Design of Three Input Electrocardiogram (ECG) Amplifier System

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Abstract : In this paper, we have present the design and development of a three input Electrocardiogram (ECG) amplifier system. The system takes the physical pulse input using sticking electrodes stuck to the arms and right leg of the patient under observation. The model encompasses of instrumentation amplifier, which are used for signal conditioning of the pulse input from the patient's body and displayed on CRO as the ECG waveform. This circuit is capable of achieving, amplifying the low amplitude and desired ECG signals. The system has been designed at 33 Hz to reject the power line frequency of 50 Hz, so as to protect the circuit from the major noise interference which is the power line frequency.

IndexTerms— Electrocardiogram (ECG), Electrodes, Eagle Software

I. INTRODUCTION

The heart in man and animals produces a small electrical signal that can be recorded through skin surface electrodes and displayed on an oscilloscope or paper strip-chart recorder [1]-[6]. The produced and recorded signal is termed as electrocardiograph or ECG signal. To produce a 1 Volt signal to apply to a recorder or oscilloscope we need a gain of 1000 mV/1 mV, or 1000 because the peak values of the ECG signals are in the order of one mill volt (1mV). ECG amplifier circuit we design must therefore provide a gain of 1000 or more [1]. Furthermore, because skin has a relatively high electrical resistance (1 to 20 K-ohms), the ECG amplifier must have a very high input Impedance.

Another requirement for the ECG amplifier is that it be an AC amplifier because the metallic electrodes applied to the electrolytic skin produces a halfcell potential [7]-[9]. This potential tends to be on the order of 1 to 2 volts, so it is more than 1000 times higher than the signal voltage[10]. By making the amplifier respond only to AC, we eliminate the artifact caused by the DC half-cell potential.

II.BLOCK DIAGRAM OF THE AMPLIFIER SYSTEM:

The block diagram of the proposed system is as shown in Figure 1. Basically, the system consists of sticking electrode or a sensor. The second stage is an Instrumentation amplifier, which has a high gain (1000) which is used to saturate the ECG signals to obtain square waveform. The third stage is Cathode Ray Oscilloscope (CRO) which is used to display the ECG.

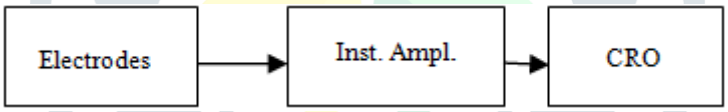

Fig 1: Block diagram of the ECG Amplifier system

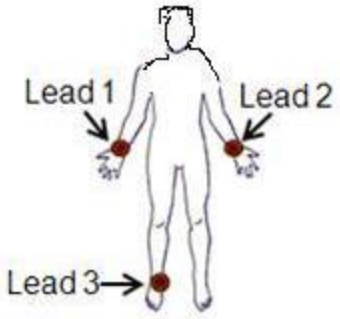

Fig. 2: A 3-Input connection [5].

A. Electrode:

It converts physical signals into electrical voltage which is in the range of 1 mV ~ 5 mV. Also there is a sensor pair which is stuck on the right arm (RA), left arm (LA) and right leg (RL) of the subject is shown in Figure.

Wilson Electrode System: For this project, Wilson Electrode system is been used. It uses the right leg of the patient as "driven right leg lead" that involves a summing network to obtain the sum of the voltages from all other electrodes and driving amplifier. The output is connected to the right leg of the patient. This arrangement is known as Wilson electrode system [4]. The effect of this arrangement is to force the reference connection at the right leg of the patient to assume a voltage level equal to the sum of the voltages at the other leads. The common mode rejection ratio of the overall system is increased by this arrangement and noise interference reduced. It also has the effect of reducing the current flow in to the right leg electrode.

B. Instrumentation Amplifier:

Instrumentation amplifiers (INAs) have been uses by many industrial and medical applications to condition small signals in the presence of large common-mode voltages and DC potentials. Here we have chosen Analog instrumentation amplifier to amplify the ECG voltage from electrodes ranging from 1mV to 5mV. We have designed the instrumentation amplifier using op-amp 741[2], with a gain of 1000 and power supply is +12V to -12V.

