



**ROHDE & SCHWARZ**

Test and Measurement  
Division

# Supplements to the Operating Manual LO/IF ports for external mixers

**R&S FSU-B21**

1157.1090.02

**Dear R&S FSU Customer,**

The following collection of pages is intended to supplement your R&S FSU operating manual.

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## Option R&S FSU-B21: LO/IF ports for external mixers

### Connecting an External Mixer

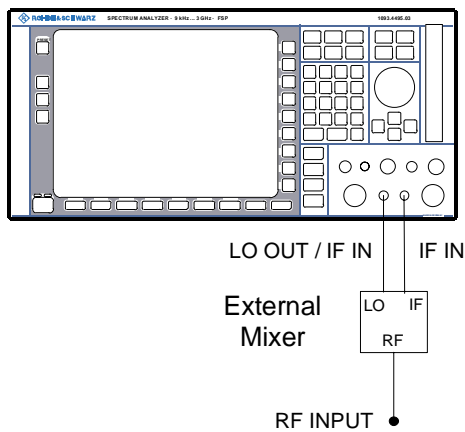
To increase the frequency range, FSU 26/46 and FSQ 26 can be operated with external mixers.

Both two-port and three-port mixers can be used. Connect mixer as follows:

**Note:** Use the coaxial cable supplied to feed in the LO signal.  
If no external mixers are connected to the analyzer, cover the two front connectors 'LO OUT / IF IN' and 'IF IN' with the SMA caps supplied.

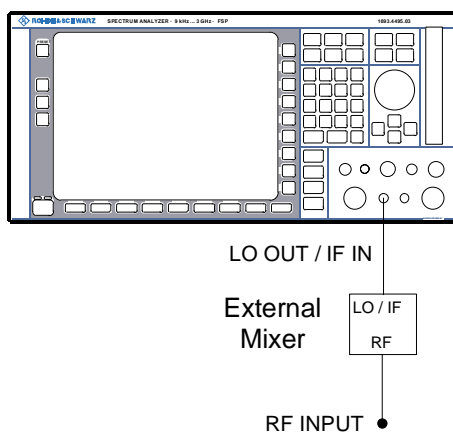
To activate the operation mode, press softkey *EXTERNAL MIXER* in the frequency menu.

#### Three-port mixer:



- Connect the 'LO OUT / IF IN' output of the analyzer to the LO port of the external mixer.
- Connect the 'IF IN' input of the analyzer to the IF port of the external mixer.
- Feed the signal to be measured to the RF input of the external mixer.

#### Two-port mixer:

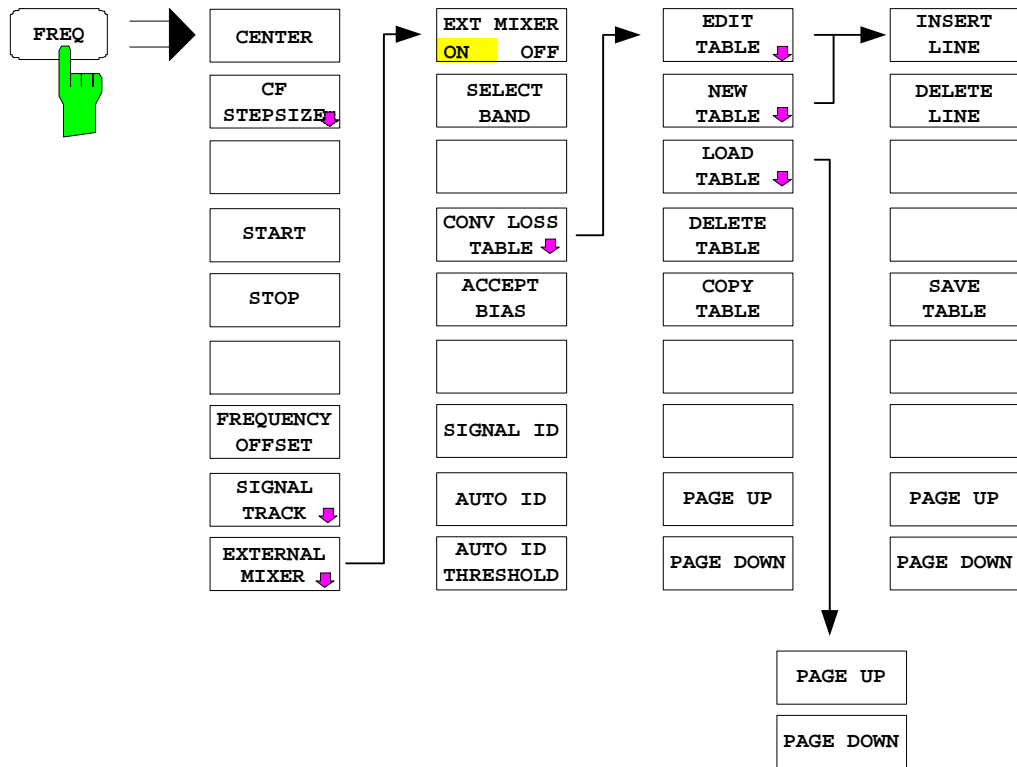


- Connect the 'LO OUT / IF IN' output of the analyzer to the LO/IF port of the external mixer.  
Because of the diplexer contained in the analyzer the IF signal can be tapped from the line which is used to feed the LO signal to the mixer.
- Feed the signal to be measured to the RF input of the external mixer.

## Manual Operation

The hardkey *FREQ* opens the menu for selecting the frequency and the frequency range which has been extended to the functions of external mixing

=



### Frequency range

The frequency of the input signal can be expressed as a function of the LO frequency and the selected harmonic of the 1st LO as follows:

$$f_{in} = n * f_{LO} + f_{IF}$$

where:  $f_{in}$  frequency of input signal  
 $n$  order of harmonic used for conversion  
 $f_{LO}$  frequency of 1st LO 7...15.5 GHz  
 $f_{IF}$  intermediate frequency 404.4 MHz

**Note:** The LO frequency range cannot be used to the full due to the signal identification functions (SIGNAL ID and AUTO ID, see chapter Signal Identification)

### Full-screen level

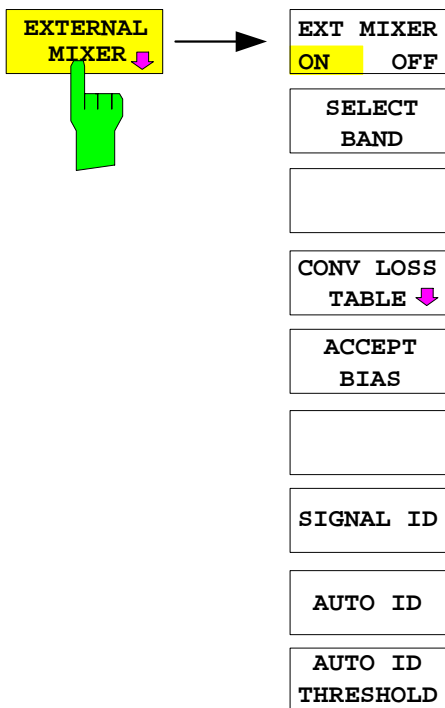
The maximum settable reference level is 0 dBm. If an IF signal with a level of -20 dBm is applied to the LO OUT / IF IN or IF IN input of the analyzer, full screen level will be attained.

When digital filters are used (IF bandwidths = 100 kHz) the overload limit is typically approx. 3 dB above the set reference level. IF signals with higher levels cause the A/D converter to be overloaded (display 'IFOVL').

If an analog IF filter is used, the overload limit is determined by the IF amplifier. In this case, the 1 dB compression point is approximately 6 dB above the reference level. Overload display 'OVL' appears at higher levels.

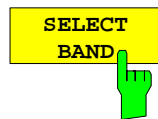
In addition to the dynamic range of the spectrum analyzer the 1 dB compression point of the mixer has to be taken into account. The levels of the input signals should lie well below this value to avoid generation of harmonics of these signals in the mixer. These are converted by the LO signals harmonics of higher order and appear in the displayed spectrum.

The *EXTERNAL MIXER* softkey opens a submenu for setting the parameters of the external mixer. The softkey automatically switches on the external mixer.



External mixing is switched on or off by the *EXT MIXER ON/OFF* softkey.

IEEE bus command    MIX ON



The *SELECT BAND* softkey opens a submenu for selecting the waveguide band and the harmonic to be used and for setting all necessary parameters. The configuration can be stored using the function *SAVE* of FILE menu.

