ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Real Time ECG Acquisition System using Raspberry PI

Dr. Ganesh V Bhat [*1], Anandraddi Naduvinamani [2]
[*1] = Professor, [2] M.Tech student, Dept. of Electronics and Communication Engineering Canara Engineering College, Mangalore, Karnataka, India
ganeshvbhat@yahoo.com

Abstract

This paper describes design of Electrocardiogram (ECG) monitoring system using Raspberry Pi(R-Pi). The motivation behind the work is the need for a small, portable ECG monitoring system. ECG monitoring is one of the main processes which are used to find the malfunctioning of the heart. To monitor ECG waveforms suitable electrodes are placed over different parts of the body. The potentials generated from the heart are applied to the instrumentation amplifier via electrodes. The amplified signal from the instrumentation amplifier is applied to the filter circuits in order to attenuate undesired potential and noises. The output of the filter circuit is then applied to the main amplifier to increase the signal level. Some of the prominent aspects are discussed in the design of ECG monitoring device and are explained. Final acquisition of the ECG signal is converted into digital by MCP3008 analog to digital converter (ADC) and which are displayed in real time by Raspberry Pi. Serial peripheral interface (SPI) communication protocol is used for communication between ADC and R-Pi. Real time response of the system is verified and results are presented.

Keywords: Electrocardiogram (ECG), Instrumentation Amplifier (IA), SPI, Electrodes, Raspberry Pi, ADC..

Introductions

An electrocardiogram (ECG) is a graphic tracing of the voltage generated by the cardiac or heart muscle during a heartbeat. It provides very accurate evaluation of the performance of heart. The heart generates an electrochemical impulse that spreads out in the heart in such a fashion as to cause the cells to contract and relax in a timely order and, thus, give the heart a pumping characteristic This sequence is initiated by a group of nerve cells called the sino atrial (SA) node, resulting in a polarization and depolarization of the cells of the heart. Because this action is electrical in nature and the body is conductive with its fluid content, this electrochemical action can be measured at the surface of the body. An actual voltage potential of approximately 1 mV develops between various body points [2]. This can be measured by placing electrode contacts on the body. The four extremities and the chest wall have become standard sites for applying the electrodes. Standardizing electrocardiograms makes it possible to compare them as taken from person to person and from time to time from the same person. The normal ECG shows typical upward and downward deflections that reflect the alternate contraction of the atria (the two upper chambers) and of the ventricles (the two lower chambers) of the heart. A typical single cardiac cycle waveform of a normal heartbeat is shown in Fig. 1.

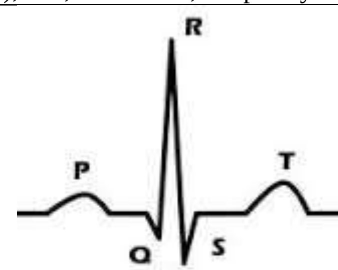


Fig. 1. A Typical ECG Waveform

Block diagram

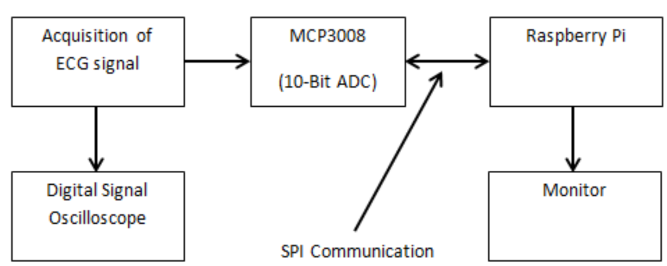


Fig. 2 Block Diagram of ECG Monitoring System

Block diagram of ECG Monitoring System using Raspberry Pi consists of acquisition ECG i.e.,

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

Analog front end circuit, ADC and Raspberry Pi. Each block is explained as follows[4].

