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A Pocket Size ECG Acquisition Model Using Non-Conventional Energy Source

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Abstract – With the day to day developing lifestyle there is increase in number of people with age 65. With this age the health problems are also increasing. At this age the heart problems are very much common and due to stressful life, irregular food habits, shift timings the heart problems are very much common today. Early detection and cure is the best option to reduce the deaths due to cardiovascular disease.

Electrocardiogram is the best available option for observation of heart activity. But conventional ECG monitoring system is very much bulky, power consuming and it is based on line voltage hence it can contain noise. Since ECG signal is very much sensitive, it should be accurate so that the diagnosis can be done correctly. Also there are many areas present in the world where electricity is not present. Such remote areas are not accessible for the advanced equipments like ECG monitoring device. Hence the system proposed her is based on non conventional energy source i.e. solar energy. By using solar energy the baseline wander noise can be removed and smooth signal can be observed. The system consists of three electrodes for ECG acquisition, solar cell, solar battery, acquisition system. The signal is observed on CRO.

Index terms –acquisition system, solar power, electrodes, ECG signal, CRO.

I. INTRODUCTION

Cardiovascular (CVD) diseases deal with various stages of heart, blood vassals, age, stress, food habits, etc. It is also a strong reason for worldwide death rate and due to today's disturbed lifestyle, shift timings the death rate is increasing day by day. According to the World Health Organization almost 17 million people around the world face death due to CVD's and about 20 million deaths are result of sudden heart failure [1].

Heart problem is a sudden event without any prior warning; hence it can result into sudden death also. Many of these life's can be saved if the diagnose and help will be provided at the golden hour. Therefore early diagnosis and cure provided accordingly is the best option to avoid such events caused by CVD. Since it is a sudden event, the real time monitoring should be done for the patients having CVD problem [1].

Researchers are working hard on this issue from many years so that the heart activity and heart problem can be detected. Electrocardiography is the best available technique provided by them until now. Electrocardiogram (ECG) helps to observe the heart activity, heart rate and problems related to heart. Conventional ECG monitoring used in hospitals and Holter monitoring are the options available now for ECG monitoring. But the conventional ECG monitor is very much bulky, power consuming and uses line voltage hence presence of noise is more and device is not handy for the patients. With the Holter monitor the device can be handy but it contains noise and more chances of loosing data [8].

Today also in many areas there is electricity problem hence the tests like ECG cannot be done in such areas; also the tests are so expensive that poor people cannot afford it. Hence the system proposed here is based on solar power as well as it is cost effective. The system consists of electrodes, solar power battery and ECG acquisition system. The system is portable, small in size, easy to handle and uses solar power hence it can be used in remote areas also.

The solar panel is used to provide power supply to the overall system. With this solar energy solar battery gets charged and it provides solar power to acquisition module. The signal is acquired from the human body with the help of electrodes, and then the signal is checked on CRO for the noise detection. Here the system s so small that can be

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kept inside pockets also. The signal to noise ratio can be obtained from the signal on CRO and accordingly the noise reduction can be observed.

The rest of the paper is organized as follows. Sections II gives the motivation for the system developed. System architecture and methodology has been explained in section III. In Section IV, the performance of the system and results are discussed. The conclusion was drawn in Section V.

II. MOTIVATION

Heart problems are very much common to all age group people now. ECG can help us to detect and provide the healthcare accordingly. But the conventional ECG machines available are very bulky, costly and based on line voltage. Hence it cannot be taken to the remote areas for diagnosis of tribal people. Also these tests are very much expensive that poor people cannot afford it. Hence the system which is cost effective, portable and easy to use is required. The system proposed here is using non conventional energy for signal acquisition hence it is cost effective. It is small in size that is why can be portable; even it can be carried in pockets also.

ECG signal is very much sensitive, it can be affected by small disturbance can affect the signal. According to the ECG signal waveform obtained further diagnosis of heart problem and heart rate can be decided. Hence the presence of noise in ECG signal should be as low as possible. The line voltage used for conventional ECG monitoring causes 50Hz baseline noise in ECG signal. That is why the signal can be disturbed and results can go wrong. Hence the system proposed here avoids line voltage and uses non-conventional energy source to avoid the noise as well as use of electricity [10].

