Development Of Sleep Inducer Device with an Electromagnetic Field for Therapy

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ABSTRACT –Sleep has a significant impact on both mental and physical health, and various factors such as lifestyle, work, and physiological issues can lead to conditions like insomnia, obstructive sleep apnea, and restless leg syndrome. Sleep deprivation can cause a range of mental and physical disorders, and while treatment drugs can be addictive and have adverse effects, intervention devices can be expensive. This project aims to address the issue of individuals who have difficulty falling asleep by creating a sleep-friendly environment using an electromagnetic radiator coil. The project will focus on building a frequency circuit that generates electromagnetic fields to induce relaxation for sleep, along with a timer circuit and a sleep-related pulse rate. The product will include the 555 Timer, Arduino Uno, a radiator coil, Bluetooth HC-06, LCD 16 x 2 pin, and Proteus Professional 8.12 software for remote testing. The project will also measure pulse oximetry and blood oxygen saturation (SpO2), with the user's SpO2 results used as a parameter for the sleep inducer application that will be attached to their phone.

KEYWORDS : Sleep, Electromagnetic, Brain Wave

1.0 INTRODUCTION

Sleep disorder is a state of divergence from the typical human healthy sleeping condition usually characterized by difficulties to fall asleep, extended awake between sleep cycles and frequent waking up earlier than normal [1]. These typically result in brief non-restive sleep which has harmful physiological and psychological repercussions on the welfare of our body system [2].

Transient insomnia affects more than one-third of people at some point in their lives, and in around 40% of cases, it may progress to a more chronic and persistent condition [3]. Insomnia is diagnosed when a patient expresses discontent with their sleep (either difficulty falling asleep or maintaining sleep) and experiences additional daytime symptoms such as drowsiness, decreased concentration, and mood problems for at least three nights per week for more than three months. Although various types of insomnia have been identified, including idiopathic, psychophysiological, and paradoxical, the diagnosis and therapy are similar.

Therefore, the product development research was effectively used to serve its purposes. The first goal was the development of a Sleep Inducer Device with an Electromagnetic Field for Therapy, which employs a frequency circuit to generate electromagnetic fields as a sleep inducer. The second goal was to create a clock circuit timer that broadcasts frequencies at predetermined intervals. Finally, for the purpose of analysis, the effectiveness and quality of sleep in electromagnetic frequency will be evaluated by measuring the user's SpO2 result, which will be displayed through the sleep inducer application that is attached to the phone. This will be done to determine the effectiveness of the sleep-inducing electromagnetic frequency.

2.0 LITERATURE REVIEW

The goal of literature reviews is to provide feedback on works published by educational publishers, including papers and journals, on subjects related to and beneficial for the development of a sleep inducer device with an electromagnetic field for therapy.

2.1 Symptom of Sleep disorder

The medical conditions associated with insomnia are too numerous to describe in detail, but they include chronic bladder infection, chronic discomfort, irritable bowel syndrome, chronic renal failure, severe liver disease, dermatitis, and neurological disease, among others.

In other cases, insomnia is not caused by the medical issue itself but by the medication used to treat it. For example, medications used to treat asthma, hypertension, and depression can have stimulant properties that lead to insomnia [4]. Insomnia is often caused by sleep disorders such as sleep apnea, narcolepsy, restless leg syndrome, and idiopathic hypersomnia. Delayed sleep phase syndrome is another common cause of insomnia. This is a condition in which sleep is delayed in relation to the clock, resulting in difficulty falling asleep and waking up at the desired time in the morning.

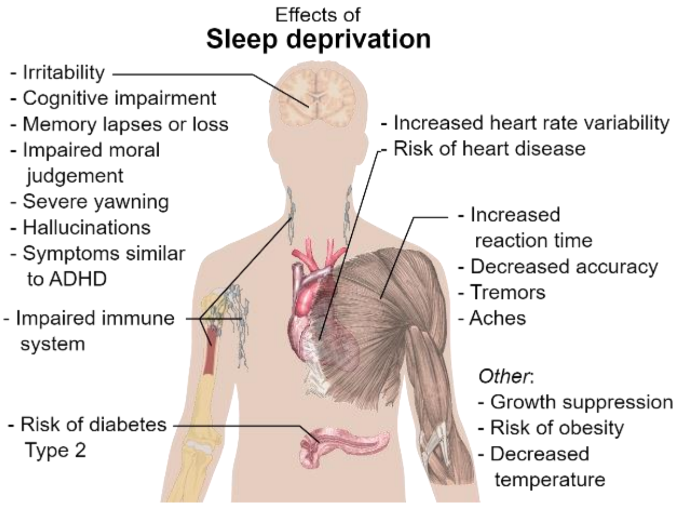

Figure 1. Main health effects of sleep deprivation [5].

