Passive Hydrogen Maser Frequency and Time Standard

VCH-1008M

Maintenance and service manual

411141.058SM

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The present manual contains information about Passive Hydrogen Maser Frequency and Time Standard VCH-1008M, its composition, main applications, principle of operation, basic configuration and technical maintenance.

It also gives the description of device specifications and information on adequate usage of the device according to its purpose.

Safety precaution

Before the device starts operating you must provide reliable device grounding. For that it is necessary to connect the ground terminal to the common ground. If the device is grounded via power cable with a grounding wire and a plug with grounding contact, then it is vital to plug it in the socket before any other connections are made.

Strength of the grounding terminal and conductors must be thoroughly fixed.

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

1 Device description

1.1 Description and operation

1.1.1 Main applications

1.1.1.1 Passive Hydrogen Maser Frequency and Time Standard VCH-1008M is designed to be used as the high-stable signal source for time frequency measurements and for the application in reference measurement systems and telecommunications.

1.1.1.2 Main applications:

— metrology;

— space tracking and navigation;

— scientific research measurements.

The device can be used as an integral part in automated measurement systems. The working and controlled parameters of the device are accessible for read and write operations via RS-232C, USB, Ethernet 10/100 (LAN) interfaces.

The external view of the device is given in Fig.1.1.

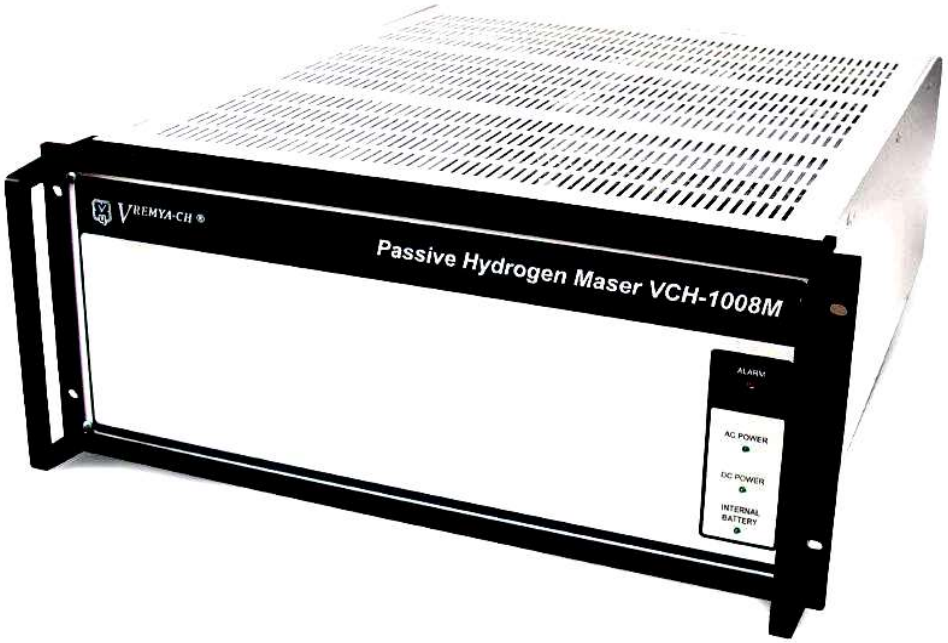

Fig.1.1

1.1.1.3 Operating conditions:

— Power supply: (100 - 240) V AC with frequency (50 – 60) Hz
— Redundant power supply source (24^{+6}_{-3}) V
— Ambient air temperature: +5 up to +40 °C
— Relative humidity: up to 90 % at +25 °C
— Atmospheric pressure 84 – 106,7 kPa (630 – 800 mm Hg)
— DC magnetic field | 0 – 2 | Gauss

1.1.1.4 Device meets the requirements for precautions and radio-electronic protection set by GOST (Federal Technical Requirement of Russia) No. 22261-94.