III. SYSTEM ARCHITECTURE AND METHODOLOGY

Our aim is to design cost effective, portable, easy to handle and system based on non conventional energy source. System proposed here contains three electrodes for ECG signal acquisition. These are the electrodes made up of conductive and sensitive material. Signal can be taken by placing these electrodes at standard positions assigned by healthcare. Then the signal is forwarded through the acquisition module which consists of amplifier, filter and adder. Then obtained signal can be observed on CRO. Here we can see the noise reduction of the signal with the help of solar power [2].

Figure 1 shows the block diagram for the proposed system. The system contains basically three parts i.e. power supply from solar cell, acquisition system, output seen on CRO. The power supply gets power from solar cell. Solar cell is designed from solar panels and it provides power to the solar battery.

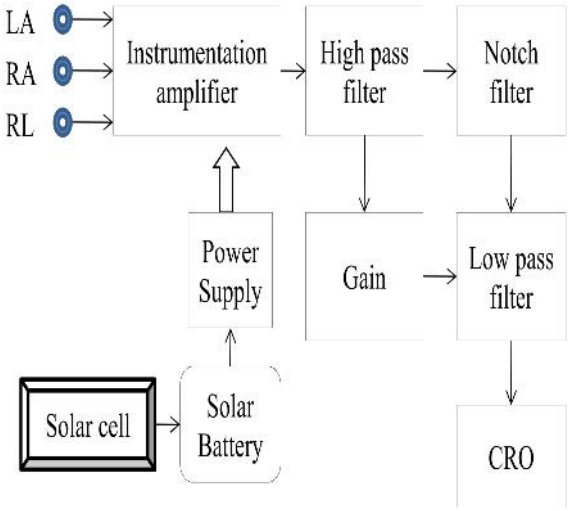

Fig. 1: Block diagram for the pocket size ECG acquisition system using solar power

The power supply of 5V is designed which gets charging from the solar battery. The whole acquisition module obtains power from this power supply. ECG electrodes provides signal from body to the acquisition module. Since ECG signal is a potential difference i.e. voltage, it can cause damage to the human body or circuit also if there is voltage fluctuation. That is why protection circuitry is provided. Then the signal is provided to the acquisition module which consists of instrumentation amplifier, high pass filter, low pass filter, notch filter and gain. Then obtained signal can be observed on CRO. The detailed methodology is as discussed below:

a. Solar cell:

Two solar cells with 5.5 V are joined serially to provide the solar power to the system designed here. The size of solar panels used here is 110mm X 69mm. These panels are made up of amorphous silicon material. This can be connected in series

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together and can gather more solar power than others. These panels can be formed by vapor deposition that is why can form large area for solar power. As the heat increases these panels gives more power.

The high frequency noise present at the output of panel has capacity to reduce the charging discharging cycles of the battery. To avoid that decoupling capacitors are used. The solar cell here provides 11V power to the solar battery which requires 9V [2].

b. Solar Battery:

Here we have used Ni-Cd battery with 9V and 300ma. This battery is chosen because of its advanced features as compared to other solar batteries. Rechargeable batteries are the important part of solar devices. There are four popular types of rechargeable batteries available for portable and solar lighting. These are the types of batteries available.

1) Ni-MH battery:

Ni-MH battery is very similar to Ni-Cd battery with its form factor and components, but instead of toxic cadmium used in Ni-Cd batteries, Ni-MH batteries have hydrogen absorbing alloy as negative electrode or anode. These batteries are available in limited sizes and that is why limited voltages.

These batteries are having high capacity and no memory problem. But these are more expensive batteries than Ni-Cd batteries. Overcharging and discharging rate as well as low life cycle are the issues with these batteries.

2) Lead Acid Battery:

Lead acid battery is the oldest type of rechargeable battery and is also widely used today. These batteries are mostly found in cars as starting batteries. Lead acid batteries are also used for high power portable flood lights.

