

DESIGN AND DEVELOPMENT OF SEMG ACQUISITION SYSTEM USING NI  
MYRIO FOR PROSTHESIS HAND

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## ABSTRACT

This project presents the design and development of SEMG acquisition system using NI MyRIO for prosthesis hand. The number of amputees is increasing yearly due to war, accident, disease and etc. Hand is a very important part on human body. Without a hand, amputees will having difficulty in daily activity. In this project, Field Programmable Gate Array (FPGA) based embedded controller, NI MyRio is used as main controller of prosthesis hand. An Electromyography (EMG) acquisition circuit was built to acquire raw EMG signal. Human EMG signal located at 5~450Hz and 30~40mV. In order to acquire EMG signal, instrumental op-amp is used to capture EMG signal from muscle. NI MyRIO is used to process the raw signal to filter, amplify, rectify, and root mean square (RMS) is calculated in order to set condition for prosthesis hand control. A EMG signal acquisition circuit has been done to capture the EMG signal and be used by NI MyRIO, prosthesis hand was printed using 3D printer and controlled with the use of servo motor. When muscle contract during hand grabbing gesture, the prosthesis hand will perform the same gesture. A SEMG acquisition system had successfully designed and develop into prosthesis hand.

## ABSTRAK

Projek ini membentangkan rekabentuk dan pembangunan sistem perolehan *SEMG* menggunakan *NI MyRIO* untuk tangan prostesis. Bilangan amputee semakin meningkat setiap tahun kerana perang, kemalangan, penyakit dan lain-lain. Tangan adalah salah satu bahagian yang sangat penting dalam badan manusia. Tanpa tangan, amputee akan menghadapi kesukaran dalam kegiatan seharian. Dalam projek ini, sistem terbenam *Field Programmable Gate Array (FPGA)*, *NI MyRIO* digunakan sebagai sistem pertama untuk tangan prostesis. Pengambilalihan litar *Electromyography (EMG)* telah membina untuk memperoleh isyarat *EMG*. Isyarat *EMG* manusia terletak di  $5 \sim 450\text{Hz}$  dan  $30 \sim 40\text{mV}$ . Untuk memperoleh isyarat *EMG*, instrumental *op-amp* digunakan untuk memperoleh isyarat *EMG* daripada otot. *NI MyRIO* digunakan untuk memproses isyarat mentah untuk menapis, menguatkan, dan punca min kuasa dua (*RMS*) dikira untuk menetapkan syarat untuk kawal tangan prostesis. Satu litar pengambilalihan isyarat *EMG* telah dibuat untuk memperoleh isyarat *EMG* dan diproses dengan *NI MyRIO*, tangan prostesis dicetak menggunakan pencetak 3D dan dikawal dengan penggunaan motor servo. Sistem perolehan *SEMG* telah berjaya direkadan berkembang menjadi prostesis tangan.

## TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	<b>PROJECT TITLE</b>	i
	<b>REPORT STATUS APPROVAL FORM</b>	ii
	<b>DECLARATION</b>	iii
	<b>SUPERVISOR APPROVAL</b>	iv
	<b>ACKNOWLEDGEMENT</b>	v
	<b>ABSTRACT</b>	vi
	<b>ABSTRAK</b>	vii
	<b>TABLE OF CONTENT</b>	viii
	<b>LIST OF FIGURES</b>	x
<b>I</b>	<b>INTRODUCTION</b>	1
	1.1 Background	1
	1.2 Problem Statement	2
	1.3 Objectives	2
	1.4 Scope of Project	2
	1.5 Chapter Conclusion	3
<b>II</b>	<b>LITERATURE REVIEW</b>	4
	2.1 Introduction	4
	2.2 Bio-signal and Electromyographic (EMG)	4
	2.3 SEMG Signal	7
	2.4 National Instruments (NI) MyRIO	9
	2.5 EMG Signal Processing	12
	2.5.1 Filtration	12
	2.5.2 Rectification	13
	2.5.3 Feature Extraction	14
	2.6 Chapter Conclusion	15
<b>III</b>	<b>METHODOLOGY</b>	16
	3.1 Introduction	16
	3.2 SEMG Acquisition	18
	3.2.1 SEMG Acquisition Requirement	18
	3.2.2 Instrumentation Amplifier Selection	19
	3.2.3 SEMG Circuit Design	21
	3.3 Signal Pre-processing	22



