

V R E M Y A – C H
Joint Stock Company

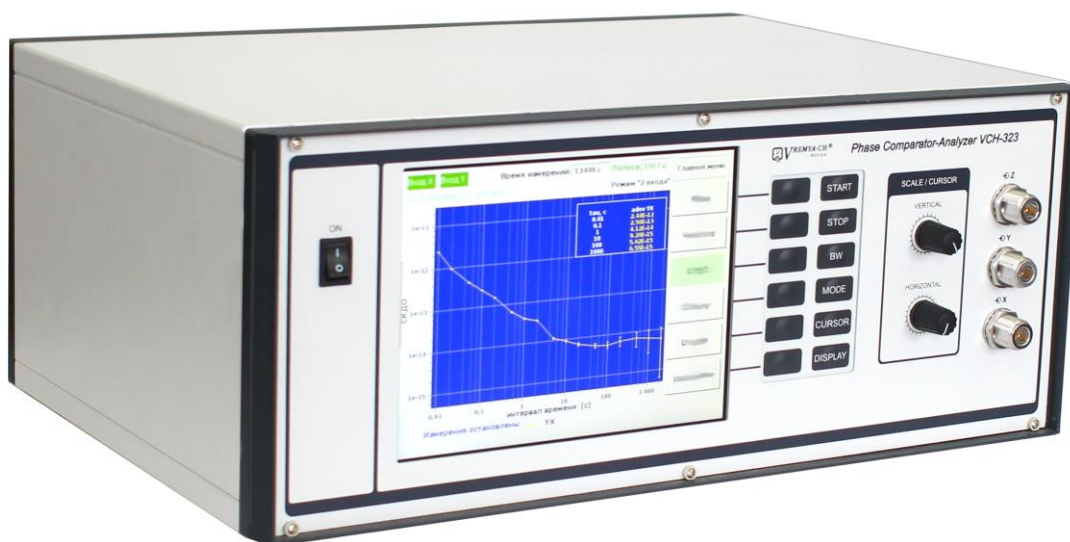
PHASE COMPARATOR-ANALYZER

VCH-323

Operational Manual

411146.034OM

Revision 8



Osharskaya str., 67, Nizhny Novgorod, 603105, Russia
 tel./ fax +7 (831) 421-02-94, <http://www.vremya-ch.com>

Инв. № подл.	Подп. и дата	Взам. инв.№	Инв. № дубл.	Подп. и дата

Contents

1	List of abbreviations.....	4
2	Safety precaution.....	5
3	Device description.....	6
3.1	Key applications.....	6
3.2	Operating conditions	6
3.3	Product composition	8
3.4	Product specifications	9
3.5	Basic configuration and operation	13
4	Preparing the device for use.....	16
4.1	Operational limitations.....	16
4.2	Safety measures.....	17
4.3	Visual inspection.....	17
4.4	Recommendations for using of peripheral devices.....	17
5	Operating procedure.....	19
5.1	Location of control and connection systems.....	19
5.2	Preparation for measurement	21
5.3	Description of the user interface and measurement process.....	23
5.4	Copying data by FTP	49
5.5	Measurement modes	50
6	Verification of the device.....	54



Figure 1 – External view of the Device and the Device composition

1 List of abbreviations

ADC – analog-to-digital converter;

ADEV – Allan deviation;

DDS – direct digital synthesis;

DSP – digital signal processor;

FTP – file transfer protocol;

GUI – graphical user interface;

HDMI – high definition multimedia interface;

PC – personal computer;

PSD – power spectral density;


LAN – local area network;

LCD – liquid crystal display;

VGA – video graphics array;

USB – universal serial bus.

2 Safety precaution

- 2.1 Carefully read the operating manual before working with the Device and note the safety information.
- 2.2 The Device must be grounded before use via protective conductor in the power cable and protective ground terminal marked  on the rear panel. To avoid the influence of static electricity all further connections must be made only with the grounded Device.

ATTENTION! Grounding failure makes the device unsafe. Operation of the ungrounded Device is prohibited.

- 2.3 Ensure that all cables are properly connected before turning on the Device.

Operation of the Device must comply with the electrical safety regulations in force at the operating facility.

3 Device description

3.1 Key applications

Phase comparator-analyzer VCH-323 is intended for phase and frequency instability and power spectral density measurements of precise signals in the frequency range from 1 MHz up to 100 MHz.

The description of the user interface (Section 5.3) is valid for software versions since 1.21.10.21.

Key applications:

- in the production of precision signal sources;
- in time and frequency reference systems;
- in scientific research;
- for measurements in time synchronization systems;
- as an integral part of automated measurement systems.

3.2 Operating conditions

Working operating conditions (in Use):

- Air temperature: +5 °C to +40 °C;
- Relative humidity: 30 % to 80 %;
- Atmospheric pressure: 70 kPa – 106,7 kPa (537 mm Hg to 800 mm Hg);
- Power supply: (220 ± 22) V.

Utmost operating conditions (Storage and Transportation):

- Air temperature: $-30\text{ }^{\circ}\text{C}$ to $+50\text{ }^{\circ}\text{C}$;
- Relative humidity: up to 95 % (non-condensing).

The Device should be kept under operating conditions for 24 hours after staying in utmost conditions.

3.3 Product composition

The Device composition is given in Table 1.

Table 1 – The Device composition

№	Model and designation	Quantity	Note
1.	Phase comparator-analyzer VCH-323	1	
2.	Power connecting cord SCZ-1	1	
3.	RF interconnecting SMA/BNC cable 685661.031	3	
4.	RF interconnecting SMA/BNC cable 685661.032	1	
5.	Adaptor N to BNC 33 N-BNC-50-1/133 UE	3	
6.	High Power Combiner ZA3CS-400-3W-S	1	
7.	Operational Manual 411146.034OM	1	

3.4 Product specifications

3.4.1 The Device measures frequency instability and power spectral density of the phase noise of input sinusoidal signals. The frequency of input sinusoidal signals should be in the range from 1 MHz up to 100 MHz.

3.4.2 The Device is controlled from the front panel using the built-in software installed by the manufacturer. The embedded software implements the following functions:

- setting device operating mode and control parameters via the screen interface;
- calculating statistical functions that characterize:
 - a) frequency instability between two signals;
 - b) single signal frequency instability (only using “three-cornered hat” method);
 - c) phase noise power spectral density for two signals and each of the signals separately (only using “three-cornered hat” method):
 - displaying measurement results in tables and graphs on the front screen;
 - saving measurement results in the built-in nonvolatile memory of the device;
 - measurement results transfer via FTP over LAN.

3.4.3 RMS voltage of input sinusoidal signals at (50.0 ± 0.3) Ohm load should be in range from 0.6 V to 1.2 V.

3.4.4 The Device has two operation modes:

- 1) "2 inputs" - comparison of two signals on Y and X inputs with comparator noise suppression;
- 2) "3 inputs" - processing of three signals on inputs X, Y, Z using "three-cornered hat" method, allowing to determine frequency instability of each signal separately.

3.4.5 The basic measurement error, frequency instability noise floor (Allan deviation – ADEV) for input sinusoidal signals should not be more than the values given in Table 2.

Table 2 – Frequency instability noise floor

Averaging time, τ	Bandwidth, Hz	Allan deviation	
		"3 inputs" mode for input signal pair YX (ADEV YX), for input signal pair ZX (ADEV ZX)	"2 inputs" mode for input signal pair YX (ADEV YX), "3 inputs" mode for input signal X, (ADEV X)
0.01 s	100	5.0×10^{-12}	3.0×10^{-13}
0.1 s		6.0×10^{-13}	1.0×10^{-13}
1 s	1	3.0×10^{-14}	1.0×10^{-14}
10 s		5.0×10^{-15}	2.0×10^{-15}
100 s		2.0×10^{-15}	1.0×10^{-15}
1 hour		5.0×10^{-16}	3.0×10^{-16}
1 day		1.0×10^{-16}	1.0×10^{-16}

for the ambient temperature change rate no more than 1 °C/hour (within the working operating air temperature range).

3.4.6 The basic measurement error, phase noise floor $L(f)$, (the Power spectral density – PSD) for the input sinusoidal signals should not be more than the values given in Table 3.

Table 3 – Phase noise floor

Frequency offset	Power spectral density, dBc/Hz					
	“3 inputs” mode for input signal pair YX (PSD YX), for input signal pair ZX (PSD ZX)			“2 inputs” mode for input signal pair YX (PSD YX), “3 inputs” mode for input signal X, (PSD X)		
	Frequency of input signals			Frequency of input signals		
	5 MHz	10 MHz	100 MHz	5 MHz	10 MHz	100 MHz
1 Hz	–130	–127	–107	–135	–130	–110
10 Hz	–143	–135	–115	–150	–145	–127
100 Hz	–145	–143	–127	–155	–153	–140
1 kHz	–146	–145	–133	–160	–158	–143
10 kHz	–147	–145	–135	–163	–160	–150
100 kHz	–148	–146	–140	–163	–160	–155

when observation time is not less 2 hours

3.4.7 The Device provides its specifications in working conditions after warm-up time:

- 1 hour when measuring of phase noise power spectral density and frequency instability for averaging time range from 0.01 s to 100 s inclusive;
- 4 hours when measuring of frequency instability for averaging times more 100 s.

NOTE During the warm-up time, the input sinusoidal signals must be applied to the inputs of the Device.

3.4.8 The averaging time range corresponds to the values given in Table 4.

Table 4 – Averaging time range

Bandwidth, Hz	Averaging time, τ
1000	0.001 s, 0.01 s, 0.1 s, 1 s; 10 s; 100 s; 1000 s, 1 hour, 1 day
100	0.01 s, 0.1 s, 1 s; 10 s; 100 s; 1000 s, 1 hour, 1 day
10	0.1 s, 1 s; 10 s; 100 s; 1000 s, 1 hour, 1 day
1	1 s; 10 s; 100 s; 1000 s, 1 hour, 1 day

3.4.9 The Device provides continuous non-stop operation in working conditions with all specifications when powered by (220 ± 22) V, (50 ± 2) Hz AC.

3.4.10 Power consumption is no more than 60 VA.

3.4.11 Dimensions: 184×449×339 mm.

3.4.12 Weight: no more than 12 kg.

3.5 Basic configuration and operation

The Device is based on digital signal processing principles and a modern high-tech element base, allowing in total to perform direct digital processing of input signals to calculate their characteristics without any conversions in analog circuits (except amplification).

Circuit diagram illustrating the operating principle of the device is shown in Figure 2. The comparator has two identical measuring channels designed to calculate phase difference between two analyzed signals. In the measuring channel the input signals are digitized by two analog-to-digital (ADC) converters and fed to the inputs of a two-channel mixer. Then the digitized input signals are multiplied with $\pi/2$ (cos and sin) phase shifted quadrature LO signals, obtained by direct digital synthesis (DDS) that allows to synthesize signals with frequencies close to the frequencies of the input signals:

$$\begin{aligned} I_F &= \cos \theta_{IN} \cos \theta_{DDS} = \frac{1}{2} [\cos(\theta_{IN} - \theta_{DDS}) + \cos(\theta_{IN} + \theta_{DDS})], \\ Q_F &= \cos \theta_{IN} \sin \theta_{DDS} = -\frac{1}{2} [\sin(\theta_{IN} - \theta_{DDS}) - \sin(\theta_{IN} + \theta_{DDS})] \end{aligned} \quad (1)$$

$\theta_{IN} = \omega_{IN}t + \varphi_{IN}$ – input signal phase, $\theta_{DDS} = \omega_{DDS}t + \varphi_{DDS}$ – synthesized signal phase.

After multiplying signal is filtered and decimated using a comb filter (CIC filter) and digital low-pass filters cascade with finite impulse response (FIR filters on the circuit). Comb filters allow to filter the signal in an extremely narrow band, which is convenient when decimating with a high coefficient (100 or more). This procedure leaves only the low-frequency components of the signals I_F and Q_F proportional to the cosine and sine of the phase difference of the input and synthesized signals, respectively. The received signals can be interpreted as the real and imaginary parts of the input signal. Then the phase difference is

calculated by dividing I_F / Q_F and taking the arc tangent of the result, these functions are implemented in the FPGA.

