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MODEL FOR CALCULATION SPECTRAL DENSITY ELECTROMYOGRAPHIC SIGNAL DURING ELECTROSTIMULATION

Prasol Igor
D.Sc. Engineering Sciences
Professor of Department of Biomedical Engineering
Yeroshenko Olha
Assistant of Department of Electronic Computer
PhD student of Department Biomedical Engineering
Kharkiv National University of Radio Electronics
Kharkiv, Ukraine

Abstract: in the course of the study, the structure of the spectrum of the electromyographic signal was obtained, which is represented as a sum of periodically following pulses shifted relative to each other in time. An analytical relationship has been established between the statistical properties of a random phase difference and the type of signal power spectrum. The obtained theoretical relations allow us to calculate the spectral density of the electromyographic signal depending on the number of motor units and various phase shifts between them.

Keywords: skeletal muscle, motor unit, electrical signal, mathematical modeling, spectral density, electromyographic signal, electrical stimulation.

Estimation of motor activity by the level of bioelectrical potentials of muscles during their superficial retraction is widely used in biomechanical and medical research. In this case, both the degree of muscle tension and the nature of their regulation, deviation from the norm and the degree of damage are determined. Modeling the electrical muscle signal [1], linking its electrical and mechanical activity, explains and to a certain extent clarifies the results of experimental studies, reflecting information about the motor activity of the muscle, contained in the signal.

The term "motor unit" was proposed by E. G. Liddell and C.S. Sherrington to designate a group of muscle fibers, innervated by terminals (branches) of one axon [1].

Currently, a motor unit is understood as an elementary functional unit of a muscle, including a motor neuron and the muscle fibers innervated by it.

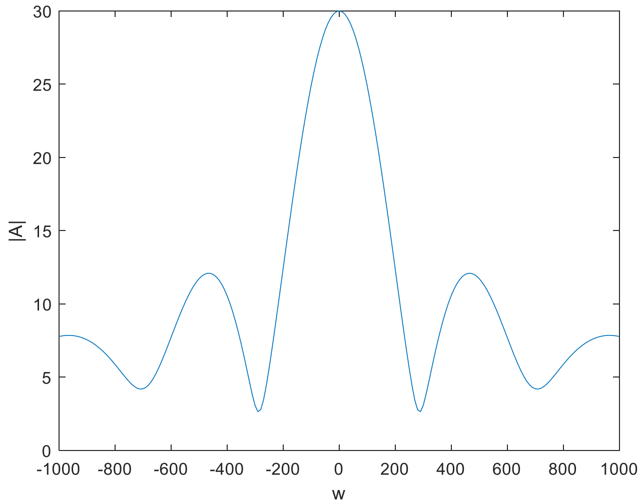
The basis for constructing a model of signals of motor units and an electrical signal of muscles is the hypothesis of the practical admissibility of using the principle of superposition for signals of muscle fibers [1-2]. An analysis of the process of formation of a potential difference on the electrodes shows that with the help of rather small needle electrodes, located near the muscle fiber, it is fundamentally possible to divert the signal of individual muscle fibers.

Signal modeling allows you to identify features of the signal compared to noise, in particular, the ways of possible signal isolation against the background of sinusoidal and noise interference, using low voltage amplitude limiting or maximum peak detection [2-4].

When measured by the skin method, the recorded signal is usually created by more than one motor unit [5-7]. Motor units located near the electrodes create some voltage on the latter. However, for various reasons, the total recorded signal will be a superposition of the signals, randomly shifted relative to each other along the time axis by a certain amount Δt_k, where the index k is the conditional number of the motor unit.

It is known that the properties of the Fourier transform imply the multiplicativity of the signal spectrum, generated by one motor unit.

On fig. 1 shows the results of numerical simulation for the Gaussian probability density distribution $p(\Delta t)$ with standard deviation $\sigma = T_0 / 2$.



Rice. 1. Results of numerical simulation for the Gaussian probability density distribution *p(Δt)*, due to a random phase shift in the range from -0,01 s to 0,01 s, with the number of motor units *K* = 30

The model of the electrical signal of the muscle in the form of the sum of impulse random signals was studied, corresponding to the signals of motor units. The spectral frequency characteristics of the electrical signal of the muscles are determined by the forms of impulses of the signal of the motor unit. Synchronization of motor units reduces the frequency of peaks. Spectral characteristics are shifted towards low frequencies. Increases the distinctive features of the signal compared to the noise signal, having a similar power spectrum.

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