3.3.1	SEMG Filtration	22
3.3.2	SEMG Amplification	23
3.3.3	SEMG Rectification	24
3.3.4	Root Mean Square Calculation	25
3.4	Condition Determination	26
3.4.1	Threshold Value Calculation	26
3.4.2	Condition Determination	26
3.5	Control System	27
3.5.1	Duty Cycle Calculation	27
3.5.2	Servo Motor Connection	28
3.6	Chapter Conclusion	30
<b>IV</b>	<b>RESULT AND DISCUSSION</b>	<b>31</b>
4.1	Circuit Construction	31
4.2	EMG Acquisition Circuit Fabrication	33
4.3	NI MyRIO Connection And Configuration	34
4.4	Prosthesis Hand Control Step	41
4.5	Chapter Conclusion	44
<b>V</b>	<b>CONCLUSION</b>	<b>45</b>
5.1	Introduction	45
5.2	Conclusion	45
5.3	Future Work	46
5.4	Chapter Conclusion	46
	<b>REFERENCE</b>	<b>47</b>

## LIST OF FIGURES

NO	TITLE	PAGE
2.1	EMG signal	5
2.2	ECG signal	5
2.3	EEG signal	6
2.4	Schematic diagram of instrumentation amplifier	6
2.5	EMG acquisition circuit with feedback loop amplified	7
2.6	Electrodes used in EMG recording	8
2.7	Comparison between Surface EMG and Intramuscular EMG	8
2.8	National Instruments MyRIO-1900	9
2.9	Hardware diagram of NI MyRIO	10
2.10	Signals on MXP connector A and B	11
2.11	Signals on MSP connector C	11
2.12	Raw EMG signal	12
2.13	Filtered EMG signal	13
2.14	Raw EMG signal compare with rectified signal	14
3.1	Block Diagram for Prosthesis hand control system	16
3.2	Flow chart of project methodology	17
3.3	Position of electrode on muscle	18
3.4	Pin configuration of INA126P	19
3.5	Circuit diagram of INA126P	20
3.6	Block diagram of SEMG acquisition circuit	21
3.7	Block diagram of SEMG acquisition circuit with hardware reduction	21
3.8	Block diagram icon of Bio-signal filtration	22
3.9	Front panel for Bio-signal filtration	22
3.10	Block diagram and connection of Bio-signal filtration	23
3.11	Block diagram icon of multiplication	23

3.12	Diode bridge rectifier	24
3.13	Block diagram icon for absolute value	24
3.14	Block diagram icon for Bio-signal RMS	25
3.15	Block diagram and connection for Bio-signal RMS	26
3.16	Block diagram icon for “greater?” comparison function	26
3.17	Flow chart for condition determination	27
3.18	Example of duty cycle percentage.	28
3.19	Pins and the angle rotation of servo motor	28
3.20	Connection diagram for index finger servo motor	29
3.21	Connection diagram for 3 finger servo motor	29
4.1	Construction of software using Eagle	31
4.2	Circuit constructed on breadboard	32
4.3	EMG acquisition circuit board design using Eagle software	33
4.4	PCB board after fabrication and component soldered (bottom)	33
4.5	PCB board after fabrication and component soldered (top)	34
4.6	Connection of EMG acquisition circuit and NI MyRio	34
4.7	Front panel of LabVIEW 2014	35
4.8	Block diagram of LabVIEW 2014	35
4.9	Waveform chart was inserted for monitoring purpose	36
4.10	Analog input pin was assigned using block diagram	36
4.11	Raw EMG signal from circuit	37
4.12	Filter block diagram is used for filter function	38
4.13	EMG signal after filter operation	38
4.14	Multiply and Absolute function is used to amplify and rectify the signal	39
4.15	EMG signal after amplification and rectification with gain equal to 1000	39
4.16	Root Mean Square (RMS) function was inserted to calculate RMS	40
4.17	RMS value shows in waveform chart and threshold value is set to produce condition	40

4.18	Condition structure is used to determine RMS value greater than threshold	41
4.19	Different duty cycle is set according to different Boolean condition	41
4.20	Angle of servo motor according to ratio of length of pulse to period	42
4.21	Connection diagram for index finger servo motor	43
4.22	Connection diagram for 3 finger servo motor	43
4.23	Connection of prosthesis hand with NI MyRio	44

# CHAPTER I

## INTRODUCTION

### 1.1 Background

The number of amputees is increasing yearly due to war, accident, disease and etc. Hand is a very important part on human body. Without a hand, amputees will having difficulty in daily activity, for example grabbing object, hold fork and spoon for eating, washing body and others. Therefore, prosthesis hand is a necessary tool to help limbs amputees to recover their self-confident and maintain their daily activities.