IEEE bus command    --

SELECT BAND							
BAND	RANGE/GHz	HARMONIC #	EVEN/ODD HARMONICS	PORTS	BIAS/ mA	AVG CONV LOSS/dB	CONV LOSS TABLE
Q	33 - 50	4	even	2	0.00	24.00	Band_U_4
√ U	40 - 52.3	4	even	2	0.00	0.00	
	52.3 - 60	6			0.00		Band_U_6
V	50 - 75	6	even	2	0.00	28.00	
E	60 - 90	8	even	2	0.00	32.00	
W	75 - 110	10	even	2	0.00	36.00	
F	90 - 140	12	even	2	0.00	40.00	
D	110 - 170	14	even	2	0.00	44.00	
G	140 - 220	18	even	2	0.00	52.00	
Y	170 - 260	22	even	2	0.00	56.00	
J	220 - 330	26	even	3	0.00	68.00	
USER	28.5 - 52.3	4	even	3	0.00	24.00	

The table contains the following parameters for each band:

**BAND**

**Designation of waveguide band**

IEEE bus command    MIX:HARM: BAND E

**RANGE**

**Frequency range**

The frequency range of the waveguide band or the frequency range which is covered by the selected harmonic is shown in this field.

IEEE bus command    --

**HARMONIC#**

**Order of harmonic**

Order of harmonic used for conversion The order is selected automatically depending on the definition made in the *EVEN / ODD HARMONICS* column. The lowest order is selected that allows conversion of input signals in the whole band.

If due to LO frequency the conversion is not possible using one harmonic, the band is splitted. Frequency range and order of harmonic of the resulting parts are shown within the field.

Within the band *USER* the order of harmonic is defined by the user. The resulting frequency range will be automatically entered into the field *RANGE*. The order of harmonic can be between 2 und 64, the lowest usable frequency being 26,5 GHz.

IEEE bus command    MIX:HARM 5



**EVEN/ODD  
HARMONICS**

**Designation of harmonic to be used**

Defines if only even, only odd, or even and odd harmonics can be used for conversion.

EVEN / ODD
EVEN
√ ODD
EVEN&ODD

Depending on what has been selected within this field the order of harmonic to be used for conversion will change (shown in the field *HARMONIC#*).

Within the band *USER* this field is not editable.

IEEE bus command      MIX:HARM:TYPE EODD

**PORTS**

**Type of mixer**

Defines if a two- or three-port mixer is used.

PORTS
√ 2
3

IEEE bus command      MIX:PORT 3

**BIAS**

**Bias current**

The bias current can range from -10 mA to 10 mA.

The current corresponds to the short-circuit current. The actual bias current is lower because of the forward voltage of the mixer diode(s).

If *CONV LOSS TABLE* is activated, changes of the bias current are temporary only, i.e. the bias current will not be changed within the file selected in *CONV LOSS TABLE*. To store the changes press *ACCEPT BIAS* softkey. (See chapter Bias Current.)

IEEE bus command      MIX:BIAS 7mA

**AVG CONV LOSS Average of conversion loss of the external mixer**

IEEE bus command      MIX:LOSS -12DB

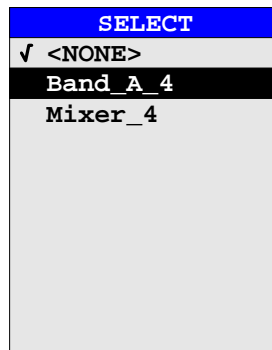
**CONV LOSS  
TABLE**

**Conversion loss depending on frequency**

Alternatively to the average value stated under *AVG CONV LOSS*, conversion loss can be taken into account as a function of frequency. The *CONV LOSS TABLE* field gives the name (without extension) of a binary file stored on the harddisk. The file contains the following data of the associated mixer:

- type designation of mixer
- serial No. of mixer
- waveguide band
- frequency range
- order of harmonic
- number of ports (2 / 3)
- bias current
- conversion loss as a function of frequency

Within an edit box the tables suited for the band can be selected. Only those tables are allowed that cover the whole frequency range and correspond to the harmonic used.



After selection of a file the parameters *BIAS* for the *SELECT BAND* table are taken from that file. The selected mixer type must correspond to the file entry *PORTS*. It is not possible to modify these parameters during operation.

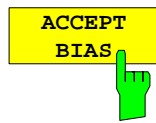
Only that part of the table is taken into account that contains reference values for frequencies that are covered by the selected order of harmonic. (See chapter Conversion Loss Tables)

IEEE bus command    `MIX:LOSS:TABL mix_1_4`



The *CONV LOSS TABLE* softkey opens a submenu for selecting and editing of conversion loss tables. (See chapter Conversion Loss Tables)

IEEE bus command    `--`

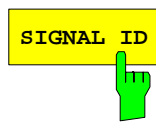


The *ACCEPT BIAS* softkey stores the in the table *SELECT BAND* selected bias setting in the file specified in the table.

The user is prompted to confirm the storage. The new setting will be stored only when confirmed with *YES*.

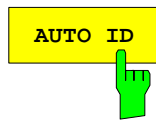
This softkey can only be used if *CONV LOSS TABLE* (conversion loss taken into account by means of frequency-dependent values) is active.

IEEE bus command --

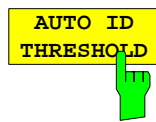


The *SIGNAL ID*, *AUTO ID* and *AUTO ID THRESHOLD* softkeys are used for signal identification.

IEEE bus command MIX:SIGN ON



See chapter Signal Identification.



### Bias Current

Single-diode mixers generally require a DC voltage which is applied via the LO line. This DC voltage is to be tuned to the minimum conversion loss versus frequency. Such a DC voltage can be set via the *BIAS* function using the D/A converter of the analyzer. The value to be entered is not the voltage but the short-circuit current.

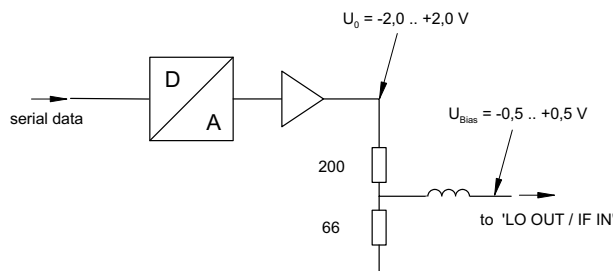


Fig. 1: Bias circuit of the analyzer

The voltage  $U_0$  at the output of the operational amplifier can be set in the range  $-2.0$  to  $+2.0$  V. An open-circuit voltage  $V_{bias}$  of  $-0.5$  to  $+0.5$  V is obtained accordingly at the output of the voltage divider. A short-circuit current of  $I_{short} = V_0 / 200 \Omega = -10$  mA to  $+10$  mA is obtained for a short circuit at the output of the voltage divider. For using biasing it is not important to know exactly the current flowing through the diode since the conversion loss must be set to minimum with the frequency. It therefore makes no difference whether the setting is performed by an open-circuit voltage or by a short-circuit current.

A DC return path is ensured via the  $66 \Omega$  resistor, which is an advantage in some mixers.

## Conversion Loss Tables

Conversion loss tables allow the conversion loss of the mixer to be taken into account as a function of frequency.

The *CONV LOSS TABLE* softkey opens a submenu for selecting and editing of conversion loss tables. A list box containing all tables currently available opens by pressing the softkey.

IEEE bus command --

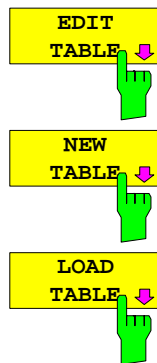
PREVIEW			
Name:	RS_Band_U_4	Mixer:	FS_Z60
Band:	U	S/N:	12345678
Harmonic#:	4	Ports:	2
Bias:	0.00 mA		
Comment:			
Freq. range:	40.000 GHz to 60.000 GHz		

TABLES	
Band_A_2	↑
Band_A_4	
Band_Q_4	
<b>RS_Band_U_4</b>	
Band_W_8	
Press ENTER to edit table	
	↓

The *PREVIEW* window shows the information characterizing the marked file:

<i>Name</i>	name of marked file
<i>Mixer</i>	type of mixer
<i>Band</i>	waveguide band
<i>S/N</i>	serial No. of mixer
<i>Harmonic#</i>	order of harmonic used for conversion
<i>Ports</i>	<i>type of mixer (two or three port mixer)</i>
<i>Bias</i>	<i>bias current</i>
<i>Comment</i>	comment
<i>Freq range</i>	frequency range

The *TABLES* table lists the files stored on the hard disk.



The *EDIT TABLE* or *NEW TABLE* softkey activates a submenu for editing or generating a file (see following section "Editing a Table").

