MYOELECTRIC CONTROL OF THE MUSCLE ELECTROSTIMULATION

Bernstein, V.M., Slavutsky, J.L., Farber, B.S.

Central Research Institute of Prosthetics and Prosthesis Design
3, Ivan Susanin St., 127486 Moscow, Russia

Electrostimuation of muscles is widely used in the training of weakened muscles, including the stump muscles after amputation of the limbs, in the working out of motor skills, compensation of the lost functions. The control of stimulation is performed by a free, non-stimulated limb or by another person with a help of a knob press or a displacement transducer. There is applied also an automatized control based on a certain software. In that case when a stimulated muscle possesses even though by a weakened electrical activity adjusted voluntarily it looks very attractive to realize myoelectric control of electrostimulation by means of natural tension of the muscle stimulated.

As in case of myoelectrically controlled prostheses an advantage of this kind of control is its naturality and simplicity. During stimulation the training of a natural regulation of a muscle takes place. Simultaneously there must increase the efficiency of electrostimulation also that results from the known experiments evidencing the increase of the electrostimulation effect in simultaneous voluntary tension of muscles.

Realization of myoelectric control by electrostimulation demands to overcome serious difficulties. The control system must have high noise-immunity in relation to the stimualtion impulses. The voltage may reach 100-200 V meanwhile the maximal electrical activity may be not higher 5-15 μV. The electrostimultion is especially indicated just in relation of the weakened muscles with a low electrical activity. But the most serious difficulties are connected with overcoming of a positive feedback arising in consequence of the fact that not only a natural electrical activity of muscles is registered by the biopotential amplifiers but and an induced electrical activity as a result of which non-controllable electrostimulation arises.

To increase the noise-immunity from stimulating impulses the same methods are effective which are used in noise-immunity systems of a myoelectric control of prostheses, in particular, selection of a rational frequency characteristic of a biopotential amplifier, the use of a circuit of impulse noises suppression, including blocks of a signal differentiation, amplitude limitation and integration. The position of pick-up electrodes in relation to stimulating ones is of a great significance. While positioning a pair of pick-up electrodes on an equapotential line relatively to the voltage created by the stimulating impulses on the skin surface, the interference from the stimulating impulses is decreased in consequence of high suppression of the in-phase signal in the biopotential amplifier. The blocking of the amplification channel in the moment of the stimulation impulses action in an effective method.

To exclude a positive feedback in the myoelectric control system of electrostimulation it is necessary to perform extraction and suppression of the induced electrical activity of muscles.

In low sensitivity of the muscles to the electrostimulation effect and, accordingly to it, low meaning of the induced electrical activity of muscles there may be expedient to block the channel of amplification directly following the stimulation impulses action. Nevertheless this method is active only in a limited number of cases. It can be used when the stimulation impulses result in short impulses of induced activity and a low frequency of stimulation impulses is used not exceeding 20-30 Hz. But in this frequency innatural vibrating contraction of muscles is observed. The most effective method of

suppression of induced electrical activity of muscles is distinct between determined by us of induced and natural electrical activity of muscles which is manifested in the fact that induced biopotentials in consequence of their synchronous activization of muscular fibers look like almost a strict sequence of periodical impulses meanwhile the natural electrical stimulation of muscles has an asynchronous noisy character. As a result of this the use of a digital filter suppressing signals with the frequency of the stimulation impulses has been proved to be extremely effective.

The tests of a model sample of a myoelectrically controlled electrostimulator has shown the high efficiency of its use in different kinds of affection of an upper extremity neuro-muscular system. 4-6 sessions increased an amplitude and the contraction force some times. With it the patients were included which underwent a usual course of electrostimulation earlier. In a certain degree it is explained by the effect found by us: a natural tension of the muscle accompanying electrostimulation decreases significantly the threshold of the electrostimulation effect and increases the biopotentials of the muscle.