The prosthesis as a tool makes no presence of trying to replace the lost limbs physiological appearance. As a matter of fact, it works as an aid to help provide some of the functions of the lost limbs. Moreover, the prosthesis is an interchangeable device that can be used only when needed.

There are a lot of prosthesis hand has commercial in the market. However, most of the myoelectric hands in the market are very expensive due to the complexity and highly functional [1], which provided for injured soldier. Hence, most of the amputees are not capable to purchase an expensive highly functional prosthesis hand.

In this project, a FPGA embedded system is use as a main controller of the prosthesis hand, SEMG signal will be capture from the muscle of the arm for controlling the prosthesis hand. SEMG raw signal will be process and RMS value calculation will be done in order to control the servo motor in the prosthesis hand.

## 1.2 Problem Statement

Prosthesis hand is a tool to help amputees that had lost limb to carry out daily activity. However, to control a prosthesis hand, SEMG signal is required to control the motion or gesture of the prosthesis hand. Hence, in this project, a SEMG acquisition system is required to acquire SEMG from the amputees substitute muscle for example biceps and flexor carpi.

Raw SEMG signal is difficult to be used because SEMG has very low potential difference and is random in frequency. To withstand this problem, raw SEMG signal captured from the acquisition system need to go through signal processing. After signal processing step, RMS value calculation need to be done and angle of the servo motor need to be calculated to control the prosthesis hand.

Prosthesis hand is build to improve the life quality of limb amputees. Therefore, a light weight, low cost, and functional prosthesis hand is needed for upper-limb loss amputees.

## 1.3 Objectives

This project has following objectives:

- I. To design simple SEMG signal acquisition circuit using instrumentation amplifier
- II. To develop real time hand grabbing gesture for prosthesis hand using NI MyRIO

## 1.4 Scope of Project

Several limitations are set to specify the range of this project

- I. An open source 3D printed prosthesis hand is used for this project.

- II. Instrumentation amplifier (INA126P) is used for SEMG acquisition
- III. 3 servo motors is used to control 3 part of the prosthesis hand, which is thumb, index finger and the rest of the finger.
- IV. Simple grabbing algorithm is build for prosthesis hand function ability.

## **1.5 Chapter Conclusion**

This thesis consists the introduction project, concept applied, method used, problem solving, analysis and conclusion of self-powered cooling system. In this report, there are 5 chapters which are introduction, literature review, methodology, discussion and result, and conclusion.

Chapter 1 explains the background of the prosthesis hand and the importance of prosthesis hand. The objectives, scope of project is also delivered within this chapter.

In chapter 2, study background related to this project will be done, the study of literature will provide a framework that shows the link between project with theories and concepts.

In chapter 3, method used within this project is discussed and the flow of the project will be shown with the help of figures. The details of the method use during this project will be explained in this chapter.

In chapter 4, the result obtain from the project will present clearly and neatly. The acquisition system and the figure of prosthesis hand will be display within this chapter.

In chapter 5, report concludes with the overall summary of the studies based on the objectives and achievement. Besides, recommend any changes and improvement approach concerned with the topic.

## CHAPTER II

### LITERATURE REVIEW

#### 2.1 Introduction

This chapter covers the description regarding the research being conducted and studied. Information about EMG, National Instrument MyRIO, and instrumentation amplifier will be explained within this chapter, Past researches were studied and compared to improve the current project.

#### 2.2 Bio-Signal And Electromyography (EMG)

Bio-signal is signal in a living beings included human, animals and plants that can be measured and monitored continuously. It usually refers as the change in electric current that produced by the sum of potential differences across a specific tissue, organ and cell system. Some of the well known bio-signals are electroencephalogram (EEG), electrocardiogram (ECG), and electromyography (EMG). These signals are common used biomedical field especially EMG which commonly used as main signal for prosthesis limb control. In this project, SEMG is used as a main signal on prosthesis hand control.

