



RF SIGNAL GENERATOR SG8-HP01M SG8-HPSS01M

Operating Manual

Rev. 1.4

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December 13, 2011

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Document Revisions

Rev.	Date	Description
0.1	November 20, 2009	Preliminary version. Based on the firmware R0.1
0.2	December 06, 2009	Section 8 on page 42 added. (Firmware Update). Based on the firmware R0.2
1.0	January 20, 2010	Added remote control operations. (SCPI commands) Based on the firmware R1.0
1.1	November 30, 2010	Revised figures of block diagram, front and rear panel view
1.2	June 19, 2011	Added the description of SG8-HPSS01M, revised Settings▷Reference Freq and Info menu items, added new SCPI commands. Based on the firmware R1.1
1.3	October 4, 2011	Added sections “Package Contents”, “Installation, Maintenance and Safety”, “Disposal”, added new SCPI command STAT:QUES?
1.4	December 13, 2011	STATUS:QUESTIONable:[EVENT]? command is replaced with STATUS:QUESTIONable:CONDition? Added *OPC? SCPI command (Firmware R1.3)

Contents

1	Package Contents	6
2	Overview	6
3	Installation, Maintenance and Safety	7
4	Control Elements and Interfaces	9
5	Graphical User Interface	11
5.1	Menu Navigation	13
5.2	Status Bar	13
5.3	Data Entry	15
6	Instrument Functions	18
6.1	Main Menu	18
6.2	Operation Modes	19
6.2.1	Continuous Wave Operation Mode (CW)	19
6.2.2	Sweep Frequency Operation Mode (SWF)	21
6.2.3	Sweep Level Operation Mode (SWL)	24
6.2.4	Frequency Modulation (FM)	26
6.2.5	Phase Modulation Operation Mode (PhM)	29
6.3	Settings of the Instrument	30
6.3.1	Reference Freq.	30

6.3.2	Analog In input	31
6.4	Storing the Current Settings of the Instrument (Save Current) . .	32
6.5	Preset the Instrument (Load Default)	33
6.6	Information about the Instrument (Info)	33
7	Remote Control	33
7.1	Quick Start	34
7.2	SCPI Commands	34
7.2.1	SCPI Compliance	34
7.2.2	SCPI Summary	36
7.3	SCPI Command List	37
7.3.1	*CLS	37
7.3.2	*IDN?	38
7.3.3	*RST	38
7.3.4	*OPC?	38
7.3.5	SYSTem:ERRor[:NEXT]?	38
7.3.6	OUTPut[:STATe]	39
7.3.7	OUTPut:ROSCillator[:STATe]	39
7.3.8	[SOURce:]FREQuency[:CW]	39
7.3.9	[SOURce:]POWer[:LEVel][:IMMediate][:AMPLitude]	40
7.3.10	[SOURce:]PHASe[:ADJust]	40
7.3.11	[SOURce:]ROSCillator:SOURce	40
7.3.12	[SOURce:]ROSCillator:EXTernal:FREQuency	41
7.3.13	MEASure[:SCALar]:TEMPerature?	41
7.3.14	STATus:QUEStionable:CONDition?	41
8	Firmware Update	42
9	Disposal	43

List of Figures

1	Block diagram of the RF-synthesizer block (HP option)	7
2	Block diagram of the RF-synthesizer with reference PLL (additional SS option)	8
3	Recommended connection of the device with sensitive input . . .	10
4	Front panel view	10
5	Rear panel view	12
6	Internal circuit connections for Aux In and Mic In inputs, resulting in <i>Analog In</i> and <i>Triggering</i> signals used in SWF/SWL and FM/PhM modes	12
7	Display	12
8	Keyboard	16
9	Main menu	19
10	Operation Modes	20

11	Continuous wave operation mode menu (Operation Modes▷ Continuous Wave)	20
12	Sweep frequency/level parameters	21
13	Sweep frequency operation mode menu (Operation Modes▷ Sweep Frequency)	22
14	Sweep frequency mode options (Operation Modes▷ Sweep Frequency-OPT)	23
15	Spectrum envelop in sweep frequency mode	24
16	Sweep level operation mode menu (Operation Modes▷ Sweep Level)	25
17	Sweep level mode options (Operation Modes▷ Sweep Level-OPT)	26
18	Frequency modulation mode (Operation Modes▷ Freq. Modulation)	27
19	Frequency modulation options (Operation Modes▷ Freq. Modulation-OPT)	28
20	Phase modulation mode (Operation Modes▷ Phi Modulation)	29
21	Phase modulation options (Operation Modes▷ Phi Modulation-OPT)	30
22	Instrument general settings (Settings)	31
23	Reference frequency settings (Settings▷ Reference Freq.)	32
24	Analog In settings (Settings▷ Analog In)	32
25	Information about the instrument (Info)	34
26	Example of the remote control using <i>HyperTerminal</i> application	35
27	COM-port settings	35
28	Instrument control and command processing model	36
29	Command structure	37
30	<i>Device Manager</i> window (My Computer▷ Manage)	42
31	Firmware update application – XMI Programmer	44

List of Tables

1	Status bar Info	15
2	Math operations and numerical data entry	16
3	Sweep frequency shapes	23
4	Sweep level shapes	26

1 Package Contents

The following items are included to the delivery package:

Item#	Description	Qty.	Note
1	SG8 RF Signal Generator 10 MHz – 8 GHz	1	
2	AC power cord with CEE 7/7 (E+F Type) plug	1	Note 1
3	USB Cable A-B, 3m (9.8ft.)	1	
4	RS-232 Cable, D-sub 9F - D-sub 9M, 3m (9.8ft.)	0/1	Note 2
5	CD with drivers and documentation	1	
6	SG8 Operating Manual (printed version)	1	
7	Calibration certificate	1	
8	Warranty certificate	1	
9	Packing List	1	

Note 1: By default the power cord with CEE 7/7 (E+F Type) plug is placed if not explicitly specified by the customer.

Note 2: By default it's not placed if not requested by customer.

2 Overview

Figure 1 shows the block diagram of the RF-synthesizer, the main block of the instrument. Reference frequency signal is fed to the positive input of phase-frequency detector (PFD). PFD output signal is fed to the loop-filter, then to the octave VCO control input. Via splitter signal is fed to fixed frequency divider by 8, then to Direct Digital Synthesizer (DDS). Signal from the output of the DDS is being filtered and fed to the negative PFD input, thus closing the feed-back loop of the PLL system. DDS is used in this scheme like frequency divider with very small step of the division factor tuning. VCO output signal is fed further to frequency division block, following by the harmonic filtering block. From the filtering block it's further fed to the automatic power control block (APC), then to the RF Out output. Output amplifier is connected with output connector directly (via APC's splitter), so it allows to gain maximum power at the RF Out which output stage is capable of.

There are some rations of output and reference frequencies at which extra spurs produced by the DDS appear at the output. In order to avoid this effect the switchable reference frequency source can be applied. Figure 2 shows the block diagram of the instrument with additional spur suppression option (SS option). The difference consists of the second reference frequency generation for the RF-synthesizer block. The original reference frequency (147 MHz) from internal TCXO is fed to the PLL with VCXO and very narrow loop filter. PLL forms the second reference frequency 150 MHz. Signals from internal reference source and PLL are connected to the switch and its output is connected with reference frequency input of the RF-synthesizer. Either 147 or 150 MHz is used in accordance with given frequency at the RF Out output. The selection of the reference frequency is automatically controlled by the instrument to obtain least possible spur level. The accuracy of the output frequency step while

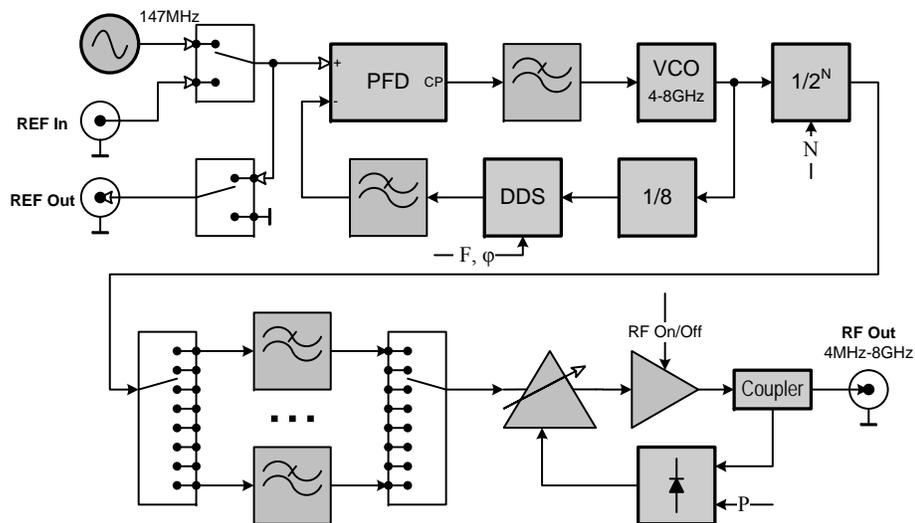


Figure 1: Block diagram of the RF-synthesizer block (HP option)

reference switching is maintained due to the fixed phase relation between 147 and 150 MHz, and narrow band phase response of the reference PLL allows to preserve the relatively low phase noise level as it would be without additional reference PLL system.

3 Installation, Maintenance and Safety

When installing the instrument, please note the following:



- SG8 Signal Generator is designed for laboratory use only and is not protected against moisture and mud.
- Some space from the bottom and rear side should be provided to ensure proper air cooling of the instrument.
- During connecting cables or other equipment make certain that connectors correspond to each other, and are in proper condition. Otherwise some damage to instrument's connectors may occur.
- A grounded, three pin AC power receptacle should be used for power supply of the instrument. The grounded pin of the AC power cord is internally connected to the instrument's chassis.
- When connecting equipment to the instrument, make sure that all equipment are properly grounded and there is no voltage difference between their cases. Otherwise it may result in damage of the instrument's input or output.

