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DEVELOPMENT OF ARDUINO BASED LOW COST SYSTEM FOR MONITORING VITAL BIOMEDICAL PARAMETERS

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ABSTRACT

The objective of a biomedical parameter monitoring system is to have a quantitative assessment of the important physiological variables of the patient under observations. For diagnostic and research purposes, it is necessary to know the trend of change in different parameters. In this paper, we propose a system that integrates the monitoring and measurement of three parameters viz. electrocardiograph, heart rate and temperature into a single system. The ECG records low-level voltages produced by the heart from a patient's limbs and chest. These voltages produce a pattern called an electrocardiogram which depicts the amplitude and timing of the potential as it transits the conduction system. Monitoring heart rate can give much vital information about body physiology and track the heart conditions. The same is true for body temperature. Here we propose a low cost Arduino based portable system to monitor heart rate from electrocardiograph and temperature. Our system is quite competent for monitoring heart rate and temperature at low cost and portability.

Keywords: ***ECG, Body temperature, Heart rate, Arduino system***

INTRODUCTION

Today due to hectic lifestyle, health is stressed perhaps more than it has been ever before. Vital sign monitoring is an essentially important activity for securing individual lives. With the aid of modern technology and better understanding of physiological processes, medical care is experiencing a rapid evolution in both diagnostics and therapeutics [1]. The electronics technology has entered almost in all aspects of day-to-day life, and the biomedical field too. Biomedical electronics plays a predominant role in improving the quality of health and diagnostic therapies [2]. The need for well-equipped hospitals and diagnostic centers is increasing day by day as the people are becoming more conscious about their health problems. Few people have worked to measure different biomedical parameters using microcontroller systems [3-4]. The present work is to make a Arduino based low cost device, affordable to average class people by system integration for monitoring ECG, temperature and heart rate with portability. Hence the health conditions can be regularly monitored and the necessary remedial corrections can be done in the diet or precautionary steps can be taken up in discussion with the doctors.

As Aurdino uno module is used, it provides faster and compact circuitry with suitable storing capability in microSD card. ECG is a tool to examine functions of the heart and is used to record the electrical activities to study disorders that manifest changes in the heart [5-6]. The measurement of heart rate is used by medical professionals to assist in the diagnosis and tracking of medical conditions. Heart rate can vary as the body's need to absorb oxygen and excrete carbon dioxide changes during exercise or sleep [7]. It is also used by individuals, such as athletes, who are interested in monitoring their heart rate to acquire maximum efficiency. The normal resting adult human heart rate ranges from 60–100 bpm [8] while athletes normally have lower heart rates i.e. 40 – 60 bpm. Also body temperature has been described as the useful measurable parameter and a sensitive indicator of the reactions to physio-environmental factors, disease processes, and physiologic functions [9]. It is included in the system.

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SYSTEM OVERVIEW

The block diagram of the system is depicted in Fig.1, which consists of three major sections. The first section is Transduction, second is Signal Conditioning and the third section is Processing. The third section may be powered by advanced tools for the intelligent monitoring and processing of the subject information which aid the physicians for easy evaluation of the severity and effective recommendations about the treatment.

Transduction unit comprises of a primary transducers for temperature and ECG monitoring. It transduces the profile of the subject (actor) for display. It consists of DS18S20 sensor for temperature sensing and disposable electrodes for ECG monitoring.

The reason for selection of DS18S20 temperature sensor is its digital nature. It provides 9-bit Celsius temperature measurement and has an inbuilt alarm function. The DS18S20 communicates over a One-Wire bus for communication with operating temperature range of –55°C to +125°C. It can derive power directly from the data line, eliminating the need for an external power supply. The DS18S20 goes in a low power idle state to initiate a temperature measurement and AtoD conversion. Following the conversion, the resulting thermal data is stored in the 2byte temperature register in the scratchpad memory and then it returns to its idle state. The DS18S20 output data is calibrated in degrees centigrade.