Lead acid batteries consist of multiple single cells. The approximate voltage of a single cell is 2.1 volts. Lead acid batteries are available with different capacities and sizes. But these are large in size and very heavy,. Their life cycle is very short also they used to charge very slowly.

3) Lithium Ion Battery:

Typical old lithium batteries were made up with lithium metal but due to its instability lithium ion is used instead. Lithium-ion batteries offer number of advantages over other type of batteries such as high energy density and low maintenance, which makes them the best solution for widely used portable applications such as laptops, digital cameras and others. But these are very expensive batteries. Also they face aging issue if not used for long time. These batteries lose their life if kept in high temperature hence cannot be used for high temperature operations.

4) Ni-Cd battery:

This is rechargeable type of battery which is made up of nickel and cadmium, separator and alkaline. Ni-Cd battery consists of,

- Nickel oxide-hydroxide as positive electrodes;
- Metallic cadmium as negative electrodes;
- Potassium hydroxide alkaline electrolyte.

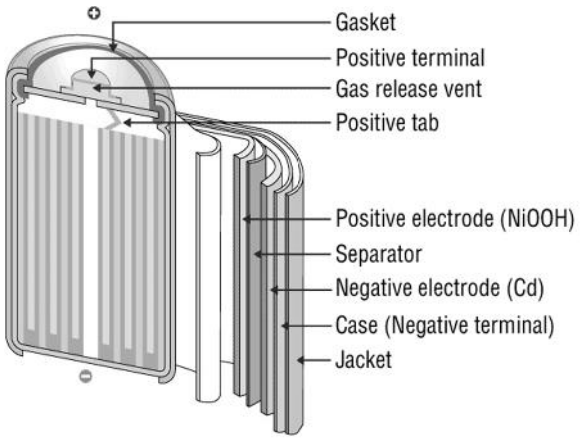

Fig. 2: Ni-Cd battery structure [15]

Ni-Cd batteries are available in various sizes hence it can be used in various applications with different requirements of voltage. Also these batteries can be available in packs with this voltage can be increased. Ni-Cd battery can be used in quite large temperature range. The recommended temperature range to safely use Ni-Cd battery is from -20 to 45°C and sometimes more than that. Advantages of Ni-Cd battery are:

1. Ni-Cd batteries can be quickly charged and discharged
2. Ni-Cd have better cycle life than Ni-MH, lead acid and some types of li-ion batteries
3. Ni-Cd battery has good low temperature tolerance.
4. These are cost effective batteries

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Because of these advanced features Ni-Cd battery is used here for the system [15].

c. Electrodes:

Electrodes plays very important role in ECG monitoring. Through ECG electrodes the signal can be captured from the patient's body and provided to the acquisition module. These electrodes are made up of sensitive conductive material, which can sense even a minute change in heart activity. Electrodes should be attached to human body to capture the signals. Some electrodes need gel to attach properly with patient's body.

It is important to clean the skin before placing the electrode on body. After this the lead wire has to be attached to the electrode, this can avoid pain to the patient's body. There are many options available day by day in field of healthcare. Following are the types of electrodes:

1) Clip Electrodes:

This type of ECG electrodes allows a flexible application for adult patients because of the adjustable clip pressure. These are reusable electrodes. But it can cause damage to the skin.

2) Suction cup type electrodes:

These are the available in various sizes for adults as well as for children. Here the suction pressure is used between electrode and skin for the connection. These are reusable electrodes.

3) Plate type electrodes:

These are mostly available for adults. They are in the form of a plate or rubber straps.

4) Tab electrodes:

These electrodes are available in reusable form and disposable form also. It can be used for child and adults with its varying sizes. They are mostly made up of Ag/AgCl material. Adhesive, foam or cotton padding is provided for noise reduction and signal acquisition even with sweaty skin [11].

These electrodes can provide the sensitive signal with even a small change. Also we require the signal with noise as low as possible. These electrodes can be used 2-3 times and after that they should be replaced. Hence these electrodes are used here for the system designing with reduced noise effect. Below is the pictorial form of electrodes used in system designed here.

