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APPLICATION OF INA122 AMPLIFIER TO MEASURE OF EMG SIGNALS

Abstract In this paper the amplifier to measure electromyographic (EMG) signals was developed. The device to recognize EMG signals was built with the use precision instrumentation amplifier INA122 made by BURR-BROWN Corporation. First, the solution was identified and the gain characteristics prepared. Next, the device was tested by measuring of EMG signals on biceps brachii muscle. Finally, the method of flex muscle identification was proposed.

1. INTRODUCTION

Recently, the electromyographic (EMG) signal has been used, in three cases: clinical practice, the rehabilitation and the control of several prosthetic and orthotic devices. EMG pattern analysis may provide better insight into the muscle recruitment strategic implemented by the Central Nervous System (CNS)[1]. Also the EMG signals offer a valuable tool for an accurate diagnosis of neuromuscular disorders [2-5]. In clinical research, EMG signals are often proposed to permit the control of several prosthetic and orthotic devices [6–9]. Generally, the activation of different muscles is involved in controlling the external device. The device controller is thus engaged in the following tasks based on processing the EMG signals: (a) accurate identification of the time instant for the muscle between the relaxed and contracted state detection, (b) feature extraction based on the segmented signals, and (c) pattern classification used to understand the motion of the user and hence the function to be executed by the prosthetic device. Much kinesiological, physiological and neurophysiological electromyography simply uses and analyses the raw EMG. The amplitude of this signal, and all other EMG data, should always be related back to the signal generated at the electrodes, not given after amplification. Further EMG signal processing is often performed in sports biomechanics in an attempt to make comparisons between studies. It can also assist in correlating the EMG signal with mechanical actions of the muscles or other biological signals[10,11]. In this paper the problem is concerned around design of simple measurement system to acquisition data from muscle and analyzing for control system. The aim of the project was to create simple solution and low power cost of the device. To develop the device, the precision instrumentation amplifier INA122 made by BURR-BROWN[12] was used. This device is characterized by low noise differential signal acquisition, single supply, low offset voltage, low power consumption and gain from 5V/V to 10000V/V set by single external resistor sets. The article presents the results of experiments for the EMG signal amplifier built based on an integrated circuit INA122.

2. MATERIALS AND METHODS

The EMG signal processing can provide information contained in the raw signal. This process can be realized by microcontroller. The location of electrodes, skin preparation and other factors can all affect the results. Even the activity or inactivity of muscle must noticeably change the signal, so the signal should be suitable amplified. The change of the EMG signal involves the expression of the amplitude of the signal as a ratio to the amplitude of a contraction and change of values of amplitude are various for different frequency of signal. The main task for the amplifier is to provide the signal of a level suitable for A/D converter and in consequences for the microcontroller.

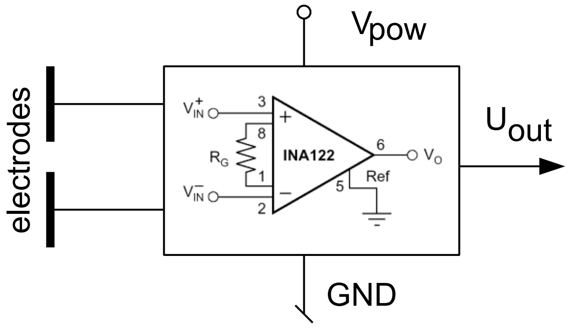

Fig.1. Block diagram of control system for prosthetic control

The measurement system for EMG signals used to control of prosthetic devices needs three basic properties: low power consumption and small dimensions and also must include components shown on Fig. 1. The amplifier should provide the proper gain to measure the EMG signal and also its sensitive to get information about small activity of the muscle recorded as a change of output voltage accepted by predicted type of A/D converter. Very good property of the amplifier INA122 is the possibility to apply a single voltage. In all experiments the $V_{pow} =$ [illegible][V] of supply voltage was used. The selection of supply voltage was based on that many microcontrollers work in range from 3.3[V] to 5[V]. For INA122 the gain can be regulated by external resistor. For experiments the gain was assumed on level 1000 [V/V]. The power was provided by a set of batteries in order to eliminate the interference generated from the electricity grid.