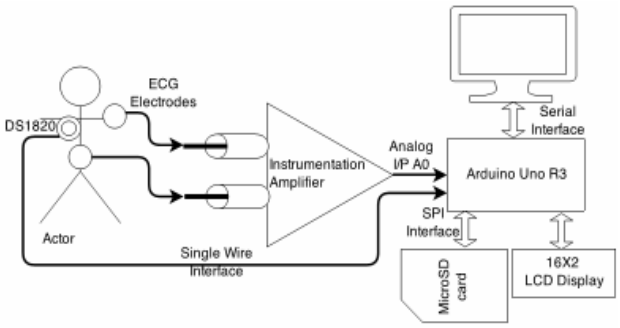
The most important part of reliable ECG - measurement is the electrodes. The disposable electrodes from Swaromed make were used to monitor ECG. Swaromed ECG-electrodes are pre-gelled and have a

Silver/SilverChloride sensor. All adhesive foams used in these electrodes are equipped with a hypoallergenic medical-grade adhesive that is practically not irritating to the skin.

Conditioning section consists of an Instrumentation amplifier which eliminates the need for input impedance matching. Thus make the amplifier particularly suitable for use in the measurement.The instrumentation amplifier composed of 3 op-amps designed from TL084 JFET. These are arranged so that there is one op-amp to buffer each input and one to produce the desired output with adequate impedance matching for the function. The device features high slew rates, low input bias, offset currents and low voltage temperature coefficient with low power consumption.

The Arduino Uno is a microcontroller board based on the ATmega328 having 14 digital input/output pins,6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button [10]. The nice thing about the Arduino board is that it is relatively cheap, plugs straight into a computer's USB port and is simple to setup and use compared to other boards. Also it has very convenient power management and built-in voltage regulation. Best thing about it is its IDE: open source software that offers programming as well as programme burning features. Large number of libraries makes programming easy. In this system we are able to monitor different parameters such as body temperature and electrocardiograph which is stored on microSD card. The PC interface in our system is not mandatory but to view the records of different patients it may be used.

Figure 1: Block diagram of Arduino uno based biomedical parameter monitoring system



RESULTS AND DISCUSSION

Measurement Procedure

The procedural steps for measurement of temperature and heart rate with ECG recording using Arduino uno is depicted in Figure 2 in the form of flow chart.

Temperature Measurement

DS18S20 is digital temperature sensor which measures body temperature. The normal body temperature of a healthy, resting adult human being is stated to be at 98.6 degrees Fahrenheit or 37.0 degrees Celsius. Though the body temperature measured on an individual can vary, a healthy human body can maintain a

Figure 2: Flow chart

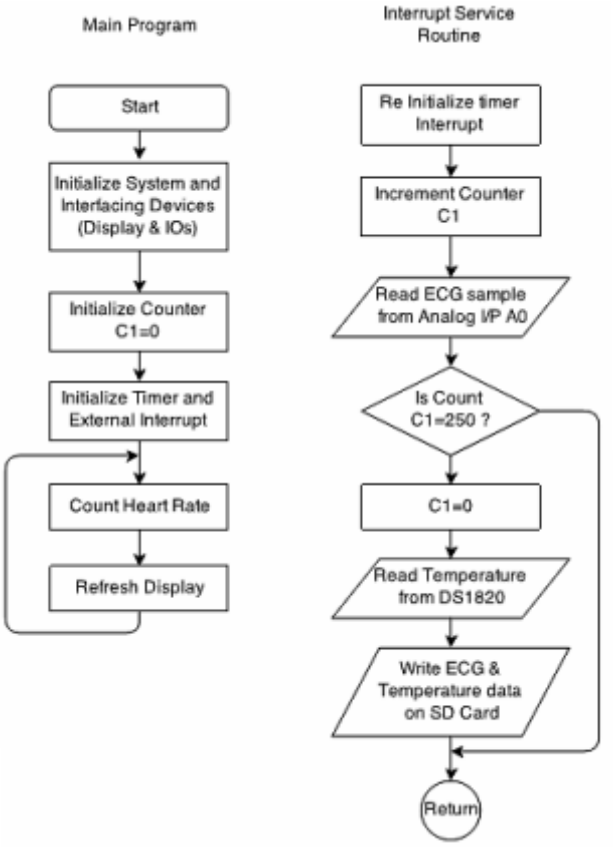
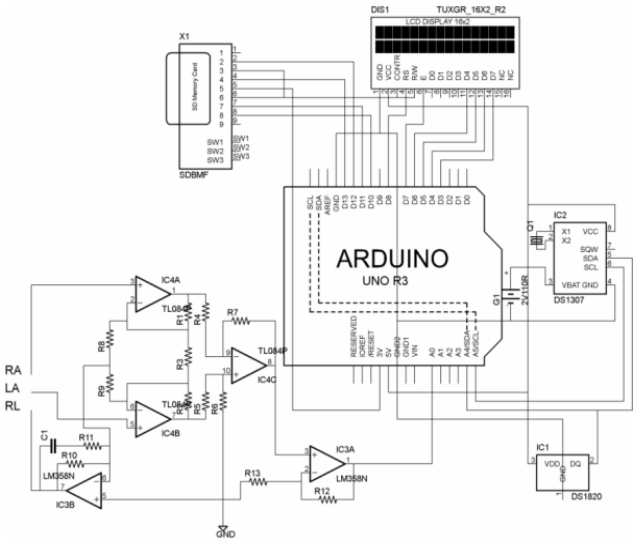


