Making EMG SPIKER BOX Machine

Department of Electrical and Computer Engineering,University of IRAN, Shiraz University

Advisor : Dr. Peyman Setoodeh

Author : Mahsa Tadrisinoor

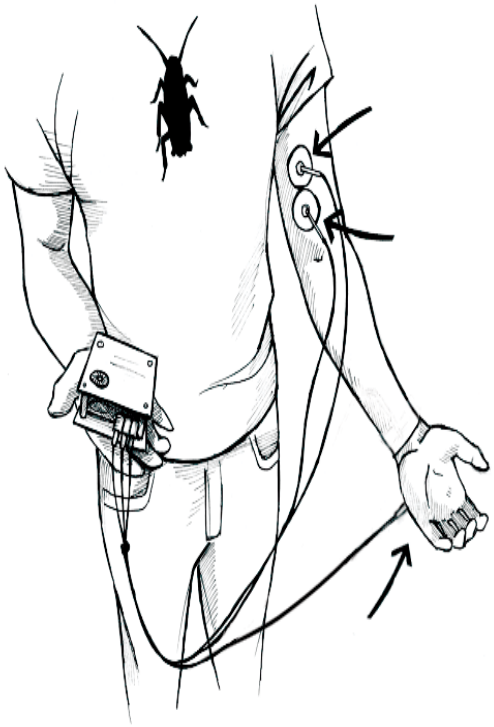
Contents :

Abstract

The age old question: Are you human or only a machine perceiving yourself as human? With our Muscle Spiker-Box you can test your muscles for bio-electrical activity and get one step closer to answering that question. The Muscle Spiker-Box can be used to detect the EMG Signal (Electromayogram) of muscles non-invasively using simple skin surface electrodes. This is the basic muscle Spiker-Box set. But what about yourself? Your body uses electricity to communicate and control parts of the body. Though all cells have ionic gradients across their membranes, the most well-known organ systems that use electricity are the brain, the muscles, and the heart

Electromayography is an empirical method in order to expand, record and analyze the muscle's electrical signals. These signals are shaped by physiological changes in fibrous membrane. Electromyography is the study of muscle performance through evaluating the electrical signals, which of begin in muscles, and include amplifying ,recording ,analysis, and interpretation the resulted signals by skeleton muscles during its activity to produce essential power.

The aim of this project is to make the EMG dual channel amplifier with EMG SPIKER BOX circuit, which includes an amplifier, one high-pass and one band-pass filter to remove the noise. Converting the amplified signal to digital is done by the "ardoino-uno" board and finally the digitalized signal would be processed by all kinds of digital devices such as smart phones.



Introduction

Due to the transition of neural signals into the muscles , mulcular fibers become activated and also the potential is made that is called EMG, which indeed is the manifestation of human will to move .EMG signal is made from small components, which name as motor unit action potential that are produced in different units. Propagating this potential continues in muscles and is perceivable on body skin with placing skin electrodes that can receive these signals from the skin .the EMG signal are varied in range from 25 HZ to some KHZ (regarding their frequency and also the signal domain (range), which depends on signal mode and its usage ,is from 100μV to 100 mV).

Genarally the EMG signal receives the noise from two different sources :

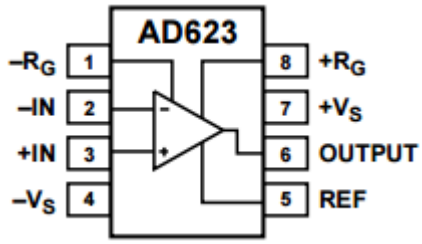
- Biological sources
- Unbiological source

Biological sources are developed from factors such as muscle motion , movement of heart muscles and also the motion resulted from blood vein's pulses and unbiological sources including measurement instruments , the interference of electricity in the town and surrounding environment .They are also because of movement of electrodes and recorder including circuits.

Maximum range of EMG signal which is acceptable, is 1mV.In designing the EMG recorder,because the frequency bandwidth is usually in the range of 25-1000 HZ , so a high pass and a low pass filter are used in order to bring the signal level to a valid level to present .We expect to reach a gain around 1000.EMG signal in comparison with EEG,ECG and EOG signals has wider frequency range and,covers lower frequencies range compared to others.

