# Analysis of brain wave signals using electroencephalography in people with depression

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**Electroencephalography is a brain signal processing technique used to detect abnormal brain waves. Electroencephalography signal recording using electrodes attached to the scalp. Electroencephalography signals are amplified by transmitting signals into notch filters, high pass filters, and low pass filters to improve signal quality such as eliminating and reducing noise. Electroencephalography recording focuses on analyzing alpha waves to determine if the subject suffers from depression. For cases of depression, the brain lobes that are installed with electrodes are the occipital and parietal lobes of the brain. In this study using the Patient Health Questionnaire Method-9 (PHQ-9). The results obtained after recording electroencephalography there are in the form of very large and abnormal alpha wave theta waves whose shape is very large.**

***Keywords— electroencephalography, depression, analysis, sinyal, electrodes.***

## I. INTRODUCTION

Depression is a condition in which a person feels sad, disappointed when experiencing a change, loss, failure, and becomes a pathologist when unable to adapt [1 ] . Depression and mood disorders are associated with the world's biggest health problems. Many life stresses, interpersonal stress and social rejection are the biggest risk factors for depression [2 ]. Electroencephalography is a brain signal processing technique used to detect abnormal brain waves [3 ]. Signal electroencephalography has frequency components that are reproduced in time dominance.The frequency component of the EEG signal informs the condition of the brain and the visual addressing of the EEG signal directly is very difficult considering the amplitude of the EEG signal is very low and the pattern is very complexs [4]. In addition, EEG signals are strongly influenced by various variables, including mental condition, health, activity of the patient, recording environment, electrical disturbances from other organs, external stimuli, and age of the patient [5]. The study will focus on analysis of alpha waves to determine if subjects suffer from depression. In the case of depression, the way to find out whether the patient suffers from depression is by means of lobes in the brain will be attached electrodes, namely the occipital and parietal lobes of the brain with the classification that the subject is declared depressed if the base frequency is below 8 Hz or more.

## II. THEORETICAL FOUNDATION

An electroencephalogram is an instrument used to capture electrical activity in the brain. EEG reflects the working status of the human brain and is considered the best physiological data that can be used as a tool to detect and diagnose depression of a disorder [6]. Visual observation of the EEG signal directly is very difficult given the low amplitude of the EEG signal (100 μV – 1 mV) and the pattern is very complex. In addition, EEG signals are strongly influenced by various variables, including mental condition, health, activity of the patient, recording environment, electrical disturbances from other organs, external stimuli, and age of the patient [7]. Based on the analysis of brain waves that have been obtained through EEG, we can classify the characteristics of these brain waves into normal brain waves and abnormal brain waves. The results of EEG examination show differences in brain wave patterns as follows [8] :

a. Usual
- Results on two sides of the brain showed similar patterns of electrical activity
- In awake adults, EEG showed more alpha waves than beta waves.
- There are no abnormal wave images of electrical activity and no slow waves
- If the patient is stimulated with light (photic) during the test, the wave results remain normal.

b. Abnormal
- Results on two sides of the brain showed unsimilar patterns of electrical activity

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- The EEG shows a picture of abnormal, fast or slow waves, this may be due to a brain tumor, infection/inflammation, injury, stroke, or epilepsy.
- Various circumstances can affect the EEG picture. An abnormal EEG can be caused by abnormalities in the bra in that are not limited to just one specific area of the brain, such as drug intoxication, brain infection (encephalitis), or metabolic disease (diabetic ketoacidosis)
- EEG shows delta waves or teta waves in awake adults. These results mark the presence of brain jury
- The EEG showed no electrical activity in the brain (flat/straight line). Marking brain function has stopped, which is generally caused by the absence (decrease) of blood flow or oxygen in the brain.

## III. METHOD

The EEG signal is a very weak signal because it has a very low voltage level in the microvolt range (about 100μV). Therefore, the weak EEG signal is conditioned using an analog circuit, then the signal is amplified and filtered. As for the block diagram of the EEG system in the figure below.

