

VREMYA-CH

Passive Hydrogen Maser Frequency and Time Standard

VCH-1006

User guide

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1. Programmable Functions

VCH-1006 Passive Hydrogen Maser Frequency and Time Standard realizes the following control and monitoring functions.

Control functions:

1. Switching ON/OFF the ion-pump high voltage, hydrogen supply source and High Frequency Oscillator (discharge HFO) with incorrect “ON” and “OFF” sequence protection.
2. Setup of output signals frequency precision correction code.
3. Automatic Frequency Lock Loop (FLL) search for crystal oscillator - “H-line searching”.
4. Manual setup of current time indicator.
5. Manual time scale synchronization.

Monitoring (Check) functions:

1. Power circuits voltages.
 - external DC source ,
 - output of DC/DC converter of the external direct current source (+27V),
 - AC/DC converter~220V/+27V,
 - internal +27V bus,
 - +15V and –15V buses,
 - +5V bus,
 - +3.3V bus,
 - internal battery (built in accumulators) voltage.
2. Purifier, ion-pump and HFO currents.
3. Cavity ovens voltage.
4. Second harmonic signal voltage.
5. IF-level voltage.
6. Representation of DAC codes, engaged in control circuits of cavity and quartz tuning.
7. RMS voltage of the sinusoidal signals 100MHz, 10MHz, 5MHz,
8. Presence of the pulse signals 2.048MHz, 1PPS.

2. Operating Instruction

Instrument operation and its monitoring is exercised in an automatic mode. However a direct control possibility is provided. To perform it the User should choose menu commands which are represented on the LCD display pressing definite keys on the keyboard of the front panel.

2.1. Initial Turn - On Procedure

This procedures should be followed when the instrument is to be turned on: Connect power cables to AC (100 – 240)V line or external +27(+3...–5)DC source to the instrument and switch ON the toggle “ACCUM” on the rear panel of the instrument.

After that time indicator will represent current time, starting at 00 hours 00 minutes 00 seconds and automatic switching on procedure is on the run. The LED-indicator “ALARM” must blink, message window given on Fig. 1 will appear on LCD display. The instrument comes to a normal operation mode automatically

```
Warm up
Auto switch on
ENTER=MENU
```

Fig. 1

As soon as the external power source is connected to the instrument the main control program switches ON the ion-pump, cavity and molecular hydrogen ovens immediately. As the pump current riches its norm and cavity warms up (approximately 8 hours), the molecular hydrogen purifier is energized.

In 5 minutes after the purifier is switched ON, the control program checks its current and if it is normal, HFO power will be ON. As soon as the normal brightness of HF-discharge in the bulb is achieved, the central processor sends a command to the FLL-processor to search Hydrogen emission line (H-line) by changing the frequency of 5 MHz crystal oscillator. At this moment the message on the LCD display changes (see Fig.2),

```
H-line searching
U2h=-3.45
Check parameters
ENTER=MENU
```

Fig. 2

where U2h is the level of the second harmonic signal measured in volts.

H-line searching procedure takes a minute and a half, after that FLL system comes to the frequency lock position. In case of successful completion of the H-line

searching procedure LED indicator “ALARM” fades and the message window on the LCD display will inform the user about normal operation of the instrument (Fig. 3).

```
Normal operation
U2h=3.45

ENTER=MENU
```

Fig. 3

Notes: 1. Second harmonic signal voltage serves as a criterion of H-maser quality. The central processor considers the quartz oscillator to be properly tuned, if $U_{2h} > 0.5$.

2. If the central processor detects insignificant faults in the system, at which normal operation is permitted, a warning (alarm minor) is shown in the message window (Fig. 4).

```
Alarm minor
U2h=3.45
Check parameters
ENTER=MENU
```

Fig. 4

In order to check parameters or control the instrument, press “ENTER” key to switch to the main menu.

Press “ESC” key several times to return to the message window out of any other window.

If there appear failures, which prevent the normal operation of the instrument during its turn-ON procedure or operation, information about that will be given in the message window (Fig. 5).

```
Alarm major
U2h=.35
Check parameters
ENTER=MENU
```

Fig. 5

In case the instrument switches to operation on the built in accumulators regardless of the fact if it was the user's command or not, a corresponding message will be shown on the LCD display (Fig. 6).

```
ATTENTION!
Accumulator engaged
Uacc=22.1
time - 10 s
```

Fig. 6

It is accompanied by the sound signal one second long at 2 seconds intervals. In the third line accumulators' voltage in units of volts will be shown, in the fourth – accumulators' work time in seconds. See paragraph 2.7 for details.

