Analysis, Design and Implementation of a Biomedical Sleep Inducer

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Abstract

There is nothing quite as pleasant as being able to relax completely whenever it is desired. In today's competitive world mental stress is acute problem. As a result insomnia is occurring all over the world. The lack of restful sleep can affect our ability to carry out daily responsibilities. As a consequence, this can lead to memory problems, depression, irritability and an increased risk of heart disease and automobile related accidents. In most of the cases people use heavy dose drug to get rid of this problem which is very harmful for human body. There is much adverse effect because in one stage people get addicted to this. In the recent time researchers are trying to solve this using electromagnetic field therapy. With the continuity of previous researches, we have designed a circuit which creates and radiates an electromagnetic field through a radiator coil and creates an environment helpful for sound sleep. This paper presents the motivation behind this project and describes the prototype developed for a low-cost and user-friendly system that helps to fight against insomnia by creating an electromagnetic field.

1. Introduction

Many people experience sleeping well in natural surroundings, into a tent or a wooden hut. This fact is due not only to the healthy atmosphere but also from our unconscious ability to perceive natural Earth's magnetic fields. The lack of restful sleep can affect our ability to carry out daily responsibilities because we are too tired or have trouble concentrating. Sleeping difficulty, called insomnia, can involve difficulty falling asleep when you first go to bed at night, waking up too early in the morning, and waking up often during the night. All types of insomnia can lead to daytime drowsiness, poor concentration, and the inability to feel refreshed and rested in the morning. Magnets have been used for centuries to treat a number of physical disorders. A theory of accelerated transition from wakefulness to sleep is proposed to explain the process of insomnia relief through low-strength static magnetic fields. Analysis by functional Magnetic Resonance Imaging (fMRI) is used to further investigate the theory. Another experiment was conducted by impulse magnetic field therapy where 2% patient got very clear improvement, 24% patient got clear remedy, 6% got slight improvement and 49% had no notable improvement [1].

In another sleep study disclosed that With a single pulse, we were able to induce a wave that looks identical to the waves that brain makes normally during sleep [2]. After that it was disclosed that slowly oscillating Delta rhythm electric stimulation applied via surface electrodes on the scalp induced an immediate increase in spectral power at the same slow wave (Delta) frequency band, increased endogenous cortical slow oscillations, and increased slow spindle activity in the frontal cortex, resulting in improved slow wave sleep and subsequently better memory consolidation. Previously a Delta rhythm magnetic device was developed and it was found that, rhythmic signals at Delta range frequencies improved sleep via brainwave entertainment [3]. Other discovered brainwave entertainment decades ago using binaural beats (sounds) and pulsating light, although it's hard to sleep with these systems due to obvious limitations. Our objective is to design a device which will create the same pattern of wave that creates in brain during sleep. It generates an electromagnetic-field, makes easier to fall asleep, and induces a prolonged and sound sleep without drugs.

2. Study On Sleep And Insomnia

2.1 Regulation and triggering of sleep:

Sleep is a naturally recurring state characterized by reduced or absent consciousness, relatively suspended sensory activity, and inactivity of nearly all voluntary muscles [4]. Sleep is a heightened anabolic state, accentuating the growth and rejuvenation of the immune, nervous, skeletal and muscular systems. Sleep is often thought to help conserve energy, but decreases metabolism only about 5–10%. Sleep is actually triggered by the nervous system. The nervous system is our body's decision and communication center. The central nervous system (CNS) is made of the brain and the spinal cord and the peripheral nervous system (PNS) are made of nerves [5]. Much of the expansion comes from the part of the brain called the cerebral cortex. This cerebral cortex is nearly symmetrical, with left and right hemispheres that are approximate mirror images of each other. Estimates for the number of neurons (nerve cells) in the human brain range from 80 to 120 billion. About 10 billion of these reside in the cerebral cortex. At a symptomatic level, sleep is characterized by lack of reactivity to sensory inputs, low motor output, diminished conscious awareness and rapid reversibility to wakefulness. However, to translate these into a biological definition is difficult because no single pathway in the brain is responsible for the generation and regulation of sleep. One of the earliest proposals was to define sleep as the deactivation of the cerebral cortex and the thalamus because of near lack of response to sensory inputs during sleep.

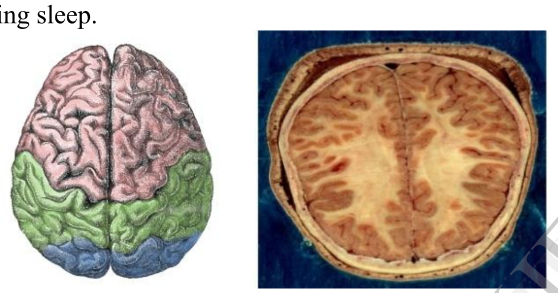


Fig 1: (a) Human brain (Cerebral lobes: the frontal lobe (pink), parietal lobe (green) and occipital lobe (blue)), (b) cerebral cortex

However, this was invalidated because both regions are active in some phases of sleep. In fact, it appears that the thalamus is only deactivated in the sense of transmitting sensory information to the cortex.

2.2 Condition of human brain during sleep:

When we close our eyes and relax, the predominant EEG pattern will be a slow oscillation between about 7 and 12 hertz. This waveform is called the alpha rhythm, and is associated with contentment and a decreased level of attention. Opening our eyes and looking around causes the EEG to change to the beta rhythm, occurring between about 17 and 20 hertz [6]. Other frequencies and waveforms are seen in children, different depths of sleep, and various brain disorders such as epilepsy, insomnia etc.