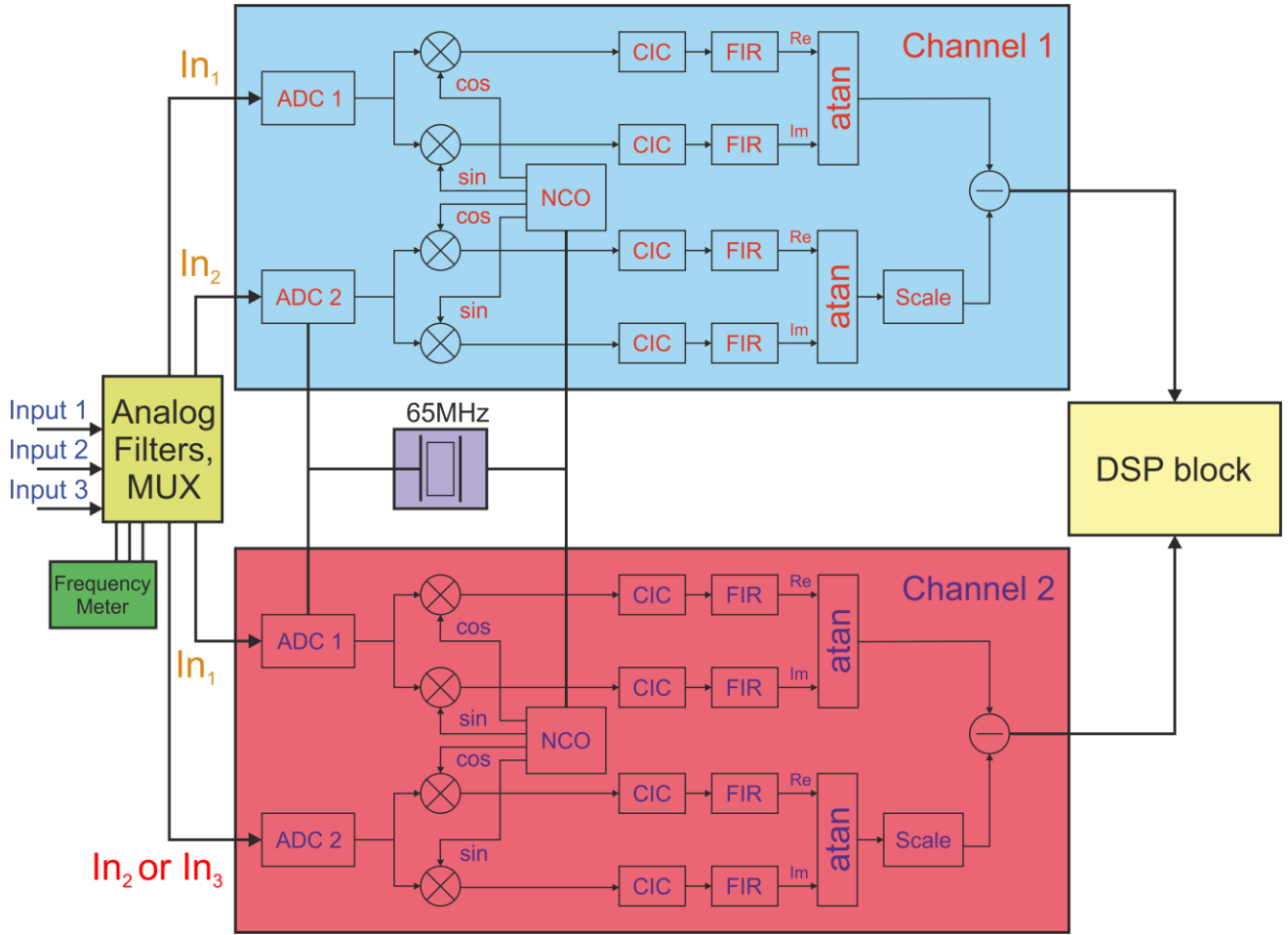


Figure 2. Block diagram of the signal processing path of the Device

Synthesizers for direct digital synthesis (DDS) are clocked by a quartz oscillator of the device, that introduces noise into the measured phase difference. Two-input subtractors for samples from two ADC channels with common clock are used to suppress the additive noise. As a result, samples of the phase difference between two input signals are fed to the output of the measuring channel:

$$\varphi_{IN1,IN2} = (\theta_{IN1} - \theta_{DDS}) - (\theta_{IN2} - \theta_{DDS}) = \theta_{IN1} - \theta_{IN2}. \quad (2)$$

If input signals of the measuring channel have different frequencies it is necessary to scale one of the phase differences with a coefficient equal to the corresponding frequency ratio before subtraction.

In the obtained phase difference the noise of the clock generator is excluded, but the noise added by the analog-to-digital conversion remains.

The circuit (Fig. 2) allows to significantly reduce the influence of ADC noise on the results of measurements due to use of cross-correlation processing of phase differences samples obtained in two parallel measuring channels. Measuring channels use different ADC chips, so the noise they contribute can be considered largely uncorrelated. In this case, cross-correlation processing allows to reduce the level of noise introduced by analog-to-digital converters by about 15 dB.

Phase difference samples are processed by the digital signal processor and the built-in microcomputer (the DSP block in Fig. 2) that calculate the relative frequency difference, ADEV, spectral density of the phase noise and perform cross-correlation signal processing.

4 Preparing the device for use

4.1 Operational limitations

Operating conditions of the Device are given in p.3.2.

The Device should be kept under operating conditions for 24 hours after staying in utmost conditions.

It is recommended to install the Device in a closed thermostated room.

ATTENTION! Do not place the Device near any engines, generators, transformers, or other equipment that can produce magnetic fields and acoustic vibrations. Placement near such equipment may impair the operation of the Device.

The power supply of the Device is a voltage (220 ± 22) V, (50 ± 2) Hz AC.

The Device provides its specifications in working conditions after warm-up time:

- 1 hour when measuring of phase noise spectral density and frequency instability characteristics for averaging time range from 0.001 s to 100 s inclusive;
- 4 hours when measuring of frequency instability characteristics for averaging times more 100 s.

NOTE The input sinusoidal signals must be applied to the inputs of the Device during the warm-up time.

WARNING! To turn off the Device, first switch the toggle on front panel to the "O" position, wait at least 10 seconds, and only after that it is possible to disconnect the Device from the AC mains.

4.2 Safety measures

4.2.1 Before usage you must ensure reliable grounding of the Device.

4.2.2 Ground terminal and conductors must be securely connected. To eliminate the effect of static electricity, all subsequent connections must be made after the Device is grounded.

4.3 Visual inspection

While inspecting the device make sure that:

- there are no visible mechanical defects;
- the seals are intact;
- the external surfaces of the Device, connectors, terminals and sockets are clean;
- connecting cables and adaptors are in good condition;
- all ventilation holes in the Device cover are open, not blocked by other objects.

4.4 Recommendations for using of peripheral devices

4.4.1 You can set the operating mode and control parameters of the Device using an external monitor and a computer mouse.

4.4.2 The external monitor is connected:

- to the “**VGA**” connector of the Device using a VGA cable with DE15M connectors (D-Sub 15, DB15HD);
- to “**HDMI**” connector of the Device using a HDMI cable.

4.4.3 The computer mouse is connected to the “**USB**” device connectors.

4.4.4 To copy the measurement results files to the user's computer using the FTP file transfer protocol, you need to connect the device to the local network (Ethernet network) by connecting the cable with the 8P8C (RJ45) connector to the LAN connector of the Device.

An FTP client must be installed on the user's computer. Examples of such programs are internet browsers or file managers.

5 Operating procedure

5.1 Location of control and connection systems

Controls and connectors on the front panel of the Device are shown in Figure 3. The description of the controls and connectors is given in Table 5.

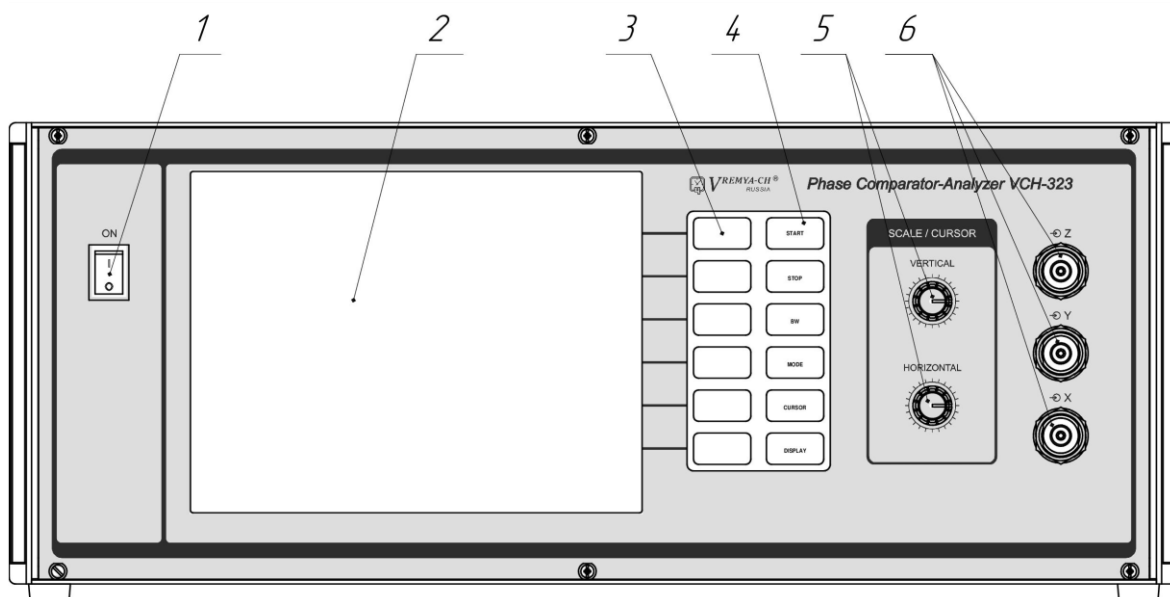


Figure 3. Controls and connectors on the front panel

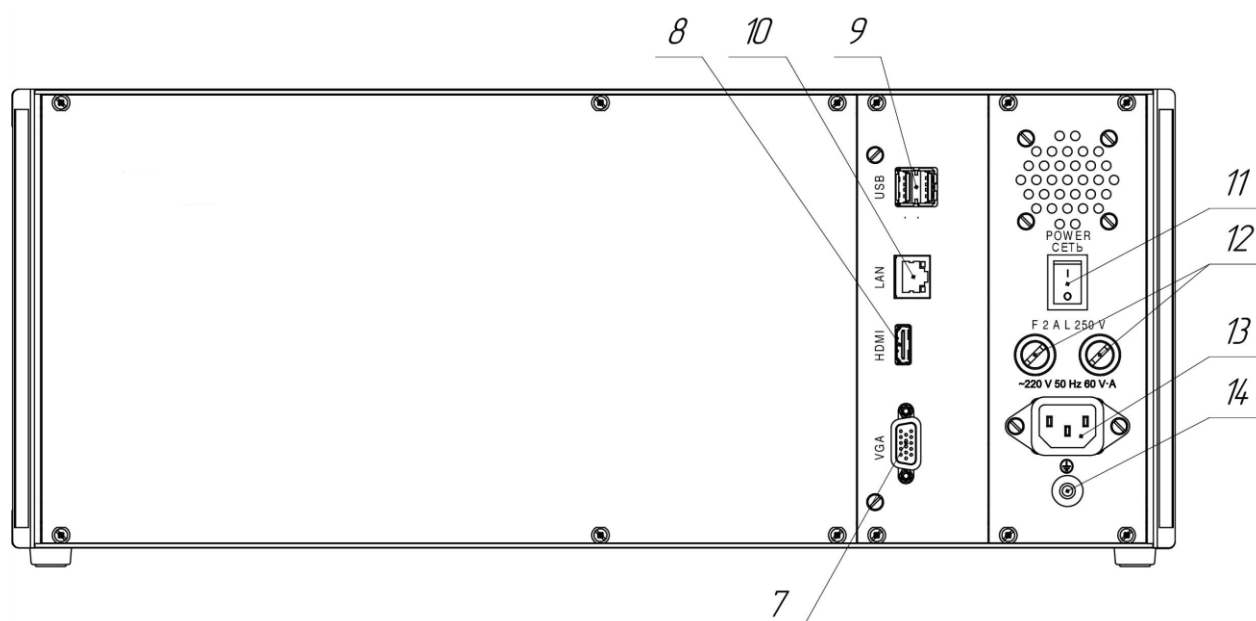


Figure 4. Controls and connectors on the rear panel

Table 5 – Description of the controls and connectors on the front panel

Position (Fig.3)	Designation	Destination
1	ON	Device system on and off switch
2		Screen (liquid crystal display)
3		Soft keys. Their functionality is displayed on the screen
4	START STOP BW MODE CURSOR DISPLAY	Control buttons. Their functionality is defined on the button
5	SCALE/CURSOR VERTICAL HORIZONTAL	Rotary encoders. It change the scale of the time axis of the phase and frequency graphs and control marker on all types of graph
6	\perp Z \perp Y \perp X	Input signal's ports (type N connectors)

Controls and connectors on the rear panel of the Device are shown in Figure 4. The description of the controls and connectors is given in Table 6.

Table 6 – Description of the controls and connectors on the rear panel

Position (Fig.4)	Designation	Destination
7	VGA	VGA connector for connecting an external computer monitor
8	HDMI	HDMI connector for connecting an external computer monitor
9	USB	USB 2.0 ports (for connecting an mouse)
10	LAN	Ethernet (LAN) port
11	POWER	Mains power on and off switch
12	F 2 A L 250 V	Protection Fuse
13	\oplus 220 V 50 Hz 60 V·A	AC power connector
14	\odot	Protective ground terminal

5.2 Preparation for measurement

5.2.1 Carefully read the operating manual and make note of the location and purpose of the controls on the front and rear panels of the Device.

5.2.2 Ensure the Device is properly grounded.

5.2.3 To reduce the measurement error it is recommended to minimize the effects of acoustic and mechanical influences, electromagnetic emissions, drafts and sudden changes in ambient temperature.

5.2.4 Connect (if necessary) the Device to Ethernet by connecting a cable with the connector 8P8C (RJ45) to “**LAN**” Device connector.

Connect (if necessary) an external monitor to the Device with a “**VGA**” or “**HDMI**” Device connector.

Connect (if necessary) a computer mouse to the Device, connecting it to the “**USB**” Device connectors.

5.2.5 Connect the Power connecting cord SCZ-1 to “ ~~Φ~~ 220 V 50 Hz 60 V·A” Device connector.

5.2.6 Turn on the power supply of the device from the AC mains by turning “**POWER**” Device switch to position “**I**” (on). Then turn the Device system on by turning “**ON**” Device switch to position “**I**” (on).

5.2.7 Connect the tested input signals according to the selected measurement mode (see section 5.4).

NOTE The connection is made by coaxial cables with connectors of type N.

