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HARDWARE AND SOFTWARE COMPLEX FOR RESEARCHING CARDIOVASCULAR SYSTEM OF A HUMAN BEING

This work is devoted to the development of hardware and software complex for the analysis of the state of the human cardiovascular system. The heart is the most important organ of the cardiovascular system. The human organism cannot exist without it, because it is the contraction of the heart muscle that ensures reliable blood flow and all processes of vital functions in organs and tissues. That is why it is crucial to check the work of the heart from time to time, even in case if there are no visible complaints about the state of health in general.

The complex consists of seven main parts: a unit for measuring pulse oximetric data, a unit for measuring heartbeat (ECG), a pre-processing and data transmission unit, a mini-computer, a special software for data processing, a display for the output of cardiovascular system data, and an input block. The block diagram of the complex is shown in Figure 1.

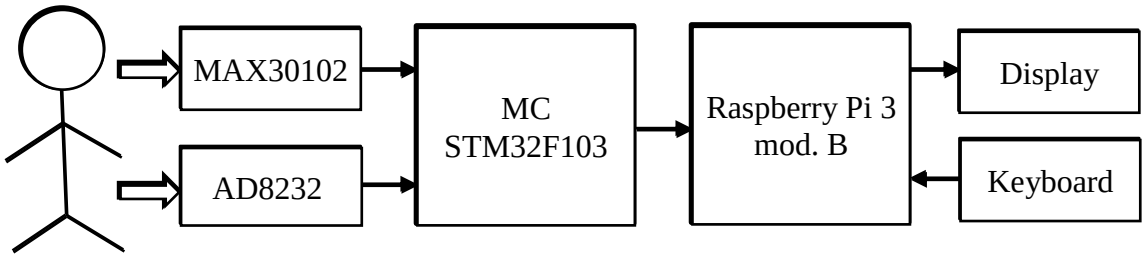

Figure 1 - Block diagram of hardware and software complex

The block for taking pulse oximetric data consists of a specialized module of Maxim Integrated called MAX30102. The MAX30102 is an integral sensor module designed to facilitate the development of portable medical devices for monitoring heart rhythm and blood oxygen saturation. Red and infra-red LEDs and a photodetector, as well as built-in optical elements, are integrated into this chip. Available in the MAX301002 electronic circuitry for signal processing is characterized by low noise level and provides suppression of external illumination. In the process of measurement, a channel of red and infrared light is used. The glow intensity and the duration of the measurement sessions are controlled by the software. The basis of the pulse oximetry method is measurement of the absorption by hemoglobin of red and infrared rays. Hemoglobin serves as a kind of filter, and the "color" of the filter depends on the percentage of oxygen in the blood. And the "thickness" of the filter is determined by the pulsation of the arteries, that occurs when the amount of blood in them changes. This unit is controlled by a ST Microelectronics STM32F103C 32-bit microcontroller. Communication and data exchange with the module occurs via the I2C data bus.

The Bioelectric Potential Registration Block (ECG) uses the specialized chip of the Analog Devices AD8232, which is an integrated signal processing unit for ECG and other biopotential tasks. The microcircuit is for reception, amplification and filtration of weak biopotential signals in the conditions of strong interference. The AD8232 has very

decent features: low current consumption of 170 mA, Rail to Rail output, built-in HF noise filter, 2-pole high pass filter, 3-pole low pass filter, 80 dB low-noise ratio. After pre-amplification and filtering, the signal is transmitted to the ADC of the microcontroller.

The STM32F103C microcontroller is used to control the MAX30102 module and acts as a bridge between the computer and the blocks for data retrieval as well as for the preliminary processing of the received data. Built-in 12-bit ADC of the microcontroller is used to digitize the ECG data. The connection between the MK and the Raspberry Pi 3 microcomputer occurs through the Serial Interface SPI.

The Raspberry Pi 3 model B is one board mini PC with a 64-bit four-core Cortex A53-based CPU running at 1.2 GHz. The amount of RAM is 1 GB. The mini PC includes a decent peripheral set: 4 USB ports, HDMI port for connecting the monitor, Ethernet, 40-pin GPIO port with the ability to connect various data transmission interfaces (UART, SPI, 1-Wire, I2C, etc.). Importantly, the cost of this PC with such features is quite low (approximately $ 30). This PC operates on the basis of the Linux operating system, which provides us with reliability, speed and free license for the use of any available distribution.

The software part is done using the cross-platform application Qt Creator. Qt Creator allows you to create a flexible graphical user interface, as well as further mathematical processing in C++ with the ability to use third-party libraries and classes. This toolkit allows you to use the generated software code on machines with different operating systems and architecture. The program will allow you to visually observe the indices of oxygen saturation, heart rate, ECG and other parameters. It is possible to save data to the PC's memory, print, and transfer to the server or to a doctor through the Internet.

In the course of this work, a complex for the study of the cardiovascular system of a person was designed. The structural and functional schemes were developed and the main element base was selected. This development is a successful combination of quality, the possibility of qualitative processing of bio-signals for a small cost of the complex components.