When we first enter sleep, our brain waves decelerate from beta (12 to 18 cycles/second) to alpha (8 to 12 cycles/second) to theta (4 to 8 cycles/second). At this point, stage one begins. The amplitude of sleep waves is lowest during wakefulness (10-30μV) and shows a progressive increase through the various stages of sleep. [7]

Table 1: Different Stages of REM Sleep

STAGE 1	STAGE 2	STAGE 3	STAGE 4	REM
1.Light Sleep 2. Eye & muscle activity, along with brain activity, all decrease.	1.Eye movement & muscle activity stop. 2.Brain waves slow down.	1.Brain produces very slow delta waves. 2.Deep sleep begins.	1 .Brain produces only delta waves. 2. Sleeper may be disoriented if wakened.	1.Heart,breath ingrates, &blood pressure rise, while muscles of the chin, limbs, neck & torso are paralyzed. 2.Eye movement is quick & irregular, and the sleeper begins to dream.

Non-REM sleep: According to the 2007 AASM standards, NREM consists of several stages [5].

Table 2: Different Stages of Non-REM Sleep

Stage N1	Stage N2	Stage N3
1. The transition of the brain wave from alpha (8–13) to theta (4–7 Hz) waves. 2. This stage is referred to as somnolence or drowsy sleep.	1. Sleep spindles ranging from 11 to 16 Hz (most commonly 12–14 Hz). 2. Muscular activity decreases, and conscious awareness of the external environment disappears. 3. This stage occupies 45–55% of total sleep in adults.	1. This Stage called deep or slow-wave sleep. 20% delta waves ranging from 0.5–2 Hz and having a peak-to-peak amplitude >75 μV. 2. In this stage parasomnias such as night terrors, nocturnal enuresis, sleepwalking and somniloquy occur.

The waveform for non REM EEG pattern has shown in figure which indicates the variation of brain wave in stage of non REM sleep.

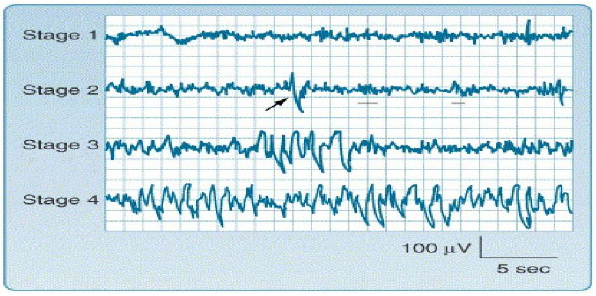


Fig 2: EEG of four pattern of non REM [19]

Hypnogram shows sleep cycles from midnight to 6.30 am, with deep sleep early on. There is more REM (marked red) before waking. Fig 3: Hypnogram showing sleep cycles

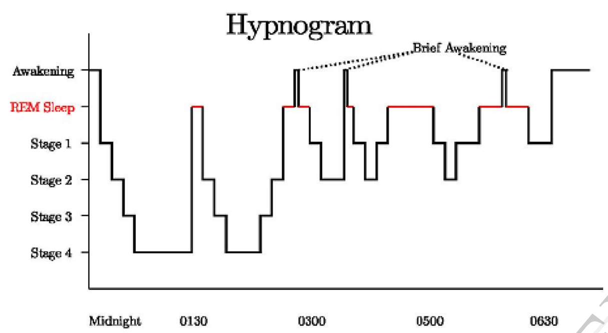


Fig 3: Hypnogram showing sleep cycles

2.3 Four Categories of Brain Wave Patterns:

Beta (14-30Hz)

- Concentration, arousal, alertness, cognition
- Higher levels associated with anxiety, disease, feelings of spa ration, fight or flight

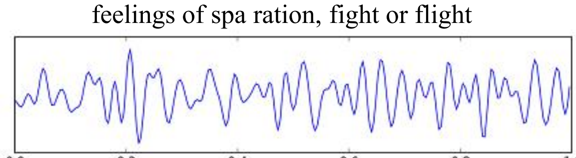


Figure 4: Beta Wave

Alpha (8-13.9Hz)

- Relaxation, super learning, relaxed focus, light trance, increased serotonin production.
- Pre-sleep, pre-working drowsiness, mediation, beginning of access to unconscious mind

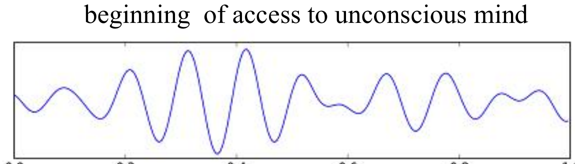


Figure 5: Alpha Wave

Theta (4-7.9 Hz)

- Dreaming sleep(REM sleep)
- Increased production of catechol amines (vital for learning and memory), increased creativity
- Integrative, emotional experiences, potential change in behaviour, increased retention of leamed material
- Trance, deep mediation, access to unconscious mind

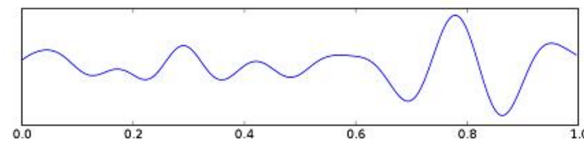


Figure 6: Theta Wave

Delta (1-3.9 Hz)

- Dreamless sleep
- Human growth hormone released
- Deep, trance-like, non-physical state, loss of body awareness
- Access to unconscious and collective unconscious mind.