2.2. Turn - Off Procedure

To switch Off the instrument toggle “ACCUM” in the lower position, disconnect external power sources 220V AC and +27V DC.

After the turn-Off procedure is completed, all settings of the instrument are saved in nonvolatile memory except current time. These settings are restored when the instrument is switched ON next time.

2.3. Main Menu

The main menu looks as follows:

VCH-1006
1.Check
2.Control
3.Information

Fig. 7

If the central processor reveals faults, that prevent normal operation of the instrument, the third point of the menu will be “Errors”. In case of normal operation of the instrument or presence of insignificant faults the third point of the menu will be “Information”.

To select a menu point press a corresponding key:

“1” - instrument parameters inspection;

“2” - control functions;

“3” - diagnostic messages review.

Press “ESC” to return to the previous window.

2.4. Menu “Check”

The central processor measures parameters of the instrument units continuously. Use a proper submenu to inspect the parameters of a certain systems. For this purpose choose one of the points shown in figure 8.

Check	
1.Maser	4.Power
2.Signals	5.Therm
3.FLL	

Fig. 8

To select a necessary submenu press a corresponding key. To return to the main menu, press “ESC” key.

2.4.1. Checking of the hydrogen discriminator – menu “Maser”

To inspect parameters of the discriminator (Maser) itself and the units, providing its operation choose point 1 - “Maser”. After its selection the corresponding window will appear on the LCD display (Fig. 9).

Upmp=3.58	Ipmp=10.0
Upur=.808	Ipur=.505
Uhfo=26.8	Ihfo=.483
Disch=2.98	

Fig. 9

Upmp – ion pump power voltage, measured in kilovolts;

Ipmp – ion pump current, measured in microamperes;

Upur –power voltage of molecular hydrogen purifier, measured in volts;

Ipur – purifier current, measured in amperes;

Uhfo – HFO power voltage, measured in volts;

Ihfo – HFO consumption current, measured in amperes;

Disch – brightness of the discharge in the discharge bulb measured in relative units.

Tolerance limits of inspected parameters are given in paragraph 2.6.

To return to menu “Check” press “ESC” key.

2.4.2. Checking of the Reference signal unit – menu “Signals”

This menu serves to inspect the internal reference signals. The sinusoidal signals are measured in volts, pulse signals are controlled for existence by logical detectors, which mark presence or absence of corresponding signals (Fig. 10).

5M1=.822	5M2=1.00	5M1=.822	5M2=1.00
5M3=.698	10M=.944	5M3=.698	10M=.944
1PPS1-ok	1PPS2-ok	1PPS1-err	1PPS2-err
2.048M-ok	CLOCK-ok	2.048-err	CLOCK-err

Fig. 10

5M1/5M2 – sinusoidal signals 5 MHz, runs to the rear panel, and marked as “5MHz-1” and “5MHz-2”.

5M3 – internal sinusoidal signal 5 MHz, which is used as a reference signal for the frequency synthesizer and the interrogation signal unit.

10M – sinusoidal signal 10 MHz, runs to the rear panel, and marked as “10MHz”.

1PPS1/1PPS2 – pulse signals 1 Hz (time scale), put on the rear panel and marked as “1PPS-1” и “1PPS-2”.

2.048M – pulse signal 2.048 MHz (meet to requirements ITU-T G.703), runs to the rear panel and marked as “2.048MHz”.

The output state of the pulse signals is marked either “OK”-signal is present, or “err” – signal is absent.

To return to menu “Check” press “ESC” key.

2.4.3. Checking of the Frequency Lock Loop system – menu “FLL”

This menu is checking the units involved in the servo loop of the FLL system: interrogation signal unit, receiver and FLL-processor. (Fig. 11).

100M=2.42	20M=.390	100M=2.42	20M=.390
IF=2.47	U2h=3.45	IF=2.47	U2h=3.45
Cav=23877	Qtz=31954	FLLP link error	
D2h=-8192	Qctl=1275		

Fig. 11

100M –frequency multiplier 100 MHz output signal level, measured in volts, RMS.