Fig.3 Ag-AgCl electrodes [11]

d. Acquisition system:

The signal from electrodes is given to the acquisition system for further processing. First of all the signal is provided to the protection circuitry. ECG signal is the potential difference that is why it can cause short circuit and it can damage the patient's body as well as to the circuit. To avoid this protection circuit is provided.

The signal from protection circuit is then given to the instrumentation amplifier. Since the signal obtained from the patient's body is very small in amplitude, it could not be processed properly in the circuit. Hence instrumentation amplifier is provided which amplifies the signal from some mV to V.

The amplified signal is then provided to the high pass filter which blocks high frequency signals causing noise to the output. Then the signal is given to the notch filter with 50 Hz frequency. This filter blocks the line frequency noise of 50 Hz. Due to this the smooth signal can be obtained. Then the signal passes through the low pass filter. Its role is to block the low frequencies which can cause spikes while sampling the signal.

The gain required for the signal processing is 1000. It is provided by dividing the gain in two parts and given to instrumentation amplifier and low pass filter [7].

e. CRO:

The signal with reduced noise can be observed on CRO. Here the signal to noise ratio can be observed from which percentage noise can be calculated. This will show that how much is the obtained signal close to the actual signal.

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IV. RESULTS AND DISCUSSION

The obtained signal from the above processing can be observed on CRO. Here we can observe the typical ECG waveform with the QRS spike. This QRS complex helps to decide the heart rate and accordingly heart status can be decided.

This signal will show the signal strength and noise spikes from which the signal to noise ratio can be obtained.

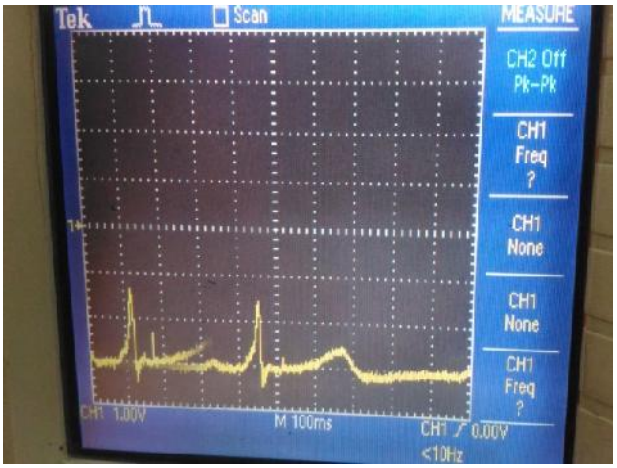

Fig. 4 ECG signal observed on CRO

This is the signal obtained from the system design. We can observe the typical ECG wave with the standard points i.e. P, Q, R, S, T. These are the standard labels assigned to the ECG waveform. QRS is the highest peak present in ECG wave. This peak can be clearly observed in the above output. From this we can observe that the signal strength is 1.6. The noise present in signal is of value 0.1. With these values the signal to noise ration can be obtained with,

SNR= signal strength / noise value.

SNR = 1.6 / 0.1 = 16

According to this value PSNR i.e. percentage signal to noise value can be calculated as,

PSNR = SNR / 100

PSNR = 16 / 100 = 0.16

Ideally the PSNR value should be 0 and the obtained value is nearly close to the standard value. Hence the system designed here provides the accurate ECG signal with reduced noise level. Our aim is to obtain the low noise and smooth ECG signal which is done with the proposed system.

V. COCLUSION

Heart problems are very much common to all the age groups now. Early detection and cure is the best option to avoid these problems. Electrocardiogram helps to detect heart status and heart rate. But the typical ECG machines available in hospitals are having some drawbacks i.e.it is very bulky, based on line voltage, more power consuming, the tests are costly. Hence the system designed here is based on solar power which is non- conventional energy source.

From this system the system can be obtained with reduced noise and smooth signal is observed. This signal shows the typical QRS complex of ECG wave. That will help to count the heart rate and status of heart from that. The line frequency noise and electricity problem can be solved with this design. This system can help poor and remote area people.

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