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Design of the Real Time ECG Signal Processing and Monitoring System using Lab VIEW with Data Acquisition System

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Abstract:- Lab VIEW is the Laboratory Virtual Instrument Engineering Workbench tool which is used for continuous monitoring of an ECG signal that is Electrocardiogram. This Electrocardiogram is the extremely powerful diagnostic and monitoring system which is used in now a days medical practices. By monitoring any person's ECG we can predict many diseases which are related with heart like Sudden Cardiac Arrest (SCA), Pulmonary diseases, Cardio Vascular diseases (CVD) etc. This ECG signal is generated due to nerves impulse stimulate to the heart. Due to the electrical activity of the heart, a very small current diffuses on surface of a body which build the small voltage drop of 0.01 mV to 3 mV in amplitude. This small signal can be further processed through instrumentation amplifier where large signal are eliminated and small signals are only amplified and given to the filters where noise can be removed from this ECG signal. The pure ECG signal from the filter is in analog form which can be given to the NI myDAQ to convert it into digital signal. This digital ECG signal which can be finely sampled at specific time interval into LabVIEW for its continuously monitoring. LabVIEW is used as the Graphical User Interface in which anyone can monitor this ECG signal very easily. This system is cost effective for clinical applications. It will save the patients history in LabVIEW with the help of excel sheets which will helps in future.

***Keywords*:-** *LabVIEW, Data Acquisition System (DAQ), NI (National Instrument).*

I. INTRODUCTION

An Electrocardiogram, or further referred to as an ECG, is an extremely powerful diagnostic and monitoring system used in all medical practices. ECG's are used to observe the electrical activity of the heart graphically to check for abnormalities in heart rate or electrical signaling. This electrical signal generated by heart's expansion and contraction builds a potential difference of amplitude 0.01 mV to 3 mV and has frequency in between 0.05 Hz to 113 Hz. This signal contains P wave, QRS complex, T wave. The typical ECG signal tracing is shown in below figure.

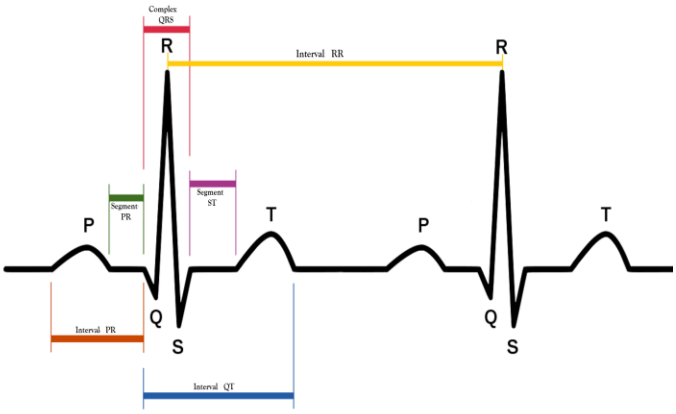

Fig 1:- Normal Sinus Rhythm

A normal ECG signal tracing is shown in above figure which contains waves like P wave, QRS complex and T waves. From an ECG reading, patients' heart rate can be determined by the time spacing between QRS complexes. The heart rate can be measured by using following formula as,

Heart Rate = (1/ RR interval in sec) * 60

The RR interval in sec is the time interval in between two QRS complexes. Other medical conditions can be detected such as Sudden cardiac arrest i.e. heart attack by an ST segment elevation. The generation these waves are of hearts motion that is, the P wave is showing the contraction of the atrium of the heart, the QRS curve is the ventricular contraction, and the T wave is the repolarization of the heart.

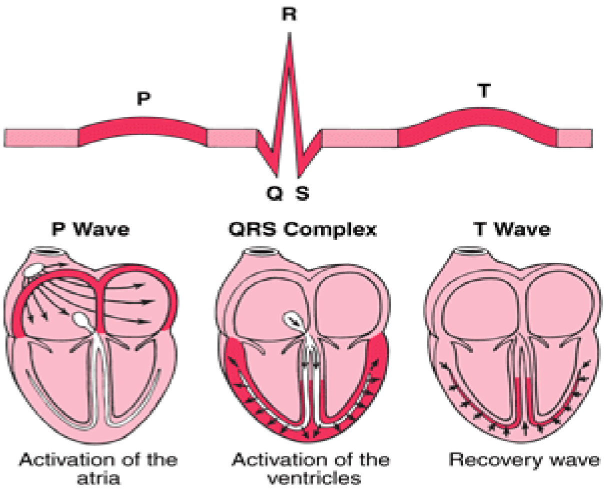

Fig 2:- Generation of ECG Waves

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Generated ECG signal on Electrocardigraph is shown is below figure 3