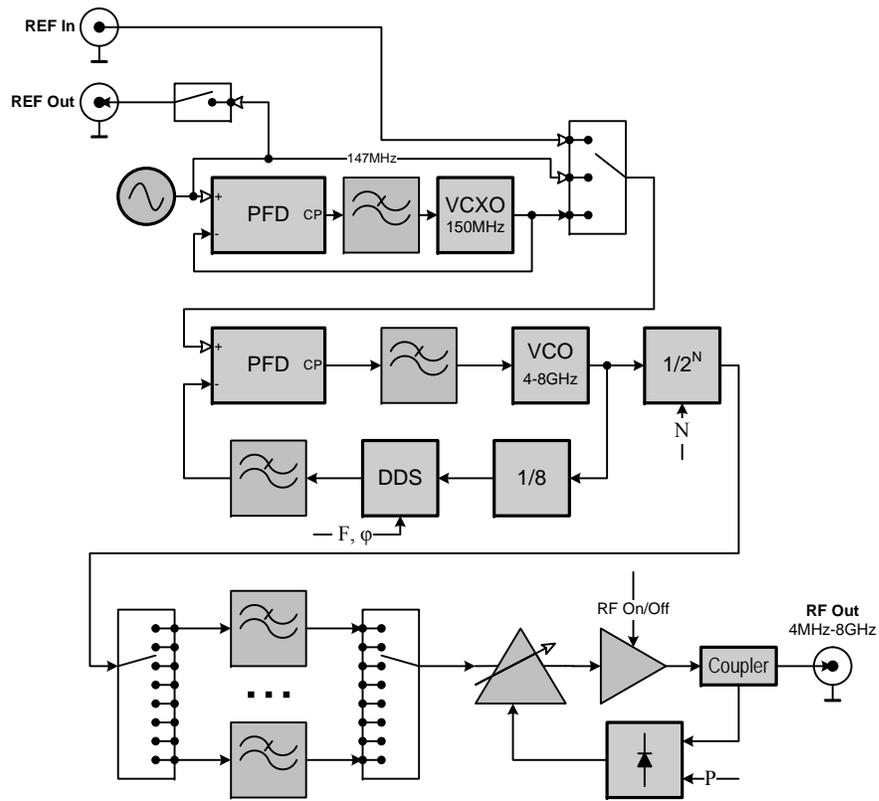


Figure 2: Block diagram of the RF-synthesizer with reference PLL (additional SS option)

When installing and turning on the instrument, it is recommended to follow the order listed below:



1. Verify that front panel power ON/OFF button (item 4, fig. 4) is turned off (not in depressed position).
2. Verify that rear panel AC power ON/OFF switch (item 1, fig. 5) is turned off.
3. Connect AC power cord to the instrument and to AC wall power supply.
4. Turn on the AC power switch at the rear panel of the instrument.
5. Turn on the ON/OFF button at the front panel of the instrument. Text corresponding to the current operation mode should be displayed on the screen.
6. To turn off the instrument just press the ON/OFF button at the front panel.

With long-term non-use of the device it is recommended to turn off the AC power switch at the rear panel. Before doing this make certain that the instrument is off.



Over time, the deviation of the output signal level and frequency from the specified values may increase, so the device should be calibrated periodically. Recommended calibration interval is 1 year.

4 Control Elements and Interfaces

Figure 4 shows the front panel view of the instrument. The elements are designated with the following callouts:

1. RF-signal output (RF Out), N-type connector;
2. RF Out ON/OFF LED indicator, light means RF Out is On;
3. RF Out ON/OFF button. Actually it turns on and off the power supply of the output stage amplifier, the other part of the instrument continues to work, i.e. even when RF-output is OFF all instrument functions are available and make an effect on the instrument state. By default RF Out is always OFF when the device is turned on or reset via remote control;
4. Power On/Off button. It turns off all circuits except first AC/DC converter;
5. Graphical OLED display with 128 x 64 resolution, yellow color, 4-bit;
6. Rotary knob, 24 positions per 360°;
7. Keyboard;



Turning on the RF Out results in short glitch of the RF level about 5 ms width. It occurs because of the absence of signal at the APC input before the RF Out turning on. At this moment the gain of the APC is maximum which results in the power jump. Therefore when connecting to the RF Out a device with sensitive input, it's strongly recommended to use external fixed attenuator (see figure 3)

8. Context sensitive menu keys.

Figure 5 shows rear panel view of the instrument. Its elements are designated with the following callouts:

1. Main AC power supply switch, it turns off all circuits including first AC/DC convertor;
2. USB interface for the connection to PC;
3. RS-232 interface for the PC's COM-port connection. 9-pin D-Sub connector;
4. Fan for cooling;
5. Grounding terminal. Actually grounding is provided via central pin of the standard power supply cord, so this auxiliary terminal should be used only if your AC socket has no any grounding pins;
6. Reference frequency output (REF Out). Signal can be translated from REF In input (HP version only) or fed from internal reference source (HP and HPSS versions). SMA-type connector, female;
7. External reference frequency input (REF In). SMA-type connector, female;
8. Auxiliary input (Aux In), can be used as external trigger input when instrument is in sweep frequency or level mode, and as analog input of modulation signal used in FM/PhM modes. BNC-type connector;
9. Microphone input (Mic In);
10. AC power supply connector with fuse.

Signals from Aux In and Mic In inputs are fed to the variable gain amplifier (VGA) and comparator, forming accordingly *Analog In*, used as modulating signal, and Triggering – for synchronous run in Sweep Frequency and Sweep Level modes, see figure 6.

i Figure 6 shows the internal circuit connections for the Aux In and Mic In inputs

i It's recommended to use 2A / 250V fuse

5 Graphical User Interface

Figure 7 shows the display screen view. It is divided into several fields: *Status Bar* (1), *Menu Items* which can be textual, numeric and graphical (2), *Context Sensitive Menu* (3) which depends on the currently selected item, and *Scroll bar* (4) showing the current position of the displayed window relative to the whole menu item list. Menu consists of the items arranged in left-to-right and top-to-bottom order. (2.1-2.4). The number of the items can vary from a few to dozens making up several lines of the screen. One line can contain more than one item. In the case of more than three lines scroll bar appears on the screen. Some items can be shaded (have less brightness, 2.3). It means that in this operation mode

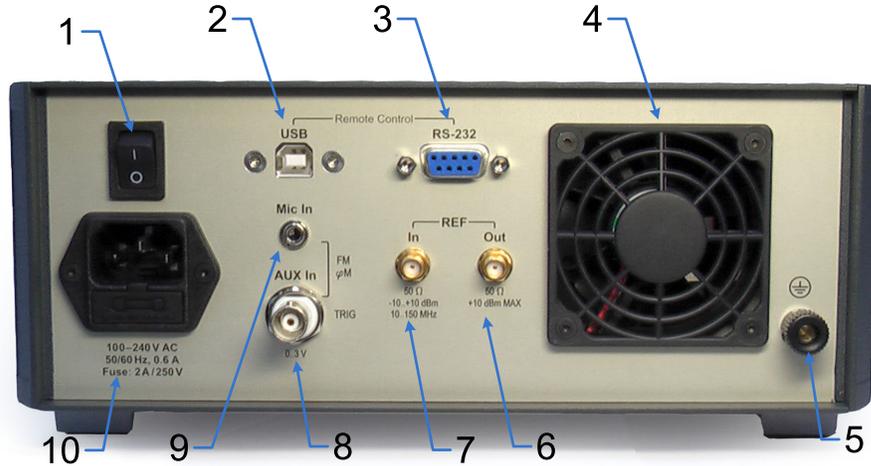


Figure 5: Rear panel view

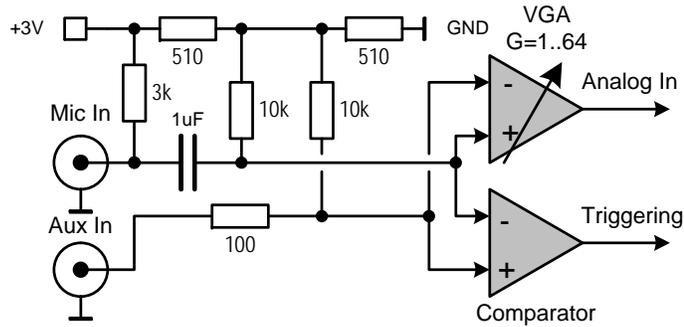


Figure 6: Internal circuit connections for Aux In and Mic In inputs, resulting in Analog In and Triggering signals used in SWF/SWL and FM/PhM modes

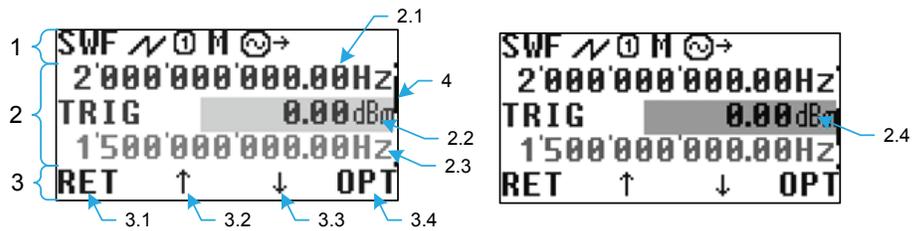


Figure 7: Display

these items are blocked (not used) or used only to display information (i.e. not editable by the user) or can't be used to launch the operation corresponding this item. When navigating through menu items the current item is being selected (2.2). When entering data numerical item turns *active* (i.e. becomes more brighter, see 2.4), it means that the item is in the numerical data *editing mode*. Menu can have hierarchical structure, the moving between levels can be performed with aid of context sensitive menu (3).

5.1 Menu Navigation

Navigation through the menu items (moving to next or previous item, entering to sub-menu or one level up) can be performed by the context menu buttons (see figure 4, item 8), and rotary knob (item 6).

- RET – moving one level up;
- ↑ – moving to previous item;
- ↓ – moving to the next item;
- >> – entering to the sub-menu (one level down);
- OPT – entering to the options menu of the current operation mode.

Rotating knob clockwise corresponds to ↓ command, counterclockwise – ↑, pressing knob – >>.

5.2 Status Bar

Status bar (top line of the screen) displays the current operation mode and settings of the instrument. An information displayed in the status bar in symbol form is listed below.

Current operation mode:

- CW** – Continuous Wave;
- SWF** – Sweep Frequency;
- SWF_c** – Sweep Frequency *Center*, the same as above but as opposed to SWF in place of *Start* and *Stop Frequency* it requires to specify *Center Frequency* and *Span* accordingly;
- SWL** – Sweep Level¹;
- FM** – Frequency Modulation;
- PhM** – Phase Modulation.

The shape of the modulating signal or the type of the frequency or level sweep.