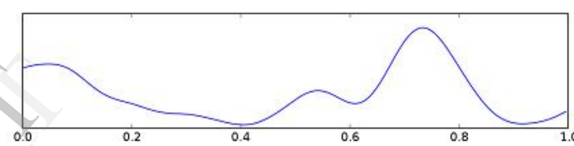


Figure 7: Delta Wave

2.4 Timing of Sleep:

Normal timing is controlled by the circadian clock, sleep-wake homeostasis, and in humans, within certain bounds, willed behaviour. The circadian clock — an inner timekeeping, temperature-fluctuating, enzyme-controlling device — works in tandem with adenosine, a neurotransmitter that inhibits many of the bodily processes associated with wakefulness [17]. Homeostatic sleep propensity (the need for sleep as a function of the amount of time elapsed since the last adequate sleep episode) must be balanced against the circadian element for satisfactory sleep [18]. Along with corresponding messages from the circadian clock, this tells the body it needs to sleep. Sleep offset (awakening) is primarily determined by circadian rhythm. [8]

A person who regularly sleeps at much late night will gradually hamper this circadian clock. As a result, he does not feel sleepy at the right time or at the time when needed. This gradually leads to insomnia.

2.5 Insomnia & Its Different Stages

Insomnia, or sleeplessness, is an individual's reported sleeping difficulties. A definition of insomnia is, "difficulties initiating and/or maintaining sleep, or non-restorative sleep, associated with impairments of daytime functioning or marked distress for more than 1 month."[9] Insomnia can occur at any age, but it is particularly common in the elderly. Insomnia can be transient insomnia (lasts for less than a week) or acute insomnia (means inability to consistently sleep well for a period of less than a month) or chronic insomnia (lasts for longer than a month) which can lead to memory problems, depression, irritability and an increased risk of heart disease and automobile related accidents. Insomnia can occur as a result of, for example, restless legs, sleep apnea or major depression. Poor sleep quality is caused by the individual not reaching stage 3 or delta sleep which has restorative properties. Major depression leads to alterations in the function of the hypothalamic-pituitary-adrenal axis, causing excessive release of cortical which can lead to poor sleep quality. It can be shown as a flow chart given below.

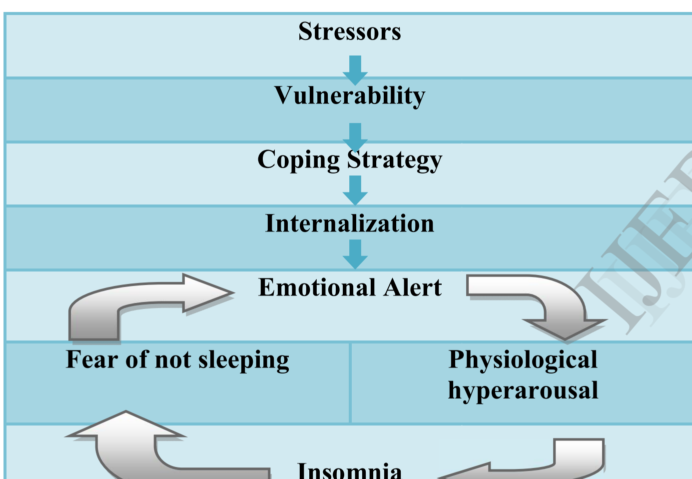


Fig 8: Flow chart (how insomnia occur) [16]

2.6 Patterns of insomnia

Insomnia Patterns are as follows:

- Initial insomnia: early- morning awakening
- Middle insomnia: difficulty in sleeping through the night without waking up and difficulty in going back to sleep
- Terminal insomnia: difficulty in falling asleep

Now, a survey is presented in the form of a bar chart where it is shown in percentage which indicates patterns of insomnia observed among people. It is clear from the figure that, major portion of these people wake up anytime from sleep and feel drowsy or tired. Among them, 56% people are at terminal stage who are suffering chronic insomnia.

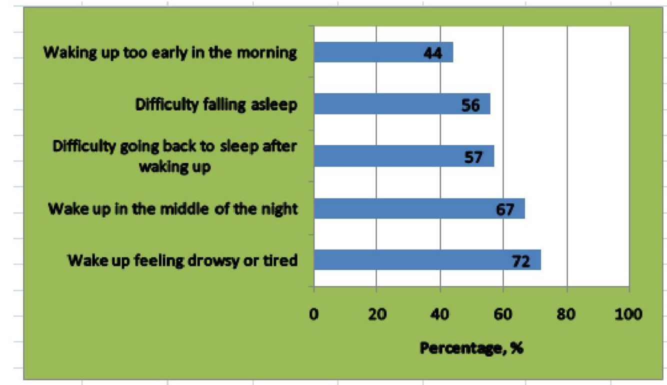


Fig 9: Occurrence of insomnia symptoms

2.7 Causes and Symptoms:

Symptoms of insomnia are as follows

Night-time Symptoms:

1. Frequent difficulty falling asleep.
2. Frequent episodes of waking up accompanied by difficulty in falling back to sleep.
3. Waking too early in the morning with inability to fall back to sleep again.
4. Non-refreshing night time sleep.

Day-time Symptoms: [21]

1. Fatigue
2. Memory of attention impairment
3. Anxiety and irritability
4. Depression
5. Sleepiness

Fig 10: Several kinds of disorders & symptoms occur due to poor or insufficient sleep

Symptoms of insomnia can be caused by or can be co-morbid with:

Symptoms of insomnia can be caused by

1. Use of fluoroquinolone antibiotic drugs, see fluoroquinolone toxicity, associated with more severe and chronic types of insomnia.
2. Restless Legs Syndrome, which can cause sleep onset insomnia due to the discomforting sensations felt and the need to move the legs or other body parts to relieve these sensations.
3. Life events such as fear, stress, anxiety, emotional or mental tension, work problems, financial stress, birth of a child and bereavement.
4. Disturbances of the circadian rhythm, such as shift work and jet lag, can cause an inability to sleep at some times of the day and excessive sleepiness at other times of the day. Chronic circadian rhythm disorders are characterized by similar symptoms.
5. Abuse of over-the counter or prescription sleep aids (sedative or depressant drugs) can produce rebound insomnia.