Tests for the EMG signal measurement system was divided into two stages. In the first stage the frequency response was determined. In the second stage the response on the EMG signal from muscle was examined.

3. FREQUENCY RESPONSE OF AMPLIFIER INA122

To determine the frequency of the amplifier, the analyzer SIGLAB 20-42 was used. The experiments was carried out for sinusoidal input signal with an amplitude 1[mV]. The dependence of frequency on gain was obtained from the relation between input and output voltage.

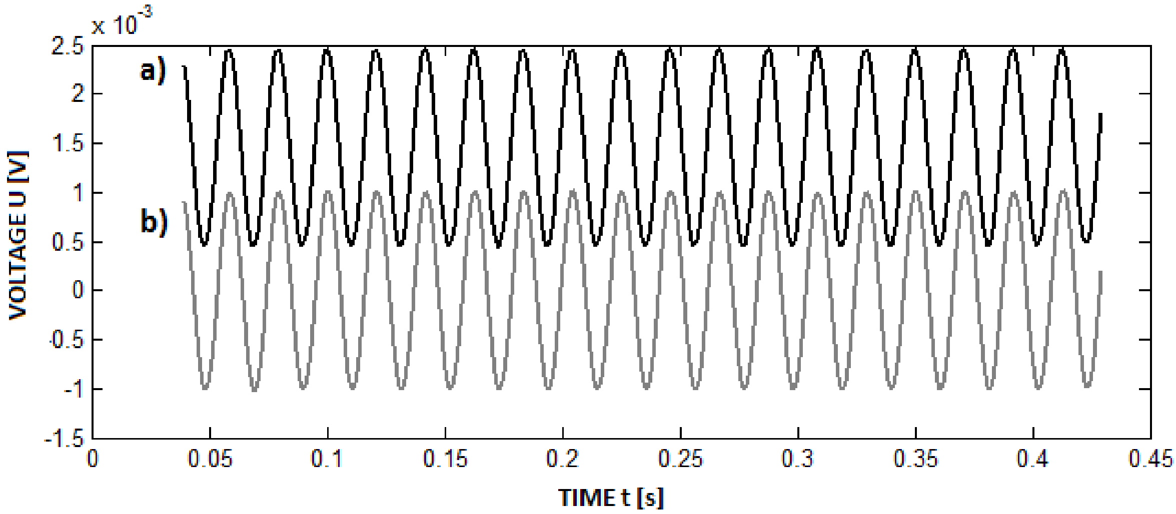

Fig.2. Course of signal for input (a) and output/1000(b)

The investigations have been conducted for wide range of frequency from 5Hz to 800Hz. The most interesting range of frequency is between 20Hz and 60Hz because the frequency of human myopotential lies in similar range[13]. The relation between frequency of input signal and gain of amplifier INA122 was presented in Fig. 3.