20M – synthesizer 20.40575168 MHz output signal level, measured in volts, RMS.

IF – receiver intermediate frequency output signal level, measured in volts, RMS.

U2h – second harmonic signal level at the output of the receiver detector, measured in volts, RMS.

Cav – digital code of the Digital-to-Analog Converter (DAC), forming cavity tuning control voltage (possible ranged between 0 and 65535).

Qtz – digital code of the DAC, forming cavity tuning control voltage (possible ranged between 0 and 65535).

Qctl – digital code of the DAC forming rough tuning (preset) crystal oscillator control voltage (possible ranged between 0 and 4095),.

D2h – digital code of the second harmonic signal calculated by the FLL processor.. D2h approximately related to U2h through the formula $U2h = - (D2h):2000$.

D2h value less than -1000, considered by the FLL processor as a sufficient value for normal operation of the FLL system.

In case of the failure of FLL processor unit there appears the message in the window: “FLLP link error”.

Press ESC key to return to menu “CHECK”.

2.4.4. Checking of the Power supply unit – menu “Power”

This menu serves to check power supply voltages. After selection submenu “Power” the following window appears on the LCD display (Fig. 12).

Acc=.098	Ext=.672
*27=27.7	+27=27.1
+15=15.3	-15=-15
+5=4.94	+3=3.22

Fig. 12

All inspected voltages are measured in volts:

Acc – voltage of the internal battery;

Ext – voltage of the external DC source +27V

*27 – output voltage of the AC/DC converter ~220V/+27V;

+27 – output voltage of the DC/DC converter +27V/+27V;

+15 – output voltage of the DC/DC converter +27/+15V;

-15 – output voltage of the DC/DC converter +27/-15V;

+5 – DC/DC converter +27/+5V;

+3 – DC/DC converter +27/+3.3V;

Press “ESC” key to return to menu “Check”.

2.4.5. Checking of thermostats and hydrogen source– menu “Therm”

This submenu allows to inspect the cavity’s ovens voltages, molecular hydrogen source oven voltage and molecular hydrogen pressure in the source. (Fig.13).

Side=10.7
Bot=8.03
Hsrc=11.4
H2pres=5.60

Fig. 13

Side – voltage of the heater of the discriminator cavity side surface in volts;
Bot – voltage of the heater of the discriminator cavity bottom in volts;
Hsrc – voltage of the heater of the molecular hydrogen source in volts;
H2pres – pressure of molecular hydrogen in atmospheres in the metal bulb (Supply of hydrogen).
Press “ESC” key to return to menu “Check”.

2.5. Menu “Control”

Menu “Control” serves to:

- Perform switching ON/OFF procedure of the instrument manually to check some maser units (ion pump, purifier, HFO) separately.
- Change the crystal oscillator frequency manually to search H-line.
- Set a correct current time (hh : mm : ss).
- Change the synthesizer frequency code to adjust output frequency to the nominal.
- Synchronize the internal time scale (1 PPS signal) to an external 1 PPS signal

When from main menu (see paragraph 2.3) “Control” submenu is selected, confirmation message will appear, at first, on the LCD display (figure 14).

```
Press '5' then press  
ENTER to get to the  
Control Menu or ESC  
To get back
```

Fig. 14

This inquiry serves to except switching to the control menu in case of erroneous key pressure. To enter control menu press sequentially keys “5” and “ENTER”, to return to the main menu - “ESC”. Control menu looks as follows:

```
Control  
1.Maser 4.1PPS sync  
2.Freq. 5.Time  
3.Search HL
```

Fig. 15

To select any submenu press a corresponding digital key. To return to the main menu press “ESC”.

2.5.1. Discriminator units control – menu “Maser”

Submenu “Maser” serves to switch ON/OFF manually such the maser units as: ion pump, purifier, high frequency oscillator (HFO).

To return to menu “Control” press key “ESC”.

Three units of the maser (quantum hydrogen discriminator) have to be switch ON/OFF in a proper sequence: the HFO can not be switched ON until the purifier is switched ON; the purifier, in turn, can be switched ON only after the ion pump is switched ON and provided a necessary vacuum level.

Thus, there is a strict sequence of switching ON/OFF these units:

- switching on – pump, purifier, HFO;
- switching off – HFO, purifier, pump.

