# User Manual

# **Focus EMG Machine**
**FDA 510(k): K102610**

# Table of Contents

# Introduction

The Focus EMG device is manufactured by **Neurosoft. Neurosoft**'s products are continuously updated and this manual is only current as of the date of its printing.

This manual is supplied along with the Focus's **Neuro-MEP.NET** software and the **Focus** EMG device for EMG, nerve conductions and evoked potentials studies.

Please send your comments and recommendations to the following address:

**TeleEMG, LLC - 27 Arlington Road, Bldg 2 – Unit 1, Woburn, MA 01801, USA**

or by e-mail:

**sales@teleemg.com**

or ask questions by phone:

1-877-TeleEMG (835-3364)

# Warning to Users

This manual contains information and warnings that need to be adhered to by the user to ensure safe operation of the Focus and maintain the device in a safe condition.

The Focus EMG device is intended to be used by qualified healthcare professionals only.

The power plug must only be inserted in a socket outlet connected to a protective ground contact.

**WARNING** Any interruption of the ground connection inside or outside the device is likely to make its use dangerous. Intentional interruption of these connections is prohibited. The ground conductor should be checked regularly.

**NOTE** In order to meet classifications, approvals, and necessary performances use only Notebooks and PCs sold or specified by the manufacturer or TeleEMG, LLC.

If the computer was purchased separately, install the software before connecting the unit to the computer (see technical manual of the device). Start the program, select the menu command **Setup|Change** and set the correct parameters of your equipment on the "Equipment" page (see more information in section 2.6 "Hardware and Software Configuration Setting" chapter).

If a file requires a license key, contact your dealer or **Neurosoft** and provide them with the device serial number to get the license key.

**To ensure safety and prevent the possibility of operator or patient electrical injury, DO NOT:**

1. Use the Focus without following the directions in this instruction manual.

2. Connect the Focus and surgical HF equipment to the patient as it can cause a flash-burn under the electrode placement and result in damage to the unit.

3. Connect any products, which are not included in the device's delivery set, to the electrode jacks.

4. Open components included in the delivery set.

5. Perform exams when the unit, computer or other digital system devices casings are opened.

**When using the Focus electrical stimulator, it is necessary to follow the precautions below:**

• Dangerous physiological effects: Current stimulant can produce dangerous LIMITED electric current and voltage.

• A patient with an implanted electronic device (for example, cardiac pacemaker) should not be exposed to electrical stimulation near the chest.

• Trans-thoracic delivery of the stimulation current is prohibited.

• To eliminate a patient's flash-burn in the stimulating electrode placement at current density exceeding (2 mA/cm2), it is necessary to control the maximal pulse current. The maximal pulse current will depend on the stimulation frequency, pulse width and electrode area.

> **If skin redness or any other unusual signs are observed during the stimulation, stop the stimulation, remove the electrodes from the skin surface and wash carefully the places of electrodes setting with disinfectant solution.**

There are no known problems associated with the use of the Photic or auditory stimulators.

## CAUTION

U.S. Federal law restricts this device to sale by or on the order of a physician or any other practitioner licensed by the law of the State in which he or she practices to use or order the use of the device.

# Indications for Use

The Focus is intended for use by a healthcare provider to perform nerve conductions and EMG studies as an aid in the evaluation of patients with diseases of muscle and nerves. The machine can also use electrical stimulus or sound stimulus for evoked potentials (EP) studies.

**WARNING** Do not use this PC-based equipment for anything else than it is intended for by the manufacturer, i.e. do not install any other software than that specified by the manufacturer and TeleEMG, LLC.

# 1.    Quick Start

## 1.1. General Requirements

This chapter serves as a quick user guide for commonly used programs and techniques.

To begin, refer to the section "The very beginning: new exam" and then proceed to the section describing the desired technique. Brackets ([ ]) in the text refer to hotkeys that can be used as a substitute for menu commands.

In this chapter, the minimum command requirements for acquiring and analyzing data will be described. Study the complete manual to master all the functions.

Program actions can be carried out in several ways. For example, to start a single stimulation you can:

- Point and click your mouse on the menu item Acquisition|Acquisition/Stimulus.  If you use the keyboard, press the  [Alt] key to activate the menu and then use the arrow keys and press [Enter] for selection.

- Use the  button, located on the toolbar, in the upper part of the screen – place the mouse cursor on the button and click its left button;

- Or if a footswitch is available, press the left foot pedal;

- For the Focus unit, press the  button on the unit's panel;

Before the first exam, go to the "Equipment" page and point and click your mouse on the menu command Setup|Change to check whether the power frequency corresponds to that of your region accepted by default (for the US – 60 Hz, for Europe and Russian Federation – 50 Hz). Then check the CRT size of the reversal pattern (if available). If the LCD monitor is used as a reversal pattern, set the delay time in the program settings, otherwise, the visual evoked potential latencies will be incorrect

# 1.2. The Very Beginning: New Exam

To start the Neuro-MEP.NET program, press the "Start" button on the taskbar and select the menu item Programs|Neurosoft|Neuro-MEP.NET.

To start a new patient examination, select the menu item Exam|New ([Ctrl+N]). In the dialog box labeled "New exam," enter the patient's basic data (optional). If you are short of time, press "OK" ([Enter]) in the dialog box without entering any information.

It is recommended to enter the patient data information in the "New exam" dialog box in the following order:

• Enter the patient's name;

• Press the [Tab] key;

• Type in the date of birth according to the date format set in your windows system. Most computer systems follow the four digit format: mm/dd/yyyy.  For example, if your patient was born on the 21st of May, 1947, you would enter 05/21/1947.

• To input the patient's height (the height is used while calculating some indexes), press the [Tab] key and enter the height in centimeters.

• To input the patient's weight, press the [Tab] key and enter the height in kilograms.

• To input the department (the number of ward, hospital etc.), press the [Tab] key and enter the name.

• To enter a provisional diagnosis, press the [Tab] key and enter the diagnosis.

• If you need to enter additional data, press the [Ctrl+Tab] key combination and continue entering data on the "Additional" page.

• Press [Enter] to close the "New exam" window.

To select a test type, use the menu item Test|New or  the "New test" toolbar buttons.

# 1.3. Motor Conduction Study

Complete the directions in chapter 1.2 "The Very Beginning: New Exam".

To conduct a motor conduction study test, press the button  on the New test toolbar and select the name of a test template from the dropdown list. If you are

unable to locate the test you need, use the menu item Test|New and select a default test template.

Connect the electrical stimulator to the unit.

Measure the impedance by selecting the menu command Acquisition|Impedance, pressing [Ctrl+Z] or using the button on the dedicated keyboard. Then place the electrodes on the patient and connect them to the amplifier input. The number of amplifier channels in use and the site names are displayed in the top left corner of the window under the "Sites" heading. When you reach the desired impedance level, close the impedance measurement window by pressing the [Esc] key.

Set the required initial value of the electrical stimulus by selecting the following menu items Acquisition|Stimulus|Increase and Acquisition|Stimulus|Decrease or by using the corresponding buttons on the dedicated keyboard. Place the electrical stimulator over the nerve under examination.

Start the single stimulation by selecting the menu item Acquisition|Acquisition/Stimulus or by using the corresponding button on the dedicated keyboard. If you are unable to get the required M-wave, try changing the stimulus intensity or move the stimulator until you get an acceptable response. A repetitive stimulation can be started by selecting the menu item Acquisition|Repetitive stimulation (or by using the corresponding button on the dedicated keyboard).

When you reach a supramaximal stimulus strength and obtain an acceptable response, save the M-wave for further analysis by selecting the menu item Acquisition|Stop (or by using the corresponding button on the dedicated keyboard). If you do not want to save results, press [Esc] to delete.

If the M-wave is not found on the trace automatically (very low amplitude), you can start a manual search by using the mouse cursor – press [Alt] and while holding it, click the left mouse button on the suspected wave location.

If the markers are placed inaccurately, you can override them with the mouse.

After you save the M-wave, enter the stimulation-site distance from the computer or dedicated keyboard. With the Focus device, change the distance value for 1 mm by turning the Sweep knob and change the distance value for 10 mm by turning the "Sensitivity" knob.

To enter or correct the distances later on, use the menu command Test|Conduction distance input ([F2]).

Move the current electrode to a new stimulation point and repeat the procedure.

After recording all the necessary M-waves, you can study the contralateral muscle Test|Change side, [F4]), some other muscle ([F5]) or you can start another technique using either the Test|Linked tests ([F3]) menu command or Test|New menu command (or the corresponding button on the New test toolbar).

To print the results and exit the program, see the chapter 1.11 "How to Print the Results and Exit the Program".

# 1.4. Sensory Conduction Study

Complete the directions in chapter 1.2 "The Very Beginning: New Exam".

To conduct a sensory conduction study test, press the [≈⌇] button on the New test toolbar and select the name of a test template from the dropdown list. If you are unable to locate the test you need, use the menu item Test|New and select a default test template.

Connect the electrical stimulator to the control unit.

Measure the impedance by selecting the menu command Acquisition|Impedance, pressing [Ctrl+Z] or using the button on the dedicated keyboard. Then place the electrodes on the patient and connect them to the amplifier input. The number of amplifier channels in use and the site names are displayed in the top left corner of the window under the *Sites* heading. When you reach the desired impedance level, close the impedance measuring window by pressing the [Esc] key.

Set the required initial value of electrical stimulus by selecting the menu items Acquisition|Stimulus|Increase and Acquisition|Stimulus|Decrease or by using the corresponding buttons on the dedicated keyboard.

Start the single stimulation by selecting the menu item Acquisition|Acquisition/Stimulus. The signal averaging is switched on/off by the menu command Acquisition|Averaging/continuous. If you are unable to get the required nerve action potential, stop the acquisition by selecting the menu command Acquisition |Cancel ([Esc]) and then restart it.

When you get a qualitative nerve action potential, finish the acquisition and save the results for further analysis by selecting the menu item Acquisition|Stop (or by using the corresponding button on the dedicated keyboard). If you do not want to save results, press [Esc] to delete.

If a nerve action potential is not found on the trace automatically (very low amplitude) you can start a manual search by using the mouse cursor – press [Alt] and while holding it, click the left mouse button on the suspected wave location.

If the markers are placed inaccurately, you can override them with the mouse.

After you save the wave, enter the stimulation-site distance from the computer or dedicated keyboard. With the Focus device, change the distance value for 1 mm by turning the "Sweep" knob and change the distance value for 10 mm by turning the "Sensitivity" knob.

To enter or correct distances later on, use the menu command Test|Conduction distance input ([F2]).

Move the current electrode to a new stimulation point (or the site electrode to a new site point) and repeat the procedure as needed.

After recording all the necessary results, you can study the contralateral nerve (Test|Change side, [F4]), some other nerve ([F5]) or you can start another technique (Test|New or the corresponding button on the New test toolbar).

# 1.5. F-Wave

Complete the directions in chapter 1.2 "The Very Beginning: New Exam".

It is recommended to conduct a motor conduction velocity test before you start an F-wave study.  To start the F-wave study, select the menu item Test|Linked tests|F-wave.

Connect the electrical stimulator to the control unit.

Set the required initial value of electrical stimulus by selecting the menu items Acquisition|Stimulus|Increase and Acquisition|Stimulus|Decrease or by using the corresponding buttons on the dedicated keyboard control. Place the electrical stimulator over the nerve under examination.

If you want to get the required M-wave before proceeding to F-waves accumulation, start the traces accumulation by selecting the menu command Acquisition|Averaging/Continuous (hotkey [Ins] or the corresponding button on the dedicated keyboard).

Start the single stimulation by selecting the menu item Acquisition|Acquisition/Stimulus (or by the corresponding button on the dedicated keyboard). If you do not get the required M-wave or F-wave, try to change the stimulus strength or move the stimulator until you get an acceptable response.

At supramaximal stimulus strength and qualitative M-wave, switch the accumulation of traces by pressing the menu command Acquisition|Averaging/Continuous (hotkey [Ins] or the corresponding button on the dedicated keyboard). You can use either manual (Acquisition|Acquisition/Stimulus or the corresponding button on the keyboard) or repeated (Acquisition|Repetitive stimulation or the corresponding button on the keyboard) stimulation. When the required number of traces is reached, the acquisition finishes automatically.  However, it is possible to finish the stimulation earlier by using the menu item Acquisition|Exit (or the corresponding button on the keyboard). If you don't want to save results, press [Esc] to delete.

To start the F-waves accumulation procedure from the first stimulus, switch to the accumulation mode by selecting the menu command Acquisition|Averaging/Continuous, by pressing the hotkey [Ins] or by using the corresponding button on the dedicated keyboard, and start stimulation.

If you do not agree with the automatic F-wave marking, you can perform a manual search. First, select the desired area with the mouse: place the cursor at the

beginning of the search area, click left mouse button, move it until the end and release the left mouse button. Then use the menu command Test|F-wave search by selection.

If the markers are placed inaccurately, you can override them with the mouse. F-wave state block (skip) on each trace is changed by the menu command Test|F-wave skip/realization ([F4]).

After recording all the necessary responses, you can study the contralateral muscle Test|Change side), some other nerve ([F5]) or you can start another technique (Test|New or the corresponding button on the New test toolbar).

# 1.6. H-Reflex

Complete the directions in chapter "The Very Beginning: New Exam".

Connect the electrical stimulator to the control unit.

To conduct a **H-reflex** test, press the button on the **New test** toolbar and select the name of a test template from the dropdown list. If you are unable to locate the test you need, use the menu item **Test|New** and select a default test template.

Measure the impedance by selecting the menu command **Acquisition|Impedance**, pressing **[Ctrl+Z]** or using the button on the dedicated keyboard. Then place electrodes on the patient and connect them to the amplifier input. The number of amplifier channels in use and the site names are displayed in the top left corner of the window under the "Sites" heading. When you reach the desired impedance level, close the impedance measurement window by pressing the **[Esc]** key..

Set the electrical stimulus at the value required by the M-wave and H-reflex by using the menu items **Acquisition|Stimulus|Increase** and **Acquisition|Stimulus|Decrease** or by using the dedicated keyboard control. Place the electrical stimulator over the nerve under examination.

Start the single stimulation by selecting the menu item **Acquisition|Acquisition/Stimulus** or by using the corresponding button on the dedicated keyboard. If you do not get the required M-wave and H-reflex, repeat the stimulation start-up and move the stimulating electrode until you get an acceptable result. Please note that after each stimulation, there is an automatic increase of the stimulus set by default for the **H-reflex** test. If you get qualitative responses, close the acquisition window by selecting the menu command **Acquisition|Cancel**, key **[Esc]** or using the corresponding button on the dedicated keyboard.

Set the minimum initial value of the stimulus and select the menu command **Acquisition|Repetitive stimulation** (or press the corresponding button on the keyboard). Please be aware that the stimulation frequency is set rather low by default (one stimulus for 10-20 sec.) to restore the H-reflex completely. If it is necessary, use the manual start-up of the stimulus by selecting the menu command **Acquisition|Acquisition/Stimulus** (or by using the corresponding button on the keyboard).

When a supramaximal stimulus strength is reached, finish the acquisition by selecting the menu item **Acquisition|Stop** (or by using the corresponding button on the keyboard). If you do not want to save results, press **[Esc]** to delete.

If you don't like the automatic H-reflex or M-wave marking, you can perform a manual search. First, select the desired area with the mouse: place the cursor at the beginning of the search area, press the left button and drag the cursor to the end of the search area, and then release the left mouse button. After that, use the menu command **Test|M-wave search by selection** or **Test|H-reflex search by selection**.

If the markers are placed inaccurately, you can override them with the mouse.

To switch the M-wave and H-reflex state block (skip), use the menu commands **Test|M-wave skip/realization** and **Test|H-reflex skip/realization**.

After recording all the necessary responses, you can study the contralateral muscle **Test|Change side**) or you can start another technique (**Test|New** or the corresponding button on the **New test** toolbar).

# 1.7. Spontaneous Activity

Complete the directions in chapter 1.2 "The Very Beginning: New Exam".

To conduct a spontaneous activity test, press the [button image] button on the "New test" toolbar and select the name of a test template from the dropdown list. If you are unable to locate the test you need, use the menu item Test|New and select a default test template.

Prepare the needle electrode for insertion, place the ground electrode on the patient and connect the electrodes to the amplifier input.

Start signal monitoring by selecting the menu command Acquisition|Monitoring (or by the corresponding button on the dedicated keyboard), insert the needle into a muscle and start signal acquisition by the menu command Acquisition|Acquisition/Stimulus.

To pause during the trace acquisition, use the menu command Acquisition|Pause (space key or the corresponding button on the keyboard). To record each new segment as a new trace, use the menu command Acquisition|Averaging/Continuous ([Ins] key or the corresponding button on the keyboard) to stop and then restart the acquisition process.

To analyze the recorded traces, use the menu command Acquisition|Stop (or the corresponding button on the keyboard) or to quit, select the menu command Acquisition|Cancel ([Esc] key or the corresponding button on the keyboard).

If it is necessary, repeat the procedure for the other puncture.

After recording all the necessary traces, you can study the contralateral muscle Test|Change side, [F4]), some other muscle ([F5]) or you can start another technique (Test|New or the corresponding button on the "New test" toolbar).

# 1.8. Interference EMG

Complete the directions in chapter 1.2 "The Very Beginning: New Exam".

It is recommended to conduct a spontaneous activity test, before you start an interference curve study. To start the interference pattern study, select the menu item Test|Linked tests|Interference curve.

Prepare the electrode needle for insertion, place the ground electrode on a patient and connect the electrodes to the amplifier input.

Start signal monitoring by selecting the menu command Acquisition|Monitoring (or by using the corresponding button on the dedicated keyboard). Next, insert the needle into a muscle and select the menu command Acquisition|Acquisition/Stimulus to start signal acquisition.

To pause during trace acquisition, use the menu command Acquisition|Pause (space key or the corresponding button on the keyboard). To register each new fragment as a new trace, use the menu command Acquisition|Averaging/Continuous ([Ins] key or the corresponding button on the keyboard) to stop and then restart the acquisition process.

To analyze the registered traces, use the menu command Acquisition|Stop (or the corresponding button on the keyboard) or to quit, use the menu command Acquisition|Cancel ([Esc] key or the corresponding button on the keyboard).

If necessary, repeat the procedure for another needle insertion.

After acquisition, you can record notes near the detected phenomena in the "Interpretation" table.

After recording all the necessary traces, you can study the contralateral muscle Test|New/Other side, [F4]), some other muscle ([F5]) or you can start another technique (Test|New or the corresponding button on the "New test" toolbar).

# 1.9. Motor Unit Potentials (MUP)

Complete the directions in chapter 1.2 "The Very Beginning: New Exam".

It is recommended to conduct a spontaneous activity test before you start the motor unit potentials (MUP) study. To start the motor unit potentials (MUP) study, select the menu item Test|Linked tests|MUP.

Prepare the needle electrode for insertion, place the ground electrode on a patient and connect the electrodes to the amplifier input.

To start signal monitoring, select the menu command Acquisition|Monitoring (or use the corresponding button on the dedicated keyboard) and insert the needle into a muscle. Adjust the strength of muscle activity so that the motor unit potentials do not superimpose on each other. Start signal acquisition by selecting the menu command Acquisition|Acquisition/Stimulus.

To pause during trace acquisition, use the menu command Acquisition|Pause (space key or the corresponding button on the keyboard). To record each new segment as a new trace, use the menu command Acquisition|Averaging/Continuous ([Ins] key or the corresponding button on the keyboard) to stop and then restart the acquisition process.

To analyze the recorded traces, use the menu command Acquisition|Stop (or the corresponding button on the keyboard) or to quit, use the menu command Acquisition|Cancel ([Esc] key or the corresponding button on the keyboard).

Repeat the procedure for the other insertion.

From each insertion, you can record a trace long enough so that each motor unit potential (MUP) can be repeated several times (as a rule, it takes 10-30 seconds). If the acquisition quality is not satisfactory, it is recommended to increase the length of the traces.

In the New MUP window that appears, the potentials will be sorted by the number of repeats (the number under the button near each MUP). Remove marks against erroneous or doubtful potentials and press "OK".

If the number of detected motor unit potentials (MUP) is not enough, you can record additional traces and repeat the classification or use a manual MUP search. To do this, place the mouse cursor on the potential of the initial trace, press [Alt] and while holding it, press the left mouse button. If it is necessary, correct the positions of the markers and select Copy MUP as new or Copy into cell No… from the dropdown list.

To delete an unsatisfactory motor unit potential, select it with a mouse click and then use the menu command Trace|Delete ([Ctrl+Del] or the corresponding button on the keyboard).

After recording all the necessary responses, you can study the contralateral muscle Test|New/Other side), some other muscle ([F5]) or you can start another technique (Test|New or the corresponding button on the New test toolbar).

# 1.10. Evoked Potentials (EP)

Complete the directions in chapter 1.2 "The Very Beginning: New Exam".

To study evoked potentials, click on the necessary button on the "New test" toolbar and select the name of a test template from the dropdown list. For example, for  a short-latency auditory EP acquisition, use the [button icon] button. If you are unable to locate the test you need, use the menu item Test|New and select a default test template.

Measure the impedance by selecting the menu command Acquisition|Impedance, pressing [Ctrl+Z] or using the button on the dedicated keyboard. Then place the electrodes on the patient and connect them to the amplifier input. The number of amplifier channels in use and the site names are displayed in the top left corner of the window under the "Sites" heading. When you reach the desired impedance level, close the impedance measurement window by pressing the [Esc] key.,

Connect the stimulator to the control unit.

Set the required initial value of stimulus by selecting the menu items Acquisition|Stimulus|Increase and Acquisition |Stimulus|Decrease or use the dedicated keyboard.

Start the repetitive stimulation by selecting the menu item Acquisition|Repetitive stimulation (or by using the corresponding button on the dedicated keyboard) and follow the process of signal averaging. If you do not get the required evoked potentials, you can stop the averaging by the menu command Acquisition|Cancel ([Esc]) and then restart it.

When you get satisfactory evoked potentials, finish the acquisition and save the results for further analysis by means of the menu item Acquisition|Stop or to delete, press [Esc].

To mark the EP components manually, click the left mouse button on the corresponding component name on the toolbar and shift the appeared crosshair cursor to the point of the assumed component and press the left mouse button once more.

If the markers are placed inaccurately, you can override them with the mouse.

To start a new technique, press Test|New or use the corresponding button on the "New test" toolbar.

## 1.11. How to Print the Results and Exit the Program

To create a new exam report use the menu command Report|New report 1 ([Ctrl+R]), To print an exam report, use the menu command Report|Print ([Ctrl+P]). Before printing you can preview your exam report and make any corrections.

To create reports of various types, use the menu commands Report|Templates.

To finish your exam, use the menu command Exam|Close, to exit the program use the menu command Exam|Exit ([Alt+X]).

## 1.12. How to Review Previous Exams

To review previous exams, start the program and select the menu command Exam|Open ([Ctrl+O]). Select the exam you need in the appeared dialog box and press the Open button.

To finish your exam review, select the menu command Exam|Close.

# 2. General Principles and Working with the Program

## 2.1. Focus Specifications

Main Specifications of Focus.

| Parameters | Values |
|---|---|
| **Amplifier** | |
| Number of channels | 2 |
| Sampling rate | 200 Hz – 80 kHz |
| A/D converter | 16 bit |
| Input impedance | not less than 200 MΩ |
| Noise level | not more than 5 µV |
| High pass filter | 0.1–3000 Hz (0.05–3000 Hz) |
| Low pass filter | 10–10000 Hz |
| On/off notch filter 50/60 Hz (switchable) | not less than 40 dB |
| Common mode rejection | not less than 100 dB |
| **Electrical Stimulator** | |
| Stimulus amplitude | 0.1–100 mA |
| Stimulus duration | 0.1–5 ms |
| Stimulation frequency | 0.05–50 Hz |
| **Auditory Stimulator** | |
| Stimulation level | 0–118 dB (TA-01) 0–126 dB (TDH-39) |
| Stimulation frequency | 0.05–30 Hz |
| *Tone stimulation:* | |
| • tone | 100–8000 Hz |
| • stimulus duration | 0.1–90 ms |
| *Click stimulation:* | |
| • stimulus duration | 100–50000 µs (100–90000 µs) |
| Left / right / double-sided stimulation | yes |
| **Photic Stimulator** | |
| Maximal brightness of LED goggles | $(1100\pm110)$ cd/m$^2$ |
| Stimulus duration | 0.1–50 ms (2–1500 ms) |
| Stimulation frequency | 0.05–100 Hz (0.1–100 Hz) |
| Left / right / double-sided stimulation when using LED goggles | yes |

| Pattern Stimulator | |
|---|---|
| Stimulation frequency | 0.1–5 Hz |
| Distance to the stimulator | 10–1000 cm |
| Pattern size | 4×3, 8×6, 16×12, 32×24, 64×48 sqr. |

*\* parameter values when using **Neuro-MEP.NET** software.*

Output of the electrical stimulators warning:

To eliminate the possibility of a patient's flash burn at the stimulating electrode placement, it is necessary to control the maximal pulse current. The maximal pulse current will depend on the stimulation frequency, pulse width and electrode area. Burns could result with prolonged stimulation and with stimulation output parameters outside the range of those recommended in this user manual.

### *Safety and Electromagnetic Compatibility*

Electromagnetic compatibility (EMC) is provided by IEC 60601-1-2:2007 requirements fulfillment and IEC 62471:2006 for Photobiological safety of lamps and lamp systems.

As for safety, the Focus complies with IEC 60601-1:1988 + A1:1991 + A2:1995, IEC 60601-1-1:2000 and IEC 60601-2-40:1998 requirements. The electronic unit is supplied by a regulated power supply through a USB interface, It has a double isolation and BF type parts in compliance with IEC 60601-1 standards.

**Symbols legend on Electronic Unit:**

⚠ – Attention: consult user and technical manuals.

🧍 –  BF type parts according to IEC 60601-1 standards.

Ⓡ ИМ18 – Mark of conformance with Russian standards requirements GOST R.

Ⓖ – Mark of device measurement conformance with Russian standards requirements.

CE 0535 – Mark of conformance with 93/42/EEC "Concerning Medical Devices" directive.

🗑 – Mark of conformance with 2002/96/EC "On waste electrical and electronic equipment (WEEE)" directive.
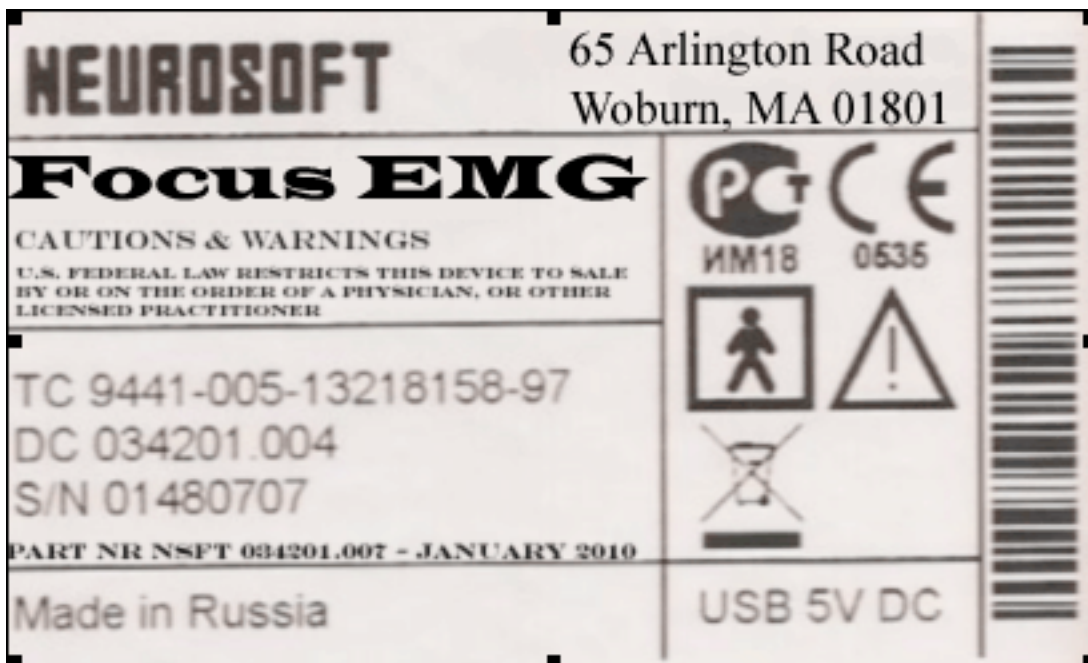


Focus Product Label

# 2.2. Neuro-MEP.NET Start and Closing

To start the Focus's **Neuro-MEP.NET** software program, go to the taskbar and click on the "Start" button.  Next, select the menu item **Programs|Neurosoft|Neuro-MEP.NET** or double-click the **Neuro-MEP.NET** icon, which is located on the desktop.

To exit the program, choose one of the following ways:

• Select the menu item **Exam|Exit**;

• Press the key combination **[Alt+X]** (first press **[Alt]**, and then, holding it, press **[X]**);

• Click on the ❌ closing button in the top right corner of the program window.

It is strongly recommended not to start other programs (applications) while recording signals from a patient because the central processor and other system resources are actively being used.

# 2.3. General Principles of Program Function

The **Neuro-MEP.NET** program functions using the Windows XP (Windows Vista) operating system. After **Neuro-MEP.NET,** loads,  its main window will appear (Fig. 2.1). There is a menu with items such as **Exam**, **Report** etc. in the action bar. Below the action bar, there are panels with speed buttons (icons). Point and click on the icons with the mouse to activate..
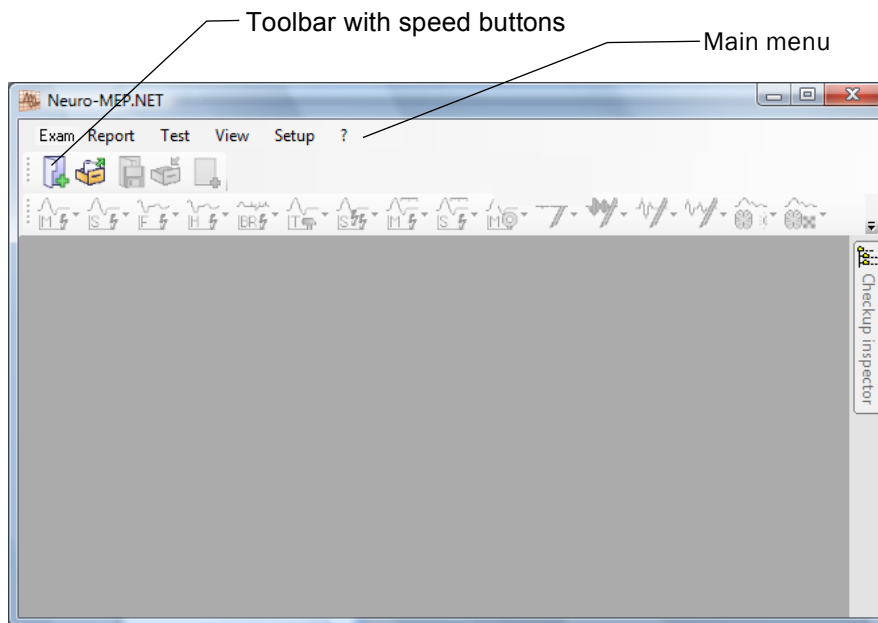


Fig. 2.1

The program control is operated with the help of a menu.. Most frequently used menu items are also represented by buttons on the toolbar.

Toolbars can be placed in the top, bottom or on the side of the window (Fig. 2.2). To place a toolbar, move the panel with the mouse cursor by the drag marker ┊ and drag it to a new place. To show or hide the panels or set their view (button size, signature, visibility and sequence) (Fig. 2.3), click the right mouse button on the panels and select the menu item **Customize…** from the context menu.
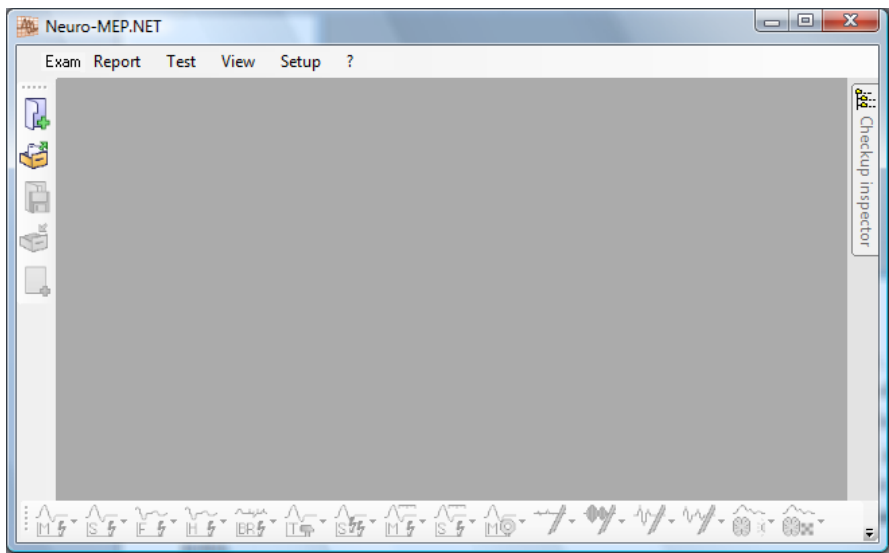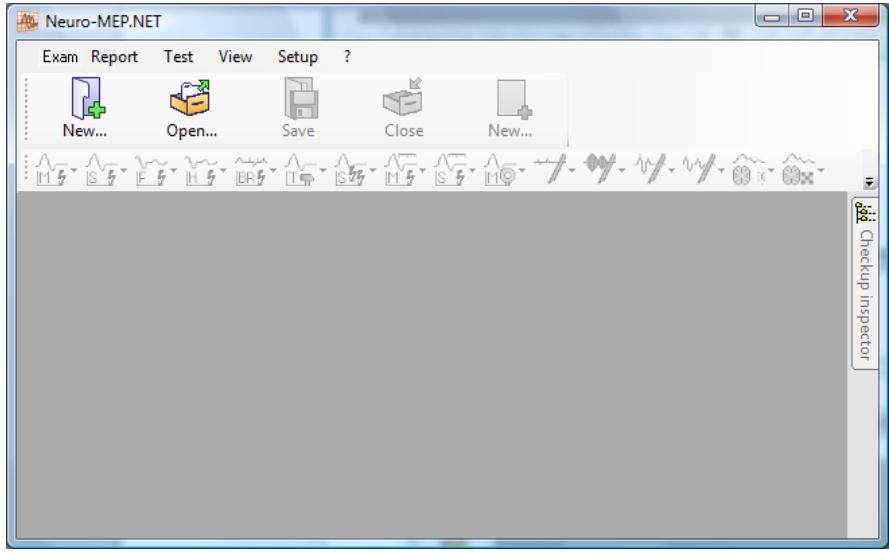
Fig. 2.2



Fig. 2.3

The **Neuro-MEP.NET** program is developed in such a way that the recording of bioelectric signals is made more efficient with the help of the dedicated keyboard. The **Focus** has a built-in keyboard. The buttons on the dedicated keyboard that perform the same function as the menu commands can be found in the keyboards' descriptions.

The exam results are saved in the database (card-file system). The first time an exam is started, a database is created automatically in the *C:\cardbaseMdb* directory on the computer hard drive. In the future, you will be able to create new databases and connect any that already exist. For a database description, terms such as *card-file*, *patient card*, *exam* and *exam test* are used.

An *"exam"* in the **Neuro-MEP.NET** program refers to a collection of data, obtained during a medical exam using a Neuro-MEP device. An exam includes data from one or more tests (traces and results of their processing) and exam reports.

An *"exam test"* is a collection of data analyzed as a single set. The data refers to the results of performing specific medical techniques (e.g., analysis of M-wave and motor conduction velocity). It contains a patient's recorded traces and the results of their processing.

Exam data is saved on a patient card.

A *"Patient card"* contains basic patient data (first and last name, year of birth etc.) and may include any exams, carried out at different times by any Neurosoft devices.

Patient cards are saved in card-files.

Each card-file has a unique name and may contain, besides patient cards, nested card-files. Cards can be combined into a card-file by any feature. A well organized card-file system will help put into order all stored information and speed up access to it.

A card-file system (database) represents several files saved in a directory (folder) on a computer hard drive. If it is necessary, you can create several data-bases on a computer hard drive (see more details below).

# 2.4. New Exam Execution

To start a *new* patient exam, select the menu item **Exam|New** (or press the button on the toolbar). The "New exam" dialog box will appear (Fig. 2.4).
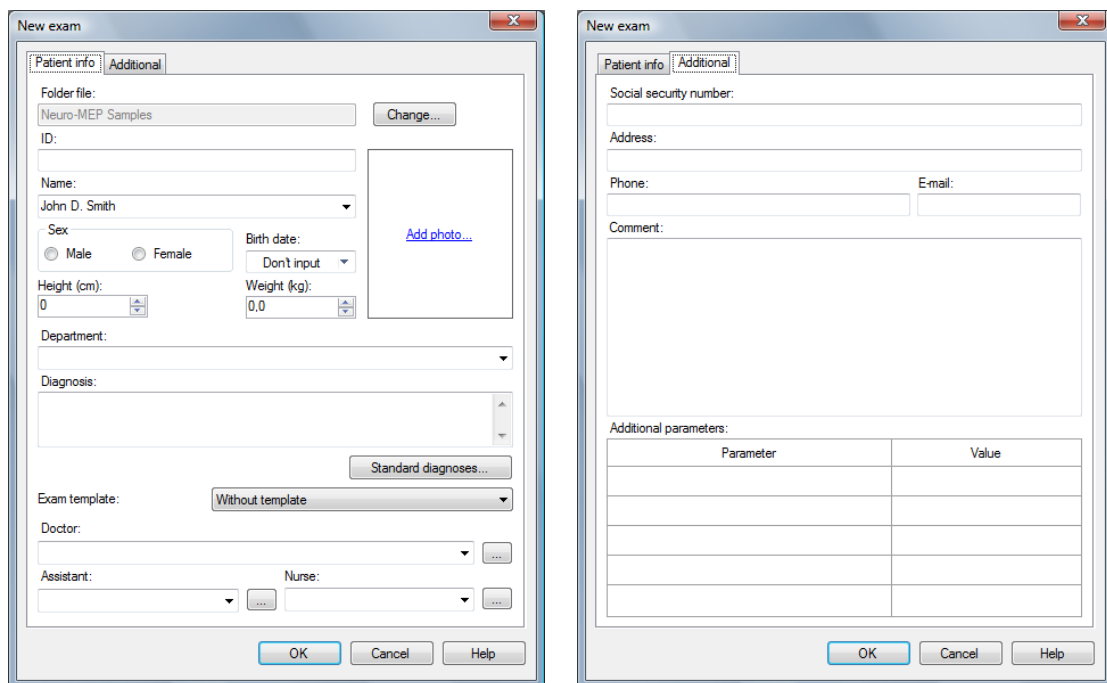


Fig. 2.4

In the "New exam" dialog box, enter the patient's basic data (optional). If you are short of time, press "OK" (**[Enter]**) without entering any information.
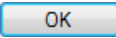
It is recommended to enter information in the "New exam" dialog box in the following order:

- Enter the patient's name;

- Press the **[Tab]** key;

- Enter the patient's date of birth by pressing numeric keys separated by a delimiter character. Most computers follow a four digit format mm/dd/yyyy. For example if your patient was born on the 21$^{st}$ of May, 1947, you would enter 05/21/1947.

- To enter the patient's height press the **[Tab]** key and enter the height in centimeters;

- To enter the patient's weight, press the **[Tab]** key and type in the height in kilograms;

- To enter the department, press the **[Tab]** key and type in a name;

- To enter a provisional diagnosis, press the **[Tab]** key and enter the diagnosis;

- If you need to enter more data, you can use the "Additional" page. Press the **[Ctrl+Tab]** key combination and continue entering;

- Press **[Enter]** to close the **New exam** window.

To add a patient's photo, click on the square located on the right side of the dialog box and indicate the image (graphic) file.

You can type your name in "Doctor:" input box, assistant's name and technician's name in the "Assistant:" and "Nurse:" input boxes correspondingly.

If an exam is performed using a planned exam template, select this template from the "Exam template" combo-box. For more details concerning the exam templates, refer to chapter 2.7.2 "Exam Templates".

After you fill in the fields, press [ OK ] or **[Enter]**..If a patient has been previously examined and has a card in the database already, a dropdown list with similar names will appear (Fig. 2.5) when entering the name. Use either arrow keys and the **[Enter]** button or the mouse cursor to select the name you need from the dropdown list. In this case, a new exam will be saved on the existing patient card.
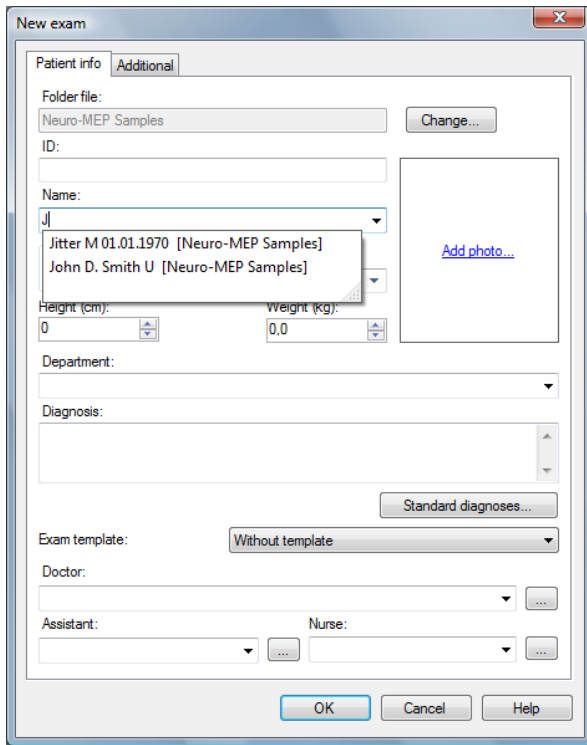
Fig. 2.5

If a mistake was made while entering patient information, you can correct it by using the menu item **Exam|Information**.

Before the exam, a window will appear with the heading "Clinical state" (Fig. 2.6). Here you can enter the clinical condition of a patient, his/her complaints or any other information you consider to be important.
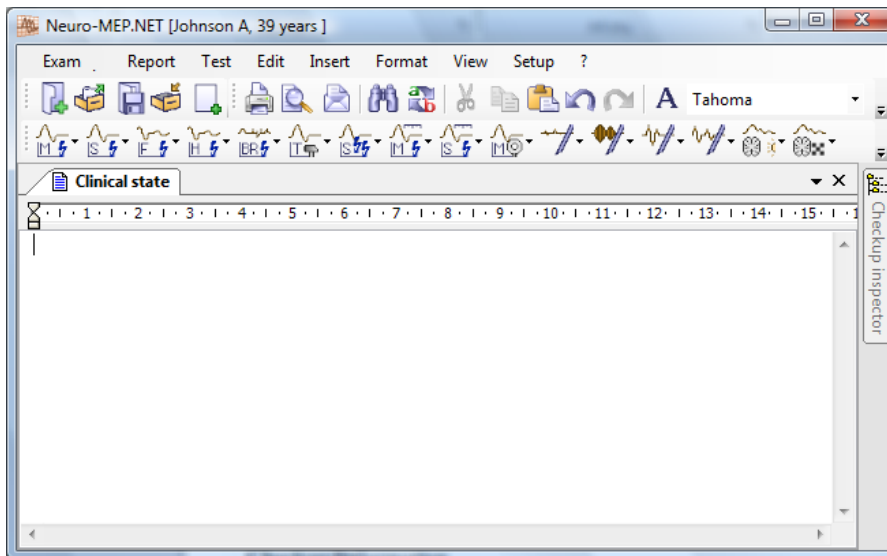


Fig. 2.6

To select a test type, click on one of the **New test** toolbar buttons and select the test template you need (Fig. 2.7) or by using **[F12]** key, arrow keys and the **[Enter]** button.
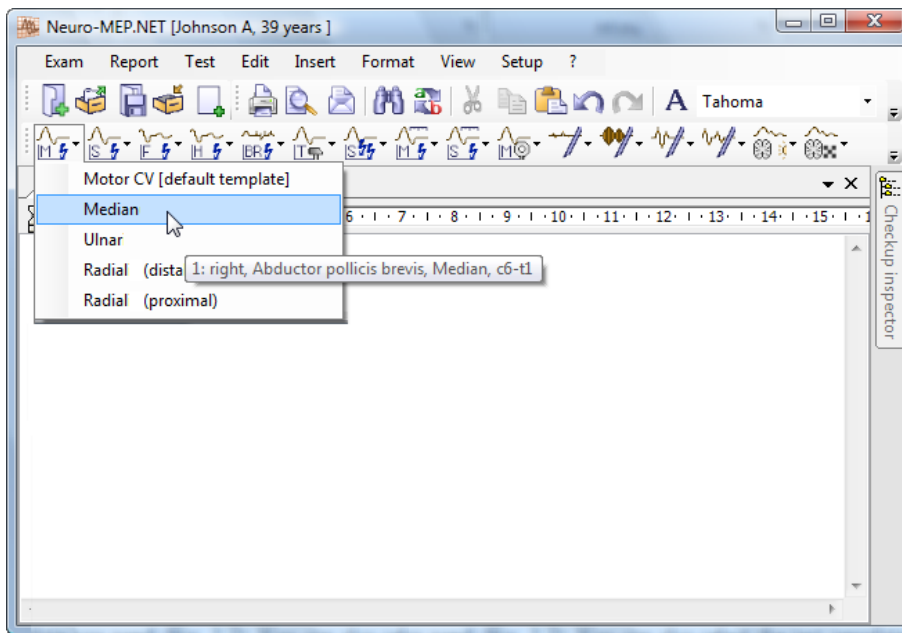
Fig. 2.7 Test template selection

Instead of using the toolbar, you can use the **Test|New** menu item to select a test type. When the "New test" dialog box appears, select a test type or a test template.

Any type of test can be included in the exam.

An exam template is a list of test (technique) templates. To use an exam template, select the menu command **Exam|Exam templates** when the "Clinical state" window (Fig. 2.6) appears. Select the template you need.

After following the directions above, a test work window will appear, for example (Fig. 2.8).
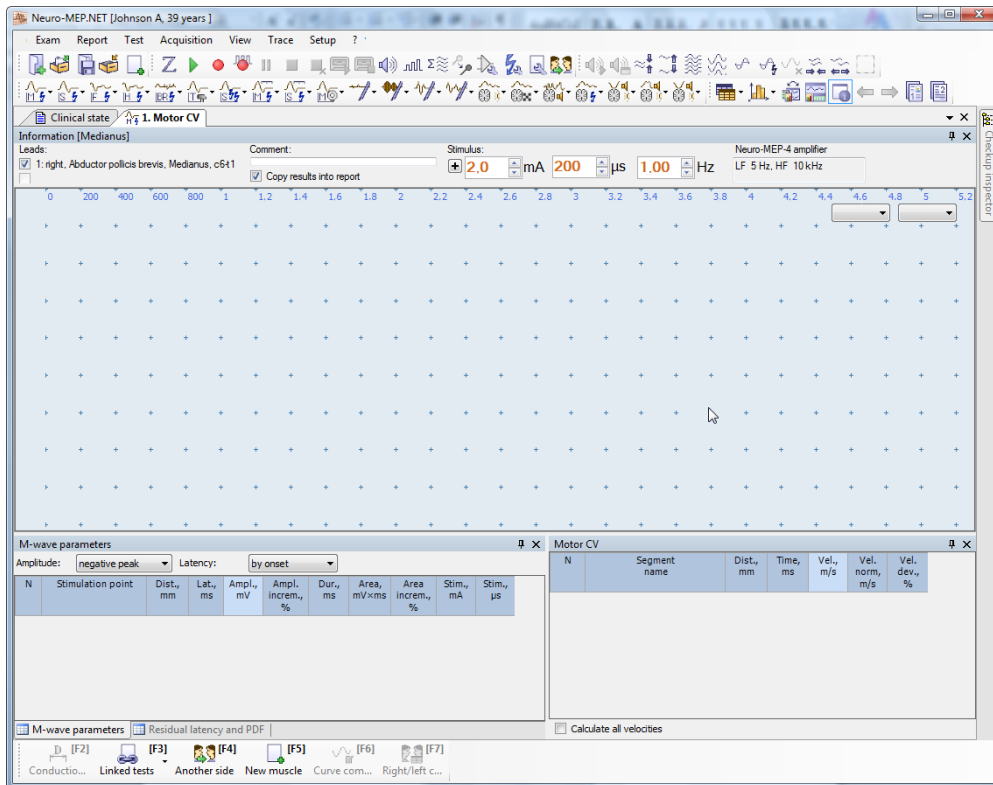
Fig. 2.8

Start the signal recording (after placing the electrodes on a patient) using the menu item **Acquisition|Acquisition/Stimulus**. The following sequence of actions is recommended:

Measure the impedance by selecting the menu command **Acquisition|Impedance** (**[Ctrl+Z]**). Place the electrodes (you should start with the ground electrode) while also viewing the received impedances on the screen (Fig. 2.9).
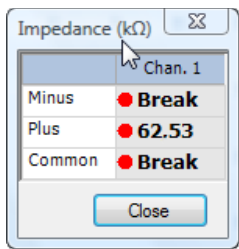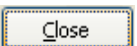


Fig. 2.9 Impedence check

If the impedance level is too high in an area, try placing the electrodes more carefully.

To complete the impedance measuring, press the `Close` button or **[Esc]**.

Start signal recording by selecting the menu command **Test| Acquisition/Stimulus**.

Depending on the test type, finish recording and/or save results by using the menu command **Acquisition|Stop**. To switch focus between monitoring, acquisition and main windows, use the corresponding key on the dedicated keyboard. To change sweep and sensitivity (vertical and horizontal scale) levels by a step, use the keys located in the right part of the keyboard: grey **[/]**, grey **[*]**, grey **[+]**, grey **[-]**.

To change the epoch of analysis, use the menu commands **Acquisition|Increase epoch of analysis** and **Acquisition|Decrease epoch of analysis**. These menu commands can be used directly at signal recording (except the averaging mode).

To change stimulus amplitude and duration as well as stimulation frequency you can use the information panel (Fig. 2.10). Either type in the information or use the ⏶⏷ keys. To change the stimulus amplitude you can also use a slider box which appears while clicking on the stimulus amplitude input line (Fig. 2.10).
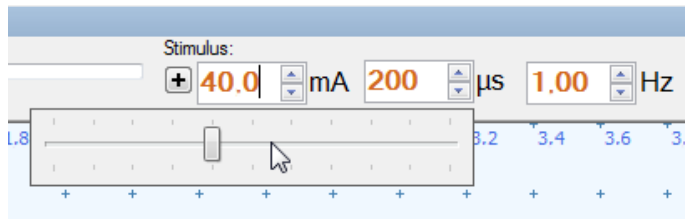


Fig. 2.10

If an error message appears during the recording, check to see if the the device is connected to the computer and then press the menu command **Setup|Device reset**.

To finish the new exam, select the menu command **Exam|Close**.

For further information about working in the acquisition window, refer to chapter 2.6 "Working in the Main Test Window." Signal recording for each test type is also described in more detail in the sections corresponding to the separate tests.

