Passive Hydrogen Maser

VCH-1008

User guide

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1. List of Abbreviations

HFO – high frequency oscillator

FLL – frequency lock loop

IF – intermediate frequency

RMS – root mean square value

DAC – digital to analog converter

ADC – analog to digital converter

PPS – pulse per second

PPM – pulse per minute

2. Control and Monitoring Functions

VCH-1008 Passive Hydrogen Maser 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 offset code.
3. Automatic Frequency Lock Loop (FLL) search for crystal oscillator – “H-line searching”.
4. Automatic time scale and frequency correction in the synchronization regime using external 1PPS signal or 1PPS signal of embedded GLONASS/GPS receiver.
5. Manual setup of current date and time.

Monitoring (Check) functions:

1. Power circuits voltages.
- external DC source (+24V) ,
- output of DC/DC converter of the external DC source (+27V),
- AC/DC converter ~220V/+27V,
- DC/DC converters +27V/+15V, +27V/–15V, +27V/+5V, +27V/+3.3V,
- internal battery (built in accumulators) voltage.
- voltage supply for ion-pump,
- voltage supply for HFO.

2. Purifier, ion-pump and HFO currents.
3. Temperature deviations of cavity ovens and hydrogen source oven.
4. Second harmonic signal level.
5. IF-level voltage.
6. Representation of DAC codes, engaged in control circuits of cavity and crystal oscillator tuning.
7. RMS voltage of the sinusoidal signals 100MHz, 10MHz, 5MHz,
8. Presence of the pulse signals 2.048MHz, 1PPS.
9. Status information about GLONASS/GPS receiver module.

3. 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 touch panel.

3.1 Initial Turn-On Procedure

These procedures should be followed when the instrument is to be turned on:

Connect power cables to AC (100 – 240)V line or external +24V DC source to the instrument and switch ON the toggle “ACCUM” on the rear panel of the instrument.

After that automatic switching on procedure is on the run. The LED-indicator “ALARM” must light.

During first 23 seconds the information about instrument status and parameters is collected, LCD display shows the message “Loading…”. After loading process the introduction window with current status information appears on the LCD display (see Fig. 1 – 4). To get more information about the instrument parameters – click “Enter the menu”.

The instrument comes to a normal operation mode automatically. 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, corresponding message window on the LCD display is presented in Fig. 1. As the pump current reaches its norm and cavity warms up, the molecular hydrogen purifier is energized.

Figure 1. Status screen before hydrogen purifier is run

In 5 minutes after the purifier is switched ON, the control program checks its current and if it is normal, HFO power is switched ON.

Figure 2. Status screen during H-line searching process

As soon as the normal brightness of HF-discharge in the bulb is achieved, the central processor sends the command to the FLL-processor to search Hydrogen emission line (H-line) by changing the frequency of 5 MHz crystal oscillator (Fig. 2). H-line searching procedure takes one minute, after that FLL system comes to the frequency lock state. In case of successful completion of the H-line searching procedure LED indicator “ALARM” fades and the message window on the LCD display informs about normal operation of the instrument (Fig. 3).

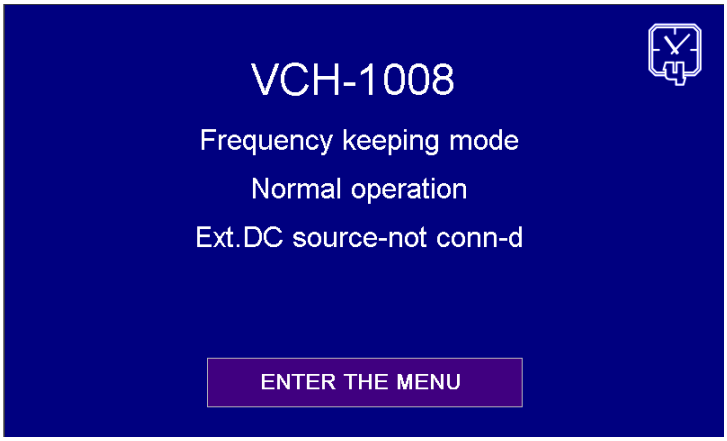

Figure 3. Status screen informing about normal operation of the instrument

If after switching on process non-critical errors have been detected, warning message will be shown in the status screen (see example in Fig. 4). To look at the full list of warning messages enter the menu and select item “Information”.

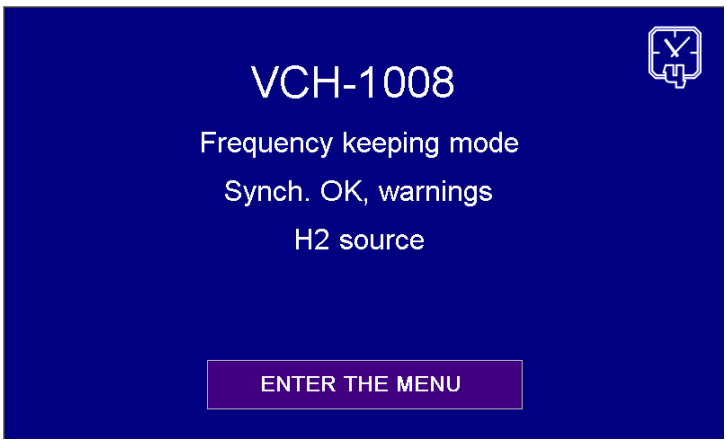

Figure 4. Status screen informing about normal operation with warning

If during switching on process or during operation of the instrument crucial failures occur and normal operation is impossible, introduction window will show message “No synchronization” and the LED-indicator “ALARM” will light.

In case of unplugging external power source, switching to internal accumulators will be done automatically, the corresponding message with the information about accumulators voltage will appear.

3.2 Turn-off Procedure

To switch off the instrument toggle “ACCUM” in the lower position, disconnect external power sources 220V AC and +24V DC. After the turn-off procedure is completed, all settings of the instrument are saved in nonvolatile memory. These settings are restored when the instrument is switched on next time.

3.3 Main Menu

The main menu looks as follows:

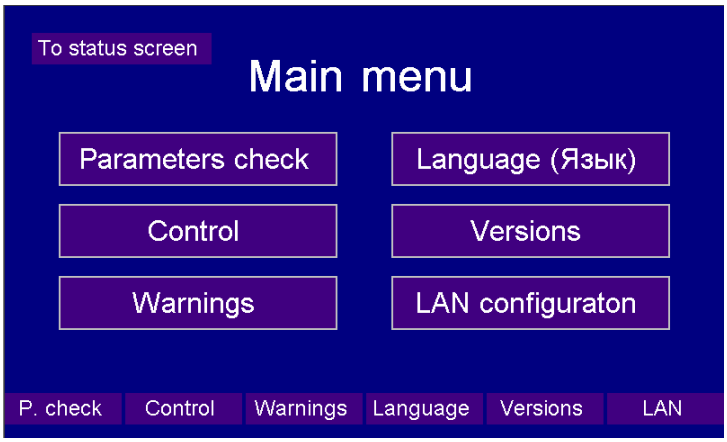

Figure 5. Main menu window

Each menu window has a button in the upper left corner to turn back to the previous menu or introduction window (“To status screen” in Fig. 5). In the bottom of each menu, submenu or information window there are items of main menu for quick navigation. To select a menu item touch corresponding area on the display. All clickable buttons of the interface are colored in dark violet.

3.4 Menu “Parameters Check”

The central processor measures parameters of the instrument units continuously. Use a proper submenu to inspect the parameters of a certain system. For this purpose choose one of the items shown in Fig. 6.