1. Design of Analog Front End Circuit ECG Monitoring System.

A. Electrodes

The potentials generated from the heart (ECG) of the human body are picked through electrodes. Here the Einthoven‘s triangle lead I system is adopted. Here the electrodes used are pre-gelled disposable electrode, which helps in reducing the possibilities of artifacts, drift and base line wandering etc. These types of electrodes are used for prolonged applications. This electrode is coated with silver-silver chloride (electrolyte) because it has high conductivity, contact impedance, etc.

B. Instrumentation amplifier

It is the pre amplifier for detecting low voltage signals like bio-potentials. 8 pin DIP low power, low cost IC AD620 is utilized for this purpose. The AD620 is a low cost, high accuracy instrumentation amplifier that requires only one external resistor to set gains of 1 to 1000. Furthermore, the AD620 features 8-lead SOIC and DIP packaging that is smaller than discrete designs.

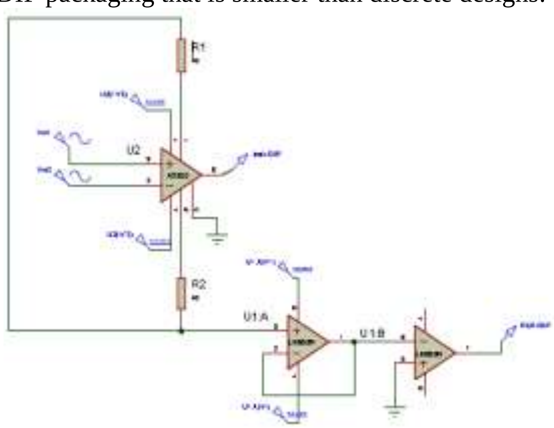


Fig. 3. Circuit if IA

- Gain design:

$$G = 1+\left(\frac{49.4k\Omega}{R_G}\right) = 1+\left(\frac{49.4k\Omega}{136\Omega}\right) = 364dB.$$

- Analog analysis:

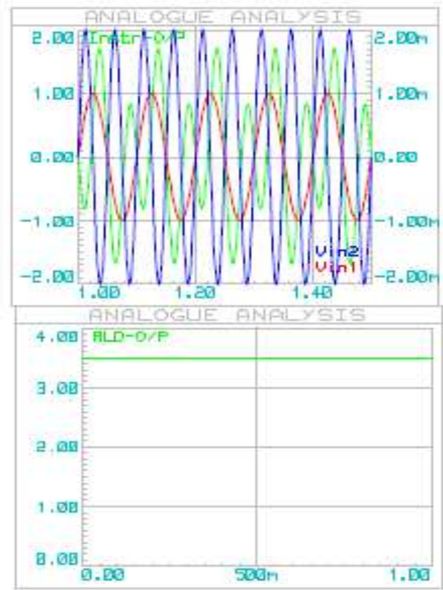


Fig. 4. Analog analysis of IA and RLD.

C. Filter

To attenuate noise signals while capturing ECG signal, filter circuits are essential. For this purpose forth order low pass filter is used. It is formed by second order active low pass filter [4].

a. Low pass filter

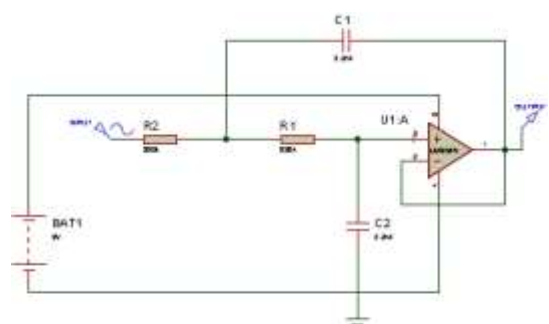


Fig. 5. LPF circuit.

- Cut-off frequency design:

$$F_C = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}} = \frac{1}{2\pi \times 330k \times 2.2n} = 219\ Hz$$

Where $R_1 = R_2 = 330k$ and $C_1 = C_2 = 2.2n$.

