ROHDE&SCHWARZ

Test and Measurement
Division

Operating Manual

OPTION: SIGNAL VECTOR ANALYSIS FOR SPECTRUM ANALYZER FSE

FSE-B7

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Contents

Index

Data sheet

Page

Remote Control is described in the operating manual for the corresponding instrument

Page

Index

I

K

L

M

N

O

P

Q

R

S

T

U

V

W

1 Preparation for Use

1.1 Introduction

This manual is an extension to the FSE manual and describes exclusively vector analysis functions. All other functions are described in the FSE manual. For a better orientation refer to the alphabetically arranged table below.

Subject	**Section in FSE manual**
Basic Steps of Operation	2.3
Emulations	AnnexE
Firmware Update	1.8
Gereral Configuration	2.4
Interfaces	Annex A
List of Error Messages	Annex B
Macros	2.8
Measurement Documentation	2.6
Programming Examples	Annex D
Remote Control Command Processing and Status Reporting System	3.7 to 3.8
Remote Control Introduction	3.1 to 3.5
Saving and Recalling Data Sets	2.7
Setup of Display and Limit Lines	2.9.4
Status Display-Remote/Manual Control	2.5

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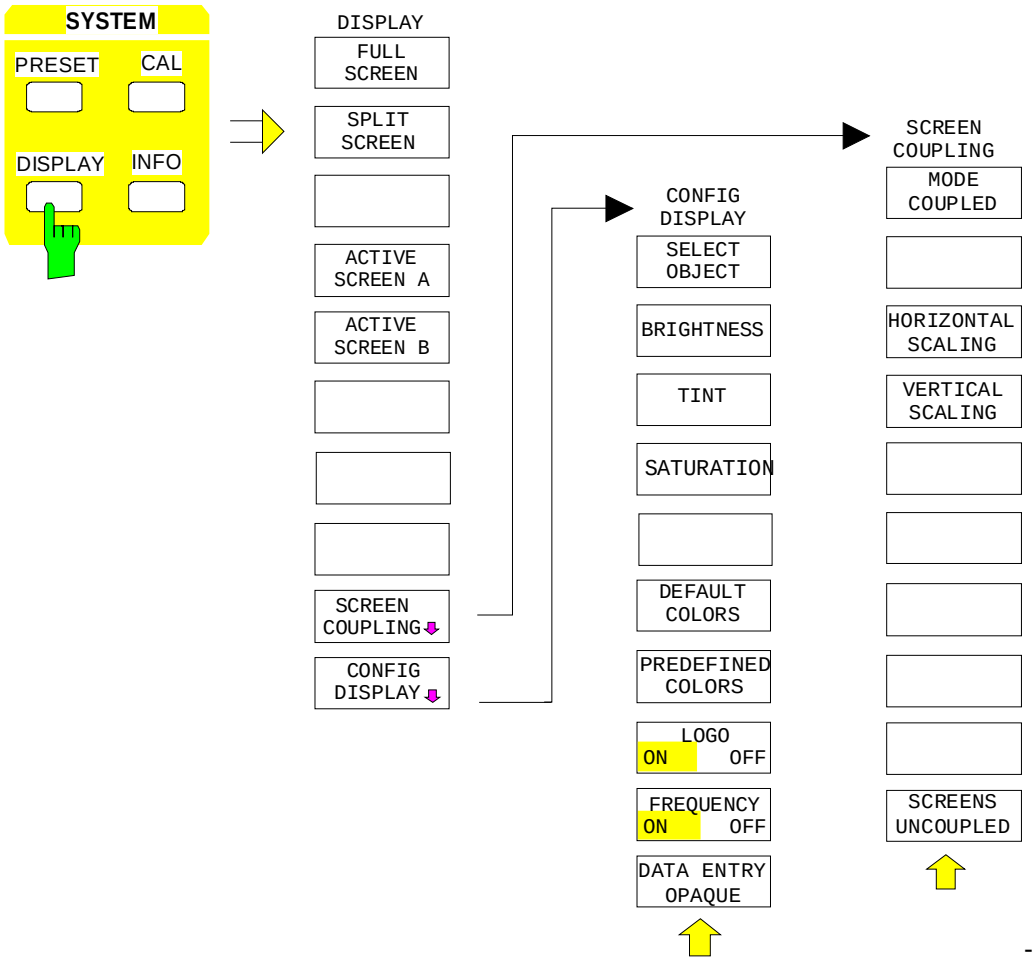
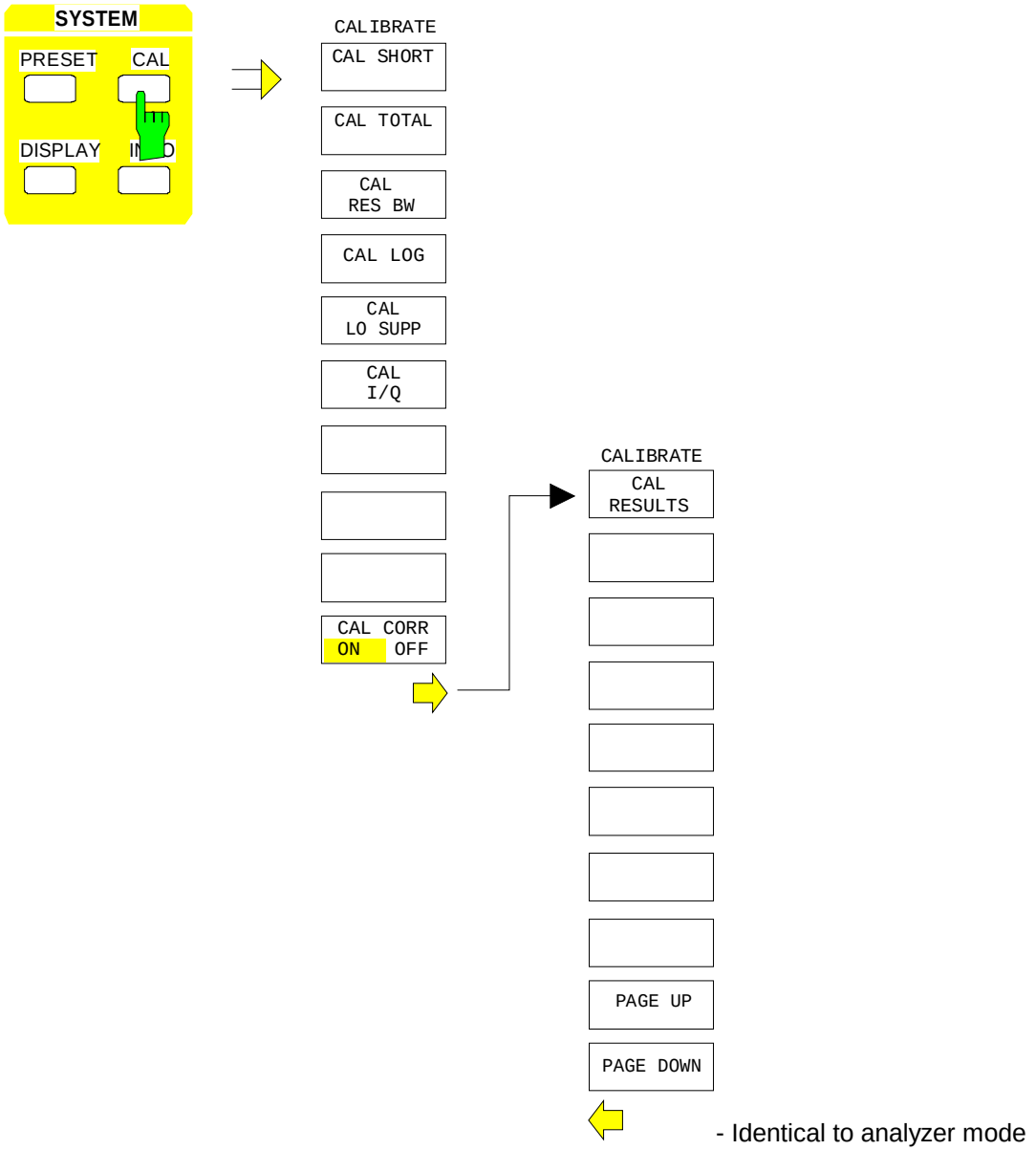
2.2 Menu Overview

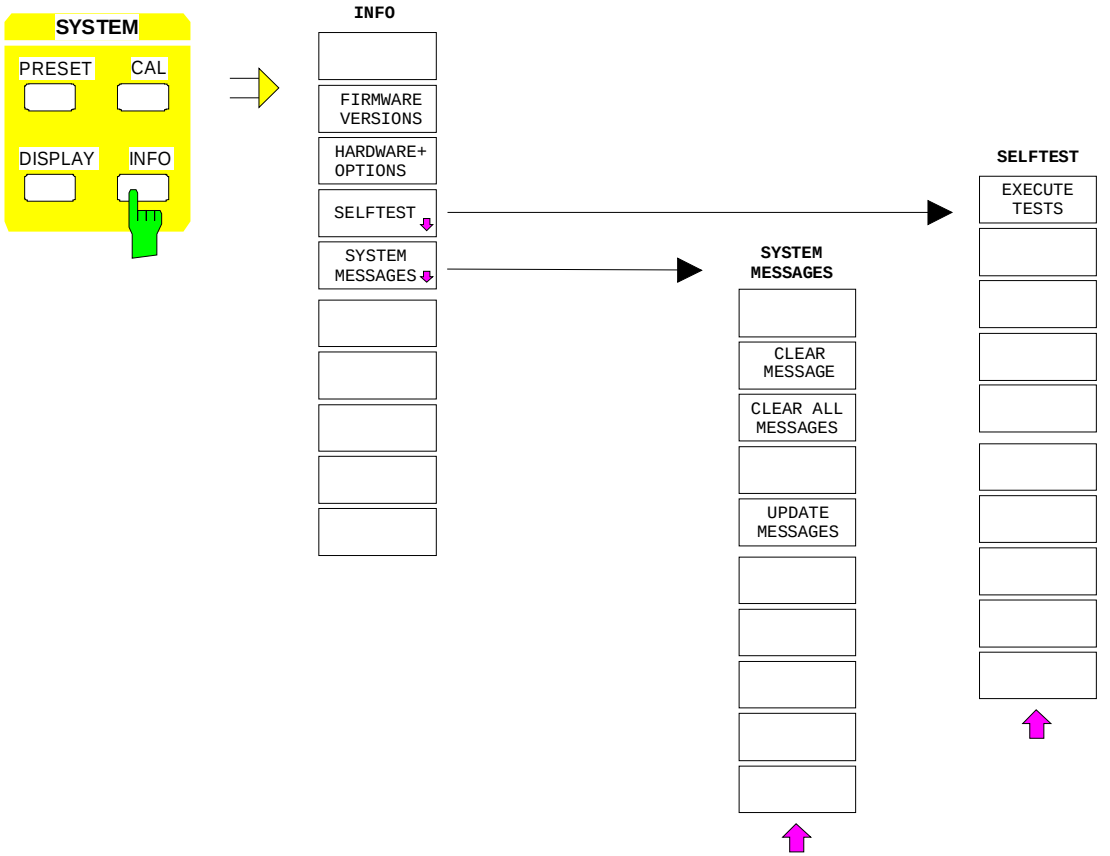
2.2.1 SYSTEM Key Group



- Identical to analyzer mode



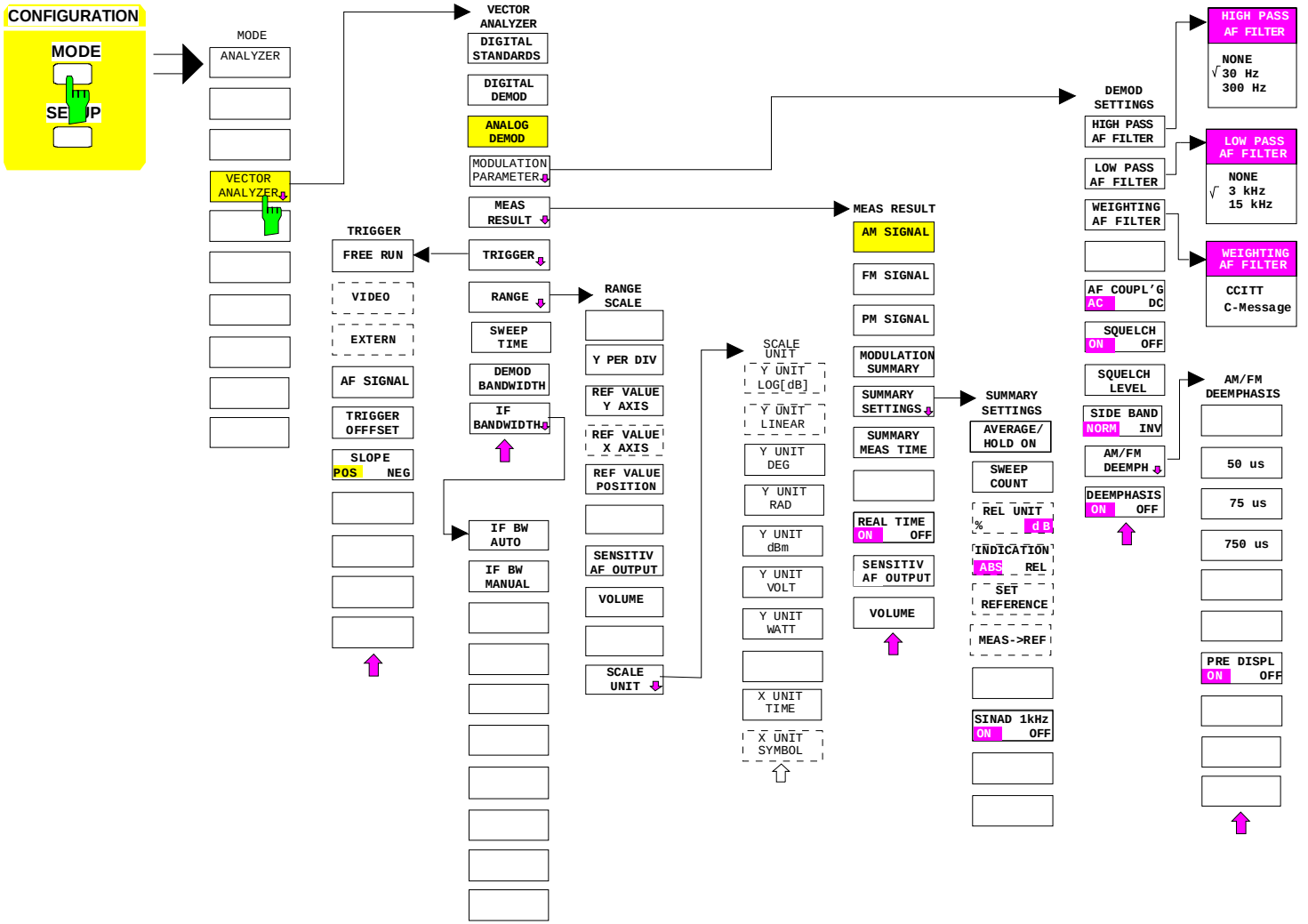
- Identical to analyzer mode



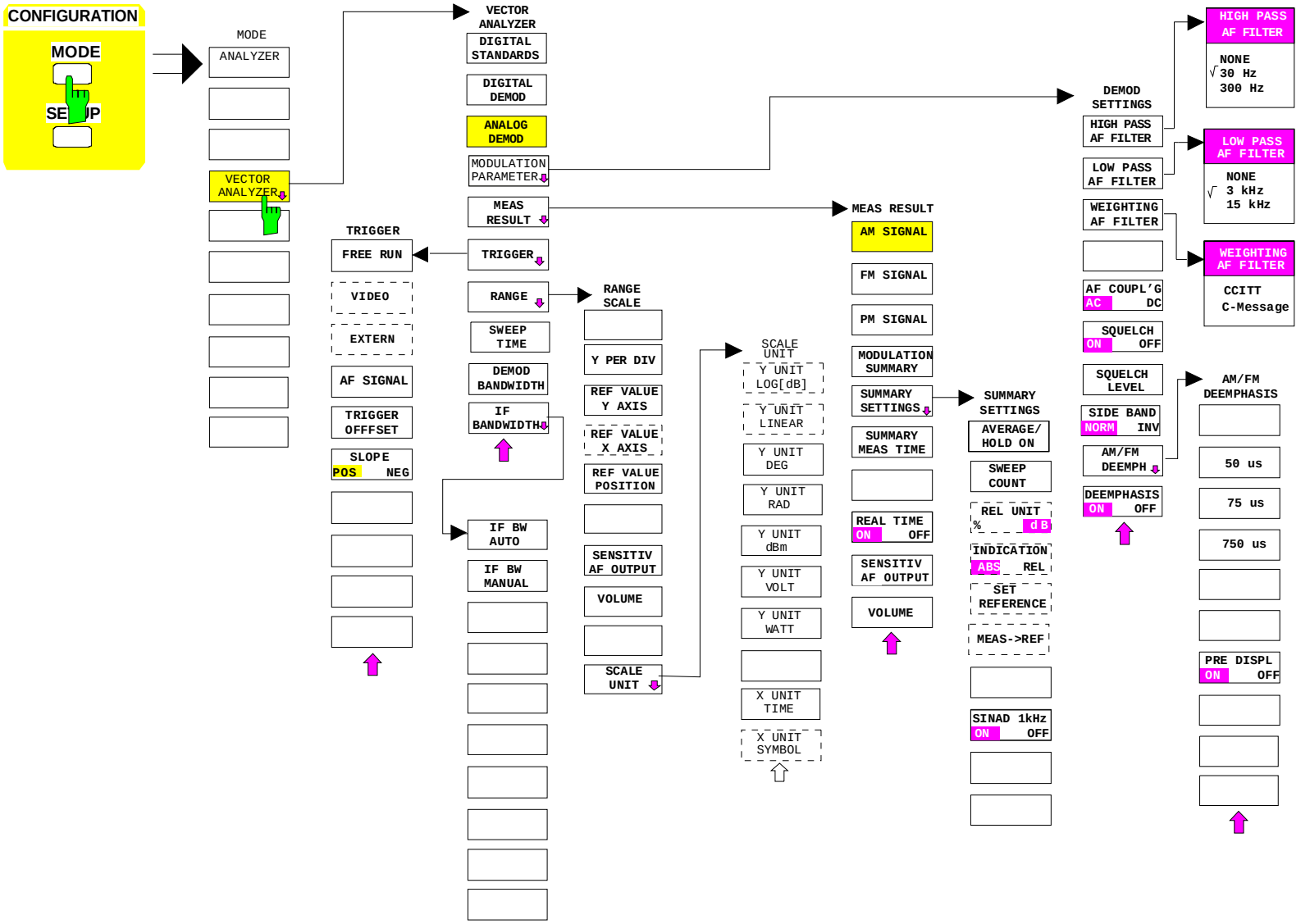
- Identical to analyzer mode

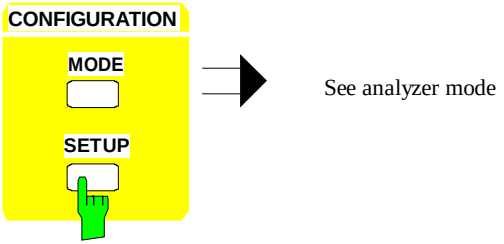
2.2.2 CONFIGURATION Key Group

a) In Digital Demodulation Mode (not FSK-Demodulation)



b) In Analog Demodulation (REAL TIME ON)



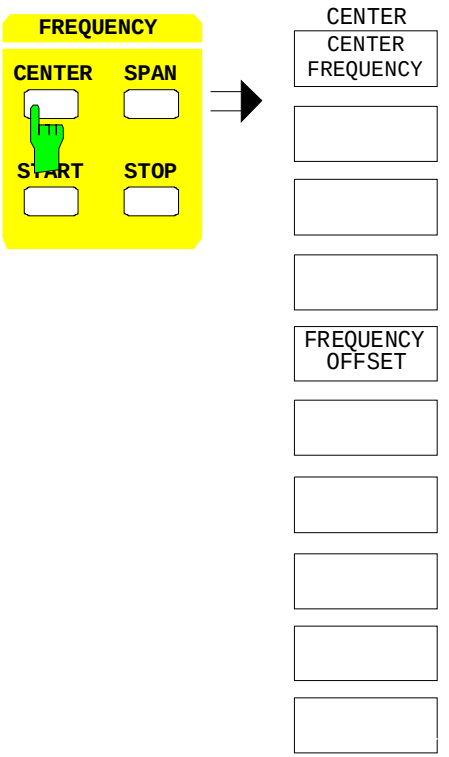


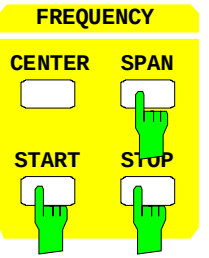
See analyzer mode

2.2.3 HARDCOPY Key Group

See analyzer mode

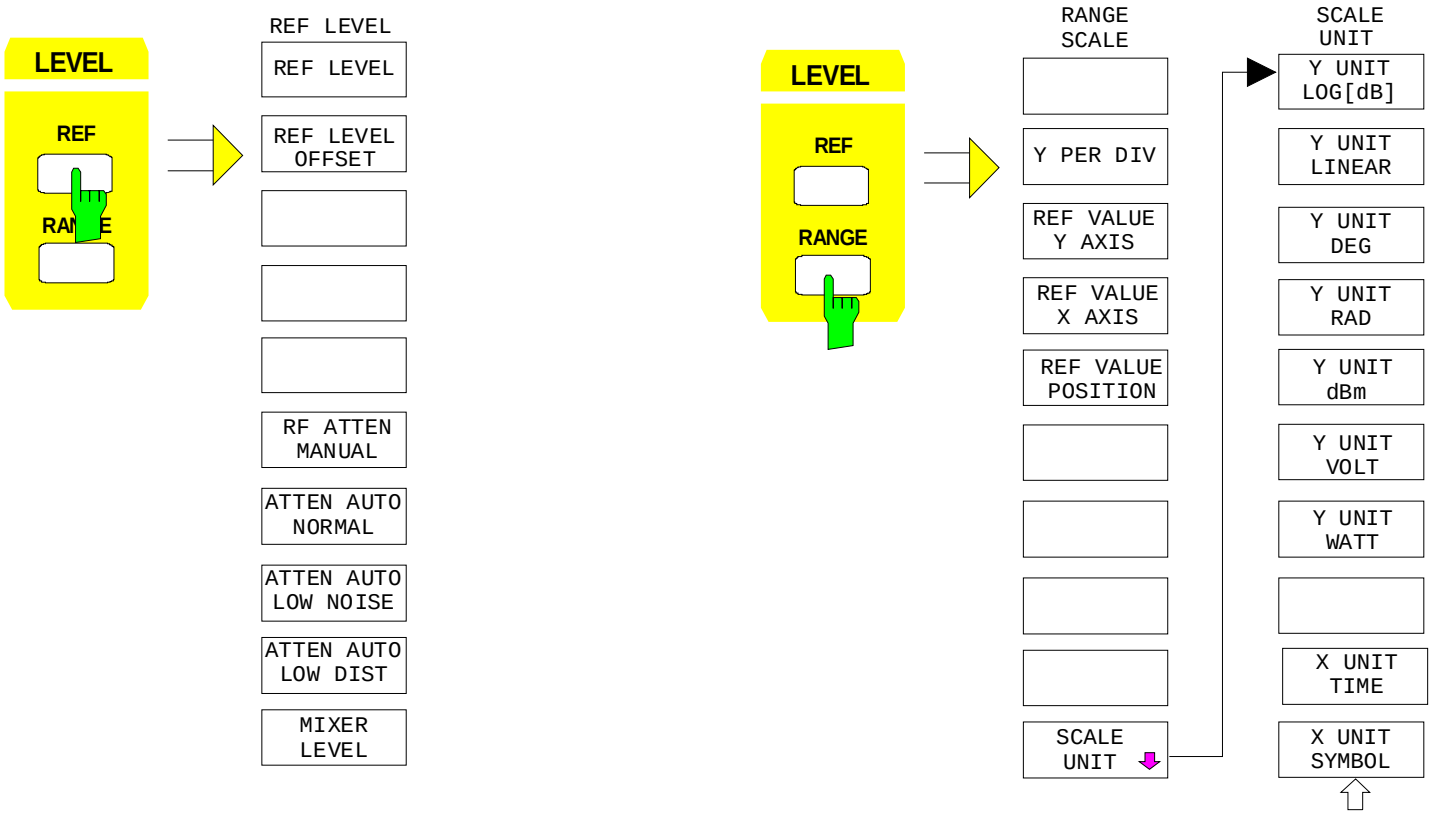
2.2.4 FREQUENCY Key Group

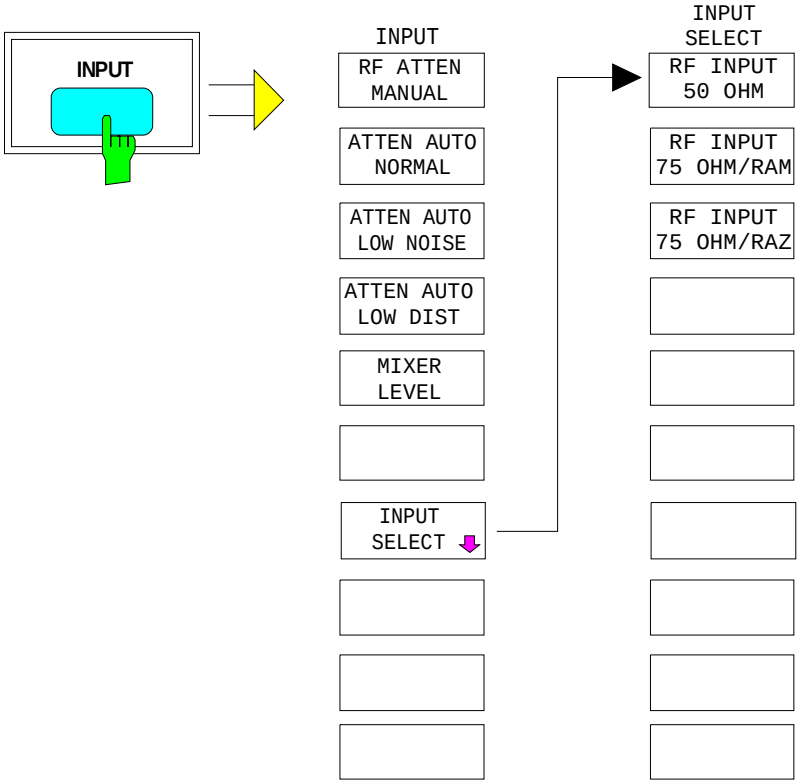




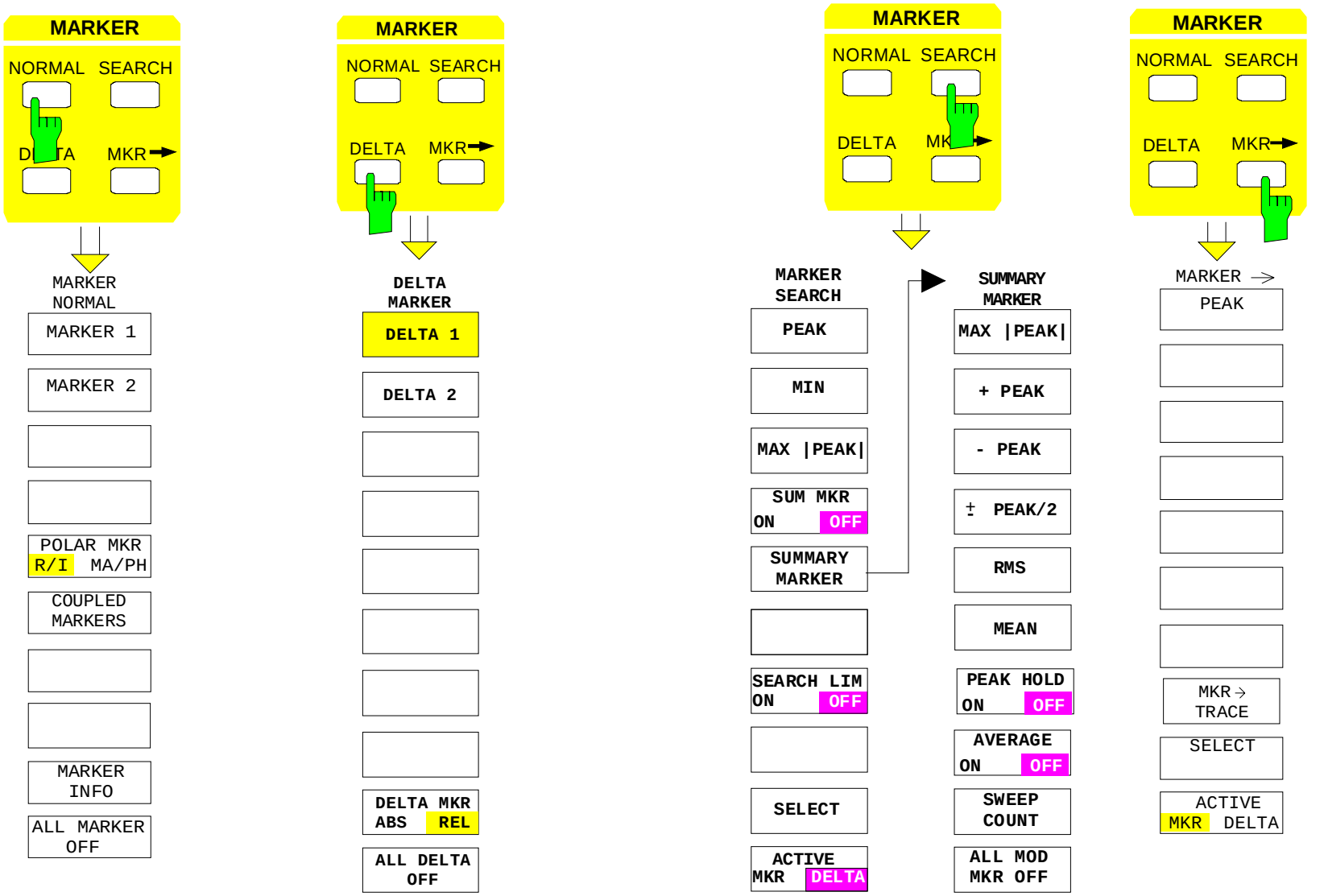
SPAN, START and STOP are without function in the vector analyzer mode!

2.2.5 LEVEL Key Group, INPUT Key

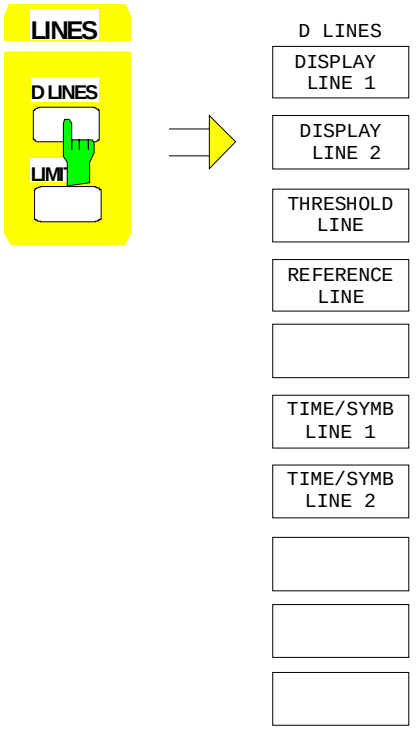


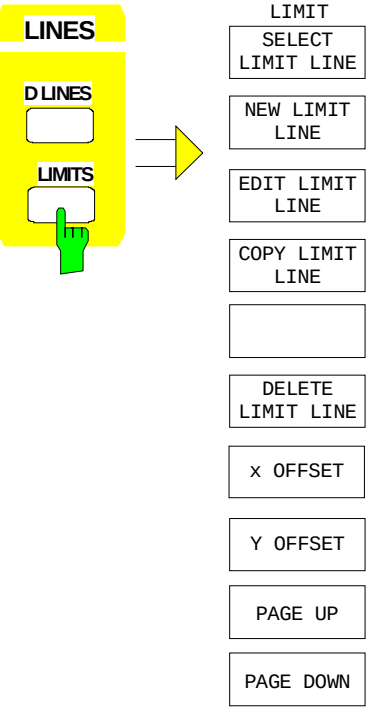

INPUT
INPUT
RF ATTEN MANUAL
ATTEN AUTO NORMAL
ATTEN AUTO LOW NOISE
ATTEN AUTO LOW DIST
MIXER LEVEL
INPUT SELECT
INPUT SELECT
RF INPUT 50 OHM
RF INPUT 75 OHM/RAM
RF INPUT 75 OHM/RAZ

2.2.6 MARKER Key Group

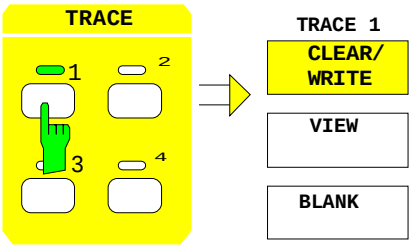


2.2.7 LINES Key Group





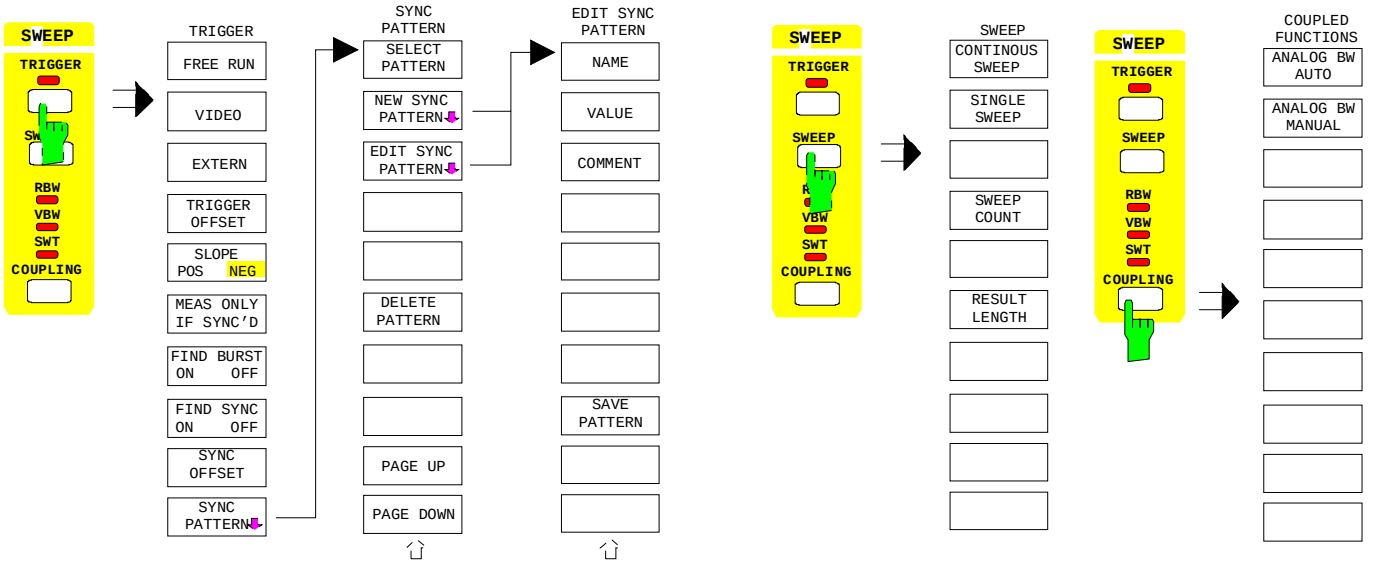
2.2.8 TRACE Key Group



TRACE 1

- CLEAR/ WRITE
- VIEW
- BLANK
- CONTINUOUS WRITE
- AVERAGE
- MAX HOLD
- MIN HOLD
- SWEEP COUNT
-
-

2.2.9 SWEEP Key Group



2.2.10 MEMORY Key Group

See analyzer mode

2.2.11 USER Key Group

See analyzer mode

2.4 Vector Analyzer Mode

The Vector Signal Analyzer in the FSE allows the analysis of analog and digital modulations. For this purpose, the FSE samples the IF signal which is band-limited by the resolution bandwidth (RBW) and mixes it into the complex baseband. The real and imaginary section of the signal is then digitally filtered and further processed in digital signal processors. The complex baseband contains the whole signal information which can be evaluated according to the different criteria.