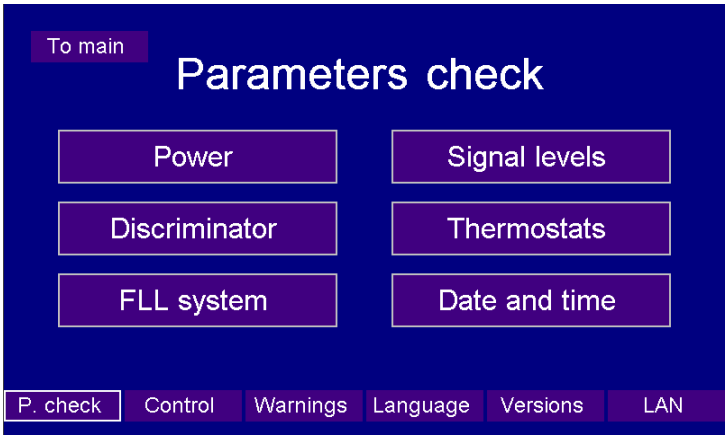

Figure 6. Menu window “Parameters check”

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

This menu serves to check power supply voltages. After selection the item “Power” the following window appears on the LCD display (Fig. 7). Description of parameters and allowable limits are presented in Table 1.

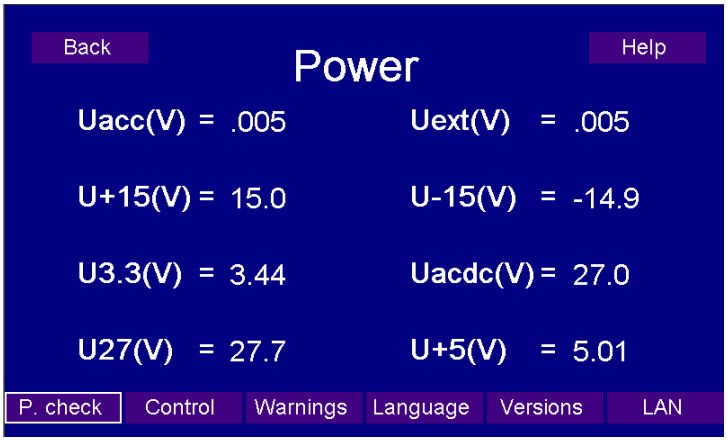

Figure 7. Power supply information window

Table 1 can be viewed on the instrument display by clicking button “Help” in the upper right corner (see Fig. 7)

Table 1. “Power” group parameters

Parameter	Description, units	Allowable limits
Uacc	Built in accumulator voltage, V	No less than 21.5V
Uext	External DC source voltage, V	No less than 20V
U+27	+27 V internal converter voltage, V	24V to 30V
U+15	+15 V internal converter voltage, V	13.5V to 18V
U−15	−15 V internal converter voltage, V	−13.5V to −18V
U+5	5 V internal converter voltage, V	4.5V to 5.5V
U+3.3	3.3 V internal converter voltage, V	3.0V to 3.5V
Uacdc	~220/+27 V internal converter voltage, V	No less than 22

3.4.2. Checking of the hydrogen discriminator – menu “Discriminator”

To inspect parameters of the discriminator (Maser) and the units, providing its operation, choose item – “Discriminator”. After its selection the corresponding window will appear on the LCD display (Fig. 8). Description of parameters and allowable limits are presented in the Table 2.

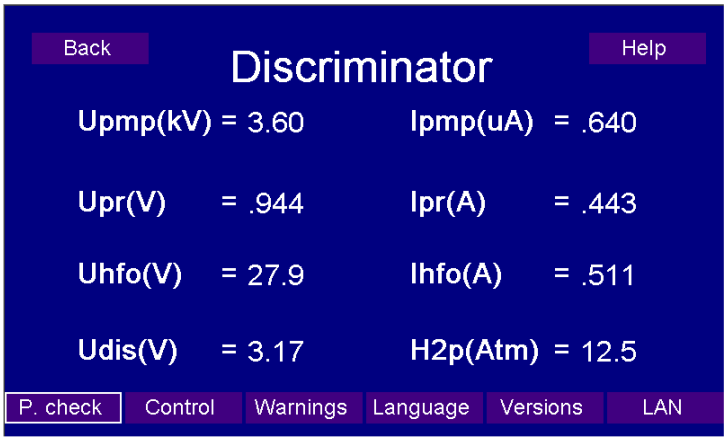

Figure 8. Information window “Discriminator”

Table 2 can be viewed on the instrument display by clicking button “Help” in the upper right corner (see Fig. 8)

Table 2. “Discriminator” group parameters

Parameter	Description, units	Allowable limits, if applicable
Upmp	ion pump power voltage, measured in kilovolts	No less than 2 kV
Ipmp	ion pump current, measured in microamperes	No more than 495 μA (during heating process) No more than 100 μA (after heating)
Upr	power voltage of molecular hydrogen purifier, measured in volts	
Ipr	purifier current, measured in amperes	0.15A to 1.2A
H2p	pressure in the hydrogen source, measured in atmospheres	1.5 to 20
Uhfo	HFO power voltage, measured in volts	
Ihfo	HFO consumption current, measured in ampere units	No more than 0.7A
Udis	voltage of photodetector (in volts) measuring brightness of the discharge in the discharge bulb	No less than 0.5V

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

This menu allows checking the units involved in the FLL system: interrogation signal unit, receiver and FLL-processor (Fig. 9). Description of parameters and allowable limits are presented in the Table 3.

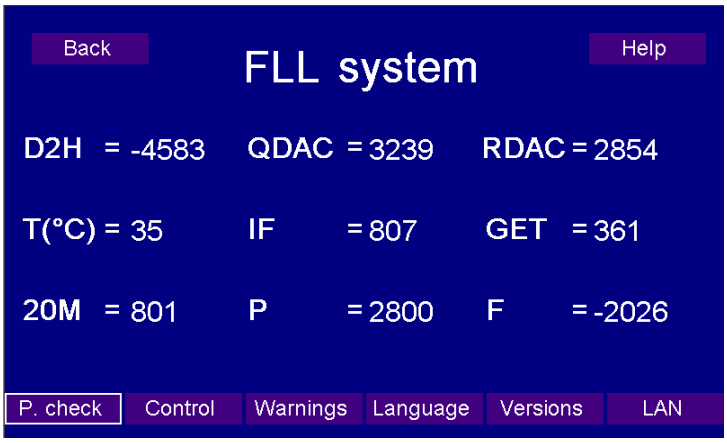

Figure 9. Information window “FLL system”

D2H – second harmonic level of mismatch signal, measured in relative units. **It is a crucial parameter indicating whether crystal oscillator signal is adjusted (locked) to the frequency of hydrogen spectral line. Crystal oscillator is considered to be synchronized if D2H < −1000.**

Table 3. “FLL system” group parameters

Parameter	Description, units	Allowable limits, if applicable
D2H	Second harmonic level of mismatch signal, measured in arbitrary units.	No more than -1000
QDAC	Crystal oscillator fine tuning DAC code, arbitrary units	1000 to 64535
RDAC	Discriminator resonator tuning DAC code	1000 to 64535
T	Temperature (°C) measured on the FLL processor board	
IF	Receiver intermediate frequency signal level, arbitrary units (ranged between 0 and 1023)	No less than 60
GET	Receiver heterodyne (oscillator) signal level, measured in ADC code units (ranged between 0 and 1023)	No less than 60
20M	20.40575168 MHz synthesizer DAC code, arbitrary units (ranged between 0 and 1023)	No less than 4
P	Selected digital code of synthesizer 20.40575168 MHz signal level, (factory set)	0 to 4095
F	Output signal frequency code, measured in units of 1.e−15	−99999 to 99999

Table 3 can be viewed on the instrument display by clicking button “Help” in the upper right corner (see Fig. 9)

3.4.4. Checking of the Reference signal unit – menu “Signal levels”

This menu serves to inspect the internal reference signals. The sinusoidal signal levels are measured in volts, pulse signals are controlled for presence by logical detectors, which mark presence or absence of corresponding signals (Fig. 10). Description of parameters and allowable limits are presented in the Table 4.

