cmd$)               'Enter frequency and level values

'--------- Activate transducer -------------------------------------

CALL IBWRT(analyzer%,"CORR:TRAN:STAT ON")  'Activate transducer factor

END SUB

REM ********************************************************************




'--------- Read out in binary format -------------------------------------

Call ibwrt(analyzer%, "FORMAT REAL,32")     'Select binary format

Call ibwrt(analyzer%, "TRAC1? TRACE1")      'Read out trace 1

Call ilrd(analyzer%, result$, 2)            'Read out and store
digits = Val(Mid$(result$, 2, 1))          'number of digits of
                                           'length information
result$ = Space$(100)                      'Initialize buffer again
```

```
Call ilrd(analyzer%, result$, digits)        'Read out
traceBytes = Val(Left$(result$, digits))     'and store length information

Call ibrd32(analyzer%, traceData(0), traceBytes) 'Read trace data into buffer

Call ilrd(analyzer%, result$, 1)             'Read the terminator <NL>

'--------- Read out binary data as pairs of frequency/level values ---------

traceValues = traceBytes/4                   'Single precision = 4 bytes

stepsize = span/traceValues                  'Calculate frequency step width

For i = 0 To traceValues - 1

  Print "Value["; i; "] = "; startFreq+stepsize*i; ", "; traceData(i)

Next i

'--------- Time domain default setting --------------------------------

Call ibwrt(analyzer%,"FREQ:SPAN 0Hz")        Switchover to time domain

CALL IBWRT(analyzer%,"INIT;*WAI")            'Perform sweep with sync

'--------- Read out in ASCII format -----------------------------------

Call ibwrt(analyzer%,"FORMAT ASCII")         'Select ASCII format

CALL ibwrt(analyzer%,"TRAC1? TRACE1")        'Read out Trace 1
CALL ibrd(analyzer%, asciiResult$)

Print "Contents of Trace1: ",asciiResult$    'Output

END SUB

REM *******************************************************************
```

Measuring the Magnitude and Phase of a Signal (I/Q Data Acquisition)

Due to the R&S FMU's internal architecture, it is capable of measuring and outputting the magnitude and phase of a signal in addition to its power values. This opens up a variety of possibilities for more in-depth analysis (FFT, demodulation, etc).

Fig. 7-3 shows the analyzer hardware from the IF to the processor. The IF filter is the resolution filter of the spectrum analyzer and can be set between 300 kHz and 50 MHz. The A/D converter samples the IF (20.4 MHz) at 64 MHz (spectrum analysis) or 81.6 MHz (signal analysis).

Lowpass filtering and reduction of the sampling rate follow the downconversion to the complex baseband. The output sampling rate is set as continuous between 10 kHz and 81.6 MHz during signal analysis. This prevents superfluous oversampling at narrow bandwidths, which reduces computation time and increases the maximum recording time. In spectrum analysis, the output sampling rate is 32 MHz.

The I/Q data is stored in memory areas that each contain 16 M words. The data can then be read out from these areas in blocks that are 512 k words each. Hardware triggering controls the memory.
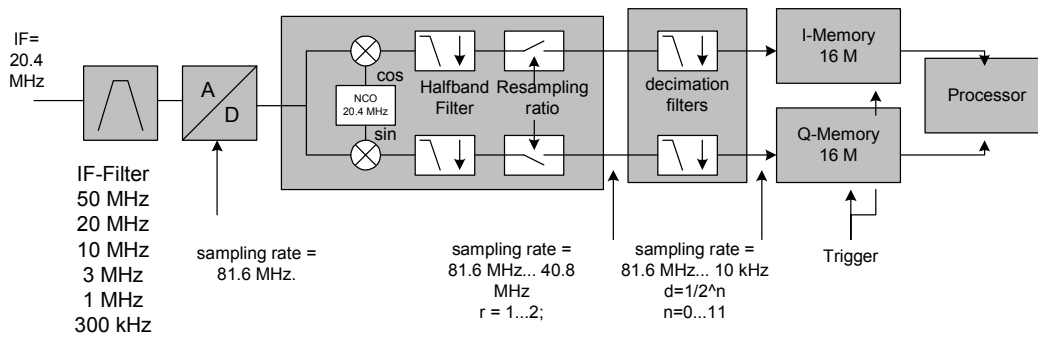
Fig. 7-3   Block diagram illustrating signal processing in the analyzer

The following maximum bandwidths are possible in this measurement depending on the selected sampling rate:

Sample rate (from)	Sample rate (to)	Max. bandwidth	Notes
81.6 MHz	40.8 MHz	30 MHz	Half band filter for the half sampling rate (81.6 MHz)
40.8 MHz	20.4 MHz	0.68 sampling rate	
20.4 MHz	10.2 MHz	0.8 sampling rate	
10.2 MHz	5.1 MHz	0.8 sampling rate	
5.1 MHz	2.55 MHz	0.8 sampling rate	
2.55 MHz	1.275 MHz	0.8 sampling rate	
1.275 MHz	0.6375 MHz	0.8 sampling rate	
0.6375 MHz	318.75 kHz	0.8 sampling rate	
318.75 kHz	159.375 kHz	0.8 sampling rate	
159.375 kHz	79.6875 kHz	0.8 sampling rate	
79.6875 kHz	39.84375 kHz	0.8 sampling rate	
39.84375 kHz	19.921875 kHz	0.8 sampling rate	
19.921875 kHz	10 kHz	0.8 sampling rate	

Due to the sampling concept of the R&S FMU (21.4 MHz IF, 32 MHz sampling rate), the image frequency is band-limited only by the analog 10 MHz filter. For an input signal at the limit of the 10 MHz band (+ 5 MHz above center frequency), an image-frequency signal 800 kHz above the input signal would be obtained.

The following example shows the steps necessary to collect data at a predefined sampling rate and read it from the I/Q memory.

Data is output in the form of voltage values referred to the analyzer input. Data can be read in binary or ASCII format.

In binary format, the length information carried in the message header is evaluated and used for calculating the x axis values.

In ASCII format, only a list of voltage values is output.

Binary data is read in three steps:

1. The number of digits carrying the length information is read.

2. The length information itself is read.

3. The trace data is read.

This procedure is necessary with programming languages like Visual Basic which support only structures of identical data types (arrays), whereas the binary data format uses different data types in the header and the data section.

Note: *The arrays for measured data are dynamically dimensioned to allow the example to be easily adapted to individual requirements.*

