V R E M Y A – C H
Joint Stock Company

MULTICHANNEL FREQUENCY COMPARATOR

VCH-315M

Operation Manual

411146.039OM

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*

Table of contents

1 List of abbreviations

ADEV – Allan deviation

PC – personal computer

RS232 – serial port

Multichannel frequency Comparator VCH-315M – device

2 Safety precaution

2.1 Carefully read the operating manual before working with the device and note the safety information.

2.2 Accessible conductive parts of the device are protected by basic insulation and electrically connected to the protective grounding.

2.3 The device is grounded via protective conductor in the power cable and protective earth terminal marked ⏚ on the rear panel.

2.4 The device is connected to the AC via three-wire power cable (two poles and ground) included in the device kit.

2.5 To avoid the influence of static electricity all further connections must be made only with the grounded device.

2.6 You must avoid contact with current-carrying parts during repair as it may result in shock.

2.7 Before touching any components or wiring always unplug the device.

2.8 All repair and maintenance of the device must be carried out by qualified personnel authorized for work on high voltage (up to 1000V).

2.9 RS-232 interface cable should be connected only when the the device is turned off. Failure to do so may result in damage to the interface.

3 Device description

3.1 Description and operation

Multichannel frequency comparator VCH-315M is intended for simultaneous frequency instability measurements of a group of sinusoidal signals 5, 10, 100 MHz.

Device can be managed and measurement results can be displayed and stored using a PC and special software. Monitored parameters and control commands are transferred via RS-232 interface, USB or local area network – LAN.

The external view of the device is given in Fig. 1.

3.2 Key applications

The main applications of the device:

− crystal and quantum frequency standards production and checking;

− scientific research.

− in metrology as an integral part of the storage systems;

− as an integral part of automated measurement systems. Built-in RS-232, USB and LAN interfaces provide remote measurement of the monitored signals frequency instability characteristics.

Figure 1 – External view of the device

3.3 Product composition

The device composition is given in Table 1.

Table 1 – Device composition

	Model and designation	Quantity
1.	Multichannel frequency comparator VCH-315M	1
2.	Fuse 3,15 A	6
3.	Power connecting cord	1
4.	Interface RS-232 cable 685622.003	1
5.	Interface cable USB 2.0 AM/BM-1.8M	1
6.	Power splitter ZFSC-2-1W-S+	2
7.	RF interconnecting cable 685670.372	4
8.	RF interconnecting cable 685670.376	2
9.	Multichannel frequency comparator VCH-315M Installation disc	1
10.	Multichannel frequency comparator VCH-315M Operating Manual	1
11.	Multichannel frequency comparator VCH-315M User guide	1

3.4   Product specifications

3.4.1 The device is managed and measurement results are displayed and stored using a PC. Monitored parameters and control commands are transferred via RS-232 interface, USB or LAN. The PC must meet the following **minimum** requirements:

- − Processor: Intel Pentium-IV 2 GHz or similar;

- − Operating system: Microsoft Windows^{TM} XP, Vista, 7, 8, 10;

- − RAM: 512 MB.

3.4.2 Input signal parameters:

- − nominal frequencies – 5; 10; 100 MHz;

- − RMS voltage: (1,0±0,2) V at (50±1) Ohm;

- − relative frequency difference: $-5,0\times10^{-9}$ to $+5,0\times10^{-9}$.

3.4.3 Number of measuring channels: 8 (eight modules with two inputs for the measured signals ("⟳fx", "⟳fy").

3.4.4 Averaging time range, τ: from 1 s up to 1 day.

3.4.5 Noise passband: 3 Hz.

3.4.6 Warm-up time:

- − 2 h, for averaging time range not more 100 s;

- − 6 h, for averaging time range >100 s.

3.4.7 Frequency instability introduced by device – Allan deviation (at zero frequency difference between input signals and temperature deviation not more than $\pm 1{,}0$ °C per hour within the operating temperature range), is displayed in the Table 2.

Table 2 – Frequency instability, introduced by device

Averaging time, τ	Frequency instability introduced by Multichannel frequency comparator VCH-315M	
	"One-channel" mode, ADEV	"Two-channels" mode, cross-ADEV
1 s	6.0×10^{-14}	2.0×10^{-14}
10 s	2.0×10^{-14}	3.0×10^{-15}
100 s	3.0×10^{-15}	1.0×10^{-15}
1 h and more	3.0×10^{-16}	2.0×10^{-16}

Note: frequency instability introduced by the comparator is guaranteed after warm-up time (according to s. 3.4.6).

3.4.8 The device provides continuous non-stop operation in working conditions with all specifications preserved.

3.4.9 Power supply voltage:

 − AC power supply: (220 ± 22) V, (50 ± 1) Hz;

 − DC power supply: $(22 - 30)$ V.

3.4.10 In the absence of AC voltage the device automatically switches to backup power from an external DC source. The device will retain its specifications during the AC/DC change-over.

3.4.11 Power consumption:

   – AC power supply: not more 40 VA;

   – DC power supply: not more 35 W.

3.4.12 Ambient temperature:

   – operating: +5 to +40 °C,

   – non-operating: –50 to +50 °C.

3.4.13 Weight: no more than 12 kg net; 16 kg in factory package.

3.4.14 Dimensions: 133×483×325 mm.

3.5 Basic configuration and operation

3.5.1 Principle of operation

Device operation is based on phase-time method: information about the phase difference of the input signals is converted into time intervals that are measured by a digital time interval meter. Then the processor transfers these measurements to the computer where all the data is processed by a special program that gives the characteristics of the input signals instability in digital and graphical forms.

3.5.2 Description of the circuit diagram

Circuit diagram illustrating the operating principle of the device is shown in Figure 2

The device consists of these main parts:

- eight identical frequency comparators (channels);

- processor;

- signal and power bus;

- indication signal driver;