1.1.1.5 Official name of the device in the documents and when making order should be stated as:

Passive Hydrogen Maser Frequency and Time Standard VCH-1008M 411141.058

1.1.2 Product specifications

1.1.2.1 The main metrological specifications of the device are given in table 1.1.

Table 1.1

Type	Nominal value	Max. deviation or accuracy	Note
1. Output signals frequency	1 Hz 2,048 MHz 5 MHz 10 MHz 100 MHz	$\pm 3\times10^{-13}$ (factory calibration)	
2. Output voltage value sinusoidal signals: **5 MHz, 10 MHz, 100 MHz** pulse signals: **2,048 MHz**	1 V 2,5 V	±0,2 ±0,2	RMS at (50±0,3) Ohm load
3. Parameters of pulse signal **1 Hz:** Amplitude Pulse polarity Pulse duration Rising edge time **2,048 MHz**: Pulse form Amplitude	 (2,5 – 5) V positive (100±0,01); (10±0,01); (1±0,01); (0,1±0,01) μs < 15 ns meander (1,5–2,8) V		 At (50±0,3) Ohm load At 50 Ohm load

Type	Nominal value	Max. deviation or accuracy	Note
4. Output signal 5; 10; 100 MHz frequency stability (Allan deviation) at time average : 1 s 10 s 100 s 1000 s 1 hour 1 day (ambient temperature changes within ± 0.5 °C)		 4×10^{-13} $1{,}5\times10^{-13}$ 4×10^{-14} $1{,}5\times10^{-14}$ 7×10^{-15} $1{,}5\times10^{-15}$	 excluding environment effects in operating temperature range from +5 to +40 °C
5. Relative frequency reproducibility		5×10^{-14}	
6. Frequency drift 1 day		 $\pm2\times10^{-15}$ $\pm1\times10^{-15}$	 for 1 year operation
7. Relative frequency accuracy, Additional instability (ambient temperature changes within ±°1°C in temperature range)		$\pm3\times10^{-13}$ $\pm1\times10^{-13}$ $\pm5\times10^{-13}$	factory calibration in GPS/GLONASS option for 1 year operation
8. Temperature sensitivity (ambient temperature changes within ± 1°C)		$\pm0{,}5\times10^{-14}$	in operating temperature range from +5 to +40 °C
9. Output frequency corrector Resolution Retuning range	 1×10^{-15} 1×10^{-10}		
10. Time synchronization to UTS Pulse parameters: period duration, not less than amplitude	 1 s 1 μs (2,5 – 5) V		 Positive polarity At (50±0,3) Ohm load

Type	Nominal value	Max. deviation or accuracy	Note
Synchronization accuracy		±50 ns	GPS/GLONASS option
11. Distortion in 5 MHz output signal, less than Harmonic Non-harmonic	 −30 dB −100 dB		
12. SSB phase noise spectral density 5 MHz outputs, not more than (1±0,3) Hz (10±3) Hz 100 Hz±10 % 1 kHz±10 % 10 kHz±10 %	 −105 dBc/Hz −130 dBc/Hz −145 dBc/Hz −155 dBc/Hz −155 dBc/Hz		

1.1.2.2 Built-in RS-232C, USB or Ethernet 10/100 (LAN) interfaces allow remote control of the device operation and complete monitoring of its parameters.
1.1.2.3 The device provides its specifications after 24 hours including thermostats warm-up time or after 2 hours with warmed thermostats.
1.1.2.4 Power supply: AC-line: (100 – 240) V, (50 – 60) Hz or redundant DC power supply 24^{+6}_{-3} V.
1.1.2.5 Standard power consumption at nominal voltage is not more than 100 VA (AC), and is not more than 100 W (DC).
1.1.2.6 Normal and utmost operating conditions must correspond with those given in the table 1.2.

Table 1.2

Operating conditions	Operation temperature	Humidity	Atmospheric pressure	Power supply
Normal	+(20±5) °C	30 – 80 % at temperature up to +25 °C	84 – 106 kPa (630 – 795 mm Hg)	AC (220±4,4) V DC 24^{+6}_{-3} V
Utmost (non-operating)	from –20 °C up to +50 °C	95 % at temperature +25 °C	70 – 106,7 kPa (630 – 800 mm Hg)	

1.1.2.7 The device preserves its specifications given in Sections 1.1.2.1 – 1.1.2.3 when provided operating conditions described in Section 1.1.1.3.
1.1.2.8 The device provides continuous non-stop operation in operating conditions with all specifications preserved.
1.1.2.9 Life time of the device is not less than 15 years. Resource – not less than 25000 hours.
1.1.2.10 Size – 200,0×482,8×549,5 mm.
1.1.2.11 Weight – not more than 33 kg.

