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Electronic Sleep Inducer with Stress Level Monitoring

Project Report

SUBMITTED TO

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ABSTRACT

Sleep is one of the most common and intricate cycles in the human body. People spend a significant portion of their lives sleeping. People sleep for a range of reasons. The body requires sleep to replace exhausted energy reserves, clear waste products from muscles, repair cells, improve the immune system, or recover physical abilities lost during the day. The human body enters a downward spiral when it is deprived of sleep for an extended period of time, which can lead to sickness or death in severe circumstances. As a result, appropriate levels of functioning necessitate adequate sleep. Many people, however, suffer from various sorts of sleep disturbances that interfere with their ability to get a good night's sleep. Insomnia is a type of sleep disorder. By definition, it is habitual sleeplessness or inability to sleep, or a very disturbed sleep cycle. This condition has seen rapid rise in the last decade.

Primary causes of Insomnia include Stress associated to major life events, like a job loss or change, the death of a loved one, divorce, or relocation, environmental factors like noise, light, or temperature, changes to your sleep schedule like jet lag, a new shift at work, and even genetics. Research has found that a tendency for insomnia may run in families.

Secondary causes of insomnia include mental health issues like depression and anxiety, medications for colds, allergies, depression, high blood pressure, and asthma, Pain or discomfort at night, caffeine, tobacco, or alcohol use, as well as use of illicit drugs, hyperthyroidism and other endocrine problems, other sleep disorders, like sleep apnea or restless legs syndrome, Alzheimer's disease and other types of dementia and ADHD.

Insomnia can be short term(acute) or can last a long period of time(chronic). About 30% of adults have short-term insomnia and 10% adults have chronic insomnia. Insomnia statistics reveal that up to 75% of the elderly population has insomnia symptoms.

1. INTRODUCTION

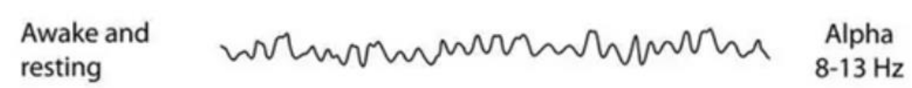
The human brain has four types of brain waves, Beta waves(14-30Hz), Alpha waves(8-13Hz), Theta waves(4-8Hz) and Delta waves(1-3Hz). Stress causes the brain to stay awake and continuously produce beta waves hence rendering them unable to sleep.
In an attempt to help combat this condition, our team is constructing an electronic sleep inducer that works based on the Faraday's principle of electromagnetic induction. This device is capable of producing magnetic fields using a radiator coil of required low frequencies that create signals in the brain and help induce sleep.
It also includes an IOT based sleep analyzer that works on motion detection sensor and can provide the sleep analysis to the user through an interactive web interface.

2. SLEEP INDUCER

2.1 Categories of Brain Wave Patterns

I. Beta (14-30Hz)
- Concentration, arousal, alertness, cognition
- Higher levels associated with anxiety, disease, feelings of spa ration, fight or flight

II. Alpha (8-13Hz)
- Relaxation, super learning, relaxed focus, light trance, increased serotonin production.
- Pre-sleep, pre-working drowsiness, mediation, beginning of access to unconscious mind.



III. Theta (4-7 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

IV. Delta (1-3.5 Hz)
- Dreamless sleep
- Human growth hormone released
- Deep, trance-like, non-physical state, loss of body awareness
- Access to unconscious and collective unconscious mind.

2.2 Induction of Sleep Through Delta Waves

Delta waves are brainwaves between the frequencies 1 to 3.5Hz. Delta waves are produced by the brain during dreamless sleep and when the brain activity is low. When we produce low frequency magnetic waves it induces our brain to generate now delta waves and makes the patient go to sleep easily. Many studies conducted show a positive correlation between sleep quality and low frequency magnetic waves. According to a study conducted in ASSAM DON BOSCO university 5 out of 10 people attained sleep while using the inducer. Their circuit produce wave of frequency 9.6Hz which is a bit high for the brain to start producing delta waves. We can improve it by producing waves of lower frequency.

2.3 Design of the Sleep Inducer

2.3.1 Delta wave generator

we have used a ic-555 timer in astable operation to produce waves of frequency, 2.4hzhz

Ton = 0.693*(RA+RB)*C;

Toff = 0.693*(RA)*C;

T = Ton + Toff

T = 0.693*(2RA + RB)*C;

RA = RB = 100k, C = 1uf

T = 0.693*3*100*10^3*10^-6 = 0.4167s

F = 1/T = 2.4Hz

The 555 timer is running in astable operation. The capacitor is initially uncharged and it charges through RA and RB once it reaches 2/3 Vcc it stops charging and it will start to discharge through RA and this cycle goes on producing a wave of frequency 2.4Hz and duty cycle of 66.67%

2.3.2 Current Amplifier

The current produced by the amplifier will vary depending on the resistance connected to its output terminal and it is generally in new milli amps. The magnetic field produced is directly proportional to the current so it is important to amplify the current. We have used BC639 which has a current gain of B = 200 to achieve this purpose.

2.3.3 Variable magnetic field strength using potentiometer

We have connected a potentiometer of resistance 10k in series with a fixed resistance of one kilo ohm. With this resistance in place, we can change the output resistance between 1k and 11k which allows the patient to choose different intensity of magnetic field based on his needs

2.3.4 Powering the Timer

It is powered using a non-rechargeable 9V dc voltage source.

2.3.5 Producing magnetic field

The magnetic field can be produced by connecting this setup to a coil. We have used a coil of 220uH to produce the magnetic field. Since the electrical current passing through the coil is of 2.4Hz the output magnetic field will be also of same frequency.

2.3.6 Calculation of Magnetic field

Maximum Magnetic field is produced when Rpot = 0 and Rout = 1k

The current through the coil at this scenario is around 630mA from LTspice simulation results.