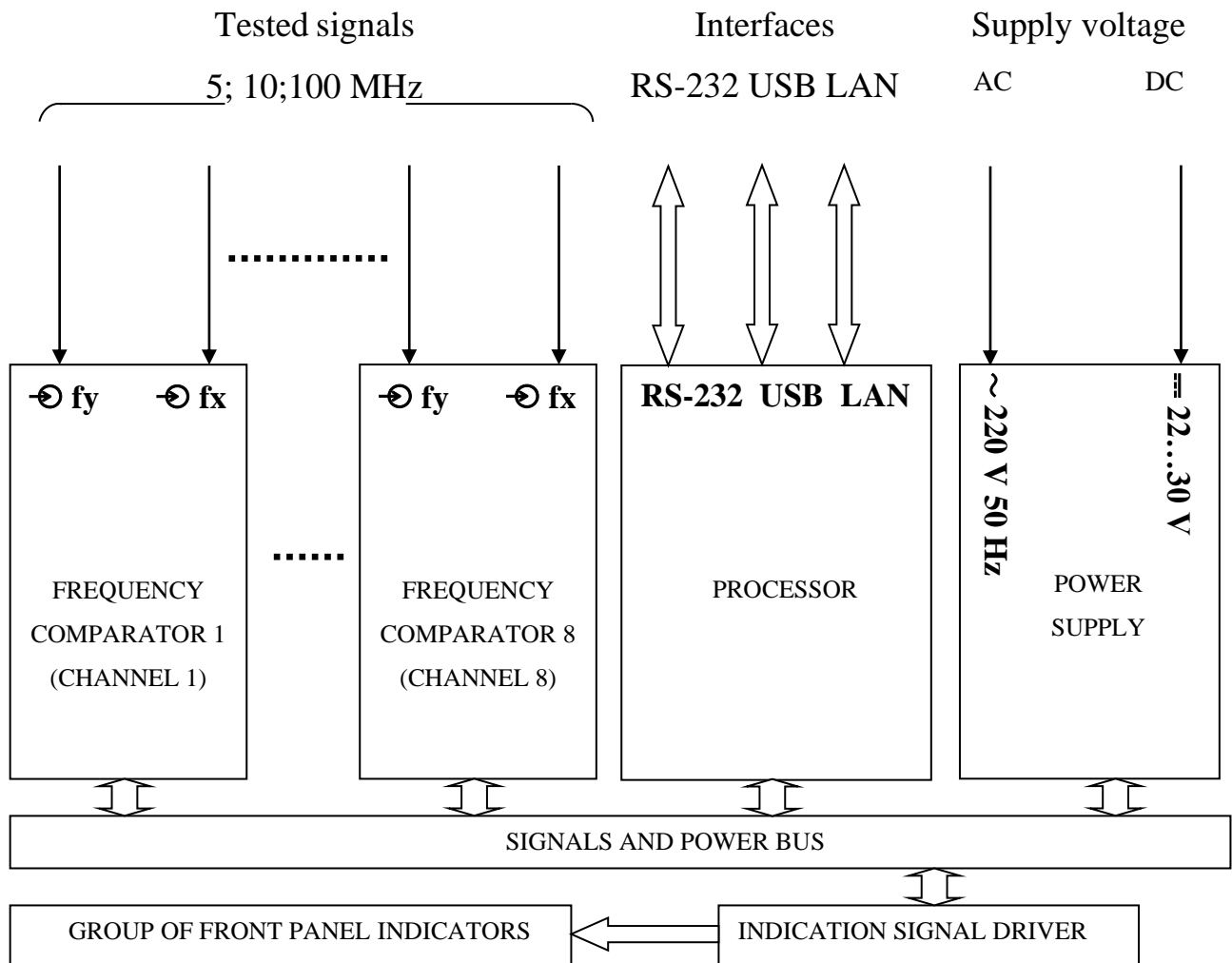- group of front panel indicators;

- power supply.

Tested signals   Interfaces   Supply voltage

5; 10;100 MHz   RS-232 USB LAN   AC   DC

Figure 2 – Circuit diagram

The frequency comparators measure the increment of the phase difference between the signals at the fx and fy inputs and feed the measured data to the processor.

Noise passband of 1 Hz is generated by digital filtering.

The processor receives the data from the frequency comparators, processes it, transmits to the PC and manages the operation of the frequency comparators by commands from the special program, and also controls the indicators. Transmission of measurement data to the computer and reception of control commands is carried out by the processor via RS-232, USB or LAN interfaces.

The power supply unit generates stabilized voltages (± 12 V, 5 V, 3.3 V) needed to power the device units from the 220 V AC. It also switches to backup DC power source with (22–30) V voltage.

The power supply unit has a AC 220 V indicator (**"POWER"**), an external DC (22–30) V power supply indicator (**"⎓ 22 ... 30 V, 35 W"**) indicator and a power supply unit normal operation indicator ("**NORM"**) which shows the presence of all output stabilized voltages of the power module.

The front panel group of indicators shows simultaneous presence of signals on the inputs "⟳ **fx**", "⟳ **fy**" for each of the eight frequency comparators ("**CHANNEL 1**" - "**CHANNEL 8**"). The indicators are green LEDs turning on and off at a frequency of about 1 Hz. The front panel also contains the AC 220 V power indicator and the external DC source indicator.

Indication signal driver generates indication signals and sends them to the front panel indicators by the processor command.

Power supply and internal information exchange between the device units are carried out via the signals and power bus. The device units are connected to it in parallel through the connecting plugs.

3.5.3 Remote control and monitoring

The device is controlled from PC using the special program via RS-232 interface, USB or LAN (Windows only).

The following functions are implemented in the program:

- receiving and automatic saving of measurement data from the comparator;

- calculation of statistical functions characterizing the frequency difference between two signals;

- display of measurement results and calculated functions in charts on the screen;

- printing charts on a printer connected to the computer.

The program for processing measurement data of frequency comparators/counters "Analyzer" is included with the program for control of multichannel frequency comparator VCH-315M. It provides the following functions:

- simultaneous processing of the data across multiple channels of the comparator, and the simultaneous processing of the data from several comparators (maximum number of concurrent entries – 32);

- processing of the previous measurements, and processing of the current measurement data with automatic update of charts and statistical characteristics;

- a wide range of computed parameters (mean relative frequency difference and frequency drift by least-squares method, standard deviation, Allan deviation, Hadamard deviation, maximum time interval error, time interval deviation, power spectral density of phase and frequency noise);

- calculation of the statistical characteristics with overlap method;

- elimination of the frequency drift;

- the cross-correlation processing that allows to reduce the noise level contribution of the comparator in the measurement of the frequency instability (with appropriate measurement scheme);

- the cross-correlation processing that allows to evaluate the characteristics of the frequency instability not only for pairs of signals, but also for each signal individually by the method of three oscillators.

4 Operating procedure

4.1 Safety requirements

Accessible conductive parts of the device are protected by basic insulation and electrically connected to the protective grounding

The device must be grounded before use via protective conductor in the power cable and protective earth terminal marked ⏚ on the rear panel

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

The device is connected to the AC via three-wire power cable (two poles and ground) included in the device composition.

ATTENTION! Usage of any other power plugs is STRICTLY PROHIBITED.

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

4.2 Location of control and connection systems

Connectors, indicators and control elements on the front and rear panels of the device, are shown in Figure 3.