# 2.5. Review and Analysis or Resumption of Previous Exams

To review (analyze) an exam, select the menu item **Exam|Open** (press **[Ctrl+O]** or the button on the toolbar). The "Exams manager" dialog box will appear (Fig. 2.11).
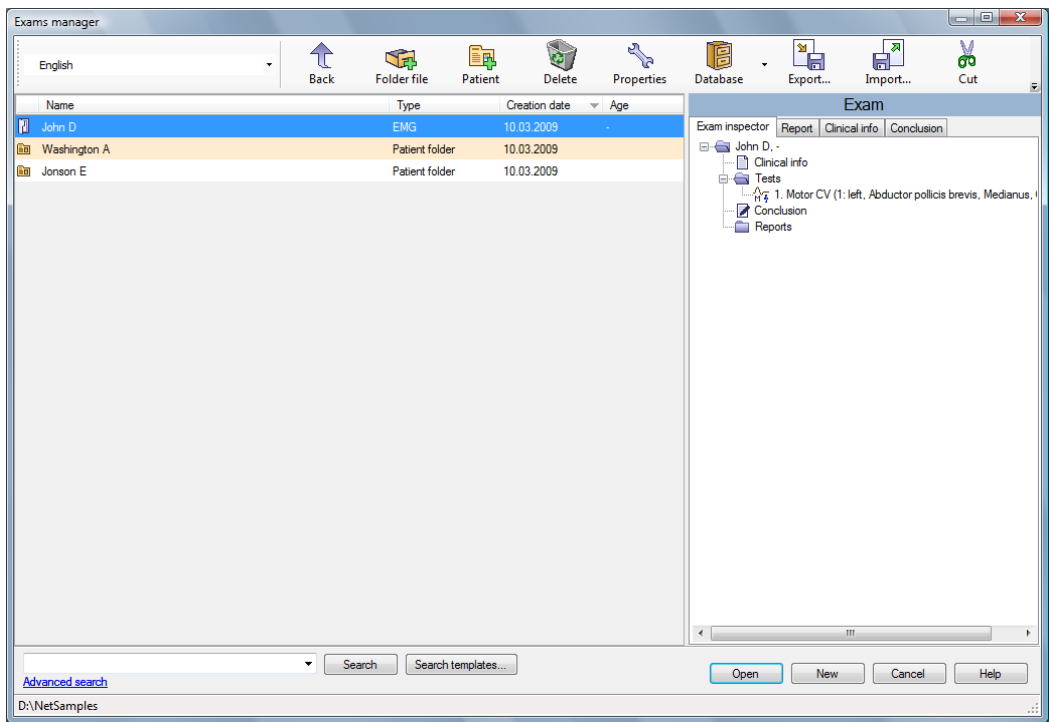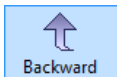
Fig. 2.11 Exam manager

To open the exam, select it from the list and press **Open** or double-click on the patient's last name. In the right window panel, all the tests (techniques) conducted for the patient are displayed.. Double-click on the test to open it,. From here you can analyze tests or create new ones.

To create a new exam for a patient, press the **New...** button. This option can be used instead of the **Exam|New** menu command.   The only difference is that the patient is selected from the list in advance.

You can switch the view mode of the "Exams manager" dialog box between "Patients" and "Exams*"* by clicking the right mouse button to activate a menu (Fig. 2.12). In the "Patients" mode, a patient's information details and all of his/her exams are displayed in the right panel. To open the exam, go to the "Exam" list and double-click on the exam you need. Next double-click on the patient's last name to open his/her card

(Fig. 2.13). To return to the list of patients press the **Backward** button.
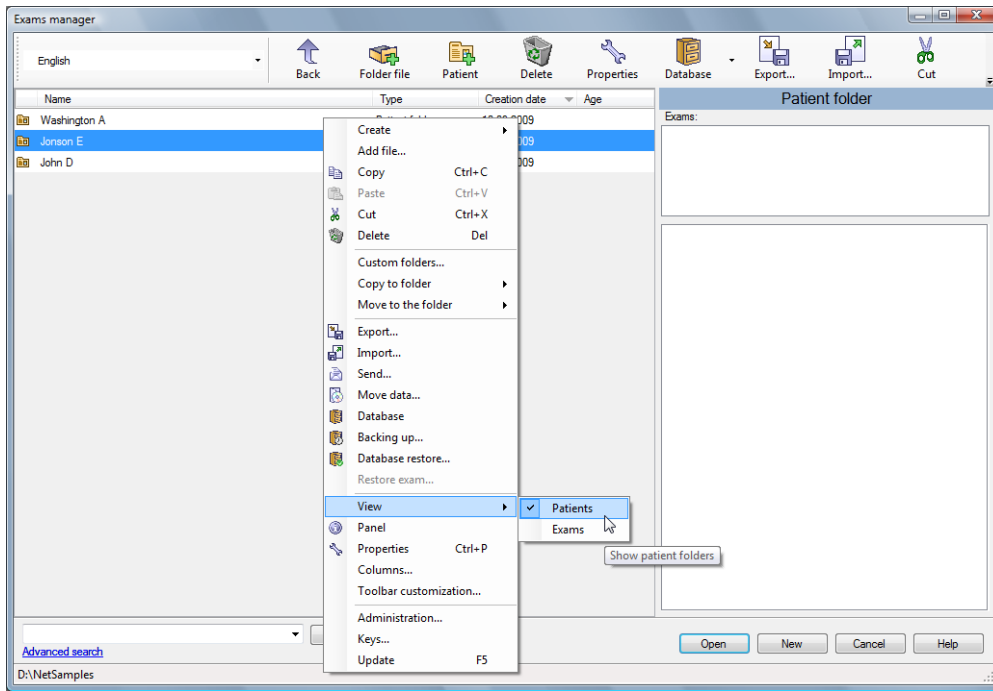
Fig. 2.12 Dialog box
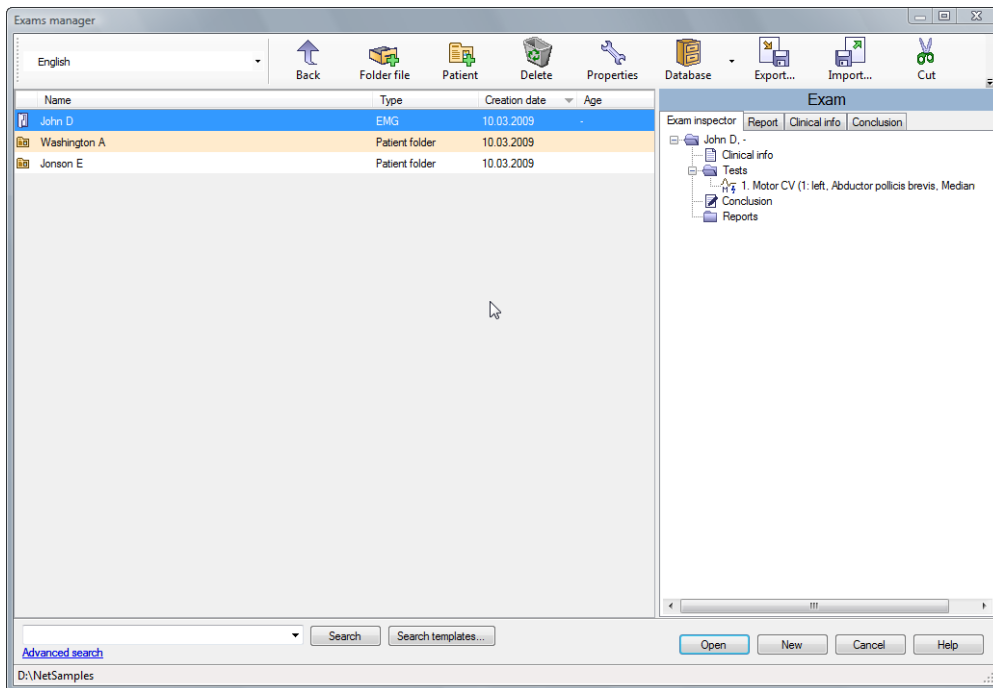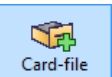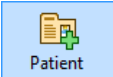


Fig. 2.13 Dialog box – patien last name

With the help of "Exams manager" you can create new card-files of any nesting level (the **Card-file** button) or new patient cards (the **Patient** button). You can also export exams to the external archive file (e.g., for moving to another computer) by pressing the **Export...** button and then import them from the archive by pressing the **Import...** button. To connect existing and create new databases, use the **Database**

button. The database is created by default in the *C:\cardbaseMdb* directory. The database is in *MDB (Microsoft Access)* format. You can create new databases either in MDB or in file format (in which the exams are not saved in a database but in files). When creating databases of any format, make sure there is a empty directory on the computer hard drive.

To find a patient or a exam, use the search window in the bottom left corner of the "Exams manager" dialog box (Fig. 2.14). Enter a part of patient's last name, diagnosis or some other information and press the [ Find ] button. All the exams containing this information will be displayed (Fig. 2.15).
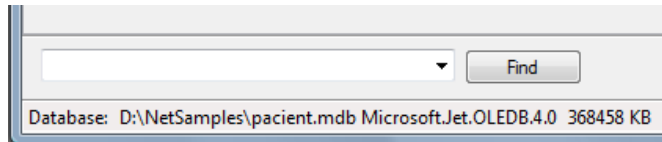


Fig. 2.14
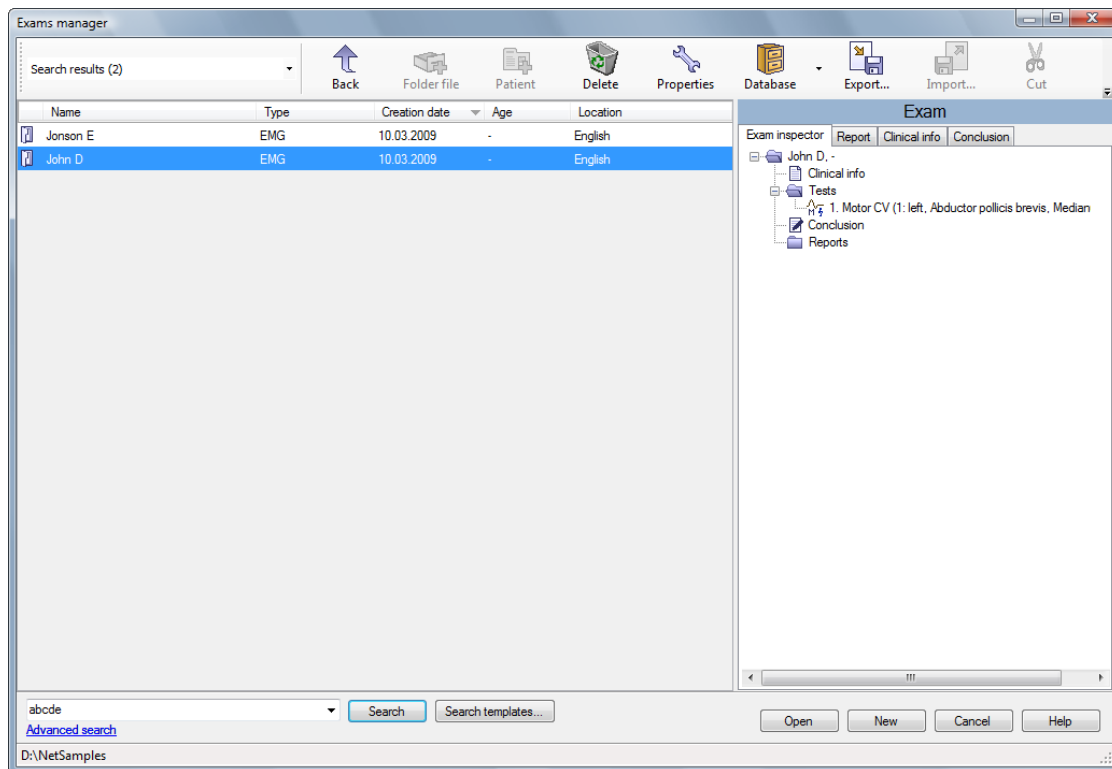


Fig. 2.15

Use the menu command **Exam|Close** to finish an exam..

# 2.6. Working in the Main Test Window

A sample view of the main test window is shown below (Fig. 2.16). The current test type is displayed (in this case – **motor conduction velocity test**) in the test window heading.

Current amplifier settings

Sensitivity and sweep current

Stimulator current settings

Sites



Movable buttons with traces names

Quick analysis window

Character points markers

Fig. 2.16

32
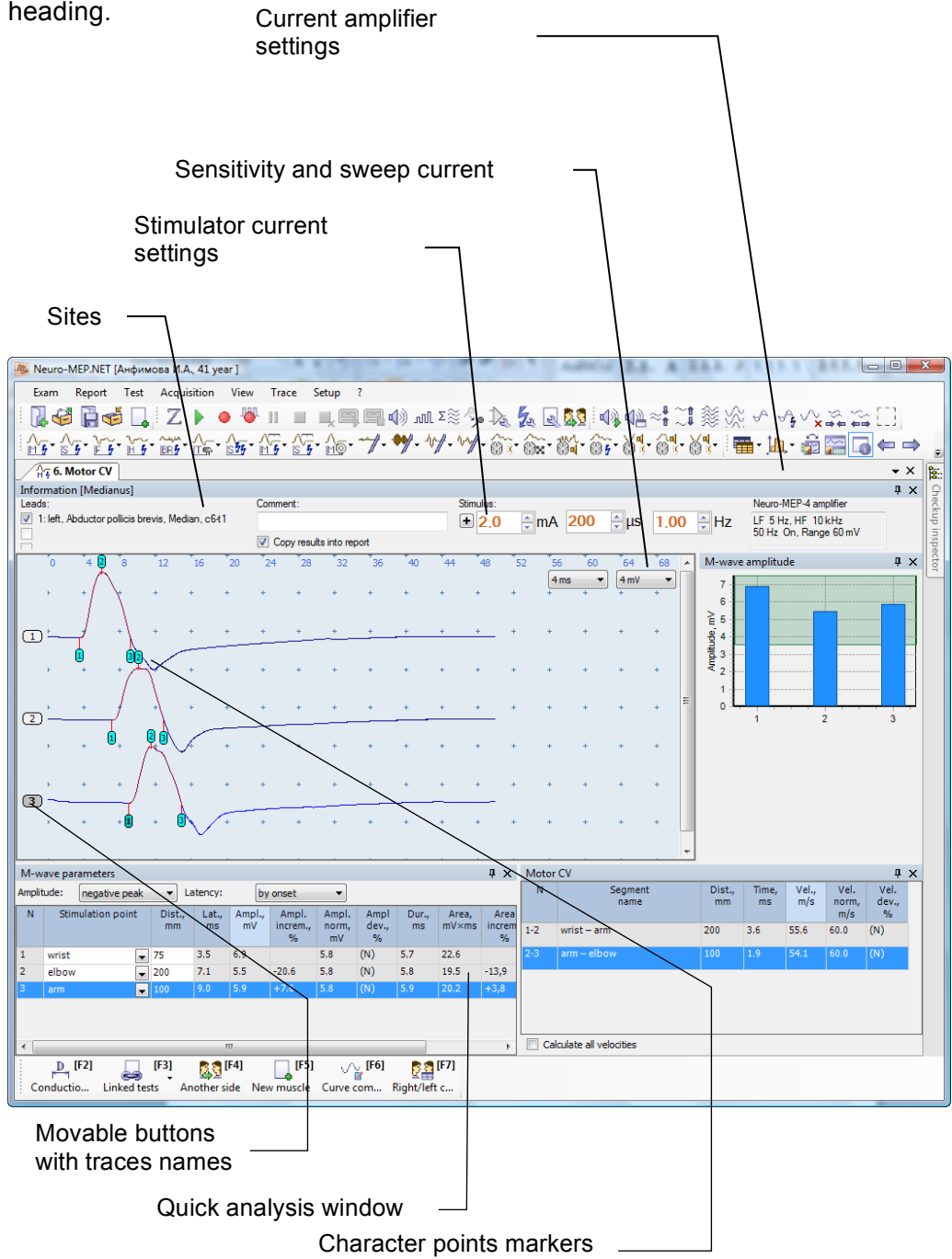
Current test data is always shown in the test window. To view data of another test, use the menu commands **Test|List**, **Test|Next**, **Test|Previous**. You can also use the exam inspector, located in the right side of the pop-up window (Fig. 2.17). Double-click on the test name and a pop-up window will appear.
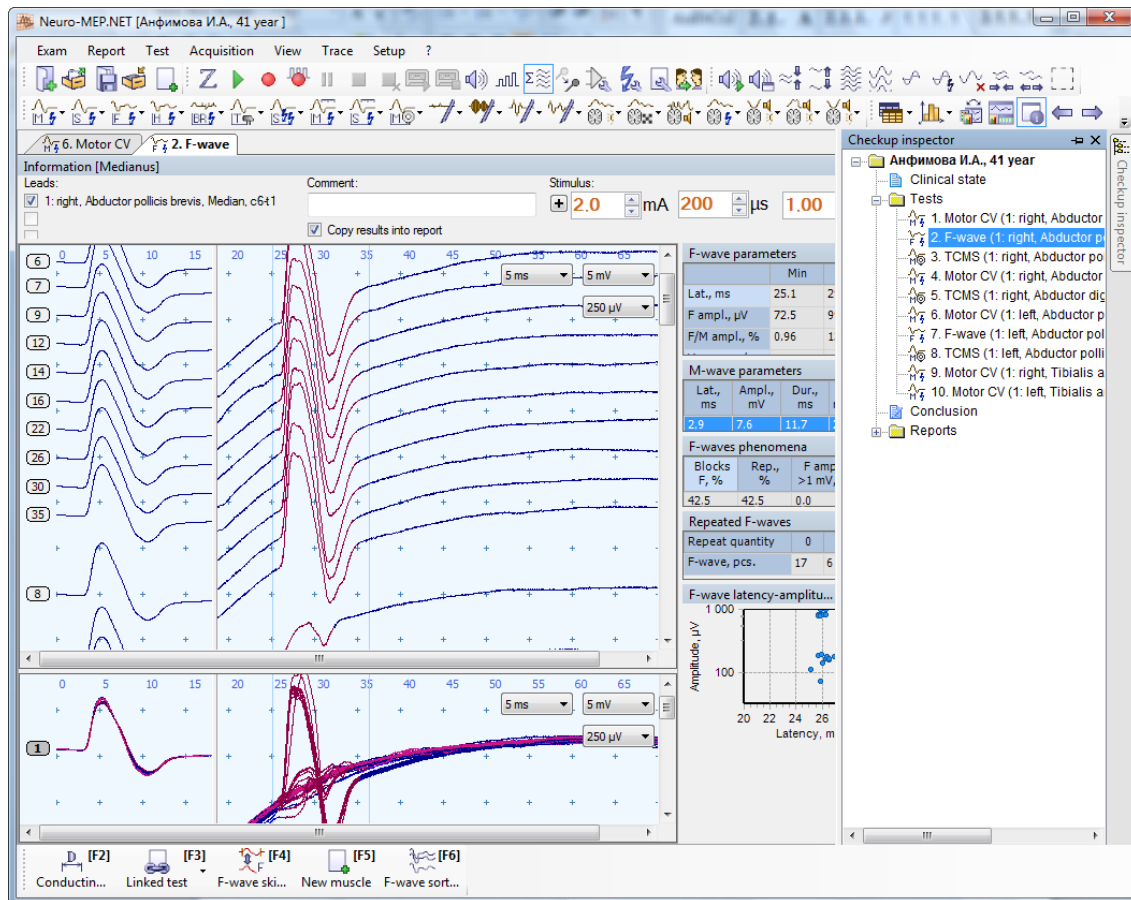


Fig. 2.17

To quickly change the amplifier channel during a bioelectric signals recording, click the right mouse button on the sites and select the corresponding option from the local menu (Fig. 2.18).
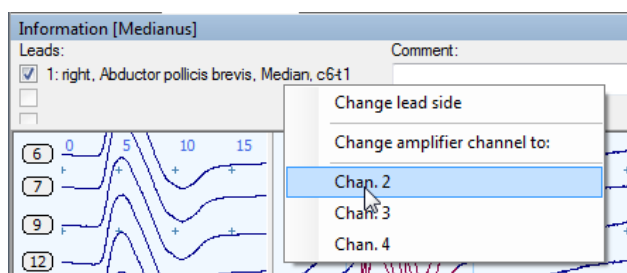


Fig. 2.18

You can add comments to the test by using the "Comment" field in the information panel.

The *"Copy results into report"* check box is selected by default when a new test is created. If you don't want the test data to be copied onto an exam report during its generation, remove the check.

To quickly change the maximum number of stimuli, click the stimulator settings with the right mouse button and select the corresponding option from the local menu (Fig. 2.20).
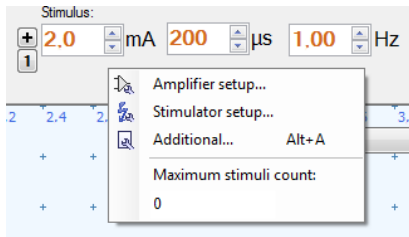


Fig. 2.19

The tabs of tests can be "dragged apart" by the mouse so that they will be displayed in different windows. This makes it easier to compare different tests of one exam. To do this, complete the following steps:

• Place the mouse cursor at a test tab (Fig. 2.20);

• Press the left mouse button and, holding it, move the mouse (Fig. 2.21);

• Release the mouse button (Fig. 2.22).
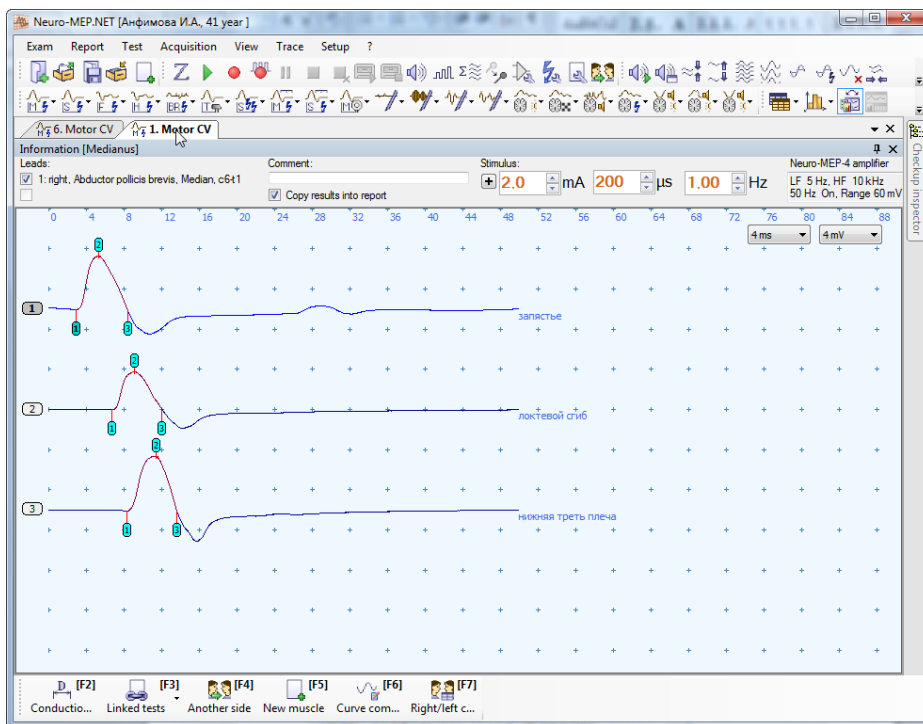


Fig. 2.20
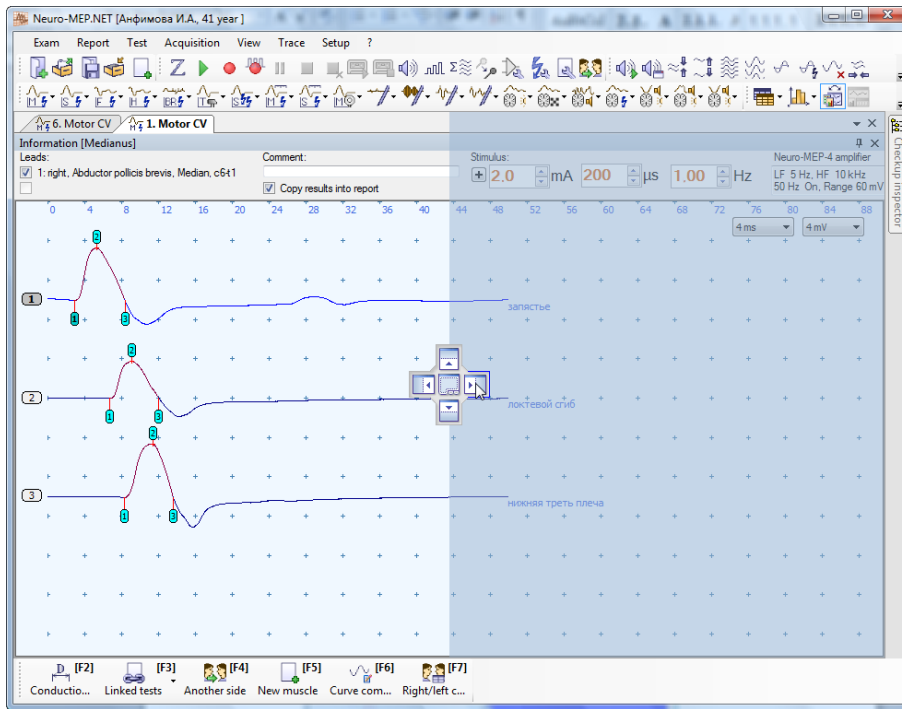
Fig. 2.21
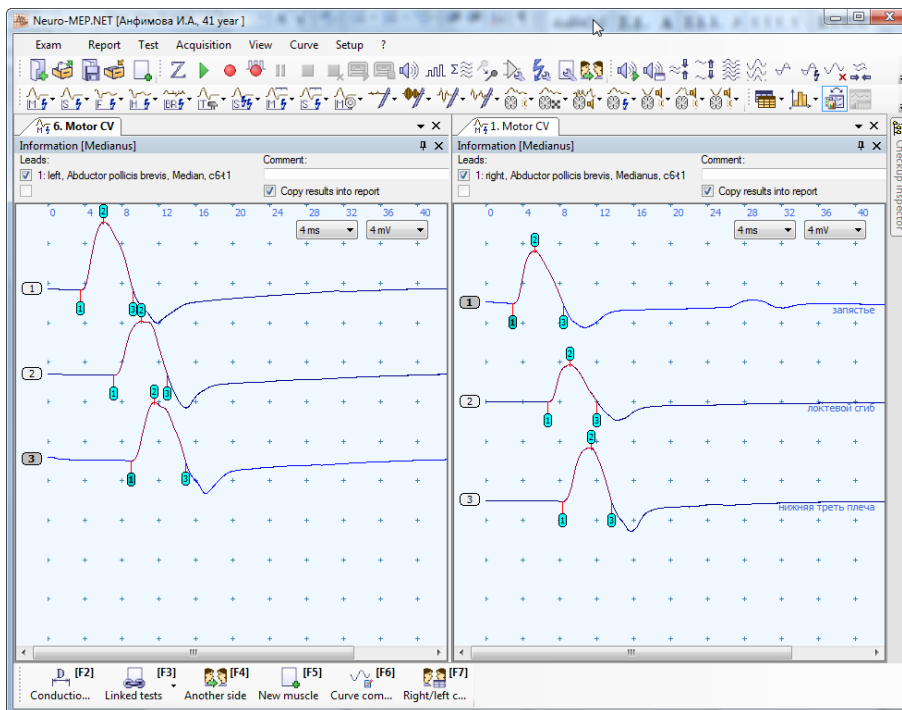


Fig. 2.22

Separate tabs with tests can be "dragged" between two analysis windows or "dragged apart" with the creation of new working windows.

## 2.6.1. Working with Traces

The advantage of **Focus** is its ability to analyze any number of traces recorded from a patient within one test.

To the left of each trace, there is a moveable button containing the trace name (Fig. 2.16). When the trace is selected, the type in the button's heading becomes bold. Most of menu commands only affect the selected trace. To select the trace, click the left mouse button on the trace or on the adjacent button. To select several traces, click the left mouse button while holding the **[Ctrl]** key on the keyboard. All traces of a test can be selected by using the menu command **Trace|Select all**. To move to the next trace, use the menu command **Trace|Next** (**[Ctrl+Down]**), to move to the previous trace, use the menu command **Trace|Previous** (**[Ctrl+Up]**). Or you can use the knob on the dedicated keyboard to switch between traces.

To change a trace position, shift it upward and downward on the screen, and drag the button containing the trace name with the mouse. You can also change the position of traces by using the menu command **View|Traces**.

To delete a trace, select the menu command **Trace|Delete**; all traces can be deleted by the command **Test|Clear**; and the current test can be deleted from the exam by the command **Test|Delete**. To delete several traces simultaneously, click on them with the left mouse button, while holding the **[Ctrl]** key and then press the menu command **Trace|Delete**. It is also possible to delete all the traces except selected ones by using the menu command **Trace|Delete all except selected**.

To remove separate trace segments, select the segment by clicking on it with the left mouse button and without releasing it, dragging the fragment (Fig. 2.23) and selecting the **Delete selected fragment** or **Delete all except selected fragment** local menu command.
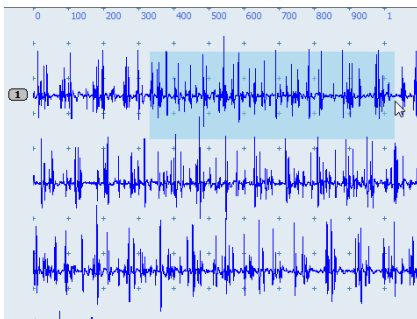


Fig. 2.23

Any trace can be temporarily hidden and excluded from analysis by using the local menu command **Hide trace** or the menu command **Trace|List** (**[Ctrl+U]**).

To show the amplitude spectrum for any individual trace, use the menu command **Trace|Amplitude spectrum**. A trace filter is carried out by the menu command **Trace|Filter**. Any recorded trace can be exported to an external .wav file by using the menu command **Trace|Playback**.

To change the type of markers on the traces or the information displayed next to each trace, use the menu command **View|Markers**.

To change scales of traces representation, use the following commands (Table 1.1).

Table 1.1

| Parameter | Menu command | Hotkey |
|---|---|---|
| To increase sensitivity (vertical scale) | **View\|Sensitivity\|Increase** | Grey **[+]** |
| To decrease sensitivity (vertical scale) | **View\|Sensitivity\|Decrease** | Grey **[–]** |
| To increase sweep (horizontal scale) | **View\|Sweep\|Increase** | Grey **[*]** |
| To decrease sweep (horizontal scale) | **View\|Sweep\|Decrease** | Grey **[/]** |

The menu commands and hotkeys shown above are used in the current window with the traces. To switch between windows on the screen (e.g., test work window, monitoring and acquisition windows), click on the window and select the menu command **View|Next window** or the corresponding button on the dedicated keyboard.

To specify a scale (scale factor of a grid), use the dropdown lists in the top right corner of the trace picture (Fig. 2.24).
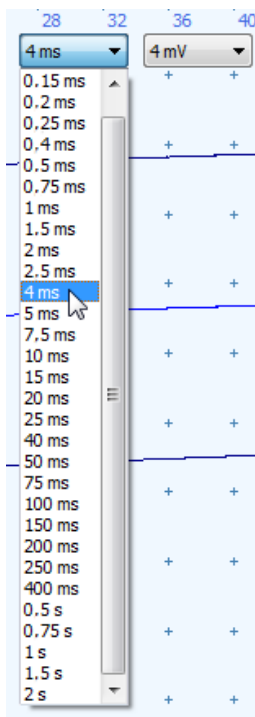


Fig. 2.24

If several traces are overlapping  (Fig. 2.25 on the left), it is possible to switch modes to view one trace at a time (Fig. 2.25 on the right).  Double-click on the trace you want to view and only the parameters of this one trace will be displayed in the quick analysis window.  To return to the mode of all traces viewing, double-click on the trace once again.
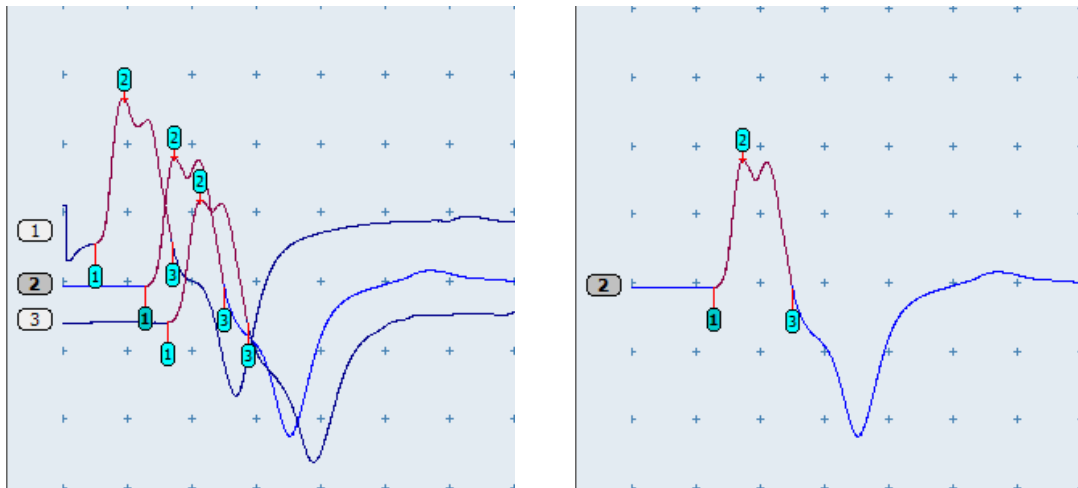
Fig. 2.25

To review the zoom-in trace segments, use the "magnifier" mode by pressing down and holding the **[Ctrl]** and **[Alt]** keys on the keyboard. The "magnifier" will appear on the screen (Fig. 2.29). You can shift the "magnifier" by moving the mouse and keeping the **[Ctrl]** and **[Alt]** keys pressed. If you release the keys, the "magnifier" will disappear. To change the ratio of "magnifier" zoom-in, use the mouse scroll.
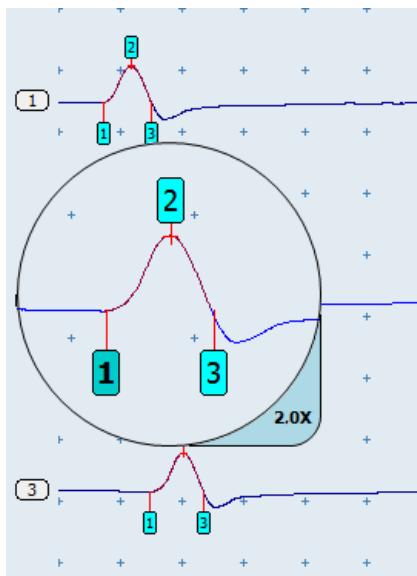


Fig. 2.26

You can enter a text comment for each trace by using the menu command **Trace|Comment** or the local menu command **Trace comment**.

To correct a marker position on the trace, move the mouse cursor to the marker (the cursor changes its view to ↔), press the left mouse button, drag the marker to a new place and release the mouse button. The marker can also be dragged by its heading (button). After shifting the markers, automatic renewal of the quick analysis window takes place (see below).

In most tests there is an automatic setting of analysis markers that occurs just after the corresponding trace acquisition. The wave onset is marked at the point where the trace deviates from the horizontal, and the wave end is marked at the point where the

trace returns to the horizontal. The amplitude markers are marked as top (negative peak) and bottom (positive peak) points between the onset and end markers. The negative peak end is marked on the cross of the back front of the negative peak and horizontal line that is drawn through the onset marker. The program does not guarantee a correct marker position. The marker position must be verified and corrected by the doctor.

In some tests, separate markers on the traces can be deleted by using the menu commands **Trace|Marker|Delete current**, **Trace|Marker|Delete all on trace** or **Trace|Marker|Delete all**.

To measure wave latencies, place the mouse cursor on the trace while holding the **[Shift]** key. The latency will be displayed next to the mouse cursor (Fig. 2.27).
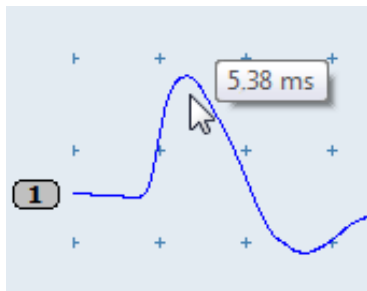


Fig. 2.27

For fast intervals and/or amplitudes measurement, it is necessary to: (Fig. 2.28):

• Move the mouse cursor to the start measuring point (e.g., to a trace peak).
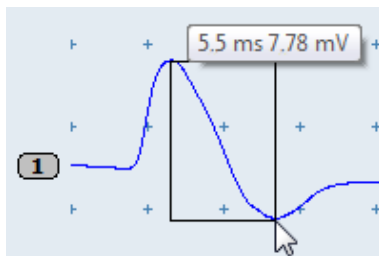


Fig. 2.28

• Press and hold the **[Shift]** key on the keyboard.

• Press the left mouse button and, while holding it, drag the mouse to the end measuring point. A rectangle with vertexes at the chosen points will appear on the screen. The numeric values of the amplitude and interval will be displayed next to it.

Thus, it is possible to view multiple amplitudes (intervals) at the same time if they have the same start measuring point.

The traces can be exported to an external file (i.e. for processing by external programs). To export test traces, use the menu command **Trace|Export into XML**. The traces will be saved in XML format.

## 2.6.2. Quick Analysis Windows

Quick analysis windows with tables and graphs are located either on the side of the window with traces or below it by default (Fig. 2.29).
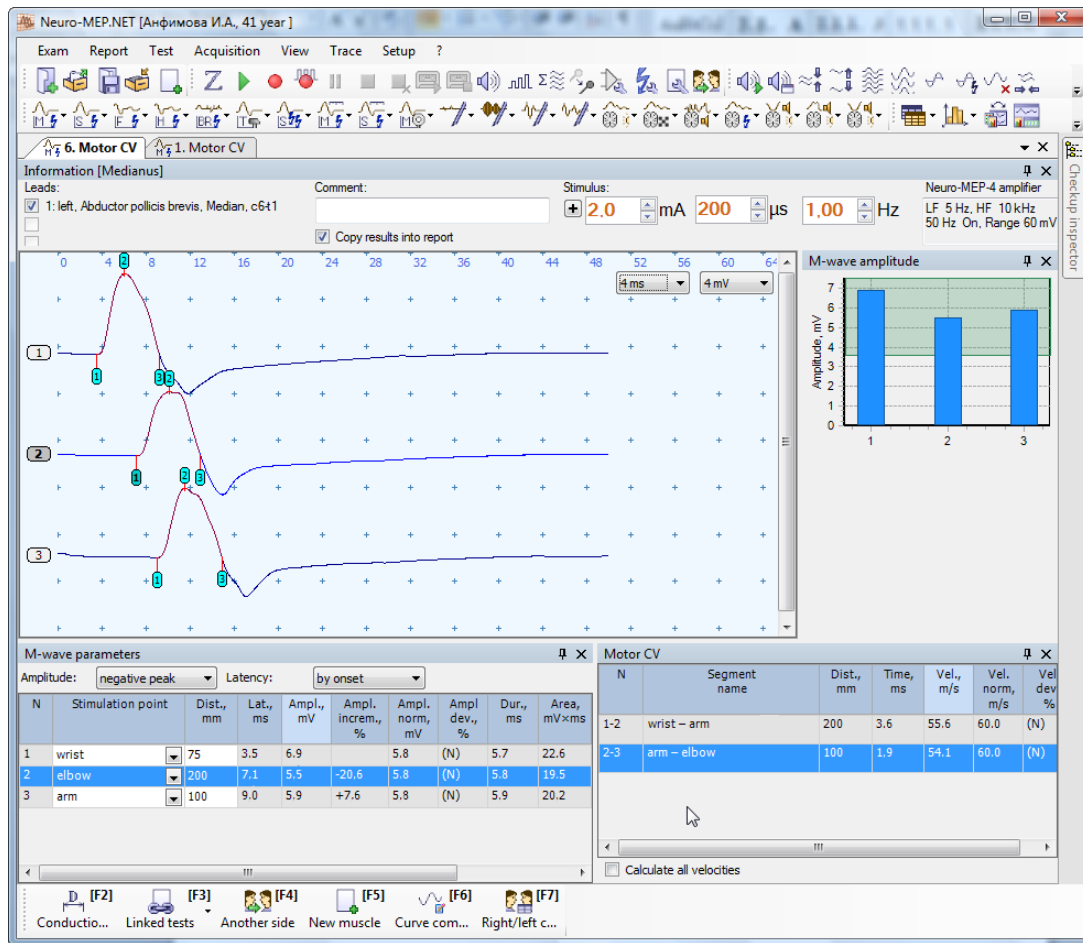


Fig. 2.29

You can switch the viewing of the quick analysis windows by using the menu commands **View|Analysis tables** and **View|Analysis graphs**.  Or you can hide an analysis window by pressing the ✕ symbol in the top right corner of the corresponding window.

There are two different layouts of analysis windows and you can switch between them by using the menu command **View|Windows layout|Switch ([Ctrl+Tab])**. You can adjust the viewing, size and position of each window in any of these layouts. The windows can be displayed either next to each other (Fig. 2.30, a) or on tabs (Fig. 2.30, d):

To change the size, move the mouse cursor to the window border and drag it by pressing the left mouse button.

To place windows on tabs, grab the window header with the mouse (Fig. 2.30, a, b), drag it to another window in the center of the appeared symbol of cross (Fig. 2.30, c) and release it (Fig. 2.30, d).

a)

b)

c)

d)
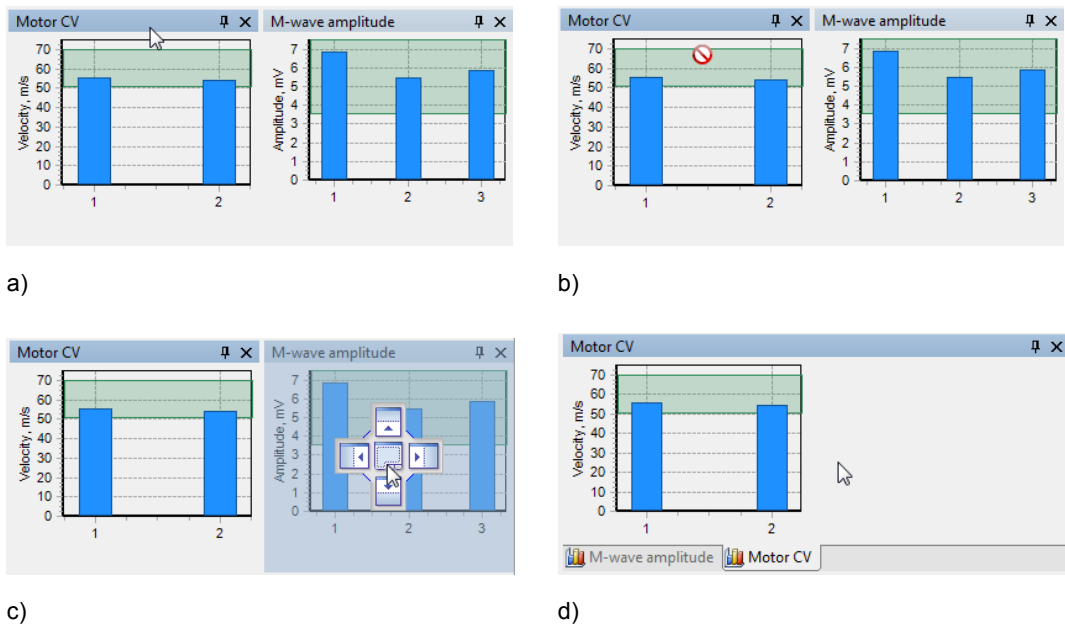
Fig. 2.30

To place windows apart on tabs, grab the window tab with the mouse (Fig. 2.31, a, b), drag it to one of the four corners of the appeared cross (Fig. 2.31, c) and release (Fig. 2.31, d). If you drag the window (Fig. 2.31, a) by the heading, the whole window and its tabs will be removed.



a)

b)

c)

d)
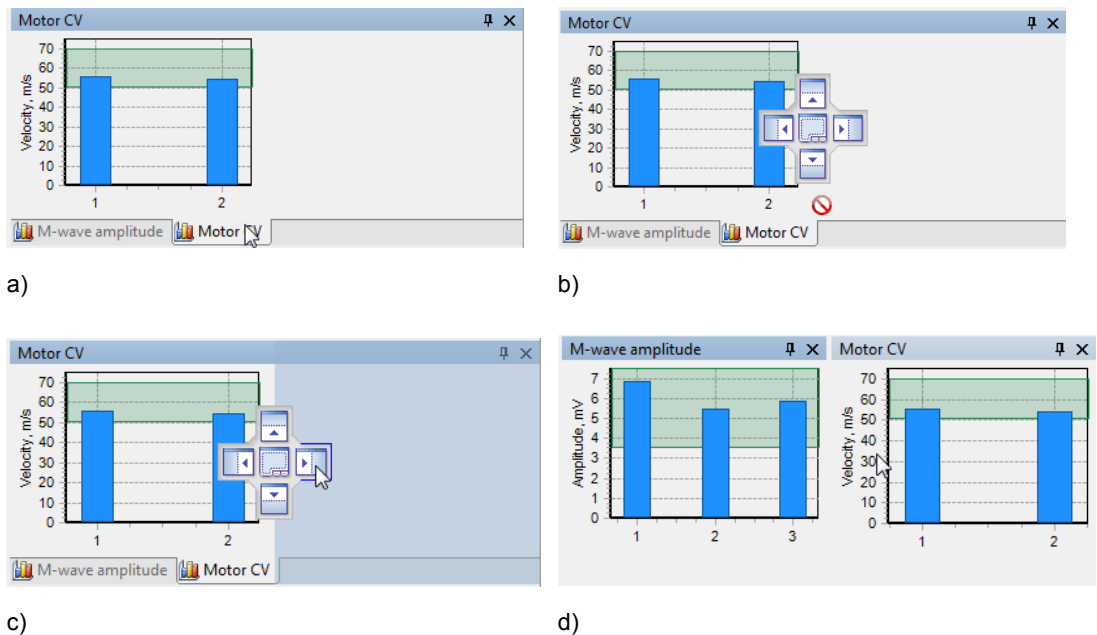
Fig. 2.31

Any window can be made to be a pop-up window so that only its heading is displayed by clicking  on the symbol in the top right corner of the analysis window (Fig. 2.32, a).

After that, only the heading will be visible (Fig. 2.32, b). To view the window contents, move the mouse cursor to its heading and wait for a second – the window will pop up (Fig. 2.32, c). If you remove the mouse cursor from the window, it will disappear

(Fig. 2.32, d). If you click on the 📌 symbol once again, the window will return to the previous (not pop-up) state.



a)



b)



c)



d)
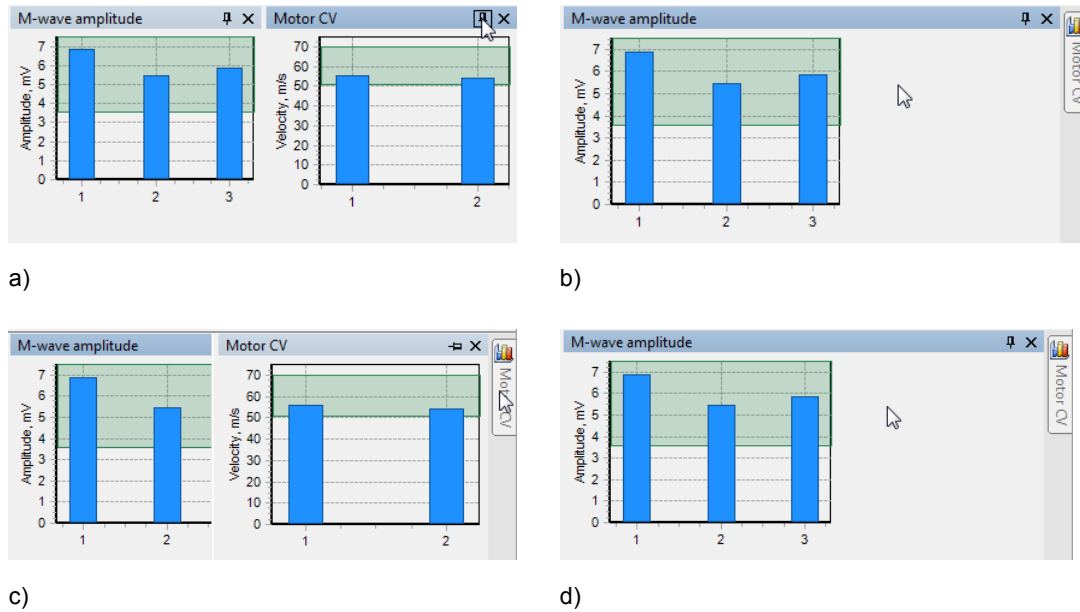
Fig. 2.32

For the tables located in the quick analysis windows, it is possible to:

• Change the width of separate columns by dragging their borders with the mouse;

• Change the visibility of separate columns (rows) by pressing the right mouse button on the table and selecting the necessary visibility parameter.

When selecting a trace, the corresponding row in the table and bar on the graph in the quick analysis window are automatically selected and vice versa (Fig. 2.33).
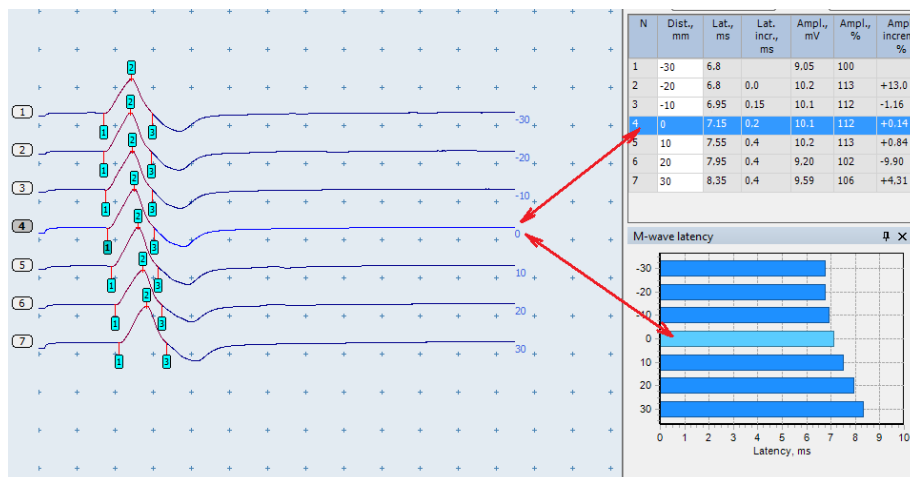


Fig. 2.33

## 2.6.3. Exam Reports

Each exam can include one or more reports. Besides text, an exam report can include tables, graphs and pictures. There are two types of reports: built-in and Microsoft

Word format (Microsoft Word 2007 or later version is necessary). You can select the type of exam report using the menu command **Report|Use Microsoft Word** (Fig. 2.34).
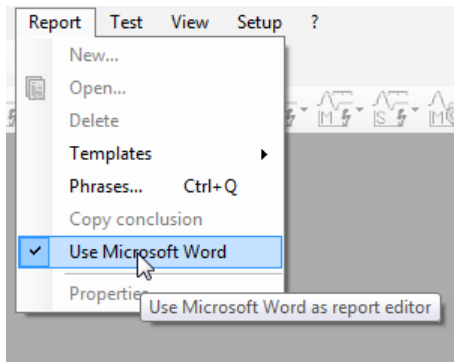


Fig. 2.34

The built-in report is similar to the standard WordPad program in Windows. (Fig. 2.35).
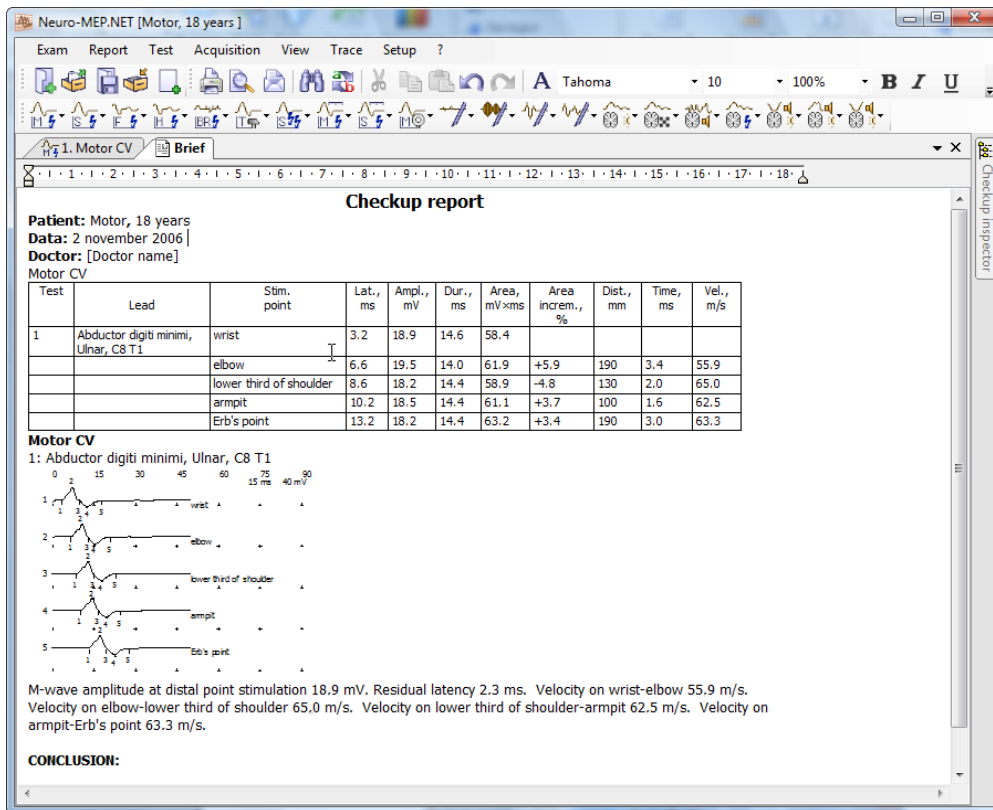


Fig. 2.35
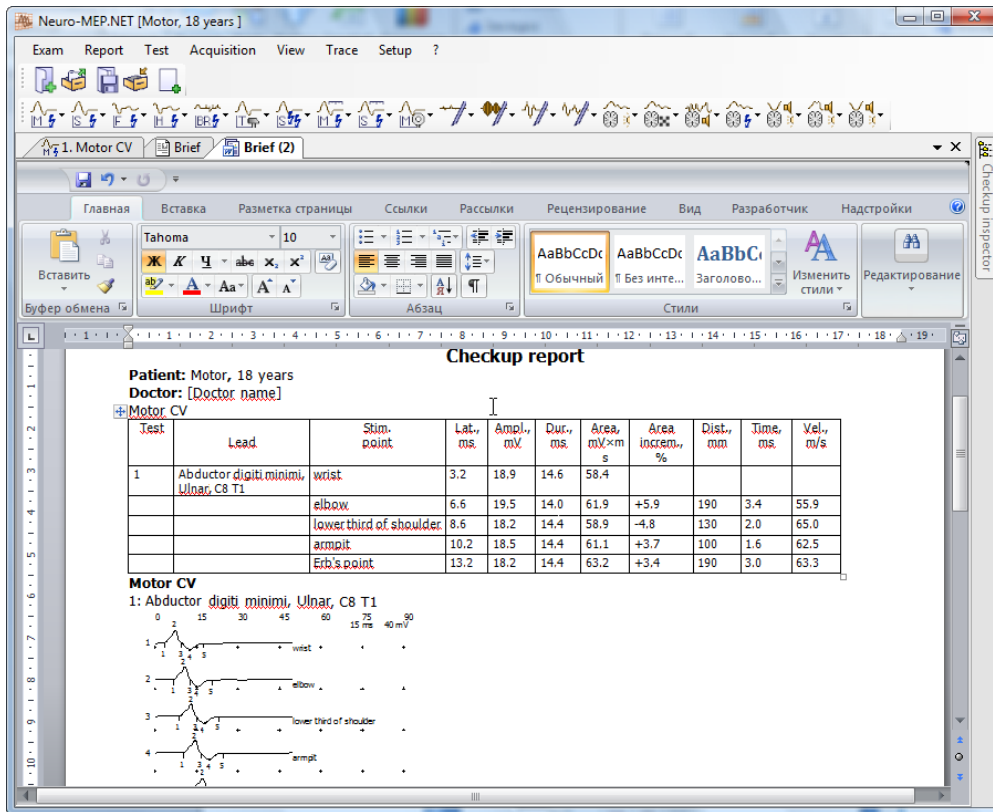
Fig. 2.36

A Microsoft Word report allows access to all facilities of the Word editor (Fig. 2.36). However, to work with this editor, Microsoft Word must be installed on your computer.

