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## **LOW COST REAL-TIME MEASUREMENT OF THE ECG, SPO<sub>2</sub> AND TEMPERATURE SIGNALS IN THE LABVIEW ENVIRONMENT FOR BIOMEDICAL TECHNOLOGIES EDUCATION**

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**Abstract:** Electrocardiography (ECG) is to measure the electrical activity of the heart. Doctors diagnose various cardiac diseases by analyzing this signal. The ECG signal is one of the best diagnostic devices for heart diseases. The purpose of this work is to display the ECG signal in the LabVIEW (Laboratory Virtual Instrument Engineering Workbench) environment. Lowering the cost by designing your own ECG circuit. The program can also easily process the ECG signal in various ways. There is no need to setup any electronic circuit. In addition to the ECG signal, modules with pulse oximeter and temperature indicating oxygen saturation are added. In this study, low cost ECG, temperature and pulse measurements were performed in our own laboratory environment. The measurement circuit was communicated with the LabVIEW program via Arduino. The data received with Arduino is shown after processing in the LabVIEW environment. The program also shows the patient's heart rate and alerts when the patient enters a heart attack.

**Keywords:** Real-Time Electrocardiography (ECG), temperature, pulse oximeter, LabVIEW, biomedical technologies education.

### **Introduction**

Electrocardiography (ECG) is the process of recording the electrical activity of the heart over a period of time using electrodes placed on the skin. These electrodes detect the tiny electrical changes on the skin. It is a very commonly performed cardiology test. This signal can be used to diagnose heart diseases. But it is difficult to design this measurement system. Because in the conventional method, the electrical signal is picked up by wired electrodes. The electrodes sense the voltage at the mV level. The ECG signal is very small volts, so it is easy to signal the noise. Noise problems arise in cable ECGs. Various filters must be used to prevent this noise. The filtering process may be hardware and software. In this study, both hardware and programmatically filter added. But programmatically adding filters is better because many parameters can be changed. Thus reducing cost by eliminating the need for electronic devices such as capacitors and resistors.

Pulse oximeters measure how much of the hemoglobin in blood is carrying oxygen (oxygen saturation). It has become one of the indispensable devices especially in anesthesia and intensive care units. Normal oxygen saturation level is between 95% and 100%. The device includes a light source and a light sensor. This sensor can be easily measured by a finger the apparatus. The sensor uses its color to detect the blood oxygen ratio. Two different wavelengths of light are sent to the finger using infrared led and red led. The difference of these waves received by the photodetector gives oxygen saturation. In addition, pulse measurements are made.

Temperature is an important parameter for diagnosis. The temperature varies depending on the disease. Temperature measurement is done in this system. These three parameters are very important for the health of the person. In this study, ECG, Temperature and SpO<sub>2</sub> (Pulse) circuits were integrated into the Arduino. The received data was displayed in the LabVIEW environment.

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ECG signal is shown in biomedical education in the course of instrumentation. Biomedical signal processing course contains these signals. It is important to learn this signal for biomedical engineers. ECG devices are usually used in biomedical engineering education laboratories. Because the devices are developed, maintained and repaired by biomedical engineers. The instrument is also calibrated by biomedical engineers. But this device is very expensive. In this study, it was developed a low cost real time ECG, Temperature and SpO<sub>2</sub> data acquisition system.

It is clear that personal computer based signal acquisition and analysis is an effective and cost-effective method for patient biomedical signal acquisition and monitoring.

There are many software packages available for the acquisition and display of electrical signals in general. Of these packages LabVIEW, by National Instruments, is one of the most popular and powerful tools available. Therefore, this study was planned to be done with LabVIEW program in computer environment.

## Materials & Methods

### 1-ECG Circuit Designing

Cell ion exchange generates small voltage. This signal is at millivolt level. First the signal is picked up by the electrodes. Then this signal is amplified. The INA129 integrated was used to design the circuit that received the ECG signal. This is an op-amp to boost the integrated low voltage.

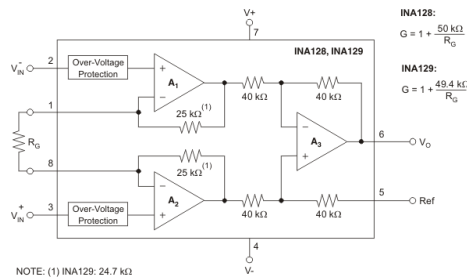


Figure 1 INA129 Functional Diagram

DESIRED GAIN (V/V)	INA128		INA129	
	R <sub>G</sub> (Ω)	NEAREST 1% R <sub>G</sub> (Ω)	R <sub>G</sub> (Ω)	NEAREST 1% R <sub>G</sub> (Ω)
1	NC	NC	NC	NC
2	50.00k	49.9k	49.4k	49.9k
5	12.50k	12.4k	12.35k	12.4k
10	5.556k	5.62k	5489	5.49k
20	2.632k	2.61k	2600	2.61k
50	1.02k	1.02k	1008	1k
100	505.1	511	499	499
200	251.3	249	248	249
500	100.2	100	99	100
1000	50.05	49.9	49.5	49.9
2000	25.01	24.9	24.7	24.9
5000	10.00	10	9.88	9.76
10000	5.001	4.99	4.94	4.87