The purpose of connectors, indicators and control elements on the front and rear panels of the device and their default states are given in Table 3.
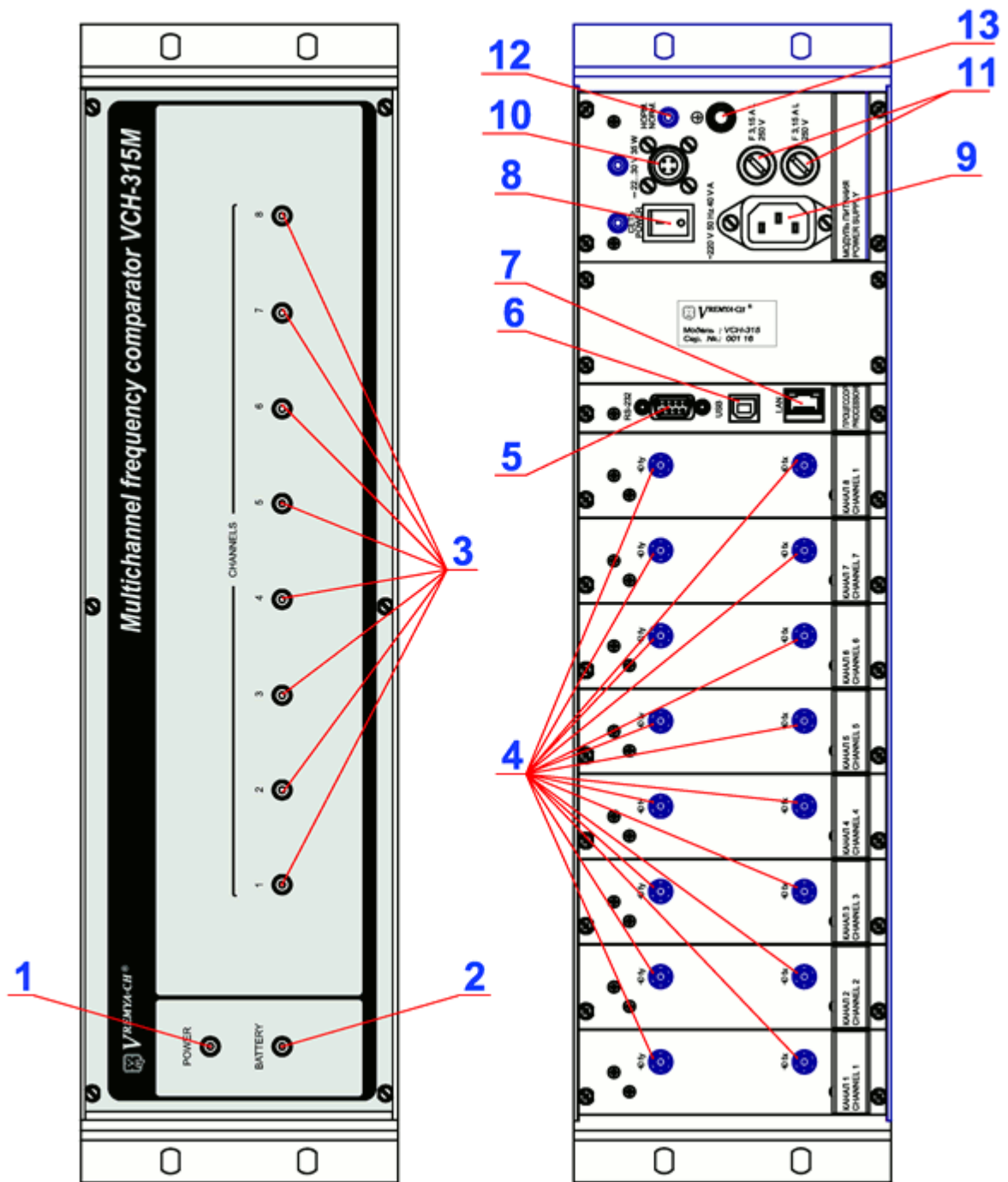
Figure 3 – Connectors, indicators and control elements on the front and rear panels

Table 3 – Connectors, indicators and control elements on the front and rear panels

No.	Designation	Usage
1	POWER	AC power indicator
2	BATTERY	DC power indicator
3	CHANNELS	Channel indicators
4	⊶fx, ⊶fy	Inputs for measured signals
5	RS-232	Serial RS-232
6	USB	USB interface
7	LAN	LAN interface (Ethernet)
8	POWER	AC power switch, AC power indicator
9	220 V 50 Hz 40 V·A	AC power socket
10	⎓ 22…32V 35 W	DC power socket, DC power indicator
11	F 3,15 A L 250 V	Protective fuse
12	NORM	Normal operation indicator of the power supply unit
13	⏚	Ground terminal

4.3 Preparing the device for use.

4.3.1 Operational limitations

It is recommended to place the device in a thermostabilized room with limited access to personnel. The place for the device should be chosen taking into account the dimensions of the device 133×483×325 mm and the need for free convection of air through the ventilation openings of the device casing.

Warning! Do not place the device near any engines, generators, transformers, or other equipment that may create magnetic fields and acoustic vibrations. Placement near such equipment may impair the performance of the device.

Power supply voltage:

- AC power supply: (100 – 240) V, 50 or 60 Hz;

- DC power supply: (22 – 30) V.

Ambient operating temperature: +5 to +40 °C,

Temperature deviation not more than ±1,0 °C per hour.

Device preserves its specifications after exposure to utmost conditions provided 6-hour warm-up time in normal operating conditions.

RS-232 interface cable should be connected only whet the device is turned off.

Warning! Failure to do so may result in damage to the device interface.

4.3.2 Preparation for measurements

Carefully read this operating manual before starting. Note the location of the controls and connections (Figure 3) for their purpose (Table 3).

Ensure reliable grounding of the device. The protective grounding terminal should be connected to the grounding conductor before other connections. The fasteners of the ground terminal ⏚ and the conductors must be securely fixed.

While the power is off, connect the device to the computer in one of the following ways:

- RS-232 socket of the device with one of the COM ports of the computer using the RS-232 interface cable;

- USB socket of the device with one of the USB ports of the computer using the USB interface cable;

- LAN interface with the local area network (Ethernet network) using a cable with an 8P8S connector.

Attention! Connecting the device to the COM port of the computer when the power of the device is turned on can damage the RS-232 interface of the device's processor.

Connect the power supply:

– from the AC power line (100 - 240) V, 50 or 60 Hz to socket "220 V, 50 Hz, 40 V·A"

– from the DC power supply: (22 – 30) V to "= 22…30 V" (backup power source).

Make sure that the "POWER", "NORM" and "= 22 ... 30 V 35 W" indicators on the power module panel are lit.

The "= 22 ... 30 V" indicator on the power unit panel lights up only if there is a DC voltage on the "= 22 ... 30 V 35 W" connector.

To connect an external power source use a power cable with a 2РМТ14КПН4Г1В1 (2PM14-4TKQB2) type connector. Pin 1 of the connector must be connected to the positive pole of the DC power supply, and pin 4 to the negative pole of the power supply (see Figure 4).

