DEVELOPMENT OF THE PORTABLE REFLECTANCE PULSE OXIMETER

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РАЗРАБОТКА МАЛОГАБАРИТНОГО ОТРАЖАТЕЛЬНОГО ОКСИМЕТРА

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Аннотация. *В статье описывается импульсный оксиметр для контроля обратно рассеянного света живых тканей. Устройство состоит из небольшого оптического преобразователя и фотодетектора. Выход фотодетектора разделяется на два канала. Информация обрабатывается компьютером. Предложенные решения позволяют снизить влияние движения на результаты. Экспериментально получено оптимальное давление датчика на тело, которое равняется 0,7 Н. Получено хорошее отношение сигнал / шум. Предварительные результаты показывают, что устройство обладает хорошим разрешением и надежностью.*

Pulse oximeters are commonly used in research and clinical settings to provide a non-invasive, continuous estimate of the oxy-haemoglobin saturation of arterial blood. Moreover, oximeters are useful for monitoring subjects under a variety of conditions: anesthesia, labor and delivery, cardiovascular or respiratory compromise. Accurate assessment of blood gases is fundamental to the support of critical-care medicine. Traditionally, blood gases have been measured by invasive sampling. Pulse, blood pressure, and oxygen saturation - the most vital and complex parameters, as they are characteristic of heart and lung function [1-3]. In the treatment of cancer with radiotherapy and chemotherapy the tumor tissues become resistant to these kinds of treatment due to an insufficient supply of oxygen. Not to spend the extra, ineffective therapy sessions there is the need to track the degree of oxygenation of the tumor during treatment. For this purpose, reflectance oximeters may be used, but they are used in medicine quite rare, due to imperfections in their design. Reflectance oximeter has a definite advantage, as it can be used to perform measurements in any part of the body [4-6]. During open heart surgery such oximeter gives more reliable results, as it can be positioned in a desired location. Reflectance oximeters are more complex devices due to the strong scattering of light and for this reason not been widely used. The main disadvantage limiting the application of the reflective oximeter is a low level of signal. Non-invasive measurement of hemoglobin saturation in the arteries based on the difference between the absorption coefficients of oxyhemoglobin and deoxyhemoglobin, measured at two wavelengths. The red light with a wavelength of 660 nm and infrared light with a wavelength of 1300 nm is commonly used in present study. The result is obtained by dividing the pulse components of red light to infrared light pulse component. Change in the intensity of light received by the detector is due to changes in vessel diameter during systole and diastole.The layout of the reflectance pulse oximeter for diagnostic purpose is designed at the department of applied physics, Physical-technical institute, National Research Tomsk Polytechnic University. Block diagram of the device is shown in Figure 1.

