

# Realization of Bio-Signal Using Arm Processor

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**Abstract:** *The objective of this paper is to study the EMG signals based on hand motions for specified tasks so as to identify the patterns of EMG signals. This work facilitates the analysis of EMG data at several contraction levels with surface electrodes. This will allow therapists to identify weak muscles of patients with motor weakness, such as spinal cord injury (SCI) and post-stroke.*

**Keywords:** Electromyography (EMG), Flash Magic, Motor Unit Action Potential (MUAP), KEIL  $\mu$ vision.

## 1. Introduction

Electromyography (EMG) is an experimental technique concerned with the development, recording and analysis of myoelectric signals. Myoelectric signals are formed by physiological variations in the state of muscle fiber membranes [4]. Recordings of muscle action during movements are useful for nervous system, as well as the instrumentation used for detection of the EMG signal and the process used to record the EMG signals. Variations in any of these processes can affect the character of the signal and the analysis and conclusions drawn from the data. The motor unit action potential is the spatial and temporal summation of the individual muscle action potentials for all the fibers of a single motor unit. Therefore, the EMG signal is the algebraic summation of the motor unit action potentials within the pick-up area of the electrode being used. Unless the electrode is very small, the pick-up area of an electrode will almost always include more than one motor unit because muscle fibers of different motor units are intermingled throughout the entire muscle. Analyzing which muscles and at what times they are active. The electromyogram (EMG) is an electrical manifestation of the contracting muscle this can be either a voluntary or involuntary muscle contraction. The EMG signal is a complicated signal which is affected by the anatomical and physiological properties of muscles, the control scheme of the periphery.

## 2. Materials and Methods

The combination of the muscle fiber action potentials from all the muscle fibers of a single motor unit is the motor unit action potential (MUAP) which can be detected by a skin surface electrode (non-invasive) located near this field. The signal is picked up at the electrode and amplified. Typically, a differential amplifier is used as a first stage amplifier. Additional amplification stages may follow. Before being displayed or stored, the signal can be processed to eliminate low-frequency or high-frequency noise, or other possible artifacts. Frequently, the user is interested in the amplitude of the signal. Consequently, the signal is frequently rectified and averaged in some format to indicate EMG amplitude.

### 2.1 Electrical noise

The amplitude range of EMG signal is 0-10 mV (+5 to -5) prior to amplification. EMG signals acquire noise while traveling through different tissue. It is important to understand the characteristics of the electrical noise.

Electrical noise, which will affect EMG signals, can be categorized into the following types:

#### a) Inherent Noise in Electronics Equipment

All electronics equipment generates noise. This noise cannot be eliminated; using high quality electronic components can only reduce it.

#### b) Ambient Noise

Electromagnetic radiation is the source of this kind of noise. The surfaces of our bodies are constantly inundated with electric-magnetic radiation and it is virtually impossible to avoid exposure to it on the surface of earth. The ambient noise may have amplitude that is one to three orders of magnitude greater than the EMG signal.

#### c) Motion Artifact

When motion artifact is introduced to the system, the information is skewed. Motion artifact causes irregularities in the data. There are two main sources for motion artifact: 1) electrode interface and 2) electrode cable. Motion artifact can be reduced by proper design of the electronic circuitry and set-up.

#### d) Inherent Instability of Signal

The amplitude of EMG is random in nature. EMG signal is affected by the firing rate of the motor units, which, in most conditions, fire in the frequency region of 0 to 20 Hz. This kind of noise is considered as unwanted and the removal of the noise is important.

## 3. Classes of EMG

There are basically three types of EMG now-a-days. They are:

#### 1) Surface Electromyography (sEMG):

Non-invasive technique for measuring muscle electrical activity resulting from contraction and relaxation exercises.

#### 2) Fine Wire Electromyography:

(INTRAMUSCULAR EMG) Invasive technique for measuring muscle electrical activity resulting from contraction and relaxation exercises.

