

User Manual

Poly-Spectrum-AM

Digital ECG System for Long-term
Ambulatory Monitoring



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1. Function

1.1. General

The digital ECG system for long-term ECG monitoring **Poly-Spectrum-AM** (hereinafter referred to as “the recorder”) is intended for recording and processing of electrocardiogram (ECG) from freely moving patient in ambulatory and stationary conditions during 24-72 hours.

The recorder can be used in clinics, hospitals, cardiological centers, medical research institutions and other health care providers.

The recorder allows long-term continuous ECG recording by Holter technique, which is typically used for diagnosing of transient heart rate disorders and also for coronary ECG changes of patients suffering from coronary artery disease (CAD). The considerable advantage of this technique is the possibility of continuous long-term (1-3 days) ECG recording in the conditions typical for a patient.

The recorder provides:

- the recording of three precordial bipolar leads and execution of standard analysis procedures;
- automatic detection of monitor type connected to processing system and information exchange between them;
- automatic analysis of rate disorders and correction of analysis results by a doctor in the dialog mode;
- analysis of ST segment changes in each recorded lead;
- heart rate variability analysis;
- bifunctional monitoring of ECG and blood pressure (if the BPLab ambulatory blood pressure monitor is available);
- heart rate turbulence analysis;
- generation and printing of the final report with the analysis report;
- generation of the monitor records archive and operation with it.

1.2. Advanced Operating Capabilities

The recorder provides the following technical capabilities:

- The moisture-proof recorder.
- The programmable sampling rate from 250 up to 1000 Hz with 40 up to 250 high pass filter which provides the possibility to perform the analysis of the ventricular late potentials, ECG recording of children, complete ECG analysis by Frank.
- The embedded solid-state bulk memory allowing to perform the recording of three ECG channels up to 72 hours with 250 Hz sampling rate or daily recording with 1000 Hz sampling rate.
- Quick data download to personal computer (PC) (less than 2 minutes for daily recording with 250 Hz sampling rate) owing to USB interface and signal compression without quality loss.
- Hardware pacemaker detection gives an advantage in comparison with many Russian analogues.
- The function of “hot” batteries replacement provides the possibility to change them during the recording: after the new batteries insertion the recording is continued automatically. The built-in autonomous timer is available which allows to consider the time fallen out the recording.
- The alternative wireless way of connection with the computer (via Bluetooth), which can be used both in device programming mode and for the check of electrodes placement quality at any moment using the PC.
- Body position sensor allows to detect a patient’s position and also the level of her/his motor activity.
- The recording of breath waves using the impedance plethysmographic technique without applying the additional sensors.
- The recording of audio comments to patient events in addition to a patient’s diary keeping.
- The electrodes placement quality (impedance measurement) is automatically checked both during the setting process and during the recording. The programmable quality level.
- Automatic detection of connected cable type (2 or 3 channels).
- The recorder state is indicated by 3 LEDs.

2. Getting Started

If you purchase the digital system together with the PC, the equipment is delivered with installed and configured software. If you purchase the digital system separately, please study carefully the following paragraphs.

The digital system software can function properly on any IBM compatible computer with **Intel Pentium IV** processor and higher ones, with not **less than 1 Gb** operating memory, and **Microsoft Windows XP SP2** or **Windows Vista** operating system. It is strongly recommended to use the monitor of **not less than 17"** and resolution should be not less than **1280x1024 points**. For software setup there should be 50 Mb of free hard disk space and not less than 2 Gb of free hard disk space for the exam archive.

The exam results performed with the use of the digital system are saved on the hard disk in a database.

The software is supplied on the compact disk (CD). The installation process is described below:

Insert the compact disk to the disk drive and wait for the installation program run. If the CD autostart is disabled on your computer, run AUTORUN.EXE file from root directory of CD.

Then press "Next" button and follow the installation instructions.

After the installation process finishing, press "Exit" button located in right bottom corner of the window. The installation procedure will be over.

2.1. Selection of Lead System and Electrodes Placement

2.1.1. Variants of Electrodes Placement for ECG Signal Recording

The recorder allows using two cable variants:

- 5-lead cable for two-channel mode (Fig. 1, Table 1);

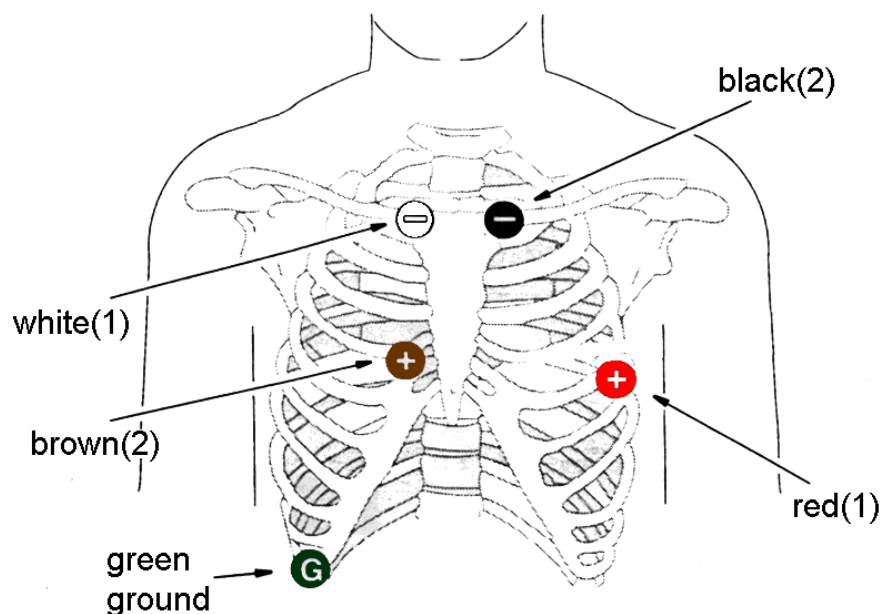


Fig. 1. Electrode placement scheme with the use of 5-lead cable for two-channel mode.

Table 1. Electrode placement

Recording channel	Electrode color	Location	Lead
B1 (-)	White	Just rightward of the manubrium of the sternum.	CM5
A1 (+)	Red	Fifth intercostal space, anterior axillary line.	
D2 (-)	Black	Just leftward of the manubrium of the sternum.	CM2
E2 (+)	Brown	2 cm rightward of the xiphoid	
G (ground)	Green	On the lower right chest wall, on a rib.	

- 7-lead cable for three-channel mode (Fig. 2, Table 2).

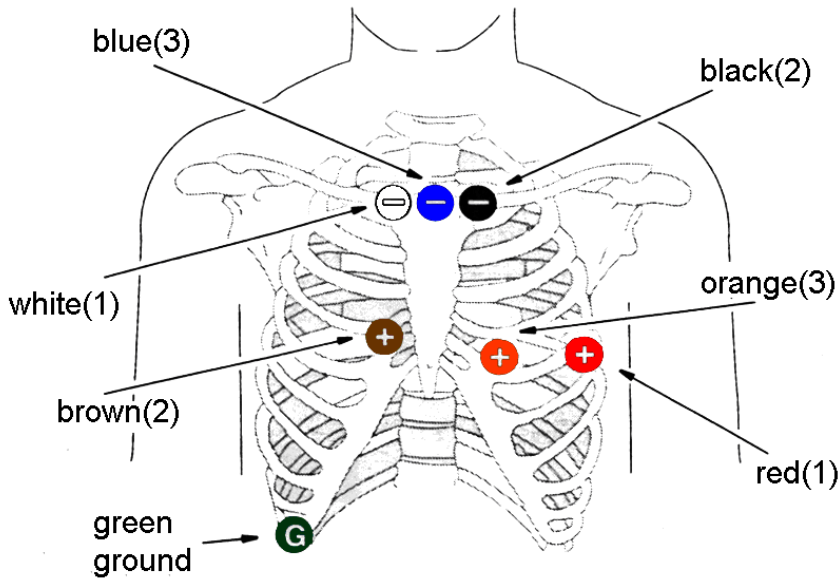


Fig. 2. Electrode placement scheme with the use of 7-lead cable for three-channel mode.

Table 2. Electrode placement

Recording channel	Electrode color	Location	Lead
1 (-)B	White	Just rightward of the manubrium of the sternum.	CM5
1 (+)A	Red	Fifth intercostals space, anterior axillary line.	CM5
2 (-)D	Black	Just leftward of the manubrium of the sternum.	CM1
2 (+)C	Brown	2 cm rightward of the xiphoid.	CM1
3 (-)F	Blue	Mid-sternum, at the level of the clavicles.	CM3
3 (+)E	Orange	5 th intercostals space, left midclavicular line.	CM3
G (ground)	Green	On the lower right chest wall, on a rib.	

The change of electrode position considering the individual peculiarities of a patient's chest structure and electrical axis position with the purpose of getting the adequate amplitude of QRS-complex is admissible.

2.2. Channels for Patient's Breath and Motor Activity Recording

The breath is recorded by oscillation measurement of patient's body resistance to probing current of high frequency in time with breath movements. The probing current goes between the "ground" electrode and electrode selected by a user. The breath recording channel provides an additional opportunity to recognize the mechanisms of heart rate change emergence, for example, during sleep apnoea.

A user has an opportunity to indicate the electrode to receive the data for breath channel during the recorder programming. The electrode selection is conditioned by a patient's breath type (abdominal or chest) to get a stable pattern of breath waves of maximal amplitude.

The motor activity and the body position of a patient are recorded with the use of a sensors located inside the recorder case. The sensor measures the acceleration rate in three axes allowing to assess the intensity of the motor activity and detect a patients' body position.

To provide the adequate displaying of the body position and motor activity, the recorder should be fixed safely on a patient's body.

2.3. Patient Preparation for Exam

It is recommended to shave the hair from electrode sites of patients with chest hairiness.

To decrease the electrical resistance between the electrodes and skin and provide the better signal quality, the skin in electrode sites should be cleaned and degreased with the use of alcohol or special paste.

It is recommended to locate the cables straight down from the electrodes, then bend at the angle of 90° degrees and fix them on a patient's body at 10 cm distance from the electrodes with the use of adhesive plaster.

3. Operation with Poly-Spectrum-AM Software

3.1. Program Run and Startup Window

To run the program, double-click the **Poly-Spectrum-AM** icon located on the desktop with the left mouse button. You can also press “Start” button, select “Neurosoft” with the left mouse button click in “Programs” section and choose “Poly-Spectrum-AM” in the appeared list.

At the program run, the startup window appears on the screen (Fig. 3).

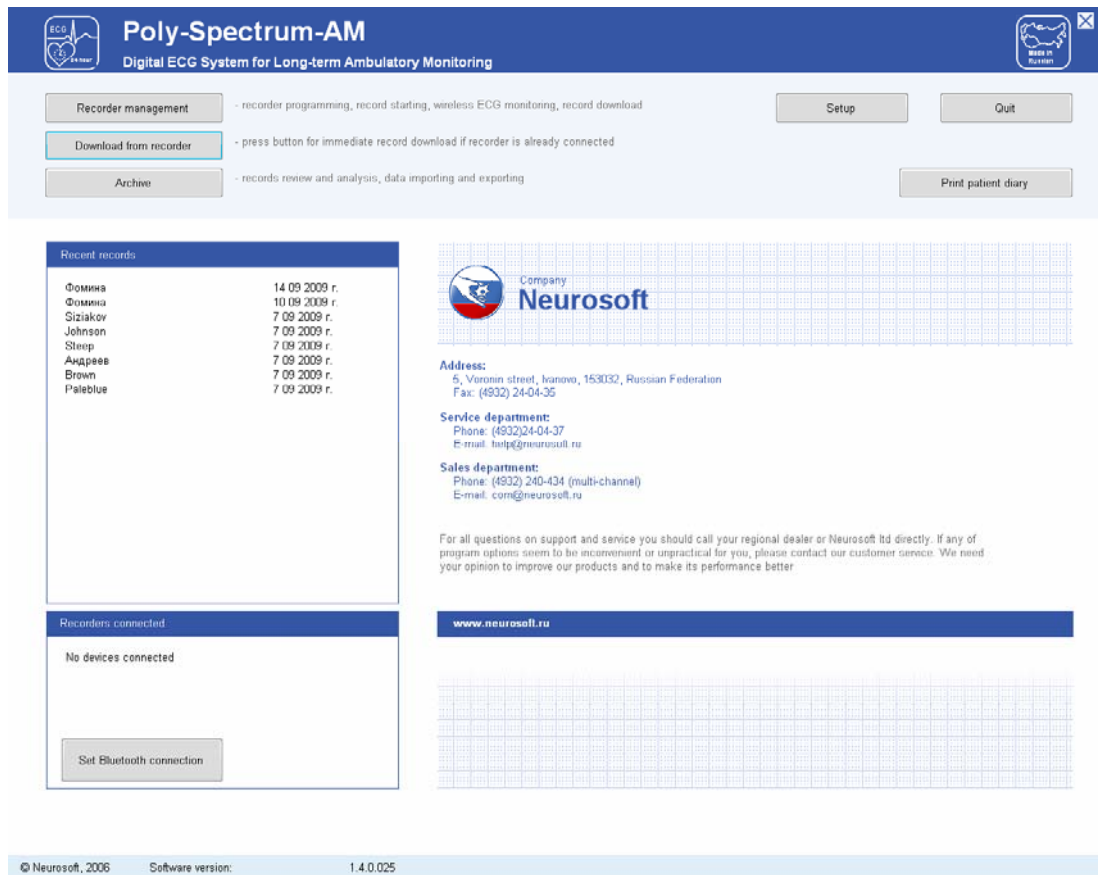


Fig. 3. The program startup window.

At the top part of the startup window the following functional buttons are located:

1. “Recorder management” – the button which opens the window which allows to fulfill all operations concerning recorder programming and preparation to work and also perform the monitoring of the record via Bluetooth channel (see chapter 3.2.2).
2. “Download from recorder” – the button which opens the data download window from the recorder to computer memory (see chapter 3.5).
3. “Archive” – the button which opens the records archive stored in computer database (see chapter 4).

4. “Setup” – the access button to parameter settings of software analysis of ECG record (see chapter 14).
5. “Quit” – the button closing **Poly-Spectrum-AM** program (you can exit the program by clicking the cross in the right top corner of the screen with the left mouse button).

The “Recent records” and “Recorders connected” panels are located below.

The panel “Recent records” represents the list of records operated on recently (download, review, analysis). The records on the panel are located in the order of addressing to them, the data opposite the name indicates the moment of record download from the recorder to computer memory. To open an exam from the list for review and editing, click it with the left mouse button.

To open an exam, which is missing on “Recent records” panel, use “Achieve” (see chapter 4).

The list of recorders connected to computer via USB cable or Bluetooth wireless channel is displayed on “Recorders connected” panel. To run “Recorder management” window, click the line with recorder name and its serial number with the left mouse button (or press the corresponding button).

The button “Set Bluetooth connection” located in the bottom part of “Recorders connected” panel starts the recorder search to connect it via Bluetooth wireless channel. If you use USB cable for the connection, this button is not required; the computer detects the recorder automatically.

3.2. Recorder Management

Make sure beforehand that:

- the device is switched off, i.e. all indicators are off;
- the communication cable is disconnected from the device, the patient cable can be connected to the recorder and to electrodes on a patient’s body;
- the computer is switched on and **Poly-Spectrum-AM** software is run;
- the recorder is within 10 meters in the direct visibility from the computer (if you want to use Bluetooth).

3.2.1. Recording Start in without PC (near Patient’s Bed)

The recorder preparation to the acquisition is possible without computer use as the function of recorder memory cleaning is provided. To do this, open the cover of battery compartment and using the thin firm object (pen stem, toothpick), press “Reset” button in the deepening over the battery compartment (Fig. 4). If you press the button,

it will result in the removal of already recorded exam data (if it was done), at that the recorder parameters will remain unchanged.