1.1.3 Product composition

1.1.3.1 The device composition is given in Table 1.3.

Table 1.3

Type	Designation	Quantity
1. Frequency and time standard VCH-1008M	411141.058	1
2. Accessory kit:		
a) Power cable 220V;	SCZ-1	1
b) Cable for source 24 V;	685650.030	1
c) RS-232C Cable;	685670.026	1
d) Cable connector;	685670.357	4
e) Interface cable;	USB2.0 AM/BM-1,8M	1
f) Fuse link;	H520-3,15A/250V	4
g) Fuse link;	H520-5A/250V	2
h) Support (optional);	301318.006	1
i) Antenna GPS/Glonass (optional);		1
j) TNC-F Connector (optional);	HYR-0246	1
k) Antenna connection cable (optional);	685670.077	1
l) Disk (optional)		1
3. Packing case	323361.017	1
4. Manual	411141.058SM	1
5. User guide	RU.ЯКУР.00216-02 34 02	1
6. Passport	411141.058PS	1
7. CD (or USB-flash-drive) with software and documentation		1

1.1.4 Basic configuration and operation

1.1.4.1 The device consists of these main parts:
— hydrogen quantum discriminator;
— interface of hydrogen quantum discriminator;
— indication unit;
— central processor;
— reference signals source;
— FLL processor;
— receiver;
— GLONASS signal processing unit;
— antenna unit;
— power supply unit.

within a case measuring 200,0×482,8×549,5 mm. The top and the bottom of the case have easy-removable covers with ventilation holes.

The left half of the case contains physical part of the device with high-frequency oscillator and hydrogen quantum discriminator.

The front panel of the right half of the case contains the indication unit. Behind it are interface of hydrogen quantum discriminator (high-voltage supply unit, pressure sensor, beam stabilizer, hydrogen source), digital thermostats unit, 220 V power supply unit and batteries. Next there is a cross-board connected to the plug-in units: power supply unit, central processor, FLL processor, GLONASS signal processing unit, reference signals source and receiver. The plug-in units panels with output connectors form the back panel of the device.

To provide the high maintainability, free access to the device's units and blocks is provided through top and bottom covers. The parts of the device can be easily removed due to use of the removable and plug-in units.

1.1.4.2 Hydrogen frequency and time standard VCH-1008M is a hydrogen standard of passive type. The principle of operation of the device is illustrated by the block-diagram in the Fig. 1.2.

VCH-1008M operation is based on the quartz oscillator frequency lock to the frequency line of hydrogen atom emission in the discriminator. The influence of the discriminator resonator frequency fluctuations on emission line is eliminated by resonator frequency adjustment to quartz oscillator frequency. The frequency modulated (FM) excitation signal generated by FLL processor is fed to the resonator to provide spectral line indication and frequency auto-tuning. The FM interrogation signal is formed by mixing the frequency modulated signal of 20,405 MHz $\pm$ 12.5 kHz with the 14^{th} harmonic of the 100 MHz signal. The excitation signal with frequency 1420,405 MHz is separated directly in the discriminator resonator.

Due to the interaction of the frequency modulated signal with atomic line and resonator it is converted into the amplitude modulated signal. The phase and amplitude of the signal envelope provide information about quartz oscillator frequency deviation

from hydrogen atom emission line frequency and about resonator frequency deviation from quartz oscillator frequency. The AM signal passes from the discriminator to the receiver, where it is amplified, converted and detected. From the receiver it passes to FLL processor that processes the signal and produces control signals for the frequency of quartz oscillator in the reference signals source and for the frequency of discriminator resonator and also performs the auto-tuning of their frequencies to the frequency of hydrogen atoms spectrum line.

The operation of the device is automatically controlled by built-in CPU. Remote control of the device parameters and monitoring of the current state (monitoring of status and parameters) is possible.