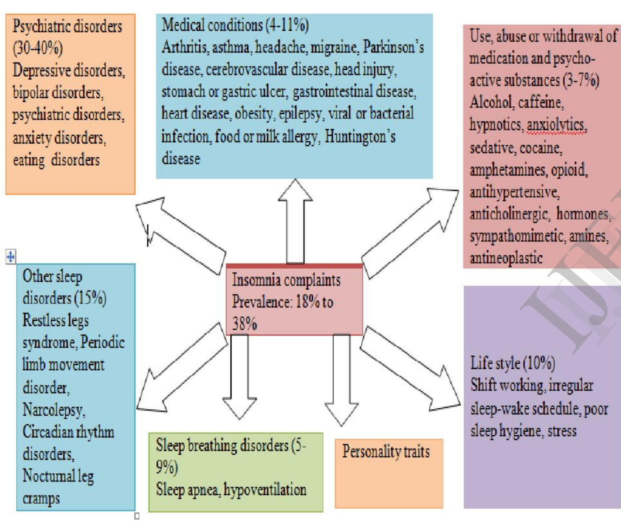


Figure 11: Common causes of insomnia complaints.

2.8 Adverse Effect:

Chronic insomnia affects approximately 9% to12% of the population and is more prevalent than heart disease, cancer, AIDS, neurologic disease, breathing problems, urinary problems, diabetes, and gastrointestinal problems. 4 Researchers estimate the total annual cost of insomnia is $30 to $35 billion. Although insomnia is highly prevalent, it is not commonly viewed as a significant threat to health. However, research has shown that a strong relationship exists between insomnia, depression, and anxiety, where insomnia may be a risk factor. [10]

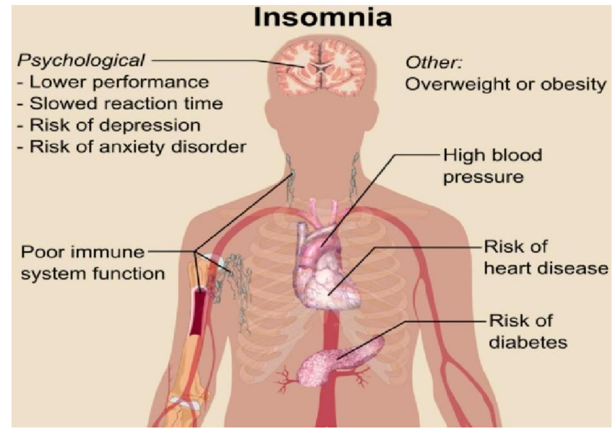


Fig 12: Adverse effect of insomnia [22]

Analysis showed that people with insomnia:

1. Are five times more likely to experience anxiety and depression. Have double the risk of developing congestive heart failure and diabetes, and have an elevated risk of death.
2. Are seven times more likely to abuse alcohol or drugs over the next three and a half years compared with those without the condition.
3. Are likely to have continuing problems; 70 percent have insomnia a year later, and half still have insomnia up to three years later.
4. May be treated with drugs such as anti-depressants and antihistamines that have little evidence to show they work well for insomnia.
5. In the figure 2 it is seen that, interval between two heartbeats is decreased during insomnia. That means, heartbeat becomes faster and as a effect of this blood pressure increases. If it continues for a long period, it is certainly very harmful to human body.

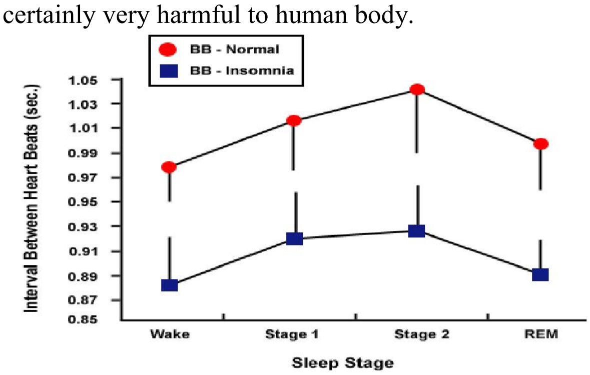


Fig 13: interval between heartbeats vs. sleep stage [20]

3. Case Study: Effects Of Electromagnetic Field Therapy

3.1 Case study 1: Subject – Rabbit

Statistically significant alterations in brain activity were observed in each animal when it was exposed to 2.5 G, 60 Hz, as assessed using each of two recurrence-plot quantifiers. Each result was replicated; a positive-control procedure ruled out the possibility that the effect of the field was a product of the method of analysis. Measurements performed while the rabbits were under anesthesia suggested that the effect was mediated by N-methyl-D-aspartame and /or a-adrenoceptors. It concludes that EMF transduction resulting in changes in brain electrical activity could be demonstrated consistently using a nonlinear method of analysis. Exposure to 16 Hz, 289 mG altered activity in rat hippocampal slices. Exposure to 200–300 mG, 60 Hz, produced both positive and negative effects, depending on the strength of an accompanying electric field. In a series of animal and human studies, it was showed that weak magnetic fields of 0–60 Hz altered the EEG in roughly half the subjects studied. These reports raised the possibility that the effects of fields on the EEG might involve nonlinear neuronal networks. [13]