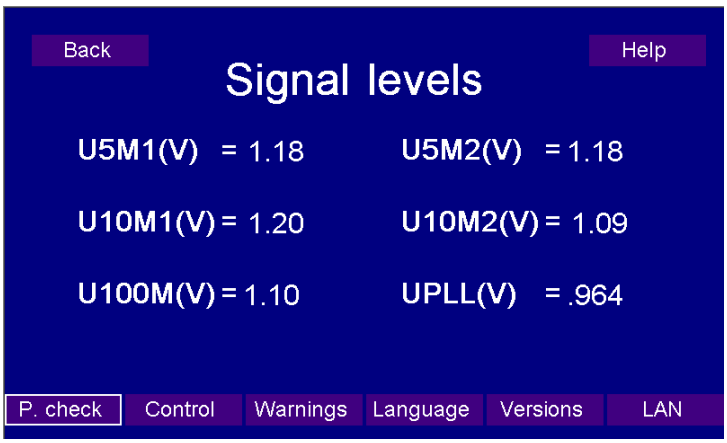

Figure 10. Information window “Signal levels”

Table 4 can be viewed on the instrument display by clicking button “Help” in the upper right corner (see Fig. 10)

Table 4. “Signal levels” group parameters

Parameter	Description, units	Allowable limits, if applicable
U5M1	5 MHz output signal voltage, output №1, V, RMS	No less than 0.3
U5M2	5 MHz output signal voltage, output №2, V, RMS	No less than 0.3
U10M1	10 MHz output signal voltage, output №1, V, RMS	No less than 0.3
U10M2	10 MHz output signal voltage, output №2, V, RMS	No less than 0.3
U100M	100 MHz output signal voltage, V, RMS	No less than 0.3
UPLL	Control voltage of PLL system for 100 MHz signal, V	0.5 to 4.5
1M	Status (OK/ERR) of pulse signal 1 MHz (the signal runs to the rear panel, and marked as “1 MHz”)	
2048	status (OK/ERR) of pulse signal 2.048 MHz (the signal runs to the rear panel, and marked as “2.048MHz”)	

3.4.5. Checking of thermostats– menu “Thermostats”

This submenu allows to inspect the cavity’s ovens voltages and molecular hydrogen source oven voltage (see Fig. 11). Description of parameters and allowable limits are presented in the Table 4.

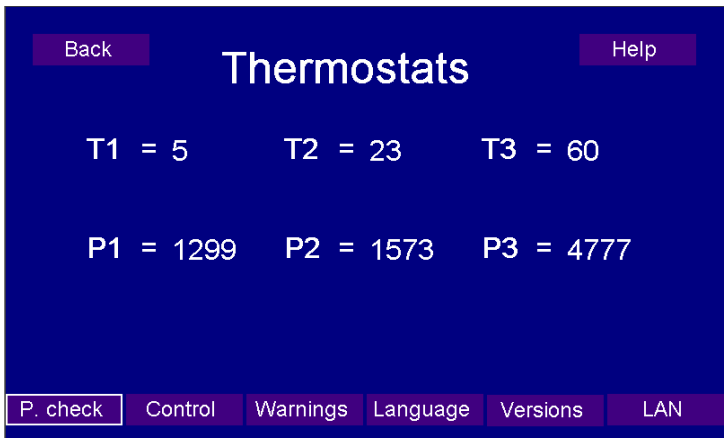

Figure 11. Information window “Thermostats”

Table 5 can be viewed on the instrument display by clicking button “Help” in the upper right corner (see Fig. 11)

Table 5. “Thermostats” group parameters

Parameter	Description, units	Allowable limits, if applicable
T1	temperature mismatch of cavity side surface, arbitrary units	No more than 150
T2	temperature mismatch of cavity base, arbitrary units	No more than 150
T3	temperature mismatch of hydrogen source, arbitrary units	No more than 1000
P1	cavity side surface heater power, arbitrary units	10 - 32767
P2	cavity base heater power, arbitrary units	10 - 32767
P3	hydrogen source heater power, arbitrary units	10 - 32767

3.5. Menu “Control”

Control submenu of main menu (Fig. 5) looks as follows:

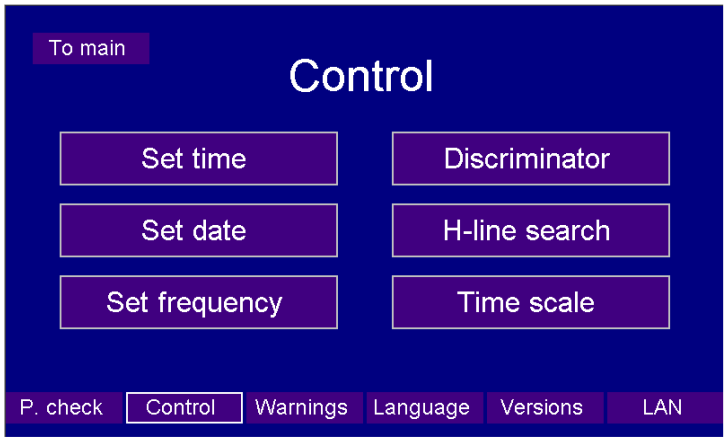

Figure. 12 Menu “Control”

Submenus of menu “Control” are described below.

03.5.1 Menu “Set time”

To set current time on the instrument use corresponding submenu of menu “Control”. The window for time setting is shown in Fig. 13. Time should be entered in the following format: hh:mm:ss, hh – hour (2 digits), mm – minute (2 digits), ss – second (2 digits). Values of hour, minute and second should be separated by “:”. To apply new time value – click “Set” button, to modify typed time value – click “Clear” button. On the left side of the display window current date and time are indicated. After setting new time value, “Time” field will be updated in two seconds.

Figure 13. User interface for time setting

3.5.2 Menu “Set date”

To set current date on the instrument use corresponding submenu of menu “Control” (Fig. 12). The window for date setting is shown in Fig. 14. Date should be entered in the following format: DD:MM:YY, DD – day (2 digits), MM – month (2 digits), YY – year (2 digits). Values of day, month and year should be separated by “.”.To apply new date value – click “Set” button, to change typed date value – click “Clear” button. On the left side of the display window current date and time are indicated. After setting new date value, “Date” field will be updated in two seconds.

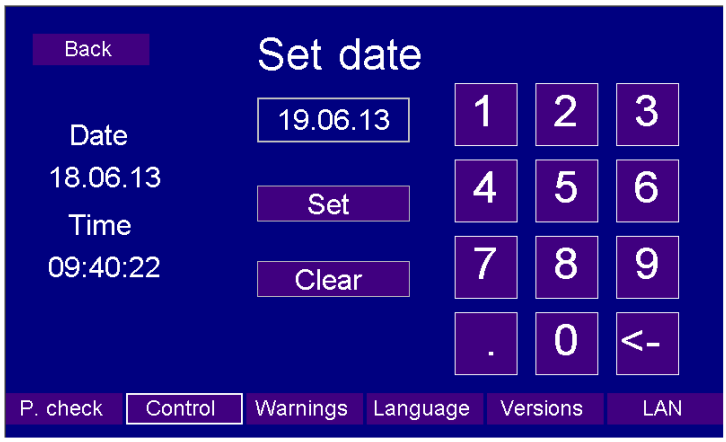

Figure 14. User interface for date setting

3.5.3 Menu “Set frequency”

Menu “Set frequency” (Fig. 15) allows to adjust output signals frequency precisely by changing digital synthesizer code. Relative value of the output frequency could be changed by steps 10^{-15} in the range from $-9.9999 \cdot 10^{-11}$ to $9.9999 \cdot 10^{-11}$ (codes from −99999 to 99999).

To apply new frequency code – click “Set” button, to change typed value – click “Clear” button. On the left side of the display window current frequency code is indicated. After setting new frequency value “Current frequency” field will be updated in three seconds.