¹Term “Signal Level” means the power of the RF-signal in this document unless otherwise noted

-  – Saw, defines the shape of the sweep (frequency or level);
-  – Triangle, defines the shape of the sweep (frequency or level);
-  – Sine, defines modulating signal of the internal source in FM/PhM modes;
-  – Square, defines modulating signal of the internal source in FM/PhM modes.

Triggering type used in SWF (Sweep Frequency) and SWL (Sweep Level) modes:

-  – Auto. The instrument doesn't wait for external triggering event to repeat new run. New run starts immediately after the previous one is over;
-  – Single run. After one run (period) is over, the instrument waits for the triggering event to start new run;
-  – Step. The instrument waits for the triggering event after each sweep step.

The source of the modulating signal and the source of external triggering event:

-  – (Manual) manual triggering by means of pressing TRIG softkey in SWF or SWL mode;
-  – (Positive Slope) triggering event occurs at the rising edge of the signal fed to Aux In input in SWF or SWL mode;
-  – (Negative Slope) triggering event occurs at the falling edge of the signal fed to Aux In input in SWF or SWL mode;
-  – (External) *Analog In* signal, formed by the Aux In or Mic In inputs (see figure 6), is used as a modulating signal in FM or PhM modes;
-  – (Internal) internal source is used as the modulating signal in modes FM or PhM.

Reference frequency settings (by default the internal reference source is used, REF Out is Off):

-  – REF Out is On. Internal reference frequency source is used, and this signal is applied to REF Out output;
-  – REF Out is Off and external reference frequency source is used;

Table 1: Status bar Info

Operation Mode	Waveform/Shape	Triggering	Source	Reference	Warnings
CW			M		UNC
SWF					OVT
SWF_c					#XX
SWL					
FM			I		
PhM					

 – REF Out is On and external reference frequency source is used.

Warnings and Errors:

UNC – (Uncalibrated) means that value of one of the parameters of the current mode of operation is out of calibrated range;

OVT – (Overtime) microcontroller does not have time to process the event queue;

#XX – (Error Code) last error code.

Table 1 shows status bar symbols in the order they appear on the screen.

5.3 Data Entry

Numerical data entry can be performed either using the keyboard (fig. 4, item 7) or the rotary knob (item 6).

The default state of the rotary knob is the menu navigation mode. Single click the knob on the selected numerical menu item (e.g. see fig. 7, item. 2.2) puts the menu item to the numerical data entry mode, rotation of the knob corresponds to the increase or decrease of the numerical value. To exit from the numerical entry mode to the navigation mode just click the knob again or press one of the context sensitive menu keys (RET, ↓, ↑).

The instrument keyboard is divided into several groups (fig. 8):

1. Numeric buttons (D group);
2. Backspace (B) – deletes the last input symbol;
3. Enter/Units (E group);

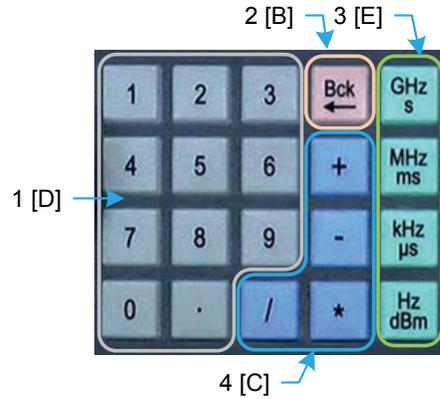


Figure 8: Keyboard

4. Operations (C group).

Numerical entry mode is automatically activated by pressing any of the D, B or C group keys. The pressing on any key of E group performs the entry of the input data following by the exit from the numerical entry mode. When pressing E group key in navigation mode, the change of the unit scale factor is performed, e.g. if the current frequency value is 1'000'000'000.00 Hz, then after pressing [MHz] key the value 1'000.000 000 00 MHz will appear on the screen, and so on. When changing unit scale factor (i.e. k – kilo, M – mega, e.t.c.) the increment step of the edited value while rotating the knob will also change. Typically the minimum step while rotating the knob equals to the one-tenth of the selected unit scale, i.e. if the current unit scale is kHz, then rotary knob step will be 0.1 kHz. With increasing rotation speed step increases.

Table 2 shows examples of some operations and corresponding command sequences.

Table 2: Math operations and numerical data entry

Sequence	Expression	Description
E	<i>R</i>	Used for unit scale factor entry, e.g. Hz, kHz, MHz, GHz, also it's used to repeat the last entered command. To do so (to repeat the operation with the last operand) the same button of E-group which was used last time should be pressed. Otherwise the exit from command repeat mode is performed. ²

(continued on next page)

²Exit from last operation repeat mode can also be performed by pressing “Bck” (after last pressed E-group button)

(continued Table 2, beginning on page 16)

Sequence	Expression	Description
C E	$R \cdot (-1)$	As a valid “C”-key it’s possible only “-”. Used for negative value entry.
D E	D	Direct input of numeric value. Unit scale factor is defined by pressed “E” button, i.e. by pressed unit (μs, ms, dBm, kHz and so on)
D C E	$D \cdot (-1)$	As a valid “C”-key it’s possible only “-”. Used for negative value entry. For example, to enter -10 dBm you should press the following: “1”, “0”, “-”, “dBm”
C D E	$R \otimes D$	It is used in conjunction with “E”-key for quick data entry with linear or exponential increment step. For example, to set consequently frequencies 100, 110, 120, 130, 140 MHz just set 100 MHz at first, then press “+”, “1”, “0”, “MHz”, and after each next pressing of “MHz” key the value will be increased by 10 MHz. This sequence can also be useful to offset from current value. For example, you need to set 0.999 998 GHz. It will take less time if you set 1 GHz first by D E sequence, and then subtract from it 2 kHz by pressing C D E sequence.
D C D E	$D_1 \otimes D_2$	Can be used for evaluation of mathematical expression along with result data entry. For example, when entering multiple frequencies. ³
C D C E	$(R \otimes D) \cdot (-1)$	Rarely used

(continued on next page)

³When evaluating expressions with several operands – all of them except the last one have current unit scale factor (μ, m, k, M, G), i.e. the factor that was valid before the entry process. The last operand has unit scale factor corresponding to pressed “E”-key closing the sequence. For the operands without units like in expressions “*” and “/” scale factor equals 1. For example the sequence “*”, “2”, “kHz” multiplies current value by 2 and displays the result in “kHz” units. Factor values in “*” and “/” operations have 10⁻³ accuracy and maximum value not less than 10⁺³.

(continued Table 2, beginning on page 16)

Sequence	Expression	Description
C D C D E	$(R \otimes_A D_1) \otimes_B D_2$	Can be used for evaluation of mathematical expression along with result data entry. When used sequences with arbitrary number of operands, the intermediate result isn't loaded to the instrument immediately, only the final result after pressing "E"-key is loaded. Thus the intermediate results are restricted only to the capacity of operands while evaluation the expression. ⁴ Each next "E"-key pressing repeats the last operation with the last operand of the input sequence.
D C D C D E	$(D_1 \otimes_A D_2) \otimes_B D_3$	Can be used to evaluate expressions such as $D \cdot m/n$

R – current value, \otimes – operation (+, −, ÷, *), D – entered numerical value.

6 Instrument Functions

6.1 Main Menu

Main menu of the instrument consists of the following items (fig. 9):

Operation Modes – contains sub-menu corresponding to modes of operation (CW, SWF, SWL, FM, PhM);

Settings – contains sub-menu with the basic settings of the instrument relating to all modes of operations or to a group of modes;

Save Current – the command saves the current settings and values of all numerical parameters. When powering up the instrument it will be initialized by the values stored by Save Current command;

Load Default – the command loads default values for all parameters;

Info – contains information about the instrument.

When powering up the instrument tries to read from the nonvolatile memory (EEPROM) setting values stored previously by Save Current command. If checksum is valid, i.e. data is valid, then stored values are loaded, if not – the default values which are defined by the vendor are loaded to the instrument.

⁴Integer 64-bit. Internal fixed point evaluation algorithm applies 10^4 factor for Hz, 10^2 – for dBm and degrees, 10^9 – for seconds.

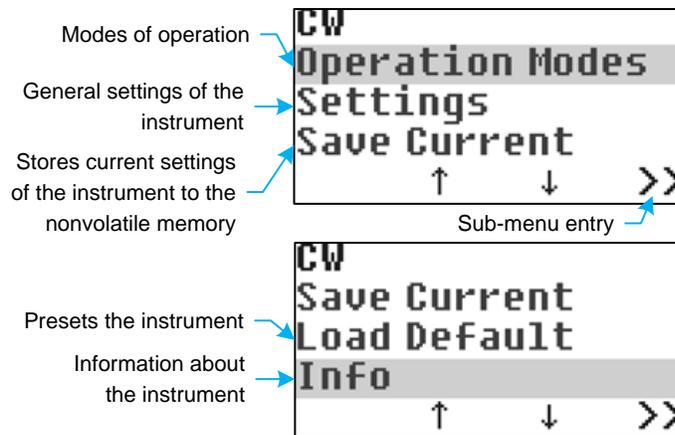


Figure 9: Main menu

6.2 Operation Modes

The instrument has five operation modes listed in Operation Modes menu (fig. 10):

Continuous Wave – CW ;

Sweep Frequency – SWF;

Sweep Level – SWL;

Freq. Modulation – FM;

Phi Modulation – PhM, phase modulation.

When powering up the instrument is in one of the modes listed above regardless of the current position within the menu system. The current mode of operation is displayed in the status bar at the top left corner of the screen. (see section 5.2 on page 13). The switching between modes is performed by entering the corresponding menu item. Each operation mode has its own independent set of parameters. Any changes made to operation mode settings are saved while exiting and switching to another mode until the power is turned off.

When powering up the mode is loaded which was current before the Save Current command was clicked. Continuous Wave (CW) is the default mode of operation.