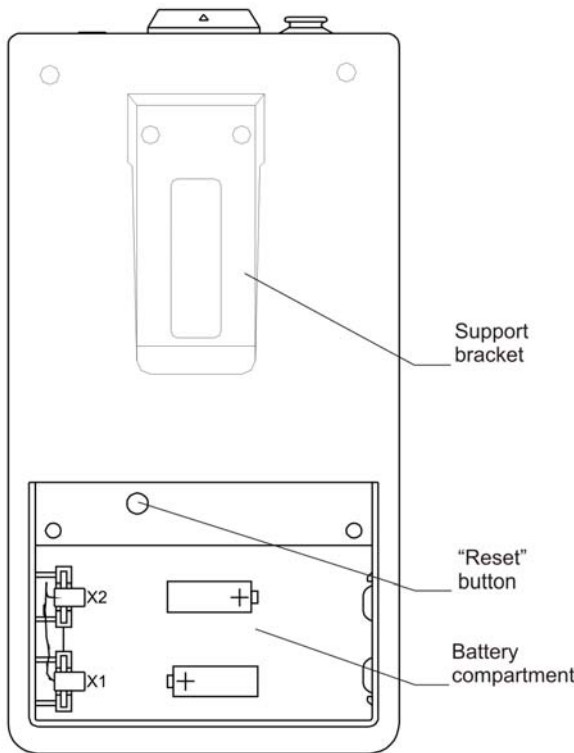


Fig. 4. Recorder.

Before using the “Reset” button, make sure that the required information is saved in the program database.

Prepare the patient for the exam as it is described in chapter 2.3 of the present document.

Place the electrodes and connect the cable to the recorder.

Fix the recorder on a patient using the bag with belts for waist and shoulder.

Press the black button on the recorder top panel. The green indicator “Operation” located on the device front panel indicates the record beginning. If the contact with one of the electrodes is lost, the recording will not start and the yellow indicator “Break” will appear. The red indicator “Battery” will highlight if the battery charge is insufficient.

Instruct a patient and give her/him a patient diary.

If the contact with one of the electrodes is lost during the recording, the yellow indicator “Break” highlights. At that, the recording is not stopped but the registration of a patient events with the use of the black button and the recording of audio comments using the headset are disabled. In this case it is recommended to check the contact of all electrodes, after that continue the recording in the normal mode.

3.2.2. Recorder Management and Recording Start in via Bluetooth

The recorder control via Bluetooth channel allows to perform the programming of an exam, the memory cleaning, the start/stop of ECG record, the quality check of the signal being received.

3.2.2.1. Connection Startup via Bluetooth

Check the presence of the charged batteries in the recorder (if necessary, install them (2 rechargeable batteries or 2 alkaline elements of AA type)) considering the polarity.

Press “Bluetooth” button located on the recorder front panel. The blue indicator “Connection” will start blinking which means that the communication channel is switched on in the wait mode.

The channel is kept in this mode for a limited time to save the batteries charge. If the connection with the computer is not established in 60 sec., the channel will deactivate automatically.

Press “Set Bluetooth connection” button located on the “Recorders connected” panel of **Poly-Spectrum-AM** startup window (left bottom corner) (Fig. 5).

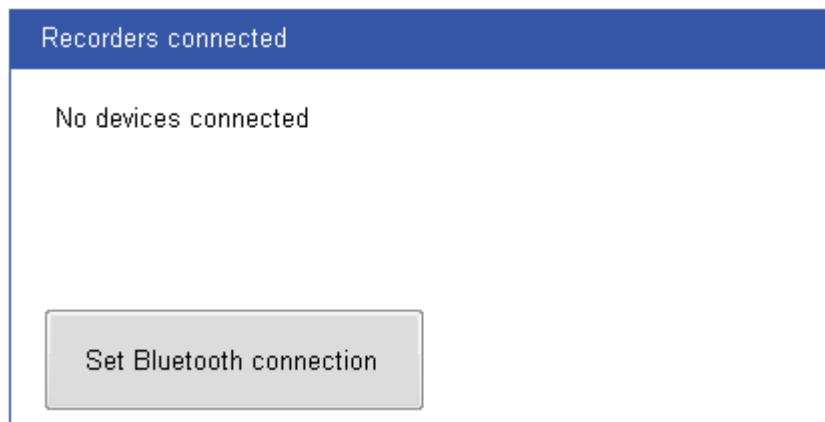


Fig. 5. “Recorders connected” panel.

The process of recorder connection with the PC takes several seconds. After the connection establishment, the recorder indicator will stop blinking and start glowing constantly. At that, the short beep will be generated.

The string with the name and the serial number of the recorder connected at that moment will appear on “Recorders connected” panel (Fig. 6).



Fig. 6. “Recorders connected” panel.

If several recorders with the activated communication channel in the wait mode are located near each other, the list of these recorders will appear. Each device is identified by the serial number. If a patient data are entered to the recorder, a patient name will appear together with the serial number. To continue the work with the recorder, click it in the list with the left mouse button.

3.2.2.2. Order of Recorder Programming

To enter the recorder programming window in the startup window of a program, press “Recorder management” button or click “Recorders connected” panel string corresponding to the required recorder with the left mouse button (Fig. 7).

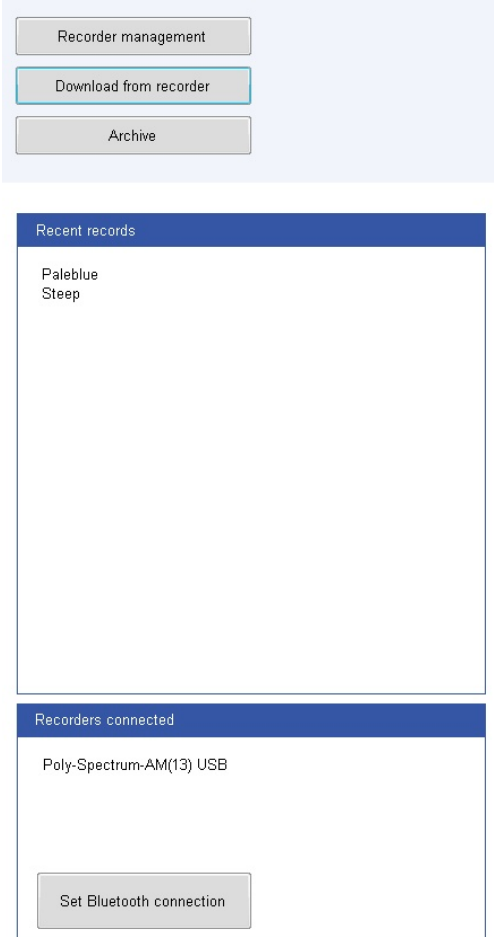


Fig. 7. Fragment of startup window.

To program the recorder in the opened “Recorder management” window (Fig. 8), it is necessary to:

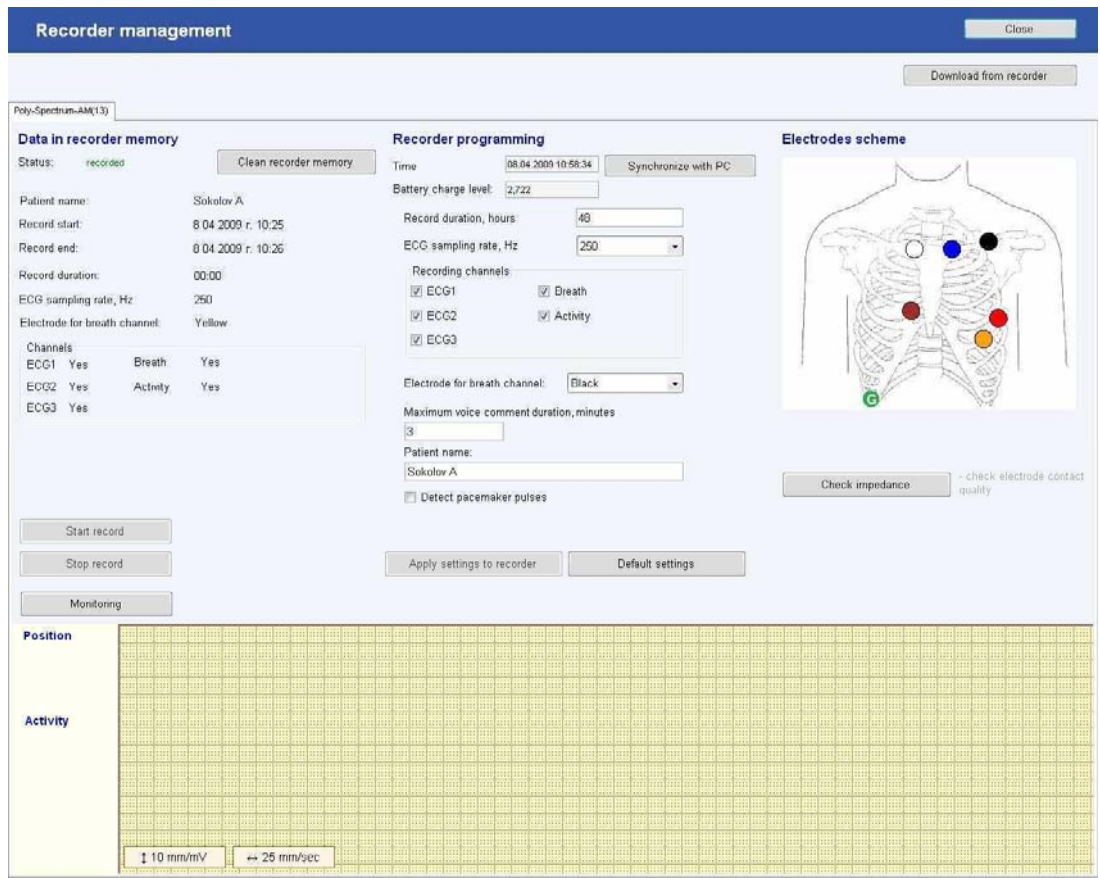


Fig. 8. “Recorder management” window.

- Clean the device memory (if the previous record is available) by pressing “Clean recorder memory” button.

At the connected recorder the settings of the previous record (if it is available) appear in this window. Before the memory cleaning, make sure, that all the necessary information is saved successfully in the program data-base.

- Enter the recorder time and date manually or press “Get time from PC” button.
- Make sure the batteries are charged enough (the battery charge is defined automatically, if it is insufficient, the warning message will appear on the screen).
- Set the record duration in hours (from 24 up to 72 hours) in “Record duration, hours” input box.

The maximal duration of the record depends on the number of the recorded channels, sampling rate of a signal and memory volume reserved for audio comments. If the memory volume is insufficient for the record acquisition according to the current settings, the program will display the warning message.

- Set the sampling rate of the recorded signal in “ECG sampling rate, Hz” combo-box. The recommended frequency for common exams is 250 Hz. The frequency 500 or 1000 Hz is required for the examination of patients with implanted pacemakers for stable displaying of stimulus artifact on ECG.
- Check the recorded channels in “Recording channels” checkboxes (define separately the electrode for breath curve recording in “Electrode for breath channel” combo-box. It is brown by default).
- Set the duration of audio comments (if you do not plan to use a patient headset, set 0).
- Check the “Detect pacemaker pulses” checkbox (if a patient has a pacemaker).
- Enter the data to “Patient name” input box.
- Fix the device on a patient as it is described in section 3.2.1 of the present manual.
- Press “Apply settings to recorder” button (Fig. 8).

If the electrodes are placed on a patient and the patient cable is connected to the recorder, you can check the quality of electrodes contact to the skin by pressing “Check impedance” button. In case of poor electrode contact to the skin, it will be marked on the electrodes placement scheme with the red cross.

To assess the quality of the recorded ECG, press “Monitoring” button, the ECG and also the breath channel, motor activity channel and patient position channel signals will appear on the screen (Fig. 9).

Press “Start record” button. The message “Recording in process” will appear in the top left corner (Fig. 9).

It is not recommended to start the recording from PC, if the recorder is not connected to a patient. In this case, the recording start is performed by patient button pressing located on the recorder top panel (see section 3.2.1).

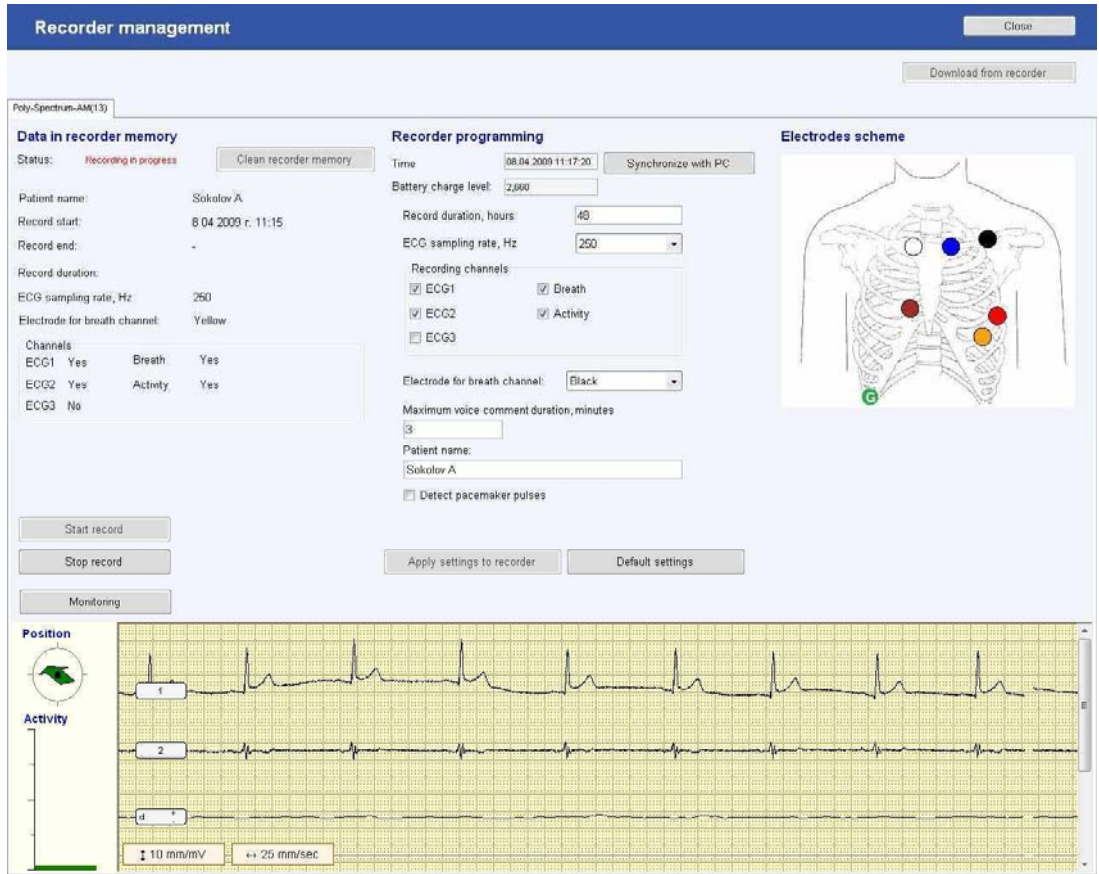


Fig. 9. The recording is in process.

To stop the on-screen monitoring, press “Bluetooth” button on a recorder or close the recorder management window and **Poly-Spectrum-AM** program. If the connection was not terminated forcibly, the recorder will disable the radio channel in 60 seconds after leaving Bluetooth adapter coverage.

The recorder state does not impact the connection establishment, i.e. the connection can be activated either if 24-hour recording is performed or already finished.

3.2.3. Recorder Management and Recording Start in via USB Cable

The sequence of operations:

1. Connect the recorder to USB port of computer using the communication cable (at that the availability of batteries inside the recorder and its charge do not matter).
2. In “Recorders connected” program window select the recorder or switch to the programming window by pressing “Recorder management” window.
3. Specify all the necessary settings of the record parameters (see section 3.2.2.2).
4. Disconnect the recorder from connection cable to PC, connect the patient cable and start the recorder (see section 3.2.1).

3.3. Monitoring during Recording

During daily ECG monitoring it is possible to review ECG record in on-line mode to control the electrodes placement, ECG recording and heart rate disturbances occurred suddenly.

To do this, it is necessary to perform the following operations during the daily recording:

- Set Bluetooth connection (see section 3.2.2.1). In the appeared window press “Monitoring” button.
- After the recording preview disable Bluetooth connection with the recorder or exit the program.

3.4. Exam End

The recording is terminated automatically when the time, specified by a doctor during the recorder programming, expires. The faded indicator “Operation” signifies the record end. After that, a patient should come to a doctor and hand the recorder for a further data processing.

The order of operations after the daily ECG record end is the following:

1. Disconnect the patient cable from the recorder:
 - 1.1. Take off the recorder from a patient;
 - 1.2. Take off the electrodes from a patient.
2. If the green indicator “Operation” blinks, switch off the recorder manually. To do this, press the patient button and hold it for 3-5 seconds until it switches off. The recorder switching off is accompanied with the audio signal and green indicator

“Operation” switching off. Besides, you can stop the record by pressing “Stop record” in recorder management window.