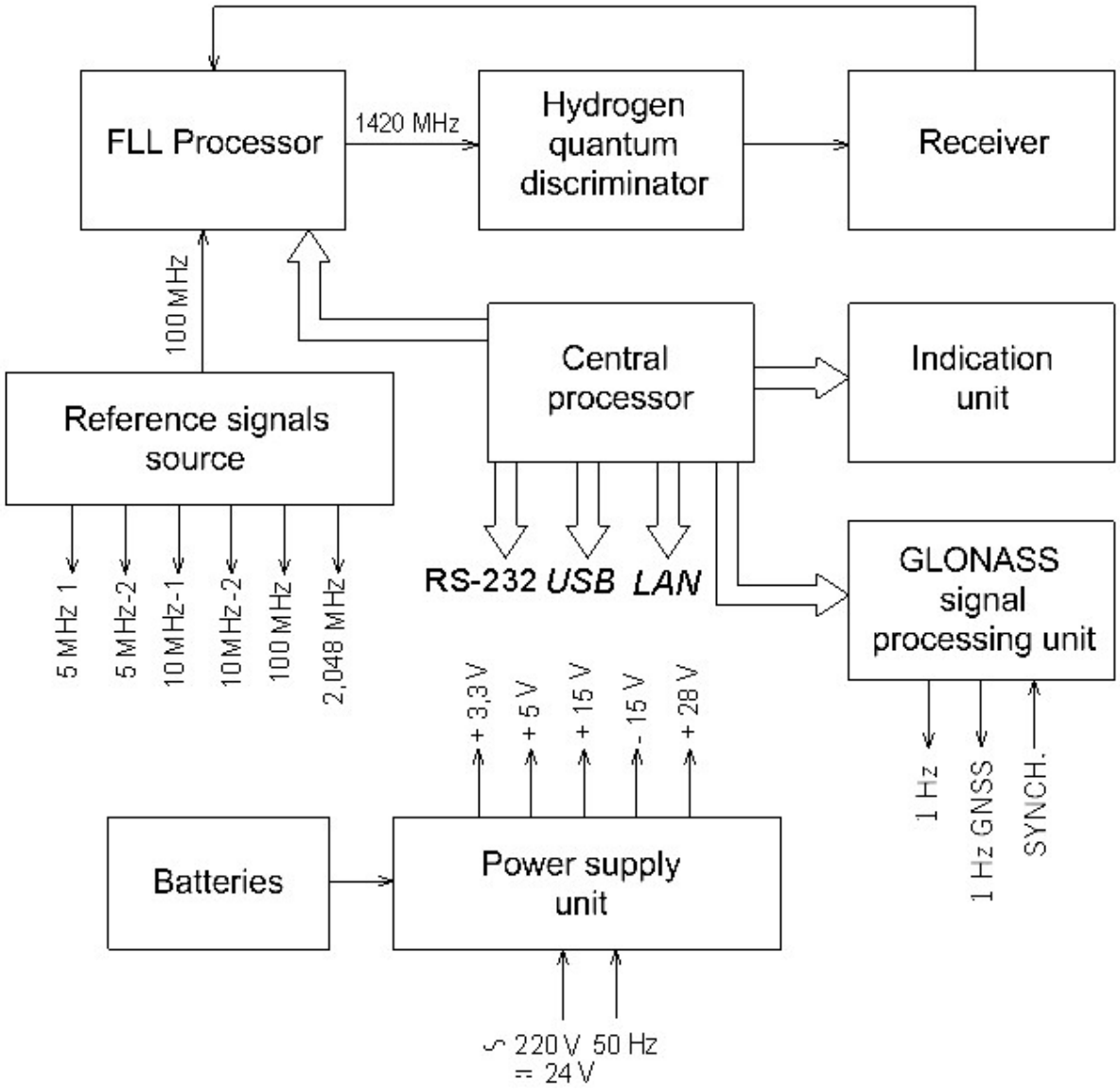

Fig.1.2. VCH-1008M block-diagram

1.1.5 Shipping marks

1.1.5.1 The device serial number and year of production are indicated at the rear panel of the device.
1.1.5.2 All elements and constituent parts of the device are marked in accordance with position signs in the list of components of circuit diagrams.
1.1.5.3 Customer shipping container must be labeled with the device name.

1.1.6 Packing

The instrument should be packed into a special packing case. Before that the device is put into polyethylene cover with celicagel according to GOST 3956. Accessory kit is also packed into the polyethylene cover and a cartone box. Inside the box the device must be enveloped with technical wadding (according to GOST 5679) or with crimped cartone of T-type according to GOST 7376.
Technical and shipping documentation must be packed into polyethylene covers according to GOST 10354.

1.2 Description and operation of the main parts of the device

1.2.1 Hydrogen quantum discriminator
Hydrogen quantum discriminator is used for FM excitation signal conversion into AM signal, which contains information about quartz oscillator frequency deviation from reference line of the atomic transition. Discriminator consists of the following units:

— RF resonator with quartz storage bulb;
— high frequency oscillator (HFO);
— hydrogen source;
— collimator;
— magnetic sorting system.