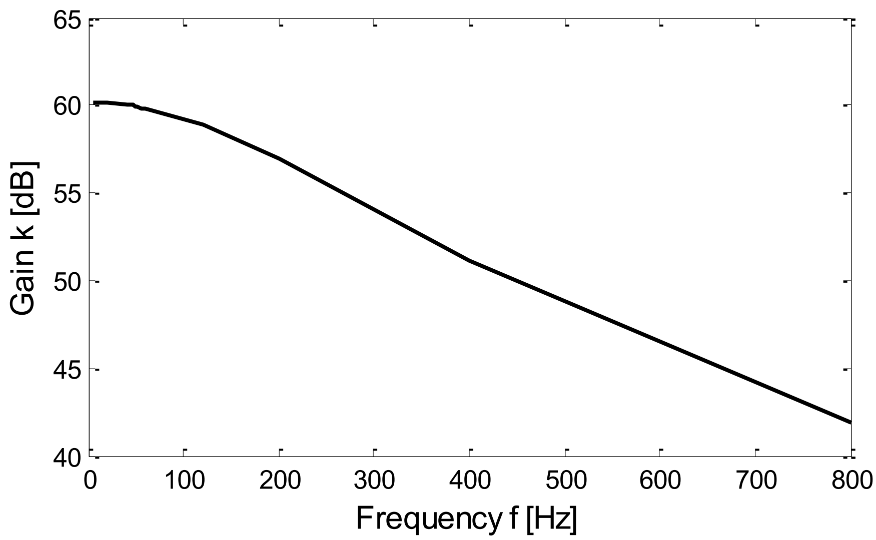

Fig.3 Relation between frequency and gain for INA 122

The maximal gain is about 60 dB and it is equivalent to 1000 V/V. The main conclusion from experiments is that the gain in range from 20 to 60 Hz is “quasi” stable. Above 150 Hz the amplifier INA 122 works like high bandwidth filter.

4. PHASE SHIFT

In INA122 the shift between input and output signal occurs. Fig. 3. presents graphs on which the relation between input and output signal is shown. The graphs have ellipsis shape, which gives the evidence of the phase shift. The calculation of phase shift is however some now difficult because for high frequency the shift in angle unit can be too high. The same shifts in time units can be compared because their values are not dependent on frequency.

Tab 1 Phase shift in time units

No.	Frequency f [Hz]	Time Shift [ms]
1	40	66
2	42	84
3	45	74
4	48	61
5	50	68
6	52	62
7	55	66
8	58	70
9	60	64
10	120	61

In Table 1 the values of time shift are presented. For given frequency the times shift between input and output signals are similar which shift between input and output signals are similar which confirms the independence of phase shift on frequency.

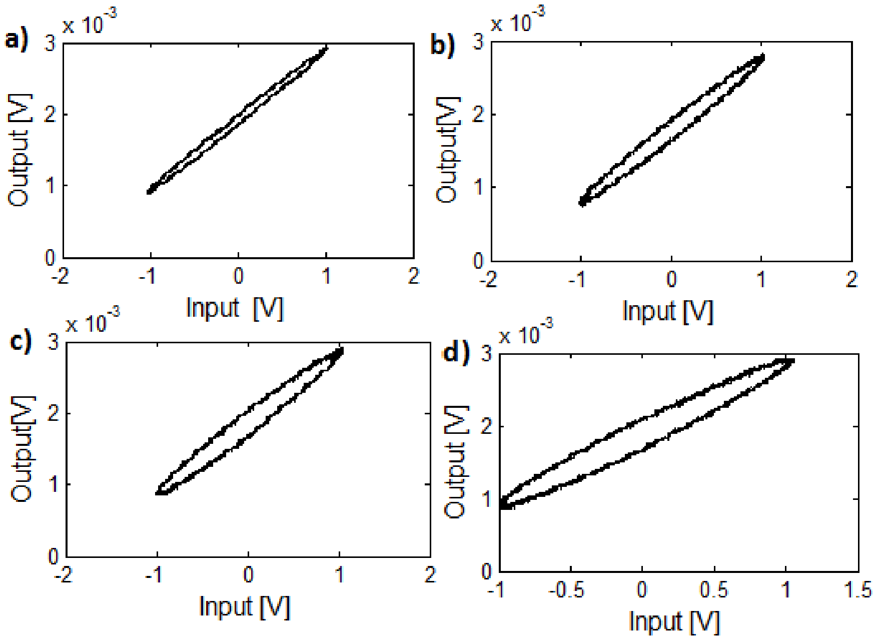

Fig.4 Relation between input and output signals for four frequency: a) 20Hz, b) 40Hz, c) 50Hz, d) 60 Hz

5. MEASUREMENTS OF ELECTROMYOGRAPHY SIGNALS

After characterization of the INA122 amplifier the EMG signal was measured. The EMG signals was collected from biceps brachii muscle. The electrodes were placed on skin in exactly selected locations. Two working electrodes, connected to invert and non-invert inputs of INA122, were placed on the ends of muscle. The third, reference electrode was placed on skin near to bone. In experiment the two-pole measurement method was used. The output signal from amplifier was recorded using signal analyzer SIGLAB 20-42.