According to Ilku Nam(2014), bio-signal can be divided into 3 frequency range, 1<sup>st</sup> is the high frequency range which is from 30Hz to 1000Hz, EMG with 50Hz to 450Hz will be located at this range [6]. 2<sup>nd</sup> is the medium frequency range, from 5Hz to 25Hz, ECG and EEG usually located at this range. Lastly is the low frequency range, which is below 5Hz. Bio-signal are very hard to captured because it has very low



amplitude which measured at a few mV and very low frequency range usually below 1000Hz. These weak bio-medical signal need to be amplified along with rejection of unnecessary noise. To overcome this problem, an instrumentation amplifier is used to suppress unwanted noise and provide amplification to the desire signal.

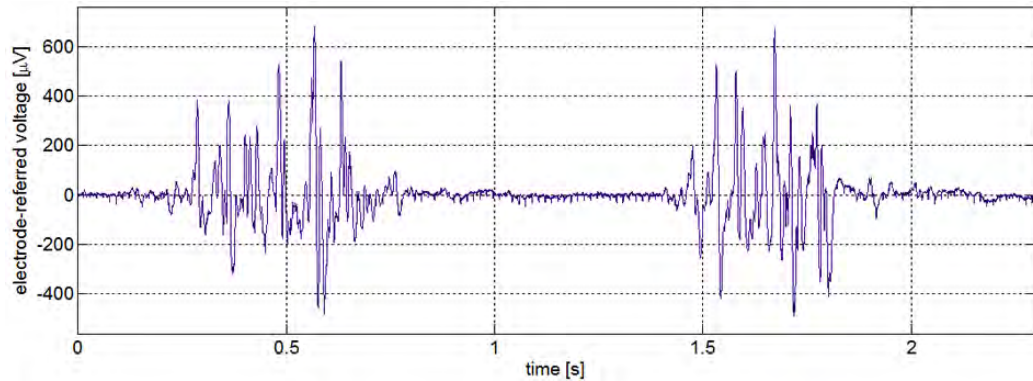


Figure 2.1: EMG signal

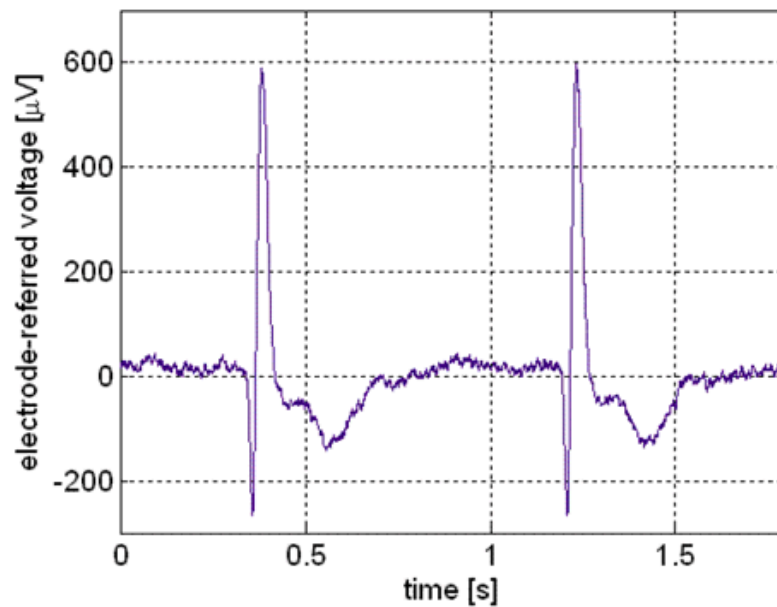


Figure 2.2: ECG signal

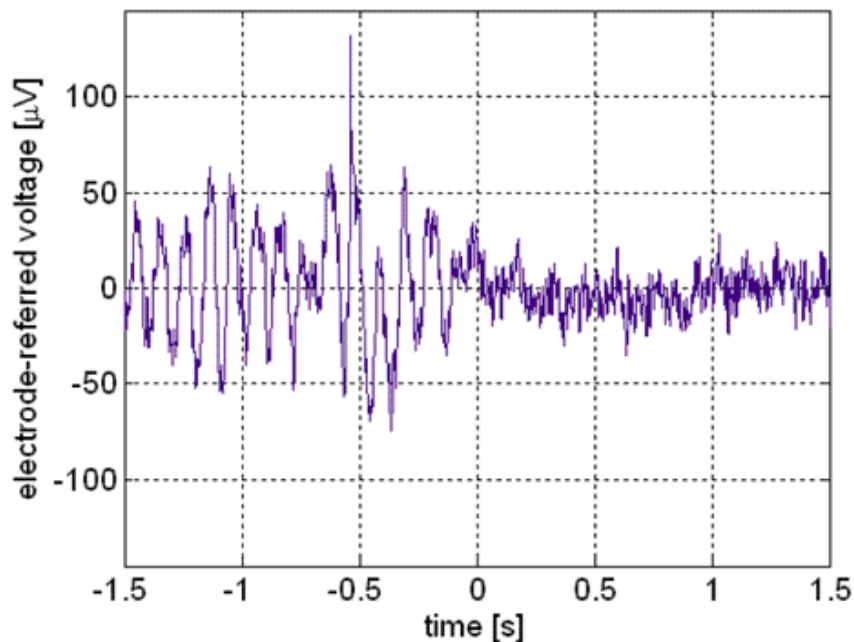


Figure 2.3: EEG signal

