

ECG Acquisition System and its Analysis using MATLAB

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ABSTRACT: This paper deals with the analysis and study of ECG signal from a Multi-Parameter Module (MPM) which is designed. The purpose is to design a light weight, portable and highly efficient ECG acquisition system for monitoring of ECG of cardiac patients. The different parts of the ECG acquisition system are MPM, Microcontroller and PC. The Silicon Labs' C8051F380 microcontroller acts as an interface between the MPM and PC. The data acquired from the microcontroller is transmitted to PC through UART serial communication. MATLAB tool is used for displaying ECG signal on PC, acquired ECG is then analyzed using MATLAB.

KEYWORDS: ECG acquisition system, Microcontroller, MATLAB software

I. INTRODUCTION

Home health care is one of the important emerging fields in the current century as it would help in reducing the medical expenses and it improves the life quality of patients at home level. Advancement in communication techniques has helped in making this home health care into reality. The main aim of this research is regarding healthcare for elder people. Aging life care solution is to enable health care providers and care takers to monitor their subjects in their residence and their native habitats and provide assistance and advice as required. This solution provides monitoring of both medical aspects and behaviour of the elder citizens. It also includes activity monitoring, vital sign monitoring etc. The purpose is to develop highly efficient and low cost biomedical device.

The doctors ratio is decreasing drastically to the overall population and the patients in rural areas for basic health checkups should travel out of their towns. The main focus is developing affordable and efficient system which will provide basic health care. Various vital parameters such as heart rate, oxygen level, respiration rate, blood pressure and many more of the patients which require consistent observations are monitored in doctor's personal computers. Multi-Parameter Monitoring system is developed to enable remote doctor to monitor their patients in hospitals and even in their homes to address these problems.

The heart signal which recorded and measured from surface of the body is the Electrocardiogram. ECG signal of a normal heart beat is shown in Figure 1. ECG records and measures the electrical activity of the heart. This can analyse any type of disease in the heart. Tiny electrical impulses are produced by the heart which spreads through the heart muscle and the heart contracts. ECG machine detects these impulses. First upward P deflection in the ECG wave is the atrial contraction, known as atrial complex. Other deflections Q, R, S and T are the ventricular complexes caused by the action of ventricles [1]. Based on electrical activity of the heart ECG generates a pattern, which follows the heart function. In one pumping cycle heart muscle exerts pressure and gives the value of voltage about 1 to 3mV. If the heartbeat is an irregular pattern then it shows abnormality which is caused due to cardiac disease. The variations in wave morphologies and variations in the intervals leads to the various life threatening and non-life threatening arrhythmias, the changes can be analyzed by ECG signal using a handy ECG monitoring system [2].

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 9, May 2016

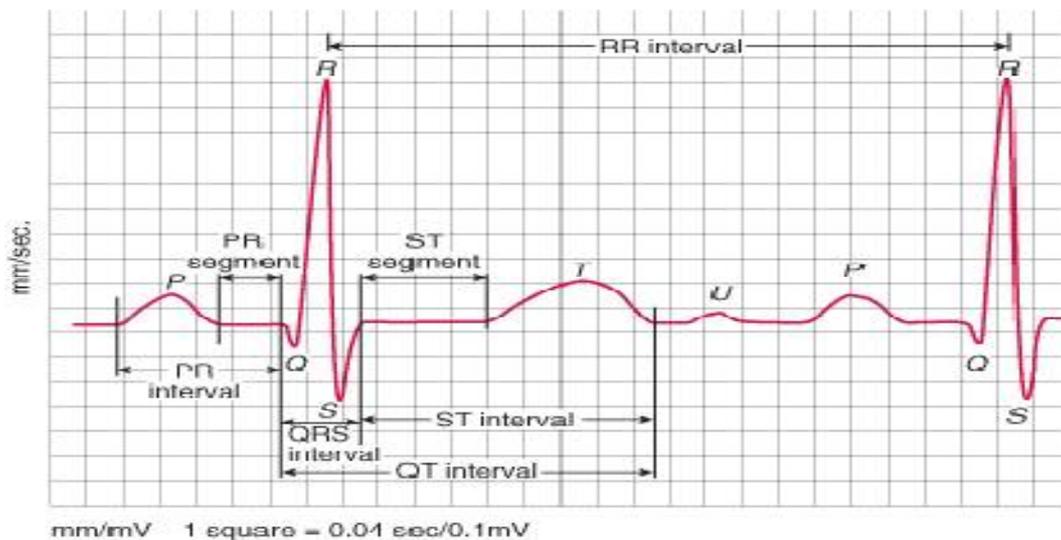


Figure 1: ECG Signal for a Normal Heart Beat

Biomedical signals such as heart rate, respiration rate, saturation level of oxygen in blood, blood pressure are used for healthcare in daily life [3]. Analysis of ECG is helpful in homecare. It helps in reducing expenses and hospital waiting lists. In biomedical engineering, biomedical signals such as ECG, EMG and EEG need real time monitoring, so for the various measurements and tests a computer system plays an important role with lower cost and better performance [4].

