Wearable ECG Recorder with MATLAB

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Abstract: Looking at the current scenario and lifestyle of individual, cardiac diseases have become common problem irrespective of person’s age. In some cases if this kind of cardiac disease is at severe level than it become the reason for death. Electrocardiograph is electrical activity of heart. By acquiring it through device and analysis, the cardiac health of person can be diagnosed. In this paper we are utilizing 3-lead wet electrode to acquire ECG Signal. The ECG signal is conditioned and filtered by AD8232 IC and acquired in MATLAB through microcontroller. It is simply wearable device and heart rate of person is displayed in MATLAB.

Index Terms: Electrocardiogram, MATLAB, Analog Front End, BioSigKit, Arduino.

I. INTRODUCTION

One of the major problem of modern healthcare is the risk of sudden cardiac attack. Different age group people either they possess cardiac disease or young age who don’t have any idea of sudden cardiac attack, suffer from health problems related to heart. To reduce this risk of sudden cardiac attack it is necessary to develop portable system that can record ECG signal as well as process it. By improving hardware and software of current ECG systems it can increase the effectiveness of heart monitoring. M-health monitoring are useful[12] in sense that it is capable enough to provide assistance for people suffering from various cardiac disease in non-clinical environment.i.e different geographical areas which belongs to city or rural surroundings, homes or work places. Currently, 12-Lead ECG monitoring system is utilized in various hospitals. This system is very bulky system and it is not possible for patient to be diagnosed for long term ECG monitoring. In another famous ECG monitoring device called Holter monitor is inconvenient for long term ECG monitoring due to need of high pressure between skin and electrode where electrode must attached to chest part. In the proposed system, 3-lead wet AgCl electrodes proved low impedance and acquire ECG signal which is amplified and filtered by analog front end AD8232 followed by microcontroller ATMega 328. Heart rate is calculated on MATLAB. The proposed system is convenient for taking patient’s ECG at remote places.

II. DESIGN OF ECG RECORDER/SYSTEM ARCHITECTURE

A. Electrodes

Bio potential electrodes are crucial in monitoring ECG & EMG Signals. Applying the right type of electrode that last for long time and assist recording high quality of signal is desirable in medical devices industry. The result provided that Ag/AgCl electrodes are the best type of electrode in comparison with orbital electrode and stainless steel electrode[]. Bio potential electrode transforms body’s bio electrical activity into measureable electrical current. The non-invasive electrode must provide low-electrode skin impedance along with good biological signal quality, amplitude and Signal to Noise ratio, low motion artifact. Ag/AgCl electrode provides low noise level while recording ECG signal along with low electrode skin interference. The non-polarizable characteristic of electrode allows the charges to cross electrode-electrolyte interface. Ag/AgCl electrode circuit model consists of capacitors and resistors in the range of nF and K-ohm.

![Fig 2.1: Block diagram of proposed system](image1)

B. AD 8232 Analog Front End

AD8232 is fully integrated Single-lead ECG analog front end which is designed such that it is able to extract, amplify and filter small bio-potential signals in presence of various noises. Those noises are generated by motion or electrode placement. It facilitates an ultra-low power analog to digital convertor or embedded microcontroller can acquire it easily.

![Fig: AD 8232 Analog Front End](image2)
AD8232 provides fast restore circuit that allows it to recover quickly and take valid measurement after connecting electrode to the subject. The benefit of fast restore circuit is it can reduce the duration of otherwise long settling tails of high-pass filters.

It operates at range of 2.0V to 3.5 V and provide 80 dB CMRR. It has operating range of -40°C to +85°C.

C. Arduino UNO

In the proposed system, we have used Arduino Uno R3 development board to log the ECG signal from AD8232. The data is converted from analog to digital form. This board contains dual inline package (DIP) ATmega328 AVR microcontroller. It has 20 digital I/O lines from which 6 can be used for PWM outputs and 6 for analog inputs.

It consists of 16 MHz resonator and its own USB bootloader. It has 32KB flash memory, 1KB of EEPROM and 2KB of SRAM. In our system for further analysis of ECG Arduino Uno R3 is connected to PC where MATLAB analysis is being done.

D. QRS detection

![Fig 2.2: Pan Tompkins algorithm for QRS detection.](image)

Pan Tompkins algorithm is used for QRS Complex detection of ECG signal. It consists of digital analysis of slope width and amplitude of ECG signal. This algorithm includes linear digital filtering, nonlinear transformation and decision making rule. Band pass filter is utilized to reduce power supply noise of 60Hz and T wave interference. To get slope and width of QRS complex, differentor followed by moving window integrator is utilized. For making positive value of signal amplitude, signal squaring is used. Decision making rule algorithm is utilized for identifying peaks of the signal by detecting threshold.

III. SIMULATION RESULTS

The proposed system serves as portable light weight wearable ECG monitoring system where output is analyzed on MATLAB. The whole experimental setup is shown in figure where 3-leads are connected to person’s body. By the methodology of Einthoven’s triangle, ECG signal of person is acquired, amplified and filtered using AD8232. Which is further converted into digital form using microcontroller and displayed on MATLAB.

![Fig 3.1: My ECG Waveform](image)

![Fig 3.2: QRS detection using Pan Tompkins and BioSigKit](image)

![Fig 3.3: Heart Rate calculation using Bitalino toolbox in MATLAB](image)

As compared to dry electrode for ECG acquisition, wet electrodes provides better conductivity and low impedance. Once ECG is stored, later on analysis includes calculation of P wave, R wave and T wave durations. BioSigKit provides matlab tools for analysis and Visualization of Bio-Signals. It is easy to update and add new algorithm to BioSigKit which is implemented on object oriented platform. It consist of six subroutines i.e Pan Tompkins, Nonlinear phase reconstruction, State machine, filter banks, QRS multilevel Teager Energy operator, Automatic multiscale based peak detection.

In this work among these subroutines, Pan-Tompkins is utilized for QRS detection of ECG Signal. To reduce false detection of T-Waves in ECG recording & to enhance the detection rate Pan Tompkins algorithm consists of set of preprocessing methods. Sampling rate 250 Hz is chosen for QRS detection. Heart rate has also been calculated using Bitalino toolbox using MATLAB.
IV. CONCLUSION

In today’s scenario with rapid updates of various technological inventions, daily ECG monitoring is useful to maintain person’s healthy life. To prevent sudden cardiac attack, proposed system is able for taking long term cardiac monitoring of person suffering from cardiovascular disease. The system is able to measure heart rate and duration of various segments of ECG wave.

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