COMPUTATIONAL PROBLEMS OF ELECTRICAL ENGINEERING
Vol. 3, No. 2, 2013

ELECTRONIC SYSTEM OF MONITORING THE PATIENTS WITH CARDIOVASCULAR PATHOLOGY

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Abstract: The construction of a clinical monitoring system applied to diagnose the patients' state in a rehabilitation period is considered. It is pointed out that in a crisis period, patients with cardiovascular pathology are connected to a life-support system, and if the patients' state takes a turn for the worse, the system lets the medical personnel know immediately.

A special attention is paid to the estimation of indexes of the cardiaovascular system. The description of a structural construction of monitoring apparatus intended to control radiotelemetry of the patients' state is given. The methods of detecting the cardiovascular indexes, which are notable for their relatively high informational capability and sensitiveness to any changes in the inpatient's state have been chosen and implemented.

Key words: cardiovascular system, patient, diagnostics, monitoring apparatus, radiotelemetry.

1. Introduction

Physical examination of a patient with cardiovascular pathology when diagnosticating and doing periodic examination is conducted by means of diagnostic systems. Such systems have high metrological performance and, accordingly, high cost. They enable a database to be accumulated for every individual patient and play an important role both in the system of modern treatment and diseases diagnosis, and in the life-support system.

In a crisis period, patients with cardiovascular pathology are connected to a life-support system, and in case the patient's state gets worse, the system lets a medical personnel know immediately. The patient's condition having been improved, s/he is transferred into a ward where the only way to call a doctor is to press a rapid call button. There are cases when a crisis comes for such patients unexpectedly (for example, being in a state of sleep), and the patients cannot call for help themselves. But a delayed medical aid can entail irreversible consequences for the patient.

2. Statement of the problem

Monitoring of the patient's state in a post-crisis period by means of electronic devices becomes complicated, for the patient can feel like moving around, and any cables, loops and other things like that being connected to the body will interfere with his/her moving freely, creating, in this way, discomfort.

The real possibility of creating off-line electronic units, able to watch the patients' state, to immediately inform medical personnel in critical cases appeared with the emergence of an element base of the modern microprocessor. Thus, the **purpose of the research** is the development of an off-line system to control the patients' state in a post-crisis period by means of electronic devices monitoring the state of the cardiovascular system.

3. A control system of cardiovascular pathology

To detect any changes in the patient's state, it is enough to watch over one or more parameters, for example by the number of the patient's heart-throbs.

In medical practice, electrocardiographs and electronic stetoscopes, the action of which is built on measuring heart tones, have found a wide application [1]. The heart tones by themselves are the oscillations of subaudio (infrasonic - above 10 Hz) and audio (sonic - up to 200 Hz) frequencies, which are passed through the tissue of the body onto the skin. In addition, the noises that arise up at different heart disorders have a frequency to 800 Hz.

In this work, we present our development of a cardiovascular pathology control system. This is a multichannel system designed to serve dozens of patients (depending on the number of patients in the same hospital ward.

Fig. 1 represents a flowchart of one of the component channels of the patients'state control system. This electronic unit includes an electronic microphone or piezoelement (1), a signal amplifier (2), a modulator (3), a signal power amplifier (4), a radio frequency amplifier (5), a demodulator (6), a warner or computer connecting port (7). The signals of a sick persons` state are transmitted over a radio channel and can be received within some hundrend of meters. The distance of their transmission can be regulated by choosing an appropriate power of the radio transmitter.

Wherther to use a microphone or a piezoelectric element is determined by the alternative of choice -

either higher sensitivity to the heart tones and lower sensitivity to the unwanted sounds, or vice versa. In the former case, it is necessary to prefer the microphone, while in the latter case – the piezoelectric elements.

It should be noted that the given electronic unit can function independently as a separate device. Being able to sound, it replaces a phonocardiograph, rather a sophisticated and expensive instrument for listening heart tones and sounds in different ranges of frequencies.

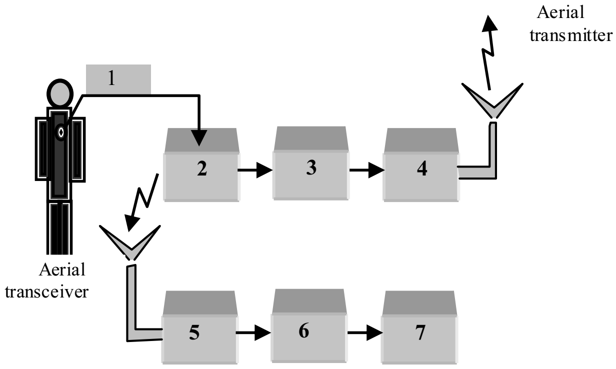

Fig. 1. The flowchart of the control system.