The necessity to terminate the record manually occurs in cases a patient comes before the appointed time. The recorder switching off using the patient button is possible, only if the cable is disconnected. This limitation is required to exclude the casual shutdown during the recording.

3.5. Information Read-out from the Recorder

Connect the device to PC using USB cable. Run **Poly-Spectrum-AM** program. Press “Download from recorder” button (Fig. 10).

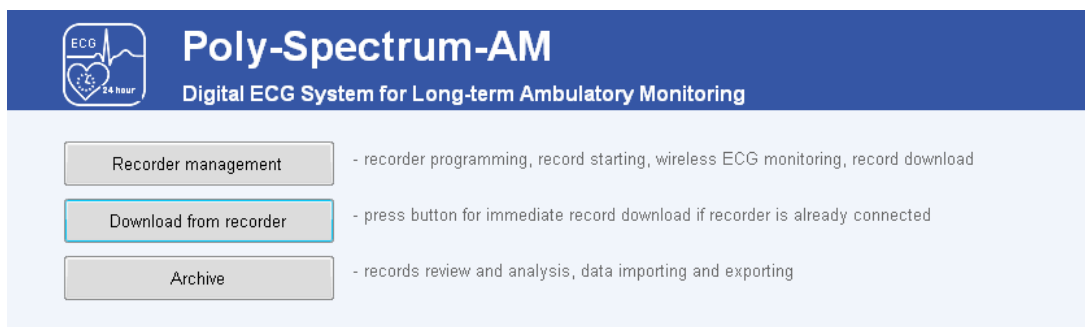


Fig. 10. Fragment of startup window.

In the appeared window (Fig. 11) press “Begin” button.

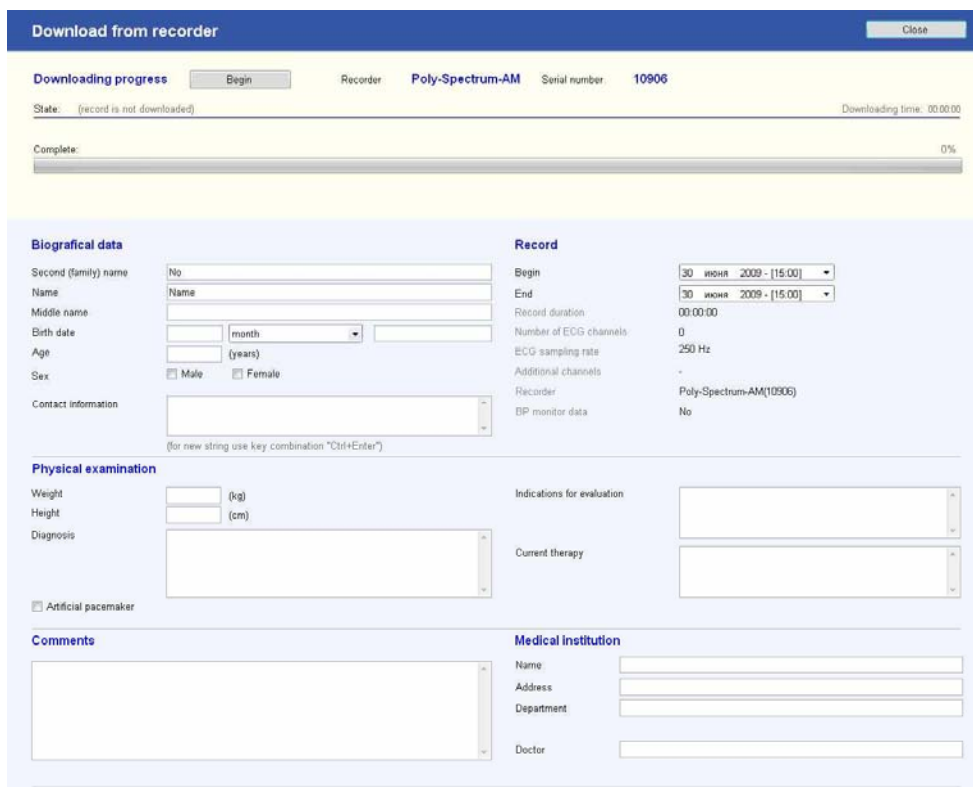


Fig. 11. Exam data download from the recorder.

The download process is represented by a green indicator filling. Do not disconnect the cable from the recorder or computer until the downloading finishes as it can lead to equipment operation failures and data loss.

It is possible to edit a patient card in the process of an exam download.

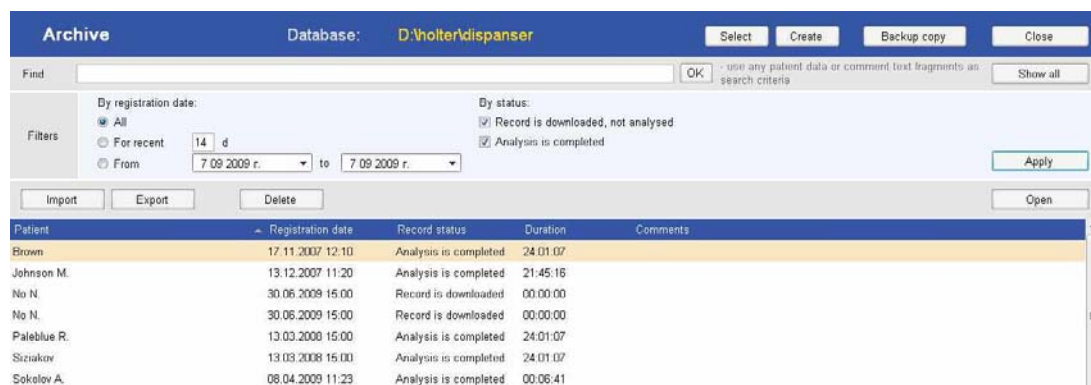
After the end of the information readout (100% green indicator filling) you can pass either to analysis of the readout exam using “Pass to analysis” button or go back to startup window of a program to work with daily ECG records by pressing “Close” button. After the downloading, an exam is automatically saved on a hard disk in a program database.

4. Operation with Archive and Exam Opening for Review and Analysis

4.1. Archive

Run **Poly-Spectrum-AM** program.

To operate with an archive, press “Archive” button of the program startup window. The “Archive” window will appear on the screen (Fig. 12).



Patient	Registration date	Record status	Duration	Comments
Brown	17.11.2007 12:10	Analysis is completed	24:01:07	
Johnson M.	13.12.2007 11:20	Analysis is completed	21:45:16	
No N.	30.06.2009 15:00	Record is downloaded	00:00:00	
No N.	30.06.2009 15:00	Record is downloaded	00:00:00	
Paleblue R.	13.03.2000 15:00	Analysis is completed	24:01:07	
Siznikov	13.03.2008 15:00	Analysis is completed	24:01:07	
Sokolov A.	08.04.2009 11:23	Analysis is completed	00:06:41	

Fig. 12. Patient diary.

The main window space is occupied by the list of the downloaded exams with the indicated names of patients, date of an exam download, record status (whether the analysis or only data downloading is performed), record duration and comments.

To open an exam for the review and the analysis, select the required daily ECG record in “Archive” and double-click it with the left mouse button to open or press “Open” button.

You can open an exam by selecting it in “Recent records” window of a program main window.

To change the sequence of the records in the list (sorting) click the column name with the left mouse button. If you click "Patient" column with the mouse, it will lead to the list sorting by the family name in the ascending alphabetical order, the repeated click is in the descending alphabetical order. In the same way you can sort the list by the registration date and other parameters.

Filters are the instruments allowing to display only records selected by the specified parameters. It is necessary when you have an extensive archive of patients. Set the required parameters of filters: the registration date, the exam state. If you press "Apply" button, only the records corresponding to the specified criteria (at that other records in the database are not removed) will be displayed on the screen. To see the complete list of exams, press "Show all" button.

If you have difficulties with the search of the definite exam, use search function. To do it, enter the name, part of the name or part of the comment phrase of an exam in a "Find" input box and press "OK" button.

To remove an exam from the database, click it with the left mouse button and press "Delete" button.

Please, remember, that the removal function is irreversible. Before using it, make sure that the given exam is not required any more.

"Export" and "Import" functions are required for the information transfer between databases as external archives. To export, select the required exam, press **Export|Exam** dropdown list. In the appeared window indicate the place of data saving (folder on a hard disk, external data medium) and press "Save" button. To import to the database, press **Import|Exam** dropdown list. In the appeared file opening dialog box indicate the file with an exam archive, which should be unpacked to the database and press "Open" button.

4.2. Automatic Analysis of Daily ECG Record

If you open an exam, the program switches to the main exam window containing the switch buttons for the corresponding analysis sections and summary statistics concerning the current exam.

If an exam had a status "Record is downloaded" (Fig. 12), the automatic run of exam analysis takes place.

To run the record analysis manually, press “Analysis” button. After the automatic analysis performing all the changes made by a user will be lost (Fig. 13).

Record [Close]

Analysis stages

- Patient info...** - patient and record information view and editing
- Begin review** - go to the first step of analysis
- Record review** - view record at different scales and HR trend
- QRS classification** - QRS-templates management - rename, edit, analyze
- Arrhythmias** - arrhythmias chart
- ST-segment analysis** - ST depression or elevation revelation, ST-trends
- Blood pressure** - 24-hours ST and BP measurements list
- Variability** - heart rate variability
- Turbulence** - heart rate turbulence
- Events** - view all record events and adding illustrations to report
- Report** - view and print the report
- Setup** - change analysis criteria and other system settings
- Analysis** - record reanalysis under current system criteria ("Settings" button). All changes made manually will be rejected

Summary report Start registration: 13 12 2007 r. 11:20 Record duration: 21:45:16

Patient info

Patient: Johnson M.
 Age (years): 59 Weight (kg): 76 Height (cm): 168

Summary statistics

Rhythm		Ventricular events	
Number of QRS analysed	1305	Single VE	9
Number of minutes analysed	119bpm at 08:25:31	VE couplets	0
HR maximum	37bpm at 04:56:11	VE salvo	0
HR minimum	0bpm	Total VT	0
Mean HR		VT with maximum HR	-
		VT with maximum HR	-
		maximum VT duration	-
		Maximum number of single VEs per hour	4 (8:00 - 9:00)

ST

Maximum ST depression	-0.10
-----------------------	-------

Supraventricular events

Single SVE	34
SVE couplets	0
Total number of SVT episodes	-
Maximum duration SVT	-
Maximum number of SVEs per hour	5 (19:00 - 20:00)
SVT with maximum HR	-

Pauses

Pauses	1
Maximum pause	1.97 c e

Analysis criteria

Prematurity level	80%
Pause	1.9 s
ST-depression	0.1
ST elevation	0.2

Conclusion

Sinus rhythm 39-119 bpm. Significant ischemic ST depression episodes (total 4 hours).

Record analysis Done: 27%

QRS complex analysis

BRADYCARDIA

Irregular rhythm 1duration 00:04

© Neurosoft, 2006

Fig. 13. Automatic analysis.

As soon as the analysis process is finished, the summary report information showing general data concerning an exam appears in the right part of a screen.

5. Record Review

If you want to pass to the first stage of an analysis, press “Begin preview” or “Record preview” button. The “Record preview” window will appear on the screen (Fig. 14).



Fig. 14. “Record preview” window.

The screen contains the following elements (top-down):

1. The navigation bar with “Back” and “Next” buttons to pass to the previous or next analysis stage or exit the main window of an exam (“Home” button). The “Conclusion” button is intended for activation of pop-up window for interpretation test entering which is included in turn in the corresponding report section. The given button is available in all analysis stages.
2. The heart rate trend (HR) during all recording period (Fig. 15).



Fig. 15. HR trend and ectopic activity histogram.

The mean, maximal and minimal HR values for the record period are provided leftward HR trend. The histogram of ventricular (yellow columns) and supraventricular

(green columns) extrasystoles distribution is located under the trend. The column height is equal to the number of the extrasystoles of the corresponding type calculated for 15 minutes interval. The red vertical line indicates the current position on the record being analyzed. You can change the current position by pressing the left mouse button.

3. The panel representing continuation of ECG (Fig. 16).

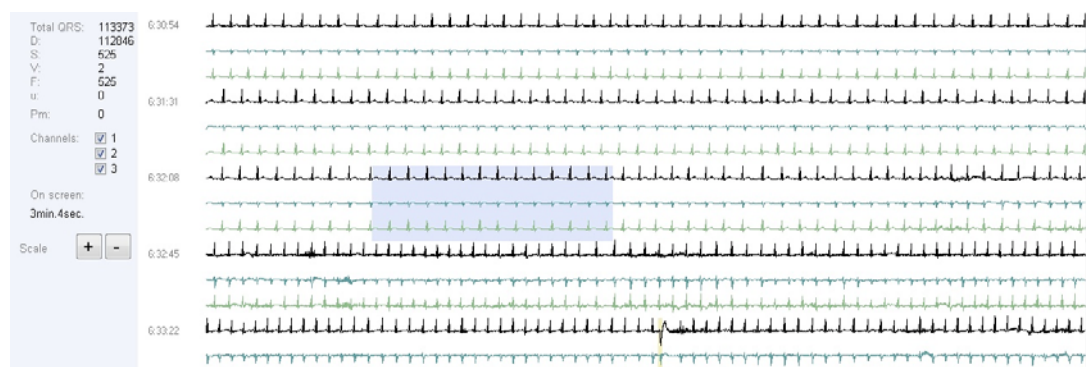


Fig. 16. Continuation of ECG.

The left part of the panel shows the QRS complexes distribution by templates, its general quantity during all the record, displayed ECG channels, which can be selected manually. Using “+” and “-” buttons you can change the duration of ECG fragment displayed on the screen in the same window. The review of complete daily ECG record is performed with the use of the runner located rightward, left mouse button or mouse scroll. To review an ECG at a define moment of time, click the HR trend with the left mouse button.

4. The detailed ECG review window displays the ECG record interval, which is intended for its review in different scales, measurement performing, editing the automatic analysis results (Fig. 17).

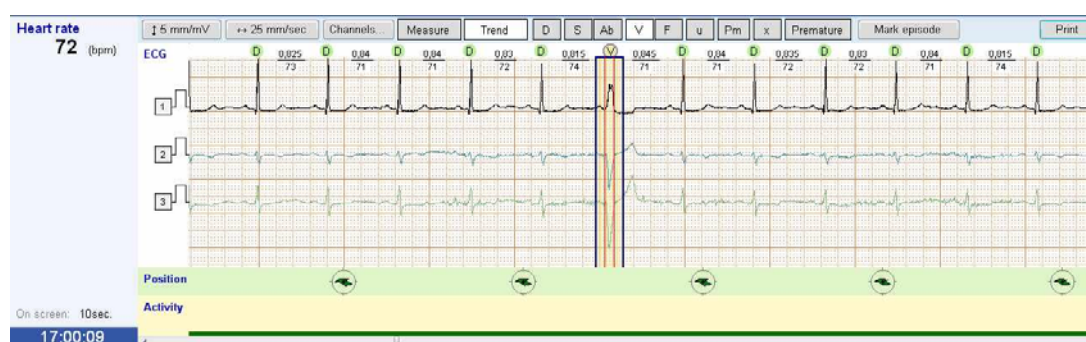


Fig. 17. Detailed ECG review.

The given window is represented in all analysis stages, which allows to address to initial ECG at any moment of time.

Leftward ECG the mean HR on the displayed area and time corresponding to ECG fragment are positioned.

The duration of RR-interval, instantaneous HR value and type of QRS complex are indicated on ECG fragment for each cardiocomplex. The heart rate disturbances are marked with the colors: ventricular ones are yellow and supraventricular ones are green. The premature contractions are outlined with the red color.

Over ECG field, you can see some control elements and the buttons allowing to:

- change the voltage scale of QRS complexes – from 5 up to 40 mm/mV;
- change ECG sweep speed – from 12.5 up to 100 mm/sec.;
- select the displayed channels;
- “Measure” button is intended to measure ECG intervals with the use of built-in ruler. The ruler is activated with the left mouse button click. To measure the interval, click its beginning with the left mouse button, the marker as a vertical blue line will appear. If you click the end of the measured interval with the right mouse button, one more marker will appear. The figure in the top part of this marker indicates the distance between markers in milliseconds;
- button of intellectual trend filter enabling/disabling;
- panel for QRS-complex type defining;
- switch of the selected complex prematurity;
- episode marking button;

- “Print” button – to print ECG fragment or include it in the report with the text comments for it (Fig. 18).



Fig. 18. Comment entering.