#### 3) Neuromuscular Electrical Stimulation

Burst of electrical pulses stimulates muscle contractions in targeted muscles via electrodes.

## 4. EMG Signal Acquisition

The EMG signals were obtained by using the acquisition system it has different stages. Each stage has different tasks by using acquisition system to detect the signal. There is Instrumental Amplifier, Band Pass filter, Notch filter, Gain stage Amplifier. Electrode converts ionic current from the muscles into the electric current and during the process two types of transducer noises are produced. Direct voltage potential is generated due to the difference in the impedance between the electrode surface and that of the skin, and the alternating voltage, is generated due to the fluctuations in impedance between the skin and the electrode. It can be reduced by using Ag-AgCl electrodes [7]. In order to remove these noises the EMG signal is required to be processed. These processes include preamplification, band limiting and after that the signal becomes usable and is a true depiction of muscular contraction force [8].

## 5. Block Diagram

In this paper different stages are used for acquiring of EMG signal. The below diagram is the block diagram of EMG acquisition system. There are different blocks are here

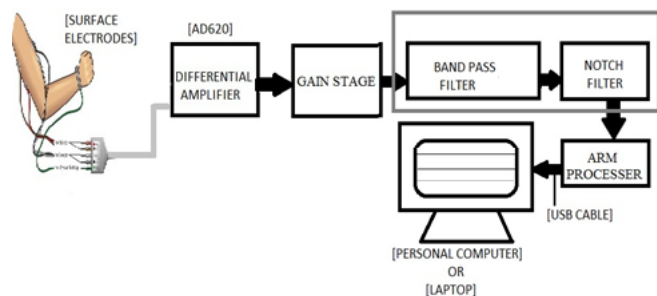


Figure 1: Block Diagram of EMG Acquisition System

## 6. Circuit Description

The electromyogram facilitates in understanding functioning of muscle for medical diagnosis. The block diagram of a typical Myography as presented in the figure consists of

1. Analog block
2. Digital block

### 6.1 Analog block

The analog block consists of the subject with surface electrodes, a differential input stage followed by an instrumentation amplifier and a signal conditioner. The surface electrodes placed at specific places on the body pick up the feeble potential. A differential DC input stage with high common mode rejection ratio is used at the first stage of amplification. A high gain instrumentation amplifier is used to amplify the signal with desired level. A low pass filter is followed by a notch filter constitute a signal conditioner. The ICs that are used in the circuit design are

- LM 741
- AD620 (Instrumentation amplifier)

#### i) AD620:

The AD620 is low cost, high accuracy instrumentation amplifier that requires only one external resistor to set gains of 1 to 1000. The AD620, with its high accuracy of 40 ppm maximum nonlinearity, low offset voltage of 50  $\mu\text{V}$  max and offset drift of 0.6  $\mu\text{V}/^\circ\text{C}$  max, is ideal for use in precision data acquisition systems, such as weigh scales and transducer interfaces.

#### ii) LM 741:

The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

### 6.1.1 Instrumentation Amplifier

The differential input signal-ended output instrumentation amplifier is one of the most versatile signal processing amplifiers available. It is used for precision amplification of differential dc or ac signals while rejecting large values of common mode noise. By using integrated circuits a high level of performance is obtained at minimum cost. It can faithfully amplify low-level signals in the presence of high common mode noise. This aspect of its performance makes it especially useful as the input amplifier of a signal processing system. Other features of the instrumentation amplifier are high input impedance, low input current and good linearity. It has never been easy to design a high performance instrumentation amplifier; however, the availability of high performance IC's considerably simplifies the problem. IC op amps are available today that can give very low drifts as well as low bias currents: however, most of the circuits have drawbacks. The most commonly used instrumentation amplifier designs utilize either 2 or 3 op amps or several precision resistors. These are capable of excellent performance: however, for high performance they require very precisely matched resistor matching and overall gain. Since op amps are now available with exceedingly high CMRR, this is no longer a problem.