Figure 3: Circuit Diagram



fairly consistent body temperature that is around the mark of 37.0 degrees Celsius [11]. The normal range of human body temperature varies due to an individual's metabolism rate. The faster it is the higher the normal body temperature or the slower the metabolic rate the lower the normal body temperature. Other factors that might affect the body temperature of an individual may be the time of day or the part of the body in which the temperature is measured at. The body temperature is lower in the morning, due to the rest the body received and higher at night after a day of muscular activity and after food intake.The observation for temperature

measurement by our system is shown in Table-1. Two sample persons temperature is measured by developed system and compared with the standard digital thermometer available. It is observed that measurement is in line 0.55% difference compared with the thermometer readings for body temperature.

ECG Recording

The low-level voltages produced by the heart from a patient's limbs and chest are recorded as electrocardiographs. It represents the amplitude and timing of these potentials as it transits. The various peaks and valleys characterize the sequence of events that comprise the cardiac electrical cycle. The P wave is generated when the S-A node develops its initial potential. Signal transit through the atria to the A-V node is indicated by P-Q interval. The R wave often called QRS complex, is generated at this potential is conducted through the Bundles of Hiss, the Purkinje system and the ventricles. A normal QRS complex is 0.08 to 0.12 second in duration [5]. The T wave characterizes the re-polarization of ventricles. ECG waveforms for two normal persons is recorded at position V2 and shown in Figure 4 and 5 having different frequencies.

Heart Rate Measurement

The heart rate normally refers to the rate of ventricular contractions. It is important to determine ventricular rates. This is done by examining an ECG rhythm, which is usually taken from V2 position in our case. Ventricular rate can be determined by measuring the time intervals between the QRS complexes, which is done by looking at the R-R intervals based on the following formula.

$$Heart\ Rate = \left(\frac{60000 \times 5}{T_{5(R-R)}}\right) bpm$$

Where, $T_{5(R-R)}$ is time interval for 5 consecutive R peaks in milliseconds.

Heart rate is calculated from ECG for two representative persons and listed in Table -1 which is comparable to heart meter.

Circuit Discussion

The circuit diagram for the proposed system is shown in Figure 3. It uses an instrumentation amplifier constructed using TL084. The signal from patient's body is picked up by pregelled Silver/Silver Chloride electrodes. The amplification is mainly implemented through a differential amplifier whereas filtering is completed through differential mode filtering. There is also the RL Drive circuit which cancels noise and maintains the common mode voltage. The TL084 worked well with tolerably small amount of noise. The amplified signal is fed to the A_0 analog input pin of AtMega328 for Analog to Digital conversion, sampled at every 4 msec resulting in sampling rate of 250 samples/sec. The sampled signals are stored in a csv (comma separated value) file. Here, the files are created every hour. The system is also recording temperature from patient's body using single wire digital sensor DS18S20. The device senses temperature and converts it into equivalent digital value in Celsius allowing it to read every second.

Arduino is a prototype board and is more peripheral rich. It has in-built ADC and several timer based peripherals and easier to program as compared to microcontrollers. The Arduino hardware platform already has the power and reset circuitry setup as well as circuitry to program and communicate with the microcontroller over USB [12]. It is an open-source platform based on flexible, easy-to-use hardware and software. On the software side, Arduino provides a number of libraries to program easily. The processing and decision making task of the system is carried out by Arduino Uno. This system uses AtMega328 microcontroller, programmed for sampling both ECG and temperature at the predefined rates and to read from attached Real Time Clock. It also stores the sampled information on microSD card. This integrated system is programmed to process the ECG signals to count heart rate using simple R wave counter. A software comparator is designed to compare the voltage levels exceeding 50% of the average value of first 250 samples. Time elapsed was measured for such six crossovers indicating R-waves. From this time period, heart rate is calculated. The system displays body temperature and heart rate on a 16x2 LCD display.