You can review the selected ECG fragment using the runner in the bottom part of the given window. During the record review you can edit the type and prematurity signs of QRS complexes (see section 6.2).

In the bottom part of detailed ECG review window the data concerning a body position and motor activity of a patient are represented. The body position is defined by the recorder position that is why to receive the reliable information, the recorder should be fixed on a patient body safely. The body position data are averaged for 2 seconds and represented as a green arrow. The vertical arrow pointing up corresponds to the vertical position of the recorder (cable connector is on top). The motor activity data are averaged for 8 seconds and represented as a graph with filled area: the wider is the filled area, the higher is motor activity. The minimal value of the motor activity corresponds to the calm patient position, the maximal one is to the intensive running.

6. Operation with QRS Complexes Templates

To switch to the analysis mode of QRS complexes templates, select “QRS classification” in the main test window or press “Next” button being in the ECG review window.

6.1. Review of QRS Classification Results

In the process of automatic analysis QRS complexes are combined to classes which can be reviewed and edited in “QRS classes” window (Fig. 19).

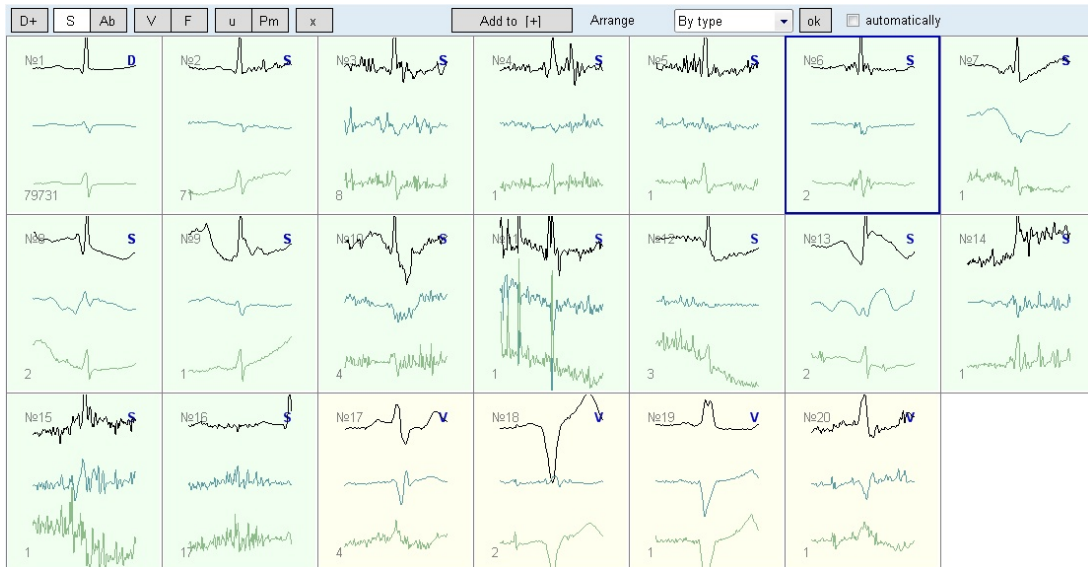


Fig. 19. “QRS complexes” window.

The integration of QRS complexes to classes occurs by the similarity principle of the form and parameters of QRS complexes. In the current program version the morphology of P and T waves is not considered. The template can include the big number of complexes but if these are really QRS complexes, the form of these complexes, as a rule, is practically the same.

The classification of most QRS complexes in automatic mode is performed on the basis of the similarity of the analyzed complex parameters with the parameters of the complexes of this or that type detected earlier. That is why at the automatic analysis the situation, when the automatic detection of complexes types results in a big amount of mistakes, is the most characteristic. But, these mistakes are related to the complexes of the similar form which make a template at the automatic analysis. In this case, you can correct the mistakes of the automatic classification by renaming the template.

Ideally, it is necessary to review each QRS complex and, if the type of this complex is defined incorrectly, change it. But, it will take too much time. To speed up the procedure, the combination of the complexes to classes is used.

The correction of the automatic processing results is the most important part of the heart rate analysis. The accuracy and thoroughness at the performing of this operation are the determining factors of the qualitative analysis of heart rate and detection of the heart rate disturbances at daily ECG monitoring.

During the automatic analysis each QRS complex (the daily record contains about 100000 ones) is related to one of the following types:

- D – dominant QRS complex in the whole daily record regardless of its morphology.
- S – supraventricular (any narrow QRS complex which differs in morphology from the dominant one).
- Pm – generated by the pacemaker.
- V – ventricular.
- x – artifact.
- u – undefined.

The program does not detect the aberrant (Ab) and fusion (F) classes of QRS complexes automatically, however, a user will be provided with an opportunity to mark them manually.

The prematurity signs of QRS complexes are defined in the process of analysis. The complexes defined as the premature ones are marked with the red circle.

QRS classes are located in the separate boxes with literal notation of a type (S, V, x, u, etc.), sequence number and quantity of QRS complexes included in them. To facilitate the review, the boxes with the classes can be sorted by type or element quantity.

To review QRS complexes combined in a template, select the template you need by clicking it with the left mouse button. The detailed ECG review window will be positioned automatically on the record fragment containing the first (most typical) complex of the selected template. The position of this QRS complex will be marked with the blue rectangle and the color and letter marking corresponding to the given template (Fig. 20).

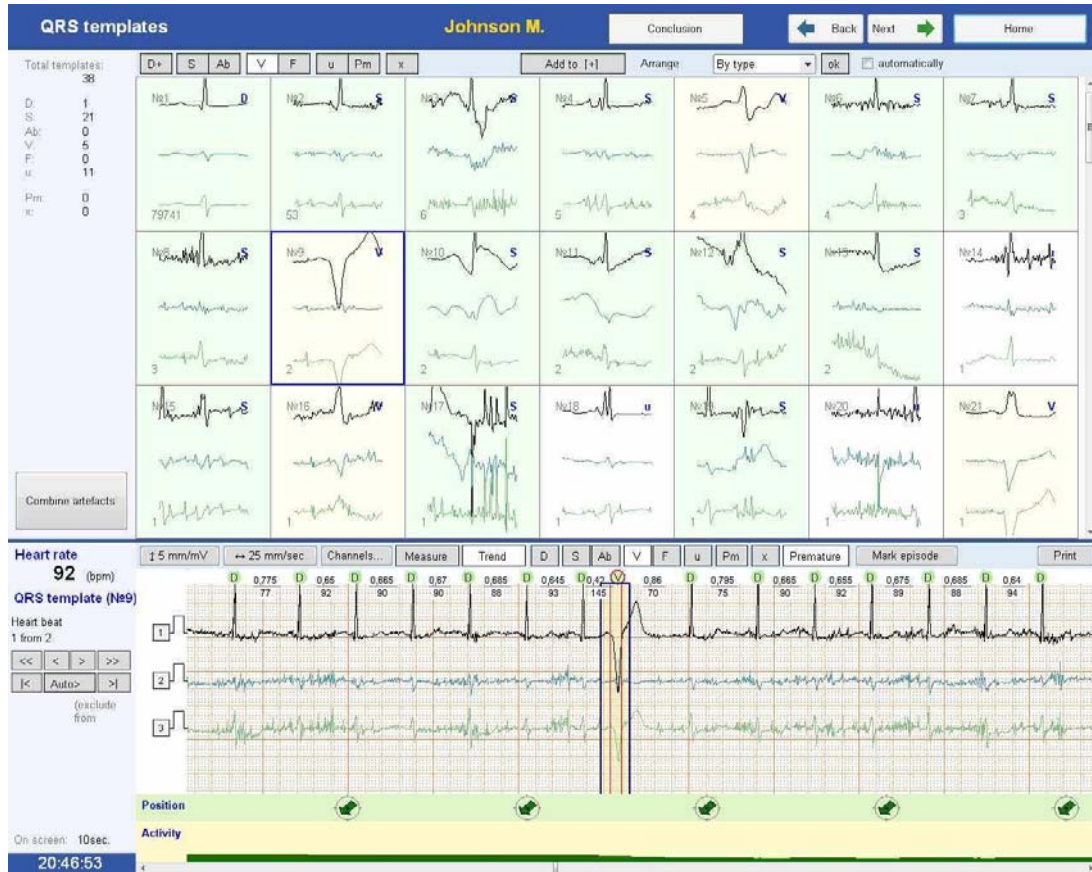


Fig. 20. Analysis of QRS classes.

If you press the corresponding arrow buttons located on the panel in the left bottom part of the screen (Fig. 21), you can perform the following operations in the selected template:

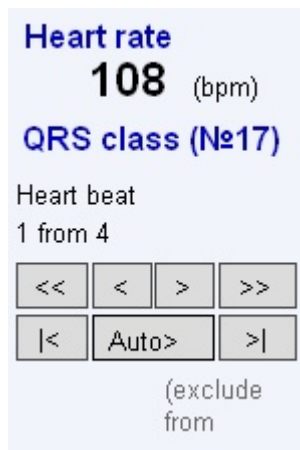









Fig. 21. Navigation buttons over the selected template.

- review forward/back   by one complex;
- review forward/back   – for 1/20 from the total number of QRS complexes;
- automatic sequential review of complexes included in the selected template, at “Auto” button  pressing;
- shift to first/last   complex of the reviewed template.

In the process of template review you can edit the results of the automatic classification.

6.2. Template Editing

To change the template type, click it with the left mouse button (it will be marked by the blue frame) and indicate the required type by pressing the button on the panel for template type definition located in the top part of the screen. To select and rename several classes, use the mouse and hold **[Ctrl]** button at that (Fig. 22).

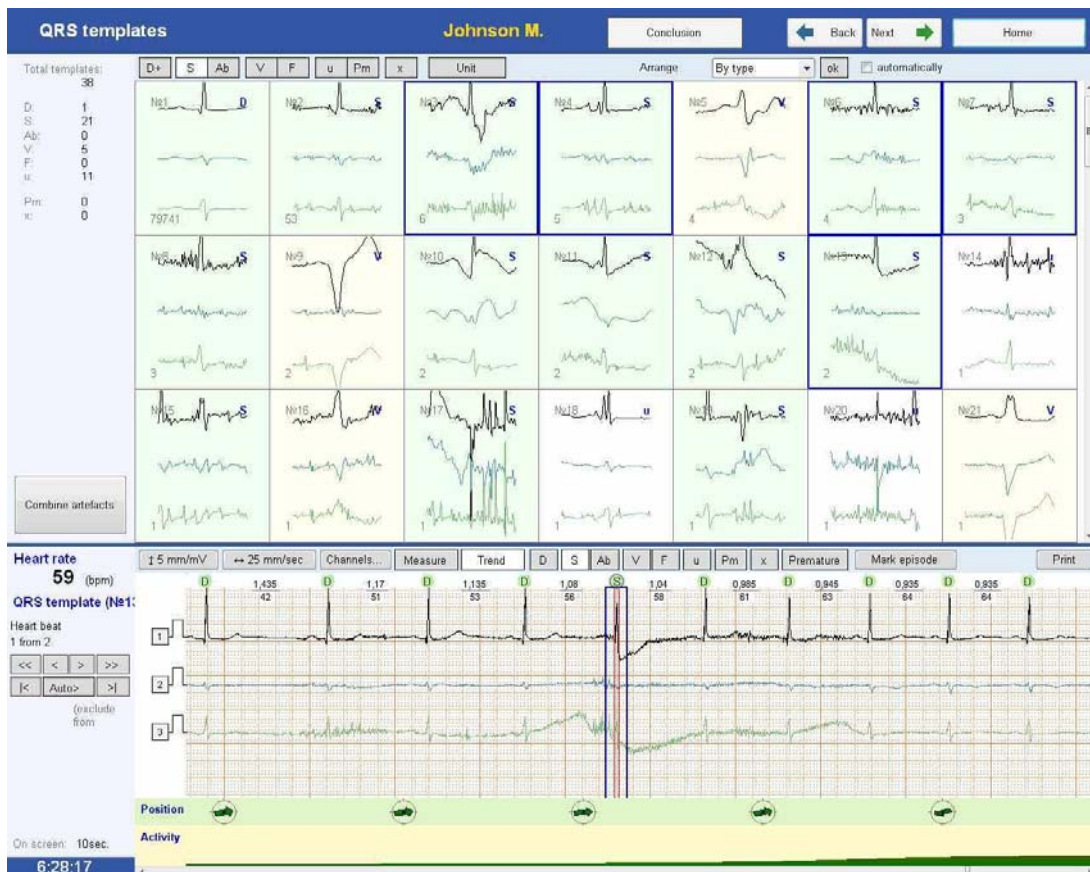


Fig. 22. Template editing.

The analysis of user changes in this window is performed automatically.

After the editing the single-type classes can be combined. To do this, mark the single-type classes using the left mouse button together with the pressed **[Ctrl]** button and then press “Merge” button.

Large S classes containing the complexes, which does not differ from the dominant ones considerably, can be joined to the dominant ones by D+ button pressing. It is sometimes necessary for the assessment of ischemic changes as far as the analysis of ST segment is performed only by complexes of the dominant template.

At any analysis stage you can also edit the properties of QRS complexes in detailed ECG review window directly (Fig. 23). In particular, to change the complex type, it is necessary to select QRS complex with the left mouse button and press the switch button corresponding to the required type on the panel of complex type identification located over ECG area. At that QRS complex will be automatically excluded from the template it belonged before the editing and added to just created template corresponding to the type indicated by a user. After the editing the created template becomes active automatically. If you hold back **[Ctrl]** key, the current template keeps active after the editing.

Do not confuse the panel of template identification (located in the top part of the screen) with the panel of complex type identification (located over ECG field directly).

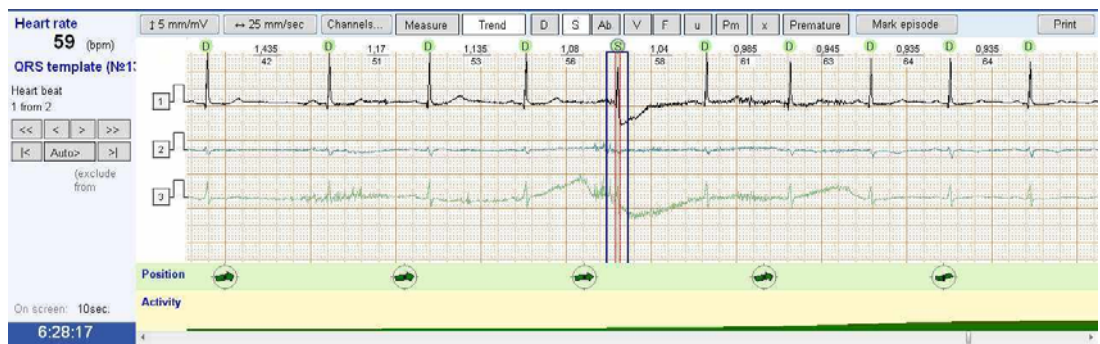


Fig. 23. The detailed ECG review window.

If the ECG fragment has complexes without marking, it is necessary to click QRS with the left mouse button (the marker as a vertical line will appear) and press the corresponding switch of template type located on the panel over ECG field.

If the other QRS complex located very closely prevents from setting a marker in a required place (when you click the left mouse button, the marker as a vertical line does not appear and the next QRS is selected with a frame), press **[Ctrl]** key and set the marker (Fig. 24).

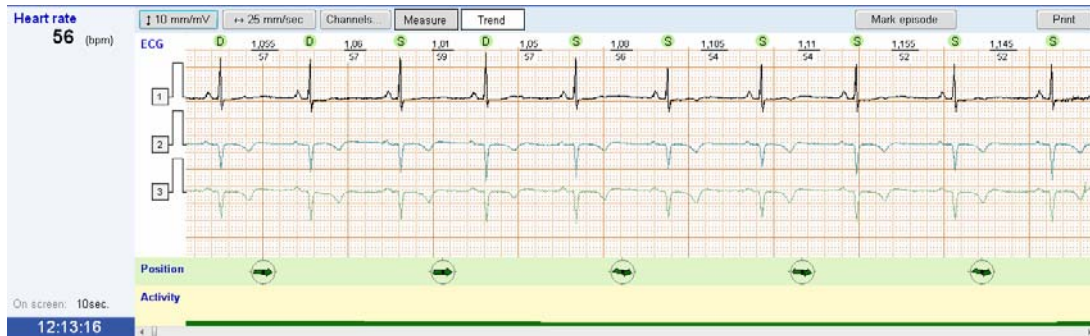


Fig. 24. The selection of the missed QRS complex.