Generation of a new exam report is carried out by the menu command **Report|Templates**. Go to the menu and select the template you need. To speed up the process, any two report templates from the list can be linked to the menu commands **Report|New report 1** and **Report|New report 2** by using the menu commands **Setup|Change**, "Software" tab, and "Default exam report". The number of reports is unlimited.

Reports are saved together with the exams in the data base by default. To simultaneously save and copy reports to a folder on the computer disc, check the "Copy reports to the folder" (Fig. 2.42) check box and select folder name.

To print the exam report, use the menu command **Report|Print**. You can also export the report to the external file (the menu command **Report|Export**) or send it by e-mail (the menu command **Report|Send**).

It is recommended to enter some information in the "Clinical state" and "Conclusion" windows when working with a new exam. Its contents can be copied to the exam report manually (**Report|Copy conclusion**) or with the use of report template.

## 2.6.4. Exam Report Templates

Exam reports can be created by copying graphs and tables from different tests manually but this can be time consuming. Exam report templates speed up the process of report creation. The sequence, composition and type of information

included in the reports are defined in the template. Several templates are provided with the program by default.  However, it is possible to change these templates or create new ones.

To edit the report templates, use **Report|Template|List…** menu command. The report templates editor is represented on the Fig. 2.37.
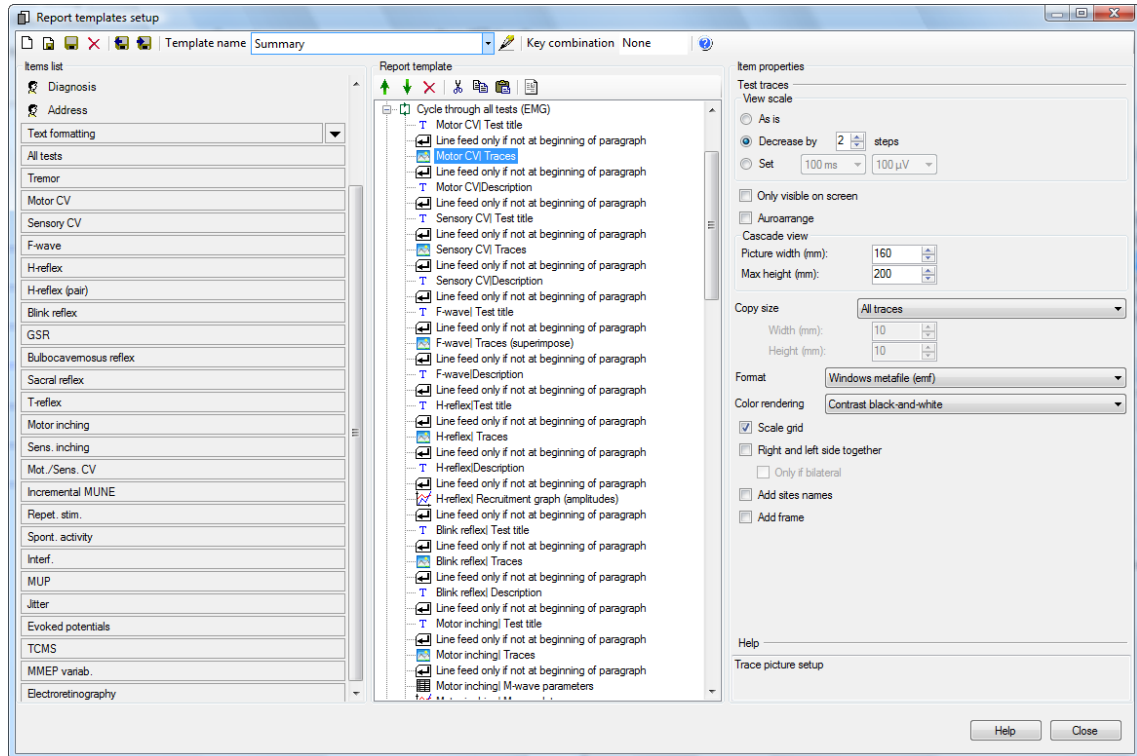


Fig. 2.37

The toolbar, located in the top part of the window, is used to: create new report templates, remove  existing ones, import templates from files, export templates to files (for example, to transport to a different computer) and rename them.

The report template combo-box is located in the middle part of the toolbar.  The templates manager window is divided into three parts.

The left part contains tabs with information available for inclusion in the report. To include a variable in the report template, point and click the mouse on a tab and drag it to the middle part of the window.

The variables listed in the middle have a tree structure, i.e. some variables can contain other variables. Using the toolbar over this list, you can change the order of the variables, remove the unnecessary ones, copy, or cut and paste them from the clipboard. There is a  report preview available so that you can look over the information to make sure it is accurate.

The right part of the manager contains the current report variable settings panel. Each variable has its own setting panel which you can use to change the appearance of information. Table 2 describes the variables of the "Text layout" group.

Table 2. The description of variables for text layout.

| Variable Name | Variable Description |
|---|---|
| Patient info | Information about a patient. It contains several nested variables, each of them is responsible for the insertion of some information about a patient to the report, for example, last name, first name, age, sex, address, telephone number, etc. You can edit the given variable by adding, changing or excluding the nested variables. |
| User tag input | It allows to enter the user's tags (see below) for their further use in the text of the report template. The values of the user's tags will be requested from a user on the step of the report generation. The tags will be replaced by their values in the report text. |
| Font selection | It is intended to set up the font of the report text. |
| Text color selection | It is intended to set up the color of the report text. |
| Background color selection | It is intended to set up the color of the report text background. |
| Alignment | It is intended to align the report text. |
| Indents setup | It is intended to specify the indents from the page border. |
| TAB | It inserts TAB symbol to the report text. |
| Space | It inserts the space to the report text. |
| Line feed | It inserts the line feed to the report text. |
| Line feed only if it is not paragraph beginning | It inserts the line feed to the report text, if the cursor is not in the beginning of a paragraph. |
| Page break | It inserts the page break to the report text. |
| Text | It is intended for the insertion of some text information to the exam report. |
| RTF-file | It inserts the content of the indicated RTF-file to the report text. The use of this variable is not recommended, as in case of report template export and further import to other computer the given file will not be found during the report generation. It is preferable to use "RTF-text" variable. |
| Picture from the file | It adds the image from the specified file to the report. The use of the given variable is not advisable (see note for RTF-file). The variable "Formated text" with the inserted picture is more preferable. |
| Table-container | It is intended for the merging of several variables of one line or several lines. Using the table-container, you can display, for example, two or more images or tables side-by-side. |
| Current date and time | It is intended for the insertion of the current date and time to the report. |

Continuation of Table 2. The description of variables for text layout.

| Variable Name | Variable Description |
|---|---|
| RTF-text | It is intended to insert some formatted text to the report. The use of so called tags or indicators to some information about an exam is allowed in the formatted text, for example, $NAME tag will be replaced to a patient name in the exam report, $AGE tag will be done to its age. Besides the tags, the logical and cyclic statements can be used in a formatted text. For example, to separate by age you can use the following conditional statement:<br>$IF $AGE >= 65 $THEN aged $ELSE young $ENDIF, or for the separation by sex and age:<br>$IF $SEX == male && $AGE >= 65 $THEN aged $ENDIF. Correspondingly, only "young" or "aged" lines depending on a patient's age will be included in the report instead of these conditional statements. The statements can be composite, with the use of logical operations && (AND), ||(OR). The comparison of the numerical values is performed with the use of the symbols > (greater-than), < (lesser-than), >= (equal-to-or-greater-than), <= (equal-to-or-lesser-than), == (equal), != (not equal). The comparison of the line values is performed with the use of the signs == (equal), != (not equal). The use of the nested conditional statements is not allowed. The use of the brackets in the statement description is also not allowed. At the same time you can use the cyclical structures together with the conditional statements, for example:<br>$FOR $I = 0 $TO $LENGTH($ARRAYTAG) - 1 $DO<br>$I). $ARRAYTAG[$I] $ENDFOR, where $ARRAYTAG – tag-array.<br>Inside the cycle body you can use the conditional statements, and the cycles can also be described inside the conditional statement. |

Displayed below is a template variable tree (Fig. 2.38).
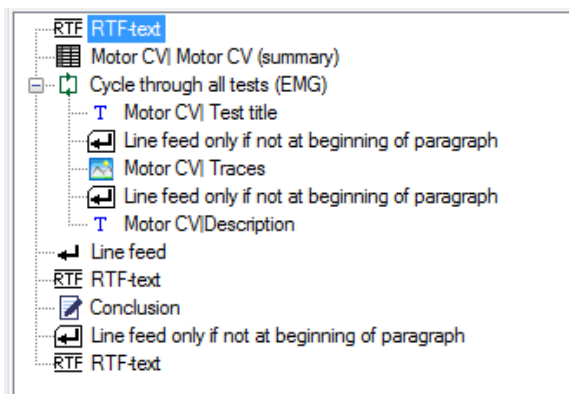


Fig. 2.38

The first variable "RTF-text" will be added to the report heading. You can set the text heading and its font in the variable's settings. The next template variable inserts the summary table by all **Motor CV** tests.

The "Cycle through all test" variable will be omitted but the variables nested in it – the test name, traces and the description of each **Motor CV** test will be included in the report. Please note that these variables are only used for the description of **Motor CV**. For other test types, these variables are ignored at the passing by cycle.

The line feed and the formatted text ("Conclusion"), the interpretation text, the line feed and formatted text with a doctor's name will be added to the report after the description of the exam's functional tests.

You can edit the existing report templates by adding, removing or setting up the variables. You can also create new report templates.

To add some basic data to a report (for example, name and age of a patient), you can use the "tags" in the text of the report templates. All the tags will be replaced by their values at the report generation stage. The table below provides a list of general tags.

Table 3. The general tags of an exam.

| Tag Name | Tag Description |
|---|---|
| $NAME | patient's name and surname |
| $AGE | patient's age |
| $SEX | patient's gender |
| $BDATE | date of birth |
| $REGDATE | date of registration in the database |
| $CARDCOMMENT | comments to patient's card |
| $ADDRESS | address |
| $PHONE | telephones |
| $LONGDATE | exam date (long format) |
| $TIME | time of exam beginning |
| $COMMENT | comments to exam |
| $DIAGNOSIS | provisional diagnosis |
| $CARDNAME | card-file name |
| $CURDATE | current date |
| $CURLONGDATE | current date (long format) |
| $CURTIME | current time |
| $WEIGHT | patient's weight (kg) |
| $HEIGHT | patient's height (cm) |
| $POLICY | number of insurance |
| $EMAIL | e-mail address |
| $EDITUSER | doctor's name |
| $CREATEUSER | doctor's name who created an exam |

Continuation of Table 3. The general tags of an exam.

| Tag Name | Tag Description |
|---|---|
| $EDITDATE | date of last change |
| $DEPARTMENT | department |
| $BMI | body mass index |

The tags listed in the table can be used in "RTF-text" and "Text" template variables. Some text variables of a template can contain specific tags that can only be used in the text of these variables. Using the "Tag" combo-box located on the toolbar of variable settings, you can add tags to the variable text.

For example, the "RTF-text" variable contains the following information with the tags:

### Exam Report

**Patient:** $NAME**,** $AGE
**Date:** $LONGDATE $IF $DIAGNOSIS!="" $THEN
**Diagnosis:** $DIAGNOSIS $ENDIF
**Exam is performed by doctor:** $DOCTOR

After the exam report generation, the text may look like this (the tags are replaced by real patient and doctor's data):

### Exam Report

**Patient:** Johnson O., 20 years old
**Date:** 7 November, 2008
**Diagnosis:** adult pseudohypertrophic muscular dystrophy
**Exam is performed by doctor:** Dr. J. Smith

In the present example the diagnosis line will only be inserted  if the diagnosis is filled in  (conditional statement IF: $IF $DIAGNOSIS!="")

You can define your own tags by using the template variable "User tag input". Enter the information at the report generation stage.  The user tags can have a string, numerical or list format. The string tags can be used for the entering of arbitrary text information. The numerical tags are intended to add quantitative data to the report and the list tags are used to add a priorly defined value to the report text.

# 2.7. Hardware and Software Configuration Setting

The setting of basic program parameters is carried out by the menu command **Setup|Change**.

"General" page (Fig. 2.39).
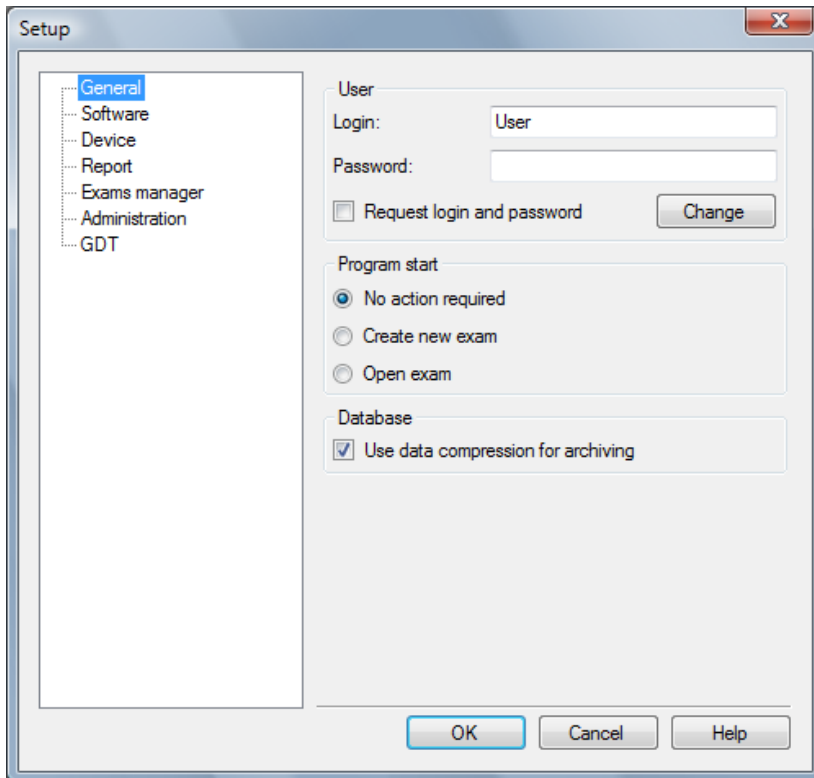


Fig. 2.39

*"User".*

*"*Login". Type the user name to login. Each user can have his/her own login setting (e.g., the possibility to change the windows layout, toolbar settings and traces color; to connect databases etc.).  Changing one user's login system does not influence the setting system of any other user. To change a user or add a new one, press the "Change" button and the program will be restarted.

*"*Password". Required each time the program is started. Keep in mind that it will be impossible to restore the password if you forget it. However, you can leave this field empty (entry without password).

*"*Request login and password". If the check box is selected, a user login and password will be required after the program startup.

To add a new user, select the "Request login and password" check box, restart the program and enter a login and password of the new user.

*"*Program start". The action carried out automatically after the program startup.

"Database. Use data compression for archiving." The data compression that occurs when saving information to the archive saves space on a disk but slows down the operation with archives.

"Software" page (Fig. 2.40).
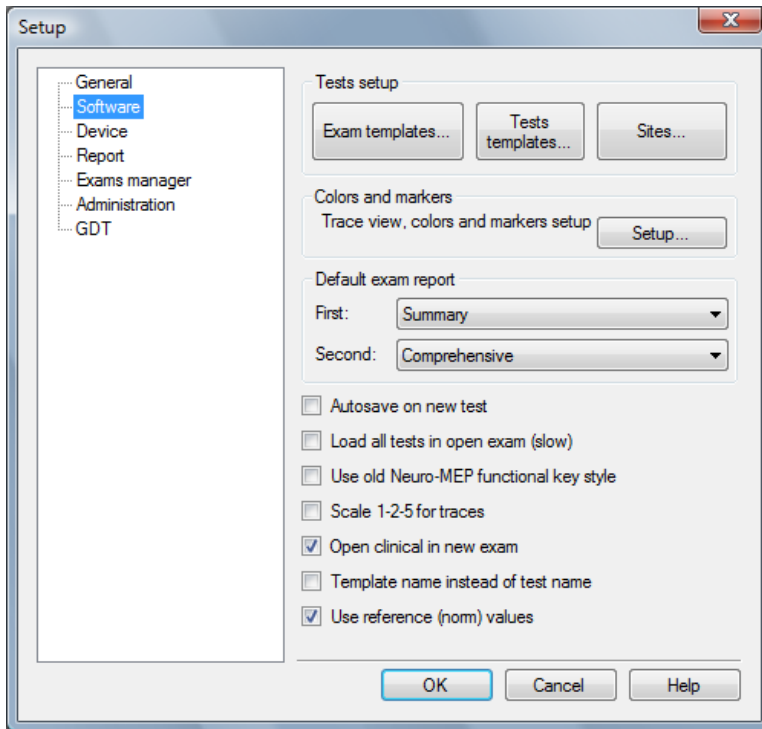


Fig. 2.40

"Tests setup"
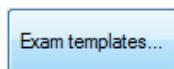
**Exam templates...** By pressing this button you can create, delete and edit test templates. A test template is a template list of separate tests that can speed up a doctor's work.
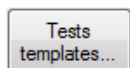
**Tests templates...** Test templates (exam techniques) setup.
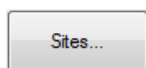
**Sites...** List setup of all possible sites of the amplifier channels.

"Colors and markers". Trace view colors and markers setup.

"Default exam report". Connecting the menu commands **Report|New report 1** and **Report|New report 2** with the appropriate report templates. In Fig. 2.40, the exam report will be generated according to a "Summary" template if the menu command **Report|New report 1** is selected.

"Autosave on new test". If the check box is selected, the **Exam|Save** command will be performed automatically when a new exam is created.

"Load all tests when open exam (slow)". If the check box is selected, all exam windows will be loaded and displayed when the menu command **Exam|Open** is selected. If there are too many tests, the exam loading can be significantly slower.

*"*Use old Neuro-MEP functional key style". If the check box is selected, the functional keys (**[F1]** – **[F12]**) of the computer keyboard will be used as hotkeys while recording bioelectric signals from the patient. This mode makes the work easier if there is no special dedicated keyboard in the delivery set.

*"*Scale 1-2-5 for traces". If the check box is selected, the trace scales (sweep and sensitivity) can only be displayed as 1-2-5, i.e. 10 ms, 20 ms, 50 ms, 100 ms per division etc. If the check box is not selected, the scale will be displayed more smoothly: 10 ms, 15 ms, 20 ms, 25 ms, 40 ms, 50 ms, 75 ms, 100 ms per division etc.

"Open clinical in new exam". If the checkbox is selected, the window for entering a patient's clinical state data will open immediately after a new exam is created.

"Template name instead of test name". If the checkbox is selected, the template name will be displayed instead of the exam technique under study in the exam inspector and test windows headings.

"Use reference (norm) values". If the checkbox is selected, the study parameters will be compared with the user inputted normal values and their comparison to the normative ones will be provided and pasted in the report.

All program settings, including exam templates, toolbar appearances, trace colors etc. can be exported to an external file by using the menu command **Setup|Save**. Then the settings can be imported into the program by the menu command **Setup|Load**. You can selectively export report templates, exam templates and site lists by using the menu command **Setup|Test templates|Export**. To import settings, use the menu command **Setup|Test templates|Import**.

*"*Device" page (Fig. 2.41).
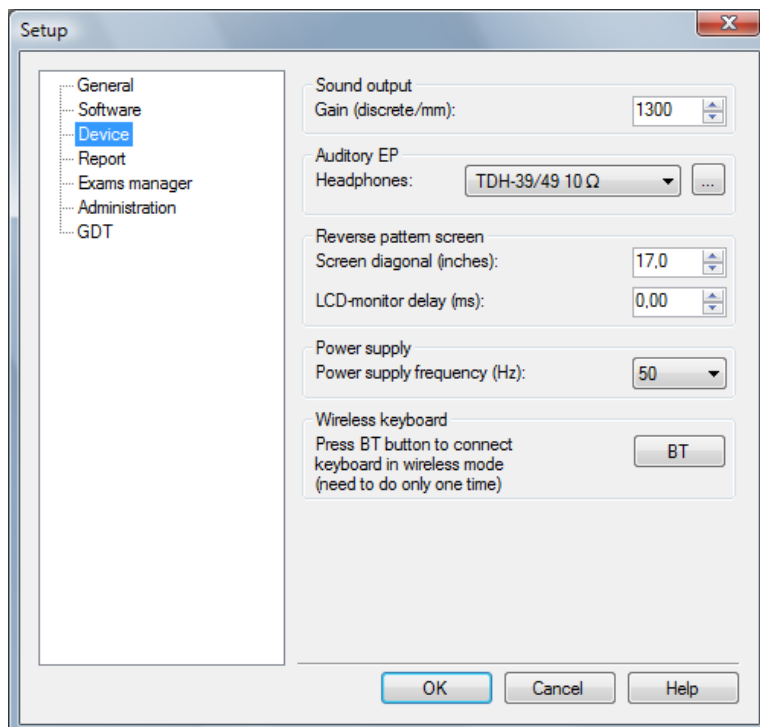


Fig. 2.41

*"Sound output. Gain (discrete/mm)"*. Ratio for the data of the displayed traces multiplied before they are transferred to a computer sound card (measured in discretes of the sound card per screen millimeter). The maximal signal value received by the sound card without distortion corresponds to 32000 discretes.

*"Auditory EP. Headphones"*. The type of headphones used for the auditory EP study.

*"Reverse pattern screen. Screen diagonal (inches)"*. It is recommended to measure the diagonal of the reversal pattern visible picture and specify its real size (1 inch = 25.4 mm).

*"Power supply. Power supply frequency (Hz)"*. Electric mains frequency in your region in Hz for the interference notch filter matching. In the USA it is 60 Hz.

*"Wireless keyboard"*. Button for Bluetooth-keyboard connection in the wireless data transfer mode (**not applicable** for the Focus device with a dedicated keyboard)

*"Report"* page (Fig. 2.42).
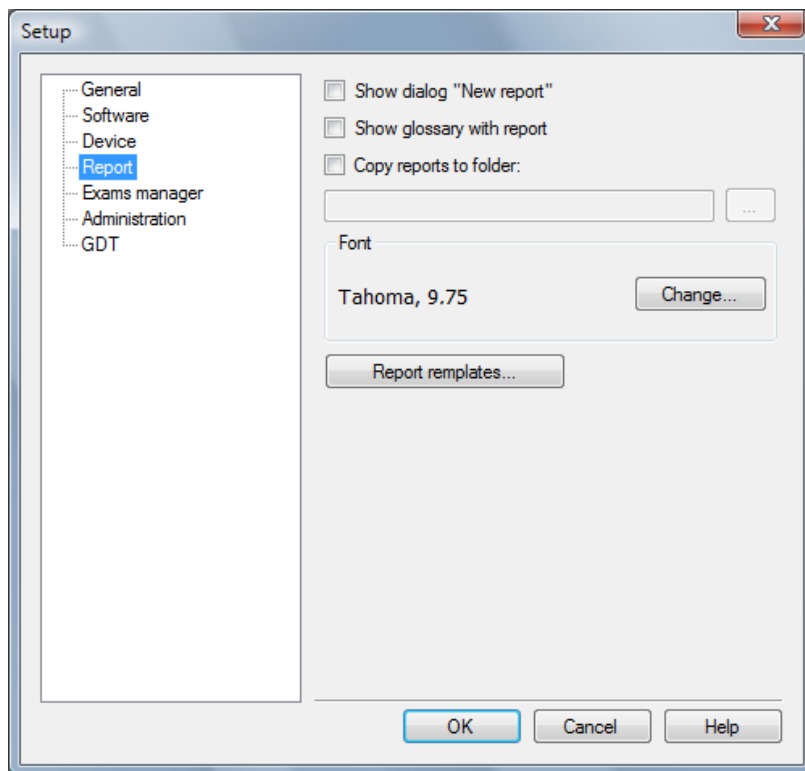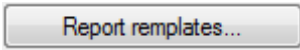


Fig. 2.42

*"Show dialog "New report"*. If the check box is selected, the dialog box with a query for a report name and comment will be displayed before creating a new checkup report.

*"Show glossary with report"*. If the checkbox is selected, a glossary window will be displayed with an exam report.

*"Copy reports to the folder"*. If the checkbox is selected, exam reports will be copied to a selected folder on your laptop during report saving.

"Font". The font of the report is set by default. The same font is used by default in "Clinical state" and "Conclusion" windows.

"The Report remplates... button". Changing of the exam report templates.

"Exams manager" page (Fig. 2.43).
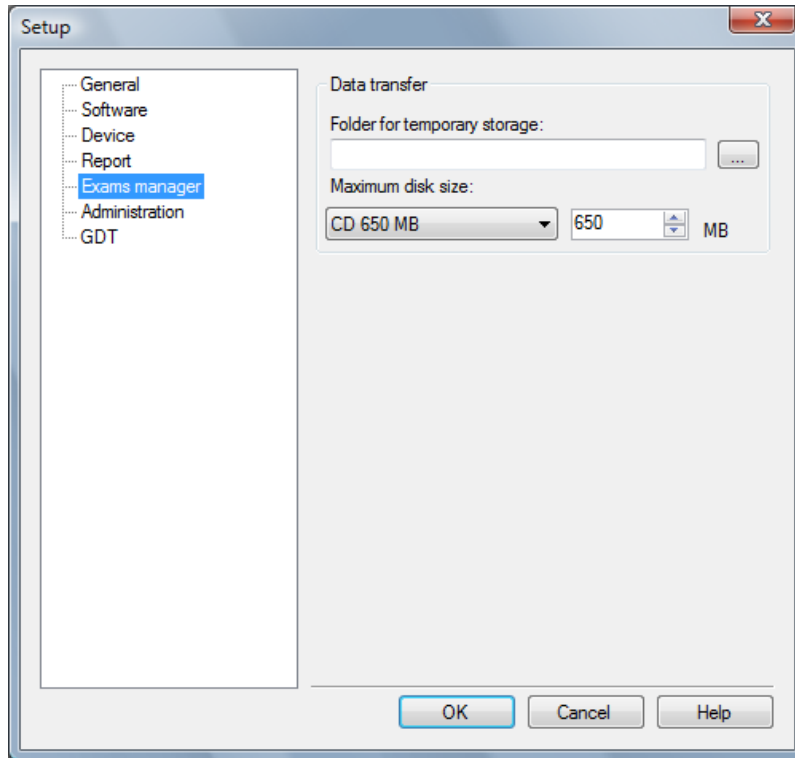


Fig. 2.43

"Data transfer". Folder for temporary storage". The folder for temporary data storage that can be transferred from a database to a CD. The data is stored in this folder until its size achieves the maximum possible size to burn it on CD.

"Maximum disk size". The used size of a compact disk for the exam recording. The size can be selected from the combo-box or specified arbitrarily.

"Administration" page (**Error! Reference source not found.**).
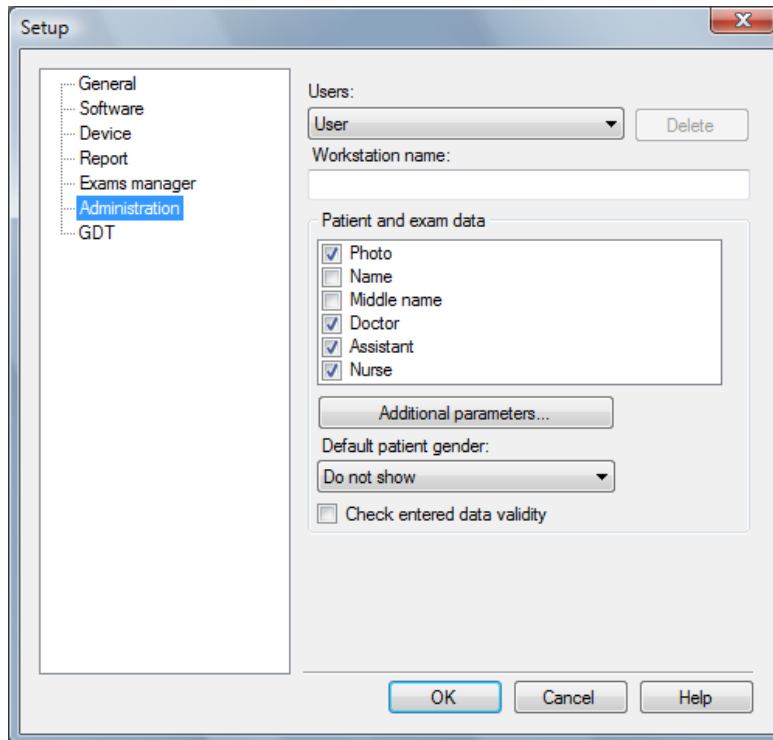


Fig. 2.44

"Users". The list of users. The "Delete" button is intended to remove users when needed.

"Workstation name". The name of network station (computer) in operation with the network database.

"Patient and exam data". The setup of a patient card appearance at the beginning of each new exam. Select the checkboxes next to the information you want included in the dialog box.

"Additional parameters…". The setup of additional (user) parameters to be added in the patient card.

"Default patient gender". This allows you to specify the patient' sex by default at the beginning of each new exam.

"Check entered data validity". If the checkbox is selected, the availability of the entered patient name, sex, age and weight will be checked at the beginning of each new exam.

## 2.7.1. Tests Templates

### 2.7.1.1. Test Types

The settings for each technique are saved in a test template. Test templates contain device settings (channel used, filter parameters, amplifier settings, stimulator settings etc.), list of sites, recorded data, trace scales by default, names of markers etc. The

program has certain tests templates by default but you can change tests templates and create new ones by yourself. To work with tests templates, use either the **Tests templates** button (Fig. 2.40) or the menu command **Setup|Tests templates|Setup**. In the **Test templates setup** window use either the [New...] button to create a new test template or the [Change...] button to change the selected test template.

In the test template wizard (Fig. 2.45) you can use the [< Back] and [Next >] buttons to switch between pages. Direct access to separate window pages is available via a pages tree to the left of the window. Pages that can be found in several tests types are described below.
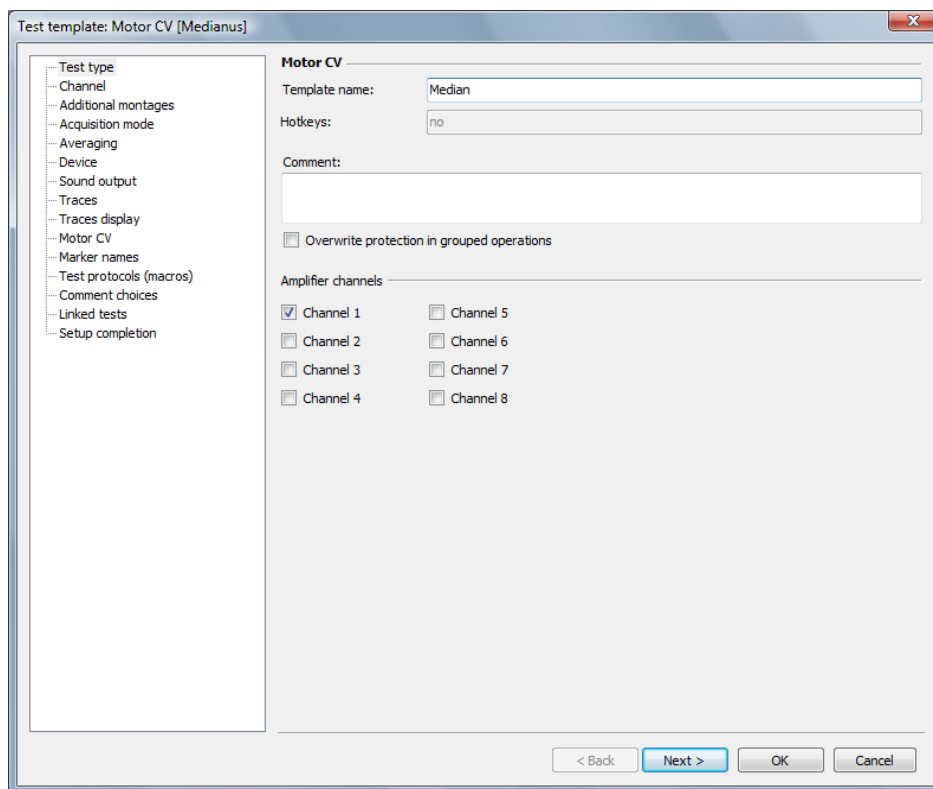


Fig. 2.45

*"Template name"*. The name of the test template name in use.

"Hotkeys". Key combinations that can help you create a new test while working with the program.

*"Comments"*. Any text information with template description.

*"Overwrite protection in grouped operations"*. If the check box is selected, the record group operations are not applied to certain template (for more details see comments to Fig. 2.61).

*"Amplifier channels"*. The amplifier channels which will be used in the test should be checked.

## 2.7.1.2. Channel

On the "Channel 1" page of the test template wizard (Fig. 2.46) you can set the site (montage) for the amplifier channel.
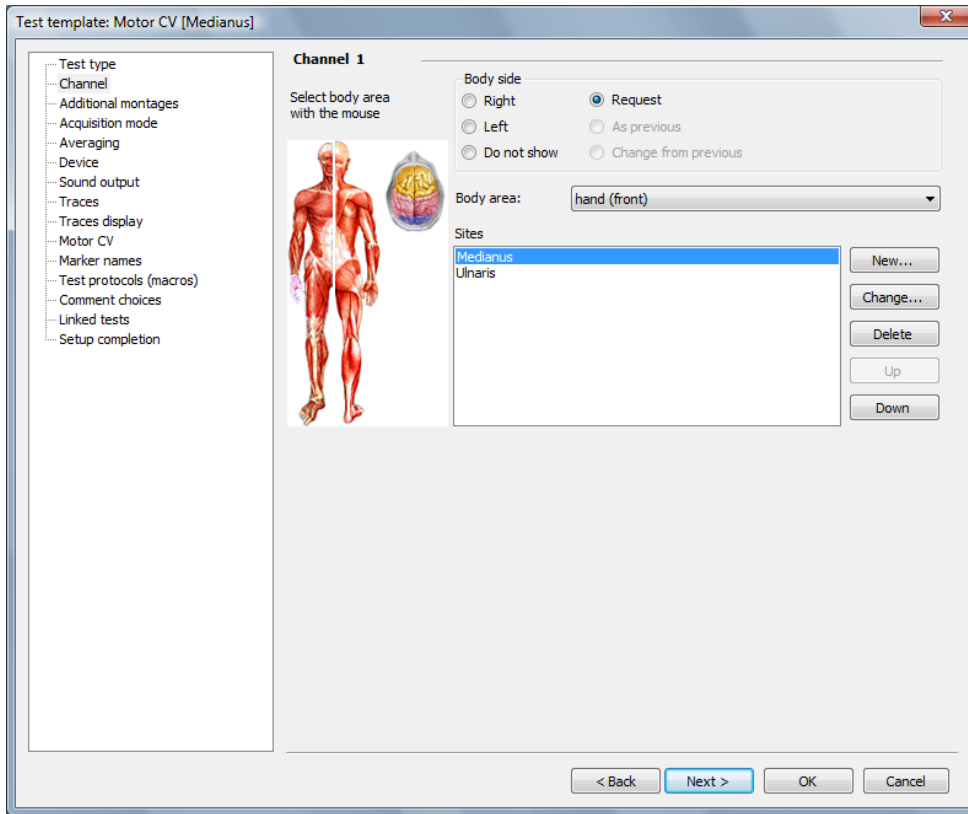


Fig. 2.46

To select a body part, either click on it in the picture or in the "Body part" dropdown list. All possible sites for this body part appear in the "Sites" list. The list of possible sites can be edited by using the buttons to the right of the list.

## 2.7.1.3. Additional Montages

The "Additional montages" page of the test template wizard (Fig. 2.47) allows the use of several montages in the test with the possibility of a quick switch between them using the buttons on the toolbar (Fig. 2.48).
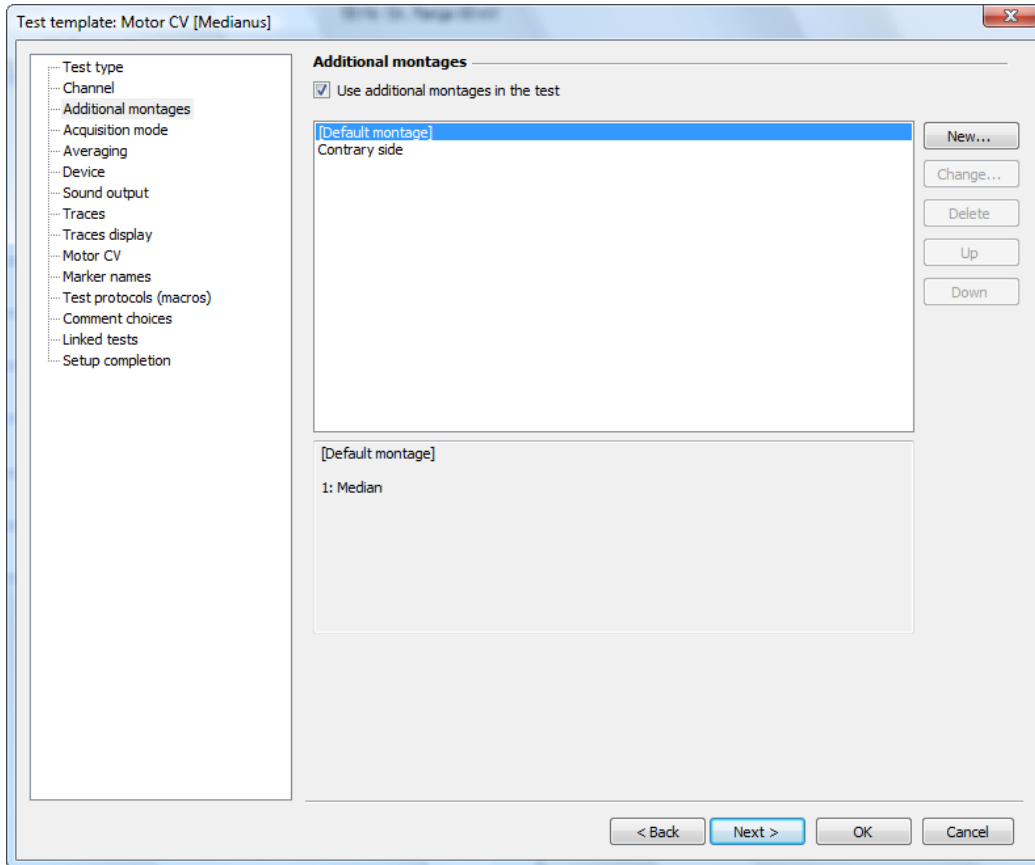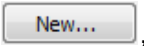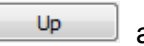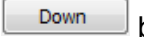


Fig. 2.47

"Use additional montages in test". The selected checkbox allows the application of additional montages.

To edit the montages list, use New... , Change... , Delete , Up and Down buttons.
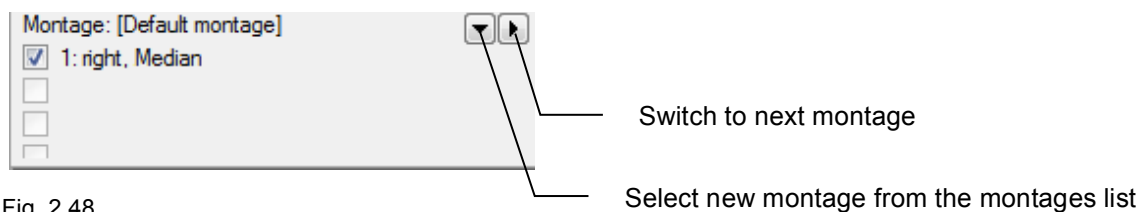


Fig. 2.48

### 2.7.1.4. Acquisition Mode

On the "Acquisition mode" page (Fig. 2.49) you can set the main technical parameters of a study.
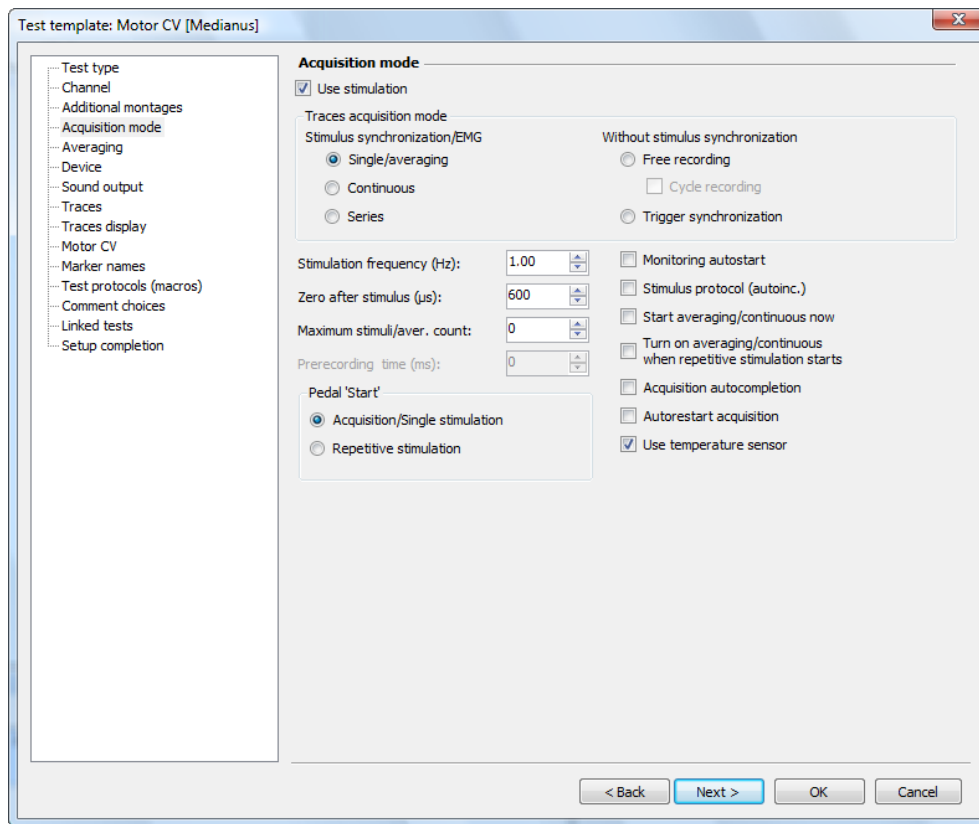


Fig. 2.49

"Use stimulation." Select the check box for any test in which a stimulator is used.

"Traces acquisition mode."

"Stimulus synchronization/EMG." Recording modes.

"Single/averaging." Single traces recording mode. This mode is used in such tests types as **Motor CV**, **Sensory CV**, evoked potentials study.

"Continuous." Recording mode to accumulate trace sets. This mode is used in tests types such as late responses.

"Series." Recording mode to accumulate trace series. Series is displayed on the screen as several traces are superimposed on each other with a small horizontal shift. This mode is used in such tests types as **Repetitive Stimulation (decrement test)**.

"Without stimulus synchronization". Use with free run recording when the trace beginning is not synchronized with the stimulus start.

"Free recording". Recording mode called **free run**. In this mode, long epochs (from 0.5 sec up to several minutes) are recorded after a manual start. If the "Cycle recording" check box is not selected, the trace display stops after the defined analysis

epoch is reached. If the "Cycle recording" check box is selected, trace display continues repeatedly (i.e. after displaying of all the analysis epoch, record starts again from the trace beginning) until it is stopped manually. This mode is used in such tests types as **Spontaneous activity**, **Interference EMG**.

*"Trigger synchronization"*. Recording mode by short epochs (as a rule, by several tens of milliseconds) while synchronizing the displayed traces with special trigger. This mode is used in such tests types as **MUP**, **Jitter**.

"Stimulation frequency (Hz)". Stimulation frequency by default after a test creation by the menu command **Acquisition|Repetitive stimulation**.

*"Zero after stimulus (μs)"*. Using this parameter you can "cut off" (replace to isolation line) a stimulus artifact at the beginning of a trace. This value does not influence the trace latency periods.

*"Maximum stimuli/aver. count"*. Maximum stimuli count displayed using the menu command **Acquisition| Periodical stimulation** or maximum number of averages.

*"Prerecording time (ms)"*. With this parameter, "skipped" phenomena can be included in the trace. For example, if the prerecording time value equals 200 ms, the record starts 200 ms earlier, i.e. a 200 ms trace fragment received before the start of recording will be included in the trace.

*"Pedal "Start"*. The menu command selection connected with the left pedal: either **Acquisition|Acquisition/Stimulus** or **Acquisition|Repetitive stimulation**.

*"Monitoring autostart"*. If the check box is checked, the menu command **Acquisition|Monitoring** is selected immediately after starting a new test.

*"Stimulus protocol (autoinc)"*. If the check box is selected, the next stimulus increases by one increment after each stimulus start.

"Start averaging/continuous now". If the check box is checked, after a new test is created, the menu command **Acquisition|Averaging/Continuous** is selected and the next trace averaging (accumulation) starts by using either **Acquisition|Acquisition/Stimulus** or **Acquisition|Repetitive stimulation** menu commands.

*"Turn on averaging/continuous when repetitive stimulation starts"*. If the check box is selected together with the the menu command **Acquisition|Repetitive stimulation**, the menu command **Acquisition|Averaging/Continuous** will start automatically, i.e. at repetitive stimulation the trace averaging (accumulation) always takes place immediately.

*"Acquisition autocompletion"*. If the check box is selected, the menu command **Acquisition|Stop** will start automatically when the preset maximal number of stimuli is reached, resulting in a closing of the recording window and inclusion of all the recorded traces into analysis.

"Autorestart acquisition". If the check box is selected, autoacquisition restarts immediately after the menu command **Acquisition|Stop** is selected.

"Use temperature sensor". If the check box is selected and the temperature sensor is included into the delivery set, the current temperature value from the sensor is displayed on the information panel.

## 2.7.1.5. Averaging

The "Averaging" page (Fig. 2.50) is available only in the "Single/averaging" recording mode.
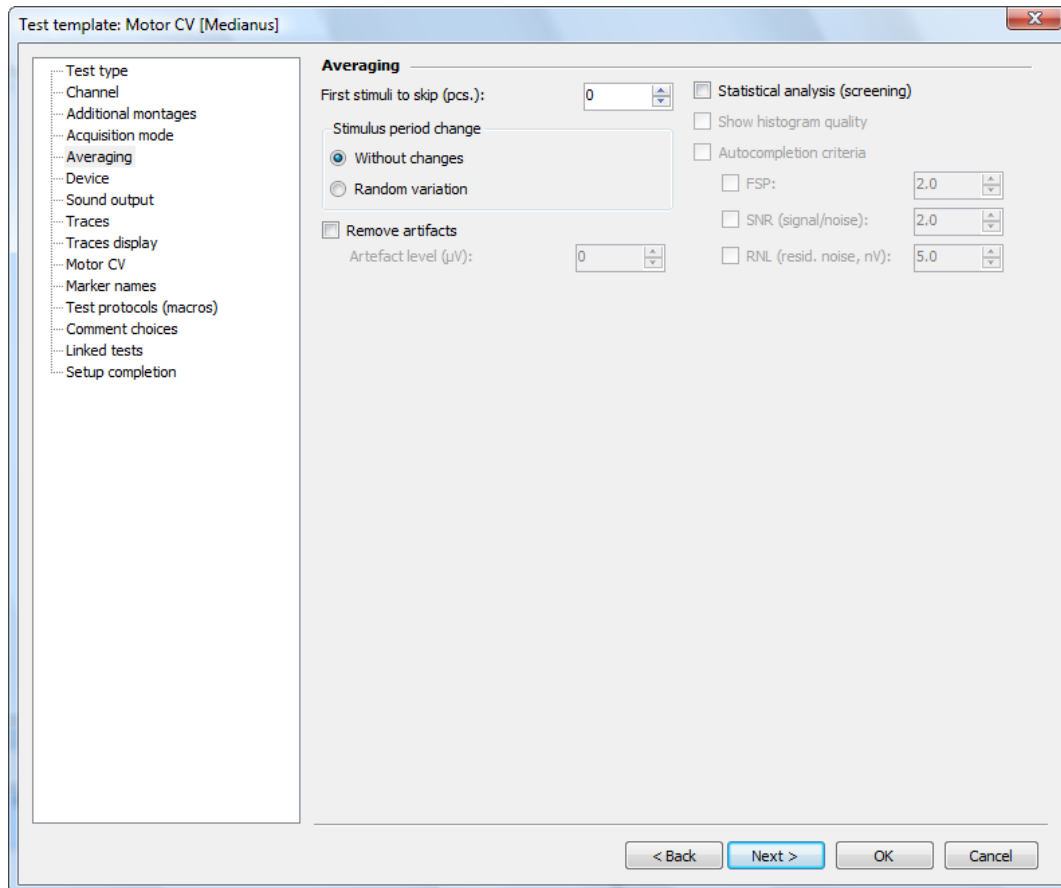


Fig. 2.50

"First stimuli to skip". Number of stimuli to skip (ignore) before the start of averaging.

"Stimulus period change". Random spread of stimulation period includes a special algorithm of stimulus changing period within narrow limits and allows decreasing the interference value in small amplitude average signal.

"Remove artifacts". If the check box is selected, the traces in which amplitude increases the "Artifact level" are screened out.

"Statistical analysis (screening)". If the check box is selected, the statistical analysis of the native traces will be made to arrange the traces by quality and include only acceptable ones into the averaging process.

*"Show histogram quality"*. If the check box is selected, the histogram of native traces distribution by quality will be displayed in the acquisition window during averaging. During the acquisition you can correct the quality level of traces manually as well as reaverage the traces.

