Chapter Four
System Design

4.1 System Design:

The basic blocks of the whole system is shown in Figure 4.1. The main blocks are microcontroller, motors, motor driver, pickup circuit and EMG signals (electrodes).

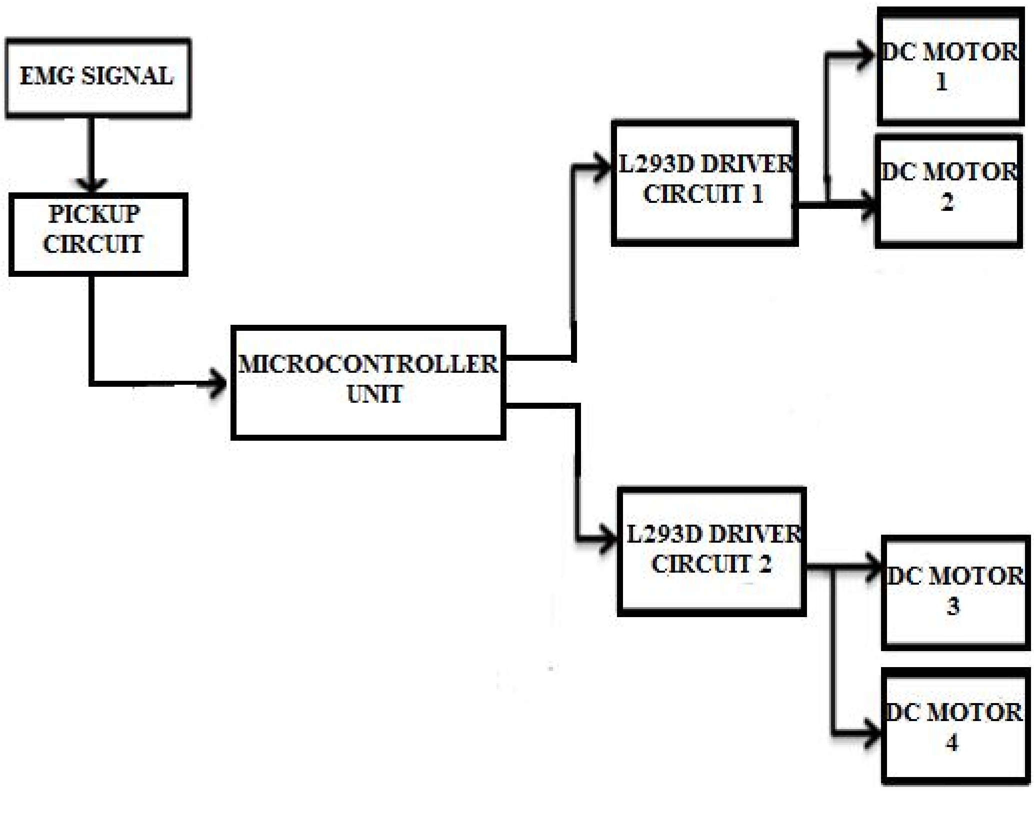

Figure 4.1: Basic block diagram of the system

DC signals from the electrodes are amplified and treated by pickup circuit and were fed to the microcontroller. The whole operation of the system was controlled by microcontroller. The whole code written for the specified operation was burnt into the microcontroller chip. The control signals for motor were provided by microcontroller. Motor driver chip was in between the microcontroller and motors.

A general scheme of the control is shown in figure 4.2. It represents the connections between the microcontroller and all the parts of the prosthesis. From this scheme, we can easily describe the functionality of the product developed. At a first time, the EMG electrodes measure a signal emitted by the contraction of the patient's healthy muscles. Secondly, this signal is treated and sent to the microcontroller. The treatment consists in recovering the envelope of the emitted signal.

After control, the decision-making process allows the signal to be amplified, treated and sent to the corresponding motor. There is one motor for each movement (elbow or hand) of the prosthesis.

The microcontroller in this dissertation was Atmel ATmega16. It has 8 channels 10 bit successive approximation ADC. Port A pins are used as ADC pins. Four ADC channels were used. Port D pins were used to drive the motor. Some pins of port D were connected to input pins of motor controller to control the motor. Port C pins are used to connected LCD display. The four motors for arm up/down and arm clockwise/anticlockwise were connected to the output pins of motor driver. There were electrodes. They were used to movement of arm by the motors. The electrodes are read signals of muscles and send the signals to microcontroller. So the microcontroller makes action according to the signal fed by electrodes.

