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Myoelectric Prosthesis using PIC16F877A Microcontroller

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Abstract – *A prosthetic limb is an artificial limb that functionally replaces the missing arms or legs that have been lost due to any injury or disease. Advancements in electronics have made these devices easier to operate and better able to mimic the normal function. This paper deals with embedding electronics to biological science. Voltage difference due to the activation of muscle groups can be easily detected using surface electrodes. The potential difference is amplified and fed into the microcontroller. The controller unit takes the analog input signal at the analog port of the controller. The controller has an inbuilt Analog to Digital Converter which converts the input analog signals to the equivalent voltage signals in digital form. The digital signals would then be processed and passed to the servo motors. The signal amplitude actually decides which servo motor is to be run which in turn decides the finger to be moved or the action to be performed.*

Key Words: Prosthetic, Electrode, Electromyography, PIC, ADC, PWM

1. INTRODUCTION

Myoelectric prosthetic devices are operated by electrical signals sent from the brain to muscles in the arm that tell the device how to move. Electrodes are placed on the specific muscles in the remaining part of the limb. When muscle groups are contracted or relaxed, there is a voltage difference in the order of a few millivolts. This difference can be easily taken by using surface electrodes. The potential created by muscle activity generally lie in the range of 20-2000μV. This voltage is depends on the electrode, placement of electrode and the muscle unit selected. The potential levels of electrodes are fed to an Instrumentation Amplifier (INA), which amplifies the difference, eliminating noise due to surface impedance and finally fed into the microcontroller.

The proposed system is divided into 3 parts

1) Acquisition of EMG signal and processing.
2) Interpretation of the input signal and decision as output signal by a controller
3) Connection of the output signal to the mechanical system.

The Fig-1 shows the basic block diagram of the proposed system.

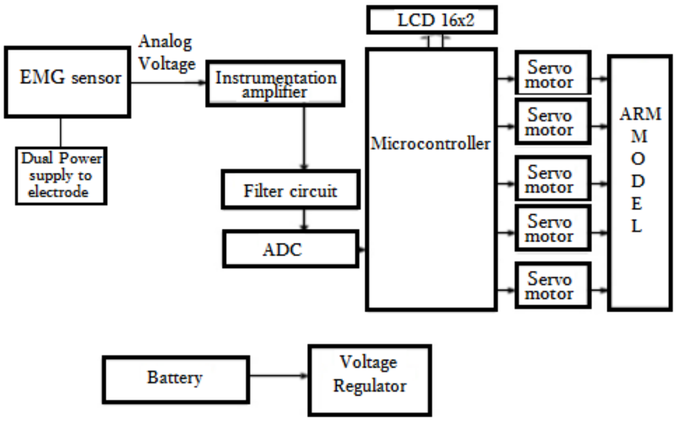

Fig -1: Block diagram

1.1 Basic mechanism of muscle contraction

It is because of the placement of the muscles that we can move. When muscle contracts, it pulls on the bone that they attach. Individual muscles can only pull in one direction and thus the Muscles work in opposite pairs.

When the biceps in the arm contracts; the triceps relaxes causing bending of the arm. When the triceps in the arm contracts; the biceps relaxes causing straightening of the arm.

1.2 Electromyography

Muscle contracts when it gets stimulation in the neuromuscular junction through a motor neuron. The method of recording nerve signals which comes from brain to the muscle fibers is called electromyography. Whenever a muscle is contracted, the EMG sensor senses a nerve signal. Surface EMG sensors and implantable sensors are the two types EMG sensors. It is traditionally been used for medical research and diagnosis of neuromuscular disorders. EMG sensors, Integrated circuits and microcontrollers have been used in prosthetics, robotics and other control systems.

1.2 Arm Movement controlling section

There are 5 servo motors connected to the controller unit. Each servo motor controls a single finger of the hand. The servo motors are actually controlled by the outputs received which are equivalent to the analog inputs received from the EMG unit. The PIC microcontroller contain 10 bit ADC which converts this EMG signal to its corresponding digital value. The control of motor is done using this digital value.

2. SIMULATION OF THE SYSTEM

Simulation of the complete system is done by the software Proteus 8 Professional and mikroC PRO for PIC. The 16F877A is a capable microcontroller that can do many tasks because it has a large enough programming memory (large in terms of sensor and control projects) 8k words and 368 Bytes of RAM. This is enough to do many different projects. Among the peripheral features of PIC here we have used the Port programming, ADC programming, LCD programming and PWM programming.

