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Real Time EEG Signal Analysis

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ABSTRACT*:* An EEG signal is a measurement of currents that flow during synaptic excitations of the dendrites of many pyramidal neurons in the cerebral cortex.EEG is used to denote electrical neural activity of the brain. Electroencephalography (EEG) is the recording of electric potentials produced by the local collective partial synchrony of electrical field activity in cortical neuropile, today most commonly measured by an array of electrodes attached to the scalp using water-based gel.

KEYWORDS*:* Electroencephalography, electric potential,neural activity, neuropile,electrodes

I. INTRODUCTION

The brain represents not only the brain function but also the status of the whole body.Electro-(referring to registration of brain electrical activities) encephalo-(referring to emitting the signals from the head), and gram (or graphs), which means drawing or writing, the term EEG is used to denote electrical neural activity of the brain[1]. An EEG signal is a measurement of currents that flow during synaptic excitations of the dendrites of many pyramidal neurons in the cerebral cortex. [2]When brain cells (neurons) are activated, the synaptic currents are produced within the dendrites. This current generates a magnetic field measurable by Electromyogram (EMG) machines and a secondary electrical field over the scalp measurable by EEG systems[2].

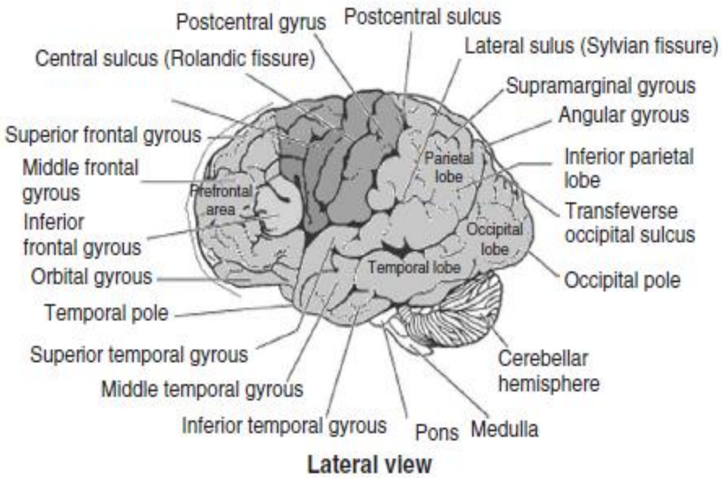

Fig. 1 Lateral view of Brain

The brain is made of three main parts: the forebrain, midbrain, and hindbrain. The forebrain consists of the cerebrum, thalamus, and hypothalamus (part of the limbic system). The midbrain consists of the tectum and tegmentum. The hindbrain is made of the cerebellum, pons and medulla. Often the midbrain, pons, and medulla are referred to together as the brainstem.

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The Cerebrum: The cerebrum or cortex is the largest part of the human brain, associated with higher brain function such as thought and action. The cerebral cortex is divided into four sections, called "lobes": the frontal lobe, parietal lobe, occipital lobe, and temporal lobe.

- Frontal Lobe- associated with reasoning, planning, parts of speech, movement, emotions, and problem solving
- Parietal Lobe- associated with movement, orientation, recognition, perception of stimuli
- Occipital Lobe- associated with visual processing
- Temporal Lobe- associated with perception and recognition of auditory stimuli, memory, and speech

II.DEFINATION OF EEG

According to Webster online dictionary, the term EEG means

-electrical activity of an alternating type recorded from the scalp surface after being picked up by metal electrodes and conductive media

-electrical neural activity of the brain.

-recording of electric potentials produced by the local collective partial synchrony of electrical field activity in cortical neuropile[1].

An EEG signal is a measurement of currents that flow during synaptic excitations of the dendrites of many pyramidal neurons in the cerebral cortex. When brain cells (neurons) are activated, the synaptic currents are produced within the dendrites[2]. This current generates a magnetic field measurable by Electromyogram (EMG) machines and a secondary electrical field over the scalp measurable by EEG systems. EEG is the most widely known and studied portable noninvasive brain imaging modality; another, less developed and not considered here, is functional near-infrared spectroscopy (FNIR)[3].The first report of signals originating in the human brain and recorded non-invasively from the scalp was that of Berger in 1924. The current generates a magnetic field measurable by Electromyogram (EMG) machines and a secondary electrical field over the scalp measurable by EEG systems.[1][2].EEG activity patterns correlate with changes in cognitive arousal, attention, intention, evaluation, and the like, thereby providing a potential B window on the mind. We believe that in the coming decades adequate real-time signal processing for feature extraction and state prediction or recognition combined with new, noninvasive, and even wearable electrophysiological sensing technologies can produce meaningful applications in a wide range of directions[3]

