

LOW COST VIRTUAL INSTRUMENT FOR FAST ECG MONITORING

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Abstract: Based on virtual instrumentation, we developed an ECG monitoring system for fast evaluation of heart health. We use low cost components for data acquisition: USB experiment interface board K8055 designed for computer peripherals and EKG-V2 amplifier module for ECG signal. The system has low power consumption and is very easy to operate. Since the acquisition board works at low sampling frequency for a more accurate representation of ECG signal, a common interpolation detection method was used.

Keywords: ECG, heart rate variability, QRS detection, sampling rate, low cost, interpolation, virtual instrumentation

1. INTRODUCTION

There are three directions that influence the development of medical instruments and establish an early position in a very competitive market: producing safe, high-quality devices for patient care; reduced development time and low cost system.

Designing a medical product that has features and capabilities necessary to use a particular customer, it is very difficult. To overcome this challenge, we need a new approach that allows increased modularity of design complexity, while allowing the implementation of innovative ideas from non-technical experts. By tightly integrating hardware, software, validation, and reporting tools, the LabVIEW platform provides the best solution for rapidly developing and testing medical devices. Graphical System Design allows an expert in designing integrated systems, to accelerate the development of medical devices.

Designers need an evaluation board to design a prototype system. However, this board often does not include all components necessary for an application signals. Most of the time is needed an extra conditioning circuit, to adapt the bioelectric signals to data acquisition system. We used an instrumentation amplifier TL048CN and K8055 USB experiment interface board. By combining the power of LabVIEW and this system can be accelerate the production and completion of the desired products.

In this paper we propose a low cost fast ECG monitoring system based on silver chloride (Ag / AgCl) electrodes, EKG-V2 amplifier module for ECG signal, USB experiment interface board K8055 designed for computer peripherals and the developed software running on the Laptop.

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In Figure 1 is illustrated the normal electrocardiogram. The figure also includes definitions for various segments and intervals in the ECG. The deflections in this signal are denoted in alphabetic order starting with the letter P, which represents atrial depolarization. The ventricular depolarization causes the QRS complex, and repolarization is responsible for the T-wave. Atrial repolarization occurs during the QRS complex and produces such low signal amplitude that it cannot be seen apart from the normal ECG [2], [6].

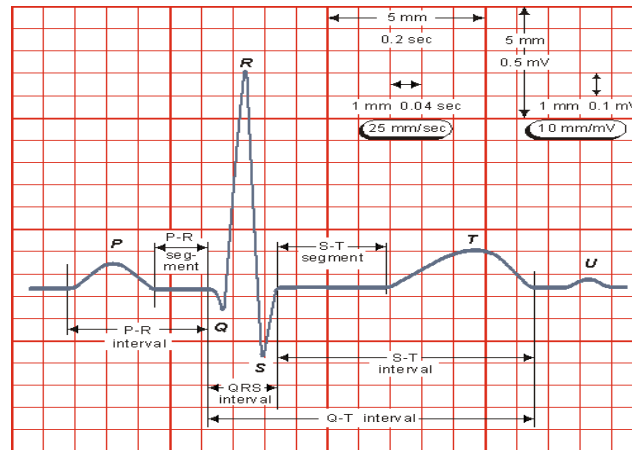


Fig. 1. The normal electrocardiogram [6].

2. EXPERIMENTAL SETUP

In Figure 2 is showed the image of ECG monitoring system.

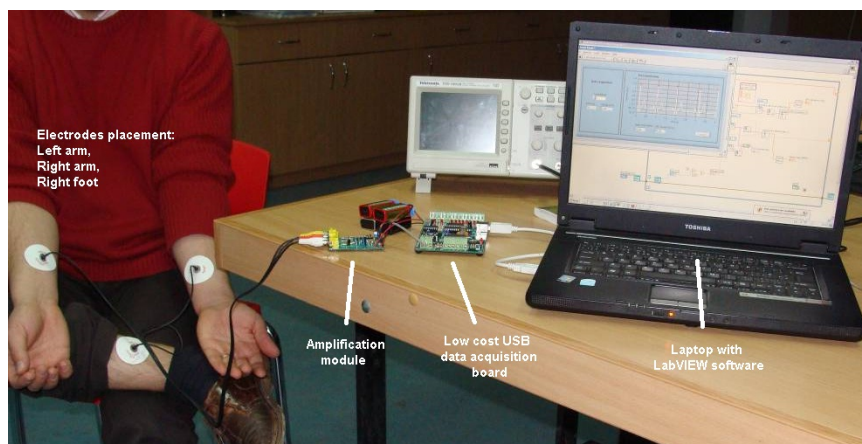


Fig. 2. Image of ECG monitoring system.

