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

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FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

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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

Projekinimembentangkanrekabentukdanpembangunansistemperolehan SEMG menggunakan NI MyRIOuntuktanganprostesis.Bilanganamputeessemakinmeningkatsetiaptahunkeranaperang, kemalangan, penyakitdan lain-lain. Tanganadalahsalahsatubahagian yang sangatpentingdalambadanmanusia.Tanpatangan, amputeesakanmenghadapikesukarandalamkegiatanseharian. Dalamprojekini,sistemterbenam Field Programmable Gate Array (FPGA), NI MyRIOdigunakansebagaisistempertamauntuktanganprostesis.Pengambilalihanlitar Electromyography (EMG) telahmembinauntukmemperolehisyarat EMG.Isyarat EMG manusiaterletak di 5 ~ 450Hz dan 30 ~ 40mV.Untukmemperolehiisyarat EMG, instrumental op-amp digunakanuntukmemperolehisyarat EMG daripadaotot.NI Myriodigunakanuntukmemprosesisyaratmentahuntukmenapis, menguatkan, danpunca min kuasadua (RMS) dikirauntukmenetapkansyaratuntukkawalantanganprostesis.Satulitarpengambilalihanisyarat EMG telahdibuatuntukmemperolehisyarat EMG dandiproseskandengan NI MyRIO, tanganprostesisdicetakmenggunakanpencetak 3D dandikawaldenganpenggunaan motor servo.Sistemperolehan SEMG telahberjayadirekadanberkembangmenjadiprostesistangan.

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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 whenneeded.

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 solder. 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 IIku Nam(2014), bio-signal can be divided into 3 frequency range, 1st is the high frequency range which is from 30Hz to 1000Hz, EMG with 50Hz to 450Hz will be located at this range [6]. 2nd 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.