If coaxial cables with BNC connectors are connecting then adaptors N to BNC 33 N-BNC-50-1/133 UE should be used.

ATTENTION! To get the correct measurement results:

- reference signal must be connected to Device connector “ \perp X”;
- tested signal must be connected to Device connectors “ \perp Y”, “ \perp Z”.

5.2.8 The Device will be ready for use with the guaranteed frequency instability noise floor and phase noise floor after a one hour warm-up period.

5.2.9 To turn the Device off toggle "ON" switch to the "O" position, main program will prepare the Device for shutdown and close, then the Device will turn off automatically. The time between toggling the switch off and shutdown should not less 10 seconds (and only after that it is possible to disconnect the Device from the AC mains).

ATTENTION! The screen might glow without any text information while turning on or off the Device. It is normal and does not indicate a malfunction!

5.3 Description of the user interface and measurement process

The description of the user interface is valid for software versions since 1.21.10.21.

The Device is controlled by buttons and rotary encoders on the front panel. All information about the progress and results of measurements is available on the Device screen.

After switching on, the operating system of the built-in computer and then the main control program are loaded. The program displays device status information and measurement results on the LCD screen.

If there are no input signals provided for the moment, the control program will inform about that and wait for connection (Figure 5).

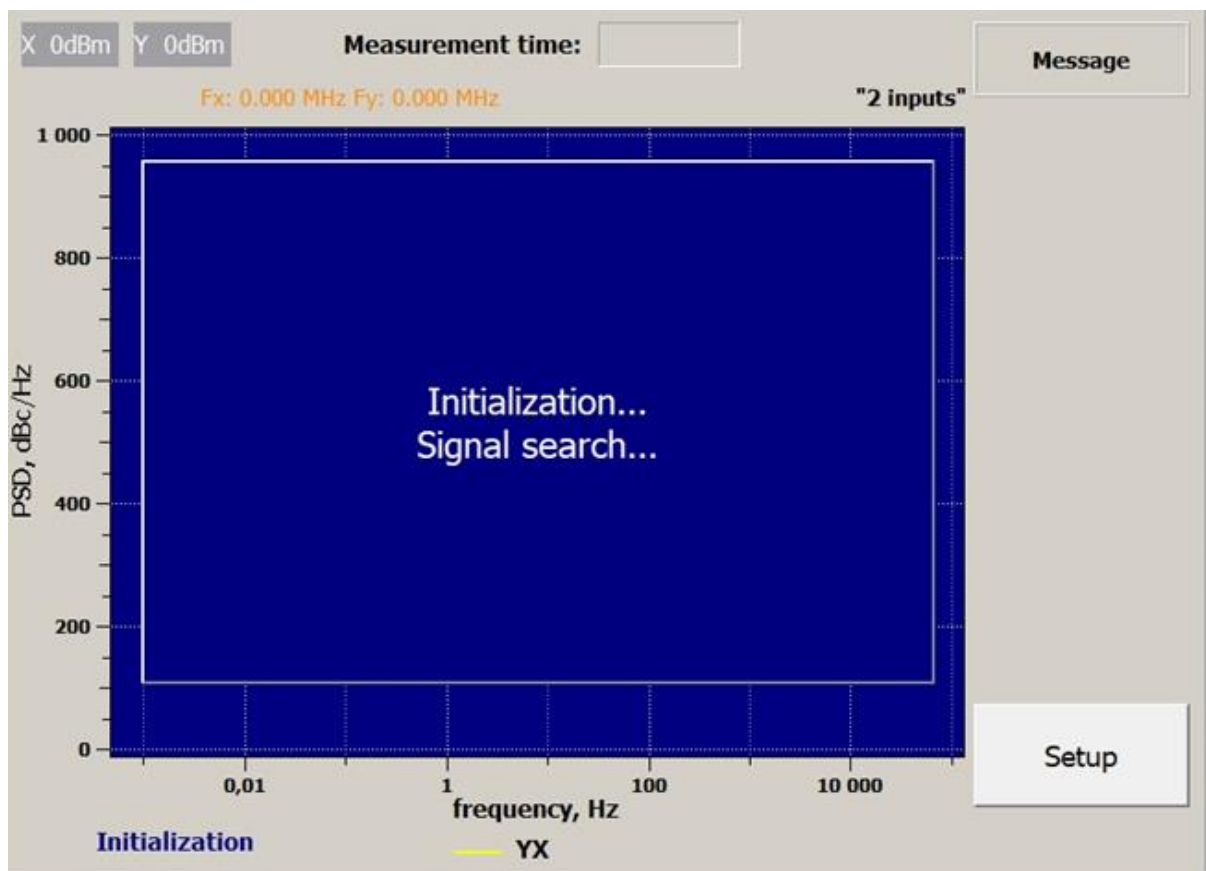


Figure 5. Waiting for input signals

After at least two signals are connected to the input ports (connectors " \perp X" and " \perp Y"), the control program will display information on the connected signals (Figure 6) and begin to prepare the Device for starting the measurements.

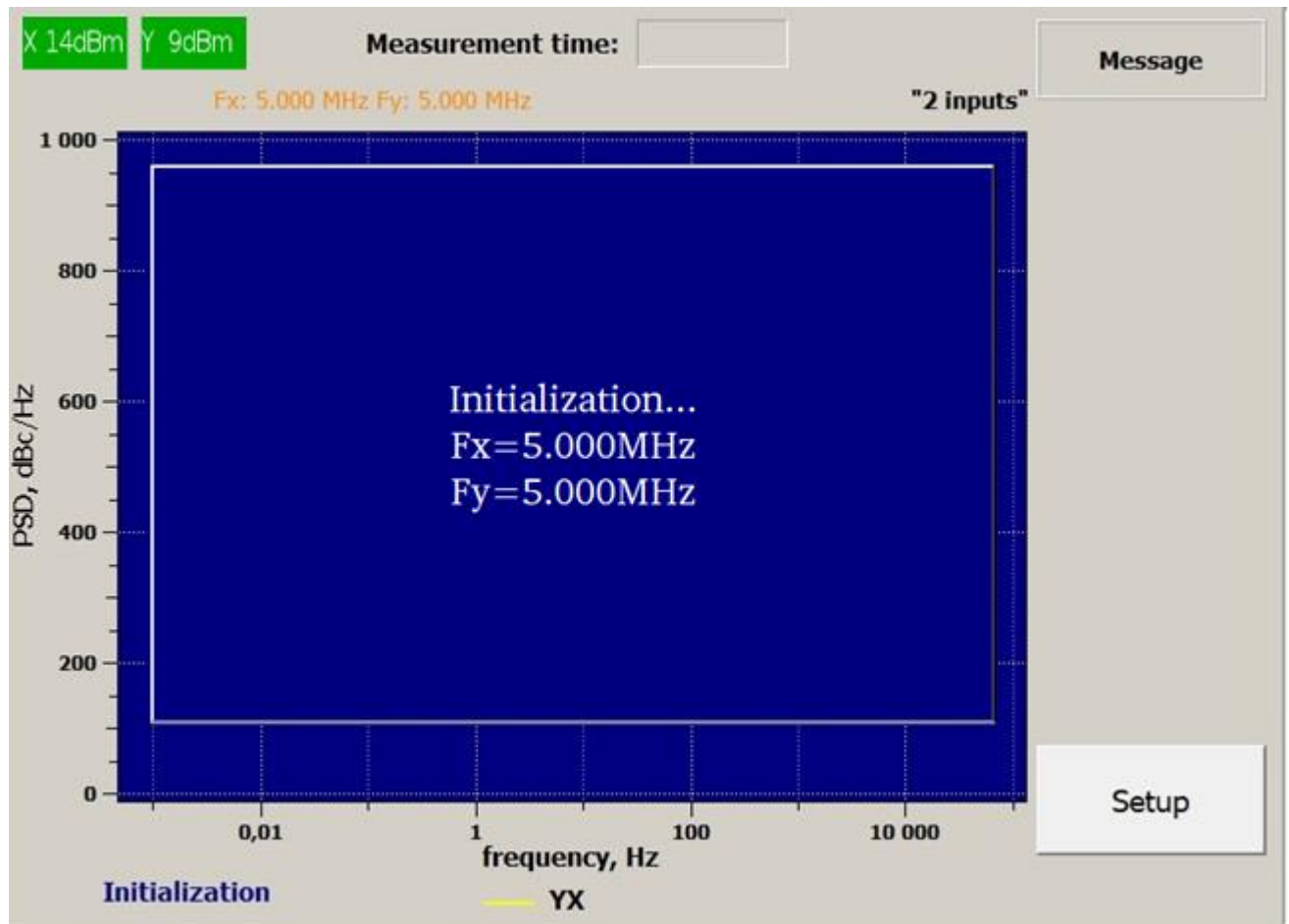


Figure 6. Preparing for measurements

When the preparation procedure is completed the main window of the control program will look like in Figure 7.

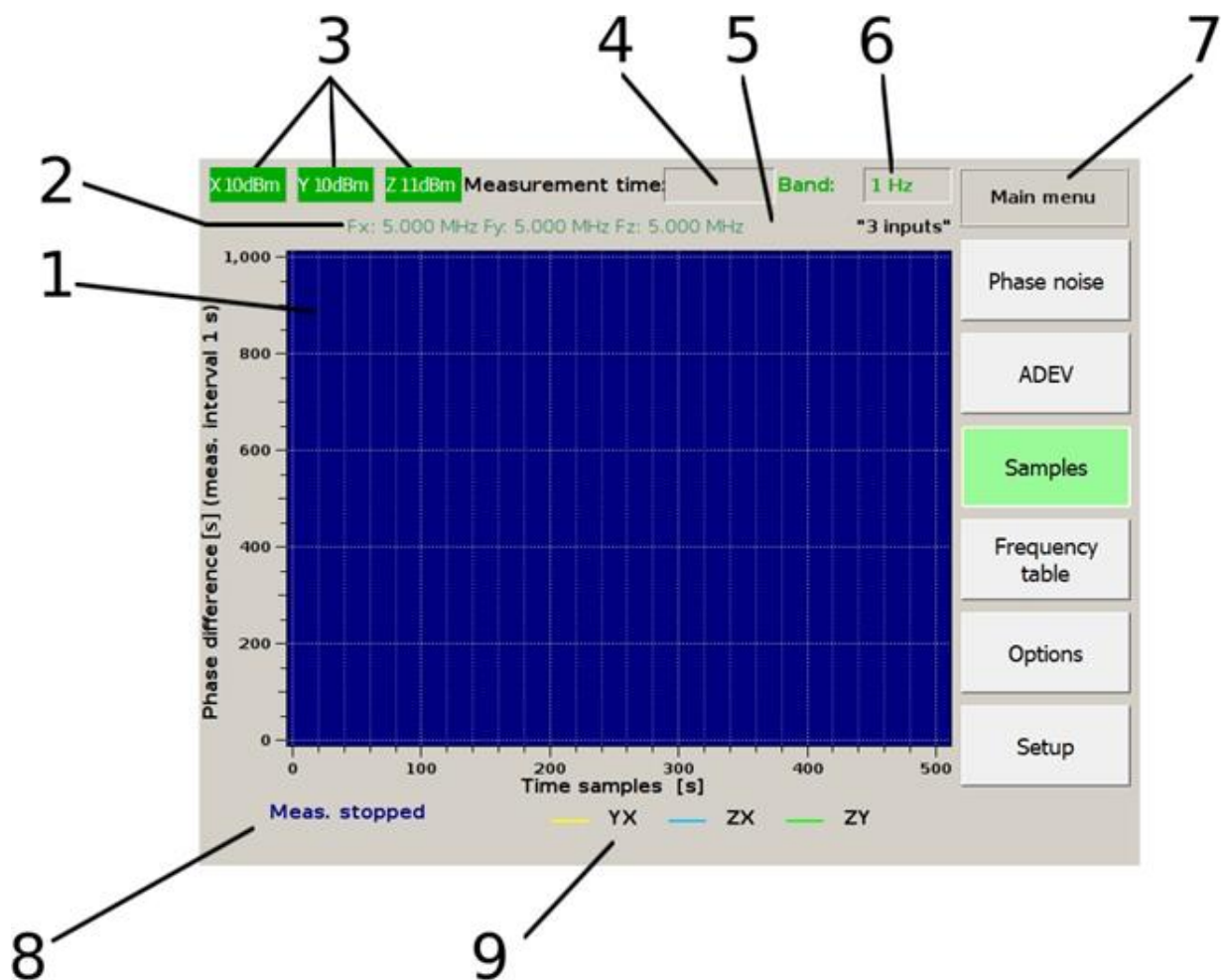


Figure 7. Control program main window

Description of the program GUI (Figure 7):

- 1 - charts;
- 2 - input signals frequencies. Show "0" if there is no signal. Frequency values are updated at least once a second when the program is running, regardless of whether the measurements have started;
- 3 - signal gain level values (dBm units) and at the same time signal presence indicators (green or gray background). The field is green if a signal is connected to the corresponding input, otherwise the field color is gray. The presence of signal is determined by nonzero counter value of frequency counter, which value is displayed in field 2;

- 4 - time from the start of the measurement process (obtaining the first sample);
- 5 - selected measurement mode;
- 6 - selected frequency band;
- 7 - selected menu and the buttons for this menu;
- 8 - state of the measurement process;
- 9 - chart color designation for the corresponding pair of signals.

Before measurements, you must select one of two possible modes by pressing the "**MODE**" button (group of control buttons pos.4 on Figure 3) and then the corresponding mode keys (group of soft keys pos. 3 on Figure 3). **Reference signal for both channels of the comparator needs to be connected to the " \perp X" port for all measurement modes.** Measurement modes are described below.