IEEE bus command    CORR:CVL:SEL 'LOSS\_T\_4'

The *LOAD TABLE* softkey opens a submenu with a table *TABLES ON DISK* specifying all files stored on the inserted disk with mixer correction data (extension '.ACL'). The file selected is copied onto the harddisk

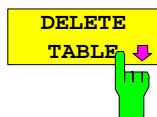
TABLES ON DISK	
Band_A_2	↑
Band_A_4	
<b>Band_Q_4</b>	
RS_Band_U_4	
Band_W_8	
Press ENTER to load table	
	↓

IEEE bus command    --

This function is needed, for example, for the initial loading of correction data of a new mixer from the supplied diskette to the analyzer harddisk. The correction data are stored in ASCII format.

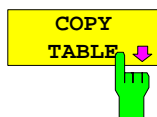
Example:

```
# Mixer Name
R&S FS-Z60
# Serial Number
832439/001
# Band
U
# Number of Harmonic
4
# Bias
0.0
# Ports
2
#Comment
R&S FS-Z60 (40..60 GHZ).
# Date
21.02.2003
# Calibration data
(40000000000, 17.49)
(40410000000, 17.5755102)
(40820000000, 17.56102041)
...
...
...
(58780000000, 19.86081633)
(59180000000, 20.08387755)
(59590000000, 19.91693878)
(60000000000, 19.95)
```



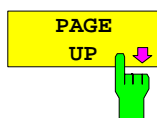
The *DELETE TABLE* softkey deletes the selected file from the hard disk of the analyzer. If the key is pressed, a window opens in which the user is prompted to confirm or abort deleting.

IEEE bus command    CORR:CVL:CLE



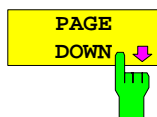
The *COPY TABLE* softkey copies the selected table. The table is stored under another name and can be edited later on.

IEEE bus command    --

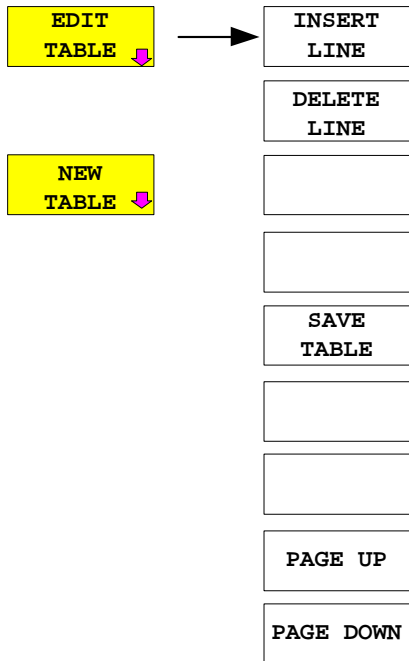


The *PAGE UP/PAGE DOWN* softkeys are used for scrolling through a selection list.

IEEE bus command    --



**Editing a Table**



The *EDIT TABLE* or *NEW TABLE* softkey activates a submenu in which all entries of an existing table can be modified or in which a new table can be generated

IEEE bus command --

The table either contains data of the mixer selected or no data at all.

EDIT CONVERSION LOSS TABLE			
Name:	RS_Band_U_4	Mixer:	FS_Z60
Band:	U	S/N:	12345678
Harmonic#:	4	Ports:	2
Bias:	0.00 mA		
Comment:			
	FREQUENCY	CONV LOSS /dB	↑
	40.000 GHz	20.5	
	41.000 GHz	20.8	
	42.000 GHz	20.9	
	43.000 GHz	21.1	
	44.000 GHz	21.4	
	45.000 GHz	21.7	
	46.000 GHz	22.2	
	47.000 GHz	22.7	
	48.000 GHz	23.1	
	49.000 GHz	23.3	
	50.000 GHz	23.7	
	51.000 GHz	24.0	
	52.000 GHz	24.5	
	53.000 GHz	24.8	
	54.000 GHz	25.4	
	55.000 GHz	25.8	
	56.000 GHz	26.2	
	57.000 GHz	26.6	
	58.000 GHz	26.8	↓

Data and type designation of the mixer can be entered into the header of the table. The columns contain the frequencies and the corresponding conversion losses.

<b>Name</b>	<p><b>File name</b></p> <p>The name of the table is identical with the name of the file (without extension) in which the table is stored. The entry in this field is mandatory. The name may consist of a maximum of 10 characters and ends with the harmonic used, e.g. Mixer_2. The extension ('.ACL') will automatically be appended at storing.</p> <p>IEEE bus command    CORR:CVL:SEL 'LOSS_T_4'</p>
<b>Mixer</b>	<p><b>Type designation of mixer</b></p> <p>The information in the <i>Mixer</i> field shows the user at a glance to which mixer a file belongs. Entries in this field are optional.</p> <p>IEEE bus command    CORR:CVL:MIX 'FS_Z60'</p>
<b>Band</b>	<p><b>Designation of waveguide band</b></p> <p>A waveguide band can be selected from a list. This field is mandatory.</p> <p>IEEE bus command    CORR:CVL:BAND E</p>
<b>S/N</b>	<p><b>Serial Number</b></p> <p>Serial number of the mixer. Entries in this field are optional.</p> <p>IEEE bus command    CORR:CVL:SNUM '123.4567'</p>
<b>Harmonic#</b>	<p><b>Order of harmonic</b></p> <p>Order of harmonic used for conversion. For the conversion loss is valid for one harmonic only, entries in this field are mandatory.</p> <p>IEEE bus command    CORR:CVL:HARM 4</p>
<b>Ports</b>	<p><b>Two- or three-port mixer</b></p> <p>A list is displayed from which the number of ports (two or three) of the mixer used can be selected. The entry in this field is mandatory.</p> <p>IEEE bus command    CORR:CVL:PORT 3</p>



**Bias**

**Bias setting**

The bias current required for the mixer has to be entered in this field. The setting range is between -10 mA and +10 mA.

The entry in this field is mandatory.

**Note:** *The current corresponds to the short-circuit current. The actual bias current is lower because of the forward voltage of the mixer diode(s).*

IEEE bus command    `CORR:CVL:BIAS 7mA`

See chapter Bias Current.

**Comment**

The comment can be freely defined by the user. It may consist of a maximum of 60 characters. This field need not necessarily to be filled in.

IEEE bus command    `CORR:CVL:COMMENT 'MIXER FOR BAND U'`

**FREQUENCY/  
CONV LOSS**

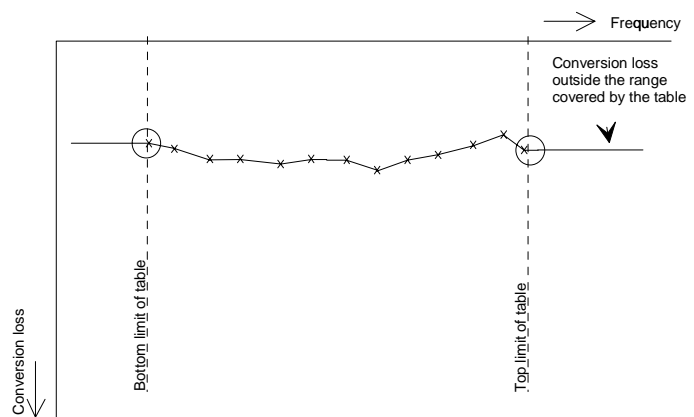
**Conversion loss table**

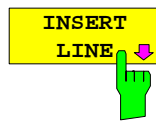
The reference values must be entered in order of increasing frequencies. A maximum of 50 reference values can be entered.

Correction values for frequencies between the reference values are obtained by interpolation. Linear interpolation is performed if the table contains only two values. If it contains more than two reference values, spline interpolation is carried out.

Outside the frequency range covered by the table the conversion loss is assumed to be the same (see illustration below) as that for the first and last reference value.

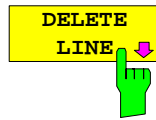
IEEE bus command    `CORR:CVL:DATA 1MHZ,-30DB,2MHZ,-40DB`





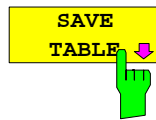
The *INSERT LINE* softkey inserts a blank line at the cursor position. Subsequent entries are shifted downwards by one line.

IEEE bus command --



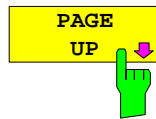
The *DELETE LINE* softkey deletes the marked line in the reference value table.

IEEE bus command --



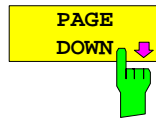
The *SAVE TABLE* softkey stores the edited table on the analyzer hard disk under the name given in the field *NAME*. The extension '.ACL' is automatically appended to the file name.