In the present approach, the system developed consists of an ECG acquisition system and a PC with MATLAB software. The acquisition system consists of ECG Simulator, MPM Board, Silicon Labs Microcontroller C8051F380 and a Power Supply. The ECG signals are acquired from the ECG simulator. The ECG output from MPM is given to the ADC channel of Microcontroller. The ADC converts the analog input from the sensors to digital form. Then the output is sent to the PC through UART serial communication.

II. RELATED WORK

M. K. Islam, A. N. M. M. Haque, G. Tangim, T. Ahammad, 2012 [8] proposed the study and analysis of ECG signal processing by means of MATLAB tool effect (i.e. Wavelet transform or so), detection of any abnormalities in ECG, calculating beat rate and so on using the most familiar and multipurpose MATLAB software along with LabVIEW.

K. Ramya and K. Rajkumar, 2013 [9] proposed ECG features of HRV and EDR including ECG filtering methods. This ECG features are compared with the simultaneously recorded respiratory signal, it is estimate from RR-interval, R-wave time duration and R-wave amplitude. These values are evaluated using discrete wavelet transform. Based on the respiratory signal, time domain measures are calculated that reflect the respiration rate variability.

Shivaram P. Arunachalam and Lewis F. Brown, 2009 [10] proposed a real-time algorithm for estimation and removal of BW noise and obtaining the EDR signal for estimation of a patient's respiratory rate. This algorithm utilizes a real-time "T-P knot" baseline wander removal technique which is based on the repetitive backward subtraction of the estimated baseline from the ECG signal. The estimated baseline is interpolated from the ECG signal at midpoints between each detected R-wave. As each segment of the estimated baseline signal is subtracted from the ECG, a "flattened" ECG signal is produced for which the amplitude of each R-wave is analyzed. The respiration signal is estimated from the amplitude modulation of R-waves caused by breathing.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Special Issue 9, May 2016

III. METHODOLOGY

The data acquisition involves acquiring data from the sensors. The measuring of physical or an electrical phenomenon such as current, voltage, pressure, temperature or sound using a PC is known as data acquisition. This system consists of sensors, hardware measurement and a PC with required programmable software. PC-based data acquisition systems exploit the productivity, processing power, display and its connectivity capabilities of industry standard computers. It provides a flexible, powerful and cost-effective solution. The microcontroller is used to control and provide feedback to other hardware devices. Signal Processing involves processing the output from the microcontroller and displaying it on PC using MATLAB Tool.

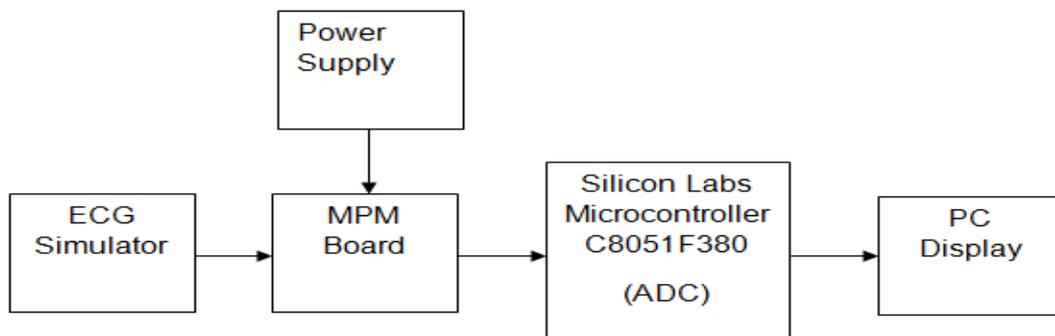


Figure 2: Block diagram of ECG Acquisition System

A. ECG Acquisition

The block diagram of ECG acquisition system is as shown in Figure 2. The circuit consists of an ECG Simulator, MPM Board, Silicon Labs Microcontroller C8051F380 and a Power Supply. The ECG signals are acquired through ECG simulator, which produce ECG waveforms. Without using ECG machine, the ECG simulator helps to study and analyse the difference between normal and abnormal ECG. ECG waveform can be simulated using ECG simulator and produce waveform of different leads and many arrhythmias. Here the simulator used to acquire data is a dummy human. Heart rate can be varied as 30/60/120bpm. It has eight different arrhythmia ECG signals.

