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EEG Signal Acquisition Using Embedded Systems

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***Abstract*—The purpose of this paper is to develop EEG signal acquisition using embedded systems. This system has been designed that recorded biological signal conditioning is a successive analog and digital transformation. These transformations are necessary to provide signals for efficacious signal processing and pattern recognition methods. An important objective of this paper is to describe the improvements of the EEG signal acquisition systems using efficient signal conditioning proceedings which gives increased amplification factor and SNR value.**

***Index Terms*— EEG, Electrode, Embedded system, Signal processing**

I. INTRODUCTION

The EEG is an electrical waveform that is recorded from the brain by using electrodes appropriately placed on the head then amplifying and displaying the electrical signal using a computer or other suitable instrument. It consists of a wave that varies in time much like a sound signal or a vibration. As such it contains frequency components that can be measured and analyzed and these frequency components have interesting and valuable properties. There are many ways to approach the understanding of brainwaves. Clinical view them for diagnostic purposes, seek to identify patterns that associate with specific pathologies or conditions. Psychologists also study them in association with mental states mental processing and to test concepts of how the brain processes information. We also know from introspective reports and structured experiments which subjective states tend to be correlated with a predominance of the various brainwave components. Brain rhythms can also be operantly trained using biofeedback. By training an individual to learn how to produce or reduce specific frequencies, changes in the brain can be produced. From a training standpoint we can learn what types of mental states or activities are affected by specific types of training. We need to study the patterns that emerge during various behavioral as well as introspective states and then see what they are defining in terms of a multidimensional representation of some state-space. Research that is focused on understanding specific properties such as attention, alertness, mental acuity, etc., has uncovered combinations of rhythms and other EEG properties that are relevant to these studies. Generally "derived" properties are found useful that involve computer-processing of the EEG to produce measurements

How brain rhythms are generated: Populations of cells generate rhythms when they depolarize in synchrony. This activity occurs primarily in the upper 4 layers of the cerebral cortex. The presence of an EEG rhythm indicates that there is some brain activity occurring in terms of millions of cells acting together in a synchronized fashion. EEG signals are seen to wax and wane which means to grow larger and smaller in time generally showing moment-to-moment variation at all times.

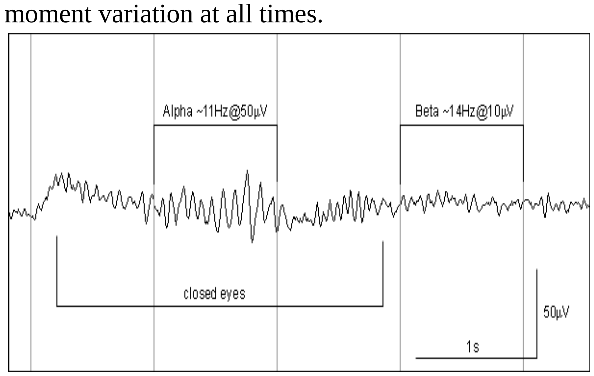


Figure1. EEG graph

Alpha is almost always seen in "spindles" and "bursts," almost never seen in a continuous wave. It is the production of more or larger bursts of rhythmic activity that is associated with their being a higher "amount" of that component. Beta for example may occur in very small bursts of 1/10 second or less so that it comes and goes very rapidly. Alpha on the other hand generally waxes and wanes with bursts of 1/5 second. Since the brain consists of broadly identifiable areas frontal (motor and sensory cortex), parietal, occipital (visual), temporal (hearing, language) rhythms are seen to be associated with the particular involved area.

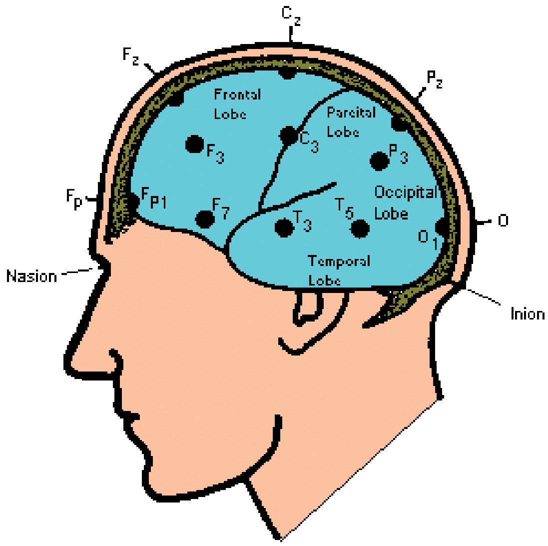


Figure2. Different brain areas

II. HARDWARE DESIGN

A. Overview

An EEG signal *is* usually acquired through silver-chloride covered electrodes though sometimes other materials like pure silver, tin, steel or gold are used. The signal amplitude is only a few microvolts and needs to be amplified several thousand times before it can be captured. Because it is faint, the signal can very easily drown in noise particularily 50/60Hz hum from the mains

