‘SMART SLEEP TRACKER’

PROJECT REPORT

Submitted for CAL in B.Tech. Bio-Medical Instrumentation

(EEE1008)

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CERTIFICATE

This is to certify that the Project work entitled "***Smart Sleep Tracker***" that is being submitted by "***Avinash Mukund, William C Francis, Alwin Jacob & Aditi Shah***" for CAL in BTech Bio-Medical Instrumentation(EEE1008) is a record of bonafide work done under my supervision. The contents of this Project work, in full or in parts, have neither been taken from any other source nor have been submitted for any other CAL course.

Place : Chennai

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ACKNOWLEDGEMENTS

We would like to express our special thanks of gratitude to our teacher, Dr. C. Umayal, as well as our institution, which gave us the golden opportunity to do this wonderful project on the topic ***Smart Sleep Tracker***, which has helped us learn and understand new things.

We would also like to thank the Dean of the School of Electrical Engineering for giving us the chance to carry out our vision.

Aditi Shah

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CONTENT

FIGURES USED :

ABSTRACT

Sleep deprivation impairs cognitive functioning, decision-making and reaction times. The cumulative effects of sleep deprivation are alarmingly serious. Therefore, it is important to devise measure to monitor and improve sleep quality. The objective is to build a device that can be worn around the wrist during sleep to analyse the sleeping pattern and depth of sleep using various sensors like accelerometer, pulse sensor and gyroscope. The sensor data is analysed to display the resultsIn this project, we used MPU 6050 gyroscope, accelerometer and pulse sensor to detect sudden movements of a sleeping person. Using information from the gyroscopic output, we can also identify the sleeping position in bed. Although there are existing devices to monitor sleep, the traditional sensors fail to give the accurate results. Therefore, the data from pulse sensor was analysed and interweaved with gyroscope data to find out the best operating modes of MPU6050 sensor for the optimal results. All possible combinations of the six operating modes have been studied of its similarity with the BPM output from heartbeat sensor. All the dynamically obtained data has been analysed real-time using PLX-DAQ feature.

INTRODUCTION

Good sleep is important for the overall health of a human being and inadequate sleep can lead to numerous health problems. Sleep deprivation could be caused due to regularly not dedicating enough time for sleep or due to a physical or mental problem that prevents sound sleep. Its adverse effects can be visible as the following symptoms. The person would feel drowsy during the day and can experience “microsleep”, which are short episodes of sleep while being awake. Lack of sleep has been identified to have played a significant role in tragic accidents involving airplanes, ships, trains, automobiles and nuclear power plants.

Lack of sleep adds up to ‘sleep debt’ which makes the person even more exhausted every day he/she is sleep deprived. Therefore, it is important to diagnose the issue before it is worse. Some of the fit-bands and smart watches already has the in-built function for sleep monitoring. But they often tend to be inaccurate and do not take the sleep position and heart beat into consideration. Finding a method to interweave the subject’s pulse rate readings with gyroscope output would give more optimised results.

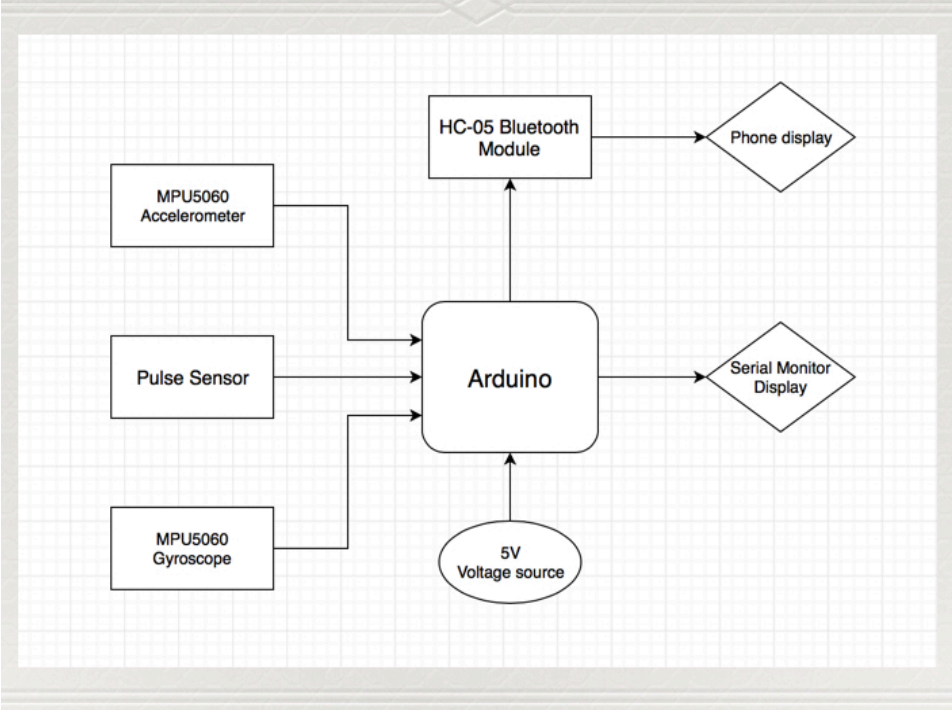
The breakthrough we expect through this project is to optimise the use of sensors for the most apt sleep monitoring system. To study the various modes, we chose MPU 6050 sensor which can work as both gyroscope as well as an accelerometer. The MPU 6050 is a six Degree-of-Freedom or a six-axis IMU sensor. It gives six values as output out of which three values are from the accelerometer and three from the gyroscope. The MPU 6050 is a sensor based on MEMS (micro electro mechanical systems) technology.

