A Low-cost EMG-EOG Signal Conditioning System for Brain Computer Interface Applications

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***Abstract*— The objective of this work is to design and construct a low cost Electromyogram (EMG) and Electrooculogram (EOG) signal conditioning system for assistive device applications. The proposed circuit is designed for capturing surface EMG signal and EOG signal available on the surface of the human skin. This paper describes the system containing two units: signal detection unit and signal conditioning unit. The developed electronic circuit is also interfaced with PC-based data acquisition and analysis software LABVIEW for recording of signals. The recorded EMG and EOG signal may be further analysed and correlated with the control of assistive devices. It is proposed to use the results for study of man-machine interaction such as development of control for assistive devices.**

Keyword- EMG, Electrodes, Filter design, man-machine interaction

I. INTRODUCTION

Electromyogram (EMG) signal is an electrical signal (motor action potential) that is generated during muscle contractions [1]. This EMG signal find application in various fields such as identification of patients with motion deficiencies, ergonomic evaluation of human activities [2], as well as the development of prosthetic and orthotic devices to aid the physically disabled[3]. Active prosthetic devices can employ EMG signals to detect the intended limb movement of amputees, and the control of prosthetic devices based on EMG signal has been a major area of research in robotics [3-7].

Electrooculogram (EOG) is also an electrical signal generated between retina and the cornea, related to movements of eye. This signal is used to estimate drowsiness level to prevent accident, cursor control for the purpose of communication aid to disabled [8-9].

Recording of EMG signal from facial muscles together with EOG signals find applications in assistive devices for people suffering from disruptive communication between brain and body due to spinal cord dysfunction. For detecting EMG and EOG signals, surface electrodes are suitable for assistive devices. One of the major problems in recording of the physiological signals is interference from various sources such as power line, motion artifacts, DC offset etc. Advances in technology help the biomedical signal researchers to develop a signal conditioning system for recording and analysing signals in laboratory.

II. EMG-EOG SIGNAL CONDITIONING SYSTEM

The design of EMG-EOG signal conditioning system is divided into two modules, namely EMG conditioning module and EOG conditioning module. The design of conditioning system consists of various units such as detection circuit, protection circuit, preamplifier, DC offset rejection filter, variable gain amplifier and filter as shown in Fig. 1.

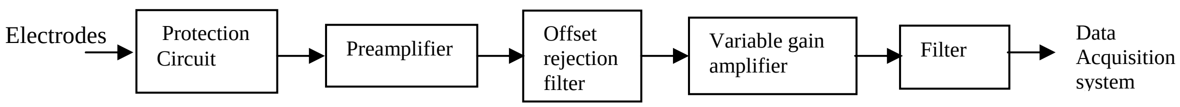

Fig.1. Block Diagram of Signal Conditioning System

To design a signal conditioning systems, it is necessary to understand the characteristics of the signals. The surface EMG signal is in the amplitude range of micro volts to milli volts and the signal information will be dominant in the frequency range of 20 Hz to 500 Hz. EOG signal is in the range of few micro volts to milli volts with frequency range between 0-38Hz. Therefore, the circuits such as detection unit, protection circuit, preamplifier and variable gain amplifier design have been kept same for both EMG and EOG conditioning system. Remaining circuits have been focussed based on the frequency characteristics.

A. Detection Unit

Each detection unit consists of two electrodes. In this work pre-gelled electrode has been used. A pair of electrodes detects the signal from the desired location on the skin surface and the third electrode acts as a reference electrode (or ground electrode) placed necessarily at the inactive portion of the surface to reduce the noise. A conductive gel or paste is often required to improve the electrical contact between the skin and the electrodes for reusable electrodes.

B. Protection Circuit

The circuit diagram of the protection circuit simulated in Multisim is shown in Figure 2. The physiological signal picked up by the two electrodes is passed through a RC filter. The initial stage RC filter suppresses the radio frequency signals that enter the preamplifier. The second stage consists of PNP and NPN transistors to protect the user and the circuitry from damage. These transistors begin to conduct at voltage exceeding ±≈0.58 V to pull the harmful currents to the ground.