IEEE bus command --



The *PAGE UP* and *PAGE DOWN* softkeys allow to scroll through the selection list.

IEEE bus command --



With the hard key *PREV*, an edited table can be accepted, checked for consistency with permissible values and stored on the hard disk under the specified table name.

The user has to confirm whether he wants to store the table (*YES*) or not (*NO*) or whether storage is to be aborted (*CANCEL*). After storage has been aborted, the table comes up again and the user can continue editing.

MESSAGE		
Do you want to store this table?		
YES	NO	CANCEL

When the file is stored, an extension is added automatically.

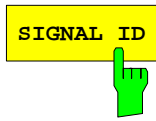
If the name of the table to be stored is already used by another file, the user is asked if the old table is to be overwritten. If the user does not wish to overwrite the old file, he can further edit the new table, eg assign it a new name not used so far.

MESSAGE	
File exists! Do you want to overwrite?	
YES	NO

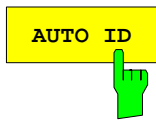
Upon exiting the *EDIT* menu, the table can be activated from the relevant selection list.

## **4.18**

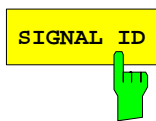
## Signal Identification



The *SIGNAL ID* and *AUTO ID* softkeys activate the functions for setting the signal identification.

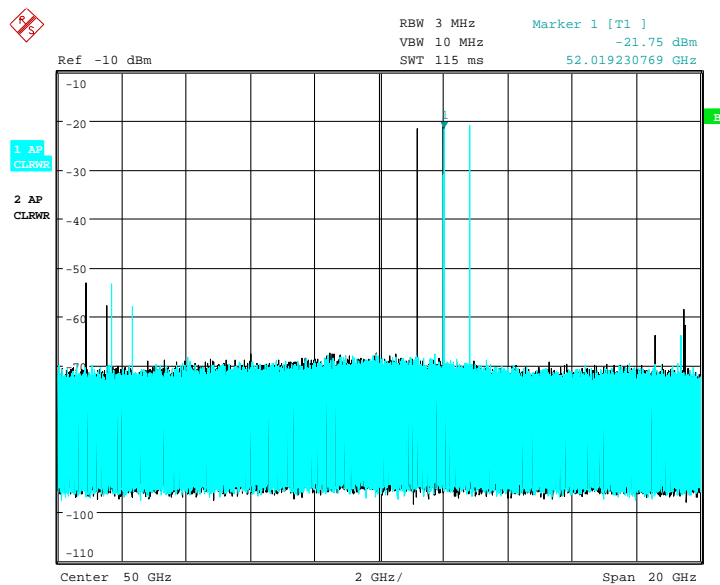


IEEE bus command      MIX:SIGN ON



The *SIGNAL ID* softkey activates or deactivates visual signal identification.

Two sweeps are performed alternately. Trace 1 shows the test sweep, trace 2 shows the reference sweep. Trace 3 is not available.



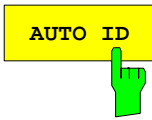
The reference sweep is performed using a LO setting shifted downwards by  $2 \cdot \text{IF} / \text{Harmonic\#}$ . Input signals in the wanted sideband that are converted by means of the set harmonic are displayed in both traces at the same position on the frequency axis. Image signals and mixer products caused by other harmonics are displayed in both traces at different positions.

The user identifies the signals visually by comparing the two traces.

Since the LO frequency is displaced downwards in the reference sweep, the conversion loss of the mixer may differ from the test sweep.

Therefore the level should only be measured in the test sweep (trace 1).

Mathematical functions with traces and trace copy cannot be used in the *SIGNAL ID* menu.



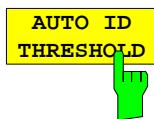
The *AUTO ID* softkey activates or deactivates automatic signal identification.

*AUTO ID* basically functions like *SIGNAL ID*. However, the test and reference sweeps are converted into a single trace by a comparison of maximum peak values of each sweep point. The result of this comparison is displayed in trace 3 if *SIGNAL ID* is active at the same time. If *SIGNAL ID* is not active, the result can be displayed in each of the traces 1 to 3. Unwanted mixer products are suppressed in this calculated trace.

As described for the function *SIGNAL ID*, real input signals are displayed at the same frequency in the test and reference sweeps, ie theoretically identical signal levels are expected in the two sweeps at the frequency of the real mixer product. If the level difference is lower than the tolerance set with *AUTO ID THRESHOLD*, the signal obtained in the test sweep is displayed.

If a signal occurs only in the test sweep or reference sweep, it is an unwanted mixer product. The level of this signal is compared to the noise floor in the other sweep. If the S/N ratio is sufficiently large, the tolerance limit for the maximum permissible level difference is exceeded. This means that the signal with the lower level, ie noise in this case, is displayed.

It should be noted that *AUTO ID* functions according to the fail-safe principle, ie unwanted mixer products may not be detected as such but signals which are in fact real input signals are not blanked out. See also "Remarks concerning Signal Identification with *AUTO ID*".



*AUTO ID THRESHOLD* allows the maximum permissible level difference to be fixed between test sweep and reference sweep during automatic comparison (function *AUTO ID*). The input range is between 0.1 dB and 100 dB.

Values of about 10 dB (ie default setting) generally yield satisfactory results. See also "Remarks concerning Signal Identification with *AUTO ID*".

## Remarks concerning Signal Identification with AUTO ID

### Type of signal

The automatic comparison of the test sweep and reference sweep with *AUTO ID* can only be usefully applied for signals with time-constant spectrum since the two sweeps are always required to determine the actual spectrum.

### Tolerance for the comparison of test sweep and reference

Since the LO frequency is displaced downwards in the reference sweep, the conversion loss of the mixer may differ from that of the test sweep. The reasons for this are the LO output power of the spectrum analyzer varying with the frequency and the non-ideal characteristics of the mixer. A certain tolerance should therefore be permitted for the comparison of the signal levels in the test sweep and reference sweep. The user can set this tolerance using the function *AUTO ID THRESHOLD*.

If the tolerance set is too tight the signal collected with the reference sweep may be displayed even for the identification of real signals.

#### Example:

A signal with a frequency of 52.5 GHz is applied to the mixer input. Let the signal level be  $-30$  dBm. The conversion loss of the mixer is 28 dB at this frequency in the test sweep and 35 dB in the reference sweep. The user has entered a tolerance of 5 dB and a conversion loss of 28 dB. Thus, the signal is recorded with the correct level of  $-30$  dBm in the test sweep, a signal level of  $-37$  dBm is obtained in the reference sweep. As the difference (7 dB) between the levels is  $>5$  dB, the signal with the lower level is displayed, ie the signal of the reference sweep. Since the set conversion loss is adapted to the test sweep, the signal displayed on the analyzer has a level of  $-37$  dBm yielding incorrect level display.

The tolerance entered corresponds to the minimum S/N ratio which signals should have to ensure correct identification. If the S/N ratio of a mixer product is less than the tolerance, the decision criterion is fulfilled even if only the noise floor is recorded in the reference sweep at the frequency of this mixer product. Unwanted mixer products are therefore not detected as such by *AUTO ID*. They can only be identified by a visual comparison of the two traces using the function *SIGNAL ID*.

In order to avoid the visual identification of such unwanted mixer products it is useful to perform the measurement test in two steps:

In the first step the tolerance is set to the minimum value (0.1 dB). This enables unwanted mixer products with low S/N ratio to be detected and blanked out.

- [ **FREQUENCY** : EXTERNAL MIXER : AUTO ID ]
- [ **FREQUENCY** : EXTERNAL MIXER : AUTO ID THRESHOLD : **0.1 dB** ]

To determine the signal levels of real input signals the tolerance is to be set to the minimum value, eg 10 dB, in the second step.

- [ **FREQUENCY** : EXTERNAL MIXER : AUTO ID THRESHOLD : **10 dB** ]

The real input signals are then displayed with the correct level.

**Mixer products with low S/N ratio**

If the S/N ratio of a mixer product is less than the tolerance set with *AUTO ID THRESHOLD*, the level difference between the test sweep and reference sweep at the frequency of this mixer product is always within limits, even if the signal occurs in one of the sweeps only. Such mixer products cannot be identified by *AUTO ID*. It is therefore recommended to perform a visual comparison of the test sweep and reference sweep using the function *SIGNAL ID*.