```
Rem *******************************************************************

Public Sub ReadIQData()


'--------- Create variables ------------------------------------------

Dim IData() As Single ' I values as single floats

Dim QData() As Single ' Q values as single floats



Dim digits As Byte     'No. of digits as length information

Dim IQBytes As Long    'Length of trace data in bytes

Dim IQSamples As Long 'No. of trace data in SamplesDim LastSize As Long
'Length of last block in bytes

Const BlockSize = 524288  'Block size in R&S FMU, as per manual

result$ = Space$(100)      'Buffer for simple results

'--------- R&S FMU default setting -----------------------------------

Call SetupInstrument     'Default setting

'Activate I/Q data acquisition mode; must be done before TRAC:IQ:SET!

Call ibwrt(analyzer%, "TRAC:IQ:STAT ON")


' Number of test points (800 000)
'   (max. test points allowed (= 16 * 1024 * 1024 - 512))
'   at RBW 50 MHz,
'   sample rate 80 MHz, trigger free run, pos. trigger edge
'   and 0 s trigger delay.

Call ibwrt(analyzer%, "TRAC:IQ:SET NORM,50MHz,80MHz,IMM,POS,0,800000")
```

```
'--------- Read-out in binary format -------------------------------------
--
Call ibwrt(analyzer%, "FORMAT REAL,32")     'Set binary format
Call ibwrt(analyzer%, "TRAC:IQ:DATA?")      'Meas. + read out I/Q data


' The data must be retrieved from device
' They have the following format:
' Example:
' "#42000"
'   |||||_____ Length of data in bytes
'   |_____ No. of digits as length

Call ilrd(analyzer%, result$, 2)            'Read and store length for
digits = Val(Mid$(result$, 2, 1))           'number of digits
result$ = Space$(100)                       'Re-initialize buffer
Call ilrd(analyzer%, result$, digits)       'Read length


' Total number of bytes that are read
IQBytes = Val(Left$(result$, digits))       'and store
' Total number of samples (I and Q) that are read
IQSamples = IQBytes / 8   '4 bytes each for I and Q samples


If IQBytes > 0 Then
  ' Dynamically create buffer for I/Q data
  ReDim IData(0 To IQSamples - 1)
  ReDim QData(0 To IQSamples - 1)
  ' "Blocks" with 512 k I/Q data each are read
  Blocks = (IQSamples - 1) \ BlockSize

  ' 0 or 1 block, each with "LastSize" I/Q data, is read
  LastSize = IQSamples - (Blocks * BlockSize)

  '  Entire blocks with 512 k samples each
  For Index = 0 To Blocks - 1
    ' Read I and Q data in buffer; index for I data counts samples
    ' Size of data for ibrd32 in bytes
    Call ibrd32(analyzer%, IData(Index * BlockSize), BlockSize * 4)
    Call ibrd32(analyzer%, QData(Index * BlockSize), BlockSize * 4)
  Next Index

  ' The last block (if any) with < 512 k data)
  If LastSize > 0 Then
```

```
    ' Read I/Q data; see above
    Call ibrd32(analyzer%, IData(Blocks * BlockSize), LastSize * 4)
    Call ibrd32(analyzer%, QData(Blocks * BlockSize), LastSize * 4)
  End If
End If


Call ilrd(analyzer%, result$, 1)          'Read in end character <NL>
Call ibwrt(analyzer%, "TRAC:IQ:STAT OFF") 'I/Q data acquisition mode
Call ibwrt(analyzer%, "DISP:WIND:Trac:Stat ON") ' Re-start screen
Call ibwrt(analyzer%, "INITiate:CONTinuous ON") ' continuous sweep on

'--------- Output of binary data as frequency/level pair ----------------
Open ".\traceiq.dat" For Output As #1    'Store in current directory
For i = 0 To IQSamples - 1
    Print #1, i; " ; "; Str(IData(i)); " ; "; Str(QData(i))
Next i
Close #1

End Sub
Rem ************************************************************************
```

Averaging I/Q Data

The R&S FMU has averaging capability also for I/Q measurements, i.e. I/Q data can be averaged over several test runs. This is subject to the following conditions:

1. An external trigger signal must be available for data measurement, and the trigger signal must be phase-locked to the signal measured.

2. The same reference-frequency signal must be used for the DUT and the R&S FMU.

3. The sampling rate must be 32 MHz, since only with this sampling frequency will the measurement be performed phase-synchronous with the trigger signal.

If all of the above conditions are fulfilled, no phase shift will occur between consecutive test runs. Phase shift may invalidate the measured average so that in extreme cases a value of 0 is obtained.

The default setting of the instrument for data measurement without averaging has to be changed as follows:

```
'--------- R&S FMU default setting ---------------------------------------
CALL SetupInstrument                        'Default setting
CALL IBWRT(analyzer%,"TRAC:IQ:STAT ON")     'Activate I/Q data acquisition
                                            'mode; this must be
                                            'done before TRAC:IQ:SET!
'Select max. number of test points (= 128 * 1024 – 512) at 10 MHz RBW,
'32 MHz sampling rate, external trigger, pos. trigger edge and 0 s trigger
'delay.
CALL IBWRT(analyzer%,"TRAC:IQ:SET NORM,10MHz,32MHz,EXT,POS,0,130560")
CALL IBWRT(analyzer%,"TRAC:IQ:AVER ON")       'Switch on I/Q averaging
CALL IBWRT(analyzer%,"TRAC:IQ:AVER:COUN 10") 'Set 10 test runs
'--------- Read data in binary format ------------------------------------
...
```

Reading and Writing Files

Reading a File from the Instrument

In the following example, file TEST1.SET stored under D:\USER\DATA is read from the instrument and stored in the controller.