1. **"2 inputs" mode.** See the soft keys group pos. 3 on Figure 3. This mode allows to reduce the noise introduced by the device when measuring the characteristics of the frequency difference between two signals using cross-correlation processing. The signals must be connected to the " \perp X" and " \perp Y" ports. In this mode, the signal connected to the " \perp Y" is distributed to both measuring channels (Figure 2). The frequency difference instability for the analyzed signals is calculated by formula (6).

2. **"3 inputs" mode.** See the soft keys group pos. 3 on Figure 3. In this mode, the characteristics of the frequency instability are calculated using cross-correlation processing by the "three-cornered hat" method. For this method three different signals with similar frequency instability characteristics must be connected to the Device inputs. **If less than three signals are connected to the**

device, this mode is not available! This method makes it possible to estimate the characteristics of the intrinsic frequency instability for each analyzed signal separately using formula (7).

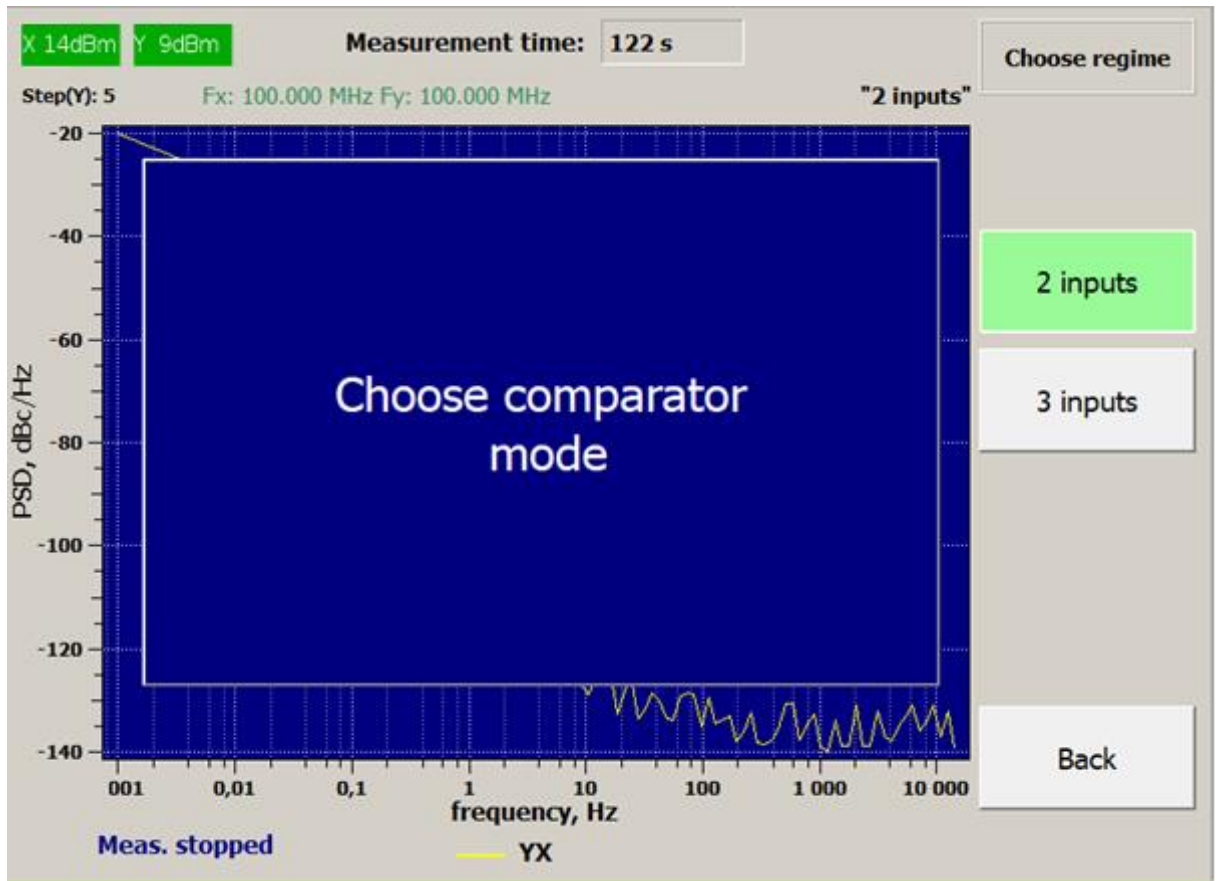


Figure 8. Mode selection menu

"**Mode**" field should display the name of the selected mode (regime).

Running measurements. After the required measurement mode was selected, by pressing the "**START**" control button on the front panel of the Device (group of control buttons pos. 4 in Figure 3) you can start measuring the relative frequency differences of the analyzed signals. Once the "**START**" button is pressed, device parameters will be set within one minute, and after that the "**Measurement time**" field should update the number of seconds elapsed since the first data was received, and in the lower left corner label "**Meas. stopped**" should be replaced by "**Meas. in progress**".

Depending on the selected main menu item the graphs field will show:

- PSD ("**Phase noise**" item);
- ADEV of the relative frequency difference, or ADEV of the frequency of each signal separately in the "3 inputs" mode ("**ADEV**" item);
- Samples: phase differences ("**Samples**"->"Options"->"**Phase samples**" item) or relative frequency differences ("**Samples**"->"Options"->"**Frequency samples**" item);
- Table of average relative frequency differences calculated for different averaging times ("**Frequency table**" item).

The displayed graphs have different colors, indicated at the bottom of the screen (Figure 7, reference 9):

- 1) **Yellow** – for the difference characteristics of the signals at the inputs **Y** and **X** or for the cross-correlation characteristics of the signal at the input **X**.
- 2) **Blue** – for the difference characteristics of the signals at the inputs **Z** and **X** or for the cross-correlation characteristics of the signal at the input **Y**.
- 3) **Green** – for the difference characteristics of the signals at the inputs **Z** and **Y** or for cross-correlation characteristics of the signal at the input **Z**.

Stopping measurements. To stop measurements, press the "**STOP**" control button on the front panel of the Device.

"BW" button. By pressing the "**BW**" button (group of control buttons pos. 4 in Figure 3) you can select which frequency band phase and frequency samples are filtered in. There are four options: 1 Hz, 10 Hz, 100 Hz and a 1000 Hz band. When the 1000 Hz band is selected the interval between phase and frequency samples is 0.001 s, ADEV is calculated from the samples in the 1000 Hz band with the minimum measurement time $\tau = 0.001$ s. When the 100 Hz band is

selected the interval between phase and frequency samples is 0.01 s, ADEV is calculated from the samples in the 100 Hz band with the minimum measurement time $\tau = 0.01$ s. When the 10 Hz band is selected the interval between phase and frequency samples is 0.1 s, ADEV is calculated from the samples in the 10 Hz band with the minimum measurement time $\tau = 0.1$ s. When the 1 Hz band is selected the interval between phase and frequency samples is 1 s, ADEV is calculated from the samples in the 1 Hz band with the minimum measurement time $\tau = 1$ s. The device performs measurements simultaneously in all four bands, so you can change the band during measurements.

"DISPLAY" button. By pressing the **"DISPLAY"** button (group of control buttons pos. 4 in Figure 3), you can choose which of the graphs or ADEV values in the table should be displayed on the screen. You can enable or disable the display of graphs during measurements.

"CURSOR" button. When the **"CURSOR"** button (from the control buttons group pos. 4 on Figure 3) is pressed, screen will show the corresponding menu (Figure 9). When the "Show Marker" key (from the soft keys group pos. 3 on Figure 3) is active, the graphs will show two crossing lines with vertical and horizontal values. And if the ">Marker" key (from the soft keys group pos. 3 on Figure 3: "View/Marker" button) is active, the position of the lines can be controlled by rotary encoders on the front panel of the Device (pos. 5 on Figure 3). When the "Precise" key is active, the minimal marker movement step is reduced by a factor of 10.

When the ">View" key (from the soft keys group pos. 3 on Figure 3: "View/Marker" button) is active and "Autoscale" button from the same menu is not pressed: "phase samples", "frequency samples" and "phase noise" graphs can be manually shifted and scaled using **"HORIZONTAL"** and **"VERTICAL"** rotary encoders. The duration of the displayed record depends on the

measurement interval that can be changed via the "Options" menu described below.



Figure 9. Using marker

“Samples” key. See the soft keys group pos. 3 on Figure 3. When this menu item is selected one of two modes (“Frequency samples” or “Phase samples”) is activated. Samples can be chosen by pressing “Options” key (from the soft keys group pos. 3 on Figure 3). “Phase samples options” or “Frequency samples options” might be selected by pressing “More” key (from the soft keys group pos. 3 on Figure 3). When “Samples” key is initially activated, the graphs field contains statistical parameters table (min, max, mean, std) in the upper right corner (Figure 10). The table can be disabled or enabled by pressing the “Samples” key.

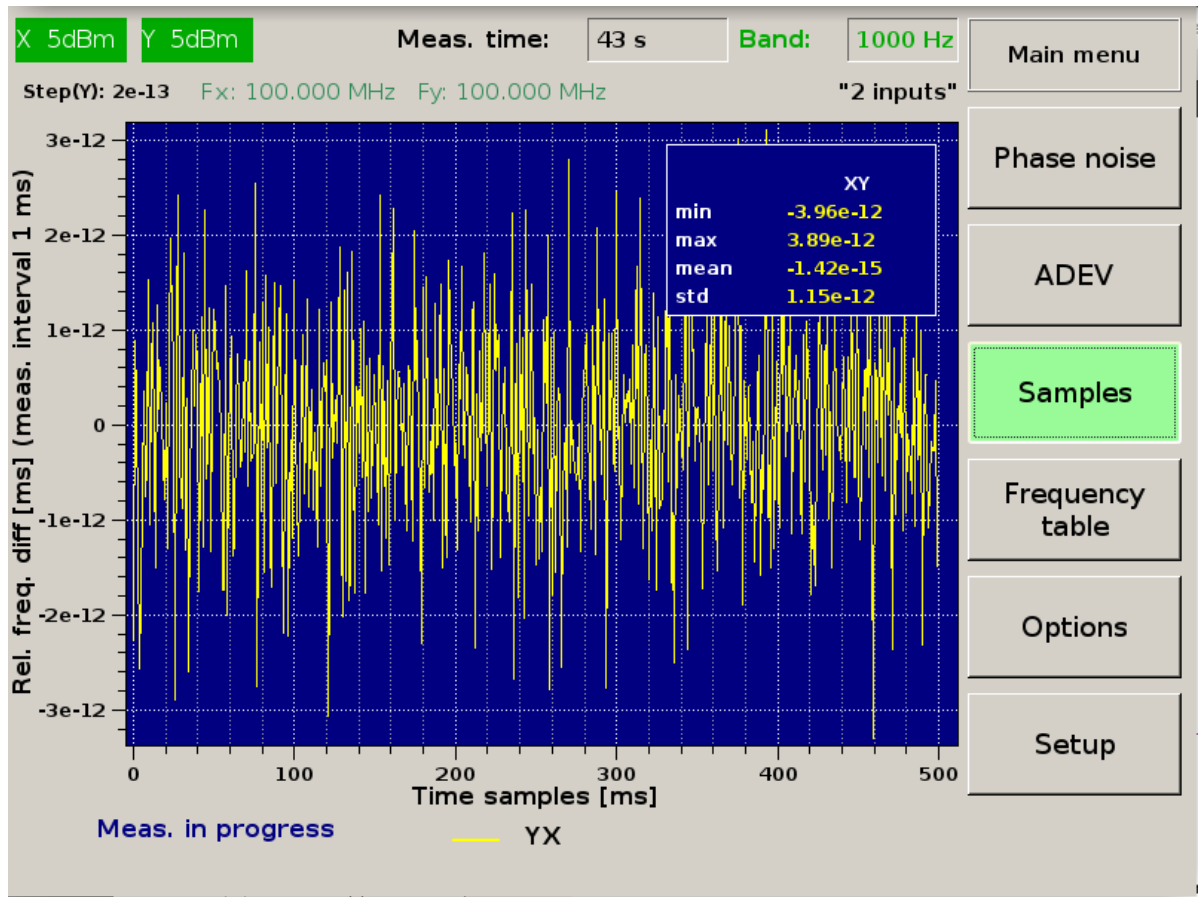


Figure 10. Statistical parameters table (frequency samples case)

"Phase samples" key. See the soft keys group pos. 3 on Figure 3. When this menu item is selected the graphs of the mutual phase differences are displayed on the screen (regardless of the measurement mode). The phase differences are displayed in seconds. Example of such phase difference at t_n moment for signals at the inputs Y and X:

$$x_{Y1,X}(t_n) = \frac{1}{2\pi} \left[\frac{\theta_{Y1}(t_n)}{f_{Y1}} - \frac{\theta_X(t_n)}{f_X} \right] \quad (3)$$

In (3), θ is the phase in radians, and f is the frequency of the corresponding input signal in Hz. The sampling period τ depends on the selected frequency band: 0.001 s for the 1000 Hz band, 0.01 s for the 100 Hz band, 0.1 s for the 10 Hz band and 1 second for the 1 Hz band.