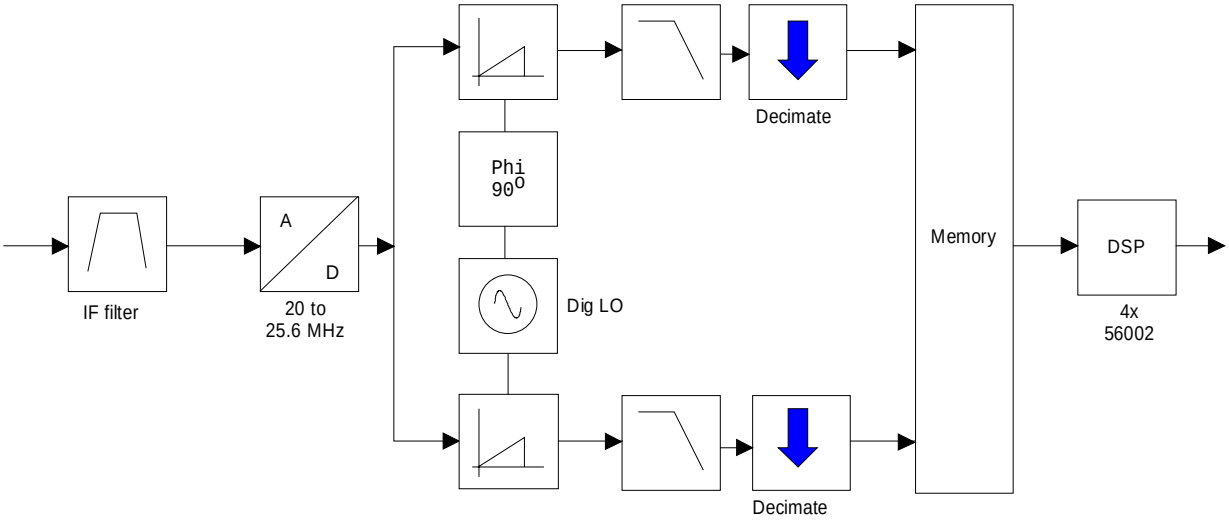


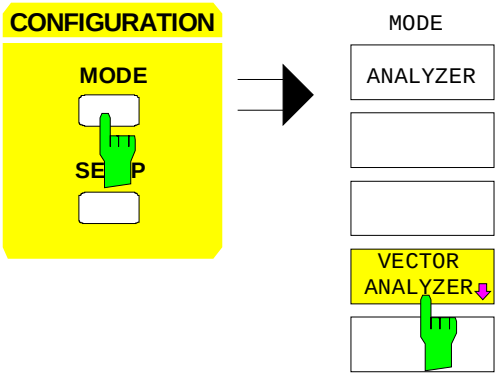
Fig. 2.4-1 Block diagram of FSE vector signal analyzer

Three types of analysis are distinguished in the vector signal analyzer:

- In the analog demodulation mode, the amplitude (AM), frequency (FM) or phase (PM) demodulated signal is represented as a function of time. Alternatively, display of a table containing the numerical demodulation parameters can be selected *(RESULT DISPLAY)*.
- For digitally modulated signals, the most commonly used demodulators are available to evaluate the modulation parameters.
- In the *DIGITAL DEMODULATION* mode, the magnitude of the non-demodulated signal can also be displayed (MAGNITUDE CAP BUFFER).

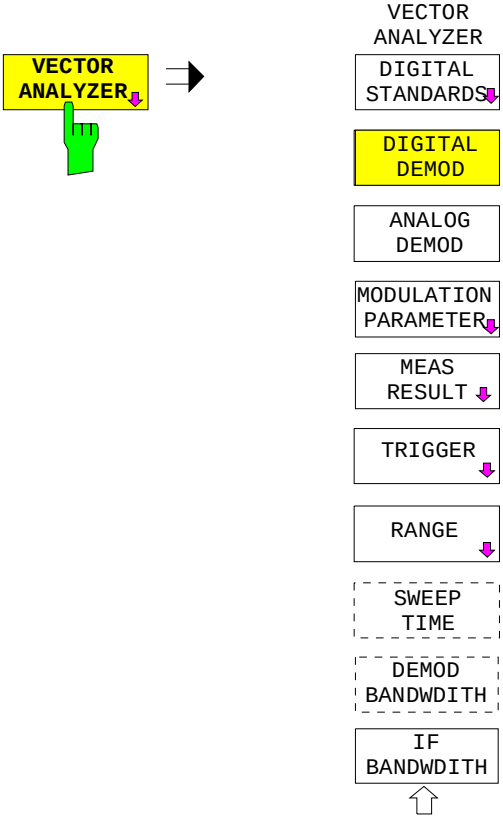
2.4.1 Selecting the Operating Mode

The vector analyzer mode is activated in the *CONFIGURATION MODE* menu



The *MODE* key calls up the menu for selecting the operating mode.

The type of analysis is selected in the *VECTOR ANALYZER* sub menu.



he *VECTOR ANALYZER* softkey calls up a submenu. The specific settings for the vector analyzer are entered into this submenu.

The menus for the test parameter settings lying below these keys (*FREQUENCY, LEVEL, MARKER, TRACE, COUPLING, TRIGGER*) are adapted to the specific capabilities of the vector signal analyzer.

The *DIGITAL STANDARDS, DIGITAL DEMOD* and *ANALOG DEMOD* softkeys are selectors with which the required type of analysis is set.

The *MODULATION PARAMETER* softkey sets the required modulation parameters for the demodulation of digitally modulated signals.

The *MEAS RESULT* softkey calls up a submenu in which the required evaluation of the selected type of analysis is set. For digital demodulation, for example, this is the evaluation of the signal itself or the reference signal, I/Q or vector errors etc.

The *TRIGGER* softkey calls up a menu equal to the *SWEEP TRIGGER* menu.

The *RANGE* softkey calls up the same menu called by the *RANGE* key in the *LEVEL* key group.

The *IF BANDWIDTH* softkey calls up a submenu in which the analog IF Bandwidth is set.

Note: *If two displays (screen A and screen B) are opened after switch-on of the vector signal analysis, the vector analyzer mode is only set for the display activated for entry (marked at the top right corner of diagram). For the other display, the previous settings remain valid. Storage and display of measured values is sequential: first in the upper and then in the lower display.*

The configuration of the vector analysis is performed in four steps:

1. Setting the type of analysis: Analog demodulation of the signal *(ANALOG DEMOD),* general demodulation of digitally modulated signals (*DIGITAL DEMOD)* or setting as required by a specific transmission mode (*DIGITAL STANDARDS,* in this case, step no. 2 can be skipped).
2. Selecting the modulation parameters (*MODULATION PARAMETER*).
3. Selecting the required measurement results (*MEAS RESULT)*.
4. Selecting the output format for measurement results (*RESULT DISPLAY*).

2.4.2 Analog Demodulation Methods

With amplitude, frequency and phase demodulation, the FSE provides all demodulation methods which can be used for analog RF carrier modulation or which may impair a carrier. The bandwidth used for demodulation depends on the demodulation bandwidth selected. Make sure that the entire modulation spectrum is included in the demodulation bandwidth. Otherwise, signal distortions that impair the modulation will be caused by analog prefiltering with the IF filters of the FSE and digital filtering for suppression of aliasing products due to sampling or data reduction. Correct measurement of the modulation parameters will no longer be possible.

For correct demodulation make sure that only the signal to be analyzed is located within the demoduation bandwidth *(DEMOD BANDWIDTH)* of the FSE. Otherwise, the demodulation would be impaired by adjacent signals. Spectral components of adjacent signals should be at a distance of at least 1.285 times the (demodulation bandwidth)/2 from the center frequency (= carrier frequency).

Depending on the demodulation bandwidth set (*DEMOD BANDWIDTH*), two modes of demodulation are provided:
With *DEMOD BANDWIDTH* ≤ 200 kHz real-time *(REAL TIME ON)* or offline *(REAL TIME OFF)* demodulation can be selected, with *DEMOD BANDWIDTH* > 200 kHz only offline demodulation is possible.
Real-time and offline demodulation differ as follows:

- Real-time demodulation *(REAL TIME ON)*
  - The bandwidth of the demodulated signal can be reduced in the AF region using switchable highpass, lowpass or weighting filters (CCITT or C-message filter) to enable spurious modulation measurements for analog radio systems in line with the standard; moreover, deemphases can also be switched on for FM (and AM). A deemphasis, if switched on, has an effect on the audio signal (provided via loudspeaker or headphones connector) **and** on the result display or on the audio signal only. The switchable filters, however, always have an effect on the display and AF/loudspeaker output.
  - The demodulated signal can be monitored via the built-in loudspeaker or via the headphones output.
  - In addition, the demodulated signal (parts of it) or a summary of numerical modulation parameters can be displayed on the sceen. With the aid of the split screen display, the demodulated signal and the summery of numerical modulation parameters can be displayed at the same time.
- Offline demodulation *(REAL TIME OFF)*
  - The demodulation is not carried out continuously, but in blocks, ie a data block is written into the memory and then demodulated and displayed:
  - The measurement result displayed on the screen is the time function of the demodulated AF signal and/or a summary of numerical modulation parameters.
  - The internal loudspeaker, the headphones output is switched off.
  - No highpass filters and no weighting filters can be activated.
    Deemphases cannot be switched on.
  - To restrict the noise bandwidth, AF lowpass filters can be selected, standardized to the demodulation bandwidth (cutoff frequency = 5, 10 or 25 % of demodulation bandwidth).

The two demodulation modes provided are designed for the following main applications:

- Real-time demodulation (*REAL TIME ON*) for demodulation bandwidths up to max. 200 kHz for modulation measurements to the standard on analog radio systems and also for monitoring.
- Offline demodulation (*REAL TIME OFF*), especially for measurement of transients (e.g. frequency settling of oscillators and synthesizers).

The following diagram shows the menus which permit to set the parameters and the result display with analog demodulation.

Menu: CONFIGURATION MODE - VECTOR ANALYZER - ANALOG DEMOD (with REAL TIME ON)

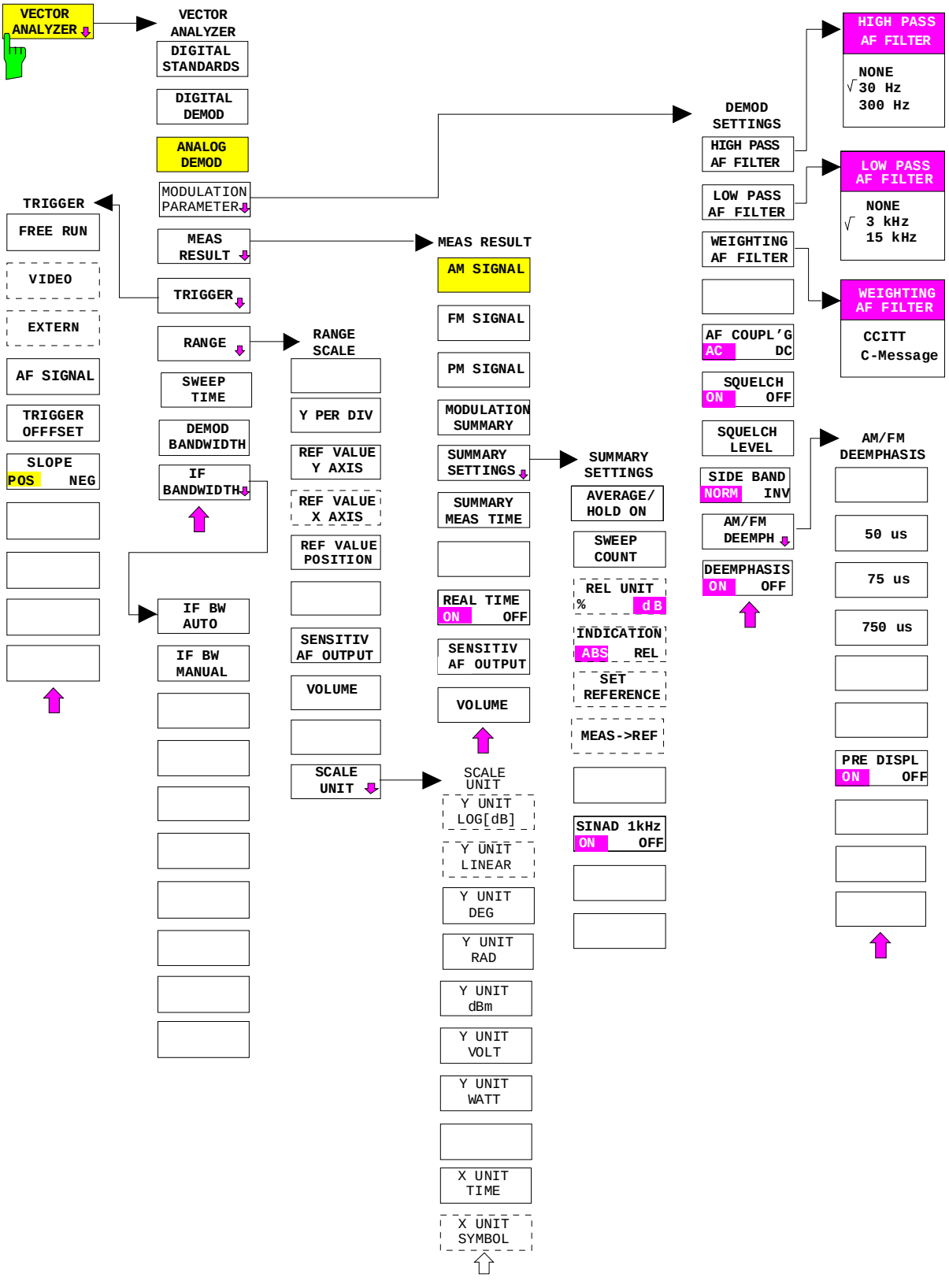
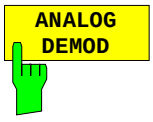


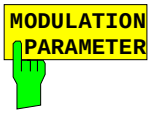
Fig. 2.4-2 Menu structure for setting the demodulation with analog-modulated signals



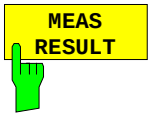
The *ANALOG DEMOD* softkey activates the analog demodulation mode.

The demodulation (AM, FM and PM demodulation) is performed in parallel.

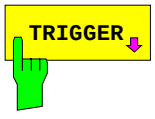
The type of demodulation or display (AM, FM or PM or numerical display) is set under MEAS RESULT.



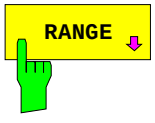
See section "Selecting the Modulation Parameters"



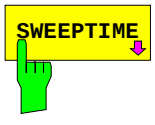
See section "Selecting the Audio Signal"



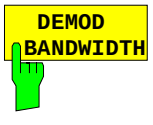
See section "Triggering with Analog Demodulation - Softkey *TRIGGER* or Hardkey *TRIGGER*"



See section "Setting the Display Range and the Scaling - Softkey *RANGE* or Hardkey *RANGE*"



See section "Sweep Menu with Analog Demodulation - Softkey *SWEEP TIME* or Hardkey *SWEEP*"

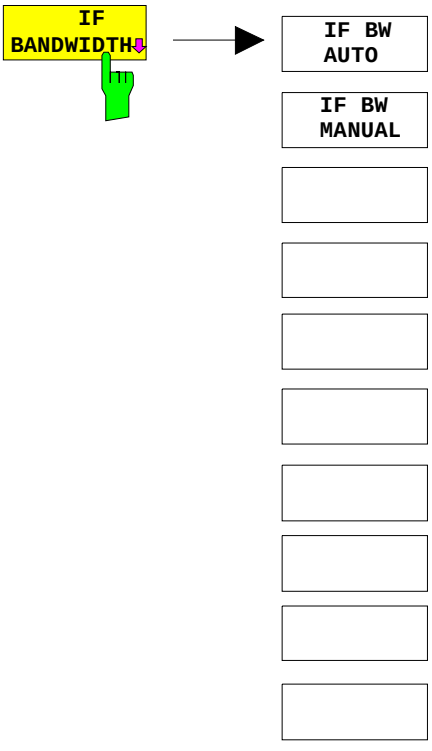


The *DEMOD BANDWIDTH* softkey calls up a field for entering the demodulation bandwidth.

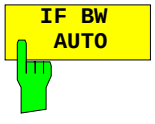
The spectrum to be demodulated should be located completely within this bandwidth, if possible (check in spectrum analyzer mode) in order to avoid demodulation distortions. Spurious signals outside the spectrum to be demodulated do not cause any demodulation errors if the frequency spacing with respect to the tuning frequency is (*CENTER FREQUENCY*) Delta f ≥ 1.28 x (*DEMOD BANDWIDTH*)/2.

The *DEMOD BANDWIDTH* can be set in steps of 1, 2, 3 and 5 in the range from 5 kHz to 5 MHz or, if different entries are made, it will be rounded off to the nearest possible step.

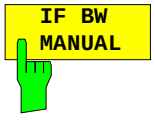
With FM demodulation the maximum deviation that can be measured is restricted to (0.4 x *DEMOD BANDWIDTH*).



The *IF BANDWIDTH* softkey opens up a submenu where the bandwidth of the analog IF filters is set (corresponds to the resolution bandwidth in spectrum analyzer mode).



The *IF BW AUTO* softkey is used to set the IF bandwidth to the maximum possible value 10 MHz (irrespective of the demodulation bandwidth).



The *IF BW MANUAL* softkey permits to restrict the analog IF bandwidth specifically.

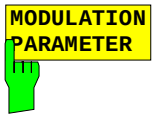
To avoid modulation distortions and errors it is recommended to set the IF bandwidth as large as possible (*IF BANDWIDTH* ≥ 5 x *DEMOD BANDWIDTH*).

If spurious signals are to be suppressed outside the useful modulation spectrum, IF BW MANUAL can be used to reduce the IF bandwidth down to a value equal to the demodulation bandwidth.

Possible input values: ≥ *DEMOD BANDWIDTH*, 5 kHz to 10 MHz.

2.4.2.1 Selecting the Modulation Parameters

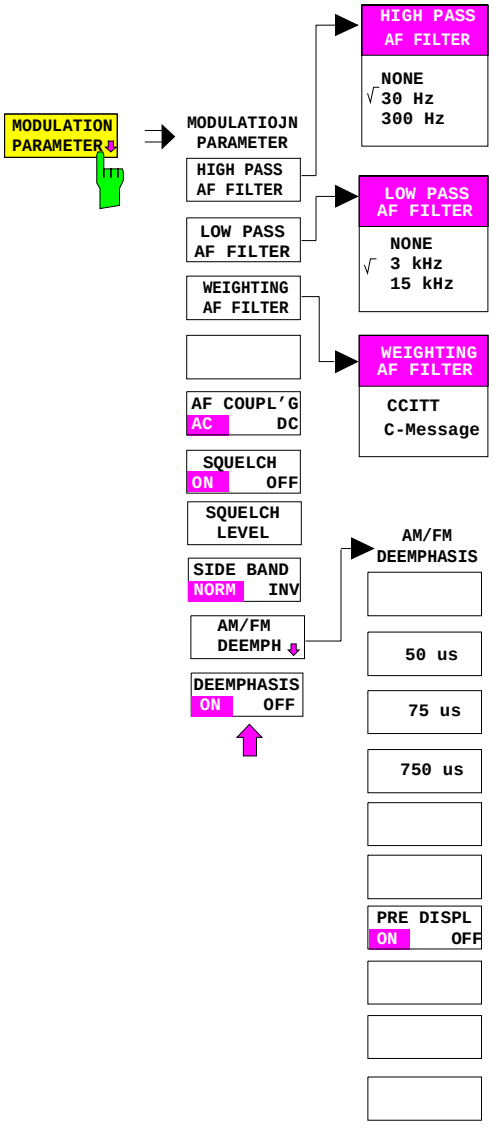
Submenu: *CONFIGURATION MODE - VECTOR ANALYZER - ANALOG DEMOD*



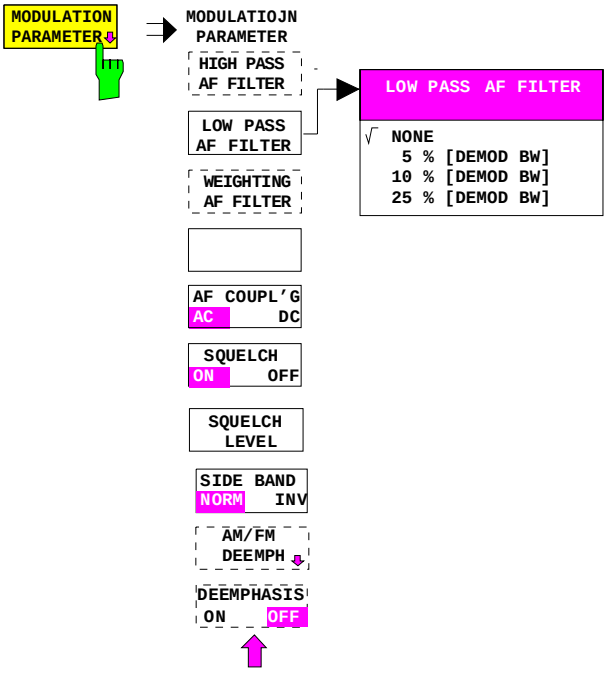
The *MODULATION PARAMETER* softkey calls up a submenu which permits to select the modulation parameters for analog demodulation.

Which menu is displayed depends on whether real-time demodulation is activated (***REAL TIME ON***) or not (***REAL TIME OFF***).

***REAL TIME ON*:**



***REAL TIME OFF*:**



Note: *The dashed softkeys cannot be activated in the operating mode selected*

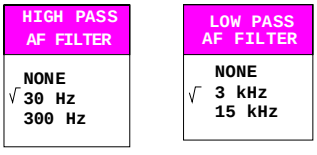
The possible selection of the filter depends on whether real-time demodulation is activated or not (*REAL TIME ON/OFF*).

REAL TIME ON:

HIGH PASS AF FILTER

LOW PASS AF FILTER

The softkeys *HIGHPASS AF FILTER* and *LOW PASS AF FILTER* call up input fields which permit to select highpass or lowpass filters for restriction of the AF bandwidth.



If *REAL TIME ON* is activated, the opposite highpass and lowpass filters as well as standard weighting filters can be selected.

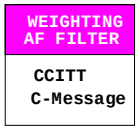
If AF filters are switched on, they act on the display and AF output or loudspeaker output.

The 3-dB cutoff frequencies are indicated for the highpass and lowpass filters.

1st-order highpass filters (6 dB/octave slope) and 2nd-order lowpass filters (12 dB/octave slope) are used.

WEIGHTING AF FILTER

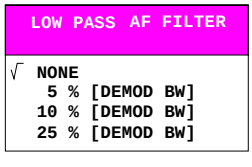
The *WEIGHTING AF FILTER* softkey calls up the inpit firld for selection of a standard weighting filter.
The CCITT filter (CCITT P.53) and the C-message filter are used as weighting filters according to US standard.



When one of the two weighting filters is activated, the demodulation bandwidth is automatically switched to 30 kHz. If the demodulation bandwidth is subsequently changed with active weighting filter, the latter is switched off.

***REAL TIME OFF*:**

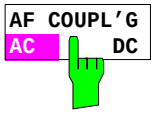
If R*EAL TIME OFF* is selected, only lowpass filters can be activated for restriction of the noise bandwidth.



The filter bandwidth (-3 dB) can be selected in % of the demodulation bandwidth.

5, 10 or 25 % of the demodulation bandwidth are possible.

The filters are designed as 2nd-order Butterworth filters (12 dB/octave slope).



The *AF COUPL'G AC/DC* softkey switches the AF analysis stages after the demodulators to DC or AC voltage coupling.

FM:

With FM, AC coupling (*AF COUPL'G AC*) is achieved by determining the center frequency of the signal to be measured and correcting the demodulated signal accordingly.

With *AF COUPL'G DC* the center frequency of the FSE is assumed as the carrier frequency, and no frequency correction is performed. The AF signal is DC-coupled.

PM:

With PM, AC coupling (*AF COUPL'G AC*) is achieved by estimating both the frequency offset and the phase offset and setting them to zero.

Only with ***REAL TIME OFF***:

With *AF COUPL'G DC*, if the center frequency of the signal to be measured deviates, the phase varies with a period corresponding to the difference between applied and set center frequency (0 to 360°).
If the frequency is consistent (e.g. in the case of synchronization to a common reference frequency) the phase is constant on an offset in the range from 0 to 360°. The PM demodulator is DC-coupled.

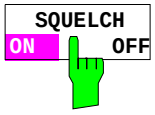
AM:

As a mere envelope demodulator, the AM demodulator is insensitive to frequency errors as long as carrier and sidebands are within the set frequency display range.

In the case of AC coupling (*AF COUPL'G AC*), the demodulated AF signal is standardized to the DC voltage (corresponds to the average carrier value) and the DC component is removed.

The amplitude of the AF signal is directly proportional to the AM modulation depth.

In the case of DC coupling (*AF COUPL'G DC*), the amplitude of the demodulated signal is proportional both to the AM depth and to the level, there is no standardization to the average carrier value. The measured value is displayed in absolute level units.



REAL TIME ON:

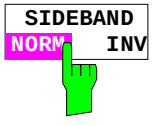
The *SQUELCH ON* softkey mutes the loudspeaker or headphones output provided that the level falls below a threshold that can be entered under SQUELCH LEVEL. The trace of the demodulated signal is also set to zero at this point in time. The muting circuit responds with a delay that is designed such that a signal modulated with ≥ 30 Hz AM does not cause the circuit to respond in a modulation low status.

Loudspeaker or headphones output are only active if real-time demodulation is selected.

REAL TIME OFF:

With *MEAS RESULT: AM-, FM SIGNAL* or *:PM SIGNAL* the frequency or phase deviation is set to zero when the value falls below the squelch. The muting circuit responds without delay, which is why it is suitable for transient measurements in particular.

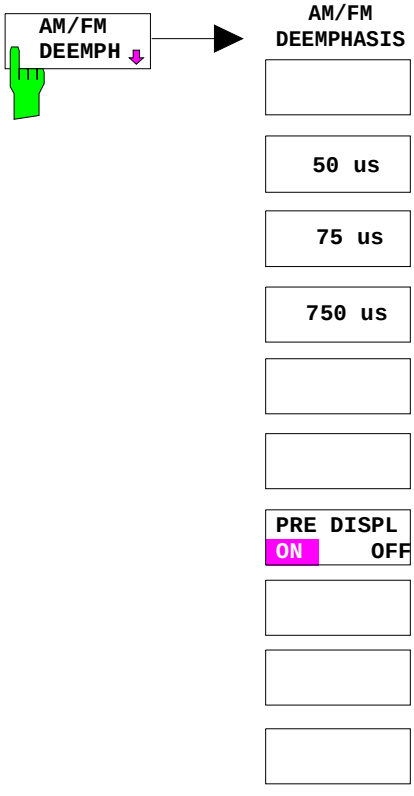
SQUELCH LEVEL permits to enter an absolute level in the unit dBm, below which the SQUELCH function is activated (only with *SQUELCH ON*).



The softkey *SIDEBAND INV (INVERTED)* demodulates and inverts the signal received.

Thus, with FM or PM demodulation, a receive signal with increasing frequency at the FSE input leads to a falling AF signal.

Default status is *SIDEBAND NORM* (normal): A receive signal with increasing frequency at the FSE input leads to an increasing AF signal.

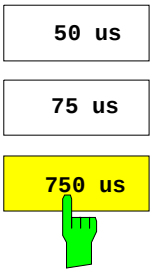


REAL TIME ON only

The *AM/FM DEEMPH* softkey opens the submenu in which a deemphasis can be selected for FM (or AM) demodulation (An AM deemphasis is prescribed in a few regulations for measurement of synchronous amplitude modulation on FM transmitters.).

Deemphases with the time constants 50 µs, 75 µs (used for radio broadcasting) and 750 µs (used for radio communication) are provided.

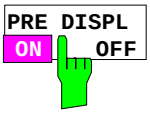
If switched on, the deemphasis acts on the audio output.



REAL TIME ON *only*

The *50us, 75 us* and *750 us* softkeys select the time constant of the deemphasis.

The default setting is 50 µs.

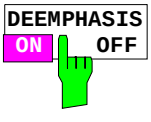


REAL TIME ON *only*

The *PRE DISPL ON/OFF* softkey switches on or off the effect of the deemphasis to the result display.

Via the function *PRE DISP ON* (PRE DISPLAY ON) the effect of the deemphasis can also be extended to the result display to enable spurious modulation measurements complying with the standard.

To be able to measure the correct deviation of the signal applied in spite of the corrected audio signal, the active deemphasis can be switched off via *PRE DISP OFF* for the result display.



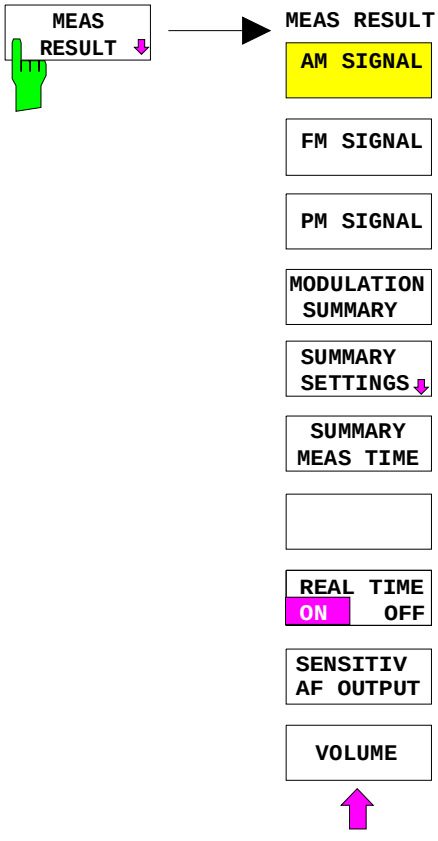
REAL TIME ON only

The *DEEMPHASIS ON/OFF* softkey switches the demphasis selected under *AM/FM DEEMPHASIS* on or off.

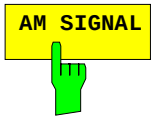
In the default status, the deemphasis is switched of

2.4.2.2 Selecting the Audio Signal

Submenu: *CONFIGURATION: MODE - VECTOR ANALYZER - ANALOG DEMOD*

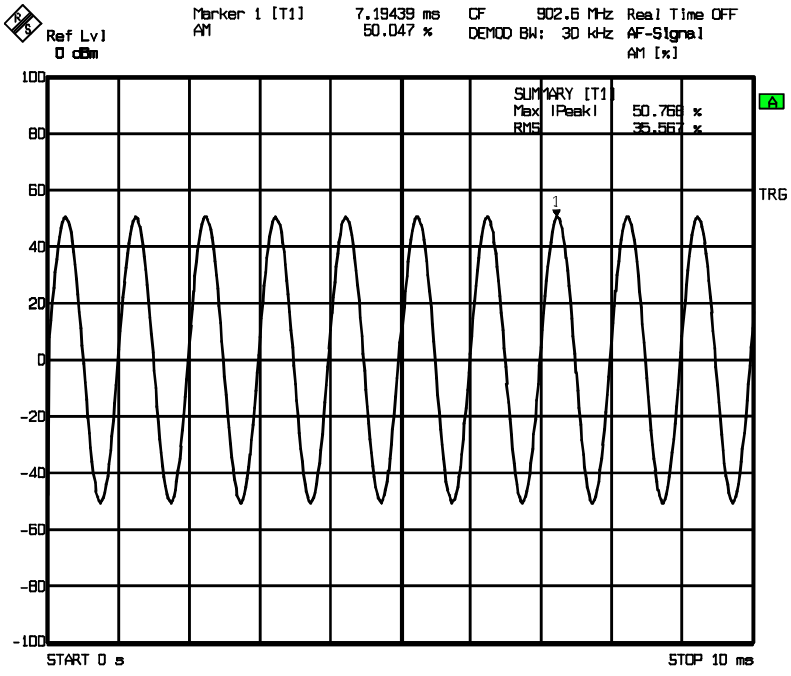


The *MEAS RESULT* softkey opens up a submenu for selection of the AM, FM, or PM demodulated audio signal (display and audio output).



The *AM SIGNAL* softkey is used to display the AM-demodulated time signal provided that MODULATION SUMMARY is not active. If MODULATION SUMMARY is active, the modulation parameters will be numerically displayed with main signal AM (see MODULATON SUMMARY).

The AM-demodulated signal is applied to the audio output (if ***REAL TIME ON***).



FM SIGNAL

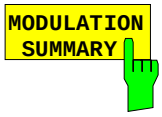
he *FM SIGNAL* softkey displays the FM-demodulated time signal provided that MODULATION SUMMARY is not active. If MODULATION SUMMARY is active, the modulation parameter will be numerically displayed with main signal FM (see MODULATION SUMMARY).

The FM-demodulated signal is present at the audio output (in the case of real-time demodulation).

PM SIGNAL

The *PM SIGNALL* softkey displays the PM-demodulated time signal provided that MODULATION SUMMARY is not active. If MODULATION SUMMARY is active, the modulation parameter will be numerically displayed with main signal PM (see MODULATION SUMMARY).

In the case of ***REAL TIME ON*** the PM-demodulated signal is present at the audio output.



The *MODULATION SUMMARY* softkey (on/off switch) switches from the display of the audio signal versus time to the summary of the numeric modulation parameters.