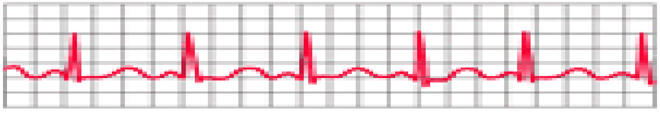

Fig 3:- Normal Heart Beats

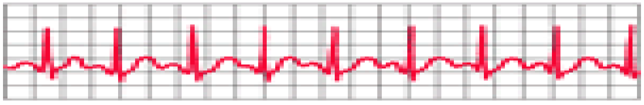

Fig 4:- Fast Heart Beats

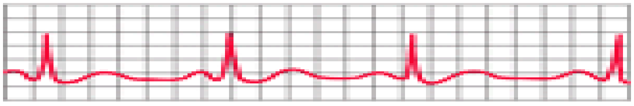

Fig 5:- Slow Heart Beats

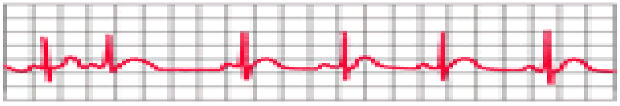

Fig 6:- Irregular Heart Beats

Fig 3:- Heart beats at different conditions

Knowing a very small information about this generated pattern of ECG signal we can quickly diagnosis abnormalities of patients heart.

II. PROPOSED SYSTEM

A. Lead Probes

A standard ECG used in medical practice has twelve electrodes that are placed in a mild semicircular pattern around the lower region of the heart. These no of electrodes causes more noise added into ECG signal. So it becomes difficult to find abnormalities in ECG signal. For that three lead probes are used in such a manner that placement of these three electrodes makes Einthoven's Triangle as shown in below figure 7.

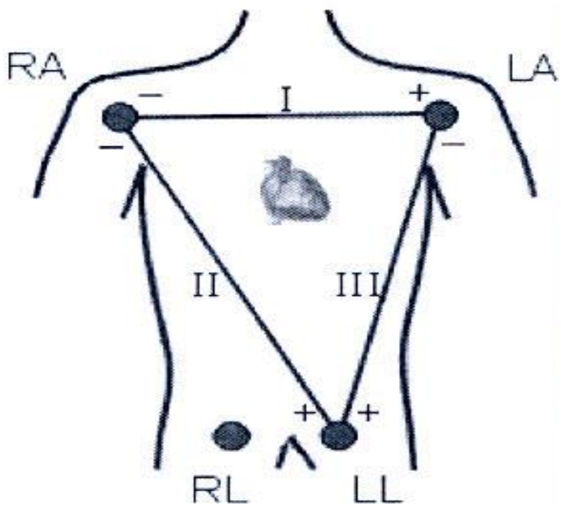

Fig 7:- Einthoven's Triangle

The positive input electrode will be placed on the left inner wrist, the negative input electrode will be placed on the right inner wrist, and the ground electrode will be connected to the ankle. This will allow for readings to be taken across the heart with relative accuracy. This placement of electrodes carried out ECG signal which can be given to the instrumentation amplifier, low pass filter, notch filter and then DAQ and finally it displayed on the LabVIEW i.e. Graphical user interface.

B. Instrumentation Amplifier :

The instrumentation amplifier offers low power consumption with higher accuracy and precision. The ECG signal carried from ECG probes is of having very small in amplitude. This signal is amplified in this instrumentation amplifier with gain of 1000. The gain of this instrumentation amplifier is controlled by the register R_G. To construct a multistage instrumentation with a gain of 1000, or 60 dB, the following equation should be applied.

$$Gain=(1+2*R1/R_G)$$

OP07 is used for instrumentation because it has very high input impedance, low output impedance, minimum input offset voltage, good CMRR. This instrumentation amplifier minimize large signals from input signal and amplifies only small signals. The design of Instrumentation amplifier is shown in bellow figure 8.