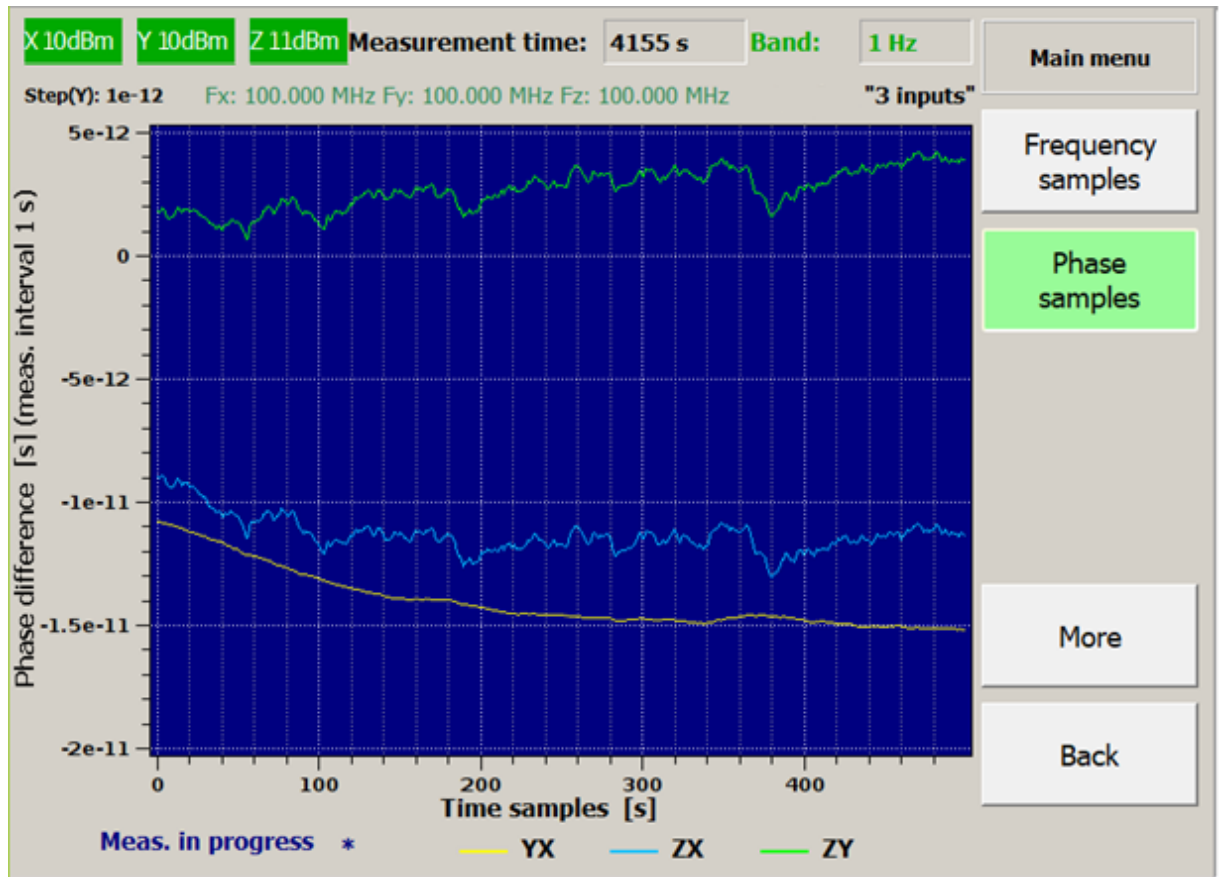


Figure 11. Phase differences graphs

"Frequency samples" key. See the soft keys group pos. 3 on Figure 3. When this menu item is selected, the graphs of mutual relative frequency differences are displayed on the screen (regardless of the measurement mode). Example of a relative frequency difference for signals at the **Y** and **X** inputs:

$$y_{Y,X}(t_n) = \frac{1}{\tau} [x_{Y,X}(t_n + \tau) - x_{Y,X}(t_n)] \quad (4)$$

Relative frequency difference y is calculated over a time interval τ , where τ is the sampling period. For the frequency band 1000 Hz – $\tau = 0.001$ s, 100 Hz – $\tau = 0.01$ s, 10 Hz – $\tau = 0.1$ s, for the 1 Hz band – $\tau = 1$ s.

"Option" key for phase or frequency graphs. See the soft keys group pos. 3 on Figure 3. Press the "Options" key (from the soft keys group pos. 3 on Figure 3) to enter menu that allows to choose between phase ("Phase samples") and frequency ("Frequency samples") outputs. Press the "More" key (from the

soft keys group pos. 3 on Figure 3) to enter menu that allows to save screenshots ("Save image") in a graphic file (select format by pressing the corresponding menu buttons) and to change the measurement time interval ("Measurement interval") and to make scaling ("Scale options": opens the same menu as "CURSOR" button described above). Intervals for phase measuring and time of frequency averaging can take the following values: 1 ms, 10 ms, 100 ms, 1 s for the 1000 Hz band; 10 ms, 100 ms, 1 s, 10 s for the 100 Hz band; 100 ms, 1 s, 10 s, 100 s for the 10 Hz band and 1 s, 10 s, 100 s, 1000 s for the 1 Hz band.

"**ADEV**". See the soft keys group pos. 3 on Figure 3. This menu item shows ADEV of mutual frequency differences or ADEV of the separate signals frequencies graphs.

ADEV of the relative frequency differences for the "**Two input**" mode in 10, 100 and 1000 Hz bands is calculated by formula (for the pair of signals Y, X):

$$\sigma_{y_{Y,X}}(\tau) = \sqrt{\frac{1}{2(N-2)} \sum_{n=1}^{N-2} [y_{Y,X}(t_n + \tau) - y_{Y,X}(t_n)]^2} \quad (5)$$

In the formula (5) N is the number of phase counts, $\tau = t_n - t_{n-1}$.

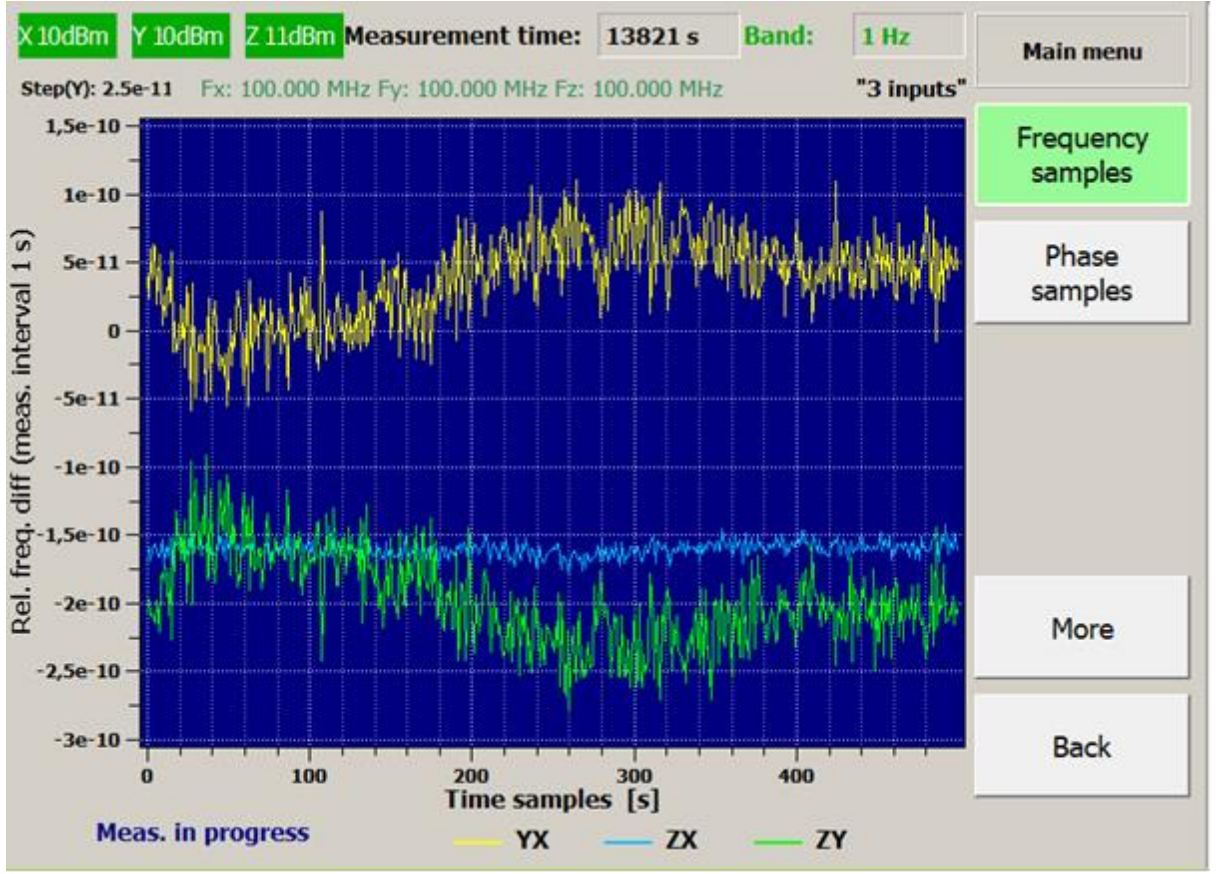


Figure 12. Relative frequency differences graph

The ADEV of the relative frequency difference in 1 Hz band with measurement time interval $\tau = m\tau_0$ is calculated using the following formula with overlaps to reduce the error associated with a finite number of counts:

$$\sigma_{y_{Y,X}}(m\tau_0) = \sqrt{\frac{1}{2(N-2m)(m\tau_0)^2} \sum_{n=1}^{N-2m} [x_{Y,X}(t_n+2m\tau_0) - 2x_{Y,X}(t_n+m\tau_0) + x_{Y,X}(t_n)]^2} \quad (6)$$

In the formula (6) N is the number of phase counts, $\tau_0 = t_n - t_{n-1} = 1$ s.

In the "2 inputs" measurement mode the noise added by the device (ADC noise mainly) is reduced by cross-correlation processing. For the 100 Hz band, the cross-correlation formula for calculating the ADEV is shown below:

$$\sigma_{y_{Y,X}}(\tau) = \sqrt{\frac{1}{2(N-2)} \sum_{n=1}^{N-2} \sigma_{Y,X}^{\text{CHANNEL 1}}(t_n, \tau) \cdot \sigma_{Y,X}^{\text{CHANNEL 2}}(t_n, \tau)}, \quad (7)$$

where

$$\sigma_{Y,X}^{\text{CHANNEL } 1,2}(t_n, \tau) = y_{Y,X}^{\text{CHANNEL } 1,2}(t_n + \tau) - y_{Y,X}^{\text{CHANNEL } 1,2}(t_n) \quad (8)$$

– samples of the frequency variation in the corresponding measuring channel. In the formula (7) N is the number of phase counts.



Figure 13. ADEV (σ_y)

For the 1 Hz band, the ADEV is calculated by the cross-correlation formula with overlaps:

$$\sigma_{yY,X}(m\tau_0) = \sqrt{\frac{1}{2(N-2m)(m\tau_0)^2} \sum_{n=1}^{N-2m} \sigma_{Y,X}^{\text{CHANNEL } 1}(t_n, m\tau_0) \cdot \sigma_{Y,X}^{\text{CHANNEL } 2}(t_n, m\tau_0)} \quad (9)$$

where

$$\sigma_{Y,X}^{\text{CHANNEL } 1,2}(t_n, m\tau_0) = \frac{1}{m\tau_0} [x_{Y,X}(t_n + 2m\tau_0) - 2x_{Y,X}(t_n + m\tau_0) + x_{Y,X}(t_n)] \quad (10)$$

- samples of the frequency variation in the corresponding measuring channel calculated from the time-overlapping phase samples. In (9) N is the number of phase counts.

A table with the calculated ADEV values for the corresponding signal or a pair of signals (depending on the selected mode: ADEV YX or ADEV YX, ADEV ZX, ADEV ZY) for the measurement time intervals τ is shown in the upper right corner of the ADEV graph field. The table can be disabled or enabled by pressing the “ADEV” key. The ADEV value for a random measurement time interval can be read from the graph using the marker (Figure 9).

The measurement error intervals $\pm 2\sigma$ are shown on the ADEV graph, the estimated value falls within the marked intervals with $\approx 95\%$ probability. The σ value is estimated in the simplest way without the noise type analysis:

$$\sigma = \frac{\sigma_y}{\sqrt{N}}, \quad (11)$$

Where N is the number of frequency variations counts for the corresponding measurement time interval.

"ADEV options" menu. See the soft keys group pos. 3 on Figure 3. The "Options" menu in ADEV mode consists of two pages (Figures 14.1, 14.2).

Using keys on the first page of the "ADEV options" menu (Figure 13) you can:

- move the table with the calculated ADEV values to suitable parts of the graphs field by pressing “Change table position” button. You can choose upper right corner (Figure 14.1), upper left corner, bottom left corner (Figure 14.2) or bottom right corner for the table – to not overlap ADEV graphs;

- save the current screen image in a graphic file (similar to phase and frequency graphs)
- view ADEV values in a separate table. Depending on the mode and values selected for the output, the columns of the ADEV table (Figure 15) show: measurement time interval in seconds, ADEV values characterizing the mutual instability of the frequency of a pair of signals or the individual instability of a single signal, number of frequency variations counts used for ADEV estimation. You can use menu soft keys to scroll the table or save it in text form. To exit the ADEV table view mode click the "Main Menu" key.