*"Autocompletion criteria"*. Autostop of averaging before the preset maximal number of stimuli is reached if the preset level of the next averaging parameters is reached.

*"FSP"*. Minimal value of signal frequency at averaging. For instance, it is recommended that short-latency auditory potentials take no less than 3.1.

*"SNR (signal/noise)"*. Signal/noise minimum ratio.

*"RNL (resid. noise, nV)"*. Maximal value of residual noise, in nanovolts.

### 2.7.1.6. Device

On the *"Device"* page (Fig. 2.51) there are hardware settings (amplifier and stimulators) depending on the device type you choose in the "Device" dropdown list.
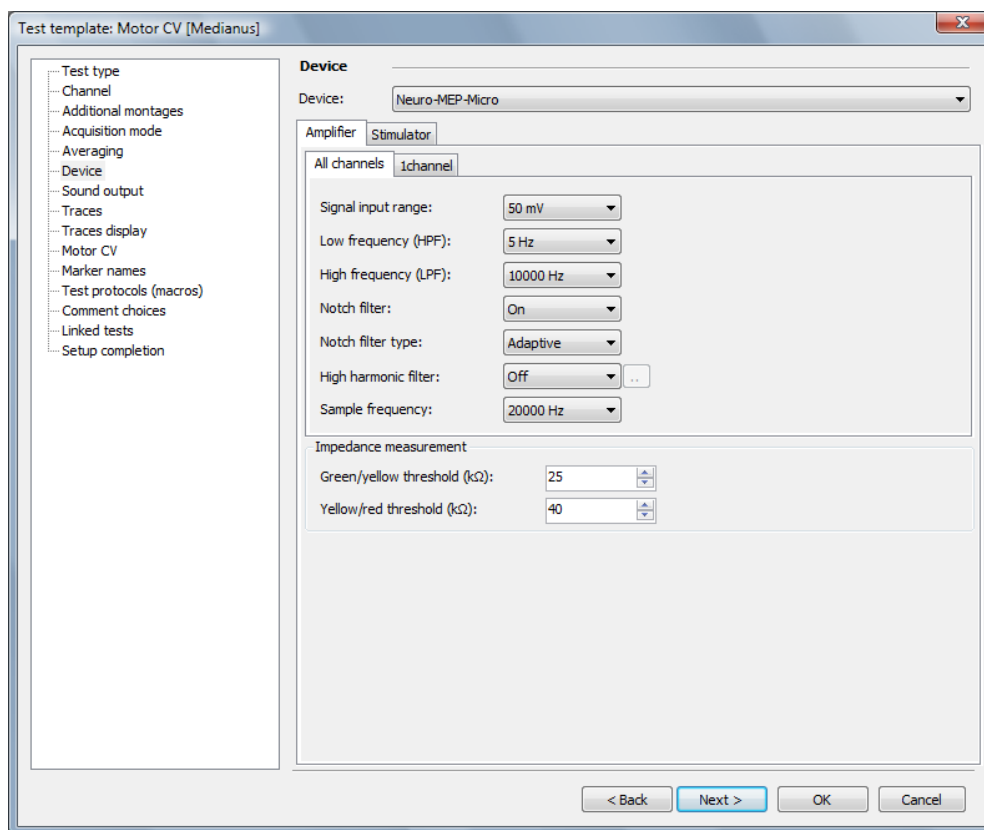


Fig. 2.51

*"Signal input range"*. Maximal signal range at amplifier input that can be received by the device without distortion. Select the input range so that it is 2-3 times higher than the maximum possible signal expected from the patient. Values of input signal that are too high increase noise level and values that are too low lead to an amplifer overswing and signal distortion.

"Low frequency (HPF)*."* Low cutoff frequency (high frequency filter).

*"*High frequency (LPF)*."* High cutoff frequency (low frequency filter).

"Notch filter." Interference notch filter state (50 or 60 Hz).

"Notch filter type." Recursive notch filter has a high suppression ratio but it can lead to distortion of high-amplitude responses, so it is recommended to only be used in the tests without stimulation. An "Adaptive" notch filter has a low suppression ratio, it does not lead to the responses distortion and can be used in tests with stimulation.

*"*High harmonic filter." An Adaptive high harmonic filter is useful when the interference level is considerable at high-frequencies.

*"*Sample frequency*".* A/D converter sampling frequency.

*"*Impedance measurement*".* Green/yellow/red thresholds are set for visual color display of electrodes placement quality.

## 2.7.1.7. Sound Output

On the *"*Sound output*"* page (Fig. 2.52) there are synchronous sound playback settings. The sound is reproduced through computer speakers.
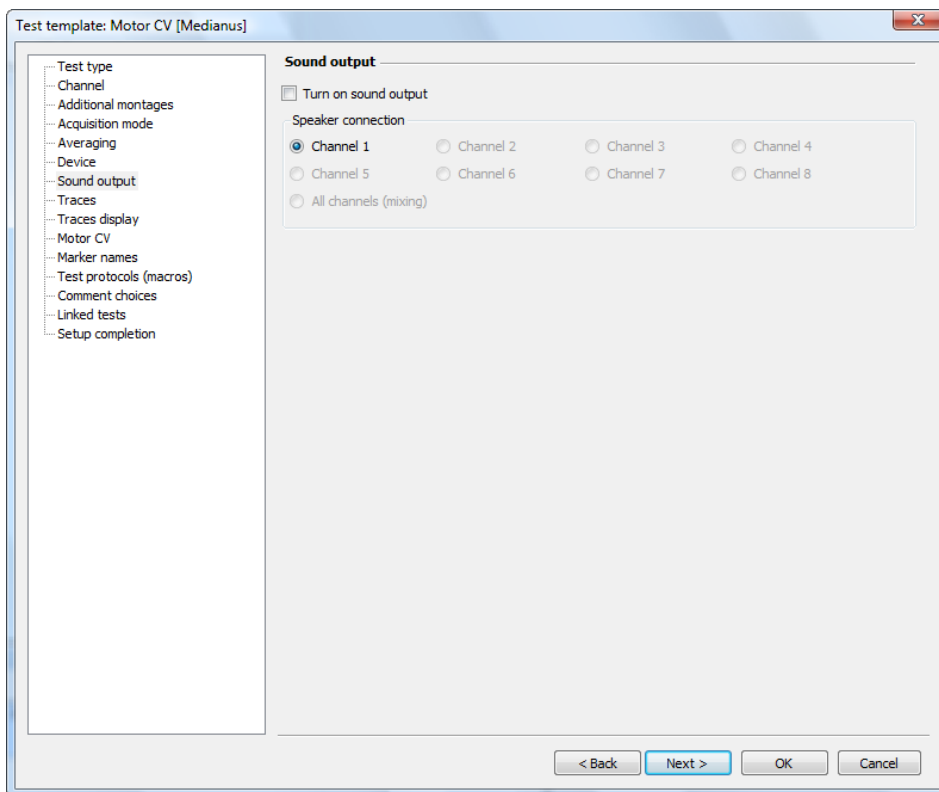


Fig. 2.52

*"*Turn on sound output". If the check box is selected, a synchronous sound output will be turned on after a new test is created.

*"*Speaker connection". Amplifier channel number to which the speaker will be connected after a new test creation.

"All channels (mixing)". If this option is activated, all channels used in a test will be mixed, i.e. the sound is emitted simultaneously from all channels.

## 2.7.1.8. Traces

The *"Traces"* page (Fig. 2.53) is only used in cases where recording - including the signals received from bio amplifier and additional (calculated) signals - is required and also in cases where special types of triggers are used to start signal recording. The special triggers can be, for example, an electrical stimulator in one test or an EMG trigger, i.e. the acquisition start at EMG signal excess in one of the channels at the specified level. To do this, select the checkbox "Traces do not correspond to amplifier channels or EMG trigger is used" (Fig. 2.54).
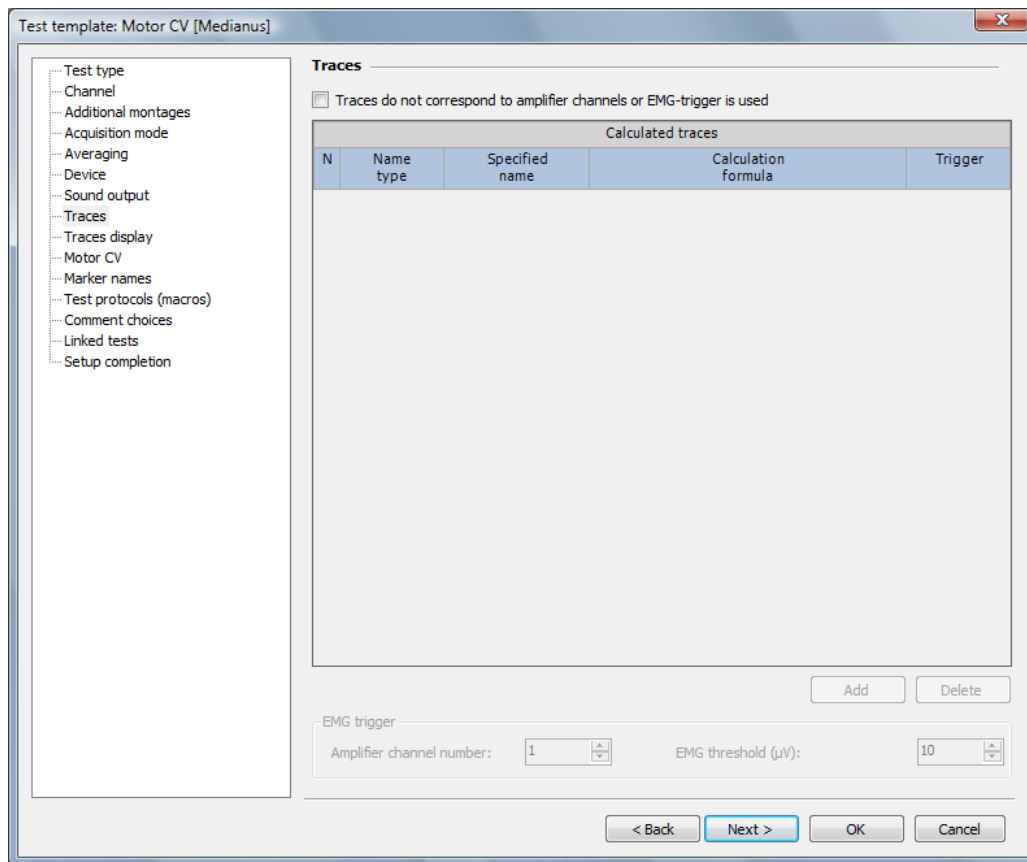


Fig. 2.53
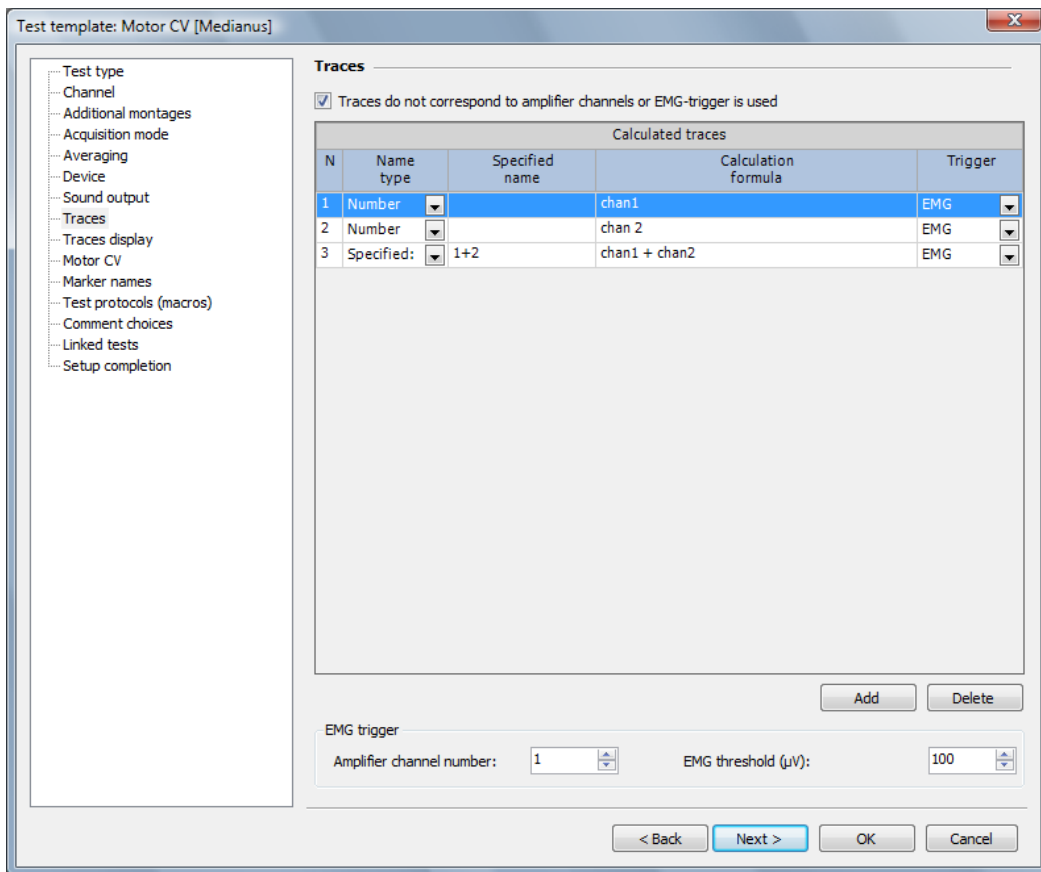
Fig. 2.54

Table "Calculated traces". Each row of the table corresponds to one trace received after recording.

"N". The trace sequence number.

"Name type". The sequence number or the name specified by a user can be placed instead of a trace name.

"Specified name". A new trace name if the type of specified name was selected.

"Calculation formula". The formula of trace calculation. For example, *chan1* indicates that the given trace corresponds to the signal received from the first amplifier channel; *chan1+chan2* means that the given trace is the sum of signals from the first and second channels. The more detailed information about calculation formulas is given below.

"Trigger". The trigger used for synchronization (recording start). The following variants are possible:

• By default – the special triggers are not used.

• Stimulus 1 (stimulus 2) – the recording of the corresponding trace by the first (second) stimulus.

• EMG – synchronization (recording) of the corresponding trace when there is an excess signal level in one of the amplifier channels. The given trigger type cannot match others.

"EMG trigger".

"Amplifier channel number" – the channel number in which the EMG signal level is tracked.

"EMG threshold (µV)" – the module of EMG signal value, in microvolts; the signal of acquisition beginning is generated at the excess of this value.

## 2.7.1.9. Formulas for Additional Traces Calculation

When you set the calculation traces in an EMG program (Fig. 2.54,) a special mathematical block is activated. For example, if two amplifier channels (first and second) are used and three calculation traces are set (Fig. 2.54), the mathematical block will look like the following (Fig. 2.55
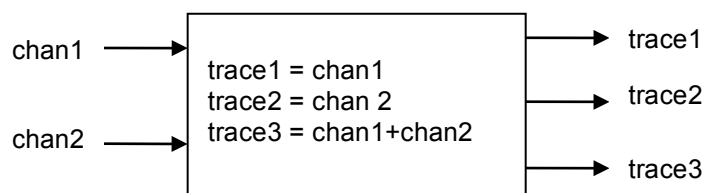


Fig. 2.55

"chan1, chan2" – the input signals of the first and second amplifier channels correspondingly.

"trace1, trace2, trace3" – the output signals of mathematical block displayed as traces.

The formula "trace1 = chan1" indicates that the signal of the first trace corresponds to the signal from the first amplifier channel. The formula "trace3 = chan1+chan2" shows that the signal of the third trace is the sum of the signals from first and second channels of the amplifier. In these formulas you can use four main mathematical operators of addition (+), subtraction (-), multiplication (*) and division (/) and parentheses to group the expressions and also special functions abs (expression module, rectified signal), sqrt (square root) and filtration functions (filters) described below. Considered below are several examples of calculation formulas, which can be set in the "Traces" window (Fig. 2.54).

"(chan3 + chan4) / 2" – the calculation average of 3 and 4 channels.

"-chan1" – the inversion of the first channel (the channel signal will be inverted, "turned over").

"chan1 – chan2 + trace1" – the difference of 1 and 2 channels, to which the trace 1 is added. Both input amplifier channels (in this case *chan1* and *chan2*) and output channels, i.e. calculated traces (in this case *trace1*) can be used in the formula.

"abs(chan2)" – rectified signal of the second channel, i.e. taken by module.

"sqrt (chan1 * chan1 + chan2 * chan2)" – the square root of the sum of squares of 1 and 2 channels.

For additional traces filtration, you can use the following filtration functions:

"hcf (<signal for filtration>, <cutoff frequency>)" – the high-cut filter. The filter passes the signal with the frequencies below cutoff frequency and cuts the signal with the frequencies exceeding the frequency cutoff.

"lcf (<signal for filtration>, <frequency cutoff>)" – the low-cut filter. The filter passes the signal with the frequencies below cutoff frequency and cuts the signal with the frequencies exceeding the frequency cutoff.

Examples of filters use.

"hcf (chan1, 500)" – the filtration of signal from channel 1 with the low-cut filter with 500 Hz frequency cutoff.

"lcf (chan2 + trace3, 2.5) + hcf(trace3, 1000)" – the filtration result of signals sum from second channel and third trace by the high-cut filter with 2.5 Hz frequency cutoff is added up to the result of signal filtration of third trace by low-cut filter with 1000 Hz frequency cutoff.

### 2.7.1.10. Traces Display

On the *"Traces display"* page (Fig. 2.56) there are the settings for the trace display in the test.
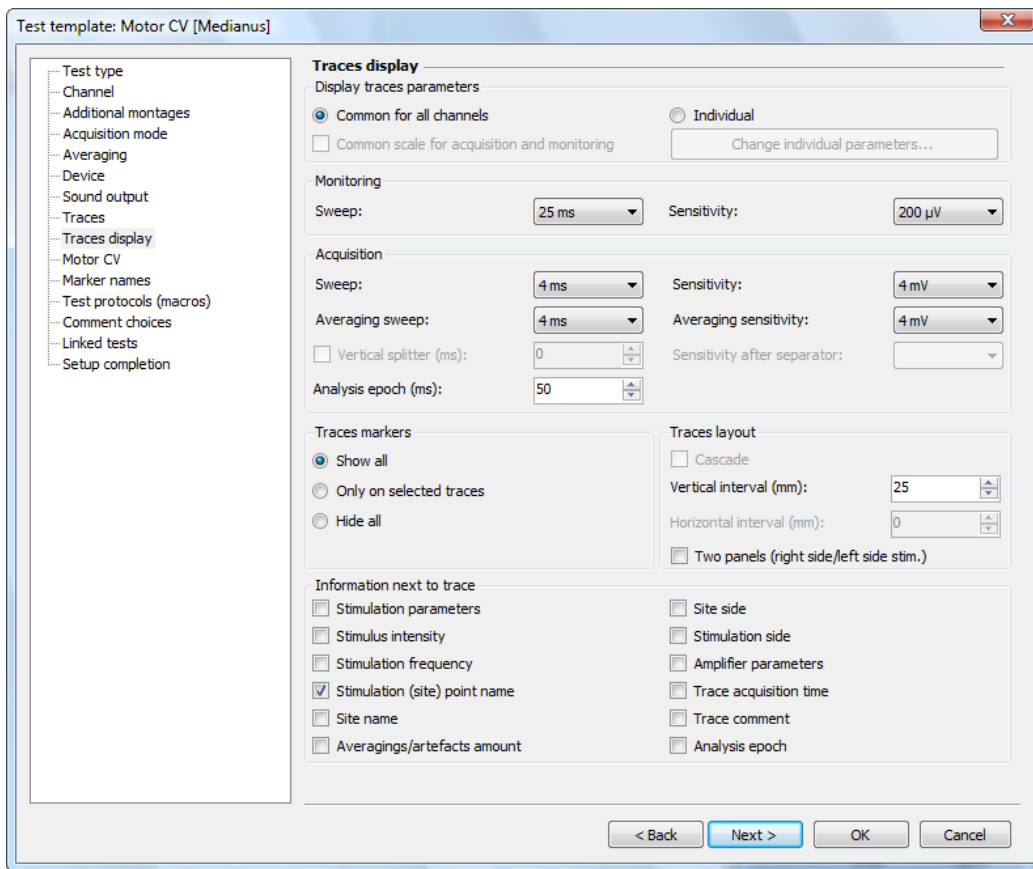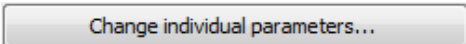


Fig. 2.56

"Display traces parameters".

*"*Common for all channels". Commonly shown parameters (sensitivity, sweep, analysis epoch) for all traces of the test.

"Individual". Individual parameters for vertical scale (sensitivity) and analysis epochs can be set for each channel. Sensitivity changing commands only impact the selected traces in the window. To set the individual parameters by default, press the

 button.

*"*Common scale for acquisition and monitoring". If the check box is selected, scale changing in the acquisition and monitoring windows takes place at the same time. If the check box is not selected, the synchronous scale changing only takes place in the active window.

"Monitoring".

*"*Sweep. Sensitivity". Sweep and sensitivity values in the monitoring window by default.

*"Acquisition"*.

*"Sweep. Sensitivity"*. Sweep and sensitivity values in the monitoring window by default.

*"Averaging sweep. Averaging sensitivity"*. Sweep and sensitivity values for averaged traces (if the average mode is used).

*"Vertical splitter"*. When the screen is divided into two parts with different sensitivities, the vertical splitter is used. For example, it is used at F-wave acquisition.

*"Sensitivity after separator"*. Sensitivity at the right of the vertical splitter.

*"Analysis epoch (ms)"*. Analysis epoch duration, i.e. recorded trace duration. For free record mode (Fig. 2.49) this value determines the maximal trace length as in this mode the trace acquisition can be stopped at any moment.

*"Traces markers"*. Traces markers display mode. The "Show all" variant is most commonly used. If there are too many markers and the scanning of traces is difficult, you can use the "Only on the selected traces" mode.

*"Traces layout"*.

*"Cascade"*. If the check box is selected, the traces with "image transfer" are displayed, i.e. the traces which don't fit to the view window width are transferred to a new "line".

"Vertical interval (mm)". Vertical distance between traces by default. After new traces acquisition, you can change trace position by dragging it with the mouse.

*"Horizontal interval (mm)"*. Horizontal distance between traces in a series. It is used at repetitive stimulation acquisition.

"Two panels (right side/left side stim.)" – the display of traces on two panels located side-by-side: one contains traces received at right side stimulation, the other one at left side stimulation.

"Information next to trace". Various additional information displayed at the right of the trace.

## 2.7.1.11. Marker Names on Traces

On the *"*Marker names*"* page (Fig. 2.57) trace settings are displayed.



| Default name | New name | Visibility on the trace | Description (comment) |
|---|---|---|---|
| 1 | | ☑ | M-wave onset |
| 2 | | ☑ | Negative peak |
| 3 | | ☑ | Negative peak end |
| 4 | | ☐ | Positive peak |
| 5 | | ☐ | M-wave end |
| F1 | | ☑ | F-wave onset |
| F2 | | ☑ | Negative peak |
| F3 | | ☐ | Negative peak end |
| F4 | | ☑ | Positive peak |
| F5 | | ☑ | F-wave end |
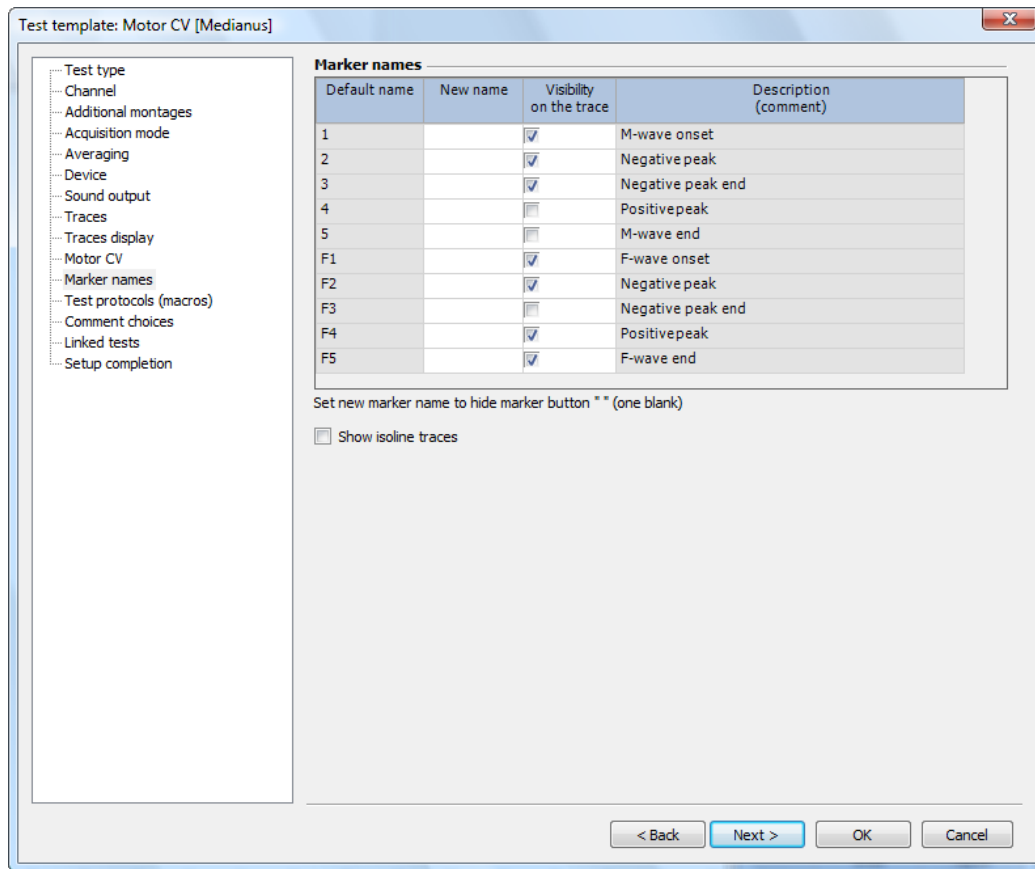
Fig. 2.57

*"*Default name*"*. Default marker name in the program.

"New name*"*. If you would like to change the marker name by default, enter a new name in this line. If you prefer to display the marker as a short line, set one empty space instead of marker name.

 *"*Visibility on the trace*"*. Marker display (presentation) on the trace.

"Description (comment)*"*. Marker type description for its identification.

"Show isoline traces". If the check box is selected, a dashed isoline will be displayed on the trace (horizontal line drawn through wave beginning marker).

### 2.7.1.12. Test Macros (Macros)

On the *"Test protocols (macros)"* page (Fig. 2.58) there are script settings for automating traces acquisition. A protocol is a sequence of menu commands executed either at a specified time or in certain sequence.
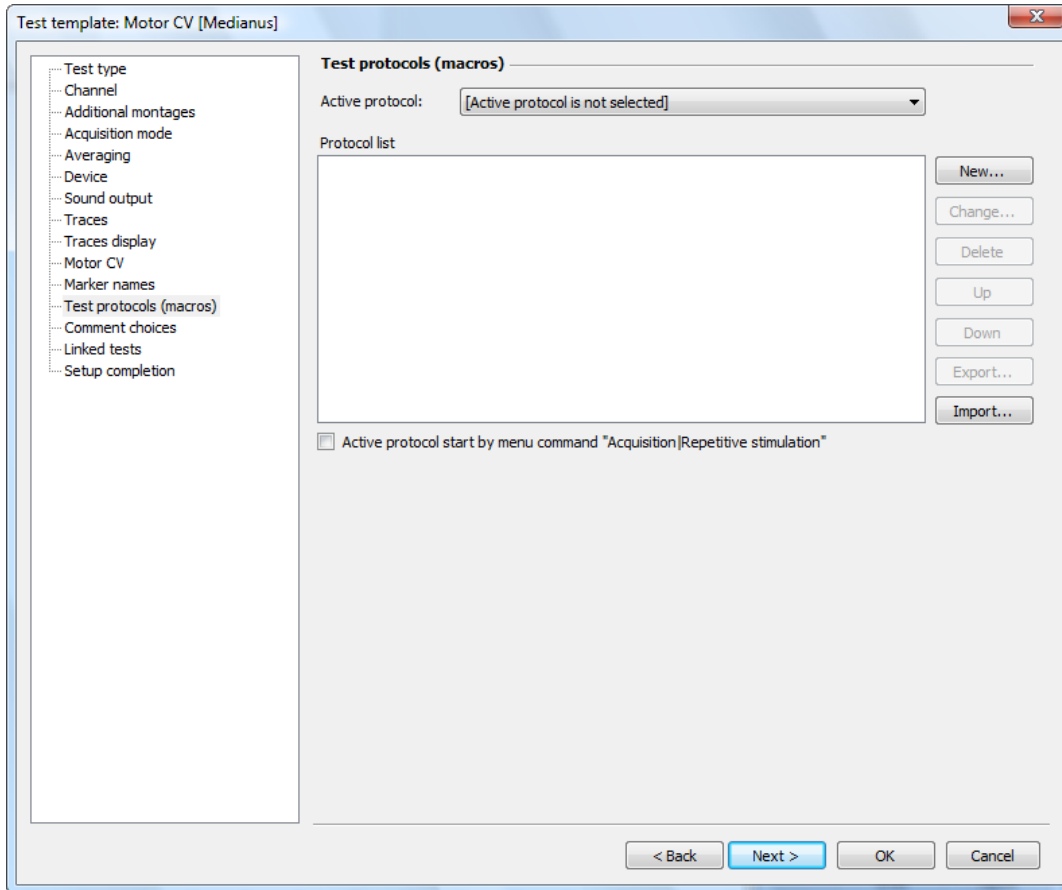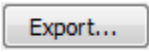


Fig. 2.58

*"Active protocol"*. Protocol name by default (active protocol after starting a new test).

*"Protocol list"*. The list of all protocols in the test template. To edit protocols use the buttons at the right of the list.

"Active protocol start by menu command "Acquisition|Repetitive stimulation". If this check box is selected, the execution of the menu command **Acquisition|Repetitive stimulation** will be replaced by the menu command **Acquisition|Protocol start.** To start protocols easily, use the dedicated keyboard.

The buttons [Export...] and [Import...] allow you to export (import) the macros to an external file (from external file) which provides the opportunity to both transfer files from one computer to another and to copy them from a template of one test to a template of another test.

## 2.7.1.13. Comments Choices/Windows Layout

"Comment choices" page (Fig. 2.59).
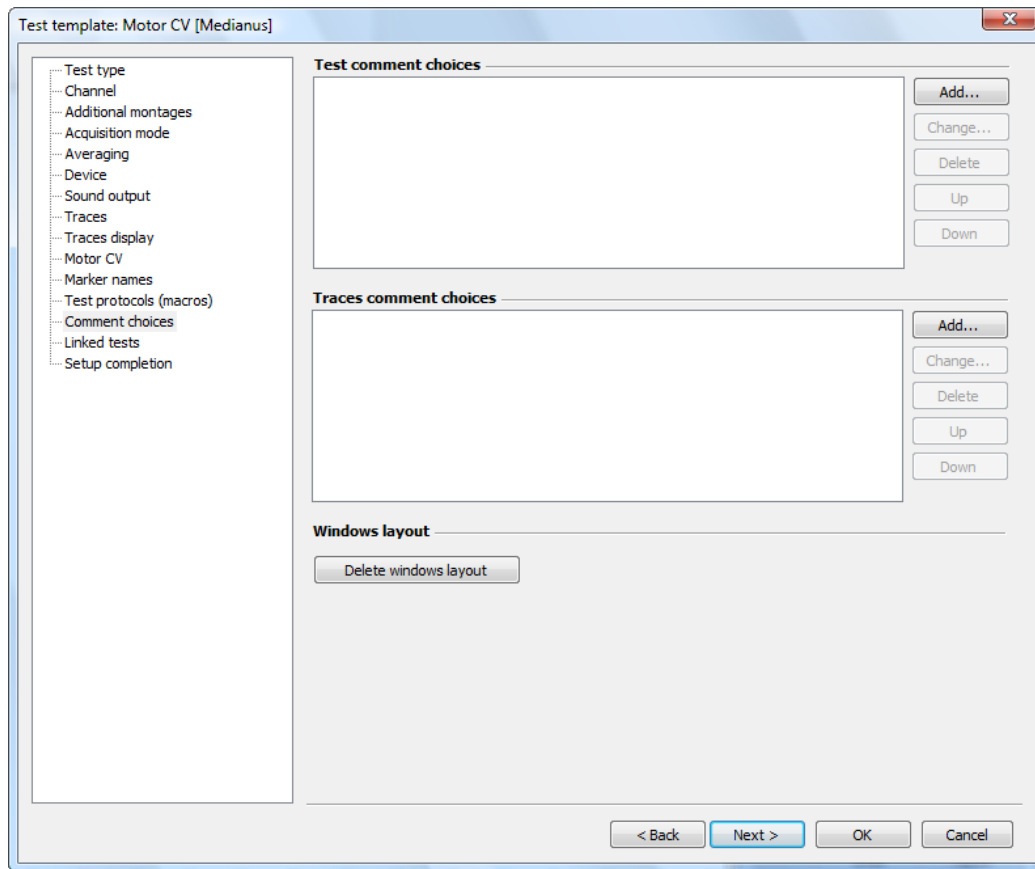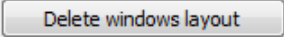


Fig. 2.59

*"Test comment choices".* Preset comment choices. To quickly set one of the choices, click the right mouse button on the "Comment" panel and select a comment from the local menu (Fig. 2.16, the upper part of the window).

*"Traces comment choices".* Preset comment choices. To quickly set one of the choices, click the right mouse button on the trace and select the comment from the local menu.

*"Windows layout".*

*"The* [Delete windows layout] *button".* To delete a window layout from a test template. This button is also useful when there is a windows layout error. For example, if you save a windows layout incorrectly, it may be necessary to delete the layout and create a new one.

## 2.7.1.14. Linked Tests

On the "Linked tests" page (Fig. 2.60) there is the linked tests list.
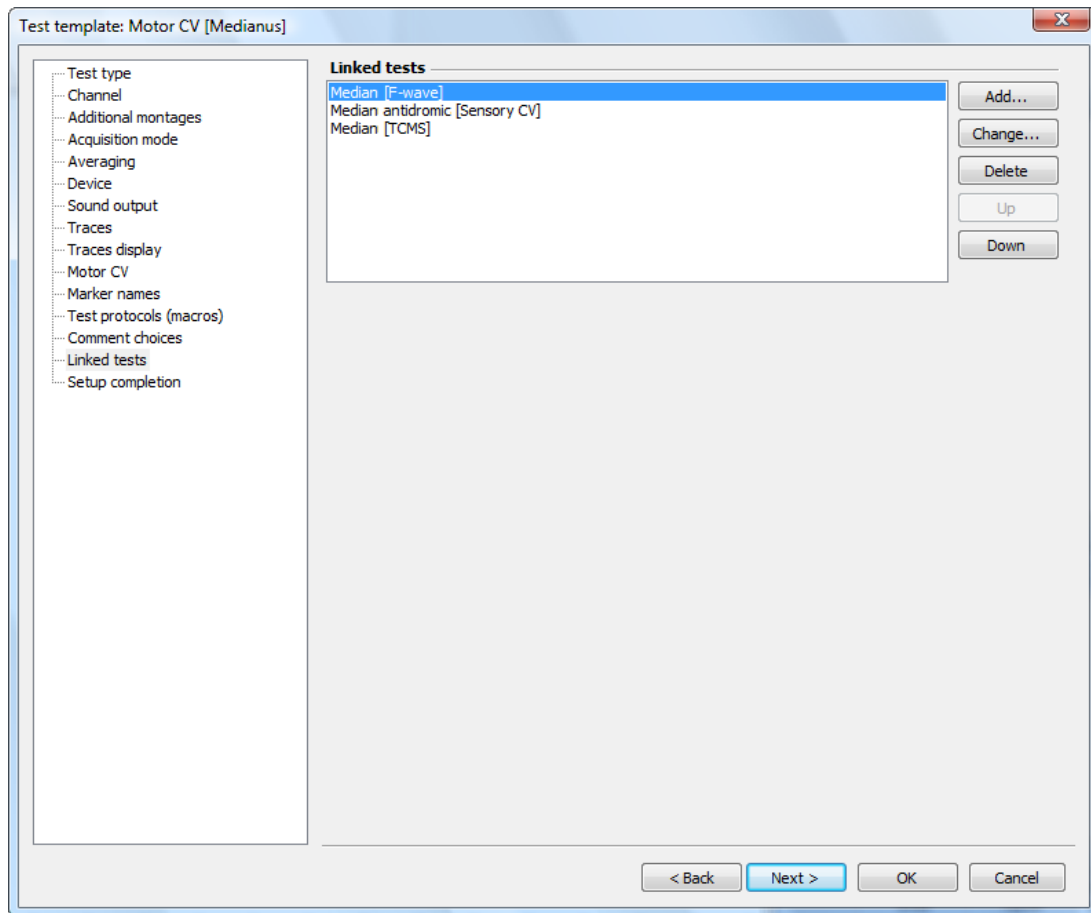


Fig. 2.60

If nothing is selected on the list, a default template will be automatically selected when going to the linked test.

## 2.7.1.15. Setup Completion

The last page of the test template wizard (Fig. 2.61).
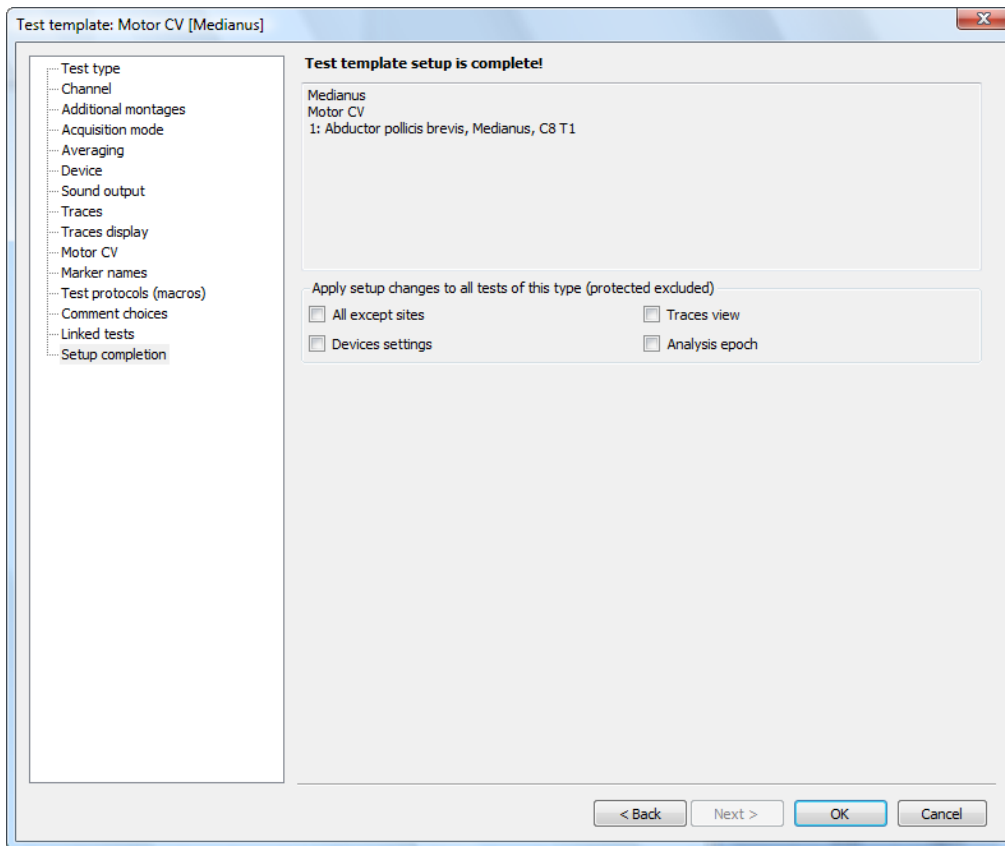


Fig. 2.61

*"Apply setup changes to all tests of this type (protected tests are excluded)"*. If the check boxes are selected, settings of the template will be copied onto all the templates of the technique (for example, into all the templates of **Motor CV** technique). The settings are not copied onto tests templates in which the *"Protect from overwrite in group operations"* check box is selected (Fig. 2.45).

"All except sites". If the check box is selected, all the template settings, except the selected sites, will be copied.

*"Traces view"*. If the check box is selected, traces scales by default, markers types and information near traces will be copied.

*"Devices settings"*. If the check box is selected, all the devices settings (input ranges, filters, stimulators settings) will be copied.

*"Analysis epoch"*. If the check box is selected, the duration of analysis epoch will be copied.

## 2.7.2. Exam Templates

An exam template is a list of tests (techniques) templates that speeds up the exam according to a predetermined plan. To create new templates or edit existing ones, use the button (Fig. 2.40).

In the "Exam templates" dialog box (Fig. 2.62) there is a list of all the exam templates available in the program.
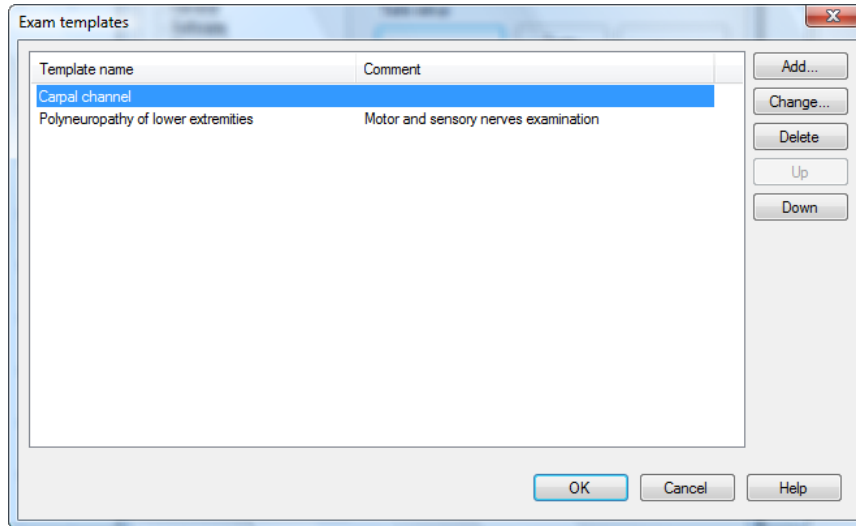


Fig. 2.62

To change the exam templates list, use the buttons at the right of the list.

The selection of an exam template can be done in the "New exam" dialog box (see Fig. 2.4). To select an exam template, after creation of a new exam, use either the menu command **Exam|Exam templates** or click the button with the mouse (Fig. 2.63).
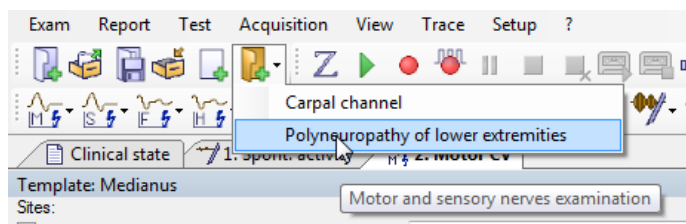


Fig. 2.63

A new test from the exam template will be created automatically. To create the next test from the exam template list, use the menu command **Test|Next.** You can select any new test from the exam template using the menu command **Test|New (exam template)** or include a new test that is not on the exam template list by using the menu command **Test|New**.

## 2.7.3. User Input of Reference Values

To input your own reference values, select the submenu "Reference values" under the menu command **Setup** (see Figure 2.66).
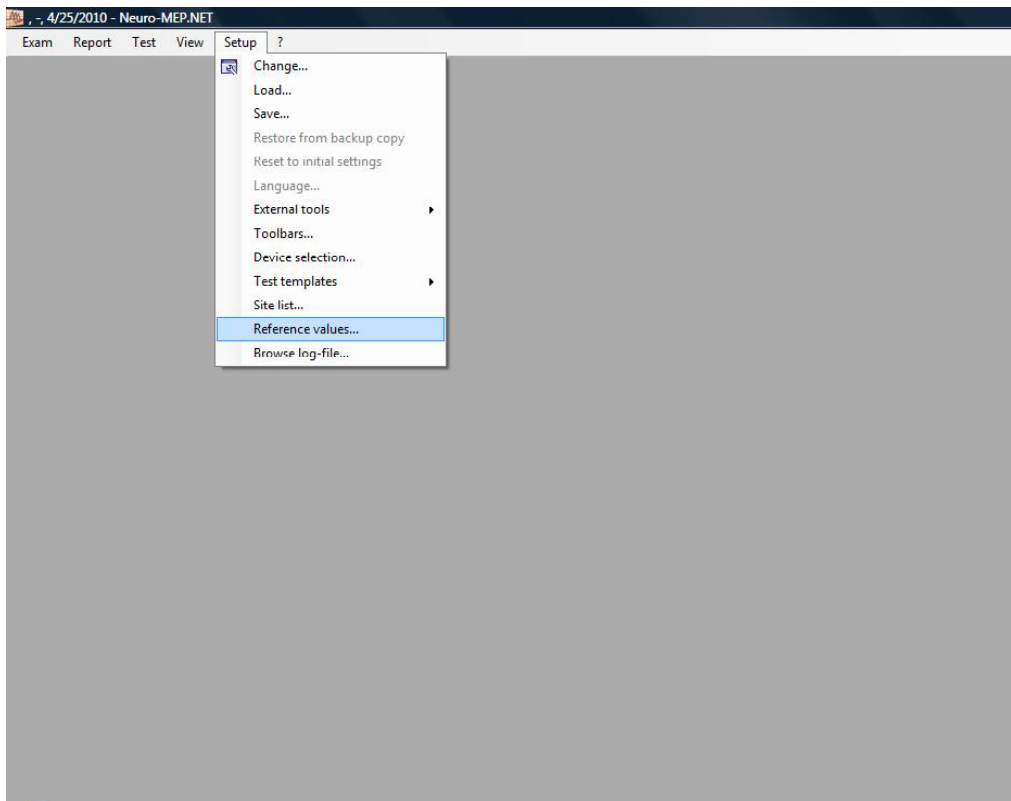


Fig. 2.64

When you select the submenu "Reference values" you will be presented with the screen below (Figure 2.67) where you can input your reference values:
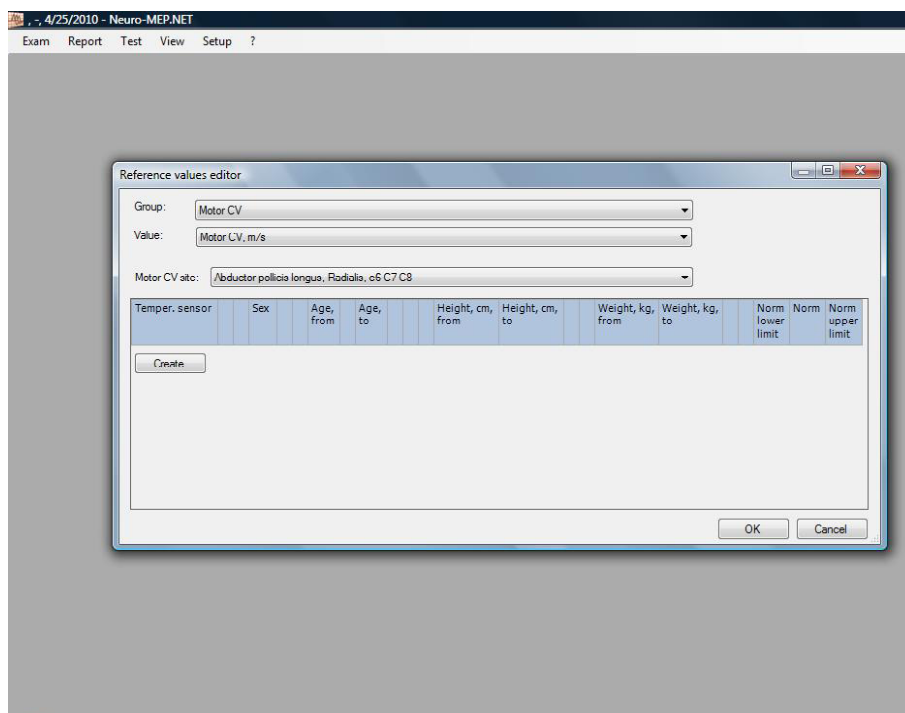


Fig. 2.67

The program gives you the option to input reference values according to age, sex, height or weight should you chose to do so. If you don't specify any of the above variables, the program will compare the study results to the set you entered without taking these variables into account.

Inputting your normal values allows you to compare your study results to your normals database and paste the results on to your report. Be sure to verify that the checkbox "Use reference (norm) values" in the menu command **Setup|Change** under the "Software" submenu (see Figure 2.41). If the checkbox is not selected, the reference to your norms will neither be displayed nor pasted to your study report.

# 3. Electroneuromyography (EMG)

## 3.1. EMG-Electrodes Marking

Surface EMG-electrodes are marked in different colors (Fig. 3.1). The active electrode (negative, "-") is marked in black (1 on the picture), the passive electrode (positive, "+") is marked in red (2 on the picture), and the ground electrode is marked in green (3 on the picture).

Similar markings are used for the finger stimulating electrodes (Fig. 3.1).
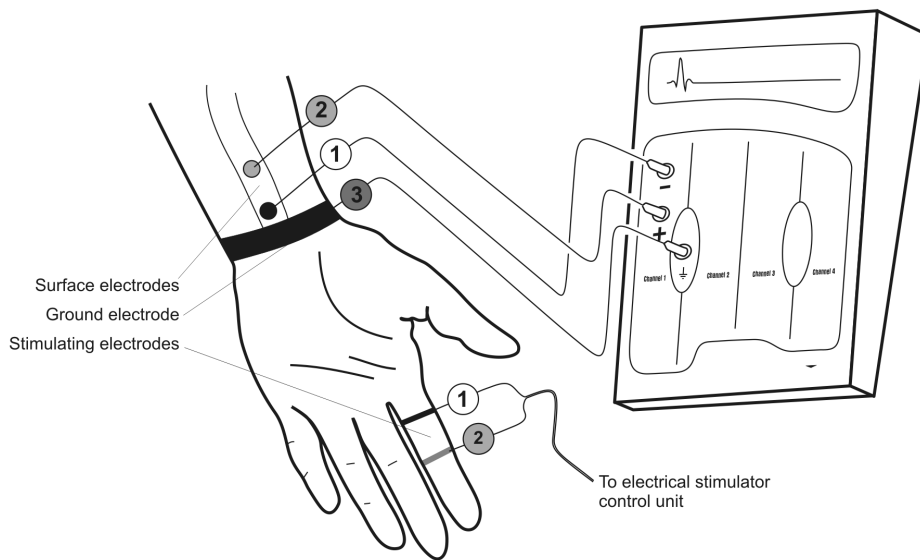


Fig. 3.1

The cathode (negative terminal) of the electric stimulator has a special marking (cross, point etc.). The following markings appear on the electric stimulator (Fig. 3.2): on the site side – positive (anode), on the opposite side – negative (cathode).
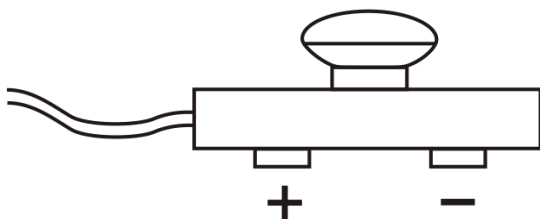


Fig. 3.2

# 3.2. Motor Conduction Velocity

## 3.2.1. M-Wave Acquisition

To conduct a **motor conduction velocity** test, press the  button on the "New test" toolbar and select the name of a test template from the dropdown list (Fig. 3.3). If you are unable to locate the test you need, use the menu item **Test|New** and select a default test template.
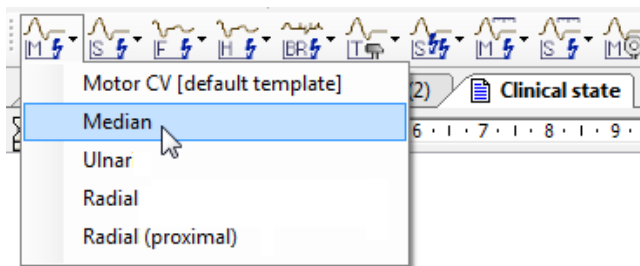


Fig. 3.3

Connect the electrical stimulator to the control unit.

