Microprocessor based EMG measurement in servo system

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Abstract—**The goal of this paper was to find a practical use for electromyography signals that can be detected on a muscle. This was achieved using an EasyPIC PRO v7 with a PIC18F87K22 microcontroller, an EMG click (MIKROE-2621), which is based on a MCP609 operational amplifier and MAX6106 micropower voltage reference, and a servo motor. The signal from the arm is processed by the microcontroller, which also controls the servo motor.**

Index Terms—**Measurement, sensors, EMG signal, servo motor.**

I. INTRODUCTION

Technology in the world is developing at a great speed, which enables people to have access to all sorts of gadgets that help in the household and in the industry.

Electromyography (EMG) is an electrodiagnostic medicine technique for evaluating and recording the electrical activity produced by skeletal muscles [1]. It is often used for checking the health of muscles and neurons that control them. They carry electric signals which are then collected into an EMG signal. On fig. 1. is a display of such a signal.
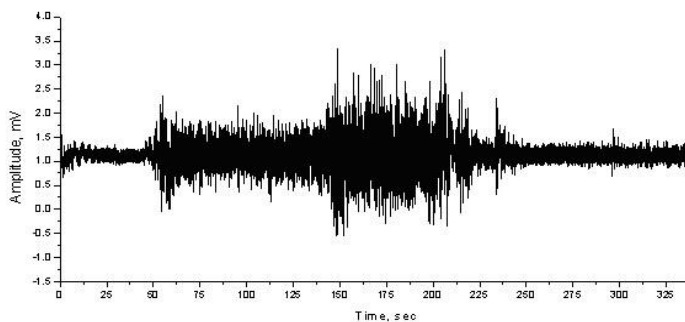

Fig. 1 - Display of an EMG signal

The signals can be analyzed to detect medical abnormalities, activation level, or recruitment order, or to analyze the biomechanics of human or animal movement. In

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Computer Science, EMG is also used as middleware in gesture recognition towards allowing the input of physical action to a computer as a form of human-computer interaction [2]. In this project the EMG signal is used as a human-computer interaction.

II. SYSTEM DESCRIPTION

The basic idea of this project was to find a use for the EMG signals that our muscles produce, so they could be used in everyday life. This was achieved by adding a servo motor to the end of the chain, which can act as an actuator. By doing this, a practical use is given to the concept.

This concept was accomplished by using an EasyPIC PRO v7 [3] development board with a PIC18F87K22 [4] microcontroller. An EMG click [5] was connected to the board using a microBUS [6] terminal. The development board and the EMG click where both developed by Mikroelektronika. The project was done as part of the Microprocessor based measurement and data acquisition systems 1 [7]. For demonstration purposes a Graphical LCD [8] display was also connected to the development board, which plays an animation of an arm moving the same way as the arm to which the electrodes are connected. All of the data acquisition and processing was done in MikroC [9] programming environment. A more detailed explanation of the sensors as well as all the other components will be given in the sections to come.

III. EMG CLICK

The EMG click measures EMG signals with the help of an MCP609 operational amplifier [10] as well as a MAX6106 micropower voltage reference [11]. It is designed to run on a 5 V power supply and has an analog output pin.

Fig. 2 - EMG click.[5]

The MCP609 operational amplifier from Microchip Technology Inc. is unity-gain stable with low offset voltage (250μV, maximum). Performance characteristics include rail-to-rail output swing capability and low input bias current (80 pA at +85 °C, maximum).

The MAX6106 is a low-cost, low-dropout (LDO), micropower voltage reference. This three-terminal reference is available with output voltage options of 1.25 V, 1.8 V, 2.048 V, 2.5 V, 3 V, 4.096 V, 4.5 V, and 5 V. For this click, the 2.048V option is used.

TABLE I
EMG CLICK SPECIFICATIONS

Type	Biometrics
Applications	Measuring the electrical activity produced by skeletal muscles.
On-board modules	MAX6106 voltage reference, 3.5 mm audio jack
Key features	ESD protection, Overvoltage protection, High-pass filter
Interface	Analog
Compatability	mikroBUS
Click board size	L(57.15 x 25.4 mm)
Input Voltage	5 V

The figure below shows the pinout of the EMG click with the corresponding pins of the mikroBUS socket.