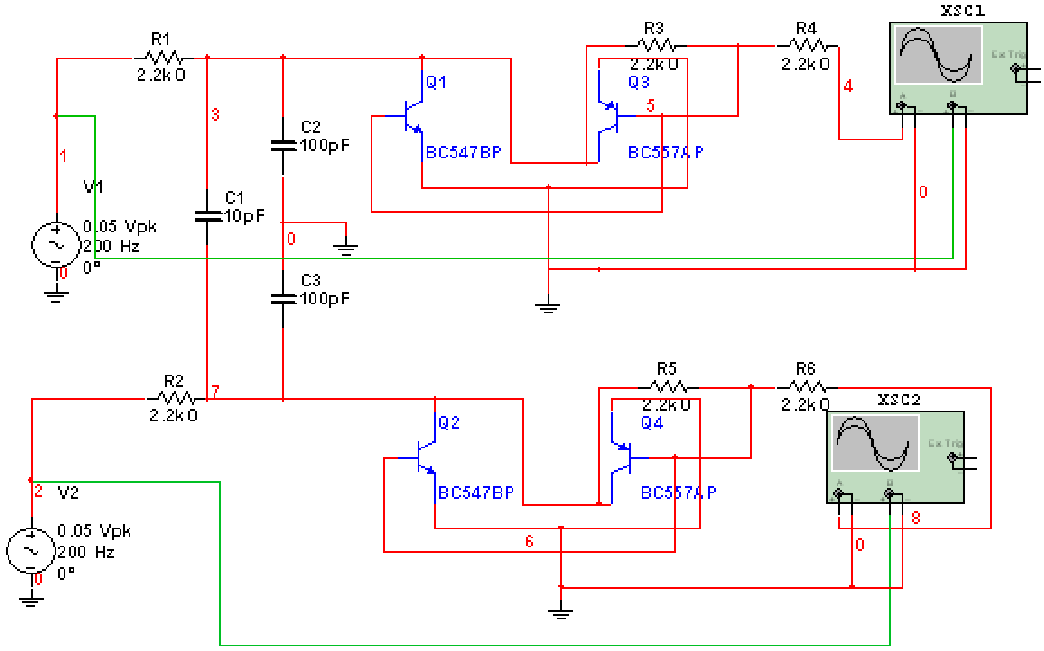

Fig. 2 Protection Circuit

C. Pre-Amplifier

Instrumentation amplifier consisting of three identical operational amplifiers is used for this purpose. The instrumentation amplifiers used should have high common mode rejection ratio (CMRR), very high input impedance, and low output impedance. Based on these requirements, INA128 instrumentation amplifier with pre-amplification gain of 12 is used.

D. Offset Rejection Filter

Some electric charge can accumulate on the surface of the electrode, which builds up to a relatively high DC voltage. To avoid such DC voltage offsets, a high pass filter is used. This is passive filter.

EMG-Offset Rejection Filter-Since the EMG signal contains usable energy in the range of 20-500Hz, a cut-off frequency nearer to 10 Hz may be selected because it will not reject the necessary information.

EOG-Offset Rejection Filter-However, EOG signal contains usable range between DC to 38 Hz. Therefore, a cut-off frequency nearer to 0 Hz such as 0.16Hz may be chosen to design RC values of high pass filter.

E. Variable Gain Amplifier

The output from the high pass filter is passed through the variable amplifier, whose gain can be varied from 6 to 100. This amplifier is constructed using TLC272 operational amplifier. TLC272 has low offset voltage, high input impedance and low noise. This makes it more appropriate to design amplifier for such low amplitude signal.

F. Filter

The final stage of conditioning system is a filter that allows signals of desired frequency range to the data acquisition system such as Dspace, LABVIEW etc.

EMG Filter-The final stage consists of band pass filter which is a combination of low pass and high pass filter. The cut-off frequency may be 10-500Hz as most of the information is contained in the range. To increase the gain of the system, gain may be included. Second order Butterworth filter has been designed using FilterPro V2.0 software.

EOG Filter-Since the energy of the signal is between DC-38Hz, a low pass filter with cut off frequency of 40Hz has been designed for final stage of conditioning system.

III. EXPERIMENT

Figure 3 shows the placement of electrodes for acquisition of EMG-EOG signal for the purpose of brain computer interface applications from the developed conditioning system in the laboratory.

Fig.3 Placement of electrodes for EMG-EOG Signal Acquisition

EMG-EOG signals are acquired for different direction of the eye and the results are observed in Digital Storage Oscilloscope (DSO) as well as stored in personal computer using LABVIEW. Figure 4 shows the EMG-EOG signal recorded in DSO for eyes gazing. Figure 5 shows the recorded EMG-EOG signal for eyes gazing from straight-left-straight-right. The signals are recorded at a sampling rate 1000 samples per second from EMG as well as EOG signal conditioning system.