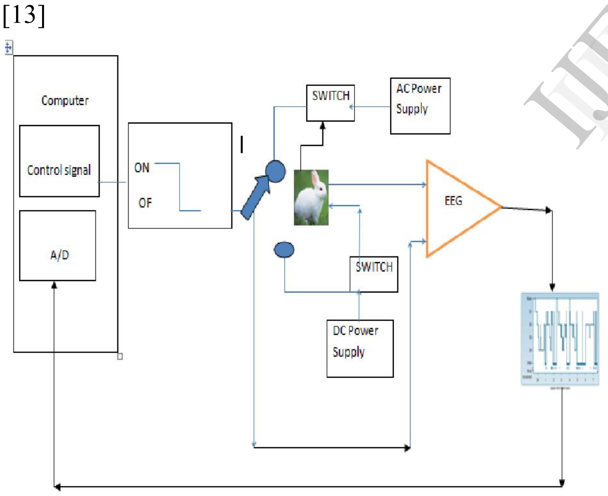


Fig 14: Experimental Setup

3.2 Case study 2: Subject - Human

To measure the response rate of normal human subjects to a low-strength, low-frequency magnetic field (MF), using nonlinear quantitative analysis of the electroencephalogram (EEG). Eight subjects were exposed to a series of trials, each consisting of the application of the MF (1 G, 60 Hz) for 2 s followed by a field-free period of 5 s, and the EEG was analyzed statistically using phase-space methods to assess whether the subject detected the MF. The 100% response rate manifested by the study group suggested that the ability to detect low-strength, low-frequency MFs is a common property of the human nervous system [14].

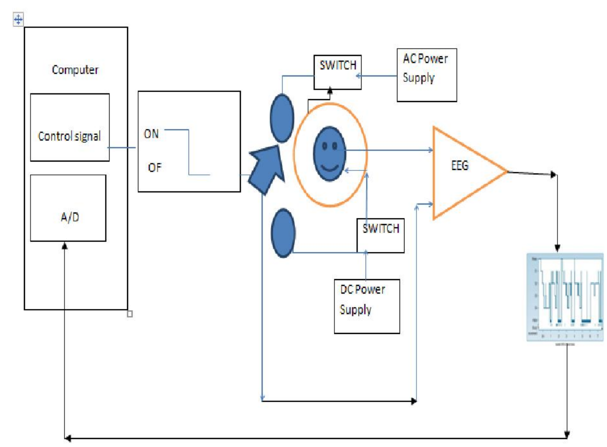


Fig 15: Experimental Setup

3.3 Case Study- Sam (33 years)

Sam is a qualified nurse and is required to work night shift duty. This disrupted his circadian rhythm and as a result he suffered with insomnia. He found it very difficult to get to sleep, often not dropping off until 2 or 3am. He would sleep for an hour or two and then wake up and would find it impossible to get back off to sleep again. Sam consulted his doctor who prescribed a conventional sleeping tablet (Temazepam). Sam found that he was unable to cope with the side effects of the Temazepam. Sam was prescribed a magnetic pillow pad. Sam was reviewed after 2 weeks and he reported that after just 5 days use he had had his first full nights sleep in 8 years. After 4 weeks Sam was reviewed for a second time and he reported that he was now able to sleep through the night 4 out of 7 nights and the 3 nights that he was unable to sleep thorough he commented that once he woke it was only a short time before he could get back off to sleep again. Sam still continues to use the magnetic pillow on a daily basis. [15]

4. Methodology

4.1 Theory:

Earth's magnetic field is one of the most complex variables known. It varies with the Sun's activity, the Sun's rotation, the Moon's rotation, the Earth's rotation, and the positions of the planets [11]. A typical

GM pattern is shown in Figure 1. The rapid fluctuations on the afternoon 7/25 correspond to a rare alignment of Mercury, Venus, Saturn, and Jupiter.

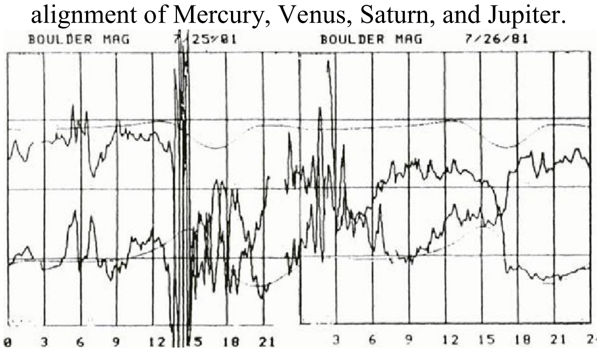


Figure 16: Earth's Geomagnetic Field. Time of day along x axis.

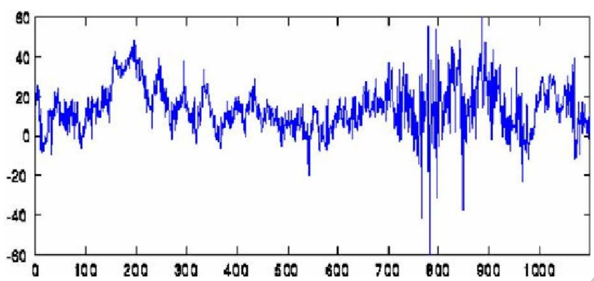


Figure 17: A Typical Brain Wave for One Second.

Although the GM field and brain waves do not appear to be similar, except that they are complex electromagnetic waves, there must be some connection that has not been noticed yet. For centuries humans have noticed connections between human behavior and planetary positions.