III.BRAIN RHTHYMS

Many brain disorders are diagnosed by visual inspection of EEG signals. The clinical experts in the field are familiar with manifestation of brain rhythms in the EEG signals.[2] In healthy adults, the amplitudes and frequencies of such signals change from one state of a human to another, such as wakefulness and sleep. The characteristics of the waves also change with age. [2]There are five major brain waves distinguished by their different frequency ranges. These frequency bands from low to high frequencies respectively are called alpha (a), theta (ɵ), beta (ß), delta (d), and gamma (r)[3].

TABLE I: - BRAIN RHTHYMS [3]

Rhythm	Freq (Hz)	Amp(µV)
Alpha	8-13	20-200
Beta	13-30	5-10
Delta	1-5	20-200
Theta	4-8	10
Gamma	30-45	10-100

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A. Alpha

Alpha waves appear in the posterior half of the head and are usually found over the occipital region of the brain. For alpha waves the frequency lies within the range of 8–13 Hz.An alpha wave has a higher amplitude over the occipital areas and has an amplitude of normally less than 50 µV.

B. Beta

A beta wave is the electrical activity of the brain varying within the range of 14–26 Hz . A beta wave is the usual waking rhythm of the brain associated with active thinking, active attention, focus on the outside world, or solving concrete problems, and is found in normal adults.

C. Delta

Delta and theta rhythms are low-frequency EEG patterns that increase during sleep in the normal adult. .Delta waves lie within the range of 0.5–4 Hz. These waves are primarily associated with deep sleep and may be present in the waking state. [1][3].

D. Theta

Theta waves lie within the range of 4–7.5 Hz.A theta wave is often accompanied by other frequencies and seems to be related to the level of arousal. [3].

E. Gamma

The frequencies above 30 Hz (mainly up to 45 Hz) correspond to the gamma range (sometimes called the fast beta wave) are located in the fronto central area.[3].The gamma wave band has also been proved to be a good indication of event-related synchronization (ERS) of the brain.[2]

IV.EEG ELECTRODES

The recording can be performed non-invasively (scalp EEG), directly on the brain cortex (cortical EEG) or within the brain (depth EEG). The placement of EEG electrodes on the scalp usually follows a standard arrangement known as the 10-20 system (Fig.3).This system was devised by the International Federation of Societies for Electroencephalography and Clinical Neurophysiology.

We are using here three surface electrodes for EEG signal Recording. Surface Electrodes have an integrated ribbon cable made of polyamide.This cable is very flexible in all directions and can be folded if needed. Crimping should be avoided as it may compromise probe insulation.Holes are designed to allow for implantation with depth probes, but can also function as perforation or anchor/suture holes.This may damage the probe if done incorrectly.[4]

Fig. 3 Electrode Position

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V. PROPOSED SYSTEM

The block diagram consists of EEG sensor, signal conditioning circuit, arm processor, LCD display and PC interfacing.

A. **EEG SENSOR:** The EEG sensor helps us to exact the analog EEG waves with the help of electrodes applied on human scalp.

B. **ARM 7:** A RISC-based computer design approach means ARM processors require significantly fewer transistors than typical CISC x86 processors in most personal computers. This approach reduces costs, heat and power use.

C. **LIQUID CRYSTAL DISPLAY:** LCD is used in a project to visualize the output of the application. We have used 16x2 LCD which indicates 16 columns and 2 rows. So, we can write 16 characters in each line. So, total 32 characters we can display on 16x2 LCD

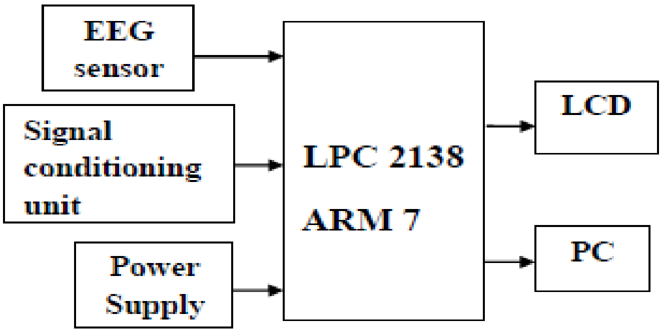

Fig. 4 Proposed design

D. **SIGNAL CONDITIONING CIRCUIT:**

The signal conditioning consists of op-amp instrumental amplifier which gives a proper output to the controller for processing. The op-amp used is OP-07.Here we have used it for amplification of analog eeg signals. Also the adder is used for summing the voltages of op-amp to get a signal output voltage V0 .