Figure 14.1. "Options" menu for ADEV, page 1



Figure 14.2. "ADEV options" menu, page 2

Measurement time: 16471 s Band: 100 Hz
 Fx: 100.000 MHz Fy: 100.000 MHz Fz: 100.000 MHz "3 inputs"

ADEV options

Save as text

Up

Down

Main menu

Meas. in progress

YX ZX ZY

	tau, s	adev YX	adev ZX	adev ZY	N
1	0.01	2.41e-10	6.01e-11	4.08e-10	1647088
2	0.02	1.60e-10	3.99e-11	2.88e-10	823543
3	0.03	1.28e-10	3.19e-11	2.35e-10	549028
4	0.04	1.09e-10	2.73e-11	2.04e-10	411771
5	0.05	9.71e-11	2.43e-11	1.82e-10	329416
6	0.06	8.82e-11	2.20e-11	1.45e-10	274513
7	0.07	8.13e-11	2.03e-11	1.19e-10	235297
8	0.08	7.59e-11	1.90e-11	9.83e-11	205885
9	0.09	7.16e-11	1.79e-11	8.22e-11	183008
10	0.1	6.78e-11	1.69e-11	6.91e-11	164707
11	0.2	4.74e-11	1.19e-11	4.88e-11	82353
12	0.3	3.87e-11	9.68e-12	3.97e-11	54901
13	0.4	3.35e-11	8.37e-12	3.43e-11	41176
14	0.5	2.98e-11	7.52e-12	3.07e-11	32940

Figure 15. ADEV table

To go to the second page of the "ADEV options" click the "Next" key (Figure 14.1). The second page of the menu "ADEV options" is shown in Figure 14.2. You can call up the table and intervals of the ADEV measurement error on the ADEV graph using menu keys.

Saving table (key "Save as text" in Figure 15) creates a text file named AVARYYYMMDD_hh_mm_ss.txt, where YY is the year, MM – month, DD – day, hh – hour, mm – minutes, ss – seconds. An example of such file is shown in Figure 16. In addition to the table of ADEV values the file contains information on the frequencies of the input signals and the relative frequency differences estimated by the Kalman filter. The file is written to the data folder on the device (and to PC if remote control is active). It can be copied by connecting to the device via FTP protocol (see below).

AVAR191126_15_24_57.txt				
Fx = 100000000.000000 Hz				
Fy = 100000000.000000 Hz				
Fz = 100000000.000000 Hz				
dFyx=-1.747E-010				
dFzx=-1.405E-010				
dFzy=-2.246E-011				
tau, c	var YX	var ZX	var ZY	N
0.0040	2.41e-010	6.00e-011	4.03e-010	1703858
0.0050	1.60e-010	3.99e-011	2.85e-010	851928
0.0060	1.28e-010	3.19e-011	2.32e-010	567952
0.0070	1.09e-010	2.73e-011	2.01e-010	425963
0.0080	9.71e-011	2.43e-011	1.80e-010	340770
0.0090	8.82e-011	2.20e-011	1.44e-010	283975
0.0100	8.12e-011	2.03e-011	1.18e-010	243407
0.0200	7.59e-011	1.90e-011	9.77e-011	212981
0.0300	7.15e-011	1.79e-011	8.19e-011	189316
0.0400	6.77e-011	1.69e-011	6.90e-011	170384
0.0500	4.74e-011	1.19e-011	4.88e-011	85191
0.0600	3.86e-011	9.66e-012	3.96e-011	56794
0.0700	3.34e-011	8.35e-012	3.43e-011	42595
0.0800	2.98e-011	7.52e-012	3.07e-011	34076
0.0900	2.73e-011	6.81e-012	2.81e-011	28396
0.1000	2.54e-011	6.34e-012	2.61e-011	24339
0.2000	2.36e-011	5.93e-012	2.45e-011	21297
0.3000	2.24e-011	5.60e-012	2.31e-011	18930
0.4000	2.12e-011	5.31e-012	2.18e-011	17037
0.5000	1.51e-011	3.74e-012	1.58e-011	8518

Figure 16. ADEV table file

"Phase noise" menu. See the soft keys group pos. 3 on Figure 3. "Phase noise" menu shows the power spectral density (PSD) of the phase noise of the

measured signals. Power density is calculated by a weighted periodogram method. The phase data x is divided into P non-overlapping segments with D samples in each, so $DP \leq N$, where N is the number of the samples. In each segment the average phase difference for the given segment is subtracted from sample then the values are weighed in Hann window:

$$x^{(p)}[n] = w[n]x[n + pD],$$

$$w[n] = 0.5 \left(1 - \cos \frac{2\pi n}{D} \right) \quad (12)$$

Then PSD is calculated for each segment using the FFT ($D = 2^k$) and averaged:

$$S_x(f) = 2.5 \cdot 2 \cdot \frac{1}{P} \sum_{p=0}^{P-1} \frac{1}{DT} \left| T \sum_{m=0}^{D-1} x^{(p)}[m] \exp(-j2\pi f m T) \right|^2 \quad (13)$$

PSD for frequency f_0 is calculated by the formula:

$$S_\varphi(f) = 4\pi^2 f_0^2 S_x(f) \quad (14)$$

In "Two input" mode PSD is always calculated using the cross-correlation method by multiplying spectral components from two channels. The result is shown on the screen.

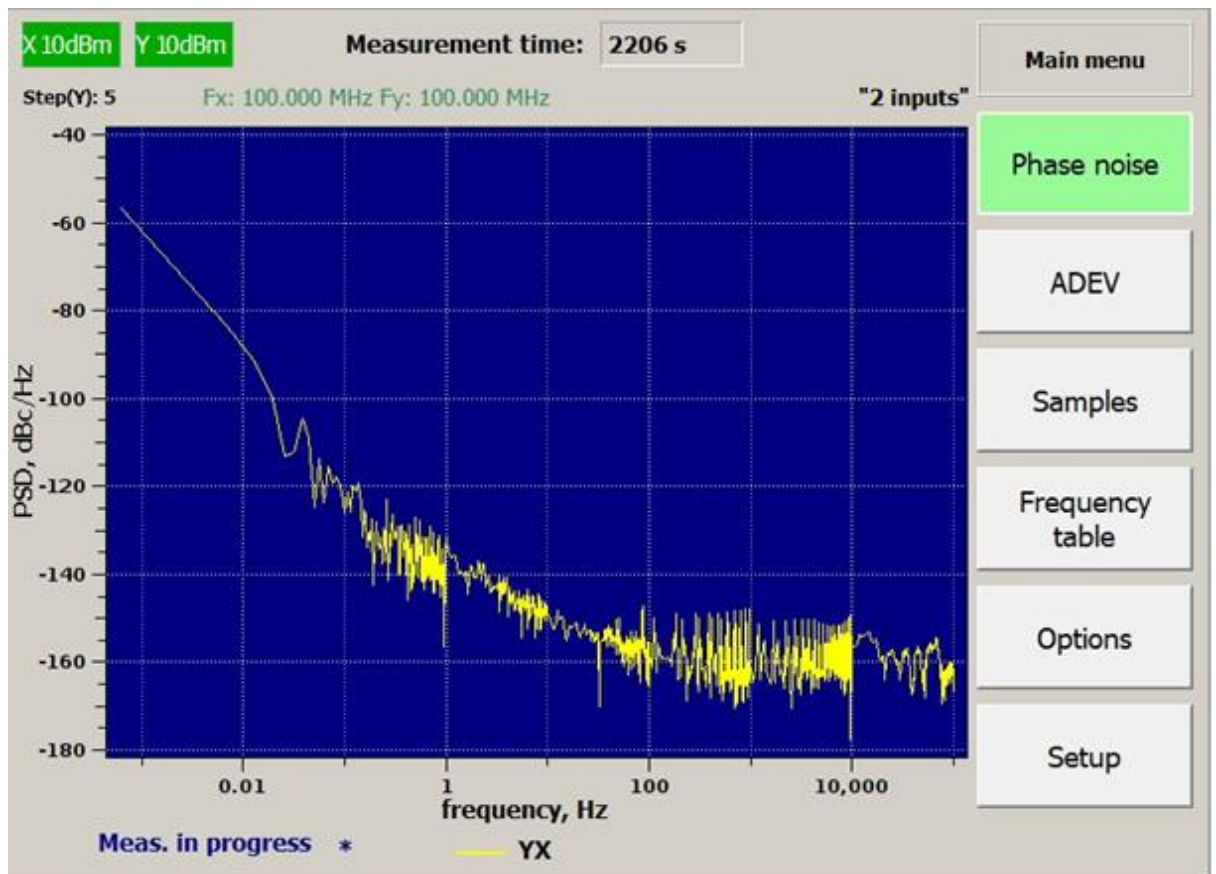


Figure 17. Spectrum for "Two input" mode

In "Three input" mode you can call up PSD graphs calculated by the cross-correlation method for the phase noise of the **XY** and **XZ** channels and the reference signal **X**.

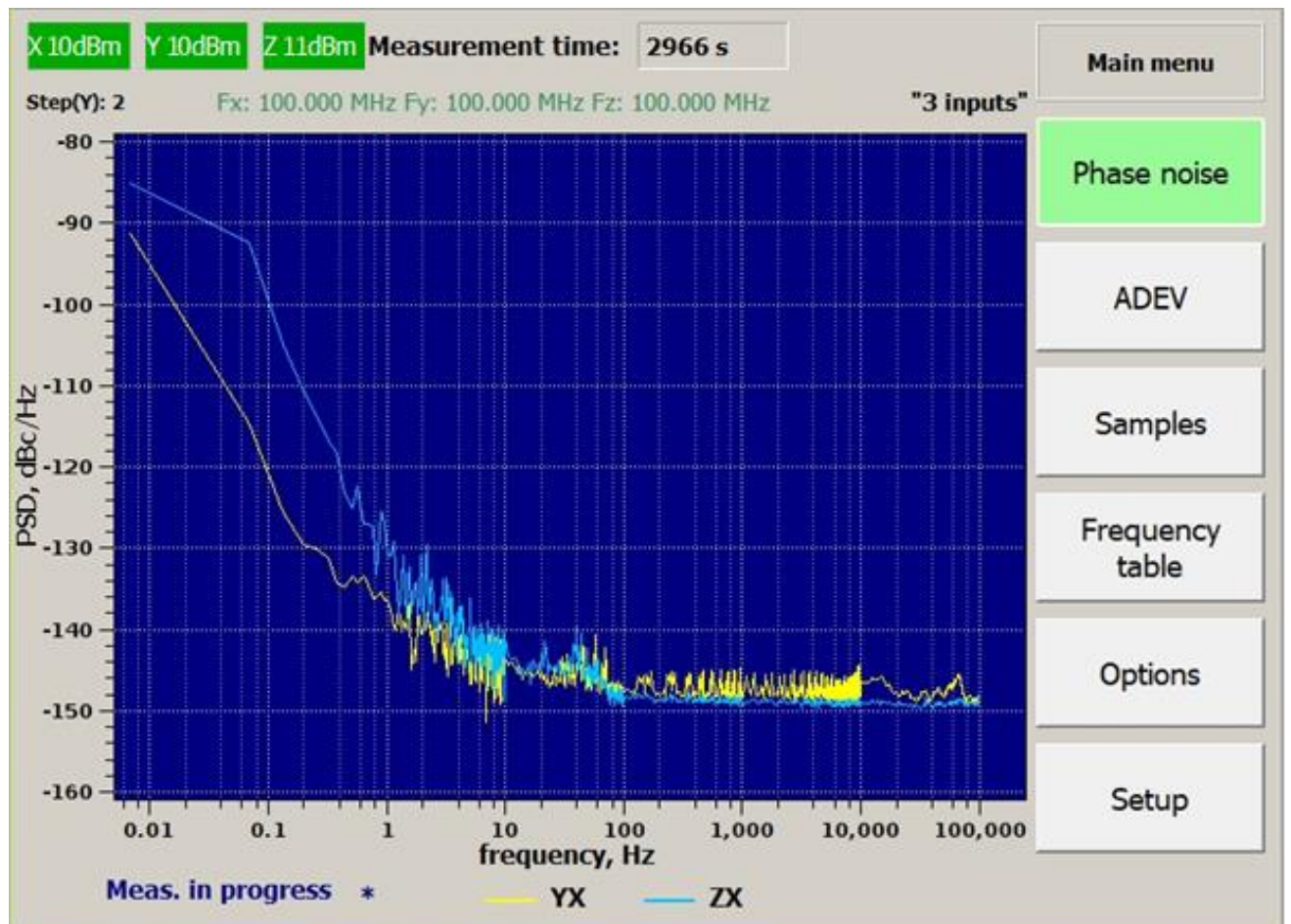


Figure 18. Spectrum for "Three input" mode

"Scale options" menu. In this menu automatic scaling can be disabled and then "phase samples", "frequency samples " and "phase noise" graphs can be manually shifted and scaled using the corresponding controls.

"Frequency table" menu. See the soft keys group pos. 3 on Figure 3. Frequency table (Figure 19) shows average relative frequency differences calculated for different averaging times.