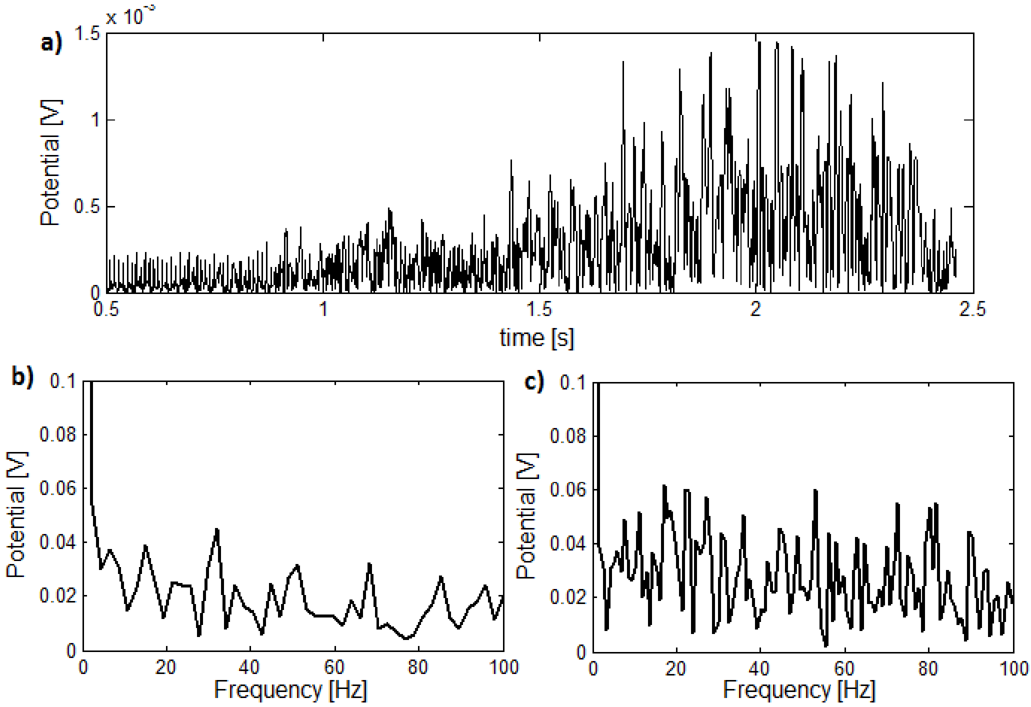

Fig.5 The EMG signal a)signal in time space, b) spectrum for loose muscle, c) spectrum for flex muscle

The EMG signals were transformed by FFT (Fourier Frequency Method). In result of the calculation the spectrum of signal was obtained. The graph a) (Fig. 4) shows the signal in time domain. This signal has two phases: first between 0,5s to 1,4s for relaxed muscle and form 1,7[s] to 2,3[s] for contracted muscle. For these two ranges the Fourier analysis was made. The graphs b) (Fig. 4) shows spectrum of signal for loose muscle and the graph c) shows signal for flex muscle. For these two cases the signal has maximal change of amplitude for frequency in range form 0 to 100Hz. The average amplitude for these spectrums are: ~0.02[V] for first and about ~0.04[V] for second.

6. CONCLUSIONS

In this paper the results of experiments with amplifier INA122 was presented. This integrated board has good parameters for application in measurements of EMG signals. This device has high gain, low noise and low power consumption. The application of the INA122 amplifier was a result of searching for solution in which the simple amplifier for microcontrollers platform can be found. The microcontroller should get EMG signal without noise and process it. Based on results shown in this paper, the proposed solution of amplifier is proper for such application. High gain (about 1000 V/V) and good characteristic of frequency assure that the INA122 amplifier is a good solution. The analysis of EMG signal for relaxed and contracted muscle confirms that the gain is sufficient. Moreover, during experiments it was evidenced that phase shift did not influence on the analyzing of the EMG signal because the change of shift for frequency in considered range is low.

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