To prevent a mistake, the control program monitors the sequences of switching ON/OFF and gives proper recommendations on LSD display. Therefore 4 message variants are possible in discriminator control mode.

1. Discriminator units are switched OFF (Figure 16).

```
Pump off, turn on-1
```

Fig. 16

Press key “1” to switch ON the ion pump and if the ion pump current and voltage are in normal tolerance limits, in 3 seconds LSD display comes to variant 2.

2. The pump is switched ON, purifier and HFO are switched OFF. Pump current in microamperes is shown in the fourth line of the LCD display (Fig.17). One can either switch OFF the pump or switch ON the purifier

```
Pump on, turn off-2
Purif off, turn on-3

Upmp=3.5 Ipmp=3.58
```

Fig. 17

Press key “3” to switch ON the purifier and, if purifier current is in normal limits in 10 seconds the LCD display will come to variant 3.

3. Pump and purifier are switched ON, HFO is switched OFF, purifier current in ampere is shown in the fourth line. One can either switch OFF the purifier or switch ON the HFO, (Fig 18).

```
Pump on
Purif on, turn off-4
HFO off, turn on-5
Upur=1.10 Ipur=.505
```

Fig. 18

Press key “4” and if HFO current and discharge brightness are in normal tolerance limits after the HFO’s switched ON, the LCD display comes to variant 4.

4. The Pump, purifier, HFO are switched on, the brightness of discharge in relative units is shown in the fourth line. In this position User can only switch OFF the HFO pressing key “6” (Fig. 19).

```
Pump on
Purif on
HFO on, turn off-6
Ihfo=.502 Disch=2.98
```

Fig. 19

From any enumerated submenu one can return to the “Control” menu, pressing key “ESC”.

Note. Switch ON/OFF manual mode is maintained in submenu «Maser» (any variant after pressing any key from «1» to «6») for 1000 seconds only. After this time period the main control program enters automatic switch ON mode, and switch ON procedure will be accomplished even if some units of the maser have been switched OFF manually by User.

2.5.2. Output signal frequency adjustment – menu “Freq”

Menu “Freq” allows to adjust output signals frequency precisely by changing digital synthesizer code. Relative value of the output frequency could be changed by steps 1×10^{-15} in full range 1×10^{-10} (codes from 00000 to 99999). Press key “2” in “Control” menu to enter submenu “Freq”(Fig 20). The second line of the LCD display contains current synthesizer code. Using digital keys or “SHIFT” for deletion of the last (wrong) digit, set the new desirable frequency code and press ENTER. In two seconds after that the new code value will be displayed in the second line of the LCD display. To leave ”Freq” submenu setup press “ESC”.

```
Set Freq.(ESC=Exit)
Set val.=62000e-15
New val.:99999_
SHIFT=BkSp, ENTER=OK
```

Fig. 20

2.5.3. Searching for Hydrogen emission line - menu “Search HL”

This submenu is designed to preset or correct the crystal oscillator frequency and tune it in the middle of H-emission line. The main 5MHz crystal oscillator is controlled by the sum of two voltages: preset control voltage 0 – 8 V divided into 4095 steps which is called Qctl, and FLL control voltage (providing by FLL processor) in the range 0 – 0,8 V divided into 65535 steps which is called Qtz. For proper operation it is advisable to set rough preset control voltage in such a way, that the code of the fine tuning will occur in the middle of the full scale (the full scale of FLL processor DAC is from 0 to 65535, the middle is about 32767).

Such a procedure is fulfilled automatically each time, when the instrument is switching ON in auto switch mode, but it can become necessary after a long operation time, if parameters of the fine tuning have changed in such a way, that FLL DAC code approached the lower or upper boundary of its full scale.

If the FLL DAC code is approaching the boundary, the control central processor generates a message “FLL DAC overflow”, which is displayed in a review menu of diagnostic messages. This menu is named as “Information” or “Errors” and to get in press key “3” being in the main menu (paragraph 2.6).

If the crystal oscillator is still locked to the H-line, but FLL DAC code is approaching the full scale boundary, indicator «ALARM» will not blink, because this situation is estimated as normal, but the message window will look like in Fig.4. After transition to the main menu and selection of the point “Information” one can see the diagnostic message about FLL DAC overflow. (For a detailed description of diagnostic messages see paragraph 2.6).