```
REM ********************************************************************

Public Sub ReadFile()

'--------- Generate variables -----------------------------------------
Dim digits As Byte                        'Number of digits of
                                          'length information
Dim fileBytes As Long                     'Length of file with trace data
                                          'in bytes
result$ = Space$(100)                     'Buffer for simple results

'--------- Default setting of status register -------------------------
Call SetupStatusReg                       'Configure status register

'--------- Read out file ----------------------------------------------
Call ibwrt(analyzer%, "MMEM:DATA? 'D:\USER\DATA\TEST1.SET'")
                                          'Select file
Call ilrd(analyzer%, result$, 2)          'Read and store number of
digits = Val(Mid$(result$, 2, 1))         'digits of length information

Call ilrd(analyzer%, result$, digits)     'Read and store length
fileBytes = Val(Left$(result$, digits))   'information

FileBuffer$ = Space$(fileBytes)           'Buffer for file

Call ilrd(analyzer%, FileBuffer, fileBytes)  'Read file into buffer

Call ilrd(analyzer%, result$, 1)          'Read terminator <NL>

'--------- Store file to controller -----------------------------------
Open "TEST1.SET" For Output As #1

Print #1, FileBuffer;                     ' ; to avoid linefeed at
                                          '   end of file

Close #1

END SUB

REM ********************************************************************
```

Creating a File on the Instrument

In the following example, the TEST1.SET file available on the controller is stored in the instrument under D:\USER\DATA\DUPLICAT.SET.

```
REM ********************************************************************

Public Sub WriteFile()

'--------- Generate variables ----------------------------------------

FileBuffer$ = Space$(100000)              'Buffer for file
Dim digits As Long                        'Number of digits of
                                          'length information
Dim fileBytes As Long                     'Length of file in bytes
fileSize$ = Space$(100)                   'Length of file as a string

result$ = Space$(100)                     'Buffer for simple results

'--------- Default setting of status register ------------------------

Call SetupStatusReg                       'Configure status register

'--------- Prepare the definite length block data --------------------

fileBytes = FileLen("H:\work\vb\test1.set") 'Determine length of file
fileSize$ = Str$(fileBytes)

digits = Len(fileSize$) - 1               'Determine number of digits of
fileSize$ = Right$(fileSize$, digits)     'length information

FileBuffer$ = "#" + Right$(Str$(digits), 1) + fileSize$
                                          'Store length information in
                                          'file buffer

'--------- Read file from controller ---------------------------------

Open "H:\work\vb\TEST1.SET" For Binary As #1

FileBuffer$ = FileBuffer$ + Left$(Input(fileBytes, #1), fileBytes)

Close #1

'--------- Write file -------------------------------------------------

Call ibwrt(analyzer%, "SYST:COMM:GPIB:RTER EOI")     'Set receive
                                                     'terminator on the
                                                     'instrument

Call ibwrt(analyzer%, "MMEM:DATA 'D:\USER\DATA\DUPLICAT.SET'," +
        FileBuffer$)                                 'Select file