An unwanted signal having a S/N ratio corresponding approximately to the tolerance set with *AUTO ID THRESHOLD* may not be blanked out permanently. Due to the fact that the noise display varies from one sweep to another, the S/N ratio changes and thus the level difference between the test sweep and reference sweep measured at a frequency too. As a result, the criterion for detecting unwanted signals is not fulfilled. To blank out unwanted signals permanently an almost constant noise indication is therefore required. This can be achieved by reducing the video bandwidth. Since the average noise indication lies well below the generated noise peak values, the minimum level diminishes. For identification using *AUTO ID* signals should have this minimum level.

**Examining unwanted mixer products with small span**

With large spans in which non-modulated sinewave signals are represented as single lines, unwanted mixer products are generally completely blanked out. If the user, however, examines closer the frequency range containing a blanked signal using a small span, eg an image-frequency response, the spectrum represented in Fig. 2 is obtained.

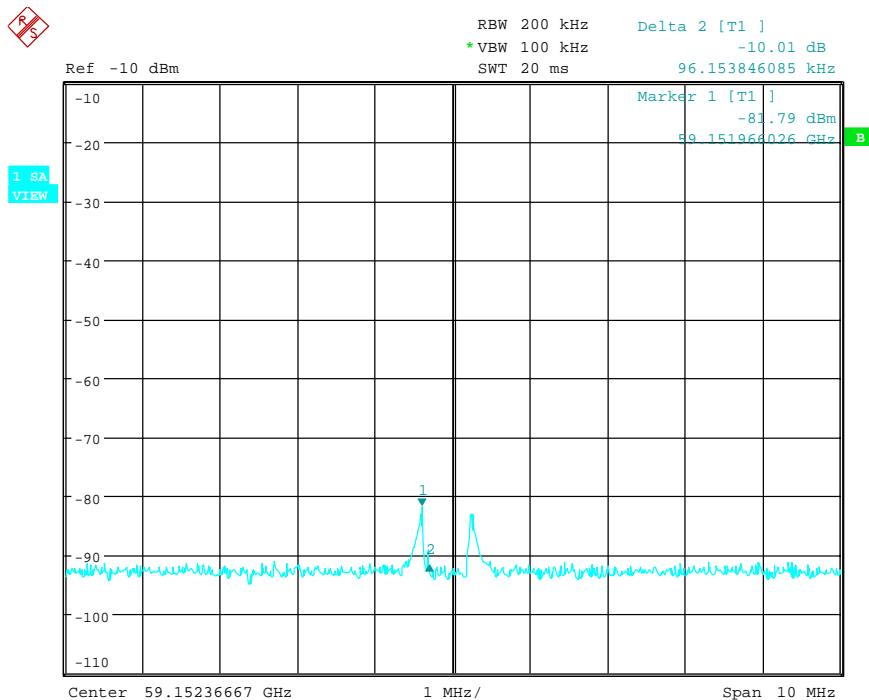


Fig. 2: Components of a mixer product blanked out with *AUTO ID*

There are components of a blanked signal the level difference of which is smaller than the tolerance predefined with *AUTO ID THRESHOLD* as compared with the noise floor. These components are therefore not blanked out. The tolerance chosen was 10 dB in this example which can be seen at the level difference between marker and delta marker (display 'Delta 2 [T1]').

Using *AUTO ID* with large spans

As already described, the comparison of maximum peak values of test and reference sweep is performed for each sweep point. A trace comprises yyy...10000 sweep values the number of which is reduced to build the 625 pixels. Each pixel contains the maximum value of the sweep points it consist of. Therefore a pixel can contain information of a number of frequency steps. If unwanted mixer products represented at frequencies which slightly differ from each other occur in the test sweep and reference sweep, the two mixer products from the test sweep and the reference sweep are displayed by the same sweep point. They will not be detected as unwanted mixer products by *AUTO ID* and therefore not be blanked out. Illustration of this follows:

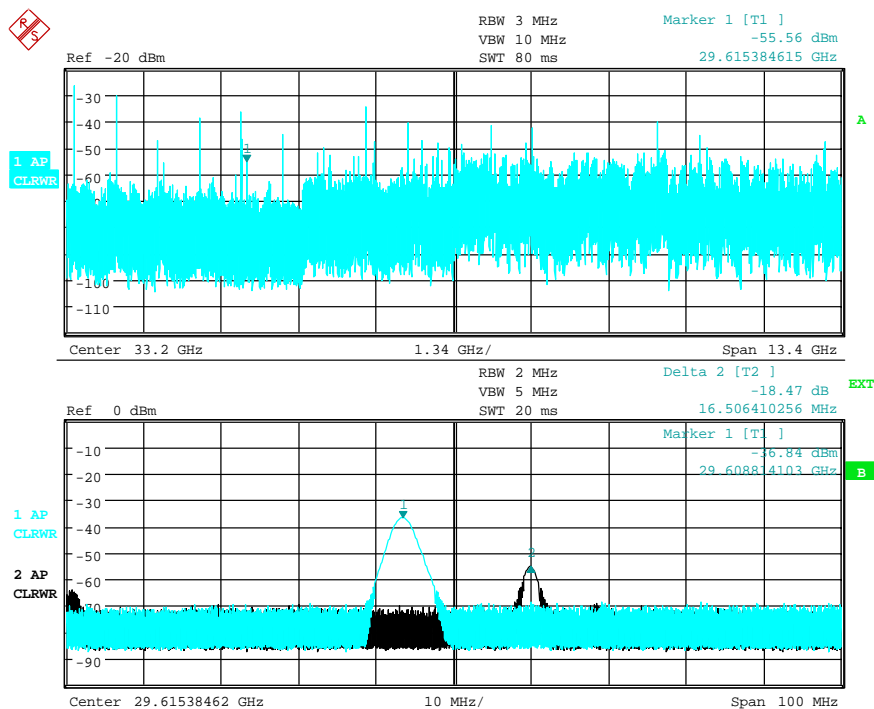


Fig. 3: Screen A: Unwanted mixer product not detected by *AUTO ID*  
Screen B: Unwanted mixer product not detected by *AUTO ID* and examined with a small span using *SIGNAL ID*

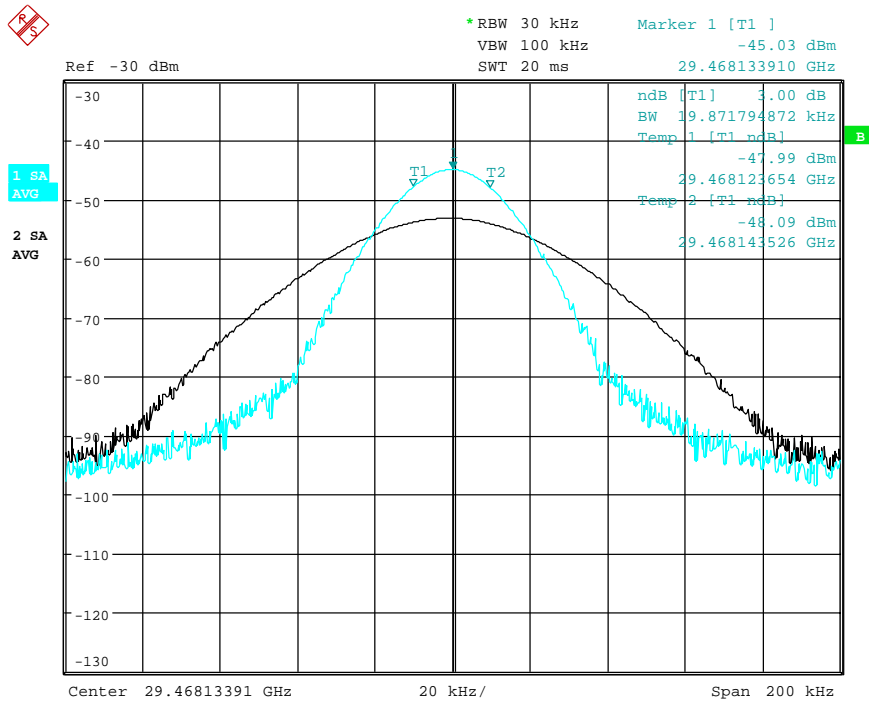
An input signal consisting of a large number of spectral components is shown in Fig. 3, screen A. Unwanted mixer products are blanked out with *AUTO ID*. If a signal identified as real is examined at approx. 29.615 GHz (see marker in Fig. 3) with a reduced span using *SIGNAL ID* (see figure 3, screen B), it can be seen that the mixer products represented in the test sweep and reference sweep differ by approx. 16.5 MHz in their frequency. For the span of 13.4 GHz set in Fig. 3, screen A, a frequency range of 21,4 MHz is displayed by one sweep point (selection 625 sweep points).

Very small spans should therefore be selected to ensure correct signal identification by means of *AUTO ID*.