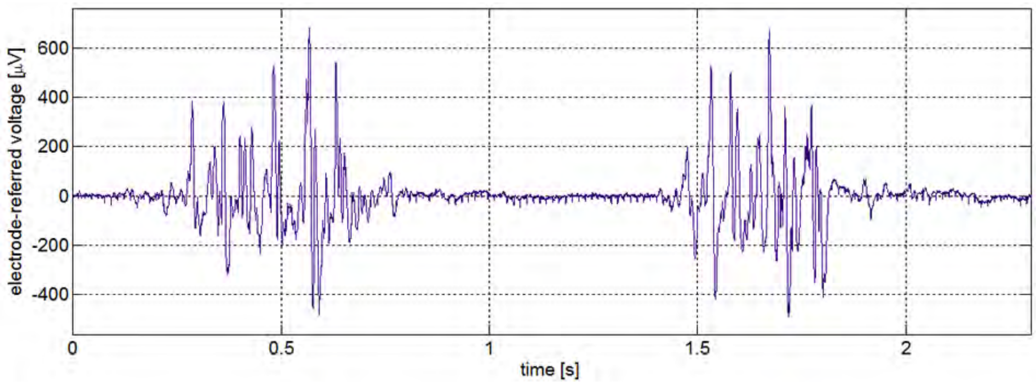

Figure 2.1: EMG signal

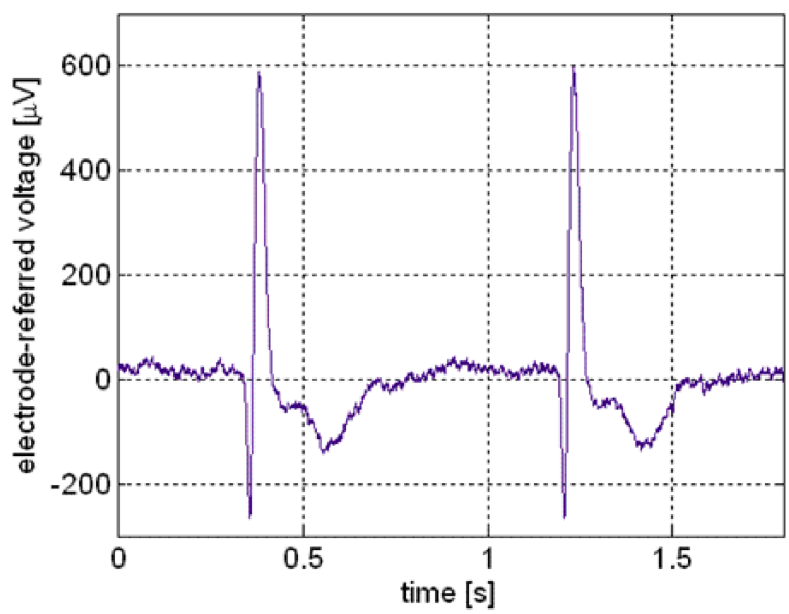

Figure 2.2: ECG signal

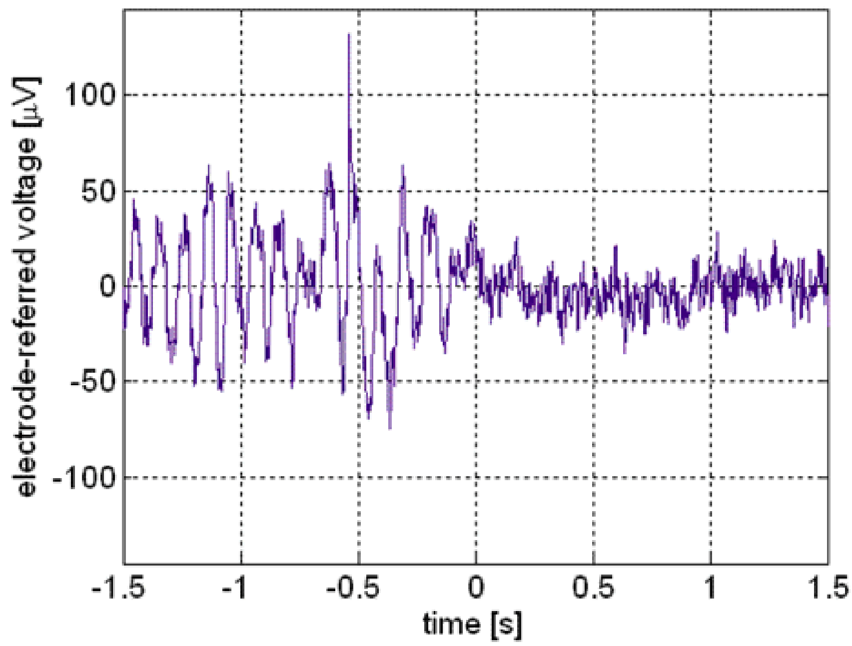

Figure 2.3: EEG signal

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.