Pinout of DC power connector 2PMT14

+VDC — 1
-VDC — 4
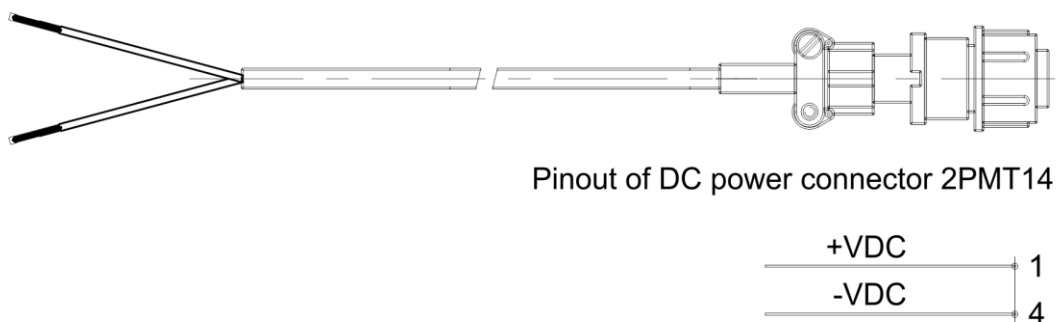
Figure 4 – DC power connecting cord

4.3.3 Program installation

Install the "Multichannel frequency comparator " program and the program for processing measurements of frequency comparators following the instructions given in the "Multichannel frequency comparator VCH-315M User Guide" and "Program for processing measurement data of frequency comparators/counters "Analyser" User Guide".

Before using the USB interface of the device install a PC driver that creates a virtual serial port when connecting the comparator via the USB interface, following the instructions in the "Multichannel frequency comparator VCH-315M. User guide".

To control the device via the Ethernet install the special software, following the instructions in the "Multichannel frequency comparator VCH-315M. User guide".

4.4 Operating procedure

4.4.1 Measurement process

Connect the measured signals according to the selected operating mode (see section 4.5 of this Operating manual).

Connection is carried out by coaxial cables with wave resistance of 50 Ohm and SMA type connectors. The tightening torque of SMA connectors should be between 0.8 and 1.1 N·m.

The device will be ready for use with the guaranteed frequency instability given in Table 2 after a warm-up period.

Start the measurements in the Multichannel frequency comparator program following the instructions in the "Multichannel frequency comparator VCH-315M User guide".

You can view the instability characteristics of the frequency of measured sinusoidal signals during or after the end of the measurements following the instructions in the "Multichannel frequency comparator VCH-315M User guide" and "Program for processing measurement data of frequency comparators/counters" Analyzer "User guide".

4.5 Measurement modes

4.5.1 "Two-oscillators, one-channel" mode

For any number of channels (one to eight) measured and reference signals (from the inputs "↻fy" and "↻fx" respectively) are involved in the measurements (see Figure 5) for each of the channels. The measuring program calculates the relative frequency difference and frequency instability of both signals and the channel itself.

Table 3 shows available functions and corresponding mathematical expectation for the measuring channel CHANNEL 1 calculated on the assumption that frequency fluctuations of all signals and measuring channel are independent.

Table 3 – Available functions for "two oscillators, one-channel" mode

Number	Calculated function	Mathematical expectation
1	Relative frequency difference measured for CHANNEL 1	$y_{y1}^N - y_{x1}^N + y_{c1}^N$
2	Standard deviation measured for CHANNEL 1	$\sqrt{\delta_{y1}^2 + \delta_{x1}^2 + \delta_{c1}^2}$
3	Allan deviation measured for CHANNEL 1	$\sqrt{\sigma_{y1}^2 + \sigma_{x1}^2 + \sigma_{c1}^2}$

where:

y_{y1}^N, y_{x1}^N – the average value of the relative frequency difference of "↻fx" and "↻fy" input signals on averaging interval $N \cdot \tau$;

y_{c1}^N – mean frequency difference introduced by the measuring channel CHANNEL 1;

$\delta_{y1}^2, \delta_{x1}^2, \delta_{c1}^2$ – N-sample variance of "↻fx" and "↻fy" input signals and the measuring channel CHANNEL 1;

$\sigma_{y1}^2, \sigma_{x1}^2, \sigma_{c1}^2$ – Allan variance of "⊙fx" and "⊙fy" input signals and the measuring channel CHANNEL 1.
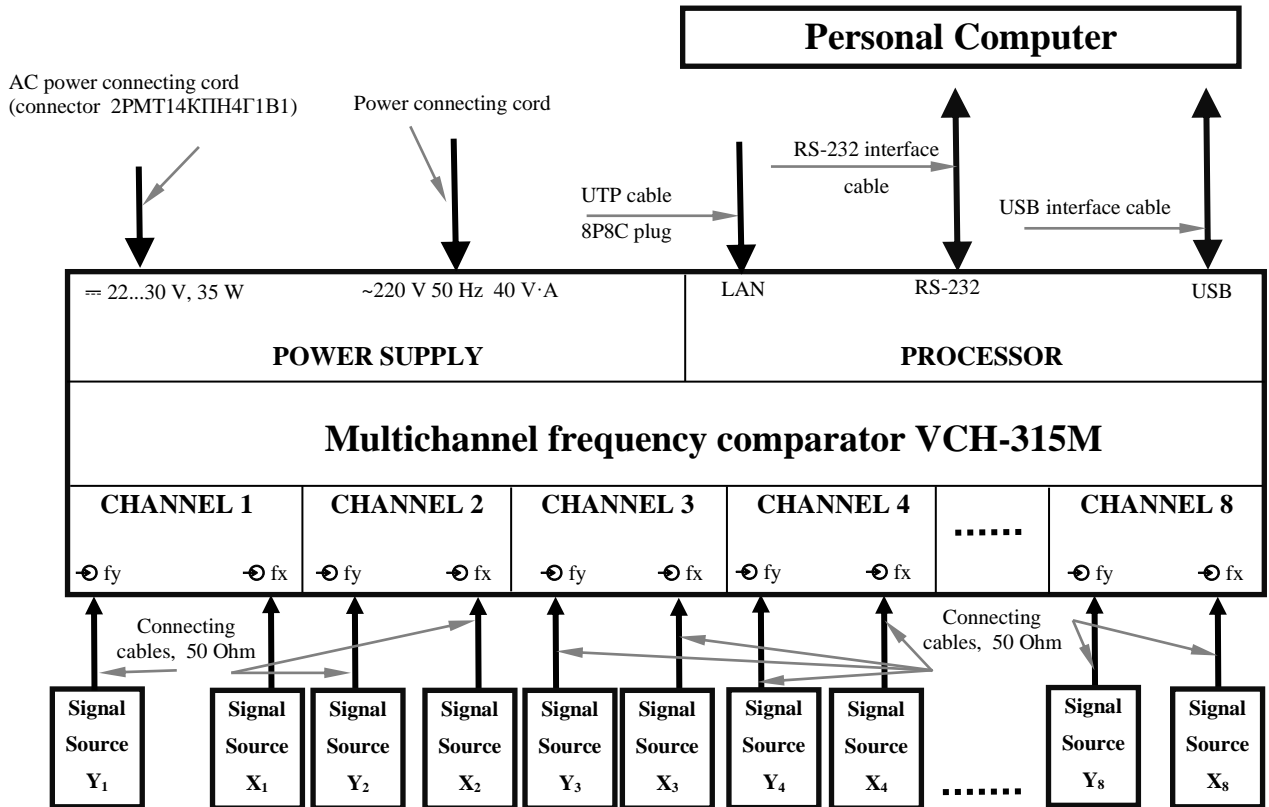
Figure 5

Instability of the measuring channel CHANNEL 1 – $y_{c1}^N, \delta_{c1}, \sigma_{c1}$ ("noise floor") can be calculated if the same signal is connected to both "⊙fx" and "⊙fy" inputs.