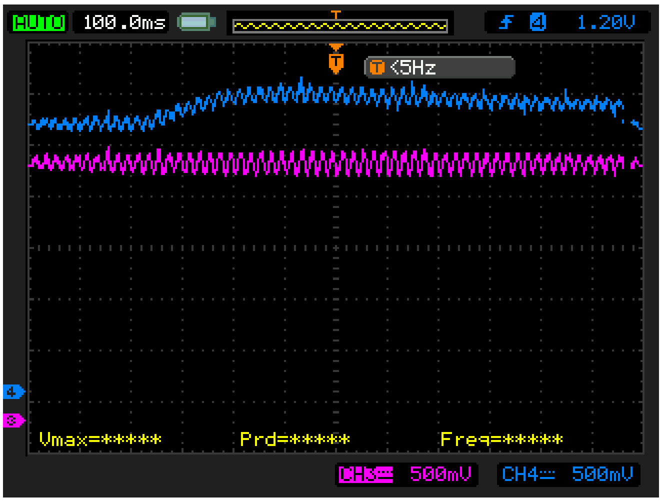

Fig.4 EMG-EOG Signals in DSO

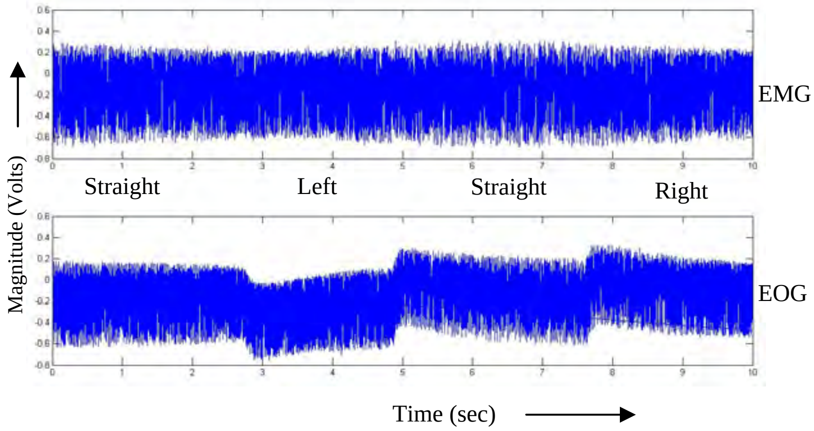

Fig.5 Recorded EMG-EOG Signals in personal computer

IV. CONCLUSIONS

A laboratory based EMG-EOG signal conditioning system by using printed-circuit board is fabricated. The present work of EMG-EOG signal acquisition can be employed without using data acquisition software by using custom-made data acquisition system using microcontroller or by using the sound card of a desktop computer.

Multi-channel EMG-EOG signals are required to increase dexterity of assistive devices in brain computer interface applications. The present circuit consists of single-channel EMG as well as EOG. The design can be extended for multi-channel EMG and EOG.

Several artificial intelligence techniques are applied for processing the recorded EMG data for feature extraction and classification of patterns, based on which assistive devices are controlled. Although research interest in EMG- EOG is increasing in developing countries, the number of research groups currently working in this area is too few. The reasons may be attributed to the highly interdisciplinary nature of the field and high cost of the equipment. This paper may help the researchers to develop ingenious equipment in the laboratory for the purpose of research.

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REFERENCES

[1] www.delsys.com/ KnowldegeCenter/ Tutorials.html

[2] P. Geethanjali, K K Ray, and P V Shanmuganathan "Actuation of prosthetic drive using EMG signal", *Proc. IEEE International Conference TENCON*, pp. 1-6, 2009.

[3] B. Hudgins, P. A. Parker, and R. N. Scott, "A new strategy for multifunction myoelectric control," *IEEE Trans. Biomed. Eng.*, Vol. 40, pp. 82–94, Jan. 1993.

[4] H. P. Huang, Y. H. Liu, and C. S. Wong, "Automatic EMG feature evaluation for controlling a prosthetic hand using a supervised feature mining method: an intelligent approach," *in Proc. IEEE Int. Conf. Robot. Automation,* 1, pp. 220–225, Sep. 2003.

[5] J.Chu, I. Moon, and M. Mun, "A real time EMG pattern recognition system based on linear-nonlinear feature projection for a multifunction myoelectric hand," *IEEE Trans. Bio. Med. Eng.*, Vol.53, pp. 2232-2239, Nov. 2006.

[6] P. C. Doershuk, D. E. Gustafson, and , A. S. Willsky "Upper extremity limb function recognition using EMG signal analysis," *IEEE Trans. Biomed. Eng.,* Vol.30, pp. 18–29, Jan. 1983.

[7] S. C. Jacobson, D. F. Knutti, R. T. Johnson, and H. H. Shears., "Development of the Utah artificial arm," *IEEE Trans. Biomed.Eng.,* Vol. 29, pp. 249–269, Apr. 1982.

[8] A. Anand, G. Kecklund, B. Peters and T. Akerstedt, "Driver sleepiness and individual differences in preferences for countermeasures", *Journal of Sleep Research*, Vol. 17, pp. 16-22, 2008.

[9] J. Keegan, E. Burke, J. Condron, and E. Coyle, "Improving Electrooculogram-based computer mouse systems: the Accelerometer Trigger", in *Proc. Bioengineeringin Ireland*, 2011.