After selection of the submenu «Search HL», the message, offering to start the procedure, appears on the LCD display (Fig. 21). The third line of the display contains H-maser cavity control code - Cav (in the range from 0 to 65535), and FLL DAC code - Qtz, (in the range from 0 to 65535), the fourth line – the digital code of the second harmonic signal D2h, (in the range from -8192 to +8191) and rough preset control voltage code Qctl (in the range from 0 to 4095).

```

Press ENTER to start
H-line searching
Cav=23875 Qtz=31899
D2h=-8192 Qctl=1275

```

Fig. 21

To start the procedure of a proper control voltage searching press key “ENTER”. The message window changes in the following way (Fig. 22):

```

H-line searching...
Cav=10000 Qtz=31899
D2h=-8192 Qctl=1275

```

Fig. 22

The course of the procedure can be watched through changing of the Cav control code, Qtz and Qctl codes. First the FLL system corrects cavity tuning, at the same time the DAC code of the cavity fine tuning (Cav) is changing. Then the DAC code of the crystal oscillator rough tuning (Qctl) starts to be determined, as well as its values are changing all through the full scale. During this procedure LED indicator “ALARM” is blinking and *output signal frequency deviates from nominal value*.

Upon the completion of H-line searching, the LCD display takes a look as in Fig.21, and, if the procedure has completed successfully, indicator «ALARM» blinking disappears.

To return to menu «Control» press key «ESC».

Note, that it is possible to return to menu «Control» from menu «Search HL» any time, even if the search procedure is in the run. The searching procedure will not be terminated.

2.5.4. Time scale synchronization – menu “1PPS sync”

Menu «1PPS sync» is used for the internal time scale synchronization to the external 1 PPS source. Connect external time scale signal to «1PPS EXT» input of the instrument and enter submenu «1 PPS sync» by pressing the key «4» in the menu «Control».

If the external signal is present, the time delay in ns between external and internal 1 PPS signals will be displayed in the second line of the LCD display (Fig. 23).

```
Ext. 1PPS Synchro  
Delay=1234560ns  
  
ESC=Exit,  
'7'=Synch.
```

Fig. 23

To synchronize internal time scale press key “7”. If synchronization is accomplished successfully, a message about synchronization accomplishment is shown in 2 seconds (Fig. 24) and then - disappears.

```
Ext. 1PPS Synchro  
Delay=20ns  
Synch. OK  
ESC=Exit,  
'7'=Synch.
```

Fig. 24

If there is no external 1 PPS on “1PPS EXT” input, a corresponding message appears in the third line of the LCD display and synchronization control key is locked (Fig. 25).

Ext . 1PPS Synchro
Ext . 1PPS absent
ESC=Exit

Fig. 25

To return to menu “Control” press “ESC”.

2.5.5. Current time setup – menu “Time”

This submenu allows to set a proper current time manually on the front panel’s time display. The LCD display in this mode takes a look as shown on Fig. 26. In the second line of the window modified time format is displayed. User can insert the proper current time in the third line pressing digital keys and “SHIFT” to shift back cursor position. After setting time press “ENTER” to start the time counter from the new position.

Set time(ESC=Exit)
HH:MM:SS
12:34:5 <u>6</u>
SHIFT=Back, ENTER=OK

Fig. 26

To return to menu “Control” press key “ESC”.

2.6. Diagnostic messages review

During the instrument operation some errors (“Alarm minor” or “Alarm major”) can occur. Diagnostic messages menu is designed to attract the user attention and perform a proper technical maintenance of the instrument. Depending on the kind of a malfunction the third line of the Main menu can be called “Information” or “Errors”.

“Alarm minor” message and “Information” in the third line of the Main menu appear if some parameters of the instrument are beyond tolerance limits defined as normal, but the control program indicates further normal operation as possible.

“Alarm major” message and “Error” in the third line of the Main menu appear if further normal operation is impossible, the LED indicator “ALARM” starts blinking.

To enter in the Diagnostic menu press key “3” in the Main menu.

If the number of messages is more than four, there will appear up/down arrows in the last positions of first and fourth lines, which inform a user that messages can be looked through with the help of keys “0”(down) and “3”(up), as shown in Fig. 27.