Sleep disturbance is a common symptom of neurological illnesses such as Parkinson's, Huntington's, and Alzheimer's disease. In some cases, the sleep disturbance may result from an underlying condition affecting the central nervous system, the motor system, or associated cognitive and psychiatric issues.

2.2 Improper electromagnetic waveform for sleep

There are natural and man-made sources of very low frequency electric and magnetic fields (ELF-EMF). Naturally occurring ELF-EMF is linked to weather phenomena such as ionospheric currents, thunderstorms, and lightning. However, artificial sources, which are often associated with the production, distribution, and use of electricity at a frequency of 50 or 60 Hz, are the primary sources of ELF-EMF. Powerlines, electrical wiring, and popular equipment like electric blankets, TVs, hairdryers, and computers all produce ELF-EMF [6].

Studies have shown that magnetic fields may harm biological processes in human cells and tissues. Exposure to such fields has been linked to interference with neuroendocrine function, stress, depression, learning disorders, irregular sleep patterns, and anxiety. This disturbance is thought to be caused by oxidative stress and the production of free radicals. While all organs may be harmed by chronic oxidative stress, the brain is particularly vulnerable [7].

For this project, there are several methods for inducing sleep, including radio waves, sound waves, and light waves. However, these waves have significant drawbacks that make them unsuitable for the project. The most obvious disadvantage of sound waves is that they must travel through a medium to propagate [8]. Additionally, the speed of sound waves depends on the density of the medium in which they travel, and the quality of sound waves can be affected by environmental disturbances. Sound waves lose energy as they propagate (which is why sound is not readily heard over vast distances) and may be cancelled out by higher-energy waves. As a result, electromagnetic waves have replaced sound waves as a reliable means of information delivery.

2.3 Condition of human brain during sleep

When a person closes their eyes and relaxes, the predominant EEG pattern is a slow oscillation between 7 and 12 hertz [9]. This waveform is called the alpha rhythm and is associated with a decreased level of attention. When the person opens their eyes wide and looks around, the EEG changes to beta rhythm, occurring between about 17 and 20 hertz. Other frequencies and waveforms are observed in children, during different sleep depths, and in various brain disorders such as insomnia. Sleep stages are divided into non-rapid eye movement (non-REM) and rapid eye movement (REM).

***Table 1**. Different stages of non-REM sleep* [10].

Stage	**Type of sleep**	***Specification***
Stage 1	Lightest stage of sleep (theta)	• Transition from wakefulness to sleep. • Last 1-7 minutes. • Lose responsiveness to stimuli. • Drifting thought of image.
Stage 2	“Real sleep” (theta)	• Gradual decrease in heart rate, respiration, body temperature & muscle tension. • Difficult to be awakened.
Stage 3	Transition Stage (delta)	• 30-45 minutes after drifting off to sleep. • Decrease in: Heart rate, respiration, temperature, and muscle tension. • Difficult to be from which to be awakened.
Stage 4	“Slow wave sleep” (delta)	• Deepest Stage of sleep • Most difficult from which to be awakened. • May sleepwalk, sleep, talk, snack, night terror.

***Table** 2. Stage of REM sleep* [10].

Stage	Type of sleep	Specification
REM	Rapid Eye Movement (beta)	• Eyes move rapidly back and forth behind closed lids. • Physiologically body is very aroused. • Voluntary muscles are paralyzed. Pass through 5-6 times a night

2.4 The efficiency of Oxygen saturation (SpO2) during sleeping

In terms of the SpO2 component, a person's blood oxygen level should normally be somewhere between 95% and 100% if they are breathing in an adequate quantity of oxygen throughout the day [11]. This phenomenon is known as oxygen saturation. During sleep, a saturation rate of 90% is considered normal. When someone has obstructive insomnia, they may have irregular breathing patterns that cause their blood oxygen levels to repeatedly decrease, resulting in oxygen desaturation. A level below 90% is considered abnormal, while less than 80% may be considered severely abnormal.

