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An Effectiveness of EEG Signal Based on Body Earthing Application

Zarith Liyana Zahari [a,b,*], Mahfuzah Mustafa [a], Noor Aisyah Ab Rahman [a], Rafiuddin Abdubrani [a], Zaridah Mat Zain [c]

[a] *Faculty of Technology Electrical Electronic Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia*
[b] *Electronics Section, Universiti Kuala Lumpur British Malaysian Institute, 53100 Gombak, Selangor, Malaysia*
[c] *Malaysia Asia Rail Center, Universiti Kuala Lumpur British Malaysia Italy Design Institute, 53100 Kuala Lumpur, Malaysia*

*Corresponding author: *zarithliyana@unikl.edu.my*

***Abstract*— Stress is part of the social lifestyle, intellectual level, and emotional strain. Stress psychology contributions include mental, cognitive, or behavioral sensation. In summative assessments of body earthing, the grounded person is less anxious and more comfortable in everyday activity because the Earth's potential becomes an intermediary to reduce a negative electrode compliment from the body to the Earth's surface when the body is grounded condition. The balanced electrode amounts in the human body could reduce anxiety, depression, and sleep disorders. This investigation analyzes the EEG signal in the frequency domain and time-frequency domain analysis based on body earthing application in ten electrode placements with a range of EEG frequency bands; Theta, Beta, and Alpha. The Power Spectrum Density (PSD) and Short Time Fourier Transformation (STFT), and Continuous Wavelet Transformation (CWT) have been used to determine the power and energy value. The theta frequency band result shows an increasing power and energy value of EEG signal after applying the body earthing application. However, the alpha frequency band influences the left area's EEG signal efficiency while the right parts beta frequency band is affected. The best classification performance is gained from Levenberg-Marquat neural network and Scale Conjugate Gradient technique for grading into stress index classes.**

***Keywords*— EEG signal; frequency domain; time-frequency domain; Levenberg-Marquat; scale conjugate gradient; stress index classes.**

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I. INTRODUCTION

The stress psychology contribution is about the feeling of strain and pressure, stress explaining that it involved thinking and judgment, physical health, emotion, and human behaviors. A person can be seen when stress is impaired, like an increased concentration or poor judgment and bad decision making or has warning signs that can be recognized as cognitive stress symptoms. Increased mood swings, general unhappiness, even depression, or the constant feeling of being overwhelmed can be categorized as emotional stress and affect a person psychologically. Also, stress can affect emotion, behaviors, thinking ability, and physical health. There are many ways to determine stress. An example of determining the stress is identifying the stress such as physical symptoms, body and brain signal signs, or self-stress assessment, including the ISMA-stress questionnaire [1]. Therefore, the objective of this study is to analyze power and energy value in the EEG signal based on body earthing application by use of the Power Spectrum Density (PSD) and Short Time Fourier Transformation (STFT) and Continuous Wavelet Transformation (CWT) method. Body earthing is a mechanism in which the Earth's free electrons are connected directly to the planet within the human body [2]. Body earthing can provide more than enough electrodes from the Earth to the human body. The human body's positive electrode charge was balanced to ensure that the body was neutral [3].

Furthermore, the direct connection to the Earth's surface allows the human body to absorb the electron effectively. Various researchers show that a grounded person reduces stress and enhances relaxation conditions [4,5]. In an example, as shown in Fig. 1 below, if a human is standing in two different situations. Situation a, on a clear day, a person was standing outdoor, wearing shoes, or standing on an isolated surface; situation b, a person in bare feet is in electrical contact with the surface of the Earth. Between the Earth and the top of the head, there is an electrical voltage of about 200 volts. While if a person is in a barefoot situation, the human being is in a good conductor, the entity remains basically within the protective "summit" of the Earth's natural field [6].

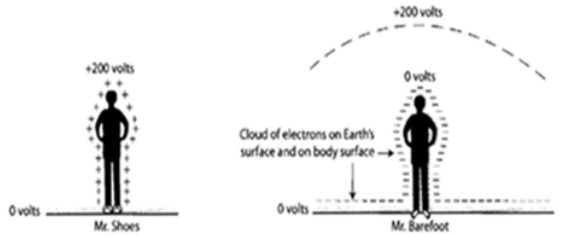

Fig. 1 A person standing outdoor (a) wearing shoe condition (b) barefoot condition [6].