To remove the unnecessary QRS, select it with the left mouse button and change its type to artifact one (x).

The selected complex can be marked manually as a premature one using the “Premature” button and vice versa the pressing of this button can disable the mark concerning prematurity performed by a program during the automatic analysis of arrhythmias (Fig. 20).

Also at any analysis stage you can mark the selected ECG fragment as a rhythm disturbance episode by selecting the corresponding item in the “Mark episode” dropdown list (Fig. 25). The beginning and the end of an episode will be automatically set at the beginning and the end of the visible area correspondingly. If it is required to indicate the episode borders, then select the episode manually before “Mark episode” button pressing. To do this, press the left mouse button at the episode beginning and, keeping it pressed, move the mouse rightward up to the episode end. If the episode continues behind the right episode border, still keeping the mouse button pressed, move the mouse cursor to the right screen border closely and the ECG will page to the right automatically. When achieving the episode end, release the left mouse button and press “Mark episode” button.

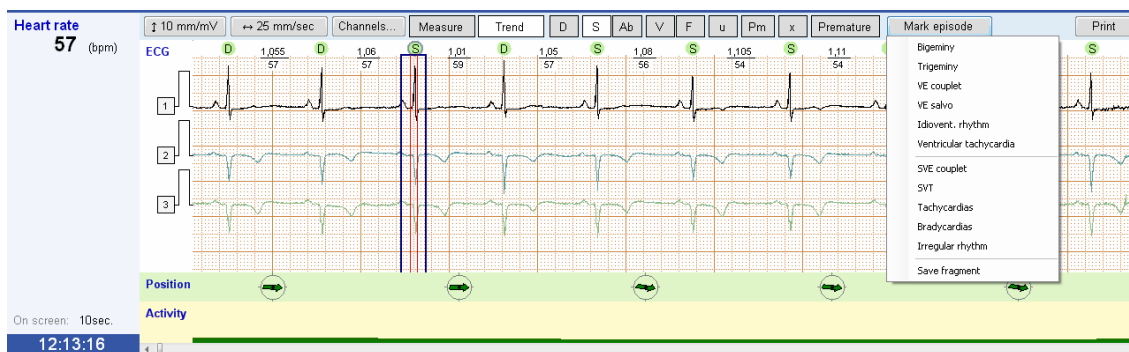


Fig. 25. The selection of an episode type.

7. Rhythm Analysis

To switch to the rhythm analysis mode, select “Arrhythmias” in the main exam window or press “Next” button from “QRS classification” window.

When you switch to the “Rhythm analysis” mode, the automatic recalculation of arrhythmias will be performed if a user made some changes after the automatic analysis.

In the summary table each row corresponds to an hour time interval. The parameters for each row in the columns are the following:

- minimal heart rate (HR min.);
- maximal heart rate (HR max.);
- mean heart rate (Mean HR);
- total number of analyzed complexes (Total number of QRS);
- number of pauses (Pauses);
- total number of ventricular complexes (Total VE);
- total number of single ventricular extrasystoles (Single VE);
- total number of ventricular tachycardia events (VT);
- total number of bigeminy/trigeminy events (Bigem./Trigem.);
- total number of ventricular extrasystole couplets (VE couplets);
- total number of ventricular extrasystole salvo (VE salvo);
- total number of idioventricular rhythm events (Idiovent. rhythm);
- total number of supraventricular tachycardia events (VT);
- total number of tachycardia episodes (Tach);
- total number of bradycardia episodes (Brad);
- total number of singular supraventricular extrasystoles (Single SVE);

- total number of episodes of supraventricular extrasystole couplets and salvos (SVE salvo);
- total number of irregular rhythm episodes (Irregular rhythm).

The arrhythmias table contains two tabs to display the ventricular and supraventricular activity. The switch between the tabs is done by pressing the corresponding button located in the top right part of the screen.

To review the recorded heart rate disturbances, minimal and maximal HR in each hour, select the table box you are interested in each hour (by pressing it with the left mouse button). The central position in the detailed review window will correspond to the beginning of the first episode of the type selected by a user in the specified time interval. Using the buttons on the left panel of the detailed review window you can look through the rest episodes of the current list (Fig. 26).



Fig. 26. The review of arrhythmias events.

To the left of the results table the information concerning the maximal, minimal HR and pause with maximal duration are located. To review the ECG fragment corresponding to the event, it is necessary to press the button near the required index. The program will provide the choice of several episodes. If the indicated fragment does not correspond (according to your opinion) to the reality, select the required fragment using the navigation buttons “<” and “>” and fix the changes by “OK” button pressing.

If in the review process the episodes defined erroneously by a program as rhythm disturbances episodes were detected, remove them. To remove the episode using the

navigation bar located in the left part of the detailed ECG review window, select the required episode and select “Delete” button. If during the review the types or QRS prematurity were corrected, press “Recalculate” button to update the information in the table.

To include the selected rhythm disturbance episode to the report, check “Add to report” checkbox located in the right top corner of the detailed ECG review window.

To print or include the current ECG fragment to the report, press “Print” button, in the appeared submenu select the corresponding operation. After that, enter the comment text in the appeared window (Fig. 27).

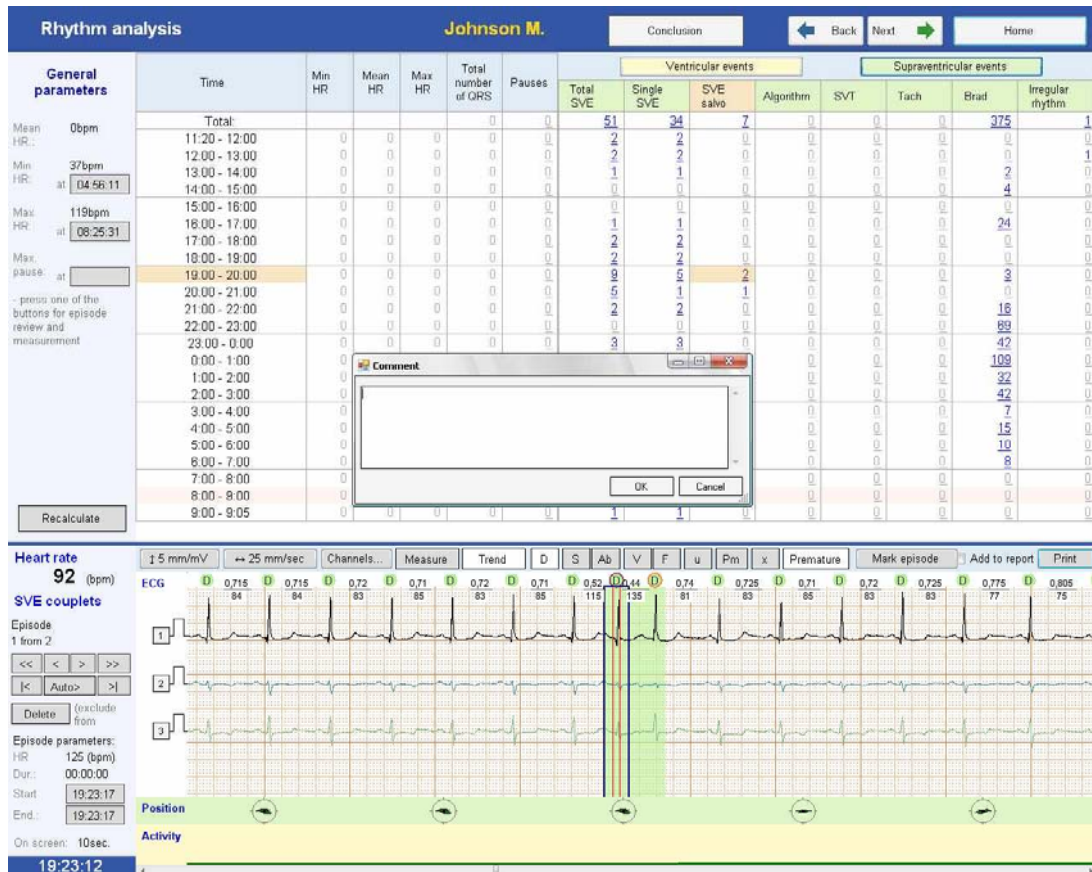


Fig. 27. Entering of comment text.

8. Assessment of ST Segment

In the main exam window select “ST-segment analysis” or being on the rhythm analysis page press “Next” button. The program will switch to the “Table” tab of “ST-segment analysis” window.

8.1. ST Analysis

The table contains the automatically detected episodes of ST segment deviation from the baseline with the indication of its onset time, duration, HR during the episode, ST deviation by each channel and also rhythm disturbances during the episode. During the review it is necessary to remember that the table represents the averaged values of ST segment deviation per 30-second time intervals.

To review the episode, click the corresponding active (underlined) element in the table or the box with the episode number with the left mouse button (Fig. 28).

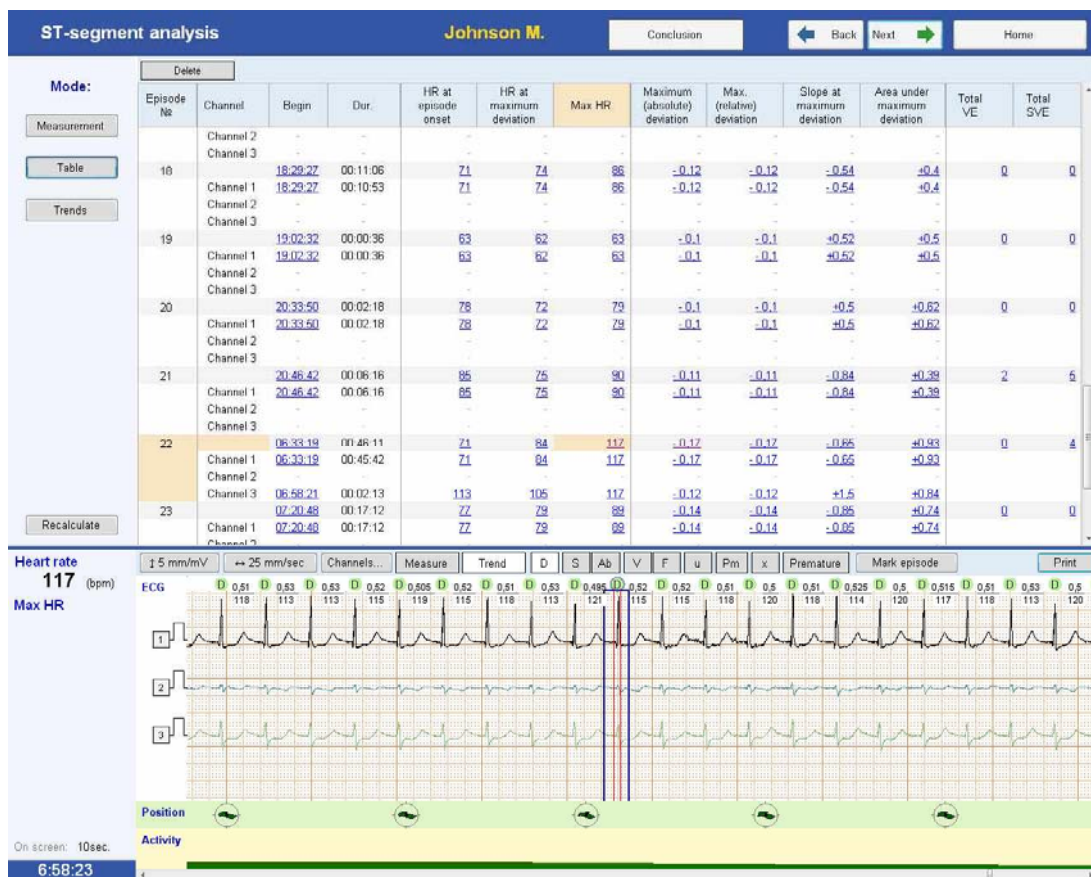


Fig. 28. Review of ST episodes.

8.2. Measurements

The “Measurement” tab is intended for the detailed measurement of ST segment parameters and also for editing of automatic analysis parameters.

To measure ST parameters, the program performs the automatic search of the following points on QRS complexes included in the dominant template (Fig. 29):

- points of isoelectricity on PQ segment (PR);
- ST1 point – QRS complex offset (J point);
- decrease and slope measurement points (ST2) – ischemia points (J point+80).



Fig. 29. ST measurement mode.

To review the cardiocomplex in the measurement window is it required to select it in detailed ECG window with mouse double-clicking (only dominant complexes are selected, as far as these ones are used for ST analysis). Using the arrow buttons in the bottom right corner of the window, you can switch to the next or previous complexes (Fig. 29).

To the right of the complex the table with the detailed description of ST-segment characteristics of the current cardiocomplex is located.

To correct the parameters of automatic ST analysis, it is necessary to press “Measurement” button. Two markers indicating the complex onset and offset will appear in the active QRS complex. To shift the onset or offset marker of the complex, click it with the left mouse button. The dashed area indicates the segment limited by J and J+80 points. If a patient has initial depression (elevation) of ST segment, it is possible to set the base level for the calculation performing (not from the isoline).

To activate the changes, press “Apply” button, and all the data in the “Table” and “Trends” will be updated automatically.

8.3. Trends

The “Trends” tab contains HR trends and levels of ST segment deviation by each of three ECG channels.

To review the fragment you need in ECG window, position the cursor on the corresponding graph fragment using the left mouse button (Fig. 30).

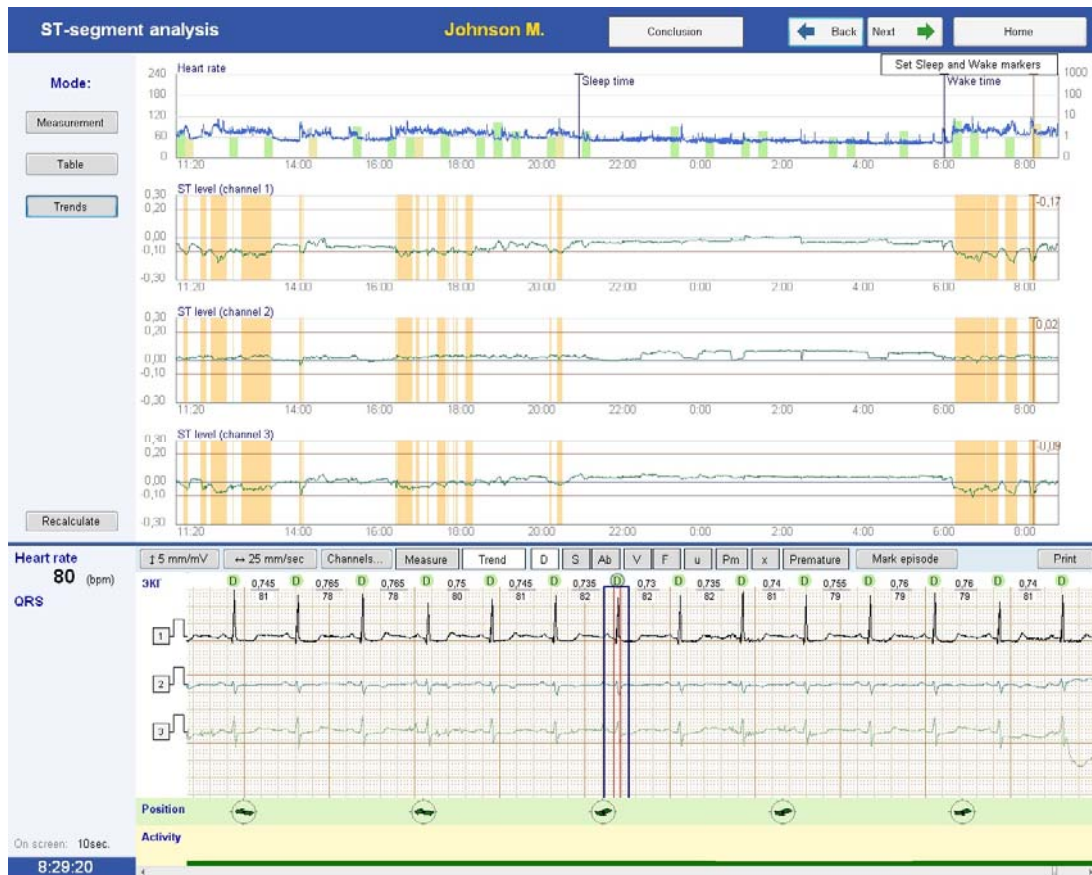


Fig. 30. Review of ECG fragment corresponding to the current position on the trend.