The "⊙fy" input signal instability estimate is biased and includes the instability (*systematic error*) of the reference signal and the measurement channel. When using this method you need to be sure that instability of the reference signal and measurement channel is much less than that of measured signal.

4.5.2 "Two-oscillators, two-channels" mode

It is the modification of "two oscillator" mode that uses two identical measuring channels to reduce the measurement channel error. Same signals are fed to "⊘fx" and "⊘fy" inputs of both channels (see Figure 6). Thus there is a duplication of the measurement results. And the measurement error introduced by the channel can be reduced using cross-correlation processing. The channels noise can be estimated along with the measured signals instability. Accuracy of estimations depends on the measurement time interval.

Table 4 shows mathematical expectation of calculated functions for the measuring channels pair – CHANNEL 1 and CHANNEL 2. These functions estimate bias caused by instability of channels and reference signal.

Table 4 – Available functions for "two oscillators, two-channels" mode

Number	Calculated functions	Mathematical expectation
1	Relative frequency difference measured in CHANNEL 1	$y_{y1}^{N} - y_{x1}^{N} + y_{c1}^{N}$
2	Relative frequency difference measured in CHANNEL 2	$y_{y1}^{N} - y_{x1}^{N} + y_{c2}^{N}$
3	Relative frequency difference of CHANNEL 1 and CHANNEL 2	$y_{c1}^{N} - y_{c2}^{N}$
4	Standard deviation measured in CHANNEL 1	$\sqrt{\delta_{y1}^{2} + \delta_{x1}^{2} + \delta_{c1}^{2}}$
5	Standard deviation measured in CHANNEL 2	$\sqrt{\delta_{y1}^{2} + \delta_{x1}^{2} + \delta_{c2}^{2}}$
6	Sum standard deviation CHANNEL 1 and CHANNEL 2	$\sqrt{\delta_{c1}^{2} + \delta_{c2}^{2}}$
7	Standard cross-deviation CHANNEL 1 and CHANNEL 2	$\sqrt{\delta_{y1}^{2} + \delta_{x1}^{2}}$
8	Allan deviation measured in CHANNEL 1	$\sqrt{\sigma_{y1}^{2} + \sigma_{x1}^{2} + \sigma_{c1}^{2}}$
9	Allan deviation measured in CHANNEL 2	$\sqrt{\sigma_{y1}^{2} + \sigma_{x1}^{2} + \sigma_{c2}^{2}}$
10	Sum Allan deviation CHANNEL 1 and CHANNEL 2	$\sqrt{\sigma_{c1}^{2} + \sigma_{c2}^{2}}$
11	Allan cross-deviation CHANNEL 1 and CHANNEL 2	$\sqrt{\sigma_{y1}^{2} + \sigma_{x1}^{2}}$

Notes:

Formulas №№1, 2, 4, 5, 8, 9 give systematic error introduced by reference signal and measuring channels;

Formulas №№ 3, 6, 10 specify instability of measuring channels;

Formulas №№ 7 and 11 give systematic error caused by measured signals.

Formulas №№ 7 and 11 also include systematic error which depends on measurement time – τ and time delay between measurements in different channels – Δ.
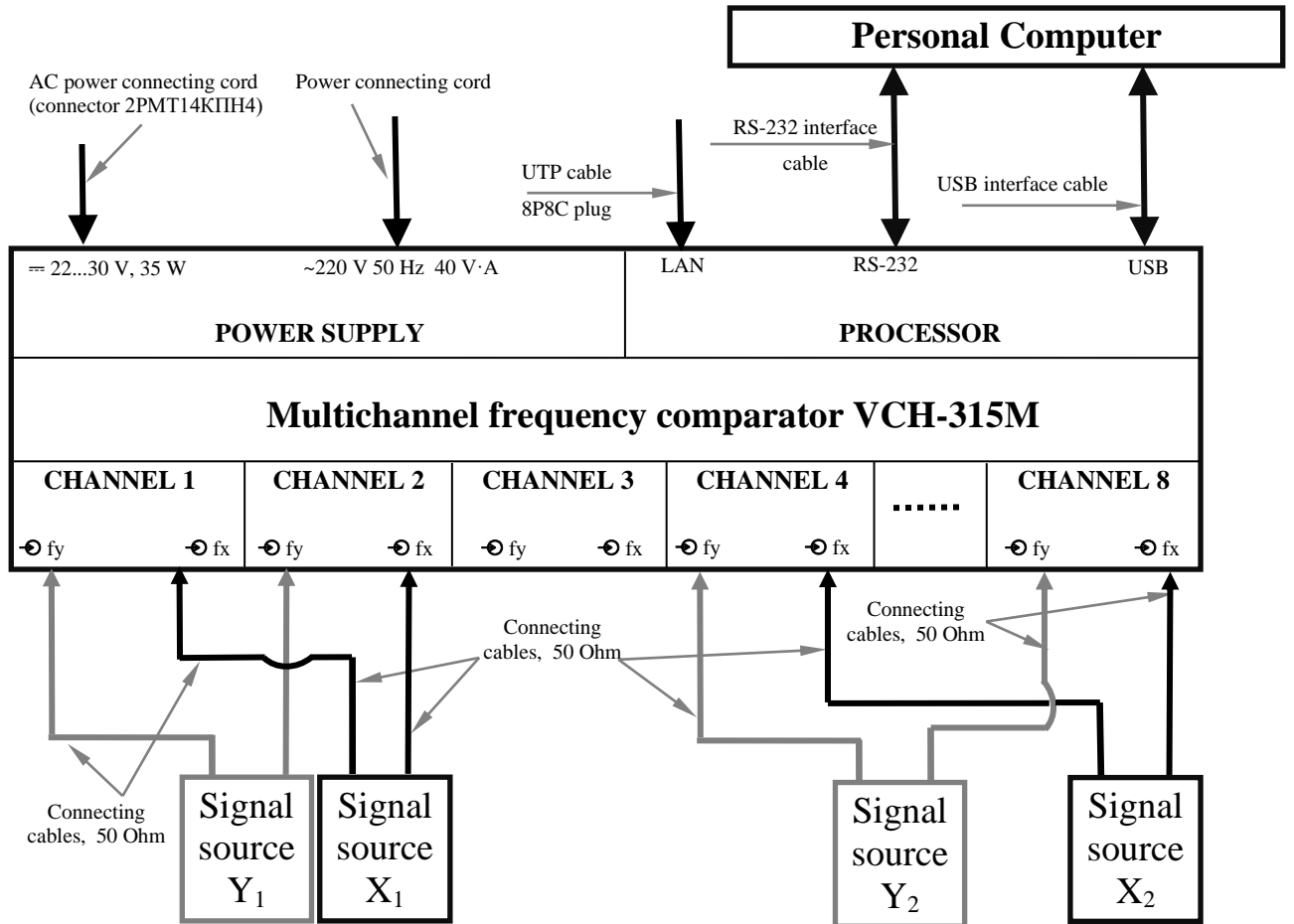
Figure 6

4.5.3 "Three oscillators, two-channels" mode

This is the most advanced mode, three oscillators and two identical measuring channels are used for instability measuring. Example for the pairs of measuring channels CHANNEL 1 – CHANNEL 2, CHANNEL 2 – CHANNEL 3 and CHANNEL 3 – CHANNEL 1 is shown in Figure 7.