Magnetic field = u*n*I

6.3*10^-3 *50 * 0.63

= 0.19 Tesla

Minimum magnetic field is produced when Rpot = 10k and the output resistance is 11k current when Rout = 11k is 90mA from LTspice simulation

So minimum Magnet field = 6.3*10^-3*50 * 90*10^-3;

= 0.02 Tesla

2.4 Motion detection using PIR sensor

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range.

It uses a pair of pyroelectric sensors to detect heat energy in the surrounding environment. These two sensors sit beside each other, and when the signal differential between the two sensors changes (if a person enters the range of sensor) It gives High as Output

2.5 Sleep Analyzer

2.5.1 Acquiring Motion data And Extracting Sleep Phases

We have connected the PIR sensor to an ESP8266 module through a digital Input pin of the ESP module. The ESP module constantly gets the data from the PIR sensor when it is turned on and uploads the data to the Real-Time Firebase Database when upload switched is turned on. Once the upload is complete a Led connected to the device will blink indicating that upload is complete

Code:

```
#include <ESP8266WiFi.h>
#include <WiFiClient.h>
#include <ESP8266WebServer.h>
#include <ESP8266mDNS.h>
#include <ESP8266Firebase.h>
#include <ESP8266WiFi.h>
#include <string.h>


int day = 0;
#include <cstring>

#define _SSID "Redmix"
#define _PASSWORD "redmi1021"
#define PROJECT_ID "sleepanalyzer2-b9951-default-rtdb"
int sensorpin = 3;
int switchpin = 5;
const int wifi_rest = 3;
char *sleeplist = "";
String sleeplist1 = "";
char *timearray = "";
Firebase firebase("sleepanalyzer2-b9951-default-rtdb");
char *FIREBASE_HOST = "your FIREBASE HOST";
char *FIREBASE_AUTH = "Your secret";
int t = 0;

void setup(void)
{
   Serial.begin(115200);
```

```
  WiFi.begin(_SSID, _PASSWORD);
  // Wait for connection
  while (WiFi.status() != WL_CONNECTED)
  {
    delay(500);
    Serial.print(".");
  }

  Serial.println("");
  Serial.print("Connected to ");
  Serial.print("IP address: ");
  Serial.println(WiFi.localIP());
  digitalWrite(5, HIGH);

  String dayurl = "/Day";
  String dataurl = "/data";

  day = firebase.getInt(dayurl);
  Serial.println("got day");
}

void loop()
{
  /*if(0){
    //digitalRead(wifi_reset)){
   String ssid = "";
    String password = "";
    ssid = firebase.getString("ssid");
     password = firebase.getString("password");
    WiFi.begin(ssid,password);

    }

  */
  int data = digitalRead(sensorpin);
  Serial.println("In loop");
  String data_c;

  if (data == 1)
  {
    data_c = "1";
  }
  else
  {
    data_c = "0";
  }
```

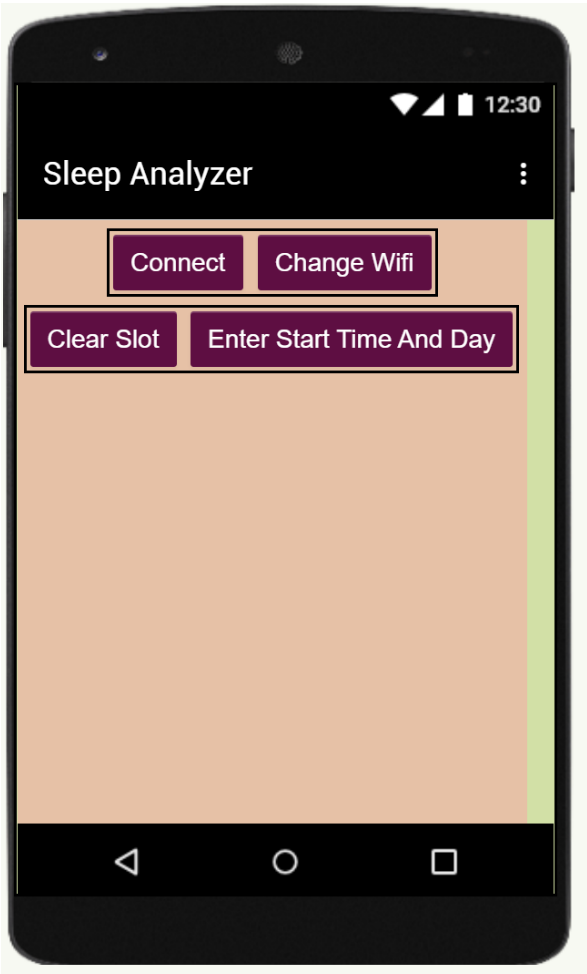
```
  sleeplist1 = sleeplist1 + data_c;

  if (digitalRead(2) == HIGH)
  {
    Serial.println("Sending Data");
    if (day == 0)
    {
      firebase.setString("data0", sleeplist1);
    }
    else if (day == 1)
    {
      firebase.setString("data1", sleeplist1);
    }
    else if (day == 2)
    {
      firebase.setString("data2", sleeplist1);
    }
    else if (day == 3)
    {
      firebase.setString("data3", sleeplist1);
    }
    else if (day == 4)
    {
      firebase.setString("data4", sleeplist1);
    }
    else if (day == 5)
    {
      firebase.setString("data5", sleeplist1);
    }
    else if (day == 6)
    {
      firebase.setString("data6", sleeplist1);
    }

    digitalWrite(5, HIGH);
    delay(1000);
    digitalWrite(5, LOW);
  }

  delay(1000);
}
```

The above is uploaded to the ESP module to achieve the said purpose.