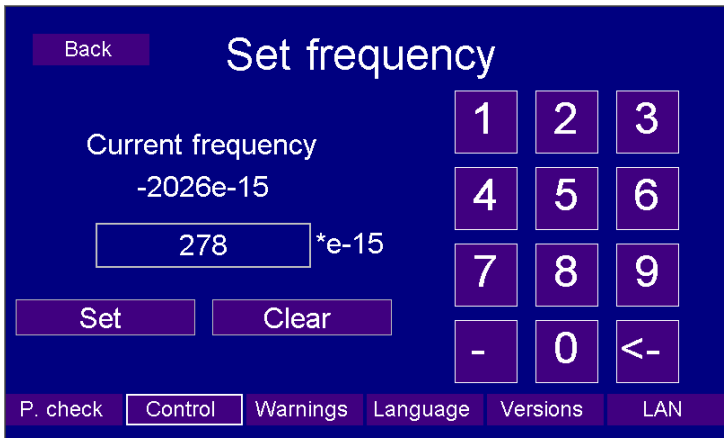

Figure 15. User interface for output signal frequency setting

3.5.4 Maser units control – menu “Discriminator”

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

Three units of the maser (quantum hydrogen discriminator) have to be switch ON/OFF in a proper sequence: the HFO cannot 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 LCD display. Therefore 4 different windows are possible in discriminator control mode.
1. Discriminator units are switched OFF (Fig. 16).

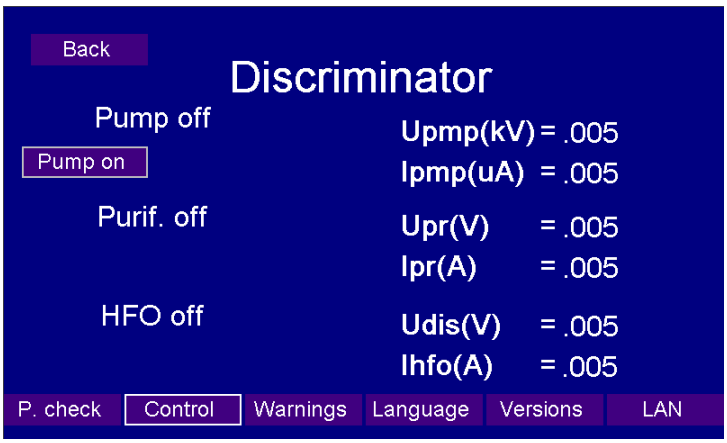

Figure 16. Submenu “Discriminator”, variant 1

In this case it is possible to switch on the ion-pump. After ion-pump has been switched ON the next variant of submenu “Discriminator” is shown (Fig. 17).
2. The pump is switched ON, purifier and HFO are switched OFF. One can either switch OFF the pump or switch ON the purifier

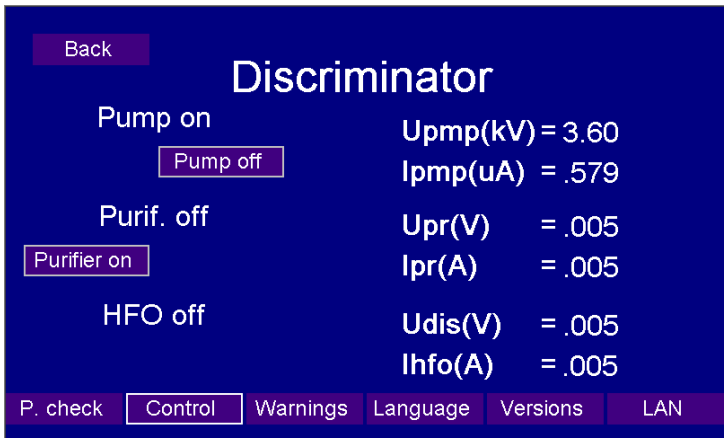

Figure 17. Submenu “Discriminator”, variant 2

3. Pump and purifier are switched ON, HFO is switched OFF. One can either switch OFF the purifier or switch ON the HFO, (Fig. 18).

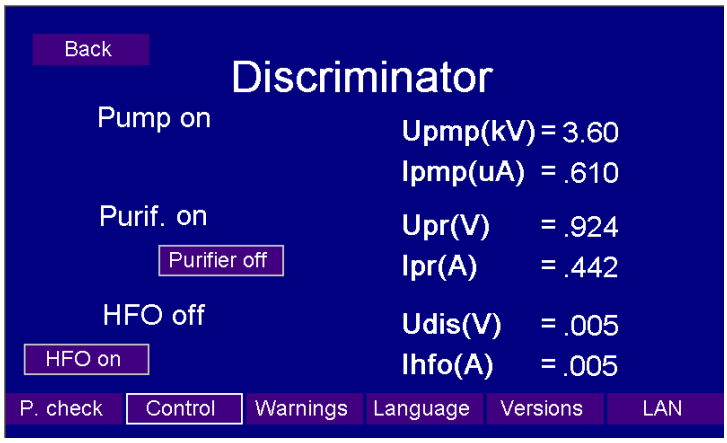

Figure 18. Submenu “Discriminator”, variant 3

4. The Pump, purifier, HFO are switched on. In this position User can only switch OFF the HFO

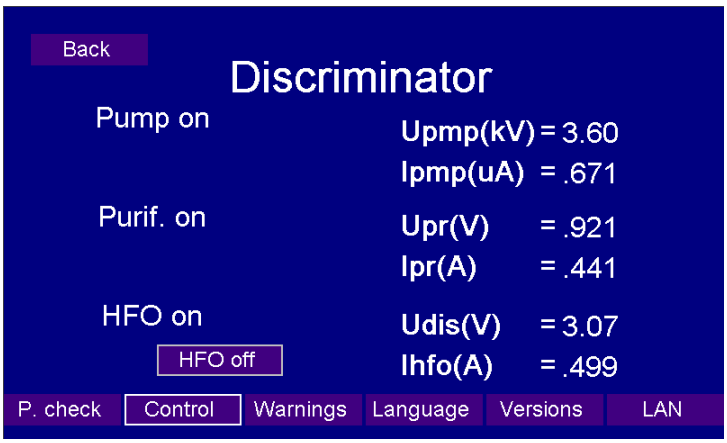

Figure 19. Submenu “Discriminator”, variant 4

Note that discriminator is controlled automatically always excepting time interval when submenu “Discriminator” is opened. If User leaves this submenu, the instrument will switch to the automatic mode after 100 seconds. So, if some units are switched off manually, control program in automatic mode will switch them on. All User manipulations are stored in nonvolatile memory of the instrument.

3.5.5 Searching for Hydrogen emission line – menu “H-line search”

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 formed by coarse DAC code Qctl (0 to 65535) and control voltage in the range 0 – 0.8 V formed by fine tuning DAC code Q (0 to 65535). For proper operation it is advisable to set coarse DAC code in such a way, that the code of the fine tuning will occur in the middle of the full scale (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 for manual switch mode operation.
If the item “H-line” of menu “Control” (Fig. 12) is selected the corresponding window will be shown on the LCD (see Fig. 20). Parameters presented in this window are described in the Table 6 and in major repeat parameters described in the paragraph 3.4.3.

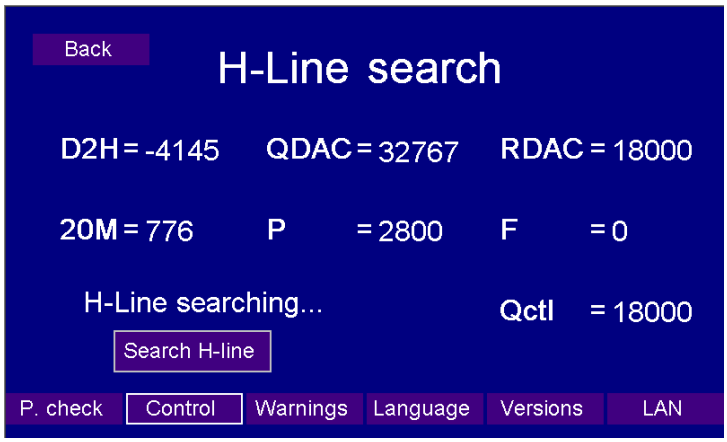

Figure 20. Submenu “H-Line search”

To start the procedure of crystal oscillator control voltage searching – click on the “Search H-line” button on the LCD. To monitor the progress of searching – look at the parameters: RDAC (discriminator resonator tuning DAC code) and Qctl (crystal oscillator coarse tuning DAC). At first the resonator is adjusted and RDAC is varying in the full range. After the resonator has been adjusted, searching a proper coarse DAC code of crystal oscillator control voltage is started. If Qctl code is successfully selected LED indicator “ALARM” will fade with 2-3 second delay.