Evaluation the components of EMG circuit

Ad623n

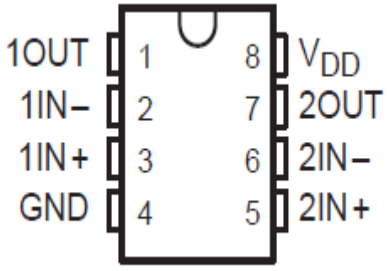


This low noise amplifier is placed in first level of circuit .This accurate differential amplifier has used to amplify EMG weak signal which as said above , this signal value is of the order of mV.

1. Input resistance of differential and common mode is equal to 2 $G\Omega$
2. Input bias current is equal to 25 Na
3. Offset voltage is equal to 25-200μV and also has the gain value about 5-10 and the CMRR is equal to 84-90 dB
4. Only by using an output resistance the control gain value is adjustable
5. This circuit is protected against external noises

In this circuit we have used this IC in order to amplify signals in gain value equal to 2.5 .

Tlc 2272



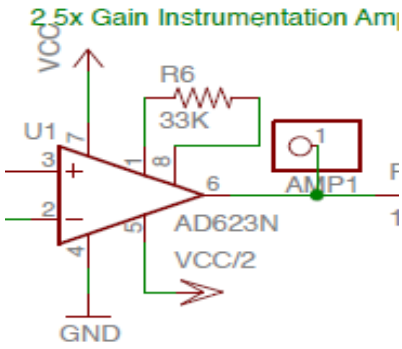
In the second level of this circuit , IC has been used as low noise and low input impedance and also used as high-pass and band-pass filter to remove the noise .In addition to providing appropriate signal amplifying recordable electrical waves in muscles are so weak and their range is relatively between 10-1000 μV .

EMG Prob :

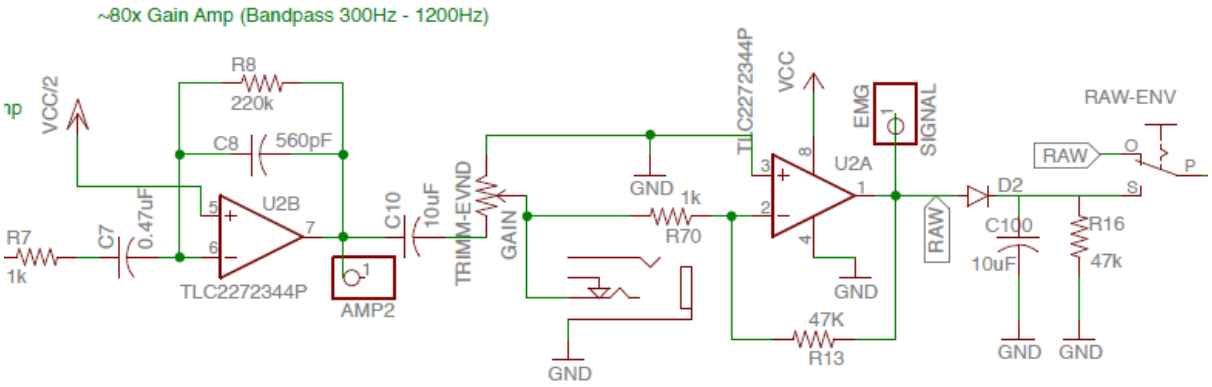
Vital potential electrodes provide the mediator action between human body and electronic measurement system in order to measure and record these potentials .When two electrodes are attached to the amplifier, the offset voltage is seen in the input of the circuit. Regarding the bioelectrical signals weakness ,in comparison with mentioned voltage,It should be improved by tuning the amplifier .Also, because the amplifier is not ideal , so a small amount of voltage with AC common gain appears in output node.So we should use an amplifier circuit, which has a very high CMRR value.

Project description

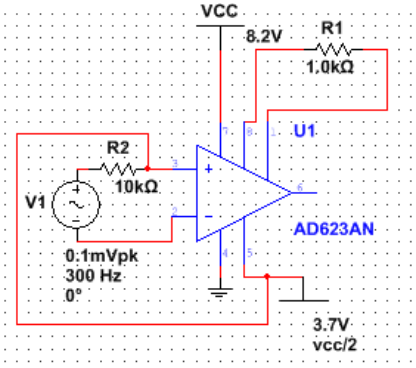
1. At first we start in first level by which activating the Ad623n to provide gain=2.5 and we adjust the below circuit but the circuit did not run like below with signal generator. In order to trigger this level, we tried connecting VCC/2to third probe which we got the appropriate response.

