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Computer Based Controlled Pacemaker Implementation

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Abstract: This paper deals about design and software implementation of a computer-controlled pacemaker external driven by P-wave with use of National Instruments SW development kit. Software part of pacemaker function were realized on hardware device NI Elvis II and software platform NI LabView. The article describes step by step the software implementation of the pacemaker and explains principles of hardware devices.

Keywords: pacemaker, design, implementation, management, computer simulation

1. INTRODUCTION

Stimulation is based on an electric field between the stimulating electrode poles and the surrounding cardiac musculature. This electric field is created by applying an electrical stimulus pulse. To stimulator evoked action potential is needed to make the difference between the extracellular and intracellular space of a cell membrane decreased to the threshold potential, ie. from approximately - 80 mV to - 60 mV. Intracellular space is charged to a negative value and a positive value extracellular. Because the intracellular space is negatively charged, can be reduced by reducing the tension on the membrane potential of the extracellular space with pulses of negative value. If they used the positive stimulus pulse, he would have a higher amplitude. At the interface between the electrode and tissue is the largest current density of pacing poles. With distance from the electrode current density decreases. (Korpas, 2013)

The emergence and spread of depolarization of the heart depends on the stimulation threshold. Pacing threshold can be expressed in units of voltage, charge or energy pulse, while there is a direct proportionality.

$$E \approx U^2 \cdot t \qquad (1)$$

For stimulation with rectangular pulse is used with an adjustable width and amplitude. Hoorweg-Weiss curve of Figure 8 shows the amplitude of the stimulation current at the threshold pulse width. The curve shows two characteristic values, namely rebase and chronaxy. Rebase threshold intensity is infinitely long rectangular electric pulse. Time at which the formation of the impulse, increasing the intensity of this initiative doubled defines chronaxy. (Calvagna & Patane, 2015; Korpas, 2013)

The amplitude of the stimulation pulse indicates the voltage output pulse leading edge devices. The amplitude can be set at different ranges. This range varies from zero values when stimulation is off, up to 7.5 V or 8.4 V or more. Range is determined by the type of the device. Pacemakers contain circuitry for fast charging after discharging the output coupling capacitor as a result of the stimulus pulse. Repeated charging capacitor output circuit is shown in Figure 9 as a charging cycle. Charging cycle is determined by the low pulse amplitude and opposite polarity than the pacing pulse.(Kukucka, Krajcuskova, Stopjakova, Durackova, & Ieee, 2013)

The pulse width determines the length of exposure pacing pulses between the stimulating electrode poles. The width is also possible to set in different ranges, which ranges from 0.05 to 2 ms. (Korpas, 2013)

1.1 Measuring system NI ELVIS II +

It is a system created by National Instruments and used to teach electrical engineering. NI Elvis II + communicates with the computer using LabVIEW. This program unlike standard program offers measuring systems which only data on the computer display, or you can manually change the parameters of instruments, allowing two-way communication in real-time. The biggest advantage of this device is that it is needed and only one device may combine several of them. All the necessary instruments are in fact part of one non soldered field. Another positive feature is that there is minimal likelihood of damage appliances that are part of this system. (Bilik, Koval, & Hajduk, 2008)

2. DESIGN OF CONTROLLED PACEMAKER

The work is focused on the preparation of a pacemaker-driven wave P. assembly to a pacemaker-type VAT. It is a pacing mode, the signal is sensed from the right atrium and after a certain time delay stimulus pulse is sent into the right ventricle. The delay time of transition corresponds to the physiological action potential from the hall to the chamber. Delay time is between 120 and 200 ms.

The device is implemented at the hardware and software level. Figure 1 shows the basic blocks of real implementation. As the signal from the right atrium is used ECG signal, which

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is then adjusted to obtain only the P wave. The stimulus pulse is applied at a real pacemaker into the right ventricle, in this thesis will be simulated on an oscilloscope.

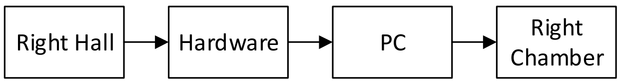

Fig. 1. Main blocks of realised pacemaker

Hardware will deal primarily loading signal and its treatment. First, the signal is filtered and then amplification is performed using a resonator, when the corresponding frequency (in this case a frequency near the frequency of the P wave) signal amplification occurs. Hardware is realized on the solder field NI ELVIS II +. Breadboard converts the analogue signal to digital signal, which is then sent to a computer for further processing.