If during H-line searching procedure user turns back to the menu “Control” or selects another menu, searching process will be continued independently.

Table 6. “FLL system” group parameters

Parameter	Description, units	Allowable limits, if applicable
D2H	Second harmonic level of mismatch signal, measured in arbitrary units.	No more than -1000
QDAC	Crystal oscillator fine tuning DAC code, arbitrary units	1000 to 64535
RDAC	Discriminator resonator tuning DAC code	1000 to 64535
20M	20.40575168 MHz synthesizer DAC code, arbitrary units	No less than 7
P	Selected digital code of synthesizer 20.40575168 MHz signal level, (factory set)	0 to 4095
F	Output signal frequency code, measured in units of 1.e-15	−99999 to 99999
Qctl	Crystal oscillator coarse tuning DAC code, arbitrary units	0 to 65535

3.5.6 Submenu “Time scale control”

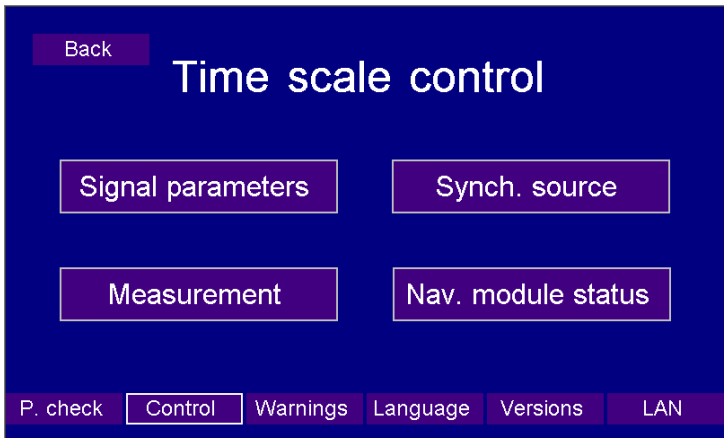

Figure 21. Submenu “Time scale control”

This submenu (Fig. 21) contains the following items:

- “Signal parameters” – selecting pulse duration for 1 PPS and 1 PPM signals;
- “Measurement” – START/STOP process of steering the output time scale of the instrument to 1 PPS synchronization signal;
- “Synch. source” – selecting 1 PPS synchronization signal source: using synchronization signal from external source connected to the input “1 PPS EXT” on the rear panel of the instrument or using 1 PPS signal produced by embedded (optional) GLONASS/GPS receiver;
- “Nav. module status” – monitoring GLONASS/GPS navigation module (optional) status and selecting antenna cable delay.

3.5.6.1 Submenu “Signal parameters”

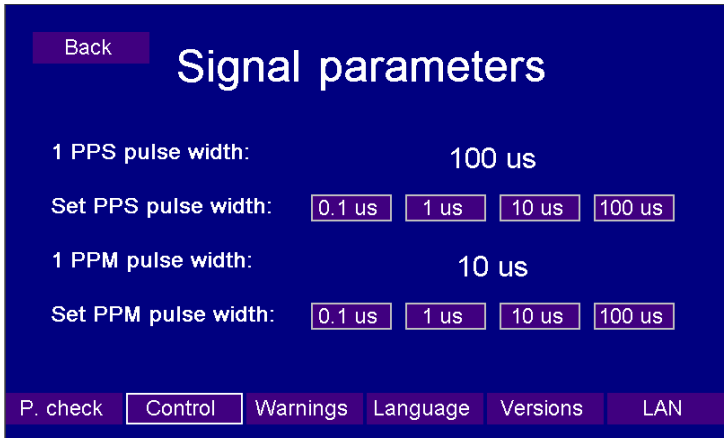

Figure 22. Submenu “Signal parameters”

This submenu shows selected pulse widths of 1 PPS and 1 PPM signals (Fig. 22). It is possible to change pulse widths clicking on the corresponding buttons positioned in the lines “Set PPS pulse width” and “Set PPM pulse width”.

3.5.6.2 Submenu “Measurement”

In case of normal operation the instrument supports two different modes: frequency keeping mode and synchronization by external signal mode. Frequency keeping mode is a default mode which is selected automatically after the instrument has been switched on and warmed up. Synchronization mode can be selected manually in the submenu “Measurement” (Fig. 23) by clicking the button “Run/stop measurement”.

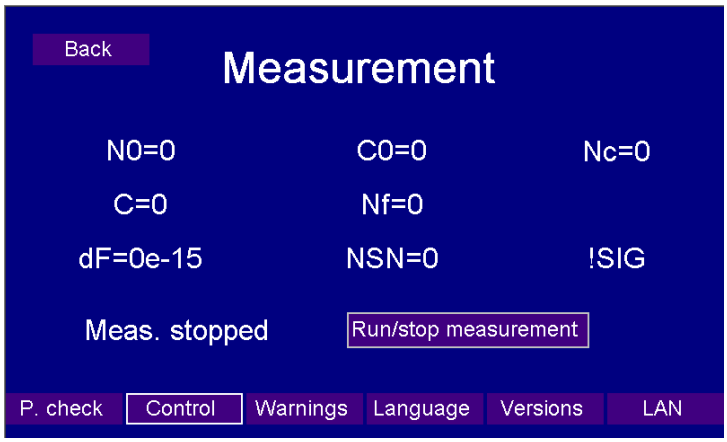

Figure 23. Submenu “Measurement”

For synchronization purpose 1 PPS signal is used. The source of 1 PPS signal can be selected in submenu “Synch. source” of menu “Time scale control”. One of two possible sources should be selected: embedded (optional) GLONASS/GPS navigation module or external source connected to the input “1 PPS EXT” on the rear panel of the instrument. External source is required to produce stable 1 PPS signal positive polarity and amplitude of at least 2.5 V into 50 ohm load.

Before run measurement process synchronization signal source should be selected (item “Synch. source” of menu “Time scale control”).
After measurement process has been run, phase differences between signals of the instrument and 1 PPS synchronization signal are measured. Using measured phase differences time scale of the instrument is steered and output frequency of the instrument is corrected.
Two 100 MHz counters are used for measurements: first one is a time interval counter between 1 PPS signal of the instrument and 1 PPS synchronization signal, second one is a frequency counter for estimating relative frequency difference between output signals of the instrument and 1 PPS synchronization signal. Relative frequency difference is calculated by phase counts averaged on 100 s intervals.
Time scale of the instrument is formed by counting of 100 MHz signal of the instrument. Time scale is steered by means of addition/exclusion of counter cycles each 2000 seconds. Output frequency of the instrument is corrected by means of changing digital code of frequency synthesizer. In automatic mode full measurement cycle contains 10 days. After measurement period central processor apply final correction of frequency code and switch the instrument to the frequency keeping mode.
In frequency keeping mode submenu “Measurement” looks like in Fig. 23. After 3 seconds delay, since measurements have been started, display will show current measurement results (Fig. 24).

