Complex device for recording and signal processing of cardiac activity

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***Abstract* – there are described structural scheme of the measurement system and processing of photopletismogram, interacting units, possibilities of software and interfaces in two modes of operation: the pc and with a special modul.there are presented characteristics and technical parameters of the system.**

Index Terms – Cardiovascular system, photopletismography, device, signal .

I. INTRODUCTION

Besides electrocardiogram, one of the methods, for determining the physiology index of the human body is photoplethysmography – computerized method based on recording and signal processing of the photoplethysmogram wave. [1,2]

The proposed system is assigned to the investigation of cardiovascular medical technology, the operating principle of which is based on the method of photopletismography wave. Photopletismography principle is reflection of radiation (infrared radiation is usually used, but may be used and another band of spectrum that would allow a good penetration of skin coatings and independence of the reflected signal by other factors such as skin pigmentation) from blood cells moving through the small vessels, under the skin. [3,4]

Photoplethismografy recording and processing allow to obtain information about the state of cardiovascular system, the segmented blood pressure, detecion of blood vessel damage through screening large caliber method.

II. STRUCTURAL SCHEME OF THE DEVICE

The device is designed for ECG and Photoplethysmography signal acquisition, its processing, computer data transmission, determining the signal parameter, graphical display of heart rate on LCD color display, storage of data and signals of the patient into the database of patients, etc.

The device is composed of several modules: the digital module, the analog module, transmitter, LCD Display, SD Memory Card and power control module (Figure 1).

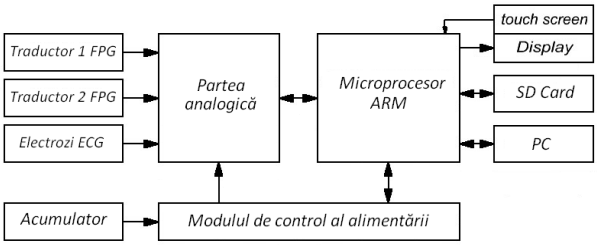

Fig.1. Structural diagram of the device for recording and processing of the ECG and photoplethysmogram waves

The functionality of the device is based on ARM Microprocessor, with 32-bit architecture that works at the clock frequency of 100 MHz. Its functions are the following:

- Interaction with the analog module into a digital signal conversion, changing the operational amplifier gain of the final cascade to achieve an optimal level of input signal at ADC, changing infrared radiation transmitter, applying a voltage (CDA) in the cascade amplifiers to maintain signal processing slow components at the desired level, digital signal processing, etc;
- Interaction of Color display device;
- Reading and decoding data from touch screen panel that is on display – the determination of coordinates of the points of interaction;
- Making a menu-user interface extensive graphical display due to large size touch screen panel;
- Interaction with the power control unit – ensuring the transition to sleep regime, provident power to all blocks of the device in active mode operating voltage level monitoring of battery charging;
- PC Connection – connecting the computer through the USB interface device can operate as a computer peripheral mode – photoplethysmography signal can be collecting and send directly to your computer , or read from memory and transmitted to the personal computer only necessary data.

Data Base allows dynamic allocation of memory space for its patients and signals. It can capture more than 65 thousands patients, each patient to 240 signals. Signal duration can be adjusted from 1 minute to 24 hours, and duration of all signals is 40 320 minutes (equivalent to 672 hours or 28 days)

Analog site of the device consists of two symmetrical channels that process signal from two photoplethysmograph transducers and one channel of ECG processing. Figure 2 shows the block diagram of the analog part of the device.

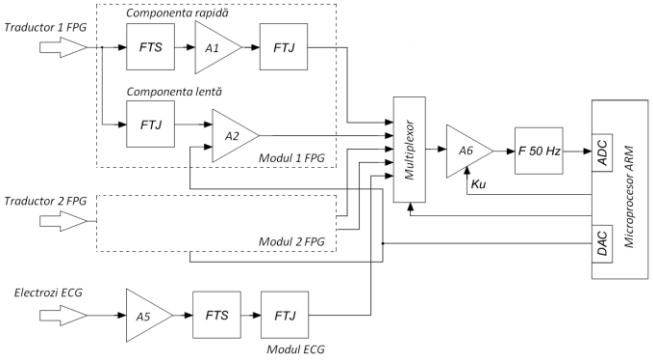

Fig.2. Block analog scheme of the device

The device measures both fast component and slow component of photoplethysmography, so the signal from the sensor is initially separated into two signals: signal of slow

component and signal of fast component of photoplethysmography.

The fast component of signal is first amplified in current then dc component is removed by using a high pass filter (Fig.2). Because the power supply of analog part is unipolar, signal is raised to the „virtual gnd" of 1,5 V. After this signal is amplified with a fixed amplification facto r (Ku = 10) and highfrequency noise filtered through a low pass filter.