Figure 2 INA129 Gain Ratios

This system used 100 gain ratios. A resistance of about 560Ω was used. It was tried to clean up the signal using the low pass filter because it contains amplified signal noise. The frequency of the ECG signal is between 0 and 150Hz. Band Pass filter is used to prevent noises. Then the signal is amplified again.

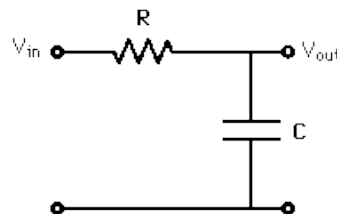


Figure 3. Low pass filter circuit

Band-reject filter was used to clean the noise. A noise-free ECG was obtained using a final filter to prevent the latest 50Hz network noise.

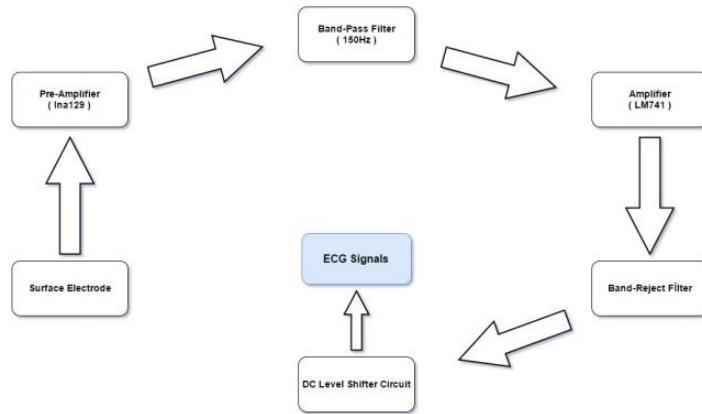


Figure 4 Block diagram of ECG measurement circuit



Figure 5 ECG signal is displayed as seen in the oscilloscope.

### 1-Pulse Oximeter and Temperature Circuit Designing

The pulse oximeter ( $SpO_2$ ) circuit and the temperature circuit were designed. A simple outer mold for the finger probe was prepared. It was drawn in the SolidWorks program. A ring-type probe is designed for a completely wrapped finger and for the passage of rays. A compact and comfortable design for the shape of the fingers was considered.

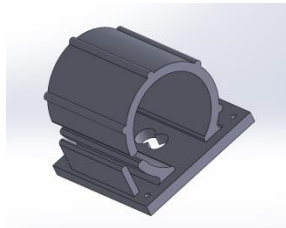


Figure 6. Finger probe design in solidworks

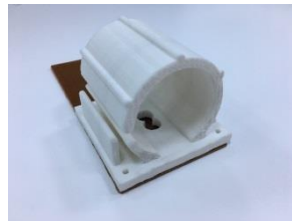


Figure 7. Finger probe printed in 3D printer

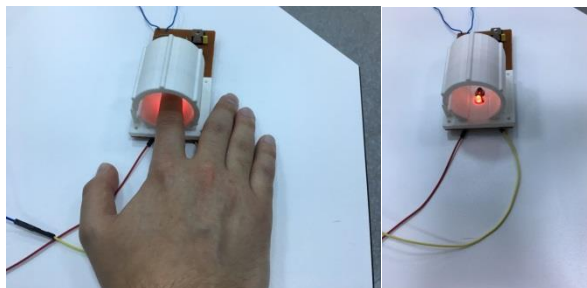


Figure 8 Probe with integrated circuit and leds



As a result, ECG, SpO<sub>2</sub> and temperature data were displayed in a computer environment. Arduino toolkit was installed from VI Package Manager. VI is the tool setup program in LabVIEW itself. This tool facilitates the visa protocol between Arduino and LabVIEW.

