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Design of Special Purpose Printed Circuit Board (Or -CADD Designing) for E.M.G. Signal Controlled Artificial Arm

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Abstract

An electromyogram (EMG) signal is the signature of a muscle contraction by which our limbs can be moved. When part of a limb is lost due to any reason, there will be no hardware but muscular signals are still there. An amputee person can then used those muscular signals to activate a myoelectric prosthesis and able to produce some movements. Myoelectric prostheses are capable of many degrees of freedoms. This paper presents a design of hardware for artificial arm controller. But some problem of delays and prosthesis mismatching occurs at time in performing some daily activities. Using this hardware the patients can save time and get quick response. On-board microcontroller controlled joints are making prosthetic arms and legs more responsive and easier to control by the user.

Keywords: ***Electromyogram (EMG) signal, EMG-based control, Motor Unit Action Potential (MUAP), Myo-Electric Arm***

1. Introduction

Biomedical signal means a collective electrical signal acquired from some organs that represents a physical variable of interest. A person who has lost his natural limb but EMG signal is still present in the remaining part. This signal is normally a function of time and is describable in terms of its amplitude, frequency and phase. The EMG signal is a biomedical signal that measures electrical currents generated in muscles. EMG signal is a complicated signal, which is controlled by the nervous system and is dependent on the anatomical and physiological properties of muscles. The shapes and firing rates of Motor Unit Action Potentials (MUAPs) in EMG signals provide an important source of information for the diagnosis of neuromuscular disorders. Muscle tissue conducts Bioelectrical potential called as muscle action potential. Surface EMG is a method of recording the information present in these muscle action potentials.

Two types of electrodes have been used to acquire muscle signal, invasive electrode and non-invasive electrode. When EMG is acquired from electrodes mounted directly on the skin, the signal is a composite of all the muscle fibre action potentials occurring in the muscles underlying the skin.

A person who has lost his natural limb has no hardware to do daily activities. Once appropriate algorithms and methods for EMG signal analysis are readily available, the nature and characteristics of the signal can be properly understood and hardware implementations can be made for various EMG signal related applications. Work has been done to the enhance traditional control schemes and more advanced methods based on machine learning techniques. There are some problems for research to make a comfortable artificial arm to patient and control the movement of artificial arm to get quick response for movement.

2. Methods

The most commonly used prostheses are body powered. These devices capture remaining shoulder motion with a harness and transfer this movement through a cable to operate the hand, wrist, or elbow. With this control method, only 1 joint can be operated at a time. Myoelectric prostheses use the EMG signal to control motors at arm joints.

The biceps and triceps muscles control the elbow, wrist, and hand movements. The EMG signal is first picked up by electrodes and amplified. Signal must be processed to eliminate low or high frequency noise, or any other factors that may affect the outcome of the data. The point of interest of the signal is the amplitude, which can range between 0 to 10 m volts (peak-to-peak) or 0 to 1.5 m volts. The frequency of an EMG signal is between 0 to 500 Hz. However, the usable energy of EMG signal is dominant between 50-150 Hz. The design of an intelligent prosthesis, for arms, involves a lot of issues that have to be solved if good results must be achieved. We have to focus our efforts on the prosthesis' hardware quality and patient's comfort to use such prosthesis.

2.1 Design Consideration

The designed hardware implements the EMG signals acquisition and process functions. The data amplification and acquisition module acquires signals from electrodes, amplifies them and implement the preprocessing functions. The output of this module is a digitized signal. The patient EMG signals are acquired by using two electrodes. These signals are amplified by the EMG amplification block. Signal is converted into digital form, then processed, time multiplexed and sent to microcontroller and output of microcontroller is used to run the different motors attached to the Myo-Electric Arm for different degree of freedoms. Here we are concentrating on four motors for different motions.

2.2 Schematic Design

ADC is used to convert analog signal to digital output. ADC 0804 is taken for this purpose. There is choice to comparator also, but for shake of better result ADC is taken. Now the signal has to be synthesized using ATMEL series microcontroller AT 89C51. Output of micro-controller is given to motor drivers L298. Stepper motors with step angle 7 degree is rotating at rent modes. Three regulators LM7815, LM7915, LM7805 are used for power suppliers I.C. devices.