Of the main signal in question the positive and negative peak modulation value, peak-to-peak value as well as the rms value are displayed with absolute display (see *SUMMARY SETTING*) (except for AM DC: the +-Pk/2 detector does not display the peak-to-peak value, but the average from positive and negative peak value).

Parallel to the main signal, the parameters of the remaining demodulators are also displayed, ie the absolute, arithmetic average from positive and negative peak value.

The following parameters of the demodulation main signal can be displayed in addition:

- SINAD value (1-kHz modulation frequency fixed)
- Audio frequency

In addition, the frequency error as well as the carrier power (to be more exact: power of the unmodulated carrier) and the configuration of the active AF filter and deemphasis are displayed.

Example: AM signal/REAL TIME ON:

```
                                        CF        978.3 MHz      REAL TIME ON
                                        DEMOD BW:   100 kHz      MOD SUMMARY AM
Ref Lvl                                                          ANALOG DEMOD
 10 dBm
```

MODULATION SUMMARY AM A

```
AM:             54.20 % +Pk       54.68 -Pk
                54.44 % ± PK/2    33.3 % RMS

SINAD 1 kHz:    35.1 dB
AUDIO FREQ:      1.001 kHz
FREQ ERROR:    101.1 Hz
CARR PWR:        7.88 dBm
FILTER:        HP 30 Hz     LP 3 kHz        DEEMPH OFF

FM:              1.031 kHz ± PK/2
PM               1.011 rad ± PK/2
```

Example: AM signal/REAL TIME OFF:

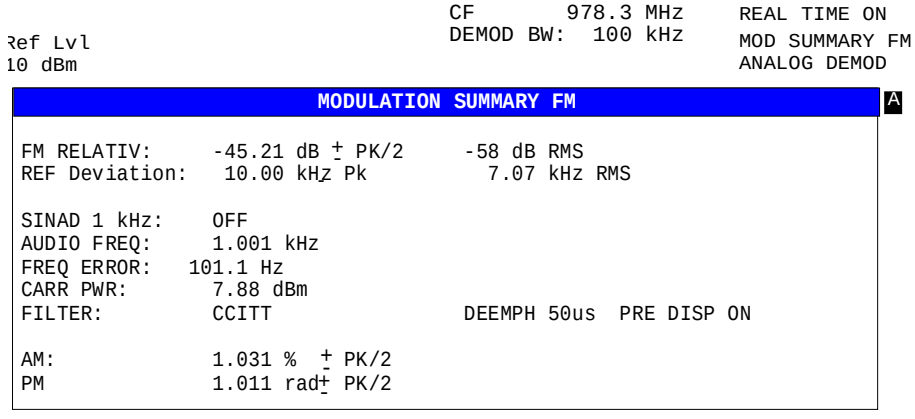
```
                                        CF        978.3 MHz      REAL TIME OFF
                                        DEMOD BW:   100 kHz      MOD SUMMARY AM
Ref Lvl                                                          ANALOG DEMOD
10 dBm
```

MODULATION SUMMARY AM A

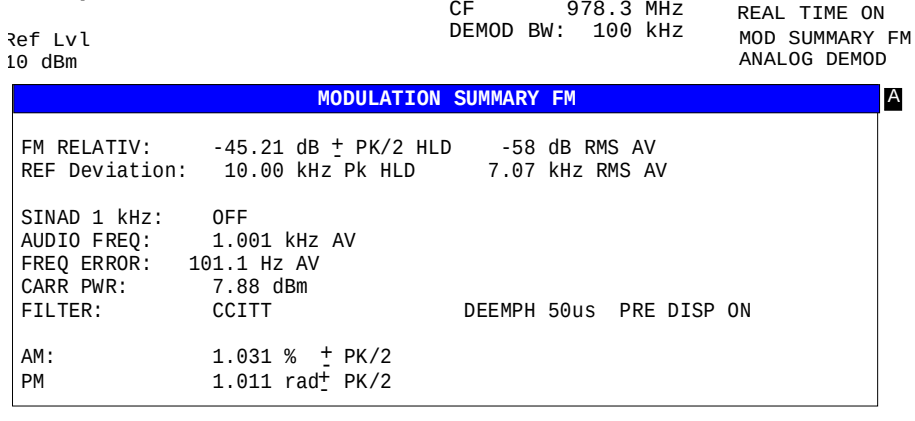
```
AM:             54.20 % +Pk       54.68 -Pk
                54.44 % ±PK/2     33.3 % RMS

SINAD 1 kHz:    --
AUDIO FREQ:      1.001 kHz
FREQ ERROR:    101.1 Hz
CARR PWR:        7.88 dBm
FILTER:        HP --        LP 10 % [DEMOD BW]            DEEMPH OFF

FM:              1.031 kHz ±PK/2
PM               1.011 rad ±PK/2
```

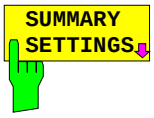
Example: FM signal, relative measurement:

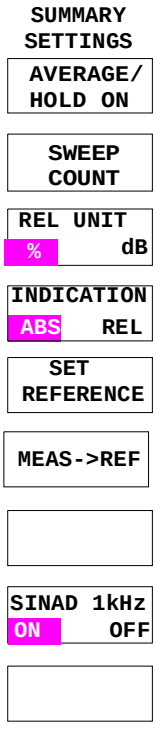
In the case of relative measurement, the absolute arithmetic average from positive and negative peak value as well as the rms value of the main signal are also displayed. The separate display of positive and negative peak value is omitted. Instead, the reference value is additionally displayed as peak and rms value.



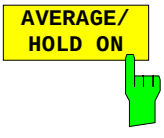
Example: AVERAGE/ HOLD ON:







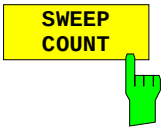
The *SUMMARY SETTINGS* softkey opens up the submenu for configuration of the summary of all numeric measured values.



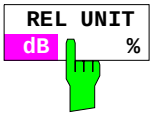
The *AVERAGE/HOLD ON* softkey permits to average all display values obtained in the number of sweeps defined under Sweep Count except for the Pk values with Single Sweep (the display *No of Measurements* appears in the modulation summary, *AV* is indicated after the units).

The Pk values are displayed in the Pk Hold mode (display *Hold* after the Pk units).

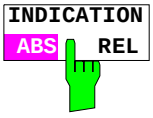
In the case of a restart, the Pk values and AV values are reset by means of Single Sweep or by switching *TRACE AVERAGE/HOLD ON* off and on.



The *SWEEP COUNT* softkey sets the number of sweeps used to determine the average or PK Hold values (see also the corresponding softkey in analyzer mode)).



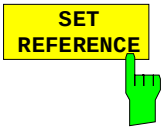
The *REL UNIT dB/%* softkey selects the unit (% and dB) with relative display (*INDICATION REL*) .



The *INDICATION ABS REL* softkey switches between absolute (*ABS*, default setting) and relative display (*REL*). The reference value for the relative display can be entered by means of *SET REFERENCE* or *MEAS→ REF*.

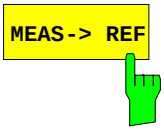
Only the main signal can be displayed in relative mode, the other signals are indicated in absolute display in any case.

For relative indication, the default unit is dB and can be changed from dB to % via the softkey *REL UNIT%*.

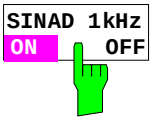


The *SET REFERENCE* softkey opens up a field for input of a reference modulation (for main signal).

The peak value of the modulation is to be entered. The rms reference value will then be peak value/√2.



The *MEAS→REF* softkey is used to represent the current absolute measured values of the main modulation signal (+-PK/2 and RMS) as reference values for the relative display.



REAL TIME ON *only.*

The *SINAD 1 kHz ON* softkey activates the SINAD measurement for the main modulation signal.

Irrespective of the signal applied, the main modulation signal is compared with the main modulation signal which is filtered by a 1-kHz notch filter. The display unit is dB.

When a signal modulated with 1 kHz is applied, the SINAD value is thus displayed correctly.
Default setting is *SINAD 1 kHz OFF*.

With ***REAL TIME OFF*** (no real-time demodulation) no SINAD measurement is possible, the softkey cannot be operated.

***REAL TIME ON** only.*

The *SUMMARY MEAS TIME* softkey opens up a field for entering the measuring time (as well as the measured value update rate) for the numerical measured values of the modulation summary.

Default setting is 100 ms

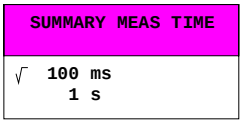
Thus, with a stationary modulation frequency of 30 (typ. 20) Hz, peak values and rms value can be determined correctly.

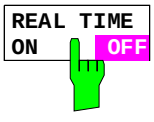
The measured values are updated at least every 100 ms, ie max. 10x/s.

With a measuring time of 1 s and a stationary modulation frequency of up to 5 Hz peak values and rms values can be determined correctly.

The measured values are updated every second, ie max. 1x/s.

In both cases, the peak values are measured continuously, the time constant of the rms detector is adapted accordingly.

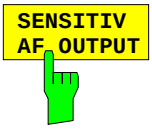




The *REAL TIME ON/OFF* softkey switches real time demodulation on or off.

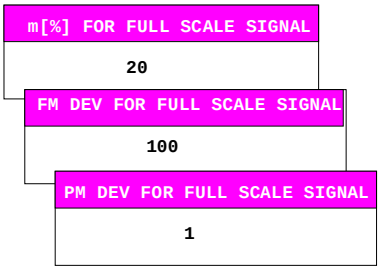
For demodulation bandwidths ≤ 200 kHz, real-time demodulation can be switched on or off.
(Off is default status).

Demodulation bandwidths > 200 kHz do not allow real-time modulation.

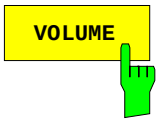


***REAL TIME ON** only.*

The *SENSITIV AF OUTPUT* softkey sets the scaling of the AF output for real-time modulation. Depending on *MEAS RESULT* (AM, FM or PM signal), an input field appears, where the modulation amplitude is to be entered so that the dynamic range of the AF output is fully utilized.
(Peak voltage 1V):



SENSITIV AF OUTPUT also has an effect on the volume of the loudspeaker and on the headphones output.



***REAL TIME ON** only*

The *VOLUME* softkey sets the volume of the demodulated signal (loudspeaker and headphones output) according to the slope of the AF output.

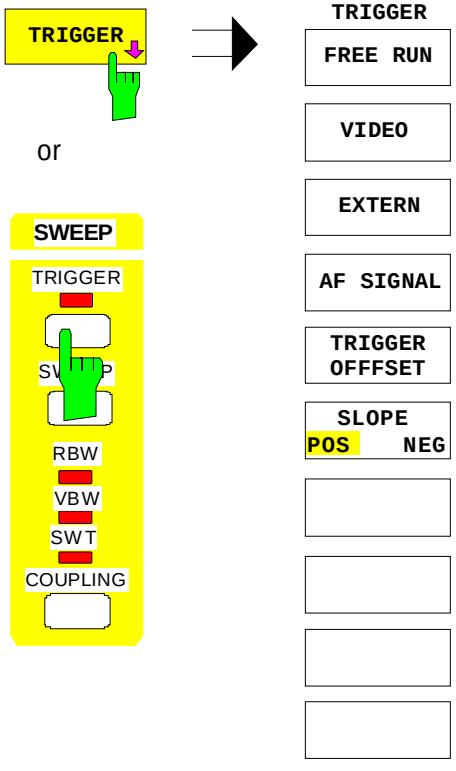
With ***REAL TIME OFF*** (no real-time demodulation) the outputs are switched off.

Note: *If the modulation depth / deviation is very small, the scaling of the AF output (softkey* SENSITIV AF OUTPUT*) is to be matched to achieve a usable volume.*

On the other hand, the modulation depth / deviation must not be greater than the full-scale setting under SENSITIV AF OUTPUT, or a distorted signal will be obtained at the loudspeaker/headphones output even with the volume reduced.

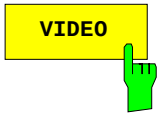
2.4.2.3 Triggering with Analog Demodulation - Softkey TRIGGER or Hardkey TRIGGER

Submenu: *CONFIGURATION MODE - VECTOR ANALYZER - ANALOG DEMOD*



The *TRIGGER* softkey as well as the *TRIGGER* hardkey permit to call up the menu for setting the trigger.

The *FREE RUN* softkey activates a measurement without trigger. After a measurement has been terminated, data acquisition for a new measurement takes place immediately.



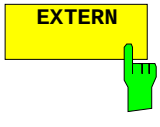
***REAL TIME OFF** only.*

The *VIDEO* softkey starts the measurement by means of the video voltage of the analog path of the spectrum analyzer. For this purpose, the analog video voltage of the spectrum analyzer is analyzed parallel to the vector signal analyzer.

Video triggering is of particular use for frequency settling measurements on synthesizers.

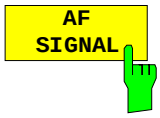
Video triggering requires the trigger threshold to be entered. It is identical with the trigger threshold of the spectrum analyzer. The trigger threshold is entered numerically into the data input field in % of the last grid that was active in spectrum analysis mode.

The appropriate value for the trigger threshold can be determined in the spectrum analysis mode.



***REAL TIME OFF** only.*

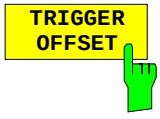
The *EXTERN* softkey activates triggering via an external voltage in the range from - 5 V to + 5 V at the BNC connector EXT TRIGGER / GATE (rear panel). Enter the desired value in the data input field.



The *AF SIGNAL* softkey opens up a data input field where the level of the AF signal is entered as the trigger level for display of the time signal.

The AF trigger level is entered in %, Hz, deg or rad according to the current demodulation AM, FM or PM (in the case of AM DC in the current absolute level unit).

Triggering on the AF signal is similarly possible with ***REAL TIME ON/OFF.***



REAL TIME OFF *only*

The *TRIGGER OFFSET* softkey opens up an input window for entry of the desired offset with video trigger or external trigger (only with).

The softkey cannot be operated with ***REAL TIME ON*** and ***REAL TIME OFF*** in conjunction with AF trigger.

The trigger offset is used to determine the start of data acquisition relative to the trigger event. Both positive values for a trigger delay and negative values for a pretrigger are permissible.

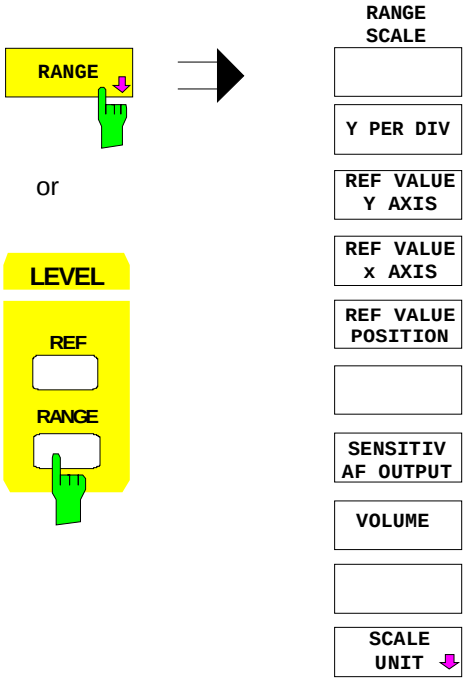
The input is made in absolute time irrespective of the scale selected for the X-axis.

The *SLOPE POS/NEG* softkey determines the trigger edge for triggering y means of the video signal, AF signal or external trigger.
The measurement run is started on a positive or negative edge of the trigger signal. With free-running trigger (*FREE RUN*), the setting is not of any significance.

2.4.2.4 Setting the Display Range and the Scaling - Softkey RANGE or Hardkey RANGE

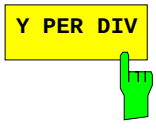
The menu for setting the range differs from that in the signal analysis mode.

Submenu: *CONFIGURATION MODE - VECTORANALYZER - ANALOG DEMOD*



The *RANGE* softkey as well as the *RANGE* hardkey are used to call up a menu, which contains all the parameters important for the vertical axis (y-axis) and the horizontal axis of the screen display of the AF signal, such as reference values, scaling, etc.

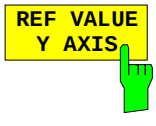
In addition, with real-time demodulation, the slope of the AF output as well as the volume of the loudspeaker or headphones connector can be set here.



The *Y PER DIV* softkey indicates the vertical scaling in the current unit.

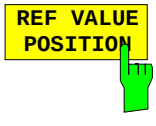
Hz or % are set for AM or FM, respectively. PM permits to choose between the units deg and rad (default status: rad).

For the relative value display of the modulation summary, it is possible to choose between % and dB (default setting dB).



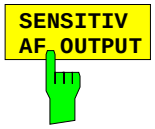
The *REF VALUE Y AXIS* softkey prompts the user to enter the reference value for the Y-axis of the diagram.

The reference value is entered in the respective display unit (see *UNIT*).

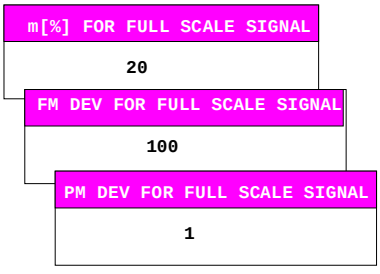


The *REF VALUE POSITION* softkey opens up an input window, in which reference value positions deviating from the default setting are set.

REF VALUE POSITION determines the position of the reference value. It is normally 50 % when the AF signal is displayed.



The *SENSITIV AF OUTPUT* (sensitivity AF output) softkey is used to set the scaling of the AF output with real-time demodulation. Depending on *MEAS RESULT* (AM, FM, or PM signal), an input field appears, where the modulation amplitude is to be entered at which the dynamic range of the AF output is fully utilized.
(Peak voltage 1V):



SENSITIV AF OUTPUT also affects the volume of the loudspeaker and the headphones output.

***REAL TIME ON** only*

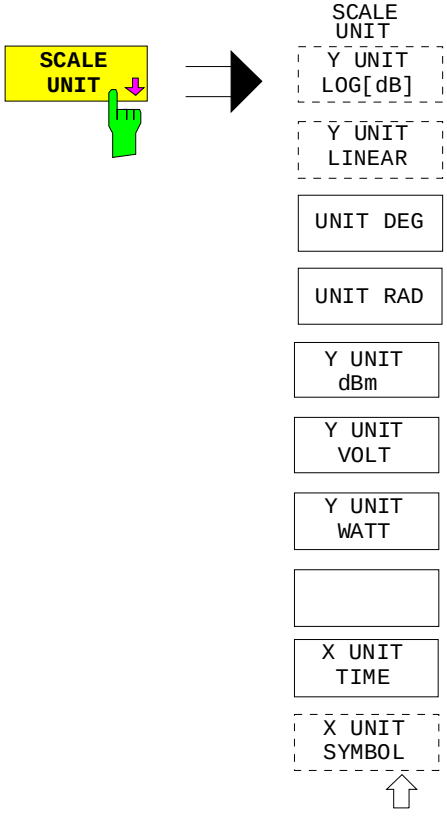
The *VOLUME* softkey sets the volume of the demodulated signal (loudspeaker and headphones output) according to the slope of the AF output.

With ***REAL TIME OFF*** *(*no real-time demodulation*)* the outputs are switched off.

Note: *If the modulation depth / deviation is very small, the scaling of the AF outputs (Softkey SENSITIV AF OUTPUT) is to be matched to achieve a usable volume.*

On the other hand, the modulation depth / deviation must not be greater than the full-scale setting under SENSITIV AF OUTPUT, or a distorted signal will be obtained at the loudspeaker/headphones output even with reduced volume.

Submenu: *CONFIGURATION MODE - VECTOR ANALYZER - ANALOG DEMOD - RANGE*



The *SCALE UNIT* softkey calls up a submenu for setting the unit of the Y-axis .

The units offered depend on the signal displayed.If a marker is switched on, the marker results are output in the current scale units.

With *ANALOG DEMODULATION,* the following Y-units are possible according to the type of modulation

AM:	AM[**%**],
FM:	Hz**,**
PM:	rad (default setting) or deg.

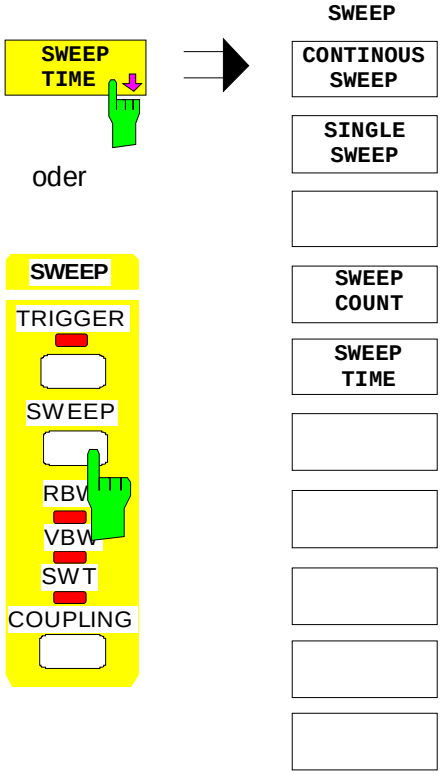
(With AM and FM, the units cannot be selected).

With time display of the AM signal and *AF COUPL'G DC* selected, the AM-demodulated signal is not standardized, but scaled in absolute levels.

Possible units are dBm, V and W. The default unit is dBm.

2.4.2.5 Sweep Menu with Analog Demodulation - Softkey SWEEP TIME or Hardkey SWEEP

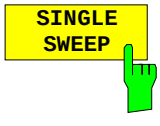
Submenu: *CONFIGURATION MODE - VECTORANALYZER - ANALOG DEMOD*



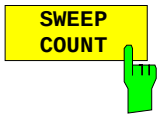
The *SWEEP* key calls up a menu, which permits to determine the type of measurement - single measurement or continuous measurement - and the length of the measurement results to be displayed in terms of time.

The *CONTINUOUS SWEEP* softkey starts a continuous measurement in accordance with the trigger condition and the selected test settings. Triggering is followed by data acquisition first and then by evaluation and display on the screen.

If, with split screen display, vector analysis mode is used for measurement in both windows, the data in the measurement RAM are used for both evaluations.



The *SINGLE SWEEP* softkeystarts n measurements in accordance with the trigger settings. The number of measurement runs n is determined by means of *SWEEP COUNT*. The measurement stops after n measurements. It can be restarted by pressing the *SINGLE SWEEP* or *CONTINUOUS SWEEP* softkey again.



The *SWEEP COUNT* softkey opens up an input field in which the number of measurements is determined for the *SINGLE SWEEP*.

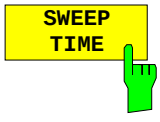
The number of measurements can be selected between 0 and 32767.

If averaging of the measured values is set (*AVG/HOLD ON*, *MODULATION MARKER*: *RMS* to be found under the *MARKER SEARCH key*), *SWEEP COUNT* also determines the number of measurements used for averaging.

If *SWEEP COUNT* = 0, 10 measured values are always used for floating averaging.

If *SWEEP COUNT* = 1, no averaging takes place.

If *SWEEP COUNT* >1, the average is taken of the set number of measured values.



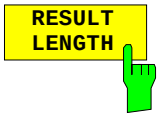
SWEEP TIME is used to define the time during which the demodulated signal is to be displayed.
The maximum time is determined by the demodulation bandwidth set and the buffer length for the demodulated signal, which is 5000 points with analog demodulation.
Thus, the following settable maximum time is obtained:

$$\text{SWEEP TIME}_{max} = \frac{5000}{0.8 * (\text{DEMOD\_BW})} \text{ [s]}$$

A minimum of 10 points can be displayed, which means for the minimum settable time:

$$\text{SWEEP TIME}_{min} = \frac{10}{0.8 * (\text{DEMOD\_BW})}$$

Example:
With Demod BW 1kHz, the maximum and minimum time scale is as follows:
TIME/DIV_{max} = 6.25 s
TIME/DIV_{min} = 12.5 ms

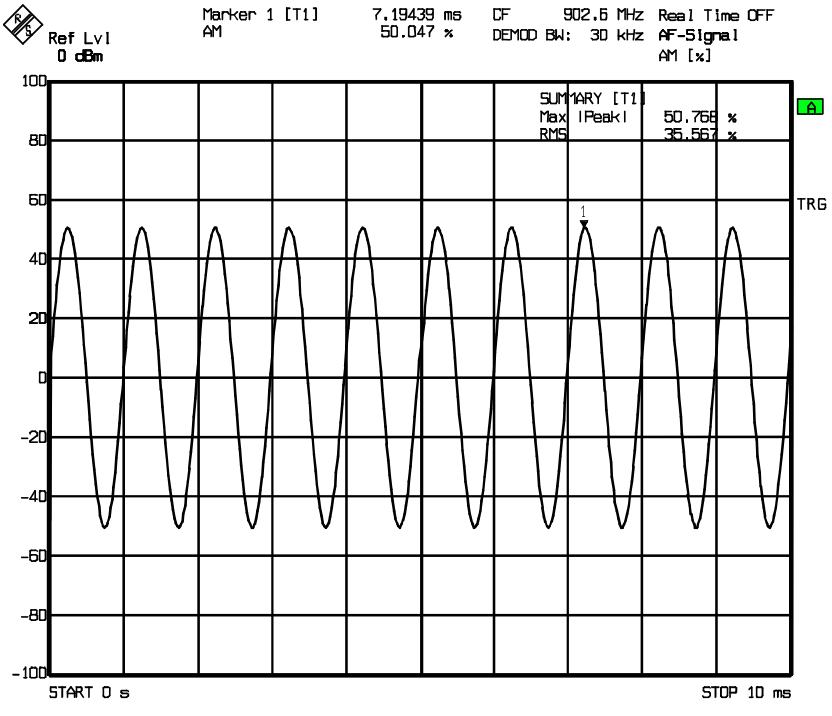


The *RESULT LENGTH* softkey cannot be operated with *ANALOG DEMODULATION*.

Example: Measurement of amplitude modulation

Measurement of a carrier modulated with 1 kHz, 50 % at 100 MHz, level 0 dBm

1. [**PRESET**]	Default setting
2. [**CENTER:** 100 MHz]	Frequency setting
3. [**REF:** REF LEVEL: +6 dBm]	Level setting (the max. level of AM-modulated signals is 6 dB above the nominal level with 100 % AM).
4. [**MODE**: VECTOR ANALYSIS]	Selection of vector analysis mode The FSE is in the analysis mode ***DIGITAL DEMODULATION*** (default setting).
5. [ANALOG DEMODULATION]	Switch to analog demodulation. The AM-modulated signal appears on the display (display in the time domain, the default setting for [*ANALOG DEMODULATION*] is AM-SIGNAL). The demodulation bandwidth (analysis bandwidth) is 100 kHz in the default setting, i.e. audio signals up to max. 0.4* demodulation bandwidth can be demodulated.
6. [DEMOD BW: 30 kHz]	The demodulation bandwidth is changed eg to 30 kHz
7. [**TRIGGER**:AF SIGNAL 0%]	Trigger setting to achieve a stable display. The display of the AF signal at the left edge of the screen starts at 0 %.
8. [**SWEEP**: SWEEPTIME 100 ms]	Setting of the sweep time. The sweep time depends on the demodulation bandwidth and the sampling points provided (=5000 with analog demodulation). With a demodulation bandwidth of 30 kHz, the max. sweep time is 208 ms in the default setting.
9. [**SEARCH**: SUM MKR ON]	Activating the summary marker for numeric trace evaluation.



2.4.3 Digital Modulation Methods

2.4.3.1 Diagram for signal processing

In modern mobile radio networks digital transmission methods are used to avoid the disadvantages of a transmission channel in mobile communication and to be able to serve more subscribers in the available frequency spectrum. The FSE offers all commonly used demodulators for digitally modulated signals. All modulation parameters for standard transmission methods can be loaded as required by the user. The FSE determines all relevant modulation parameters such as frequency, phase, amplitude and vector errors, etc. Measurements are carried out on continuous as well as pulsed signals such as TDMA signals. Bit patterns can be defined to be able to trigger to known bit sequences like preambles or midambles. The demodulator requires neither a coherent carrier nor a symbol clock for demodulation. It comprises matched filters and synchronizes automatically to the carrier and to the symbol clock. Furthermore, the demodulator can generate the ideal I/Q signal from the demodulated bit stream and thus determine the errors of the analyzed signal.

For a correct demodulation of digital signals, a number of modulation parameters in addition to the modulation mode has to be specified for the signal to be analyzed. The most important are the symbol rate and the input filter. And in addition, the frequency of the FSE (approx. 2% of the symbol rate) has to be tuned exactly to the frequency of the signal to be analyzed.

The bandwidth for demodulation is a function of the symbol rate and the selected oversampling method (*POINTS PER SYMBOL*). At least 4-fold oversampling is performed. If the number set under *POINTS PER SYMBOL* is reduced, fewer points are used in the display. The demodulation bandwidth for 1, 2 and 4 points per symbol is 3.125 times the symbol rate, with 8 points per symbol 6.5 times and for 16 points per symbol 13 times. It should be ensured that no modulation spectrum of adjacent signals is within the displayed range during demodulation, as this may introduce errors in the measurement of modulation parameters. If required, check for correct settings in the analyzer mode. The block diagram below shows the digital demodulator and its measurement capabilities:

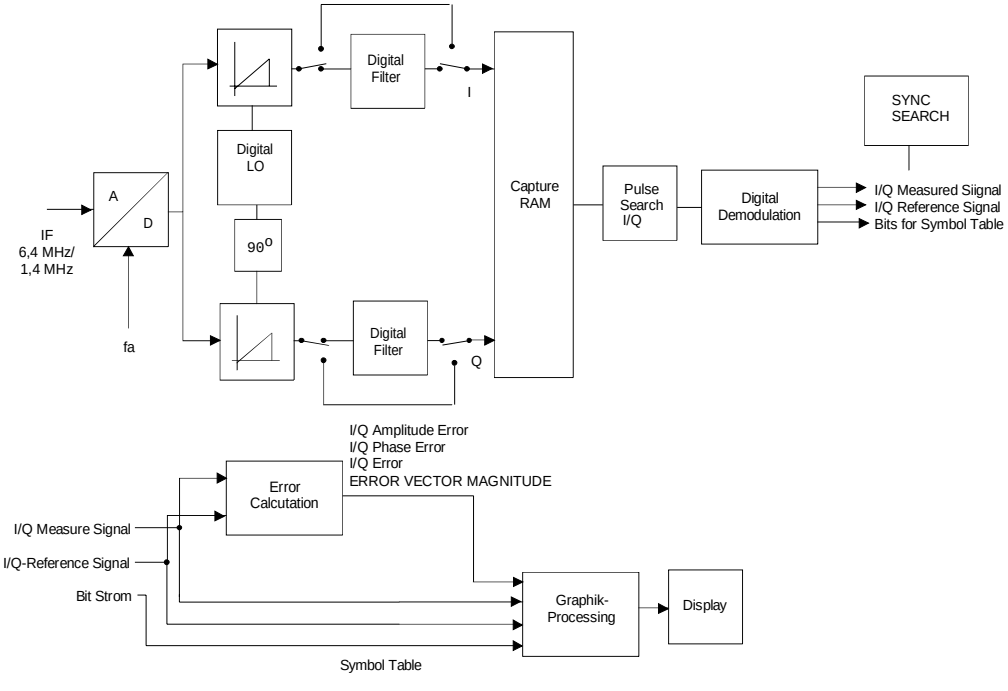


Fig. 2.4-4 Block diagram for signal processing during digital demodulation

2.4.3.2 Symbol Mapping

The following types of symbol mapping are used for representing the results in the vector and constellation diagrams (PSK, MSK, QAM) and for the time/frequency representations with FSK modulation. The symbols are always in the binary code (MSB at left).

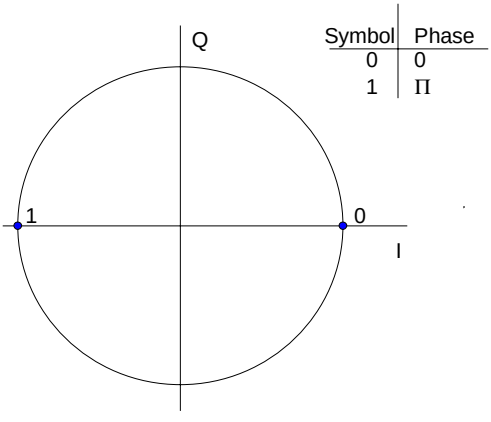
2.4.3.2.1 Phase Shift Keying (PSK)

With these modulation types, the symbol represents the absolute phase of the received signal at the decision time. The following representations are given:

- a constellation diagram containing all symbols
- a table containing the symbol designations and the associated reference phases

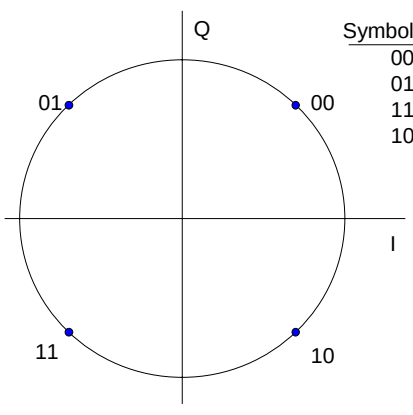
With this type of phase modulation, transitions from any symbol to any other in the constellation diagram are permitted.

BPSK



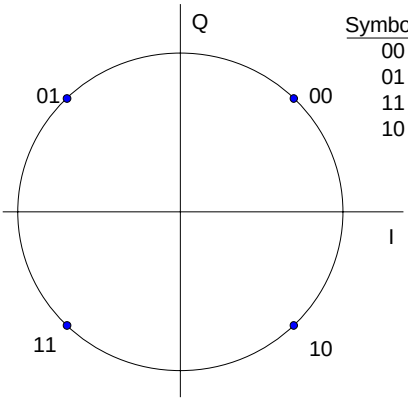
Symbol	Phase
0	0
1	Π

QPSK (WCDMA)



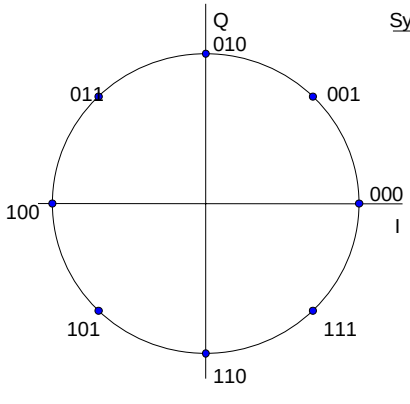
Symbol	Phase
00	Π/4
01	3Π/4
11	5Π/4
10	7Π/4

QPSK (QCDMA FWD; WCDMA; APCO25)
OQPSK (QCDMA REV)



Symbol	Phase
00	Π/4
01	3Π/4
11	5Π/4
10	7Π/4

8PSK



Symbol	Phase
000	0Π/4
001	1Π/4
010	2Π/4
011	3Π/4
100	4Π/4
101	5Π/4
110	6Π/4
111	7Π/4

Fig. 2.4-5 Symbol mapping - phase shift keying

3PI/8-8PSK (EDGE)

For these modulation methods the digital information is **NOT** coded in the phase transitions but in the absolute position of the constellation diagram. The constellation diagram consists of 16 points. For each symbol transition, an offset of 3pi/8 is inserted counterclockwise.
The symbol allocation in the constellation diagram is thus only valid for the first symbol of the data record.
Five symbol transitions with an offset of 3pi/8 each is given as an example. The modulated symbol "111" remains constant.
This phase offset is taken into account during decoding and the display of symbols.

