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DEVELOPMENT OF PLATFORM FOR ELECTROMYOGRAPHIC SIGNAL ACQUISITION AND ANALYSIS

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Abstract. *The electromyographic signal is used in lots of bioengineering studies for controlling systems and to give information about muscle behavior. In order to use this signal that comes from muscle activities this work proposes to develop a platform for electromyographic signal acquisition and analysis. This platform allows to conditioned the signal and analyze its behavior. Then it is an important device to support a large range of researches as prosthesis control system and devices based on functional electrical stimulation (FES). The platform is portable what makes it adequate to use in different places as hospital, rehabilitation centers and laboratories. The signal analyses response is friendly and the platform allows to use the signal to control some devices through the out signal port. This equipment demonstrates to be suitable for various researches studies in the areas of rehabilitation, physiotherapy, sport physiology and other areas related to biomedicine and bioengineering.*

Keywords: *Biomedical device, EMG, electromyographic signal, bioengineering*

1. INTRODUCTION

In the Robotics and Rehabilitation Laboratory (LABORE) there are various researches in progress that uses electromyographic signal in different ways. This signal can be used to obtain feedback information or directly to control some systems, as myoelectric prosthesis for example (Aguiar and Caurin, 2004). Consequently it becomes necessary to develop a device that allows capturing and conditioned this signal. This work aims to design this device called Platform for Electromyographic Signal Acquisition and Analysis (PESA).

PESA is composed by three parts; the first one is responsible to get the electromyographic signal through superficial electrodes and conditioning this biological signal. Therefore the signal is already to go to the second part of PESA, acquisition data. In this part the analogical signal is converted to a digital signal and the data can be processed and used by a personal computer, allowing the signal study and analyses. The third and last part of PESA is the power board, which makes possible some mechanism control. As a result PESA is a complete device to work with electromyographic signals.

A one degree-of-freedom gripper, to simulate hand prosthesis, was developed in order to test PESA's performance.

In this case PESA works since capturing the signal, conditioning the signal, processing the signal to controlling the prosthesis mechanism. The open-close task was successfully developed by the gripper. However the interference and noise from the electrodes-human interface prejudiced the repeatability.

2. HUMAN-PESA INTERFACE

The utilization of PESA begins when an electromyographic signal is available (Basmajian and De Luca,1995), then it is necessary establish an interface able to capture the signal. The interface between human and PESA is given by surface electrodes (De Luca, 2002).

The electrodes are elements of transduction that converts potential ionic energy, which is present in nerve and muscle tissue, in electrical potential energy (Gyton and Hall, 1996). Thus it converts ionic current into electrical current. This conversion is necessary to excite the analog circuit, allowing the interpretation of the information from the electrode covered muscle region.

3. ANALOG SIGNAL CONDITIONING HARDWARE

This is the part of the system that really works with analog signals, not a digital representation of the electromyographic signal, as occur with the digital part of the circuit. The signal conditioning is necessary because the characteristics of the acquired signal does not correspond with the characteristics that the AD (analog-to-digital converter) needs to converts the signal. A *preprocessing block* is usually necessary to amplify and filter the signal (Northrob, 2011). This *processing block* aims to satisfy the hardware signal requirements based on the proper dynamic amplitude; undesirable characteristics compensation and noise reduction. In addition, the continuous time signals must

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be bandlimited before the analog-digital converter. Thus an operation is necessary to reduce the aliasing effect caused by the sampling. The acquisition procedure should preserve the information contained in the waveform of the original signal, which it is not an easy operation using electromyographic signal. Figure 1 shows the *analog hardware* for eletromyographic signal conditioning scheme. The main block represents the *analog hardware*, electrodes are the electromyographic signal input and the *analog hardware* output goes to Digital Acquisition Device.