END SUB

REM ********************************************************************
```

Contents - Chapter 8 "Maintenance and Instrument Interfaces"

8 Maintenance and Instrument Interfaces

The R&S FMU following chapter contains information on the maintenance of the R&S FMU and on the instrument interfaces.

Please follow the instructions in the service manual when exchanging modules or ordering spares. The order no. for spare parts can be found in the service manual.

The address of our support center and a list of all Rohde & Schwarz service centers can be found at the beginning of this manual.

The service manual includes further information particularly on troubleshooting, repair, exchange of modules (including battery exchange, adjustment of the OCXO oscillator) and calibration.

Maintenance

Mechanical and Electrical Maintenance

The R&S FMU does not require any special maintenance. Remove any contamination on the instrument by means of a soft cloth. Make sure that the air vents are not obstructed.

Storing and Packing

The R&S FMU can be stored at a temperature of $-5\,°C$ to $+60\,°C$. When stored for an extended period of time the instrument should be protected against dust.

The original packing should be used, particularly the protective covers at the front and rear, when the instrument is to be transported or dispatched. If the original packing is no longer available, use a sturdy cardboard box of suitable size and carefully wrap the instrument to protect it against mechanical damage.

List of Power Cables Available

Table 8-1   List of power cables available

Stock No.	Earthed-contact connector	Preferably used in
DS 006.7013	BS1363: 1967' complying with IEC 83: 1975 standard B2	Great Britain
DS 006.7020	Type 12 complying with SEV-regulation 1011.1059, standard sheet S 24 507	Switzerland
DS 006.7036	Type 498 / 13 complying with US-regulation UL 498, or with IEC 83	USA / Canada
DS 006.7107	Type SAA3 10 A, 250 V, complying with AS C112-1964 Ap.	Australia
DS 0025.2365 DS 0099.1456	DIN 49 441, 10 A, 250 V, angular DIN 49 441, 10 A, 250 V, straight	Europe (except Switzerland)

Instrument Interfaces

Probe Connector (PROBE POWER)

To allow the connection of probes, the R&S FMU provides the PROBE POWER power connector. It delivers the power supply voltages +15 V and -12,6 V and ground.

The connector is also suited for powering the high-impedance probes from Agilent.

Pin	Signal
1	GND
2	-12.6 V; max 150 mA
3	+15 V; max 150 mA
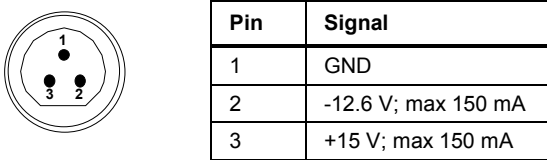
Fig. 8-1   Pin assignments of PROBE POWER connector

Probe Compensation Connector (PROBE COMPENSATION)

To align high-impedance 10:1 probes, the R&S FMU provides a Probe Compensation connector. A 1 V / 1 kHz square wave signal is output.

Probe Calibration Connector (PROBE CAL / PROBE $\overline{\text{CAL}}$)

The PROBE CAL BNC connector allows you to calibrate measurement cables and probes.
The output signal is adjustable:
- Precise DC voltage to calibrate attenuation and offset (adjustable from 0 to 2.4 V)
- Pulse (comb spectrum) to calibrate the frequency response (peak 1 V, frequency selectable from 10 kHz to 8 MHz)
- 1 kHz / 1V square wave suitable to align high-impedance 10:1 probes

The PROBE $\overline{\text{CAL}}$ connector supplies the inverted signal for the simultaneous calibration of two probes in a differential measurement.
The signals are adjusted automatically during probe calibration. In a test setup you can also adjust the signals manually (Probe Cal menu).

IEC Bus Interface

The standard instrument is equipped with an IEC/IEEE Bus connector. An IEEE 488 interface connector is located on the rear panel of the R&S FMU. An external controller for remote control of the instrument can be connected via the IEEE 488 interface connector using a shielded cable.

Interface Characteristics

- 8-bit parallel data transfer
- bi-directional data transfer
- three-line handshake
- high data transfer rate of max. 350 kbyte/s
- up to 15 instruments can be connected
- maximal length of the interconnecting cables 15 m (single connection, 2m)
- wired-OR connection if several instruments are connected in parallel.
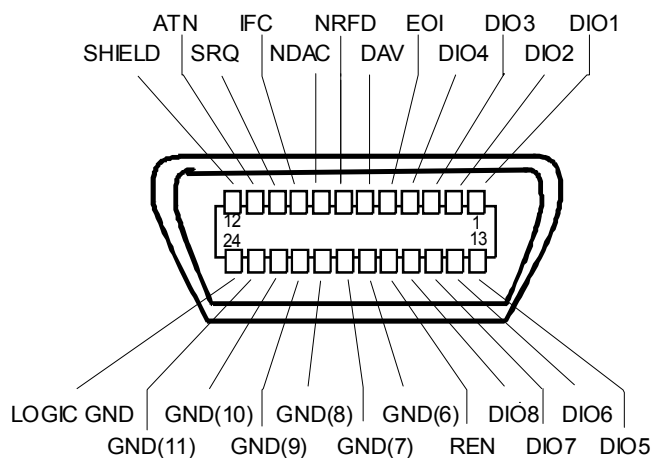
Fig. 8-2   Pin assignment of IEC-Bus interface

Bus Lines

1. Data bus with 8 lines DIO 1 to DIO 8.
The transmission is bit-parallel and byte-serial in the ASCII/ISO code. DIO1 is the least significant, DIO8 the most significant bit.

2. Control bus with 5 lines.
IFC (Interface Clear),
active low resets the interfaces of the devices connected to the default setting.

ATN (Attention),
active low signals the transmission of interface messages
inactive high signals the transmission of device messages.

SRQ (Service Request),
active low enables a device connected to send a service request to the controller.

REN (Remote Enable),
active low permits the switch over to remote control.

EOI (End or Identify),
has two functions in connection with ATN:
active low marks the end of data transmission when ATN=high
active low triggers a parallel poll when ATN=low.

3. Handshake bus with three lines.
DAV (Data Valid),
active low signals a valid data byte on the data bus.

NRFD (Not Ready For Data),
active low signals that one of the devices connected is not ready for data transfer .

NDAC (Not Data Accepted),
active low as long as the device connected is accepting the data present on the data bus.

Interface Functions

Instruments which can be remote controlled via the IEC bus can be equipped with different interface functions. Table 8-2 lists the interface functions appropriate for the instrument.

Table 8-2 Interface functions

Control character	Interface function
SH1	Handshake source function (source handshake), full capability
AH1	Handshake sink function (acceptor handshake), full capability
L4	Listener function, full capability, unaddress if MTA.
T6	Talker function, full capability, ability to respond to serial poll, unaddress if MLA
SR1	Service request function (Service Request), full capability
PP1	Parallel poll function, full capability
RL1	Remote/Local switch over function, full capability
DC1	Reset function (Device Clear), full capability
DT1	Trigger function (Device Trigger), full capability
C0	No controller function

IEC Bus Messages

The messages transferred via the data lines of the IEC bus can be divided into two groups:

– **interface messages**   and
– **instrument messages.**

Interface Messages

Interface messages are transferred on the data lines of the IEC Bus when the "ATN" control line is active (LOW). They are used for communication between controller and instruments and can only be sent by the controller which currently has control of the IEC Bus.

Universal Commands

The universal commands are encoded 10 - 1F hex. They affect all instruments connected to the bus without addressing.

Table 8-3   Universal Commands

Command	QuickBASIC command	Effect on the instrument
DCL (Device Clear)	IBCMD (controller%, CHR$(20))	Aborts the processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument settings.