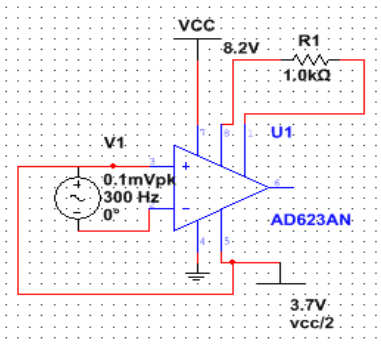


2. Then, we set the second level (Tlc227) so that from this stage, we should provide gain =90 but the resulting gain was equal to 1.



3. In this step, we apply a sinusoidal input to the Ad623n and also we add a V_{reff} to the circuit also we connect this IC to the VCC/2. Therefore, two level had the expected gain. In order to connect this two levels to each other, their VCC voltage of which, were not the same so the output was not appropriate and went wrong. Also, we observed that the Tlc227 is so sensitive to the VCC and VCC/2 voltages even by changing the voltage about just 0.1 V different responses were seen and only worked in a specific point which VCC/2 is not equal to half of the VCC.
4. With changing VCC and VCC/2, we tried to find a value by which, each two level could appropriately work, therefore this point approximately placed in 8.2 and 3.7 V. In this state the circuit by sinusoidal input and signal generator were working but by connecting EMG probe, we could not receive any signal in output.

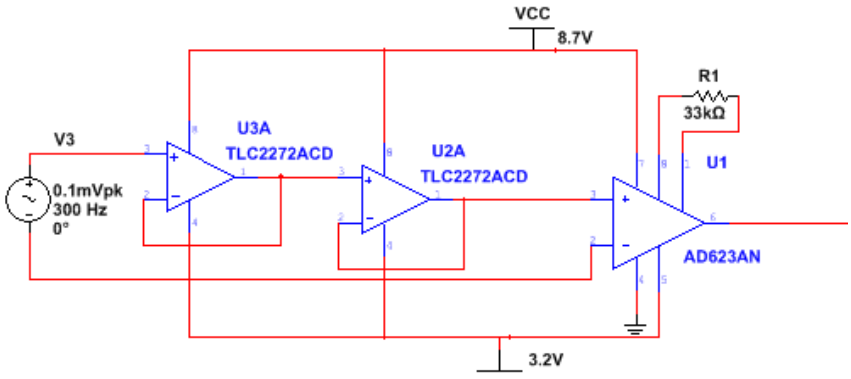




5. We used a 1MΩ resistance to compensate the resistance of the body .When using the sin source in place of EMG probe and also to have noise effect ,our circuit didn't respond and finally by lowering the value of resistance equal to 10K it was applicable provided that ,we increase the input amplitude to about 1V.

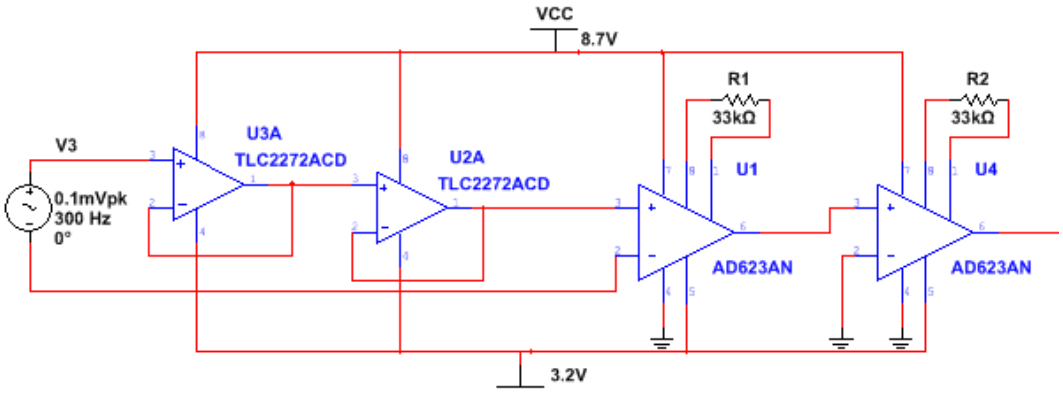
6. After placing in the input a resistance, to supply the Ad623n current instead of using a high resistance we tried a buffer.