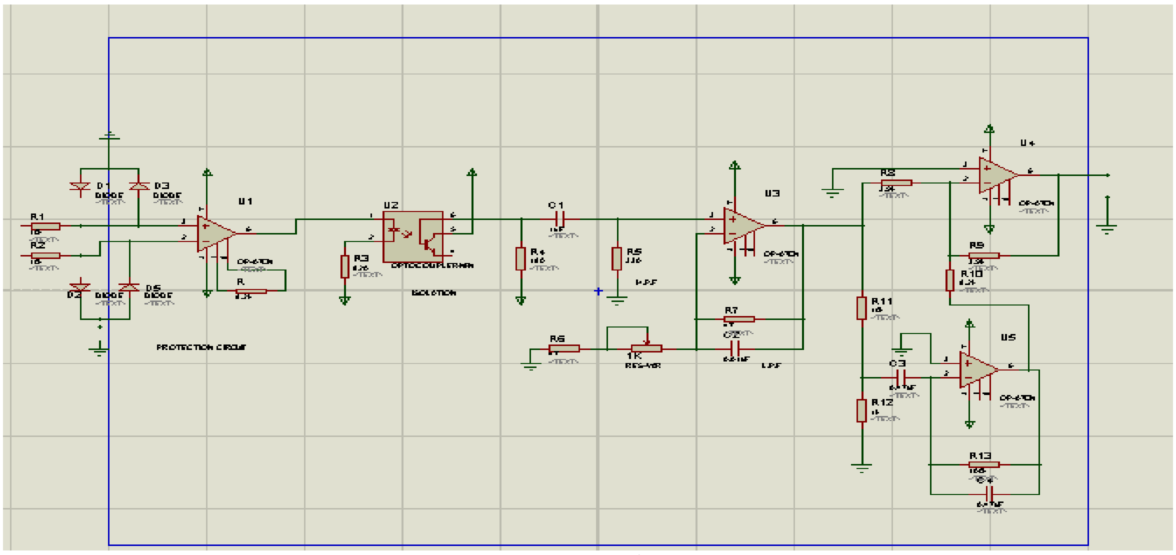

Fig. 4 Signal conditioning circuit for EEG measurement

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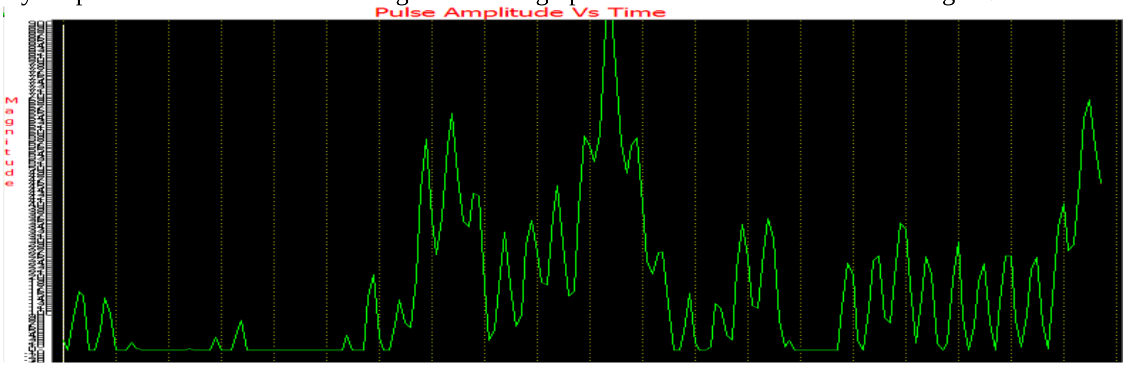
VI. EEG RESULTS