6.2.1 Continuous Wave Operation Mode (CW)

Continuous Wave operation mode (CW) has following parameters (fig. 11 on the next page):

Frequency – RF output signal frequency;

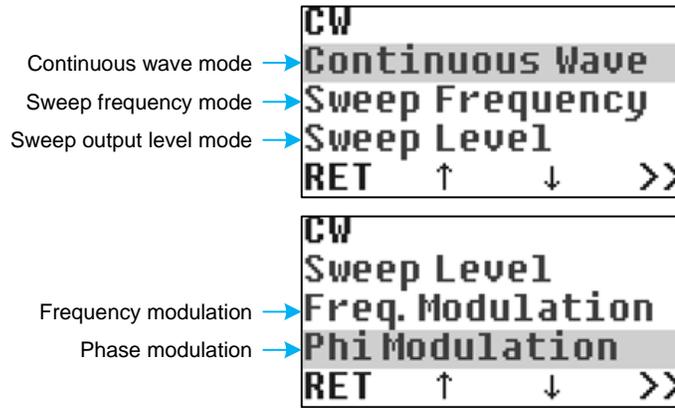


Figure 10: Operation Modes

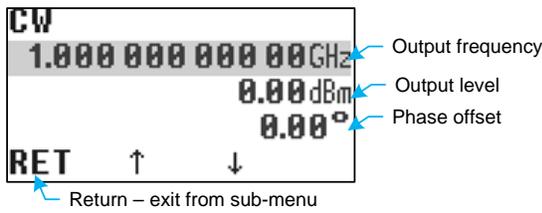


Figure 11: Continuous wave operation mode menu (Operation Modes> Continuous Wave)

Level – RF signal level;

Phase – RF signal phase offset.

The frequency can be set in increments of 0.0001 Hz in spite of the fact that only 12 leading digits are displayed on the screen. Such values can be set directly by “D E” sequence, and the digits which are do not fit the screen are nevertheless took into account, or another way – you can use “C D E” sequence, when you can set rounded value first and then using “+” or “-” operations you can add the appropriate offset. In most cases it’s not necessary to set values with such precision, since the stability of the reference source is usually much lower. However if one reference frequency source common for both instruments is used, and you need to provide slow phase drift of one RF signal relative to another, it can be done as described above.

Resulting RF signal phase is described by the following equation

$$\varphi_{out} = \omega_c t + \varphi_o(\omega_c) + \varphi,$$

where ω_c – RF signal central frequency, t – time, $\varphi_o(\omega_c)$ – initial phase offset (generally depends on the central frequency and start time), φ – phase offset

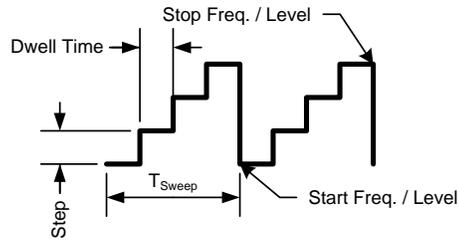


Figure 12: Sweep frequency/level parameters

defined by Phase parameter of the CW mode. Thus, in order to produce two RF signals with a given phase offset you need to use single frequency reference source for both instruments, set the same frequency, and adjust φ one of the instruments to compensate for the initial phase offset φ_o . A further change in phase gives relative φ phase offset with a quite high accuracy.

6.2.2 Sweep Frequency Operation Mode (SWF)

Sweep frequency is a step change of output frequency by the specified shape (e.g. triangle, saw) at a constant signal level. (fig. 12). T_{Sweep} – time of one period.

SWF mode has the following parameters (fig. 13):

Start Frequency – start frequency;

Stop Frequency – stop frequency;

Level – RF signal level;

Dwell Time – one step time;

Frequency Step – frequency step size.

Sweep frequency mode has the following options (fig. 14):

- Sweep mode type:
 - Auto – automatic, after one period pass it repeats automatically;
 - Single – single period pass. Sweep starts at triggering event. Then after one pass it returns to the start and waits for the next triggering event;
 - Step – stepping mode. Each step is performed after triggering event;
- Triggering options:
 - Manual – triggering event performed manually by pressing TRIG soft-key (see fig. 13);

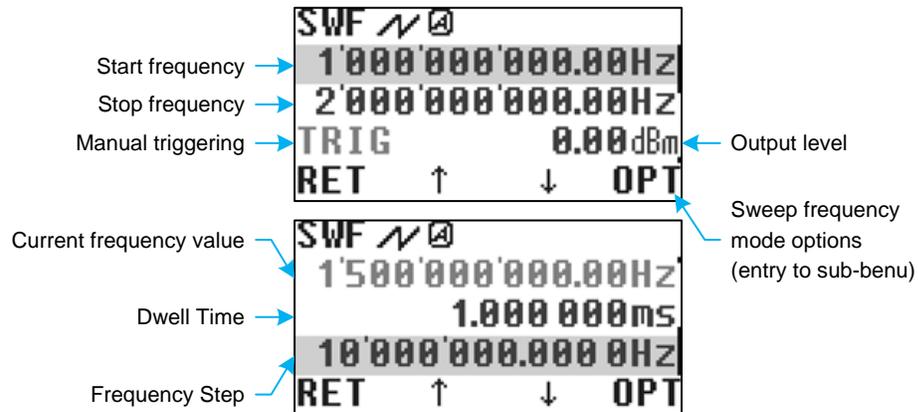


Figure 13: Sweep frequency operation mode menu (Operation Modes▷Sweep Frequency)

i When Ext option is activated triggering event can also be generated manually by TRIG softkey

- External – triggering event is generated by external signal fed to Aux In input;
- * Trig Slope:
 - Positive – triggering event is generated at the rising edge of the external signal;
 - Negative – triggering event is generated at the falling edge of the external signal;
- Dwell Time – this sub-menu item duplicates the corresponding menu item in fig. 13;
- Frequency Step – this sub-menu item duplicates the corresponding menu item in fig. 13;
- Sweeping law (i.e. Shape):
 - Saw – saw shape;
 - Tri – triangle;
- Frequency display settings:
 - $F_1 - F_2$ – when this option is activated first and second frequency fields shown in fig. 13 correspond to the start and stop frequency, accordingly;
 - $F_C \pm \Delta$ – when this option is activated first and second frequency fields shown in fig. 13 correspond to the central frequency and span, accordingly.

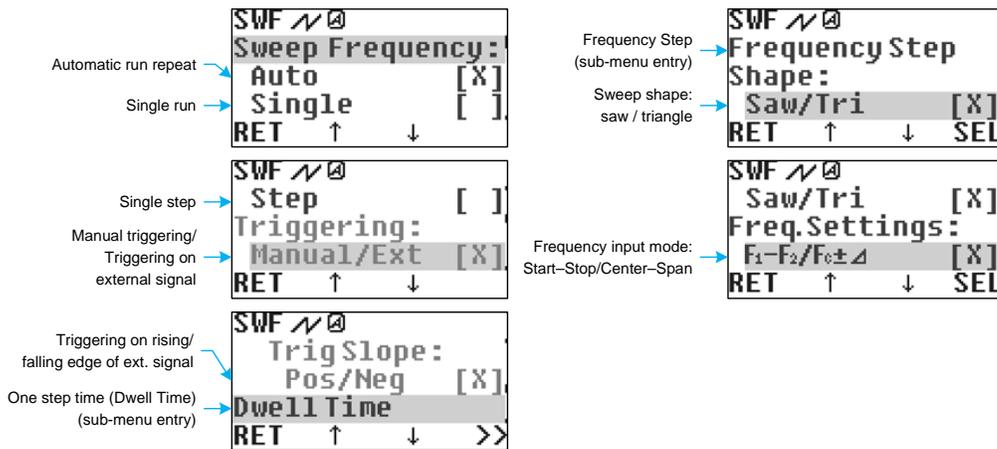


Figure 14: Sweep frequency mode options (Operation Modes▷Sweep Frequency-
 OPT)

Table 3: Sweep frequency shapes

SWF (SWF _C)	F _{Start} < F _{Stop} (Span>0)	F _{Start} > F _{Stop} (Span<0)
Saw		
Triangle		

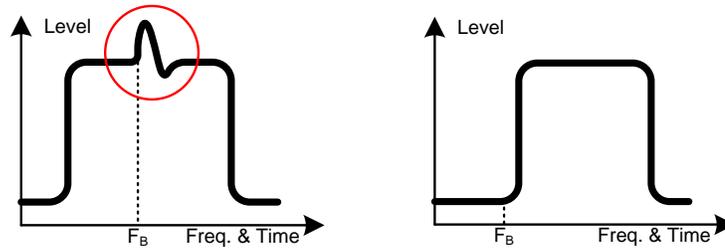


Figure 15: Spectrum envelop in sweep frequency mode

Table 3 shows shapes of frequency sweep at various relations of start and stop frequency values.

Output RF signal frequency is produced by dividing the octave VCO band by factor multiple of two. The switching boundaries are as follows: 4 000, 2 000, 1 000, 500, 250, 125, 62.5, 31.25, 15.625, 7.8125, 3.90625 MHz. In the sweep frequency mode the calibrated output level is calculated and set for each frequency step. Therefore, even for wide range of frequency sweeping the output level remains constant (within the error). If the sweeping range includes one of the switching boundaries of the frequency divider, then while switching to another divider an unavoidable frequency glitch occurs, since the VCO can't be tuned instantly. In order to avoid the frequency components in spectrum outside the given sweeping range (it may have significance in some applications) the output signal is turned off for some time while the VCO is tuned. When turning on the signal the jump of output level occurs as a result of APC operation. Figure 15 shows spectrum envelop in sweep frequency mode at small dwell time values and when the switching boundary F_B resides within and outside sweeping range.

To avoid this issue you can use frequency modulation (FM) mode instead of SWF. In this way the switching of the dividers doesn't occur, since the VCO margin is used. However the same margin limits the maximum sweep span to a much less value compared to SWF mode.

6.2.3 Sweep Level Operation Mode (SWL)

SWL mode is the step change of output level by the specified law (e.g. triangle, saw) at constant frequency (fig. 12). T_{Sweep} – one pass (period) time. Sweep level mode (SWL) has the following parameters (fig. 16):

- Frequency** – output frequency;
- Start Level** – output start level;
- Stop Level** – output final level;
- Dwell Time** – time of one step;
- Level Step** – level step size.