2.1. System hardware components

Electrodes can be made by metal pellets with 15-25 mm diameter to be applied to the body through a conductive cream or tap water (not distilled). We used three electrodes (Ag / AgCl) connected to a low power amplifier of high gain which was easily run with batteries. The electrodes were fixed with patches through conductive greases.

The amplification module (EKG-V2) allows viewing of ECG signals on the oscilloscope or Laptop screen and its schematic diagram is shown in Figure 3. Instrumentation amplifier (IC1A and B) amplifies the signals from left and right arm with a 180 gain and the third operational circuit applies the signal on the right leg with a 31 gain. As a result the patient's body is passed by a well-defined common mode level in the allowable range of instrumentation amplifiers. Common mode rejection can be reduced by P1. Calibration can be made by applying a 100 mV signal at 50 Hz. The output signal is about 200 mV. The continuous ECG signal component is eliminated by amplifying circuit IC1 D and C1 R15 filter. Consumption of the entire circuit is maximum 2mA.

and batteries will operate for long time. We used an autonomous source energy for the body security reasons and to avoid noise introduced by the supply network [3], [4], [5].

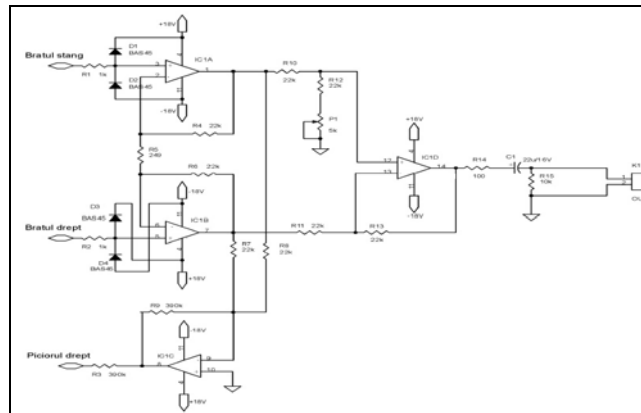


Fig. 3. Circuit diagram of EKG-V2 amplification module.

The EKG-V2 output signal is connected to the analog input A1 of the K8055 data acquisition board. The diagram circuit is presented in Figure 4. The interface board main features are:

- 5 Digital inputs (0= ground, 1= open). On board test buttons provided.
- 2 Analog inputs with attenuation and amplification option. Internal test +5V provided.
- 8 Digital open collector output switches (max 50V/100mA). On board LED indication.
- 2 Analog outputs - 0 to 5V, output resistance 1K5 and PWM 0 to 100% open collector outputs.
- On board LED indication.
- Power supply through USB approx. 70mA.