**Display of mixer products at the same frequency**

If the input signal consists of a very large number of spectral components, it will become more and more probable that two different unwanted mixer products will be displayed at the same frequency in the test sweep and reference sweep. Such a case is shown in Fig. 4.



**Fig. 4: Different mixer products represented at the same frequency in the test sweep and reference sweep**

The external mixer has been working using 2<sup>nd</sup> order harmonic. The signal recorded in the test sweep is displayed by trace 1. The IF filter of the analyzer is represented at a 3 dB bandwidth of 20 kHz, the real IF bandwidth being 30 kHz. If, however, the 3 dB bandwidth (trace 2) of the signal recorded in the reference sweep is examined, it will be found to be larger exactly by a factor of 2. This shows that the two products were generated by mixing with LO harmonics of different orders

The signal recorded in the test sweep was generated by mixing with 3<sup>rd</sup> order harmonic. Since the frequency axis scaling is based on the 2<sup>nd</sup> order, the mixer product or the resulting diagram of the IF filter is compressed by a factor of 2/3.

The signal recorded in the reference sweep was generated by mixing with the fundamental of the LO signal. Since the frequency axis scaling is based on the 2<sup>nd</sup> order, the mixer product or the resulting diagram of the IF filter is expanded by a factor of 2.

Automatic identification with a large span is not possible since the two mixer products are displayed at the same frequency. The diagram shown in Fig. 5 is obtained when examining products with a narrow span using *AUTO ID*. The user can easily recognize unwanted mixer products from the clear diagram obtained using *AUTO ID* or *SIGNAL ID*.

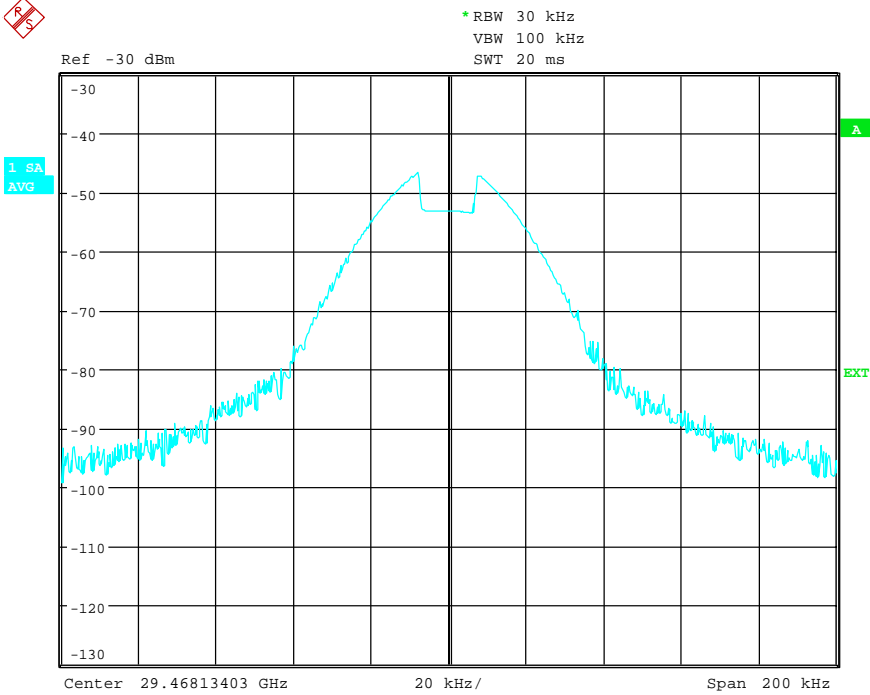


Fig. 5: Signal as in Fig. 3, but with the use of *AUTO ID*

## Introductory Example of Operation

The following example serves to explain the operation of external mixers as well as the required settings:

A sine wave signal with  $f = 14.5$  GHz is applied to the input of a multiplier. The spectrum at the multiplier output is to be recorded in the range of 52 to 60 GHz using a 2-port mixer for the V band. The mixer used is a double-diode mixer.

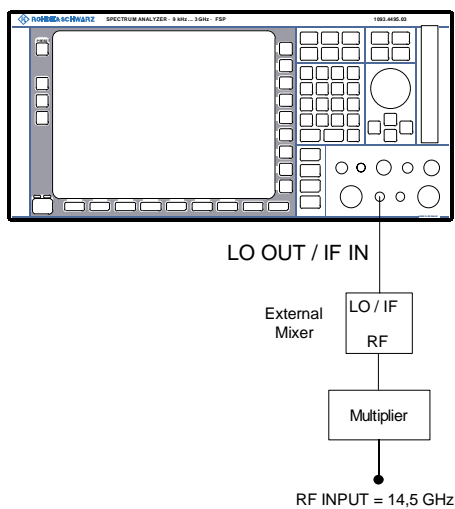
**Note:** Conventions for setting the analyzer during measurement:  
 [ <KEY> ] Press a key on the front panel, eg [ **FREQUENCY** ]  
 [ <SOFTKEY> ] Press a softkey, eg [ **EXTERNAL MIXER** ]  
 [ <nn unit> ] Enter a value and terminate by entering the unit, eg [ **1 MHz** ]

Successive entries are separated by [:], eg [ **FREQUENCY: EXTERNAL MIXER : SELECT BAND**].

The example of operation is described in the following steps:

1. Test setup
2. Activating the external mixing
3. Default setting
4. Level correction
  - 4.1 Frequency dependent level correction
  - 4.2 Level correction with average value
5. Taking into account the cable loss in the IF path
6. Functions for signal identification

### 1. Test setup



- Connect the 'LO OUT / IF IN' output of the analyzer to the LO/IF port of the external mixer.
- Connect the multiplier to the external mixer.
- Apply a sinewave signal with  $f = 14.5$  GHz to the input of the multiplier.

---

**2. Activating the external mixing and selecting the mode****Activation**

- Activate the external mixing with  
- [ **FREQUENCY** : EXTERNAL MIXER ]
- 

**3. Default setting****Selection of the required band**

- Prior to the measurement select the required band (in this case the V band) with  
[ **FREQUENCY** : EXTERNAL MIXER :  
SELECT BAND]  
Select the V band using the cursor keys and  
ENTER
- 

**4. Level correction**

The conversion loss of the mixer can be taken into account both as a function of frequency and with an average value. The frequency-dependent level correction is used in this example for obtaining a higher precision. First select a table valid for the selected band. As an alternative, level correction based on average value can be used (see 4.2).

---

**4.1 Frequency-dependent level correction****Selection of table**

- Activate a selection list which contains all tables stored on the hard disk of the analyzer with  
[**FREQUENCY** : EXTERNAL MIXER : SELECT  
BAND]  
and select the field CONV LOSS TABLE by  
means of the cursor keys.

First way:

A file with correction data already exists for the mixer used.

- Select a table valid with the cursor keys or the rollkey and confirm with ENTER.

Second way:

Such a table is not yet available.

- Create a new table with  
*CONV LOSS TABLE : EDIT TABLE*  
or
- copy from a disk to the hard disk of the analyzer with  
*CONV LOSS TABLE : LOAD TABLE.*

(See chapter Conversion Loss Tables)

- Select the file created or loaded from a disk in the selection list as described before.

A selected file is marked by  $\surd$  and will be drawn into the table *SELECT BAND*.

No further settings are necessary since the selected file contains all required parameters.

- Quit the *SELECT BAND* menu using  
[ **ESC** ] key

A span is automatically set which covers the whole V band (50 to 75 GHz).

---

#### Set frequency range

- Set the frequency range to be examined using  
[ **FREQUENCY START : 52 GHz** ]  
and  
[ **FREQUENCY STOP : 60 GHz** ]

---

#### Reduction of video bandwidth

- Reduce video bandwidth with  
[ **SWEEP COUPLING : VIDEO BW MANUAL :  
1 MHz** ]

A correct signal identification using *AUTO ID* is thus possible (see also "Remarks concerning Signal Identification with *AUTO ID*").

The display shown in Fig. 6 is obtained.