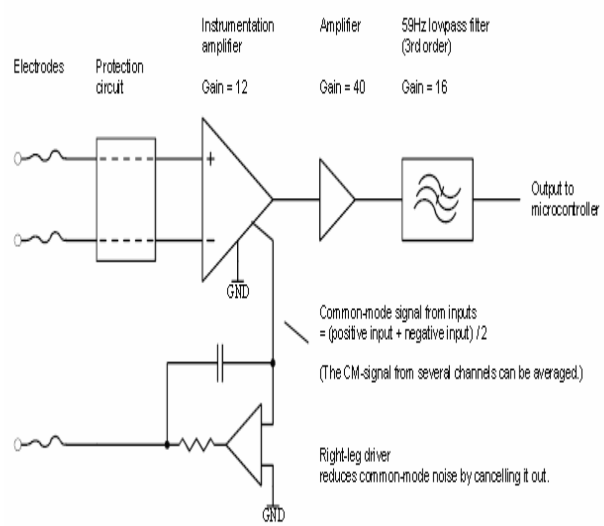


Figure3. Simplified block diagram of the Modular EEG amplifier

B. Description

The EEG signal is picked up by the two topmost electrodes and passed through the protection circuit. It serves two purposes: First, it protects the circuitry from electrostatic discharge (ESD) and second it protects the user from failing circuitry. Leaving the protection circuit the signal enters the instrumentation amplifier where it is amplified 12 times. After that the signal is amplified about 40 times in a second amplifier stage. Between the two stages there is a high-pass filter which removes DC-voltage offsets. Finally the signal is amplified 16 times more and low pass filtered. The filtering is done to prevent aliasing effects later on when the signal is digitized. Below the signal amplifiers and the filter sits a third amplifier pointing the other way. The purpose of the DRL is to reduce common-mode signals such as 50/60Hz mains hum by cancelling them out. After the filtering, the signal is ready for acquisition by the analog-to-digital converter which in our case is located inside a microcontroller. The microcontroller sends the digitized EEG to a PC via a standard serial cable. To protect the user from electrical faults the EEG device is electrically isolated from the PC and external power sources

C. Schematic

The following figure shows the schematic of the modular EEG system

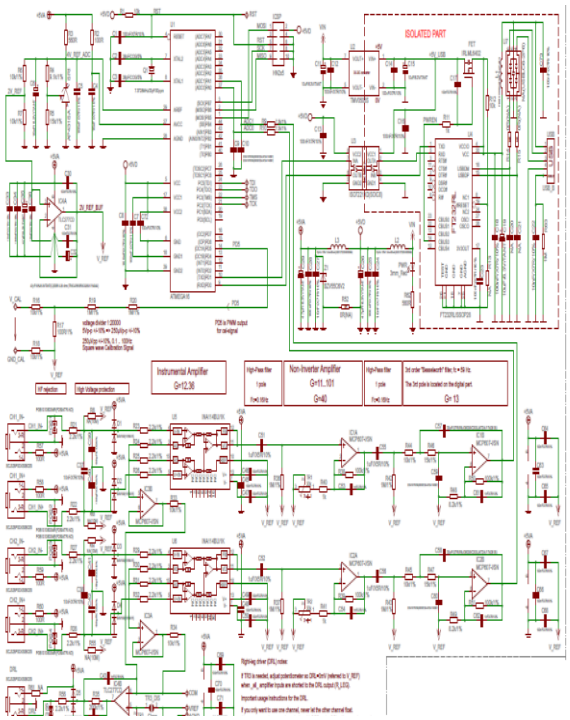
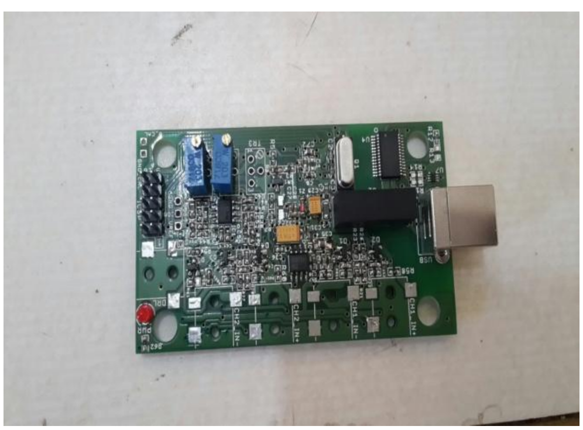


Figure4. Schematic

C. PCB design of modular EEG



D. Components

FT232R USB UART IC, Atmega32 AVR® 8-bit Microcontroller, INA114 Instrumentation amplifier. LinCMOS Precision dual operational amplifiers, Micropower CMOS Op Amp. BAV199 Low-leakage double diode, HEXFET power MOSFET.

III SOFTWARE DESIGN

A.Programming

Micro pro c Software provides software development tools for the AVR® **8-bit Microcontroller** family of microcontrollers.

B. Front end design

Electric Guru V0.40 monitoring software

IV. DISSCUSSION

System gives the possibility of calibrating the offsets of the inputs, the calibration of the voltage amplification and the possibility to measure the impedance of skin-electrode contact.The possibility to utilize the different modules in different applications in case there are necessary specific values for potential amplifications with a low number of passive components. An easy possibility to interface the electrodes with other digital equipments. An easy way to integrate and miniaturize making it usable in portable recording systems. The possibility to integrate such a bio-signal recording module into a BCI (Brain Computer Interface) dedicate system.

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