The operation of the device is based on the stimulated emission of hydrogen atoms in the interaction with the external excitation signal in the microwave cavity.

1.2.2 Indication unit
The indication unit is designed to indicate on the front panel of the device the connected power supply and the malfunction of the device.

1.2.3 Interface of hydrogen quantum discriminator
Interface of hydrogen quantum discriminator provides the control and monitoring functions of quantum hydrogen:

— hydrogen source;
— pressure sensor;
— purifier current stabilizer;
— thermal control unit;

— high-voltage unit;
— switching and monitoring circuit.

1.2.4 Central Processor

Central processor unit is based on the DSP TMS320VC5402. It collects data on the state of all blocks of the device, provides the power on procedures of the device units (ion pump, hydrogen source, HFO). Central processor is controlled via RS-232C interface.

1.2.5 Reference signals unit

Reference signals unit contains the 5 MHz precision crystal oscillator adjusted to the hydrogen emission line and is used to form the device output signals as well as signals used for the device units and blocks operation. From oscillator signal amplified by the output amplifier is directed to "5 MHz-1" and "5 MHz-2" output sockets.

1.2.6 FLL processor

FLL processor is based on signal processor TMS320VC5402. It is used to process the frequency mistuning signal from the receiver and to form the 1420,405 MHz pump signal by AD9852 synthesizer. The 12.5 kHz mistuning signal goes to ADC (analog digital converter) and then to microprocessor, which performs its digital processing (filtration, synchronous detection and accumulation). This processor produces control signals for 5 MHz crystal oscillator and resonator, adjusting them to the hydrogen spectrum line.

1.2.7 Receiver

Receiver is used for amplification and frequency conversion of the signal coming from the hydrogen quantum discriminator and to detect 12.5 kHz AM mistuning signal. The receiver consists of low noise preamplifier, double balance mixer and IF wide band amplifier. SAW local oscillator is used as heterodyne. At the output of the receiver there is the amplitude detector and selective amplifier for FLL analog digital converter.

1.2.8 GLONASS signal processing unit

GLONASS signal processing unit is designed for processing signals received by the antenna from the satellites (optional) and generate 1 Hz output signal. In tracking mode signal processing unit synchronizes the 1 Hz output signal to the UTC (SU) scale (or to the external 1 Hz signal) and corrects the nominal frequency of the device.

1.2.9 Power supply unit

Power supply unit provides all units of the device with necessary voltage and current. It is divided into three blocks: AC/DC power converter (~220 V→+24 V), internal batteries and external supply unit. External supply unit panel contains 5 power converters/stabilizers: +24 V→ +3,3 V, +24 V→ +5 V, +24 V→ +15 V, +24 V→ -15 V, +24 V→ +28 V.

2 Maintenance

2.1 Preparation for operation

2.1.1 Sequence of the product external view inspection

While inspecting the external view of 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 converters are in good condition;
— all ventilation holes in the device cover are open, not blocked by other objects.

2.1.2 Switches, connectors and indicators of the device.

The descriptions of switches, connectors and indicators of the device are given in the Table 2.1.

Their positions are shown in Fig.2.1 and Fig.2.2

Table 2.1

Positions in Fig.2.1	Means of control or connectors designation	Description
1	ALARM	Indicator of device malfunctions
2	AC POWER	Indicator of the device operation from AC line
3	DC POWER	External battery indicator
4	INTERNAL BATTERY	Internal battery indicator
5	⊶ 2,048 MHz	Output connector for signal 2,048 MHz signal
6	⊶ 100 MHz	Output connector for 100 MHz signal
7	⊶ 10 MHz	Output connectors for 10 MHz signal
8	⊶ LF	Output connector for LF signal
9	⊶ 5 MHz	Output connectors for 5 MHz signal
10		Connector – FLL processor adjustment.
11	LAN	LAN interface connector