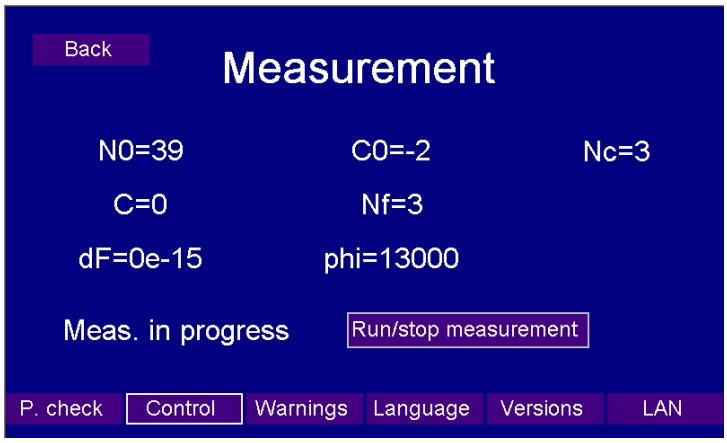

Figure 24. Submenu “Measurement”

If only single adjustment of 1 PPS output signal is required it is necessary to manually switch off synchronization mode by clicking the button “Run/stop measurement” after parameter N0 reaches 10. To adjust 1 PPM output signal measurements should be stopped after parameter N0 becomes more then 60 or parameter Nf becomes more than 0.
Measurements are divided into 100-seconds-cycles. Phase difference is averaged during 100-second interval and averaged value is used for calculation of relative frequency difference. Each 20 cycles (2000 seconds) time scale of the instrument is corrected. Parameters presented in Fig. 23, 24 are described below.
N0 is the number of counts in the current measurement 100-second cycle.
C0 is the time scale mismatch measured in the current 100-second cycle with 10 ns step.
Nc is the number of 100-second cycles after the last time scale correction (or since start of measurement process).
C is the last time scale correction, in units of 10 ns.
Nf is the total number of counts are used for relative frequency difference calculation.

dF is the relative frequency difference estimated since synchronization mode had been switched on.
Phi is the phase measured by the frequency counter, in units of 0.1 ns.

If measurement process is started, the instrument is in synchronization mode, so in status screen the message “frequency keeping mode” is changed to “Ext 1PPS tracking mode” (Fig. 25) or “Nav. sys. track. mode” (Fig. 26) depending on selected synchronization source (see next paragraph 3.5.6.3).

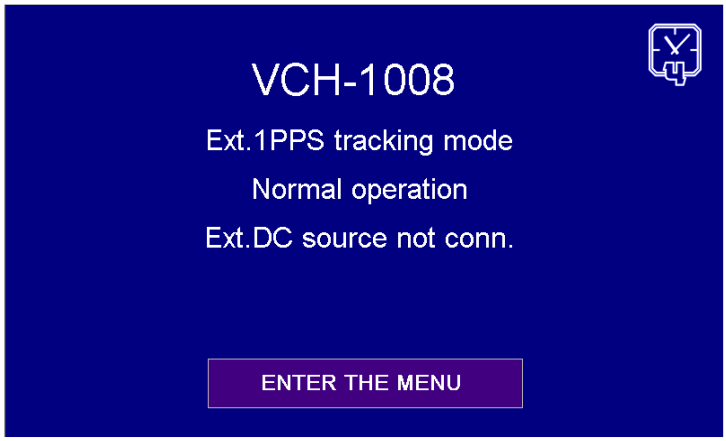

Figure 25. Example of status screen in case of measurement process is in progress and synchronization source is external 1 PPS

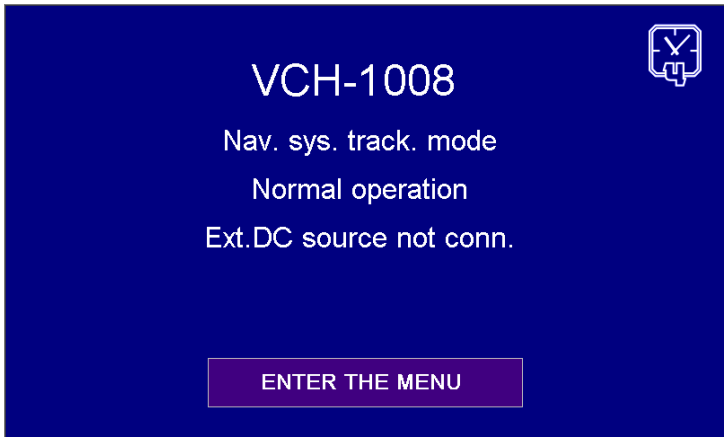

Figure 26. Example of status screen in case of measurement process is in progress and synchronization source is navigational module

If during measurement process frequency mismatch between synchronization signal and output signal of the instrument becomes too large, time interval counter can be overflowed. In this case LCD display will show information message “!OV”. In case of time scale malfunction, the message “!INT0” will be shown. When no synchronization signal, the message – “!SIG” (Fig. 27).

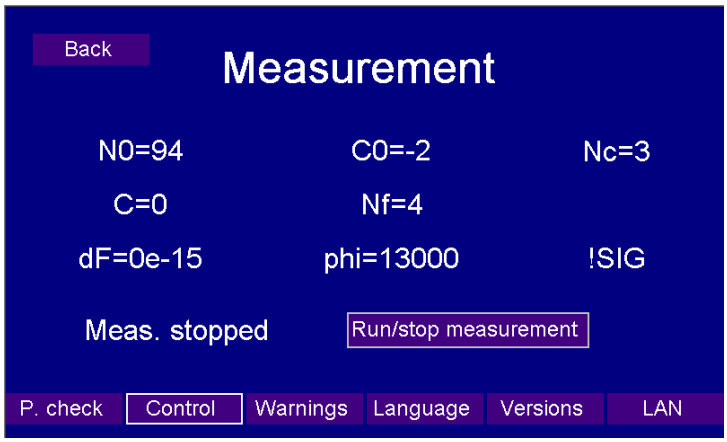

Figure 27. Submenu “Measurement”

3.5.6.3 Submenu “Synchronization source”

This submenu (Fig. 28) is selected by clicking on the item “Synch. source” in the menu “Time scale control” (Fig. 21).
Synchronization source should be selected before measurements have been started (before synchronization mode has been switched on).

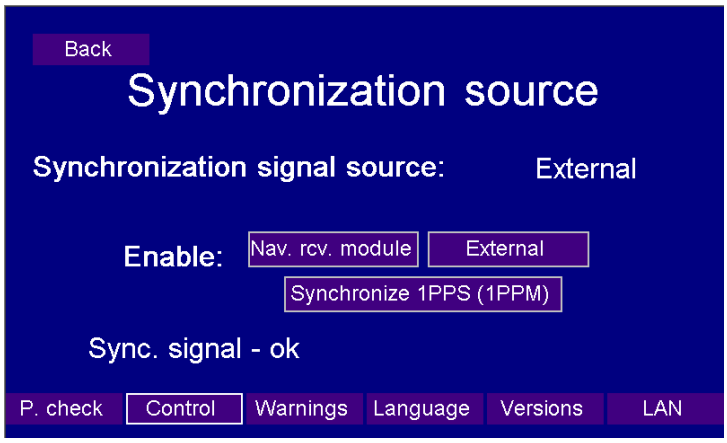

Figure 28. Submenu “Synchronization source”

Two sources are possible: embedded navigational receiver module (“Nav. rcv. module” – optional) or external source of 1PPS signal (“External”).
Field “Synchronization signal source” contains information about current synchronization source. Field “Sync. signal” informs about presence of selected signal. To change the source, click the corresponding touch-area (“Nav. rcv. module” or “External”).
If the instrument is not completed with navigational receiver module, corresponding button (touch-area) will be disabled and colored with gray (Fig. 28).
Clicking button “Synchronize 1PPS(1PPM)” leads to opening information window (Fig. 29) which contains instruction about time scale adjustment. To do synchronization, click “Yes” and start measurements (see instruction in paragraph 3.5.6.2).

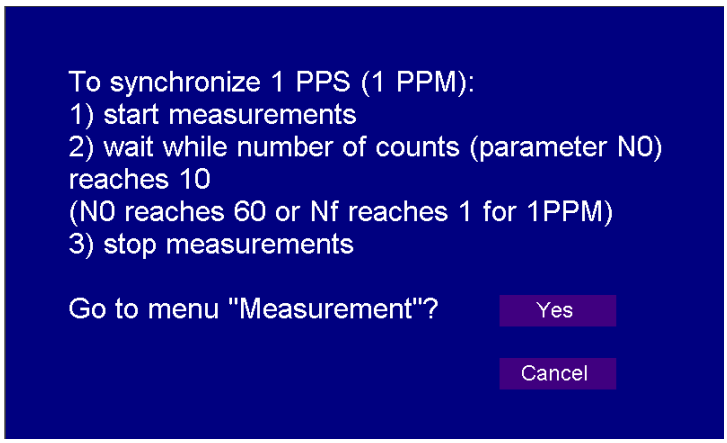

Figure 29. Screen with information about time scale adjustment procedure

3.5.6.4 Submenu "Nav. module status"

Submenu "Nav. module status" can be disabled if the instrument is not completed with navigational module.