Different studies have described the impact of grounding on the human body. Grounding therapists also enable patients with higher pain levels to become more comfortable, have less anxiety and depression, and improve sleep quality [4]. Gaétan Chevalier et al. mention that some people suffering from higher pain levels and less relaxed anxiety symptoms, and poor sleep be solved and detected by showing people in more comfortable and better sleep after using a body earthing treatment [7]. Earthing applications in the human body can simulate the parasympathetic condition for increased muscle relaxation and stabilized heart rate rhythm [8].

In medical science, microscopic functions could have definitively positively affected the human body by the study's applied electric field result. Seegers et al. were informed that a study reported that the clinical report presents a positive clinical effect. The exposure of earthing applications in various frequencies and electrical areas in relatively little strength [9]. In therapy, the practice of yoga exercises supported with a grounded yoga mat for one hour causes exercise-induced inflammation, reducing blood viscosity for ten subjects involved [10]. This observation pattern has been shown in works that may support the predicted result by Oschman et al. [11] that humans attached to the grounding element can improve sleep, normalize the cortisol rhythm, circadian cortisol secretion levels, and blood viscosity. The result has remarkably reduced pain and stress and increased heart variability. The physiological condition performance can be analyzed in the EEG signal as done by Mahfuzah et al. [12]. The EEG signal determined the average power signal of FP1 and FP2 in the selected frequency band. The observation of applying body earthing shows that the alpha frequency band contributes more positively than the beta frequency band. Besides, body earthing applications can neutralize positive and negative charges in the human body.

The EEG signal is used to analyze and extract the features function since the interpretation communication signal of electrical impulses in the brain cells demonstrates the brain wave character. The EEG Emotiv EPOC+ device is applied to capture the brain wave by attaching the human brain scalp electrode. The placement of electrodes is labeled according to the adjacent area of the brain: F(frontal), C (Central), T (temporal), P(posterior), and O(occipital). The letters F, C, T, P, and O have a uniform number accordingly. The even number of an electrode is in the right hemisphere area, while an odd number of an electrode is in the left hemisphere. Wu et al. mention the new spatial and frequency fusing method, which was only implemented in two channels of the frontal EEG signals on Fp1 and Fp2 was described using frontal brain asymmetry theory. However, two frontal EEG output is not enough and will be used for studies on minimal emotional recognition [13].

Foong et al. [14] used the differential signal between Fp1 and Fp2 are measured to eliminate the eye blinking effects, and the correlation with reaction time (RT) features is analyzed. Delta band power shows a positive correlation, while theta and alpha band power show a negative correlation sign. The RT feature effect is insignificant in beta band power but has a positive association sign. The short theta of drowsiness is primarily seen in older adults during sleepiness and light sleep, and in the alpha, the band has seen a wakeful trend has decreased at 6 to 11 Hz with amplitude ranging from 60 to 200 μV [15]. The specific EEG power densities have also been determined at four sides in three cerebrums: mid-frontal, central, and parietal. The three region signal characteristics are analyzed in alpha slow, alpha fast, and beta frequency bands [16]. Most four frequency bands are considered to be used in the common practice of studying an EEG data signal. The frequency band is alpha, beta, theta, and delta. This research is focused on three important frequency bands: theta, beta, and alpha. For instance, theta is related to emotions and stress, while beta is about a high mental activity(tension). Examples of human behavior are awake, quiet, and resting state presented at the alpha frequency band. All the frequencies band were used for ten channels (AF3, F7, F3, FC5, T7, AF4, F4, F8, FC6, and T8). The study of power ratio in the EEG signal comprises five frequency bands, including the delta, theta, alpha, beta, and gamma, from the one-second scalp EEG [17]. The signal power spectrum amplitude is the 'frequency domain content' of the signal or the frequency range of signal power. The averaged frequency at 4-8Hz elements of F3, FZ, and F4 channel power values have been used to measure frontal theta rhythms amplitude. The frontal midline theta (FmT) has been correlated with several cognitive processes, including working memory, executive function, episodic encoding and retrieval, mental arithmetic, spatial orientation, emotional perception, error processing, and medication [18],[19],[20].

II. Materials and Method

Fig. 2 shows a block diagram of the signal processing for body earthing application. Firstly, the experiment was formally taken from nine subjects aged nineteen to thirty years old, and the standard of this experiment is taken from 9 am to 5 pm. However, each test needs 18 minutes per person session, as explained in Fig. 3 below.