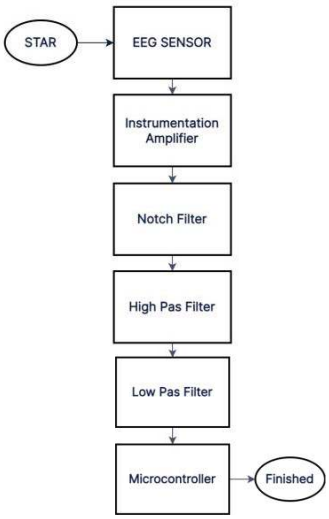


Figure 1 EEG Diagram Block

*a. Instrumentation Amplifier*

*The instrumentation amplifier* is the first part of the circuit configuration. Due to the high output impedance of the EEG source to obtain a signal, instrumentation amplifiers are implemented at the front of the design having a high input impedance of more than ten times the output impedance of the source. The high Common Mode Rejection Ratio (CMRR) of the instrumentation amplifier supports to take two signals from the scalp and amplify them separately with the same gain and provide a differential signal as output

*b. Notch Filter*

The main source of EEG interference is the electric power system Even if it uses batteries to power the circuit, the circuit will still have noise. Therefore, a notch filter is required. Notch filters which are a type of bandstop filter reduce the narrow frequency range designed to reduce noise caused by interference from surrounding power lines.

*c. High Pass Filter*

To remove dc offset from the signal before amplification, a high pass filter with a low cutoff frequency is used, as well as sharpen brain waves to make the signal look clearer at the output.

*d. Low Pass Filter*

*Low pass filters* are designed just before digital to ana log conversion as antialiasing filters. The LPF cut-off frequency is set to 40 Hz which is sufficient for delta, theta, alpha and beta band analysis and is able to reduce power line interference to some degree and is used to clarify brain waves.

PHQ-9 is a depression scale with nine statements to assist in diagnosing depression as well as selecting and monitoring treatment. The PHQ score range is from 0 to 27, as each item is graded from 0 (never) to 3 (almost daily). PHQ scores of 5, 10, 15, and 20 represent mild, moderate, moderately severe, and severe depression. Interpretation of the total score on PHQ9 as shown in Table below

| Total Score | Depression Levels |
|---|---|
| **1-4** | ***Minimal Depression*** |
| **5-9** | ***Mild Depression*** |
| **10-14** | ***Moderate Depression*** |
| **15-19** | ***Moderately Severe Depression*** |
| **20-27** | ***Severe Depression*** |

Table 1 Interpretation of PHQ-9 total scores

The brain works using the electrical system, which produces small electrical signals in a regular pattern and is channeled through a network of nerve cells called neurons. The difference in ionic composition in intracellular and extracellular fluids results in an electrical voltage gradient across the membrane called the membrane potential. It is this potential that is recorded by the electroenchephalograph. The human brain consists of several parts where each part has a role in a process in the body. In general, the brain is divided into 3 parts as follows:

1. The largest part of the human brain is the cerebrum. The cerebrum is divided into two hemispheres, right and left. The left hemisphere governs the functions of the right body and vice versa. Each hemisphere of the brain consists of 4 lobes, namely frontal, pariental, temporal and occipital.
2. Midbrain The midbrain functions to help eye movements, narrowing and dilating pupils, auditory reflexes, control and balance centers, nerve fibers that connect the front and back of the brain.
3. The back brain has several parts:
   - Cerebellum: the largest part of the hindbrain is below the occipital lobe. The cerebellum is divided into right and left hemispheres that function to regulate body balance, posture and body position and muscle coordination when conscious.
   - Varol Bridge: is the connecting nerve between the cerebellum and cerebrum and the left and right hemispheres of the cerebellum
   - Advanced Marrow: Forms the lower part of the brainstem and connects the varol bridge with the spinal cord.