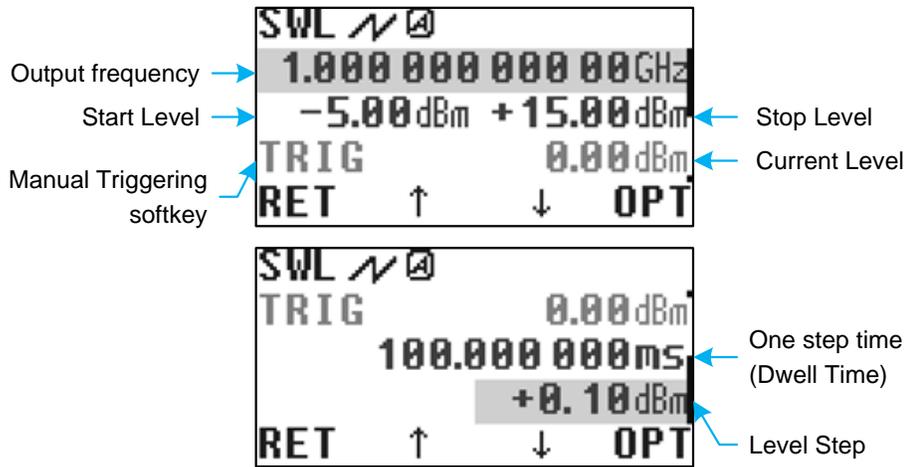


Figure 16: Sweep level operation mode menu (Operation Modes▷Sweep Level)

Sweep level operation mode has the following options (fig. 17):

- Sweep mode type:
 - Auto – automatic, after one period pass it repeats automatically;
 - Single – single period pass. Sweep starts at triggering event. Then after one pass it returns to the start and waits for the next triggering event;
 - Step – stepping mode. Each step is performed after triggering event;
- Triggering options:
 - Manual – triggering event performed manually by pressing TRIG softkey (see fig. 16);
 - External – triggering event is generated by external signal fed to Aux In input;
 - * Trig Slope:
 - Positive – triggering event is generated at the rising edge of the external signal;
 - Negative – triggering event is generated at the falling edge of the external signal;
- Dwell Time – this sub-menu item duplicates the corresponding menu item in fig. 16;
- Level Step – this sub-menu item duplicates the corresponding menu item in fig. 16;

i When Ext option is activated triggering event can also be generated manually by TRIG softkey

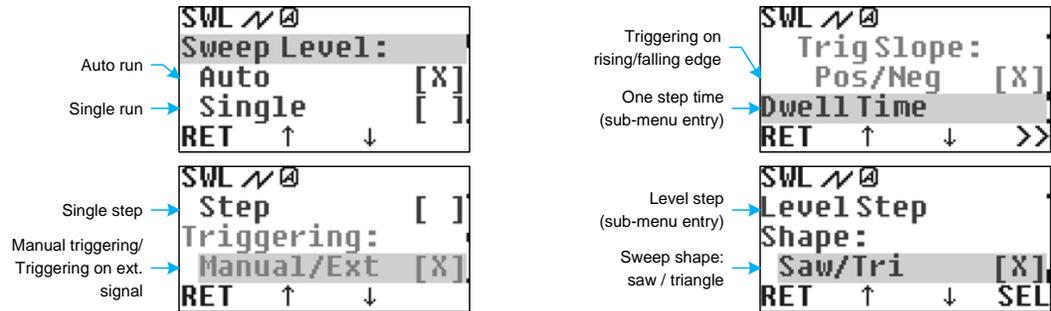


Figure 17: Sweep level mode options (Operation Modes▷Sweep Level-OPT)

Table 4: Sweep level shapes

SWL	$P_{Start} < P_{Stop}$	$P_{Start} > P_{Stop}$
Saw		
Triangle		

• Sweeping law (i.e. Shape):

- Saw – saw shape;
- Tri – triangle;

Table 4 shows shapes of level sweep at various relations of start and stop level values.

6.2.4 Frequency Modulation (FM)

Frequency modulation is the deviation of instantaneous frequency from its central (i.e. mean) value in accordance to the modulating signal. It can be represented by the following expression:

$$\omega(t) = \omega_C + \Delta \cdot s(t),$$

where $\omega(t)$ – instantaneous frequency, ω_C – central frequency (mean value), $s(t)$ – modulating signal, Δ – Frequency Sensitivity, Hz/V. The value of $\max |\Delta \cdot s(t)|$ is referred to as the Frequency Deviation. Since the frequency is the first derivative of the phase, the phase of the output signal will be

$$\varphi(t) = \omega_C t + \Delta \int_{-\infty}^t s(\tau) d\tau.$$

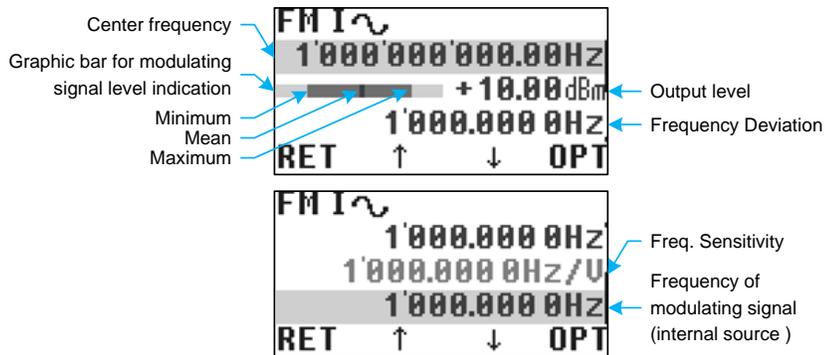


Figure 18: Frequency modulation mode (Operation Modes > Freq. Modulation)

If sinusoidal signal with intrinsic frequency Ω and deviation Δ is used as the modulating signal in FM mode, then phase of output RF signal can be represented in the following form

$$\varphi(t) = \omega_C t + \frac{\Delta}{\Omega} \sin(\Omega t).$$

Frequency modulation mode has the following parameters (fig. 18):

Center Frequency – central (mean) frequency;

Level – output signal level;

Frequency Deviation – used only for internal source of modulating signal (item is grayed in other modes);

Frequency Sensitivity – used only in mode of external modulating signal fed to Aux In or Mic In input (it's grayed in other modes);

Source Frequency – frequency of modulating signal (only for internal source, this item is grayed otherwise).

In FM mode such parameters of modulating signal as its minimum, maximum and mean values are displayed in form of graphical bar (fig. 18).

Frequency modulation mode has the following options (fig. 19):

- Source of modulating signal:
 - Internal – internal source;
 - External – external signal fed to Aux In or Mic In input;
- Waveform of modulating signal:
 - Sine – sinusoidal signal;

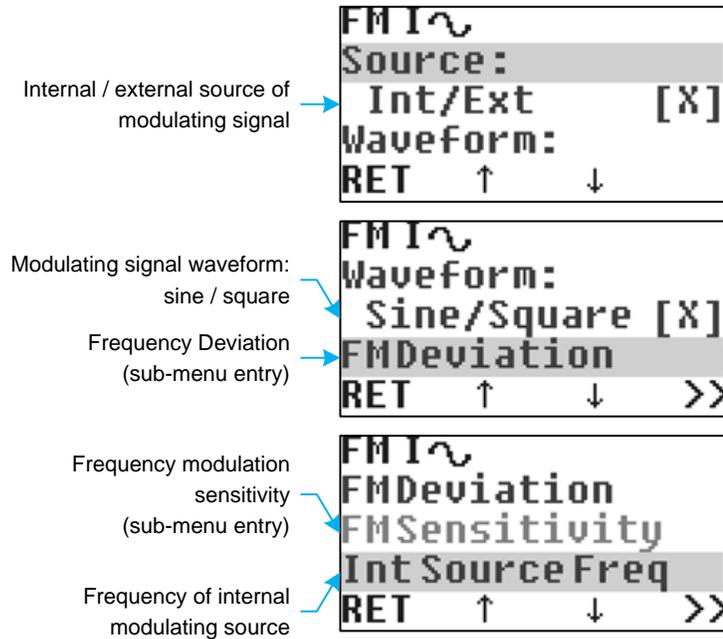


Figure 19: Frequency modulation options (Operation Modes▷Freq. Modulation-OPT)

– Square – square signal;

- FM Deviation, FM Sensitivity, Int Source Freq – these sub-menu items duplicate the corresponding items shown in fig. 18.

Modulation modes in the instrument are implemented in digital form. That is the modulating signal is the result of analog to digital conversion of *Analog In* signal or digital waveform implementation. Sampled values are converted to frequency (for FM) or phase (for PhM) and then loaded into the RF synthesizer block.

 Frequency modulation is implemented in digital way

Unlike the SWF mode, where the RF output level calculation is performed for each frequency using special calibrating data corresponding to particular frequency, in FM mode in order to accelerate the computation only center frequency calibration data is used. Since the deviation is much less than central frequency, it doesn't lead to considerable error.

For an effective use of ADC resolution the input variable gain amplifier (VGA) is provided, fig. 6. Graphical bar, fig. 13, shows minimums and maximums of sampled signal relative to the full scale of ADC.

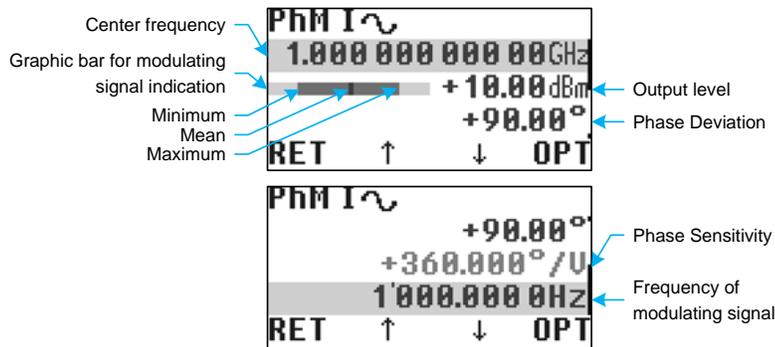


Figure 20: Phase modulation mode (Operation Modes▷Phi Modulation)

6.2.5 Phase Modulation Operation Mode (PhM)

Phase modulation of RF signal is the current phase deviation from the value corresponding to the integral of its center frequency

$$\varphi(t) = \omega_C t + \Delta \cdot s(t),$$

where ω_C – center frequency, $s(t)$ – modulating signal, Δ – Phase Sensitivity, rad/V. Value $\max|\Delta \cdot s(t)|$ is referred to as Phase Deviation.

Phase modulation mode has the following parameters (fig. 20):

Center Frequency – center frequency of RF signal;

Level – output level of RF signal;

Phase Deviation – used only in internal source mode, grayed otherwise;

Phase Sensitivity – used only in external source mode, when modulating signal is fed to Aux In or Mic In input;

Source Frequency – intrinsic frequency of modulating signal (only for internal source).

In PhM mode the min, max and mean values of modulating signal are displayed on the screen in form of graphic bar (fig. 20).