Notes	Pin	mikro° BUS		Pin	Notes
Analog output	AN	1 AN	PWM 16	NC	
	NC	2 RST	INT 15	NC	
	NC	3 CS	TX 14	NC	
	NC	4 SCK	RX 13	NC	
	NC	5 MISO	SCL 12	NC	
	NC	6 MOSI	SDA 11	NC	
	NC	7 3.3V	5V 10	+5V	Power supply
Ground	GND	8 GND	GND 9	GND	Ground

Fig. 3 - EMG pinout. [5]

The click board measures the EMG signal through an electrode that is connected via a 3.5 mm audio jack. The electrodes collect the voltage from the skin (few milivolts), and that signal then gets amplified and filtered. This process can be presented with a block diagram presented on the figure below.
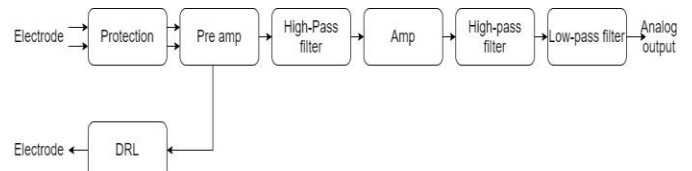

Fig. 4 - EMG click block diagram.

The EMG click should be connected to an MCU that has an at least 10-bit ADC, and the sampling rate should be at least 256 Hz as specified by the manufacturer. On the figure below is a picture showing the position of the electrodes used in this project.
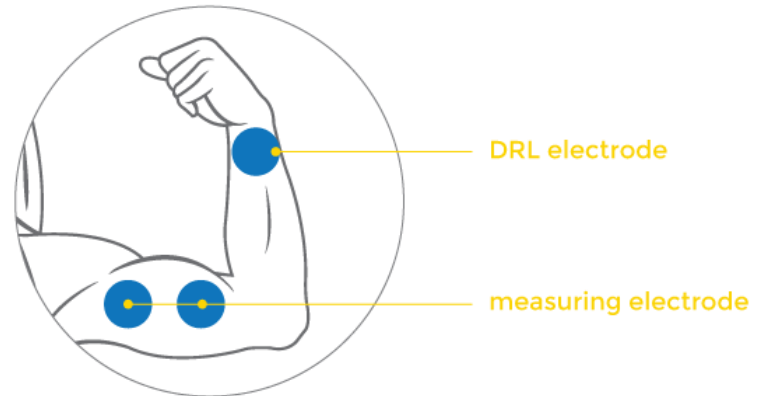

Fig. 5 - Position of the electrodes

The signal from the EMG click was lead to the ADC of the microcontroller found on the development board, from which it was filtered again by using standard deviation for the purpose of recognizing the movement of the arm.

IV. SERVO MOTOR

In this project the servo motor serves as an actuator, which we could later connect to some other moving parts. This demonstrates the vast use for configurations like these.

A servo motor is a closed-loop servomechanism that uses position feedback to control its motion and final position.
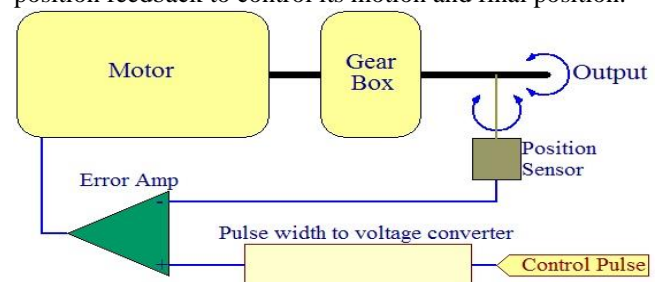

Fig. 6 - Feedback loop of a servo motor

The RC servo motor used here has three input pins, one for control and two for powering the motor. The control signal is used for controlling the angular velocity. The most common form of this signal is a PWM signal. In modern RC servos the angle of mechanical rotation is determined by the width of an electrical pulse that is applied to the control wire. The typical RC servo expects to see a pulse every 20 ms, however this can vary within a wide range