DESCRIPTION OF SYSTEM

Components used are:

- Arduino UNO
- MPU6050 Gyroscope + Accelerometer
- Pulse sensor
- Bluetooth Module

Block Diagram:

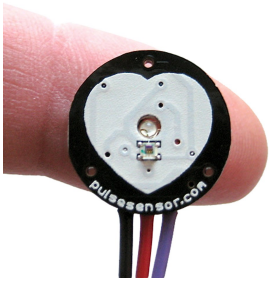


COMPONENTS AND THEIR ROLES

1. Pulse Sensor

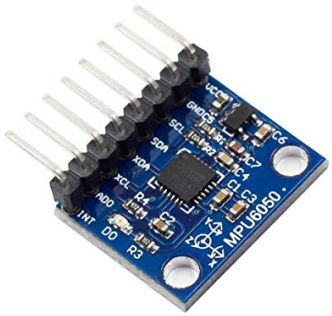
_Pulse sensor is a plug-and-play heart-rate sensor for Arduino. The pulse of a sleeping

person tells about the calm of the body and the quality of sleep. If the pulse rate is high, it means that the person is sleeping under stress and this reduces the quality of sleep. Pulse sensor uses the principle of light reflection and the time it takes to reflect the light. It gives results in beats per minute (BPM).



2. MPU5060 accelerometer and gyroscope

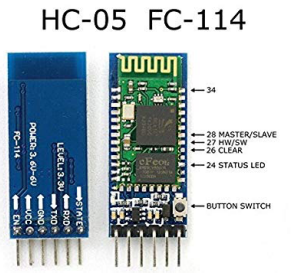
The accelerometer and gyroscope can detect any sudden change in the position of sleep, the number of such movements and the position of sleep. The more the unwanted movements during sleep, the less the quality of sleep is.



3. HC-05 Bluetooth Module

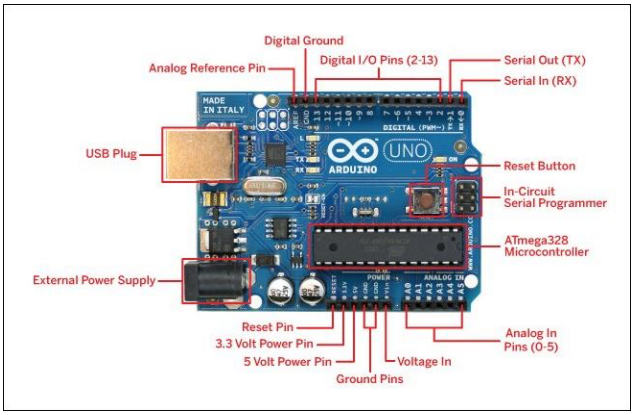
The results of sleep analysis will be calculated and displayed in the serial monitor. This is not a feasible way to display the results. So we use the bluetooth module to display the

results directly in an application on phone which makes it much easier and simpler to keep track of sleep.



4. Arduino UNO

For processing data, we are using Arduino microcontroller. Arduino Uno is a microcontroller board. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Arduino works as the brain of the device. It takes in data from all three sensors and calculated the sleep quality and displays it by sending the results into the bluetooth module.



MONITORING SYSTEM

The monitoring system consists of an MPU 5060 sensor and a pulse sensor. A person's stress level can be indicated by the heart beats per minute (BPM). The sleep can be monitored by taking into account, the stress during sleep as well as the interruptions during sleep. Interruptions during sleep such as sudden movements, change of sleeping position mid-sleep or waking up in between a sleep session shows that the sleep quality is poor. At the same time, increased stress during sleep has also proved to adversely affect sleep. Therefore the inter connected use of gyroscope, accelerometer and pulse sensor is a good approach.

MPU-6050 Gyroscope + Accelerometer

The MPU-6050 devices combine a 3-axis gyroscope and a 3-axis accelerometer on the same silicon die, together with an on-board Digital Motion Processor which processes complex 6-axis Motion Fusion algorithms. The device can access external magnetometers or other sensors through an auxiliary master I²C bus for communication between master slave networks.