2.1 Analog to Digital Conversion

In this section the analog signal from EMG module is intended to be converted to its digital value for controlling the servomotor. For the purpose of simulation here we used variable potentiometer for giving different voltages. Digital value as well as the voltage is displayed on the LCD provided.

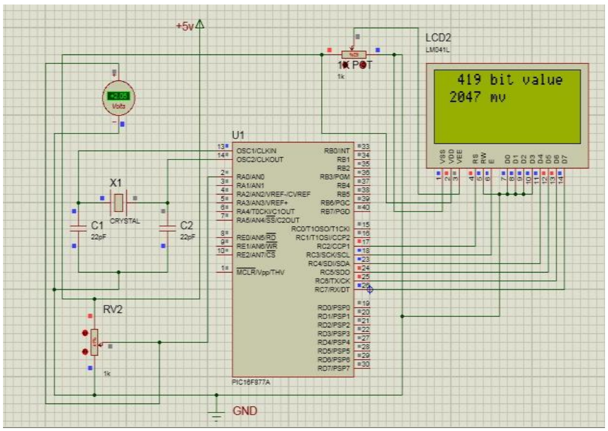

Fig-2: Analog to digital conversion and display

2.2 PWM generation using CCP module

PIC16F877A microcontroller has two CCP (Capture Compare PWM) modules which is capable of generating PWM signals. Waveform with different duty cycle can be obtained through programming.

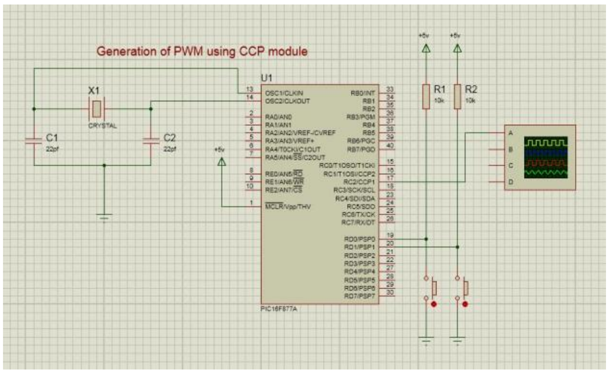

Fig-3: PWM Generation using CCP module

2.2 Servo motor controlling

Each servomotor gets waveforms with specific duty cycle depending on the input voltage that will set the degrees of rotation and the speed of the servomotor.

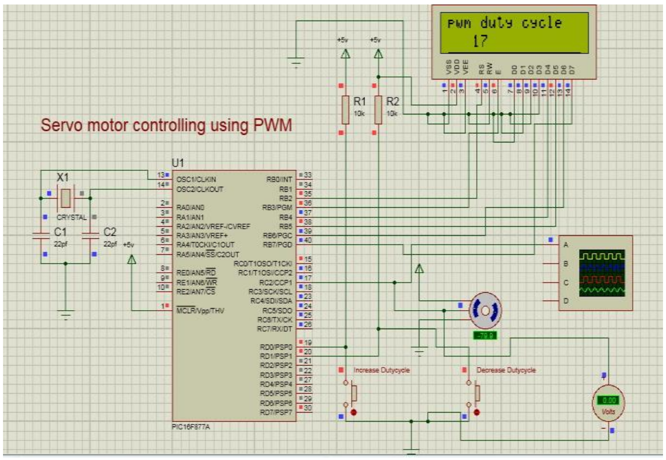

Fig-4 Controlling of single Servo motor using PWM

Figure below shows different PWM control signals.

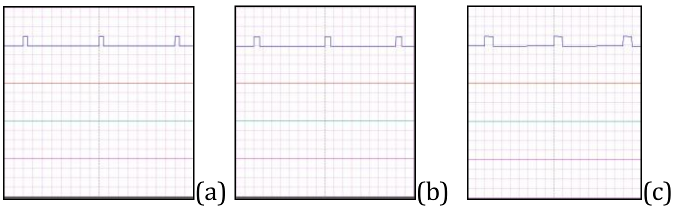

Fig-5: PWM control signals to set degrees of rotation of servo.