Fig. 2 Block diagram of the signal processing for body earthing application

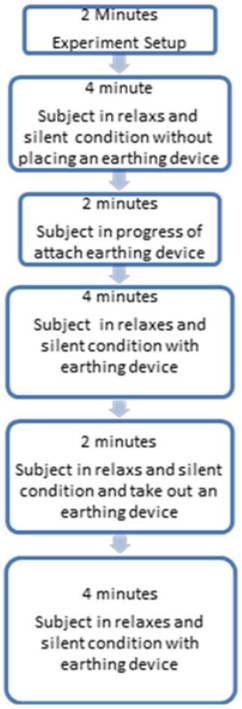

Fig. 3 Experiment process flow for an earthing application

Second, the EEG signal must be recorded and considered a data collection set. The signal-generated data capabilities are in offline mode, and the experiment is focused on ten channels using EEG Emotiv EPOC+. The device allows the ten channels (AF3, F7, F3, FC5, T7, AF4, F4, F8, FC6, and T8) to detect the signal. Last, the participant was seated on the lands of his feet with Earth conductive patches.

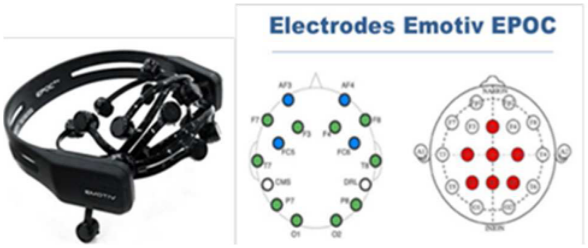

Fig. 4 Electrode Emotive Epoc

The pre-processing stage is through two simple steps: bandpass filter and threshold. The bandpass filter is to remove the unwanted noise and artifact signal. The interference EEG signals with a power line interference signal are found from the electrode interface, the noise element in the whole signal wave, and various physiological signals [22]. Hence, the applied range of EEG signal amplitude in this research is -100µv until 100µv without any noise by the threshold technique [21]. Then, the frequency signal content is set up according to the desired frequency band. This research exploited three frequency bands: theta, alpha, and beta. The raw EEG data are filtered into a frequency range of Theta (4Hz-8Hz), Alpha (8Hz-12Hz), and Beta (13Hz-16Hz). Power and energy value features are used to analyze the EEG signal from the desired frequency based on body earthing application. The power and energy value result are calculated using a formula and applying the autocorrelation function as Eq. (1-3).

$$s_x(f) = \lim_{T\to\infty} E\left\{\frac{1}{2T}\left|\int_{-T}^{T} x\,(t)e^{-j2\pi ft}dt\right|^2\right\} \quad (1)$$

$$s_x(f) = \int_{-T}^{T} R_x(\tau)e^{-j2\pi ft}\,dt \quad (2)$$

Were,

$$R_x(\tau) = E\,\{x\,(t)\,x\,(t+\tau)\} \quad (3)$$

Lastly, the power value can be determined from a random signal across a specific frequency band as follows:

$$P_{12} = \int_{f_1}^{f_2} s_x\,(f)df = R_x(0) \quad (4)$$

The energy value is obtained from the Short-Time Fourier Transformation (STFT) and Continuous Wavelet Transformation (CWT) by the applied corresponding range of EEG signal amplitude can de determine the features by use of Eq. (5)[23].

$$\mathrm{E} = \Sigma\,\mathrm{s}(:\,),\ \mathrm{S} = |\mathrm{coe}fs. * \mathrm{coe}fs| \quad (5)$$

For the classification, the stage presents the classification accuracy by using the neural network technique. The Levenberg-Marquat (LM) is the best training approach to do a classification process and a common way to apply the features function value. Therefore, LM is used to find a F(x) function in a gauss-newton way for calculating a sum of features function, referring to in Eq. (6).

$$F(x) = \tfrac{1}{2}\textstyle\sum_{i=1}^{m}[fi(x)^2] \quad (6)$$

Then, identify the stress classes into three categories by used of Eq. (7). The equation is mentioned below, whereas the f_K is shown the result from the $J_K^T$is a Jacobian function. Plus, the λ_k are non-negative scalars, I is the identity matrix and P_k class function. The classification function is divided into three categories: stress, mild stress, and high stress (tension).

$$(J_K^T J_K + \lambda_K l)P_k = -J_K^T f_K \quad (7)$$

III. Result and Discussion

The frequency domain and time-frequency domain will show the result of power and energy value concerning the selected EEG frequencies range will classify into three categories stress, mild stress, and high stress (tension) are present in this paper.