IFC (Interface Clear)	IBSIC (controller%)	Resets the interfaces to the default setting.
LLO (Local Lockout)	IBCMD (controller%, CHR$(17))	The LOC/IEC ADDR key is disabled.
SPE (Serial Poll Enable)	IBCMD (controller%, CHR$(24))	Ready for serial poll.
SPD (Serial Poll Disable)	IBCMD (controller%, CHR$(25))	End of serial poll.
PPU (Parallel Poll Unconfigure)	IBCMD (controller%, CHR$(21))	End of the parallel-poll state.

Addressed Commands

The addressed commands are encoded 00 - 0F hex. They are only effective for instruments addressed as listeners.

Table 8-4   Addressed Commands

Command	QuickBASIC command	Effect on the instrument
SDC (Selected Device Clear)	IBCLR (device%)	Aborts the processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument setting.
GTL (Go to Local)	IBLOC (device%)	Transition to the "Local" state (manual control).
PPC (Parallel Poll Configure)	IBPPC (device%, data%)	Configure instrument for parallel poll. Additionally, the QuickBASIC command executes PPE/PPD.

Instrument Messages

Instrument messages are transferred on the data lines of the IEC bus when the "ATN" control line is not active. ASCII code is used.
Structure and syntax of the instrument messages are described in Chapter 5. The commands are listed and explained in detail in Chapter 6.

Printer Interface (LPT)

The 25-pin LPT connector on the rear panel of the Fig. 8-3 is provided for the connection of a printer. The LPT interface is compatible with the CENTRONICS printer interface.
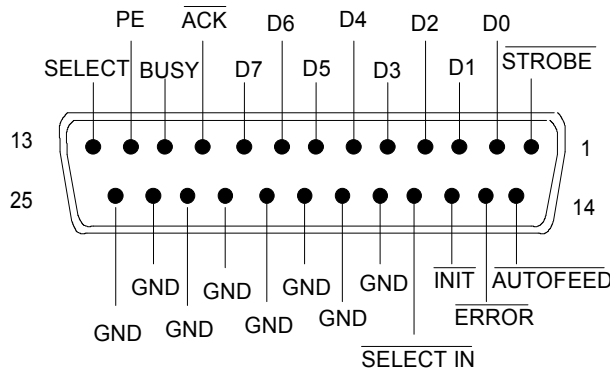
Pin	Signal	Input (I) Output (O)	Description
1	STROBE	O	Pulse for transmitting a data byte, min. 1µs pulse width (active LOW)
2	D0	O	Data Line 0
3	D1	O	Data Line 1
4	D2	O	Data Line 2
5	D3	O	Data Line 3
6	D4	O	Data Line 4
7	D5	O	Data Line 5
8	D6	O	Data Line 6
9	D7	O	Data Line 7
10	ACK	I	Indicates that the printer is ready to receive the next byte. (active LOW)
11	BUSY	I	Signal is active when the printer cannot accept data. (active HIGH)
12	PE	I	Signal is active when the paper tray is empty. (active HIGH)
13	SELECT	I	Signal is active when the printer is selected. (active HIGH)
14	AUTOFEED	O	When signal is active, the printer automatically performs a linefeed after each line. (active LOW)
15	ERROR	I	This signal is high when the printer has no paper, is not selected or has an error status. (active LOW)
16	INIT	O	Initialize the printer. (active LOW)
17	SELECT IN	O	If signal is active, the codes DC1/DC3 are ignored by the printer. (active LOW).
18 - 25	GND		Ground connection.

Fig. 8-3   Pin assignments for the LPT connector.

RS-232-C Interface (COM)

The standard R&S FMU is equipped with a serial interfaces (RS-232-C; COM connector at the rear of the instrument). The interface can be set up and activated manually in the *SETUP-GENERAL SETUP* menu in the *COM PORT* table (Selection *OWNER = INSTRUMENT*).

Interface Characteristics

- Serial data transmission in asynchronous mode
- Bi-directional data transfer via two separate lines
- Transmission rate selectable from 110 to 19200 baud
- Logic '0' signal from +3 V to +15 V
- Logic '1' signal from -15 V to -3 V
- An external instrument (controller) can be connected.
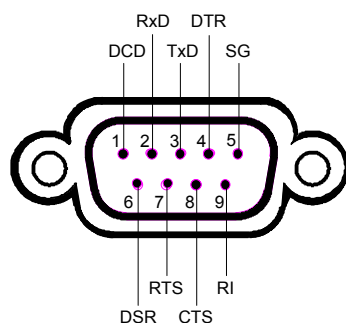
Fig. 8-4   Pin assignment of the RS-232-C interface

Signal Lines

DCD (Data Carrier Detect),
Not used in R&S FMU.
Input; active LOW.
Using this signal, the local terminal recognizes that the modem of the remote station receives valid signals with sufficient level. DCD is used to disable the receiver in the local terminal and prevent reading of false data if the modem cannot interpret the signals of the remote station.

RxD (Receive Data)
Input, LOW = logic '1', HIGH = logic '0'.
Data line, local terminal receives data from remote station.

TxD (Transmit Data)
Output, LOW = logic '1', HIGH = logic '0'.
Data line, local terminal transmits data to remote station.

DTR (Data Terminal Ready),
Output, active LOW,
Indicates that the local terminal is ready to receive data.

GND
Interface ground, connected to instrument ground

DSR (Data Set Ready),
  Input, active LOW,
  Indicates that the remote station is ready to receive data.

RTS (Request To Send),
  Output, active LOW.
  Indicates that the local terminal wants to transmit data.

CTS (Clear To Send),
  Input, active LOW.
  Used to tell the local terminal that the remote station is ready to receive data.

RI (Ring Indicator),
  Not used in R&S FMU.
  Input, active LOW.
  Used by a modem to indicate that a remote station wants to establish a connection.

Transmission Parameters

To ensure error-free data transmission, the parameters of the instrument and the controller must have the same settings. The parameters are defined in the *SETUP-GENERAL SETUP* menu.

Transmission rate (baud rate)	the following transmission rates can be set in the instrument: 110, 300, 600, 1200, 2400, 4800, 9600, 19200.
Data bits	Data transmission is in 7- or 8-bit ASCII code. The first bit transmitted is the LSB (least significant bit).
Start bit	Each data byte starts with a start bit. The falling edge of the start bit indicates the beginning of the data byte.
Parity bit	In order to detect errors, a parity bit may be transmitted. No parity, even parity or odd parity may be selected. In addition, the parity bit can be set to logic '0' or to logic '1'.
Stop bits	The transmission of a data byte is terminated by 1, 1,5 or 2 stop bits.

Example:
Transmission of character 'A' (41 hex) in 7-bit ASCII code,
with even parity and 2 stop bits:

| 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 |

Bit 01   Bit 02...08   Bit 09   Bit 10...11
Start bit   Data bits   Parity bit   Stop bits
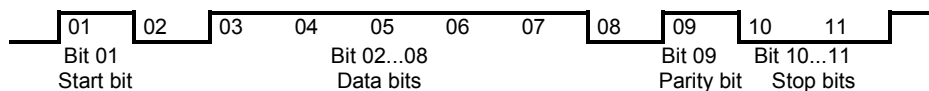
Control Characters

For interface control, several strings are defined and control characters are reserved which are based upon IEC Bus control.

Table 8-5 Control strings or control characters of the RS-232 interface

Control string or character	Function
'@REM'	Switch over to remote
'@LOC'	Switch over to local
'@SRQ'	Service Request SRQ (SRQ is sent by the instrument)
'@GET'	Group Execute Trigger (GET)
'@DCL'	Reset instrument (Device Clear DCL)
<Ctrl Q> 11 Hex	Enables character output / XON
<Ctrl S> 13 Hex	Inhibits character output / XOFF
0D Hex, 0A Hex	Terminator <CR>, <LF>

Handshake

Software handshake

In the software handshake mode of operation, the data transfer is controlled using the two control characters XON / XOFF.

The instrument uses the control character XON to indicate that it is ready to receive data. If the receive buffer is full, it sends the XOFF character via the interface to the controller. The controller then interrupts the data output until it receives another XON from the instrument. The controller indicates to the instrument that it is ready to receive data in the same way.

Cable required for software handshake

The connection of the instrument with a controller for software handshake is made by crossing the data lines. The following wiring diagram applies to a controller with a 9-pin or 25-pin configuration.