III.DESIGN OF THE SYSTEM

In this section we have discussed mostly about the hardware implementation of the system. The hardware implementation consists of two parts: the ECG amplifier circuit and PCB layout. The Figure 3 indicates the circuit diagram of the ECG Amplifier system.

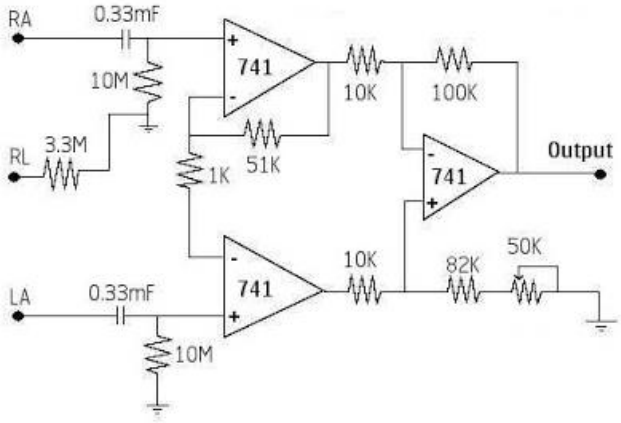

Fig 3: Designed Circuit Diagram Of The System

Connect the +Vcc to +15V and -Vee to -15V (Dual voltage power supply)
Connect the terminals of electrode RA,LA and RL to the Right Arm, Left arm, and Right leg respectively.
Connect the output terminals to CRO or paper strip-chart recorder.
Adjust the 50K Pot, which is wired as CMRR adjust.

IV.RESULTS AND DISCUSSION

A prototype that incorporates all the above capabilities has been built on a printed circuit board as shown in figure 4. Conventional pre-gelled ECG sensors were used to achieve the ECG signals from the subject. These sensor outputs were connected to the circuit shown and the circuit output was connected to a CRO.

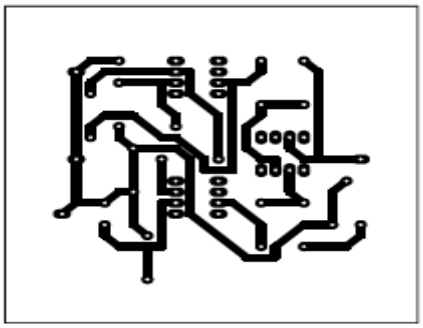

Fig 4: PCB layout from Eagle Software

PCB Layout (Fig. 4) of proposed designed is carried out using eagle software. It is implemented on Copper clad.

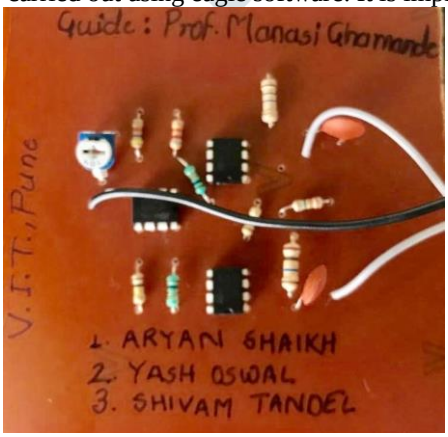

Fig 5. Assembled circuit on a Printed circuit board

We have got the ECG waveform display on CRO through electronic hardware implementation of our project successfully. This can be seen by Figure 6, which shows an ECG signal acquired by the electrode on a CRO.

Fig 12: ECG waveform observed on CRO

VI. CONCLUSION AND FUTURE SCOPE

A. Conclusion:

This paper presents the implementation of an ECG Amplifier System. This project has been implemented successfully and the output has been displayed on the CRO.

B. Future Scope:

1. The project can be further developed in future by adding low pass filter , Microcontroller, displaying 12 lead graphs, and monitoring ECG wave form on PC monitor.
2. We can enhance the feature of the project by enabling the transmission of ECG signals through mobiles, signal transmitters or internet.

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