2.5.2 Android App

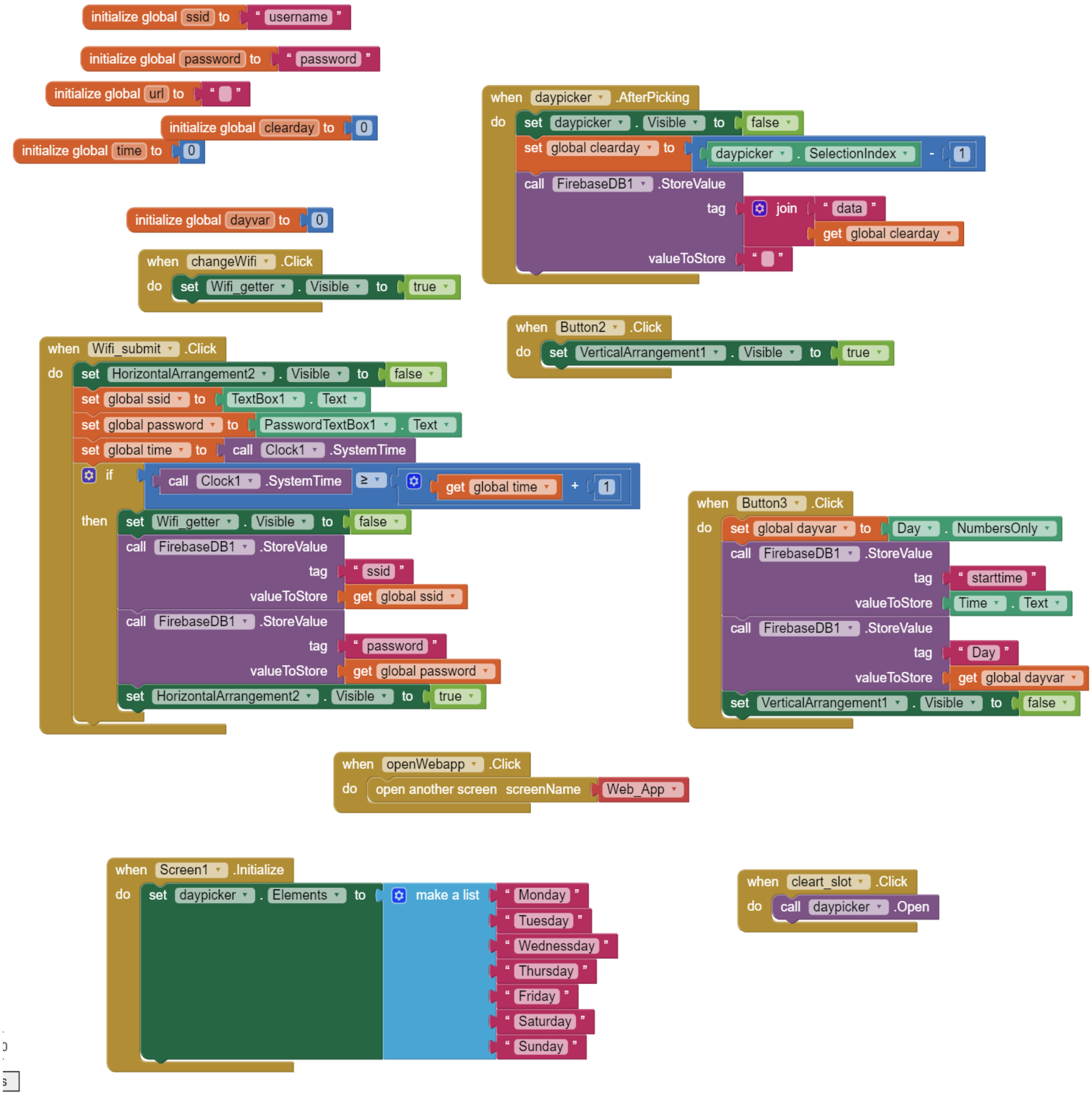
We have created an Android App using MIT app inventor which links directly to our webpage and it also allows us to clear and manage the available slots for storing sleep data

2.5.2.1 Home screen



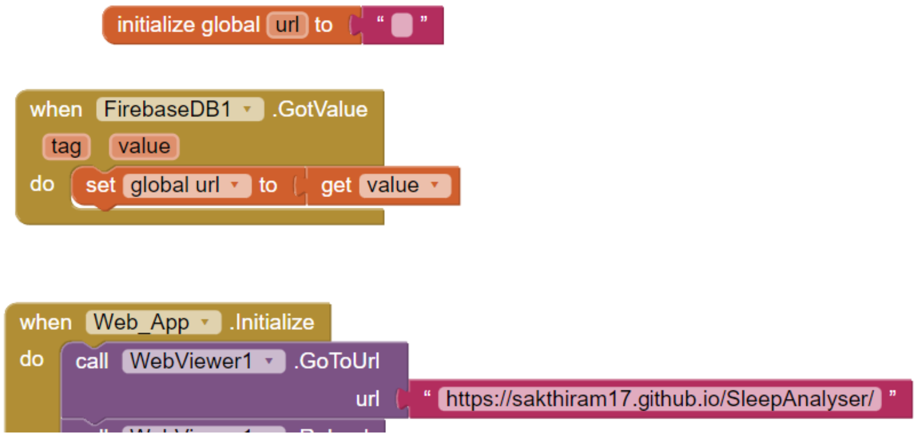
The home screen consists of 4 buttons. The Connect button will directly open the web application . The clear slot button will allow you to clear the slot used in the database and the Change wifi button will upload the details of the your wifi to the database which will then be used by the esp module to switch to new network when a reset switch is pressed. Enter Start Time and Day will allow the user to choose the slot(Monday – Sunday) and set the time when the recording starts.

Block Code for the Home Screen



2.5.2.2 Web App screen

Block Code



This screen when opened using the connect button in home screen only connects us to our web application.

