Comparison of the Excitation Efficiency of the Biological Structures of Single-And Bipolar Pulse

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Abstract – **The article compares the efficiency of excitation of biological structures and electrical single bipolar pulse.**

Keywords – **biological structure, stimulation, electrical pulses.**

I. Introduction

The comparison of the excitation efficiency of biological structures (neurons, heart muscle) with the help of electrical pulses of different shapes is an important task in biomedical engineering.

II. The Basic Material

Known mathematical model of the neuron excitation [1], which provides constant power output of a linear frequency-selective filter E_{in} feeding its input unipolar rectangular pulses whose amplitude and duration are related with Hoorweg-Weiss proportion:

$$U_{in} = U_R(1-e^{-aT})^{-1},$$

where: U_R – the voltage of rheobase – time constant.

The transfer characteristic of a frequency-selective filter is

$$K(jw) = \frac{K_0 jwa}{(jw+2a)(jw+a)}.$$

The filter is with low quality factor, it's quality factor is $Q = 0{,}27$ with resonance frequency, which is $w_p = \sqrt{2}a$.

For input pulses with T duration:

$$u_1(t) = \begin{cases} H, |t| \le \dfrac{T}{2} \\ 0, |t| > \dfrac{T}{2} \end{cases} \quad \text{и} \quad u_2(t) = \begin{cases} H, -\dfrac{T}{2} \le t < 0 \\ -H, 0 \le t \le \dfrac{T}{2} \\ 0, |t| > \dfrac{T}{2} \end{cases}$$

The signal energy on the output of the filter will be

$$E_1 = H^2 a^{-1}(1-e^{-aT})^{-1},$$

$$E_2 = H^2(2a)^{-1}(6-8e^{-\frac{aT}{2}}+3e^{-aT}-e^{-2aT}).$$

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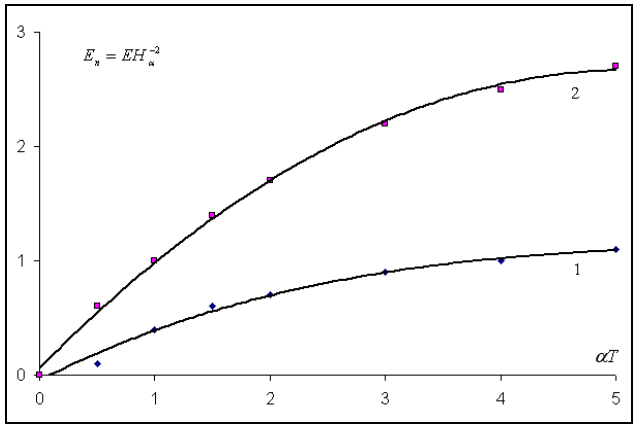

Fig. 1. Dependence of output energy on the pulse duration.

Fig. 1 shows the normalized $E_n = E \cdot H^{-2}a$ dependence E_1 (curve 1) and E_2 (curve 2)on the length of the input pulses. The boundary values of the signal energy at the output of the filter for bipolar pulse is three times bigger than for the unipolar, with the energy input in both cases are identical. The comparison results of one-and bipolar rectangular pulses in terms of coordination with the band-pass filter are the same with the results of experimental studies of animal heart defibrillation using similar pulses.[2].

III. Conclusion

The analysis showed that the efficacy of bipolar rectangular pulses of the excitation of biological structures above the single-ended, according to their output energy which is 2-3 times more than single-ended, which is consistent with the experimental results of animal heart defibrillation.

References

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