Three main advantages of this mode:
- simultaneous frequency instability measuring of three oscillators;
- calculations of the instability of each individual oscillator;
- reduced systematic error caused by instability of reference signal and measuring channel.

Figure 7

Table 5 shows calculated functions and corresponding mathematical expectation.

Table 5 – Available functions for "three oscillators, two-channels" mode

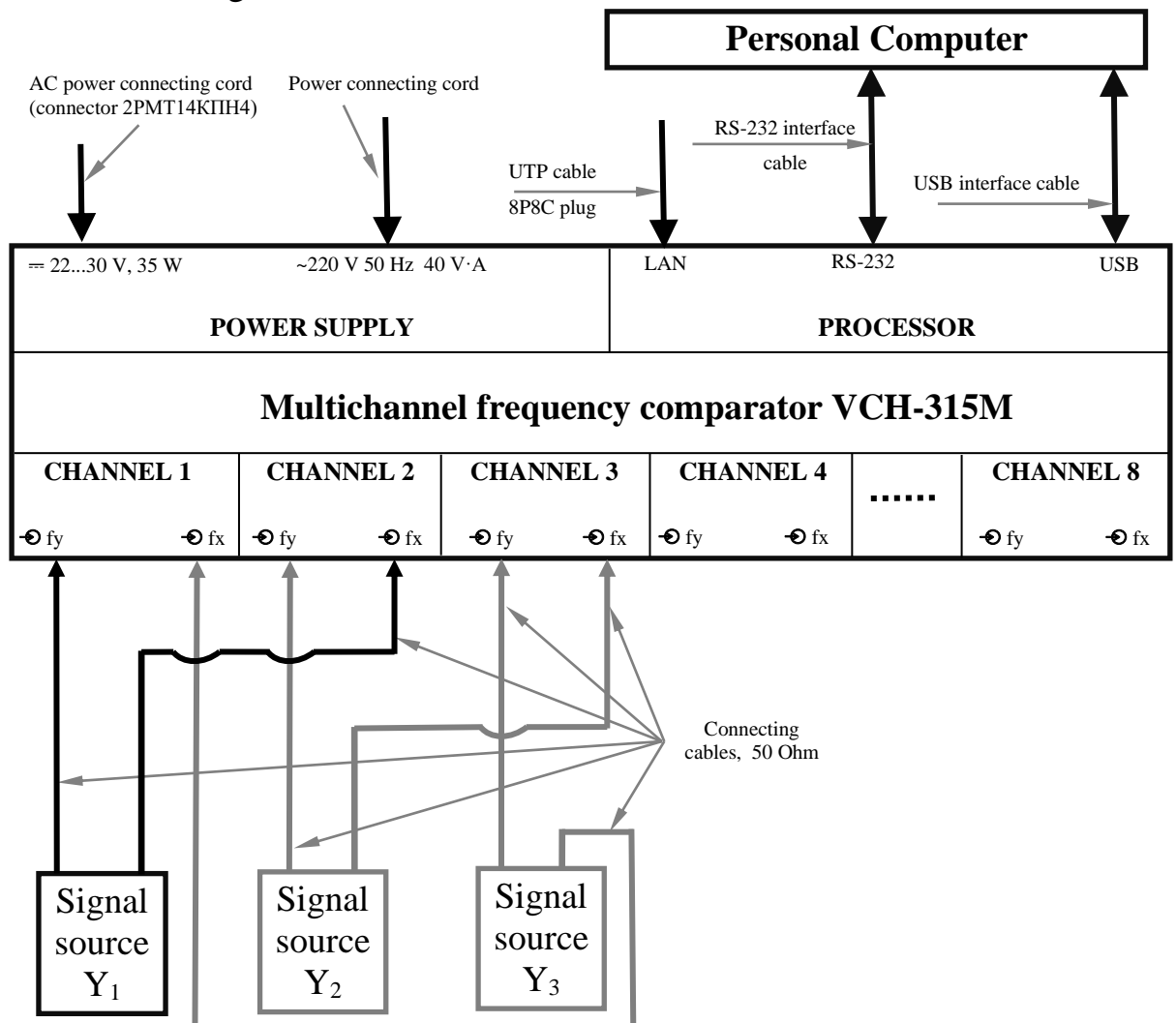| Number	Calculated functions	Mathematical expectation
1	Relative frequency difference measured in CHANNEL 1	$y_{y1}^{N} - y_{y3}^{N} + y_{c1}^{N}$
2	Relative frequency difference measured in CHANNEL 2	$y_{y2}^{N} - y_{y1}^{N} + y_{c2}^{N}$
3	Relative frequency difference measured in CHANNEL 3	$y_{y3}^{N} - y_{y2}^{N} + y_{c3}^{N}$
4	Sum relative frequency difference CHANNEL 1 and CHANNEL 2	$y_{y1}^{N} - y_{y3}^{N} + y_{c1}^{N} - y_{c3}^{N}$
5	Sum relative frequency difference CHANNEL 2 and CHANNEL 3	$y_{y2}^{N} - y_{y1}^{N} + y_{c2}^{N} - y_{c1}^{N}$
6	Sum relative frequency difference CHANNEL 3 and CHANNEL 1	$y_{y3}^{N} - y_{y2}^{N} + y_{c3}^{N} - y_{c2}^{N}$
7	Standard deviation measured in CHANNEL 1	$\sqrt{\delta_{y1}^{2} + \delta_{y3}^{2} + \delta_{c1}^{2}}$
8	Standard deviation measured in CHANNEL 2	$\sqrt{\delta_{y2}^{2} + \delta_{y1}^{2} + \delta_{c2}^{2}}$
9	Standard deviation measured in CHANNEL 3	$\sqrt{\delta_{y3}^{2} + \delta_{y2}^{2} + \delta_{c2}^{2}}$
10	Sum standard deviation CHANNEL 1 and CHANNEL 2	$\sqrt{\delta_{y3}^{2} + \delta_{y2}^{2} + \delta_{c1}^{2} + \delta_{c2}^{2}}$
11	Sum standard deviation CHANNEL 2 and CHANNEL 3	$\sqrt{\delta_{y1}^{2} + \delta_{y3}^{2} + \delta_{c2}^{2} + \delta_{c3}^{2}}$
12	Sum standard deviation CHANNEL 3 and CHANNEL 1	$\sqrt{\delta_{y2}^{2} + \delta_{y1}^{2} + \delta_{c3}^{2} + \delta_{c1}^{2}}$
13	Standard cross-deviation CHANNEL 1 and CHANNEL 2	$\sqrt{\delta_{y1}^{2}}$