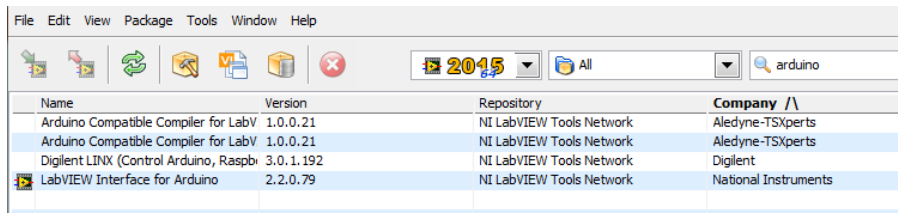


Figure 13. VI Package manager

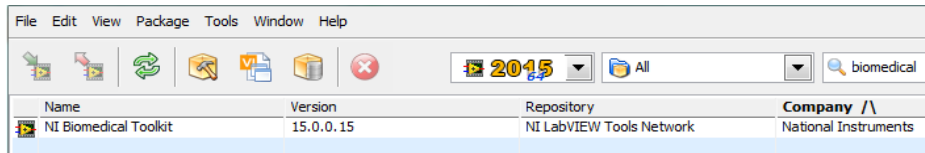


Figure 14. Biomedical toolkit was installed from VI Package manager

Biomedical toolkit allows many signals to be processed and adjusted. For example it can make ECG simulations. USB port must be set to connect to the Arduino. Then the baud rate and Arduino type should be entered. A baud rate of 9600 was considered adequate. It should be notified that the connection will be USB or wireless. XBee is required for wireless connection. XBee is a kind of module that can be integrated into the Arduino. After these settings the Arduino can be connected to the LabVIEW. It is shown in figure 15.

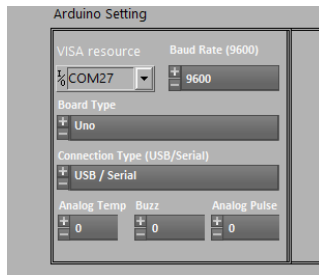


Figure 15 Various setting parts for Arduino and LabVIEW in communication

Human temperature is normally 36.5 degrees. If the temperature rises above 38 degrees, it is given a warning. And also the buzzer sounds when there is a warning. In addition, the program can simulate the ECG signal. Many parameters can be set for this signal. The benefit of this simulator is that students learn the signal in many ways. For example, noise can be added to the signal. Then the student can programmatically prevent this noisy. In this way students learn noise prevention methods. This simulation is quite instructive for the basic ECG signal.