The Fig-6 shows the complete structure of the system with 5 servomotors used for the movement of fingers. When the microcontroller gets a specified voltage the five stepper motors runs 90 degree or 180 degrees.

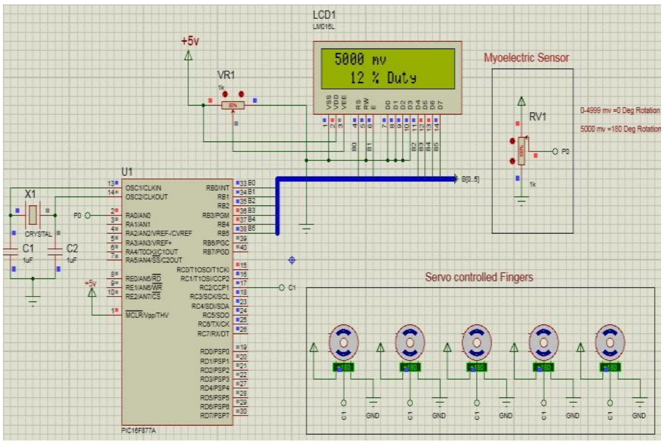

Fig-6: Complete structure of the system

3. HARDWARE SECTIONS

Main hardware sections used in this project are PIC microcontroller, Servomotors, Arm model, EMG sensor module and LCD for display the voltage and duty cycle. Fig-7 shows the setup for the Arm with servomotors.

Fig-7: Set up for the Arm and servomotors

Servomotors are connected to each fingers and rotation of servomotor causes the bending of each finger.

3.1 Microcontroller-PIC16F877A

The controller unit takes the analog input from the EMG module at the analog port of the controller. The controller has an inbuilt 10-bit ADC (Analog to Digital Converter). The converter converts the input analog signals to the equivalent digital form. The digital signals would then be used for the generation of PWM signal to control the rotation of servomotor. The signal amplitude actually decides which servo motor is to be used which in turn decides the finger to be moved or the action to be performed.

Features

The midrange PIC Microcontroller offer several features that help to achieve these goals. The special features include:

- 5 Digital I/O Ports –Port A,B,C,D,E
- Three timer/counter modules
- A 10-bit ADC with 8 inputs
- Two Capture, Compare, PWM modules
- Synchronous Serial Port (SSP) with SPI (Master mode) and I2C (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9- bit address detection
- Parallel Slave Port (PSP) 8-bits wide, with external RD, WR and CS

3.2 Servo motor

The servo motor unit is controlled by the signals from the micro controller unit. The voltage from the EMG sensor decide which servo motor should work. There is one motor for each finger. Position and feedback is obtained since the motor is paired with an encoder. Primarily, only the position is measured. The current position of the output is compared with the required position. The difference in the signal Error signal generated rotates the motor in both directions which is due to the output position which is seen different from that required; this brings the output shaft to the appropriate position. The motor stops since the error signal reduces to zero.

3.3 EMG sensor module

The myoelectric signals for the EMG unit are acquired by surface electrodes that are placed on the human arm. There is a positive unit, a negative unit and a ground unit of electrode placed on the human body. Positive and negative units are placed on the muscle of interest and ground unit is placed on the bones. The acquired signals are given to the signal generating module in the EMG unit.

Fig-8: EMG Unit and Electrodes

The module consists of an inbuilt amplifier, a filter and a rectifier. The module gives an output which is unipolar analog signal that would be in range of Volts. The original signals acquired by the electrode are actually in range of millivolt range. The module processes to give a strengthened signal which is in the range of Volts.

Features

- Small size (1inch X 1inch)
- Specially designed for microcontrollers
- Adjustable Gain – Improved Ruggedness
- On-board 3.5mm Cable Port

3. 4 LCD module

A 16x2 LCD (Liquid Crystal Display) screen is used to display the voltage obtained from the EMG sensor and duty cycle of the PWM signal generated.

3.5 Voltage regulator

The voltage regulators are here used to regulate the DC voltage to a stable voltage level. In this project stable voltages 5V and 12V are required. For this 7805 and 7812 voltage regulators are used.

4. CONCLUSIONS

Accurate measurement of the EMG signal gives accurate operation of the arm. Keeping an eye on technology advancements in the area of reproducing battery and electric impulses there is lot scope for the myoelectric limbs. In future this may have lighter weight, high user operability and an extended battery life, High accuracy and low response time.

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