2.5.3 Web application

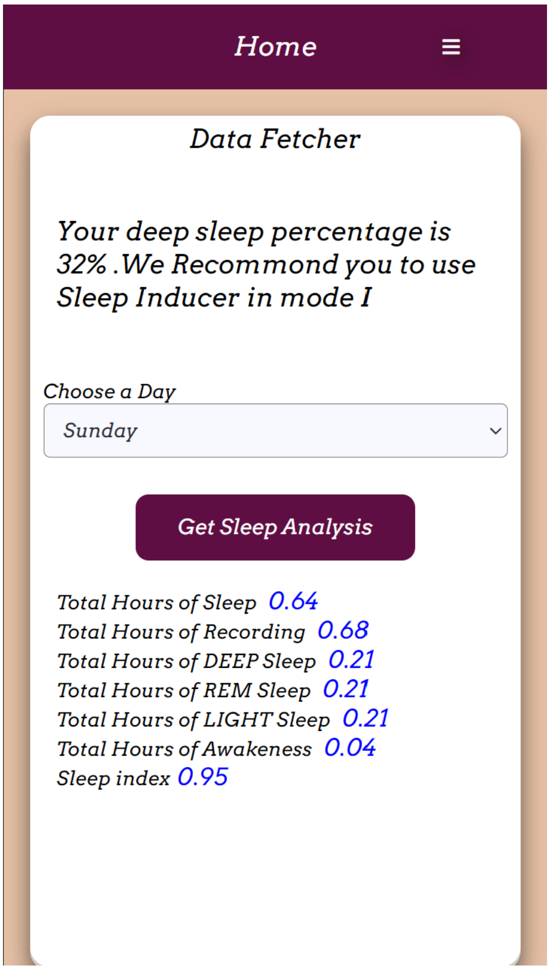
2.5.3.1 Structure of your web App

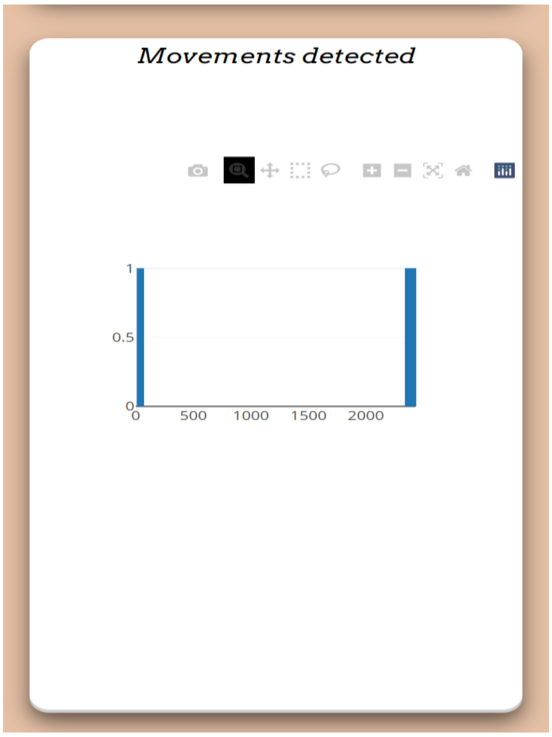
The website consists of three pages

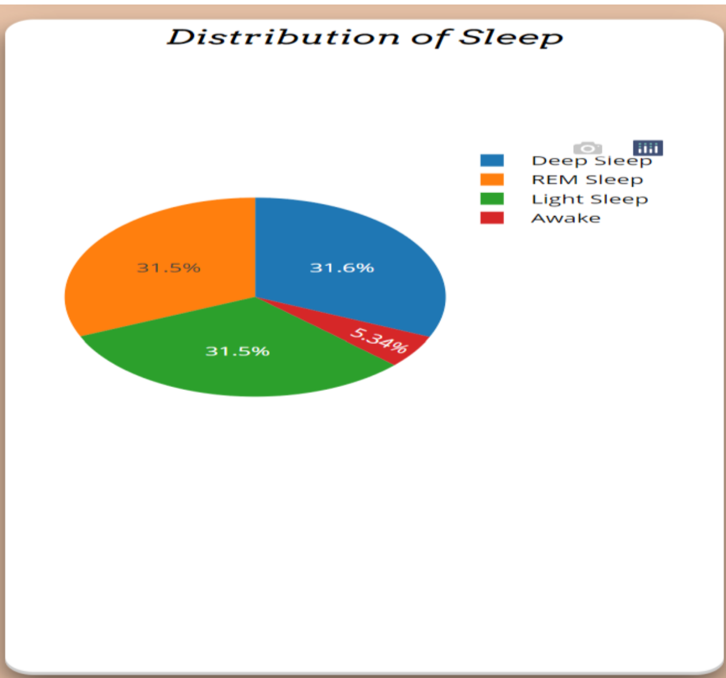
- Home: home of the webpage which allows us to see the sleep analysis and visualize it
- Weekly: It shows the same sleep analysis but for entire week
- Guide: It shows how to use the sleep inducer

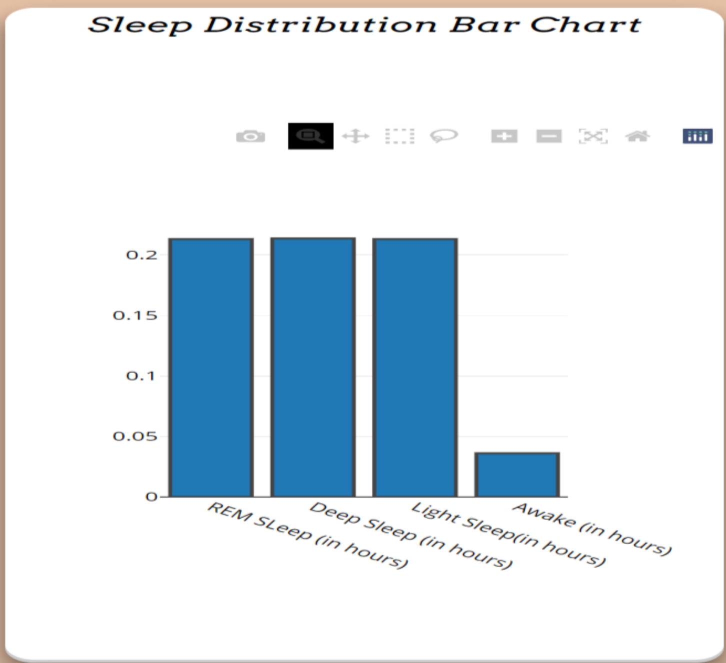
And also, there is an additional styles.css file to style this page.