Table 1.Measurement of body temperature and heart rate using our proposed system

Sample Person 1					
Sr. No.	Time (min)	Heart Rate (BPM)		Temperature (°C)	
		By H. R. Meter	By our System	By Digital Thermometer	By our System
1	10	73	72	36.7	36.9
2	20	75	73	36.7	36.9
3	30	76	75	36.8	37.0
4	40	76	74	36.8	37.0
5	50	76	76	36.8	37.0

Sample Person 2				
Time (min)	Heart Rate (BPM)		Temperature (°C)	
	By H. R. Meter	By oursystem	By Digital Thermometer	By our System
10	77	79	36.8	37.0
20	79	80	36.8	37.0
30	81	82	36.8	37.0
40	80	81	36.8	37.0
50	78	79	36.7	36.9

Figure 4 : ECG with respect to time observed using our system 250Samples/Sec (at 76bpm)

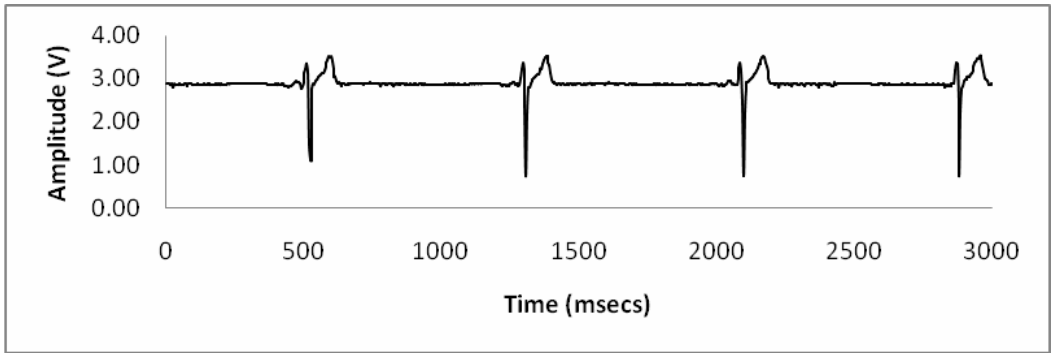
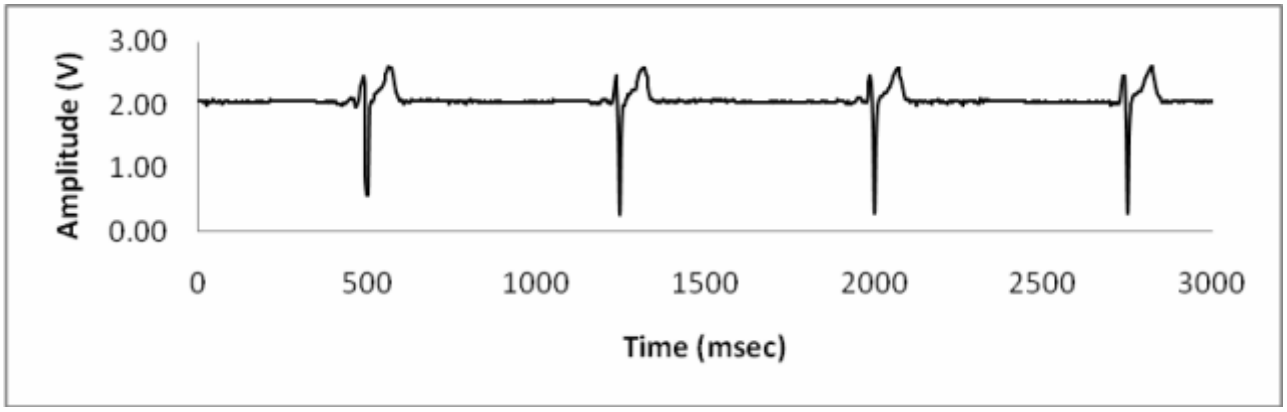


Figure 5 : ECG with respect to time observed using our system 250Samples/Sec (at 80bpm)



CONCLUSIONS

Development of Arduino uno based system for monitoring vital biomedical parameters has been presented. The system is portable, durable, and cost effective. This system is efficient and easy to use. Tests have shown good agreement with actual heart rates and body temperature. This system could be used in clinical and nonclinical environments for ECG monitoring. It can also be easily used by individual users with care, e.g. athletes during sporting activities. Thus the system has ease of use, highly reliable, safely operated, low-power consumption for operation, high measurement accuracy and affordable cost.

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