To print or add the selected fragment to the report, press “Print” button. In the appeared dropdown list, select the required option: “Print” or “Add to report”.

9. Bifunctional Monitoring of ECG and BP

To switch to the blood pressure analysis mode (BP), select the “Blood pressure” button in the main exam window or being in the “Events and episodes for report”, press “Next” button (the latter is available if BP data is already downloaded from the recorder otherwise you will pass to heart rate variability analysis window, see chapter 10 “Heart Rate Variability”. To download BP data, switch to “Record” window and press “Blood pressure” button).

During the analysis of bifunctional monitoring (in the addition to the data downloaded from “Poly-Spectrum-AM” recorder) the results of daily monitoring of the arterial pressure received from the compatible recorder are required. At present time the program provides the opportunity to receive the data concerning the arterial pressure from BPLab recorders manufactured by Petr Telegin Ltd. (Nizhniy Novgorod, Russian Federation).

If you want to download the arterial pressure data, connect BPLab recorder according to the manual for the device and press “Download data from BP recorder” button (Fig. 31).



Fig. 31. “BP analysis” window.

Poly-Spectrum-AM program is not the specialized software for the recorders control and detailed analysis of daily BP monitoring. BPLab software is intended for this purpose. After the data download to Poly-Spectrum-AM program, the initial information is saved in the recorder memory and can be downloaded then to the main program of BP monitoring.

As soon as you pressed “Download data from BP recorder” button, the panel displaying the process of data download from the monitor will appear on the screen. It is required to wait for the data uploading to the computer memory. If the “Pressure monitor is not detected” message appears on the screen, check the BP recorder connection and repeat the uploading.

After the downloading of BP monitor data, the results will appear in the table of daily BP monitoring located in the left top part of the screen and also on the graph in the center of the screen (Fig. 31).

If by some reason the time and/or date of the beginning of arterial pressure monitoring were set incorrectly in the recorder memory, the results in the table and on BP graphs will not be seen or will be displaced by time axis. The correction can be performed with the use of time/date change function in “Beginning” input box. To do this, enter the date of BP monitoring beginning and set the date and time correctly using the dropdown calendar.

In the process of the analysis the program arranges the markers of sleep and wake periods (indicated as “Sleep time” and “Wake time” on the rhythmogram) by default at 7.00 and 23.00 correspondingly (Fig. 32). To specify the real time of sleep and wake beginning, use “Set Sleep and Wake markers” button. As soon as you press this button, the markers will change the color to the brown one and they can be moved using the mouse button. Using the left mouse click you can shift “Sleep time” marker on HR graph and using the right mouse button click you can move the “Wake time” one. After the markers position change, the data will be recalculated automatically.

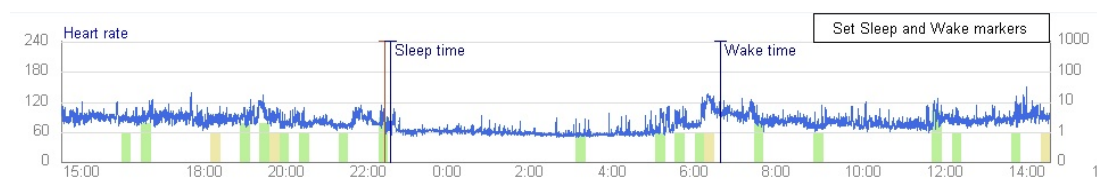


Fig. 32. Rhythmogram.

The results table displays the main indices of arterial pressure monitoring per day and night hours: the mean level of systolic (SAP) and diastolic pressure (DAP), the time indices of systolic and diastolic BP (the percent of arterial pressure measurements during the analyzed period exceeding the normal values); systolic and diastolic BP variability (the root-mean-square deviation of BP indices from the mean value per the analyzed time period), the daily index of systolic and diastolic pressure (the change of the mean level of BP per night period in relation to the day one in percents).

Besides, the table contains the results of all BP measurements fulfilled during the twenty-four hours.

The detailed information concerning the daily BP monitoring indices and its interpretation you can find in the corresponding manuals.

10. Heart Rate Variability

If you want to switch to the heart rate variability analysis mode (HRV), press “Variability” button in the main exam window or being in the “BP analysis” window, press “Next” button.

HRV analysis during twenty-four hours is the technique allowing to assess how the heart rate changes in different time periods and on the background of different activities of a patient. These changes represent the heart ability to adapt to variable conditions of life and allow making the prognosis for the patients suffering from cardiovascular pathologies by the data accumulated to that moment. Also the daily heart rate variability allows assessing the peculiarities of neurohumoral regulation of human body during 24 hours (although these data are less specific than results of HRV analysis on 5-minute records in the stationary conditions).

The left part of the screen (Fig. 33) contains the panel allowing to include/exclude the definite types of complexes or rhythm disturbance episodes to/from analysis. On the basis of HRV analysis methodology the calculation of indices should be based on the processing only intervals between the normal sinus contractions. From the point of QRS complexes classification applied in **Poly-Spectrum-AM** software, the dominant and (in some cases) supraventricular complexes can be referred to normal QRS ones. Thus, at HRV analysis the “Dominant” and “Supraventricular” checkboxes should be checked on the given panel. Also uncheck “Tach” (tachycardia) and “Brad” (bradycardia) checkboxes on “Exclude following arrhythmic episode” panel if the previous analysis of arrhythmias defined that the tachycardia and/or bradycardia episodes has sinus origin.

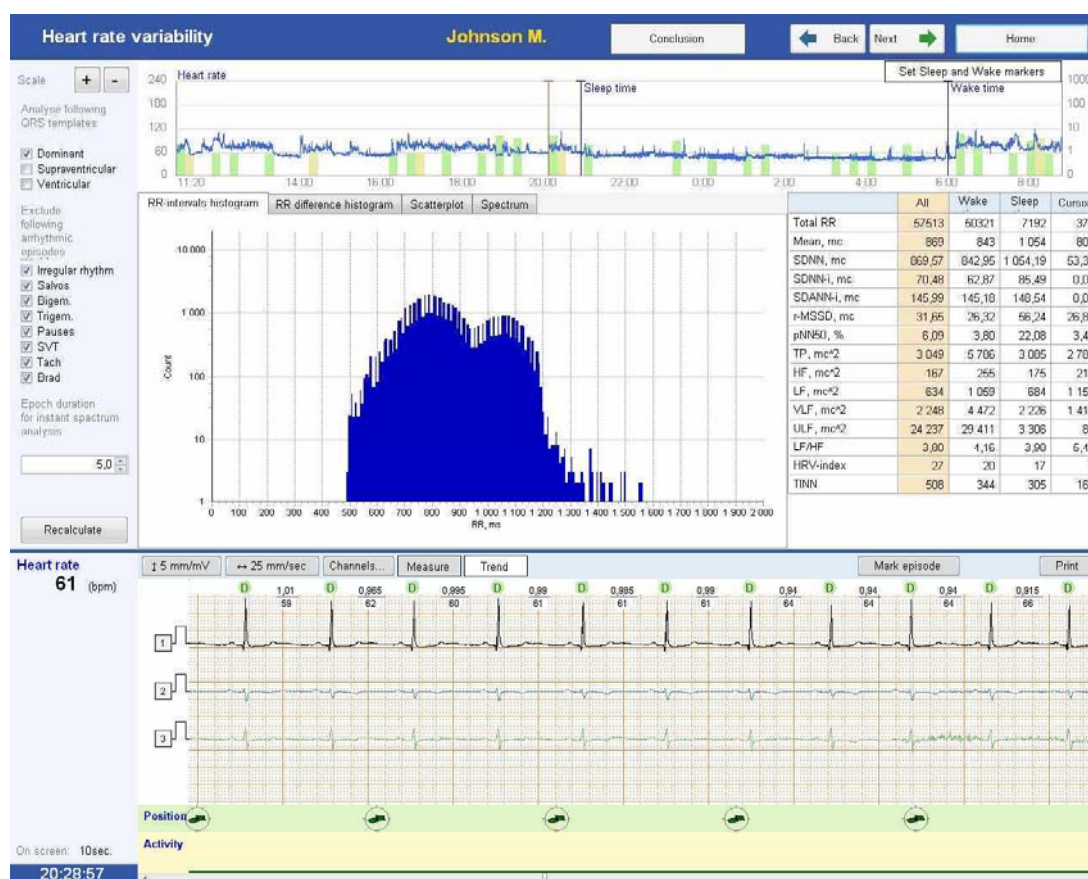


Fig. 33. HRV analysis window.

The adding of nonsinus episodes and contractions to the analysis can be used in specific cases, at that one should remember that the norms and reference values worked out for sinus rhythm are inapplicable in this case.

To update the graphs and table values after the change of analysis parameters it is necessary to press “Recalculate” button.

The graphs are located in the central part of the screen, the switch between them is carried out with the use of corresponding tabs in the top part of the field:

- Histogram is the graph of RR-intervals distribution depending on its duration. The values of RR-intervals duration are set on the horizontal axis, the RR-intervals number in each time interval is by vertical one. The time interval length (histogram column) set according to the International recommendations of 1996 year is equal to 1/128 sec. The histogram allows assessing the total rhythm variability and also used for the HRV-index and TINN calculations. The histogram color represents the analyzed period: 24 hours – blue color, day time – red one, night time – green one, selected short fragment near the cursor – yellow one (Fig. 34).

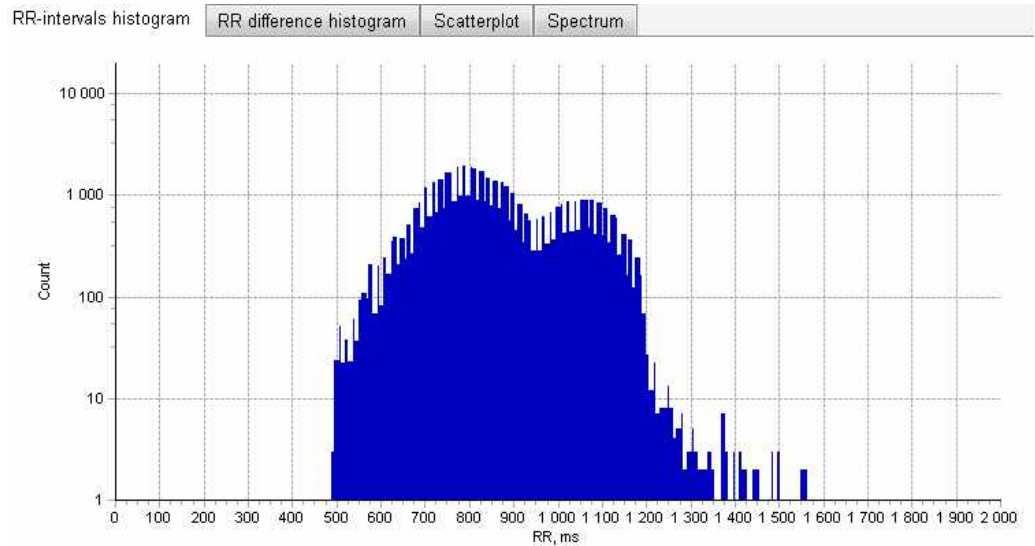


Fig. 34. Histogram.

- RR difference histogram is the graph analogous to the histogram, however the analysis object is not RR-interval value itself but the difference in the following and previous intervals between cardiac contractions. The histogram allows assessing the distribution of rhythm acceleration and slowing down during 24 hours. The histogram color represents the analyzed period: 24 hours – blue color, day time – red one, night time – green one, selected short fragment near the cursor – yellow one (Fig. 35).

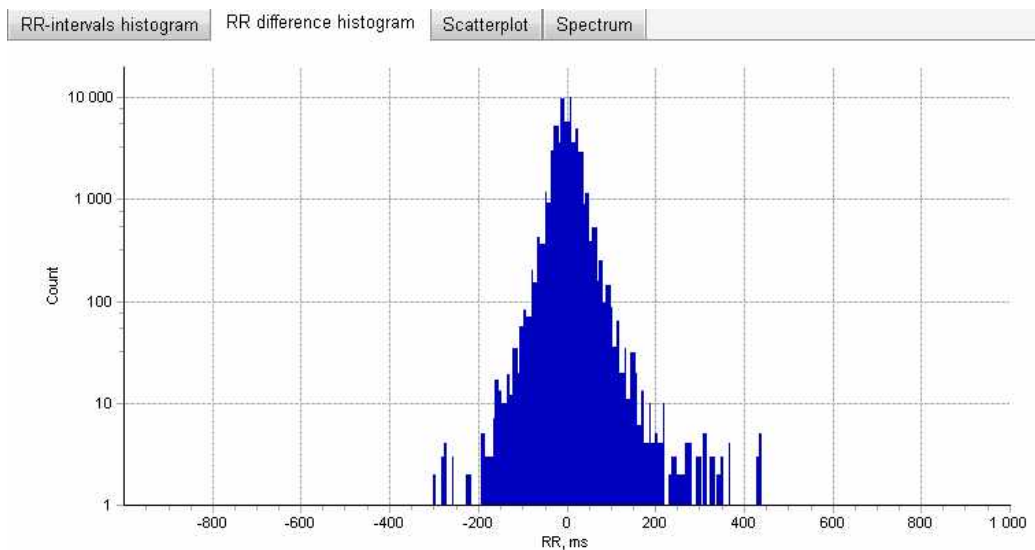


Fig. 35. RR difference histogram.

- Scatterplot is the graph of RR intervals distribution constructed on the surface where the absciss of each point is the duration of the current RR interval and ordinate is the duration of the previous one. The scatterplot allows assessing the character of rhythm variability in extrasystoles presence (as far as they impact lesser the main cloud form). The estimation of character of rhythm regulation can be carried out by the form and location of main cloud of the scatterplot. The color of histogram fragment (from blue up to red) indicates the density of points distribution (Fig. 36).

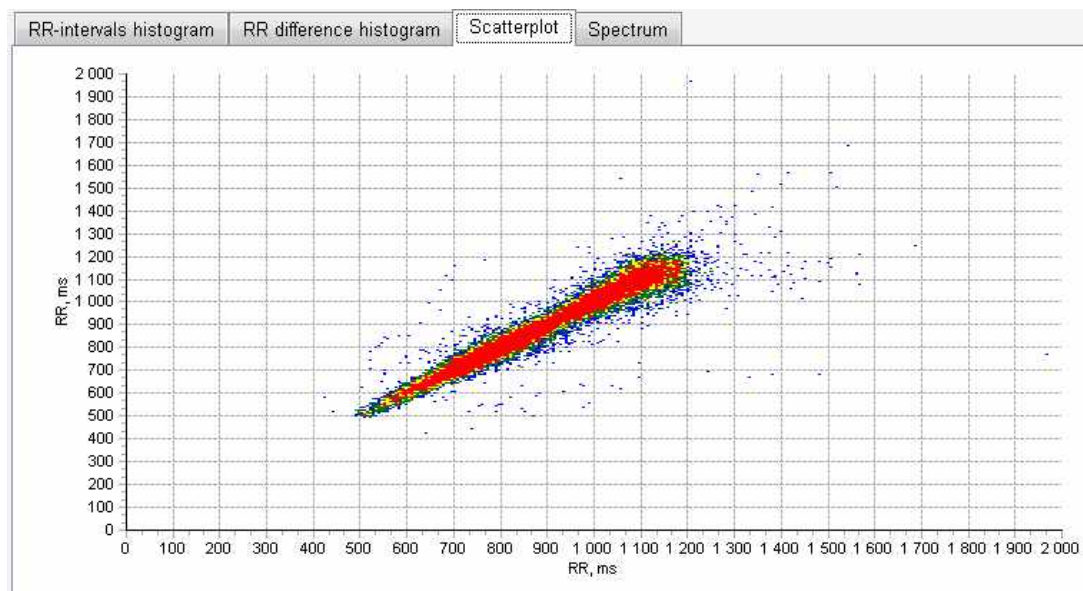


Fig. 36. Scatterplot.

- Spectrum is the graph of the spectrum power distribution depending on the oscillations frequency (Fig. 37). The limits of the ranges are specified according to the recommendations of 1996 year. The colors indicate the following ranges (from the right to the left):
 - blue – HF (high frequency oscillations – 0.4–0.15 Hz): represents mostly the activity of parasympathetic regulation;
 - red – LF (low frequency oscillations – 0.15–0.04 Hz): represents mostly the activity of sympathetic part of nervous system;
 - green – VLF (very low frequency oscillations – 0.04–0.003 Hz): represents the complex activity of range of hormonal systems, subcortical centers, etc.;

- yellow – ULF (ultra low frequency oscillations – 0.003–0 Hz): represents the slow regulatory impacts and paracircadian rhythms. There is some data concerning the independent prognostic value of oscillations power in the given range.

