ELECTROCARDIOGRAM (ECG) MEASUREMENT CIRCUIT DESIGN

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ABSTRACT

In this Project, our main purpose is to design an ECG circuit with three electrodes. These electrodes are used to perceive the signals on human body produces by heart.

As can be guessed, the electrical signals on human body is very small (1mV-5mV). In order to amplify these small signals, a special amplifiers are used,which are called *"Instrumentation amplifier"*. These amplifiers have very high open loop gain,common mode rejection ratio(CMRR) and also very low noise. Thanks to the these properties, human body signals can be amplified.To get the ECG signal, a special filter circuit must be designed. Moreover if we want to perform pure ECG signal, we must design 50Hz noise filter circuit.

GENERAL INFORMATION ABOUT ECG

➢ WHAT İS ECG?

An electrocardiogram (ECG) is a test that checks for problems with the electrical activity of heart. An ECG translates the heart's electrical activity .The spikes and dips in the line tracings are called special P-Q-R-S-T waves. Figure-1 shows that ECG components and internals.

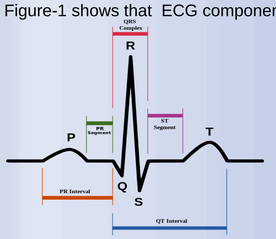


Figure-1 Structure of ECG signal

➢ HOW DOES HEART GENERATE THE ECG SIGNAL?

The heart has four chambers. The two upper chambers are called atria (the right atrium and the left atrium), and the two lower chambers are called ventricles.

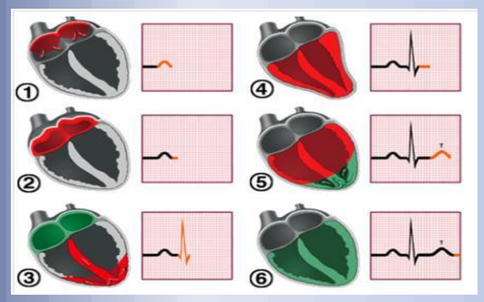


Figure-2 Electrical activity of heart

1. Atrium begins to depolarize.
2. Atrium depolarizes.
3. Ventricles begin to depolarize at apex. Atrium repolarizes.
4. Ventricles depolarize.
5. Ventricles begin to repolarize at apex.
6. Ventricles repolarize.

➢ P-Q-R-S-T WAVES PROPERITIES

Normal ECG signal (P-Q-R-S-T waves) must be similar to given Figure 1 and also have the following properities (for adults);

- ***P wave*** must be above the reference duration changes 0.8-0.11 seconds
- ***PR interval*** duration changes 0.12-0.20 seconds
- ***PR segment*** duration changes 50 to 120 ms
- ***QRS complex*** duration changes 0.8-0.12 seconds
- ***ST segment*** duration changes 80 to 120 ms
- ***T wave*** duration changes 150-160ms
- ***ST internal*** duration changes 300-320ms
- ***QT internal*** duration changes up to 420ms in heart rate of 60bpm

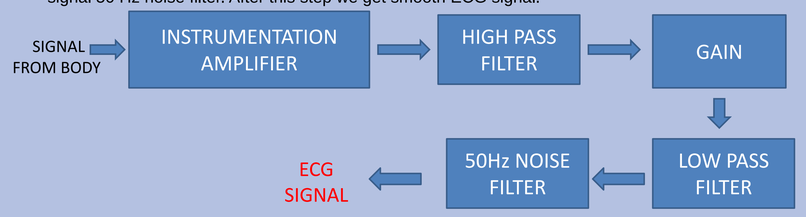
➢ IS ECG SIGNAL RESULT CAN BE REFERENCE EXAMINATION?

ECG signal gives information about electrical activity of heart so, it helps to diagnosis on heart or body. However it cannot be the reference by itself. In other words, normal ECG signal does not mean absolutely healty heart or body at the same time anormal ECG signal does not mean absolutely unhealty heart or body.

To sum up ,ECG signal is not only reference examination.It taking the account with other examinations.

DESIGNING OF AN ECG CIRCUIT

In order to design an ECG circuit,the first thing that amplifying the signals which come from the body. We can do this by an instrumentation amplifier. After this step in order to diagnose the ECG signal, we must design a filter circuit that consists of high pass and low pass filter.At the same time we amplify the signal in order to see all parts of signal fluently.Lastly, we pass through the signal 50 Hz noise filter. After this step we get smooth ECG signal.