3.0 METHODOLOGY

This section explains the fundamental usage of the project, which involves electrical components. The device's operation is demonstrated using a flowchart, and its functionality is illustrated through an overview graphic and a Tinkercad 3D drawing.

3.1 Schematic diagram
Proteus (PROcessor for Text Easy to Use) allows for the creation of schematic diagrams and the simulation of circuits to test their functionality. Proteus includes a wide range of simulator models for popular micro-controllers, as well as a set of animated models for related peripheral devices such as PIC and LCD displays, resistors, capacitors, and more. The program can also convert the schematic diagram to a PCB layout and display the circuit in 3D. Proteus is an important tool for circuit design and simulation.

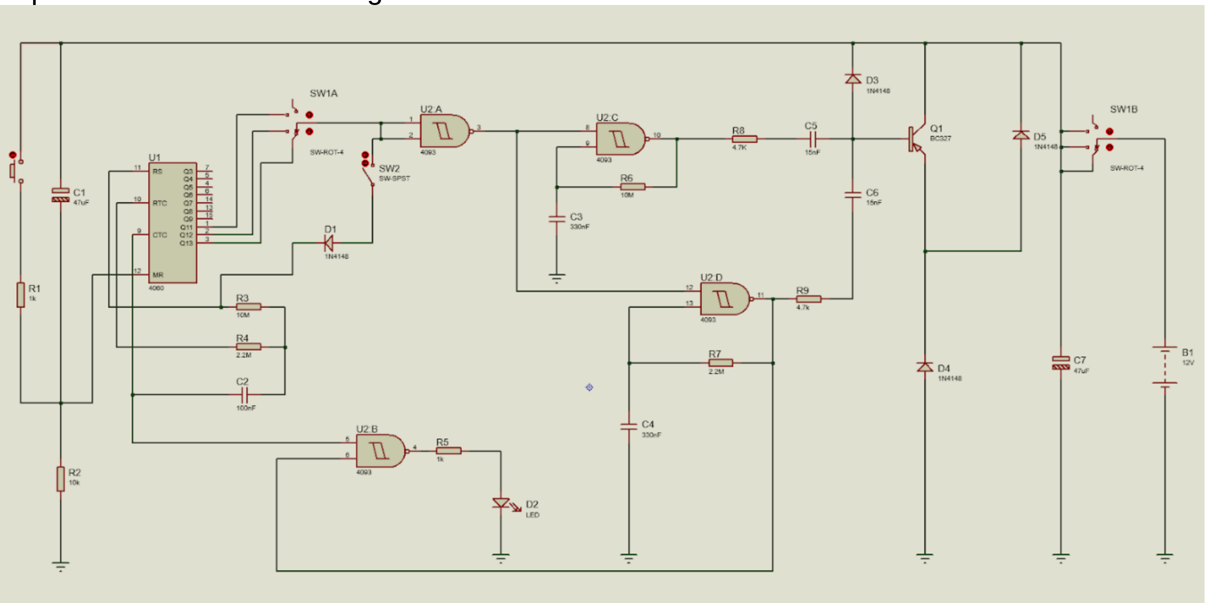

Figure 2. Using Proteus Professional software to draw a schematic

3.2 Circuit operation
The timer is composed of three integrated circuits: IC1, IC2A, and IC2B. When the switch is turned on, C1 and R2 immediately reset IC1. The 14-stage ripple counter is powered by IC1's internal oscillator, and output pin 1 goes high after approximately 15 minutes. Pin 3 of IC2A goes low, causing IC2C and IC2D to stop oscillating.

In alternate mode operation, if SW2 is left open for 15 minutes, pin 1 of IC1 goes low, pin 3 of IC2A goes high, and the oscillators are reset. In stop mode operation, if SW2 is closed, D1 deactivates the internal oscillator of IC1 the first-time output pin 1 of IC1 goes high. As a result, the circuit remains switched off until a reset pulse is applied to pins 12 through P1 or until the entire device is turned off and restarted. The same phenomenon occurs whether SW1 is set to 30 or 60 minutes, indicating that the period of time is affected.