---

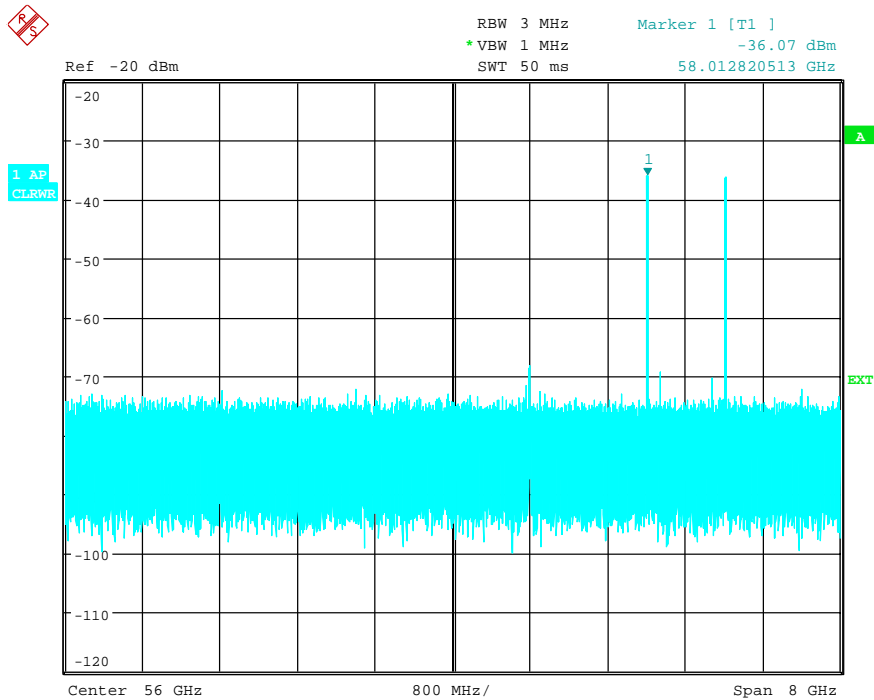


Fig. 6: Spectrum at the multiplier output recorded with an external mixer

**4.2 Level correction with average value**

If an average value is to be taken into account instead of the frequency-dependent level correction, enter the following parameters for the selected band in the *SELECT BAND* table:

- Enter the table with  
**[ FREQUENCY : EXTERNAL MIXER :  
 SELECT BAND} dB ]:**  
 Enter the average of the conversion loss into the field **AVG CONV LOSS:**  
**{conversion loss} dB ]**
- Enter the type of mixer (in this example 2-port mixer) into the field **PORTS.**
- Enter the permissible harmonic (in this example even, since a double-diode mixer is used) into the field **EVEN/ODD HARMONICS:**  
 By pressing **ENTER** a list box will be opened to select the permissible harmonic.

The entered average value is taken into account for the spectrum display irrespective of the frequency. The precision that can be obtained depends on the frequency response of the mixer. With this type of level correction measurements can be easily performed at single frequencies.

### 5. Taking into account the cable loss in the IF path

---

On performing level correction, the conversion loss of the mixer and also the insertion loss  $a_0$  of the cable used to tap off the IF signal are to be taken into account. This additional loss is frequency-dependent.

- Determine the insertion of the cable at the intermediate frequency  $f_{IF} = 404.4$  MHz.

For level correction with average value, add the cable insertion loss to the average conversion loss.

---

For frequency-dependent level correction each reference value should be increased by the insertion loss to the same extent.

- For this the cable loss can be entered via a transducer table.

Such a table should only contain two reference values (band start and end) for which  $a_0$  is specified.

---

### 5. Functions for signal identification

The spectrum represented in Fig. 6 contains the input signal and also a large number of unwanted mixer products. Two functions are provided in the analyzer to identify real input signals. The implemented methods are described in section Signal Identification. The *AUTO ID* function is used in this example.

- Activate the function *AUTO ID* with

[ **FREQUENCY** : EXTERNAL MIXER : SIGNAL ID : AUTO ID ] .

To obtain a display with the correct level when using *AUTO ID*, the tolerance limit taken as a basis for the use of *AUTO ID* is to be adapted to the mixer (see explanations on the *AUTO ID* function and "Remarks concerning Signal Identification with *AUTO ID*"). The tolerance limit has been set to 5 dB in this example.

- Adapt the tolerance limit with

[ **FREQUENCY** : EXTERNAL MIXER : SIGNAL ID : AUTO ID THRESHOLD : {tolerance limit} dB ] .

The trace shown in Fig. 7 is obtained in which unwanted mixer products are blanked out.

---

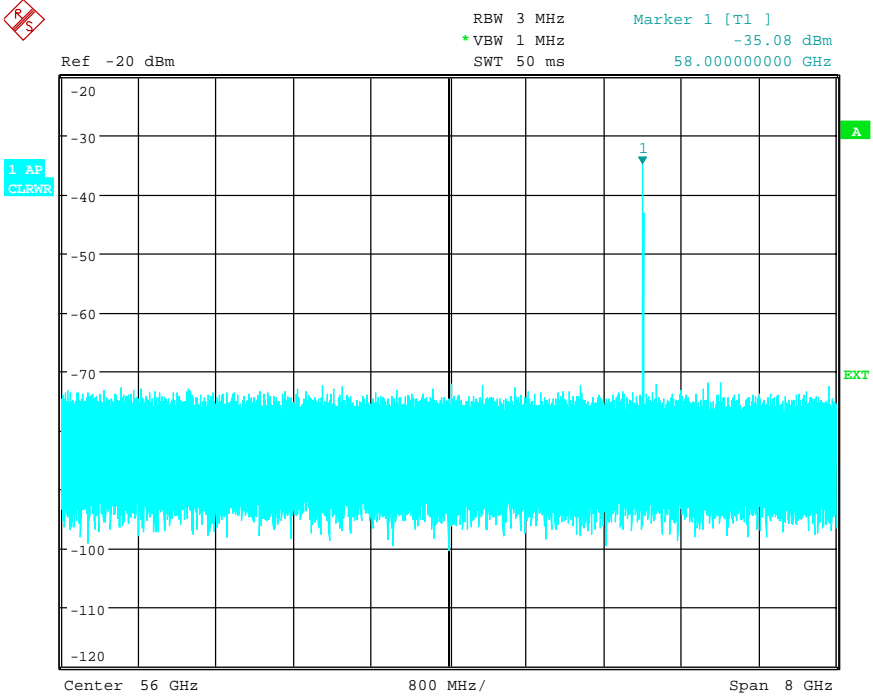


Fig. 7: Output spectrum of the multiplier recorded with an external mixer and AUTO ID



## Remote Control - Description of IEC/IEEE-Bus Commands

### SENSe:CORRection - Subsystem

The SENSe:CORRection subsystem controls the settings of the conversion loss table.

COMMAND	PARAMETERS	UNIT	COMMENT
[SENSe] :CORRection :CVL :SElect :MIXer :SNUMber :BAND :HARMonic :PORTs :BIAS :COMMeNT :DATA :CLEar	<file_name> <string> <string> A Q U V E W F D G Y J USER <numeric_value> 2   3 <numeric_value> <string> <freq> , <level> .. --	      A   HZ , DB --	          no query

#### [SENSe:]CORRection:CVL:SElect <file\_name>

This command selects the Conversion Loss Table designated with <file\_name>. If <file\_name> is not available, a new Conversion Loss Table will be created.

**Parameter:** <file\_name>::= Name of Conversion Loss Table as string data with a maximum of 8 characters

**Example:** "CORR:CVL:SEL 'LOSS\_TAB\_4' "

**Features:** \*RST value: -  
SCPI: device-specific

This command must be sent prior to the subsequent commands used to change/activate the Conversion Loss files.

#### [SENSe:]CORRection:CVL:MIXer <string>

This command defines the type designation of the mixer in the Conversion Loss Table.

**Parameter:** <string>::= Type designation of mixer with a maximum of 16 characters

**Example:** "CORR:CVL:MIX 'FS\_Z60' "

**Features:** \*RST value: -  
SCPI: device-specific

Command SENS:CORR:CVL:SEL must be sent prior to this command.

**[SENSe:]CORRection:CVL:SNUMber** <string>

This command defines the serial number of the mixer in the Conversion Loss Table.

**Parameter:** <string>:= Serial number of mixer with a maximum of 16 characters

**Example:** "CORR:CVL:SNUM '123.4567'"

**Features:** \*RST value: -

SCPI: device-specific

Command SENS:CORR:CVL:SEL must be sent prior to this command.

**[SENSe:] CORRection: CVL:BAND** A|Q|U|V|E|W|F|D|G|Y|J|USER

This command defines the waveguide band in the Conversion Loss Table.

**Example:** "CORR:CVL:BAND E"

**Features:** \*RST value: -

SCPI: device-specific

Command SENS:CORR:CVL:SEL must be sent prior to this command.

**[SENSe:]CORRection:CVL: HARMonic** <numeric\_value>

This command defines the harmonic of the mixer in the Conversion Loss Table.

**Example:** "CORR:CVL:HARM 4"

**Features:** \*RST value: -

SCPI: device-specific

Command SENS:CORR:CVL:SEL must be sent prior to this command.