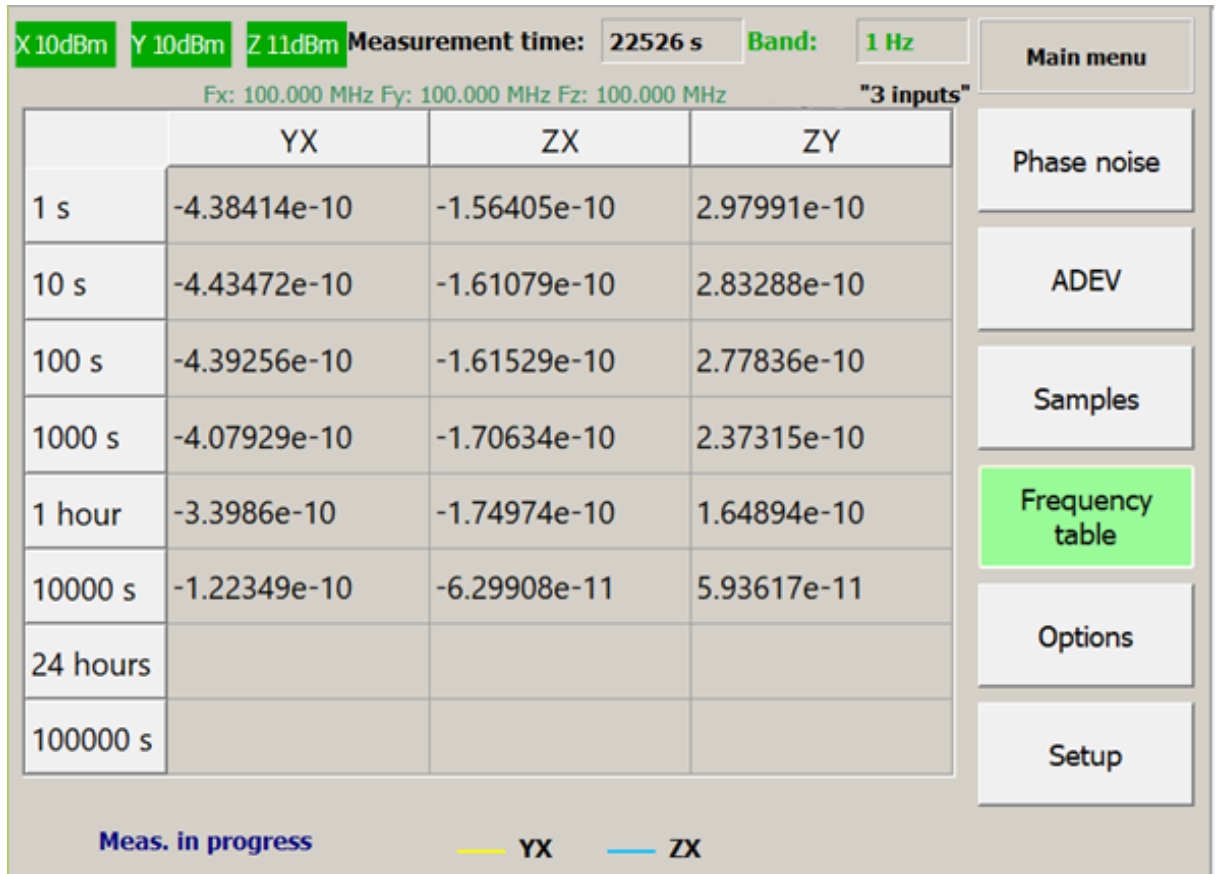


Figure 19. Frequency table

"Device setup" menu. Click the "Setup" key (from the soft keys group pos. 3 on Figure 3) to open the "Device setup" menu (Figure 20). Software version, network settings, current date and time on the device, full operating time and serial number will be shown on the screen.

The menu contains "Delete records", "Date and time", "Network setup" and "Language" items.



Figure 20. "Device setup" menu

"Delete records" menu. To purge the catalogues with data and image files stored on the device, select the "Delete records" item in the "Device setup" menu (Figure 20). Setup window will appear (Figure 21, the first image). Pressing "Delete data" or "Delete images" button will open a file browser (Figure 21, the second image), which allows to navigate through the corresponding catalogue to select and delete files.

Device setup

Device software version: 1.19.09

Device ip: 192.168.2.181

Subnet mask: 255.255.0.0

Control port: 1111

Date and time: 26.11.19 19:13:58

Full operating time (hours): 395

Device serial number: 0000

Setup

Delete data

Delete images

Back

Select files to be deleted and press "Delete" button.

	Select	File name	Size (bytes)
1	<input type="checkbox"/>	190711_01.dat	314016
2	<input type="checkbox"/>	190711_01.inf	1038
3	<input type="checkbox"/>	190711_02.dat	314016
4	<input type="checkbox"/>	190711_02.inf	1038
5	<input type="checkbox"/>	190711_03.dat	314016
6	<input type="checkbox"/>	190711_03.inf	1038
7	<input type="checkbox"/>	190712_01.dat	947844
8	<input type="checkbox"/>	190712_01.inf	346
9	<input type="checkbox"/>	190712_02.dat	947844
10	<input type="checkbox"/>	190712_02.inf	346
11	<input type="checkbox"/>	190712_03.dat	947844
12	<input type="checkbox"/>	190712_03.inf	346
13	<input type="checkbox"/>	190713_01.dat	947916
14	<input type="checkbox"/>	190713_01.inf	346
15	<input type="checkbox"/>	190713_02.dat	947916
16	<input type="checkbox"/>	190713_02.inf	346

Setup

Up

Down

Select

Select all

Delete

Back

Figure 21. Records deletion

Date and time setup. To change date and time on the device, select the "Date and time" item in the "Device setup" menu (Figure 20). Setup window will appear (Figure 22). Date and time digits can be set using "+" and "-" buttons, "←" and "→" buttons allow to move between digits. To confirm changes, "Apply" button should be pressed.

Setup date

D D . M M . Y Y Y Y

27 . 11 . 2019

Setup time

H H : m m : S S

11 : 18 : 35

Setup

+

-

->

<-

Apply

Back

Figure 22. Date and time setup

Changing IP address, subnet mask and port. To change the network settings of the device, click the "Network setup" button (Figure 20). An example of the setup window is shown in Figure 23, the first image.

"DHCP" or "Static" network mode can be chosen by clicking "Static/DHCP" button. Active network mode is marked by ">" sign. Selecting the "IP setup" menu allows to edit IP address, subnet mask and control port in the same way as the date and time values. An example of "IP setup" menu is shown in Figure 23, the second image.

Device IP-address

192.168.001.137

Subnet mask

255.255.000.000

Control port

1111

Setup

Static
>DHCP

IP setup

Apply

Back

Device IP-address

192.168.001.137

Subnet mask

255.255.000.000

Control port

1111

Setup

+

-

->

<-

Apply

Back

Figure 23. Network settings (network mode and IP setup)

Language menu. To change the GUI language, select the "Language" item in the "Device setup" menu (Figure 20) and then activate "English" or "Russian" key in the menu. To apply the changes, restart the program (turn the Device off and then turn it on), see Figure 24.

The screenshot displays the 'Device setup' menu with the following configuration parameters and values:

Parameter	Value
Device software version:	1.20.08
Device ip:	N/A
Subnet mask:	N/A
Control port:	1111
Date and time:	13.08.20 10:00:24
Full operating time (hours):	3
Device serial number:	0000

On the right side of the menu, there are three buttons: 'Setup', 'English' (highlighted in green), and 'Russian'. At the bottom center, a red text prompt reads: 'Restart device to set up selected language!'. At the bottom right, there is a 'Back' button.

Figure 24. " Language" menu

Output settings. This menu allows activating the option for saving measurement data in ASCII files in addition to binary files in the folder “samples” shared via FTP (see Figure 25).



The screenshot displays a web-based configuration interface titled "Device setup". It lists several system parameters with their current values in blue text. On the right side, there are three buttons: "Setup", "ASCII output", and "Back".

Parameter	Value
Device software version:	1.20.08
Device ip:	N/A
Subnet mask:	N/A
Control port:	1111
Date and time:	11.08.20 15:57:50
Full operating time (hours):	1
Device serial number:	0000

Figure 25. Output settings

5.4 Copying data by FTP

The Device allows to copy files using FTP protocol to a PC on the same LAN with the Device or directly connected to the Device via LAN interface.

FTP server program starts automatically (with a LAN cable connected) after the Device is turned on and the GUI is loaded. To copy files, you need to establish an FTP connection with the device using IP address shown in the device setup menu (Figure 20). You can use the widespread Winscp client, FileZilla or Internet browser. If there is no FTP connection, connect a LAN cable and reboot the device.

Use anonymous login to access FTP folder (no user name and password to be entered if you use Internet browser or Windows Explorer).

Saved images files are located in the “**image**” directory. Files with the samples of relative phase differences data are located in the “**samples**” directory.

The folder “**samples**” contains “*.inf” and “*.dat” files, which can be opened by Analyser program, available on the web-site:

http://www.vremya-ch.com/english/support/supp_set/set_Analyser/index.html

The folder “**samples**” can contain “.txt” files in ASCII format if this option was activated in the menu “Setup”.

Using FTP connection, you can only copy to PC, except the folder “**update**”. This folder can be used for embedded software update. If required the file “update.zip” provided by the vendor to be copied to this folder and switch off/on procedure to be applied for automatic update.

5.5 Measurement modes

5.5.1 "2 inputs" mode

We can reduce the Device measurements error by using two identical measuring channels (see Figure 2). In this case we supply the same signals Y and X to both channels. Technically, this is done by switching the channel input from connector “**└ Z**” to connector “**└ Y**” using a relay.

ADEV of the relative frequency differences in the "Two input" mode is described by formula (for the pair of signals Y, X):

$$adev_{YX} = \sqrt{\sigma_Y^2 + \sigma_X^2}, \quad (15)$$

σ_Y^2, σ_X^2 – Allan variation of Y and X signals.

NOTE From a comparison of formula (15) and table 7 (number 1,2), it is seen that the measurement error of ADEV for the pair of signals Y, X in "2 inputs"

mode is less than the measurement error for the pair of signals Y, X in "3 inputs" mode due to the lack of instability introduced by the Device measuring channels.

For the "2 inputs" mode measurement use the configuration shown in Figure 26.

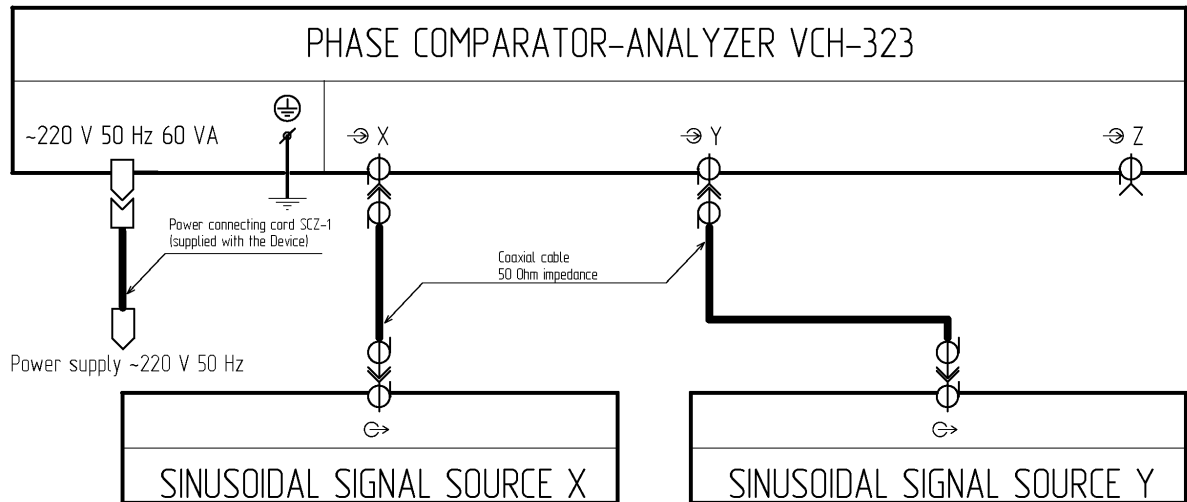


Figure 26. "2 inputs" mode configuration

5.5.2 "3 inputs" mode

For the "3 inputs" mode measurement use the configuration shown in Figure 27.

It is the most advanced mode, when we use for instability measuring three oscillators and two identical measuring channels. One can see three main advantages of this mode:

- simultaneous frequency instability measuring of three oscillator's
- calculation frequency instability of each individual oscillator
- reduced systematic error due to frequency instability of reference signal and measuring channels.

Table 7 shows calculated functions and corresponding mathematical expectation

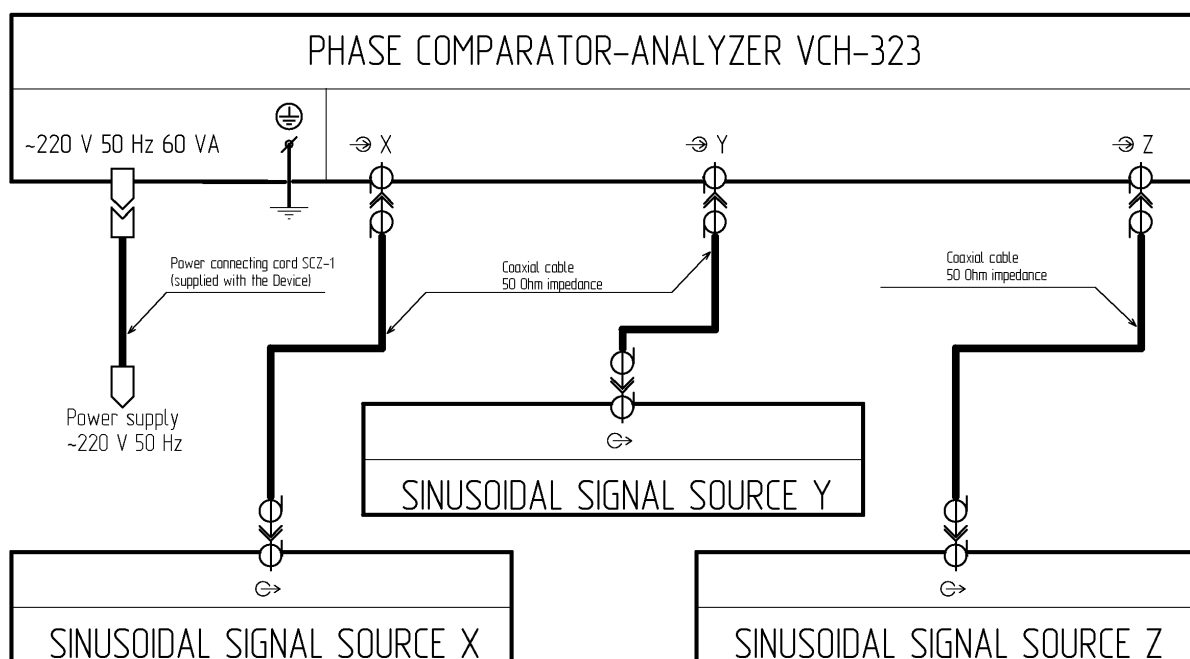


Figure 27. "3 inputs" mode configuration.