As mentioned by AkshayGoel (2013), instrumentation amplifier is a closed loop gain block that has a differential block with two inputs and a single ended output. It has a very low DC offset, low noise, very high gain and very high input impedance [3]. Due to these properties, instrumentation amplifier is capable to rejecting common mode noise and provide amplification to desire signal.

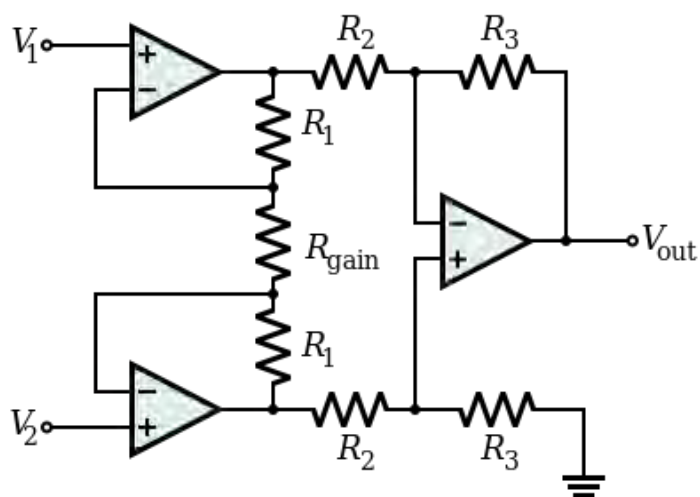


Figure 2.4: Schematic diagram of instrumentation amplifier

The bio-signal from the muscle surface contact electrode is amplified by an instrumentation amplifier. In order to improve the signal-to-noise ratio (SNR) of the signal acquire by instrumentation amplifier. Feedback loop amplifier is connected to the circuit as shown as Figure 2.5

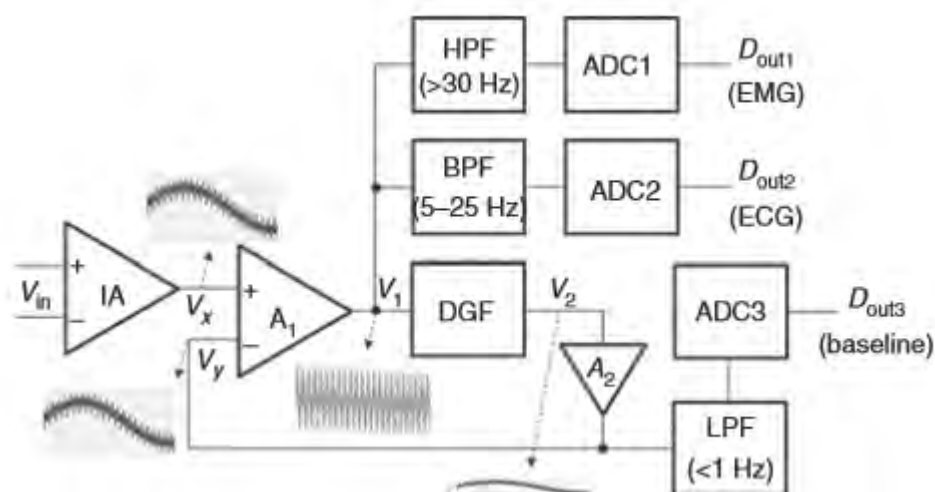


Figure 2.5: EMG acquisition circuit with feedback loop amplified

### 2.3 SEMG Signal

EMG can be classified into 2 categories, which is surface electromyography and intramuscular electromyography. Surface EMG is bioelectrical signal by detecting muscle activity from surface on the skins above the muscle. Surface EMG can be detected by using electrodes, sensors used to recording EMG signal by attached it to surface of the skins.