Number	Calculated functions	Mathematical expectation
14	Standard cross-deviation CHANNEL 1	$\sqrt{\delta_{y3}^2 + \delta_{c1}^2}$
15	Standard cross-deviation CHANNEL 2	$\sqrt{\delta_{y1}^2 + \delta_{c2}^2}$
16	Standard cross-deviation CHANNEL 2 and CHANNEL 3	$\sqrt{\delta_{y2}^2}$
17	Standard cross-deviation CHANNEL 2	$\sqrt{\delta_{y1}^2 + \delta_{c2}^2}$
18	Standard cross-deviation CHANNEL 3	$\sqrt{\delta_{y2}^2 + \delta_{c3}^2}$
19	Standard cross-deviation CHANNEL 3 and CHANNEL 1	$\sqrt{\delta_{y3}^2}$
20	Standard cross-deviation CHANNEL 3	$\sqrt{\delta_{y2}^2 + \delta_{c3}^2}$
21	Standard cross-deviation CHANNEL 1	$\sqrt{\delta_{y3}^2 + \delta_{c1}^2}$
22	Allan deviation measured in CHANNEL 1	$\sqrt{\sigma_{y1}^2 + \sigma_{y3}^2 + \sigma_{c1}^2}$
23	Allan deviation measured in CHANNEL 2	$\sqrt{\sigma_{y2}^2 + \sigma_{y1}^2 + \sigma_{c1}^2}$
24	Allan deviation measured in CHANNEL 3	$\sqrt{\sigma_{y3}^2 + \sigma_{y2}^2 + \sigma_{c1}^2}$
25	Sum Allan deviation CHANNEL 1 and CHANNEL 2	$\sqrt{\sigma_{y3}^2 + \sigma_{y2}^2 + \sigma_{c1}^2 + \sigma_{c2}^2}$
26	Sum Allan deviation CHANNEL 2 and CHANNEL 3	$\sqrt{\sigma_{y1}^2 + \sigma_{y3}^2 + \sigma_{c2}^2 + \sigma_{c3}^2}$
27	Sum Allan deviation CHANNEL 3 and CHANNEL 1	$\sqrt{\sigma_{y2}^2 + \sigma_{y1}^2 + \sigma_{c3}^2 + \sigma_{c1}^2}$
28	Allan cross-deviation CHANNEL 1 and CHANNEL 2	$\sqrt{\sigma_{y1}^2}$
29	Allan cross-deviation CHANNEL 1	$\sqrt{\sigma_{y3}^2 + \sigma_{c1}^2}$

Number	Calculated functions	Mathematical expectation
30	Allan cross-deviation CHANNEL 2	$\sqrt{\sigma_{y1}^2 + \sigma_{c2}^2}$
31	Allan cross-deviation CHANNEL 2 and CHANNEL 3	$\sqrt{\sigma_{y2}^2}$
32	Allan cross-deviation CHANNEL 2	$\sqrt{\sigma_{y1}^2 + \sigma_{c2}^2}$
33	Allan cross-deviation CHANNEL 3	$\sqrt{\sigma_{y2}^2 + \sigma_{c3}^2}$
34	Allan cross-deviation CHANNEL 3 and CHANNEL 1	$\sqrt{\sigma_{y3}^2}$
35	Allan cross-deviation CHANNEL 3	$\sqrt{\sigma_{y2}^2 + \sigma_{c3}^2}$
36	Allan cross-deviation CHANNEL 1	$\sqrt{\sigma_{y3}^2 + \sigma_{c1}^2}$

Notes:

Formulas №№ 1 – 12 and 22 – 27 give systematic error caused by instability of reference signal in both channels and instability of measuring channels;

Formulas №№ 14, 15, 17, 18, 20, 21, 29, 30, 32, 33, 35, 36 give systematic error caused by instability of measuring channels.

Formulas №№ 13, 16, 19, 28, 31, 34 give non-biased estimations.

We can measure without systematic error:
- only "Y1" signal in measuring channels CHANNEL 1 – CHANNEL 2;
- only "Y2" signal in measuring channels CHANNEL 2 – CHANNEL 3;
- only "Y3" signal in measuring channels CHANNEL 3 – CHANNEL 1.

All error calculations were made on assumption that frequency fluctuations of measured signals and measuring channels are independent.

4.5.4 Frequency instability introduced by the device

In this mode "⟳fx" and "⟳fy" input signals for both channels are taken from the same signal source (see Figure 8) for any pair of channels to estimate frequency instability introduced by the device. For any pair of the channels the measuring program calculates relative frequency difference and frequency instability of each channel ("noise floor") using the correlation method eliminating auto-correlation of the pair of the channels.

To use this mode connect the device and sine signal source with frequency distribution amplifier (in the example for CHANNEL 1, 2) or with power splitters (in the example for CHANNEL 4, 8) as shown in Figure 8. After 6 hour warm-up time start measuring frequency instability (Allan deviation) introduced by measuring channels for averaging times 1 s, 10 s, 100 s, 1000 s, 1 h for 16 – 18 hours.

Note: Use RF interconnecting SMA / BNC cables 685670.154 and RF interconnecting SMA / BNC cables 685670.154-01 from the device composition to provide the power splitters ZFSC-2-1W+ connection as shown in Figure 8.

Table 6 shows available functions and corresponding mathematical expectation for the measuring channels CHANNEL 1 and CHANNEL 2.

Table 6 – Mathematical expectation of calculated functions when channels "noise floor" measuring

Number	Calculated functions	Mathematical expectation
1	Relative frequency difference measured in CHANNEL 1	y_{c1}^{N}
2	Relative frequency difference measured in CHANNEL 2	y_{c2}^{N}
3	Sum relative frequency difference CHANNEL 1 and CHANNEL 2	$y_{c1}^{N} - y_{c2}^{N}$
4	Standard deviation measured in CHANNEL 1	$\sqrt{\delta_{c1}^{2}}$
5	Standard deviation measured in CHANNEL 2	$\sqrt{\delta_{c2}^{2}}$
6	Sum standard deviation CHANNEL 1 and CHANNEL 2	$\sqrt{\delta_{c1}^{2} + \delta_{c2}^{2}}$
7	Standard cross-deviation CHANNEL 1 and CHANNEL 2	0
8	Allan deviation measured in CHANNEL 1	$\sqrt{\sigma_{c1}^{2}}$
9	Allan deviation measured in CHANNEL 2	$\sqrt{\sigma_{c2}^{2}}$
10	Sum Allan deviation CHANNEL 1 and CHANNEL 2	$\sqrt{\sigma_{c1}^{2} + \sigma_{c2}^{2}}$
11	Allan cross-deviation CHANNEL 1 and CHANNEL 2	0

Notes:

Formulas №№ 4, 5, 6, 8, 9, 10 give systematic error caused by channels noise;

Formulas №№ 7, 11 give non-biased estimations.