### 6.1.2 BAND PASS Filter

Typical band pass frequency ranges are from between 10 and 20Hz (high pass filtering) to between 500 and 1000Hz (low-pass filtering). High-pass filtering is necessary because movement artifacts are comprised of low frequency components (typically <10Hz). Low pass filtering is desirable to remove high-frequency components to avoid signal aliasing. So to eliminate the unnecessary frequencies (i.e. below 20 and above 500 Hz) we are using band pass filter.

### 6.1.3 Notch Filter

A notch filter is a filter that passes all frequencies except those in a stop band centered on a center frequency. The most common example is 50Hz noise from power lines. In every high precision electronic circuits notch filter is included to avoid the noise due to fluctuations in the input supply. A closely related knowledgebase item discusses the concept of the Q of a filter. This knowledgebase item focuses on high Q notch filters- the type that eliminates a single frequency or narrow band of frequencies.

The amplitude response of a notch filter is flat at all frequencies except for the stop band on either side of the

center frequency. The standard reference points for the roll-offs on each side of the stop band are the points where the amplitude has decreased by 3dB to 70.7% of its original amplitude.  $Q$  is the Quality Factor of a band pass or notch filter. It is defined as the center frequency of a filter divided by the bandwidth. The bandwidth is the frequency of the upper 3 dB roll-off points minus the single frequency of the lower 3 dB roll-off point. As the  $Q$  value becomes more the rejection of single frequency becomes more. Does this mean that any  $Q$  is possible? Unfortunately, no. At very high  $Q$  values, the response of the circuit will begin to have overshoot and understood that will destroy the integrity of the notch. The frequency that was supposed to be rejected may actually be amplified.

The twin "T" network is one of the few RC filter networks capable of providing an infinitely deep notch. By combining the twin "T" with voltage follower, the usual drawbacks of the network are overcome. The  $Q$  is raised to something greater than 50. Further, the voltage follower acts as a buffer, providing a low output resistance; and the high input resistance of the op-amp makes it possible to use large resistance values in the "T" so that only small capacitors are required, even at low frequencies. The notch frequency occurs where the capacitive reactance equals the resistance  $X_c=R$  and if the values are close, the attenuation can be very high and the notch frequency virtually eliminated.

## 6.2 Digital Block

The digital block normally consists of a S/H amplifier, an A/D Converter and a digital computer. The S/H amplifier samples the analogue signal at regular intervals and passes it into the input of the A/D Converter. The ADC converts them into digital codes to be stored in a digital computer. The digital block, used in the present system consists of LPC2148 development board, and a laptop/PC. LPC2148 development board consists of an ARM7TDMI processor and a UART controller. This board is energized by using a 9v battery. The battery inside the laptop is fully charged and mains connection is removed while recording the EMG signal to ensure safety of the patient which is very important.

LPC2148 DEVELOPMENT BOARD

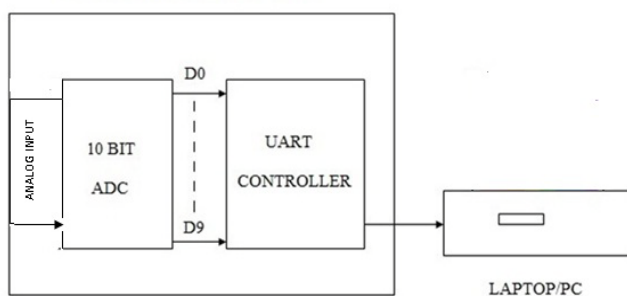


Figure 2: Block Diagram of Digital Block

LPC2148 has:

- ARM7TDMI processor
- Two 10-bit ADC's with 3.3v reference
- Multiplexed----- 10inputs
- Sampling rate----- 256samples/sec

## 6.2.1 Introduction to ARM Processor

ARM stands for Acorn RISC Machine and is the product of Acorn Computers Limited of Cambridge, England. RISC (Reduced Instruction Set Computing) concept originated at Stanford and Berkley Universities around 1980, helped in shaping the ARM processor. It is a 32-bit microcontroller.