- Frequency response:

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

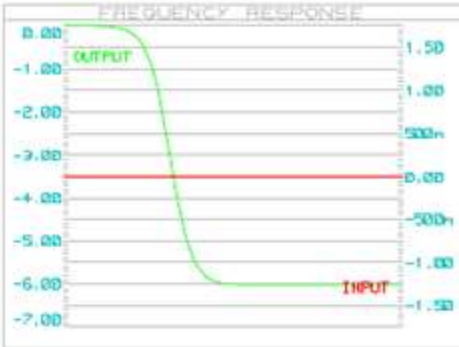


Fig. 6. Frequency response of LPF.

b. High pass filter

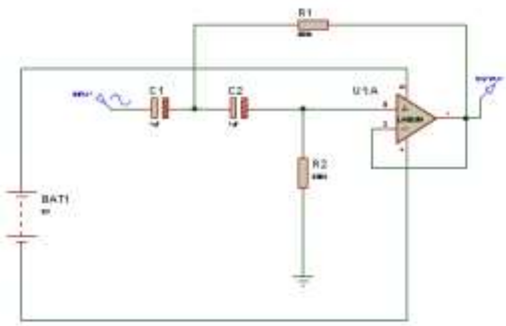


Fig. 7. HPF circuit.

- Cut-off frequency design:

$$F_C = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}} = \frac{1}{2\pi \times 990k \times 1\mu} = 0.16\ \text{Hz}$$

Where $R_1 = R_2 = 990k$ and $C_1 = C_2 = 1\mu$.

- Frequency response:

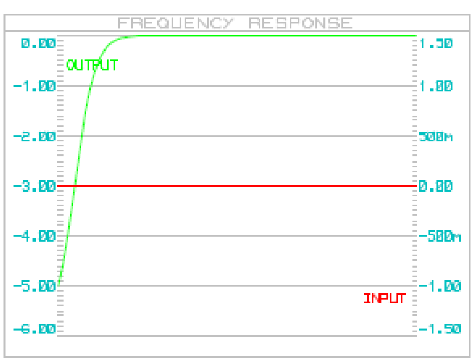


Fig. 8. Frequency response of HPF.

c. Notch filter

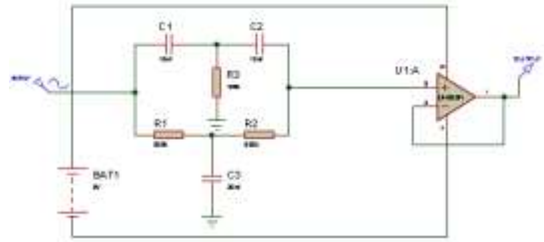


Fig. 9 Notch filters circuit.

- Cut-off frequency design:

$$F_C = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}} = \frac{1}{2\pi \times 330k \times 10n} = 48.2\text{Hz}$$

Where $R_1 = R_2 = 330k$ and $C_1 = C_2 = 10n$.

- Frequency response:

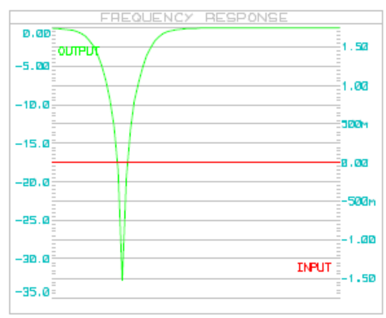


Fig. 10 Frequency response of notch filter.