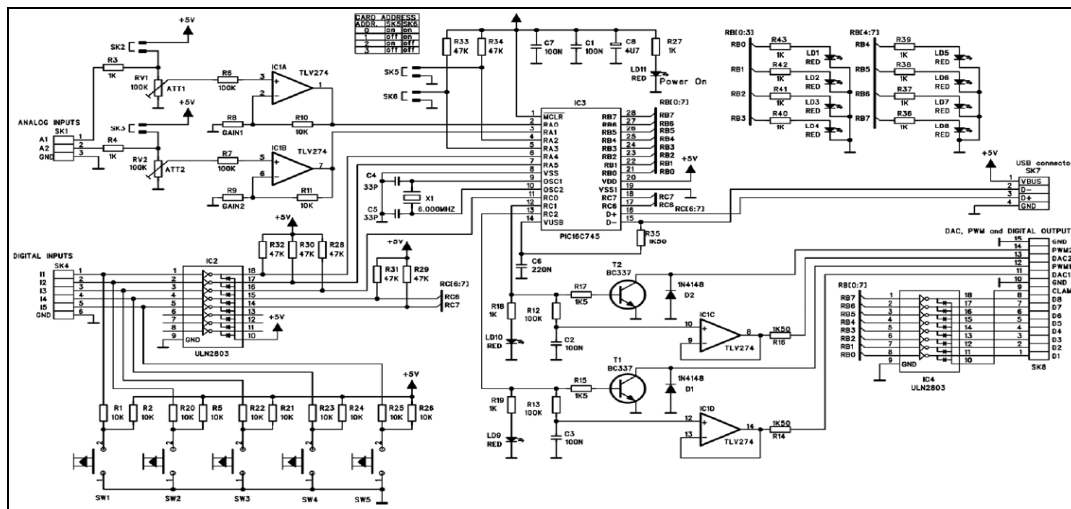


Fig. 4. Diagram circuit of K8055 data acquisition board.

The analogue inputs A1 and A2 have a standard range of 0 ÷ 5 Vdc. We remove the jumper caps on SK2 and SK3 to use them externally. The internal 5V voltage source can only be used for testing purposes. Because ECG signal from amplification module is voltage is too low we amplified it by x15. This requires a resistance of 820ohm. The gain factor can be calculated using the following formula:

$$\text{GainA1} = 1 + (R10/R8); \text{GainA2} = 1 + (R11/R9) \quad (1)$$

The sampling frequency of the ECG measurement depends on the used instrumentation and data storage. The sampling rate used in some ambulatory ECG recorders can be as low as 100 Hz. The HRV time series is generally extracted from the electrocardiogram (ECG) recording by measuring successive RR intervals. At low sampling frequency we need methods for improving the ECG-wave detection accuracy. The most common method for improving the detection accuracy is to use ECG-wave interpolation [1]. Since the K8055 acquisition

board works at low sampling frequency for a more accurate representation of ECG signal, a spline interpolation detection method was used.

2.2. System software components

We developed LabVIEW drivers for the K8055 board. This allows configuration and data reading/writing from analog / digital input / output board channels. In order to achieve the virtual instrument for fast ECG monitoring, we used different processing tools. Next we present the description of virtual instrument in a few steps: Open device; Creating a voltage analog input channel and start acquisition; Continue reading and displaying of ECG raw signal; Use filtering tools: wavelet denoises and wavelet detrend; Use spline interpolation tool; Subset of ECG filtered signal extraction to detect peaks with Multiscale Peak Detection instrument, and to compute QRS complex duration using Compute QRS duration instrument; After peaks detection the RR interval is determined by the Extract Heart Rate instrument for displaying; Clear device. In Figure 5 is showed the front panel image of virtual instrument for ECG monitoring.

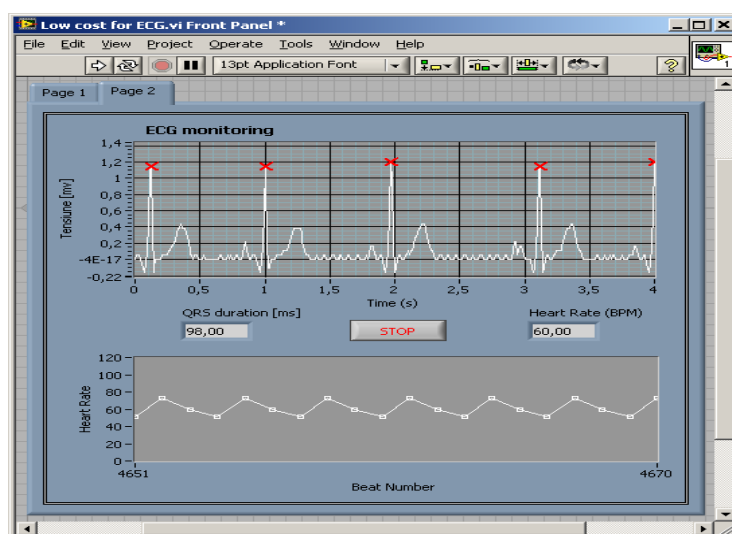


Fig. 5. Front panel of ECG virtual instrument.

3. CONCLUSIONS

The work presented is part of this trend to use virtual instrumentation, in a sense of reducing the costs, flexibility and biological signal processing systems modularization. Using a Laptop and low cost hardware to process and measure signals, our solution allows rapid product development, resulting in quicker deployment to first responders and fast patient heart diseases assessment diagnoses. The LabVIEW software that we developed stands to serve as important tools by helping critical caretakers speed up diagnoses and save lives.

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