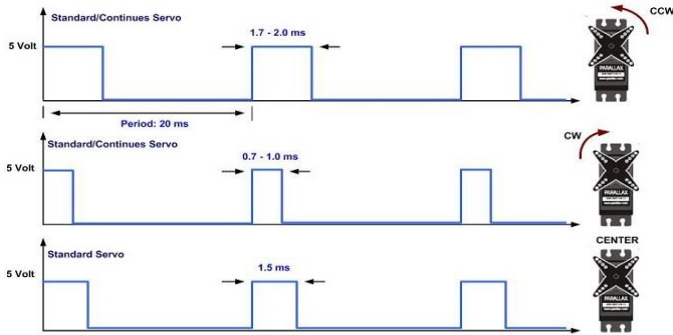that differs from servo to servo. The width of the pulse will determine how far the motor turns [12].

Fig. 7 - Movement of the servo motor depending on the pulse width [13]

V. THE ALGORITHM OF THE CODE

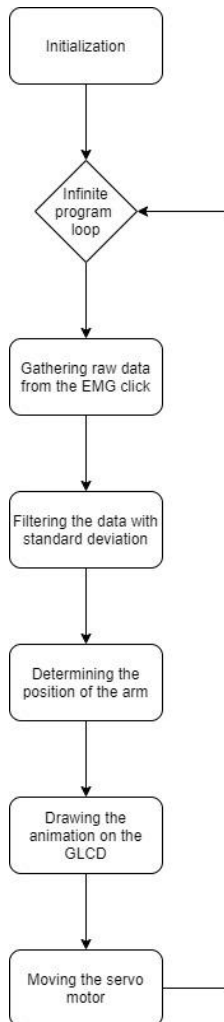The algorithm of the code is given on the figure below.

Fig. 8 - Algorithm showing the different steps of the program

The first step is the initialization of all the components that are connected to the development board, such as the EMG click, GLCD display etc. This is the only step outside the infinite program loop, as it should only be executed once.

After that we get into the infinite program loop.

The first step there is to gather the data from the EMG click via the ADC found on the microcontroller. Since the raw data from the EMG click is really noisy, there was a need to filter it out. This was done by getting the standard deviation of the signal. The number of the samples taken for the standard deviation was determined by experiments. After this the signal is smooth, and it is easy to determine the position of the arm by finding the values of the signal for both positions of the arm. For demonstration purposes a GLCD display was connected to the development board to show the movement of the arm via an animation. After this the PWM signal is generated, which depends on the position of the arm, so it turns clockwise if an extension happened, or counterclockwise if a flexion happened.

VI. CONCLUSION

This project shows a basic example for the EMG click, or other products of this kind, as they are not intended to be used in medical purposes. Also, the project can be developed further to match the practical needs of the industry or household.

On the figure below is a picture of the whole project.

Fig. 9 – Picture of the project

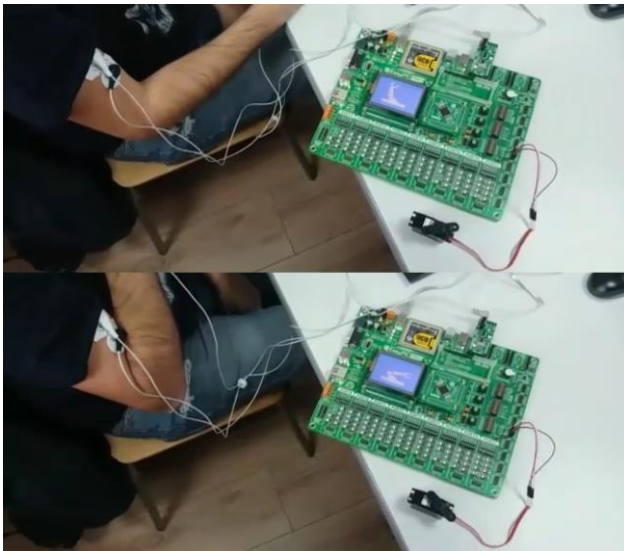The two main states of the system (flexion and extension) are showed on the figure below.

Fig. 9 – The extension (first picture) and flexion (second picture)

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