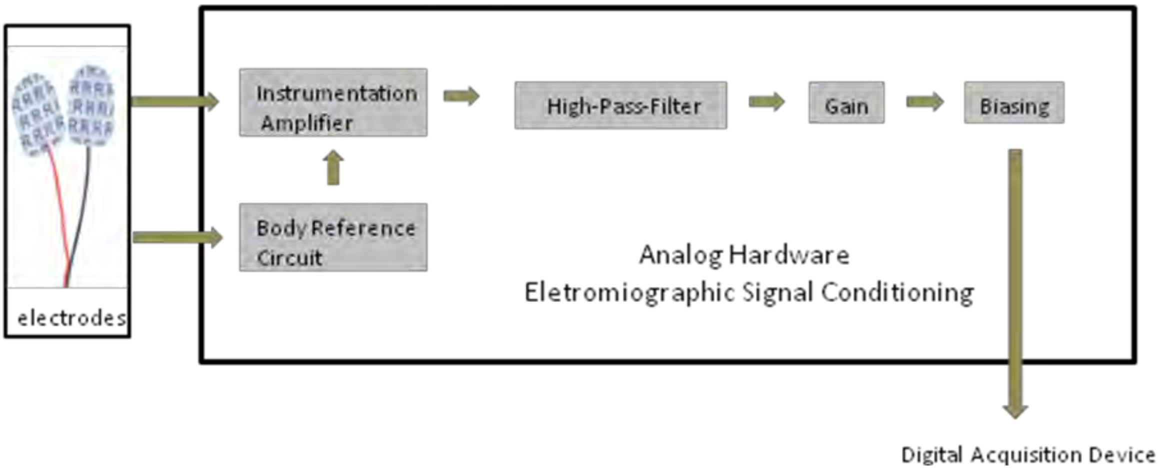

Figure 1. Scheme of analog hardware for eletromyographic signal conditioning

The following figure (Fig.2) shows the Analog Hardware Electromyographic Signal Conditioning board. An important aspect of this board is the electromyographic signal amplifier. Here was used the INA128 amplifier (Burr Boughs) that is an interesting device to be applied to electromyographic signals, allowing the differential amplification. According to Koh and Grabiner (1993), a differential amplifier and its inherent common-mode rejection ratio (CMRR), are the most efficacious technique to minimize the Electromyographic signal crosstalks.

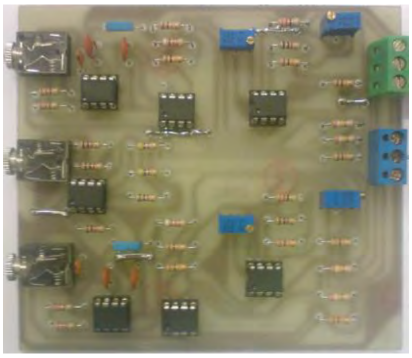

Figure2. Board of analog hardware for eletromyographic signal conditioning

4. ANALOG –TO- DIGITAL CONVERTER

An analog-to-digital converter is a device that converts a continuous physical quantity to a digital number that represents the quantity's amplitude. In this work the NI USB 6009 DAQ from National Instruments has been used whit a personal computer (Figure 3). The electromyographic amplified signal output is connected to the DAQ analog input port (vertical arrow in figure 3). The signal will be displayed like a two-channel oscilloscope screen, showing the current signal waveform. Therefore by a *digital signal processing* (DSP) it is possible to manipulate the signal through filters activation. The frequency spectrogram of the two channels now is available, allowing checking the RMS (root mean square) averages and the signal integration. The electromyographic signals can be saved to a data file in a TDMS format (National Instruments software). These data can be analyzed for future task and to perform a resource of pattern classification (Najarian and Splinter,2006).

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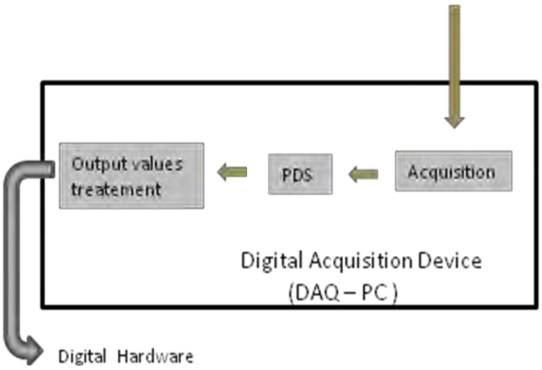

Figure 3. Scheme of analog-to-digital converter

At this moment the system for electromyographic signal acquisition (Figure 4) is completed by the integration of the previous two systems: *Human-PESA interface* and *Analog signal conditioning hardware*.