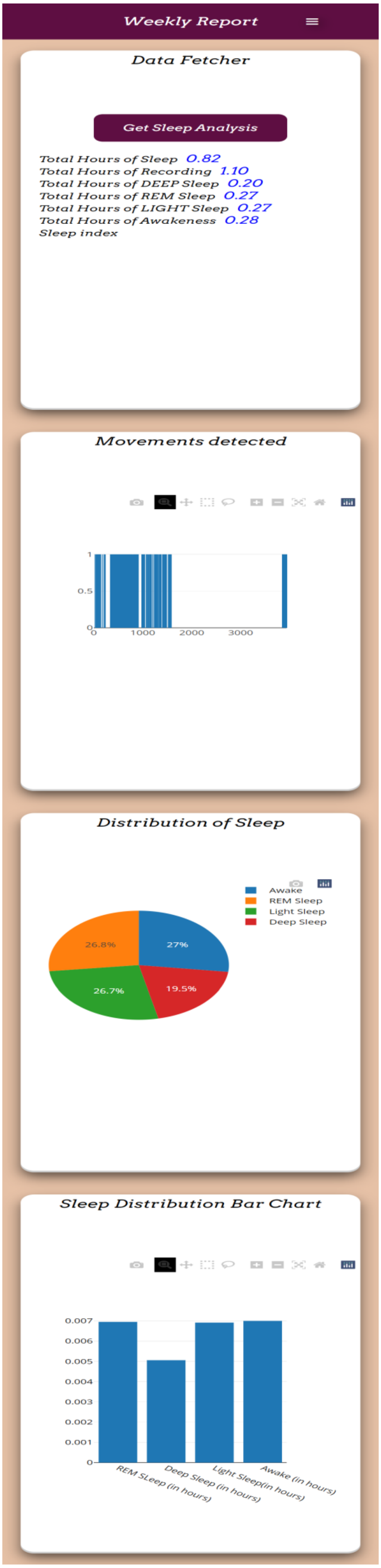
Home Screen


Home
Data Fetcher
Your deep sleep percentage is 32% .We Recommond you to use Sleep Inducer in mode I
Choose a Day
Sunday
Get Sleep Analysis
Total Hours of Sleep 0.64
Total Hours of Recording 0.68
Total Hours of DEEP Sleep 0.21
Total Hours of REM Sleep 0.21
Total Hours of LIGHT Sleep 0.21
Total Hours of Awakeness 0.04
Sleep index 0.95


Movements detected
1
0.5
0
0
500
1000
1500
2000

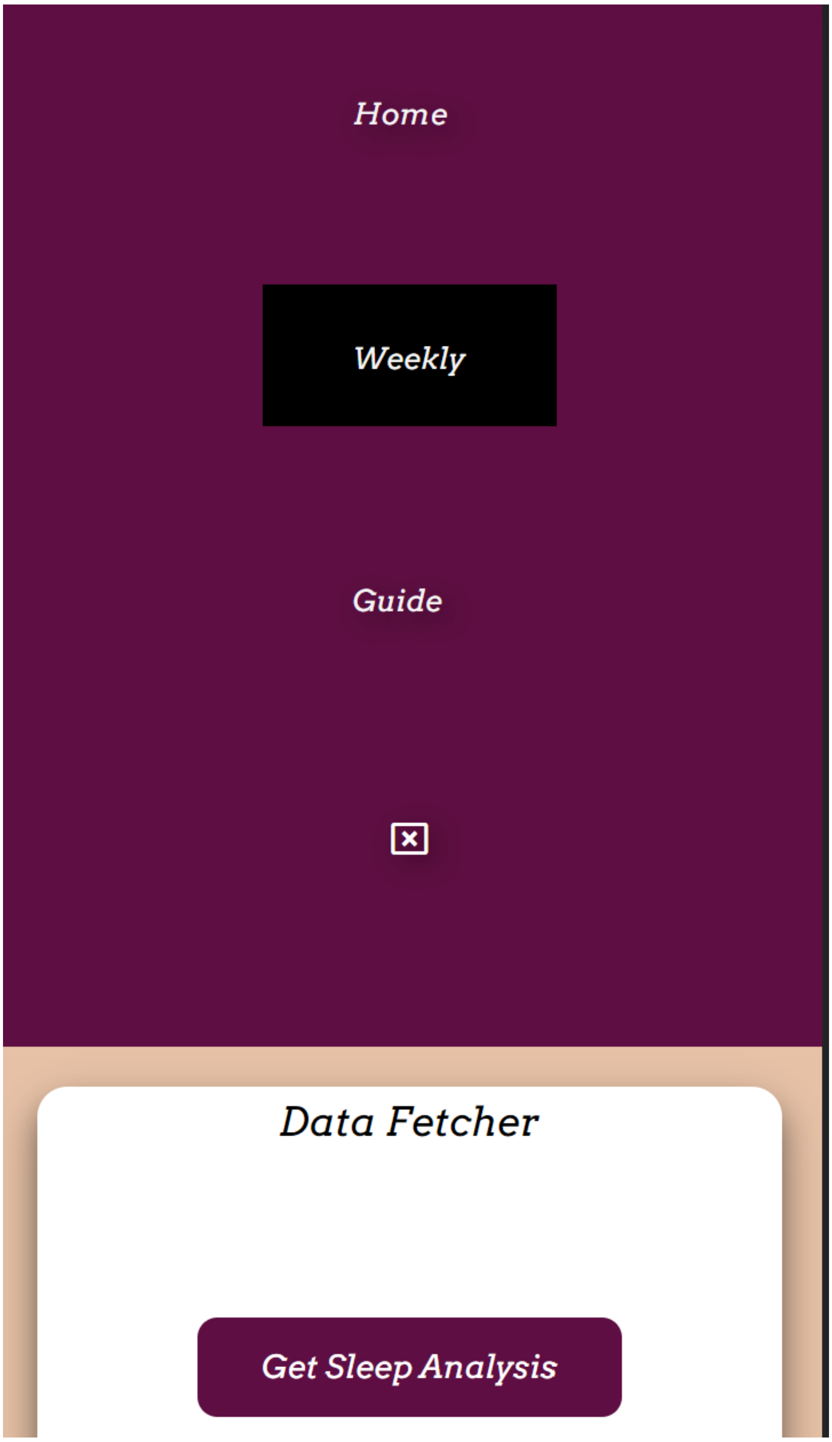

Distribution of Sleep
Deep Sleep
REM Sleep
Light Sleep
Awake
31.5%
31.6%
5.34%
31.5%