To get the slow component, the signal from the sensor is amplified in current and then the rapid component of the signal is filtered using a low pass filter with cutoff frequency of 0,5 Hz. After this, signal is applied to the inverting input of a differential amplifier A2 with amplification gain 10. To the non-inverting input of this amplifier is applied a voltage from the digital-analog converter (CDA). This voltage is necessary to maintain the signal voltage range from 0 to 2.56 V and exclusion of the amplifier saturation regime.

Electrocardiograph signal (ECG) are gathered using three electrodes placed on the patient's body - two active electrode (or warm) and a neutral electrode (or cold). The signal is amplified with an instrumentation amplifier A5, after which the dc component is filtered using a high-pass filter with cutoff frequency of 0,05 Hz, and noise at frequency above 100 Hz with a low-pass filter.

The fast and slow components of signal from output of photoplethysmograph module and ECG signal is applied to the inputs of a multiplexer, with which the microprocessor selects the appropriate signal to be recorded. The analog signal from the multiplexer output is applied to the operational amplifier A6, whose amplification factor can be adjusted by the microprocessor. Because of using digital potentiometers are obtained 256 steps of the amplification gain. This allows obtaining the ADC input signal with amplitude that can be converted in large numbers without quantifying losses and without the need for further scaling.

After amplification the signal is filtered by the noise induced by power grid frequency of 50 Hz.

Getting data from analog to digital converter, microprocessor continuously monitors the signal level. If the signal amplitude is too low for a period of time, will made to increase the coefficient of amplification, if too high - to zoom out. Another action on the part of the device is changing the value of analog voltage output digital-analog converter to minimize the slow component signal.

The microprocessor also changes intensity of infrared radiation, which allows the transducer to adjust the properties of different patients.

The display of the device is an LCD Color, with resolution of 320×240 pixels and 65 536 colors, which allows to display the time evolution of one or two signals simultaneously, but also create a user interface, extensive menu, intuitive and easy to interact. Using the graphic display combined with touch screen panel allows us to create a device without many buttons, operator interaction with the device being made by pressing with a special pen, called the stylus, directly on the Touch Screen panel, placed above the display. Because of this, the menu consists of pages, buttons, keyboard - similar to a personal computer, making it easier to access the menu for personal computer users.

User menu consists of four pages: "Patient", "Display", "Graphics" and "Settings." Page "patient" is intended to work with the database, add a new patient into the database or choose a patient previously investigated. At the bottom of the window, designed to introduce a new patient database, is the keyboard, similar to the personal computer (Figure 3).

Fig.3. Introducing a new patient window

The patient's page can be accessed and the device database. Database interface allows us to navigate through the list of patients to look for a particular patient in the database, to remove a patient and to select a particular patient.

Fig.4. Browsing through the database window

On the page "Display" choose the desired signals to be viewed. It can be selected up to two signals. For this, press the squares that stand beside the name of each signal. Clicking on these squares, each a check mark appears in them, which means it has been successfully selected, and the right square is the abbreviated name of the signal. If the patient was already introduced in the database, you can choose it to view previously stored signals. To compare the signal obtained before and that obtained in time, choose a signal from memory and a signal from the sensor.

Page "Graphics" is provided to view selected signals for display. Can be viewed one or two signals simultaneously. With "Start" button will start collecting data and displaying on the display, the "Stop" will stop collecting data, and by using the "Memo." will store data in memory. If you select a signal from memory for display on this page we can place directly on the screen of photoplethysmograph basic points and to calculate photoplethysmograph few basic parameters, which can give some clues about the state of the cardiovascular system.

Page "Settings" contains the device settings: setting the time, date, backlight, view memory status and the option of switching off the device. A fairly large part of the energy

consumption of the device has LEDs backlight. To reduce the energy consumption of the device is provided for automatically disconnecting the lights over a certain time after you last press a touch screen panel. Length of time it can be set by choosing one of values: 20, 40, 60 seconds or disconnect backlight.

III. CONCLUSION

The developed device allows the time analysis of electrocardiograms and photoplethysmograms, quality parameters, allows to compare the visual signals and those collected previously made at the moment, allow to study heart rate variability.

The system has the following technical parameters:

- Number of channels – 2 channels of simultaneous recording of slow and fast components of photoplethysmography and 1 channel electrocardiography;
- Frequency Band – from 0.05 to 18 Hz (FPG) and from 0.05 to 100 Hz (ECG);
- Signal sampling frequency – 500 Hz;
- Active mode power consumption – 0.6 W;
- Minimum operating time without recharging in active mode – 16 hours;
- Dimensions – 110X65X30 mm;
- Weight 200 g.

The measurement and data processing of photopletismograph has technical characteristics (price, size, number of functions performed, parameters) high, competitive with existing ones and can be recommended for the production and subsequent implementation in health care.

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