2.3 Microcontroller Section

Choose microcontroller of ATMEL series AT 89S51. This is 40 pin (I.C.) controller. Pin 9th is RESET pin to controller and reset circuit is made to it work with resister (10 kilo ohm), capacitor (104uf) and given power supply of +5volts through net allias. Net allias is local name of net on the same page. For NET ALLIAS go to pin which is to be connected to other, from place wire tool click on it and extend some wire from both pins. Click on net allias on the place part tool, a box is on the screen, give name +5volt to that wire which is to be connected to another wire. Click on both the wires, name given to connection is shown in box on both the connecting wires. Pin 18th and 19th are connected to OSCILATOR 11.0592 MHz. Through two capacitors of 33 pf capacity and then grounded. Pin 31st and 40th are given +5volt power supply.

Port 0 is connected with SIP (P 0.0 - P 0.7). Pin 20th is GROUND PIN so grounded. Pin 5,6,7,8,10,11,12,16,17,29,30 are of no use so marked cross from tool pallet on right hand side. Pin 2,3,5 of A.D.C. are net alllias with P3.4,P3.5,P3.6 of microcontroller also pin 11 to18 of A.D.C. are connected through net allias with port 2 to all pins of microcontroller from P2.0 to Microcontroller pin P0.0 to P0.7 and P 1.0 to P1.3 are net allias with Pin 5, 7, 10, 12, 6, 11 of each motor driver

2.4 A.D.C. Section

Place A.D.C. (20 pin I.C.) from place part tool and connect to connector which is output of low pass filter to A.D.C. pin 6th. Pin 1st and 4th are connected through capacitor and pin 19th and 4th are connected through resister of value 10 kilo ohm. Pin 7th, 8th and 10th are shorted and grounded. Pin 20th is given power supply of +5 volt by NET ALLIAS. Pin 11to 18 are net allias with pin P2.0 to P2.7. Also pin2,3 and 5 are net allias with pin P3.4, P3.5 and P3.6 . Pin 9th is of no use so marked cross from tool pallet.

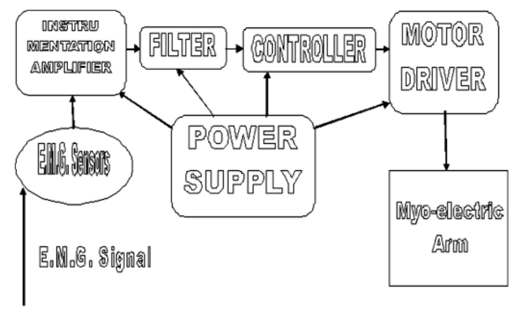
2.5 Power Section

There is need of power supply to each component to work. As operational amplifier need +15 volt and -15 volt to operate. Also there need +5 volt power to operate microcontroller, motor drivers and A.D.C. Diodes are employed to get D.C. power.
Power regulators LM7815, LM7915 and LM7805 for
+15volt, -15 volt & +5volt power.
Power can be given from battery.

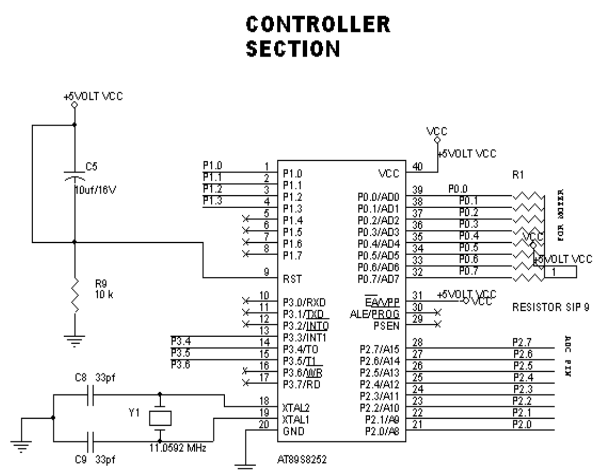
2.6 Motor Section

Now two motor drivers are placed. One driver can drive two motors. They have pin 9, 4 connected to +5volt power supply and pin1, 15 shorted and grounded also pin 8 is grounded of each L298. Pin 2, 3, 13, 14 are connected with two pin two connectors of each L298. Pin 5, 7, 10, 12, 6, 11 of each driver is net allias with controller pin P0.0 to P0.7 and P 1.0 to P1.3.