Sleep Distribution Bar Chart
0.2
0.15
0.1
0.05
0
REM SLeep (in hours)
Deep Sleep (in hours)
Light Sleep(in hours)
Awake (in hours)



Weekly Report Screen

Navigation bar



2.5.3.2 K Means Clustering Algorithm

It is an unsupervised learning algorithm. Clustering divides the complete dataset into various labels (here called clusters) with related data points into one cluster. For exploratory descriptive analysis, it is a particularly powerful tool.

To process the learning data, the K-means algorithm in data mining starts with a first group of randomly selected centroids, which are used as the beginning points for every cluster, and then performs iterative (repetitive) calculations to optimize the positions of the centroids It halts creating and optimizing clusters when either:

- The centroids have stabilized — there is no change in their values because the clustering has been successful.
- The defined number of iterations has been achieved.

Human sleep can be primarily divided into three phases

- Light Sleep
- REM sleep
- Deep sleep

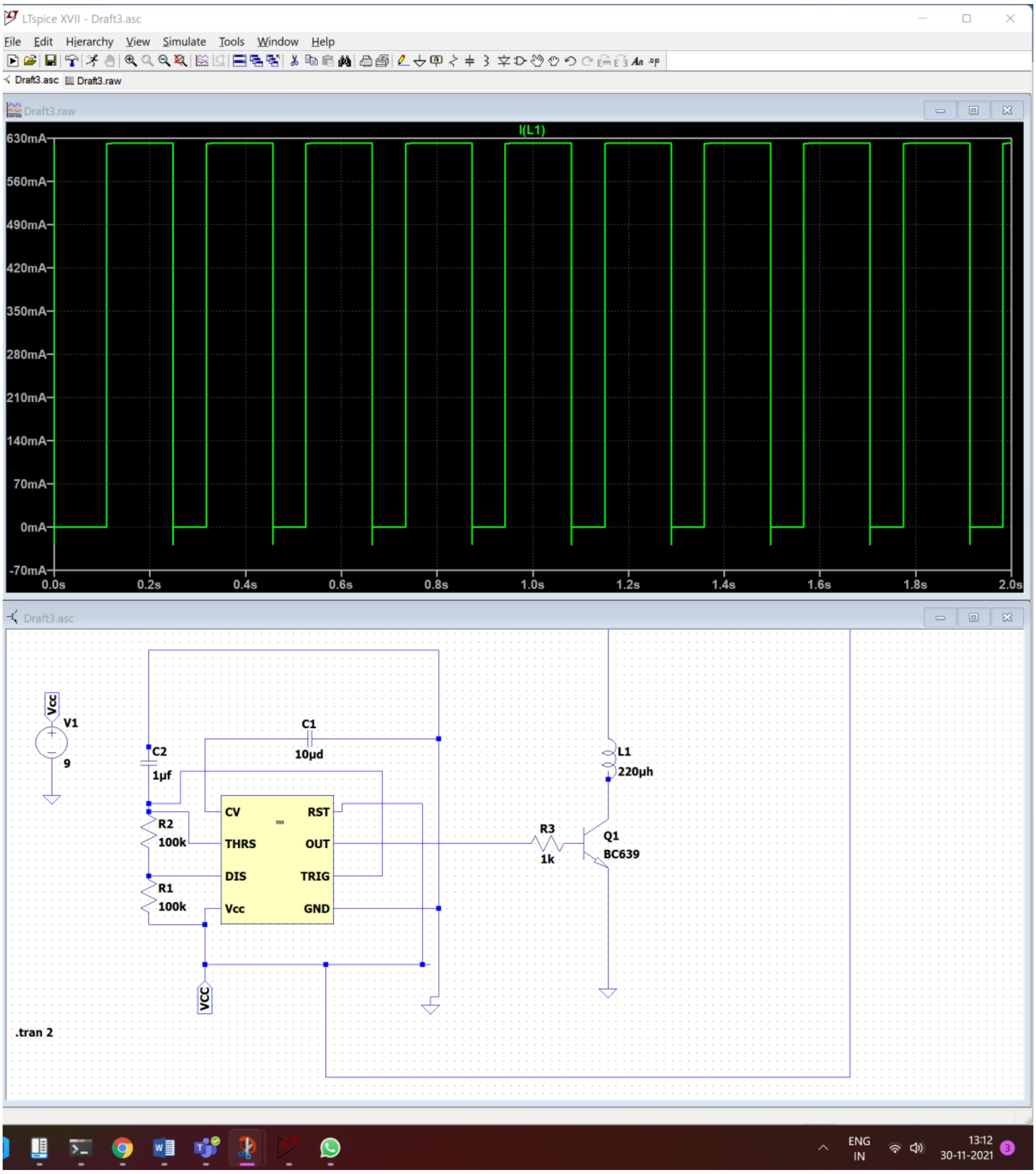
From the research paper (quoted in reference), we can conclude that the Body Movement Index (BMI) of each phase of sleep can have signification difference for each phase. Hence, we have used K-means clustering algorithm to divide the entire sleep duration into four phases (REM, Light, Deep, Awake).

The algorithm clusters the data into groups based on their means which is mathematically similar to BMI. These clusters are assigned appropriate titles based on their average body movement in each phase hence, helping in sensing the type of sleep phase the user is in.