The device is considered operational if the values of the calculated statistical functions that estimate the frequency instability do not exceed those given in the table 2.

Personal Computer

AC power cord
(connector 2PMT14КПН4)

Power cord

UTP cable
8P8C plug

RS-232 interface
cable

USB interface cable

| ⎓ 22...30 V, 35 W | ~220 V 50 Hz 40 V·A | LAN | RS-232 | USB |

POWER SUPPLY

PROCESSOR

Multichannel frequency comparator VCH-315M

| **CHANNEL 1** | **CHANNEL 2** | **CHANNEL 3** | **CHANNEL 4** | ...... | **CHANNEL 8** |

fy   fx   fy   fx   fy   fx   fy   fx   fy   fx

Connecting
cables, 50 Ohm

OUT A1   OUT A2   OUT A3   OUT A4

Frequency Distribution Amplifier

IN A

Signal
Source
X_1

| 1 | 2 |
**Power splitter
ZFSC-2-1W+**
s

| 1 | 2 |
**Power splitter
ZFSC-2-1W+**
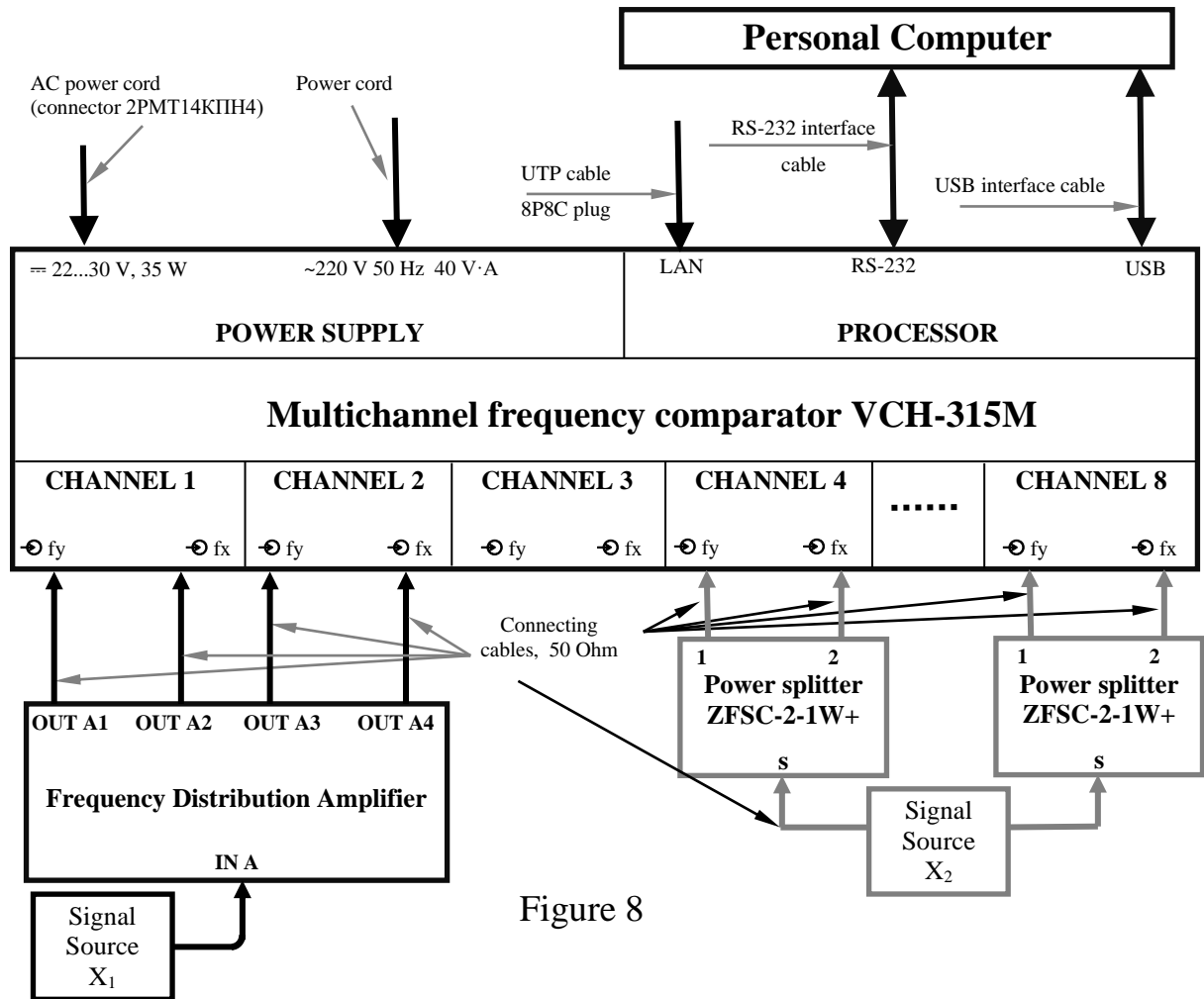**s**

Signal
Source
X_2

Figure 8

5 Troubleshooting

You may experience issues related to the limited resource of device components. The most likely problems and guidance for their elimination are given in Table 7.

Table 7 – The list of the most likely problems

Problem	Probable cause	Solution	Notes
"POWER" indicators are off	Power cord fault	Repair or replace the power cord	
	Fuse fault	Replace the fuse, If fuse fault persists – Factory repair	
	Device malfunction	Factory repair	
"⎓ 22…30 V " and "BATTERY" indicators are off	Power cord fault	Repair or replace the cable	
	Device malfunction	Factory repair	
Front panel "CHANNELS 1 2 3 4 5 6 7 8" indicators not flashing at 1 Hz when input signals are present	No input signal	Connect input signal	
	Connecting cable fault	Repair or replace the interconnecting cable	
	Device malfunction	Factory repair	
RS-232 communication failure	RS-232 interface cable fault	Repair or replace the RS-232 interface cable	
	PC serial interface error	Test the PC RS-232 interface	
	Device malfunction	Factory repair	
USB communication failure	USB interface cable fault	Repair or replace the USB interface cable	
	PC USB interface error	Test the PC USB interface	
	Device malfunction	Factory repair	

Problem	Probable cause	Solution	Notes
LAN communication failure	Ethernet error	Repair or replace the Ethernet cables	35
		Test the PC Ethernet interface	
	Device malfunction	Factory repair	