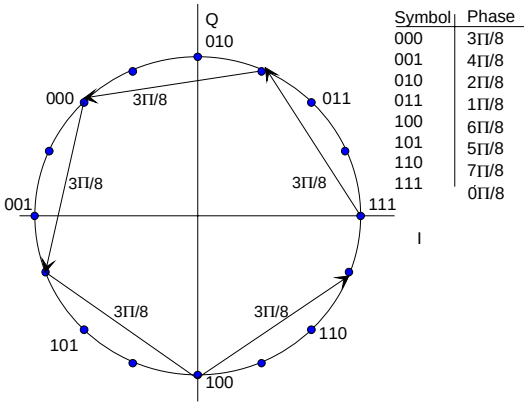


Fig. 2.4-6 Symbol mapping - phase shift keying - EDGE

2.4.3.2.2 Differential PSK

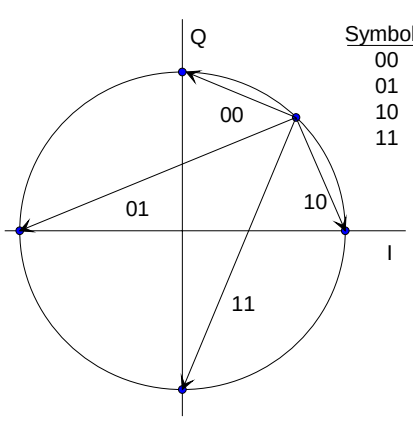
When using differential phase modulation, the symbol is the result of the phase difference between the current and the previous decision point. The absolute position of the pointer at the decision time is therefore not relevant. In the following diagrams, the phase transitions are shown, as examples, in the first quadrant, while the pointers point to the constellation point relevant for the current decision time. The signal is demodulated such that the decision times coincide with the constellation points.
The following representations are given:

- a constellation diagram containing all permissible symbol transitions
- a table containing the symbol designations and the associated phase differences

The absolute phase of the signal is not relevant for the symbol decision.

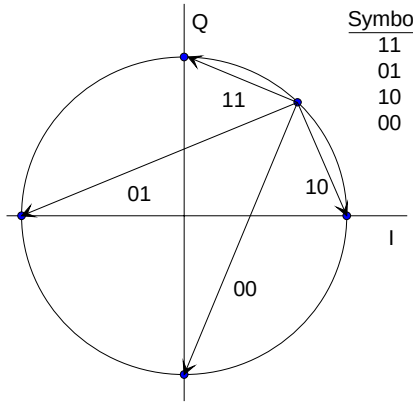
PI/4 DQPSK
The positions of the permissible constellation points is as with 8PSK. With this technique, only the phase transitions given in the tables are permitted.

NADC, PDC, PHS, TETRA, APCO25, PWT



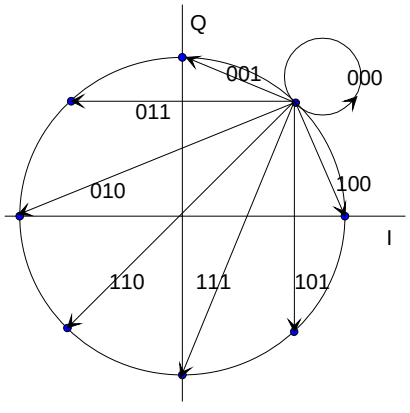
Symbol	Phase difference
00	Π/4
01	3Π/4
10	-Π/4
11	-3Π/4

TFTS



Symbol	Phase difference
11	Π/4
01	3Π/4
10	-Π/4
00	-3Π/4

D8PSK
The positions of the permissible constellation points is as with 8PSK. With this technique, transitions to all 8 constellation points possible are permitted.



Symbol	Phase difference
000	0*Π/4
001	1*Π/4
011	2*Π/4
010	3*Π/4
110	4*Π/4
111	5*Π/4
101	6*Π/4
100	7*Π/4

Fig. 2.4-7 Symbol mapping - differential phase modulation

2.4.3.2.3 Frequency Shift Keying (FSK)

When working with FSK demodulation, a frequency/time diagram will be displayed instead of the constellation and vector diagrams. The symbol decision is based on the signal deviation at the decision times.

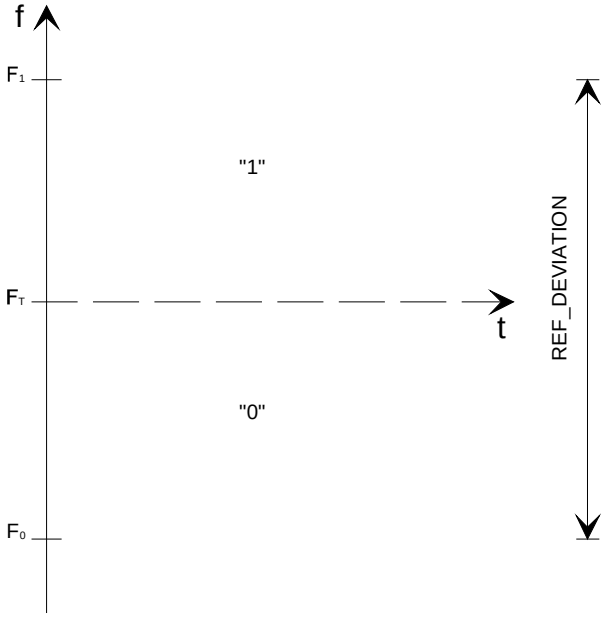
2FSK (DECT, CT2; FLEX16_2; FLEX32_2)

With 2FSK, the symbol decision is taken by a simple frequency discriminator with the following decision threshold:

$$f_T = f_{mid}$$

$$\text{Symbol} = \begin{cases} \text{"1"} & \text{for } f_E \geq f_T \\ \text{"0"} & \text{for } f_E < f_T \end{cases}$$

f_I = instantaneous frequency
f_T = decision threshold
f_{MID} = middle frequency of analyzer



4FSK (ERMES; MODACOM; APCO25; FLEX32_4; FLEX64_4)

With 4FSK the symbol decision is taken by a frequency discriminator using three decision thresholds derived from the operating parameter REF_DEVIATION:

$$f_{T1} = f_{MID} - \frac{1}{3} \cdot \text{REF\_DEVIATION}$$

$$f_{T2} = f_{MID}$$

$$f_{T3} = f_{MID} + \frac{1}{3} \cdot \text{REF\_DEVIATION}$$

$$\text{Symbol} = \begin{cases} \text{"11"} & \text{for } f_E \geq f_{T3} \\ \text{"10"} & \text{for } f_{T2} \leq f_E < f_{T3} \\ \text{"01"} & \text{for } f_{T1} \leq f_E < f_{T2} \\ \text{"00"} & \text{for } f_I < f_{T1} \end{cases}$$

f_I = instantaneous frequency
f_{T1}, f_{T2}, f_{T3} = decision thresholds
f_{MID} = middle frequency of analyzer

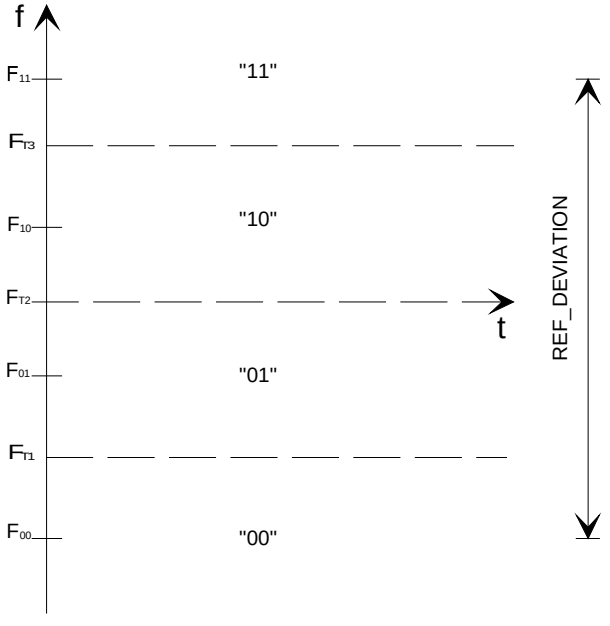


Fig. 2.4-8 Symbol mapping - FSK demodulation

2.4.3.2.4 Minimum Shift Keying (MSK), CDPD

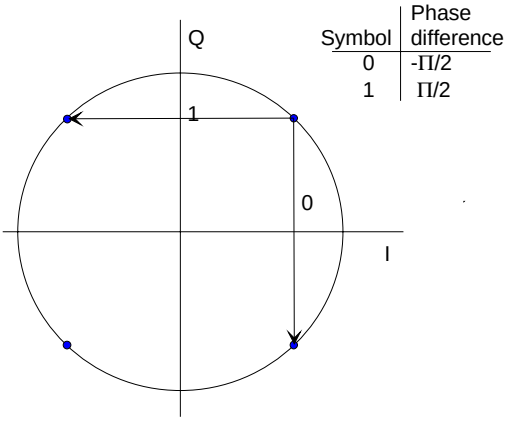


Fig. 2.4-9 Symbol mapping - minimum shift keying (MSK)

DMSK (and the derived GSMK) uses additional difference coding of two subsequent symbols. Static symbol mapping therefore does not exist.

2.4.3.2.5 Quadrature Amplitude Modulation (QAM)

With the QAM technique, the symbols are counted linearly from right to left and from top to bottom (linear mapping).

Note: *For reliable demodulation make sure the available symbols are utilized. If only some of the symbols or only the symbols in one quadrant are utilized, demodulation errors may occur.*

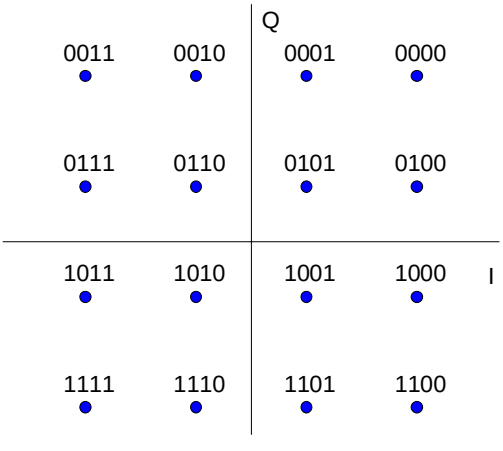
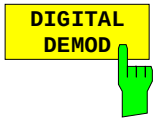


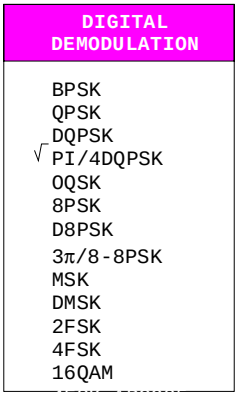
Fig. 2.4-10 Symbol mapping - 16QAM

2.4.3.3 Selecting the Digital Demodulators

Submenu: *CONFIGURATION MODE - VECTOR ANALYZER*



The *DIGITAL DEMOD* softkey opens a list of all available demodulators.



Demodulators are provided for the two-, four- and eight-level PSK modulation modes BPSK, QPSK and 8PSK. For QPSK and 8PSK demodulation, the demodulators for differential signals DQPSK and D8PSK can be selected additionally.

Demodulators are also availabe for the special versions of QPSK modulation, such as differential QPSK with π/4 phase offset (π/4-DQPSK) and offset QPSK (OQPSK).

QPSK is used, for instance, by the IS95- CDMA for modulating signals from the base station to the mobile, OQPSK for signals from the mobile to the base station. The American TDMA system NADC (IS54) uses π/4-DQPSK for digital signal transmissions.

For higher-level modulation modes the demodulator for 16QAM is available. MSK (minimum shift keying) demodulators pertain to the group of continuous-phase demodulators. MSK with Gaussian filters (GMSK = Gaussian minimum shift keying) is used for the European mobile radio systems GSM and DCS1800 or PCS1900 in the USA. For correct bit detection for GSM, DCS 1800 and PCS 1900 and 1800 the MSK demodulator with additional differential decoding (DMSK) should be activated.

For FSK (frequency shift keying modulation, two-level (2FSK) and four-level (4FSK) demodulators can be selected.

2FSK modulation methods are used for instance for the digital cordless telephone to DECT standard, 4FSK for the paging system to ERMES standard.

2.4.3.4 Standard Settings

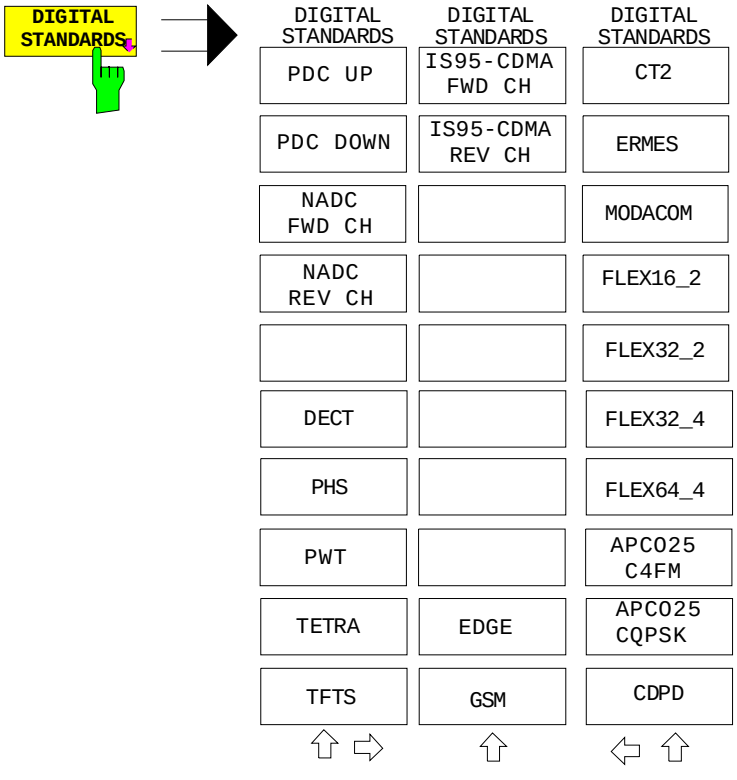
To simplify the selection of parameters when standard transmission methods are used, standard setups are available in the FSE. All modulation parameters and the width of the display range are set automatically.
The following table shows available standards and respective settings.
For the GSM, DCS1800 and PCS 1900 standards the sync pattern GSM_BTS0 with the associated synchronization offset of 61 symbols is preset in addition. When selecting the NADC standard, the instrument is set to the burst of the base station with a slot length of 162 symbols. When selecting the NADC FORWARD CH standard, the instrument is set to the non-burst signal of the base station with a slot length of 162 symbols. For the burst of the mobile station, the standard length NADC REVERSE CH must be set.
For the DECT standard the sync pattern of the fixed part DECT_FP is preset, the sync offset is set to 0. When selecting the TETRA standard, the sync pattern Tetra_1 is preset, the sync offet is preset to 122.

Sync pattern and sync offset become active be switching *FIND SYNC* (menu *SWEEP TRIGGER*) on.

Note: *The pager standards ERMES and FLEX (2FSK and 4FSK modulation) feature modulation filters with increased bandwidth (B*T> 1). This means that with normal oversampling (4 points per symbol) there is an intolerable bandwidth restriction which causes a distinctly higher demodulation error probability. Therefore the number of points per symbol is preset to 8 when the ERMES standard is selected and to 16 when the FLEX standard is selected.*

Attention: *In case of departures from the preset value (which may happen automatically when increasing the frame length or result length) there is a higher system error probability.*

Submenu: *CONFIGURATION MODE - VECTOR ANALYZER*



The *DIGITAL STANDARDS* softkey calls up a submenu of available standard setups.

If one of the following modulation parameters is modified, any digital standard that may be selected is switched off automatically:

- Symbol rate
- Measurement filter
- Reference filter
- α/BT

Table 2.4-1 Standard settings

Modulation/ Standard	Symbol rate	Measurement filter	Reference filter	Alpha BT	Synchro-nization	Sync Pattern	SYNC OFFSET	Points/ symbol
IS95-CDMA FWD CH QPSK	1.2288 MHz	IS95_FM	IS95_FR	--	--	--	--	4
IS95-CDMA REV CH OQPSK	1.2288 MHz	IS95_FR	IS95_RR	--	--	--	--	4
EDGE 8π/8-8PSK	270.833 kHz	EDGE_MES	EDGE_REF	--	BURST SEARCH	EDGE_BT00	61	4
GSM, (DCS1800, PCS 1900) MSK	270.833 kHz	NONE	GAUSSIAN	0,3	BURST SEARCH	GSM_BTS0	61	4
NADC FWD CH*) π/4 DQPSK	24.3 kHz	ROOT RAISED COS	RAISED COS	0,35	SYNC SEARCH	NADC_S1	0	4
NADC REV CH π/4 DQPSK	24.3 kHz	ROOT RAISED COS	RAISED COS	0,35	BURST SEARCH	NADC_S1	8	4
PDC DOWN π/4 DQPSK	21 kHz	ROOT RAISED COS	RAISED COS	0,5	SYNC SEARCH	PDC_S1	57	4
PDC UP π/4 DQPSK	21 kHz	ROOT RAISED COS	RAISED COS	0,5	BURST SEARCH	PDC_S1	57	4
PHS π/4 DQPSK	192 kHz	ROOT RAISED COS	RAISED COS	0,5	BURST SEARCH	PHS_DO1	32	4
CDPD MSK	19.2 kHz	NONE	GAUSSIAN	0,5	--	--	--	4
DECT 2-FSK	1152 kHz	NONE	GAUSSIAN	0,5	VIDEO TRIGGER + BURST SEARCH	DECT_FP	0	4
TETRA π/4-DQPSK	18 kHz	ROOT RAISED COS	RAISED COS	0,35	BURST SEARCH	TETRA_1	122	4
CT2 2-FSK	72 kHz	NONE	GAUSSIAN	0,5	BURST SEARCH	CT2_CFP	0	4
ERMES 4-FSK	3.125 kHz	NONE	BESSEL 1_25		--	--	--	8
MODACOM 4-FSK	4.8 kHz	ROOT RAISED COS	RAISED COS	0,2	--	--	--	4
FLEX 16_2 (FLEX 1600) 2-FSK	1.6 kHz	NONE	BESSEL 2_44	--	--	--	--	16
FLEX 32_2 (FLEX 3200) 2-FSK	3.2 kHz	NONE	BESSEL 1_22	--	--	--	--	16
FLEX 32_4 (FLEX 3200 4-FSK	1.6 kHz	NONE	BESSEL 2_44	--	--	--	--	16
FLEX 64_4 (FLEX 6400) 4-FSK	3.2 kHz	NONE	BESSEL 1_22		--	--	--	16
PWT WCPE π/4 DQPSK	562.5 kHz	ROOT RAISED COS	RAISED COS	0,5	BURST SEARCH	WCPE_FP1	0	4
TFTS π/4 DQPSK**)	22.1 kHz	ROOT RAISED COS	RAISED COS	0,4	BURST SEARCH	TFTS_G1	0	
APCO25 C4FM	4.8 kHz	NONE	RAISED COS	0.2	--		--	8
APCO25 CQPSK	4.8 kHz	APCO25FM	RAISED COS	0.2	--		--	4

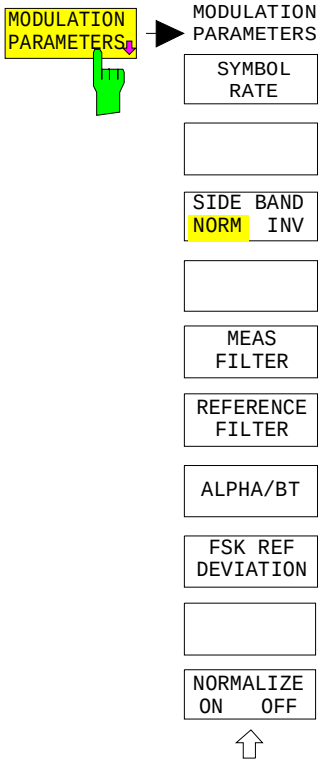
*) The standard setting is matched to the slot of the NADC base station. As the base station doesn't burst, the FIND BURST function is disabled.

**) When selecting the TFTS standard, the special bit decoding is made according to the TFTS standard.

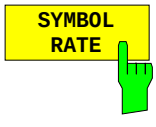
The standard settings are called up by means of the DIGITAL STANDARD softkey.

2.4.3.5 Selecting Modulation Parameters for Digital Demodulation

Submenu: *CONFIGURATION MODE - VECTOR ANALYZER*



The *MODULATION PARAMETERS* softkey calls up a submenu for setting of the modulation parameters.

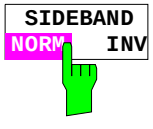


The *SYMBOL RATE* soft key opens a window for entering the symbol rate of the digitally modulated signal to be measured.

The symbol rate is a function of the bit rate determined via the modulation level and corresponds to the baud rate. With QPSK, for instance, the symbol rate corresponds to half the bit rate (= 2 bits per symbol). Symbols are only valid while the signal is evaluated by the receiver. The time of demodulation is the point of decision. The demodulator of the FSE uses the set symbol rate to find the points of decision.

To be able to select the correct symbols, the symbol rate has to be entered exactly. The more complex (high-level) the modulation method, the more critical the exact definition of the symbol rate. An inaccurately defined symbol rate causes demodulation errors. The settings below should also be observed for selecting the symbol rate:

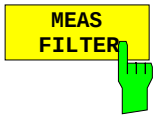
- Maximum possible symbol rate is 2.133 MHz.
- The number of points per symbol is limited to 8 for symbol rates >200 kHz and to 4 for symbol rates >400 kHz.



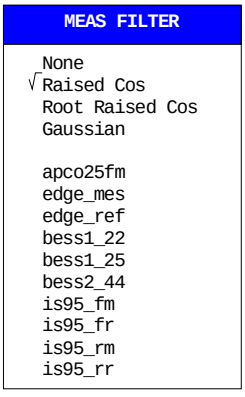
The *SIDE BAND NORM / INV (INVERTED)* demodulates and inverts the signal received.

Thus, with FSK demodulation, the frequency states are inverted, and, with non-FSK modulation, the I and Q signal are inverted.

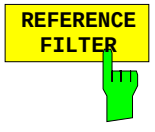
Default status is *SIDEBAND NORM* (normal).



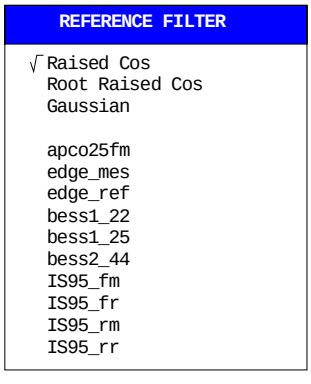
The *MEAS FILTER* softkey selects the input filter for the signal to be measured. The required filter is selected in a table:



Further information is given in the description of the *REFERENCE FILTER* softkey.



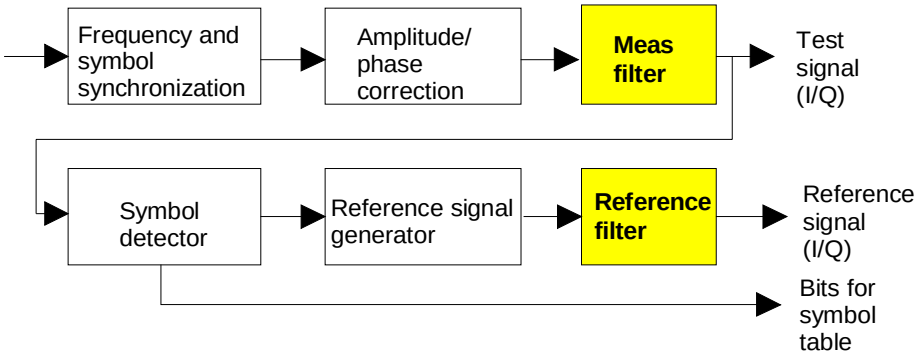
The *REFERENCE FILTER* softkey selects the filter for the ideal reference signal for detecting modulation errors at the baseband level. The required filter is selected in a table:



Predefined filters are the squarewave filter (only for setting *MEAS FILTER:NONE*), the raised cosine filter, the root raised cosine filter and the Gaussian filter. Cosine filters are generally used for PSK modulation, Gaussian filters by MSK and FSK modulators.

The filter parameters are set via *ALPHA/BT*.

The digital demodulator of FSE generates two signals at the I/Q level, the signal to be measured (*MEAS SIGNAL*) and the reference signal (*REFERENCE SIGNAL*).

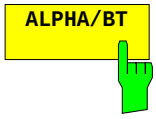


The signal to be measured is present at the RF input after demodulation. The reference signal is the signal that would be obtained in the case of an ideal RF signal. A separate filter is provided for the signal and the reference signal. For digital transmissions, filtering can be carried out at the transmitter or receiver end or be split up between both. The filter at the receiver is the measurement filter. The reference filter is used for the total system. Depending on the configuration of filters, the following combinations can be used:

Filters of transmission system		**Filters to be selected**	
Transmitter	**Receiver**	**MEAS FILTER**	**REFERENCE FILTER**
Root-raised cos	Root-raised cos	Root-raised cos	Raised cos
Raised Cos	none	none	Raised cos
Gaussian	none	none	Gaussian

If no modulation filter is provided in the transmitter, it may also be useful to employ a RAISED COS or GAUSSIAN filter as measurement filter.

However, the non-existing band limiting at the FSE input may cause unwanted aliasing products in the vector analyzer mode, which might impair the measurement. A measurement without reference filter is not possible!



If an input filter is used for demodulation or a filter for generating the reference signal, the filter characteristic has to be determined by means of *ALPHA/BT*. With Nyquist filters *ALPHA* has to be specified, with Gaussian filters the product of the symbol period T and bandwidth B (*BT*).

The A*LPHA/BT* soft key opens a window where the roll-off factor (*ALPHA*) for the cosine filters or the bandwidth/symbol period product *BT* for the Gaussian filters is entered. All filters are computed up to a length of 16 symbols.

Permissible input values are 0.2 to 3 in steps of 0.05. The value for *ALPHA/BT* applies to the measurement and to the reference filter. Values for *ALPHA* or *BT* are determined by the digital transmission system. These values should be used for measurements with FSE as higher demodulation errors could otherwise occur.

For *ALPHA/BT >1*, the demodulation bandwidth with sampling of 4 points per symbol is usually not sufficient. In this case it is recommended to set the number of points per symbol to 8 or 16. See also the note under DIGITAL STANDARDS. *ALPHA* describes the transmission characteristic of a Nyquist filter (cosine filter). It is also designated as roll-off factor or bandwidth factor. The greater ALPHA, the greater is the bandwidth occupied by the digitally modulated signal relatives to the theoretical minimum. In digital transmission systems typical bandwidth factors of 0.25 to 0.5 are used, ie the occupied bandwidth is 25% to 50% larger than the theoretical minimum. The bandwidth/time product *BT* describes the characteristic or the bandwidth factor of Gaussian filters.

The *FSK REF DEVIATION* softkey opens a window for entering the reference deviation for FSK demodulation.

FSK deviation is defined as the (unilateral) deviation from the center frequency occurring in the case of modulation with constant 0 or 1 sequences, ie the stationary value.

For 4FSK, the modulation deviation is the deviation from the center frequency for the bit sequences causing maximum frequency deviation.
The reference deviation is used for computing the deviation error in *NORMALIZE ON* mode

NORMALIZE	
ON	OFF

The *NORMALIZE ON/OFF* softkey has the following effect:
The measurement result in the vector and constellation diagram is always normalized to a circle, the radius of which corresponds to the mean distance between the center of the circle and the mid-points (of all groups of sampling values).
This circle is defined as a unit circle with the radius 1.

Softkey *NORMALIZE ON* shifts the center of the unit circle by the I/Q offset to the center for the group mid-points.

NORMALIZE ON is the default state:

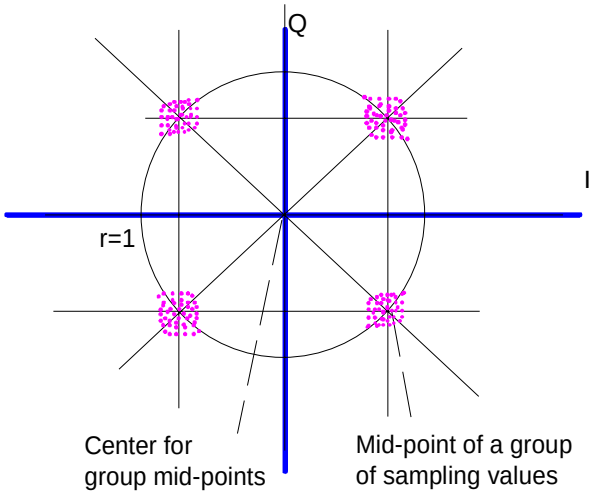
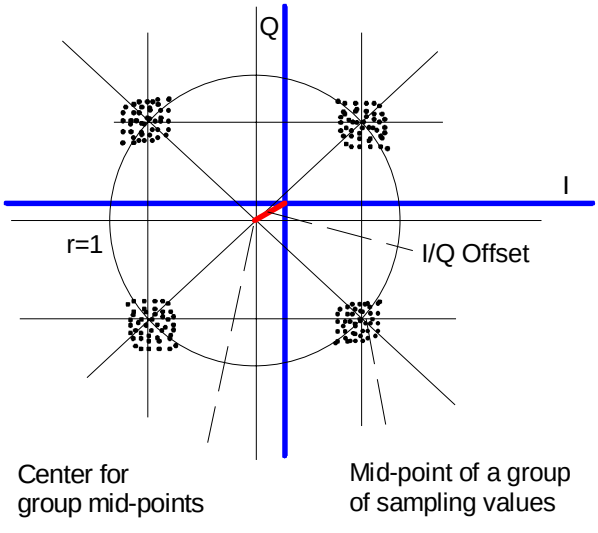


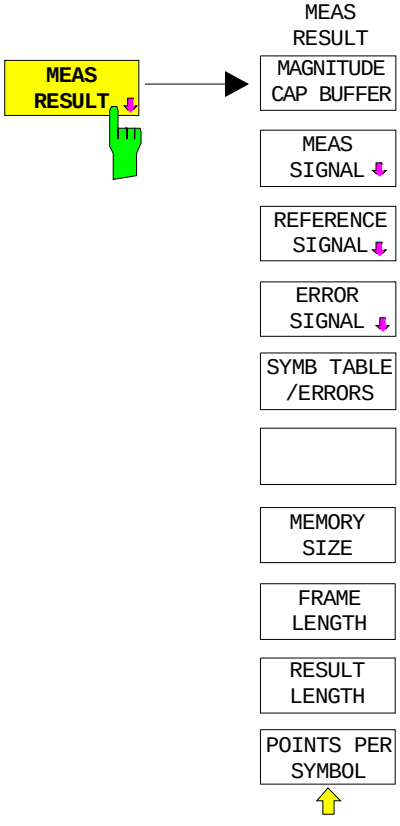
Diagram in the case of *NORMALIZE OFF*:



2.4.3.4 Selecting Measurement Results for Digital Demodulation

After entering all modulation parameters the required measurement is selected using the *MEAS RESULT* softkey. The contents of the trace memory (magnitude), the demodulated measurement signal, the reference signal, i.e. the ideal signal derived from the measurement signal, or the error signal can be displayed as the measurement result. The I/Q error and the vector error are the two possible error signals. A table is available listing all errors together with the demodulated bits.

Submenu: *CONFIGURATION MODE - VECTOR ANALYZER*



The *MEAS RESULT* softkey opens a submenu in which the different displays for the measured signal can be selected.

The *MAGNITUDE CAP BUFFER*, *MEAS SIGNAL*, *REFERENCE SIGNAL*, *ERROR SIGNAL* and *SYMB TABLE/ERRORS* softkeys are selection switches, i.e. only one of the measurement results offered can be selected per screen. If two screens are available, (split-screen mode) a different measurement result can be displayed in each screen.

When the measurement signal, the reference signal and the error signal are displayed, submenus are called up by the corresponding softkeys and the associated parameter can be set.

Moreover, softkeys are available for setting the memory size, the number of bits to be demodulated and displayed.

2.4.3.4.1 Magnitude of Capture Buffer

The capture buffer is the memory comprising the samples that are entered during the storage of measured values. These samples are used for demodulation but are retained over the complete measurement. A reason for this is the loss in the dynamic range during the synchronization and demodulation of the signal. For synchronization, an interpolation between the samples is necessary, for example, for determining the symbol decision point accurately. Interpolation is always synonymous with a loss in the amplitude dynamic range. In case of synchronization, the signal has to be normalized. The normalization is also linked with a loss in the dynamic range.
When measuring the power ramping of a TDMA burst, a maximum dynamic range is required. This dynamic range is obtained when using the capture buffer for samples.

Submenu: *CONFIGURATION MODE - VECTOR ANALYZER - MEAS RESULT*

The *MAGNITUDE CAP BUFFER* softkey indicates the magnitude of the signal in the capture buffer in the time domain.

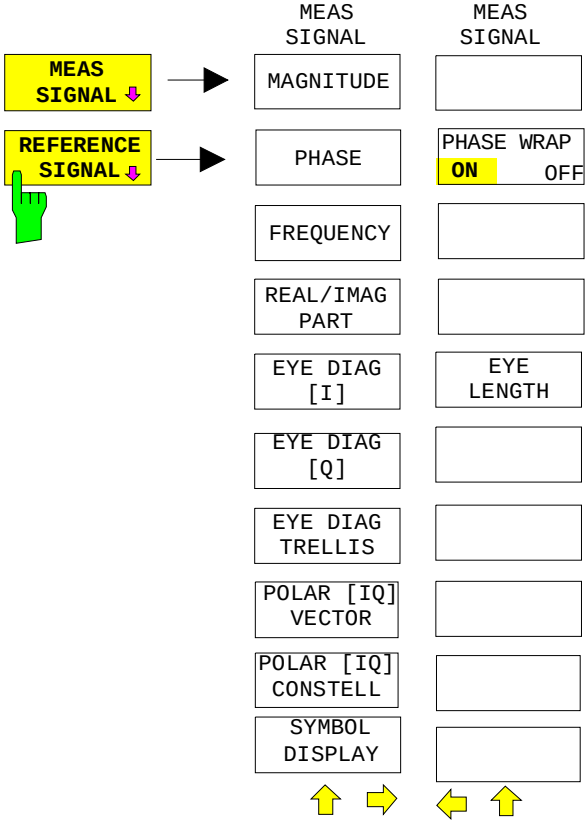
The *MAGNITUDE CAP BUFFER* mode is therefore recommended in all cases where power ramping of TDMA bursts should be measured with a wide dynamic range. Timing will be accurate to less than or equal to half a clock period of the sampling unit

Example:
A signal is sampled with 8 values per symbol. The maximum timing error of the TDMA burst synchronized to a bit sequence is 1/16, i.e. 6.25% of the symbol period.