A. Frequency domain analysis

The EEG signal's power value in ten placement electrodes (AF3, F7, F3, FC5, T7, AF4, F4, F8, FC6, and T8) will be verified in three frequency bands; theta, beta, and alpha. These three frequencies band will go through the ten-electrode placement showing human emotion, stress, disappointment, and frustration. The theta frequency band describes a good sign for all electrodes when the power value is increased, as shown in Fig. 5. The sign shows a positive effect of electrons throughout the body and may improve human stress [2]. Fig. 6 shows that the alpha frequency band significantly highlights that the F7 electrode channel has a very high peak power value before applying the body earthing application compared with other channels. It means the signal contains an unstable condition between emotion and stress condition. However, after the body earthing, the power peak is decreased until it reaches the stable or approximate equal

power value between all electrodes. The stable condition of power value has analyzed the incident when the electron positive emotion input increases, and it causes a mood regulation to become a reason for relaxed awareness. The beta frequency band describes the high mental activity (stress or tension) condition. This frequency band is involved in various cognitive tasks, such as understanding, memorizing, and decision making. The left and right brain positions analyze the cognitive functions. The most important factor in increasing the power value is comparing the task decision with understanding. Therefore, Fig. 7 shows that the left-brain area produces a higher peak power value than the right-brain area. The decrease of power peak value occurs after the earthing applies to the bodies except for F7. The effect of its high mental activity is also reduced and improves human stress conditions. For the brain region's general concept, the left area focuses on task decision-making and emotion, while the right brain function is to understand and memorize functions.

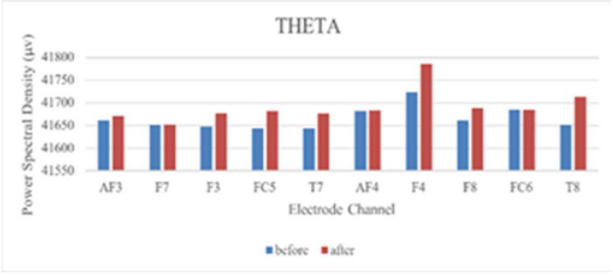

Fig. 5 Power value for a theta frequency band

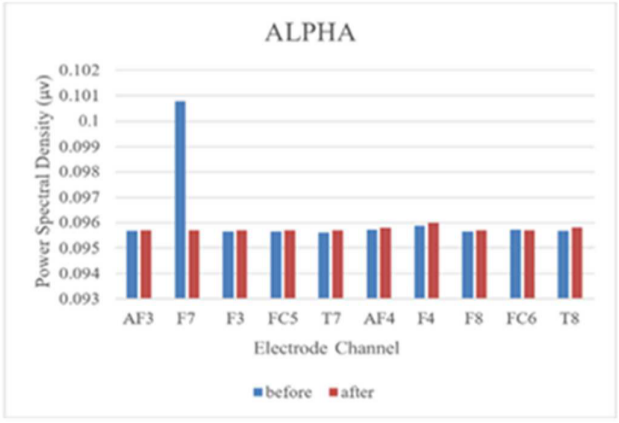

Fig. 6 Power value for an alpha frequency band

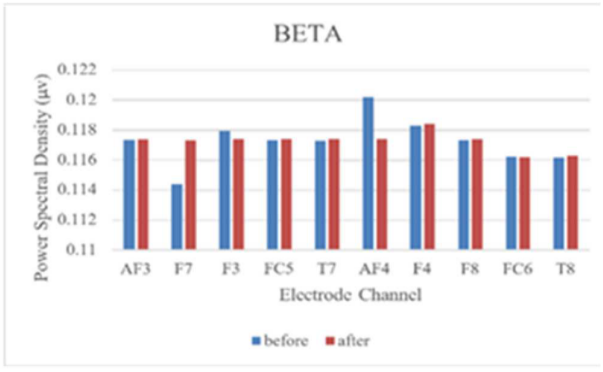

Fig. 7 Power value for a beta frequency band

B. *Time-frequency Domain Analysis*

In time-frequency domain analysis, the Short-Time Fourier Transformation (STFT) and Continuous Wavelet Transformation (CWT) method are used to determine the EEG signal's energy value for three frequency bands, which is theta, alpha, and beta. The energy value of the theta band for the nine-electrode channel is consistently increased except for the AF3 channel. Referencing the standard electrode position nomenclature, AF refers to the anterior frontal and contains signal concentration and attention. Therefore, energy must boost concentration and attention, as proven when energy decreases occur in the AF3 channel, as in Fig. 8. Besides, the lack of attention is encouraged toward increasing the unstable emotional and stress state. The energy value performance for alpha-band and beta-band increases for all electrode channels after applying the body earthing application shown in Fig. 9 and Fig. 10 below. The human acceptance of body earthing application shows a positive sign, and energy increment is aggregated at the right and left human brain areas.