As software is used LabVIEW program that is suitable for virtual stimulation pacemaker and is it possible to connect with NI ELVIS II +. The software part is already working with the actual filtered and amplified digital signal. (Augustynek, Labza, Penhaker, & Korpas, 2010)

2.1 Main blocks of Pacemaker

First was generated ECG signal. This signal was modified by filtration and amplification. Thereby obtaining a signal, wherein the P wave stronger than other visible waves and oscillations ECG signal. Then the signal is amplified, so that the peaks P waves visible. Subsequently, peak detection is performed in the signal. Of squaring waves it is possible to calculate the heart rate of P waves. Once the peaks are detected, the system waits 120 ms. After the expiry of the PQ interval (120 ms) followed by a pacing pulse generation. The last block used to display the stimulus pulse in the ECG signal where the pulse should be located in the oscillation R.

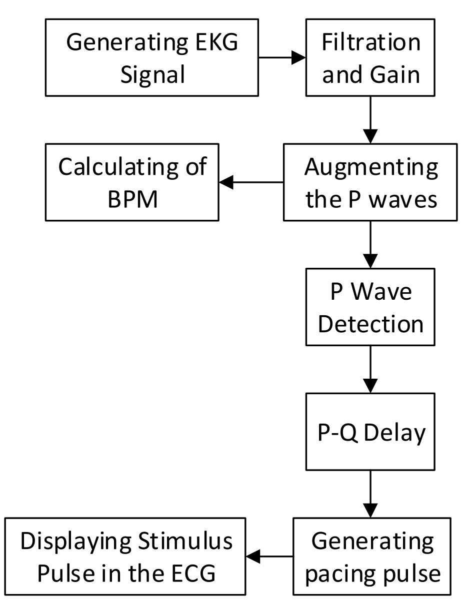

Fig. 2. Main blocks of realised pacemaker

2.2 Pacemaker Hardware realisation

The input ECG signal is required filter to obtain only the P wave and the other components of the ECG signal has been suppressed. Originally, the signal is filtered in software, but in this method of filtration delays signal. Finally, this signal was not realistic to work, since it cannot be returned in time. Thus, after detecting the peak was not back in time to send the stimulus pulse. For this reason, the signal is filtered by the hardware.

Individual parts of the hardware:

- Filter
- Quick start
- Resonator (corresponding filter)

The signal in the hardware part enters into the first filter (1) which serves to suppress the R-oscillation. Next, the signal enters the area called quickstart (2) in this section is to remove any DC component. The last piece of hardware in the resonator (3). This connection serves to amplify the signal of the set frequency. The frequency range is adjusted using resistors and capacitors in the RC circuit. The residue frequency remains at the initial voltage level, and therefore are consequently suppressed. For this active filter was used operational amplifier type TL071. In essence, it is a band pass filter. Are thus obtained reinforced P wave which are important for future processing. (Musil, Janckulik, Motalova, Krejcar, & Society, 2010)

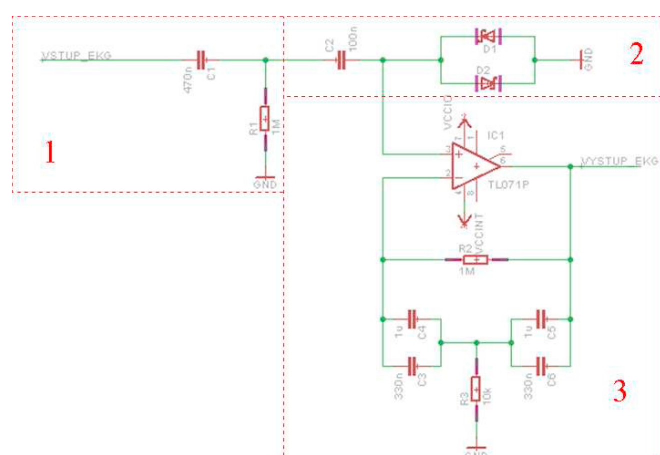

Fig. 3. Main blocks of hardware realisation

2.2 Pacemaker Software Realisation

Software LabVIEW means literally "laboratory workplace virtual instruments". Thus, it is possible to demonstrate the function of a device virtually (unrealistically). Each virtual device consists of two contiguous windows. These windows include a user interface, or so-called Front panel and block diagram, or Block Diagram.