

## Electroneuromyograph

N. V. Turushev<sup>1, a\*</sup>, D. K. Avdeeva<sup>1, b</sup>, M. G. Grigoriev<sup>1, c</sup>

<sup>1</sup> *Medical Instrument-Making lab No63, Non-Destructive Testing Institute, National Research Tomsk Polytechnic University, 30, Lenin Ave., Tomsk, 634050, Russia*

**Abstract.** The present article describes the methods of muscle electroneuromyographic study. The analysis of the existing electroneuromyographic diagnostic unit configurations commercially available at Russian and foreign markets is executed. The unit developed in the laboratory No. 63 of the Non-Destructive Testing (NDT) Institute of the National Research Tomsk Polytechnic University, its functional layout and main characteristics are considered. The present article focuses on the use of more sensitive equipment for better human body study. The results of measurements executed by means of unit developed are provided.

### 1 Introduction

Human psychophysiological state influences his/her activity results and its life duration. Due to this there is a necessity to develop new and improve existing organism study and disease diagnostic methods.

Human organism suffers from numerous physiological muscle work disorders. Reasons for such disorders can be connected both with genetic pathologies, intoxication with different substances, virus diseases, body injuries, psychosomatic syndromes. Myasthenia, myopathies, myotonias can be classified as such diseases. For disease diagnostics and treatment introduction and development of special technical means allowing determination of liability to disease or its diagnostics at the early stages are necessary.

### 2 Electromyography

Electromyography is a medical diagnostics sphere aimed at study of muscular tissue activity by means of registration of its bioelectric potentials. Electromyography can be divided into two types depending on types of electrode used: local (needle) myography and interferential (surface) myography [1].

Local electromyography is a diagnostic method used for myogram obtaining needle electrodes and belonging to invasive study methods that are methods where electrodes are not placed over muscles and deepened into muscular tissue. This method is in general aimed at local diagnostics of muscle fibre, its groups and motor unit.

Surface electromyography is characterized by the fact that muscle biopotential taking is executed by placing pair of electrodes on clean skin surface located over motor point of muscle under examination and registration of potentials obtained between these electrodes.

This method is good for obtaining general interferential activity pattern of all fibres of one muscle or muscle group, coordination relations of different muscle groups evaluation, neuromotor system liability study, topical diagnosis in case of compression radicular syndromes.

Several diagnostics combination necessity in medicine for more harmonic study and device operation principle coincidence for this study execution led to new methods synthesis and as the result of such synthesis method combining myography and neurography that is called electroneuromyography arose.

Electroneuromyography (stimulation myography) is a set of human muscles-nerves system diagnostic methods. Owing to this sphere of medical diagnostics human nervous system interaction with its muscles as well as nervous and muscular activity as separate phenomena can be studied. Differential characteristic of electroneurography is stimulation of organism areas under examination by external factors (electric, magnet, optic, acoustic, mechanical stimulations).

Stimulation myography has a wide application range and allows determination of larger neuromuscular activity parameter list, these are some of them: motor nerve conduction velocity; sensory nerve fibre conduction velocity; motor muscle response; delayed neurographic phenomena; blink reflex; neuromuscular transmission reliability [2].

Devices executing muscular activity diagnostics are called electromyographs and those applied in electroneuromyography electroneuromyographs. In connection with the fact that at market necessity in more universal devices with larger number of functions arises, developers give much preference to creation of electroneuromyographs.

The simplest electroneuromyograph includes functional blocks: electrodes, stimulation block, biosignal

<sup>a</sup> Corresponding author: [nvtur90@mail.ru](mailto:nvtur90@mail.ru)

amplification block, biosignal filtration block, biosignal processing block, information display device, and measurement data memory.

Electrodes provide for biopotential taking from an organ under diagnostics, amplification block increases signals received to levels convenient for their processing in processing block. Filtration block clears signal from noise. Processing block usually includes AD converter of high resolution and high frequency microcontroller providing for data processing and control interface. Indication unit displays measurement results, and display with a driver installed into a unit as well as external display or personal computer can be an indicating device. Stimulation block is used as an additional option for stimulation myography execution.

There are several combinations of functional blocks of the following configuration in units existing at present: electroneuromyograph without indicating device with communication interface with personal computer (lap-top) installed and unit based on personal computer (lap-top). Hardware and software complex for muscle electric activity evaluation MYOKOM by Experimental Design Bureau (EDB) "Rhythm" JSC can be classified as a unit of the first configuration, and unit KEYPOINT PORTABLE produced by MEDTRONIC company (USA) can be classified as a unit of the second configuration. The first configuration allows using unit for organism study in dynamics without additional means (bicycle ergometers, treadmills) use. The second configuration allows executing muscle activity monitoring on a real time basis. Owing to communication interface installed the both configurations allow executing data obtained analysis by digital means, thus making personnel's work simpler and decreasing fault occurrence probability. Unit under development includes the following functional blocks (Fig. 1): electrodes, biosignal amplification block, biosignal processing block, measurement data memory, simulation block. Differential characteristic of the present unit is absence of filtration blocks, this solution allow

executing much detailed muscle activity analysis with minimum data loss that takes place during filtration.

Electrodes of nano type are used. Signal amplification block makes scaled signal increase to levels convenient for its processing. The following takes place at signal amplification block: analogue signal transformation into digital type and its further processing and recording into a memory, simulation block control, unit communication with personal computer and data transmission from memory installed.