```
   Instrument              Controller         Instrument              Controller
   9-pin                   9-pin              9-pin                   25-pin

   1                       1                  1                       8
   2    -----------RxD / TxD------------- 3   2    -----------RxD / TxD-------------- 2
   3    -----------TxD / RxD------------- 2   3    -----------TxD / RxD-------------- 3
   4                       6                  4                       6
   5    -----------GND / GND------------- 5   5    -----------GND / GND------------- 7
   6                       4                  6                       20
   7                       8                  7                       5
   8                       7                  8                       4
   9                       9                  9                       22
```
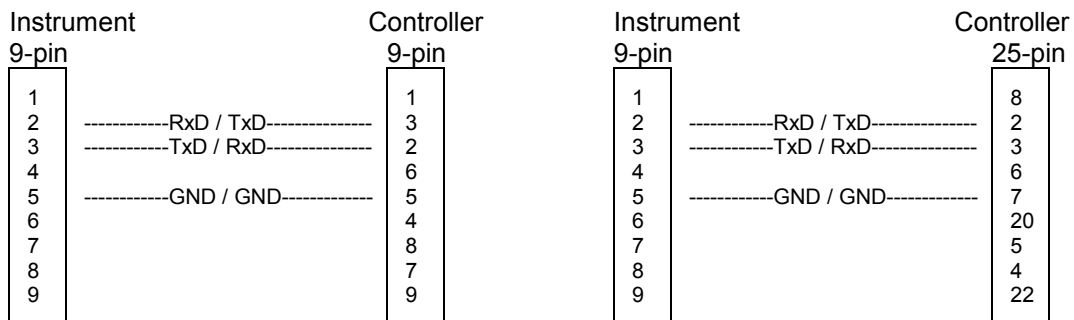
Fig. 8-5   Wiring of the data lines for software handshake

Hardware handshake

For hardware handshake, the instrument indicates that it is ready to receive data via the lines DTR and RTS. A logic '0' on both lines means 'ready' and a logic '1' means 'not ready'. The RTS line is always active (logic '0') as long as the serial interface is switched on. The DTR line thus controls the readiness of the instrument to receive data.

The readiness of the remote station to receive data is reported to the instrument via the CTS and DSR line. A logic '0' on both lines activates the data output and a logic '1' on both lines stops the data output of the instrument. The data output takes place via the TxD line.

Cable for hardware handshake

The connection of the instrument to a controller is made with a so-called zero modem cable. Here, the data, control and acknowledge lines must be crossed. The following wiring diagram applies to a controller with a 9-pin or 25-pin configuration.

```
   Instrument              Controller          Instrument              Controller
    9-pin                    9-pin               9-pin                    25-pin