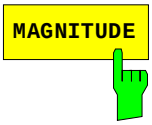
2.4.3.4.2 Measurement of Reference Signal

The FSE can display both the waveform of the measurement signal, which is derived from the samples in the baseband, and that of the reference signal. To this effect, the measurement signal is filtered and synchronized to the carrier and the symbol clock. The I/Q offset and the amplitude reduction of the signal is compensated prior to the display. The reference signal is generated from the demodulated bits by modulation down to the baseband. It is identical to the measurement signal freed of modulation errors and noise.
The output formats for the measurement signal and the reference signal are identical. The output formats are different for FSK demodulation and thel other demodulation modes.

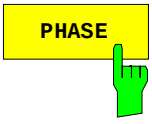
Output formats for non-FSK demodulation:
Submenu: *CONFIGURATION MODE - VECTOR ANALYZER - MEAS RESULT*



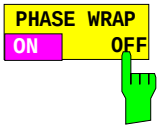
The *MEAS SIGNAL* and *REFERENCE SIGNAL* softkeys call up identical submenus. The output formats of the two signals can be selected there.



The *MAGNITUDE* softkey displays the magnitude of the demodulated measurement or reference signal, which is normalized to 1, as a function of time and symbol.



The *PHASE* softkey displays the phase of the measurement or reference signal.

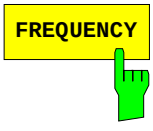


The *PHASE WRAP ON/OFF* softkey activates/deactivates a phase shift.

The phase of a signal can have very high values due to the modulation. Therefore, scaling should be very coarse to display the phase over many bits. FSE therefore offers the phase to be shifted by means of the *PHASE WRAP ON/OFF* softkey.

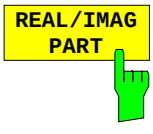
ON The FSE displays the phase in the range of ±180°. If the phase exceeds +180°, for example, 360° is subtracted from the phase value so that >-180° is indicated. This avoids very high phase values to be displayed which would impair the reading accuracy.

OFF The phase is not shifted. It is displayed within the range of the Y axis. Phase values above or below this range are cut off at the diagram edges.



The *FREQUENCY* softkey displays the time or symbol-dependent frequency response of the signal, i.e., the frequency-demodulated signal. The softkey is only available for MSK demodulation.

The frequency display is suitable for measuring the frequency deviation by using the markers.



The *REAL/*IMAG *PART* softkey calls up the display of the real and imaginary parts of the measurement or reference signal in separate diagrams.
To this effect, the diagram is split up. The real part is displayed in the upper half whereas the imaginary part is displayed in the bottom half. The X axis (which is scaled in time units or symbols) is identical for the two diagrams.

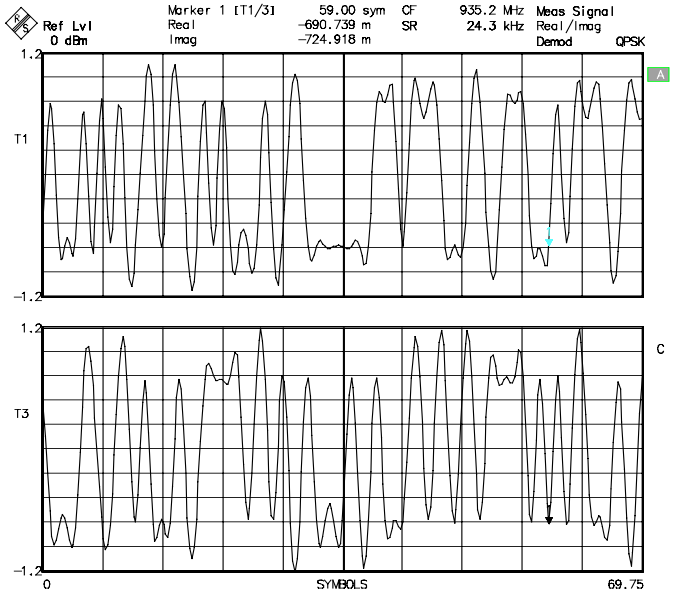


Fig. 2.4-11 Simultaneous display of inphase and quadrature component in a single diagram (here: screen A in split-screen display)

EYE DIAG [I]

EYE DIAG [Q]

EYE DIAG TRELLIS

The *EYE DIAG [I]*, *EYE DIAG [Q]* and *EYE DIAG TRELLIS* softkeys select the various eye diagrams:

- eye diagram for the inphase signal,
- eye diagram for the quadrature signal and
- trellis diagram.

The eye diagram is the representation of inphase and quadrature signal (*EYE DIAG [I] or EYE DIAG [Q]*) as a function of time. It is triggered by the symbol clock at the points of decision. The display range of the eye diagram (number of states on the time axis) is determined by softkey *EYE LENGTH*.

The individual traces of the eye diagram are superimposed on each other until the number of symbols specified with *RESULT LENGTH* is attained. The successive traces are the continuation of the trace written last, i.e. the total trace is displayed in a folded form. To obtain a complete eye diagram, all the states of a signal have to be traced at least once. The number of eyes vertically corresponds to the number of modulation states less 1. The eye aperture is a measure for differentiating between two decision levels. A small eye apertures indicate a high, large eye apertures a small bit error rate.

The trellis diagram is used for representing the states of continuous-phase modulation methods (e.g. MSK). It indicates the phase versus time and permits also phases above ±180° to be displayed. The trellis diagram is similar to the eye diagram in that measured traces are superimposed onto each other in the display until the number of symbols defined by *RESULT LENGTH* is attained.

For the FSE, the trellis diagram is particularly useful for testing MSK and GMSK modulation. The symbols are spaced by 90°. A phase shift of +90° corresponds to logic 1, a shift of -90° to logic 0. A rising phase edge therefore indicates a logic 1, a falling edge a logic 0. Same as with the eye diagram, the width of the trellis diagram is defined by *EYE LENGTH*. To obtain a clear display, a minimum of 5 symbols should be selected as display width.

The number of P*OINTS PER SYMBOL* should be as high as possible to obtain a continuous trace in the eye diagram. 8 to 16 points are recommended.

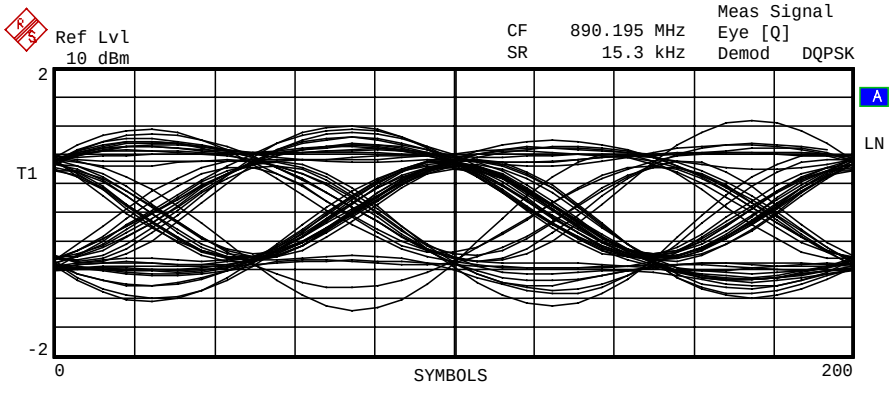
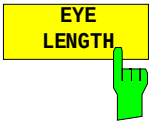
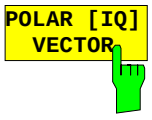


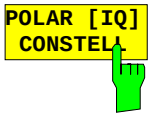
Fig. 2.4-12 Eye diagram over 200 symbols of a DQPSK-modulated signal.
Display range is five symbols.



The *EYE LENGTH* softkey determines the display width of the eye diagram in symbols. The number of symbols is entered in the field.

At least one symbol length or two states are required for a complete eye. To be able to detect the errors particularly at the zero crossings, two to five symbols are recommended. The number of symbols is limited with *RESULT LENGTH*. In the case of *EYE LENGTH* = *RESULT LENGTH*, however, the signal versus time is displayed, the eyes are no longer visible.





The *POLAR [IQ] VECTOR and POLAR [IQ] CONSTELL* softkey display the trace in the form of a polar diagram. In the vector diagram, all the points are marked. In the constellation diagram only those at the points of decision.

In the I/Q diagram, the FSE displays the inphase component of the signal on the X axis, the quadrature component on the Y axis. Each trace represents a vector. The magnitude of the vector is the distance to the zero point, the phase is the angle between the positive X axis and the vector measured counterclockwise.

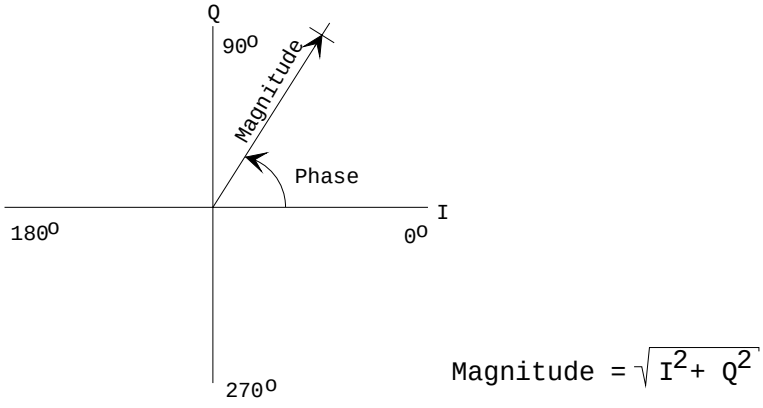


Fig. 2.4-13 Vector in the I/Q diagram

In the vector diagram the number of points between the points of decision is determined with *POINTS PER SYMBOL*. For instance, if 5 points per symbol have been selected, every 5th point is a symbol at the point of decision. The other four points are intermediate values. The points of decision can be marked by selecting *DOTS* under *SYMBOL DISPLAY*.
The constellation diagram displays only the measurement values at the points of decision.

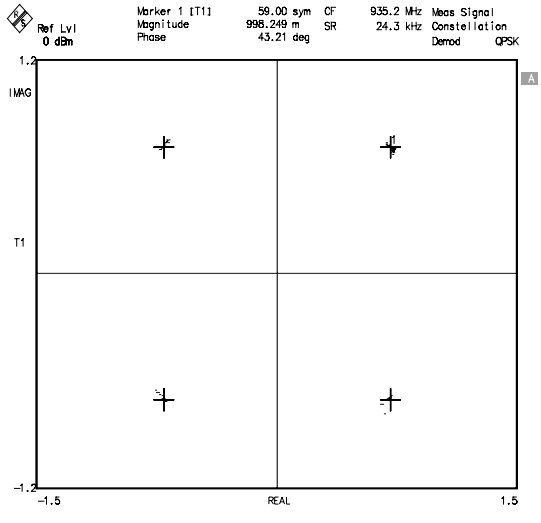
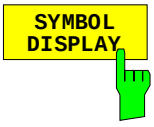


Fig. 2.4-14 Constellation diagram (example QPSK)



The S*YMBOL DISPLAY* softkey marks the symbol decision points in the displayed trace. The desired form of highlighting can be selected from the table. Points of decision can be marked by vertical lines or by means of dots.

SYMBOL DISPLAY
off
Dots
√ Lines

With *off* selected, the points of decision are not marked. When *Dots* are selected, points are drawn on the trace and for *Lines*, (except for vector and constellation diagrams) vertical lines are drawn between the X axis and the trace.

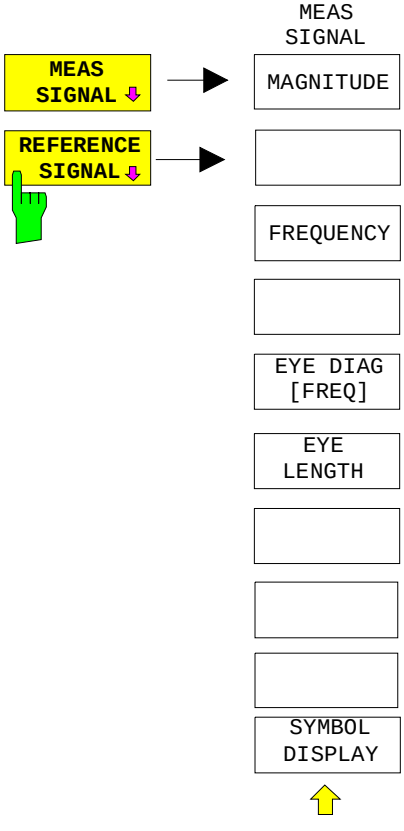
For vector and constellation diagrams dots are inserted with *Dots* **and** *Lines*.

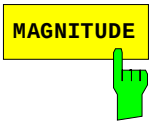
For the constellation diagram dots are also displayed even in the *off* mode.

This function is used for displaying the time characteristic of measurement results, e.g. as an I/Q characteristic or error signal.

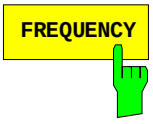
Output formats with FSK demodulation:

Submenu: *CONFIGURATION MODE - VECTOR ANALYZER - MEAS RESULTS*





The *MAGNITUDE* softkey displays the magnitude of the demodulated measurement or reference signal as a function of time and symbol.

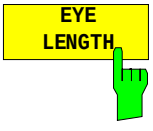


The *FREQUENCY* softkey displays the time- or symbol-dependent frequency response of the signal, i.e., the frequency-demodulated signal.

The frequency display is for instance suitable for measuring the frequency deviation by using the markers.

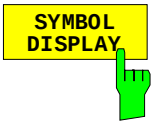
The *EYE DIAG [FREQ]* softkey displays the frequency-demodulated signal as a function of time. This signal is triggered by the symbol clock at the points of decision. The display range of the eye diagram (number of states on the time axis) is determined by *EYE LENGTH*.

The individual traces of the eye diagram are superimposed on each other until the number of symbols specified with *RESULT LENGTH* is attained. The successive traces are the continuation of the trace written last, i.e. the total trace is displayed in a folded form. To obtain a complete eye diagram, all the states of a signal have to be traced at least once. The number of eyes corresponds to the number of modulation states less 1. The eye aperture is a measure for differentiating between two decision levels. A small eye apertures indicate a high, large eye apertures a small bit error rate.

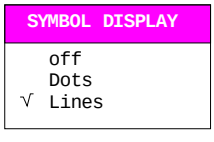


The *EYE LENGTH* softkey determines the display width of the eye diagram in symbols. The number of symbols is entered in the field.

At least one symbol length or two states are required for a complete eye. Two to five symbols are recommended however to detect the errors particularly at the zero crossings. The number of symbols is limited by *RESULT LENGTH*. In the case of *EYE LENGTH* = *RESULT LENGTH*, however, the signal versus time is displayed, the eyes are no longer visible.



The *SYMBOL DISPLAY* softkey marks the symbol decision points in the displayed trace. The desired form of highlighting can be selected from the table. Points of decision can be marked by vertical lines or by dots..



With *off* selected, the points of decision are not highlighted. When *Dots* are selected, points are drawn on the trace and with *Lines* selected (except for vector and constellation diagrams), vertical lines are drawn between the X axis and the trace.

2.4.3.4.3 Measurement of Modulation Errors

The FSE evaluates the modulation errors by comparing the measurement signal with the internally generated ideal reference signal. The output formats differ depending on whether FSK demodulation is selected or not. The different output formats of the error are selected by means of the *ERROR SIGNAL* softkey.

Non-FSK demodulation:

The modulation error of the measurement signal can be displayed separately, i.e. according to magnitude and phase, as I and Q error, error vector magnitude or, in polar diagrams, as vector or constellation diagram.

The magnitude and phase error are determined according to the following equations:

Error signal magnitude = $\sqrt{I^2 + Q^2}$ - $\sqrt{I_{ref}^2 + Q_{ref}^2}$ and

Error signal phase = $\arctan\frac{Q}{I} - \arctan\frac{Q_{ref}}{I_{ref}}$, where

the real and imaginary part of the error signal are given as follows

Error signal real part = I - I_{ref} and

Error signal imag part = Q - Q_{ref}

The magnitude of the error vector (error vector magnitude) is

$$EVM = \sqrt{(I - I_{ref})^2 + (Q - Q_{ref})^2}$$

I, Q = measured I/Q component
I_{ref}, Q_{ref} = I/Q components ideally calculated from the bit sequence.

The following vector diagram indicates the different types of errors resulting from the measurement signal and the reference signal:

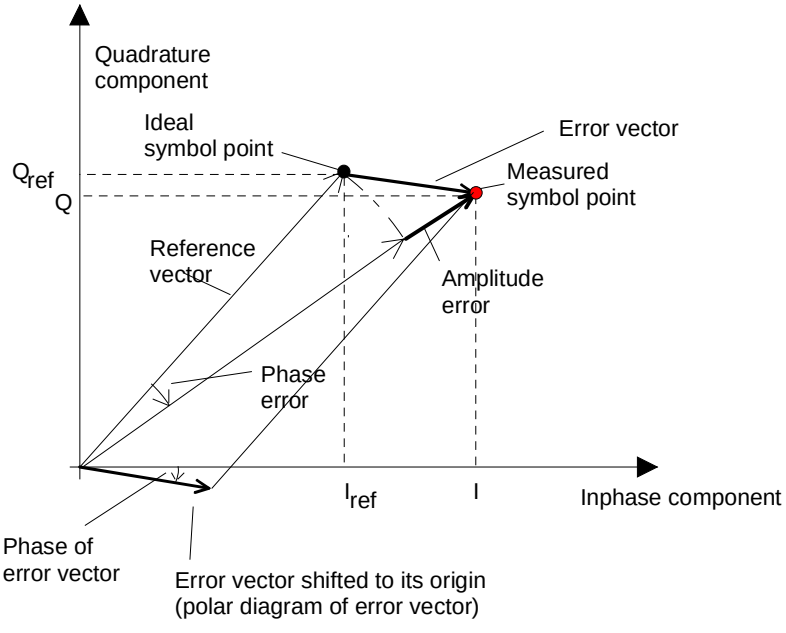
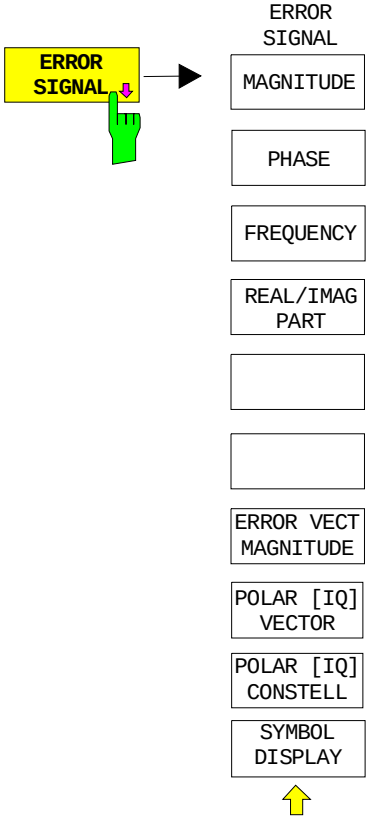


Fig. 2.4-15 Graphic display of modulation errors by means of a point of decision

Submenu: *CONFIGURATION MODE - VECTOR ANALYZER - MEAS RESULT*



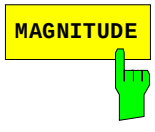
The *ERROR SIGNAL* softkey opens the submenu for selecting the type of error to be displayed.

The following types of error representation are available

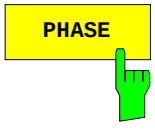
- amplitude error (MAGNITUDE)
- phase error (PHASE)
- frequency error (FREQUENCY)
- error if the real part (REAL/IMAG PART) and
- error of the imaginary part (REAL/IMAG PART)
- magnitude error (ERROR VECTOR MAGNITUDE)

For error representation the FSE compares all the points of the measurement and reference signal and displays them in the error diagram (except for *POLAR [IQ] CONSTELL*). Thus, the number of measurement results depends on the number of points per symbol. If only the errors are to be evaluated at the points of decision, the number of points per symbol has to be set to one.

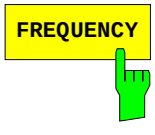
To maintain the correct error for discontinuous transmission, e.g. for TDMA methods, make sure that only valid symbols are displayed. The result length and the trigger condition have to be set appropriately.



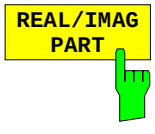
The *MAGNITUDE* softkey starts the point by point comparison of the magnitude of the measurement signal with the magnitude of the ideal signal. The difference of the two magnitudes is displayed..



The *PHASE* softkey starts the point by point comparison of the phase of the measurement signal with the phase of the ideal signal. The difference of the two phases is displayed as phase error.

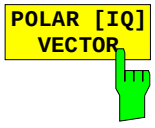


The *FREQUENCY* softkey displays the frequency error. The frequency response of the measurement signal is compared with that of the ideal reference signal and the difference between the two responses is displayed as a function of time and symbol. The softkey is only available for MSK demodulation .

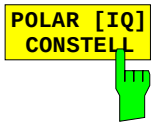


The *REAL/IMAG PART* softkey displays the error of the real and imaginary part in separate diagrams. To this effect, the measurement diagram is split up. The real part is displayed in the top half and the imaginary part in the bottom half. The X axis (time or symbols) is identical for the two diagrams.

The *ERROR VECT MAGNITUDE* softkey displays the magnitude of the error vector versus time or symbols.



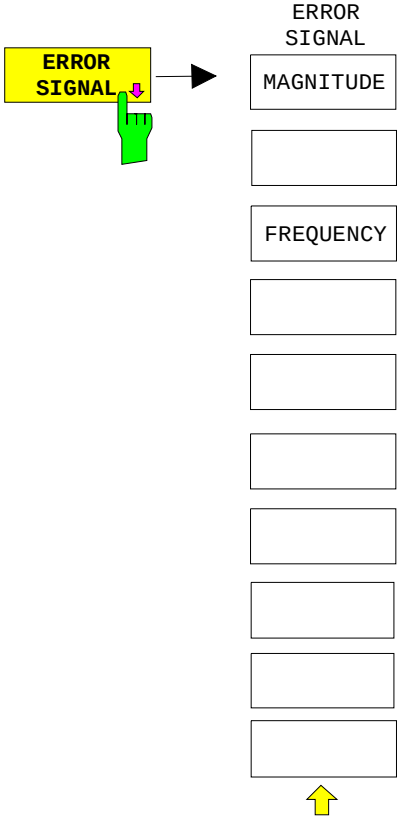
The *POLAR [IQ] VECTOR* and *POLAR [IQ] CONSTELL* softkeys display the error vector in the polar diagram. The error vector diagram and the error constellation diagram.



With these forms of representation, the points of decision are all shifted back to the origin and are laid on top of each other. The errors at the points of decision can thus be seen at a glance.

FSK demodulation:

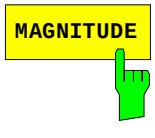
Submenu: *CONFIGURATION MODE - VECTOR ANALYZER - MEAS RESULT*



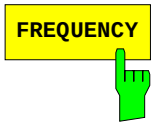
The *ERROR SIGNAL* softkey opens the submenu for selecting the type of error to be displayed.

The following quantities can be displayed:

- Magnitude error (MAGNITUDE)
- Frequency error (FREQUENCY)



The *MAGNITUDE* softkey starts the point by point comparison of the measurement signal with the magnitude of the ideal signal. The difference of the two magnitudes is displayed.

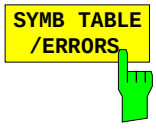


The *FREQUENCY* softkey displays the frequency error.
The frequency response of the measurement signal is compared with that of the ideal reference signal and the difference between the two responses is displayed as a function of time and symbol.

2.4.3.4.4 Symbol Table and Table of Modulation Errors

The symbol table and the table with modulation errors are indicated in the same display. In this case, the two tables are assigned to a trace. Similar to the trace display, the corresponding trace can be frozen (*VIEW*) or faded out (*BLANK*).
The range for the error calculation can be limited by means of the time lines (TIME LINES 1/2; *MARKER SEARCH* menu, *SEARCH LIM ON/OFF* menu).
If only one window is displayed, the symbol table is assigned to trace 1 and the error table to trace 2.

Submenu: *CONFIGURATION MODE - VECTOR ANALYZER - MEAS RESULT*



The *SYMB TABLE / ERRORS* softkey displays a table of demodulated bits and a table of modulation errors of the measured signal.

The symbol table shows the demodulated bits of the signal. The number of bits is defined under *RESULT LENGTH* in the same menu. Bits can be related to the traces (in split screen mode) by means of the marker coupling. The marker on the trace and the associated symbol are marked at the same time.
The indicated modulation errors differ depending on whether FSK signals are demodulated or one of the other digital demodulators is active.

The following parameters are indicated as sum errors of the modulation (except with FSK demodulation):

- Frequency error
- Magnitude error
- Phase error
- Error vector magnitude
- I/Q offset
- I/Q imbalance and
- Amplitude droop
- Rho factor.

The FSE evaluates these errors within the result length or in a range limited by the vertical lines within the result length.

With FSK demodulation, the following parameters are indicated as sum errors of the modulation:

- Frequency error
- Magnitude error
- FSK deviation
- FSK deviation error

The entered reference deviation is indicated in addition (*FSK REF DEVIATION*).

Non-FSK demodulations:

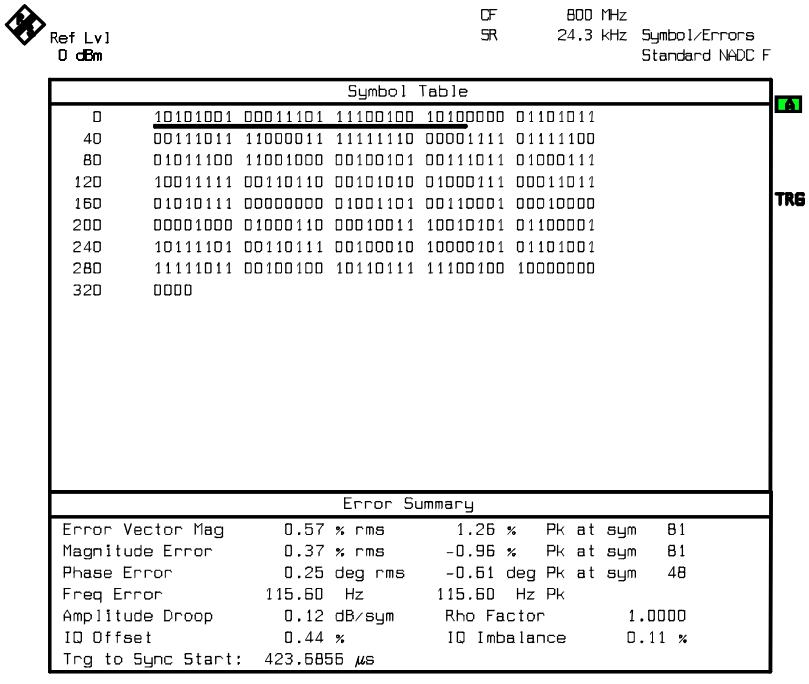


Fig. 2.4-16 Symbol table and table of sum errors (not FSK demodulation)

Description of errors as follows **(not FSK signals):**

Magnitude error: The magnitude error is the amplitude difference of the I/Q components of measurement signal and reference signal at the points of decision. For MSK modulations, all the points are considered in the calculation. It is a measure for the quality of the amplitude component of the modulated signal.

Phase error: The phase error is the phase difference of the I/Q components of measurement signal and reference signal at the points of decision. For MSK modulations, all the points are considered in the calculation.

Vector error: The error vector magnitude is the magnitude of the error vector which links the measured I and Q value in the complex plane to the ideal I and Q value at the points of decision. The error is calculated according to the following equation:

Error vector magnitude (EVM) = $\sqrt{I_{err}^2 + Q_{err}^2}$, where

I_{err} = error of the inphase signal and
Q_{err} = error of the quadrature signal

Frequency error : The frequency error is the deviation of the FSE center frequency from the measured carrier frequency. It is derived from the frequency shift to be effected for synchronization to the carrier. The reference error of the FSE is also part of the frequency error.

Amplitude droop: The amplitude droop indicates the amplitude variation of the signal between the two symbols at the points of decision in dB. This parameter is very important for TDMA signals and is a measure for the quality of pulse modulation.

I/Q offset: The I/Q offset is a measure for the LO feedthrough with analog I/Q modulators. It can be seen through a shift of the zero point in the constellation diagram. Without LO feedthrough (LO 100 % suppressed), the I/Q offset is zero. It is measured at the points of decision.

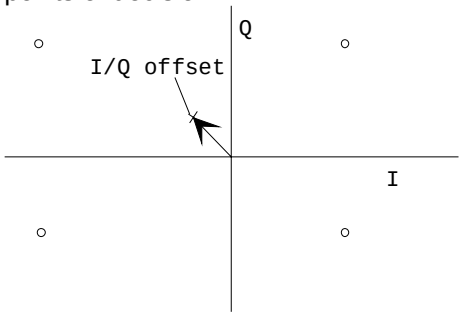


Fig. 2.4-17 Constellation diagram with I/Q offset

Amplitude and vector errors are given in %, phase errors in degrees (deg) or radian (rad). Prior to calculation, the measurement result is normalized in the vector or constellation diagram to a circle around the center of the group mid-points, the radius corresponding to the mean distance of all group mid-points to the center. This circle is defined as a unit circle with the radius 1 (see *NORMALIZE* function in the *MODULATION PARAMETER menu*)
Then, the errors at the points of decision are determined and the rms of the individual error values is calculated. Since the constellation diagram is normalized, the result is the rms value of the error in %.

I/Q imbalance: The I/Q imbalance is a measure for the symmetry of the I/Q modulator to be measured. The I/Q gain error is the result of unequal gain factors in the I and Q path of the transmitter. The I/Q imbalance is calculated from the square root of the quotient of the vector magnitude for the wanted and interfering signals averaged over all points of decision:

$$\text{I / Q imbalance} = 100 * \sqrt{\sum_{i=1}^{n} \frac{|\text{Interferencevector}|^2}{|\text{Signal vector}|^2}} \quad [\%]$$

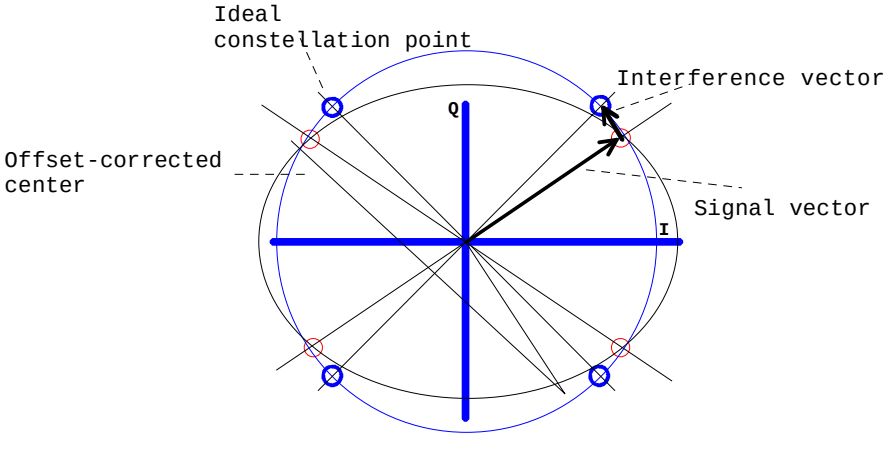


Fig. 2.4-18 Constellation diagram with I/Q imbalance

Rho factor: Similar to the error vector magnitude, the Rho factor is a measure for the quality of digital modulation. It is determined by measurement of the normalized correlated power between the measured signal and reference signal (IS95-CDMA to US standard IS-98) and is designated as waveform quality factor.
The Rho factor can assume a maximum value of 1.0 (measured signal and reference signal are a 100% identical).

FSK demodulation:

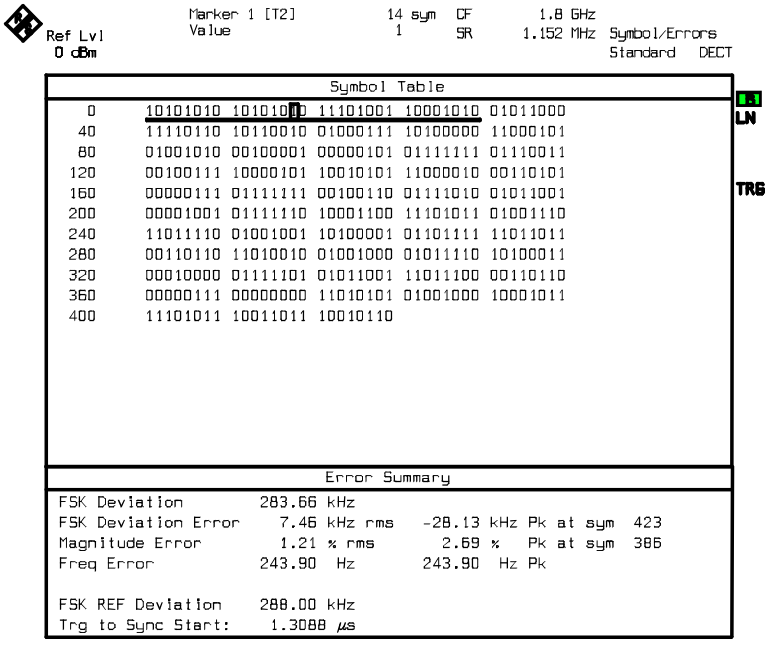


Fig. 2.4-19 Symbol table and table of sum errors (FSK demodulation)

The various errors and measured values have the following meaning (**FSK signals**):

FSK deviation: The FSK deviation is determined by the square difference between measurement and reference signal being minimized. The reference signal is based is formed on the basis of the known demodulated bits and modulation parameters. The frequency offset is determined separately and indicated under Freq Error. The frequency error is not considered in the indicated FSK deviation.

FSK deviation error: The FSK deviation error is the deviation difference between the measured signal and the reference signal, measured as an rms and peak value over all symbols. Frequency errors (frequency offset) are part of the indicated FSK deviation error.

Normalize ON The entered FSK reference deviation is used for scaling of the reference signal.