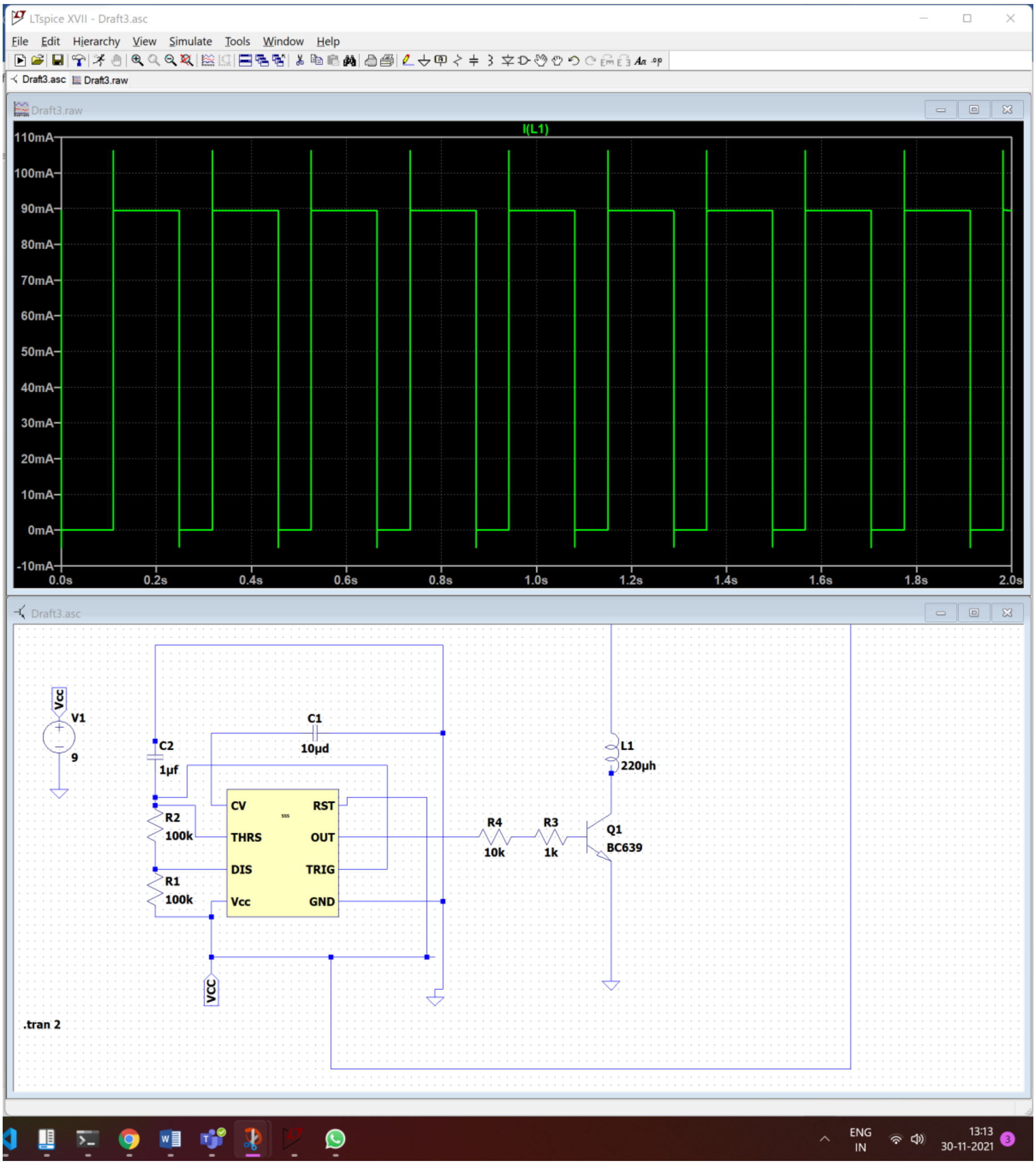
3. SIMULATION RESULT

Current through the inductor when

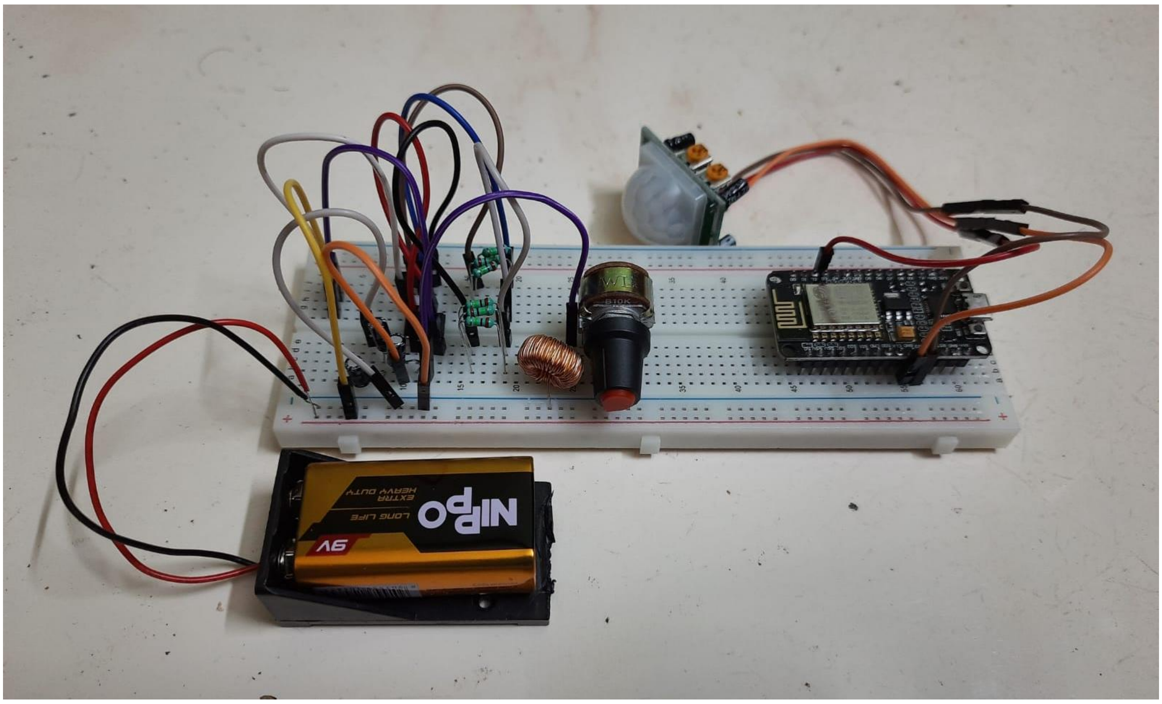
- When Rpot= 0 (maximum Intensity for magnetic field generator)



