Development of an EEG amplifier for Brain-Computer-Interface

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Abstract— **This paper describes the development of a bi-polar EEG amplifier designed specifically for use in a brain-computer-interface (BCI). AC coupling is performed in the input stage to prevent electrode offset voltages from saturating the amplifier when high gain is used. The amplifier is easily modified to amplify other biopotential signals. The circuit described is suitable for low power consumption, battery power application. The low power requirement of the amplifier allows it to be powered through the USB connection and thus suitable for portable applications.**

Keywords— **EEG, differential amplifier, pre-amplifier, ac-coupled.**

I. Introduction

A brain-computer-interface (BCI) is a communication system that does not depend on the brain's normal output pathways of peripheral nerves and muscles. BCI employs either EEG activity recorded from the scalp, or the activity of individual cortical neurons recorded from implanted electrodes [1]. BCI has been introduced to record the EEG signals from subject and process the recorded signals for further application.

The EEG or electroencephalograms represents the electrical activity of the brain. EEG records the electrical potentials generated due to excitatory and inhibitory post-synaptic potentials developed by cell bodies and dendrites of pyramidal neurons [2].

EEG signal, as one of the biological signals, are recorded at very low level of voltage ranging between 1μV and 100mV. These signals have to be amplified to make compatible with other devices such as display, recorders or A/C converters for computerized equipment. A specific high gain amplifier (gain of 10,000 - 1,000,000) is required to boost signal strength up to an acceptable level required, as an input to recording devices.

However, the typical BCI system is designed specifically for one particular BCI method and is, therefore, not suited to the systematic studies that are essential for continued progress for new BCI method and further signal processing [3].

Thus, to condition the EEG signal for further processing and applications for an EEG based BCI system, a low frequency, high gain EEG amplifier, is preferable.

Over the decades, various biopotential amplifiers had been designed by researchers to record the biopotential signals [4-12]. These proposed designs used the differential amplifier as the main core for the modules. Most of these designs are relying on three op-amp instrumentation-amplifier (IA), to differentiate and amplify the signal [4-7] [11-12].

Integrated Circuit (IC) chips had been used as the differential amplifier for the designs [4-12]. However, the commercial IC chips had had specific value of gain, which had been preset initially, and do not meet with the biopotential signal requirements. To adapt these amplifiers to the applications, the circuits require some modifications such as the addition of passive component such as resistors and capacitors, in order to control the amplification.

Due to this problem, it is necessary to design and develop an EEG amplifier using the discrete components such as transistor, resistor and capacitor, instead of IC chips. By using the transistors, the amplifier characteristic can be easily designed and set to the desired values with the help of resistors and capacitors. Thus, the amplifier can be perfectly matched to the biopotential signal applications requirements.

II. The Proposed Designed Circuit

As illustrated in Figure 1, the proposed circuit consists of 3 main parts: pre-amplifier, differential amplifier, and filter. The collector output signal is captured through a data acquisition card (DAQ) for further processing on a computer.

The proposed design circuit is as shown in Figure 2.

Fig. 1 Overall block diagram of the BCI system.

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