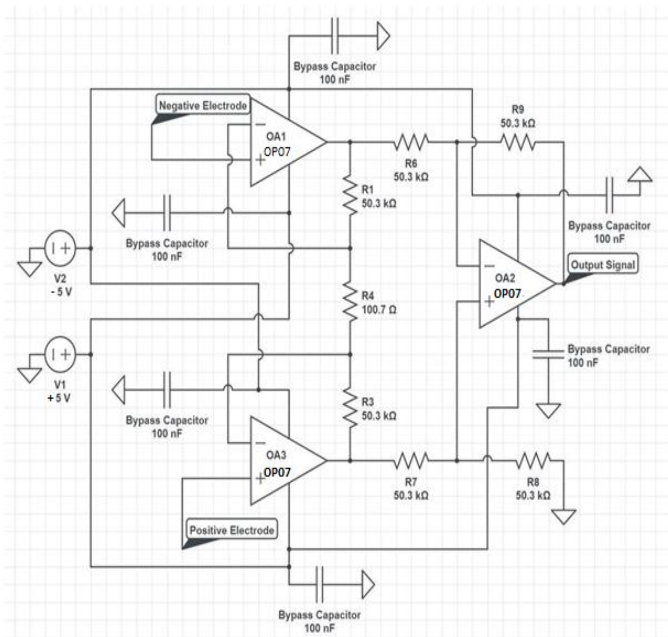

Fig 8:- Circuit diagram of OP07 Instrumentation amplifier

This amplifier is having + 5 V and – 5 V power supply because AC power supply introduce more noise into signal so to avoid it DC power supply is used in this circuit. Bypass capacitors are used near to power supply to ground AC contents from input signal.

C. Low Pass Filter

The low pass filter is designed in such a way that it will remove the signal which is of above 150 Hz frequency and can filtered out signal of low frequency. Here second order low pass filter is used because it gives better filtration than single order low pass filter. The gain of this filter has chosen to be equal to one. So all the input signal will arrived at output side.

The circuit diagram of this second order low pass filter is shown in below figure 9.

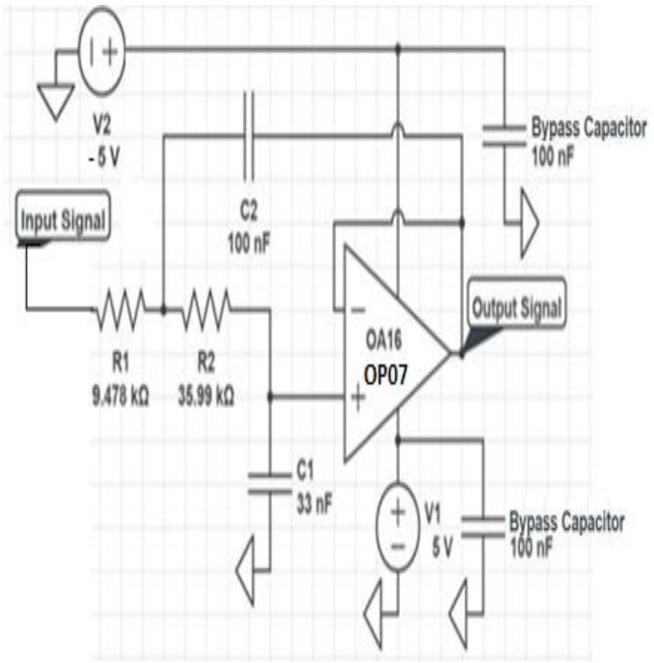

Fig 9:- Circuit diagram of Second Order Low Pass Filter

D. Notch Filter (Band pass)

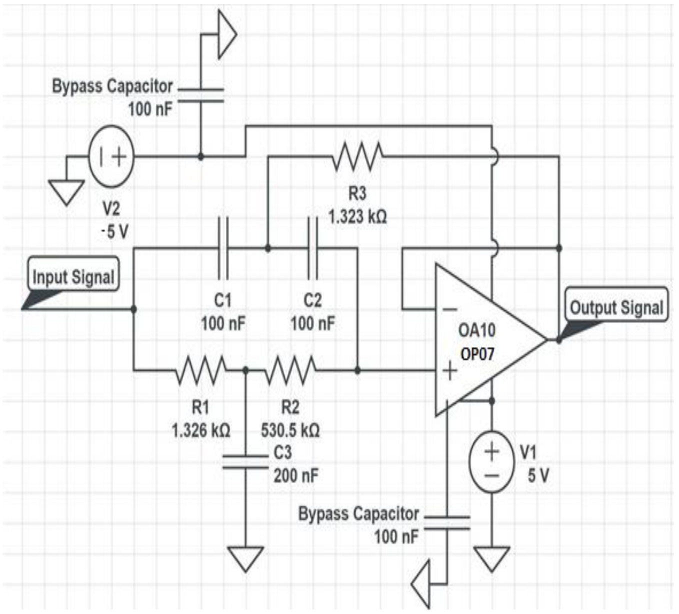

Fig 10:- Circuit diagram of Notch Filter

Notch filter is the very important circuit of this system for measuremnet of a small frequncies. Here, notch filter filtered out the frequncy band where an ECG signal is preserved and remove specific frequencies. While designing the notch filter quality factor i.e. Q is very important and should be high in value, which will give very sharp cut off at interest point.