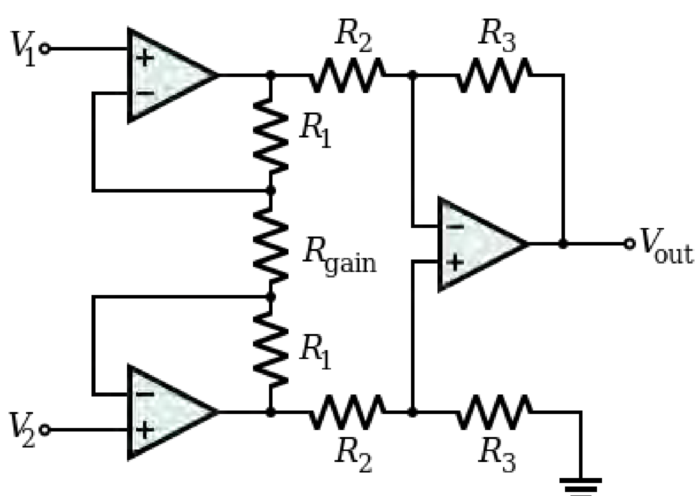

Figure 2.4: Schematic diagram of instrumentation amplifier

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

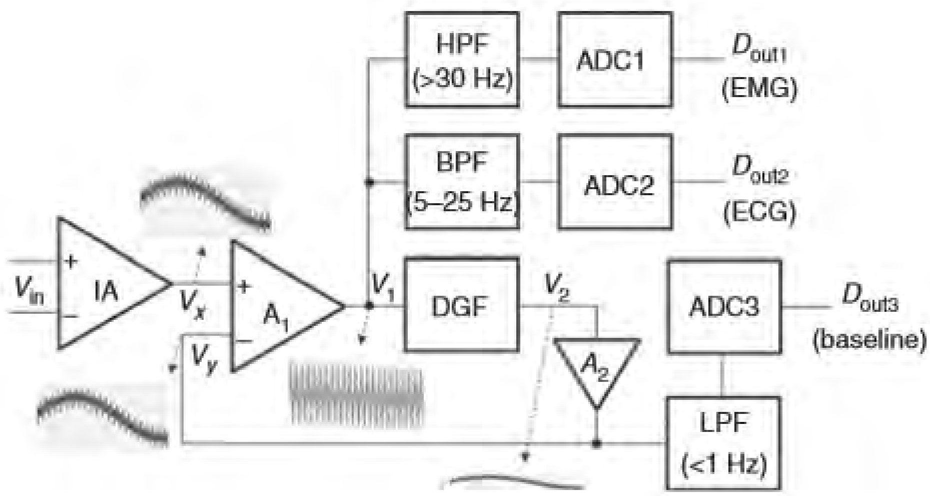

Figure 2.5: EMG acquisition circuit with feedback loop amplified

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.