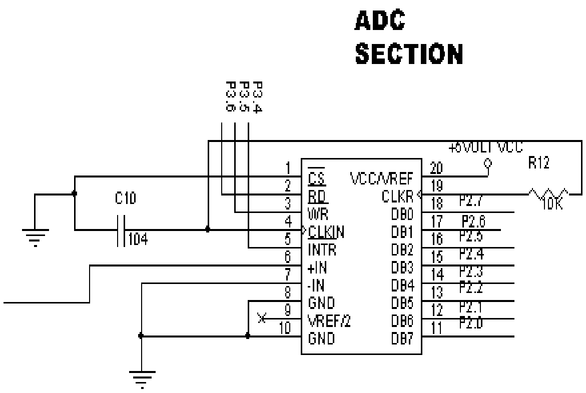
3. Figures



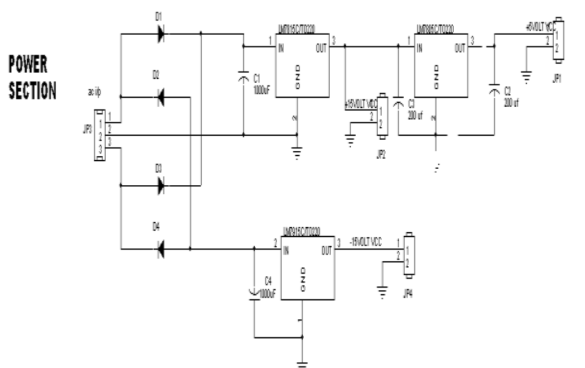
(Fig. 1 Block Diagram)



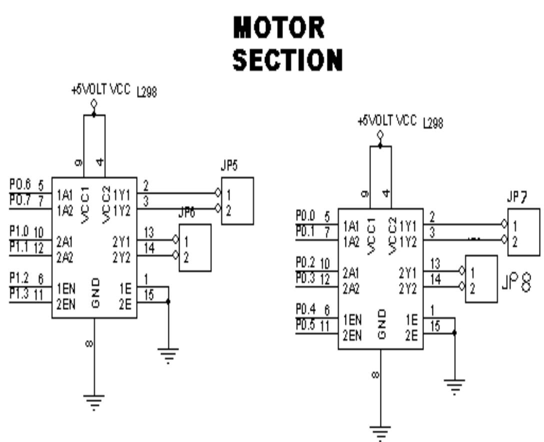
(Fig. 2 Microcontroller)



(Fig. 3 A.D.C.)



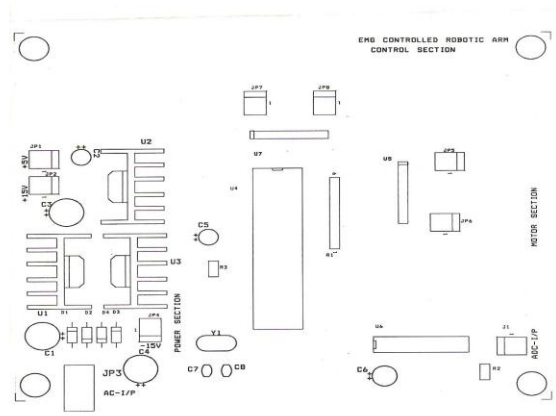
(Fig. 4 Power Supply)



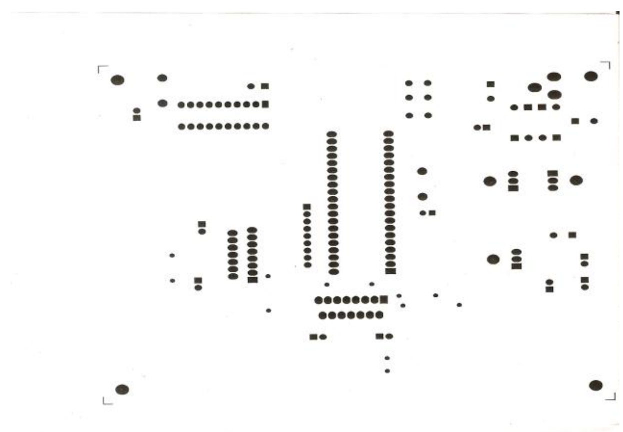
(Fig. 5 Motor Drivers)