Laboratory studies have found that magnetic fields can affect brain waves although precise correlation's between brain wave patterns and the geomagnetic field have not yet been discovered, it seems a strong working hypothesis. [11]

The brain is always generating a pattern of internal neural frequencies, so called alpha, theta, delta, and beta; names for different ranges of frequencies, plus others, some of which are altered by the patterns of electromagnetism in our environment. Radio waves, cell phone microwaves, TV, and general noise from electric circuits also generate electromagnetic frequencies. The minute electromagnetic patterns of the Earth are also a part of the environment. Brain waves are a mixture of these frequencies, which vary depending on human activity, that is, sleeping, meditating, visualizing, concentrated alertness, etc. During meditation, the higher frequencies diminish and the lower ones become dominant. Quieting the internally generated neural patterns can make us more receptive to the geomagnetic patterns.

The world is surrounded by magnetic fields: some generated by the earth's magnetism, others generated by solar storms and changes in weather. Magnetic fields are also created by electrical devices (e.g. motors, televisions, office equipment, computers, microwave ovens, electrical wiring in homes, power lines). Even the human body produces a subtle magnetic fields generated by chemical reaction within cells and ionic currents of the nervous system. An electromagnetic field (EMF) is composed of both an electric and a magnetic field. The electric field is due to the presence of charged particles (such as electrons) and the magnetic field is due to the movement of the charged particles (such as an electron current). Recently, scientists discover that external magnetic fields affect the body's functioning in both different ways.

Magnetic field therapy diagnoses and treats both physical and emotional pain; it relieves symptoms and retards the cycle of new disease. Magnets and electromagnetic therapy devices are now being used to eliminate pain, facilitate healing of broken bones, and counter the effects of stress. It has been found that, a magnetic field applied to the top of the head has a calming, sleep-inducing effect on brain and body functions, due to the stimulation of the production of the hormone melatonin.

According to University of Lubeck, Department of Neuroendocrinology, there is compelling evidence that sleep contributes to the long-term consolidation of new memories. This function of sleep has been linked to slow (<1 Hz) potential oscillations, which predominantly arise from the prefrontal neocortex and characterize slow wave sleep. However, oscillations in brain potentials are commonly considered to be mere epiphenomena that reflect synchronized activity arising from neuronal networks, which links the membrane and synaptic processes of these neurons in time. It is proved that inducing slow oscillation-like potential fields by transcranial application of oscillating potentials (0.75 Hz) during early nocturnal non-rapid-eye-movement sleep, that is, a period of emerging slow wave sleep, enhances the retention of hippocampus-dependent declarative memories in healthy humans. The slowly oscillating potential stimulation induced an immediate increase in slow wave sleep, endogenous cortical slow oscillations and slow spindle activity in the frontal cortex. Brain stimulation with oscillations at 5 Hz--another frequency band that normally predominates during rapid-eye-movement sleep--decreased slow oscillations and left declarative memory unchanged. Several findings indicate that endogenous slow potential oscillations have a causal role in the sleep-associated consolidation of memory, and that this role is enhanced by field effects in cortical extracellular space. It is also proved that slowly oscillating Delta rhythm electric stimulation applied via surface electrodes on the scalp induced an immediate increase in spectral power at the same slow wave (Delta) frequency band, increased endogenous cortical slow oscillations, and increased slow spindle activity in the frontal cortex, resulting in improved slow wave sleep and subsequently better memory consolidation.

4.2 Design Of The Device:

Now we want to design a device based on the theory discussed above through which it is possible to fight against insomnia.