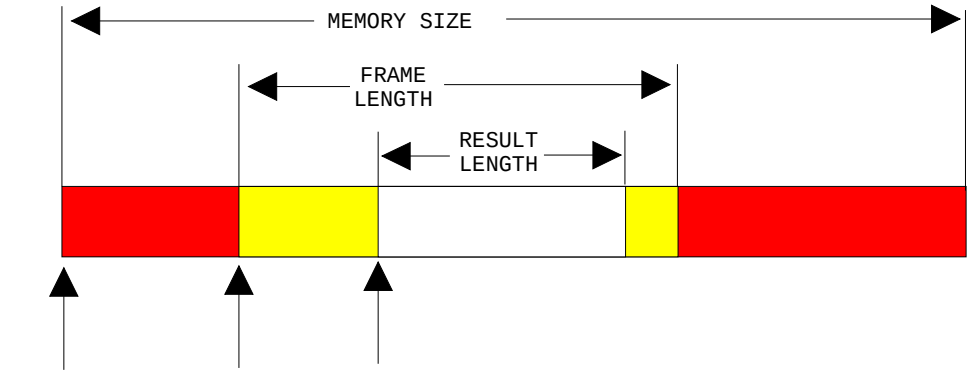
Normalize OFF The reference signal is automatically derived from the measurement signal on the basis of the known demodulated symbols and modulation parameters so as to ensure maximum agreement between measurement and reference signal.

Magnitude error: With FSK, the magnitude error is the deviation of the individual amplitudes of the AM envelope from the mean (rms) carrier amplitude, measured as an rms value over all symbols displayed and as a peak value normalized to the rms amplitude in %.

Frequency error: The frequency error is the deviation of the FSE center frequency from the measured carrier frequency. It is derived from the frequency shift to be effected for synchronization to the carrier. The reference error of the FSE is also part of the frequency error.

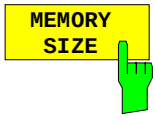
2.4.3.5 Selecting Memory Size, Demodulation Length and Display Range

The size of the capture buffer containing the stored samples, the frame length to be demodulated and displayed and the number of points per symbol can be set to allow an adaptation to the measurement or to optimize the measurement speed.
At the beginning of a measurement, the FSE stores the samples into the capture buffer which can be selected between 1 and 16-k symbols. It then tries to find the suitable frame length for further processing according to the trigger condition (*FIND BURST*). The frame length to be displayed or used for error calculation is defined with *RESULT LENGTH*. It can be positioned within the frame length by synchronization sequence triggering (*FIND SYNC*).

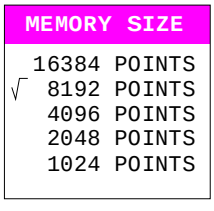


Finally, the number of points per symbol can be set. This number defines the maximum number of symbols that can be processed in the *FRAME LENGTH.*

Submenu *CONFIGURATION MODE - VECTOR ANALYZER - MEAS RESULT*

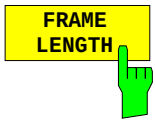


The *MEMORY SIZE* softkey calls up a table in which the number of samples saved in the capture buffer per measurement is determined. Within the memory size a burst, e.g. in the case of a TDMA signal, can be searched for (*FIND BURST* function).



Only the symbols entered under *FRAME LENGTH* are used for demodulation.

For symbol rates > 1 MHz the data are stored in the memory without prior filtering and reduction. The maximum memory size is therefore reduced to 4096 points.



The *FRAME LENGTH* softkey calls up a table in which the number of symbols to be demodulated or evaluated is defined.

FRAME LENGTH
1600 SYMBOLS
1500 SYMBOLS
1400 SYMBOLS
1300 SYMBOLS
1200 SYMBOLS
1100 SYMBOLS
1000 SYMBOLS
900 SYMBOLS
√ 800 SYMBOLS
700 SYMBOLS
600 SYMBOLS
500 SYMBOLS
400 SYMBOLS
300 SYMBOLS
200 SYMBOLS
100 SYMBOLS

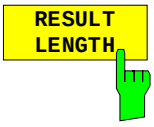
With up to 4 points per symbol a maximum of 1600 symbols can be demodulated per measurement and their modulation parameters measured. With 8 points per symbol up to 800 symbols, and with 16 points per symbol up to 400 symbols can be handled.

With symbol rates >1 MHz to ≤1.28 MHz a maximum of 600 symbols can be handled. This is due to the fact that the data are stored in the memory without prior reduction. The subsequent reduction limits the FRAME LENGTH in the specified frequency range.

The frame length markedly influences the time required for evaluating a measurement signal. It is therefore recommended to choose the frame length as short as possible. 400 symbols, for example, are sufficient for determining the phase error of a GSM burst as only 147 symbols are to be evaluated. The FSE automatically searches for the correct time domain by trigger functions *FIND BURST* and *FIND SYNC* .

The choice of the frame length influences the maximum number of points per symbol. With up to 400 symbols a maximum of 16 points, with >400 up to 800 symbols a maximum of 8 points and with >800 symbols a maximum of 4 points per symbol is possible.

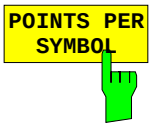
With symbol rates >1MHz to ≤1.20 MHz, the maximum number of symbols is 500!



The *RESULT LENGTH* softkey opens a window for defining the number of symbols for display on the screen.

The maximum result length is identical to the frame length.

With the *FIND SYNC* function activated (synchronization to bit sequences in the signal), the maximum result length can be reduced (or the frame length increased).



The *POINTS PER SYMBOL* softkey opens a window for entering the number of points per symbol.

1, 2, 4, 8 and 16 points per symbol can be selected. With one point per symbol, each point in the display corresponds to a symbol sampled at the time of decision. With n points per symbol, each n-th value is a point of decision. With 1 and 2 points per symbol, the FSE demodulates with 4 points per symbol for reasons of accuracy. Only one or two samples are output, however.
For up to 4 points per symbol, a frame length of max. 1600 symbols is possible, with 8 points per symbol a frame length of max. 800 symbols and with 16 points per symbol of max. 400 symbols.

In the case of MSK demodulation, the number of points per symbol influences the result of the error measurement as all the points are considered in the calculation. With all other demodulators, only the values measured at the points of decision are taken into account. For GSM (DCS1800 and PCS1900) less than 4 points per symbol should not be used.

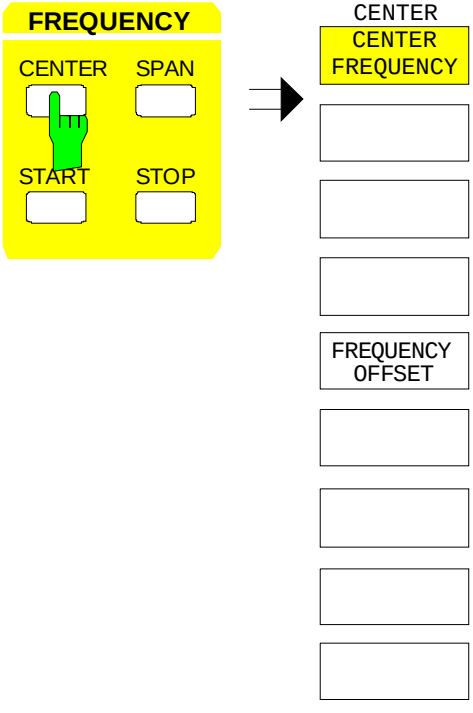
The number of points per symbol largely influences the measurement speed attained during the evaluation of the signal. If high measurement rates are to be attained for automatic tests, for example, a low number of points per symbol is recommended.

2.4.4 Frequency Settings - FREQUENCY Key Group

In vector signal analysis, FSIQ is always set to a fixed frequency. The RF signal is analyzed by converting the signal into the complex baseband.

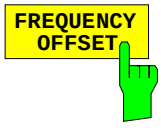
The frequency of FSIQ is set in the same way as in the spectrum analysis mode, i.e. with the *CENTER* key in the *FREQUENCY* key group.

FREQUENCY CENTER menu



The *CENTER* key calls up the entry window for the center frequency .

For the demodulation of digitally modulated signals, the FSIQ frequency has to be accurately set to the frequency (carrier) of the signal to be measured so that synchronization to the carrier is possible. The required setting accuracy depends on the symbol rate and must not exceed 2% of the symbol rate.



The *FREQUENCY OFFSET* softkey activates the input of a frequency offset which can be added to the frequency-axis labeling. The displayed frequency is shifted by the frequency offset. The range of values for the offset is -100 GHz to +100 GHz.

2.4.5 Setting the Frequency Span - START, STOP, and SPAN Key

The *SPAN*, *START* and *STOP* keys are not assigned in vector signal analysis for the demodulation of digitally modulated signals since FSIQ is always set to a fixed frequency and the measurement results are displayed in the time domain. The analysis bandwidth by which the demodulation is performed is predefined by the symbol rate and the number of sampling points.

2.4.6 Setting the Level Display and Configuring the RF Input

2.4.6.1 Setting the Reference Level

With spectrum analysis (ANALYZER mode) of the FSIQ, the level applied to the RF input is always indicated on the display so that one can see the relationship between the setting of the reference level and the measurement results on the display.

With vector signal analysis, this only applies to operating mode *DIGITAL DEMODULATION*, *MAG CAP BUFFER* In operating mode *DIGITAL DEMODULATION* with activated demodulation , e.g. when the demodulated signal is displayed this relationship is not obvious. That is why a strict distinction has to be made between setting the **reference value** which is an important reference point for the measured-value display and the **reference level** relating to the RF input.

To obtain a maximum dynamic range it is important for the signal level at the A/D converter to be close to the maximum level of the converter. The maximum level of the converter corresponds to the reference level (*REF LEVEL*) in the spectrum analysis mode. This means that a signal whose amplitude attains the reference level in the spectrum analysis mode is ideal for the vector analyzer mode. An important factor is the **sum level** within the IF bandwidth (=*ANALOG BANDWIDTH* in vector signal analysis mode) of the analyzer.

The reference level can be manually set by checking the signal level in the spectrum analysis mode against the set frequency (at the same IF bandwidth!) and by operating the vector analyzer with the same setting.
The FSET can perform this in vector signal analysis but also by a single automatic setting of the reference level.

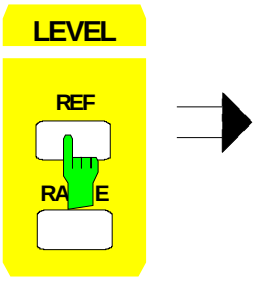
Certain settings of the spectrum analysis mode such as center frequency, reference level and attenuation are taken over by the vector signal analysis. Parameters that are not affected are span (in vector signal analysis, the frequency span has a different meaning: it corresponds to the analysis bandwidth and is thus independent in the two operating modes), resolution bandwidth, ref. level offset as well as trace and trigger settings

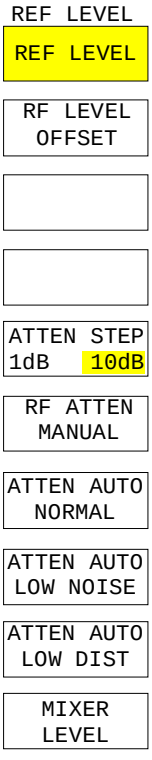
The **reference value** (*REF VALUE*) of the vector signal analysis is the reference point for scaling the measured value. Apart from *DIGITAL DEMODULATION-RESULT DISPLAY-MAGNITUDE CAP BUFFER* it is decoupled from the setting of the reference level, i.e. a direct relationship cannot be determined.

With the ***REF*** key, the **reference level** can be set like in the spectrum analysis mode.

The ***RANGE*** key calls up a menu comprising all the settings required for scaling the measured value such as auto scaling (*AUTO SCALE*), scaling (Y per Div), reference values in the X and Y direction (X/Y_REF VALUE) and the relative position of the reference value on the diagram (*REF VALUE POSITION*).

LEVEL REF Menu





The REF key calls up the menu for setting the reference level and at the same time activates the level entry field.

Operation and softkey functions identical to analyzer mode:

ATTEN STEP 1dB/10dB
RF ATTEN MANUAL
ATTEN AUTO NORMAL
ATTEN AUTO LOW NOISE
ATTEN AUTO LOW DIST
MIXER LEVEL

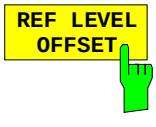
Softkey *ATTEN STEP 1dB/10dB* is only available when the FSIQ is equiped with option FSE-B13, 1dB attenuator

The *REF LEVEL* softkey activates entry of the manual gain of the FSIQ. For a maximum dynamic range, it has to be ensured that the A/D converter is driven to its full range but not overdriven.

In the vector analyzer mode, this is indicated by the messages *IF OVLD* (overload) and *UNLD* (underrange) which inform on the dynamic range when measured data are read in.
When *IF OVLD* is displayed, the instrument or the A/D converter is overdriven during data read-in and entered data are invalid.
With *UNLD* displayed, the A/D converter is not sufficiently driven during data read-in (level <-6 dB of full range). Indicated values may have a reduced dynamic range, i.e. have a greater error.

For a correct level setting in the case of *IF OVLD*, reduce the REF LEVEL (continuous sweep mode) in sufficiently small steps (e.g. 2 dB) until the message disappears.
Proceed analogously for increasing the REF LEVEL when *UNLD* is displayed until the message disappears.
The maximum dynamic range is attained approx. 1 dB below the *OVLD* level.

The reference level can also be set to the test signal in the spectrum analysis mode at the same IF bandwidth as in the vector signal analysis mode (with *COUPLED: ANALOG BW AUTO* also 10 kHz) and vector signal analysis can then be selected again.

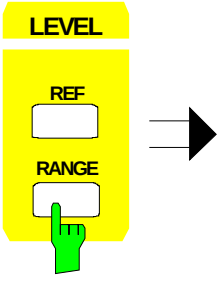


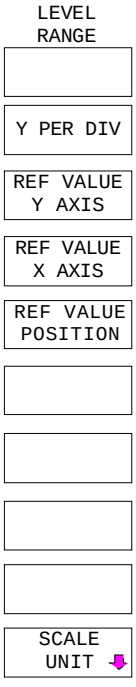
The *REF LEVEL OFFSET* softkey activates the entry of a level offset.
It is added to the measured level, irrespective of the unit used. The scaling of the Y axis is changed accordingly.
This function is used to take into account the effect of an external attenuator on the displayed values.
The setting range is ± 200 dB in 0.1 dB steps.

2.4.6.2 Setting the Display Range and Scaling - RANGE Key

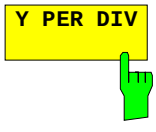
The menu for setting the display range is different from that of the spectrum analysis mode.

LEVEL RANGE menu





The *RANGE* key calls up a menu comprising all the important display parameters such as reference value, scaling etc.

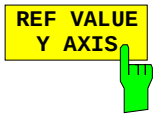


The *Y PER DIV* softkey calls for the entry of the vertical scaling in the current unit.

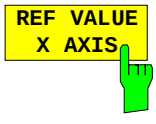
For vector or constellation diagrams, the corresponding X scaling is linked with Y scaling:

X PER DIV =5/4 *(Y PER DIV)

Reason: The diagram has 400 x 500 points. In case of a free X scaling circles would be reproduced as ellipses.



The *REF VALUE Y AXIS* and *REF VALUE X AXIS* softkeys call for the entry of the reference value for the Y or X axis of the measurement diagram. The *REF VALUE X AXIS* softkey is only displayed if a polar diagram has been selected for the trace.



The reference value is entered in the corresponding unit of the diagram (See *UNIT*).

Example 1: Constellation diagram: y reference value: +1.20; x reference value: - 0,35
(reference position: 50%)

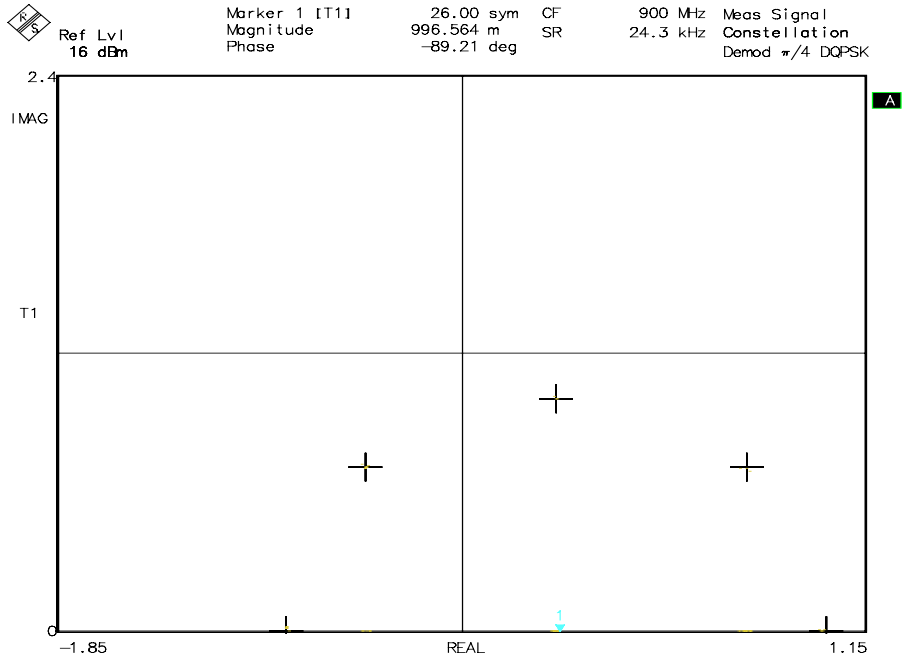


Fig. 2.4-17 Representation of the reference values in the constellation diagram

Example 2: Display of I and Q signals: Y reference value: -0.2 REF position: 50%

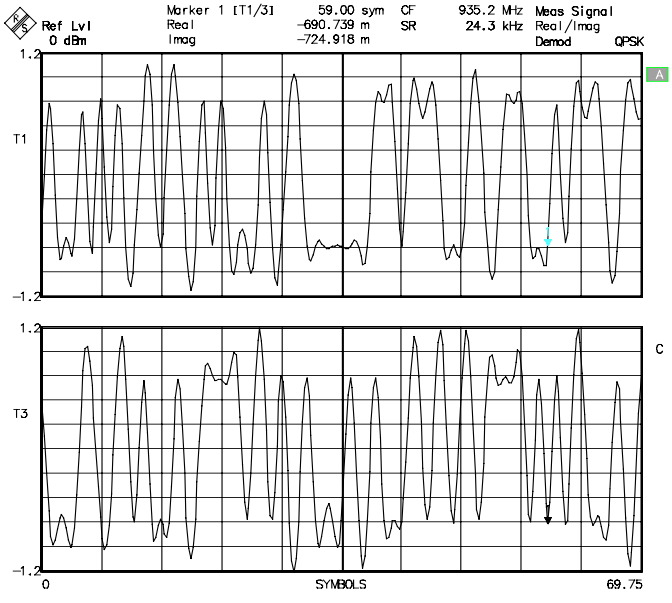
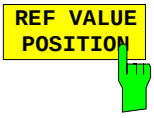


Fig. 2.4-18 Display of I and Q signals

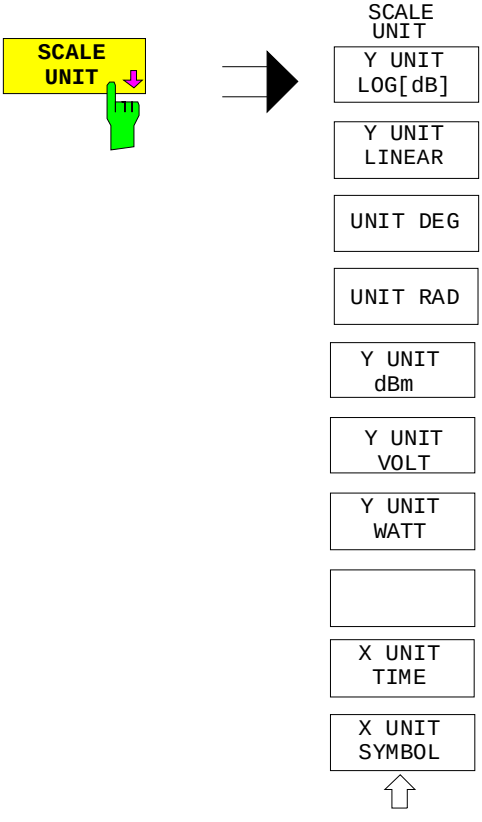


The *REF VALUE POSITION* softkey opens a window for setting the reference positions diverging from the basic setting.

REF VALUE POSITION defines the position of the reference value. It normally lies at 100%, i.e. the maximum displayable Y value is also the reference value. It is best to use this setting for displaying the magnitude which is then the basic setting.

When, for example, the timing of I/Q signals or the phase spectrum is displayed it might be desirable to set the reference value to the center. The basic setting is thus 50% (also for polar diagrams).

Submenu: *LEVEL RANGE*



The *SCALE UNIT* softkey calls up a submenu in which the unit of the Y axis and the X axis are set.

The units offered depend on the setting of *RESULT DISPLAY* and *MEAS RESULT*.

The logarithmic unit dB (*Y UNIT [dB]*) or dimensionless linear units (*Y UNIT LINEAR*) are permissible for the Y axis.

ERROR and *MAGNITUDE* are displayed in the following units:

Y UNIT LOG [dB]: dB

Y UNIT LINEAR : %.

Errors of *REAL/IMAG PART* are always displayed in %.

Phase errors are displayed in DEG or RAD, frequency errors in Hz.

Units which are not allowed in the current operating mode are disabled.

In polar diagrams, the units for the X-axis and Y-axis are equal. The softkeys *X UNIT...* are suppressed.

The time representation, the units time (*X UNIT TIME*) or symbols (*X UNIT SYMBOLS*) can be used for the X-axis. The softkey for the X-axis unit are only shown in time representation.

If a marker is active, the marker values are read out in the current scale units.

Only for MEAS RESULT: MAGNITUDE CAP BUFFER:

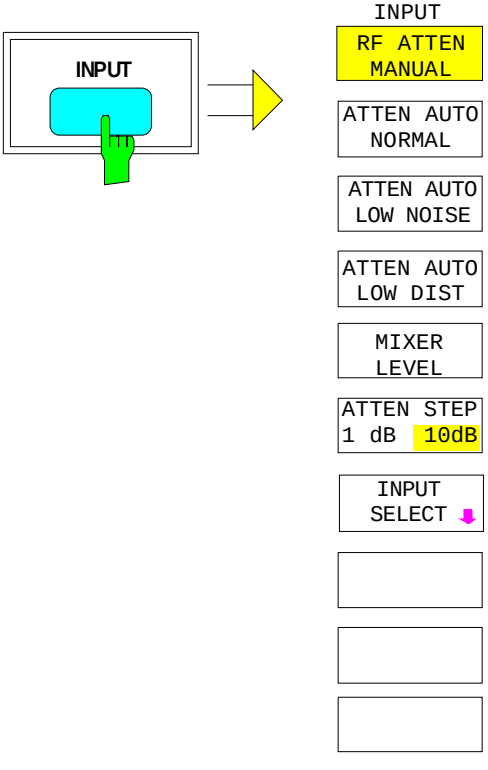
Possible display units: *YUNIT LOG [dB], YUNIT LINEAR, dBm , Volt* and *Watt.*

Table 2.4-3 Allocation table of selectable units or, in case of error display, of the displayed units in operating mode *DIGITAL DEMODULATION* depending on *RESULT DISPLAY* and *MEAS RESULT*

RESULT DISPLAY ---------- MEAS RESULT	MAGNITUDE CAP BUFFER	MAGNI-TUDE	PHASE	FREQUENCY [with FSK and MSK only]	REAL/ IMAG PART	EYE DIAG	POLAR [IQ] VECTOR	POLAR [IQ] CONSTELL
MEAS SIGNAL	Y_UNIT LINEAR Y-UNIT LOG[dB] dBm VOLT WATT	Y_UNIT LINEAR Y-UNIT LOG[dB]	DEG/RAD	Hz	Y_UNIT LINEAR	Y_UNIT LINEAR	Y_UNIT LINEAR	Y_UNIT LINEAR
REFERENCE SIGNAL	--	like MEAS SIGNAL	like MEAS SIGNAL	like MEAS SIGNAL	like MEAS SIGNAL	like MEAS SIGNAL	like MEAS SIGNAL	like MEAS SIGNAL
ERROR SIGNAL	--	[%] [dB]	PHASE DEG/RAD	Hz	--	-	-	-
VECTOR ERROR	--	[%] [dB]	DEG/ RAD	--	[%]	-	[%]	[%]

2.4.6.3 Configuration of RF Input in Vector Signal Analysis

This section is identical to that of the spectrum analysis mode.



Note: *The operating mode recommended for the vector analyzer input is ATTEN AUTO NORMAL. If ATTEN AUTO LOW NOISE is set (or for MIXER LEVEL ≥ –30 dB), the higher signal modulation occuring within the IF-bandwidth causes a nonlinear behavior in the IF branch. This leads to increased measurement errors, in particular for modulation types with a non-constant level (e.g. PSK).*

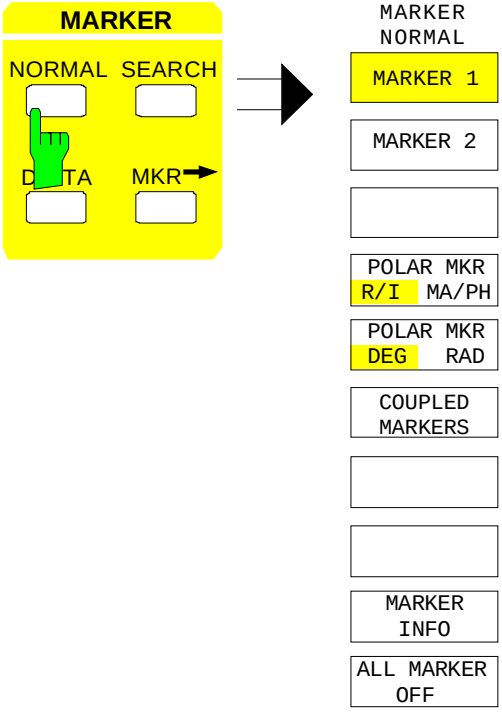
2.4.7 MARKER Key Group

In the vector analyzer mode markers may be used for highlighting points in a trace and for reading out measured values.
For detailed information see section 'Marker Function' in chapter 'Analyzer Mode'.
In the vector analyzer mode marker softkey functions depend on the selected measurement.

2.4.7.1 Main Marker - *NORMAL* Key

The main markers and their functions are selected with the *NORMAL* key.

MARKER NORMAL menu



The *NORMAL* key calls up a menu comprising all standard marker functions.

Activated marker functions are indicated by a dark background of the softkeys. If no marker is activated when the *NORMAL* key is pressed, MARKER 1 is activated as a reference and set to the maximum value in the curve. (automatic switch-on of peak search function provided at least one trace is active; not with polar diagram). In all other cases the reference marker is activated but no automatic peak search is performed.

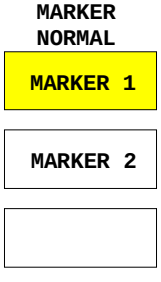
In the marker field the marker position (time), the measured value or values (in the case of a complex display) and the trace relevant for the marker (here [T1]) are displayed.

Example:
Marker display in the digital demodulation and I/Q display mode:

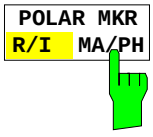
```
Marker 1 [T1/3] 22.3 µs
Real             0.998
Imag            -0.124
```

When the symbol table is displayed (softkey *SYMB TABLE/ERRORS* in submenu *MEAS RESULT*) the marker moves from symbol to symbol in the table. The position of the marker is indicated by a dark background and its numerical value in inverse video.

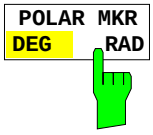
In the marker field, the marker position and the decimal value of the symbol are displayed.



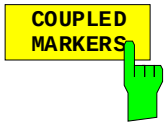
The *MARKER 1* and *MARKER 2* softkeys switch the respective marker on or off or define it as an entry marker (reference marker).



The *POLAR MARKER R/I / MA/PH* softkey selects magnitude and phase (*MA/PH*) or real and imaginary part (*R/I*) for the numeric result display in the polar diagram.
When measured values are indicated versus time this softkey is disabled.

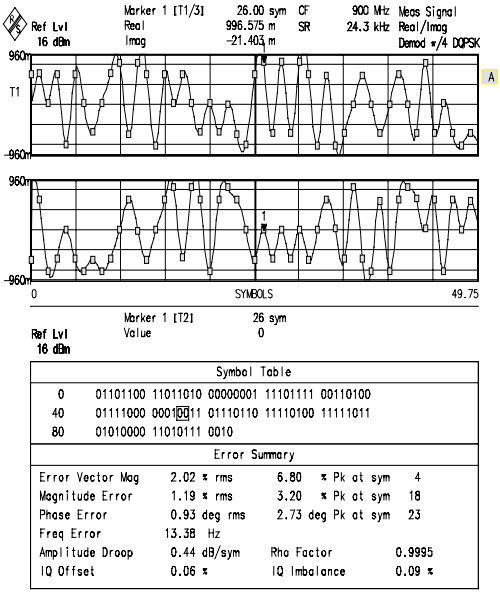


The *POLAR MARKER DEG/RAD* softkey selects the unit degree (*DEG*) or radiant (*RAD*) for indication of the phase of the marker in the respective diagram.

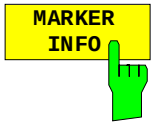


The *COUPLED MARKER* softkey couples markers (and delta markers) of different traces in the combined display mode *REAL/IMAG PAR*. In this case the X position of corresponding markers is identical.
This allows complex marker values to be displayed which correspond to the polar display.

Marker 1 6.75 SYM [T1/3]
RE 0.895
IM 1.002
If several windows are displayed, the markers of **all** windows are coupled when the *COUPLED MARKERS* function is active.



The *ALL MARKER OFF* softkey switches all markers including reference and delta markers off and closes the marker entry window. In addition the *MARKER INFO* softkey is switched off.



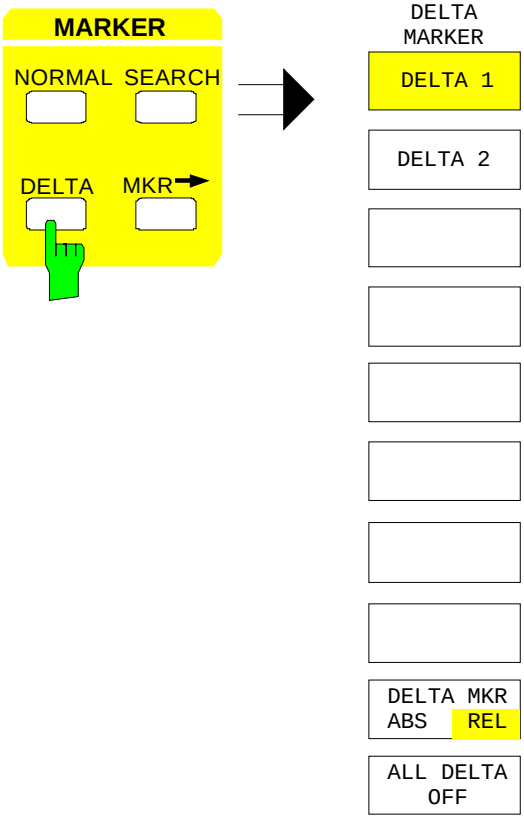
The *MARKER INFO* softkey allows several markers to be displayed in the grid, in addition to the display of marker information in the marker field of the diagram headline.
In the top right-hand corner of the grid the two markers or delta markers are displayed with symbols ∇/Δ, marker number (1, 2), position and measured value (may be complex). The number of symbols for specifying the marker position is limited in certain cases.

If there are not enough lines for displaying all active markers and delta markers, the markers are listed first and then the delta markers.

In the *SPLIT SCREEN* display this list is divided into two lists, one for *SCREEN A* and one for *SCREEN B*.

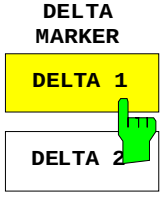
2.4.7.2 Delta Marker - DELTA Key

MARKER DELTA menu



The *DELTA* key in the MARKER key group selects the delta markers.

Delta markers are always referenced to the active reference marker . When no marker is active, switching on a delta marker automatically activates marker 1. Delta markers are displayed as an unfilled symbol ▽. When the delta marker is active for entry, a filled symbol ▼ is displayed.



The *DELTA 1* and *DELTA 2* softkeys switch on delta markers 1 and 2.

Operation of delta markers is identical to that of markers. When a delta marker is switched on, all entries apply to the delta marker. For changing the position of the main marker, the main marker has to be reactivated. Displayed differences normally apply to the active reference marker.

In the delta marker field, the number of the delta marker, the time difference to the reference marker and the difference of measured values between the active delta marker and reference marker are displayed.

The *DELTA ABS / REL* softkey switches between absolute (*ABS*) and relative (*REL*) input of time of the delta marker.

Default setting is *REL* (input relative to the reference marker)

The *ALL DELTA OFF* softkey switches off all active delta markers and any associated functions.

2.4.7.3 Search Functions (Marker Search menu) - SEARCH Key

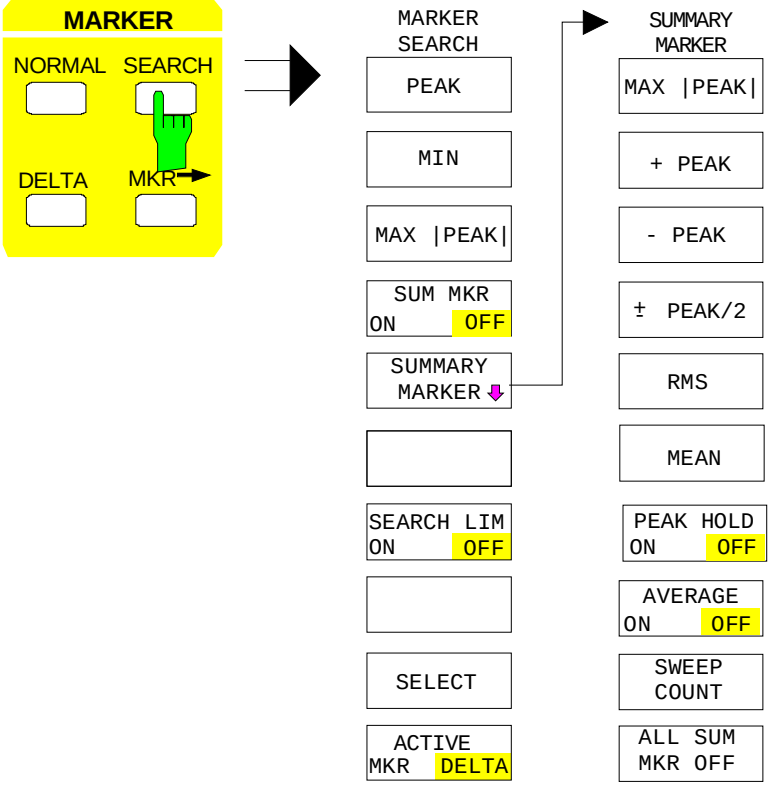
The menus called up with *SEARCH* offer functions for a peak/min search and universal marker functions for overall evaluation of traces. The search functions can be used for markers and delta markers.

Important: With polar diagrams, peak/min. peak values refer to the vector length (with origin as reference), in all other cases to the Y deflection. In this diagram, summary markers cannot be switched on or are not displayed.