Place the skin temperature sensor (if available and selected in the test template) on the patient's skin over nerve under examination. The temperature will be displayed on the information panel (Fig. 3.4) and saved with each M-wave during its recording.
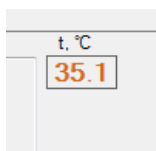


Fig. 3.4

Measure the impedance by selecting the menu command **Acquisition|Impedance**, pressing **[Ctrl+Z]** or using the button on the dedicated keyboard). Place electrodes on the patient and connect them to the amplifier input. When you reach the desired impedance level, close the impedance measurement window by pressing the **[Esc]** key.

Set the required initial value of electrical stimulus by selecting the menu items **Acquisition|Stimulus|Increase** and **Acquisition|Stimulus|Decrease** or by using the dedicated keyboard. Place the electrical stimulator over the nerve under examination.

Start the single stimulation by selecting the menu item **Acquisition|Acquisition/Stimulus** or by using the corresponding button on the dedicated keyboard (Fig. 3.5). If you do not get the required M-wave, try changing the stimulus intensity or moving the stimulator until you get the acceptable result. To start repetitive stimulation, use the menu item **Acquisition|Repetitive stimulation** (or by the corresponding button on the dedicated keyboard). Displayed on top of the acquisition window are the following: current amplitude of M-wave in millivolts (mV) (if the value is not normal, it will be displayed in red color provided you have inputted your normal values as described above), the increment of amplitude in comparison with the previous stimulus (displayed only after the second stimulus), latency and duration of the recorded M-wave in milliseconds (ms) (Fig. 3.5). The trace of the previous stimulus is displayed on the screen in grey color.
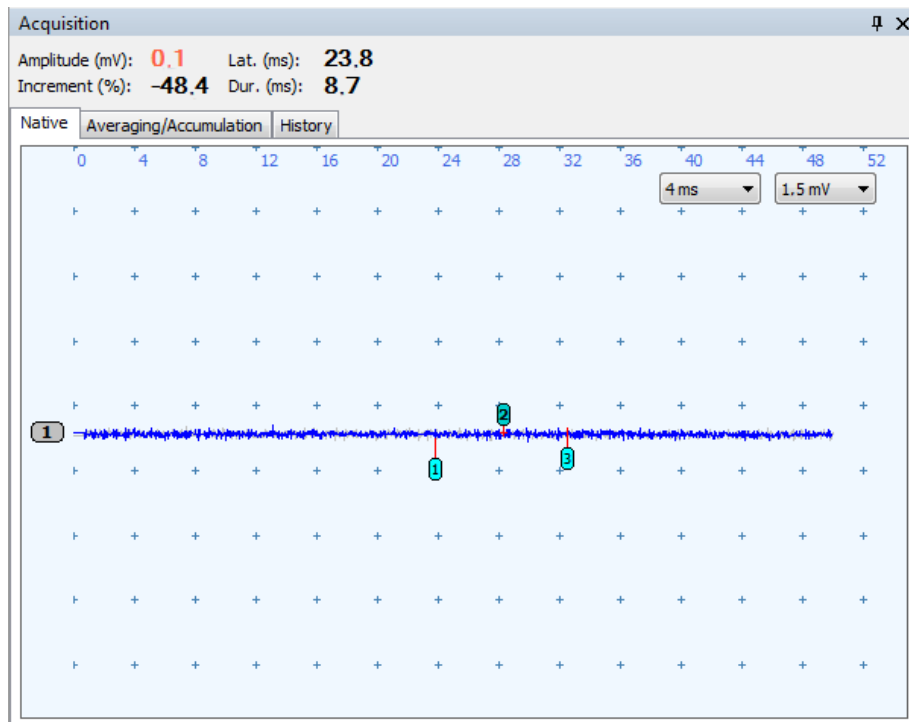


Fig. 3.5

If the message "Stimulus differs from the specified one" or "Open circuit of electric stimulator" appears, check the stimulating electrode connection to the electric stimulator and place it more carefully.

When you reach a supramaximal stimulus strength and a satisfactory M-wave, finish the acquisition and save the M-wave for further analysis by selecting the menu item **Acquisition|Stop** (or by the corresponding button on the dedicated keyboard) or press **[Esc]** to delete.

After you save the M-wave, enter the stimulation-site distance from the computer or dedicated keyboard. With the Focus device, change the distance value for 1 mm by

turning the **Sweep** knob and change the distance value for 10 mm by turning the "Sensitivity" knob.

To enter or correct the value distance later on, use the menu command **Test|Conduction distance input (\[F2\])** or click on the distance input field.

The input of standard distances is possible for each stimulation point. This option is set in the test template (Fig. 3.8).

Move the current electrode to a new stimulation point and repeat the procedure.

Traces are usually recorded sequentially from a distal point to a proximal point. If the reversal recording order was used (from proximal to distal point) or traces were recorded in an irregular order, you can use either the menu command **Trace|Sort by latency** or the **Sort by latency** local menu to change the trace order.

If you need to mark or rerecord a trace, use either the menu command **Trace|Mark for overwrite** or the **Mark for overwrite** local menu. In this case the marked trace will be replaced by the current recorded trace. If the most recently recorded M-wave is poor, it is easier to delete the trace using the menu command **Trace|Delete** (**\[Ctrl+Del\]**) or the local menu command **Delete trace**.

A situation can occur where you record an M-wave of good quality but still try to record a better one. If the new results turn out to be worse than the previous, you can go to the "History" page of the acquisition window (Fig. 3.5), and select **Take into analysis** from the local menu to find and keep the best M-wave.

If the M-wave is not found on the trace automatically (very low amplitude), you can conduct a manual search by using the mouse cursor – press **\[Alt\]** and while holding it, click the left mouse button on the suspected wave location.

If the markers are placed inaccurately, you can override them with the mouse.

On the M-wave there can be 5 markers of the feature points:

1 – wave onset marker;

2 – negative peak marker;

3 – marker of negative peak end (if M-wave amplitude measurement is carried out according to the negative peak, this marker is also considered to be the wave end marker);

4 – positive peak marker;

5 – wave end marker.

M-wave amplitude measurement is usually carried out according to the negative peak, so that markers 4 and 5 are not displayed.

In the **Motor CV** test, you can study the F-wave together with M-wave. To select F-wave on the trace, place the mouse cursor on it, press the **[Alt]** key and, while holding it, press the left mouse button. If the F-wave analysis table (Fig. 3.13) does not appear, use the menu command **View|Analysis tables|F-wave parameters**.

After recording several traces, the test window will look as follows (Fig. 3.6).
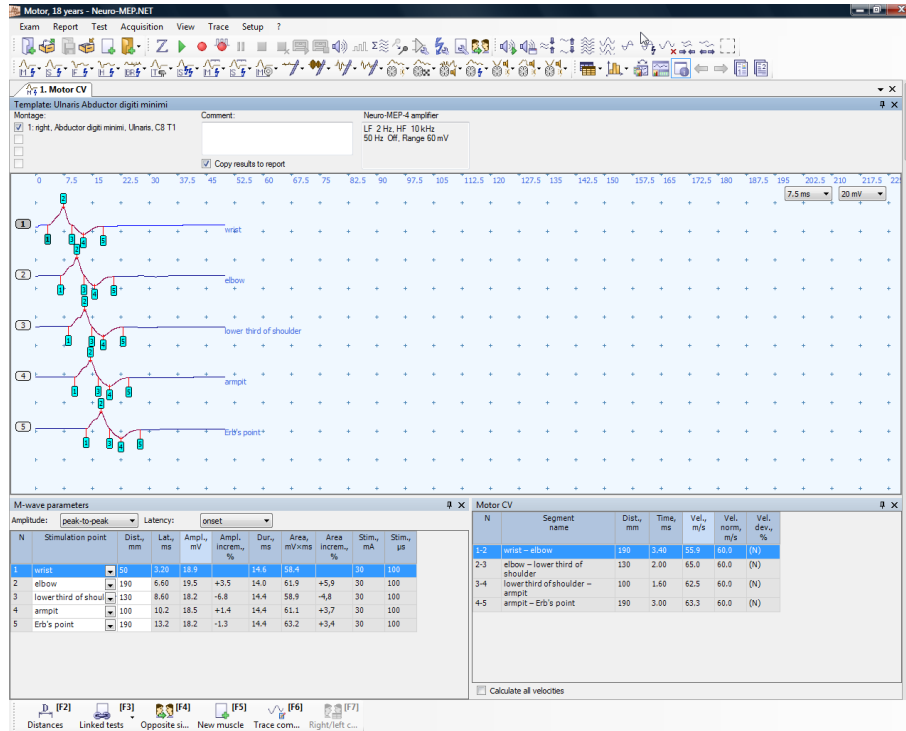


Fig. 3.6

After switching the windows layouts by the menu command **View|Windows layouts|Switch** (**[Ctrl+Tab]**), the test window will look as follows (Fig. 3.7).
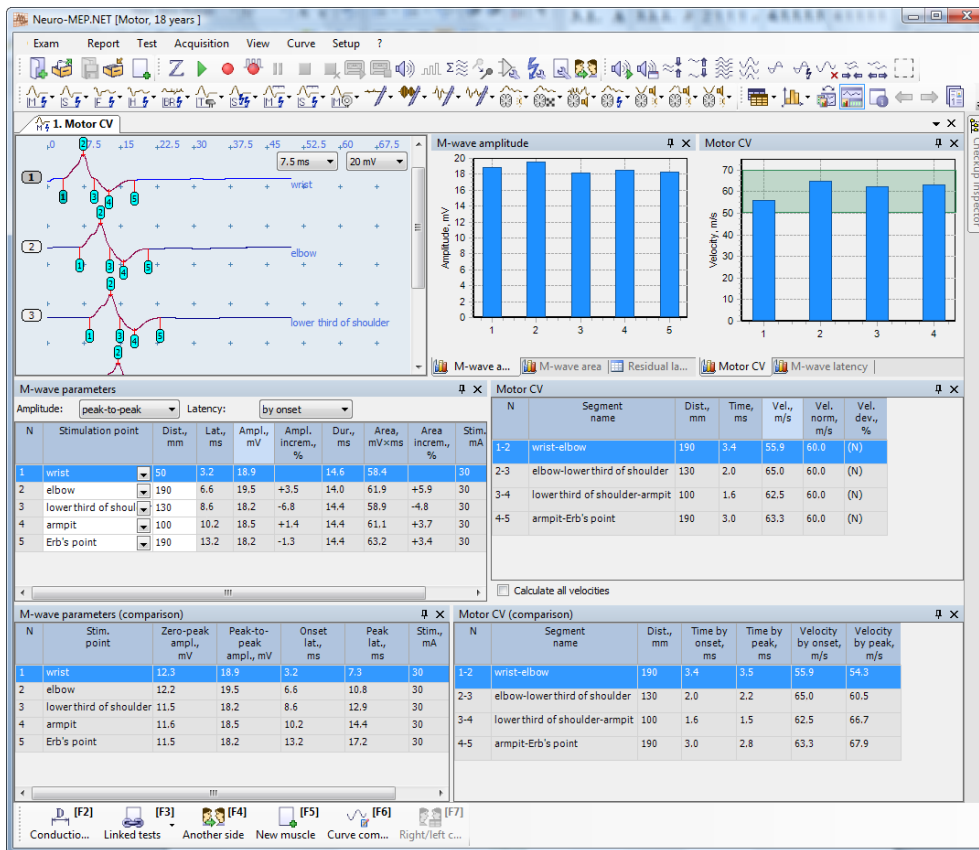


Fig. 3.7

To preset a test template, use the menu command **Setup|Tests templates|Setup**. The *"Motor CV"* page of the test template wizard contains the following information (Fig. 3.8).
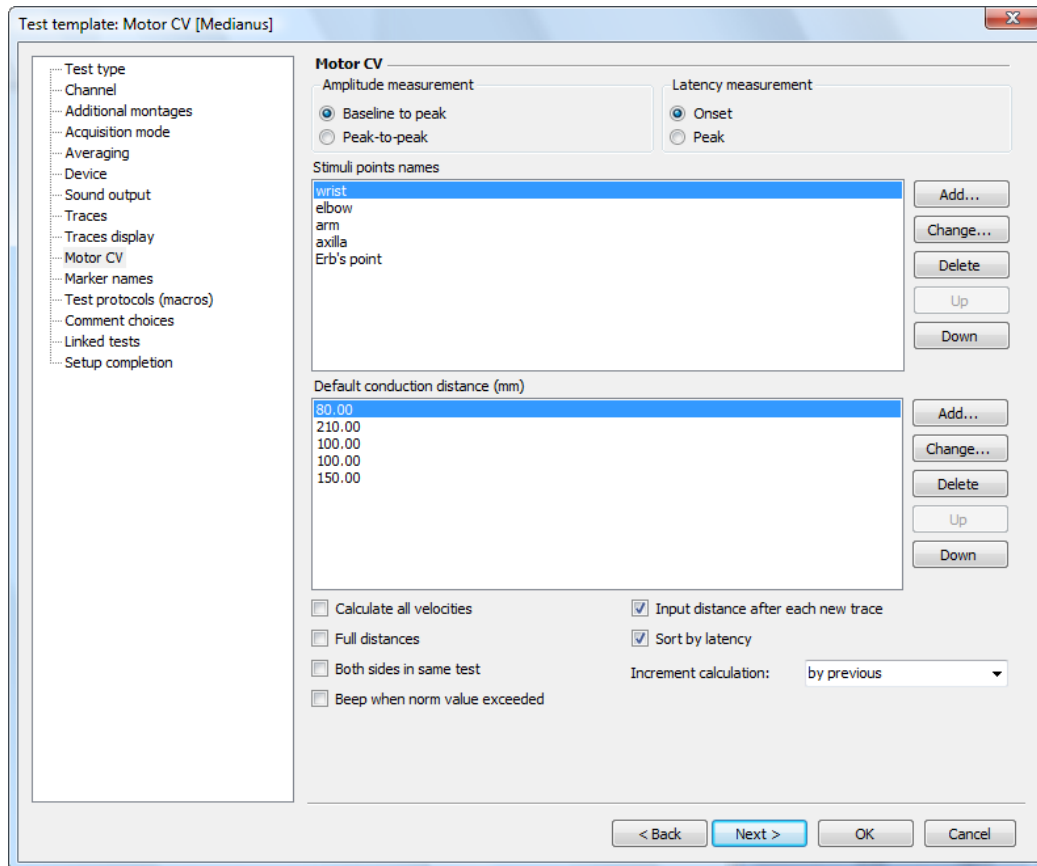


Fig. 3.8

*"Amplitude measurement"*. The method of M-wave amplitude measuring after a new test has been created. This value can be changed during the analysis (see comments to Fig. 3.9).

*"Latency measurement"*. The method of M-wave latency measuring after a new test has been created. This value can be changed during the analysis (see comments to Fig. 3.9).

*"Stimuli points names"*. Stimuli points (sites) names by default according to traces acquisition. These names are given to new traces automatically when they are recorded but the names can be changed later.

*"Default conduction distance (mm)"*. Default distances in millimeters. They are given automatically to new traces when they are recorded but they can be changed later.

"Calculate all velocities". See comment to Fig. 3.10.

*"Full distances"*. If the check box is selected, distances are interpreted as full distances from the stimulation point to the site point. If the check box is not selected, conducting distances are interpreted as distances from the stimulation point to the previous stimulation point (for the first trace – in relation to the site point).

*"Both sides in same test".* If the check box is selected, a new test is not created by the menu command **Test|Change side.** Using this menu command, you can switch the site side in the current test and perform the exam from both sides in one test. In the last case it is recommended that you make visible the "Site" column in the "M-wave parameters" (Fig. 3.9) and "Motor CV" (Fig. 3.10) tables to display the site side.

*"Beep when norm value exceeded".* If the checkbox is selected, the computer will make a beeping sound when an M-wave exceeds the maximum amplitude norm during signal acquisition (provided you have inputted your reference values as described above).

*"Input distance after each new trace".* If the check box is selected, the input will go to the distance input box and will start immediately when keyboard or encoders of the device keyboard are used. If the distances are entered after acquisition or to use distances by default, uncheck the box.

*"Sort by latency".* If the check box is selected, the conduction velocity calculation of traces is carried out in increasing order of M-wave latency instead of in the order of acquisition. It is important to do this in cases where the acquisition is performed from proximal segments to distal ones.

"Increment calculation". The calculation of amplitude increment is performed either by the previous or by the very first trace.

## 3.2.2. Analysis Windows

If you have inputted your set of normal values, the "M-wave parameters" analysis window contains the following information (Fig. 3.9). Please note that no comparison will be displayed or pasted into your report if no normal values were inputted.

| N | Site | Stimulation point | Dist., mm | Lat., ms | Lat. norm, ms | Lat. dev., % | Ampl., mV | Ampl. increm., % | Ampl. norm, mV | Ampl dev., % | Dur., ms | Dur. norm, ms | Dur. dev., % | Area, mV×ms | Area increm., % | Stim., mA | Stim., µs | t, °C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | right, Abductor digiti minimi, Ulnar, C8 T1 | wrist | 50 | 3.20 | | | 18.9 | | | | 14.6 | | | 58.4 | | 30 | 100 | |
| 2 | | elbow | 190 | 6.60 | | | 19.5 | +3.5 | | | 14.0 | | | 61.9 | +5.9 | 30 | 100 | |
| 3 | | lower third of shoul | 130 | 8.60 | | | 18.2 | -6.8 | | | 15.4 | | | 58.4 | -5.7 | 30 | 100 | |
| 4 | | armpit | 100 | 10.2 | | | 18.5 | +1.4 | | | 14.4 | | | 61.1 | +4.7 | 30 | 100 | |
| 5 | | Erb's point | 190 | 13.2 | | | 18.2 | -1.3 | | | 14.4 | | | 63.2 | +3.4 | 30 | 100 | |

Fig. 3.9

*"N"* – trace number (name).

"Site" – site side and name.

"Stimulation point" – name of stimulation point. By default, each test template contains a list of stimulation points that are displayed automatically in this field. You can select any other stimulation point from the dropdown list or enter a new one.

"Dist., mm" – conduction distance in millimeters. By default, each test template contains a distance list that is displayed automatically in this field. For the first trace, the distance from stimulation point to site one, is entered in this field. For the second

trace and the following ones it is necessary to enter the distance from the stimulation point of the current trace to the previous stimulation point.

"Lat., ms" – M-wave latency in milliseconds. Latency is measured either by M-wave onset or by the negative peak according to the value set in the *Latency* dropdown list on the top of the window (Fig. 3.9). By default, the value for the latency calculation method is set in the test template.

"Lat. norm, ms" – M-wave latency norm, in milliseconds (ms). It is usually used for short nerve segments with only one stimulation point.

"Lat. dev., %" – latency deviation from norm in percents.

"Ampl., mV" – M-wave amplitude in millivolts. The amplitude is measured either from peak to peak or only by negative peak according to the value set in the *Amplitude* dropdown list on the top of the window (Fig. 3.9). By default, the value for amplitude calculation method is set in the test template.

"Ampl. norm, mV" – M-wave amplitude norm in millivolts.

"Ampl. dev., %" – amplitude deviation from norm in percents.

"Dur., ms" – M-wave duration in milliseconds. Duration depends on the amplitude measuring method. If the amplitude is measured by "peak-to-peak" method and all 5 markers of M-wave are present, then all the wave phases are included in the duration. If the amplitude is measured by "baseline-negative peak" method, the duration is calculated only by the negative peak.

"Dur. norm, ms" – M-wave duration norm in milliseconds.

"Dur. dev., %" – M-wave duration deviation from norm in percents.

"Area, mV×ms" – area under M-wave in mVxms. Calculated area depends on the M-wave amplitude measuring method.

"Stim., mA" – stimulus intensity at which the current M-wave is received in milliamperes.

"Stim., µs" – stimulus duration at which the current M-wave is studied in microseconds.

"t, °C" – skin temperature recorded from the skin temperature sensor during M-wave recording in Celsius degrees.

The "Motor CV" analysis window contains the following information (Fig. 3.10).

Fig. 3.10

"N" – trace numbers (names) for which the conduction time is calculated.

"Site" – site side and name.

"Segment name" – names of stimulation points between which the conduction velocity is calculated.

"Dist., mm" – distance between stimulation points in millimeters.

"Time, ms" – conduction time between stimulation points in milliseconds.

"Vel., m/s" – motor conduction velocity in meters per second.

"Vel. norm, m/s" – conduction velocity norm in meters per second (when user inputted norms are available).

"Vel. dev., %" – conduction velocity deviation from norm in percents (when user inputted norms are available).

"Calculate all velocities" – if the check box is not selected, only sequential segments will be calculated. If the check box is selected, the calculation will be made for all segments.

The "M-wave parameters (comparison)" analysis window allows comparing amplitudes and latencies at various measuring methods and contains the following information (Fig. 3.11).



Fig. 3.11

"N" – trace number (name).

"Site" – site side and name.

"Stim. point" – name of stimulation point.

"Onset lat., ms" – M-wave latency by wave onset marker in milliseconds.

"Peak lat., ms" – M-wave latency by negative peak marker in milliseconds.

"Baseline-to-peak ampl., mV" – M-wave amplitude by negative peak measuring in millivolts.

"Peak-to-peak ampl., mV" – M-wave amplitude by peak-to-peak measuring in millivolts. To make the correct calculation of this value, both negative peak (2) and positive peak (4) markers must be positioned on the trace.

"Baseline-to-peak area, mV×ms" – area under M-wave at the measurement by negative peak, in millivolts per millisecond.

"Peak-to-peak area, mV×ms" – area under M-wave at the measurement from peak-to-peak, in millivolts per millisecond. For the correct calculation of the given value both negative peak (2) and positive peak (4) markers should be positioned on the trace.

"Stim., mA" – stimulus intensity at which the current M-wave is studied in milliamperes.

"Stim., μs" – stimulus duration at which the current M-wave is studied in microseconds.

The "Motor CV (comparison)" analysis window allows comparing conduction velocities at various methods of latency measuring and contains the following information (Fig. 3.12).

| **Motor CV (comparison)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| N | Site | Segment name | Dist., mm | Onset lat., ms | Peak lat., ms | Onset velocity, m/s | Peak velocity, m/s |
| 1-2 | right, Abductor digiti minimi, Ulnar, C8 T1 | wrist – elbow | 190 | 3.40 | 3.50 | 55.9 | 54.3 |
| 2-3 | | elbow – lower third of shoulder | 130 | 2.00 | 2.15 | 65.0 | 60.5 |
| 3-4 | | lower third of shoulder – armpit | 100 | 1.60 | 1.50 | 62.5 | 66.7 |
| 4-5 | | armpit – Erb's point | 190 | 3.00 | 2.80 | 63.3 | 67.9 |

Fig. 3.12

"N" – trace numbers (names) for which the conduction velocity is calculated.

"Site" – site side and name.

"Segment name" – name of stimulation points between which the conduction velocity is calculated.

"Dist., mm" – distance between stimulation points in millimeters.

"Time by onset, ms" – conduction time between stimulation points according to M-wave onset markers in milliseconds.

"Time by peak, ms" – conduction time between stimulation points according to M-wave negative peak markers in milliseconds.

"Velocity by onset, m/s" – motor conduction velocity at latency measuring by M-wave onset in meters per second.

"Velocity by peak, m/s" – motor conduction velocity at latency measuring by M-wave negative peak in meters per second.

The "F-wave parameters" analysis window contains the following information (Fig. 3.13).

| F-wave parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Lat. F, ms | Ampl. F, µV | Area F, nV×s | Ampl., F/M, % | Area F/M, % | F periph. lat., ms | Flat.-M lat., ms | Stim.-vertebra dist, mm | V pr., m/s |
| 24.95 | 734.0 | 2924.0 | 3.8 | 4.7 | 15.27 | 18.35 | 0 | |

Fig. 3.13

"Lat. F, ms" – F-wave latency in milliseconds.

"Ampl. F, µV" – F-wave amplitude in microvolts.

"Area F, nV×s" – area under F-wave in nanovolts per second.

Ampl., F/M, % – F-wave and M-wave amplitudes ratio in percents.

Area F/M, % – F-wave and M-wave areas ratio in percents.

"F periph. lat., ms" – F-wave peripheral latency in milliseconds.

"Flat.-M lat., ms" – the difference between F-wave and M-wave latency in milliseconds.

"Stim.-vertebra dist., mm" – the distance from the stimulation point to the corresponding vertebra to calculate proximal conducting speed in millimeters. To enter or correct the distance, click on this field and enter the distance.

In case there are two **Motor CV** tests in which similar muscles from the different body sides are examined, the comparison window **Motor CV (right/left)** can be displayed on the screen by selecting the menu command **Test|Comparison right/left** (Fig. 3.14).
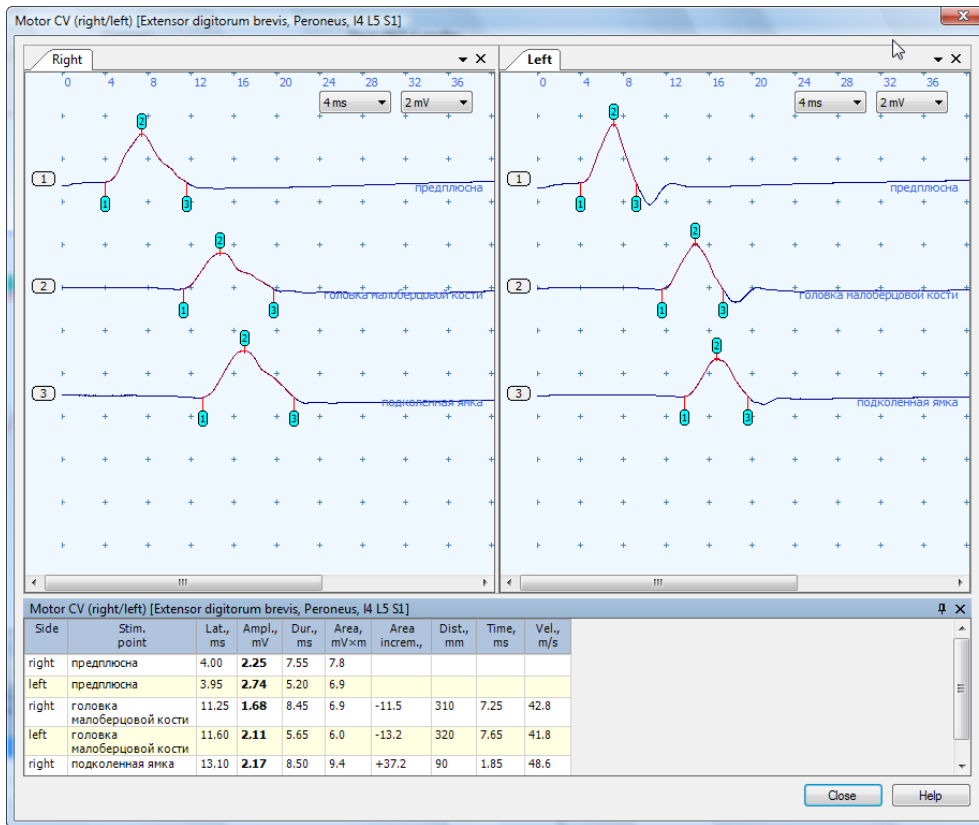
Fig. 3.14

"Side" – stimulation (site) side.

"Stim. point" – stimulation point name.

"Lat., ms" – M-wave latency in milliseconds.

"Ampl., mV" – M-wave amplitude in millivolts.

"Dur., ms" – M-wave duration in milliseconds.

"Area, mV×ms" – area under M-wave in millivolts per milliseconds.

"Dist., mm" – the distance between stimulation points in millimeters.

"Time, ms" – the conducting time between stimulation points in milliseconds.

"Vel., m/s" – motor conduction velocity in meters per second calculated for the area between the current and the previous stimulation points.

The "M-wave amplitude" analysis window (Fig. 3.15) contains the graph of M-wave amplitude dependence on a stimulation point number.

Fig. 3.15

The "M-wave area" analysis window (Fig. 3.16) contains a graph of the M-wave area dependence on a stimulation point number.



Fig. 3.16

The "Motor CV" analysis window (Fig. 3.17) contains the graph of motor conduction velocity dependence on a segment number. The fill area corresponds to user inputted normal values.
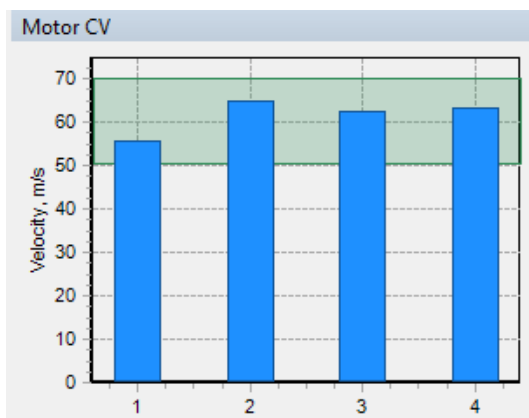


Fig. 3.17

The "M-wave latency" analysis window (Fig. 3.18) contains the graph of M-wave latency dependence on a stimulation point number.
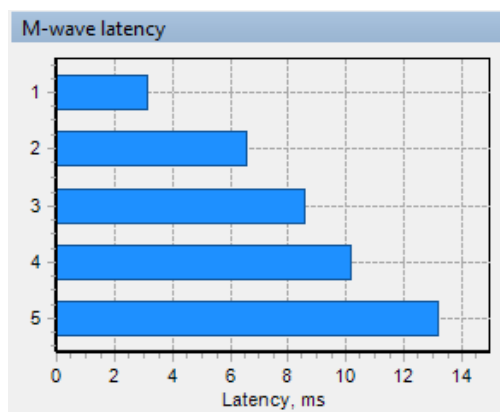
Fig. 3.18

# 3.3. Sensory Conduction Velocity

## 3.3.1. Nerve Action Potential Acquisition

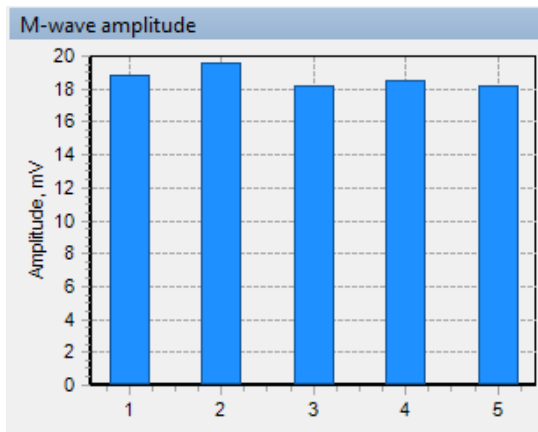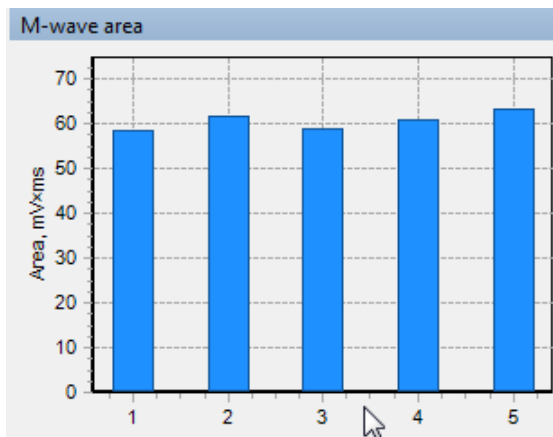To conduct a **sensory conduction velocity** test, press the ⬛ button on the "New test" toolbar and select the name of a test template from the dropdown list (Fig. 3.19). If you area unable to locate the test you need, use the menu item **Test|New** and select a default test template.
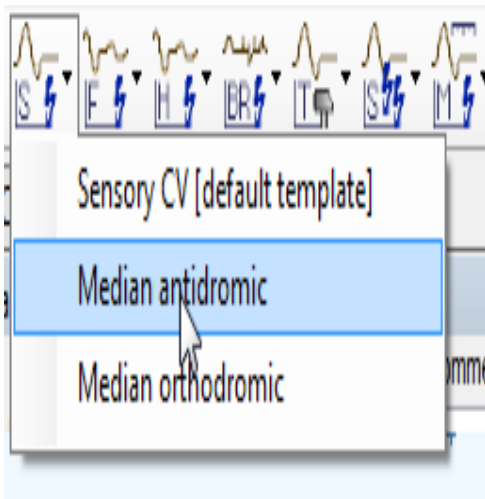


Fig. 3.19

Connect the electrical stimulator to the control unit.

Place the skin temperature sensor on the patient's skin over the nerve under examination. The temperature will be displayed on the information panel (Fig. 3.20) and saved with each nerve action potential during its recording.
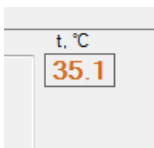


Fig. 3.20

Measure the impedance by selecting the menu command **Acquisition|Impedance**, **pressing [Ctrl+Z]** or by using the button on the dedicated keyboard.  Place the electrodes on the patient and connect them to the amplifier input. When you reach the desired impedance level, close the impedance measurement window by pressing the **[Esc]** key .

Set the required initial value of electrical stimulus by selecting the menu items **Acquisition|Stimulus|Increase** and **Acquisition|Stimulus|Decrease** or by using the dedicated keyboard. Place the electrical stimulator over the nerve under examination.

You can either start a single stimulation (the menu item **Acquisition|Acquisition/Stimulus** or the corresponding button on the dedicated

keyboard) or a repetitive stimulation (the menu item **Acquisition|Repetitive stimulation** or the corresponding button on the dedicated keyboard). The signal averaging is switched on/off by the menu command **Acquisition|Averaging/Continuous**.

If the message "Stimulus differs from the specified one" or "Open circuit of electric stimulator" appears, check the stimulating electrode connection to the electric stimulator and place it more carefully.

To finish the acquisition and save the results for further analysis, select the menu item **Acquisition|Stop** (or by the corresponding button on the dedicated keyboard). If you do not want to save results, press **[Esc]** to delete.

After you save the results, enter the stimulation-site distance. With the **Focus** device, change the distance value for 1 mm by turning the "Sweep" knob and change the distance value for 10 mm by turning the "Sensitivity" knob.

You can enter or correct the distances later by using the menu command **Test|Conduction distance input ([F2])** or clicking on the distance input field.

The distance of trace fitting for each trace is set in accordance to the previous stimulation (site) point. The distances from the stimulation point to site point will be entered for each trace. This option is set in the test template (Fig. 3.22).

Move the current electrode to a new stimulation point (or the site electrode to a new site point) and repeat the procedure.

A situation can occur where you record a sensory response of good quality but still try to record a better one.  If the new results turn out to be worse than the previous,you can go to the "History" page of the acquisition window and select **Take into analysis** from the local menu to find and keep the best M-wave.

If the nerve action potential is not found on the trace automatically (very low amplitude), start a manual search by using the mouse cursor – press **[Alt]** and while holding it, click the left mouse button on the suspected wave location.

If the markers are placed inaccurately, you can override them with the mouse.

On the nerve action potential there can be 5 markers:

1 – wave onset marker;

2 – negative peak marker;

3 – marker of negative peak end (if the measurement of nerve action potential amplitude is carried out according to the negative peak, this marker is also considered to be the wave end marker);

4 – positive peak marker;

5 – wave end marker.

The measurement of a nerve action potential amplitude is usually carried out according to the negative peak, so markers 4 and 5 are not displayed. The display and names of the nerve action potential markers are set in a test template.

After recording all the necessary potentials, you can study the contralateral nerve **Test|Change side**, **[F4]**), some other nerves (**[F5]**) or you can start another technique using either the **Test|Linked tests** (**[F3]**) menu command or **Test|New** menu command (or the corresponding button on the **New test** toolbar).

After recording several traces, the test window looks as follows (Fig. 3.21).
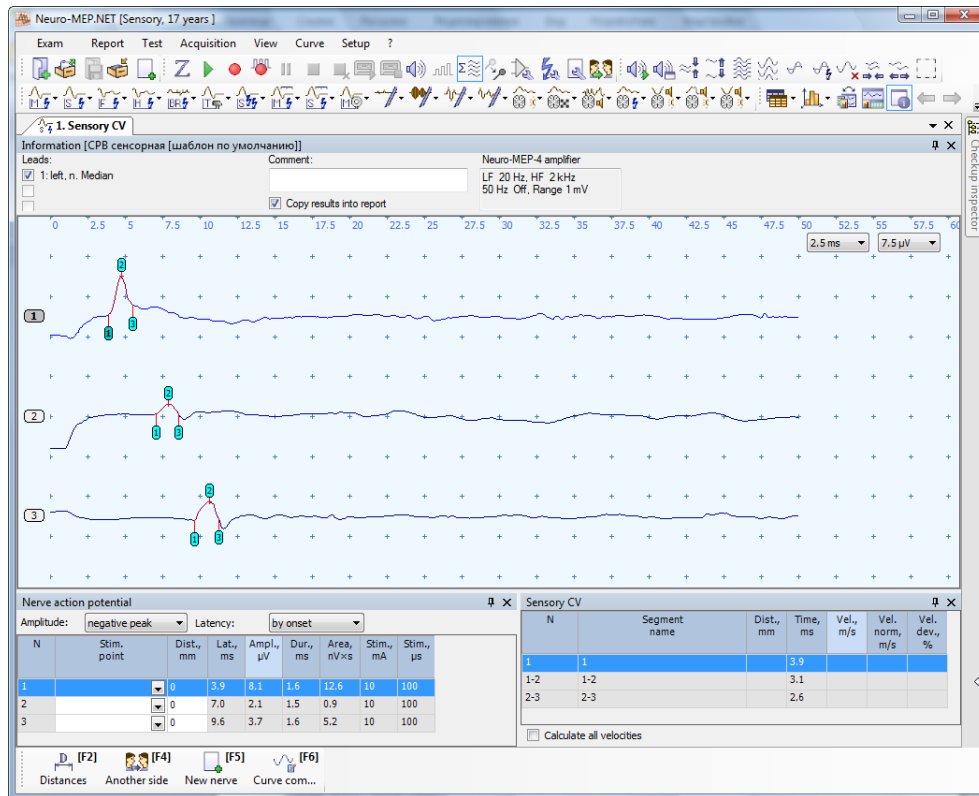


Fig. 3.21

To preset a test template, use the menu command **Setup|Tests templates|Setup**. The "Sensory CV" page of the test template wizard contains the following information (Fig. 3.22).
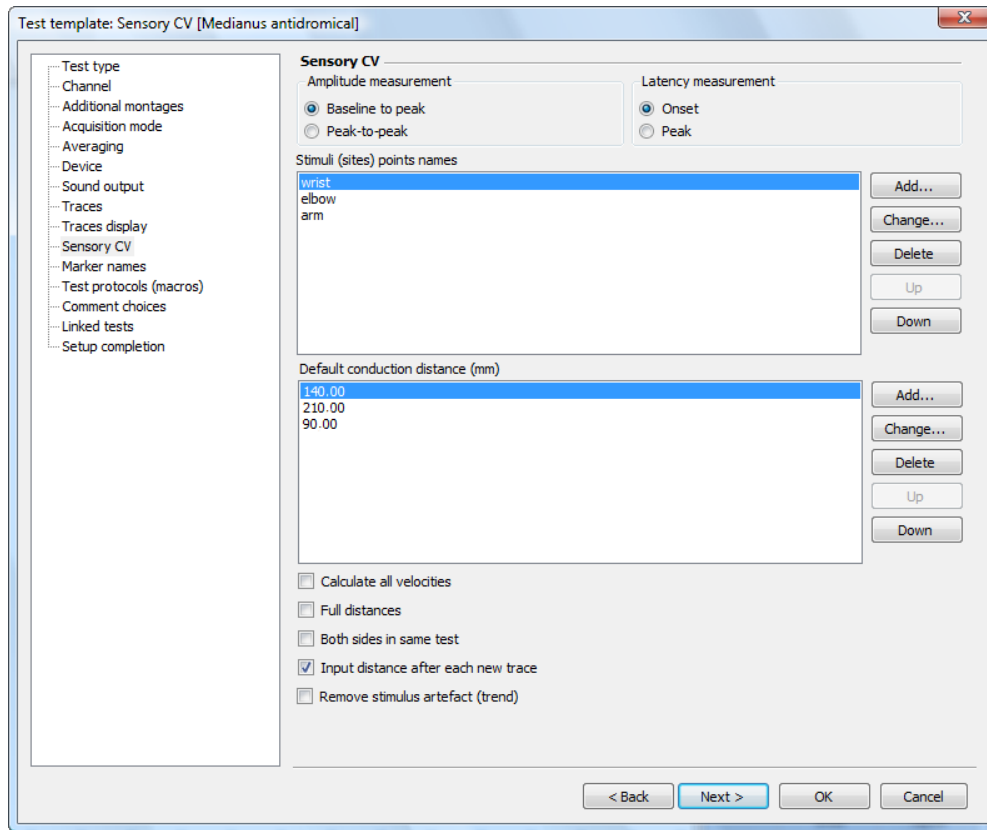
Fig. 3.22

"Amplitude measurement". Measurement of a nerve action potential amplitude after a new test has been created. This value can be changed during the analysis (see comments to Fig. 3.23).

"Latency measurement". Measurement of a nerve action potential after a new test has been created. This value can be changed during the analysis (see comments to Fig. 3.23).

"Stimuli (sites) points names". Stimuli or site point names by default according to traces acquisition. These names are given to new traces automatically when they are recorded but the names can be changed later.

"Default conduction distance (mm)". Default conducting distances in millimeters. They are given automatically to new traces when they are recorded but they can be changed later.

"Calculate all velocities". See comment to Fig. 3.10.

"Full distances". If the check box is selected, conducting distances will be interpreted as full distances from the stimulation point to the site point. If the check box is not selected, conducting distances will be interpreted as distances from the stimulation (site) point to the previous stimulation (site) point.

"Both sides in same test". If the check box is checked, a new test will not be created when the menu command **Test|Change side** is selected. Instead, selecting this menu command will allow you to switch the site side and perform the exam from both sides

in one test. In the last case, it is recommended to switch the "Nerve" column in the "Nerve action potential" (Fig. 3.23) and "Sensory CV" (Fig. 3.24) tables to display the site side.

*"*Input distance after each new trace". If the check box is selected, the distance will be entered into the conducting distance input box after each potential acquisition by pressing digital keys on the keyboard or using encoders of the device keyboard. If you wish to enter distances after acquisition of all traces or you always use distances by default, uncheck the check box.

## 3.3.2. Analysis Windows

If you have inputted your set of normal values, the "Nerve action potential" analysis window will display the comparison of your patient data to these. Please note that no comparison will be displayed or pasted into your report if no normal values were inputted (Fig. 3.23).



Fig. 3.23

"N" – trace number (name).

"Nerve" – name of nerve under study.

"Stim. point" – name of site point when using orthodromic technique or name of stimulation point when using antidromic technique. Each test template lists stimulation points by default. You can also select other stimulation points from the drop-down list or enter a new one.

"Dist., mm" – conduction distance in millimeters. By default, each test template contains the distance list displayed automatically in this field. For the first trace, the distance from stimulation point to site one is entered in this field. For the second trace and the following ones, you must enter the distance from the stimulation point of the current trace to the previous stimulation point.

"Lat., ms" – nerve action potential latency in milliseconds. Latency is measured by nerve action potential onset or negative peak according to the value set in the *Latency* dropdown list on the top of the window (Fig. 3.23). The value for latency calculation method is set in the test template by default.

"Lat. norm, ms" – nerve action potential latency norm, if it is specified in the system of standards, in milliseconds.

"Lat. dev., %" – latency deviation from norm (when available) in percents.

"Ampl., μV" – nerve action potential amplitude in microvolts. The amplitude is measured either from peak to peak or only by negative peak according to the value set in the "Amplitude" dropdown list on the top of the window (Fig. 3.23). The value for amplitude calculation method is set in the test template by default.

"Ampl. norm, μV" – nerve action potential amplitude norm in microvolts.

"Ampl. dev., %" – amplitude deviation from norm in percents (when available).

"Dur., ms" – nerve action potential duration in milliseconds. Duration depends on the amplitude measuring method. If the amplitude is measured by "peak-to-peak" method and all 5 markers of nerve action potential are present, then all the wave phases are included in the duration. If the amplitude is measured by a "baseline-negative peak" method, the duration is calculated only by the negative peak.

"Area, nV×s" – area under nerve action potential in nanovolts per seconds. The area depends on the measuring method of nerve action potential amplitude.

"Stim., mA" – stimulus intensity at which the current nerve action potential is received in milliamperes.

"Stim., μs" – stimulus duration at which the current nerve action potential is received in microseconds.

"t, °C" – skin temperature recorded from the skin temperature sensor during nerve action potential recording in Celsius degrees.

The "Sensory CV" analysis window contains the following information (Fig. 3.24).

| N | Nerve | Segment name | Dist., mm | Time, ms | Vel., m/s | Vel. norm, m/s | Vel. dev., % |
|---|---|---|---|---|---|---|---|
| 1 | left, n. Median | 1 | | 3.9 | | | |
| 1-2 | | 1-2 | | 3.1 | | | |
| 2-3 | | 2-3 | | 2.6 | | | |

☐ Calculate all velocities

Fig. 3.24

"N" – trace numbers (names) for which the conduction time is calculated.

"Nerve" – name of nerve under study.

"Segment name" – name of stimulation points between which the conduction velocity is calculated.

"Dist., mm" – distance between stimulation points in millimeters.

"Time, ms" – conduction time between stimulation points in milliseconds.

"Vel., m/s" – sensory conduction velocity in meters per second.

"Vel. norm, m/s" – conduction velocity norm in meters per second.

"Vel. dev., %" – conduction velocity deviation from norm in percents (when available).

"Calculate all velocities" – if the check box is not selected, only sequential segments will be calculated. If the check box is selected, a calculation will be made for all segments.

The "Nerve AP parameters (comparison)" analysis window contains the following information (Fig. 3.25).

**Nerve AP parameters (comparison)**

| N | Nerve | Stim. point | Zero-peak ampl., µV | Peak-to-peak ampl., µV | Onset lat., ms | Peak lat., ms | Stim., mA | Stim., µs |
|---|---|---|---|---|---|---|---|---|
| 1 | left, n. Median | | 8.1 | 8.1 | 3.9 | 4.8 | 10 | 100 |
| 2 | | | 2.1 | 2.1 | 7.0 | 7.9 | 10 | 100 |
| 3 | | | 3.7 | 3.7 | 9.6 | 10.6 | 10 | 100 |

Fig. 3.25

"N" – trace number (name).

"Nerve" – name of nerve under study.

"Stim. point" – name of stimulation (site) point.

"Zero-peak ampl., µV" – nerve action potential amplitude by negative peak measuring in microvolts.

"Peak-to-peak ampl., µV" – nerve action potential amplitude by peak-to-peak measuring in microvolts. To make the correct calculation of this value, both negative peak (2) and positive peak (4) markers must be present on trace.

"Onset lat., ms" – nerve action potential latency by wave onset marker in milliseconds.

"Peak lat., ms" – nerve action potential latency by negative peak marker in milliseconds.

"Stim., mA" – stimulus intensity at which the current nerve action potential is received in milliamperes.

"Stim., µs" – stimulus duration at which the current nerve action potential is received in microseconds.

The "Sensory CV (comparison)" analysis window allows comparing conduction velocities at various methods of latency measuring and contains the following information (Fig. 3.26).

| Sensory CV (comparison) | | | | | | | |
|---|---|---|---|---|---|---|---|
| N | Nerve | Segment name | Dist., mm | Time by onset, ms | Time by peak, ms | Velocity by onset, m/s | Velocity by peak, m/s |
| 1 | left, n. Median | 1 | | 3.9 | 4.8 | | |
| 1-2 | | 1-2 | | 3.1 | 3.1 | | |
| 2-3 | | 2-3 | | 2.6 | 2.7 | | |

Fig. 3.26

"N" – trace numbers (names) for which the conduction velocity is calculated.

"Nerve" – name of nerve under study.

"Segment name" – name of stimulation (site) points between which the conduction velocity is calculated.

"Dist., mm" – distance between stimulation (site) points in millimeters.

"Time by onset, ms" – conduction time between stimulation points according to nerve action potential onset markers in milliseconds.

"Time by peak, ms" – conduction time between stimulation points according to nerve action potential negative peak markers in milliseconds.

"Velocity by onset, m/s" – sensory conduction velocity at latency measuring by the onset of nerve action potential in meters per second.

"Velocity by peak, m/s" – sensory conduction velocity at latency measuring by nerve action potential negative peak in meters per second.

In case two "Sensory CV" tests are available, in which similar nerves from the different body sides are examined, the comparison window "Sensory CV (right/left)" can be displayed on the screen by the menu command **Test|Comparison right/left** (Fig. 3.27).
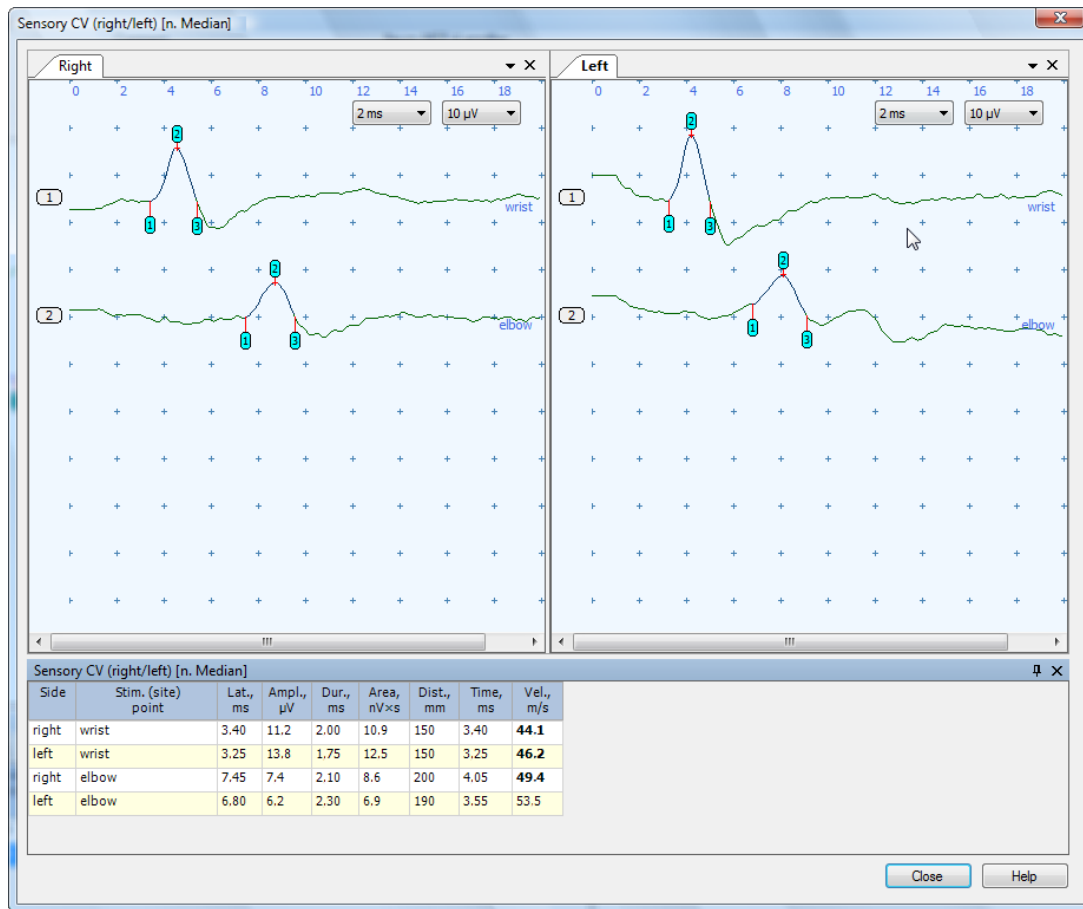


Fig. 3.27

"Side" - stimulation (site) side.

"Stim. (site) point" - stimulation (site) point name.

"Lat., ms" – nerve action potential latency in milliseconds.

"Ampl., µV" – nerve action potential amplitude in microvolts.

"Dur., ms" – nerve action potential duration in milliseconds.

"Area, nV×s" – area under nerve action potential in millivolts per milliseconds.

"Dist., mm" – the distance between stimulation (site) points in millimeters.

"Time, ms" – the conducting time between stimulation (site) points in milliseconds.

"Vel., m/s" – motor conduction velocity in meters per second calculated for the area between the current and the previous stimulation (site) points.