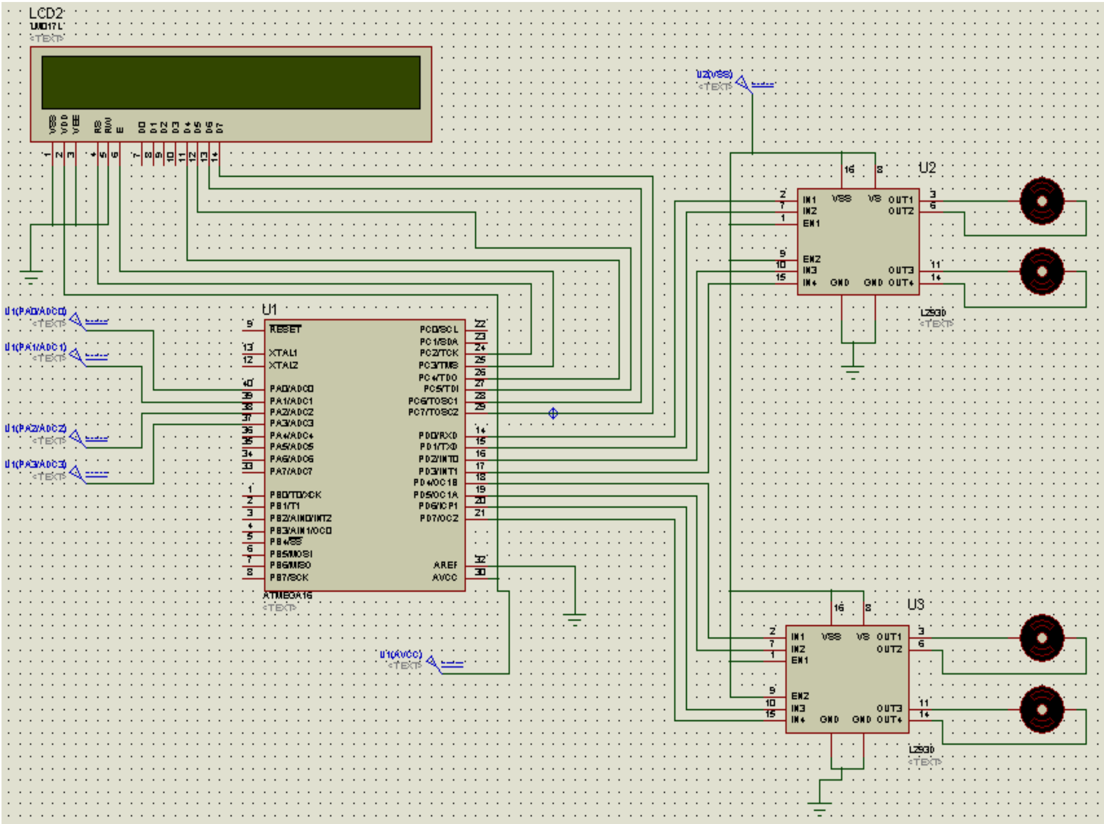

Figure 4.2: Connections between the microcontroller and all the parts

The logic of the software is detailed below:

(i). The direction of rotation of motors can be varied by changing the inputs to the corresponding L293D driver. An input Combination of 1, 0 or 0, 1 results in the motor rotating clockwise or anti-clockwise direction whereas an input combination of 0, 0 or 1, 1 will result in stopping of the motor.

(ii). The arm motors are connected to the PORTD pins (4, 5) for up/down hand and pins (6, 7) for clockwise/anticlockwise hand. To move motor in the forward direction by giving an input of 1, 0 and rotate in the anti-clockwise direction by giving an output of 0, 1 and then stop the motors after a delay.

(iii). The elbow motors are connected to the PORTD pins (0, 1) and pins (2, 3) respectively to up/down and clockwise/anticlockwise elbow. To move motor in the forward direction by giving an input of 1, 0 and rotate in the anti-clockwise direction by giving an output of 0, 1 and then stop the motors after a delay.

(iv). Above steps are repeated continuously in order to achieve the continuous movement.

4.2 Movement of Arm:

4.2.1 Arm Up/Down Movement:

When level of the dc signal is below 1volt the (arm or elbow) up/down motor should be at rest. The movement of motor for the (arm or elbow) up/down movement depends on the signal voltage:

- If the signal between 1volt and below or equal 2volt the (arm or elbow) up/down motor will move to up movement.
- If the signal between above 2volt and below or equal 5volt the (arm or elbow) up/down motor will move to down movement.