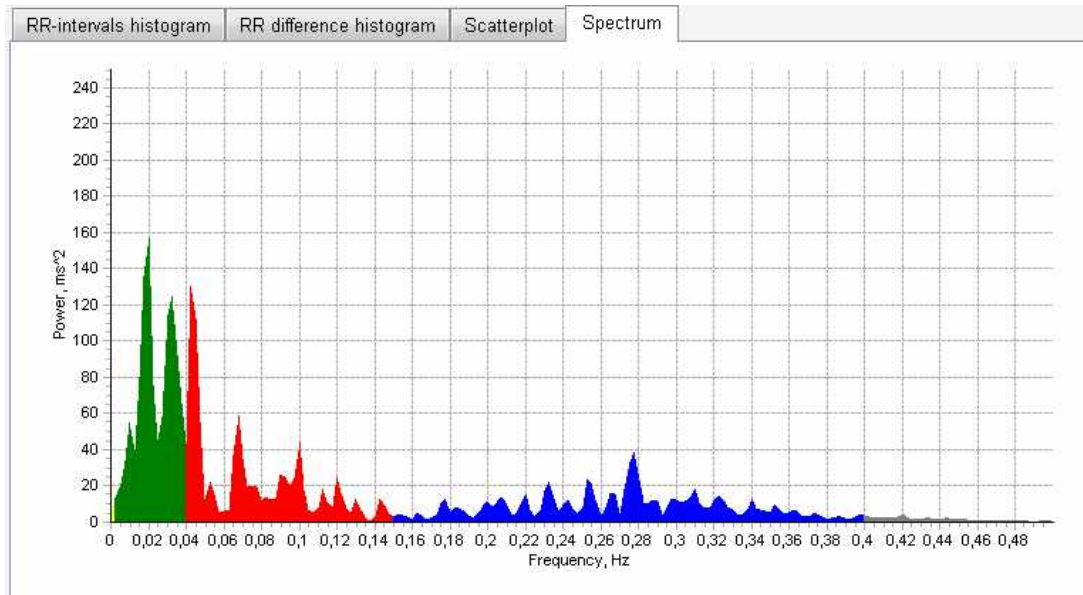


Fig. 37. Spectrum.

To the right the table with the results of statistic, spectral and geometric analysis of heart rate variability is located (Fig. 38). The data in the columns correspond to the following periods:

- all – the indices per 24 hours;
- wake – the indices per period marked as day time on the rhythmogram (from “Wake” marker up to “Night” marker);
- Sleep – the indices per period marked as night time on the rhythmogram (from “Night” marker up to “Wake” marker);
- Cursor – the indices per time period from the cursor on the rhythmogram and during the “Cursor width (minutes)” period which lasts 5 minutes by default. The duration of analysis epoch can be specified by a user manually (Fig. 33).

To change the arrangements of sleep and wake beginning markers, use “Change wake and sleep markers” button. Set the required markers positions using the left mouse button (“Sleep”) and right mouse button (“Wake”). If you want to recalculate the analysis parameters after the change of the markers positions, press “Recalculate” button.

	All	Wake	Sleep	Cursor
Total RR	110975	84244	26731	429
Mean, mc	765	701	969	692
SDNN, mc	89,44	24,82	293,29	71,25
SDNN-i, mc	69,55	63,39	83,64	0,00
SDANN-i, mc	149,87	109,57	216,33	0,00
r-MSSD, mc	42,88	34,14	62,94	36,43
pNN50, %	15,95	9,43	36,50	12,35
TP, mc ²	4 531	7 895	5 981	5 141
HF, mc ²	797	1 065	1 405	629
LF, mc ²	1 629	3 117	1 806	2 568
VLF, mc ²	2 105	3 713	2 769	1 944
ULF, mc ²	23 493	11 578	10 340	135
LF/HF	2,05	2,93	1,29	4,08
HRV-index	30	26	30	14
TINN	492	414	469	250

Fig. 38. The table of heart rate variability analysis results.

The table displays the following parameters:

- Total RR – the total number of analyzed RR intervals in the specified time interval;
- Mean – the mean value of RR intervals;
- SDNN – the root-mean-square deviation of RR duration from the mean one. It represents the total HRV;
- SDNN-i – the standard deviation index, average value (per 24 hours) of standard deviation calculated per all 5-minute intervals: represents the rhythm variability during the short periods of time;
- SDANN-i – the standard deviation calculated by RR intervals values averaged for 5-minute fragments. It represents the rhythm variability on the fragments exceeding 5 minutes (relatively slow rhythm oscillations);
- r-MSSD – the root mean square successive difference of RR intervals duration. It represents the quick rhythm oscillations, mainly of parasympathetic genesis;
- PNN50 – percentage of RR intervals which differ from the previous cardiointerval for more than 50 ms. It represents the quick rhythm oscillations, mainly of parasympathetic genesis;
- TP – the total spectrum power. It represents the total rhythm variability;

- HF (high frequency oscillations – 0.4-0.15 Hz). They represent mainly the activity of parasympathetic regulation;
- LF (low frequency oscillations – 0.15-0.04 Hz). They represent mostly the activity of sympathetic part of nervous system;
- VLF (very low frequency oscillations – 0.04–0.003 Hz). They represent the complex activity of range of hormonal systems, subcortical centers, etc.;
- ULF (ultra low frequency oscillations – 0.003–0 Hz). They represent the slow regulatory impacts and paracircadian rhythms. There is some data concerning the independent prognostic value of oscillations power in the given range.
- LF/HF – the ratio of the sympathetic and parasympathetic regulation activity;
- HRV-index – triangular index (index of St. George hospital), the geometric measure of total heart rate variability;
- TINN – the triangular interpolation index, also the geometric index of total heart rate variability.

11. Heart Rate Turbulence

To switch to the heart rate turbulence (HRT) analysis mode, press “Turbulence” button in the main exam window or being in the “Heart rate variability” window, press “Next” button (Fig. 39).



Fig. 39. “Heart rate turbulence” window.

The technique of heart rate turbulence analysis is based on the assessment of intervals duration measurement between sinus complexes (RR intervals) after the ventricular extrasystole. Normally, the dynamics of the RR intervals duration has definite patterns: the quick phase of the starting shortening changes with the gradual lengthening with the further recovery up to the initial level (up to extrasystole). The given response is fulfilled with the participation of baroreflex regulation mechanisms and can be one of the criteria of autonomous nervous system reactivity. The response decrease, according to some authors data, is accompanied with the prognosis worsening and increase of cardiovascular complications for patients suffering from cardiovascular diseases.

Considering the technique peculiarities, check the correctness of the ventricular complexes (V) detection by the program in the mode of QRS complexes classes analysis or in the arrhythmias analysis mode before switching to the turbulence analysis.

Traditionally, the electrocardiogram panel is located in the bottom part of the screen. Using it, you can review and edit QRS complexes.

In the top right part of the screen the rhythmogram panel is located. On this panel the graph of RR intervals (rhythmogram) duration as a broken yellow line is represented for each ventricular extrasystole satisfying the condition of inclusion to the analysis (the ventricular extrasystole with the coefficient of prematurity defined in the program settings, the number of consecutive sinus complexes up to the extrasystole is not less than 5, after the extrasystole is not less than 15). The zero interval is the interval of extrasystole cohesion.

The red line represents the averaged rhythmogram of all extrasystoles included in the analysis.

The blue color indicates the rhythmogram of the selected extrasystole.

The panel of extrasystoles selection for the analysis is located to the left of the graph panel. The extrasystole can be selected by the left mouse clicking on the row with the time of extrasystole appearance (at that the corresponding rhythmogram is marked with the blue color and the corresponding ECG fragment with extrasystole is displayed in the bottom part of the screen). If you uncheck the checkbox opposite the extrasystole using the left mouse button, it will be excluded from the analysis, at that, the indices of rhythm turbulence will be recalculated automatically. To return the extrasystole to the analysis, it is required to check the checkbox again using the left mouse button.

In the left top part of the screen the panel of rhythm turbulence parameters is located. It displays:

- TO (turbulence onset) – the coefficient representing the relative increment (positive value) or shortening (negative value) of first two sinus RR intervals duration just after the ventricular extrasystole (according to the norm $<0\%$);
- TS (turbulence slope) – the coefficient of line slope of graph regression of sinus RR intervals after the extrasystole (according to the norm >2.5 ms/RR);
- Turbulence score – the total value based on TO and TS values. The assessment of 0 scores means that both turbulence parameters are in norm, 1 score indicates that TO or TS is deviated from norm, 2 scores – both parameters (TO and TS) are deviated from norm.

12. Events and Episodes for the Report

To switch to the events and episodes editing mode, in the main exam window select “Events” page or being in the heart rhythm turbulence window, press “Next” button.

The window “Events and episodes for report” (Fig. 40) is intended to define the events which will be included in the report.

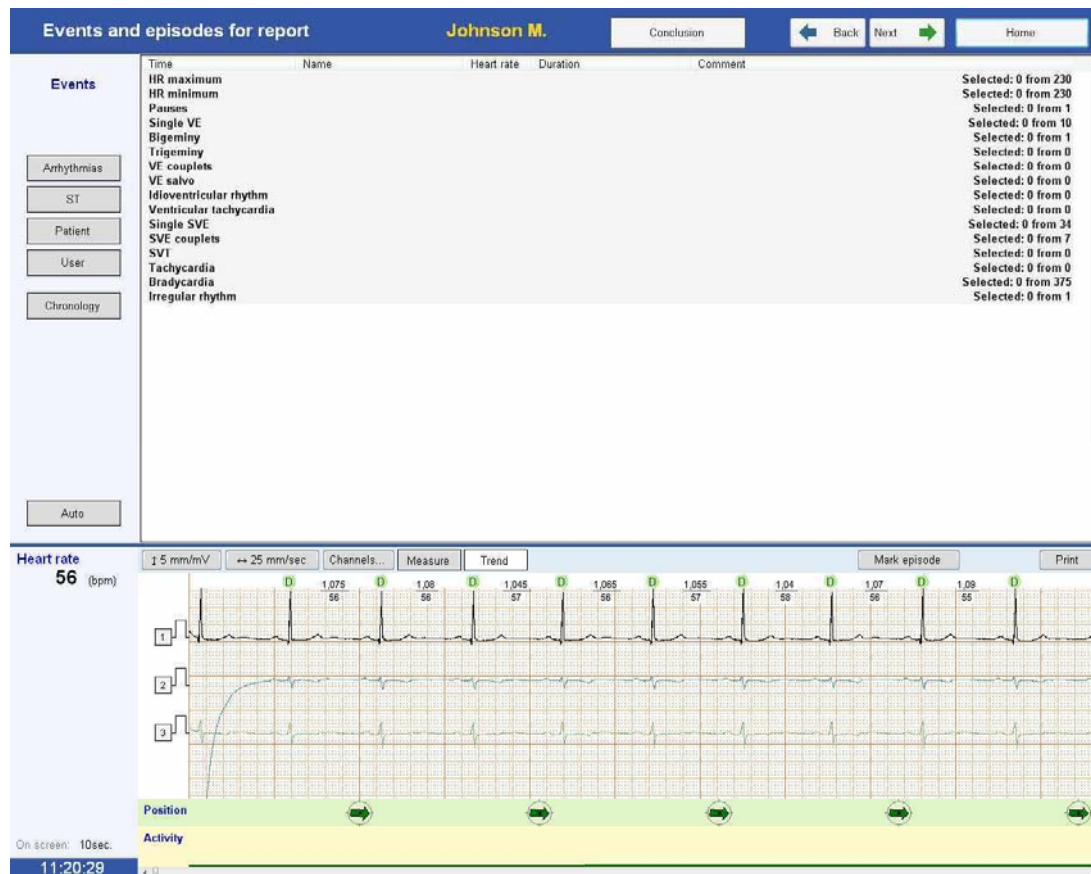


Fig. 40. Events and episodes for the report.

The buttons located to the left allow to select the category of the events displayed in the table to the right.

If you press “Arrhythmias” button, the table with the list of rhythm disturbances episodes will appear in the table to the right, for each of them the total number of episodes on the record and the number of episodes already included by a user to the report on the previous analysis stages are displayed (see p. 7, 8). To include the episode to the report, it is necessary to select the required category from the list using the left mouse button. In the detailed ECG window the first episode of the given category is represented. To include it in the report, it is necessary to check “Add to report” checkbox in the field located to the right over the ECG review window. If you want to select other episode from the category, it is required to use the scroll buttons. The list of the selected episodes is displayed in the table. To add the comment to the selected episode (it will be printed in the report together with ECG), double-click the row with the episode name in “Comment” column with the mouse, the row for the text entering

will be activated. The comment text will be saved automatically after “Enter” button pressing or mouse clicking in any part of the screen.

The work with the episodes of ST displacement is organized in the same way. Use “ST” button to switch to the corresponding table.

If you press “Patient” button, the list of the events marked by a patient by pressing the button on the recorder (“Patient” event) or audio comment recording (“Audio comment” event) will display on the screen. To review the ECG corresponding to the time of the button pressing/audio comment recording, click the corresponding event row with the left mouse button. To play back the audio comment, click the dynamics icon. To add ECG fragment corresponding to the event to report, check “Add to report” checkbox.

The “User” button allows reviewing the list of events included arbitrary by a user to the report on different stages of analysis and not included in “Arrhythmias” and “ST” categories.

To display the events in the chronological order, press “Chronology” button (Fig. 40).

Press “Auto” button to generate automatically the list of representative episodes of rhythm disturbances, ST displacement episodes and patient events. The first elements of arrhythmical events lists of each time will be added automatically (Fig. 41).



Fig. 41. Arrhythmical events included to the report.

At the event selection in the table, the corresponding ECG fragment is displayed below in the detailed ECG window. To add it to the report, check “To report” checkbox.

13. Report

To switch to the report window, press “Report” button in the main exam window or being in the event window, press “Next” button.

It is generated automatically at the switch to the report window basing on the already performed analysis.

The report can contain the following sections: main data, arrhythmias, trends, ST data, patient events and user events (Fig. 42). One can change the report composition by checking and unchecking the checkboxes opposite the sections names. To validate the changes, press “Update” button.

The section “Main data” contains the passport data and general report (general statistics) by all events of rhythm disturbance and ST segment (Fig. 42).

Report Johnson M. Conclusion Back Next Home

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Export to PDF

Basic data
 Arrhythmias
 Trends
 ST data
 Patient defined events
 User defined events
 Blood pressure graph
 HRV
 Turbulence

Refresh

Neurosoft Rd, Clinical research
5, Voronin str. Ivanovo

Summary report
on 24-hour ECG monitoring

Start of the record 13.12.2007 r. 11:20 Record duration 21:05:16

Patient info

Patient:	Johnson	Birth day:		Sex:	female	Recorder:	Igor Chirpov CM2
Age (years):	58	Height (cm):	168	Serial number:	10006		
Weight (kg):	78						

Summary statistics

Rhythm		Ventricular events	
Number of QRS analyzed	1305	Single VEC	9
Number of minutes analyzed	1198pm at 00:25:31	VEC couplets	0
HR maximum	119bpm at 04:26:11	Total VT	0
HR minimum	37bpm at 04:26:11	VT with maximum HR	-
Mean HR	65bpm	VT with maximum HR	-
		Maximum VT duration	-
		Maximum number of single VECs per hour	4 (0:00 - 9:00)

ST-ANALYSIS		Supraventricular events	
Maximum ST depression	-0.2	Single SVE	34
Maximum ST elevation	0.0	SVE couplets	7
The longest ST depression episode (84 lems)	00:48:11 s 06:33	Total number of SVT episodes	0
Total duration of ST depression	04:08:35	Maximum duration SVT episode	-
ST depression episode with maximum HR	00:10:20 s 08:22 (80 lems)	Maximum number of single SVE per hour	5 (18:00 - 20:00)
		SVT episode with maximum HR	-
		Irregular rhythm	1 duration 00:04

Pauses

BRADYCARDIA	0
Maximum pause	

Analysis criteria

Prematurity level	00%
Pause	1.9 s
ST-depression	0.1
ST elevation	0.2

Conclusion

Sinus rhythm 79-119 bpm. Significant ischemic ST depression episodes (total 4 hours).

Doctor: J. Smith

Fig. 42. Report.