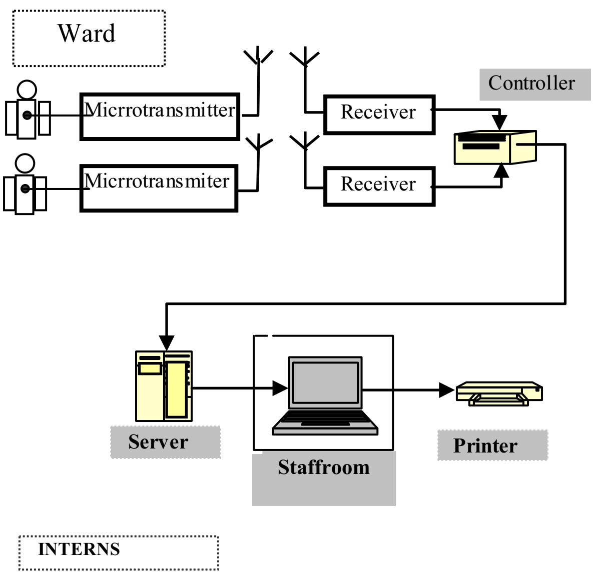

Fig. 2. The dlock-diagram of the control system.

In Fig. 2 we can see a simplified block diagram of a control system intended for monitoring the state of patients with cardiovascular pathology. The receivers receive certain specific signals from the transmitters connected to the GREW 16C73 controller (produced by Microchip Technology Inc.). The controller, by means of a special algorithm, processes the data obtained. The data having been processed, the results achieved are passed to the server to be archived. if the patient`s state becomes very close to critical, the system gives out an alarm tone at once, informing the personnel. A doctor, making use of the archive, can view the number of heart-throbs at any moment, or draw a diagram for the period of time chosen.

Miniature receivers with a low (subzero) supply current, e.g. transceivers, microcontroller-based transmitters, receivers, etc which are made on a single crystal are produced by Infineon Technologies AG, Gran - Jansen AS, Xemics, RF Monolithics Inc., Microchip, Maxim, Telecontrolli. For example, Telecontrolli offers both amplidute modulated and frequency modulated transmitters. Basic parameters of such transmitters are given in the Table 1 below, and a typical circuit diagram of a RT4 radiotransmitting module is presented in Fig. 3.

Table 1

Basic parameters of the transmitters of firm Telecontrolli

Parameters	RT 4	RT 5	RT 6	RTQ 1	RTFQ1
Voltage, V	2..14	2..14	2,7..14	2,2….4	2,1….4
Current, мА	4	3	3..9	7	7
Working frequency, kHz	303-433	303-433	303-433	433-868	315-868
Initial capacity (50 Ohm load), dB	7	7	3..15	5..1	5
Harmonic spurious radiation, dB	-30	-35	-50	-40	-40
Data transmission rate, kHz (RTQ - KB/sec)	4	4	4	9. 6	9.6
Working temperature range, °C	-25 +80	-25 +80	-25 +80	-25 +80	-25 + 80

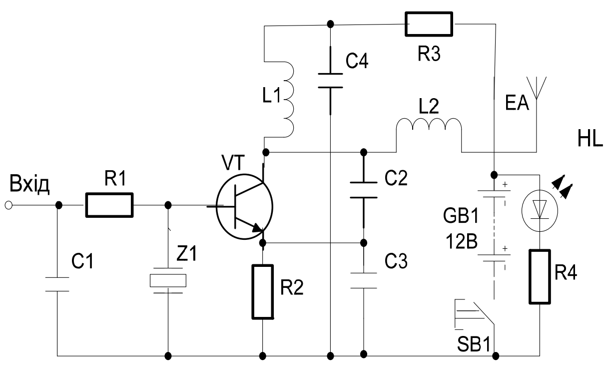

Fig. 3. RT4 radiotransmitting module.

The transmitter is built on the basis of a transistor quartz oscillator according to the capacitive three-point circuit. *R1* and *R2* are the resistors intended for setting an operating mode of the transistor in a direct current circuit and its indispensable stability. The capacitor *C1* acts as a filtre, which blocks access of high-frequency interference that get into the module along with a diagnostic cardiosignal. The capacitors *C2*, *C3* and *C4* form a capacitive divider for providing a positive feedback and partial linking of a tank (*L1, C2, C3, C4*) to a load (of the EA) through the inductor *L2*. The light-emitting HL-diode signals that the transmitter has been switched on.

The structure of the patients` state control system also means the use of the electrocardiograph by connecting appropriate sensors – three-tap electrodes.

Phono or electro-cardio signals are passed to the host receiver, displayed on the monitor screen, and stored in the computer memory.

Action potentials of the heart are picked up by the electrodes attached to different points of the thorax (it is done lest the wires should impede patient`s motions). Since we usually mean a protracted period of treatment, the electrodes are sticked to the skin with a sticky tape or special-purpose glue. The electrocariograph amplifier accepts biological currents of the heart. The amplified signals are fed to the modulator of the transmitter and modulated high-frequency electromagnetic oscillations which are radiated by the aerial into space. The receiving aerial receives radio waves that are transformed by the demodulator of the receiver into the source of ECG signals. An *R*-wave is chosen as a diagnostic "alarm" parameter. The choice of the R wave is determined by its considerable information capability. The *R*-wave, in some cases, is accepted as a reference when the heart work is checked by some other methods, for example, sphygmography. For the automatic determination of this parameter in an electrocardiogram, it is possible to use one of the alternative methods.