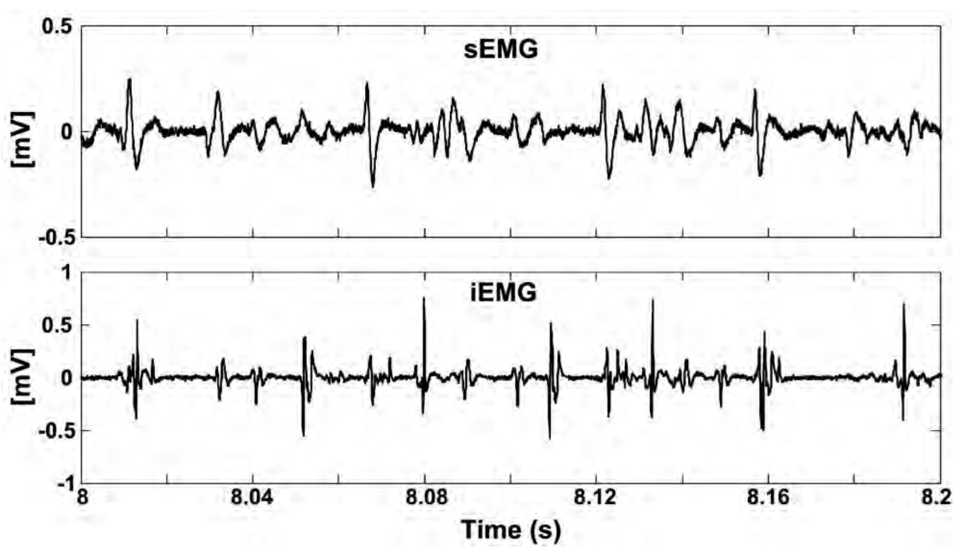

Figure 2.7: Comparison between Surface EMG and Intramuscular EMG

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

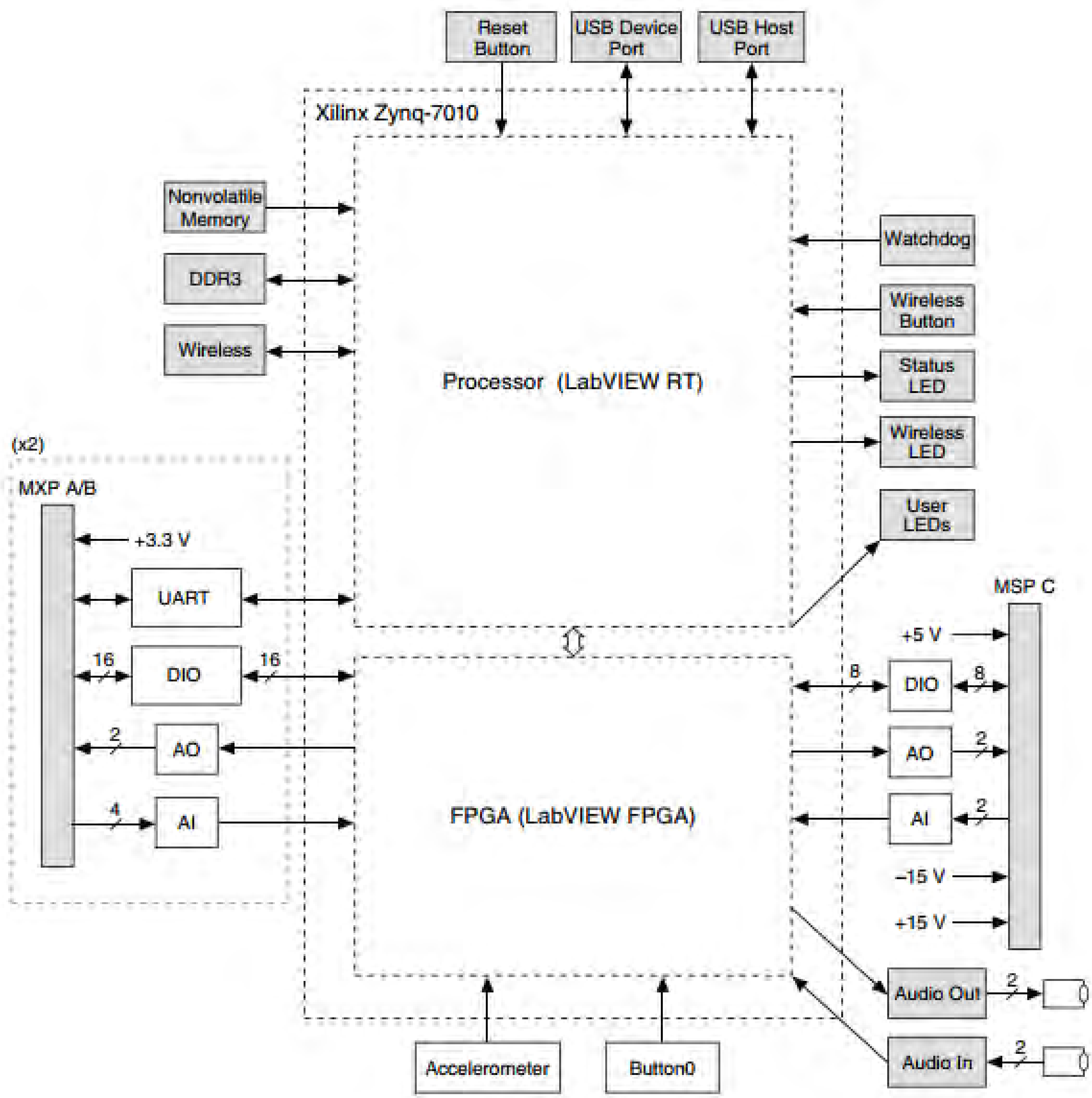

Figure 2.9: Hardware diagram of NI MyRIO

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.