7. We observed that, by using only one buffer the current of the circuit couldn't be provided, therefore we use two buffers in Ad623n input and we made the circuit of the buffer using TLC272.

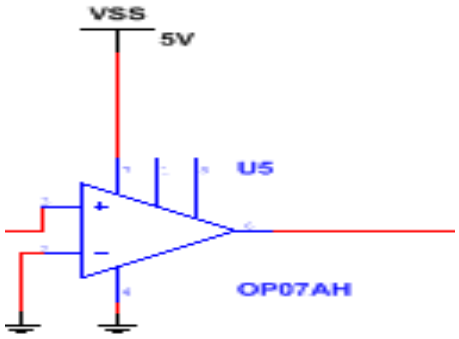


8. In this stage, we connect the buffer's output port to the Ad623,but under this condition ,we could provide better gain from our circuit .Also the circuit had the gain limitation and we couldn't get appropriate gain from it .The output after these two levels ,had good range of amplifying the potential but we saw a high noise in place of its amplifying when we used buffer the circuit function changed, in other words, the circuit damped the output instead of amplifying.

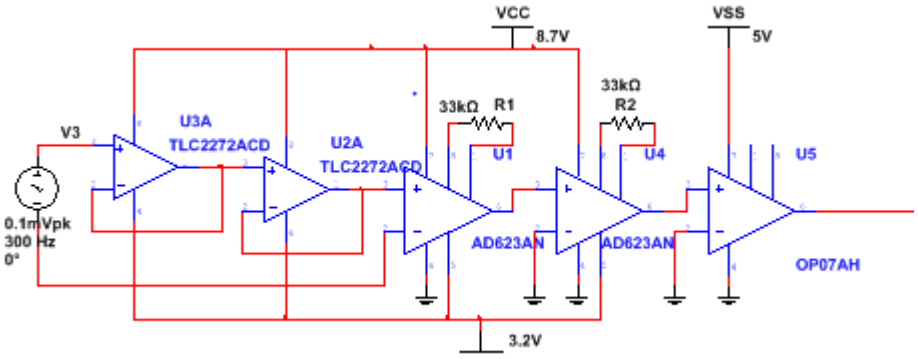
When a 100Ω resistance was put in parallel with the capacitance in the filter level ,the resulted gain should be equal to 600-700 theoretically but the signal was weakened.



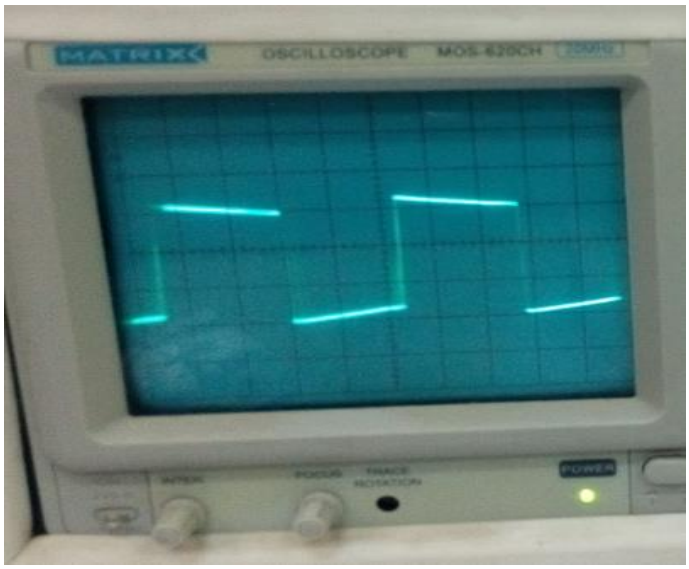
9. In order to resolve this problem , we tried to amplify this output signal but again a problem observed so that our signal was not exactly a sinusoidal signal .Therefore, we tried to put an amplifier stage before this signal using LM348 and TLC272 IC's and also OP07 ,consequently we get the proper response in the domain and created an amplifier with gain value of 10.