➢ INSTRUMENTATION AMPLIFIER

Instrumentation amplifier is a type of differential amplifier.The reason of using this amplifier in our project, it has very high common mode rejection ratio(CMRR) and very low noise.

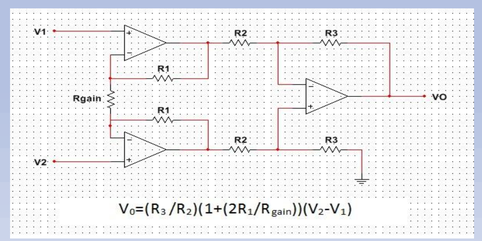


Figure-3 Structure of instrumentation amplifier

In this project, AD620 is used as the instrumentation amplifier. Gain of AD620 up to 1000 and its CMRR is 80-130 dB. In this amplifier R1=24.7KΩ and R2=R3=10K Ω.Therefore we can calculate easily gain of this amplifier by using following formula;

$$G=(1+(49.4k\Omega/R_{gain}))$$

As can be seen from the formula we can adjust gain, just changing R_{gain} . This is also simplicity of instrumentation amplifiers.

We choose R_{gain}=560Ω so, our gain is nearly equal to 90.

➢ FILTER & GAIN CIRCUITS

HIGH PASS & LOW PASS FILTERS

In this part of project we use passive RC high pass and low pass filters.High pass cut-off frequncy is nearly 0.03Hz and low pass filter cut-off frequency is nearly 160Hz. The high frequency limit 160Hz ensures that tracing allow assessment QRS complex. The low frequency limit allows representation of P and T wave morphology and ST segment analysis.

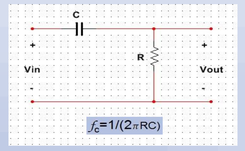


*Figure-4 H*igh pass filter

For the high pass filter
R=5.6K and C=1000uF.
For the low pass filter
R=10K and C=1uF

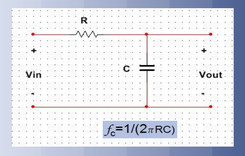


Figure-5 Low pass filter

GAIN

In order to better analysis we set up non-inverting amplifier with UA741. G=R2/R1

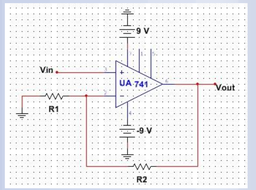


*Figure-6 N*on-inverting amplifier

T TWIN NOTCH FILTER

The aim of using this filter is that filtering noise where comes from electrical devices. We use T twin notch filter which consists of passive RC high pass and low pass filters.We use the same formula, and choose R and C values for eliminate the 50Hz noise. We choose R=100K and C=34nF

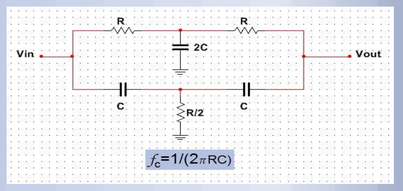


Figure-7 T Twin notch filter

➢ ECG MEASUREMENT CIRCUIT

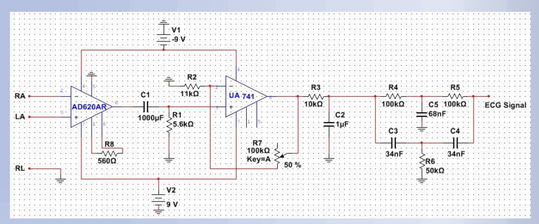


Figure-8 whole circuit

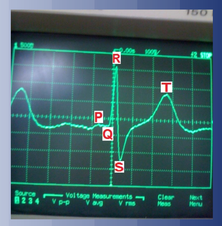


Figure-9 output of our circuit

As can be seen from the Figure-9, we get ECG signal successfully.

CONCLUSION

In this Project, an ECG signal is performed.It is difficult part is that , we cannot simulate on computer because ECG signal is a special wave which cannot simulated on simulating programs.Therefore we studied in real life and sometimes we damaged instrumentation amplifier because of some connected mistakes.Figure-9 is shown my own ECG signal and it is nearly like an standart ECG signal. We made some tests on other people and most of them have nearly standart ECG signal. To sum up,ECG signal is produced by our circuit and it can measure all parts of P-Q-R-S-T waveform.

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Special Thanks to **Assist. Prof. Dr. M. Zübeyir ÜNLÜ, Assist. Prof. Dr. Barbaros ÖZDEMİREL,Yunus Emre ÜRGÜN, Candeğer AVŞAR**