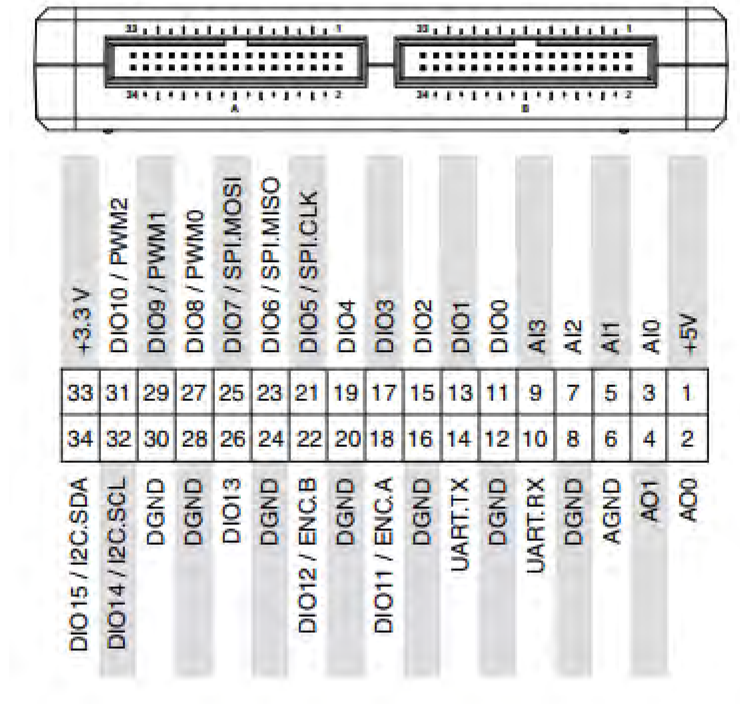

Figure 2.10: Signals on MXP connector A and B

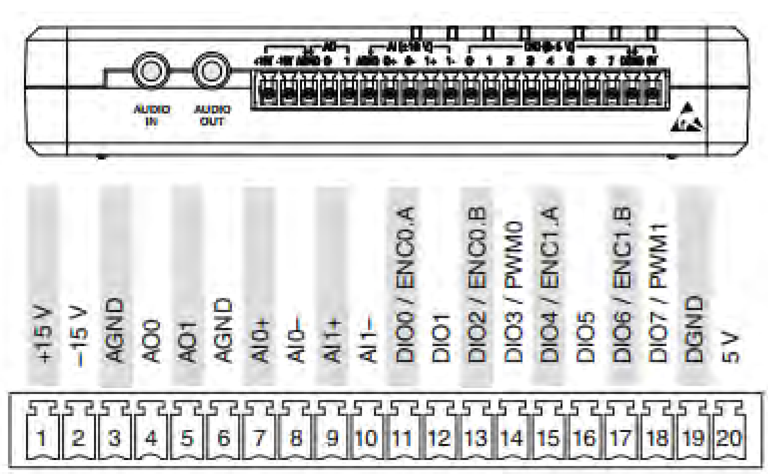

Figure 2.11: Signals on MSP connector C

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.

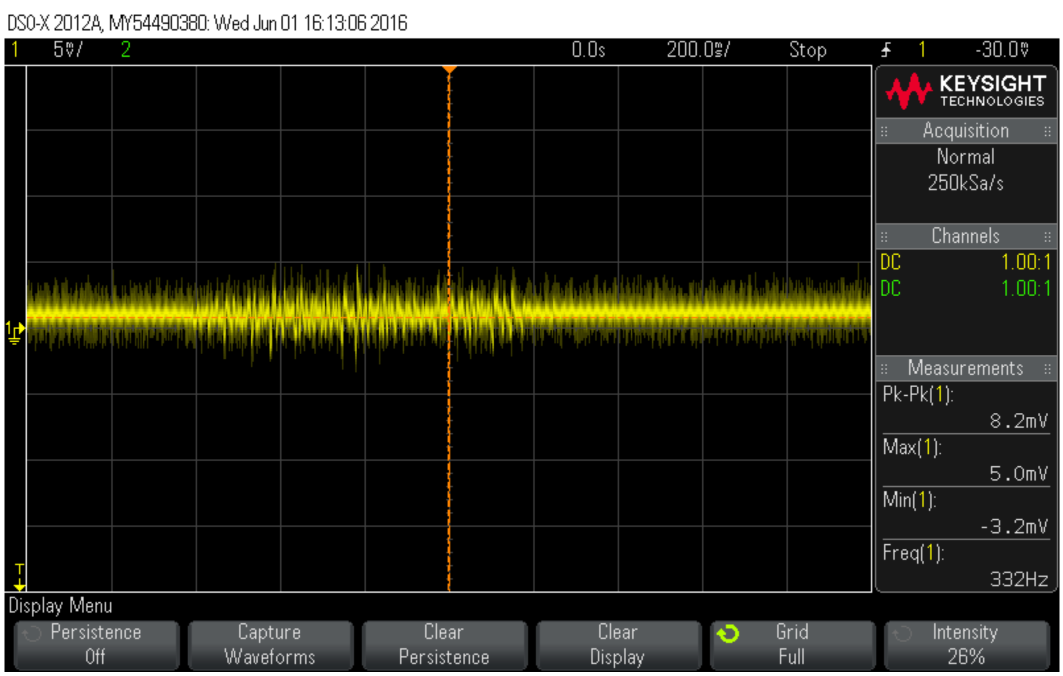

Figure 2.12: Raw EMG signal