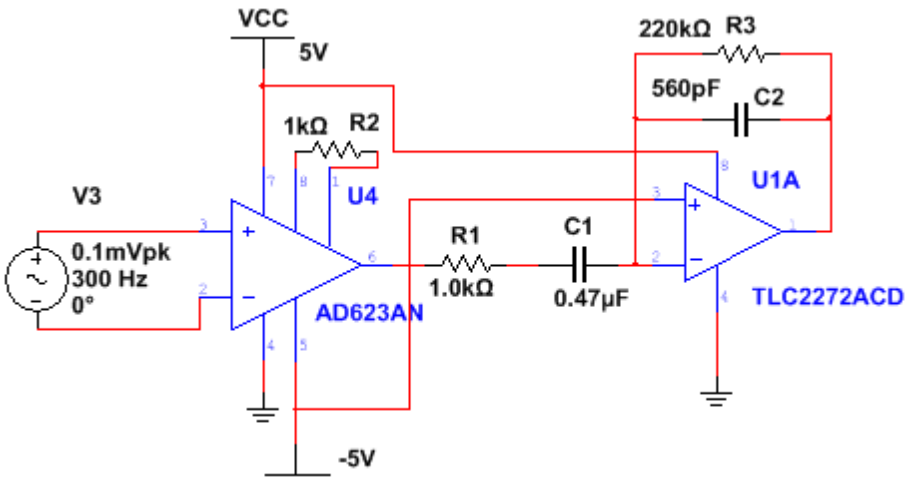
10. When we attached output port of the Ad623n to the input port of OP07, it seemed that the IC didn't turn on so we tried another VCC and as a result we got an appropriate output in low frequencies and we forced to change the gain of this amplifier. We see that acceptable responses are in range of 1Mv-50Mv .



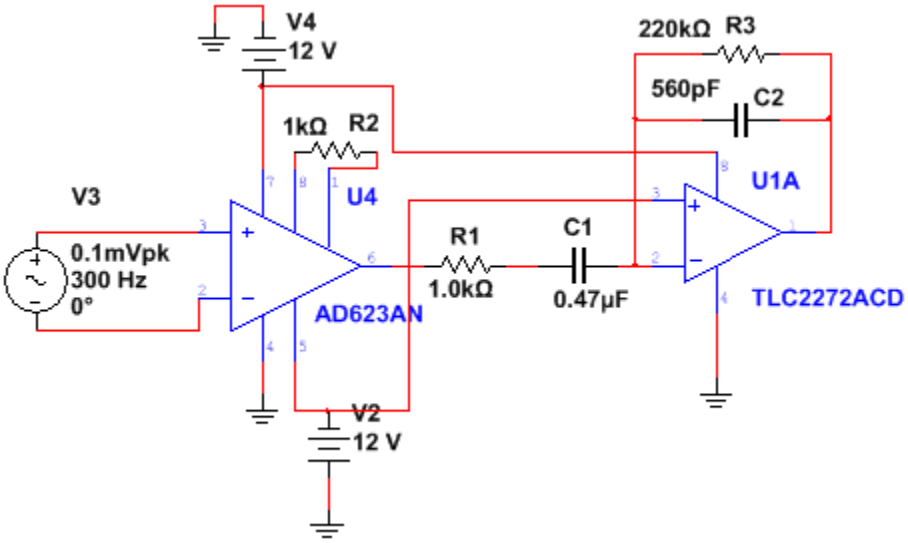
11. Another problem in this experiment was that the Ad623n oscillated (with the frequency of about 220 HZ) when we disconnect the input and also showed no response to the probes which are attached to the body. To solve this problem we connected the Ad623n port 3 to the ground but got nothing.



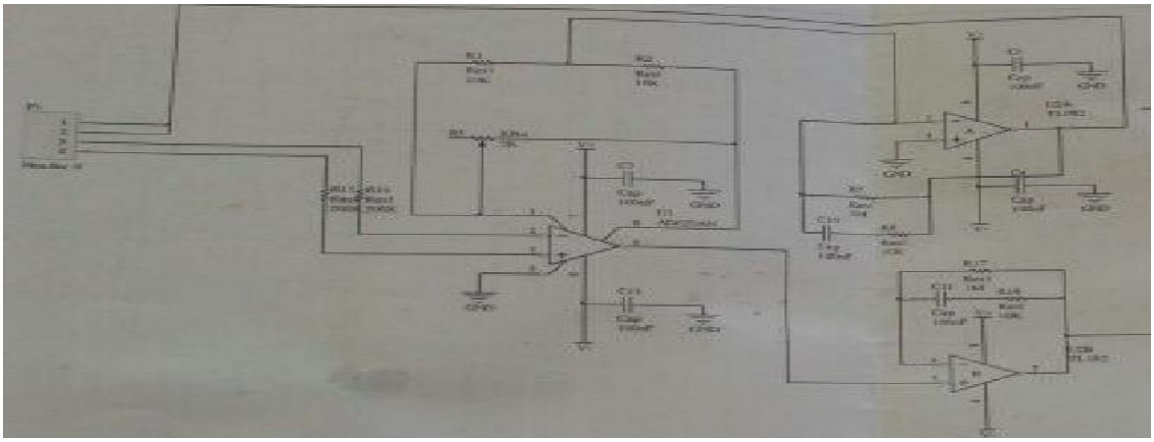
12. After making the changes ,we tried to get response from the probes .Based on some other researches we found out that putting a 1MΩ instead of body resistance and simulating the probes are not correct .So we measured the probe's resistance ,it was about 7Ω.we concluded that Ad623n and buffer are redundant .also, we used +VCC and –VCC instead of VCC and VCC/2 .By changing the gain of the circuit and using function generator (instead of probes) we got the best response.