Positions in Fig.2.1	Means of control or connectors designation	Description
12	USB	USB interface connector
13	⊖ 1 PPS GNSS	Output connector for GNSS receiver
14	⊖ 1 PPS	Output connector for 1 Hz signal
15	DC POWER	+24 V external power source ON /OFF switch
16	⎓ 24V 4A	Connector – external battery connection Connector contacts assignment: 1 contact “+”; 4 contact “–”; 3 contact “body”. Note: 3 and 4 contacts are connected
17	⊖ SYNCH	Input connector for 1 Hz signal (for time scale synchronization)
18	F 5 A 250 V	Fuse link in +24 V DC power line
19		Indicators of the internal voltages states
20	ACCUM	Internal battery ON /OFF switch
21	PC	Connector – GLONASS SPU adjustment
22	F 3,15 A L 250 V	Fuse links in AC line
23	~100-240 V 50/60 Hz 100 VA	AC line power connector
24	⊖ ANTENNA	Connector – GPS/GLONASS antenna connection
25	ERROR	Alarm signal output: Log ”1”- when normal
26	RS-232	RS-232 interface connector
27	⊖ IF	Output connectors for IF signal

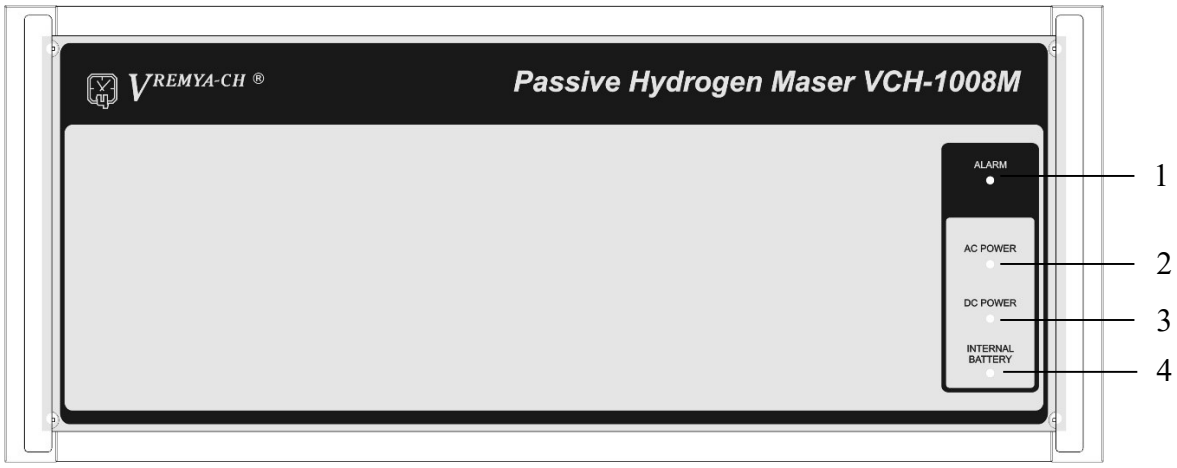

Fig.2.1

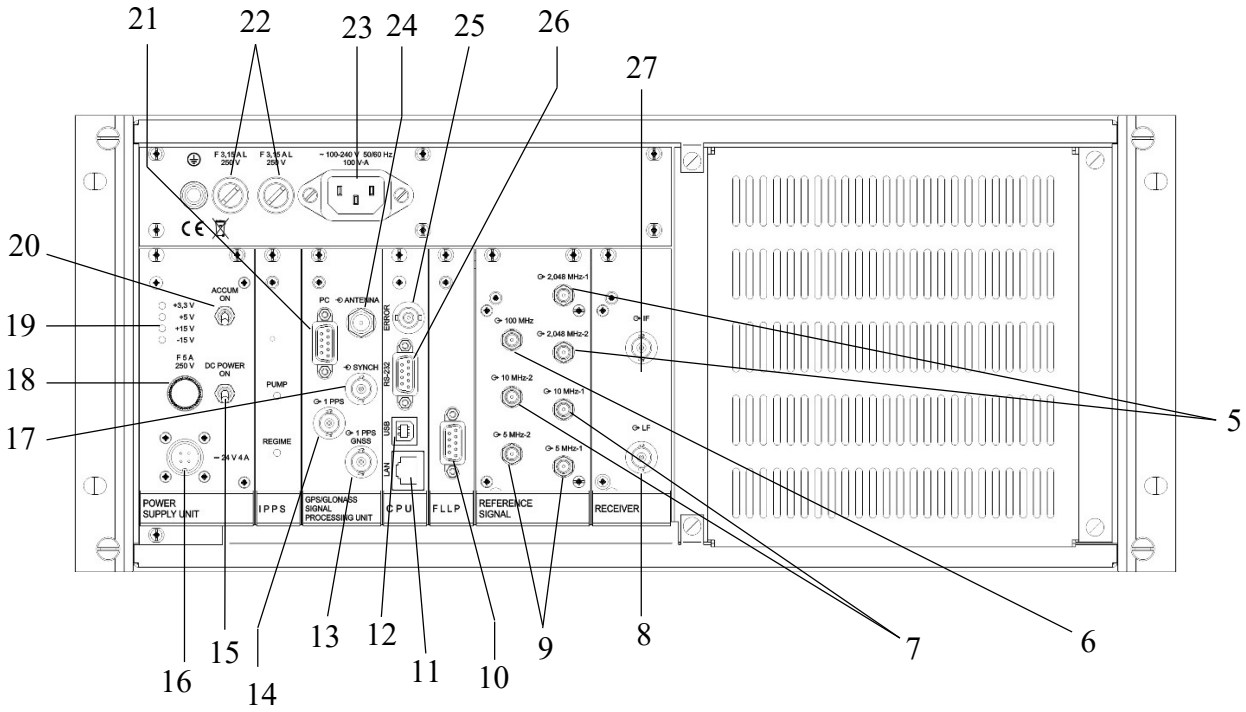

Fig.2.2

2.1.3 Before Switching ON!

2.1.3.1 It is recommended that this maintenance manual must be read prior to switching on the device.

2.1.3.2 Check the reliability of the device ground connection.

2.1.3.3 If the conditions of the device storage or transportation were different from the operating conditions, it is necessary to keep the device in operating conditions not less than 8 hours before switching on.

2.1.3.4 The device has no power switch, so it is turned on immediately after you connect it to the AC.

2.2 Recommendations on usage

2.2.1 Safety requirements

2.2.1.1 The safety of the device maintenance is provided by performing of the requirements of the present Maintenance and service manual.
2.2.1.2 The device must be grounded before it is connected to power line, and disconnection of the ground must be made only after the device is disconnected from power line.

2.2.2 Device operation

2.2.2.1 Operation of the device is performed in accordance with “Passive hydrogen maser, User guide RU.ЯКУР.00216-02 34 02”.
2.2.2.2 The device has no power switch, so it is turned on immediately after you connect it to the AC source.
2.2.2.3 Information on the state of the device and the operating parameters is obtained remotely via RS-232, USB, LAN on the rear panel.

3 Technical service

3.1 General recommendations

3.1.1 The reliability of the device operation depends on qualified and adequate technical service. Ordinary technical service means periodical monitoring of the device technical state by checking of all device-operating parameters.