E. NI myDAQ 6008

The National Instruments USB-6008 devices provide eight single-ended analog input (AI) channels, two analog output (AO) channels, 12 DIO channels, and a 32-bit counter with a full-speed USB interface. It consists of one 16 bit ADC and one 16 bit DAC. Here we used 16 bit ADC where the signal from notch filter is in analog converted into digital format and given to LabVIEW for graphical presentation. The block diagram of this NI USB 6008 is shown in below figure 11

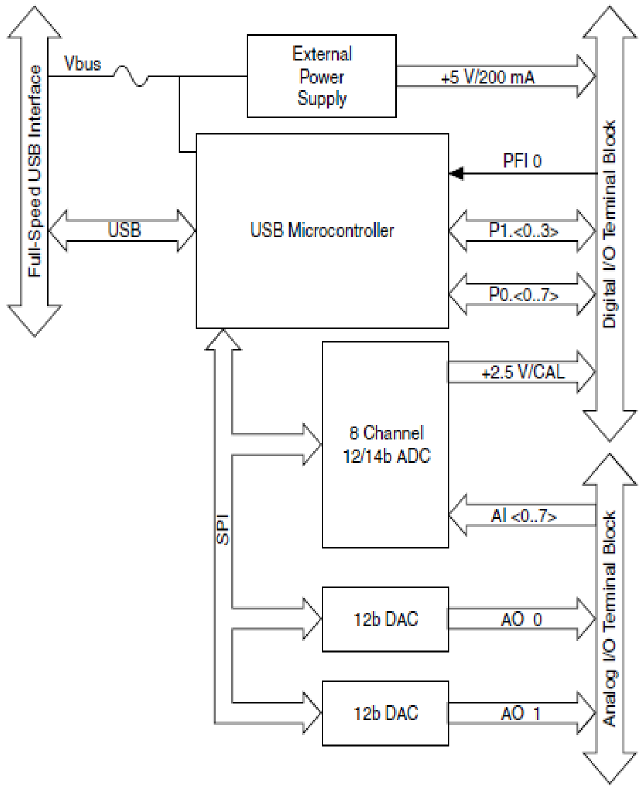

Fig 11:- Block diagram of NI myDAQ 6008

The single ended analog input is having input signal coming from Notch filter and this signal is converted into digital ouput with 2^{16} = 65535 counts. Which gives more accouracy in digitised output signal. This DAQ (Data Acquisition) System further interfaces this signal with LabVIEW.

F. LabVIEW :

LabVIEW is Laboratory Virtual Instrumentation Engineering Workbench tool. Here we interfaced NI myDAQ 6008 USB with LabVIEW. The digitised ECG signal is graphically represented on this LabVIEW software.

III. RESULT

The digitized signal from NI myDAQ system is processed in LabVIEW software and put it in continuous While Loop so we can monitor digitized ECG signal continuously. For example below image shows the results of an ECG signal processed.

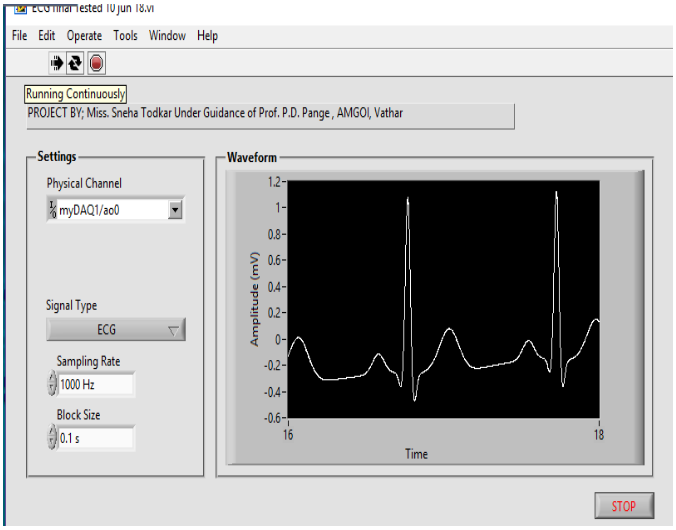

Fig 12:- Displays of ECG Signal on LabVIEW

Here ECG signal is displayed at 1000 Hz sampling rate. In graphical representation the Y-axis shows the amplitude of the ECG signal in mV and X-axis shows time in second.

IV. CONCLUSION

LabVIEW is the effective tool for the ECG signal processing with some additional hardware. It is of very low cost and user friendly system that anyone can handle it. This system removes very effectively noise and other signal interference from the ECG signal. The future scope of this system is we can save any patients history in this software so at any instant we will have all medical history of a patient.

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