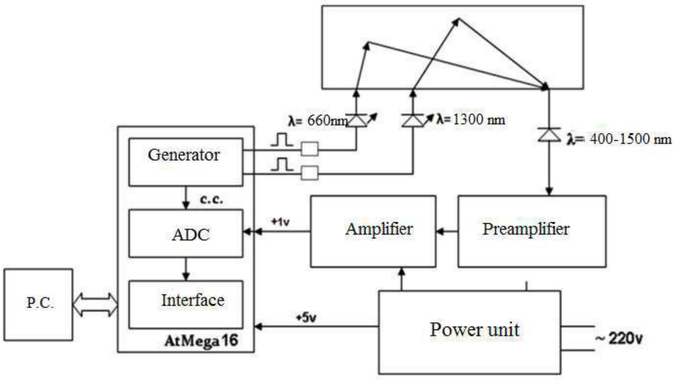

Fig.1. Block-diagram of the device

The device consists of an optical transmitter and receiver part for collecting and processing data. The main control element is a microcontroller Atmega16. Signal is processed by a 10-bit ADC. Each LED is controlled via a multiplexer. The main task is to find the AC signal by eliminating its constant part. This task is accomplished by an operational amplifier. Typically, LEDs are directly controlled by the voltage. The disadvantage of this method is the dependence of the LED's amplitude flash on the temperature. To eliminate this shortcoming, the current source is designed. The saturation of hemoglobin is a measure of the average amount of oxygen bound to each hemoglobin molecule. One of the factors affecting the change in the intensity of the recorded light is a sensor motion, which is caused by the formation of the gap between the skin and the sensor. The second factor is the perturbation of venous blood flow, which depends on the movement of the muscles surrounding the veins. To reduce the impact of movements on the readings, two ways of attaching the sensor - adhesive tape and elastic tape have been tested. Mounting the sensor with adhesive tape led to a significant reduction of the reading changes. If the sensor's contact pressure on the body is too low, it results in a reading distortion. Too much pressure value manifested in reducing the blood flow and the probe readings, while during prolonged use can lead to necrosis. To select the optimal value of the contact pressure, the experiment was conducted. Different values of the load were applied to the sensor. Measurements of oxygen saturation were performed for each value of the load. Special attention was paid to the uniform distribution of the load. The results of the measurement are shown in Figure 2.

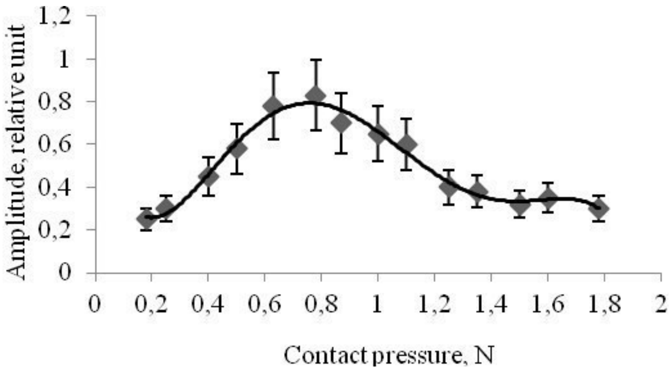

Fig.2. Amplitude dependence on sensor's contact pressure

As it can be seen from the graph, the optimal pressure value is 0.7 N. Next, the device was checked for the presence of hypoxia. The device was attached to the volunteer's forehead with a tape. Then the oxygen saturation measurement was conducted during normal breathing, followed breath holding for 30s. This test confirmed operability of the device Fig.3

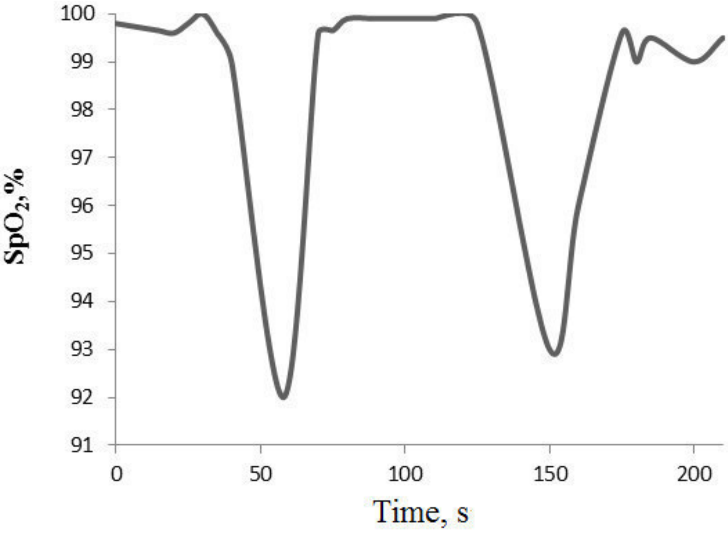

Fig.3. Typical view of the presence of hypoxia

The proposed solutions made it possible to reduce the impact of movement on the probe readings. Experimentally obtained optimum sensor contact pressure on the body is - 0.7N. Applied schematics have improved device characteristics compared with existing analogues.

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