3.2 Precautions

3.2.1 When performing the device technical maintenance it is strongly recommended to take safety precautions given in paragraph 2.2.1 of the present Manual.
3.2.2 All the external circuits of the device (except the input 220 V AC) have voltage less than 30 V and are not dangerous.

3.3 Procedure of technical maintenance of the instruments

3.3.1 To be sure of the device operation periodical diagnostic of device technical state is required.
3.3.2 During the normal operation the device performs full self-diagnostic automatically. In case of malfunction or significant detour of any operating parameters, ALARM indicator is lighted.
3.3.3 While the device is stored it is necessary to perform the procedures of technical maintenance described in Section 5.

4 Repair

4.1 If the device does not meets its technical specifications or if there are some other reasons, which make the device operation and usage impossible, the device must be directed for repair.
4.2 Repair of The Hydrogen frequency and time standard VCH-1008M and its components requires special equipment and can therefore be made only by manufacturer

5 Storage

5.1 The device must be stored in the heated apartment with ambient temperature from 0 ºC up to +50 ºC and humidity not more than 80 % at temperature 25 º C.
5.2 The storage apartment must be clean from dust, acid and alkali vapor and from other harmful admixtures that may cause corrosion.

5.3 Periodically (once in six months) the device must be unpacked. Then it should be connected to the AC line to start ion pumps of the discriminator and recharge the internal batteries. In 30 minutes after switching on the current of the high voltage power supply must not exceed 100 μA. In case the current is higher than 100 μA the device must be directed for repair. Built-in battery should be charged to the voltage at least 28 V.

6 Transportation

6.1 Before transportation takes place the device must be packed into the packing case.
6.2 The device can be transported by any means of transportation.
6.3 Transportation conditions must correspond with those of the device operation conditions and must not exceed the utmost operation conditions, indicated in Table 1.2.
6.4 Places used for the device transportation (ship hold or car body) must not have leftovers of coal, cement, chemicals etc.
6.5 When airway transportation is used the device must be located in normal pressure cabin.