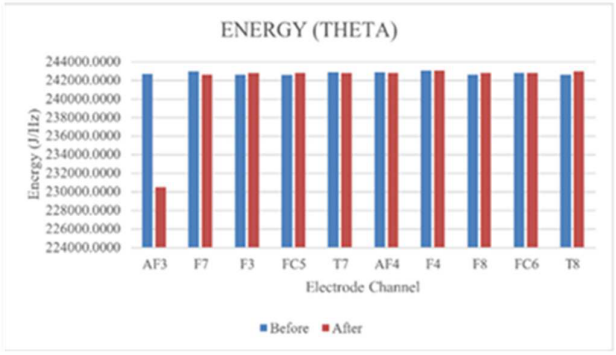

Fig. 8 Energy values for a theta frequency band

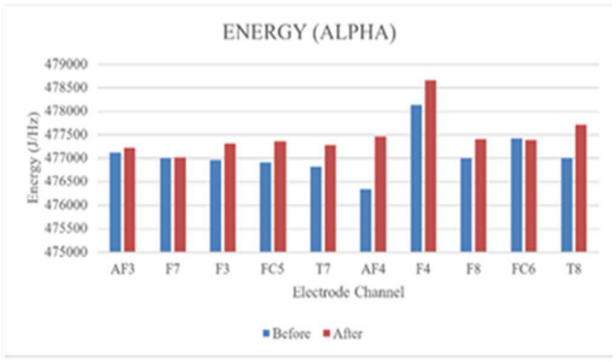

Fig. 9 Energy values for an alpha frequency band

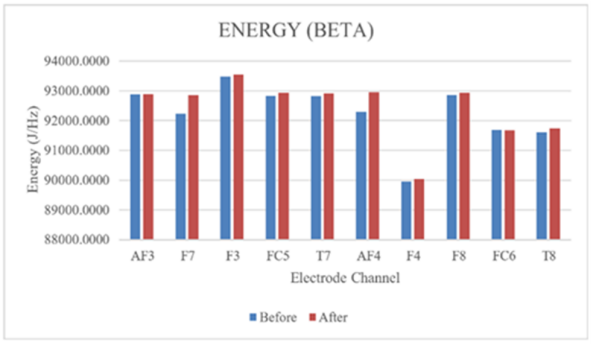

Fig. 10 Energy values for a beta frequency band

C. Classification

The method applied in domain analysis produces the result of power and energy value. These power and energy values consider the value of a feature. After completing the feature's value, the classification process is required to classify the features into three categories stress, mild stress, and high stress (tension). The description of stress categories is present in table 1 below. Body earthing application is important to classify human stress level become the second aim of this research.

TABLE I
DESCRIPTION OF STRESS CATEGORY [1]

Stress Category	Description
Stress	You are less vulnerable to stress associated disease
Mild stress	You are more likely to experience emotional, physical, or both stress-related ill health
High stress	You are the most stressed and showing unhealthy behavior

The Levenberg-Marquat and Scale Conjugate Gradient technique is the best training approach to do a classification process to identify the stress index classes. Levenberg-Marquat technique used ten hidden layers, seven iterations, and two hundred neurons as a training process criterion for the frequency domain analysis. The approach's outcome reaches 100% accuracy with a 0.003 MSE value. The Scale Conjugate Gradient technique applied the three hidden layers, seven iterations, and two hundred and fifty neurons to perform 100% accuracy with 0.001 MSE value result.

IV. CONCLUSION

The techniques applied can analyze the power and energy value from the EEG signal in the frequency domain and time-frequency domain analysis. Both features present a relaxed awareness with high concentration and attention. Besides, improve the emotion and stress state for the theta, alpha, and beta frequency band. Levenberg-Marquat and Scale Conjugate Gradient classify stress level classes and indicate 100% accuracy with a low MSE value. The result of the MSE value from power spectral density can be improved in future work by using other techniques such as support vector machine (SVM) and ANOVA.

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