Figure 2.6: Electrodes used in EMG recording

A pair or multiple electrodes is used to record EMG because EMG display the potential difference between two electrodes attached at different position.

Intramuscular EMG or needle EMG can be performed using wire/needle electrode inserted into muscle to record muscle activity. EMG signal can be recorded by insert one fine wire into deeper muscle and a surface electrode as a reference.

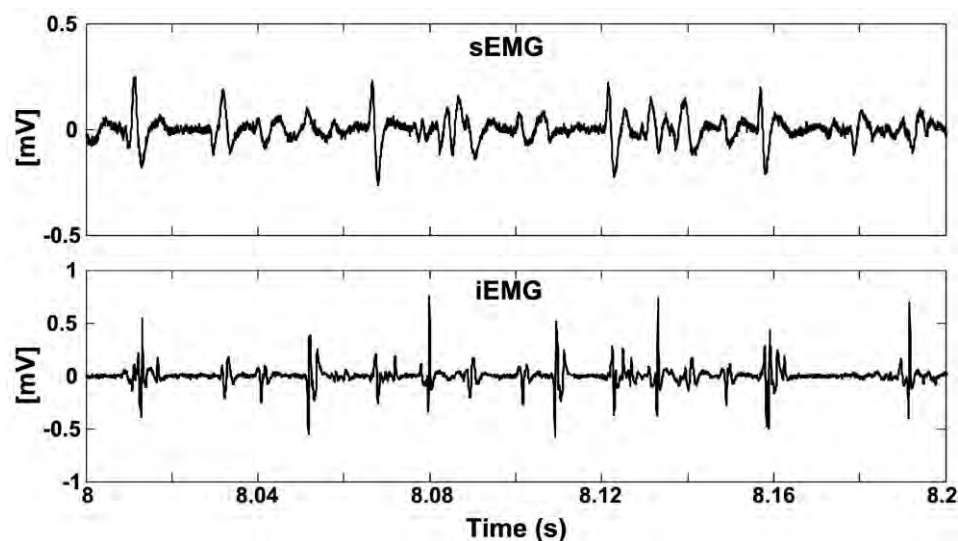


Figure 2.7: Comparison between Surface EMG and Intramuscular EMG

## 2.4 National Instruments (Ni) MyRIO

The National Instruments MyRIO is a portable reconfigurable I/O (RIO) device that developed by National Instruments, an American company which produce automated test equipment and virtual instrumentation software. NI MyRIO is used to design control, robotics and mechatronics systems. MyRIO has four base components, a processor Xilinx Zynq-7010 dual-core ARM® Cortex™-A9 real-time, a reconfigurable FPGA Xilinx Zynq-7010, high-performance I/O, and graphical design software. The NI myRIO-1900 provides analog input (AI), analog output (AO), digital input and output (DIO), audio, and power output in a compact embedded device. The NI myRIO can connects to a host computer over USB and wireless 802.11b,g,n.