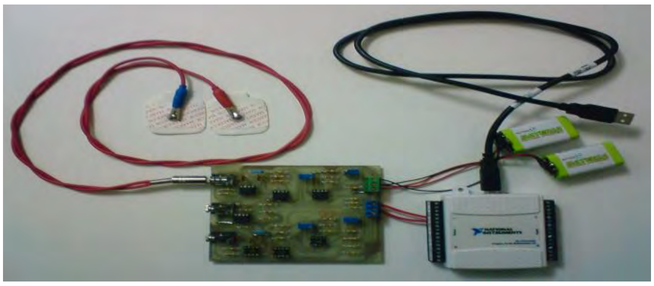

Figure 4 - System for electromyographic signal acquisition

It is important to mention that the supply circuit (figure 5) is based on batteries, thus the electrical interference provided by the power grid is annulated, and moreover it is important to human safety during the tests.

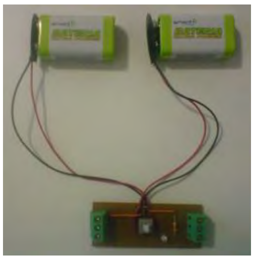

Figure 5. Battery supply circuit

5. DIGITAL HARDWARE AND POWER CIRCUIT CONTROL

The digital hardware and power circuit control, it is a circuit board which purpose is the interpretation of analog signals input from the DAQ, and then generates a Pulse-width modulation (PWM) as output signal to control two independent electric motors. This circuit board was developed with a microcontroller PIC18f4532, as shown in the figure on the next page (Fig.6), and a firmware also was developed to complete this controller board. The firmware provides the control of the hand prosthesis, which was developed for testing the complete system.

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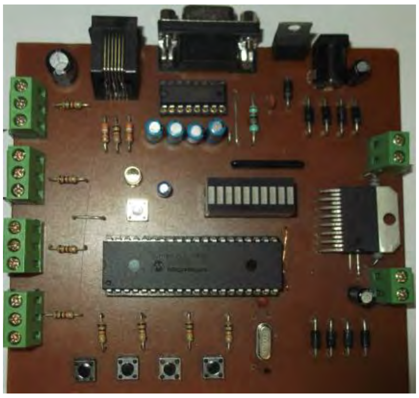

Figure 6. Power circuit board

6. TESTS AND RESULTS

In the tests, the surface electrodes were placed on the investigator forearm as showed in figure7. After some adjusts the subject started to open and close his hand repeatedly to generate electromyographic signal. The first results observed by the software showed different amplitudes, even without muscle activities. Nevertheless it was possible to get the signal using the surface electrodes. The second test was to control mechanical hand prosthesis. The task was to open and to close the gripper through the electromyographic command signal. The prosthesis followed the human command. Both tests were performed several times with 75% successful rate. However when the electrodes were pressed against the forearm or when the tests ran late at night the response was better.

Figure 7. Surface Electrodes Arrangement

7. DISCUTIONS AND CONCLUSIONS

The difficulty in working with electromyographic signal was evident in the development of this work. Due to the low amplitude of the signal, that is lower than noise and environment signals. Even so into the laboratory far from lots of environmental interferences the electromyographic signal analyses demonstrated be realizable. Nonetheless the main goal of this work is to use the PESA to control electro-mechanisms as the hand prosthesis. Furthermore this project has been continued and new electrodes have been applied as well special cables. This project aims to allow the development of several devices controlled by electromyographic signal and projects that need the electromyographic signal as data base to compute process. Although this can be considered as a preliminary result, it is a very important point that opens a path for new developments.

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9. RESPONSIBILITY NOTICE

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