Then the reports concerning the arrhythmias follow. The HR data (minimal, maximal and average) by the hours, information about supraventricular and ventricular disturbances of heart rate are represented there as tables.

The next two pages contain HR trend and histograms of supraventricular and ventricular ectopic activity.

The ST data include the table of recorded episodes which represents the level of maximal depression and ST elevation, duration of ST segment depression episodes. The next page contains the trends of ST deviation by each channel.

The pages “User defined event” and “Patient defined event” represent ECG fragments marked by a user and/or patient.

The entered doctor’s interpretation is automatically included to the report. To add the interpretation text, press “Conclusion” button and enter the text to the appeared window (Fig. 43). Please, remember, the given window is available on all analysis stages (see p. 5).

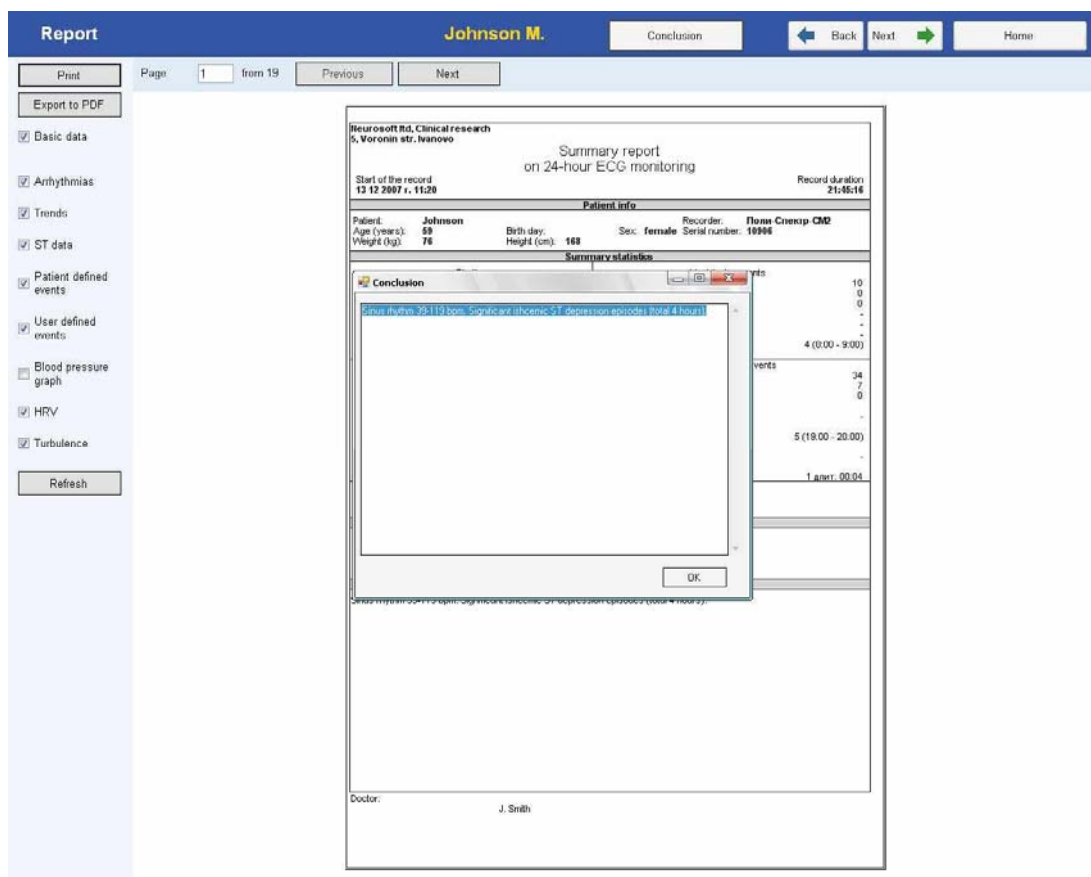


Fig. 43. Interpretation

15. Settings

If you want to switch to the settings window, press “Setup” button in the main program window or in the main exam window.

The “Setup” window has three categories of settings for the automatic analysis of daily ECG record. The user can change these settings according to her/his requirements.

15.1. QRS Complex Analysis

On “QRS analysis” tab you can specify the following: main and auxiliary channels for the QRS complexes search; dissimilarity level of elements inside template which increase decreases the number of the detected templates of QRS complexes; the magnitude level for complex height to complex shape defining the amplitude priority relative to the morphology (Fig. 45).

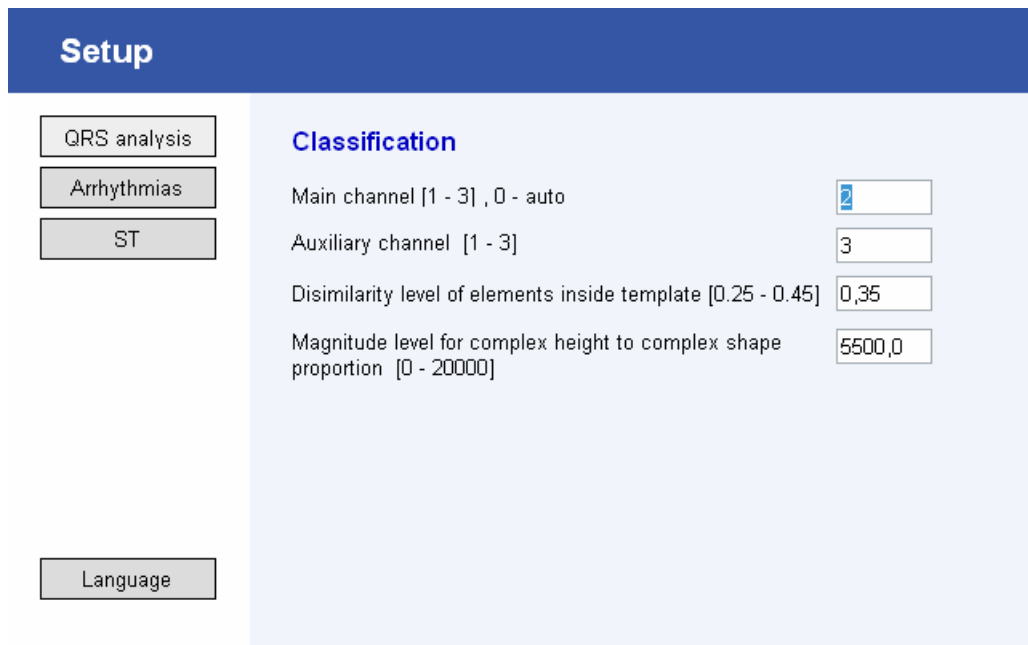


Fig. 45. “QRS analysis” tab.

15.2. Arrhythmias Analysis

The “General parameters” section contains the settings impacting the detection of heart rate, episodes of maximal and minimal HR during 24 hours, pause of maximal duration and premature (extrasystolic) complexes (Fig. 46).

Section	Parameter	Value	Range
General parameters	Number of variants for maximal and minimal HR and pauses	10	(10)
	Maximum interval adjacent to QRS-complex for HR calculation (sec.)	10.0	(10.0)
	Number of RR-intervals for HR calculation	10	(10)
	Prematurity level for supraventricular complex	0.0	(0.0)
Pauses	Criterion for pause detection during sinus rhythm	1.9	(1.9)
	Criterion for pause detection after premature ventricular contraction	2.4	(2.4)
SVT	HR at SVT episode onset	120.0	(120.0)
	HR increment level at SVT onset (%)	0.3	(0.3)
	HR during SVT episode	90.0	(90.0)
Rhythm irregularity	Number of RR-intervals for rhythm irregularity analysis	3	(3)
	Threshold for irregular rhythm detection	0.05	(0.05)
	Minimum irregular rhythm episode length	40.0	(40.0)
Tachycardias	HR at episode onset	130.0	(130.0)
	HR during the episode	110.0	(110.0)
Bradycardias	HR at episode onset	50.0	(50.0)
	HR during the episode	55.0	(55.0)

Fig. 46. “Arrhythmias” tab.

The “Number of variants for maximal and minimal HR and pauses” item is related to the automatic program search of the corresponding event on the record during 24 hours. For example, if the given parameter is equal to 100, the program will select 100 episodes with maximal HR by arranging them in descending order of rhythm frequency and a user in “Rhythm analysis” window (see p. 7) can review the offered variants and decide which of them is really the fragment with maximal HR per 24-hour record.

The “Prematurity level for supraventricular complex” and “Prematurity level for ventricular complex” items allow to specify the sensitivity for the automatic detector of extrasystoles (this is especially important for the supraventricular ectopias as far as the given program detects them only by time characteristics of rhythm). The lesser is the prematurity level, the more complexes will be included to the template of premature ones at the rhythm analysis and vice versa. That is why to get the optimal results of the automatic analysis, it is required to correct the value of the given parameter in the concrete case depending on the sinus rhythm character of a patient and number of extrasystoles on her/his record.

In the “Pauses” chapter you can change the sensitivity of the automatic algorithm at the pauses search on the sinus rhythm and ECG fragments containing the extrasystoles with the complete compensatory pause.

The setting in “SVT” section allow to correct the search parameters of ectopic tachycardias with narrow ventricular complexes.

The “Rhythm irregularity” section provides an opportunity to set the search criteria of the fragments with the evident oscillations of intervals between the cardiac complexes which is characteristic for auricular fibrillation episodes or ECG fragments contains a great number of polipotic extrasystoles.

The settings of “Tachycardias” and “Bradycardias” sections set the criteria of program episodes search of rhythm slowing and quickening.

15.3. ST Segment

The parameters of “ST” tab define the elevation and depression levels of ST segment and also specify the sensitivity of the algorithm for search of ST displacement episodes (Fig. 47).

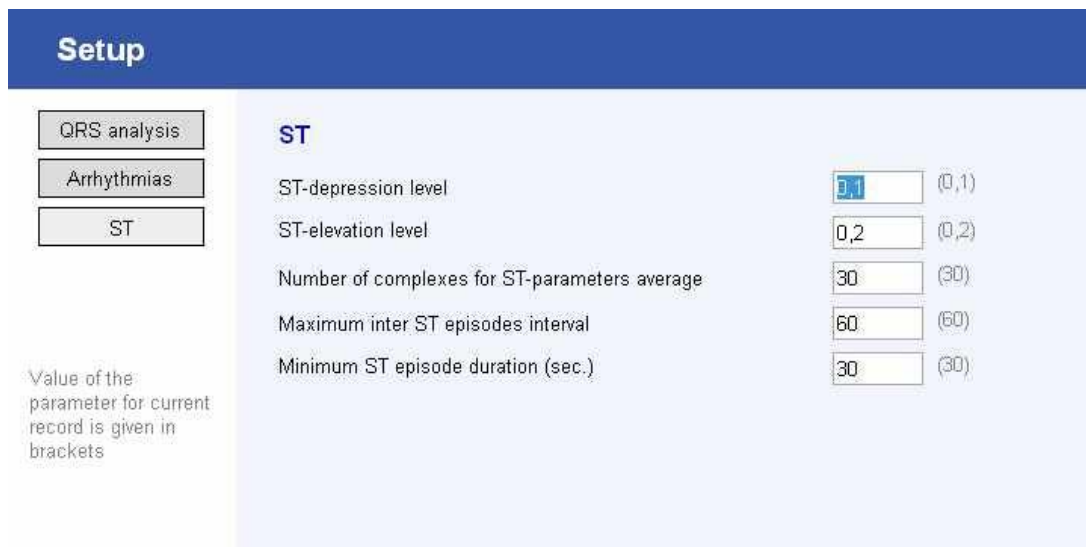


Fig. 47. “ST” tab.

In case you press “OK” button, all the changes will be applied and used for the further record analysis. If you want the changes to be applied to the already analyzed records, open them and press “Analysis” button.

If you want to return all the parameters specified at the initial program setup, press “By default” button.

16. Patient Memo at Daily Monitoring by Holter Technique Using "Poly-Spectrum-AM" Digital System

The daily ECG monitoring technique is intended for the assessment of heart performance in the process of common day-to-day activity. The diagnostic efficiency of the given exam depends on your respecting the doctor's instructions.

During the operation the device does not impact unfavorably a patient's body.

The electrocardiogram recording lasts continuously for 24 hours. Please, pay attention that during this period you will be prohibited to take water procedures, go to the swimming pool or sauna as far as the moisture can damage the device. During the sleeping time the device will continue to operate but it should be in placed in a special bag.

The device operates noiseless. The highlighting indicators are located on its front panel (Fig. 48).

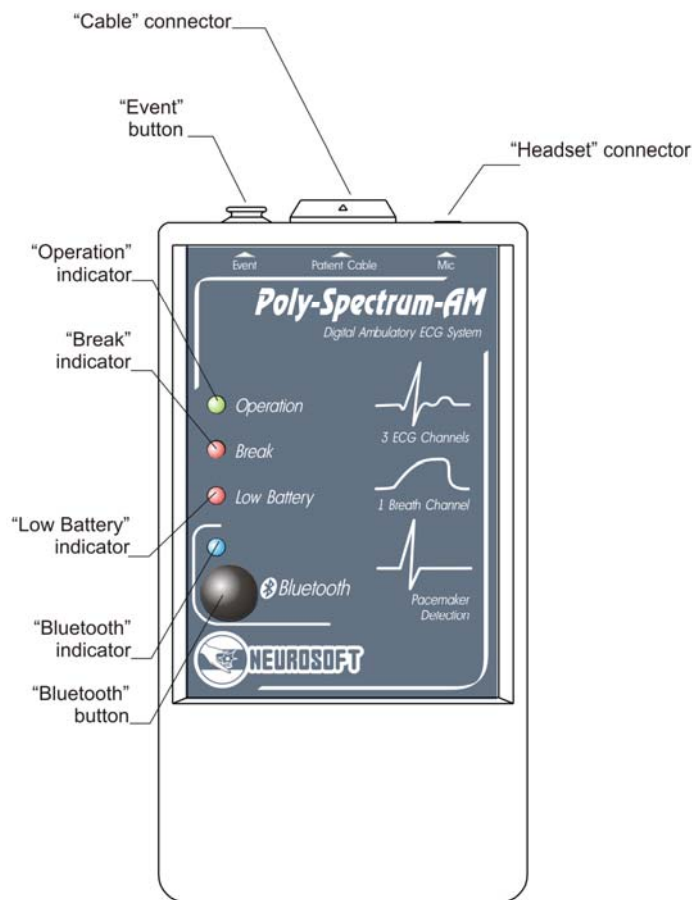


Fig. 48. The external view of the recorder.

1. The green indicator blinking means that the exam process goes correctly and the device operates well.
2. The yellow indicator means the contact fault of one of the cables. If you noticed such signal, please, check whether the electrodes are adhered well to a body and the cable of one of the electrodes or device are connected. In case the electrode is unstuck, try to place it back, you can use the additional adhesive plaster. If the cable is disconnected from the electrode on a patient body, connect it by pressing the adapter up to the snap. If the cable is disconnected from the device, insert it to the slot up to the snap by matching the arrows on the device slot and cable end.
3. The red indicator blinking and periodical audio signal indicate the low battery charge. Without disconnecting the device from the cable open the battery compartment located on the rear device panel, extract the batteries from it, insert the new ones considering the polarity and close the compartment. The green indicator should start blinking on the front panel. If the indicator does not blink, press "Event" button once. The audio signal should sound and the green indicator should start blinking. If it does not happen, check the correctness of the battery installation and repeat the start. In case of failure, try to contact the doctor (nurse) to get the consultation.

To help a doctor to assess the monitoring results correctly, please, use the functions of the audio marks and "Patient event" marks and also keep your diary.

If any sense of heart discomfort emerges, especially that you addressed with to a doctor, record this event. To do this, you can:

1. record the time of this sense emerging/disappearing, sense character, possible cause, provoked this sense and also measures taken by you to release it (termination of the physical exercise, taking the drag, etc.);
2. press the patient button located on the top part of the device up to audio signal appearing. As a result, the doctor will see the mark on ECG during the analysis. It is advisable to record the information to a diary as it is described in previous item.
3. leave the audio comment if the device is supplied with the special headset. Press the button on the headset and after a short beep say the character of your complaints, feeling to the microphone (it is not required to tell the time as the device records it automatically). After that you will hear one more audio signal and the recorded information will be played back in the headphones.

The device is programmed for 24-hour record. In 24 hours from the record start the indicator on the front panel will fade. You should return the device to the medical establishment where the device was placed. The electrodes and the device will be put off there, after that the doctor can analyze the results. Please, do not forget to hand in the diary to the doctor (nurse).