 ┌──────┐                  ┌──────┐           ┌──────┐                  ┌──────┐
 │  1   │                  │  1   │           │  1   │                  │  8   │
 │  2   │----------RxD / TxD------------│  3   │           │  2   │----------RxD / TxD------------│  2   │
 │  3   │----------TxD / RxD------------│  2   │           │  3   │----------TxD / RxD------------│  3   │
 │  4   │----------DTR /DSR-------------│  6   │           │  4   │----------DTR /DSR-------------│  6   │
 │  5   │----------GND / GND------------│  5   │           │  5   │----------GND / GND------------│  7   │
 │  6   │----------DSR / DTR------------│  4   │           │  6   │----------DSR / DTR------------│ 20   │
 │  7   │----------RTS / CTS------------│  8   │           │  7   │----------RTS / CTS------------│  5   │
 │  8   │----------CTS / RTS------------│  7   │           │  8   │----------CTS / RTS------------│  4   │
 │  9   │                  │  9   │           │  9   │                  │ 22   │
 └──────┘                  └──────┘           └──────┘                  └──────┘
```
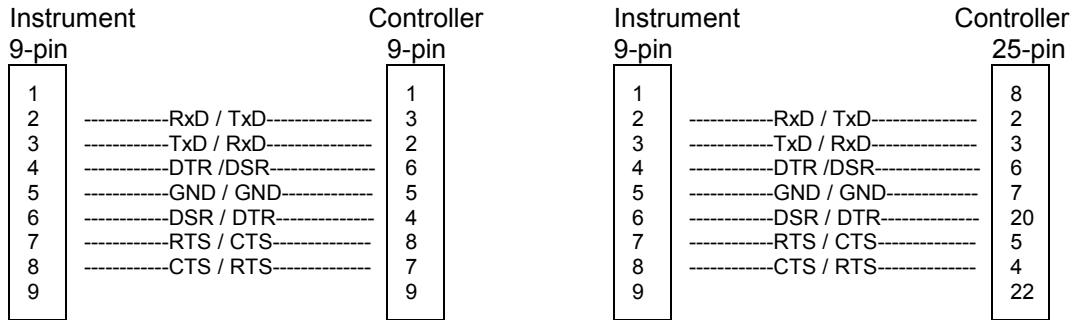
Fig. 8-6   Wiring of the data, control and acknowledge lines for hardware handshake

The configuration of the user ports takes place in the *SETUP* menu (SETUP key) in the *GENERAL SETUP* sub-menu.

Monitor Connector (MONITOR)

Pin	Signal	Pin	Signal	Pin	Signal
1	R	6	GND	11	(NC)
2	G	7	GND	12	(NC)
3	B	8	GND	13	HSYNC
4	(NC)	9	GND	14	VSYNC
5	GND	10	GND	15	(NC)
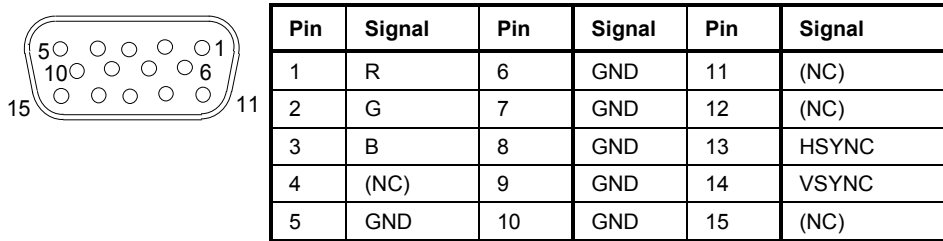
Fig. 8-7   Pin assignments of the MONITOR connector.

External Trigger Input (EXT TRIG)

The EXT TRIG connector is used for controlling the measurement via an external signal. The trigger level can be set from 0.5 V to 3.5 V. The default value 1.4 V is suitable for TTL signals. Typical input impedance is 10 kOhm.

Mouse Connector (MOUSE)

A PS/2 connector is provided at the rear panel to connect a PS/2 mouse:
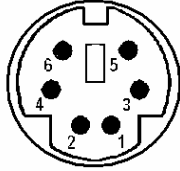
Pin	Signal
1	MOUSEDATA
2	KEYBOARDDATA
3	MOUSEGND
4	MOUSEVD5
5	MOUSECLK
6	KEYBOARDCLK

Fig 8-8   Pin assignments for the MOUSE connector.

USB Connector (USB ⇔)

Two USB dual connectors are provided, one at the rear panel and one at the front panel of the R&S FMU. These USB connectors are used to connect up to four USB devices at a time.

USB connector	Standard
Front panel, both connectors	USB 2.0
Rear panal upper connector	USB 1.1
Rear panal lower connector	USB 2.0
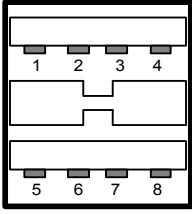
Pin	Signal
1	+ 5 V USB0
2	USBDATA0 -
3	USBDATA0 +
4	GND
5	+ 5 V USB1
6	USBDATA1 -
7	USBDATA1 +
8	GND

Fig. 8-9   USB connector assignment

Note: *Passive USB connection cables should not be longer than 1 m.*

Reference Output/Input (REF IN and REF OUT)

For operation with an external reference, the internal reference oscillator is then synchronized to the 10-MHz reference applied to the connector. The necessary level is > 0 dBm.

The internal 10 MHz reference signal is also available at the REF OUT connector and thus provides the capability of, e.g., synchronization of external instruments to the R&S FMU. The output level is typ. +10 dBm.

Selection between internal and external reference is possible in the *SETUP* menu.

LAN Interface

The the LAN interface allows the instrument to be connected to local networks. The pin assignment of the RJ45 connector supports double-paired category 5 UTP/STP cables in star configuration. (UTP means unshielded twisted pair, and STP stands for shielded twisted pair).

Contents - Chapter 9 "Error Messages"

9 Error Messages

Error messages are entered in the error/event queue of the status reporting system in the remote control mode and can be queried with the command `SYSTem:ERRor?`. The answer format of R&S FMU to the command is as follows:

<error code>, "<error text with queue query>;
<remote control command concerned>"

The indication of the remote control command with prefixed semicolon is optional.

Example:

The command "`TEST:COMMAND`" generates the following answer to the query `SYSTem:ERRor?` :

-113,"Undefined header;TEST:COMMAND"

The subsequent list contains the description of error texts displayed on the instrument.

Distinction is made between error messages defined by SCPI, which are marked by negative error codes, and the device-specific error messages for which positive error codes are used.

The right-hand column in the following tables contains the error text in bold which is entered in the error/event queue and can be read out by means of query `SYSTem:ERRor?`. A short explanation of the error cause is given below. The left-hand column contains the associated error code.

SCPI-Specific Error Messages

No Error

Error code	Error text in the case of queue poll Error explanation
0	**No error** This message is output if the error queue does not contain any entries.

Command Error - Faulty command; sets bit 5 in the ESR register.

Error code	Error text in the case of queue poll Error explanation
-100	**Command Error** The command is faulty or invalid.
-101	**Invalid Character** The command contains an invalid sign. Example: A header contains an ampersand, `"SENSe&"`.
-102	**Syntax error** The command is invalid. Example: The command contains block data the instrument does not accept.
-103	**Invalid separator** The command contains an imallowed sign instead of a separator. Example: A semicolon is missing after the command.
-104	**Data type error** The command contains an invalid value indication. Example: ON is indicated instead of a numeric value for frequency setting.
-105	**GET not allowed** A Group Execute Trigger (GET) is within a command line.
-108	**Parameter not allowed** The command contains too many parameters. Example: Command `SENSe:FREQuency:CENTer` permits only one frequency indication.

Continuation: Command Error

Error code	Error text in the case of queue poll Error explanation
-109	**Missing parameter** The command contains too few parameters. Example: The command `SENSe:FREQuency:CENTer` requires a frequency indication.
-110	**Command header error** The header of the command is faulty.
-111	**Header separator error** The header contains an imallowed separator. Example: the header is not followed by a "White Space", "`*ESE255`"
-112	**Program mnemonic too long** The header contains more than 12 characters.
-113	**Undefined header** The header is not defined for the instrument. Example: `*XYZ` is undefined for every instrument.
-114	**Header suffix out of range** The header contains an imallowed numeric suffix. Example: `SENSe3` does not exist in the instrument.
-120	**Numeric data error** The command contains a faulty numeric parameter.
-121	**Invalid character in number** A number contains an invalid character. Example: An "A" in a decimal number or a "9" in an octal number.
-123	**Exponent too large** The absolute value of the exponent is greater than 32000.
-124	**Too many digits** The number includes too many digits.
-128	**Numeric data not allowed** The command includes a number which is not allowed at this position. Example: The command `INPut:COUPling` requires indication of a text parameter.
-130	**Suffix error** The command contains a faulty suffix.
-131	**Invalid suffix** The suffix is invalid for this instrument. Example: nHz is not defined.
-134	**Suffix too long** The suffix contains more than 12 characters.