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

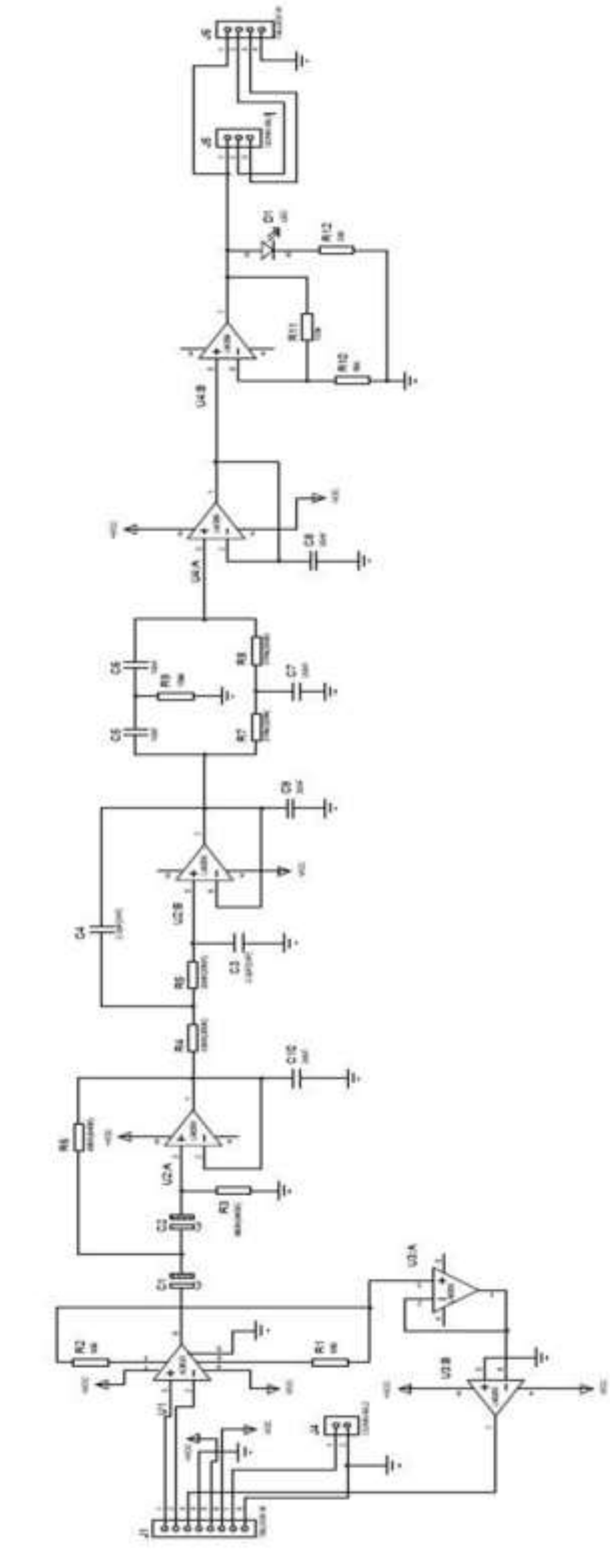


Fig .11 Front end ECG circuit

Pberry PI

The Raspberry Pi is a credit-card-sized computer created by the non-profit Raspberry Pi Foundation in the UK. After several years of tinkering, the Foundation came up with two designs for the Raspberry Pi. The $35 Model B was released first, around February 2012, originally with 256 MB of RAM. A second revision, with 512 MB of RAM, The R-Pi has 17 GPIO pins brought out onto the header, most have alternated functions other than just I/O, there are two pins for UART, two for I2C and six for SPI. All the pins can be use for GPIO with either INPUT or OUTPUT and this raspberry pi operates on LINUX base platform and here, I run the all my codes in python idle or Nano editors [5].

The MCP3008 is 10-bit Analog-to-Digital Converter (ADC). These are simple to use, cheap and quite fast converters with 8 input channels. It will convert a DC voltage varying from 0-3.3 V to a digital reading of 0-1023 ($2^{10} – 1$).

The ADC is a critical component of the ECG module. It takes the received ECG signal from the electrode circuitry and digitizes and allowing for easy data transfer. The ADC and the Raspberry Pi communicate using hardware SPI which is a synchronous serial protocol. It needs a clock line as well as data in and out lines. It also has a chip enable line that is used to choose which SPI device to talk to.

