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Hardware and software for monitoring heart in portable electrocardiograph

Portable electrocardiograph is intended for individual usage by human to reveal and follow heart diseases. This kind of heart monitoring is necessary for people who work in harsh conditions and are exposed to various negative factors. Usage of the device will help to detect the heart diseases at early stage.

One of the features, implemented in the device, is the possibility of registration of the electrocardiogram on the fingers of the patient. The ability to connect chest data transmitters is implemented for more detailed checkup in the device. It will allow to make reading the electrocardiography (ECG) in other projections.

The special feature of the device is a use of analog-to-digital converter (ADC) of high resolution (sigma-delta 24-bit ADC), that gave possibility to use digital filters instead of analog ones. Such design of the device was possible by using new components. List of the main elements, used in the device, is described in table 1.

Table 1

List of elements with the interface interaction

Element name	Interface of interaction
ADS1292	SPI
LCD Screen	SPI
SD Card	SDIO
Keyboard	GPIO
STM32F152	SWD

Compute core of the device is the 7th family ARM-controller with built-in DSP and FPU functions hardware. It's power is sufficient for all mathematical calculations of digital filters and for the activity of real-time system, which performs necessary functions and operations. The remaining structural elements are standard for devices, which interact with human and a computer.

An embedded software deserves special attention. The development carried out in a framework named CooCox CoIDE, which is intended for software development of microcontrollers of an ARM architecture. GCC compiler was used to compile the source code, it's included in the GNU Tools for ARM-embedded processors. These tools are free and they have a very good support. The debug board STM32F4Discovery is used for debugging.

The software is built on the basis of real-time system named FreeRTOS v4.7.2 [1]. By using of the real-time system it was able to reduce development time by creating relevant tasks. [2]. There is a special set of API functions to control the task. Description of these functions can be found on the FreeRTOS official website [3].

Besides using of the real-time system and creating its objectives, it's required to create of sub-functions of conversion from the ADC 24 – bit data format to 32 – bit format of the microcontroller for the device' work organization. This operation is necessary for the correct work of the microcontroller with negative values obtained from the ADC. Among the required functions for the work of the device there is a builder function of graphs. The function gathers four values, completes the required values between the received values and sends the entire array on the display by SPI interface. Similar organization is necessary because of the hardware requirements of the display. Besides the above-described features it may be noted that the data are

sent to the memory card with a frequency of 500 SPS, but the data, which are sent to the display, have frequency of 125 SPS. This change of the sampling frequency was necessary to fit for about two seconds of time on the display.

It is also necessary to note that there are two IIR digital filter used for correct displaying of the ECG. High-pass filter with a cutoff frequency of 1 Hz removes baseline drift, which can be about 300 mV, according to it, ECG graph does not go beyond the borders of the display. Low-pass filter with a cutoff frequency of 45 Hz is meant for filtering power-supply noise and other high-frequency noises that greatly distort the ECG graph on the display. The infinite impulse response (IIR) filters were used due to they have greater signal attenuation at a intended frequency under the small order of the filter in comparison with finite impulse response (FIR) filters.

As a result of all the above-described developments there is a graph of the data, imported from the Secure Digital (SD) card, built with the help of a software package MatLab (fig. 1).

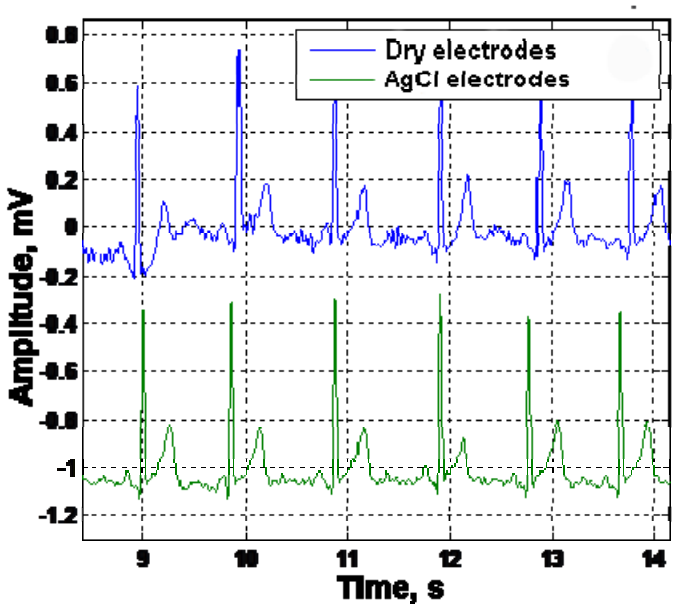

Fig. 1. The patient's ECG № 1

Fig. 1 shows the electrocardiogram read out the fingers of the patient. It is possible to carry out simple methods of analysis of the heart conditions in the form of registration of various arrhythmias with the help of obtained data.

References

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