If navigational receiver module is selected as a synchronization source, parameters of navigational module should be checked before synchronization (measurement) process start. To check these parameters, enter submenu "Nav. module status" from menu "Time scale control" (Fig. 21). In case of normal operation submenu "Navigational module status" looks like in Fig. 30.

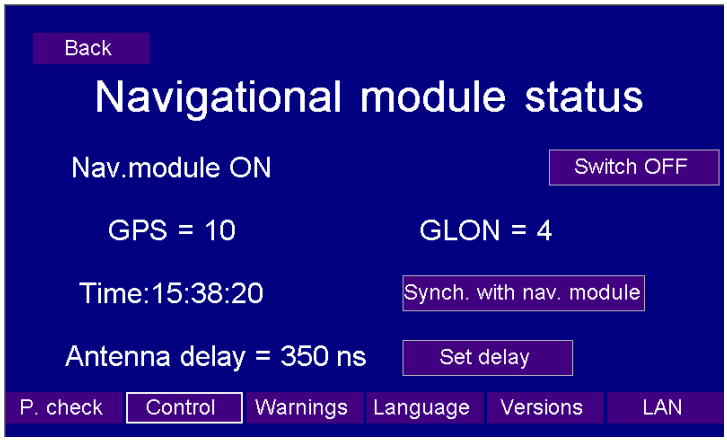

Figure 30. Submenu "Navigational module status", normal operation

Parameters "GPS" and "GLON" shows the number of satellites, which are available and can be used for navigational problem solving. **It is possible to start measurement process (switch to synchronization mode) only if at least one of these parameters is nonzero.**
"Time" shows current time of the instrument, it is updated every 3 seconds. Button "Synch. With nav. module" allows adjusting **minutes and seconds** to UTC time obtained by navigational receiver.
"Antenna delay" shows summary delay which takes into account delay in antenna cable and delay in circuits of navigational module. This value is set by manufacturer; it can be

changed only in case if antenna cable length was changed. Fig. 31 shows submenu for antenna delay changing, which appears after button “Set delay” is clicked.

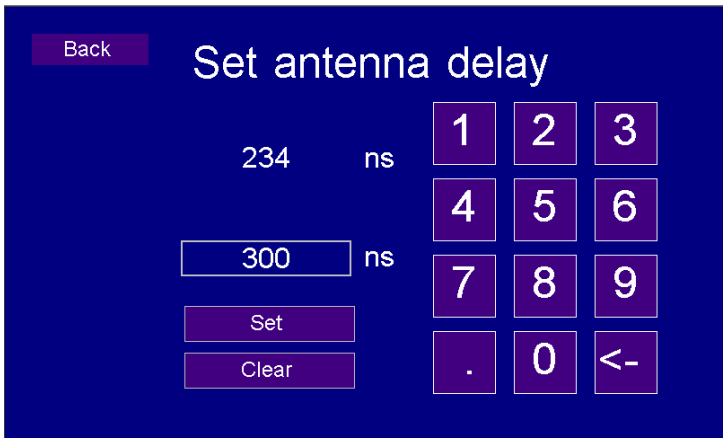

Figure 31. Submenu “Set antenna delay”

If the instrument is already in synchronization mode (even if external 1PPS is selected to be synchronization source) submenu “Navigational module status” looks like in Fig. 32. The module cannot be switched off, and time cannot be adjusted and antenna delay cannot be changed.

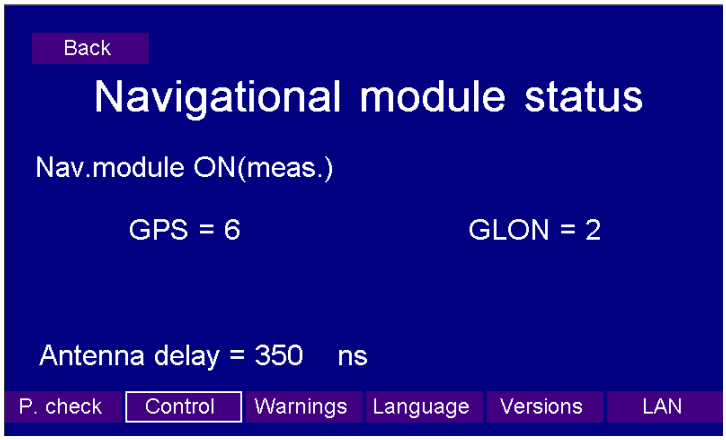

Figure 32. Submenu “Navigational module status”, measurement process is in progress

If errors in operation of navigational module are detected, message describing error is displayed. The following error messages are possible:

1) “GPS-antenna disconnected”,
2) “Nav. module-conn. error”,
3) “GPS test failed”, “GLON test failed”.

If only one message about disconnected antenna is shown – check the antenna and cable connectors.

Note, appearance of message “Nav. module-conn. error” for a short time is allowable.

3.6 Diagnostic messages – menu “Information”

“No synchronization”. The crystal oscillator is not locked to the hydrogen emission line. The program shows this message if parameter D2H from menu “Parameters check/FLL system” (paragraph 3.4.3) is greater than −1000 (parameter D2H can be either positive or negative).

“Warming up”. The message appearing when the instrument is switching on in automatic regime and thermostats are warming.

“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 warming process – 495 microamperes, after warming up – 100 microamperes. To check these parameters use menu “Parameters check/Discriminator” (paragraph 3.4.2).

“Pump Unit off”. The Ion pump is switched OFF, either due to its parameters are out of the tolerance limits, or it is switched OFF by User in manual control mode. To check the parameters of the pump unit use menu “Parameters check/Discriminator” (paragraph 3.4.2).

“Purifier Unit”. The purifier current is out of the tolerance limits: lower value is 0.15 A, upper value is 1.2 A. To protect the maser, in this case, control program switches OFF the power of the purifier unit. To check the parameters of the purifier unit use menu “Parameters check/Discriminator” (paragraph 3.4.2).

“Purifier Unit off”. The purifier is switched OFF either due to the instrument is in warm up state, or it is switched OFF by User in manual control mode. In a warming up mode (auto switching ON) the purifier is switched 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. To check H-pressure (H2p) use menu “Parameters check/Discriminator” (paragraph 3.4.2). To monitor warming process use menu “Parameters check/Discriminator” (paragraph 3.4.5).

“**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 the menu “Parameters check/Discriminator” (paragraph 3.4.2). If these parameters are out of limits, control program switches off HFO power.

“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.

“Cavity Thermostats”. Temperature mismatch of one of heated areas of cavity exceeds allowable limit – 150 arbitrary units (it corresponds to 0.0015 ºC approximately). To check parameters of cavity thermostats use menu “Parameters Check\Thermostats” (paragraph 3.4.5).

“Power Unit”. Voltages of some voltage converters go out of tolerance limits. The following limits are set for power units:
External +24 V: minimum is +20 V;
AC/DC converter ~220/+27 V (output): minimum is +22.5 V;
Converter +27 V/+27 V: minimum is +24 V, maximum is +30 V;
Converter +27 V/+15 V: minimum is +13.5 V, maximum is +18 V;
Converter +27 V/−15 V: minimum is −18 V, maximum is −13.5 V;
Converter +27 V/+5 V: minimum is +4.5 V, maximum is +5.5 V;
Converter +27 V/+3.3 V: minimum is +3.0 V, maximum is +3.5 V;
To check these parameters use menu “Parameters Check/Power”(paragraph 3.4.1).

“Acc. charge”. This message informs about charging the accumulators of the instrument when an external power source (AC 220 V or DC +24 V) is used. The message disappears if charge level exceeds 95 %. If the instrument does not use external power source, this message informs about low voltage of the built-in accumulators (voltage less than +24 V). To prevent premature failure of the accumulators the instrument is switched off if accumulator voltage is less than +23V and it is unplugged from external power source.