13. for noise reduction, we used the battery 9V and a 5V regulator and again we didn't get response, and after disconnecting the function generator, the Ad623n oscillated.

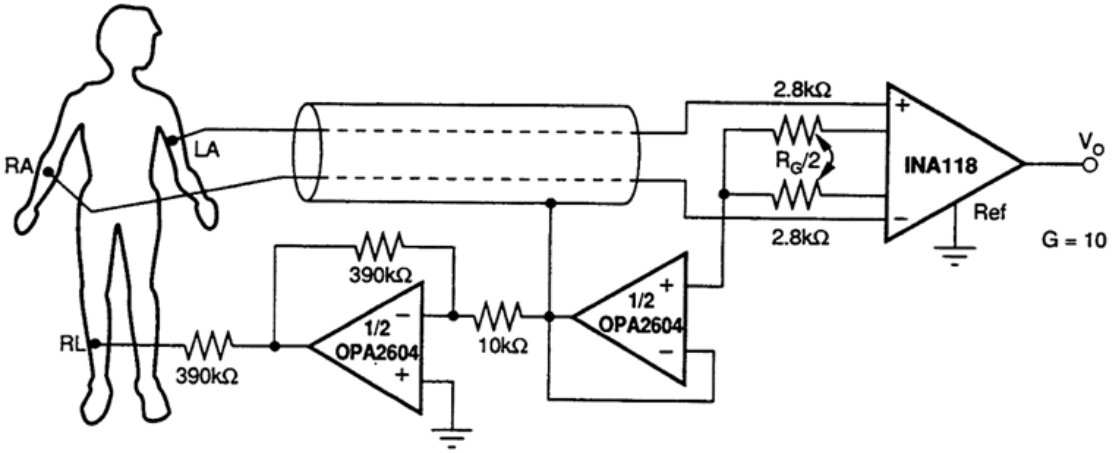


14. So as to the circuit react to the probe and get input from them, we used a mediator circuit named "drive and right leg", which is shown below.

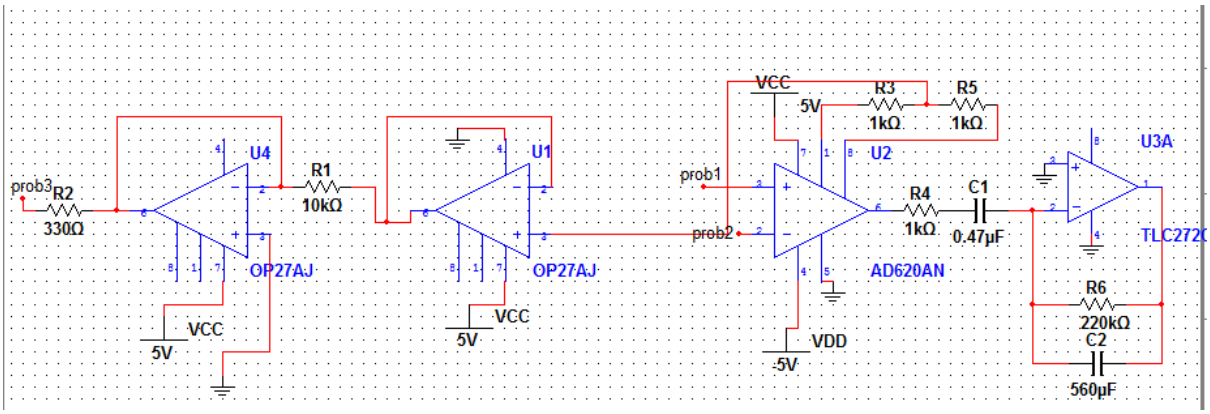


With changing the filters, we observed the signal shown below.