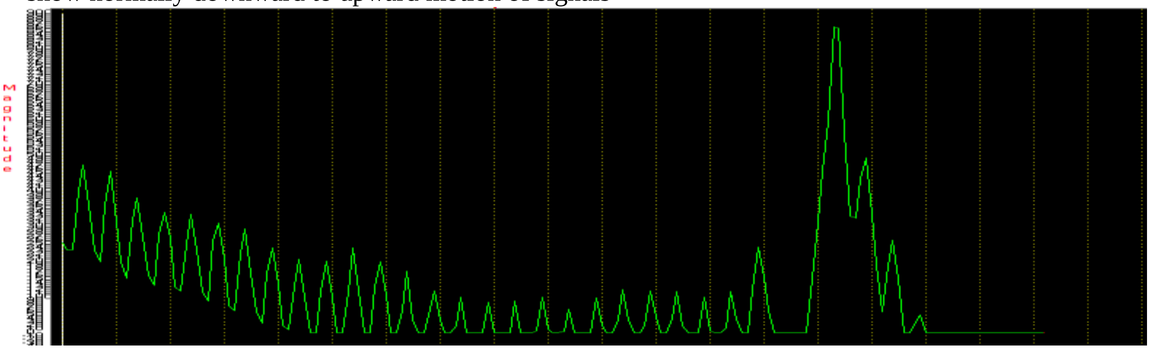
A. Results obtained at condition 'Eyes opened':

Eyes open show variation in EEG signal including upward and downward motion of signal.



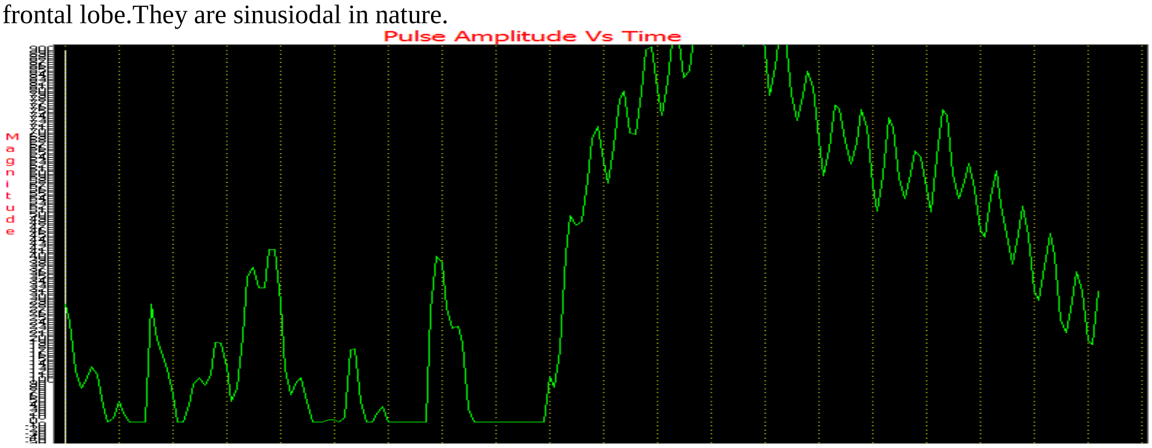
B. Results obtained at condition 'Eyes closed':

Eyes closed show mere changes and normally are seen when the patient is in relaxed mode.eyes closed show normally downward to upward motion of signals



C. Results obtained when electrodes placed on frontal lobe:

Frontal lobe describes the brain rhtyms of low frequency.Mainly alpha waves(8-13hz) are observed in the frontal lobe.They are sinusiodal in nature.



VII.APPLICATIONS OF EEG

- Monitor alertness, coma and brain death
- Locate areas of damage following head injury, stroke, tumour, etc.
- Monitor cognitive engagement (alpha rhythm)
- Produce biofeedback situations, alpha, etc.;
- Control anaesthesia depth ("servo anaesthesia")
- Test epilepsy drug effects

VIII.ACKNOWLEDGEMENT

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IX.CONCLUSIONS

This paper will enable the students to get familiar with real time signals & gain the experience of processing real world signals. Also provide learning for how to acquire and analyze EEG signals using high end embedded system. In future, this project will be advanced for developing more sophisticated algorithms to process the EEG signals in real-time for the applications such as BCI, anesthesia depth monitoring, sleep testing, hearing aid etc.

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