During creation of the present unit the task to develop a unit of higher resolution with nanovolt measurement scale and possibility to measure continuous biopotential for muscular tissue study and new peculiarities of biopotential measured detection, was set. Research in the field of muscular tissue biopotential with level of (100-200) nV within frequency band from 0 to 100 Hz allows obtaining detailed understanding of work mechanism of muscle and nervous system connected with it that will probably lead to disease and pathology diagnostics at the earliest stages of their development in future [3, 4].

Unit under development possesses the following characteristics: measurement range is from  $\pm 0.2 \mu\text{V}$  to  $\pm 100 \text{ mV}$ ; discretization frequency is 2000 Hz; minimal quantization step is 20 nV; amplification coefficient adjustment is 1, 4, 8, 16, 32.

Test measurements executed on unit for patient's biceps with intense muscular dystrophy by means of human nervous system acoustic stimulation application showed that unit provides for diagnostics of muscle tensions of lower values (Fig. 2, line 2). For more accurate tracing of reaction to stimulation electrocardiogram (Fig. 2, line 1) as well as galvanic skin response (Fig. 2, line 3) were additionally taken [5]. Within stimulation process myogram amplitude started growing due to psychological tension associated with acoustic effect series and decreases in case of patient's adaptation to stimulation starting from the 250th second. In future it is planned to increase unit automation level, its testing and myographic study result accumulation.

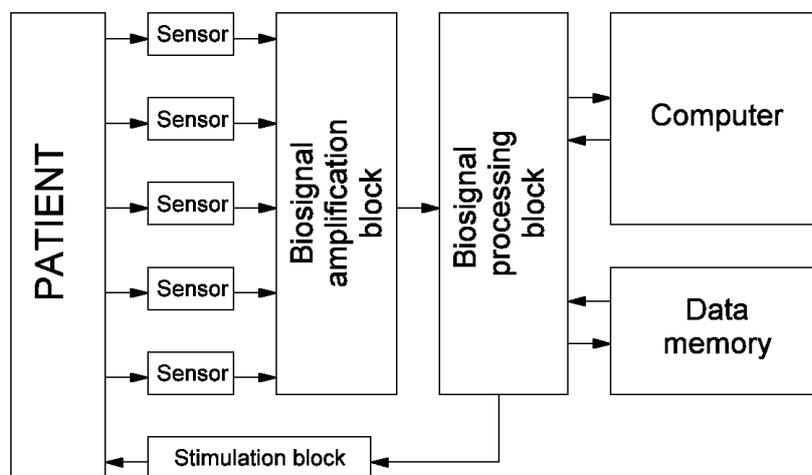


Figure 1. Unit functional layout

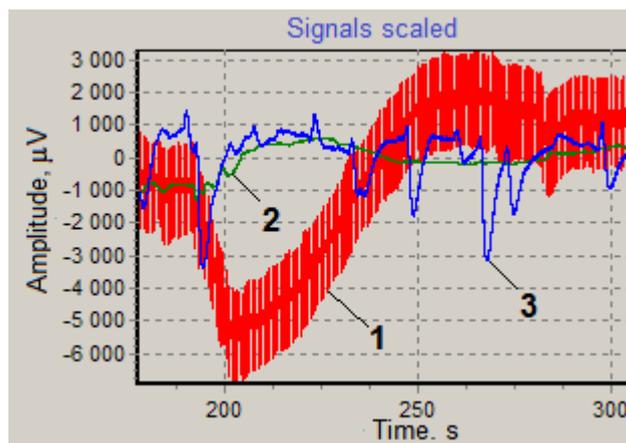


Figure 2. Biopotential registration record: 1-ECG, 2-EMG, 3-GSR

### 3 Conclusion

Unit under development will allow reaching new level of sensitivity and cross-talk reduction required in modern medicine and biomedical engineering spheres. As a future appliance this device will be used in project of bioelectrical prosthetic interface with myoelectric control signals. The developing unit technical characteristics will make possible gathering new kind of low-level bioelectrical signals providing more information unseen before and better understand work of muscle. This information can be used for creating control system for prosthetic device and developing pattern recognition system with high sensitivity. New bioelectric activity patterns allow performing natural human-machine interface control which is mentioned in [6]. Such interface is more comfortable for user and didn't require strong concentration for performing any intended action.

### References

- Information on <http://en.wikipedia.org/wiki/Electromyography>
- S. G. Nikolaev. Laboratory manual on clinical electromyography, Ivanovo, (2008).
- D. K. Avdeeva, I. A. Lezhnina and M. M. Yuzhakov, Perspectives of physiological human parameters taken by electrodes quality improvement, Measurement, control and diagnostics theory, methods and means: The VIII International Scientific and Technical Conference, Platov South-Russian State Polytechnic University (NPI). 8 (2007). (In Russian).
- D. K. Avdeeva, N. V. Turushev, N. M. Natalinova, M. L. Ivanov, The analysis of filter units impact on electroencephalography and electromyography nanoelectrode-based high sensitive channel readings, J. Naukovedenie. 19 (2013) (In Russian).
- M. G. Grigoriev, N. V. Turushev, D. K. Avdeeva, Device for human locomotor apparatus electroneuromyography, Journal of Radioelectronics. 4 (2014). (In Russian).
- Max Ortiz-Catalan, Rickard Branemark, Bo Hakansson, Jean Delbeke, On the viability of implantable electrodes for natural control of artificial limbs: Review and discussion, BioMedical Engineering OnLine. 11 (2012).
- M. Ben Rabha, M.F. Boujmil, M. Saadoun, B. Bessaï, Eur. Phys. J. Appl. Phys. (to be published)
- Luigi T.De Luca, Journal of First Class Online Learning. J. E 14, 7 (2004)
- F. De Lillo, F. Cecconi, G. Lacorata, A. Vulpiani, EPL, 84 (2008)