# 3.4. F-Wave

## 3.4.1. F-Wave Acquisition

To conduct the **F-wave** test, press the [button icon] button on the "New test" toolbar and select the name of a test template from the dropdown list (Fig. 3.28). If you are unable to locate the test you need, use the menu item **Test|New** and select a default test template. The **F-wave** test can also be created from a **motor conduction velocity** test by selecting the menu item **Test|Linked tests|F-wave**.
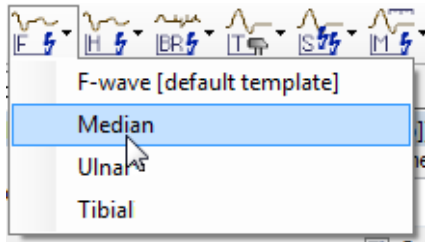


Fig. 3.28

Connect the electrical stimulator to the control unit.

Measure the impedance by selecting the menu command **Acquisition|Impedance**, pressing **[Ctrl+Z]** or using the button on the dedicated keyboard. Then place the electrodes on a patient and connect them to the amplifier input. When you reach the desired impedance level, close the impedance measurement window by pressing the **[Esc]** key.

Set the required initial value of electrical stimulus by selecting the menu items **Acquisition|Stimulus|Increase** and **Acquisition|Stimulus|Decrease** or by using the dedicated keyboard control. Place the electrical stimulator over the nerve under examination.

If you want to get the M-wave before F-waves accumulation, start traces accumulation by selecting the menu command **Acquisition|Averaging/Continuous** (hotkey **[Ins]** or the corresponding button on the dedicated keyboard).

Start the single stimulation by selecting the menu item **Acquisition|Acquisition/Stimulus** (or by the corresponding button on the dedicated keyboard). If you do not get the required M-wave or F-wave, try changing the stimulus strength or moving the stimulator until you get an acceptable result.

When you reach a supramaximal stimulus strength and obtain a good quality M-wave, switch the accumulation of traces by selecting the menu command **Acquisition|Averaging/Continuous** (hotkey **[Ins]** or the corresponding button on the dedicated keyboard). You can use either manual (**Acquisition|Acquisition/Stimulus** or the corresponding button on the keyboard) or repeated (**Acquisition|Repetitive stimulation** or the corre-sponding button on the keyboard) stimulation. To finish the

stimulation early, select the menu item **Acquisition|Exit** (or the corresponding button on the keyboard). If you do not want to save results, press **[Esc]** to delete.

To start the F-waves accumulation procedure from the first stimulus, switch to the accumulation mode by selecting the menu command **Acquisition|Averaging/Continuous**, pressing the hotkey **[Ins]** or using the corresponding button on the dedicated keyboard and start stimulation.

If you don't like the automatic F-wave marking you can start a manual F-wave search in the desired area. First, select the desired area with the mouse: place the cursor at the beginning of the search area (Fig. 3.29, a), click the left mouse button, move it until the end and release the left mouse button (Fig. 3.29, b). Then, use the menu command **Test|F-wave search by selection**.



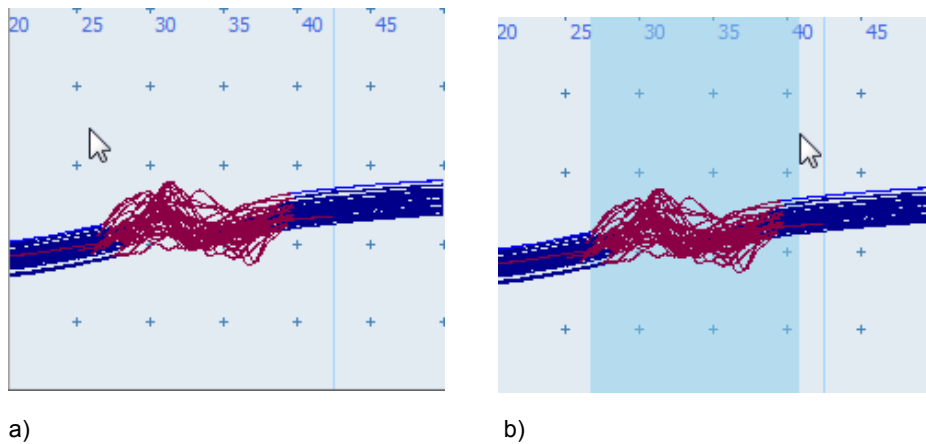a)                                          b)

Fig. 3.29

If the markers are placed inaccurately you can override them with the mouse.

On the M-wave and F-wave there can be 5 markers of the feature points:

1 – wave onset marker;

2 – negative peak marker;

3 – marker of negative peak end (if the wave measurement is carried out according to the negative peak, this marker is also considered to be the wave end marker);

4 – positive peak marker;

5 – wave end marker.
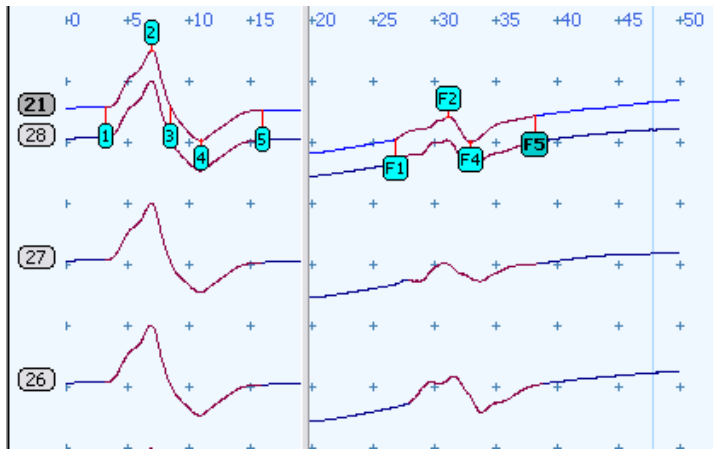
By default, all F-wave markers have **F** prefix.

Fig. 3.30

After recording all the necessary results you can study the contralateral muscle **Test|Change side**, **[F4]**), some other muscle (**[F5]**) or you can start another technique using either the **Test|Linked tests** (**[F3]**) menu command or **Test|New** menu command (or the corresponding button on the **New test** toolbar).

After recording several traces, the test window will look as follows (Fig. 3.31).
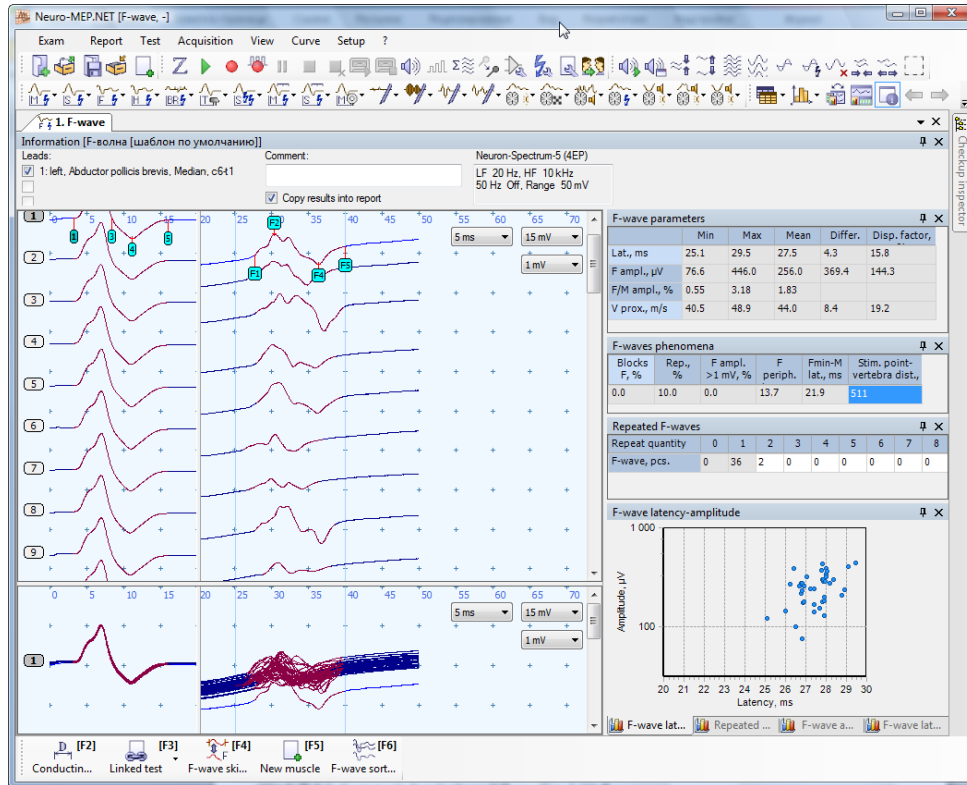


Fig. 3.31

After switching the windows layouts by the menu command **View|Windows layouts|Switch** (**[Ctrl+Tab]**) the test window will look as follows (Fig. 3.32).



Fig. 3.32

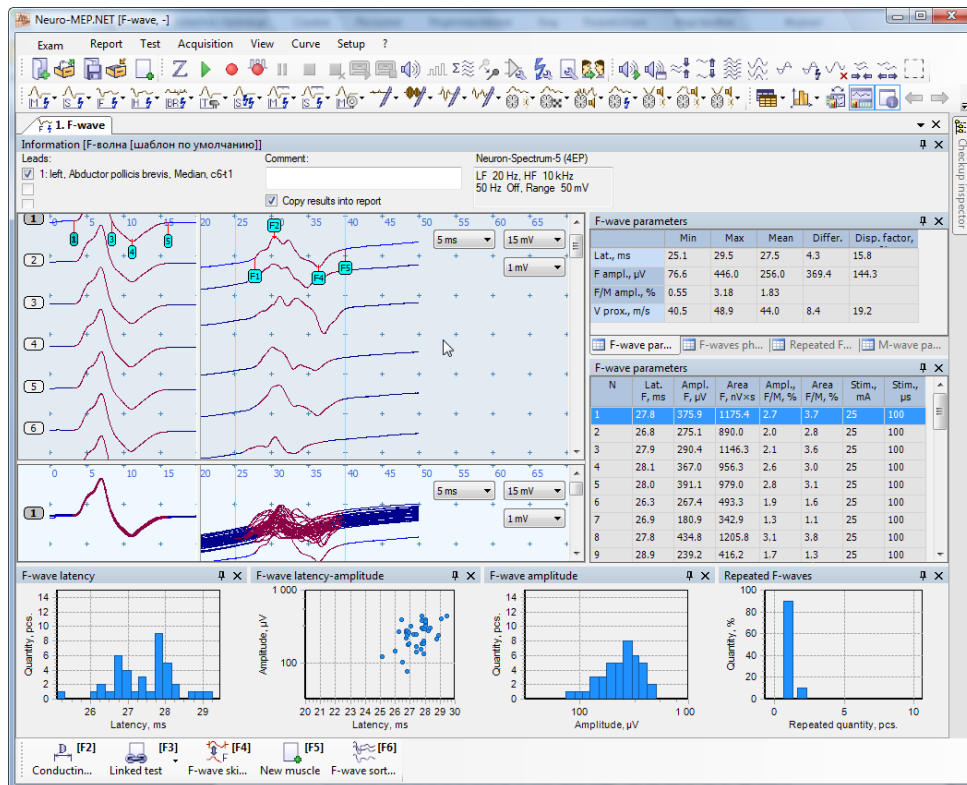To preset a test template, use the menu command **Setup|Tests templates|Setup**. The "F-wave" page of the test template wizard contains the following information (Fig. 3.33).
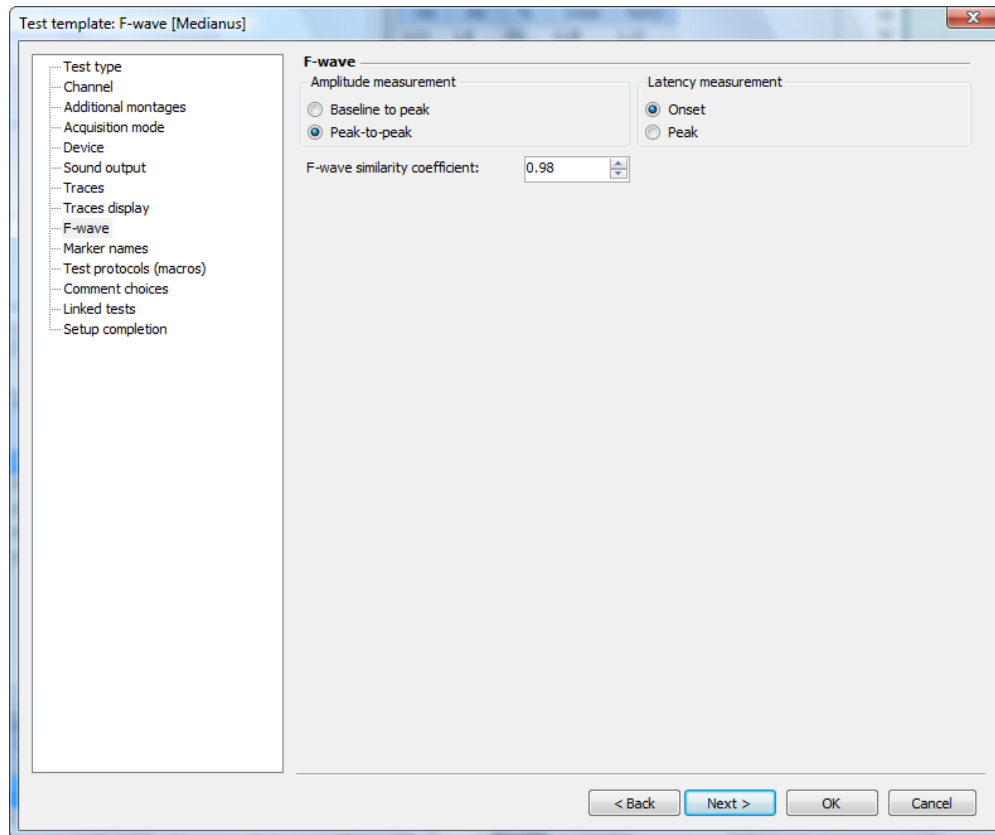


Fig. 3.33

"Amplitude measurement". The method of M-wave and F-wave amplitude measuring after a new test has been created.

"Latency measurement". The method of M-wave and F-wave latency measuring after a new test has been created.

## 3.4.2. Analysis Windows

The "F-wave parameters" analysis window contains the following information (Fig. 3.34).

| F-wave parameters | Min | Max | Mean | Differ. | Disp. factor, % |
|---|---|---|---|---|---|
| Lat., ms | 25.1 | 29.5 | 27.5 | 4.3 | 15.8 |
| F ampl., µV | 76.6 | 446.0 | 256.0 | 369.4 | 144.3 |
| F/M ampl., % | 0.55 | 3.18 | 1.83 | | |

Fig. 3.34

"Min, Max, Mean and Differ." – minimum, maximum and mean parameter value correspondingly, parameter mean value, the difference between maximum and minimum value and parameters dispersion factor in percents.

"Lat., ms" – F-wave latency in milliseconds.

"F ampl., µV" – F-wave amplitude in microvolts. The value depends on the amplitude measuring method set in the test template.

"F/M ampl., %" – F-wave and M-wave amplitude ratio in percents.

The "M-wave parameters" analysis window contains the following information (Fig. 3.35).

| M-wave parameters | | | |
|---|---|---|---|
| Lat., ms | Ampl., mV | Dur., ms | Area, mV×ms |
| 3.2 | 14.0 | 5.2 | 31.6 |

Fig. 3.35

"Lat., ms" – M-wave latency in milliseconds. The value depends on the latency measuring method set in the test template.

"Ampl., mV" – M-wave amplitude in millivolts. The value depends on the amplitude measuring method set in the test template.

"Dur., ms" – M-wave duration in milliseconds. The value depends on the amplitude measuring method set in the test template.

"Area, mV×ms" – area under M-wave in millivolts per milliseconds. The value depends on the amplitude measuring method set in the test template.

The "F-wave latency" analysis window (Fig. 3.36) contains the histogram of F-wave latency distribution in milliseconds.
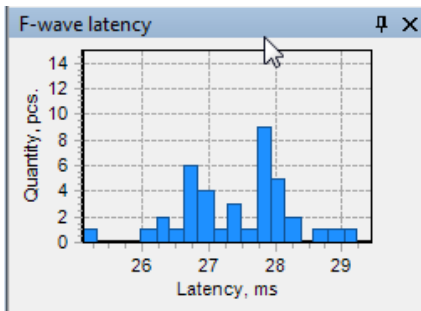
Fig. 3.36

The "F-wave amplitude" analysis window (Fig. 3.37) contains the histogram of F-wave amplitude distribution in microvolts (in logarithmic scale).
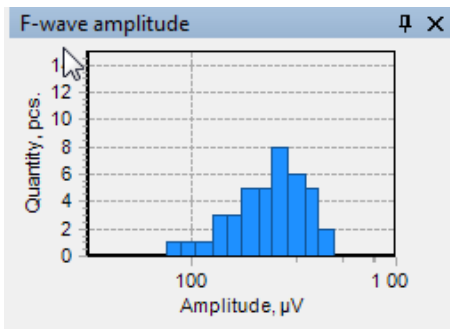


Fig. 3.37

The "F-wave latency-amplitude" analysis window (Fig. 3.38) contains the scatter diagram on which the dependence of F-wave amplitude in microvolts on F-wave latency in milliseconds is displayed.



Fig. 3.38

# 3.5. Spontaneous Activity

## 3.5.1. Spontaneous Activity Acquisition

To conduct a **spontaneous activity** test, press the [icon] button on the **New test** toolbar and select the name of a test template from the dropdown list (Fig. 3.39). If you are unable to locate the test you need, use the menu item **Test|New** and select a default test template.

Fig. 3.39

Prepare the needle electrode for insertion, place the ground electrode on a patient and connect the electrodes to the amplifier input.
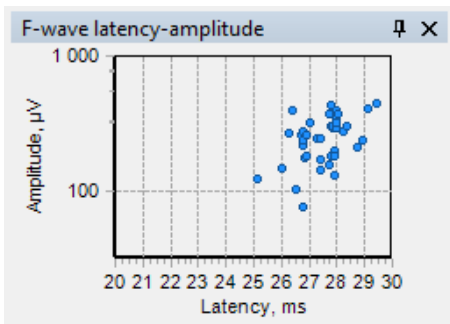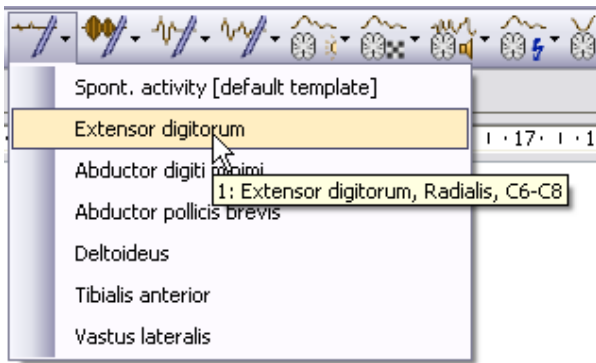
Start signal monitoring by selecting the menu command **Acquisition|Monitoring** (or by the corresponding button on the dedicated keyboard), insert the needle into a muscle and start signal acquisition by selecting the menu command **Acquisition|Acquisition/Stimulus**.

To pause during trace acquisition, use the menu command **Acquisition|Pause** (space key or the corresponding button on the keyboard). To record each new segment as a new trace, use the menu command **Acquisition|Averaging/Continuous** (**[Ins]** key or the corresponding button on the keyboard).

To analyze the traces, use the menu command **Acquisition|Stop** (or the corresponding button on the keyboard) or to quit, use the menu command **Acquisition|Cancel** (**[Esc]** key or the corresponding button on the keyboard).

If spontaneous activity occurs, put marks near the detected activity in the "Phenomena" window (Fig. 3.40). You can also differentiate and measure them more thoroughly by placing the mouse cursor on the activity, pressing **[Alt]** and while holding it, press the left mouse button. Select the necessary activity type from the dropdown list (Fig. 3.41) to paste it in your report at the end of the study.



Fig. 3.40

Fig. 3.41

The search results of spontaneous activity phenomena by all test traces will be displayed in the window (Fig. 3.47 ) After pressing the [ OK ] button, the analysis window is filled automatically (Fig. 3.51).



| Phenomenon | Count | Max ampl., µV | Mean ampl., µV | Mean freq., Hz |
|---|---|---|---|---|
| Fibrillation potentials | 15 | 320 | 71 | 2.8 |
| Fascicullations | | | | |
| Positive sharp waves | 10 | 145 | 69 | 3.5 |
| Other | 6 | 248 | 115 | 1.7 |

Fig. 3.42

For a more detailed review of all phenomena, use the Details... button or double-click the trace with the mouse, and the window in Fig. 3.43 will appear. The number of potentials are indicated under the trace buttons. To remove a potential from analysis, use the checkbox near each trace. Using local menu commands, you can change the activity type or remove separate potentials.
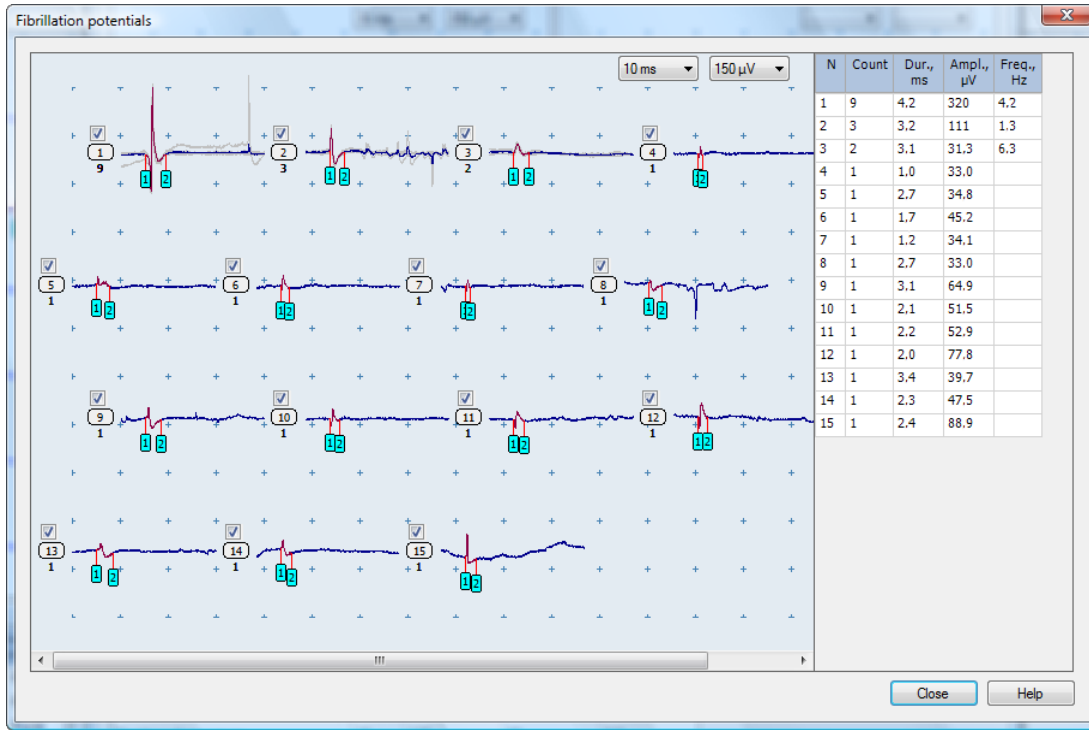


Fig. 3.43

To review all potentials, double-click on the trace (Fig. 3.43). The averaged potential is displayed in the left part of the window, all source potentials are superimposed in the right top part of the window and all source potentials in cascade representation are displayed in the left bottom part. To remove separate potentials, use the buttons in the top part of the window or local menu commands.
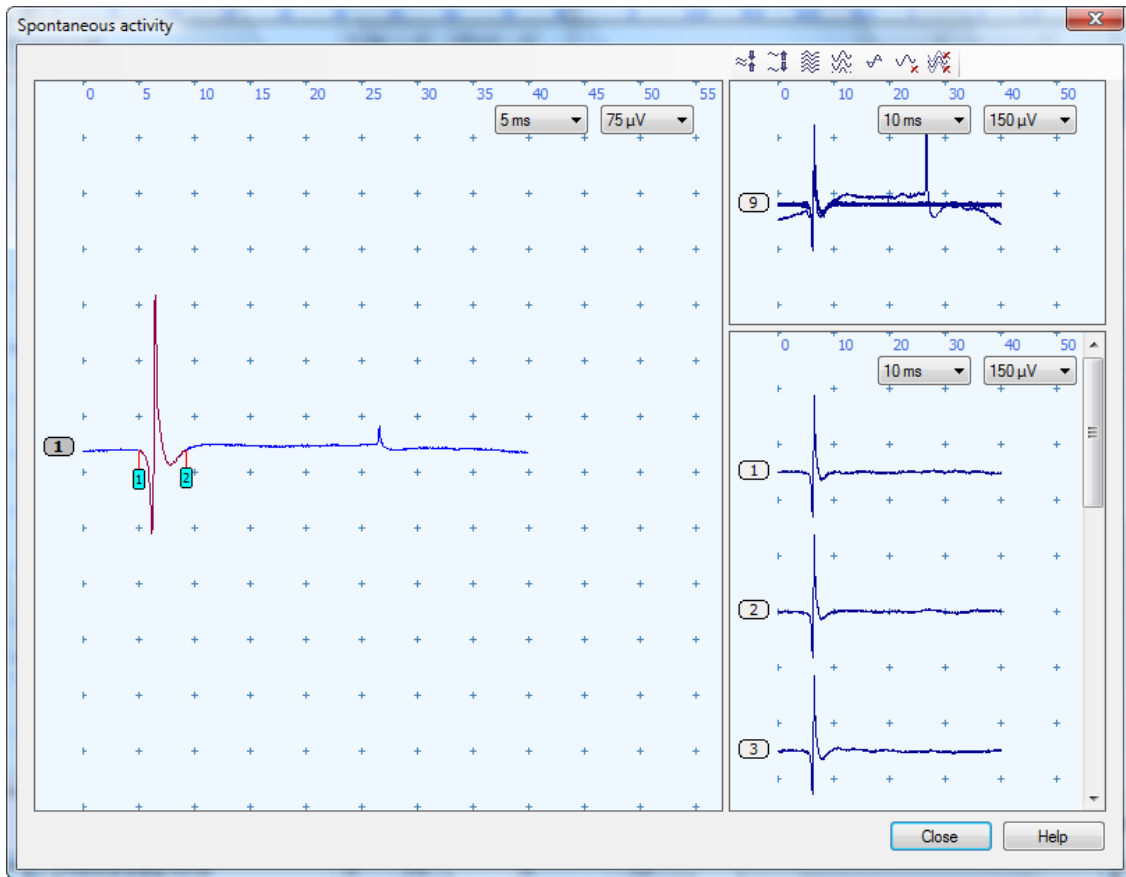


Fig. 3.44

To review the spontaneous activity phenomena identified earlier, use **Test|Classification results** (**[F8]**) menu command.

You can calculate the mean amplitude and wave frequency for any segment of spontaneous activity. Follow the directions below:
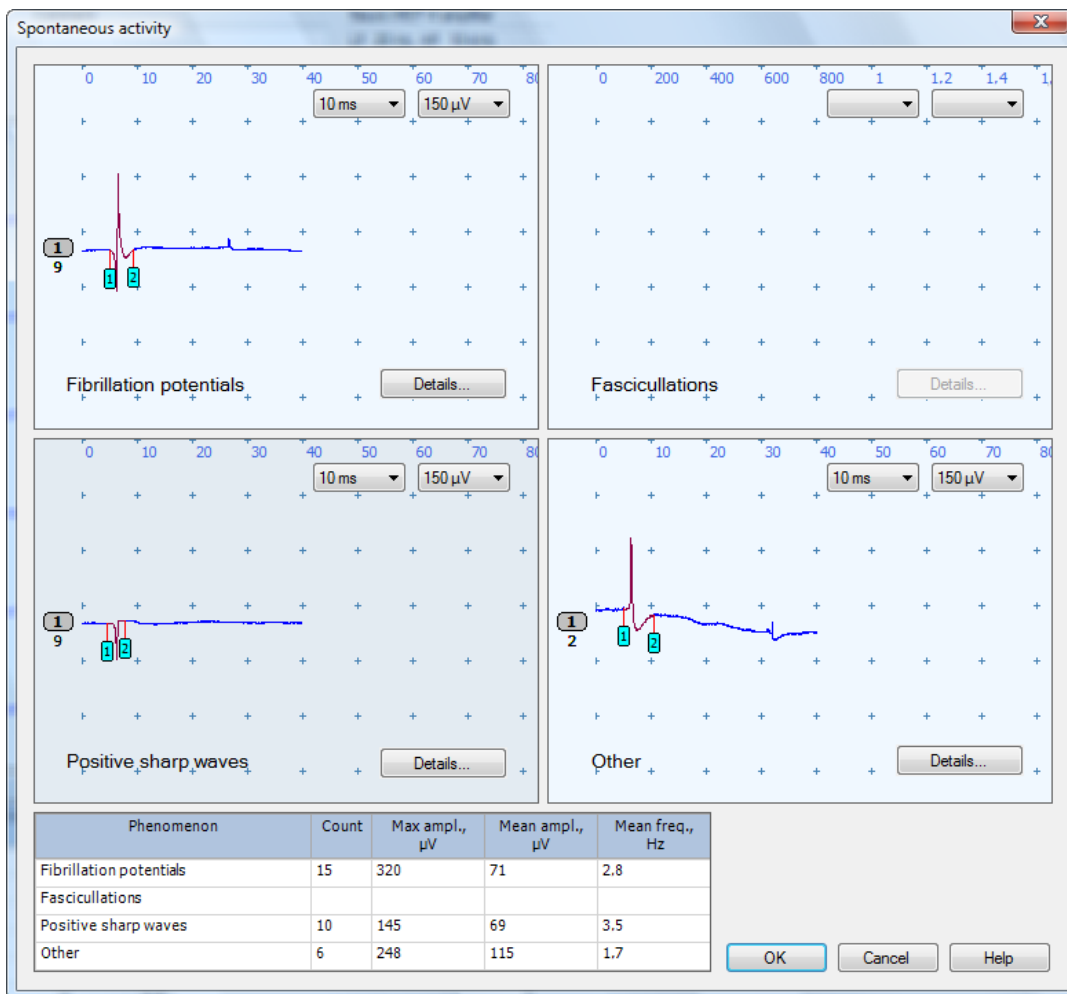
- Mark the trace with the fragment by clicking the mouse either on it or on the link button.

- Place the mouse cursor in the top left corner of the fragment (Fig. 3.45, a).

- Press and hold the **[Ctrl]** and **[Shift]** keys on the keyboard.

- Press the left mouse button and, while holding it, shift the mouse to the right bottom corner of the fragment (Fig. 3.45, b), then release the left mouse button.

- Release the **[Ctrl]** and **[Shift]** keys on the keyboard.

- When the calculation results and phenomena list appears, mark the necessary phenomenon (Fig. 3.45, c). If the phenomena list does not appear, it means that the trace is not selected or there are less than 2 peaks in the square (rectangle).



a)



b)



c)
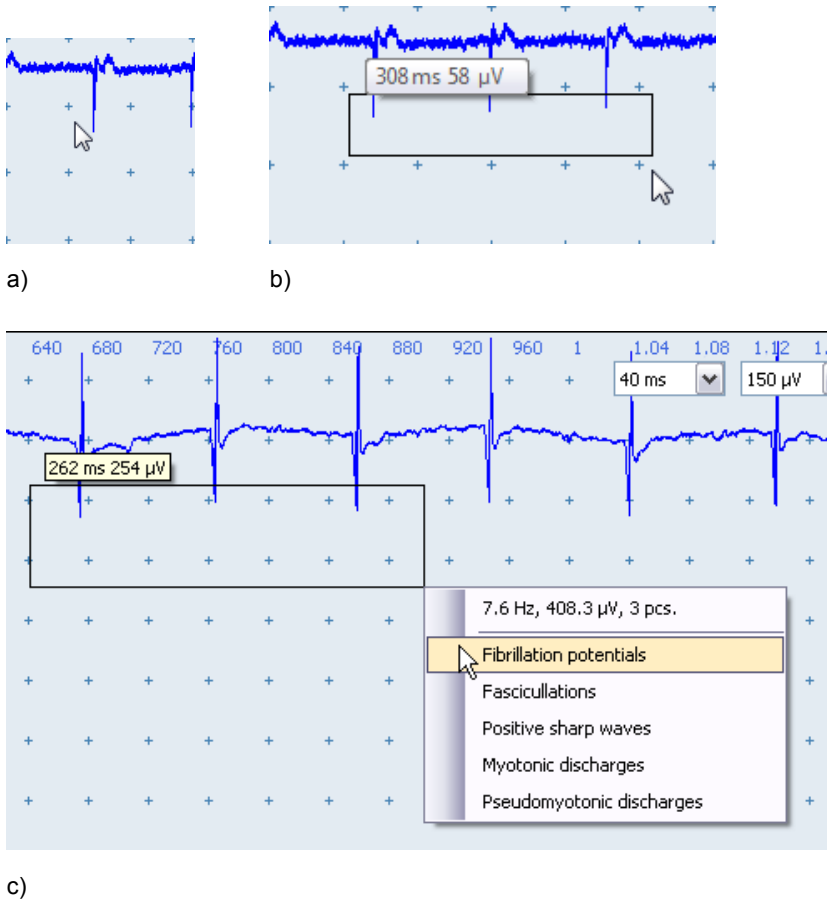
Fig. 3.45

The results are displayed in the "Frequency" analysis window (Fig. 3.49). If you don't want to make measurements, press **[Esc]**.

To delete the current description line from the quick analysis window (Fig. 3.49), click on it with the right mouse button and select the **Delete current line option** from the local menu. To clear the entire table, select the **Clear table option**.

After recording all the necessary traces you can study the contralateral muscle **Test|Change side**, **[F4]**), some other muscle (**[F5]**) or you can start another technique (**Test|New** or the corresponding button on the "New test" toolbar).

After recording several traces, the test window looks as follows (Fig. 3.46).
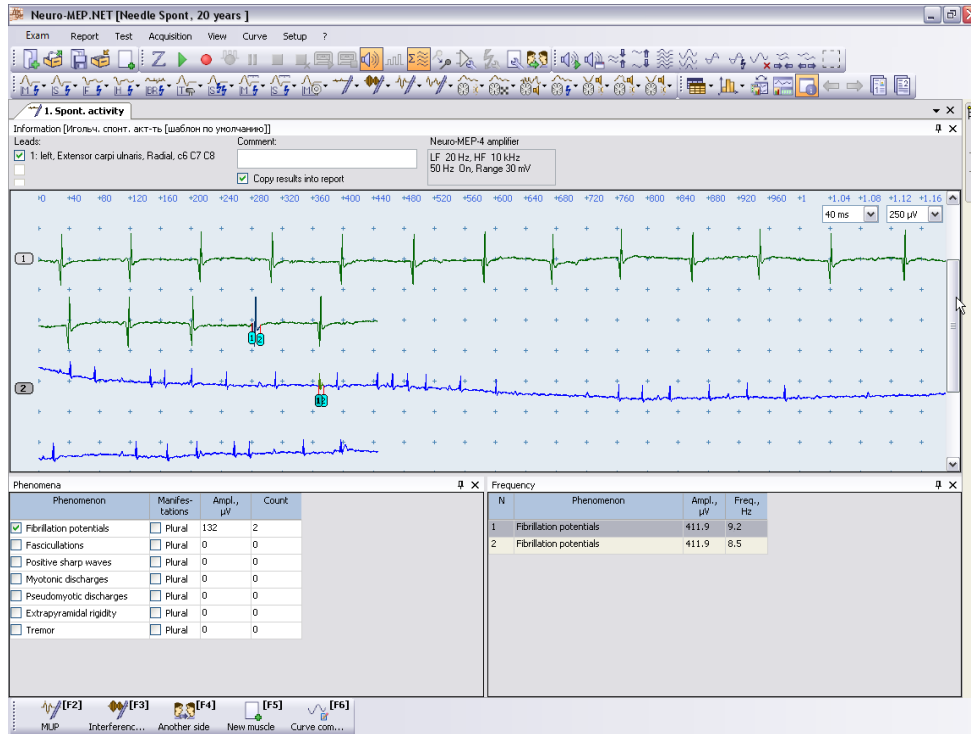


Fig. 3.46

To switch the windows layout, use the menu command **View|Windows layouts|Switch** (**[Ctrl+Tab]**) and the test window will look as follows (Fig. 3.47).
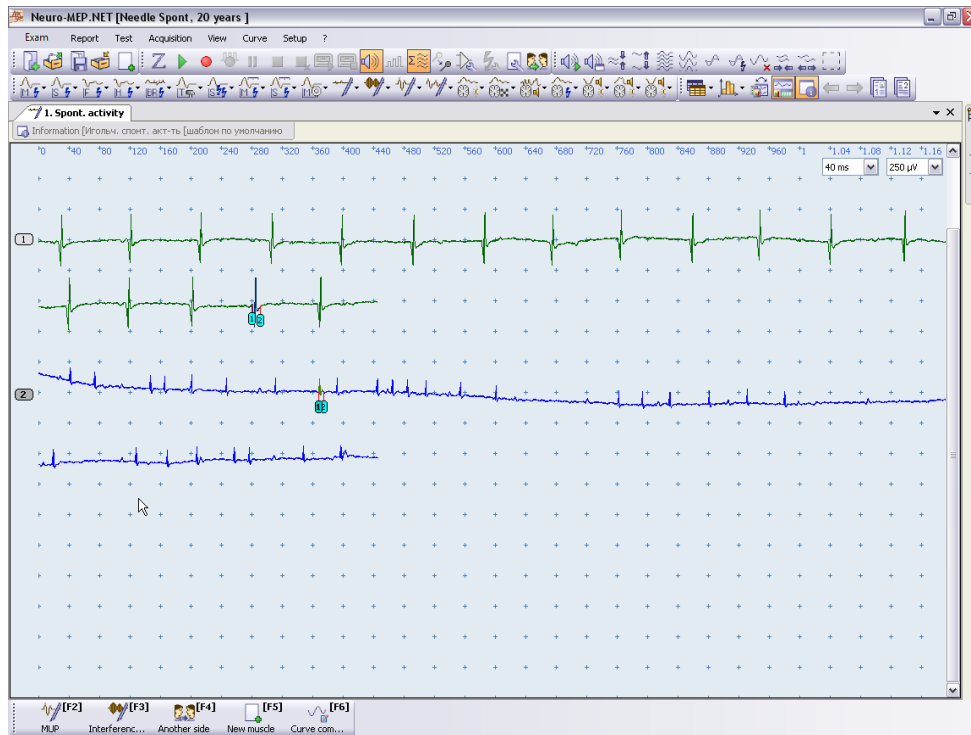


Fig. 3.47

## 3.5.2. Analysis Windows

The "Phenomena" analysis window contains the following information (Fig. 3.48).

| Phenomenon | Manifes-tations | Ampl., μV | Count |
|---|---|---|---|
| ☑ Fibrillation potentials | ☐ Plural | 132 | 2 |
| ☐ Fasciculations | ☐ Plural | 0 | 0 |
| ☐ Positive sharp waves | ☐ Plural | 0 | 0 |
| ☐ Myotonic discharges | ☐ Plural | 0 | 0 |
| ☐ Pseudomyotic discharges | ☐ Plural | 0 | 0 |
| ☐ Extrapyramidal rigidity | ☐ Plural | 0 | 0 |
| ☐ Tremor | ☐ Plural | 0 | 0 |

Fig. 3.48

"Phenomenon" – Name of observed phenomenon of spontaneous activity. Put marks against the corresponding phenomena.

"Manifestations" – Put marks at multiple manifestations of phenomena.

"Ampl., μV" – Phenomena amplitude in microvolts, which can be set either manually or automatically (see above).

"Count" – Number of corresponding phenomena, which increases automatically or can be set manually.

The "Frequency" analysis window contains the following information (Fig. 3.49).

| N | Phenomenon | Ampl., μV | Freq., Hz |
|---|---|---|---|
| 1 | Fibrillation potentials | 411.9 | 9.2 |
| 2 | Fibrillation potentials | 411.9 | 8.5 |
| 3 | Fasciculations | 410.6 | 10 |

Fig. 3.49

"Phenomenon" – Name of observed phenomenon.

"Ampl., μV" – Mean phenomenon amplitude in microvolts.

"Freq., Hz" – Mean phenomenon frequency in Hertz.

# 3.6. Interference EMG

## 3.6.1. Interference EMG Acquisition

It is recommended to conduct a **spontaneous activity** test before you start the **interference curve** study. To start the **interference curve study**, select the menu item **Test|Linked tests|Interference curve**.

Prepare the needle electrode for insertion, place the ground electrode on a patient and connect the electrodes to the amplifier input.

Start signal monitoring by selecting the menu command **Acquisition|Monitoring** (or by the corresponding button on the dedicated keyboard), insert the needle into a muscle and start signal acquisition by selecting the menu command **Acquisition|Acquisition/Stimulus**.

To pause during trace acquisition, use the menu command **Acquisition|Pause** (space key or the corresponding button on the keyboard). To record every new section as a new trace, use the menu command **Acquisition|Averaging/Continuous** (**[Ins]** key or the corresponding button on the keyboard) to stop and then restart the acquisition process.

To analyze the recorded traces, use the menu command **Acquisition|Stop** (or the corresponding button on the keyboard). To quit, use the menu command **Acquisition|Cancel** (**[Esc]** key or the corresponding button on the keyboard).

If it is necessary, repeat the procedure for the other insertions.

After acquisition you can put the marks near the detected phenomena in the "Interpretation" table.

After recording all the necessary traces, you can study the contralateral muscle **Test|New/Other side**), some other muscle (**[F5]**) or you can start another technique (**Test|New** or the corresponding button on the **New test** toolbar).

After recording several traces, the test window will look as follows (Fig. 3.50).

Fig. 3.50

To switch the windows layout, select the menu command **View|Windows**

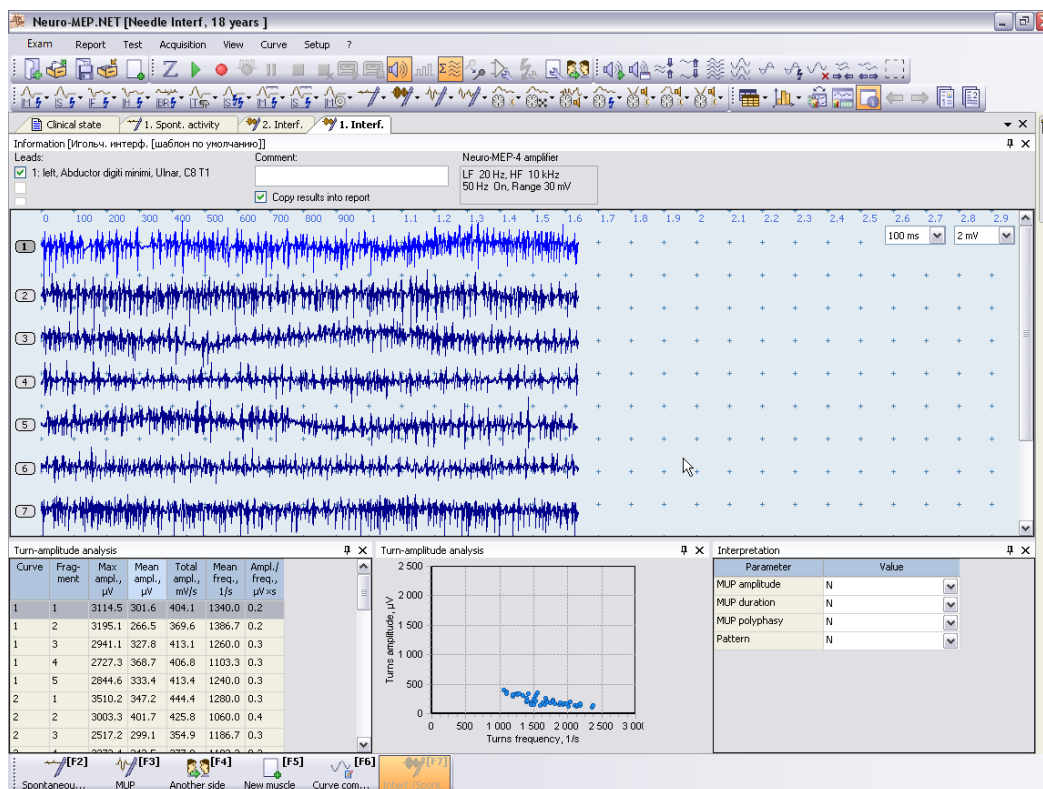**layouts|Switch** (**[Ctrl+Tab]**) and the test window will look as follows (Fig. 3.51).
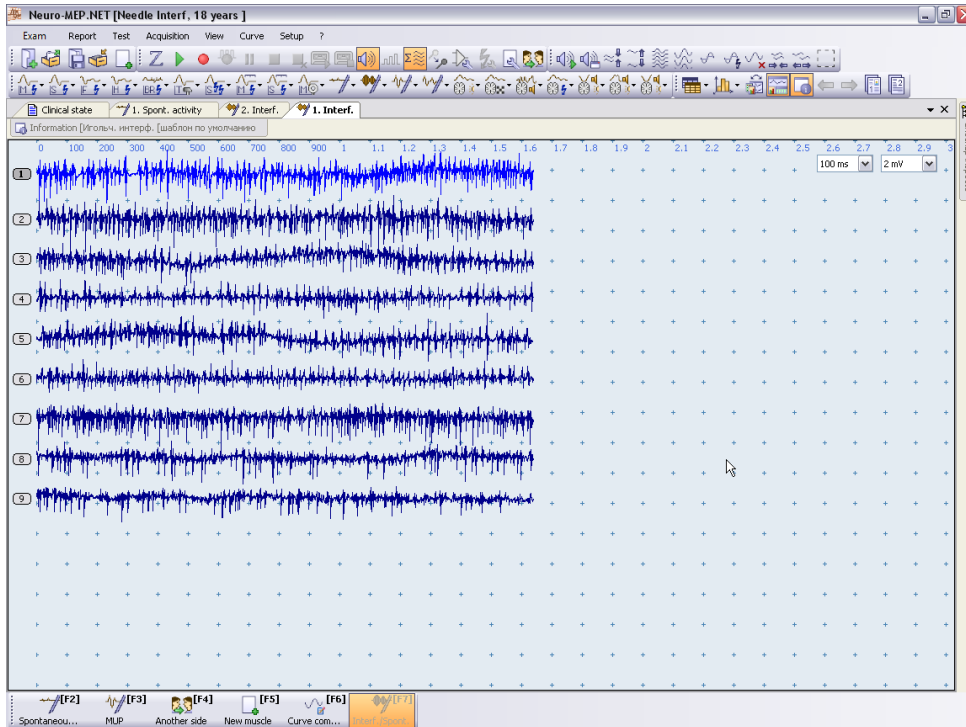


Fig. 3.51

To preset a test template, use the menu command **Setup|Tests templates|Setup**. The "Interference pattern" page of the test template wizard contains the following information (Fig. 3.52).
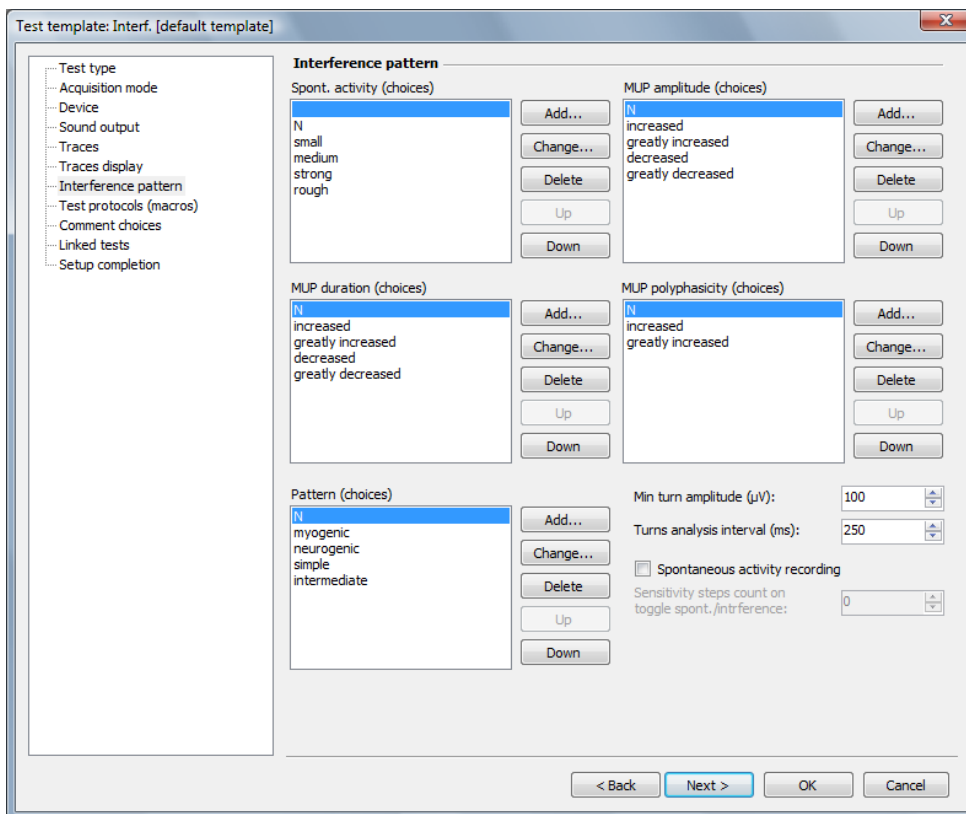


Fig. 3.52

"Spont. activity (choices)". Spontaneous activity choices for the "Spontaneous activity" dropdown list of the analysis window (Fig. 3.53).

"MUP amplitude (choices)". MUP amplitude choices for the "MUP amplitude" dropdown list of the analysis window (Fig. 3.53).

"MUP duration (choices)". MUP duration choices for the "MUP duration" dropdown list of the analysis window (Fig. 3.53).

"MUP polyphasy (choices)". MUP polyphasy choices for the "MUP polyphasy" dropdown list of the analysis window (Fig. 3.53).
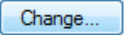
"Pattern (choices)". EMG pattern choices for the "Pattern" dropdown list of the analysis window (Fig. 3.53).
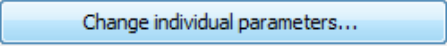
"Spontaneous activity recording". If the check box is selected, the recording of spontaneous activity and interference curve will occur at the same time (see below).

None of these parameters are calculated by the device, they are chosen and inputted by the physician, as the name ("choices") indicates.

"Count of Sensitivity steps on toggle spont./interference:" The number of **View|Sensitivity|Increase** menu commands required for switching from a scale used for displaying spontaneous activity to a scale used for displaying interference patterns. To activate this option, select individual parameters of traces displaying on the "Traces display" page (see Fig. 2.56).

## 3.6.2. Spontaneous Activity Recording in the Interference EMG Test

Record spontaneous activity in the **Spontaneous activity** test, and from this test, create an **Interference EMG** test by pressing the **[F3]** key to record an interference curve at tonic contraction. To save time, you can combine the recording of spontaneous activity and interference curve in the **Interference EMG** test by making the following changes in the test template: Use the menu command **Setup|Tests templates|Setup**, then select the test template you need and press the Change... button.

- On the "Traces displaying" page, select the "Traces displaying parameters. Individual" check box, press the Change individual parameters... button and set the scales to display the spontaneous activity.

- On the "Interference pattern" page (Fig. 3.52) select the "Spontaneous activity recording" check box and enter the number of steps required for scale switching (see comments to Fig. 3.52).

In this mode, the menu command **Test|Interf./Spont.** is in a spontaneous activity recording state (the button is "released") and all registered traces are marked as

spontaneous activity traces. The turn-amplitude analysis for these traces is not performed.

When all spontaneous activity traces are recorded, select the menu command **Test|Interf./Spont.** to switch into the interference curves recording mode (the button is "pressed"). The sensitivity (vertical scale) by default will be changed and all the registered traces will be marked as interference curves. The turn-amplitude analysis for these traces is performed.

The menu command **Test|Interf./Spont.** can be selected several times, interchanging the recording of spontaneous activity and muscle contraction.

If a trace is recorded in an incorrect mode (for instance, if the spontaneous activity trace is recorded in the interference curve mode), change the trace properties by selecting it with the mouse and pressing the "Spontaneous activity" local menu command.  You can also define whether a trace is a spontaneous activity trace or a tonic contraction trace by selecting or unselecting the check box near the command. To change the properties of several traces simultaneously, select these traces with the mouse, while holding the **[Ctrl]** key.

Keep in mind that each trace can have its own sensitivity (vertical scale) and the commands for sensitivity changing are effective for the selected traces only.