4.2.1 Circuit Diagram:

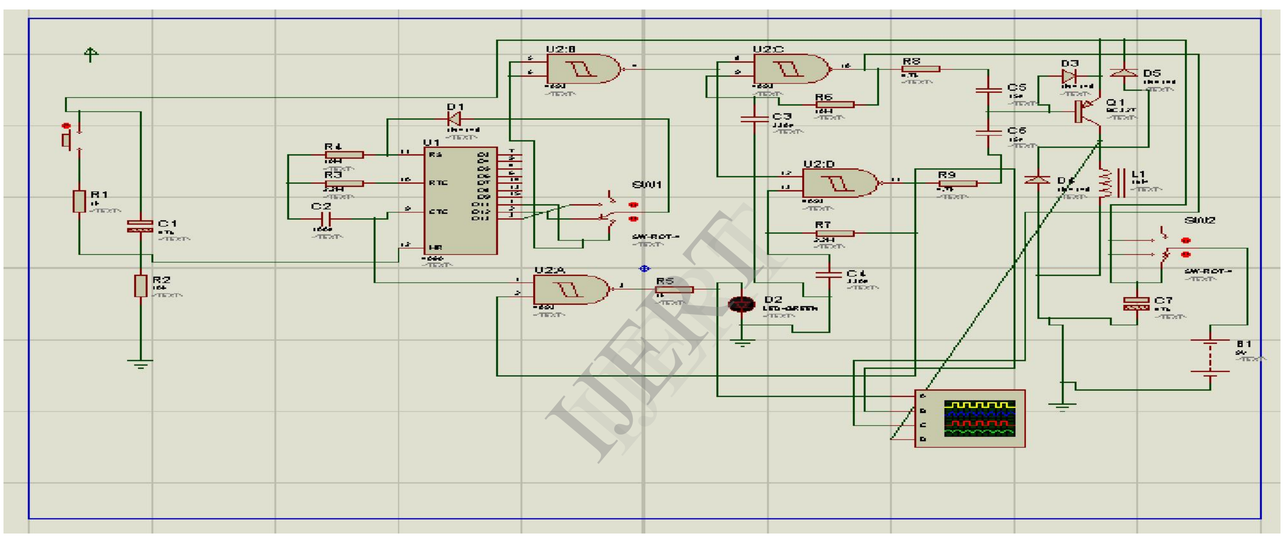


Figure18: Proteus simulation

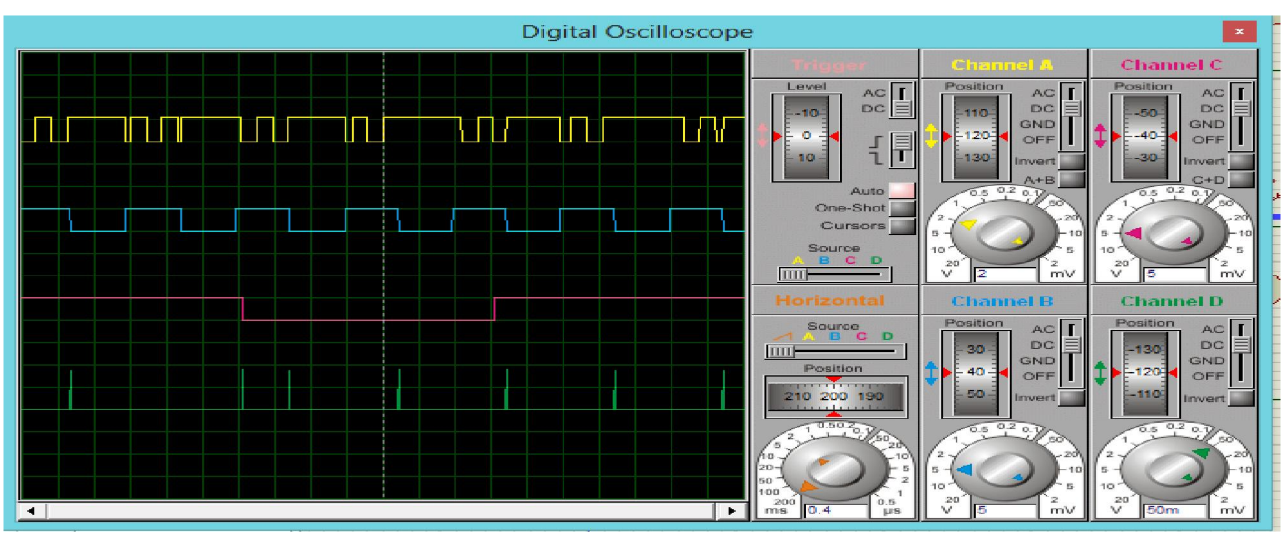


Figure 19: Waveform using Proteus simulation

4.2.2 Selection Of ICs:

Selection of IC 4060:

The selection criteria need to select such an IC which can be used to reset the whole operation and which also has a specific operation time. IC 4060 meets these two criteria [12]. In 4060, there are three oscillator terminal, one master reset pin and ten buffer output. Among these ten outputs three are low and seven are high. For higher timing operation we need to use low buffer outputs.

Calculation of operation time:

Operation time, $t = 2.5*2^{n}*R4*C2$
Here, n= Output number (O_n),
2.5 = Multiplier,
R4 = Resistor connected to oscillator pin 10
C2 = External Capacitor connected to in 9
Now, consider pin 1 i.e. O_{11} (n = 11),
R4 = 2.2 MΩ, C2 = 100nF
So, $t = (2.5*2^{11}*2.2*10^{6}*100*10^{-9})$ sec.
$= 1126.4$ sec.
≈ 18 min.
Similarly, for output pin 2 (O_{12}) & pin 3(O_{13}) operation time are 36 minutes and 72 minutes respectively.

Selection of IC 4093:

Here, to provide the wave its desired shape IC 4093 is used because it is good as a wave and pulse shaper. The waveshape and frequency is obtained by varying the capacitor and resistor values. Here, external resistors connected to pin 10 and 11 work as feedback paths which control the output frequency of these pin.

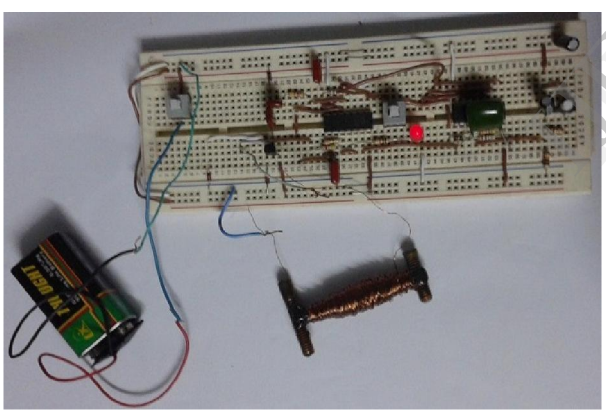
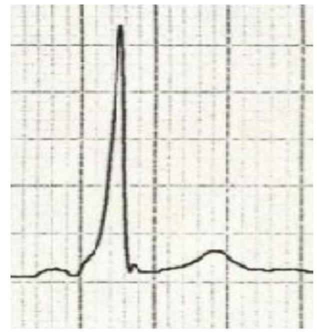


Figure 20: Hardware implementation

4.3 Wave shape Analysis:

Here, our target is to generate delta wave. Here is a sample of typical delta wave. But, it is not exactly same always. Its shape may differ a little but its frequency is limited to the range of 0-5 Hz.