-138	**Suffix not allowed** A suffix is not allowed for this command or at this position of the command. Example: The command `*RCL` does not permit a suffix to be indicated.
-140	**Character data error** The command contains a faulty text parameter
-141	**Invalid character data** The text parameter either contains an invalid character or it is invalid for this command. Example: Write error with parameter indication;`INPut:IQ:TYPE XIQ.`

Continuation: Command Error

Error code	Error text in the case of queue poll Error explanation
-144	**Character data too long** The text parameter contains more than 12 characters.
-148	**Character data not allowed** The text parameter is not allowed for this command or at this position of the command. Example: The command `*RCL` requires a number to be indicated.
-150	**String data error** The command contains a faulty string.
-151	**Invalid string data** The command contains a faulty string. Example: An END message has been received prior to the terminating apostrophe.
-158	**String data not allowed** The command contains a valid string at a position which is not allowed. Example: A text parameter is set in quotation marks, `INPut:IQ:TYPE "IQ"`
-160	**Block data error** The command contains faulty block data.
-161	**Invalid block data** The command contains faulty block data. Example: An END message was received prior to reception of the expected number of data.
-168	**Block data not allowed** The command contains valid block data at an imallowed position. Example: The command `*RCL` requires a number to be indicated.
-170	**Expression error** The command contains an invalid mathematical expression.
-171	**Invalid expression** The command contains an invalid mathematical expression. Example: The expression contains mismatching parentheses.
-178	**Expression data not allowed** The command contains a mathematical expression at an imallowed position.

Execution Error - Error on execution of a command; sets bit 4 in the ESR register

Error code	Error text in the case of queue poll Error explanation
-200	**Execution error** Error on execution of the command.
-201	**Invalid while in local** The command is not executable while the device is in local due to a hard local control. Example: The device receives a command which would change the rotary knob state, but the device is in local so the command can not be executed.
-202	**Settings lost due to rtl** A setting associated with hard local control was lost when the device changed to LOCS from REMS or to LWLS from RWLS.
-210	**Trigger error** Error on triggering the device.
-211	**Trigger ignored** The trigger (GET, *TRG or trigger signal) was ignored because of device timing considerations. Example: The device was not ready to respond.
-212	**Arm ignored** An arming signal was ignored by the device.
-213	**Init ignored** Measurement initialisation was ignored as another measurement was already in progress.
-214	**Trigger deadlock** The trigger source for the initiation of measurement is set to GET and subsequent measurement is received. The measurement cannot be started until a GET is received, but the GET would cause an interrupted-error)
-215	**Arm deadlock** The trigger source for the initiation of measurement is set to GET and subsequent measurement is received. The measurement cannot be started until a GET is received, but the GET would cause an interrupted-error.
-220	**Parameter error** The command contains a faulty or invalid parameter.
-221	**Settings conflict** There is a conflict between setting of parameter value and instrument state.
-222	**Data out of range** The parameter value lies out of the allowed range of the instrument.
-223	**Too much data** The command contains too many data. Example: The instrument does not have sufficient storage space.

Continuation: Execution Error

Error code	Error text in the case of queue poll Error explanation
-230	**Data corrupt or stale** The data are incomplete or invalid. Example: The instrument has aborted a measurement.
-231	**Data questionable** The measurement accuracy is suspect.
-240	**Hardware error** The command cannot be executed due to problems with the instrument hardware.
-241	**Hardware missing** Hardware is missing. Example: An option is not fitted.
-250	**Mass storage error** A mass storage error occured.
-251	**Missing mass storage** The mass storage is missing. Example: An option is not installed.
-252	**Missing media** The media is missing. Example: There is no floppy in the floppy disk drive.
-253	**Corrupt media** The media is corrupt. Example: The floppy is bad or has the wrong format.
-254	**Media full** The media is full. Example: There is no room on the floppy.
-255	**Directory full** The media directory is full.
-256	**File name not found** The file name cannot be found on the media.
-257	**File name error** The file name is wrong. Example: An attempt is made to copy to a duplicate file name.
-258	**Media protected** The media is protected. Example: The write-protect tab on the floppy is present.
-260	**Expression error** The expression contains an error.

Device Specific Error; sets bit 3 in the ESR register

Error code	Error test in the case of queue poll Error explanation
-300	**Device-specific error** R&S FMU-specific error not defined in greater detail.
-310	**System error** This error message suggests an error within the instrument. Please inform the R&S Service.
-313	**Calibration memory lost** Loss of the non-volatile data stored using the *CAL? command. This error occurs when the correction data recording has failed.
-330	**Self-test failed** The selftest could not be executed.
-350	**Queue overflow** This error code is entered in the queue instead of the actual error code if the queue is full. It indicates that an error has occurred but not been accepted. The queue can accept 5 entries.

Query Error - Error in data request; sets bit 2 in the ESR register

Error code	Error text in the case of queue poll Error explanation
-400	**Query error** General error occurring when data are requested by a query.
-410	**Query INTERRUPTED** The query has been interrupted. Example: After a query, the instrument receives new data before the response has been sent completely.
-420	**Query UNTERMINATED** The query is incomplete. Example: The instrument is addressed as a talker and receives incomplete data.
-430	**Query DEADLOCKED** The query cannot be processed. Example: The input and output buffers are full, the instrument cannot continue operation.
-440	**Query UNTERMINATED after indefinite response** A query is in the same command line after a query which requests an indefinite response.

Device-Specific Messages

Error code	Error text in the case of queue poll Error explanation
2022	**OPTIONS.INI invalid** This message is output when an error has been recognized in the file OPTIONS.INI which contains the clearing codes for retrofitable firmware applications. If this file is not correctly recognized, all firmware applications are blocked for this instrument.
2033	**Printer Not Available** This message is output when the selected printer is not included in the list of available output devices. A possible cause is that the required printer driver is missing or incorrectly installed.
2034	**CPU Temperature is too high** This message is output when the temperature of the processor exceeds 70 °C.

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.