The 3-lead ECG signal is acquired using the concept of Einthoven's triangle as shown in Figure 3. Einthoven law is defined as in the Electrocardiogram in lead II the potential of any wave is equal to the sum of its potentials in lead I and lead III. Einthoven's triangle formed by right arm, left arm and left leg is an imaginary formation of three limb leads in a triangle. An inverted equilateral triangle is formed, with the heart at the centre. When all the voltages are summed, zero potential is produced.

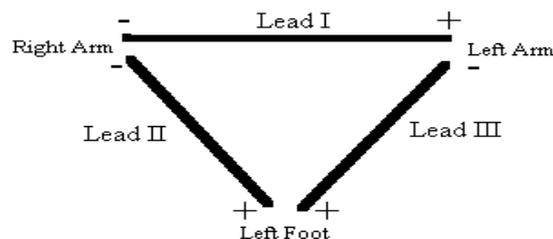


Figure 3: Einthoven's Triangle[7]

The MPM board consists of IC's to amplify and bandpass filter the ECG signals. In the MPM Board, the acquired ECG signals are first passed through buffer stage opamp. The first stage buffer opamp does the low pass filtering and

International Journal of Innovative Research in Science, Engineering and Technology

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inverting the signal collected from the negative electrode. Inverting of the signal is done so that in the second stage the signals do not cancel out with each other after addition. The signals are then passed to the next stage where the signals are added up and passed through three stages of band pass filters and amplifiers. The output of MPM is the amplified and filtered ECG. The ECG output from MPM is given to the ADC channel of the Microcontroller. The ADC converts the analog input from the sensors to digital form. Then these converted values are sent to the PC through UART serial communication.

B. Acquiring of ECG Signal

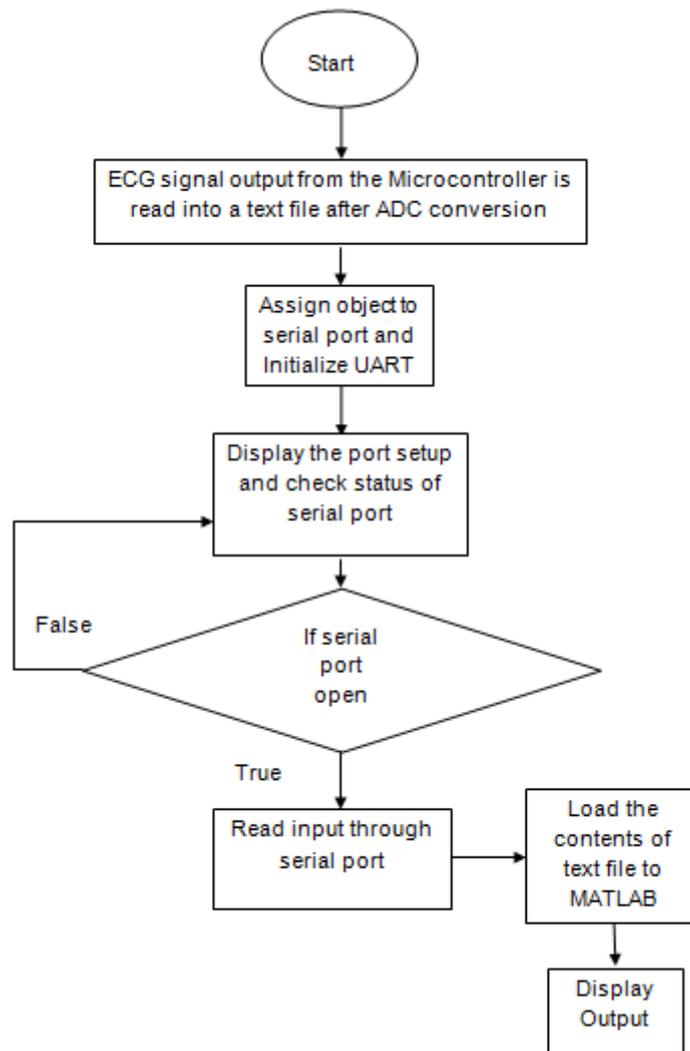


Figure 4: Flowchart for Acquiring ECG Signal

The flowchart for acquiring ECG signal is as shown in Figure 4. The Silicon Labs C8051F380 Microcontroller [6] has to be clocked and initialised. In port initialization, I/O pins are enabled as UART Transmitter and Receiver respectively. Timer is configured to generate an interrupt. This interrupt triggers ADC conversion. UART is initialized. The ADC is initialized to make single ended analog measurement at analog port pin. The analog measurements are stored in the digital form in ADC register as a right justified manner. Whenever timer overflows, the conversion is triggered. Also