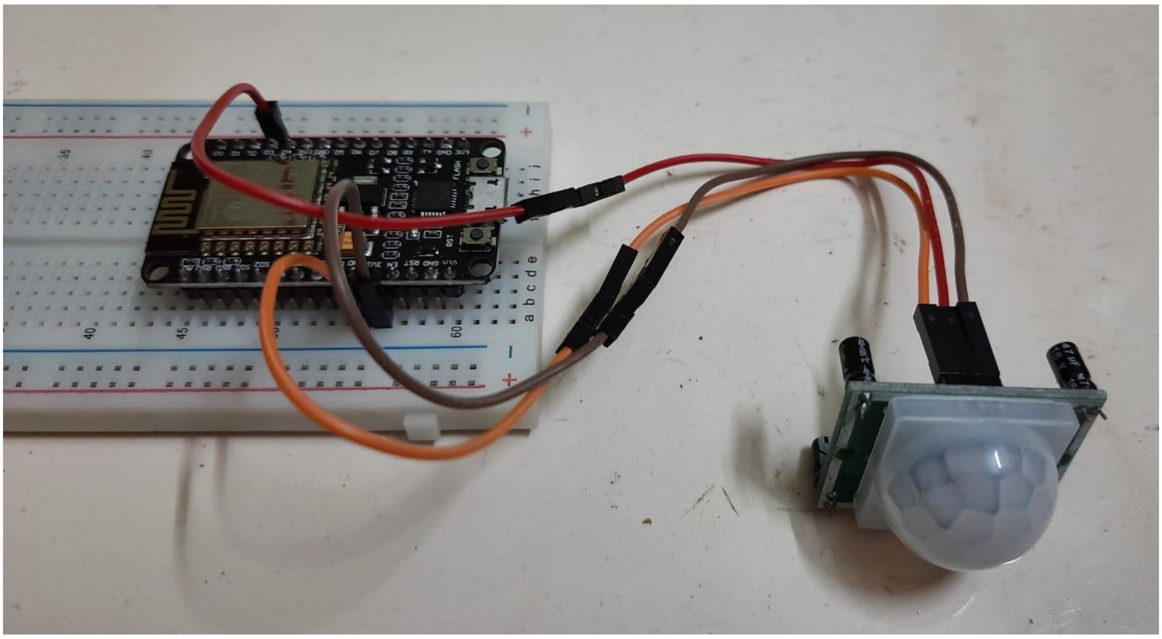
- When Rpot = 10k, (minimum Intensity of Magnetic field generator)



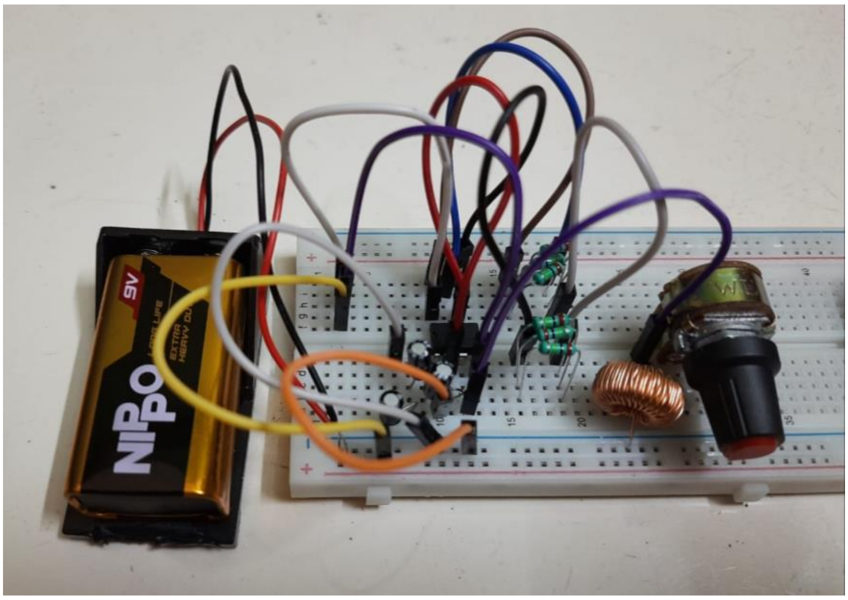
4. HARDWARE



Sleep Inducer and Analyzer Hardware



Sleep Analyzer Circuit



Sleep Inducer Circuit

5. RESULTS AND DISCUSSION

The development of this project provided knowledge and practical expertise.

This technology creates magnetic fields, which assist the brain in being surrounded by an optimum environment for a sound sleep.

This project aids in the treatment of insomnia. Apart from that, it helps with relaxation, sleep management, and sleep induction.

6. CONCLUSION

Sleep is an essential part of life and existence since it is a natural, dynamic process. It's a condition of diminished awareness characterized by a lack of response to waking stimuli. It serves biological goals such as development, hormone production, and healing. Mental pressure and tension are a major issue in today's competitive environment. Sleep deprivation can result in a variety of problems, one of which is insomnia.

This project generates a magnetic field and helps the brain relax by creating an ideal environment for a sound sleep. It also collects data of the user's sleep quality and amount, allowing them to keep track of their sleep.

ACKNOWLEDGEMENTS:

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LIST OF ABBREVIATIONS:
ADHD: Attention Deficit Hyperactivity Disorder
ESP: Electronic Stability Program
PIR: Passive Infrared
REM: Rapid Eye Movement

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