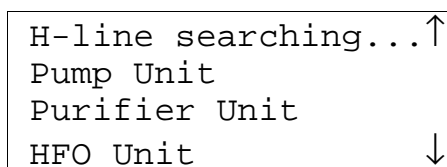


Fig. 27

The full list of diagnostic messages is represented below.

1) No synchronization

The crystal oscillator is not locked to the hydrogen emission line. The program shows this message if U2h value is less than 0,5 V.

2) H-line searching...

This message is shown while control voltage of the crystal oscillator is changing to search H-emission line (p. 2.5.3).

3) Pump Unit

Ion pump current is above the normal limit or its voltage is below the normal limit. Limit for voltage is 2 kilovolts, for current: during switching on – 500 microamperes, after warming up – 100 microamperes. To check these parameters use menu “Check/Maser” (p. 2.4.1).

4) Purifier Unit

The purifier current is out of tolerance limits: lower value is 0.15 A, upper value is 1.2 A. To save the maser, in this case, control program switches OFF the power of the purifier unit.

5) HFO Unit

The discharge brightness sensor voltage is lower than normal (0.5V) or the HFO current is higher than normal (0.7A). These parameters are available for examination from menu “Check\Maser” (paragraph 2.4.1). If these parameters are out of limits, control program switches off HFO power.

6) Pump Unit off

The Ion pump is switched OFF, either due to its parameters are out of tolerance limits, or it is switched OFF by the User in manual control mode.

7) Purifier Unit off

The purifier is switched OFF either due to the instrument is in warm up state, or the purifier are out of tolerance limits, or it is switched OFF by User in manual control mode. In a warm up mode (auto switching ON) the purifier is switches ON only when the cavity of the discriminator is warmed up and the H-pressure and voltage on the heater of the molecular hydrogen source are normal.

8) HFO Unit off

The HFO unit is switched OFF either due to the instrument is in a warm up state, or the HFO working parameters are out of the tolerance limits, or it is switched OFF by User in manual control mode. In a warm up mode (auto switching on) the HFO unit is switched ON in five minutes after switching ON the purifier unit, if the purifier current is normal.

9) Cavity Thermostats

The cavity of the discriminator is not warmed up: voltages on the heaters of the bottom and side surfaces are out of tolerance limits or changing rate of these voltages is too high. The control program compares voltages on the heaters with previous values after each 500 seconds, and if the absolute difference is bigger than 0.5 V, it takes decision that the cavity of the discriminator is not warmed up yet. The lower limit of voltage for the heaters is 1.0 V, the upper is - 21 V. To check these parameters use menu “Check\Therm” (paragraph 2.4.5).

10) Power Unit

Voltages of some voltage converters go out of tolerance limits. The next limits are set for power units:

External +27 V (input): minimum is +22 V, maximum is +32 V;
 AC/DC ~220/+27 V (output): minimum is +23.5 V, maximum is +30.5 V;
 +27 V (output): minimum is +24 V, maximum is +30 V;
 +15 V (output): minimum is +13.5 V, maximum is +18 V;
 -15 V (output): minimum is -13.5 V, maximum is -18 V;
 +5 V (output): minimum is +4.5 V, maximum is +5.5 V;
 +3.3 V (output): minimum is +3.0 V, maximum is +3.5 V;
 To check these parameters use menu “Check\Power”(paragraph 2.4.4).

11) Acc. discharged

The built in accumulator is discharged, voltage on its terminals is lower than 21.5 V. To check this parameter use menu “Check\Power” (paragraph 2.4.4).

12) Signals Unit

The level of one or several sinusoidal signals of the reference signal unit is low, or one or more pulse signals are absent.

The control program checks the following sinusoidal signals:

The signal on the rear panel “5MHz-1” – minimal level is 0.3 V RMS;

The signal on the rear panel “5MHz-2” – minimal level is 0.3 V RMS;

The internal source 5 MHz which is used by frequency multiplier 5-100 MHz – minimal level is 0.3 V RMS;

The signal on the rear panel “10MHz” – minimal level is 0.3 V RMS.

The control program also checks the presence of pulse signals, which are put on the rear panel of the reference signal unit: “1PPS-1”, “1PPS-2”, “2.048MHz”. To check the signals described above use menu “Check\Signals” (paragraph 2.4.2).