15. Ultimately we were able to observe input but with high noise, which not can be removed by passing through filter. Again, we changed the mediator circuit.It should be mentioned that there wasn't any OP-AMP and IC available so we substituted OP2604 by OP27 and INA118 by Ad623.The result is shown below.



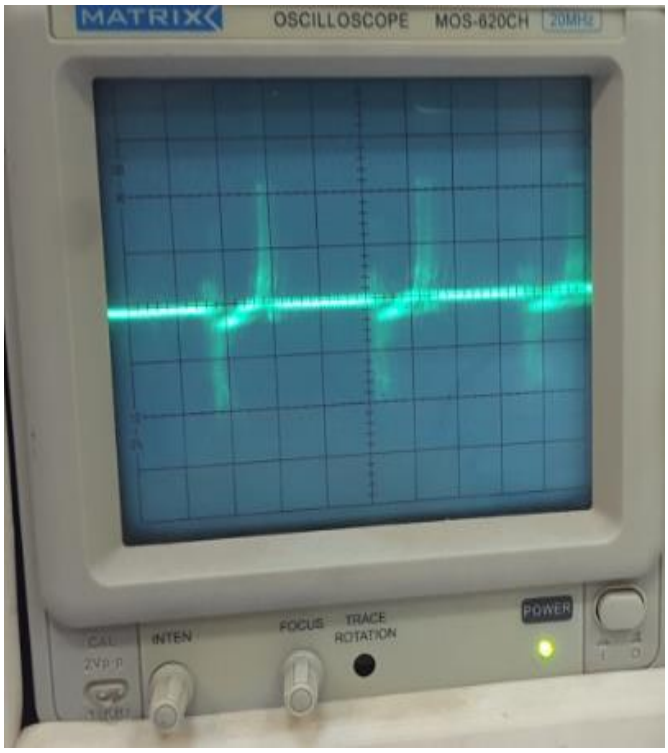
The final circuit, which we got the response from is shown below.