IC2B powers pilot LED D2, which operates in three modes:
- When the radiator coil is operating, it flashes rapidly and almost randomly.
- When the radiator coil is paused during alternate mode operation, it flashes slowly and consistently.
- It is turned off when the circuit auto-shuts down in stop mode operation.

3.3 Evaluation of the product's usability by adhering to the product's standard operating procedure
The project begins with the user lying down in bed, which can make it easier for them to fall asleep and get a good night's rest. If the user has difficulty falling or staying asleep, they can activate the device by pressing the button on the side of the unit. Figure 3 illustrates that the user must first wear the oximeter and then connect their phone via Bluetooth. They can then select one of three different time intervals (15, 30, or 60 minutes) to customize the length of the session. The device should be placed next to the user's head on the pillow, as shown in Figure 4.

Once the signal is emitted into the atmosphere, the device begins to operate. If the user does not start feeling drowsy after a short period of time, they can reset the device by pressing the push button on the side. If the user falls asleep, the device will turn off automatically. IC2C and IC2D generate two square waves at approximately 1.2 and 5 Hz, respectively. These waveforms are transformed into 60-second pulses at the same frequency by using C5 and C6, and they are combined at the Base of Q1. This transistor generates a series of pulses with a duration of 60 seconds and an amplitude of 9V to drive the Radiator coil.

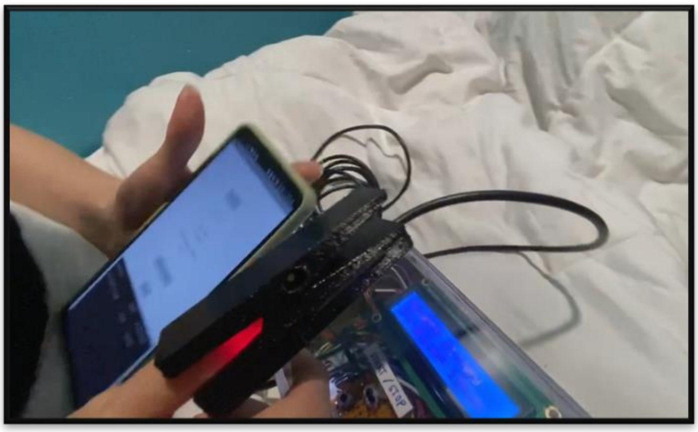

Figure 3. After setting up the timer on the device, the user wears the oximeter and links their phone via Bluetooth.

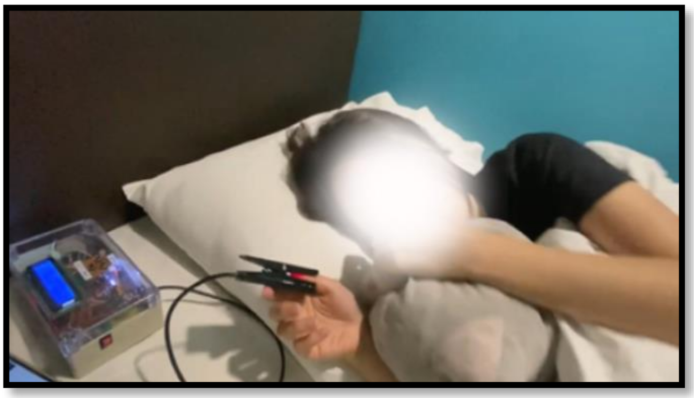

Figure 4. The user should position the device next to their head on the pillow.

4.0 CONCLUSION

The aim of this study was to develop a portable sleep inducer device for treating individuals who have difficulty falling asleep due to a sleep disorder. The study aimed to evaluate the effectiveness of sleep quality over time and the electromagnetic frequency in replicating the same brainwave pattern that occurs during sleep. The goal was to detect these brainwaves and generate a low-frequency (1.5-5Hz) electromagnetic field through a radiator coil, creating an optimal environment for comfortable sleep around the user's brain.

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