Figure 2.8: National Instruments MyRIO-1900

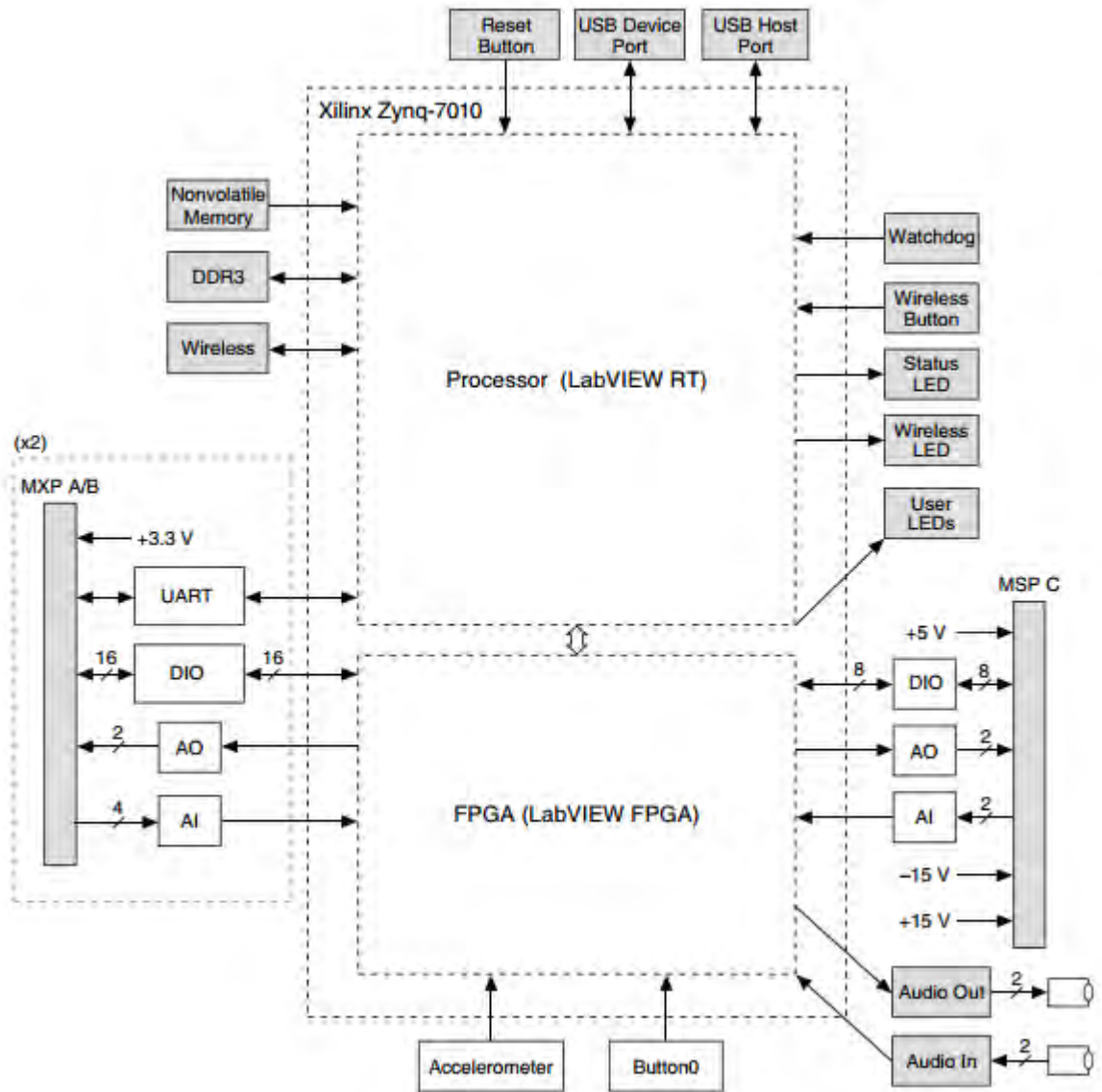


Figure 2.9: Hardware diagram of NI MyRIO

NI MyRIO consists of expansion port (MXP) connector A and B and mini system port connector C. In this project, connector A and B is used as the output PWM signal to control servo and connector C is used as power supply and analog output for SEMG acquisition circuit and also PWM to control index finger servo motor.