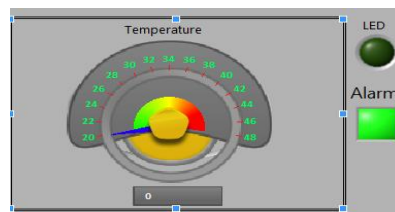


Figure 16 Temperature display and alarm led

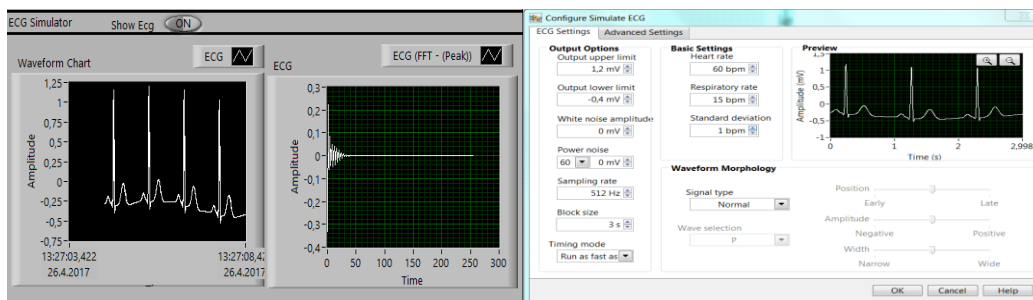


Figure 17 ECG simulator and configure simulator

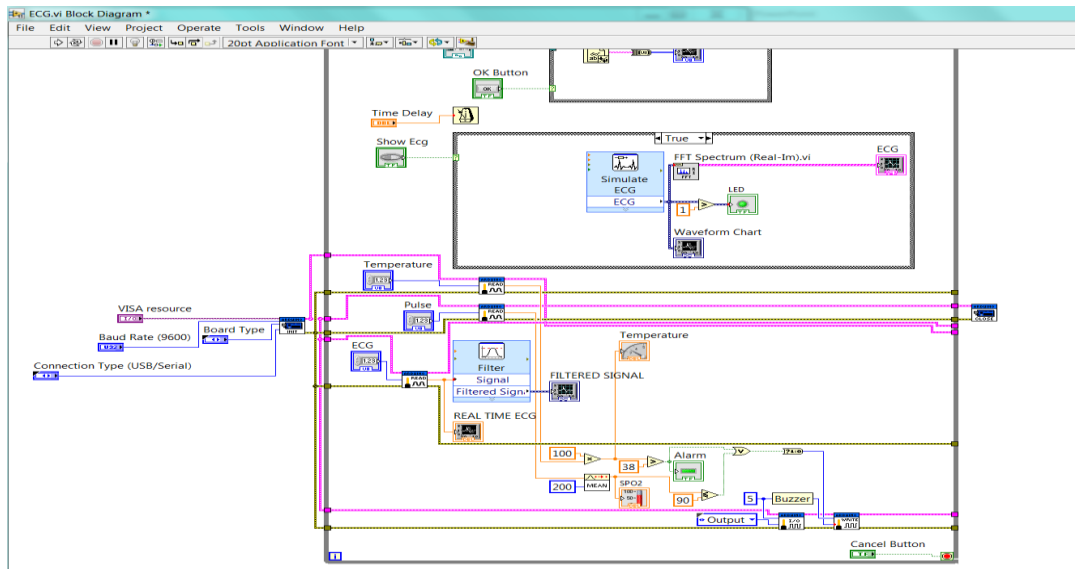


Figure 18 Designing the LabVIEW diagram

Real time ECG recording is shown in figure 19. At the same time temperature and SpO<sub>2</sub> measurements were made. The Fourier of the ECG signal can also be examined. The sampling rate of the real time signal can be changed. Also any ECG file can be imported. The student can filter the ECG signal using various filters.

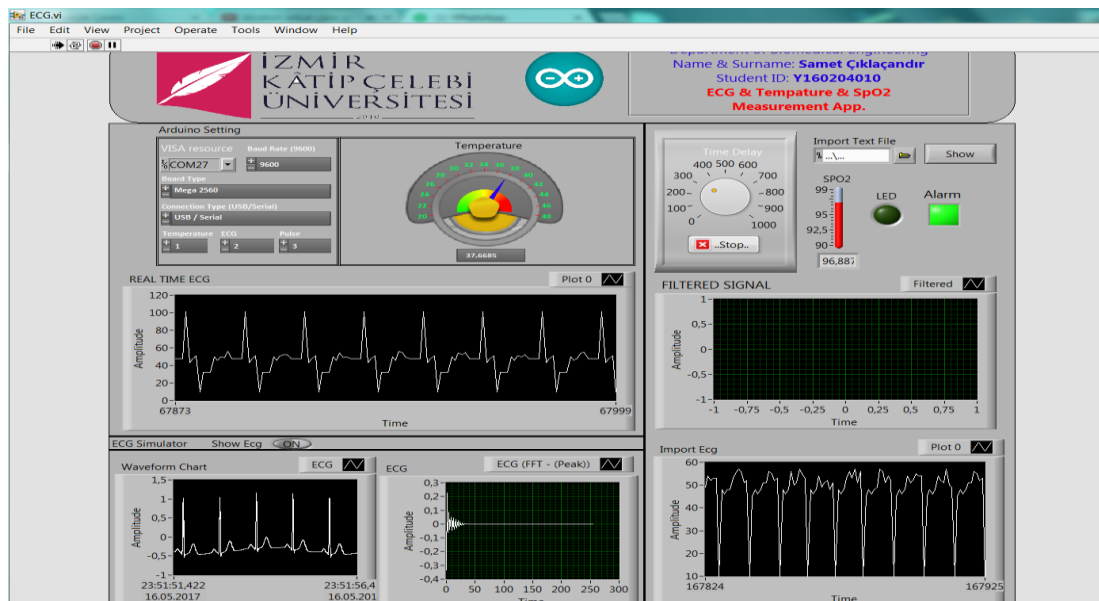


Figure 19 Designing the LabVIEW interface

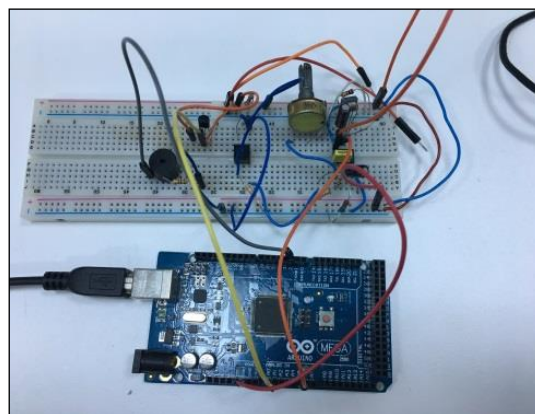


Figure 20 Taking ECG signals with Arduino

## **Conclusion**

ECG devices are usually used in biomedical engineering education laboratories. But these devices can be taken in small amounts because it is expensive. It cannot be seen the circuits in devices, because this device is a closed box device. Additionally, students can only obtain measuring of the ECG signal so they do not know how the device works. As a result, they do not get the skills. The number of students per ECG devices is about 8 in any university. So the quality of education given is falling. In this study, low cost ECG, Temperature and SpO<sub>2</sub> measurement system was developed to solve all these problems. In addition, students can modify the program for their on studies or works. Programming skills of students develop with this method. It is hoped that this system can be benefit for student who makes investigation in this area.

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