4.2.2 Arm Clockwise/Anticlockwise Movement:

When level of the dc signal is below 1volt the (arm or elbow) clockwise/anticlockwise motor should be at rest. The movement of motor for the (arm or elbow) clockwise/anticlockwise movement depends on the signal voltage:

- If the signal between 1volt and below or equal 2volt the (arm or elbow) clockwise/anticlockwise motor will move to clockwise movement.
- If the signal between above 2volt and below or equal 5volt the (arm or elbow) clockwise/anticlockwise motor will move to anticlockwise movement.

4.3 Pickup circuit:

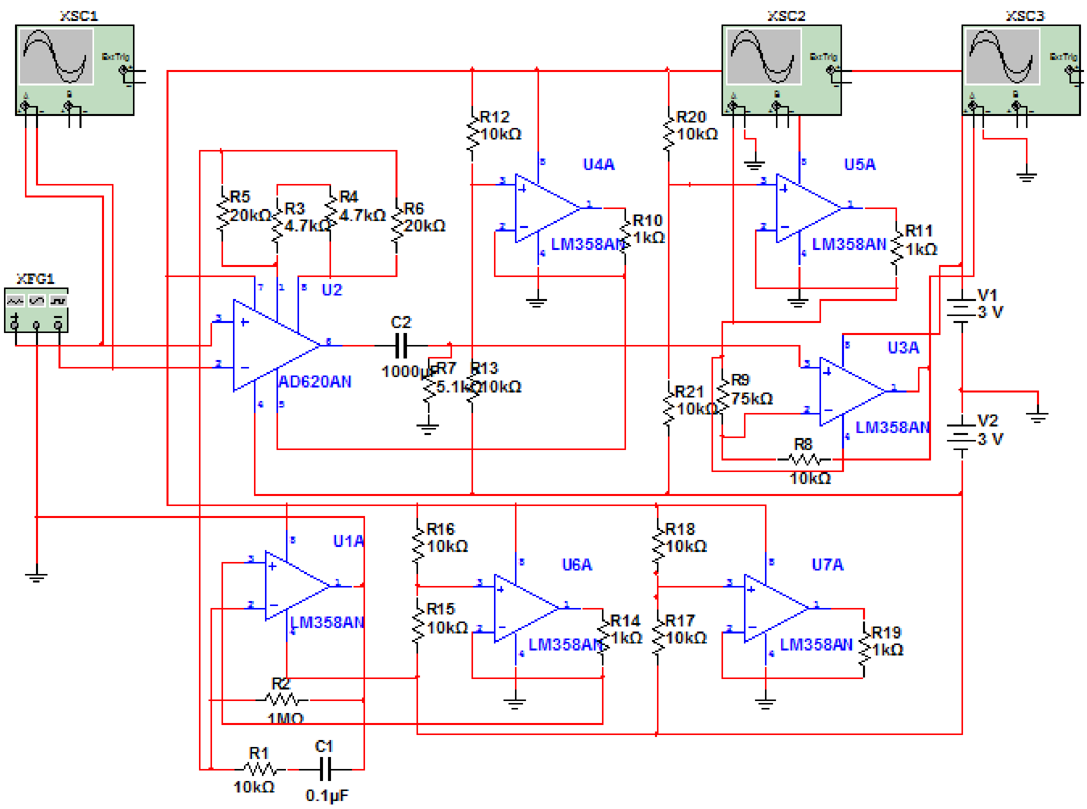

Figure 4.3: Pickup circuit diagram

The pickup circuit diagram as shown in figure 4.3 above. This circuit build to pickup the electrical potential of muscles. The EMG signals acquired are first sent to the instrumentation amplifier, then to the band-pass filter (low and high filters). The output from this circuit will be fed into the microcontroller.

- ***The Instrumentation Amplifier:***

The first stage of the system is an instrumentation amplifier which receives inputs from the two electrodes attached to the muscles. The instrumentation amp has very high input impedance and doesn't require impedance matching which makes the design simple and efficient. The output of the instrumentation amplifier will be a signal consisting of the signal we are interested in between 50-500Hz and noise which is spread over the entire spectrum of frequencies.

- ***The Low Pass Filter:***

The low pass filter is designed to remove frequencies that are above 500Hz. The low pass filter removes the frequencies above 500Hz because that is above the maximum signaling rate of the nerves in human muscles. Therefore any energy in frequencies above 500Hz is noise and will degrade the overall performance of the system if it is not removed.