### 6.2.1.1 ARM architecture is characterized by:

- Reduced instruction set with 32-bit instruction size
- Load Store architecture in which instructions process data only in registers
- A large set of registers to support instruction processing

### 6.1.2 ARM organization is characterized by:

- Hard wired instruction decode logic
- Pipe lined execution to increase the through put
- Single cycle execution of any instruction

### 6.2.1.3 Advantages of RISC architecture are:

- Smaller die size with reduced number of transistors on the chip
- Shorter development time for applications
- Higher performance

## 6.2.2 10-BIT A/D Converter:

### 6.2.2.1. Features:

- Two 10 bit successive approximation analogue to digital converters.
- Input multiplexing among 6 or 8 pins (ADC0 and ADC1).
- Power-down mode.
- Measurements range 0 V to VREF (typically 3 V; not to exceed VDDA voltage level).
- 10 bit conversion time  $\geq 2.44 \mu s$ .

### 6.2.2.2. Description

Basic clocking for the A/D converters is provided by the VPB clock. A programmable divider is included in each converter, to scale this clock to the 4.5 MHz (max) clock needed by the successive approximation process. A fully accurate conversion requires 11 of these clocks.

## 2.3 UART Controller

### 2.3.1 Features

- 16 byte Receive and Transmit FIFOs
- Register locations conform to '550 industry standard.

## 6.3. Software Development

### 6.3.1 KEIL $\mu$ vision

The analog input from the analog block is given to the P0.5 pin and GND pin on the LPC2148 development board. Programming for AD conversion is loaded using the UART 0 port with the help of a RS232 DB9 cable. The board is energized using a 9v battery and the digitized output is taken through the UART1 port and displayed on the laptop.

Keil  $\mu$ Vision is software which solves many of the pain points for an embedded program developer. This software is an integrated development environment (IDE), which integrates a text editor to write programs, a compiler and

converts the source code to hex files. Working with Keil  $\mu$ Vision which can be used for

- Writing programs in C/C++ or Assembly language
- Compiling and Assembling Programs
- Debugging program
- Creating Hex and Axf file
- Testing the program without Available real Hardware (Simulator Mode)

### 6.3.2 Flash Magic

LPC2148 microcontroller incorporates a capability to self program itself using the on chip UART boot loader. This eliminates the need of an external programming hardware. The boot loader code is dedicated to use UART0 on the microcontroller. Once the code is loaded on the microcontroller UART0 is free to be used in the application. The host, in this case PC or Laptop, requires software to transmit the hex file to the microcontroller over the serial link. In our project we use Flash Magic programming.

### 6.3.3 Operating Procedure:

To enter in to the boot load mode:

1. Connect a DB9 cable between the COM2port on the PC and the UART0 Port on LPC2148 development board
2. Plug in an9V DC supply to the development board and slide ON/OFF Switch to ON position.

## 7. Result and Discussion

In the fig 1, it shows the graph of time Vs amplitude of acquisition system. The fig represents the stretching and relaxation of muscle. This is the output wave form of ARM processor plotted in MAT LAB. After detection of signal from bipolar electrodes by using of instrumentational amplifier and filters detect the SEMG signal. Here arm processor used for A/D conversion then getting the data by using DB9 connector. In pc by using TERA TEM to convert the data into Excel sheet format. By using mat lab, process the sEMG signal. This signal use full for allow therapists to identify weak muscles of patients with motor weakness, such as spinal cord injury.