Below figure shows the mcp3008 and Raspberry Pi connection diagram.

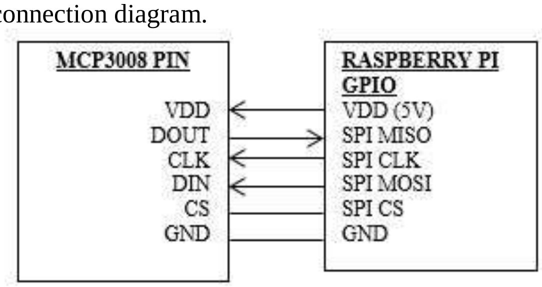
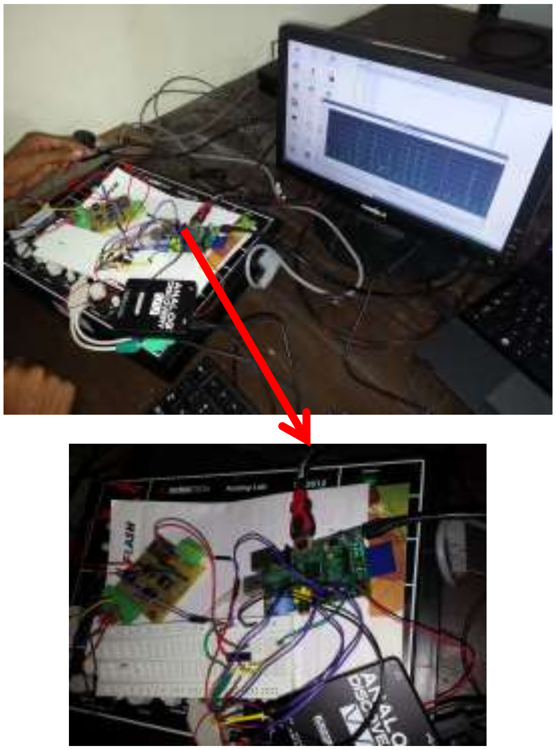


Fig.12 Raspberry Pi to ADC Connections

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852



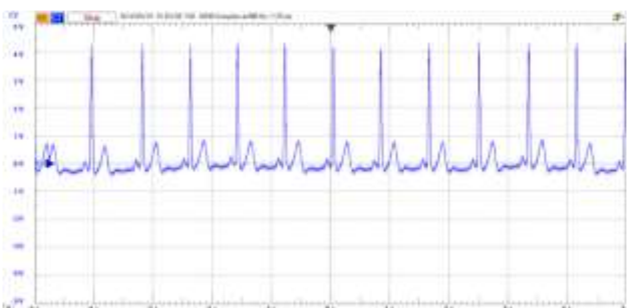


Fig. 13. Result of Analog Front End Circuit

Fig. 14 Real time ECG in monitor

Conclusion

This paper is to design a Raspberry Pi based Monitoring System of ECG Signal. With low cost and less hardware complexity. The system can operate in real time and real mode.in future we can to be analysis QRS detection and heart beat counter.

References

1. *G. Eason, B. Noble, and I.N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955. (references)*
2. *Mobyen Uddin Ahmed, Shahina Begum and Mohd. Siblee Islam" Heart Rate and Inter-beat Interval Computation to Diagnose Stress Using ECG Sensor Signal"*
3. *Tsung-Heng Tsai, Jia-Hua Hong, Liang-Hung Wang, and Shuenn-Yuh Lee." Low-Power Analog Integrated Circuits for Wireless ECG Acquisition Systems" IEEE Transactions on information Technology in biomedicine, vol. 16, no. 5, September 2012.*
4. *Mr.Bhimsen G Tasganva, Dr Ganesh V Bhat, "ECG Acquisition system", International Journal of Engineering Research and Technology(IJERT), ISSN:2278-0181, Vol.3 Issue 3, March-2014. www.raspberry pi.org*