The *R*-wave-based method for the processing of electrocardiosigals and distingushing diagnostic indexes of the sick person`s state deserves attention [2]. The algorithm of this method is implemented as follows.

A high-frequency filtration of the interference is carried out.

On the basis of the initial data, we can find the R waves. By using this formula

$$E_i = \sum_{n=i}^{i+m} (x_n - x_{n-1})^2 ,$$

where m is the size of a sliding window (0.1 sec), $i \in [0...k-m]$, we calculate the sliding sum of the squares of an initial signal increase. Then we find limits of a change in minimum E_{min} and maximal E_{max} energies of the initial signals and choose their threshold $E_{thr} = E_{min} + 0,5(E_{max} - E_{min})$. Thus, if the value of the current signal`s energy Ei is greater than the calculated threshold, then this point is fixed either as a position of the previous *R*-peak (if it lies nearer than R_{min} (0.3 sec), or as a new *R*-peak. For the purpose of an exact position, the *R*-peak is determined as a local maximum. The approximate positions of the *R*-peaks by the local maxima of the vector *E* having been found, the initial data vector within the radius m of the *R*-peak positions found is analysed to determine an exact position of the *R*-peak as a local maximum.

The mean value of the *RR* interval length (R_{med}) and the standard deviation of all chosen *RR* intervals are clculated.

The processing correctness control subsystem monitors any possible change in the defined *R*-peak relative to a sure position of *R*-peak within the QRS complex. An error of the method is connected with the quantization of an electrocardiogram. With the frequency of signal discretisation decreasing, the error increases. If there is a known form of the signal in a required point, it is possible to get an effective interpolation of the signal around this point, as well as rerefinement of the point position by the interpolated function. However, often a simpler method is an increase in the frequency of the selection.

Processing imperfect signals using this algorithm, it is possible to detect superfluous *R*-peaks in a recursive way. In this case, the processing correctness control subsystem registers a decline of the average length of the *RR* interval less than 0.3 sec, and stops its working informing about the error occured.

Realization of this algorithm is based on the computer program Matlab 6.1. It executes the calculation of a KIX filter, chosen for this purpose. The structure of the filter is built on the basis of the blocks of Simulink's package.

The system automatically activates alarm when the frequency of heart-throbs (FHT) is beyond the norm. The system also indicates some technical parameters (battery discharging, blackout, etc.).

The work of the complex is continuously monitored by a duty cardiologist and a nurse.

By methods given in [3] we identified the groups of patients, who were prescribed a radiomonitoring ECG:

- patients, transferred from a resuscitation unit to a general ward of the department;
- patients with fatal rhythm disorders;
- patients after trombolytic therapy;
- patients with temporary rhythm disorders;
- active rehabilitation of the patients suffering from heart attacks;
- selection of antiarrhythmic remedies and control of treatment efficiency;
- control of surgical treatment of rhythm disorders.

The system suggests that the patients who have passed a rehabilitation period are followed up by a medical institution by means of portable electro-cardiographes.

A patient is to independently take his/her electrocardiogram and send it to his/her cardiologist via a telephone line. After answering the call, the doctor compares the ECG received with the previous ones and looks throught the medical patient`s history, which is systematized in the process of ambulant therapy. The situation having been estimated, the doctor gives reasonable recommendations, and in the case of necessity immediately sends an emergency team.

The ECG taken is added to the memory of a cardiograph and can be passed to the center using any telephone (including a cellphone).

It is important to note that being connected to the system, a patient gets rid of a heavy psychic tension, which, as a rule, is accompanied by heart attacks.

A possibility of getting in touch with a cardiologist at any moment, and receiving professional medical services makes the patient confident that may relieve a psychological load and sense of helplessness.

4. Conclusion

The system of clinical monitoring, used for diagnostics of the patients' state in the rehabilitation period by means of cardiovascular indexes (R-peaks, FHT), has been considered. The methods of detecting cardiovascular indexes, which are distinguished by relatively high information capability and sensitivity to changes in the sick person's state have been selected and implemented. The structure of monitoring apparatus intended to control radio telemetry of the patients' state has been described.

References

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ЕЛЕКТРОННА СИСТЕМА КОНТРОЛЮ СТАНУ ПАЦІЄНТІВ З СЕРЦЕВО-СУДИННОЮ ПАТОЛОГІЄЮ

Сергій Мещанінов

Розглянуто побудову системи клінічного моніторингу, вживаної для діаностики стану хворих у реабілітаційний період. Доведено, що у кризовий період хворі з серцево-судинною патологією перебувають підімкненими до системи життєзабезпечення і у разі погіршення стану система терміново інформує медичний персонал. Особливу увагу звернено на оцінку показників серцево-судинної системи. Описано структурну побудову моніторної апаратури контролю радіотелеметрії стану пацієнтів. Обрано й реалізовано методику знаходження серцево-судинних показників, яка позначається порівняно високою інформативністю та чутливістю змін стану хворого. Описано структурну побудову моніторінгової апаратури контролю радіотелеметрії стану пацієнтів.

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