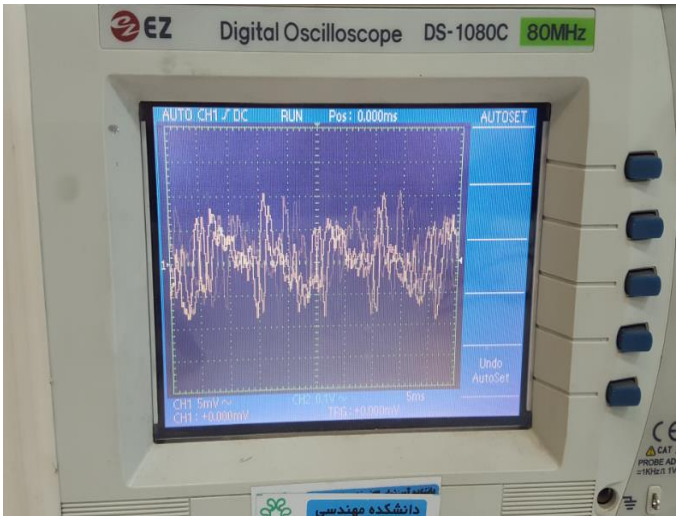


Conclusion

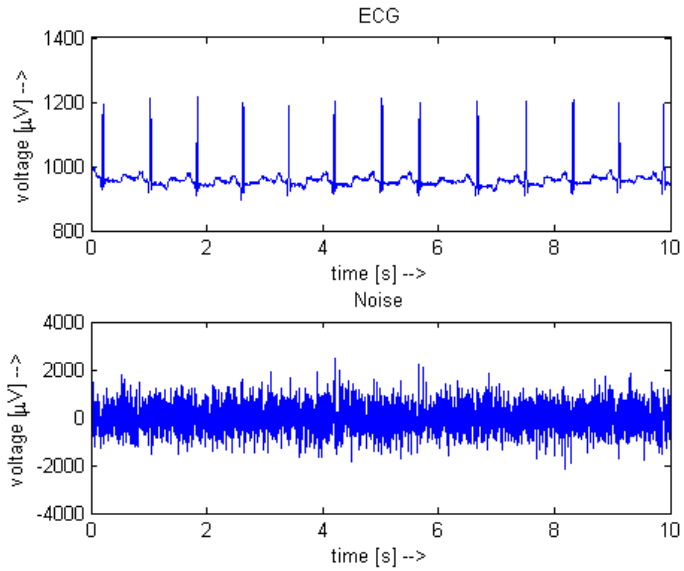
The final result relatively had a low noise level. In such environment where the noise level is high, we should be careful. Noise is mainly due to the incorrect grounding or external equipments.It seems that to solve these problems we can use various filters, which are more accurate and sharper.Different factors are associated with this matters such as physiological Cross-Talk. Adjacent muscles contribute to the EMG signals, which are not higher than 10-15 percent of the EMG total values.Also, the sort of mediator circuit and the probe as well as the experimental environment have the substantial impact on results.

Electrod's quality and internal noise of amplifiers(which are not higher than 5V) may add some signals to the baseline EMG signal.These mentioned factor are adjustable and controlable according to accurate preparing and evaluation of experimental conditions.

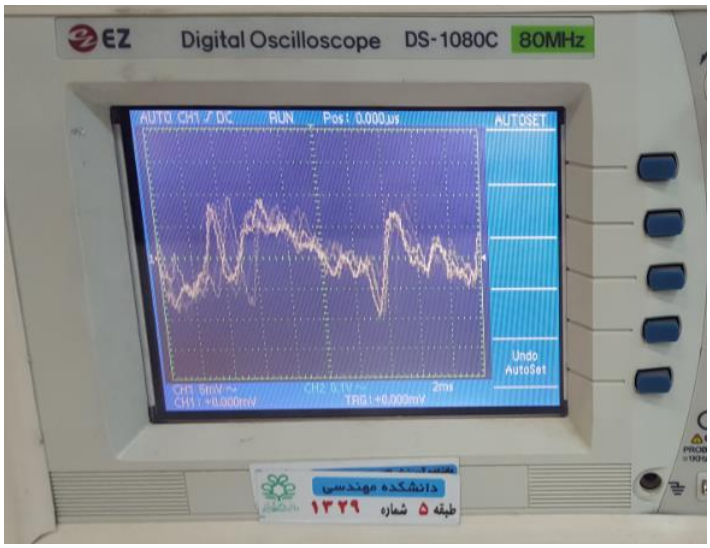




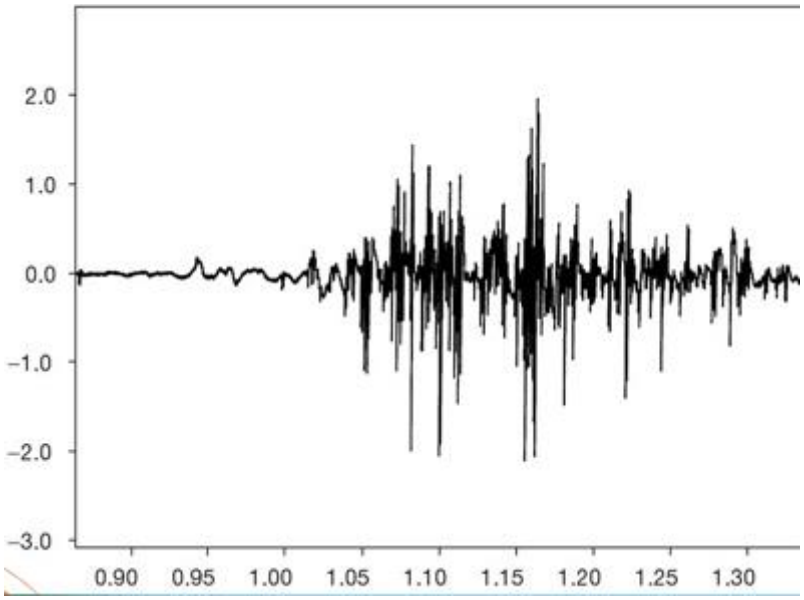
a) The noisy heart signal which was received from our circuit is shown on oscilloscope
b) The noisy heart signal which was received from our circuit is shown on digital oscilloscope



c) An ideal heart signal without noise



a) Muscle's signal which is received from the circuit



b) Noiseless muscle's signal