Functions in the *MARKER SEARCH* menu refer to the marker or delta marker active during entry. Switchover between the active marker and delta marker is possible with the *ACTIVE MKR DELTA* softkey.
If no marker is switched on when the *SEARCH* key is pressed, marker 1 is activated as reference marker (by means of peak search).

The search range can be limited by time lines (*TIME LINE 1/2*) switched on with *SEARCH LIM ON/OFF*. The limitation of the search range is valid for all the marker search functions including the SUMMARY MARKERS and for error calculation during *SYMB TABLE/ERRORS*.
The time lines are only visible for diagrams versus time, i.e. not for polar diagrams and for diagrams of *SYMB TABLE/ERRORS*. The limitation of the search range is valid for *SEARCH LIMITS ON* for all diagrams irrespective of whether the time lines are visible or not.

MARKER SEARCH menu



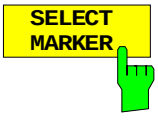
The search range can be limited by the time lines (TIME LINE 1/2) (softkey *SEARCH LIM ON/OFF)*. The limitation of the search range extends to all marker search functions including the *SUMMARY MARKER* as well as to error calculation during *SYMB TABLE/ERRORS*.

The time lines are only visible for diagrams versus time, ie not for polar diagrams and for diagrams representing *SYMB TABLE/ERRORS* . The limitation of the search range during *SEARCH LIM ON* extends to all types of representation, irrespective of whether the time lines are visible or not.
The functions in the *MARKER SEARCH* menu refer to the marker or delta marker that is currently active for entries. Softkey *ACTIVE MKR DELTA* may be used to switch between the active marker and the active delta marker. If no marker is switched on before *SEARCH* is pressed, marker 1 will be activated as reference marker (with peak search).

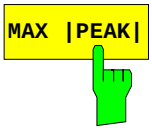
The *ACTIVE MKR / DELTA* softkey switches over between active marker and active delta marker.

With *DELTA* highlighted, subsequent search functions are carried out with the active delta marker.

Note: *Switchover between marker and delta marker entry is also possible with the NORMAL and DELTA keys.*

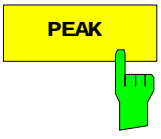


The *SELECT MARKER* softkey opens the table for selection of the marker or delta marker.

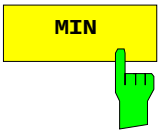


The *MAX |PEAK|* softkey sets the active marker or delta marker to the highest magnitude displayed (*PEAK* or *MIN*) in the associated curve.

For instance, the function searches for the maximum phase error of a signal, which may be positive or negative.



The *PEAK* softkey sets the active marker or delta marker to the highest value displayed in the associated measured curve.



The *MIN* softkey sets the reference marker to the lowest value in the associated curve.

The *SEARCH LIMIT ON/OFF* switches between limited (ON) and unlimited (OFF) search range.
The search range can be limited by time lines (*TIME LINE1/2)* for peak- and min-search functions as well as for the summary markers.

If *SEARCH LIMIT* is *ON*, a search for the corresponding signals is only performed between the two lines.

If only one line is switched on, *TIME LINE 1* is valid as lower limit (the upper limit is the stop frequency), *TIME LINE 2* defines the upper limit value.

If no line is active, lines 1 and 2 are switched on automatically and positioned to 20 % and 80 % of the grid.

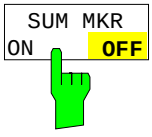
If the function is switched off, the lines continue to be switched on.

Time lines are not visible for polar diagrams and for Symb Table/Errors. The limitation of the search range, however, remains effective.

Default value is *SEARCH LIMIT OFF.*

2.4.7.3.1 The Summary Marker

MARKER SEARCH menu



The *SUM MKR* softkey switches the display of the summary marker values in the marker info field on and off. The measured values are updated after every sweep end (in case of AVG/*HOLD OFF)*.

If one trace is in *AVERAGE*, *MAX HOLD* or *MIN HOLD* mode, the summary markers for this trace cannot be switched on.

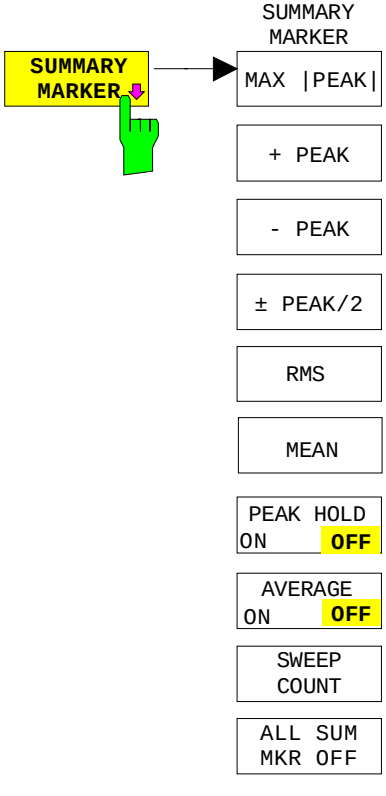
On the other hand, the summary markers are switched off if the trace functions *AVERAGE*, *MAX HOLD* or *MIN HOLD* are activated (only valid for the same trace).

The maximum and average values can be maintained or displayed for all summary markers by means of function *HOLD ON/OFF* or *AVERAGE ON/OFF* if Sweep Count >0.

Example:
Marker info field for :
Summary Marker: + *PEAK* and *MEAN* switched on, *PEAK HOLD ON* and *AVERAGE ON*:

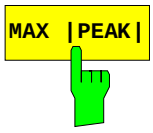
```
▼1              63. sym
  MAGN CAP     2.40 Watt
 +PEAK HOLD    2.55 Watt
 +PEAK AV      2.39 Watt
  MEAN HOLD    2.33 Watt
  MEAN AV      2.29 Watt
```

The measurement range can be restricted by means of the function *SEARCH LIMITS ON* and the time lines (*TIME LINE 1,2*).



The *SUMMARY MARKER* softkey calls up the submenu for selecting the summary marker values to be displayed in the marker info field.

The measured values are updated for every sweep.
(In case of setting *SYMB TABLE/ERRORS* the marker info field is not displayed).

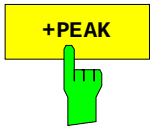


The *MAX |PEAK|* softkey selects the measurement of the magnitude of the higher of the two peaks *+PEAK* and *-PEAK* per sweep.

The search range can be limited by means of function *SEARCH LIMITS ON*.

With the *PEAK HOLD* function activated, the highest peak value that has occurred since the activation of *PEAK HOLD* is displayed.

With the *AVERAGE* function activated, the highest peak values are averaged and displayed.

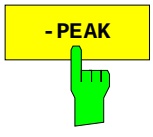


The *+PEAK* softkey selects the measurement of the positive peak value per sweep.

The search range can be limited with the function *SEARCH LIMITS ON*.

With the PK Hold function activated, the highest positive peak value that has occurred since the activation of *PEAK HOLD* is displayed.

With the AVERAGE function activated, the positive peak values are averaged and displayed.

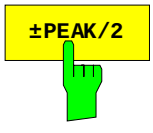


The *-PEAK* softkey selects the measurement of the negative peak value per sweep.

The search range can be limited with the function *SEARCH LIMITS ON*.

With the peak hold function switched on, the highest negative peak value that has occurred since the activation of *PEAK HOLD* is displayed.

With the *AVERAGE* function switched on, the highest negative peaks are averaged and displayed.

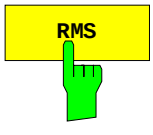


The *±PEAK* softkey selects the measurement of the average value of the positive and negative peak value per sweep.

The search range can be limited with the *SEARCH LIMITS ON* function.

With the peak hold function switched on, the highest average value that has occurred since the activation of *PEAK HOLD* is displayed.

With the AVERAGE function switched on, the average values of the positive and negative peak value (versus time) are averaged and displayed.

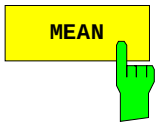


The *RMS* softkey selects the measurement of the rms value of the signal per sweep.

The search range can be limited with the *SEARCH LIMITS ON* function.

With the peak hold function switched on, the highest rms value that has occurred since the activation of the *PEAK HOLD* function is displayed.

With the *AVERAGE* function switched on, the rms values are averaged versus time and displayed.

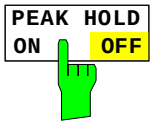


The MEAN softkey selects the measurement of the average value of the signal per sweep. Thus, the average carrier power can be measured during a GSM burst (during display of *MAGNITUDE CAP BUFFER*).

The search range can be limited with the *SEARCH LIMITS ON* function.

With the peak hold function switched on, the highest average value that has occurred since the activation of *PEAK HOLD* is displayed.

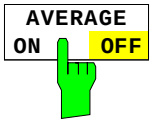
With the *AVERAGE* function switched on, the average values (of a trace) are averaged versus time and displayed.



The *PEAK HOLD ON / OFF* softkey switches the peak hold function of the summary markers on or off.

All active summary markers are only updated after every sweep end if higher values have occurred.

The measured values can be reset by switching the *PEAK HOLD ON / OFF* softkey off and on again.



The *AVERAGE ON / OFF* softkey switches the averaging of the summary markers on or off.

The measured values can be reset by switching the *AVERAGE HOLD ON / OFF* softkey off and on again.

The *SWEEP COUNT* softkey activates the entry of the number of measurements (sweeps) in the *SINGLE SWEEP* mode.

The number of measurements can be selected between 0 and 32767.

If an averaging of measured values or the peak hold mode is set, *SWEEP COUNT* also determines the number of measurements required for averaging or maximum averaging.

SWEEP COUNT = 0	10 measured values are always required for a running averaging.
SWEEP COUNT = 1	no averaging is performed.
SWEEP COUNT > 1	averaging is performed over the set number of measured values.

In case of *CONTINOUS SWEEP* the FSET (*AVERAGE ON*) performs an averaging until the number of sweeps set under *SWEEP COUNT* is attained and then performs a running averaging.

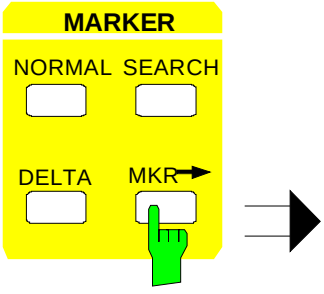
Maximum averaging is infinite irrespective of *SWEEP COUNT*.

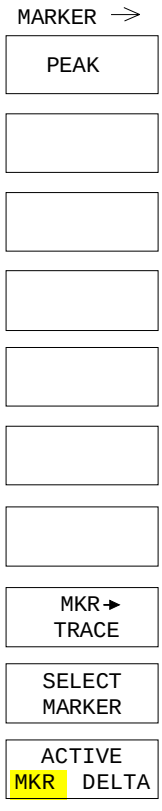
Note : *This setting is equivalent to the settings in the menus TRACE and* SWEEP-SWEEP.

The *ALL SUM MKR OFF* softkey switches off the summary markers.

2.4.7.4 Varying Instrument Settings by means of Markers - MKR➔Key

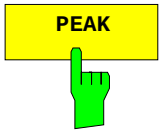
MARKER MKR➔ menu





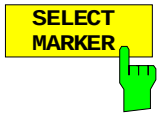
The *MKR ->* key calls up a menu which offers functions for varying instrument parameters by means of the currently active marker. Same as in the *SEARCH* menu, the functions are also valid for the delta markers.

The selection of marker or delta marker depends on the currently active frequency entry for marker or delta marker. If no entry is active, the marker with the lowest number is activated as reference marker.

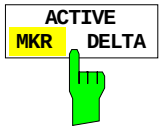


To simplify operation, the *PEAK* search function is also available in the *Marker→* menu.

The *MKR → TRACE* softkey opens a window in which the marker can be positioned on a new trace. Only selectable traces are displayed in the window.



The *SELECT MARKER* softkey opens the table for selection of the marker or delta marker.



The *ACTIVE MKR / DELTA* softkey is used for switchover between active marker and delta marker.

With *DELTA* activated (highlighted), the following marker functions are carried out with the active delta marker.

Note: *Switchover between marker and delta marker entry is also possible by means of the NORMAL and DELTA keys.*

2.4.8 Setup of Display and Limit Lines – *LINES* Key Field

2.4.8.1 Display Lines – D LINES Key

Display lines are aids which, similar to markers, make the evaluation of measurement curve data more convenient. The function of display lines is similar to that of a movable scale which can be used to measure absolute and differential values on measurement curves.
In addition, the display lines can also be used to limit the range of search for marker functions.

In vector analyzer mode, the FSE provides four different types of display lines:

- two horizontal threshold lines for marking measurement values or for defining measurement value search ranges – Display Line 1/2,
- two vertical time lines for marking times or for defining time search ranges – Time Line 1/2,
- a threshold line which, for example, sets the search threshold for maximum values (Peak Search) – Threshold Line
- a reference line – Reference Line

For purposes of clarity, each line is annotated on the right side of the display diagram by the following abbreviations:

D1	Display Line 1	D2	Display Line 2
T1	Time Line 1	T2	Time Line 2
TH	Threshold Line	REF	Reference Line

The lines for level, threshold and reference are displayed as continuous, horizontal lines over the full width of the diagram. They are movable in the y-direction.
The lines for time are displayed as vertical, continuous lines over the total height of the diagram. They are movable in the x-direction.

For measurement operations in two separate windows, (Split Screen-Modus), the display lines are available independently in both windows. In the currently active window, the display lines can be activated and/or shifted. Lines previously defined in the currently inactive window remain unchanged.

Note: *The softkeys for setting and switching the display lines on and off operate similar to a three-position switch:*
Initial condition: The line is switched off (softkey has grey background)

1st press: The line is switched on (softkey has red background) and data entry is activated. The position of the display line can be adjusted by using the roll-key, the step keys or through direct numerical inputs via the data-entry keypad. If some other arbitrary function is requested, the data-entry keypad is disabled. In this case, the display line remains switched on (softkey has green background).

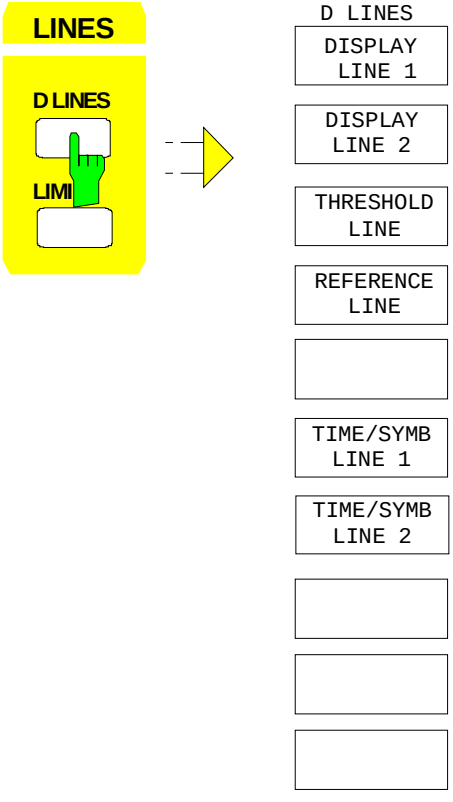
2nd press: The display line is switched off (softkey has grey background).

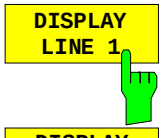
Initial condition: The line is switched on (softkey has green background)

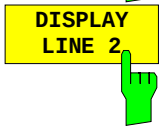
1st press: The line is switched on (softkey has red background) and data entry is activated. The position of the display line can be adjusted by using the roll-key, the step keys or through direct numerical inputs via the data-entry keypad. If any other arbitrary function is requested, the data-entry keypad is disabled. In this case, the display line remains switched on (softkey has green background).

2nd press: The display line is switched off (softkey has grey background).

Menu *LINES-D-LINES*

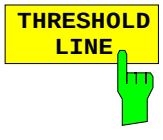




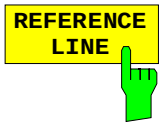


The *DISPLAY LINE 1/2* softkeys switch the display lines on/off and activate the entry of the line location.

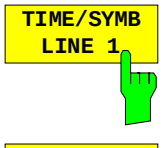
The display lines mark the selected levels in the measurement window.

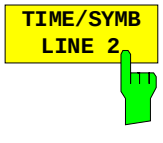


The *THRESHOLD LINE* softkey switches the threshold line on/off and activates the entry of the line location.
The threshold line is a display line which defines a threshold value. This threshold value serves as a lower search limit for maximums/minimums in the marker functions (*MAX PEAK*, *MIN PEAK*, *NEXT PEAK* etc.).



The *REFERENCE LINE* softkey switches the reference line on/off and activates the entry of the line position.





The *TIME/SYMB LINE 1/2* softkeys switch the time lines 1/2 on/off and activate the entry of line locations.

The time lines mark the selected times or define the search range (see section "Marker Functions").

2.4.8.2 Limit Lines – *LIMITS Key*

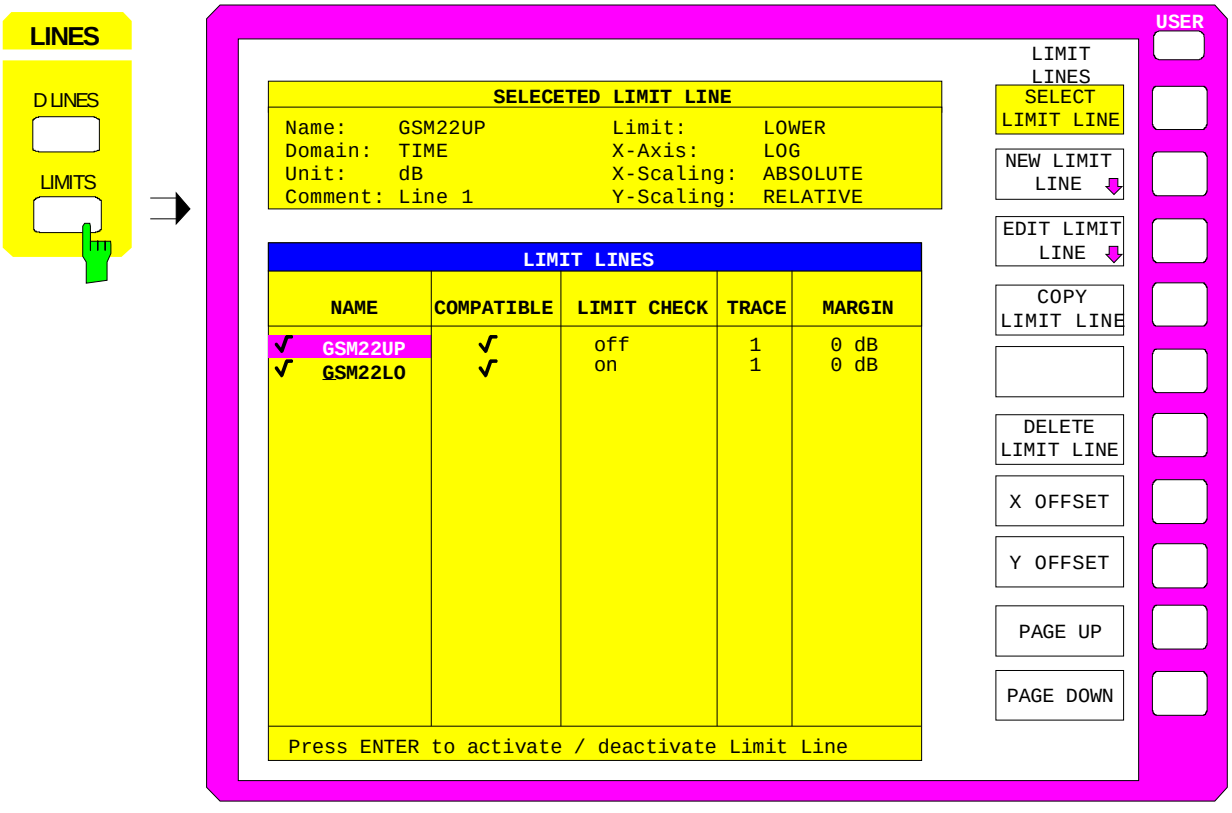
Limit lines are used to define amplitude curves or error boundaries on the display screen which are not to be exceeded. They indicate, for example, the upper limits for modulation errors which are permissible from a Unit Under Test (UUT). For transmission of information in TDMA (e.g. GSM), the amplitude of the bursts in a time slot 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 FSE supports up to 300 limit lines, each of which may have a maximum of 50 data points. For each limit line, the following characteristics must be defined:

- The name of the limit line. The limit line can be specified for time units or symbols. Time units can be entered as absolute time or time in relation to set reference time. Symbols can be entered as absolute symbols or symbols in relation to set reference symbol
- The reference of the interpolation points to the X-axis. The limit line may be specified either for absolute times or for times which are 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). If the reference line is switched on, it is used as reference when relative setting has been selected.
- The type of limit line (upper or lower limit). With this information and the active limit checking function (*LIMIT CHECK* softkey), the FSE checks for compliance with each limit.
- The limit line units to be used. The units of the limit line must be compatible with the vertical axis in the active measurement window.
- The measurement curve (trace) to which the limit line is assigned. For the FSE, 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.

In the *LINES LIMITS* menu, the compatible limit lines can be enabled in the *LIMIT LINES* table. The *SELECTED LIMIT LINE* display field provides information concerning the characteristics of the marked limit lines. New limit lines can be specified and edited in the *NEW LIMIT LINE and EDIT LIMIT LINE* sub-menus, respectively.

LINES LIMIT menu

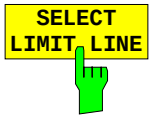


2.4.8.2.1 Limit Line Selection

The *SELECTED LIMIT LINES* table provides information about the characteristics of the marked limit line :

Name	name
Domain	time domain (unit: seconds or symbols)
Unit	vertical unit
Comment	commentary
Limit	upper/lower limit
X-Axis	linear or logarithmic interpolation
X-Scaling	absolute or relative times
Y-Scaling	absolute or relative Y-units

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 columns contain the following information:

Name	Enable the limit line.
Compatible	Indicate whether 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. 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 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 trace assigned to a line is not switched on, the line is displayed in the window the trace would be displayed in.

Example:
In split screen mode, trace 2 is assigned measuring window B. A line assigned to trace 2 is always displayed in measurement window B.

If the scale of the Y-axis is 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.

***Limit Check* - Activate automatic limit violation check**

When *LIMIT CHECK ON* is activated, a GO/NOGO test is performed. 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 2 active limit lines:

```
LIMIT CHECK: FAILED

LINE VHF_MASK: Failed
LINE UHF2MASK: Margin
```

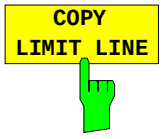
A check for violations of limit lines takes place only if the limit line of the assigned measurement curve (trace) is enabled.
If *LIM CHECK* is set to *OFF* for all active limit lines, then the limit line check is not executed and the display window is activated.

***Trace* - Select the trace to which the limit line is assigned.**

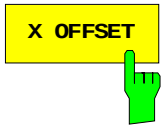
The selection of the measurement curve (trace) takes place in an entry window. Allowed are the integer entries 1, 2, 3 or 4. The default setting is trace 1. If the selected limit line is not compatible with the assigned measurement curve, then the limit line is disabled (display and limit check).

***Margin* - Setting a margin.**

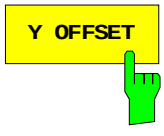
The margin is defined as the signal-level distance to the limit line. When the limit line is defined as an upper limit, the margin means that the level is below the limit line. When the limit line is defined as a lower limit, the margin means that the level is above the limit line. The default setting is 0 dB (i.e. no margin).



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).

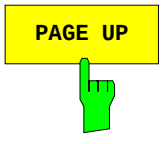


The *X OFFSET* softkey activates the entry of the value for horizontally shifting a limit line which has been specified for relative times (X-axis).

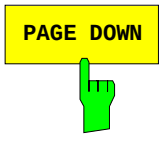


The *Y OFFSET* softkey activates the entry of the value for vertically shifting a limit line, which has relative values for the Y-axis (levels or linear units such as volt).

The *DELETE LIMIT LINE* softkey erases the selected limit line. Before deletion, a message appears requesting confirmation.



The *PAGE UP* softkey sets the limit line table to the next page.



The *PAGE DOWN* softkey sets the limit line table to the previous page.

2.4.8.2.2 Entry and Editing of Limit Lines

A limit line is characterized by

- its name
- the unit of the time data points
- the vertical unit
- linear or logarithmic interpolation
- the scaling in absolute or relative times
- the vertical scaling
- the definition of the limit line as either upper or lower limit.
- the data points for time and level or modulation measurement values.

At the time of entry, the FSE immediately checks that all limit lines are in accordance with certain guidelines. These guidelines must be observed if specified operation is to be guaranteed.

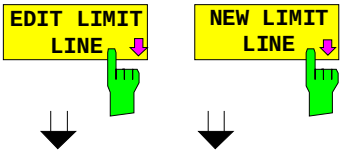
- The times for each data point must be entered in ascending order, however, for any single time, two data points may be input (vertical segment of a limit line).

  The data points are allocated in order of ascending time. Gaps are not allowed. If gaps are desired, two separate limit lines must be defined and then both enabled.

- The entered times must not necessarily be selectable in FSE. A limit line may also exceed the specified time domain and negative times may also be entered. The allowable range is -1000 s to +1000 s.

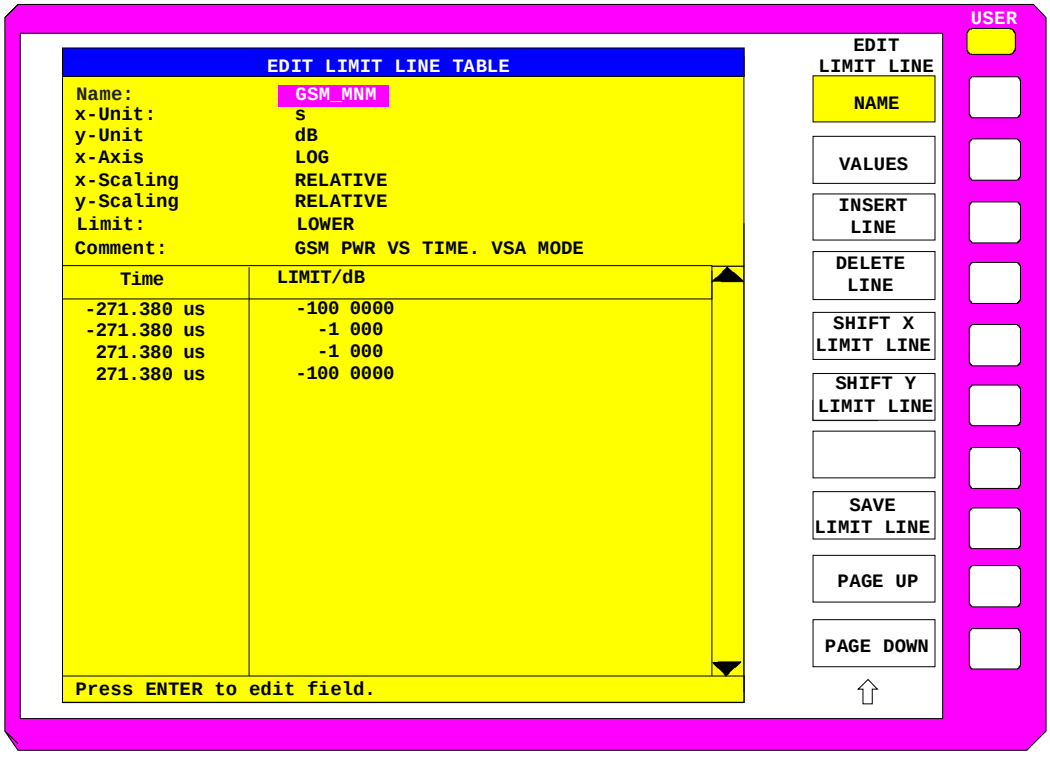
- The minimum/maximum value for a limit line is -200 dB to +200 dB for the logarithmic or 10^{-20} to 10^{+20} or-99.9% to + 999.9% for the linear amplitude scales.

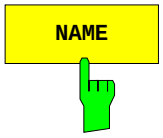
LINES LIMIT-EDIT LIMIT LINE menu



The *EDIT LIMIT LINE* and *NEW LIMIT LINE* softkeys both call the *EDIT LIMIT LINE* sub-menu used for editing limit lines. In the table heading, the characteristics of the limit line can be entered. The data points for time and level values are entered in the columns.

Name	Enter name.
x-Unit	Selection of unit.
y-Unit	Selection of vertical unit.
X-Axis	Selection of interpolation
X-Scaling	Entry of absolute or relative values for the X-axis
Y-Scaling	Entry of absolute or relative values for the Y-axis
Limit	Select upper/lower limit.
Comment	Enter comments.
Time	Enter time for the data points.
Limit/dB(..)	Enter magnitudes for the data points.





The *NAME* softkey enables the entry of characteristics in the table heading.

***Name* - Enter name**

A maximum of 8 characters are 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.

***x-Unit* - Select the unit (TIME)**

Only time domain is available in vector analyzer mode. Possible units are s or Symb.

***y-Unit* - Select the vertical unit for the limit line (LIMIT)**

The selection of the unit is made in the selection box. The default setting is dBm.

***X-Axis* - Indication of interpolation**

Linear or logarithmic interpolation can be carried out between the reference points of the table. Selection is via the *ENTER* key which is toggled between *LIN* and *LOG* (toggle function).

***Scaling* - Select absolute or relative scaling**

The limit line can either be scaled in absolute 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 times are interpreted as absolute physical units.
X-Scaling RELATIVE	In the data point table, the times are referred to the left boundary of the diagram.
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 units dB or % are always relative values.

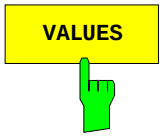
The *RELATIVE* scaling is always suitable, if masks for bursts are to be defined.
An X-offset with half the sweep time may be entered in order to shift the mask into the center of screen.

***Limit* - Select upper/lower limit**

A limit line can be defined as either an upper or lower limit.

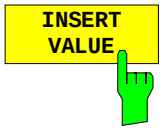
***Comment* - Enter comments**

Comments are arbitrary, however, they must be less than 40 characters long.

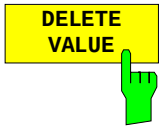


The *VALUES* softkey activates the entry of the data points in the table columns *Time* and *Limit/dB*..

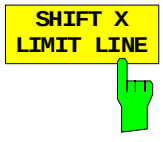
The desired time data points are entered in ascending order (two repeated time values are permitted).



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 time.



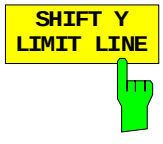
The *DELETE VALUE* softkey erases the data point (complete line) at the cursor position. All succeeding data points are shifted down accordingly.



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 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).



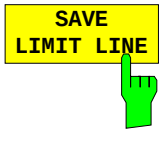
The *SHIFT Y LIMIT LINE* softkey calls an entry window where the complete limit line may be shifted parallel in the vertical direction.

The shift takes place according to the vertical scale:

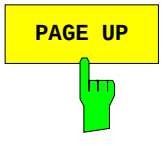
– for logarithmic units, relative, in dB

– for linear units, as a factor

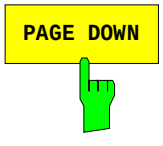
In this manner, a new limit line can be easily generated based upon an existing limit line which has been shifted vertically and stored (*SAVE LIMIT LINE* softkey) under a new name (*NAME* softkey).



The *SAVE LIMIT LINE* softkey stores the currently edited limit line. The name can be entered in an input window (max. 8 characters)



The *PAGE UP* softkey displays the next page of data points.

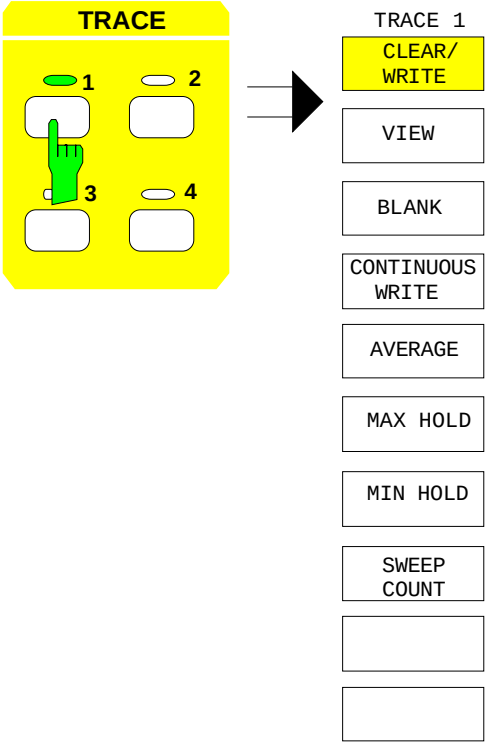


The *PAGE DOWN* softkey displays the previous page of data points.

2.4.9 Selection and Setting of Traces - TRACE Key Group

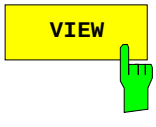
The function of keys TRACE 1 to 4 in vector signal analysis is largely identical with the function in *ANALYZER* mode as long as traces are displayed. If numeric values or tables (e.g. *SYMBOL TABLE*) are displayed, they are also linked with a trace (some of the trace functions are not available then).

Example: In diagram *SYMB TABLE / ERRORS* the symbol table refers to trace 1 and the error table to trace 2 (not for *SPLIT SCREEN*!) .

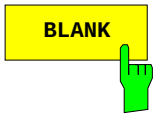


The TRACE keys 1 to 4 call up a menu in which the selected trace can be set.

The *CLEAR/WRITE* softkey displays a new trace for each measurement or outputs a measured value. Values from previous measurements are deleted.

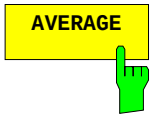


The *VIEW* softkey freezes the current contents of the trace memory and displays them. If the device setting is changed, the displayed trace does not change. The measurement data are then invalid with reference to the current setting. This is shown by the enhancement label "*" at the right grid end.



The *BLANK* softkey blanks the trace or the measured values on the display. They are internally stored so that they can be displayed again with the aid of *VIEW*. The markers linked to a trace are also deleted with *BLANK*, but restored after reactivating the trace with *VIEW* or *CLEAR/ WRITE*.

The *CONTINUOUS WRITE* softkey outputs measured values for each sweep or displays a trace without clearing the previous measurements.
This function can be useful for the display of the constellation or eye diagram, where test runs are required for in-depth information.



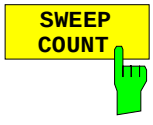
The *AVERAGE* softkey switches the trace averaging on. The average value is derived from several sweeps.

After switch-on of averaging, the first trace is written in the *CLEAR/WRITE mode*. Successive averaging is performed from the second sweep.
Averaging is restarted if the *AVERAGE* softkey is pressed. The trace memory is then deleted. This is also the case if the trace memory is set to *VIEW* or *BLANK* in the *AVERAGE* position.

If the *AVERAGE* function is active, the highest values are indicated for peak values (incl. AMPLITUDE DROOP) for the display of the error table. A square averaging is performed for RMS values. For all other displays a linear averaging is performed.