## 3.6.3. Analysis Windows

The analysis window contains the characteristics and pattern of motor unit potential (MUP) (Fig. 3.53).

| Interpretation | |
|---|---|
| Parameter | Value |
| Spont.activity | |
| MUP amplitude | N |
| MUP duration | N |
| MUPpolyphasy | N |
| Pattern | N |

Fig. 3.53

"Spont. activity" – qualitative evaluation of spontaneous activity.

"MUP amplitude" – qualitative evaluation of MUP amplitude.

"MUP duration" – qualitative evaluation of MUP duration.

"MUP polyphasy" – qualitative evaluation of MUP polyphasy.

"Pattern" – qualitative evaluation of interference curve pattern.

# 3.7. Motor Unit Potentials (MUP)

It is recommended to conduct a **spontaneous activity** test before you start a **motor unit potentials (MUP)** study.  To start the **MUP** study, select the menu item **Test|Linked tests|MUP**.

Prepare the needle electrode for insertion, place the ground electrode on a patient and connect the electrodes to the amplifier input.

Signal recording can be carried out in two ways:

• Long epochs acquisition (10-30 seconds) and further MUP selection from them.

• Short epochs acquisition (single MUP) by means of trigger. It is possible to use both level trigger and range trigger.

It is recommended to use the first acquisition mode as it is easier. To switch between the two acquisition modes, use the menu command **Test|Template|Additional** (**[Alt+A]**) (Fig. 3.54).
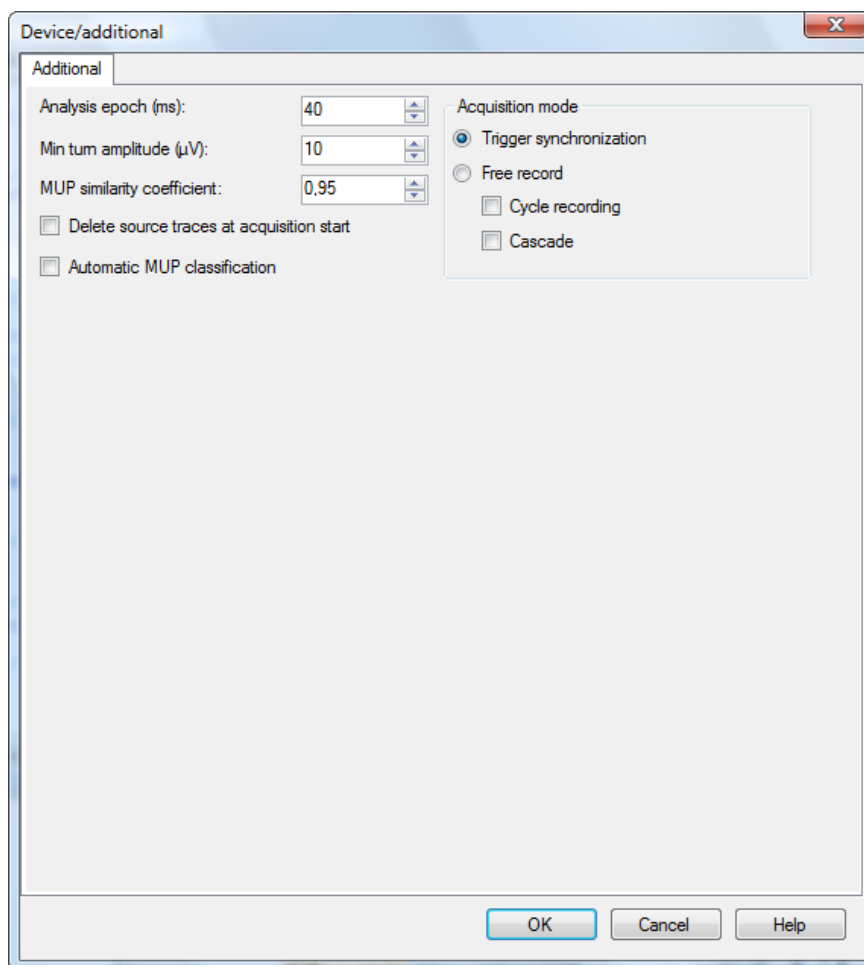


Fig. 3.54

"Analysis epoch, ms" – duration of trace being recorded in milliseconds.

"Min turn amplitude, µV" – minimal threshold for calculation of MUP turns in microvolts.

"Delete source traces at acquisition start" – if the check box is selected, the initial traces from which motor unit potentials are selected will be deleted automatically after each execution of the menu command **Acquisition|Acquisition/Stimulus**.

"Acquisition mode"

"Trigger synchronization" – this mode is used for short epochs acquisition (single motor unit potentials).

"Free record" – this mode is used for long epochs recording.

"Cycle recording". If the "Cycle recording" check box is unchecked, the trace filling will be stopped at the specified analysis epoch achievement. If the check box is selected, it will continue cyclically (i.e. after the filling of all analysis epoch the recording starts from the trace beginning) up to the manual record stop.

"Cascade" – display of traces with a "wrap", i.e if a trace does not fit the screen width, it is forwarded to the next line and can be displayed in several lines.

# 3.7.1. Long Epochs Acquisition

Start signal monitoring by selecting the menu command **Acquisition|Monitoring** (or by the corresponding button on the dedicated keyboard) and insert the needle into a muscle. Adjust the strength of muscle activity so that motor unit potentials do not superimpose on each other and start signal acquisition by the menu command **Acquisition|Acquisition/Stimulus**.

To start recording, use the menu command **Acquisition|Averaging/Continuous** (**[Ins]** key or the corresponding button on the keyboard).

To pause the trace acquisition, use the menu command **Acquisition|Pause** (space key or the corresponding button on the keyboard).  To register each new fragment as a new trace, use the menu command **Acquisition|Averaging/Continuous** (**[Ins]** key or the corresponding button on the keyboard) to stop and then restart the acquisition process.

To analyze the recorded traces, use the menu command **Acquisition|Stop** (or the corresponding button on the keyboard). To quit, use the menu command **Acquisition|Cancel** (**[Esc]** key or the corresponding button on the keyboard).

Repeat the procedure for the other puncture.

From each insertion, you can record a trace long enough so that each motor unit potential (MUP) will be repeated several times (as a rule, it takes 10-30 seconds). If the acquisition is of poor quality, it is recommended to make the traces longer.

## 3.7.2. Short Epochs Acquisition (Single MUP)

Start signal monitoring by selecting the menu command **Acquisition|Monitoring** (or by the corresponding button on the dedicated keyboard) and insert the needle into a muscle. Adjust the strength of muscle activity so that motor unit potentials do not superimpose on each other and start signal acquisition by selecting the menu command
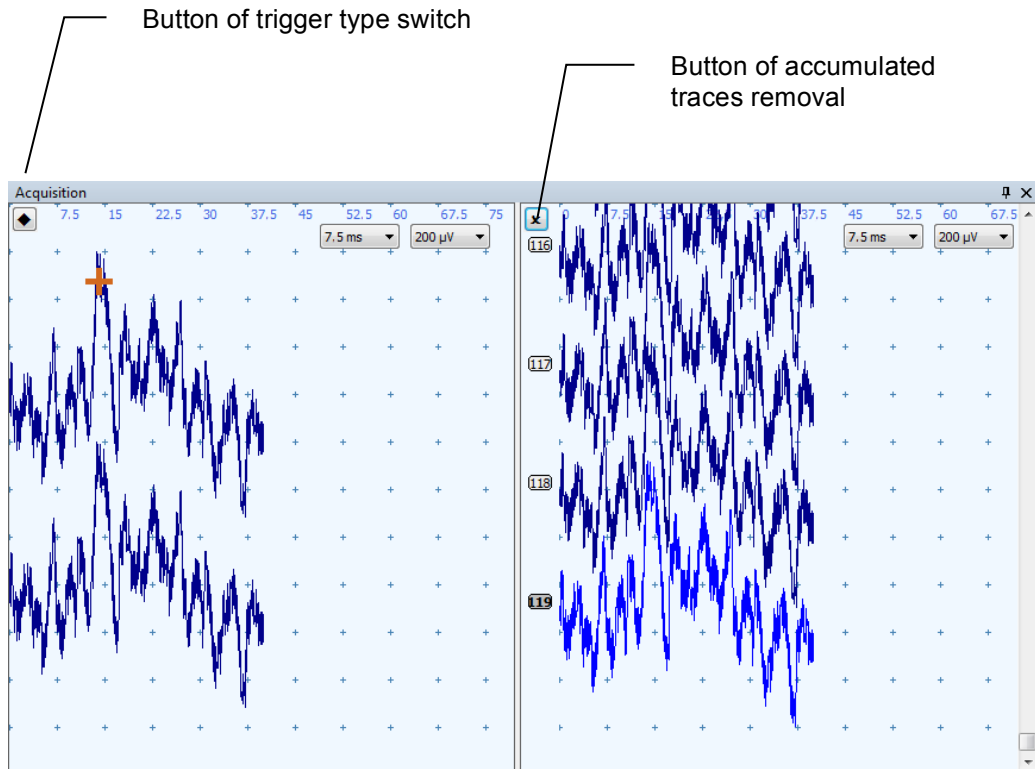**Acquisition|Acquisition/Stimulus** (Fig. 3.55).



Fig. 3.55

To synchronize the motor unit potentials, shift the trigger by using the arrow keys (press **[Ctrl]** to shift faster), the knobs on the dedicated keyboard or the mouse, Next, start their accumulation in the right part of the window (Fig. 3.55) by pressing **[Ins]** or by using the corresponding button on the dedicated keyboard.

To pause during trace acquisition, use the menu command **Acquisition|Pause** (space key or the corresponding button on the keyboard). To stop and then restart the acquisition process, use the menu command **Acquisition|Averaging/Continuous [Ins]** key or the corresponding button on the keyboard).

To delete a trace, press the removal button (Fig. 3.55).

If high amplitude MUPs alternate with low amplitude MUPs, record only the low amplitude MUPs. Switch the trigger type by using the button, located in the top left corner of the window (Fig. 3.55), so that only traces with narrow interval peaks are recorded. This type of trigger is shifted using the arrow buttons (the moving is quicker

if **[Ctrl]** is pressed), its size (height) is changed using the arrow buttons and pressing the **[Alt]** key.
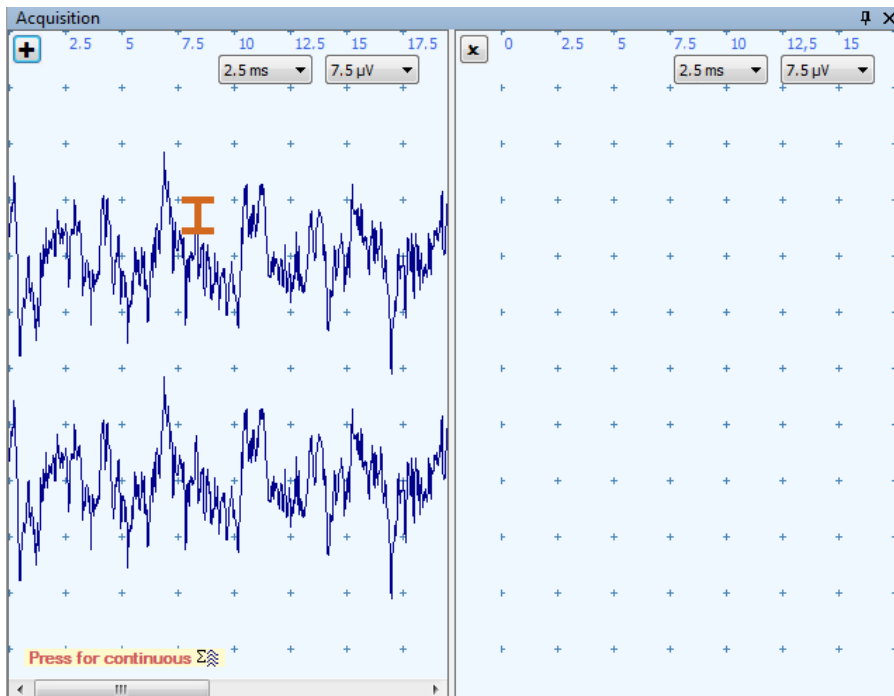


Fig. 3.56

To analyze the recorded traces, use the menu command **Acquisition|Stop** (or the corresponding button on the keyboard). To quit, use the menu command **Acquisition|Cancel** (**[Esc]** key or the corresponding button on the keyboard).

Repeat the procedure for the other puncture.

It is possible to record several tens of motor unit potentials from each puncture. If the acquisition is of poor quality, it is recommended to record more motor unit potentials.

## 3.7.3. Manual MUP Selection

After recording a sufficient number of traces, start the manual MUP search by placing the mouse cursor on the potential of the initial trace (Fig. 3.57, a), pressing and holding down the **[Alt] key** and then clicking the left mouse button (Fig. 3.57, b). If it is necessary, correct the position of markers and select **Copy MUP as new** or **Copy into cell N…** from the dropdown list (Fig. 3.57, c).



a)          b)          c)

Fig. 3.57

## 3.7.4. MUP Analysis

You can switch between three different reviews of traces by using the menu command **Test|Show native/analyzable**:

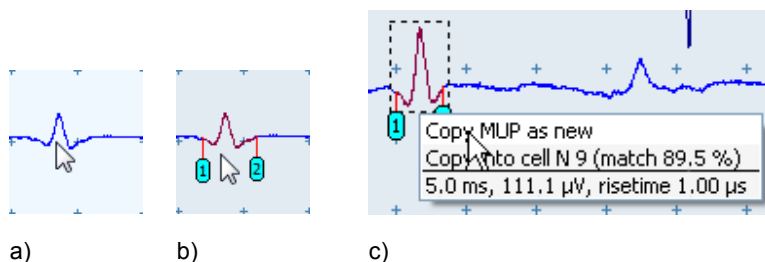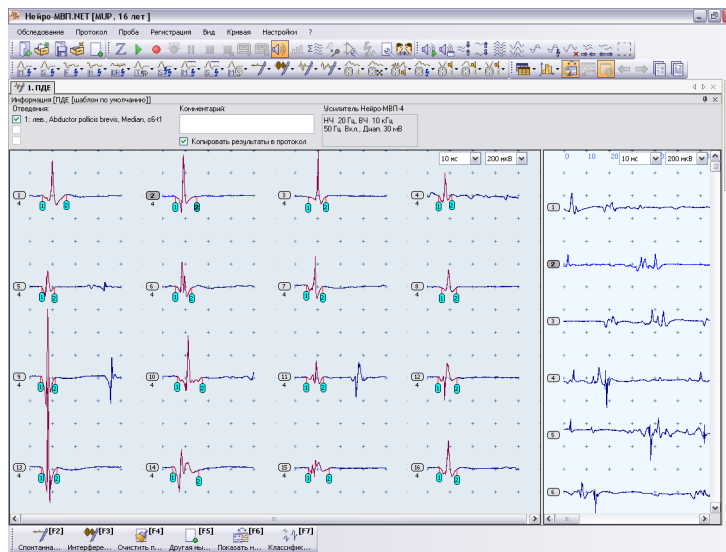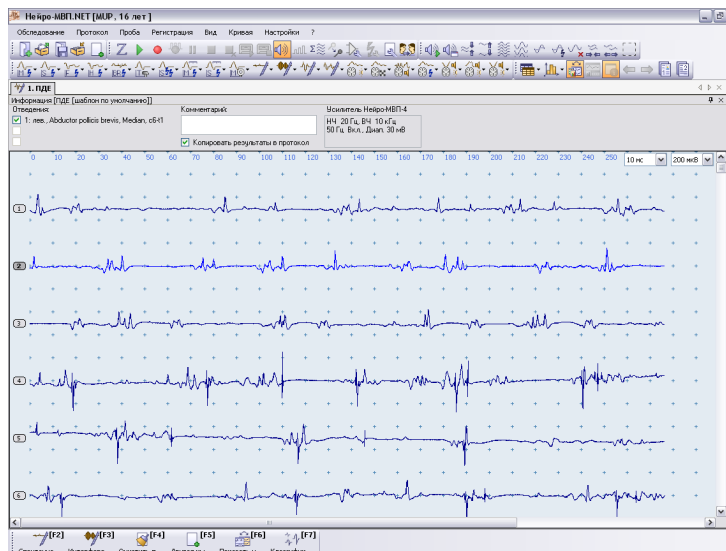• Simultaneous review of native traces and motor unit potentials selected for analysis (Fig. 3.58, a).

• Review of native traces only (Fig. 3.58, b).

• Review of motor unit potentials selected for analysis only (Fig. 3.58, c).



a)



b)
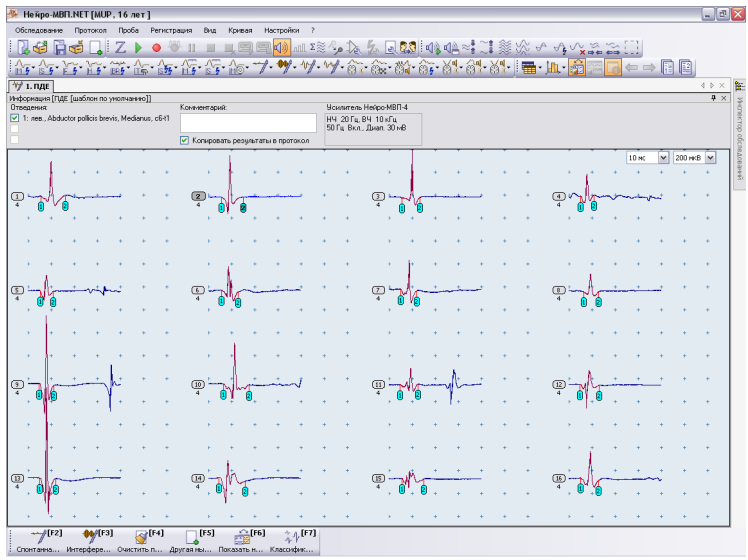
c)

Fig. 3.58

To delete a poor motor unit potential, select it with the mouse and then use the menu command **Trace|Delete** (**[Ctrl+Del]** or the corresponding button on the keyboard).

There are two ways to remove MUP from analysis without deletion: you can either hide MUP by using the local menu command "Hide trace" (motor unit potentials disappear from the screen) or cancel its inclusion into analysis by using the local menu command **"Do not take into analysis"** (motor unit potentials remain on the screen, but they are crossed). You can also change the MUP recording status during analysis by selecting the check box in the "MUP parameters" analysis window.

To make more precise corrections and view all potentials of the current MUP (in case of MUP averaging), double-click on the MUP selected for analysis. In the appeared window (Fig. 3.59) the scaled-up MUP is located on the left; the superposition of all motor unit potentials from which the current potential is formed is located on the right; and the cascade display of the same motor unit potentials is located on the bottom right side of the window.
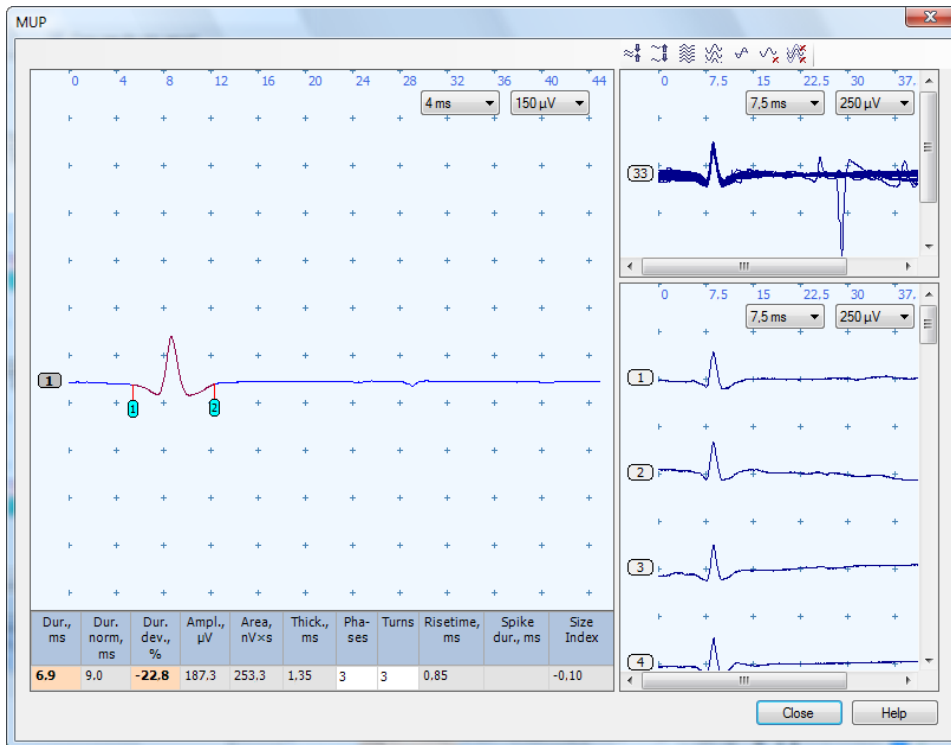
Fig. 3.59

To delete poor motor unit potentials, click on the necessary potential (bottom right of the window Fig. 3.59), then press the right mouse button to open the right-click menu and select the command "Delete trace" (**[Ctrl+Del]**). To delete several potentials, use the mouse and hold down the **[Ctrl]** key simultaneously. You can correct the number of MUP phases and turns by changing the values in the table located on the bottom right side of the window. Keep in mind that while shifting MUP on-set and end markers, the potential parameters will be recalculated automatically.

To close the "MUP" window, press "Close" or **[Esc]**.

To combine motor unit potentials from two different cells, use the mouse to select these potentials (the **[Ctrl]** key must be also pressed) and activate the menu command **Test|MUP Combine** (or the local menu command "MUP Combine").

To hide motor unit potentials which are not included into analysis, use the local menu command "Hide nonanalyzable".

Use the dialog box (Fig. 3.60) to select data for deletion (MUP in cells and/or initial traces) by selecting the menu command **Test|Clear** (**[F4]**).
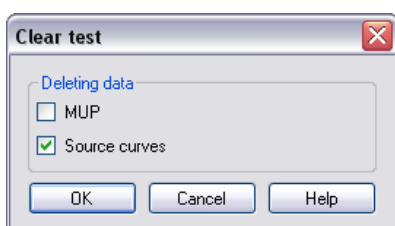


Fig. 3.60

After recording all the necessary results you can study the contralateral muscle **Test|New/Other side**), some other muscle (**[F5]**) or you can start another technique (**Test|New** or the corresponding button on the "New test" toolbar).

After recording several traces, the test window looks as follows (Fig. 3.61).
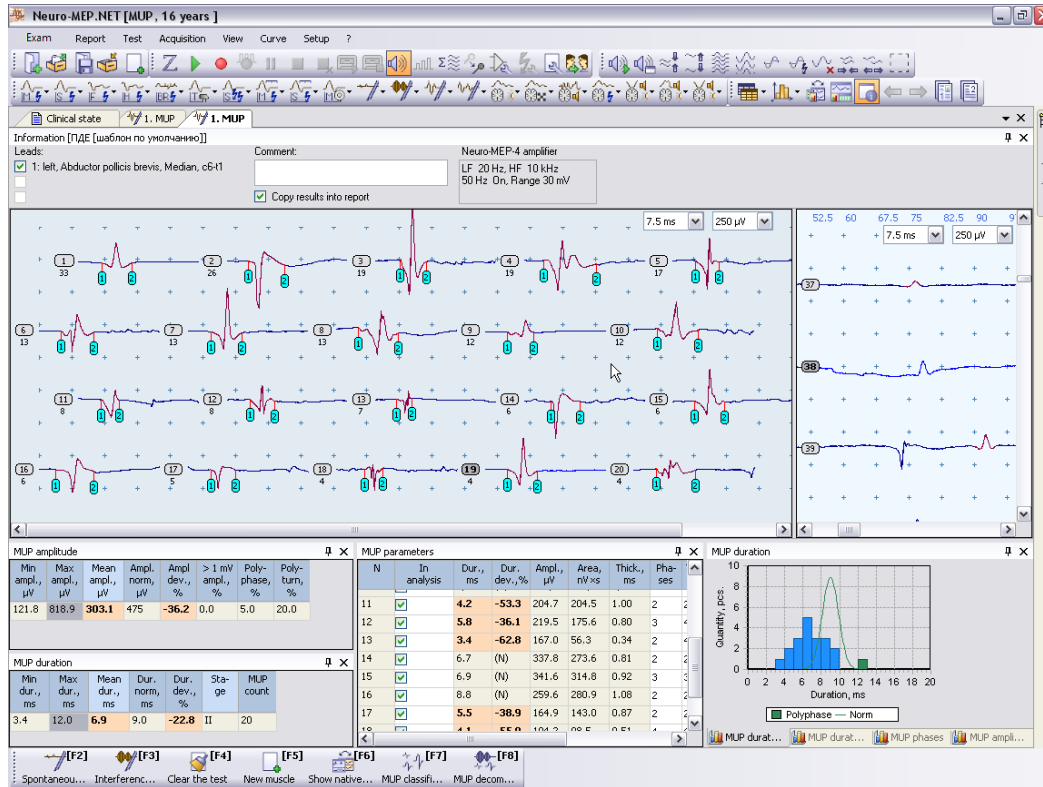


Fig. 3.61

After switching the windows layout by selecting the menu command **View|Windows layouts|Switch** (**[Ctrl+Tab]**), the test window looks as follows (Fig. 3.62).
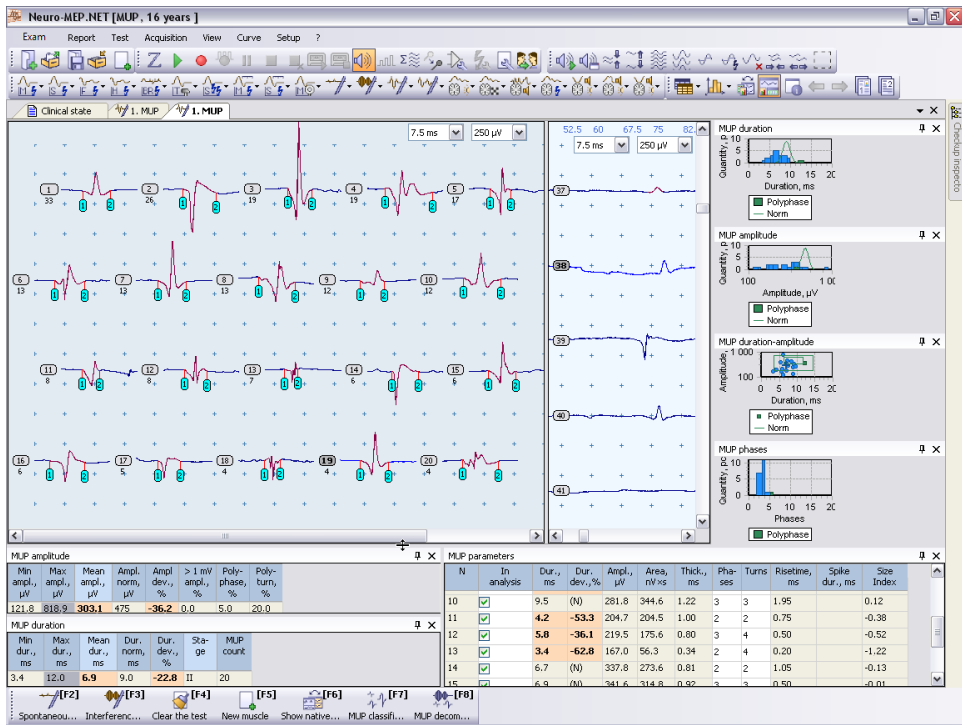
Fig. 3.62

To preset a test template, use the menu command **Setup|Tests templates|Setup**. The "MUP" page of the test template wizard contains the following information (Fig. 3.63).
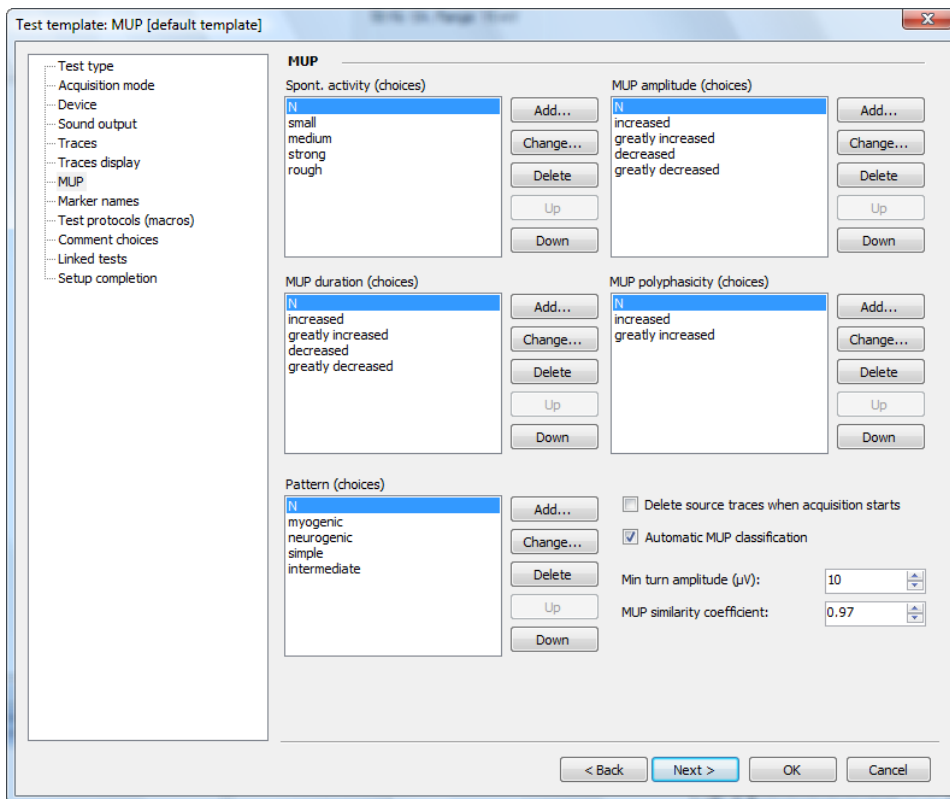


Fig. 3.63

"Spont. activity (choices)". Spontaneous activity choices for the "Spontaneous activity" dropdown list of the "Interpretation" analysis window.

"MUP amplitude (choices)". MUP amplitude choices for the "MUP amplitude" dropdown list of the "Interpretation" analysis window.

"MUP duration (choices)". MUP duration choices for the "MUP duration" dropdown list of the "Interpretation" analysis window.

"MUP polyphasy (choices)". MUP polyphasy choices for the "MUP polyphasy" dropdown list of the "Interpretation" analysis window.

"Pattern (choices)". EMG pattern choices for the "Pattern" dropdown list of the "Interpretation" analysis window.

"Delete source traces when acquisition starts". If the check box is selected, after each execution of the menu command **Acquisition|Acquisition/Stimulus**, the selected motor unit potential source traces will be deleted automatically.

"Min. turn level (µV)". Minimal level to calculate MUP turns, in microvolts.

# 3.8. Single Fiber EMG

## 3.8.1. Jitter Acquisition

To conduct a **jitter** test, press the [button icon] button on the "New test" toolbar and select the name of a test template from the dropdown list. If you are unable to locate the test you need, use the menu item **Test|New** and select a default test template.

Prepare the needle electrode for insertion, place the ground electrode on a patient and connect the electrodes to the amplifier input.

Start signal monitoring by selecting the menu command **Acquisition|Monitoring** (or by the corresponding button on the dedicated keyboard), insert the needle into a muscle and start signal acquisition by using the menu command **Acquisition|Acquisition/Stimulus** (Fig. 3.64).
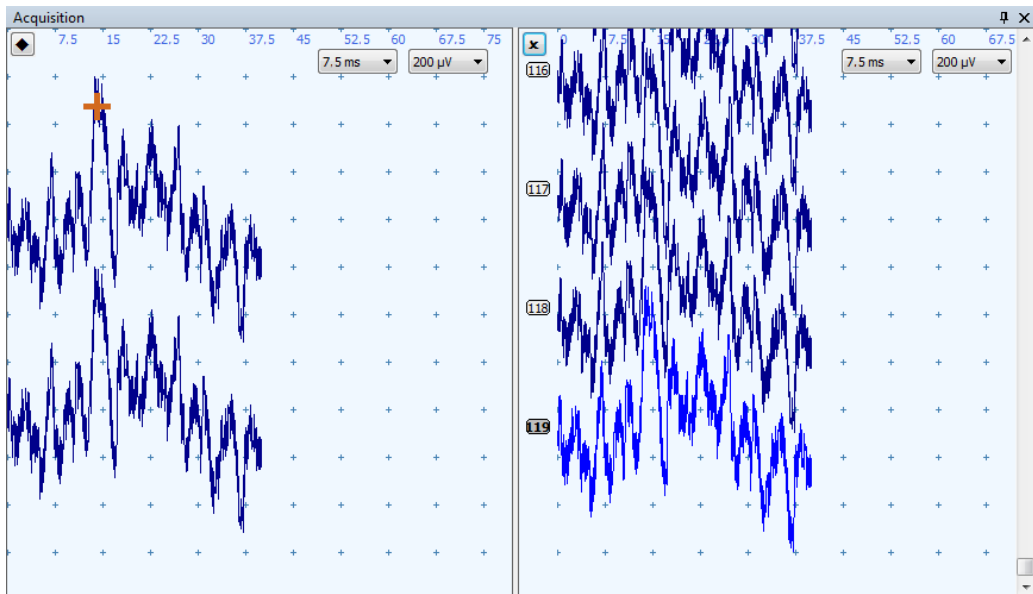
Fig. 3.64

Shift the trigger by using: arrow keys (if you press **[Ctrl]**, the shifting will be faster), knobs on the dedicated keyboard or the mouse to achieve synchronization of single-fiber action potentials (SFAP) that will appear at the bottom of the window. Start their accumulation by pressing **[Ins]** or the corresponding button on the dedicated keyboard.

To stop the trace acquisition, use the menu command **Acquisition|Pause** (space key or the corresponding button on the keyboard). To stop and then restart the acquisition process, use the menu command **Acquisition|Averaging/Continuous** (**[Ins]** key or the corresponding button on the keyboard).

To analyze the registered traces, use the menu command **Acquisition|Stop** (or the corresponding button on the keyboard) or to quit, use the menu command **Acquisition|Cancel** (**[Esc]** key or the corresponding button on the keyboard).

It is possible to repeat a recording several times. After completion of each recording, a new SFAP group will be created. To switch between windows with groups of traces, click on the corresponding line of the "Jitter (all traces)" table.

The superposition of all SFAP pairs in the current ßgroup is displayed in the left side of the window and the cascade of all SFAP pairs is displayed in the right side (Fig. 3.65).
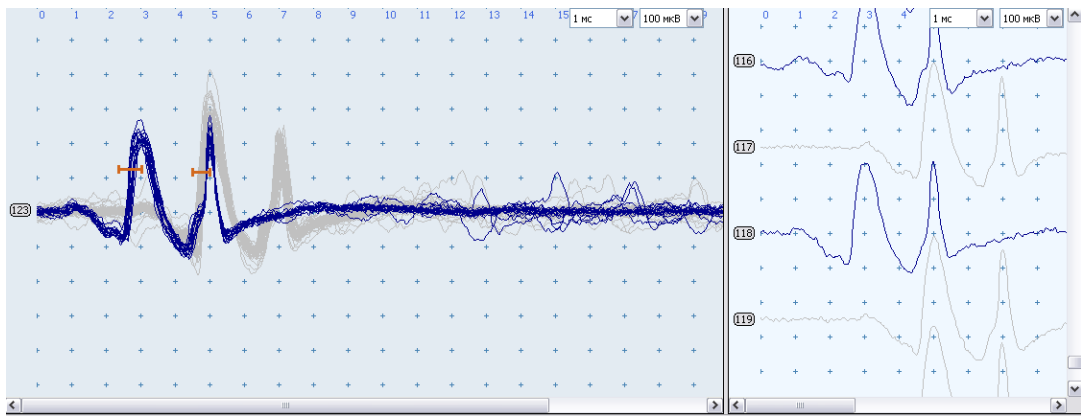
Fig. 3.65

To select SFAP pair, use the mouse to place two markers so that the fronts of the first and second SFAP in pair are within their boundaries (Fig. 3.66).
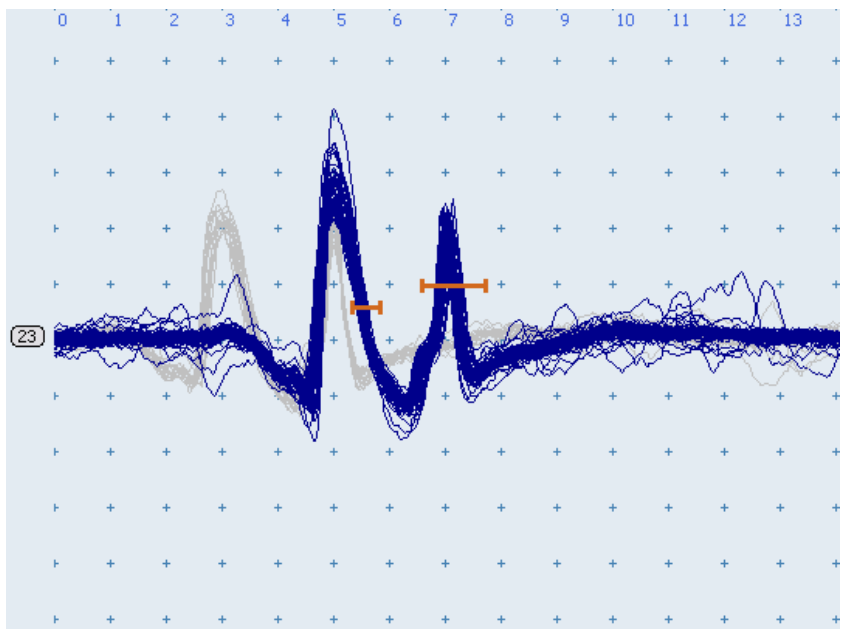


Fig. 3.66

Traces not included in the analysis are marked in grey; traces only intersecting with the first (left) marker (blocks) are marked in pink. To hide traces that are not included in the analysis, use the menu command **Test|Hide artefacts**.

To delete the current group of traces, use the menu command **Test|Delete set of traces**. To create a new group of traces that were not included in the analysis, use the menu command **Test|New pair**.

To select more accurate SFAP pairs for analysis, use the "Interpeak intervals" graph (Fig. 3.67).
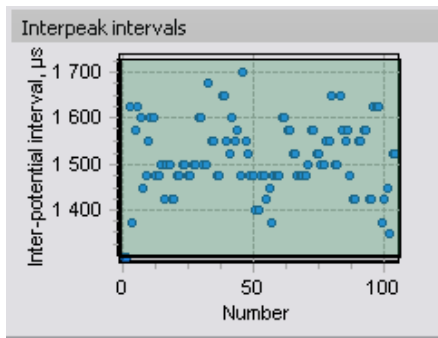
Fig. 3.67

Interpeak interval dependence on trace serial numbers is displayed in the graph above. The interval will equal to ±4σ after acquisition of traces by default. To exclude pairs with interpeak intervals that are too long or too short from analysis, drag the upper or lower boundary of the fill area with the mouse.

After recording all the necessary traces you can study the contralateral muscle **Test|Change side**), some other muscle or you can start another technique (**Test|New** or the corresponding button on the "New test" toolbar).

After recording several traces, the test window will look as follows (Fig. 3.68).
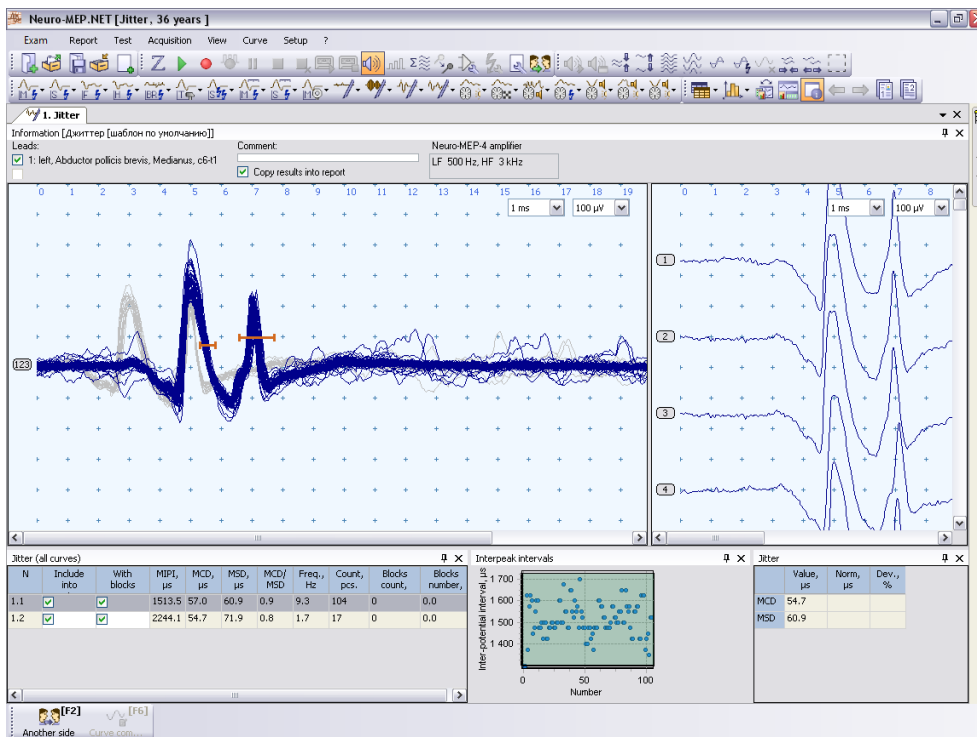


Fig. 3.68

## 3.8.2. Analysis Windows

The "Jitter (all traces)" analysis window contains the following information (Fig. 3.69).

| N | Include in analysis | With blocks | MIPI, µs | MCD, µs | MSD, µs | MCD/MSD | Freq., Hz | Count, pcs. | Blocks count, | Blocks count, % |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.1 | ✓ | ✓ | 1513 | 57.0 | 60.9 | 0.9 | 9.3 | 104 | 0 | 0 |
| 1.2 | ✓ | ✓ | 2244 | 54.7 | 71.9 | 0.8 | 1.7 | 17 | 0 | 0 |

Fig. 3.69

"N" – number of traces group.

"Include into analysis" – this check box shows whether the group is included into analysis, i.e. into calculation of MCD and MSD end values (Fig. 3.70).

"With blocks" – if the check box is selected, the traces with blocks (absence of the second SFAP in pair) will be included into analysis; if the check box is not selected, the traces with blocks will be considered to be artifacts.

"MIPI, µs" – mean interpeak interval between SFAP in pair in microseconds.

"MCD, µs" – mean consecutive difference in microseconds.

"MSD, µs" – mean successive difference sorted by IDI (interval between SFAP pairs), in microseconds.

"MCD/MSD" – ratio between MCD and MSD.

"Freq., Hz" – mean frequency of SFAP pairs occurrence in Hertz.

"Count, pcs." – number of SFAP pairs in the group which are neither artifacts nor blocks.

"Blocks count, pcs." – number of blocks (skips of the second SFAP) in the group.

"Blocks number, %" – number of blocks in percents.

The "Jitter" analysis window (Fig. 3.70) contains information about the value, norm and deviation from norm for MCD and MSD calculated on the basis of all the traces groups taken into analysis when user inputted normal values are available.



| Jitter | Value, µs | Norm, µs | Dev., % |
|---|---|---|---|
| MCD | 54.7 | | |
| MSD | 60.9 | | |

Fig. 3.70

# 3.9. Galvanic Skin Response (GSR), also known as Sympathetic Skin Response

## 3.9.1. GSR Acquisition

Important note: The GSR, as its name implies, is indicated for the measurement of the galvanic skin response **and not as an aid in the evaluation of muscles, nerves or the central nervous system.**

To conduct a **GSR** test, use the menu item **Test|New** and select the name of a test template. If you are unable to locate the test you need, use a default test template.

Connect the electrical stimulator to the control unit.

Measure the impedance by selecting the menu command **Acquisition|Impedance**, pressing **[Ctrl+Z]** or by using the button on the dedicated keyboard. Then place the recording electrodes on a patient and connect them to the amplifier input. When you reach the desired impedance level, close the impedance measurement window by pressing the **[Esc]** key.

Set the required initial value of electrical stimulus by selecting the menu items **Acquisition|Stimulus|Increase** and **Acquisition|Stimulus|Decrease** or by using the dedicated keyboard control. Place the electrical stimulator over the nerve under examination.

Start a single stimulation by selecting the menu item **Acquisition|Acquisition/Stimulus** or by using the corresponding button on the dedicated keyboard. If you do not get the required M-wave, repeat the stimulation start-up. The trace of the previous stimulus is displayed on the screen in grey color.

If the message "Stimulus differs from the specified one" or "Open circuit of electric stimulator" appears, check the stimulating electrode connection to the electric stimulator and place it more carefully. Please remember to moisten stimulating electrode felt inserts with physiological solution.

To calculate conduction distances, use the menu command **Test|Distance input** (**[F2]**) and enter distances (3.9).
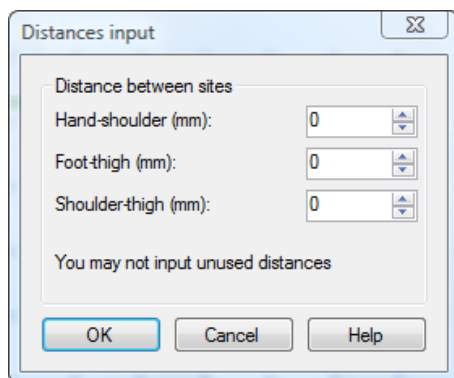


Fig. 3.9

If markers cannot be found on the trace automatically (very low amplitude), start searching for them manually by using the mouse – press **[Alt]** and while holding it click the left mouse button on the suspected wave location.

If markers are placed inaccurately you can override them with the mouse.

There can be 4 markers of the feature points on the trace:

• H – potential onset;

• 1 – the first component;

• 2a – the second component (the first wave);

• 2b – the second component (the second wave).

After recording all the necessary results, you can study the contralateral site side **Test|Change side**, **[F4]**), some other site (**[F5]**) or you can start another technique using the menu command **Test|New** (or the corresponding button on the "New test" toolbar).

After recording several traces, the test window looks as follows (Fig. 3.)
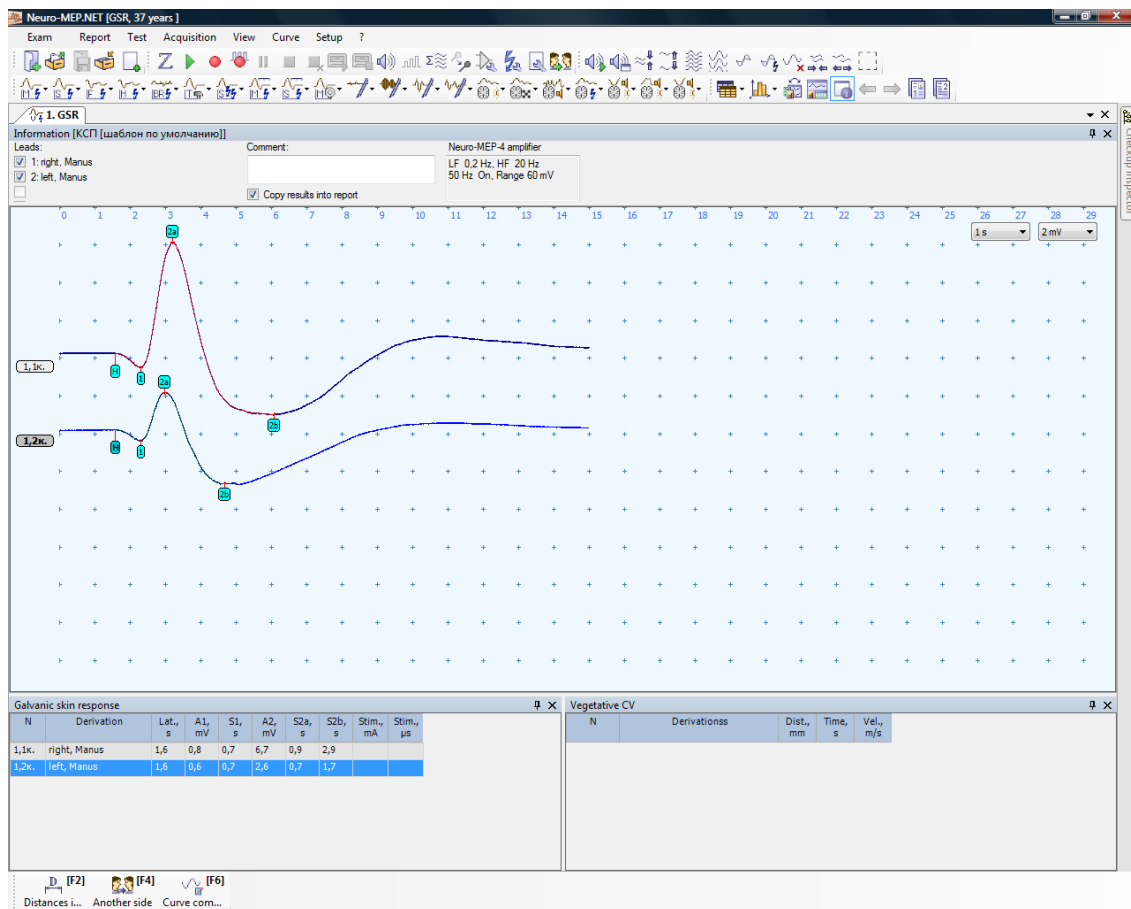


Fig. 3.91

## 3.9.2. Analysis Windows

The "Galvanic skin response" analysis window contains the following information (Fig. 3.).

| Galvanic skin response | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| N | Site | Lat., s | A1, mV | S1, s | A2, mV | S2a, s | S2b, s | Stim., mA | Stim., μs |
| 1.1к. | right, Manus | 1.6 | 0.8 | 0.7 | 6.7 | 0.9 | 2.9 | | |
| 1.2к. | left, Manus | 1.6 | 0.6 | 0.7 | 2.6 | 0.7 | 1.7 | | |

Fig. 3.92

"N" – trace (name) number.

"Site" – site point name.

"Lat., s" – wave latency in seconds.

"A1, mV" – first component amplitude in millivolts.

"S1, s" – first component duration in seconds.

"A2, mV" – second wave amplitude in millivolts.

"S2a, s" – ascending part duration of the second component in seconds.

"S2b, s" – descending part duration of the second component in seconds.

"Stim., mA" – stimulus intensity in milliamperes.

"Stim., μs" – stimulus duration in microseconds.

The "Autonomic CV" analysis window contains the following information (Fig. 3.).

| Autonomic CV | | | | |
|---|---|---|---|---|
| N | Sites | Dist., mm | Time, s | Vel., m/s |
| | | | | |

Fig. 3.93

"N" – traces (names) numbers for which the conduction velocity is calculated.

"Sites" – sites names between which the conduction velocity is calculated.

"Dist., mm" – distance between site points in millimeters.

"Time, s" – conduction time between site points in seconds.

"Vel., m/s" – conduction velocity through vegetative (autonomic) fibers in meters per second.

# 4. Evoked Potentials

## 4.1. Recommendations for EP Acquisition

For EP acquisition, it is very important to have a low interference level in the room. The device and computer must be safely grounded and all powerful electric devices must be shut off.

Fig. 4.1 shows an example of poor electrodes positioning: big loops, made up by sites, work as antenna and cause a high interference level. Fig. 4.2 shows perfect positioning of electrodes: twisted wires prevent the forming of big loops and allow a lower noise level. It is recommended to place wires from a patient as close to each other as possible and to twist them if there is a high interference level.
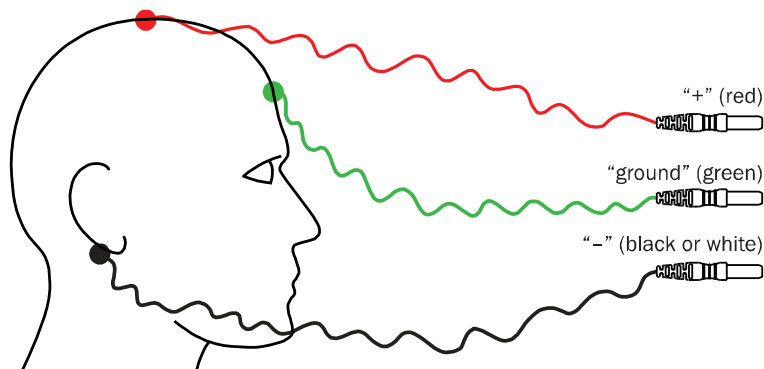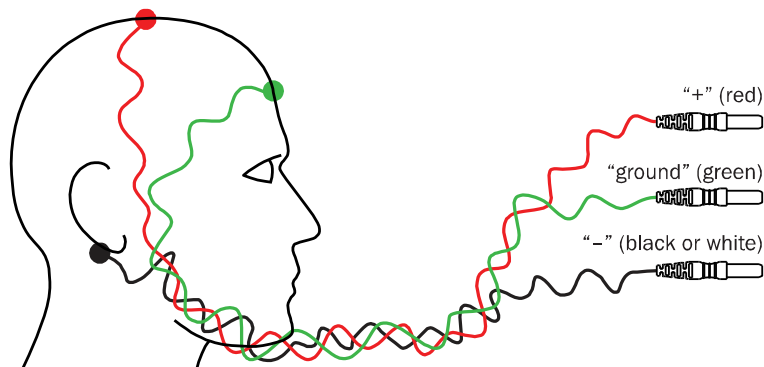


Fig. 4.1



Fig. 4.2

Each amplifier channel has two outputs on the panel: the first one is touchproof and has separate (red "+" and black "-") round white sockets with pins (basically used for EP-exams), and the second one

– DIN – in the form of combined 6-pins round socket (basically used for EMG studies). If you use one of the amplifier channel outputs, you must disconnect the electrodes of the other output to avoid an increase in interference level.