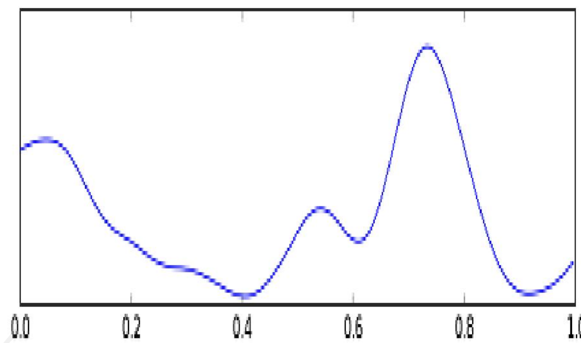


Figure 21: Standard delta Wave

In our experiment the obtained output waveshape is given below:

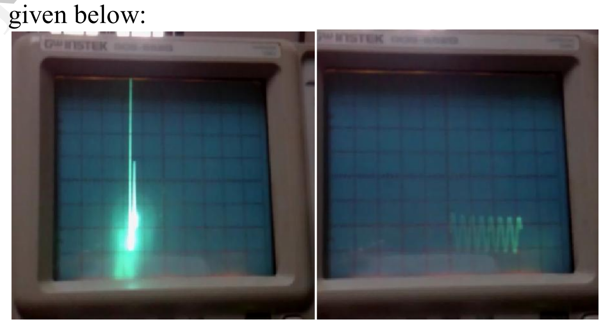


Figure 22: Wave obtained from the circuit

This wave is almost similar to the waveform of standard delta wave shown in figure. But in practical case it is not become possible to capture the both impulse and sinusoidal part of the same delta wave simultaneously. So, these parts are captured by two separate snapshots and shown side by side in the figure.

4.4 Important Points About Circuit:

The following points should be noted.

- L1 is obtained by winding randomly 600 turns of 0.2 mm. enamelled wire on a 6 mm. diameter, 40 mm. long, steel bolts. Secure the winding with insulating tape.

- Mean current drawing is about 7mA, decreasing to less than 4mA during pauses when in Alternate mode operation.
- Battery life can be dramatically increased omitting LED D2 and its associated resistor R5.
- Plastic box is to be used to enclose the circuit: metal cases can severely limit electromagnetic radiation.

4.5 Procedure:

Select a timing option by means of the rotary switch SW1.

- Choose 15, 30 or 60 minutes operation.
- Select "Stop" or "Alternate" mode operation by means of SW2.
- With SW2 closed (Stop mode operation) the electromagnetic radiation stops after the pre-set time is elapsed.
- With SW2 opened (Alternate mode operation) the device operates for the pre-set time, then pauses for the same amount of time: this cycle repeats indefinitely.
- Place the unit under the pillow and sleep like a log.
- To reset a cycle press P1 push button.

4.6 Construction And Working:

- ❖ IC2C and IC2D generate two square waves at about 1.2 and 5 Hz respectively. These wave-forms are converted into 60µS pulses at the same frequencies by means of C5 & C6 and mixed at Q1 Base. This transistor drives the Radiator coil with a scalar series of pulses of 60µS length and 9V amplitude.
- ❖ IC1, IC2A & IC2B form the timer section. C1 & R2 provide auto-reset of IC1 at switch-on. The internal oscillator of IC1 drives the 14 stage ripple counter and, after about 15 minutes, output pin 1 goes high. Pin 3 of IC2A goes low and stops IC2C & IC2D oscillation.
- ❖ If SW2 is left open (Alternate mode operation), after 15 minutes pin 1 of IC1 goes low, pin 3 of IC2A goes high and oscillators are enabled again.
- ❖ If SW2 is closed (Stop mode operation), the first time output pin 1 of IC1 goes high, the internal oscillator of the IC is disabled by means of D1. Therefore the circuit remains off until a reset pulse is applied to pin 12 by means of P1 or when the whole device is switched-off and then restarted.
- ❖ The same thing occurs when SW1 is switched on 30 or 60 minutes positions, obviously changing time length. IC2B drives pilot LED D2 which operates in the following three modes:
- ❖ Flashes quickly and almost randomly when the Radiator coil is driven
- ❖ Flashes somewhat slowly and regularly when the Radiator coil is pausing during the Alternate mode operation
- ❖ Is off when the circuit auto-stops (Stop mode operation)

4.7 Power Calculation:

Table 3: comparison between simulation & practical value

Output taken from	Voltage (volts)		Frequency (Hz)	
	proteus	practical	proteus	practical
Pin-10	5.00	6.00	1.20	3.00
Pin-11	5.50	7.50	5.00	3.02
Base	9.00	8.70	2.48	3.00
Collector (with coil)	8.80	8.82	2.42	2.50
(Without coil)	0.09	0.38	2.30	2.50

Here, pin 10 & 11 belongs to IC 4093 and collector & base belongs to transistor BC 327. Voltage & frequency are shown in tabular form which has been measured with & without coil in proteus & oscilloscope. Here measured current is 0.35mA at collector.

Result:

- Power calculation using simulation:
  P=0.35*10^-3*8.8=3.08mW (without coil)
  P=0.35*10^-3*0.09=31.5µW (with coil)

- Power calculation using oscilloscope (practical):
  P=8.82*0.35*10^-3=3.09mW (without coil)
  P=0.397*0.35*10^-3=139 µW (with coil)

4.8 Limitation Of This Circuit:

1. Radiated power is very small. Because of this, we cannot measure the radiation by using conventional instruments.
2. Measuring frequency is difficult in practical case by using oscilloscope.
3. Practical value is surprisingly more than theoretical or simulation value.

4. Electromagnetic field has been detected through galvanometer deflection but it cannot be measured accurately because lack of fluxmeter in the lab.

5. Conclusion and Future Work:

Figure 23: Sound sleep without drugs

Our Project induces a prolonged and sound sleep without drugs. This project can be improved more. As discussed in previous research work it is clear that, the result is not so satisfactory and the research on this respect is yet to develop further more. Now we should try to get more efficiency and also avoid any kind of adverse effects.

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