Switch-on of function *AVERAGE* on a trace where the summary markers are active results in a switch-off of summary markers.
On the other hand, summary markers cannot be activated on a trace if one of the *AVERAGE (or MAX HOLD or MIN HOLD)* functions is switched to this trace.

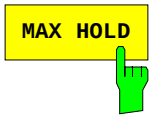
For description of average procedure see 'Traces - TRACE Key Group' in chapter 'Analyzer mode.



The SWEEP COUNT softkey activates the entry of the number of sweeps required to perform the averaging.
The permissible range of values for the Sweep Count is 0 to 32767. In case of 0, the FSE carries out a running averaging over 10 sweeps in the Average mode. No averaging is performed in case of 1.

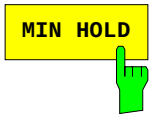
The default setting is 10 sweeps (Sweep Count = 0). Programming of course influences the sweep duration. The number of sweeps required for averaging or the average time are identical for all 4 traces.

Note: *This sweep number setting in the trace menu is equivalent to that of the sweep menu. If both averaging and hold functions of the summary markers or trace averaging (or MAX HOLD or MIN HOLD) are active on different traces, the SWEEP COUNT counter simultaneously refers to summary markers and trace averaging.*



The *MAX HOLD* softkey activates peak-value averaging.
For every sweep run, the FSE identifies the highest value and compares it with the current value. The highest of the two values is then stored in the updated trace memory. Thus, the maximum value of a signal can be evaluated over several test runs.

The trace memory is deleted by pressing the *MAX HOLD* softkey again. Peak-value averaging is started again.



The *MIN HOLD* softkey activates minimum-value averaging. For every sweep run, the FSE identifies the smallest of the two values and compares it with the current value. The smallest of the two values is then stored in the updated trace memory. Thus, the minimum value of a signal can be evaluated over several test runs.

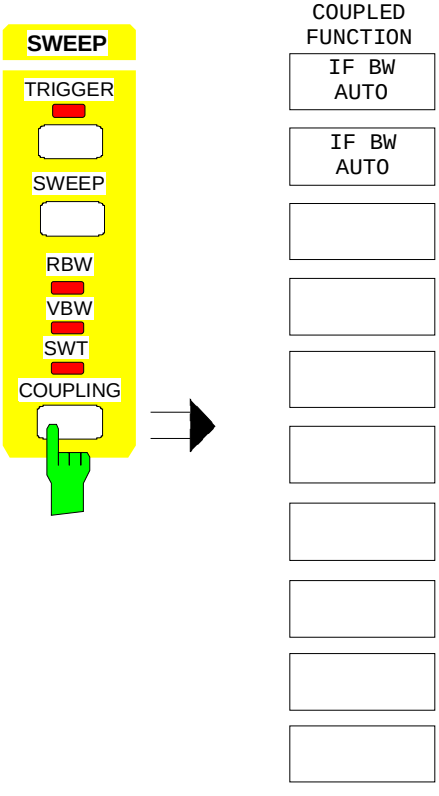
The trace memory is deleted by pressing the *MIN HOLD* softkey again. Minimum averaging is stared again.

2.4.10 *SWEEP* Key Group

2.4.10.1 Setting the Analog Bandwidth - *COUPLING* Key

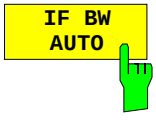
In the vector analysis mode, bandwidth limiting is not at the IF but in the baseband by means of digital filtering. The analog IF filters only serve for attenuating far off signals. The IF filters are set more broadly as required by the signal to be measured in order to increase the measurement accuracy. Thus, the measurement signal is less distorted by the amplitude and phase response of the IF filtering.

SWEEP COUPLING menu

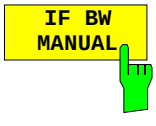


The *COUPLING* key calls up the menu for setting the analog bandwidth.

The *MAIN PLL BANDWIDTH* softkey in the side menu is without function in vector analyzer mode.



The *IF BW AUTO,* the *FSE* automatically sets the resolution bandwidth to the maximum 10-MHz bandwidth for digitally modulated signals.



The *IF BW MANUAL* softkey opens a window for entering the bandwidth for the analog prefiltering.

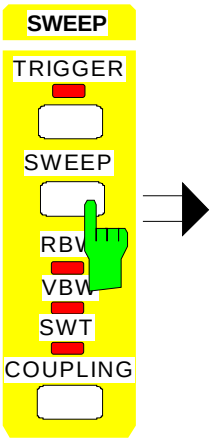
With *IF BW MANUAL,* the FSE can be manually set. When the demodulators are used for digitally modulated signals, the minimum analog bandwidth corresponds to the set symbol rate. Since modulation errors increase when narrow analog bandwidths are selected because of the amplitude and phase distortions, UNCAL is displayed for analog bandwidths below 10 times the symbol rate.

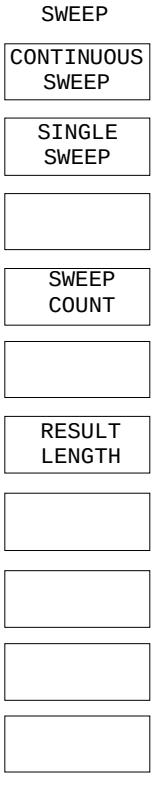
Bandwidths below 1 kHz cannot be set as the smallest bandwidth implemented by analog filtering is 1 kHz. When a smaller bandwidth than permitted is set, the FSE signals:

RBW out of range

2.4.10.2 Sweep Setup - SWEEP Key

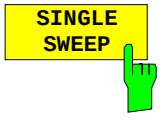
Menu SWEEP SWEEP



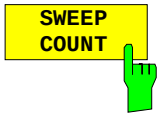


The *SWEEP* key calls up a menu in which the type of measurement - single or continuous measurement - and the measurement result length to be displayed in time or symbols are defined.

The *CONTINUOUS SWEEP* softkey starts a continuous measurement after defining the trigger condition and selected measurement settings. Following triggering, the measured values will be collected and then evaluated and displayed.
If, for split screen display, measurements in both windows are in the vector analysis mode, data in the measurement RAM are used for the two evaluations.

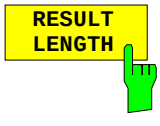


The *SINGLE SWEEP* softkey starts n measurements with the given trigger settings. The number of sweeps n is determined with *SWEEP COUNT*. The measurement is stopped after n measurements. It can be restarted by pressing *SINGLE SWEEP* again or by *CONTINUOUS SWEEP*.



The *SWEEP COUNT* softkey opens a window for entering the number of measurements for the single sweep
The number of measurements can be selected between 0 and 32767.
With averaging of measured values set, SWEEP COUNT also determines the number of measurements required for averaging.

SWEEP COUNT = 0	10 measurements are used for a running averaging.
SWEEP COUNT = 1	no averaging is performed.
SWEEP COUNT >1	averaging is performed for the set number of measurements.

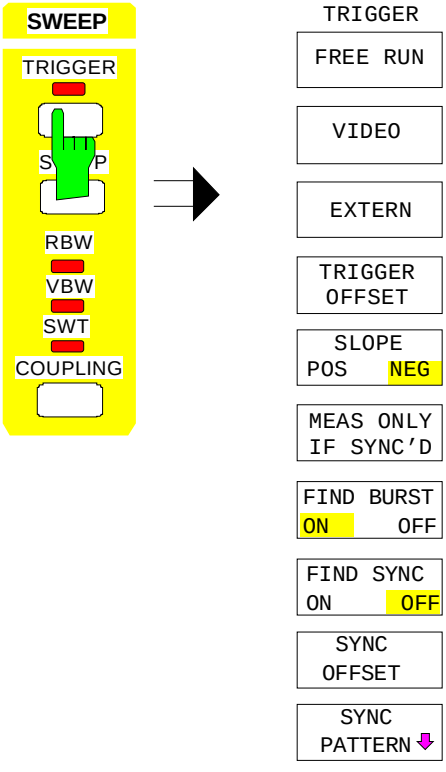


The *RESULT LENGTH* softkey defines the number of symbols or the time slot to be displayed. The maximum number of symbols that can be displayed is equal to the frame length.

2.4.10.3 Triggering Data Storage - *TRIGGER* Key

The trigger in the vector analyzer mode determines the time from which data are stored in the result memory. For the demodulation of digitally modulated signals, the time reference can also be obtained by synchronization to a given bit sequence or, for TDMA signals, by searching for a burst in the result memory.

Menu: *SWEEP TRIGGER*

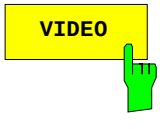


The *TRIGGER* key opens a menu in which the different trigger sources can be set and trigger slopes selected.

The *FREE RUN* softkey activates the measurement without trigger. After a measurement, the memory is prepared to store data for a new measurement.

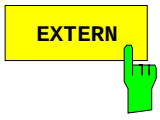
The free-run mode is recommended if a continuously modulated signal is applied to the RF input or, for TDMA signals, the capture time is long enough to enter a full burst into the result memory.

The capture time is influenced by the memory size (max. 16384 points), the set symbol rate as well as the number of points per symbol.

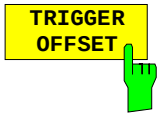


The *VIDEO* softkey starts the measurement by the video voltage of the analog path of the spectrum analyzer. Parallel to the vector signal analyzer, the analog video voltage of the spectrum analyzer is evaluated.

Video triggering calls for the entry of the trigger threshold. It is identical to the trigger threshold of the spectrum analyzer. The entry of the trigger threshold into the data window is numeric in % of the last grid which has been active in the analyzer mode.
To determine a suitable value for the trigger threshold it is possible to switch to the display MAGNITUDE CAP BUFFER or to measure the threshold in the analyzer mode.



The *EXTERN* softkey activates triggering by means of an external voltage between -5 V to +5 V at the rear BNC connector *EXT TRIGGER / GATE*. The desired value is to be entered into the window.

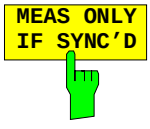


The *TRIGGER OFFSET* softkey opens a window for entering the desired offset.

With *TRIGGER OFFSET,* the start time for the data storage relative to the trigger event is determined. Both positive values (for a trigger delay) and negative values (for a pretrigger) are permitted.

Entry is in absolute time independent of the scaling of the X axis.

For positive values of the trigger offset (trigger delay), values from 1 µs to at least 10 ms are permitted, depending on the symbol rate and the number of points per symbol. The range of values for negative trigger offsets (pretrigger) depends on the selected memory size and is not more than half the memory size.

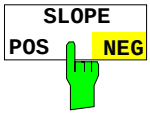


Softkey *MEAS ONLY IF SYNC'D* sets the vector analyzer so that measurements are performed if synchronization to the selected sync pattern was possible.
The measured values are displayed and taken into account in the error analysis only if the set sync pattern is found. Bursts with a wrong sync pattern (sync not found) are ignored.
If an invalid sync pattern is found or if there is none, the measurement is halted and continued in the presence of a valid sync pattern.

This softkey is available only if *FIND SYNC = ON*.
The default setting is OFF. If the digital standard is changed, OFF is always activated.

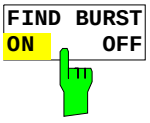
Example:

An EDGE-compatible base station can send EDGE and GSM bursts alternately. The demodulator thus sees EDGE (8PSK) and GSM bursts (GMSK).
If GSM is activated in the vector analysis, the measurement and error analysis are disturbed by an EDGE burst. This can be prevented by activating softkey *MEAS ONLY IF SYNC'D.* The EDGE bursts are ignored in the error analysis.



The *SLOPE POS/NEG* softkey determines the trigger slope in case of triggering by means of the video signal or external trigger.

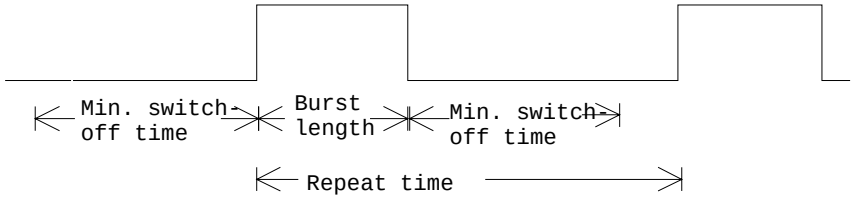
The sweep starts after a positive or negative slope of the trigger signal. With a free-running trigger the setting is irrelevant.



The *FIND BURST ON/OFF* softkey searches for a burst in the stored data (within the entered memory size), demodulates it within the entered frame length and displays it with the set result length.

The *FIND BURST* mode is particularly useful for TDMA signals if a burst is to be completely displayed (and would otherwise not be demodulated due to the mark-to-space ratio at the maximum setable frame length of 800 symbols*)*. The time required for searching for a burst is determined with memory size.
A burst must have a minimum length of 30 symbols to be identified.

Digital communication systems operating according to the TDMA access methods transmit or receive information in the form of bursts. The carrier power is only switched on for a certain time. The transmitter switches the carrier on if an information is to be transmitted and switches it off again.



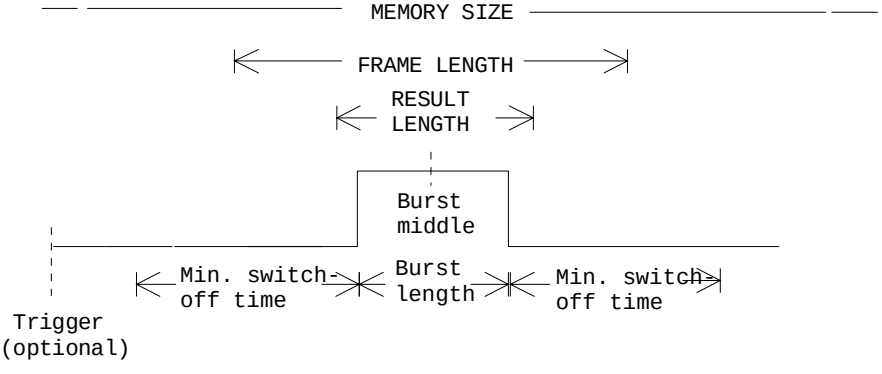
The carrier power is switched off between two bursts. With *FIND BURST,* the FSE earches for a complete burst, i.e. for a carrier that can be switched on ***and*** off. If no complete burst is found within the search time, the message *BURST NOT FOUND* is displayed.

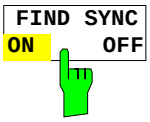
If a trigger (video or extern) is used for the storage of the measured values, a negative trigger offset (pretrigger) is recommended so that a sufficiently long switch-off time of the carrier is available at the beginning of the search time.

The search time has at least to be as long as the burst length plus twice the switch-off time to ensure that the burst is found.

For a free-running trigger, set the length of the captured data *(MEMORY SIZE)* to a minimum (repeat time + 2 x switch-off time + burst length) so that the burst can be found.

The FSE centers the number of symbols (*FRAME LENGTH*) required for demodulation as well as the displayed symbols (*RESULT LENGTH*) to the center of the found burst (*FIND SYNC OFF*).



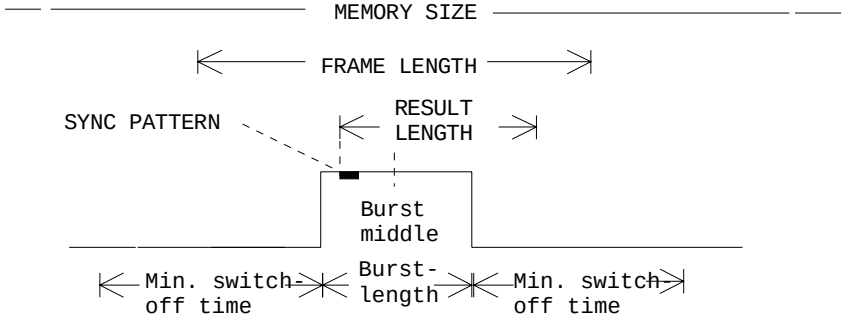


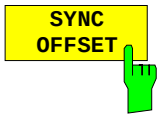
The *FIND SYNC ON,* softkey searches for a defined bit sequence (sync pattern) within the set frame length. The measurement result is displayed with the set result length with reference to the first symbol of the synchronization sequence.

If the synchronization sequence is not found, a result is still output according to the set result length. The message*: SYNC NOT FOUND* is then output.

Centering the burst on the middle of the picture cannot be carried out if the burst is found at the very beginning of the data set (of the memory size) and a **Result Length >Burst Length + 2×20 symbols** is set. A precondition for burst recognition is that before the rising edge measured values corresponding to at least 20 symbols are present in the current trace memory. In this case, the burst is represented from the first measured value in the trace memory.
If the consequent centering of the burst is indispensable for the user, the result length has to be reduced according to the above precondition.

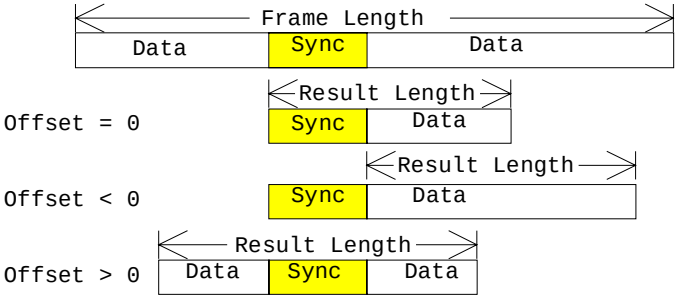
In case of *FIND BURST ON* and *FIND SYNC ON,* the FSE only centers the frame length to the center of the burst while the result length is displayed from the beginning of the bit sequence (in case of *SYNC OFFSET* 0) or around the *SYNC OFFSET*.





The *SYNC OFFSET* softkey opens a window for entering the offset in symbols.

SYNC OFFSET defines the display time prior to the synchronization sequence in SYNC SEARCH. It thus determines the position of the displayed trace or symbols (result length) within the demodulated signal (frame length). The modulated signal may have a preamble or a midamble. Depending on the configuration it is thus desirable to display the measurement signal from a synchronization sequence or prior to the synchronization sequence.



A positive or a negative offset can be set.

The minimum or maximum offset depends on the following parameters:

- frame length
- result length and
- position of the sync sequence in the burst

In order to find the sync sequence correctly regardless of its position within the burst and to obtain enough measured values for the diagram, the *FRAME LENGTH* for the *FIND SYNC* function should be set at least twice as large as the *RESULT LENGTH*.

Any offset can basically be entered provided that the measurement result is within the *FRAME LENGTH*. If the *FRAME LENGTH* is extended, a higher offset can be entered. If the *RESULT LENGTH* is extended, the maximum offset is reduced.

If an offset is set that is too large (i.e. that, togeher with the selected *FRAME LENGTH, prevents the RESULT LENGTH combined with the determined sync sequence to be* completely displayed), the error message *SYNC OFFSET INVALID* ! appears on the screen.

In this case, either the *FRAME LENGTH* must be increased, or the sync offset must be adapted to the position of the sync sequence in the burst.

The frame buffer contains the data available for the evaluation (*FRAME LENGTH*).

The message "SYNC OFFSET INVALID" indicates that there are not enough data available for displaying the *RESULT LENGTH*.

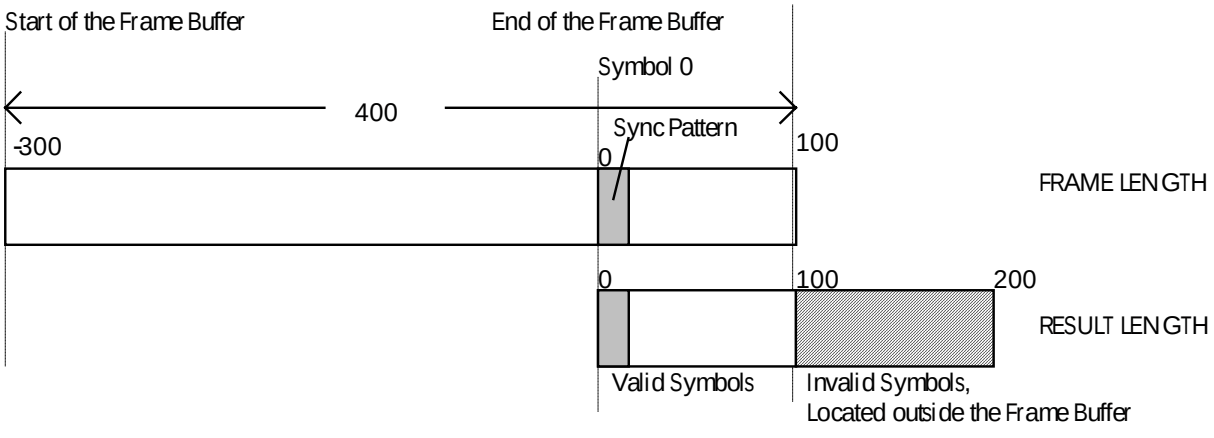
The following examples explain how *FRAME LENGTH*, *SYNC OFFSET* and *FRAME LENGTH* are related.

Example 1 (input signal without burst):

Device settings:

- Input signal (without burst)
- FIND BURST off
- FIND SYNC on
- FRAME LENGTH = 400
- RESULT LENGTH = 200
- SYNC OFFSET = 0

The start of the frame buffer is at symbol -300 (with respect to the sync pattern), the FSE displays the results starting with symbol no. 0, but there are no more than 100 valid symbols in the file, 100 symbols of the result length are invalid because they are located outside the frame buffer.



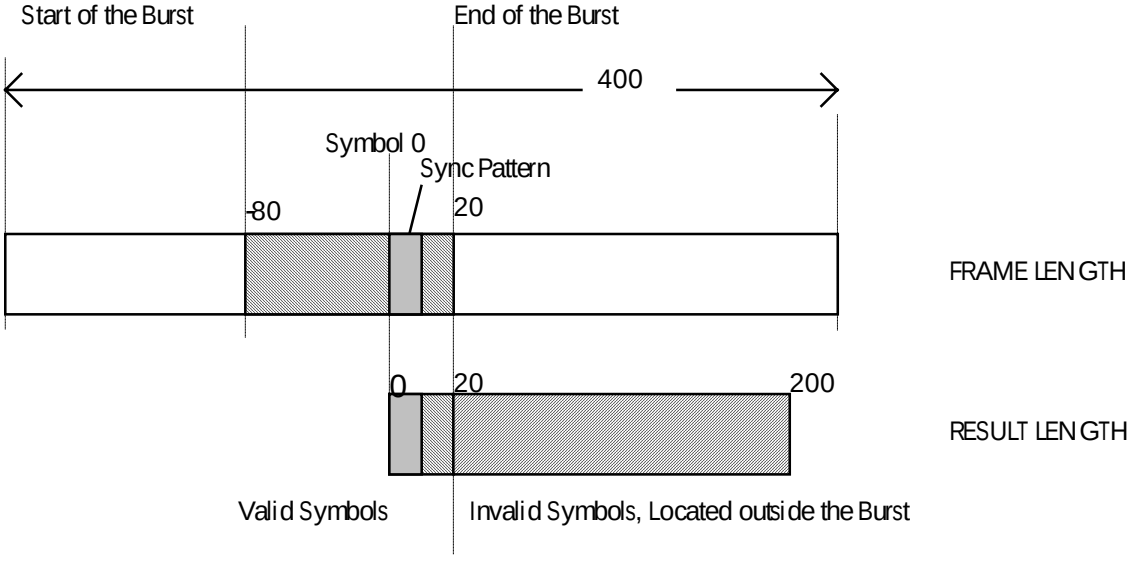
Solution: diminish result length to 100 symbols *or*
extend frame length to 800 symbols.

Example 2 (input signal with burst):

Device settings:

- Input signal (burst length 100 symbols)
- FIND BURST on
- FIND SYNC on
- FRAME LENGTH = 400
- RESULT LENGTH = 200
- SYNC OFFSET = 0

After successful search of the burst, only the symbols inside the burst are marked as valid.
The synchronization pattern is found in the burst (Symbol 0), the FSE displays starting with symbol no.0, but there are only 20 valid symbols in the burst, 180 symbols of the result length are invalid because they are located outside the burst.



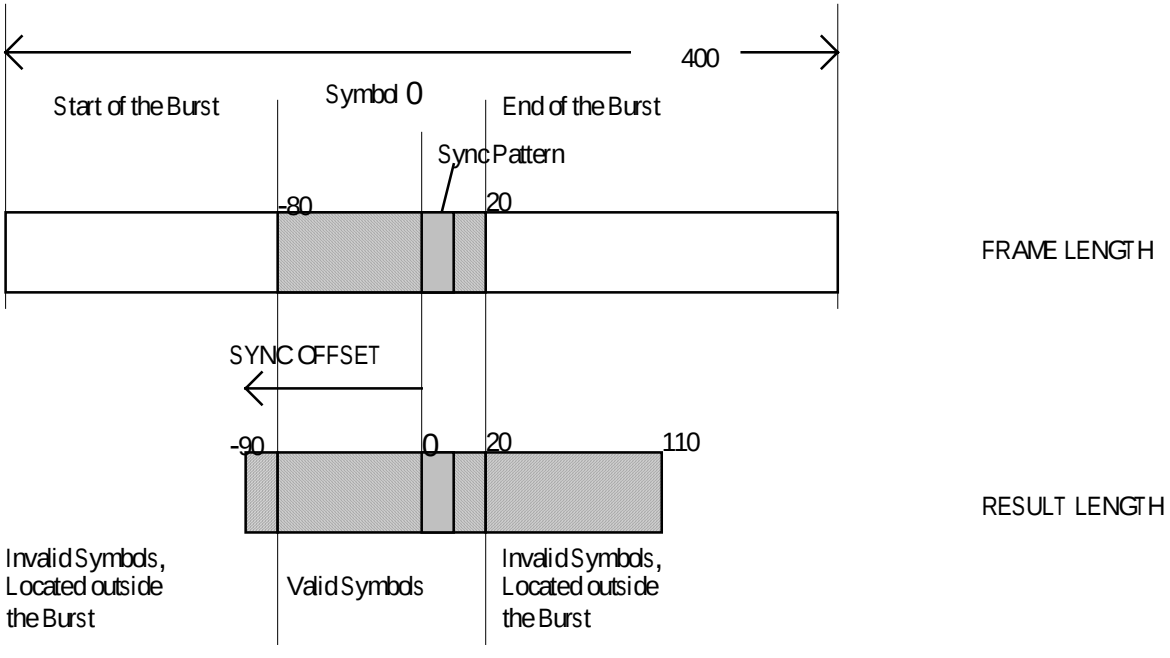
Solution: diminish result length to 20 symbols.

Example 3 (input signal with burst):

Device settings:

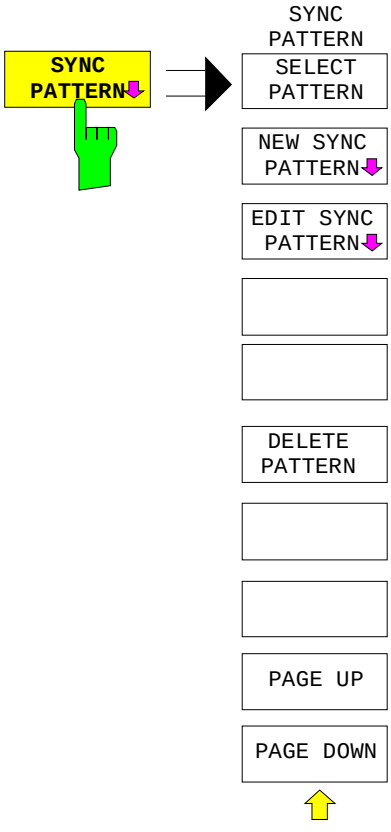
- Input signal (burst length 100 symbols)
- FIND BURST on
- FIND SYNC on
- FRAME LENGTH = 400
- RESULT LENGTH = 200
- SYNC OFFSET = 90

After successful search of the burst, only the symbols inside the burst are marked as valid.
The synchronization pattern is found in the burst (Symbol 0), the FSE displays starting with symbol no. -90 up to +19, the beginning of the display range is located before the start of the burst !



Solution: diminish result length to 100 symbols (= burst length)
set sync offset to 80 (beginning of the burst lies 80 symbols before the sync-pattern).

Submenu: *SWEEP TRIGGER*



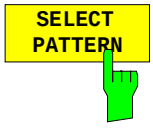
The *SYNC PATTERN* softkey calls up a submenu, allowing to select available patterns.

These patterns are displayed in the table *PATTERN NAME*. If a pattern is activated, the bit sequence of the selected pattern is displayed in the table *PATTERN VALUE*.

The synchronization pattern defines a bit sequence which is searched for in the signal to be demodulated. When the *FIND SYNC* function is activated, this bit sequence is used for synchronizing measurement results. The FSE demodulates the signal to be measured down to bit level and searches for this predefined sequence. The first symbol in the bit sequence is the reference time (for *SYNC OFFSET* = 0).

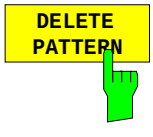
The bit sequence of digitally modulated signals often includes a preamble or midamble which is used on the one hand for assessing the channel impulse response and setting the channel equalizer in the receiver and on the other hand to synchronize the receiver. This bit sequence may be used in the FSE to find and display particular signal sections.

The maximum pattern length of the FSE is 200 bits. The number of symbols depends on the significance of the modulation method. With QPSK, for instance, 200 bits correspond to 100 symbols, with 16QAM to 50 symbols. The FSE always uses an integral multiple of the bits per symbol. Bits which are not multiples or exceed the maximum length are omitted.

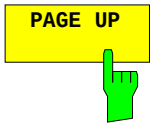


The *SELECT PATTERN* softkey marks the first field in the *PATTERN NAME* table.

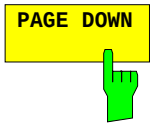
The bit sequence of the selected pattern is displayed simultaneously with the *PATTERN VALUE* table.



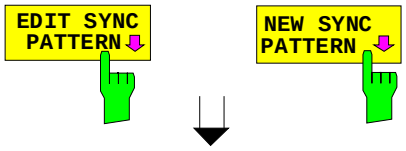
The *DELETE PATTERN* softkey clears the pattern marked by the cursor.
To avoid the pattern being inadvertently deleted, a confirmation is required..



The *PAGE UP/PAGE DOWN* softkey causes the next/last page of the sync pattern table to be displayed.

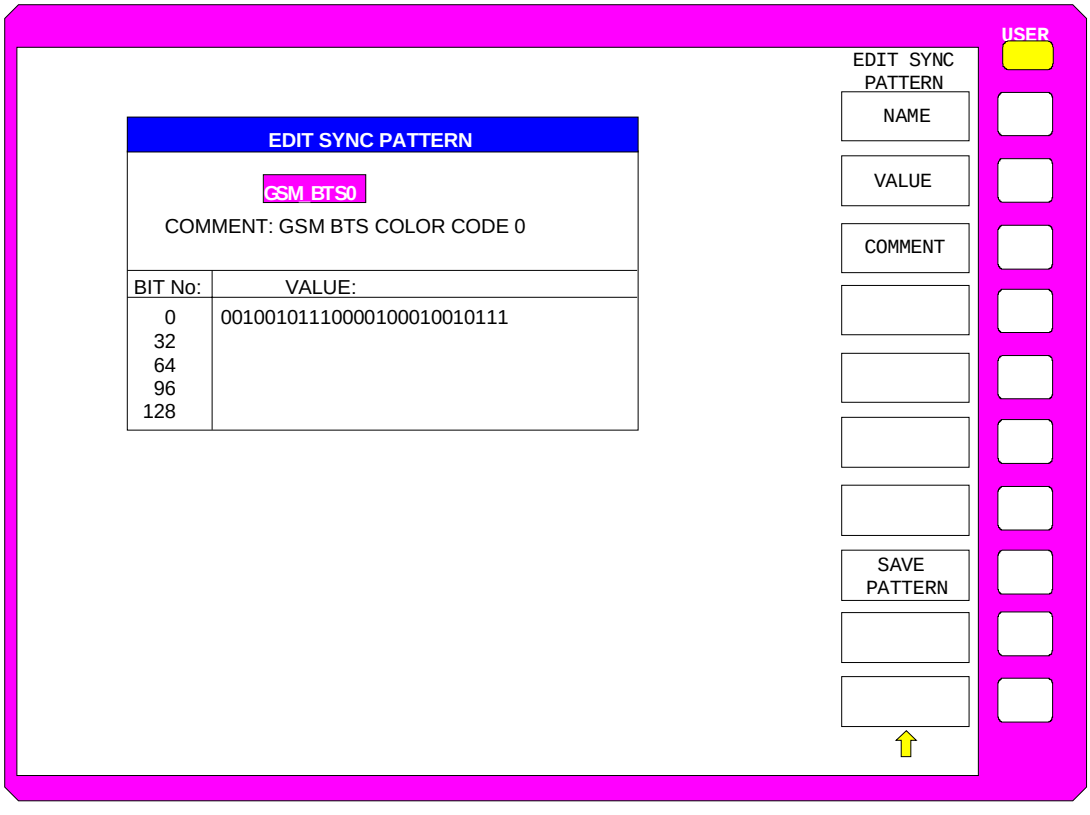


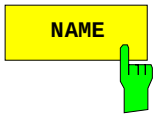
Submenu: *SWEEP TRIGGER - SYNC PATTERN*



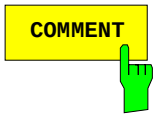
The *NEW PATTERN* and *EDIT PATTERN* softkeys call up the *EDIT SYNC PATTERN* submenu for generating sync pattern.
In the head line of the table the name and comment of the sync pattern to be edited or modified can be entered.

The sync pattern is entered or modified in the *VALUES* field, using the DATA ENTRY keys "*0*", "*1*" und "**.**" .





The *NAME* softkey activates the input of the name of the sync pattern. A maximum of eight characters can be entered.
When the sync pattern is stored, the extension .PAT is automatically appended.



The *COMMENT* softkey activates the input of a comment for the sync pattern.

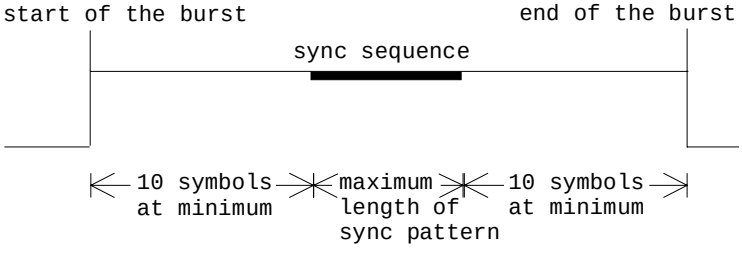
VALUE

The *VALUE* softkey activates the input of the bit pattern of the sync pattern.

The sync pattern may include "don't care bits" which are not considered when searching for the valid bit pattern.. The don't care bits are marked by an 'x' in the *VALUE* field.

The sync pattern has to start and end with a valid bit, a don't care bit can not be the first or last bit of the sync pattern.

During burst search, the sync pattern has to start and to end 10 symboles before the beginning and end of the burst, respectively.



SAVE PATTERN

The *SAVE PATTERN* softkey stores a newly edited pattern under the current name.