During EP studies, the black ("-") amplifier output is considered to be the active electrode and the red ("+") amplifier output is considered to be the reference one. For EP studies, it is necessary to place the ground (general) electrode on the patient.

# 4.2. EP Acquisition

For EP acquisition, click on the necessary button in the "New test" toolbar and select the name of a test template from the dropdown list. An example of short-latency auditory EP selection is shown in Fig. 4.3. If you are unable to locate the test you need, use the menu item **Test|New** and select a default test template.
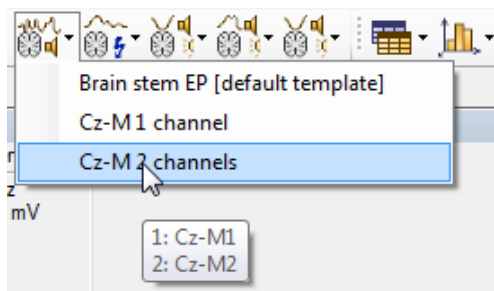


Fig. 4.3

Measure the impedance by selecting the menu command **Acquisition|Impedance**, pressing **[Ctrl+Z]** or by using the button on the dedicated keyboard. Then place the electrodes on a patient and connect them to the amplifier input. The number of used amplifier channels and the site names are displayed in the top left corner of the window under the "Sites" heading. When you reach the desired impedance level, close the impedance measurement window by pressing the **[Esc]** key.

Connect the stimulator to the control unit.

Set the required initial value of stimulus by selecting the menu items **Acquisition|Stimulus|Increase** and **Acquisition |Stimulus|Decrease** or use the dedicated keyboard.

Before recording, you can start the signal monitoring window by selecting the menu command **Acquisition|Monitoring** and follow the signal level received from the electrodes and presence of interference.

Switch the averaging mode on (the menu command **Acquisition|Averaging/Continuous** or the corresponding button on the dedicated keyboard), start the repetitive stimulation by selecting the menu command **Acquisition|Repetitive stimulation** (or press the corresponding button on the dedicated keyboard) and follow the process of signal averaging.

If you do not get the required evoked potentials, stop averaging by selecting the menu command **Acquisition|Cancel** (**[Esc]**) and then restart it.

When you get qualitative evoked potentials, finish the acquisition and save the results for further analysis by selecting the menu item **Acquisition|Stop** or press **[Esc]** to delete.

If it is necessary to start stimulation and and wait a period of time before signal averaging, first switch off averaging (the menu command **Acquisition|Averaging/Continuous**), then start recording (the menu command **Acquisition|Repetitive stimulation**) and at the right moment, switch on the averaging (the menu command **Acquisition|Averaging/Continuous**).

During signal acquisition, you can switch the averaging on or off (the menu command **Acquisition|Averaging/Continuous**) any number of times or you can stop the stimulation by using the menu command **Acquisition|Pause**.

EP traces can be viewed as all (summarized) or even/odd (recorded while averaging even and odd stimuli separately) traces. To switch between these modes, use the menu command **View|Traces|Even-Odd/All** (**[Ctrl+E]**).

To mark the EP components manually, click the left mouse button on the component name on the toolbar (Fig. 4.4, a) and shift the crosshair cursor to the point of the assumed component and press the left mouse button once more (Fig. 4.4, b). If you do not want to mark the component, press the "Reset" button or the **[Esc]** key.

a)                            b)
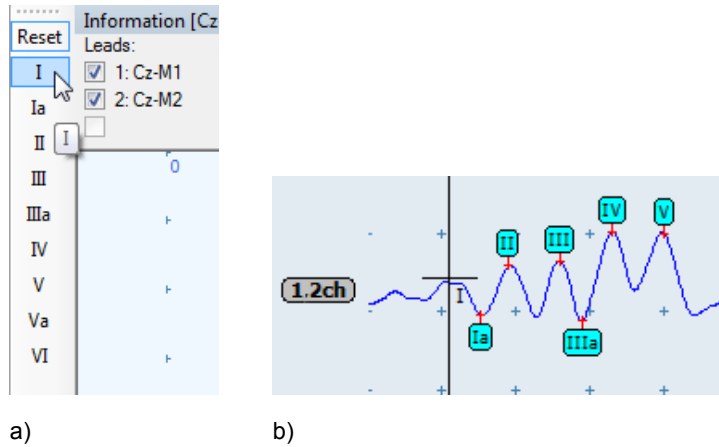
Fig. 4.4

If the markers are placed inaccurately, you can override them with the mouse.

To place EP components automatically, use the menu commands **Trace|Place EP components** and **Trace|Place all EP components**. To delete EP components, use the menu commands **Trace|Marker|Delete current**, **Trace|Marker|Delete all on trace** and **Trace|Marker|Delete all**.

After recording all the necessary traces, you can start another study by selecting the **Test|New** menu command or the "New test" button on the toolbar.

To preset a test template, use the menu command **Setup|Tests templates|Setup**. The "EP/ERG components" page (Components) of the test template wizard contains the following information (Fig. 4.5).



Fig. 4.5

"Name". EP (ERG) component name.

"Comm." – the text comment to the component.

"Min., ms; Max, ms" – the minimal and maximal latency for the automatic search of a component.

"Peak" – the peak direction (up or down) for the automatic search of a component.

"Site N" – the site number for the automatic search of a component. If a component can be found in any site, it is not necessary to indicate the number.
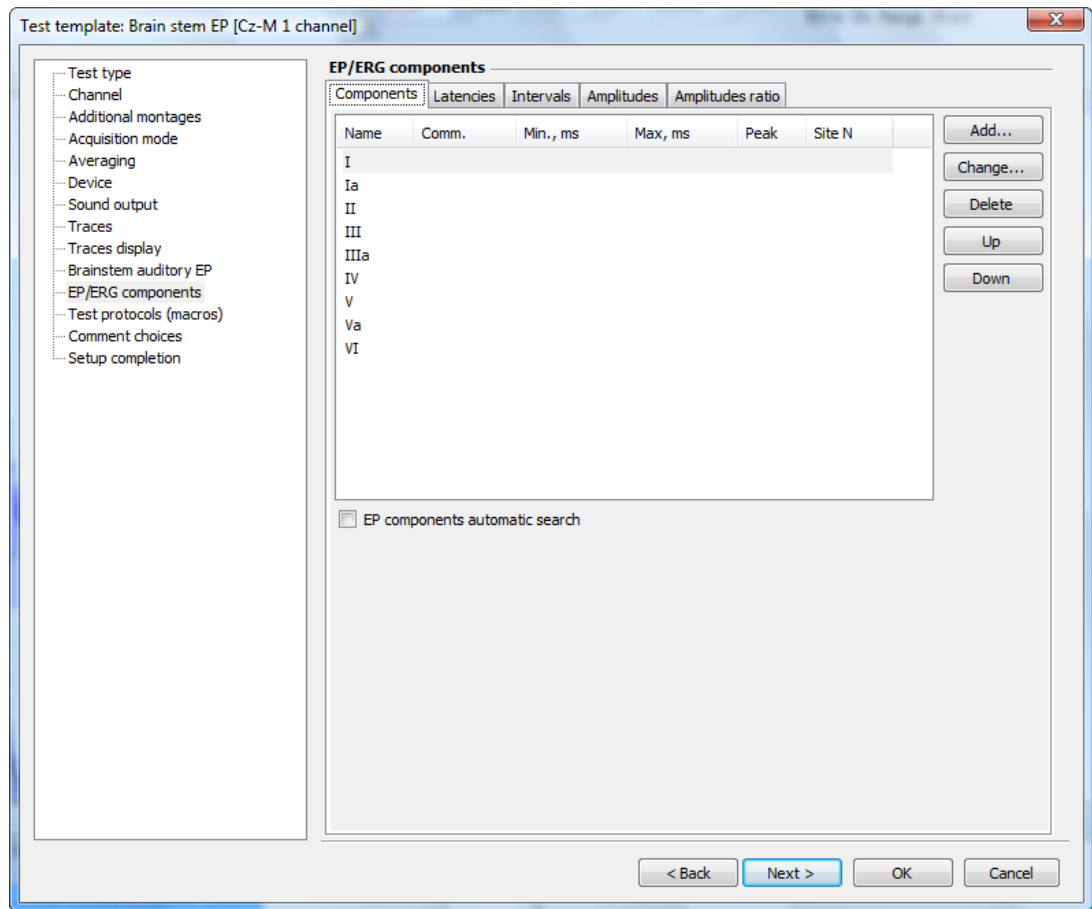
"EP components automatic search". If the check box is selected, the automatic search for EP components begins immediately after a new trace acquisition. There is a search algorithm for some common EP components installed in the program. If this algorithm doesn't suit you or you add your own components, it is possible to set the parameters for the automatic search of the components.

To edit the components list and set automatic search parameters, use the buttons on the right side of the window. While pressing the **Add...** and **Change...** buttons, the "EP component" dialog box is displayed (Fig. 4.6).
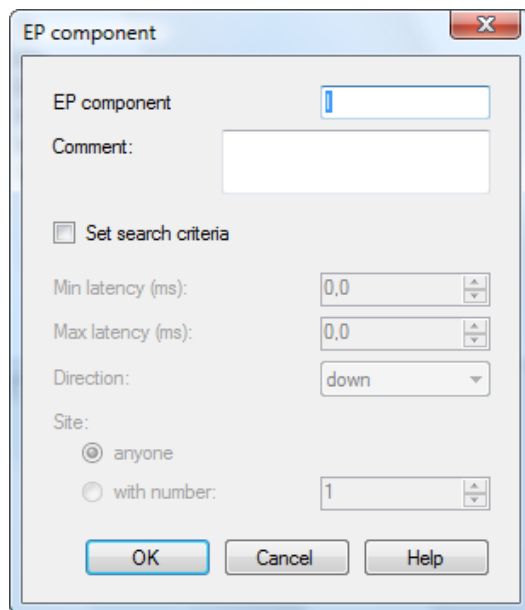


Fig. 4.6

"EP component". EP component name.

"Comment". Any text information to describe EP component.

"Set search criteria". If the check box is selected, the criteria for the automatic search of EP components can be set.

"Min. latency (ms)". EP component minimal latency during an automatic search.

"Max. latency (ms)". EP component maximal latency during an automatic search.

"Direction". EP peak direction on trace during an automatic search.

144

"Site". Site number in a series that can be set for a component during an automatic search.

The "EP/ERG components" page (Latencies) of the test template wizard contains the following information (Fig. 4.7).
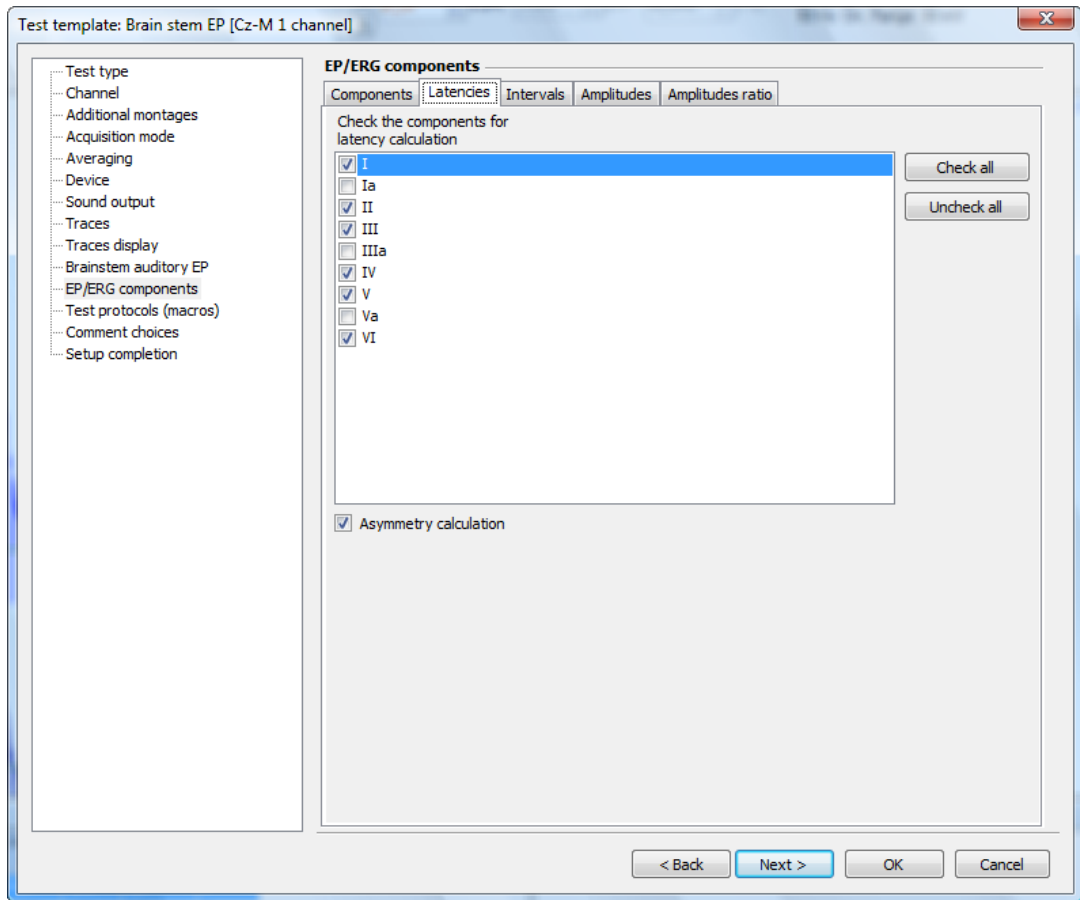


Fig. 4.7

Components with latency numerical values that you are interested in should be checked.

"Asymmetry calculation". If the check box is selected, asymmetry calculation (i.e. latencies differences received from the different sites) is performed in addition to latency calculation.

The "EP/ERG components" page (Intervals) of the test template wizard contains the following information (Fig. 4.8).



Fig. 4.8

To change intervals, use the buttons on the right side of the window.

"Asymmetry calculation". If the check box is selected, asymmetry calculation ( i.e. intervals differences received from the different sites) is performed in addition to calculation of intervals.

"Calculation of markers on different traces". If the check box is selected, the intervals calculation will be performed even when the components involved are on different traces.

The "EP/ERG components" page (Amplitudes) of the test template wizard contains the following information (Fig. 4.9).
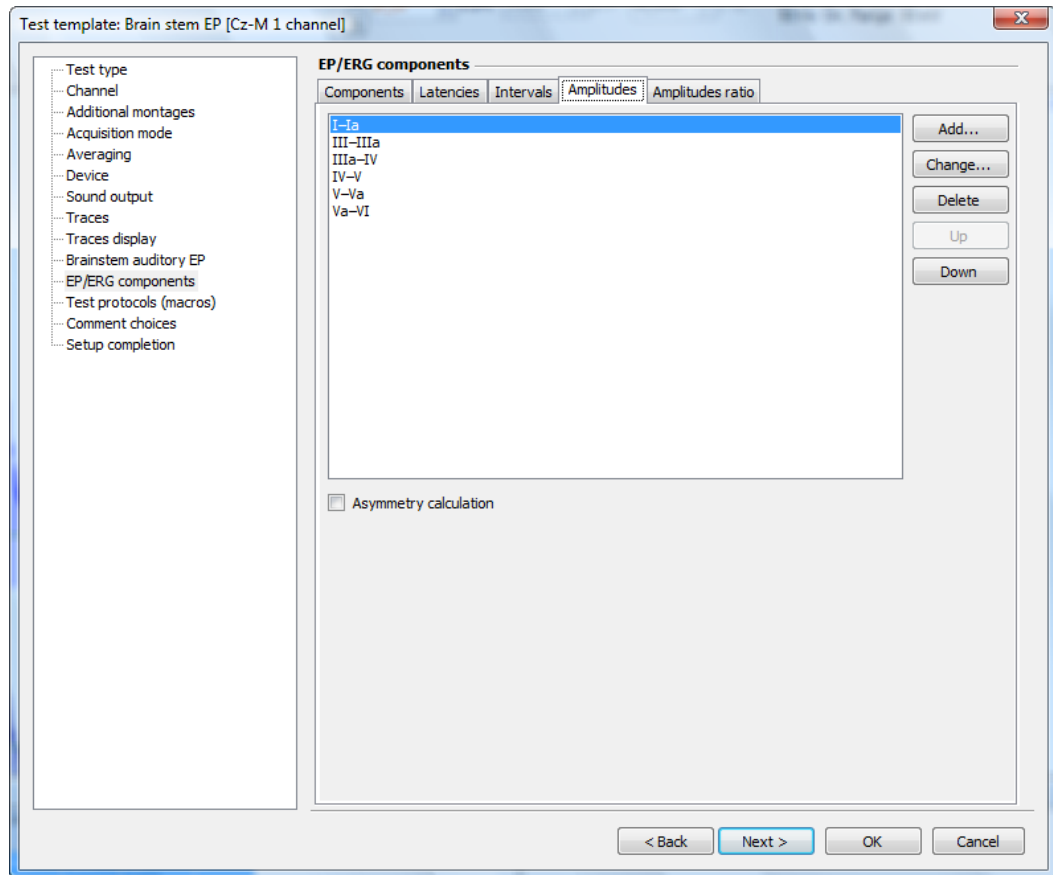


Fig. 4.9

To change the amplitudes to be calculated, use the buttons on the right side of the window.

"Asymmetry calculation". If the check box is selected, asymmetry calculation is performed, i.e. amplitude ratios received from the different sites, in addition to the amplitudes calculation.

The "EP/ERG components" page (Amplitudes ratio) of the test template wizard contains the following information (Fig. 4.10).



Fig. 4.10

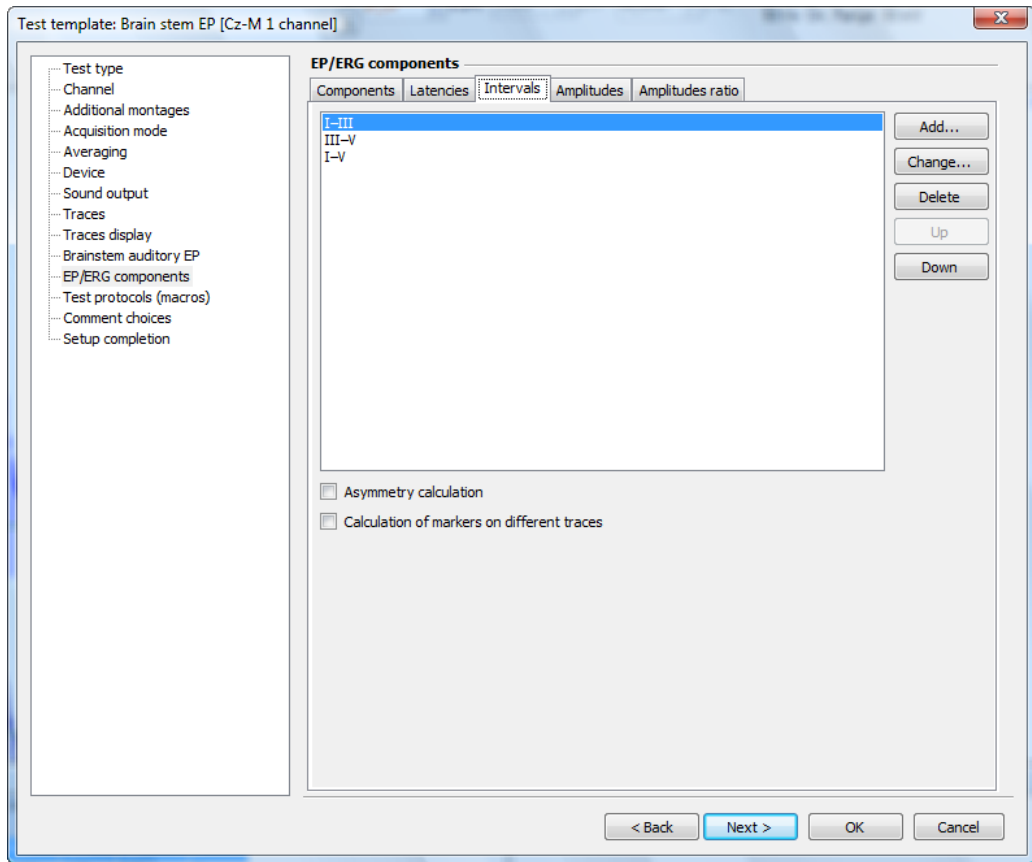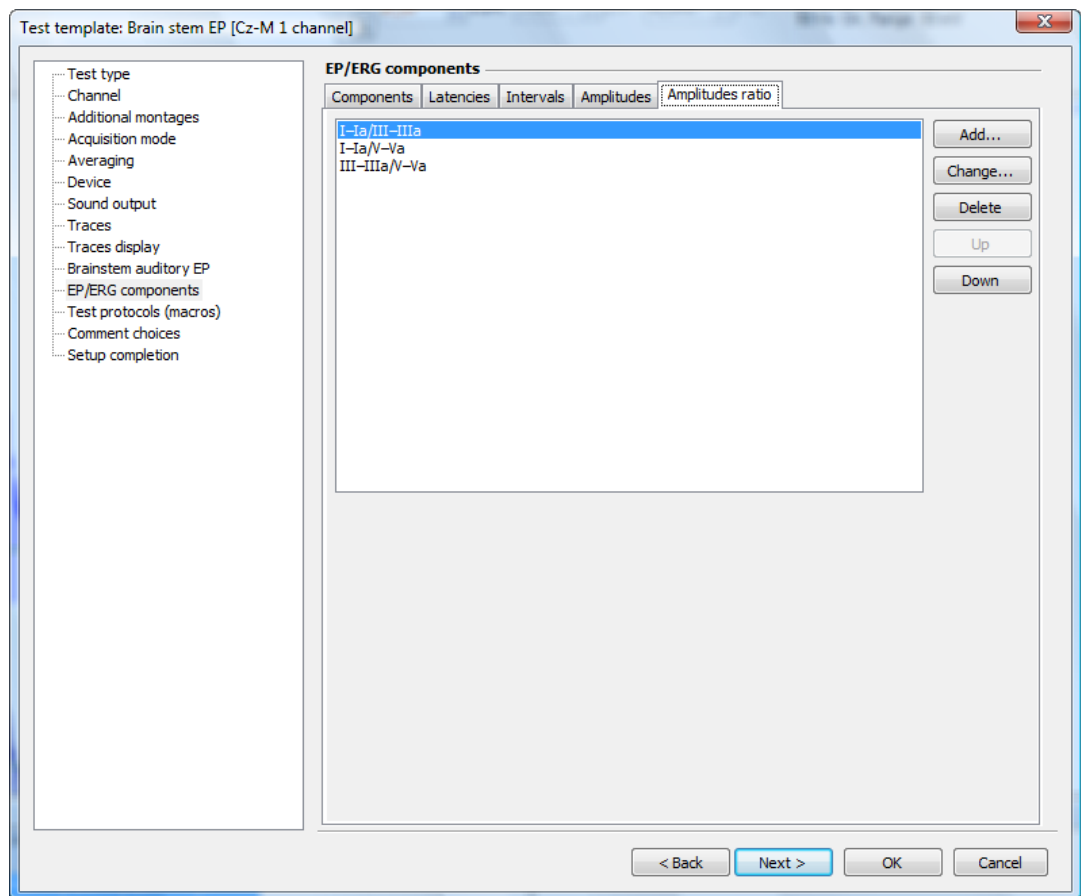To change the ratio of amplitudes to be calculated, use the buttons on the right side of the window.

# 4.3. Analysis Windows

The "Latencies" analysis window contains the following information (Fig. 4.11).

| N | Site | Com-ment | Compo-nent | Lat., ms | Norm, ms | Dev., % | Stim. side | Stimulus | Stim. dur. |
|---|---|---|---|---|---|---|---|---|---|
| 1.1ch | Cz-M1 | | I | 1.61 | 1.7 | (N) | right | 100 dB | 100 µs |
| | | | II | 3.04 | 2.8 | (N) | | | |
| | | | III | 3.86 | 3.9 | (N) | | | |
| | | | IV | 4.88 | 5.1 | (N) | | | |
| | | | V | 6.00 | 5.7 | (N) | | | |
| 1.2ch | Cz-M2 | | I | 1.61 | 1.7 | (N) | right | 100 dB | 100 µs |
| | | | II | 2.81 | 2.8 | (N) | | | |
| | | | III | 3.86 | 3,9 | (N) | | | |
| | | | IV | 4.91 | 5.1 | (N) | | | |
| | | | V | 5,96 | 5.7 | (N) | | | |
| 1.1ch 1.2ch | Cz-M1 Cz-M2 | | I | 0.0 | | | right | 100 dB | 100 µs |
| | | | II | 0.22 | | | | | |
| | | | III | 0.0 | | | | | |
| | | | IV | 0.04 | | | | | |
| | | | V | 0.04 | | | | | |

Fig. 4.11

"N" – trace number (name).

"Site" – name of trace site.

"Comment" - comment to trace.

"Component" – name of EP component.

"Lat., ms" – latency of EP component in milliseconds. For two channels – latencies difference.

"Norm, ms" – latency norm for EP component in milliseconds.

"Dev., %" – latency deviation from norm in percents (when user inputted normal values are available).

"Stim. side" – stimulation side.

"Stimulus" – stimulus intensity.

"Stim. dur." – stimulus duration.

The "Intervals" analysis window contains the following information (Fig. 4.12).

| N | Sites | Com-ment | Compo-nents | Int., ms | Norm, ms | Dev., % | Stim. side | Stimulus | Stim. dur. |
|---|---|---|---|---|---|---|---|---|---|
| 1.1ch | Cz-M1 | | I-III | 2.25 | 2.1 | (N) | right | 100 dB | 100 µs |
| | | | III-V | 2.14 | 1,9 | (N) | | | |
| | | | I-V | 4.39 | 4.0 | (N) | | | |
| 1.2ch | Cz-M2 | | I-III | 2.25 | 2.1 | (N) | right | 100 dB | 100 µs |
| | | | III-V | 2.10 | 1,9 | (N) | | | |
| | | | I-V | 4.35 | 4.0 | (N) | | | |

Fig. 4.12

"N" – trace number (name).

"Sites" – name of traces sites.

"Comment" – comment to trace.

"Components" – names of EP components between which the intervals are calculated.

"Int., ms" – interval between EP components in milliseconds.

"Norm, ms" – norm of EP interval in milliseconds.

"Dev., %" – interval deviation from norm in percents (when user inputted normal values are available).

"Stim. side" – stimulation side.

"Stimulus" – stimulus intensity.

"Stim. dur." – stimulus duration.

The "Amplitudes" analysis window contains the following information (Fig. 4.13).

151

| Amplitudes | | | | | | | | | 🖈 |
|---|---|---|---|---|---|---|---|---|---|
| N | Sites | Com-ment | Compo-nents | Ampl., µV (/) | Norm, µV | Dev., % | Stim. side | Stimulus | Stim. dur. |
| 1.1ch | Cz-M1 | | I-Ia | 0.1 | 0.28 | -53.3 | right | 100 dB | 100 µs |
| | | | III-IIIa | 0.1 | 0.23 | (N) | | | |
| | | | IIIa-IV | 0.4 | 0.25 | +61.9 | | | |
| | | | IV-V | 0.0 | | | | | |
| 1.2ch | Cz-M2 | | I-Ia | 0.2 | 0.28 | (N) | right | 100 dB | 100 µs |
| | | | III-IIIa | 0.3 | 0.23 | (N) | | | |
| | | | IIIa-IV | 0.4 | 0.25 | +78.5 | | | |
| | | | IV-V | 0.0 | | | | | |

Fig. 4.13

"N" – trace number (name).

"Sites" – name of traces sites.

"Comment" – comment to trace.

"Components" – names of EP components between which the amplitude is calculated.

"Ampl., µV (/)" – amplitude between EP components in microvolts. For two channels the amplitudes ratio is calculated.

"Norm, µV" – norm of EP amplitude in microvolts.

"Dev., %" – amplitude deviation from norm in percents (when user inputted normal values are available).

"Stim. side" – stimulation side.

"Stimulus" – stimulus intensity.

"Stim. dur." – stimulus duration.

The "Amplitudes ratio" analysis window contains the following information (Fig. 4.14).

| Amplitudes ratio | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| N | Sites | Com-ment | Ampli-tudes | Ampl. ratio | Ratio norm | Dev., % | Stim. side | Stimulus | Stim. dur. |
| 1.1ch | Cz-M1 | | I-Ia/III-IIIa | 0.9 | | | right | 100 dB | 100 µs |
| 1.2ch | Cz-M2 | | I-Ia/III-IIIa | 0.5 | | | right | 100 dB | 100 µs |

Fig. 4.14

"N" – trace number (name).

"Sites" – name of traces sites.

"Comment" – comment to trace.

"Amplitudes" – names of EP components between which the amplitudes ratio is calculated.

"Amplit. ratio" – amplitudes ratio between EP components.

"Ratio norm" – norm of amplitudes ratio.

"Dev., %" – amplitudes ratio deviation from norm in percents (when user inputted normal values are available).

"Stim. side" – stimulation side.

"Stimulus" – stimulus intensity.

"Stim. dur." – stimulus duration.

# 4.4. Visual EP Features

LED goggles are used in the "Flash visual EP" test. The right and left eye positions on the goggles are marked with "R" and "L" letters correspondignly. It is recommended to perform the acquisition of potentials from a patient with eyes closed.

The stimulator in "Reversal pattern visual EP" test is the additional monitor connected to the device or computer if a high resolution pattern is available. **Neurosoft** Ltd manufactures a wide range of pattern stimulators from the simplest one (only five different sizes of black-and-white checkerboard squares) to the high resolution pattern which allows to display the images in TrueColor. The settings of the high resolution pattern are given on Fig. 4.15.
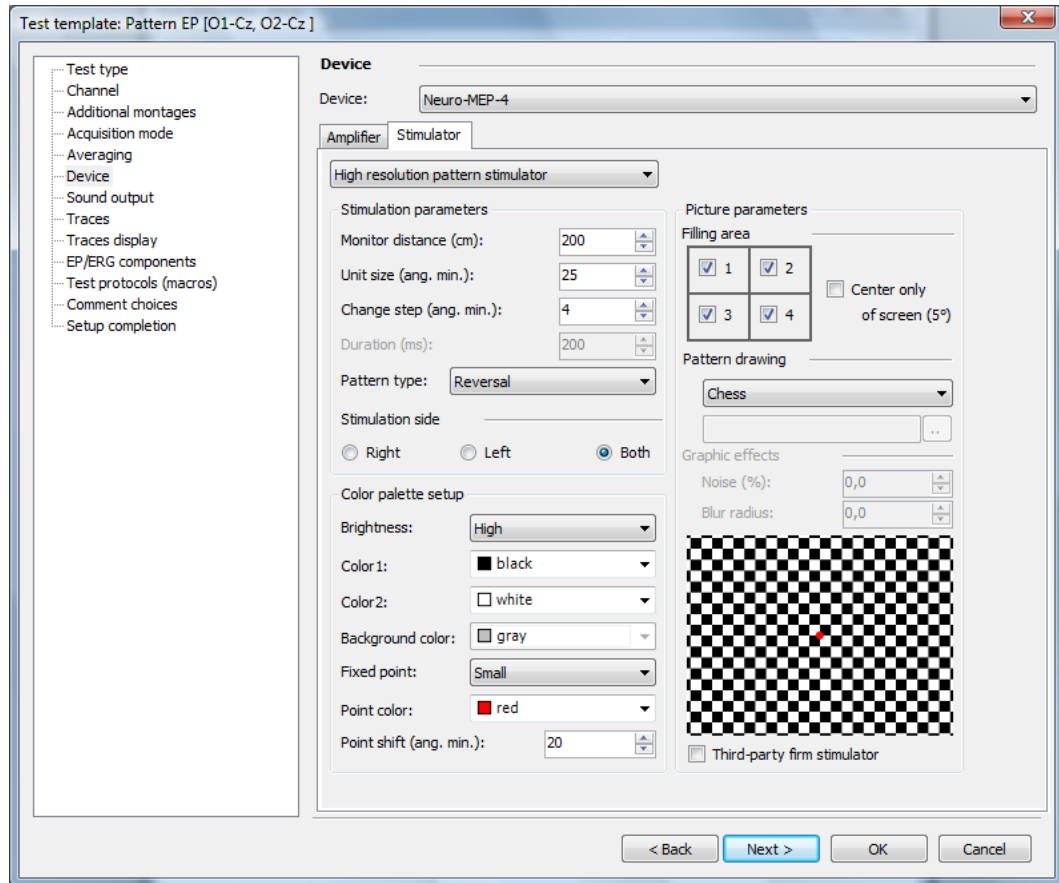
Fig. 4.15

"Stimulation parameters"

"Monitor distance (cm):" is the distance from the reversal pattern monitor up to the patient's eyes in centimeters.

"Unit size (ang. min.):" is the size of the minimal element being visible to a patient in angle minutes. It is useful only for checkerboard pattern (square size), vertical/horizontal bars (bar width) and concentric rings (ring width).

"Change step (ang. min.):" is the step of size change of minimal element in angle minutes using the menu commands **Acquisition|Stimulus|Increase stimulus** and **Acquisition|Stimulus|Decrease stimulus**.

"Duration (ms):" is the duration of stimulus visualization (only for "Direct" pattern type, see below).

"Pattern type:". The stimulation type can be either the reversal pattern (interchange of two images) or direct (interchange of one image and background color, the duration of image visualization can be specified).

"Stimulation side" is the stimulated patient's eye. If only one eye is selected, the other should be closed.

"Color palette setup".

"Brightness:". The image brightness can be either high or low.

"Color1", "Color2". The colors for pattern image generation.

"Background color". The background color in case the direct pattern is selected or the fill area in the reversal pattern is used.

"Fixed point:". The point size of patient's gaze fixation, it can be either small, middle, large or is absent.

"Color point:". The point color of gaze fixation.

"Point shift (ang. min.):" is the shift of gaze fixation point relative to the screen center in angle minutes. It is used only for the selected fill area and takes place only along the background (area which is not used for the stimulation).

"Picture parameters"

"Filling area". The fill area is specified by including/excluding the screen quarters from the simulated area. Only central part of the screen (circle) with angular size of 5 degrees can be set.

"Pattern drawing". The type of picture displayed: checkerboard, horizontal/vertical bars, concentric rings, "windmill", "darts" or from a specified list of images (pictures). If you prefer the image list, select it by pressing ⬚ button. You can create you own lists and include in them arbitrary images of any graphical formats. The list of images can be of any length, but for visual EP only two first images will be used. The complete list of images can be applied only for cognitive EP test.

"Graphic effects". The special effects to decrease the image quality (recognizability) by adding white noise to the picture or picture washout.

# 4.5. Auditory EP Features

Please make sure the correct type of headphones is selected in the program. To do this, use **Setup|Change** menu command, "Device" page.

In "Short latency (brainstem) auditory EP" test it is possible to fix the hearing threshold for each ear and further semiautomatic setup of operational stimulus for EP acquisition. To do this, the acquisition should be performed in the following order:

• Create the new brainstem auditory EP test.

• Run the repetitive stimulation (**Acquisition|Repetitive stimulation**) and by changing the stimulus and using the patient feedback adjust the stimulus value that is equal to the hearing threshold. Finish the recording without saving data (**[Esc]** key).

• To set the value of stimulus threshold, use **Test|Hearing threshold** menu command.

• If needed, change the stimulation side and repeat the two previous items.

• To set the operational stimulus, use **Test|Operational stimulus** menu command. The stimulus intensity will be equal to sum of the threshold stimulus value for the current stimulation side and specified level of the operational stimulus relative to the threshold one in the test template (see Fig. 4.16).
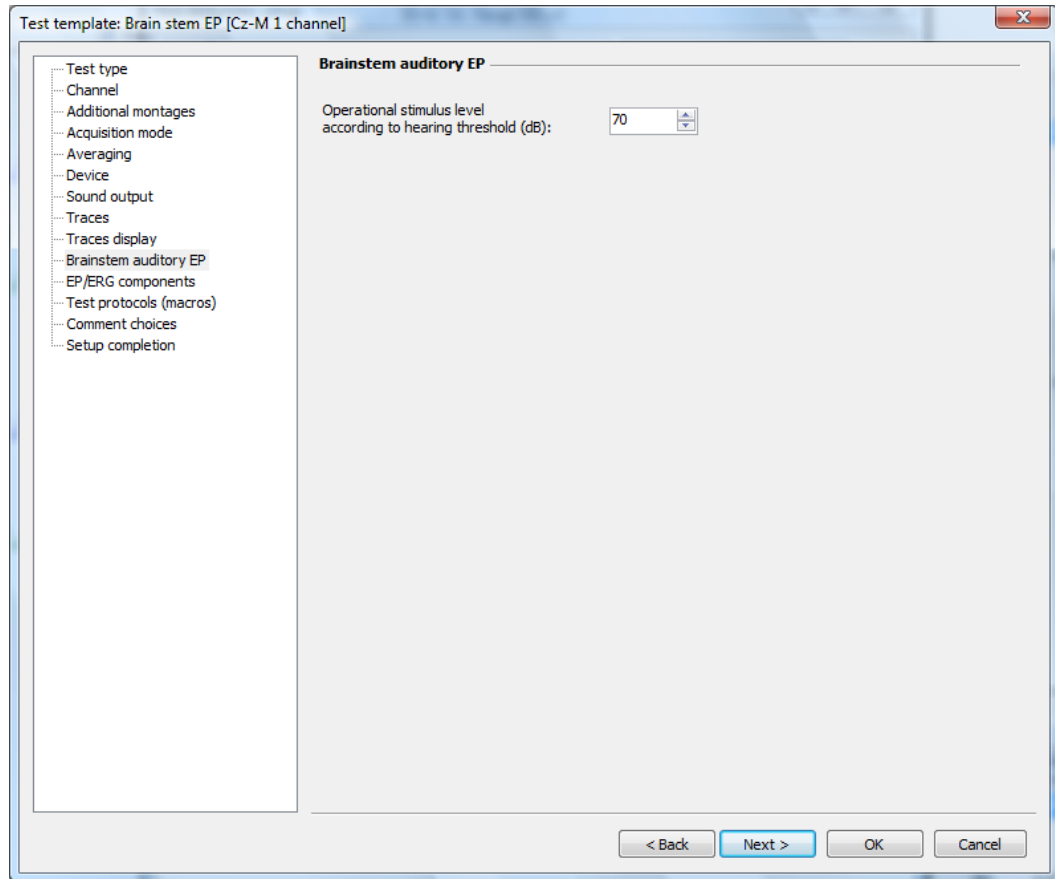
Fig. 4.16

The test provides the new "Auditory threshold" analysis window (Fig. 4.17).



Fig. 4.17

# 4.6. P300 Features

Two stimuli that interchange arbitrarily (meaningful and non-meaningful) are used for P300. Each of them can be chosen at will, for example, the meaningful stimulus can be the visual one, the non-meaningful stimulus can be the auditory one. There is only one limitation, if the meaningful stimulus is the reversal pattern, the non-meaningful stimulus should be also the reversal pattern. The parameters of meaningful and non-meaningful stimuli are set on "Device" page of setup wizard of test template (Fig. 4.).
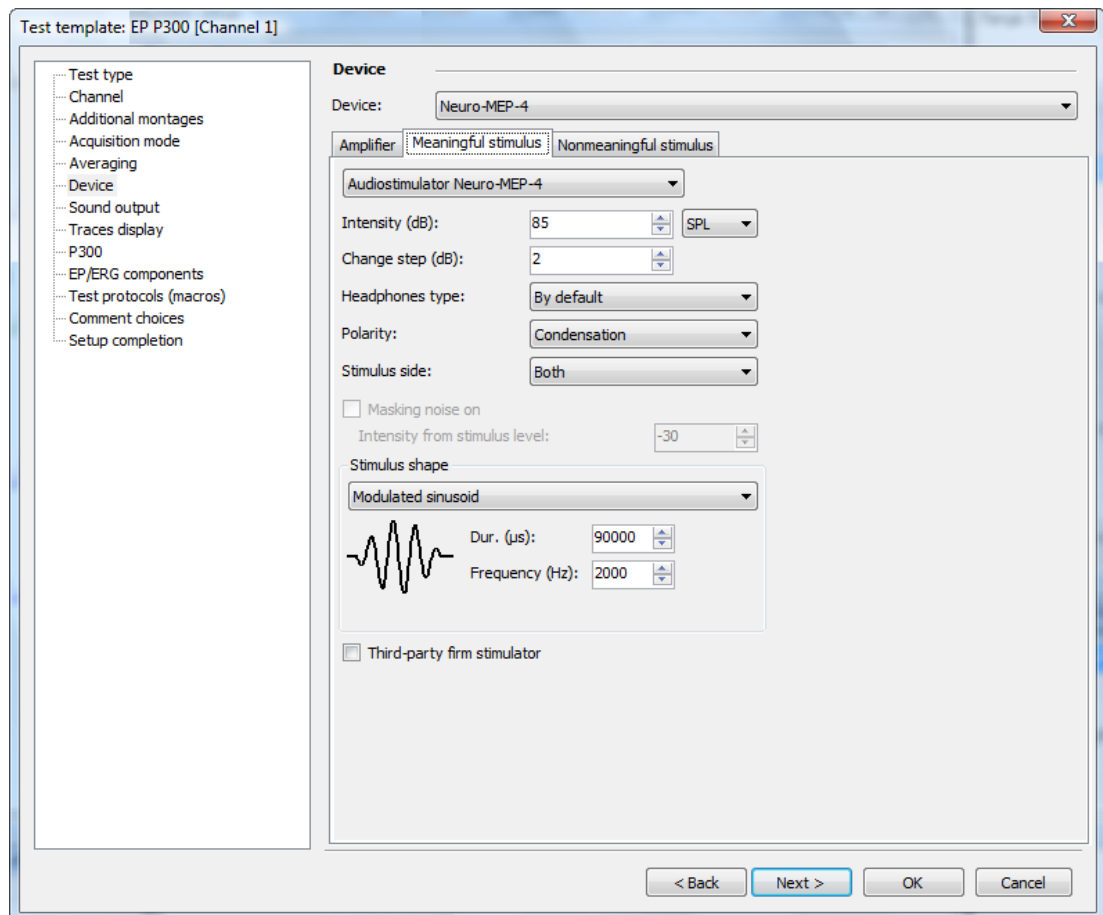


Fig. 4.6

"P300" page of setup wizard for test templates contains the following information (Fig. 4.).
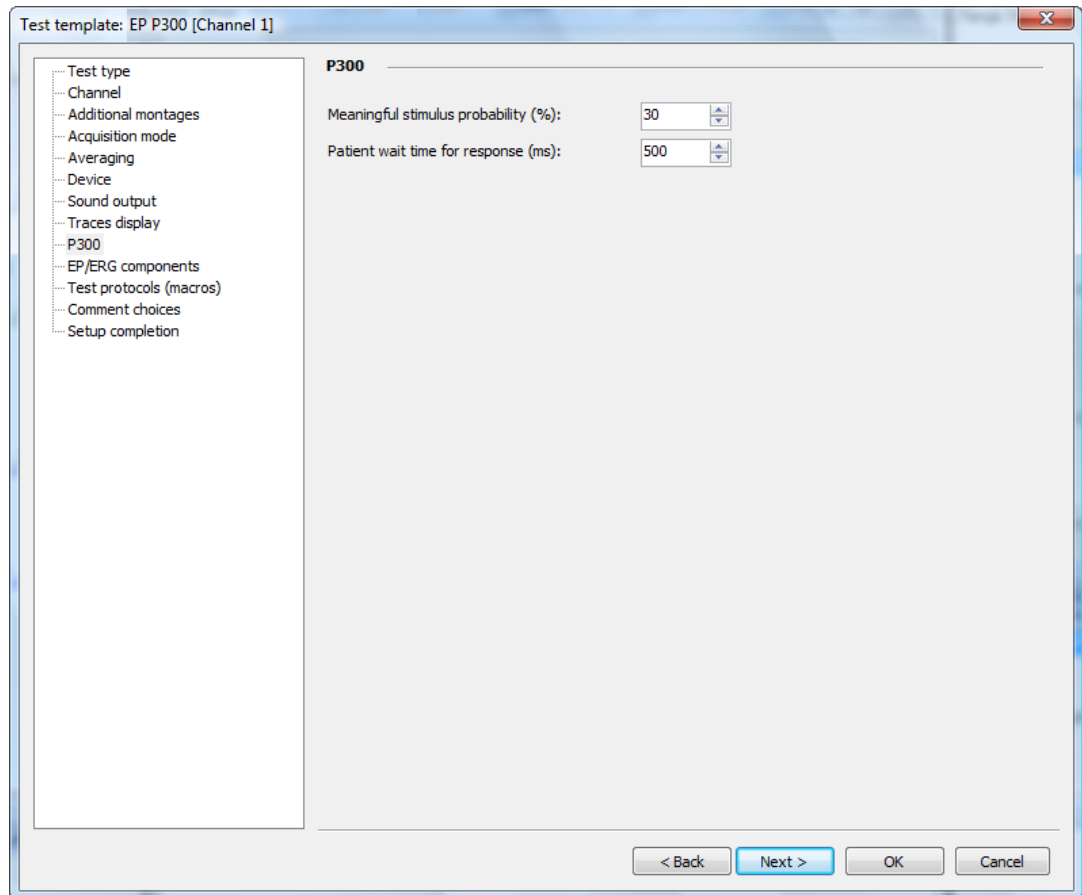


Fig. 4.61

"Meaningful stimulus probability (%):" is the probability of meaningful stimulus delivery relative to the overall number of stimuli.

"Patient wait time for response (ms):" is the time from meaningful stimulus delivery during which the pressing of patient button is considered to be correct.

The use of patient button is not mandatory, however, it facilitates the test performance. If the patient button is available, a patient should press the button (any of two ones) only for meaningful stimulus. When done, the information concerning correct/incorrect response is displayed on the screen. If the patient button is absent, a patient should count the meaningful stimuli.

After starting the new test, it is necessary to play back the meaningful and non-meaningful stimuli for a patient for her/him to remember and

distinguish them during the recording. To do this, use **Acquisition|Meaningful stimulus** (**[F2]**) and **Acquisition|Nonmeaningful stimulus** (**[F3]**) menu commands.

After the signal acquisition from a patient, a double number of traces is obtained, as far as the averaging is performed separately by meaningful and non-meaningful stimuli (four top traces on the Fig. 4., two-channel recording). Besides, it is possible to obtain the different trace of meaningful and non-meaningful stimuli where P3 (P300) peak is visualized clearer. To do this, it is required to select one trace from the set of meaningful and non-meaningful stimuli (for example, 1.1k and 2.1k, see Fig. 4.) using the mouse clicking together with pressed **[Ctrl]** key and execute **Trace|Calculation|Difference|Epochs** menu command.
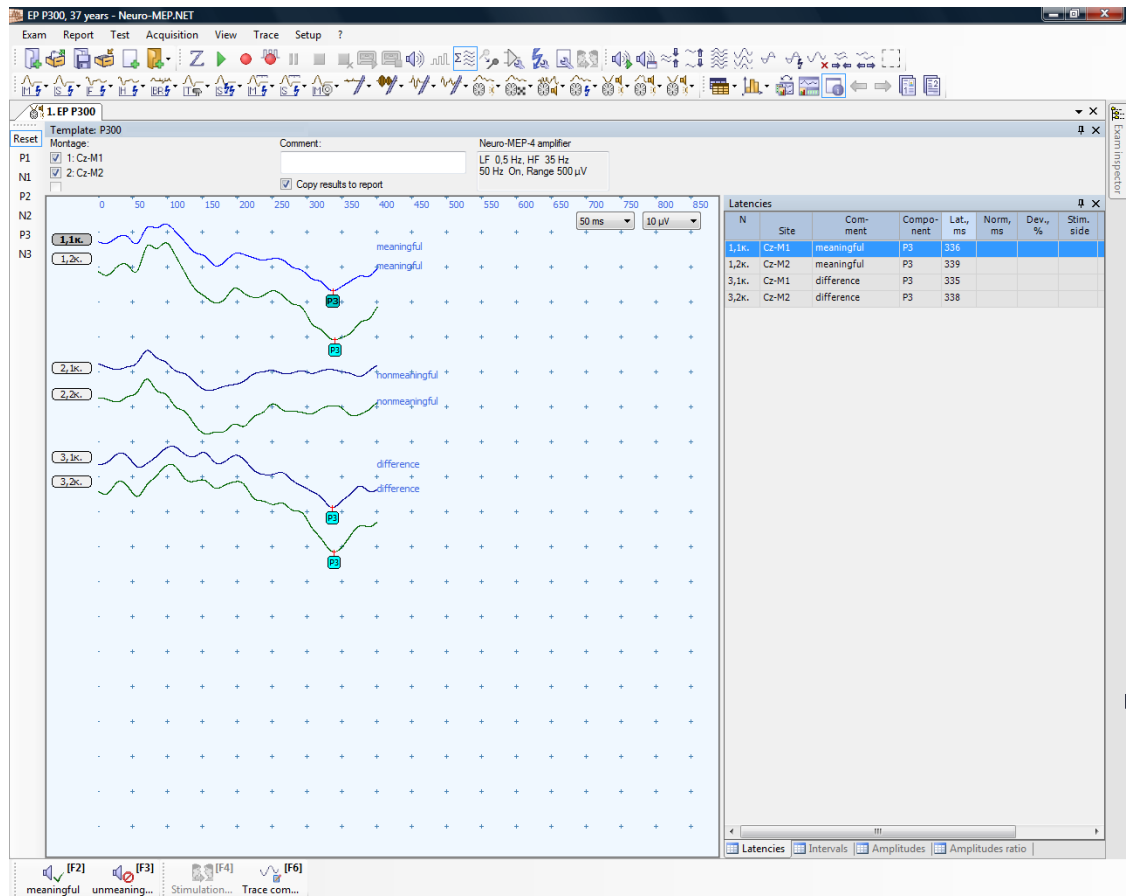


Fig. 4.62

If patient button is used, the test contains additional analysis windows with "Response time" table (Fig. 4.63) and "Response time" histogram of patient response time distribution (Fig. 4.64)

| Response time | | | |
|---|---|---|---|
| N | Mean response time, ms | RMS dev., ms | True clicks, % |
| 1 | 317 | 41,7 | 100 |

Fig. 4.63

"N" – the trace number for which a patient's response time is displayed.

"Mean response time, ms" – the average time of patient's response.

"RMS dev., ms" – the root-mean-square deviation of response time from mean value.
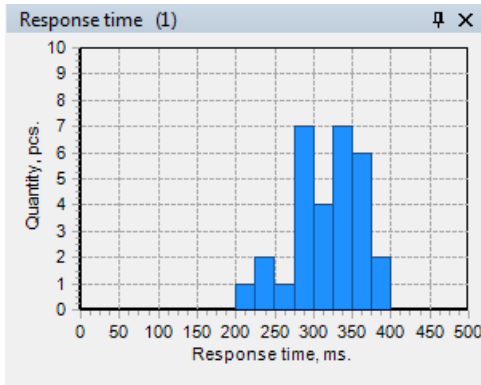
"True clicks, %" – the percentage of true clicks.



Fig. 4.64

# 5.    Appendix A - Standard Accessories

## 5.1. Surface Stimulating Electrodes

Stimulating bar electrode with replaceable steel and felt stimulation pads (Fig. 5.1).

Felt pads

Fig. 5.1