PhM mode has the following options (fig. 21):

- Source of modulating signal:
 - Internal – internal source;
 - External – external modulating signal fed to Aux In or Mic In input;
- Waveform of modulating signal:
 - Sine – sinusoidal signal;

 Phase modulation is implemented digitally

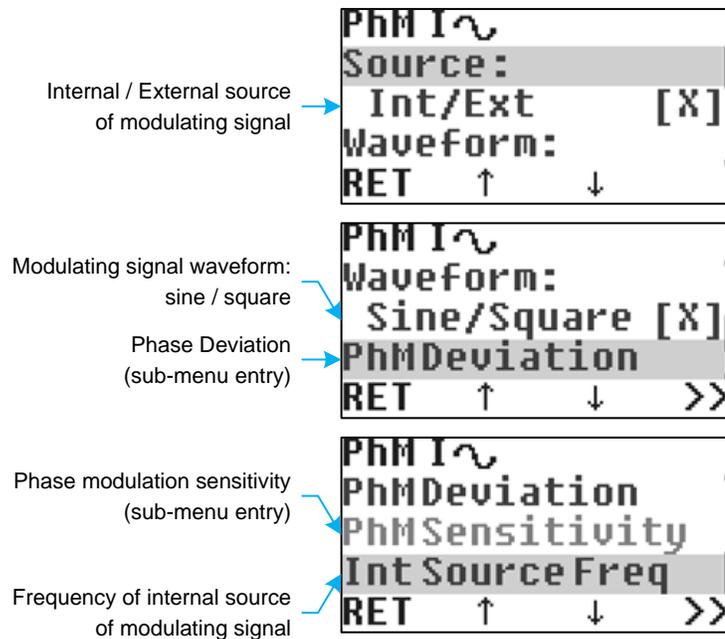


Figure 21: Phase modulation options (Operation Modes▷Phi Modulation-OPT)

– Square – square signal;

- PhM Deviation, PhM Sensitivity, Int Source Freq – these sub-menu items duplicate the corresponding items shown in fig. 20.

6.3 Settings of the Instrument

Settings menu contains the following items (fig. 22):

Reference Frequency – sub-menu with settings of reference frequency;

Analog In – sub-menu with settings of analog signal inputs – Aux In and Mic In.

6.3.1 Reference Freq.

Reference Freq. menu contains the following items (fig. 23):

- External reference frequency value (Ext Ref Freq) – used to set frequency of external reference source. For the correct operation of the instrument it should correspond to the actual frequency of the signal fed to Ref In input.;

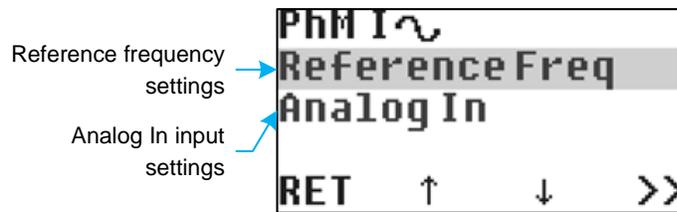


Figure 22: Instrument general settings (Settings)

- Internal reference frequency value (Int Ref Freq), not editable.
- Reference frequency source (Source):
 - Internal – internal source is used;
 - External – signal fed to the REF In input is used as the reference;
- Reference frequency output (Ref Output):
 - On – output is on, and the reference frequency signal is available at REF Out output. When internal source is used the signal is taken from it, when external is used – signal is taken from REF In input and duplicated to the REF Out output (only in SG8-HP);
 - Off – REF Out output is off.
- Dual reference frequency mode (Int Ref Mode).⁵
 - Auto – automatic switching of used reference frequency. In this mode the instrument automatically chooses the right frequency to minimize the spurs at the RF output. An Auto mode works only in CW mode of operation, in other cases the fixed 174 MHz reference is used;
 - Fixed 147 – fixed 147 MHz reference;
 - Fixed 150 – fixed 150 MHz reference.

6.3.2 Analog In input

Analog In settings menu (fig. 24) contains the gain of the *Analog In* signal, which is the difference between the signal fed to Aux In and Mic In inputs (see. 6). The gain can take one of the following values: 1, 2, 4, 8, 16, 32, 64. Looking at the signal level displayed by the graphical bar on the screen in FM or PhM mode,

⁵These menu items are available only in SG8-HPSS option, in SG8-HP option Auto and Fixed 150 items are grayed. When powering up the instrument for HPSS option Auto is set by default, in HP option – Fixed 147 is set. After launching Save Current command the settings of this option doesn't saved to nonvolatile memory, and after power up they are always set to their default values.

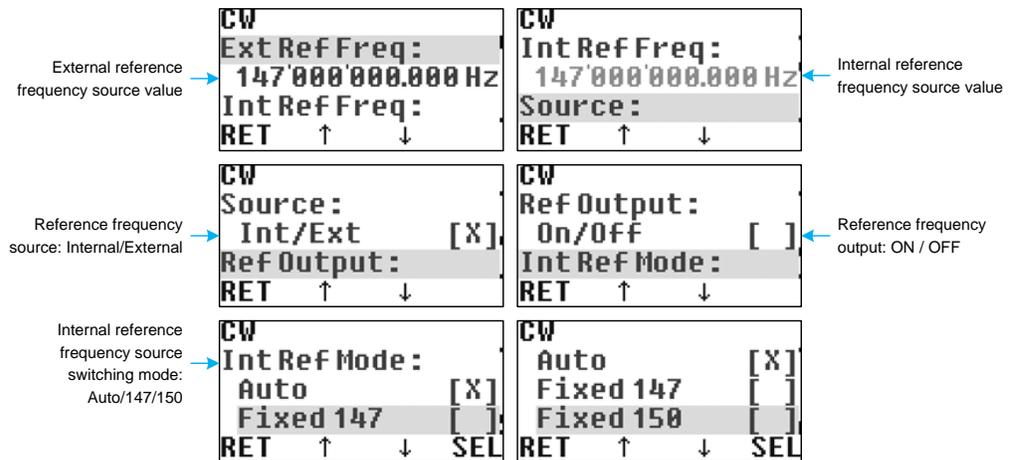


Figure 23: Reference frequency settings (Settings>Reference Freq.)

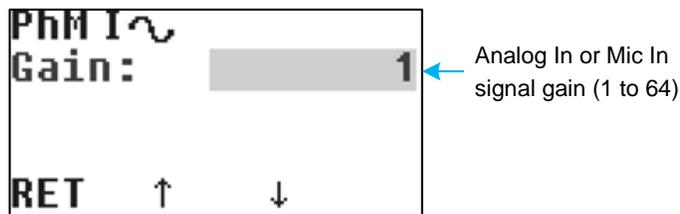


Figure 24: Analog In settings (Settings>Analog In)

you can adjust the gain so that maximum and minimum would be in the bar range, and would not be less than a half of a bar at the same time. In this case the resolution of the ADC is used in most effective way.

6.4 Storing the Current Settings of the Instrument (Save Current)

This menu command stores the current settings and values of parameters of the instrument to nonvolatile memory (EEPROM). After power on the instrument reads stored data, analyzes its integrity, and initializes parameters and values by the stored data. If integrity check is failed,⁶ the default values are loaded.

⁶It could be after firmware update, when new version's parameter set is incompatible with the older version

6.5 Preset the Instrument (Load Default)

This menu command presets all parameters of the instrument by the default values and enters the CW operation mode. It can be useful if you want to reset all parameters.

6.6 Information about the Instrument (Info)

Info menu contains the following items (fig. 25):

Part Number – the full name of the instrument, including the series number, its modification, and assembly variant;

Serial Number – the unique ID number of the instrument.

Firmware Revision – the version of the firmware in Rx.x mm/dd/yy format, where x.x – firmware revision, mm - month, dd – day, yy – year of the firmware;

Operation Time – total time of operation of the instrument in hours. It increments each hour. If operation time since powering on is less than one hour then when powering off it remains the same;

Power-On Count – number of powering up events.

Temperature – the internal temperature of the RF-synthesizer block of the instrument. The power supply of its output stage is automatically shut down when temperature reaches 75-80 °C.

7 Remote Control

The remote control of the instrument is based on the SCPI (Standard Commands for Programmable Instruments) protocol. It is implemented via RS-232 and USB interfaces located on the rear panel of the instrument, fig. 5, (USB looks in OS like COM-port), so it can be easily managed by any software which has access to the COM-port of the PC. Only one port can be active, the choice is automatic and remains the same until the power off. The choice of the active port occurs when any byte comes to the one of the ports (not necessary a valid command). The connection via USB is implemented with aid of USB to UART bridge, so from the view point of PC software it looks like a COM-port, fig. 30. This method requires driver installation ⁷ (integral circuit CP2102). The driver is available for the following OSes: Win2K/XP/2K3, Vista, Windows 7, Mac OS, Linux 3.1.

⁷The driver (its last version) can be downloaded from CP2102 bridge vendor site [Silicon Labs](http://SiliconLabs.com)

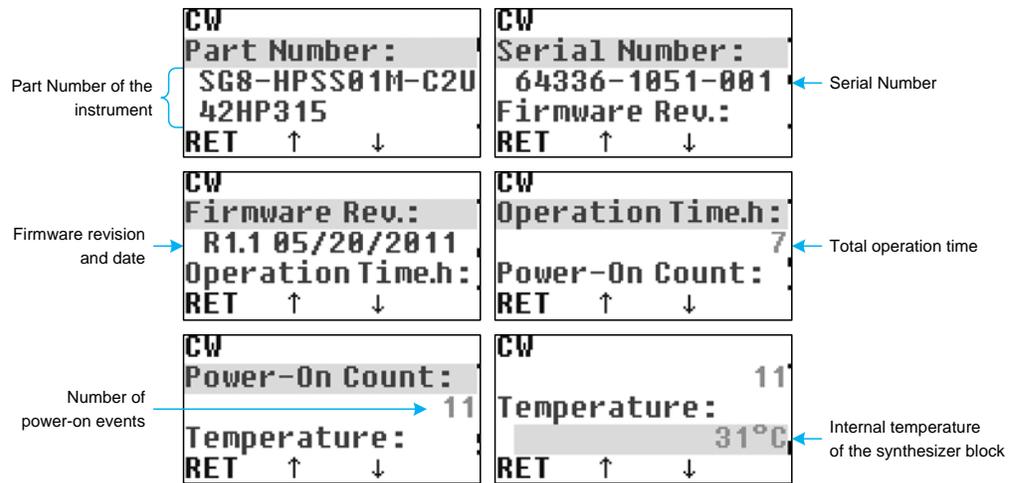


Figure 25: Information about the instrument (Info)

7.1 Quick Start

As a simple remote control application you can use the standard Windows application – *HyperTerminal* (Start>Programs>Accessories>Communications>HyperTerminal) to send the SCPI commands to the instrument, fig. 26. COM-port settings are the following: 115200 bps, 8 data bits, parity none, 1 stop bit, flow control none, fig. 27. For more convenient use of the *HyperTerminal* it's recommended to configure the settings (File>Properties, Settings tab, ASCII Setup... button) “Echo typed characters locally” and “Send line ends with line feeds”. For example, the following typed sequence in *HyperTerminal* application

```
*rst
freq 100MHz
pow -1dBm
```

will reset the instrument, set the output frequency to 100 MHz, and output RF level to –1 dBm.