4. Conclusions

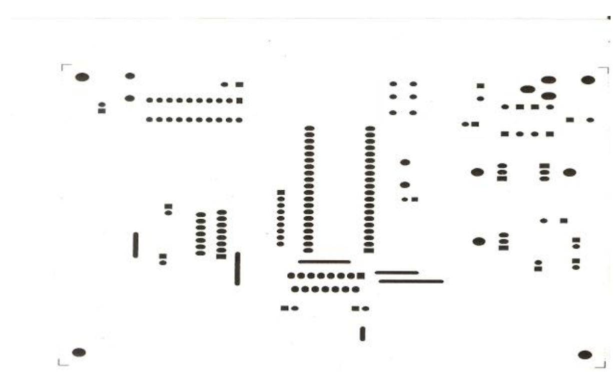
In the designing of P.C.B. Layout Outlooks are obtained as:



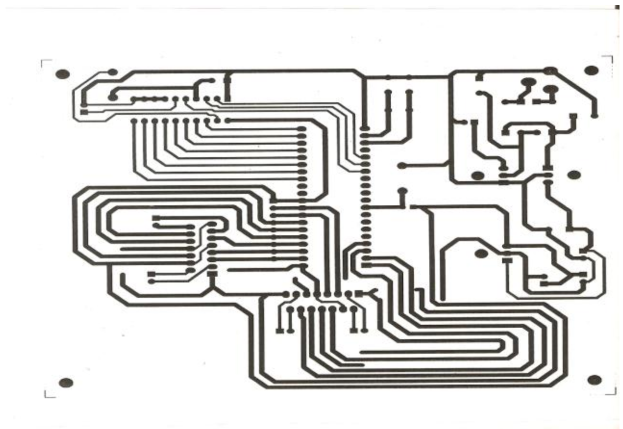
(Fig. 6 Silk Screen Top)



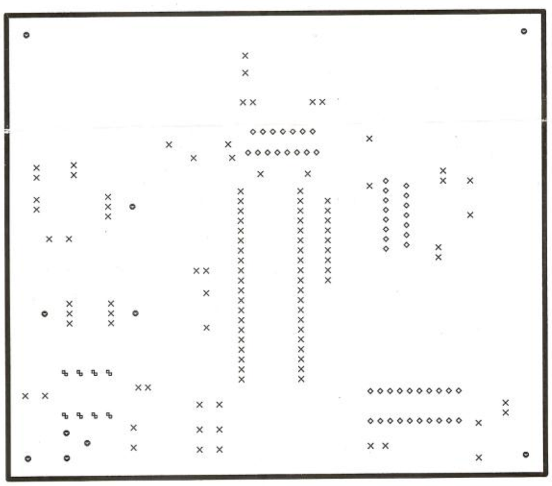
(Fig. 7 Solder Mask Top)



(Fig. 8 Top Layer)



(Fig. 9 Bottom Layer)



DRILL CHART				
SYM	DIAM	TOL	QTY	NOTE
×	0.032		108	
◇	0.039		50	
◦	0.047		8	
⊙	0.120		10	
	TOTAL		176	

(Fig. 10 Drill & Drill Chart)

On applying the signal stepper motors rotation with step angle 7 degree is rotating at different modes.

Programming for microcontroller is done in the Embedded "C" to run the motors. When electrodes are placed properly at the upper arm of amputee, following results are observed.

1. While moving arm, up &down:	4th motor is running
2. While moving hand left & right:	2nd motor is running
3. While capturing the weight:	3rd motor is running
4. While releasing the weight:	1st motor is running

It is observed that all motors are running with quick response so hardware and circuit is much suitable for prosthetic Arm control than a general purpose PCB.

The EMG signal is easily acquired and processed by EMG sensors and amplifiers. The work so far reported is the beginning of the development of a system intended to assist people suffering of Neuro-motor diseases, including people with severe dysfunctions. A person who has disability of prosthetic limb will be beneficial by this hardware. On implementing this hardware on artificial arm, this hardware response to the movements will be fast. Disable person will feel better control on the Myoelectric Arm for his daily activities.

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