“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. This message is shown in case of control voltage for crystal oscillator 2.048 MHz is out of allowable range.
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 signal on the rear panel “10MHz-1” – minimal level is 0.3 V RMS;
The signal on the rear panel “10MHz-2” – 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: “1 MHz”, “2.048MHz”. To check the signals described above use the menu “Parameters Check\Signal levels” (paragraph 3.4.4).

“FLL 100M/20M level”. This message appears if signals of frequency 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 0.3 V RMS, level of signal 20.40575168 MHz is measured in arbitrary units, minimal permissible value is 4. To check these parameters use the menu “Parameters Check\FLL” (paragraph 3.4.3).

“FLL detuning sig.”. This message is shown in case of detected level of second harmonic signal (detuning signal) in FLL system is out of tolerance limits. Second harmonic level indicates whether the crystal oscillator is locked to the Hydrogen emission line or not. The crystal oscillator is considered to be synchronized if detected level D2H is less than −1000. If D2H parameter value is between −200 and 200, it is assumed that detuning signal is not present in FLL system. To check D2H level use the menu “Parameters Check\FLL system” (paragraph 3.4.3).

“**FLL IF-level**”. The level of the intermediate frequency in the receiver unit is below the tolerance limit, which is equal to 100 units of ADC code. To check this parameter use the menu “Parameters Check\FLL system” (paragraph 3.4.3).

“**FLL DAC overflow**”. In the passive hydrogen maser VCH-1008 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 “FLL DAC overflow”. To define exactly which DAC has crossed the limit value one needs to view corresponding parameters from menu “Check\FLL” (paragraph 3.4.3). The DAC controlling the crystal oscillator can be set to the middle position by “Search H-line” procedure (see menu “Control\H-line search”, paragraph 3.5.5).

“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.

“H2 source”. The molecular hydrogen pressure in source or its thermostat temperature are out of tolerance limits. The limits of H-pressure are from 1.5 till to 20 atmospheres; the temperature – from 0 up to 1000 code units (~0.01 ºC). To check the H-pressure use menu “Parameters Check\Discriminator” (paragraph 3.4.2), parameter H2p. To check temperature mismatch of hydrogen source thermostat use menu “Parameters Check\Thermostats” (paragraph 3.4.5), parameter T3.

“User's control”. The instrument is in the manual switch ON/OFF mode or H-line searching procedure has been initiated. This message also informs that the instrument will switch to automatic mode in 100 seconds.

“Ext. DC off”/“Ext.DC source not conn.”. This message is appear if the toggle “DC POWER ON” on the rear panel is switched on, but external DC source is not connected to the instrument.

“Acc. switched off”/“Int.bat. switched off”. It informs about switched off position of the toggle “ACCUM ON” on the rear panel of the instrument.

“AC/DC convertor”. This message indicates absence of DC voltage at the output of AC/DC converter. Possible reasons: absence of external AC 220 V voltage or failure of AC/DC converter. External power source or internal accumulator should be used for power supply.

3.7 Language setting – menu “Language”

Submenu “Language” of main menu (Fig. 5) allows to select user interface language: English or Russian. Language setting is optional function and can be not available in some instruments.

3.8 Versions of embedded software of the instrument – menu “Versions”

To list versions of embedded software of the instrument – click on the item “Versions” of the main menu (Fig. 5).

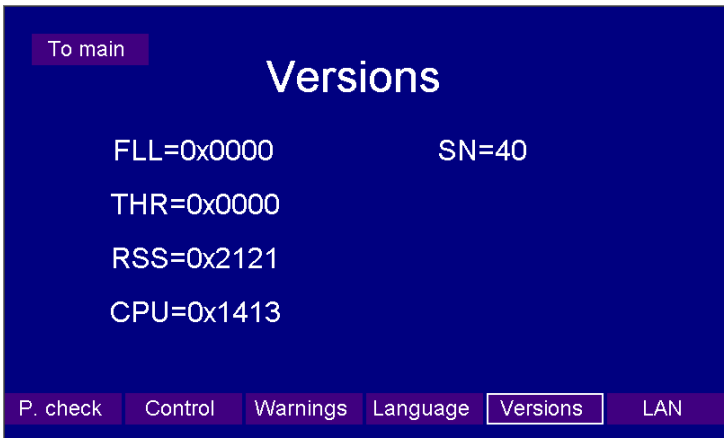

Figure 33. Menu “Versions”

Menu “Versions” is shown in Fig. 33.
FLL – software version FLL (frequency lock loop) processor.
THR – software version of thermostat processor.
RSS – software version of reference signal source unit.
CPU – software version of central processor.
SN – serial number of the instrument.

3.9 LAN settings of the instrument – menu “LAN configuration”

The instrument allows remote monitoring via LAN by means of computer program “Monitor VCH-1008”.

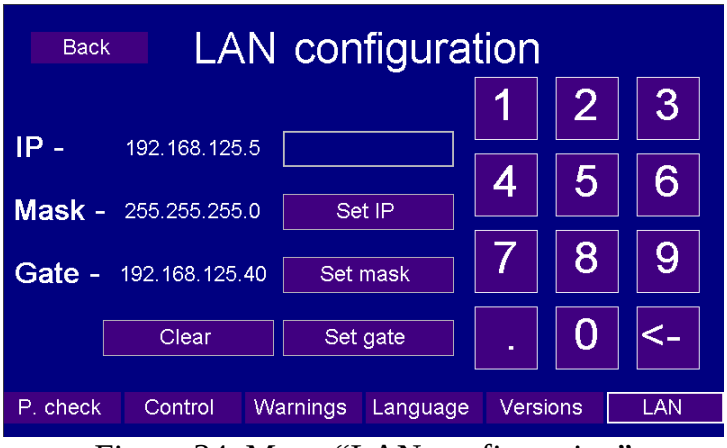

Figure 34. Menu “LAN configuration”

To set network parameters – click on the item “LAN configuration” of main menu (Fig. 5), the corresponding menu will appear (Fig. 34). To use the instrument in LAN the following parameters should be set: IP-address of the instrument, network mask and network gate (optional). After necessary value has been typed – click on the corresponding set button. New value of the network parameter will be updated in three seconds in the left part of the window (Fig. 34). To clear typed value – click on the “Clear” button.

3.10 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 message “Int. bat. engaged!” with information about the voltage on the built in battery is displayed in the introduction window (Fig. 35) and the message “AC/DC converter” is displayed in the menu “Information” (paragraph 3.6).

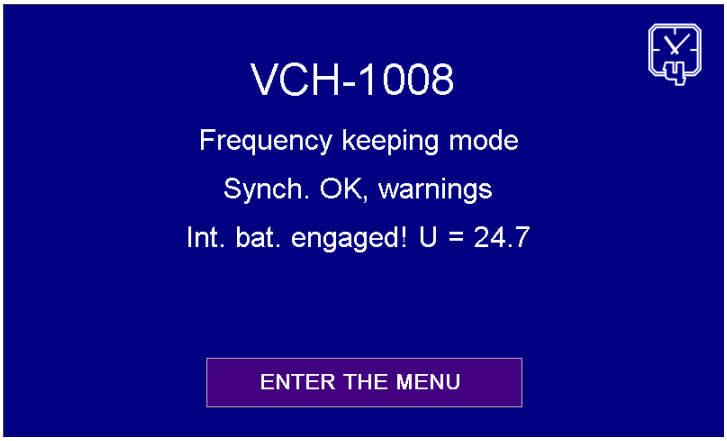

Figure 35. Status screen with information about accumulator’s discharging

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

Attention! The instrument switches OFF automatically as soon as battery voltage becomes 23 V. Battery resource is not less than 2 hours. If voltage level becomes less than 24 V the instrument emits periodic beep.

During operation of the instrument from an external power source built in battery is charging, the full charge time is about 50 hours. If the battery is not fully charged, time of autonomous operation could be shorter. During charging process menu “Information” contains the message “Acc. charge” which disappears if charge level becomes more than 95% (paragraph 3.6).