7.2 SCPI Commands

Figure 28 shows the model of SCPI command processing.

7.2.1 SCPI Compliance

Instrument control command set is based on the SCPI v. 1999.0, but it's not fully compatible. The differences are listed below:

- not all required commands are implemented (see the command list);

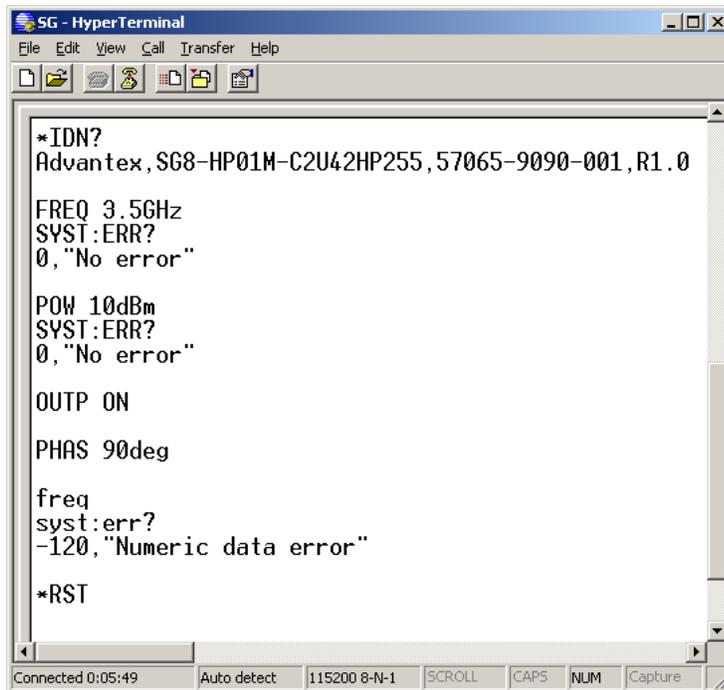


Figure 26: Example of the remote control using *HyperTerminal* application

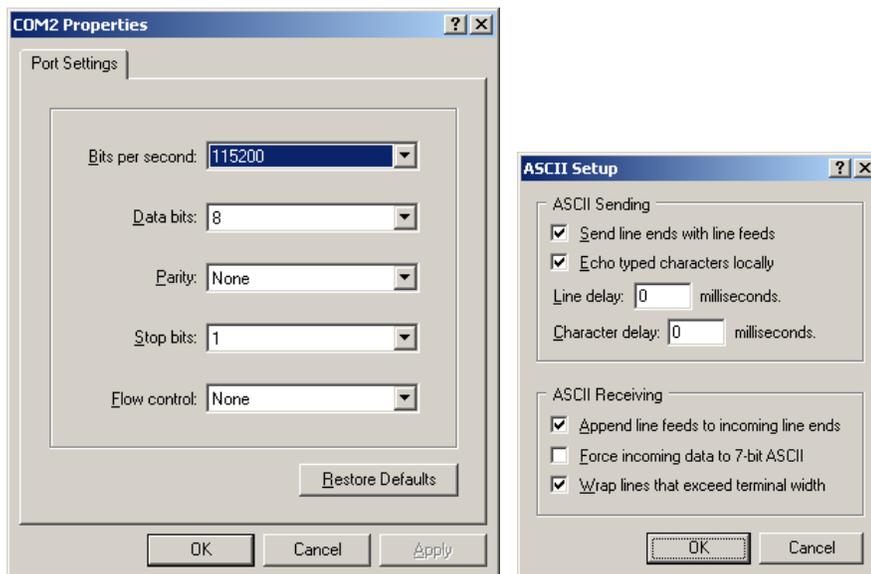


Figure 27: COM-port settings

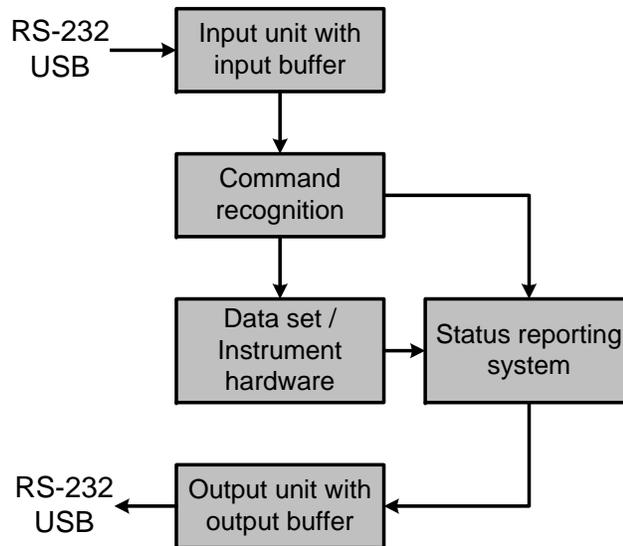


Figure 28: Instrument control and command processing model

- command parser recognizes only one command in single string, and the string size shall not exceed 64 symbols;
- command buffer length equals two, i.e. it is possible to send second command after the first one immediately (not waiting for completion of the first command), but not more;
- status information is not fully supported;
- not all data formats are supported;
- documentation doesn't meet all the requirements of the standard.

i In applications where one command follows after another immediately without any time delay, for proper SCPI operation it is recommended to use *OPC? command

7.2.2 SCPI Summary

Some notes listed below can help the newcomers to start the work with SCPI instrument.

- SCPI-commands are not case sensitive, i.e. commands *RST and *rst are identical.
- The first part of the command name, which is written in capitals, corresponds to a short form of the command. For example, to set frequency you can write **FREQ**, as well as **FREQuency**.
- Commands placed to the brackets are optional. For example the command **[SOURce:]FREQuency[:CW]** have the same effect when written in following

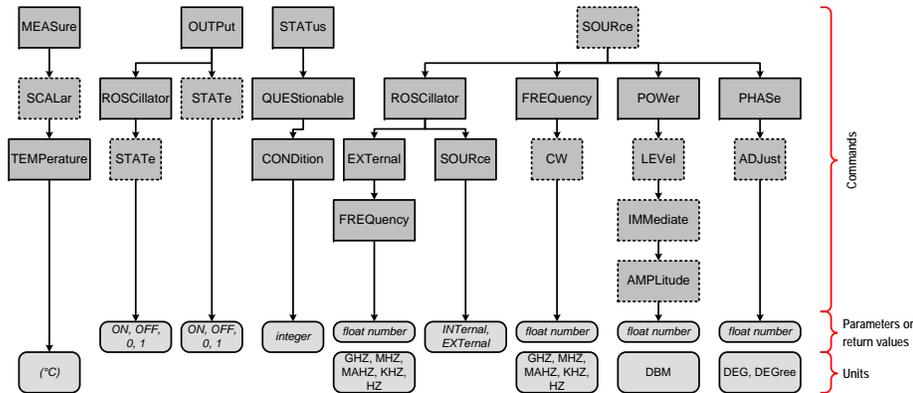


Figure 29: Command structure

forms SOURce:FREQuency:CW,
 FREQuency:CW, SOURce:FREQuency, FREQuency.

- If command requires the numerical parameter expressed in some units then the default unit exists. For example commands `FREQ 1GHZ`, `FREQ 1E9Hz` and `FREQ 1000000000` sets the same frequency value 1 GHz, and the default unit is one Hz.
- Commands ending with a question mark, are the queries and return a response. For example the `*IDN?` command returns an instrument ID. Many commands that set some value, also have a query form to read the current value, e.g. `FREQ?` – returns the current value of frequency.
- Commands that provide input of numerical parameters, can also take the following: `MINimum` – minimum value, `MAXimum` – maximum value, `DEFault` – default value. For example `FREQ MAX` command sets the maximum frequency (8 GHz), and `FREQ DEF` sets 1 GHz (default value).
- If the entered command didn't produce the desired effect, it's worth checking the error buffer by means of request `SYSTem:ERRor:[NEXT]?`. If it were not an error, the return value will be the following string `0,'No error'`, otherwise it returns error code and short description.

7.3 SCPI Command List

Figure 29 represents the available command tree (except standard commands). Optional parts of commands are marked with dotted line.

7.3.1 *CLS

*CLS command clears error buffer.

7.3.2 *IDN?

This query command returns the string containing the information about the instrument in the following format: *manufacturer,part number,serial number,firmware info*.

7.3.3 *RST

This command presets the instrument (as the Load Default menu command do), in more detail: mode CW (Continuous Wave), frequency 1 GHz, level 0 dBm, phase 0 degrees, RF output is off.

It's a good practice to start the remote control process with the *RST command.

7.3.4 *OPC?

This query command returns 1 after its completion. It means that all previous commands are completed. It's good practice to use this command instead of fixed time delay between commands.

Examples: If you need to send several commands following immediately one after another, for example to set frequency and level, it's recommended to do it this way:

```
freq 100 mhz
*opc?
1
pow 1 dbm
*opc?
1
```

7.3.5 SYSTem:ERRor[:NEXT]?

This query command returns the string containing the error code and its description from the error buffer. If the buffer is empty then the returned string contains 0, "No error".

Error buffer is organized in form of FIFO (First In First Out). If input command doesn't meet the requirements of parser, or for whatever reason can not be executed, the corresponding message is placed to the error buffer. The buffer can contain 2 messages. There are two ways to clear the buffer: by reading the errors with aid of SYST:ERR? command one by another, or using *CLS command. When the buffer is already full, and one more error message comes, then the last error message will be rewritten by the following -350, "Queue overflow".

7.3.6 OUTPut[:STATe]

The command turns on or off the RF output as the hardware RF OUT ON/OFF button located at the front panel do.