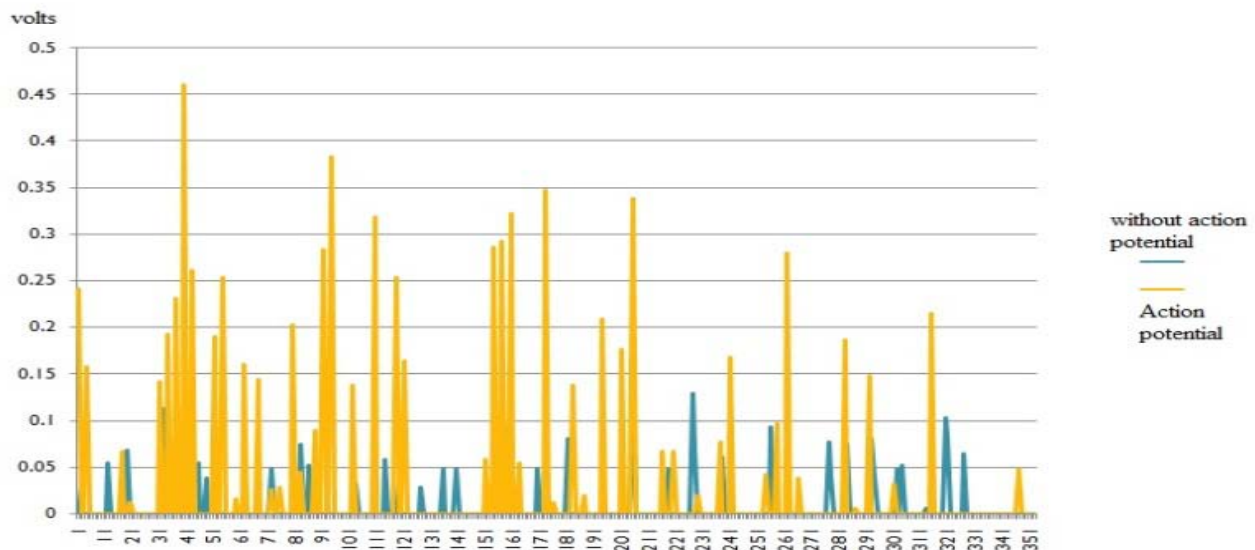


Figure 3: Stretching and Relaxation of Muscle

## 8. Conclusion

The paper demonstrates the generation of the EMG signal. The future work also use this process to different devices by using this technique, Mat lab is the good tool to process the EMG signal. This work facilitates the analysis of EMG data at several contraction levels with surface electrodes. This will allow therapists to identify weak muscles of patients with motor weakness, such as spinal cord injury.

## References

- [1] K. R. Chowdhury, M. Di Felice, "Search: a routing protocol for mobile cognitive radio ad hoc networks," Computer Communication Journal, vol. 32, no. 18, pp. 1983-1997, Dec.20
- [2] K. M. Passino, "Biomimicry of bacterial foraging for distributed optimization," IEEE Control Systems Magazine, vol. 22, no. 3, pp. 52-67, 2002.
- [3] J. Yaothak\*, P. Phukpattaranont and B. Wongkittisuksa." Improvement in the Algorithm for Accurate Detection of Muscle Activity from EMG" The 2012 Biomedical Engineering International Conference (BMEiCON-2012).
- [4] Hamzah Sakeran, Mohammad Fauzi Mahmud, Mawar Indah Jamal," EMG Analysis of Upper and Lower Rectus Abdominis During Exercises Performed On and Off a Swiss Ball" 978-4577-1991-2/12/ ©2011 IEEE.
- [5] Qi Xu, Yazhi Quan, Lei Yang, and Jiping He," An Adaptive Algorithm for the Determination of the Onset and Offset of Muscle Contraction by EMG Signal Processing" IEEE transactions on neural systems and rehabilitation engineering, vol. 21, no. 1, January 2013.

- [6] Y. Y. Huang, K. H. Low and H. B.” Initial Analysis of EMG Signals of Hand Functions Associated to Rehabilitation Tasks” ,February 21 - 26, 2009.
- [7] Mihaela Corina Ipate,” Analysis of Electromyography Records During Voluntary Contraction and the Identification of Specific Characteristics of Muscular Activity”
- [8] Ali Salman, Javaid Iqbal, Umer Izhar, Umar Shahbaz Khan, Nasir Rashid, “Optimized Circuit for EMG Signal Processing “ , 978-1-4673-4886-7/12 ©2012 IEEE.

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