Based on its properties, electrodes can be divided into two types, namely active electrode and passive electrode. An

active electrode is an electrode that has a pre-amplifier inside. With the presence of pre-amplifiers, the large impedance of dry skin (several MΩ) can be overcome because the pre-amplifiers used have high input impedance specifications. A passive electrode is an ordinary electrode without a preamplifier inside. In use, a low impedance is required between the electrode surface and the skin. Therefore it is necessary to apply special preparations on surfaces that are in contact with each other between the skin and electrodes, such as scraping of the epidermis and administering gels. The international standard 10-20 electrode placement system as shown below

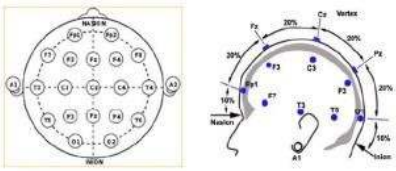

Figure 2 International Standard for Electrode Laying 10- 20

The AD620 is a low-cost, high-accuracy instrumentation amplifier that requires only one external resistor to set a gain of 1 to 10000 with a supply range of 2.3V-18V. Thus, making it a suitable hardware for use in health instrumentation. The specifications of the AD620 as shown in the table below

| | |
|---|---|
| **Pin 1** | **Gain Setting** |
| **Pin 2** | **Negative Input** |
| **Pin 3** | **Positive Input** |
| **Pin 4** | **-Vs** |
| **Pin 5** | **Ref** |
| **Pin 6** | **Output** |
| **Pin 7** | **+Vs** |
| **Pin 8** | **Gain Setting** |

Table 2 AD620 Specifications

Arduino microcontroller is an open source physical computing platform that functions as a board-shaped electronic circuit. This microcontroller has analog input pins with ADC (Analog to Digital Converter) features and a lso has voltage output pins needed to connect a pre-designed EEG circuit. The specifications of Arduino Uno are as follows:

| | |
|---|---|
| ***Microcontroller*** | **ATmega 328P** |
| ***Operating Voltage*** | **5V** |
| ***Digital I/O Pins*** | **14 (6 PWM outputs)** |
| ***Analog Input Pins*** | **6** |
| ***Flash Memory*** | **32 KB (ATmega 328P)**<br>**Where 0.5 KB is used for the bootloader** |
| **SRAM** | **2 KB** |
| **EEPROM** | **1 KB** |

Table 3 Arduino Uno Specifications

## IV. Results and Discussion

For depression cases, EEG recording focuses on a lpha waves, where the analysis of EEG recording results will be carried out based on the standard pattern of EEG signals as shown below .

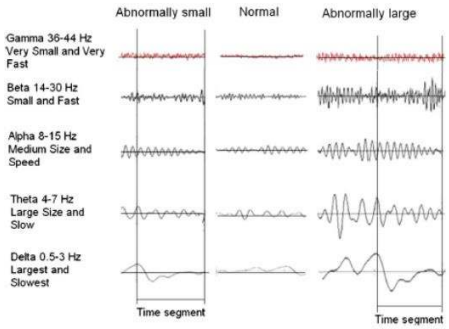


Figure 3 EEG Signal Standard Pattern

After knowing the results of the PHQ9 questionnaire, one of the participants categorized as a depressed subject was selected to do an EEG recording. EEG recording is carried out for approximately 3 minutes. The results obtained after recording as shown below

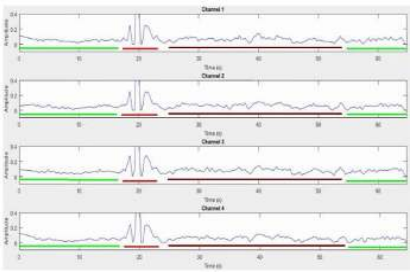

Figure 4 EEG Participant Recording Results

In the picture above, the part marked with a green line when compared to the standard pattern of the EEG signal is a normal EEG signal. When the EEG signal is abnormal, it means that there is an imbalance in the brain and can be seen in the waves marked with red lines. These waves are no longer included in the category of alpha waves but theta waves that are abnormally large. Then, for waves with brown lines are abnormal alpha waves that are abnormaly large.

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