Parameters: To turn on the output: 1 or ON, to turn off – 0 or OFF.

In query form the command returns 0 – if RF output is off, and 1 – if it's on.

Examples:

```

output on
outp off
outp:state 1
OUTPUT 0
OUTP:STAT?
  
```

7.3.7 OUTPut:ROSCillator[:STATe]

The command turns on and off the REF OUT output located on the rear panel of the instrument.

Parameters: To turn on the output: 1 or ON, to turn off – 0 or OFF.

In query form the command returns 0 – if REF OUT output is off, and 1 – if it's on.

Examples:

```

output:rosc on
outp:rosc off
outp:rosc:state 1
  
```

7.3.8 [SOURce:]FREQuency[:CW]

The command sets output frequency

Parameters: Parameter has the following form

[+|-]float_num[E[+|-]int_num] [GHZ|MHZ|MAHZ|KHZ|HZ].

The default unit is HZ. Input value is rounded with accuracy of 10^{-4} . If the specified value is out of valid range, then the nearest limit value is applied, error message will not be formed.

Query form of the command returns current frequency in Hz. The result has the following form: [+|-]float_num.

Examples:

```
freq 2.1GHZ
frequency 21e-1ghz
sour:freq:cw 21E8
freq max
```

7.3.9 [SOURce:]POWer[:LEVel][:IMMEDIATE][:AMPLitude]

The command sets RF output level.

Parameters: Parameter has the following form $[+|-]float_num[E[+|-]int_num]$ [DBM]. The default unit is DBM. Input value is rounded with accuracy of 10^{-2} . If the specified value is out of valid range, then the nearest limit value is applied, error message will not be formed.

Query form of the command returns current output level in dBm. The result has the following form: $[+|-]float_num$.

Examples:

```
pow 5.1dbm
source:power 1.23
POWER 123E-2DBM
POW MAX
```

7.3.10 [SOURce:]PHASe[:ADJust]

The command sets RF signal phase offset.

Parameters: Parameter has the following form $[+|-]float_num[E[+|-]int_num]$ [DEGREE]. The default unit is DEGREE. Input value is rounded with accuracy of 10^{-2} . If the specified value is out of valid range, then the nearest limit value is applied, error message will not be formed.

Query form of the command returns current phase offset in degrees. The result has the following form: $[+|-]float_num$.

Example:

```
phas 90deg
PHASE 90DEG
phase:adj 90.1e-1
```

7.3.11 [SOURce:]ROSCillator:SOURce

The command turns on and off the REF IN input, i.e. switches between internal and external reference frequency source.

Parameters: Input parameter value may be **INTernal** – internal reference source is used, or **EXTernal** – external reference source is used.

Query form of the command returns current source in use: **INT** or **EXT**.

Examples:

```
rosc:source INT
rocs:sour ext
```

7.3.12 [SOURCE:]ROSCillator:EXTernal:FREQUENCY

The command sets the value of external reference frequency at REF IN input.

Parameters: Input parameter has the following form:

[+|-]float_num[E[+|-]int_num] [GHZ|MHZ|MAHZ|KHZ|HZ].

The default unit is HZ. Input value is rounded with accuracy of 10^{-4} . If the specified value is out of valid range, then the nearest limit value is applied, error message will not be formed.

Query form of the command returns current reference frequency value in Hz. The result has the following form: [+|-]float_num.

Examples:

```
rosc:ext:freq 100MHZ
SOURCE:ROSC:EXTERNAL:FREQUENCY 32MHz
rosc:ext:freq DEF
```

7.3.13 MEASure[:SCALar]:TEMPerature?

The command reads the internal temperature of RF synthesizer block in °C. The result has the following form: [+|-]float_num.

Examples:

```
meas:scal:temp?
meas:temp?
```

7.3.14 STATus:QUEStionable:CONDition?

The command returns current status of the instrument. The result has the following form: integer_num. Zero value means that all is OK, “1” in 3-rd bit means that power which was set to the instrument is outside of the calibrated area.

Examples:

```
STAT:QUES:COND?
8
```

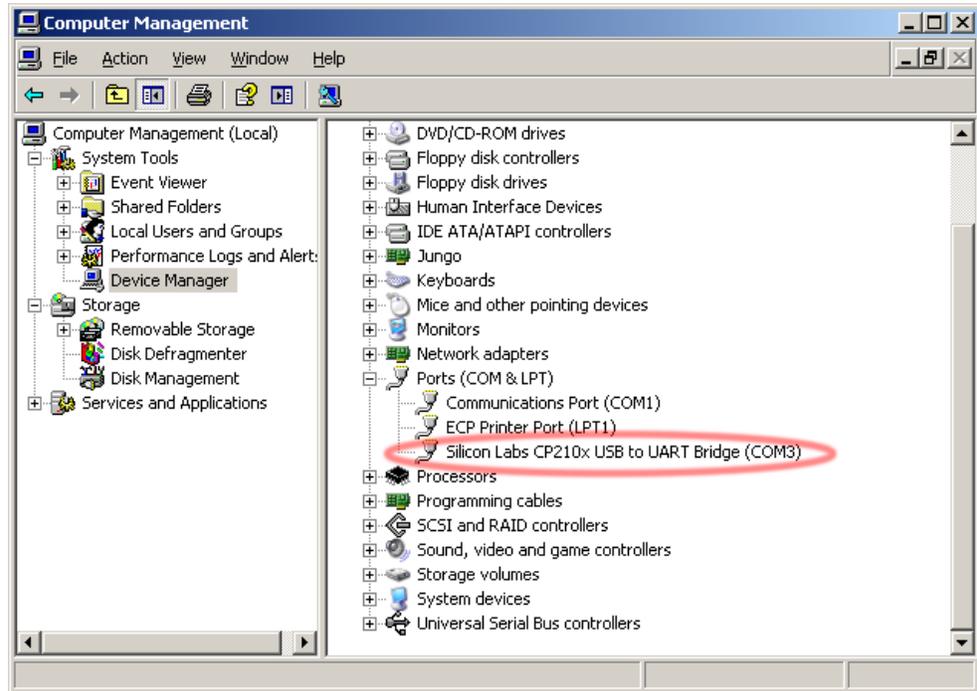


Figure 30: *Device Manager* window (My Computer > Manage)

8 Firmware Update

The instrument comprises a microcontroller (MCU), which controls all RF-blocks, graphical display and handles keyboard and rotary knob events. MCU has two types of nonvolatile memory: Flash that contains program code, and EEPROM which stores all information about the device, including information about current firmware version. Thus the firmware update consists of two files in Intel Hex format, one – for Flash, and the other – for EEPROM. Firmware update is carried out through RS-232 or USB interface, connected to the PC. The connection via USB is implemented with aid of USB to UART bridge, so from the view point of PC software it looks like a COM-port, fig. 30. This method requires driver installation ⁸ (integral circuit CP2102).

After driver installation and when the instrument is connected to the PC, the COM-port appears in the hardware list. Its number is indicated at the end of the string (fig. 30).

When powering up the instrument, it enters firmware update mode and waits for the appropriate command from the PC. If it doesn't receive the command

⁸The driver (its last version) can be downloaded from CP2102 bridge vendor site [Silicon Labs](#)

within a half of a second, it exits the update mode and no longer responds to the read/write Flash or EEPROM commands, since in regular mode RS-232 and USB interfaces are used for remote control. For the firmware updating the XMI Programmer (XMEGA Instrument Programmer)⁹ application is used, fig. 31. The sequence of actions is the following:

1. Turn off the instrument;
2. Connect it to the PC via RS-232 or USB cable;
3. Launch the XMI Programmer software;
4. Select the port, then press Connect button. If you chose the wrong port, then press the Stop button, select the right port, then press Connect;
5. Turn on the instrument. The connection should be established within a second (you will see the string Connecting... Ok!). If it's not happened then probably wrong port was selected. In such a case press the Stop button, turn off the instrument, change the port in drop-down list, press Connect and then turn on the instrument. The string Connecting... Ok! should be displayed;
6. Select the Write to MCU radio-box, the Rewrite All EEPROM Data flag should remain inactive¹⁰;
7. Select the files for Flash and EEPROM;
8. Press Go! button. The firmware update process takes about 30 seconds and comprises the data integrity check, the results of the operations are displayed in the log window;
9. After successful verifying the written data you may close the application.

You can save the current firmware and EEPROM data by selecting Read from MCU radio-button at 6-th step.

9 Disposal

Once a lifetime of the product has ended, it should be disposed of by the local representative of the company specializing in electronic equipment recycling, or you can contact us by email sales@advantex.ru.

⁹XMI Programmer software supports the following OSes: WinXP, Vista, Windows 7.

¹⁰If you select this flag, then all EEPROM memory will be re written, not only the part, that contains the information about current firmware revision. That is the personal data of the instrument (serial number, operation time, power-on count) will be erased, which is not desirable

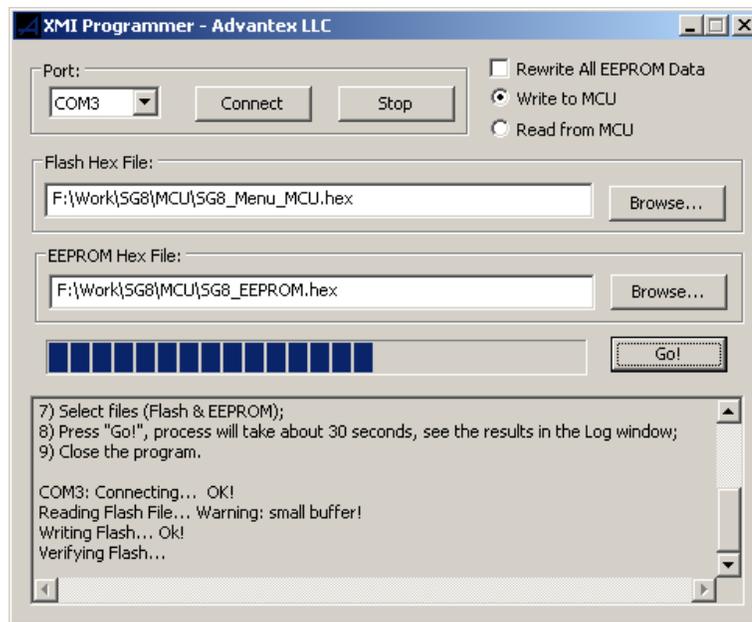


Figure 31: Firmware update application – XMI Programmer