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The method of stabilization and reduction of noise in the measurement signal through the "dry" electrodes for electrocardiography

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Abstract. The last 10 years have been actively developed for "dry" electrodes. Such electrodes should simplify the use of portable medicine. But scientists around the world are faced with difficulties in development. The article presents arguments about how to improve existing sensors.

1. Introduction

After the adoption of the law on telemedicine in the Russian Federation, which allows for remote medical diagnostics in 2018, telemedicine in the country began to develop, but still lags far behind foreign competitors.

The main goal is to achieve reliability of the data on human health using telemedicine gadgets (ECG, etc.). Doctors are skeptical of telemedicine gadgets without medical certification or clinical trials.

A group of young scientists of the Tomsk Polytechnic University were able to create a portable cardiograph and determine the diagnostic value of indications [1].

2 Materials and methods

Previously, the authors have already obtained the following results:

- tests of the prototype of the electrocardiograph in people with heart disease were carried out in order to determine the diagnostic value of the electrocardiogram obtained by recording the signal from the "dry" electrodes;
- a measuring system was manufactured and tested using the unique “dry” electrodes of the company Plessey Semiconductors;
- developed a special system for fixing electrodes, for better contact with the patient's body;
- the application field was identified - remote individual ECG monitoring systems (ST segment abnormalities, as well as cardiac rhythm disorders) in patients with coronary heart disease (CHD).

In the cardiograph were used “dry” electrodes from Plessey Semiconductors, which enable non-contact measurement without prior preparation (lubrication of the skin with contact gel) and additional sensors. Due to this, the measurement time is reduced, and the housing design provides ease of use and correctness of the imposition of electrodes.

The need to develop contactless electrodes appeared not so long ago (less than 10 years ago). So far, only Plessey Semiconductors is developing similar electrodes for sale. But since 2016, due to the sanctions imposed, the import of such electrodes into the Russian Federation has been banned, which at the moment makes their use in cardiographs impossible.

The assessment of the availability of diagnostic information in the signal obtained from the “dry” embedded electrodes was originally made on the basis of a comparison of the original electrocardiogram (ECG) obtained using the standard method, i.e. using chest leads using standard medical "wet" self-adhesive electrodes, with an ECG obtained using the built-in electrodes.

The study was conducted by the Research Institute of Cardiology of Tomsk. The research results are presented in the article [2]. Cardiologists of the Research Institute of Cardiology, as well as patient tests confirmed the diagnostic value of the ECG obtained from non-standard sensors. It was decided to create their own analogs of capacitive electrodes, while implementing the scheme in such a way as to avoid the disadvantages of the electrodes of the company Plessey Semiconductors.

3. Results and discussion

The main disadvantage of “dry” electrodes is their susceptibility to interference, which leads to the need to use additional means to improve the quality of the received signal, and this will also expand the possibilities of

using the device in various conditions [3]. In order to determine which signal components need to be removed, was performed a spectral analysis of the signal. The results are presented in Figure 1.

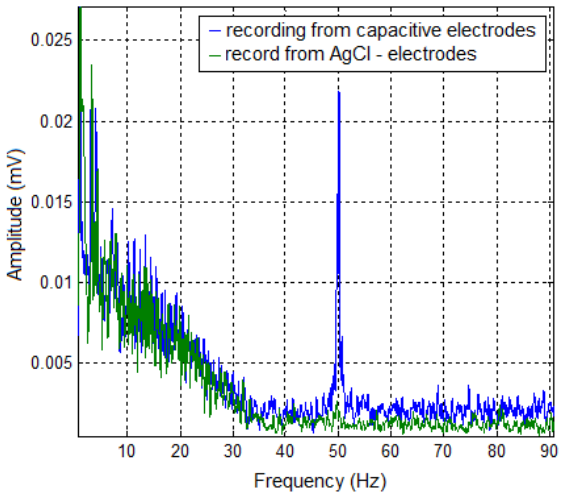

Figure 1. Spectral composition of signals.

Analyzing the obtained spectra, can conclude that during the use of capacitive electrodes two interferences appear in the signal:

- 50 Hz interference («power supply noise" or interference from power networks);
- broadband interference at a frequency of 10 Hz to 20 Hz.

50 Hz interference is removed from the signal in two ways:

- using a frequency filter;
- perform a complete shielding of the “dry” electrode and provide better alignment of signals between the human body and the device layout.

Broadband interference at frequencies of 10–20 Hz cannot be filtered by a frequency filter, since the spectrum of this interference overlaps the spectrum of the useful signal and the use of a frequency filter will lead to signal distortion, which will subsequently lead to incorrect interpretation and, as a result, incorrect diagnosis.

A review of the literature in the field of this problem was conducted, in consequence of which it was hypothesized that a solution could be found in recording the bioimpedance between the electrode and human skin. The studies were carried out with the help of the EKG-Express personal cardiograph (Figure 2 shows the “model” version of the device). Figure 3 shows the correlation dependence of bioimpedance and ECG.

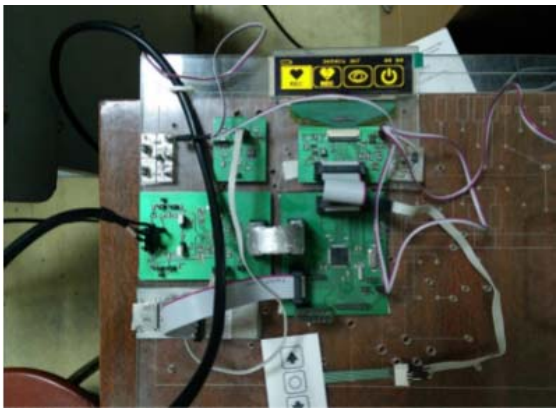

Figure 2. Layout for experiments.

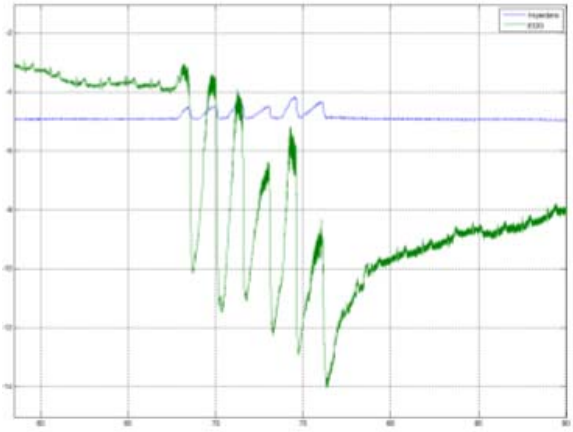

Figure 3. Registration of bioimpedance and ECG.

4 Conclusion

From Figure 3 it can be seen that the noise present in the ECG signal correlates with the change in bioimpedance. Based on this, it can be concluded that it is possible to create an adaptive system capable of isolating and subtracting interference from an ECG signal based on a signal from bioimpedance, thereby producing its stabilization. The next stage of work is the development of a new generation of capacitive electrodes for personal electrocardiography with detuning from the effect of the capacity of the skin-electrode contact.

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