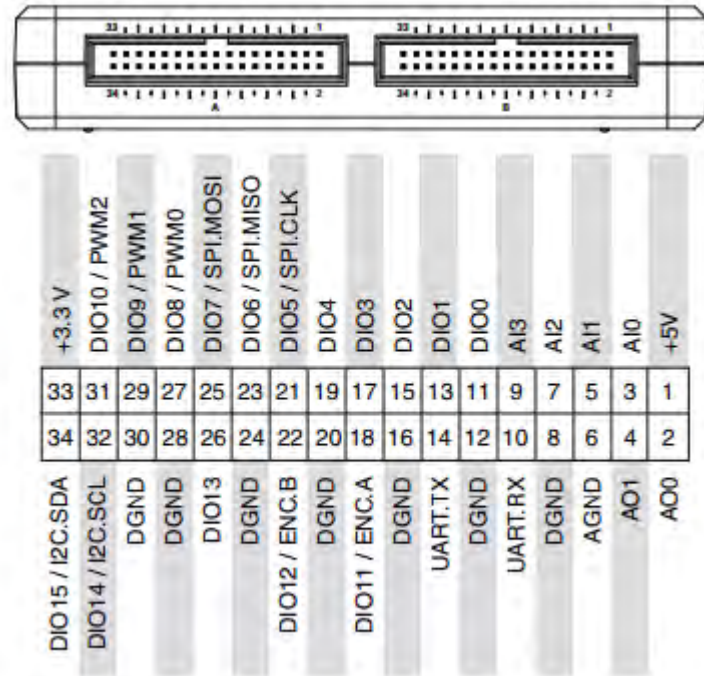


Figure 2.10: Signals on MXP connector A and B

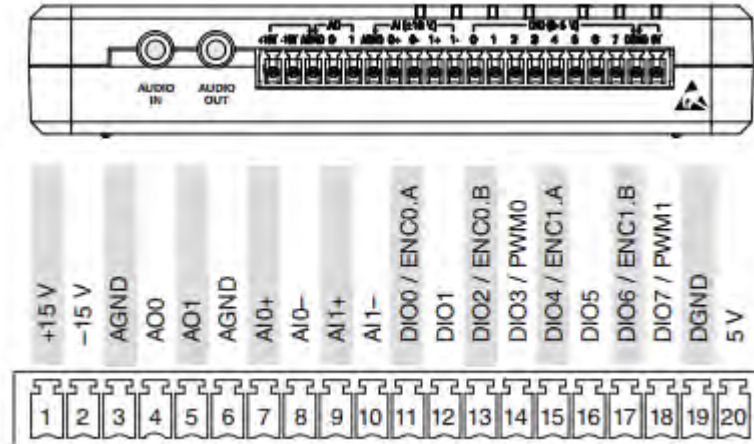


Figure 2.11: Signals on MSP connector C

## 2.5 EMG Signal Processing

Raw SEMG signal are unable to be used without pre-processing. In order to use the SEMG signal to control prosthesis hand, several signals processing step has to be passed through. These included filtration, rectification and feature extractions.

### 2.5.1 Filtration

In signal processing, filter is a method or process to filter out unwanted components from a raw signal. Most often, filter is used to remove unwanted frequency and reduce background noise. In EMG signal processing, filter is used to differential different type of bio-signal and noise.

The frequency filter can be classified into different bandforms which allow certain frequency to pass through and rejects the others. Type for frequency filter is Low-pass filter, High-pass filter, Band-pass filter and Band-stop filter.

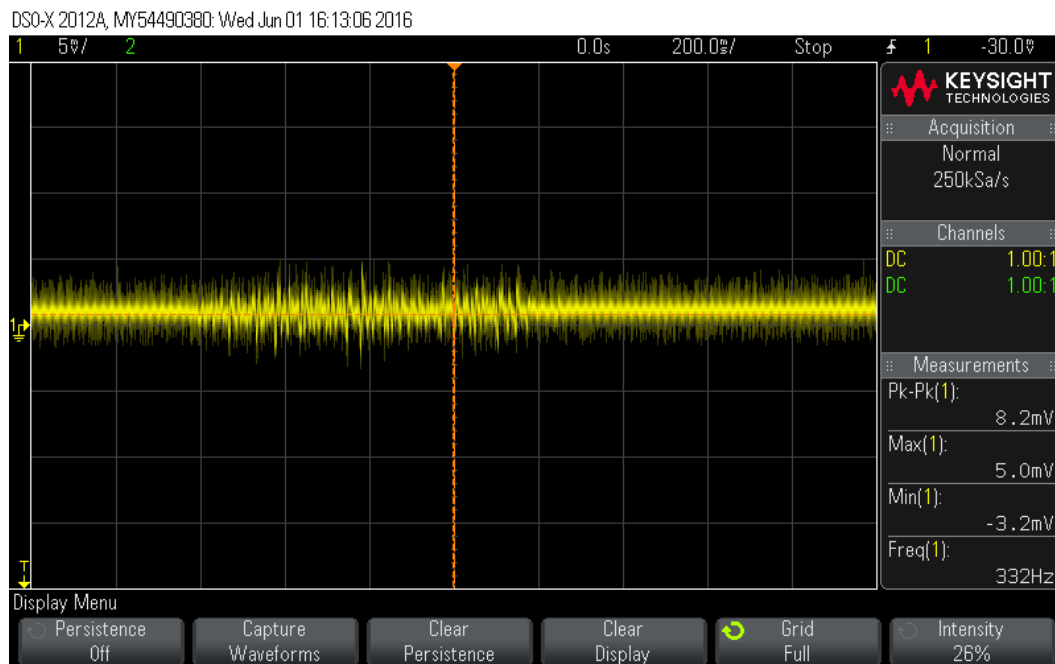


Figure 2.12: Raw EMG signal