Table 7 – Available functions for "3 inputs" mode

Num-ber	Calculated functions	Mathematical expectation
1	Allan deviation for pair of signals YX (adev YX)	$\sqrt{\sigma_Y^2 + \sigma_X^2 + \sigma_{C_Y}^2}$
2	Allan deviation for pair of signals ZX (adev ZX)	$\sqrt{\sigma_Z^2 + \sigma_X^2 + \sigma_{C_Z}^2}$
3	Allan deviation for pair of signals YZ (adev YZ)	$\sqrt{\sigma_Y^2 + \sigma_Z^2 + \sigma_{C_Y}^2 + \sigma_{C_Z}^2}$
4	Allan deviation for signal X (adev X)	$\sqrt{\sigma_X^2}$
5	Allan deviation for signal Y (adev Y)	$\sqrt{\sigma_Y^2 + \sigma_{C_Y}^2}$
6	Allan deviation for signal Z (adev Z)	$\sqrt{\sigma_Z^2 + \sigma_{C_Z}^2}$

where

$\sigma_Y^2, \sigma_Z^2, \sigma_X^2$ – Allan variation of Y, Z and X signals,

$\sigma_{C_Y}^2, \sigma_{C_Z}^2$ – Allan variation of measuring channels.

NOTE

Available functions number 1, 2, 3 are results, having systematic error due to instability of reference signal X and measuring channels.

Available functions number 5, 6 are results, having systematic error due to instability of measuring channels.

Available function number 4 is result having no systematic error.

Thus we can measure without systematic error only signal X.

NOTE All error calculations were made supposing that frequency fluctuations of tested signals' and comparators' are independent. It is close to real practice only for short-term stability ($\tau=1$; 10 and may be 100 s).

6 Verification of the device

6.1 Introduction

This procedure is used to verify the basic measurement errors:

- frequency instability noise floor (the Allan deviation – ADEV) for averaging times 0.01 s, 0.1 s, 1 s, 10 s, 100 s;
- phase noise floor $L(f)$, (the Power spectral density – PSD), for the input sinusoidal signal frequency 5 or 10 MHz (by user's choice) .

6.2 Service Equipment Required

Equipment required for the verification procedure is listed in Table 8.

Any equipment that satisfies the critical specification listed in the table 8 may be substituted for the recommended models.

Table 8 – Equipment required for the verification procedure

Instrument (Quantity)	Required Characteristics	Model
Sinusoidal signal source (1 piece)	<ul style="list-style-type: none">- Outputs- number of ports: 2- frequency: 5 MHz, 10 MHz- amplitude: (1.0 ± 0.2) V_{rms}- load impedance: 50 Ohm- phase noise spectral density: not more -140 dBc/Hz- stability, two-samples Allan variance for averaging time 1 s: not more 5.0×10^{-11}	—
Adaptor N to BNC (3 pieces)	Connectors: N plug , BNC jack. Impedance: 50 Ohm. Frequency range: 5 to 100 MHz	Adaptor N to BNC 33 N-BNC-50-1/133 UE (supplied with the device)

Table 8 Continue

Instrument (Quantity)	Required Characteristics	Model
Three way reactive power divider (1 piece)	Connectors: SMA jack (4 pieces). Impedance: 50 Ohm. Frequency range: 5 to 10 MHz.	High Power Combiner ZA3CS-400-3W-S (supplied with the device)
Special cables (3 pieces)	Coaxial cable, length: 0.2 to 0.5 meters Connectors: SMA cable plug, BNC cable plug. Impedance: 50 Ohm.	RF interconnecting SMA/BNC cable 685661.031 (supplied with the device)
Special cable (1 piece)	Coaxial cable, length: 1.5 to 3.0 meters Connectors: SMA cable plug , BNC cable plug. Impedance: 50 Ohm.	RF interconnecting SMA/BNC cable 685661.032 (supplied with the device)

6.3 Environmental Control

6.3.1 The quality of the measurements made by the Device is highly influenced by environmental conditions.

6.3.2 The Device and all test equipment used during this verification procedure shall be shielded from air drafts. Also, the device and all test equipment used during this verification procedure shall be isolated from all sources of shock and vibration.

6.3.3 Verification procedure operating conditions:

- Ambient temperature range: +5 °C to +40 °C;
- Ambient temperature change: no more than 1 °C/hour;
- Relative humidity: 30 % to 80 %;
- Atmospheric pressure: 70 kPa – 106,7 kPa (537 mm Hg to 800 mm Hg);
- Power supply: (220±22) V, (50±2) Hz AC.

6.4 Test A. The frequency instability noise floor checking

6.4.1 Make preparation for measurement according section 5.2

6.4.2 For the frequency instability noise floor checking use the configuration shown in Figure 28.

The frequency of sinusoidal signal source may be 5 or 10 MHz by user's choice.

Use adaptor N to BNC 33 N-BNC-50-1/133 UE (supplied with the device) for docking of RF interconnecting SMA/BNC cables 685661.031 and the Device connectors “ \perp X”, “ \perp Y”, “ \perp Z”.

6.4.3 Set “3 inputs” mode and run measurement by pressing the **"START"** button on the front panel of the device.

6.4.4 Allow the Device to collect data until the data collection period is in the range 150 to 200 minutes.

CAUTION! Bumping or moving cables or the device or the signal source will invalidate the following tests.

6.4.5 Finish measurement by pressing the **"STOP"** button on the front panel of the Device.

6.4.6 Press the **"BW"** button on the front panel of the device. Then by pressing the soft keys set bandwidth 100 Hz.

6.4.7 Press the soft keys to navigate to the ADEV table with the calculated ADEV values for pair of signals YX and ZX (ADEV YX, ADEV ZX).

Record the calculated ADEV values for pair of signals YX and ZX (ADEV YX, ADEV ZX) at $\tau = 0.01\text{ s}$, 0.1 s to the Device checking report (the Table – Test A. The frequency instability noise floor checking).

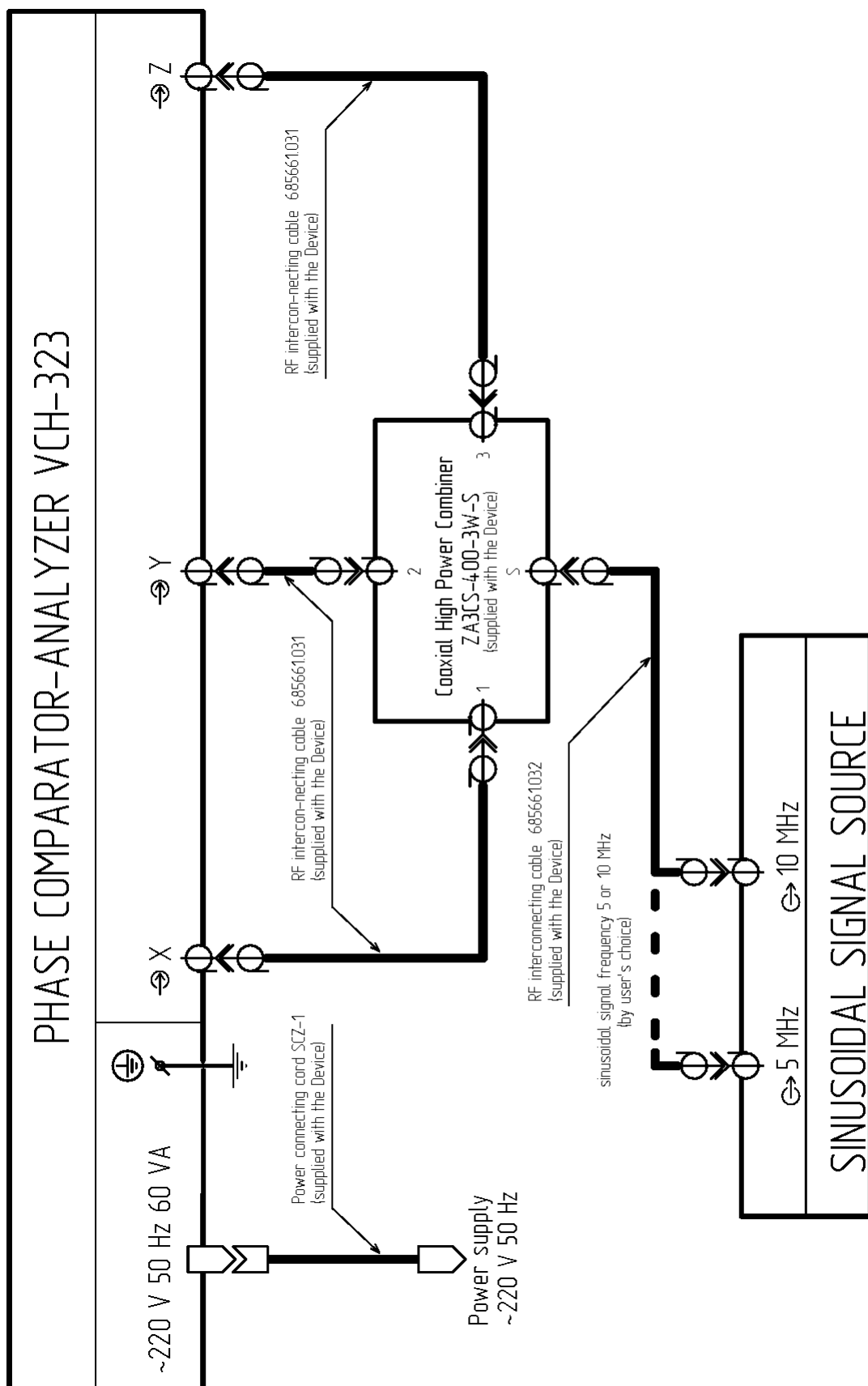


Figure 28. Noise floor checking configuration

6.4.8 Press the soft keys to navigate to the ADEV table with the calculated ADEV values for individual signal X (ADEV X).

Record the calculated ADEV values for individual signal X (ADEV X) at τ 0.01 s, 0.1 s to the Device checking report (the Table – Test A. The frequency instability noise floor checking).

6.4.9 Press the "**BW**" button on the front panel of the Device. Then by pressing the soft keys set bandwidth 1 Hz.

6.4.10 Press the soft keys to navigate to the ADEV table with the calculated ADEV values for pair of signals YX and ZX (ADEV YX, ADEV ZX).

Record the calculated ADEV values for pair of signals YX and ZX (ADEV YX, ADEV ZX) at τ 1 s, 10 s, 100 s to the Device verification report (the Table – Test A. The frequency instability noise floor checking).

6.4.11 Press the soft keys to navigate to the ADEV table with the calculated ADEV values for individual signal X (ADEV X).

Record the calculated ADEV values for individual signal X (ADEV X) at τ 1 s, 10 s, 100 s to Device checking report (the Table – Test A. The frequency instability noise floor checking).

6.4.12 Verify that the calculated ADEV values for pair of signals YX, ZX (ADEV YX, ADEV ZX) and for individual signal X (ADEV X) at τ 0.01 s, 0.1 s, 1 s, 10 s, 100 s are less than the value in the table 2 at each specified averaging time.

6.5 Test B. The phase noise floor checking

6.5.1 This checking uses the data just collected during the frequency instability noise floor checking.

6.5.2 Press the soft keys to navigate to the PSD graphs calculated for pair of signals YX and ZX (PSD YX, PSD ZX).

Record the PSD values for pair of signals YX and ZX (PSD YX, PSD ZX) at frequency offset 1 Hz, 10 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz to the Device checking report (the Table – Test B. The phase noise floor checking).

- 6.5.3 Press the soft keys to navigate to the PSD graphs calculated for individual signal X (PSD X).

Record the PSD values for individual signal X (PSD X) at frequency offset 1 Hz, 10 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz to the Device checking report (the Table – Test B. The phase noise floor checking).

- 6.5.4 Verify that the calculated PSD values for pair of signals YX and ZX (PSD YX, PSD ZX) and for individual signal X (PSD X) are less than the value in the table 3 at each specified frequency offset and frequency of the input sinusoidal signal.

6.6 Device verification report

Below is a possible form of the Device verification report.

Table A records the calculated ADEV values obtained in the execution of section 6.4.

Table B records the calculated PSD values obtained in the execution of section 6.5.

Device verification report

Date _____

Model Type _____

Serial Number _____

Table A – Test A. The frequency instability noise floor checking

Averaging time, tau	Allan deviation		
	ADEV YX	ADEV ZX	ADEV X
0.01 s			
0.1 s			
1 s			
10 s			
100 s			

Table B – Test B. The phase noise floor checking

Frequency offset	Power spectral density, dBc/Hz		
	PSD YX	PSD ZX	PSD X
1 Hz			
10 Hz			
100 Hz			
1 kHz			
10 kHz			
100 kHz			