13) FLL 100M/20M level

This message appears if signals of frequencies multiplier 100 MHz or digital synthesizer 20.40575168 MHz, which are formed in the interrogation signal unit are

below the tolerance limits. For 100 MHz signal permissible value is 0.5 V RMS, for 20.40575168 MHz – 0.1 V RMS. To check these parameters use menu “Check\FLL” (paragraph 2.4.3).

14) FLL D2h-level

To check the operation of FLL system (both the crystal oscillator and maser cavity servo loops) digital synchronous detector of the second harmonic is realized in the program of the FLL processor, output value of that detector is used as a criterion of FLL system operation:

- D2h is less than (-1000), FLL system operates normally, crystal oscillator and maser cavity properly tuned to the top of H-emission line;
- D2h is more than (+200), there is no H-line servo-signal (possible reasons: the maser is faulty, purifier or HFO is not working or switched off, crystal oscillator frequency is out of H-line band), but maser cavity is tuning properly;
- D2h is near the zero (from –200 up to +200), FLL system does not work, there are no servo-signals both the crystal oscillator and H-maser cavity circuits.

To check current value of this parameter use menu “Check\FLL” (paragraph 2.4.3).

15) FLL IF-level

The level of the intermediate frequency in the receiver unit is below the tolerance limit, which is equal to 0.5 V RMS. To check this parameter use menu “Check\FLL” (paragraph 2.4.3).

16) FLL DAC overflow

In the passive hydrogen maser VCH-1006 FLL system there are two servo loops: crystal oscillator and H-maser cavity. Control voltages of the crystal oscillator and cavity varactors are formed by digital-to-analog converters (DAC) located in FLL processor unit. In both loops 16-bits converters are used, the full scale of which is ranged from 0 to 65535. If the DAC code of some of these loops is less than 1000 or more than 64500, the control program of the central processor forms the message “DAC overflow”.

To define exactly which DAC has crossed the limit value one needs to view corresponding parameters from menu “Check\FLL” (paragraph 2.4.3).

The DAC controlling the crystal oscillator can be set to the middle position by SEARCH HL procedure (see menu “Control\Search HL”, paragraph 2.5.3).

The cavity DAC overflow could require repair of quantum discriminator.

17) FLLP Unit link

This message can be shortly displayed and then disappear if the exchange data error between the central and FLL processor occurs. This is a normal situation, since the main task of the FLL processor is continuous tuning the crystal oscillator, data exchange has lower priority and takes time that remains free from the main task of the

FLL processor. When such a message is presented permanently, it indicates that there are some faults in the FLL unit or frequency synthesizer.

18) H2 source

The molecular hydrogen pressure in source or its thermostat control voltage are out of tolerance limits. The limits of H-pressure are from 1.5 till to 14 atmospheres; the heating voltage - from 1 up to 21 V. To check the corresponding parameters use menu "Check\Therm" (paragraph 2.4.5).

19) User's control

The instrument is in the manual switch ON/OFF mode or HL - searching procedure has been initiated.

20) S/W Ver 2.3

At the end of diagnostic messages software version of the central processor control program is displayed.

If the control program did not reveal any faults, then "Normal operation" message, current synthesizer code and software version are displayed on the LCD display in review mode of diagnostic messages, as shown on Fig. 28.

```
Normal operation
F=50000e-15
S/W Ver 2.3
```

Fig. 28

2.7. Operation using built in accumulators

Internal built in battery (accumulator) is used in the instrument as a standby power supply source preventing the instrument failure in case of short breaks in external power circuits. In case of external power disappearance (220 V AC and 27 V DC), the instrument automatically turns to operation from internal battery.

The corresponding message (Fig.29) is displayed immediately and beep signal is given. In the third line of the LCD display accumulators voltage is displayed, in the fourth line – time of operation from accumulators in seconds.

Note. To use built in battery toggle "ACCUM" on the rear panel must be switched ON.

```
ATTENTION!
Accumulator engaged
Uacc=22.1
time - 10 s
```

Fig. 29

Attention! Built in battery switches OFF automatically as soon as its voltage becomes lower than 20 V. Battery resource is estimated approximately as for 10 minutes.

During operation of the instrument from an external power source built in battery is charging, the full charge time is about 40 hours. If the battery is not fully charged, time of autonomous operation could be shorter.