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Vol. 5, Special Issue 9, May 2016

on chip reference voltage is enabled. Accumulator value is initialized to zero and then output voltage is displayed. The output from ADC has to be displayed on PC monitor using MATLAB. This can be done by acquiring the information from ADC unit of the microcontroller and storing it in text file. The information from the microcontroller is transmitted to PC through serial communication using the UART. The port used for serial communication is specified and object is assigned to represent the serial port. After setting up the UART for serial communication the status of the serial communication is displayed. The status of serial port is continuously monitored. Whenever the serial port is open the information coming through the serial port will be read. If the serial port is not open then the status of serial port will be monitored. The information that is read from the serial port is written onto a text file. The content of text file is loaded to the MATLAB workspace. Then the output values are displayed in a graphical form.

IV. RESULTS AND DISCUSSION

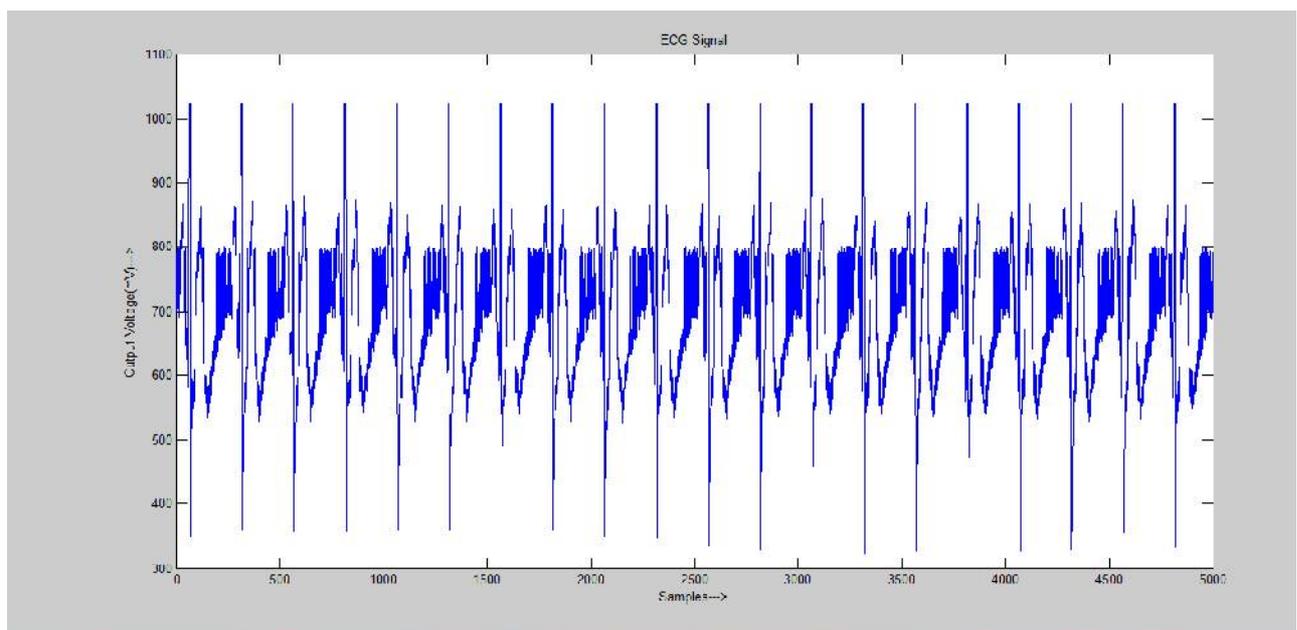


Figure 5: Graphical Representation of Acquired ECG

The output voltages of ECG are converted from analog to digital form by the ADC unit of the C8051F380 microcontroller. Then the output voltages are acquired and displayed using the graphical representation features of MATLAB. The graphical representation of acquired ECG is as shown in Figure 5.

V. CONCLUSION AND FUTURE WORK

The work has been done on the acquisition of the ECG signal from the MPM board by varying gains, resistances to increase the sensitivity of the board. The MPM board designed is used to acquire and process the ECG signals. The MPM output has been given to Silicon Labs' C8051F380 microcontroller which has ADC and converts the analog values from the MPM to digital output. The digital values are acquired and stored in a text file. This text file is executed in MATLAB to display ECG signal. In future the acquired ECG signal is used for heart rate and respiration rate calculation.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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