**[SENSe:]CORRection:CVL:PORTs** 2 | 3

This command defines the type of mixer in the Conversion Loss Table.

**Example:** "CORR:CVL:PORT 3"

**Features:** \*RST value: -

SCPI: device-specific

Command SENS:CORR:CVL:SEL must be sent prior to this command.

**[SENSe:]CORRection:CVL:BIAS** <numeric\_value>

This command defines the bias current in the Conversion Loss Table.

**Example:** "CORR:CVL:BIAS 7mA"

**Features:** \*RST value: -

SCPI: device-specific

Command SENS:CORR:CVL:SEL must be sent prior to this command.

**[SENSe:]CORRection:CVL:COMMeNt** <string>

This command defines the comment in the Conversion Loss Table.

**Parameter:** <string>::= Comment of mixer with a maximum of 60 characters

**Example:** "CORR:CVL:COMMENT 'MIXER FOR BAND U' "

**Features:** \*RST value: -  
SCPI: device-specific

Command SENS:CORR:CVL:SEL must be sent prior to this command.

**[SENSe:]CORRection:CVL:DATA** <freq>,<level>..

This command defines the reference values of the selected Conversion Loss Tables. The values are entered as a result of frequency/level pairs. The frequencies have to be sent in ascending order. A maximum of 50 pairs of frequency/level may be entered.

**Example:** "CORR:CVL:DATA 1MHZ,-30DB,2MHZ,-40DB"

**Features:** \*RST value: -  
SCPI: device-specific

Command SENS:CORR:CVL:SEL must be sent prior to this command.

**[SENSe:]CORRection:CVL:CLEAr**

This command deletes the selected Conversion Loss Table.

**Example:** "CORR:CVL:CLE"

**Features:** \*RST value: -  
SCPI: device-specific

This command is an event which is why it is not assigned an \*RST value.  
Command SENS:CORR:CVL:SEL must be sent prior to this command.

## SENSe:MIXer - Subsystem

The SENSe:MIXer subsystem controls the settings of the external mixer.

COMMAND	PARAMETERS	UNIT	COMMENT
[SENSe] :MIXer			
[:STATe]	<Boolean>	--	
:PORTs	2   3		
:SIGNal	OFF   ON   AUTO		
:HARMonic	<numeric_value>		
:TYPE	ODD   EVEN   EODD	--	At waveguide bands query only
:BAND	A Q U V E W F D G Y J USER		
:LOSS			
[:LOW]	<numeric_value>		
:HIGH	<numeric_value>	dB	
:TABLE		dB	
[:LOW]	<file_name>		
:HIGH	<file_name>		
:BIAS			
[:LOW]	<numeric_value>	A	
:HIGH	<numeric_value>	A	
:THReshold	<numeric_value>	dB	

### [SENSe:]MIXer[:STATe] ON | OFF

This command activates or shuts off the external mixer.

**Example:** "MIX ON"

**Features:** \*RST value: OFF  
SCPI: device-specific

### [SENSe:]MIXer:PORTs 2 | 3

This command activates the 2- or 3-port mixer. The command refers to the active band selected with SENSe:MIXer:HARMonic:BAND.

**Example:** "MIX:PORT 3"

**Features:** \*RST value: 2  
SCPI: device-specific

**[SENSe:]MIXer:SIGNal ON | OFF | AUTO**

This command activates the Signal ID or Auto ID mode.

**Example:** "MIX:SIGN ON"

**Features:** \*RST value: OFF  
SCPI: device-specific

**[SENSe:]MIXer:HARMonic 2 to 64**

With band USER, this command sets the nth harmonic. The command may be a query with waveguide bands.

**Parameter:** <numeric\_value> := 2.. 64: ( max depending on the LO)

**Example:** "MIX:HARM 5"

**Features:** \*RST value: 2  
SCPI: conforming

**[SENSe:]MIXer:HARMonic:TYPE ODD | EVEN | EODD**

This command sets the type of harmonic.

**Example:** "MIX:HARM:TYPE EODD"

**Features:** \*RST value: EVEN  
SCPI: device-specific

**[SENSe:]MIXer:HARMonic:BAND A|Q|U|V|E|W|F|D|G|Y|J|USER**

This command sets the active band.

**Example:** "MIX:HARM:BAND E"

**Features:** \*RST value: U  
SCPI: device-specific

**[SENSe:]MIXer:LOSS[:LOW] <numeric\_value>**

This command sets the conversion loss of the mixer. If two harmonics are used for the band, it is set for the lower harmonic.

**Example:** "MIX:LOSS -12DB"

**Features:** \*RST value: 0 dB  
SCPI: conforming

**[SENSe:]MIXer:LOSS:HIGH <numeric\_value>**

This command sets the conversion loss of the mixer for higher harmonics in bands with two harmonics.

**Example:** "MIX:LOSS:HIGH -14DB"

**Features:** \*RST value: 0 dB  
SCPI: device-specific

**[SENSe:]MIXer:LOSS:TABLE[:LOW]** <file\_name>

This command selects a conversion loss table and sets it for the active band. If two harmonics are used for the band, it is set for the lower harmonic.

**Parameter:** <file\_name> := file name

**Example:** "MIX:LOSS:table mix\_1"

**Features:** \*RST value: no table set  
SCPI: device-specific

**[SENSe:]MIXer:LOSS:TABLE:HIGH** <file\_name>

This command sets the conversion loss table for higher harmonics in bands with two harmonics.

**Parameter:** <file\_name> := file name

**Example:** "MIX:LOSS:TABL:HIGH mix\_1\_6"

**Features:** \*RST value: no table set  
SCPI: device-specific

**[SENSe:]MIXer:BIAS[:LOW]** <numeric\_value>

This command sets the bias current for the active band. If two harmonics are used for the band, it is set for the lower harmonic.

**Example:** "MIX:BIAS 7mA"

**Features:** \*RST value: 0 A  
SCPI: conforming

**[SENSe:]MIXer:BIAS:HIGH** <numeric\_value>

This command sets the bias current of the mixer for higher harmonics in bands with two harmonics.

**Example:** "MIX:BIAS:HIGH 7mA"

**Features:** \*RST value: 0 A  
SCPI: conforming

**[SENSe:]MIXer:THReshold** <numeric\_value>

This command determines the maximum permissible level difference between measurement and reference sweep in AUTO ID mode.

**Parameter:** <numeric\_value> := 0.1 ... 100 dB

**Example:** "MIX:THR 20"

**Features:** \*RST value: 10  
SCPI: device specific

Softkeys and Related IEC/IEEE-Bus Commands

..... FREQ	
EXTERNAL Mixer	
EXT MIXER ON OFF	[SENSe:]MIXer[:STATe] ON OFF
SELECT BAND	[SENSe:]MIXer:HARMonic:BAND A Q U V E W F D G Y J USER [SENSe:]MIXer:HARMonic <value> [SENSe:]MIXer:HARMonic:TYPE ODD EVEN EODD [SENSe:]MIXer:PORTs 2 3 [SENSe:]MIXer:BIAS <value> [SENSe:]MIXer:LOSS[:LOW] <value> [SENSe:]MIXer:LOSS:HIGH <value> [SENSe:]MIXer:LOSS:TABLE[:LOW] <file_name> [SENSe:]MIXer:LOSS:TABLE:HIGH <file_name>
CONV LOSS TABLE	
EDIT TABLE	[SENSe:]CORRection:CVL:SElect <file_name> [SENSe:]CORRection:CVL:MIXer <string> [SENSe:]CORRection:CVL:BAND A Q U V E W F D G Y J USER [SENSe:]CORRection:CVL:SNUMber <string> [SENSe:]CORRection:CVL:HARMonic <value> [SENSe:]CORRection:CVL:PORTs 2 3 [SENSe:]CORRection:CVL:BIAS <value> [SENSe:]CORRection:CVL:COMMENT <string> [SENSe:]CORRection:CVL:DATA <x1-val>,<y1-val>,<x2-val>,... Input of further values in CVL table:
INSERT LINE	--
DELETE LINE	--
SAVE TABLE	--
PAGE UP	--
PAGE DOWN	--
NEW TABLE	See Softkey EDIT TABLE
DELETE TABLE	[SENSe:]CORRection:CVL:CLEar
COPY TABLE	--
ACCEPT BIAS	--
SIGNAL ID	[SENSe:]MIXer:SIGNAL OFF ON
AUTO ID	[SENSe:]MIXer:SIGNAL OFF AUTO

AUTO ID THRESHOLD
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[SENSe:]MIXer:THReshold <numeric\_value>