- ***The High Pass filter:***

The high pass filter is filters out frequencies that are below 50Hz because we know that they are noise. Putting a low pass filter and high pass filter effectively creates a band pass filter that only allows frequencies between 50-500Hz to pass through without attenuation; which is the range of frequencies human nerves can transmit signals.

4.4 The flowchart:

The flowchart shown in Figure 4.4 describes the flowchart of the proposed software.

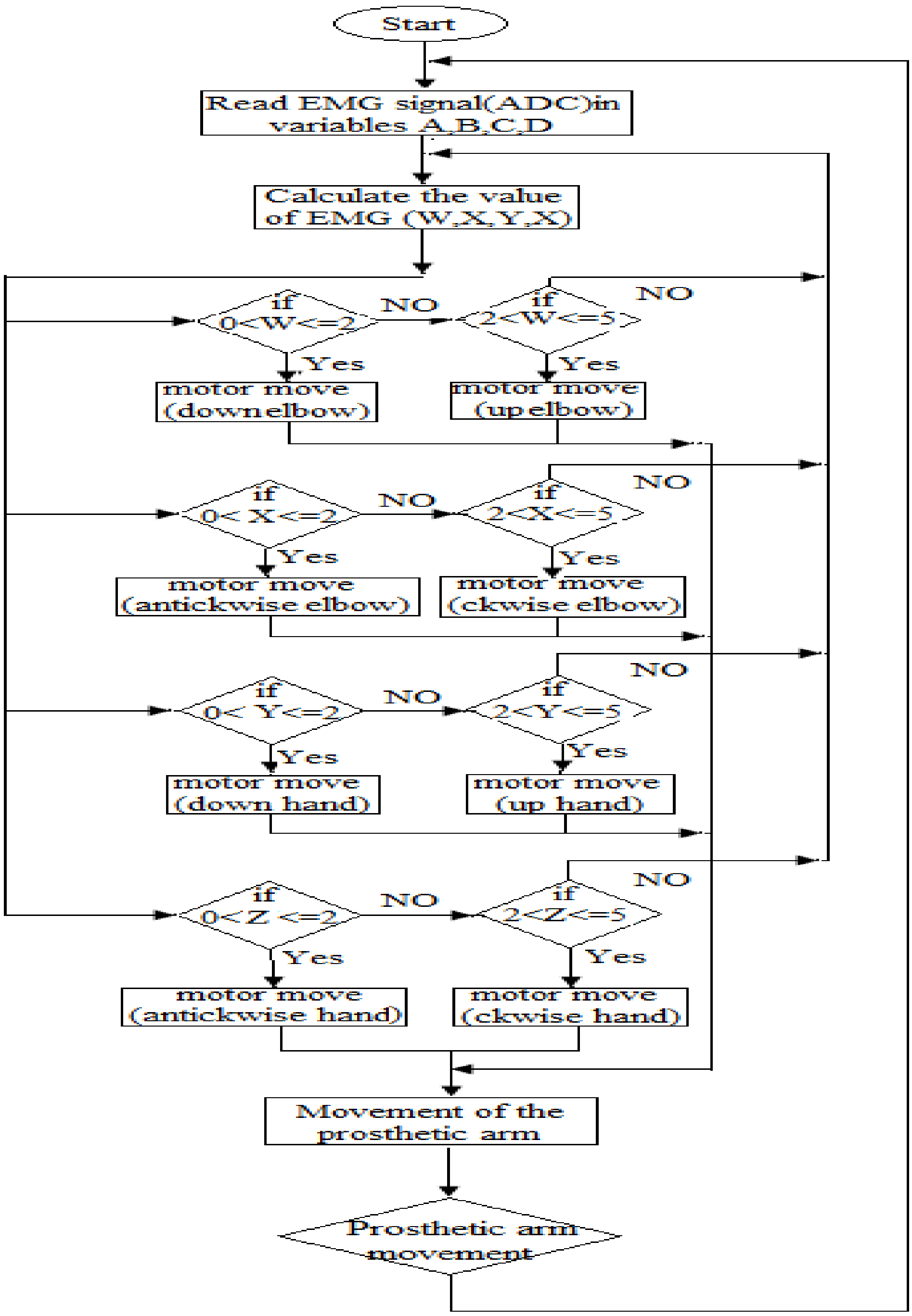

Figure 4.4: Flowchart