The first objective is to find out which mode out of the 6 modes available in MPU 5060 is the best for sleep monitoring. To know this, we first take a deeper look into each of the modes and their impact on the project. The two most important working modes are

A.Output Readable Yaw-Pitch-Roll

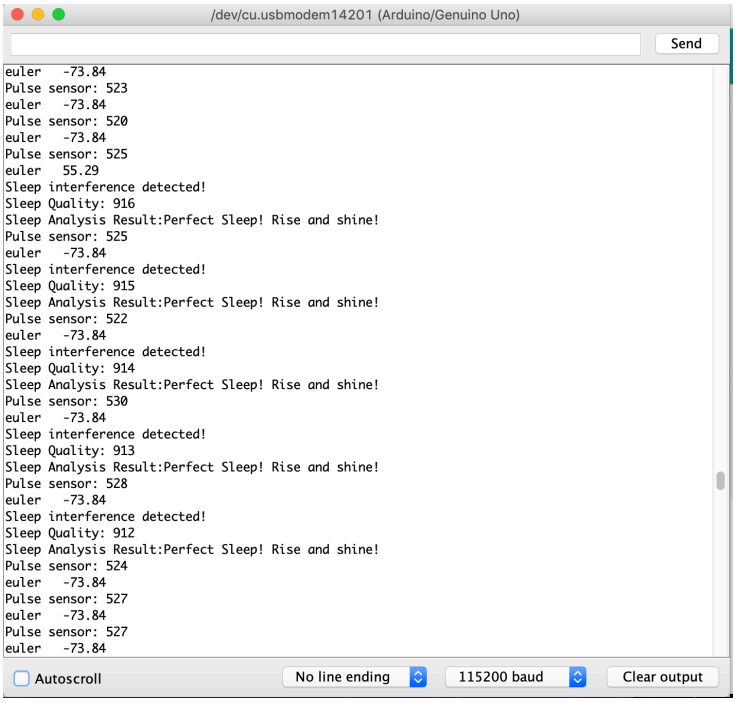
Any moving object is free to move in 3 dimensions, change their altitude and rotation along the orthogonal axes passing through its centre of gravity. The three axes of movement are the longitudinal, horizontal and vertical axis. Motion about the longitudinal axis is termed roll, Motion about the perpendicular axes is called yaw and that along the lateral axis is called as pitch.

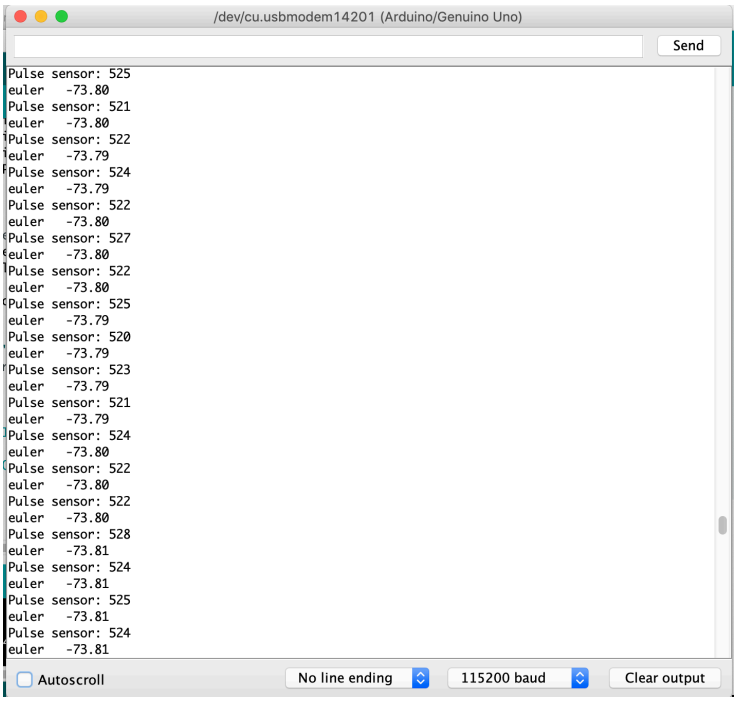
Unit quaternions is the mathematical notation for representing the orientations and rotation of an object in three dimensions. Whereas the Euler angles and the three angles used to describe the orientation of a rigid body where the frame of reference is a fixed coordinate system. Any orientation can be achieved by composing three elemental rotations of the axes of the coordinate system.

B.Output Readable Real Acceleration

The MEMS technology used in MPU6050 helps in measuring acceleration calculation. When the body suddenly turns, the acceleration affects the sensor changing the distance

between the plates of the capacitor which changes the capacitance value and thereby the output voltage across the capacitor. This can be mapped to obtain the adequate acceleration changes.





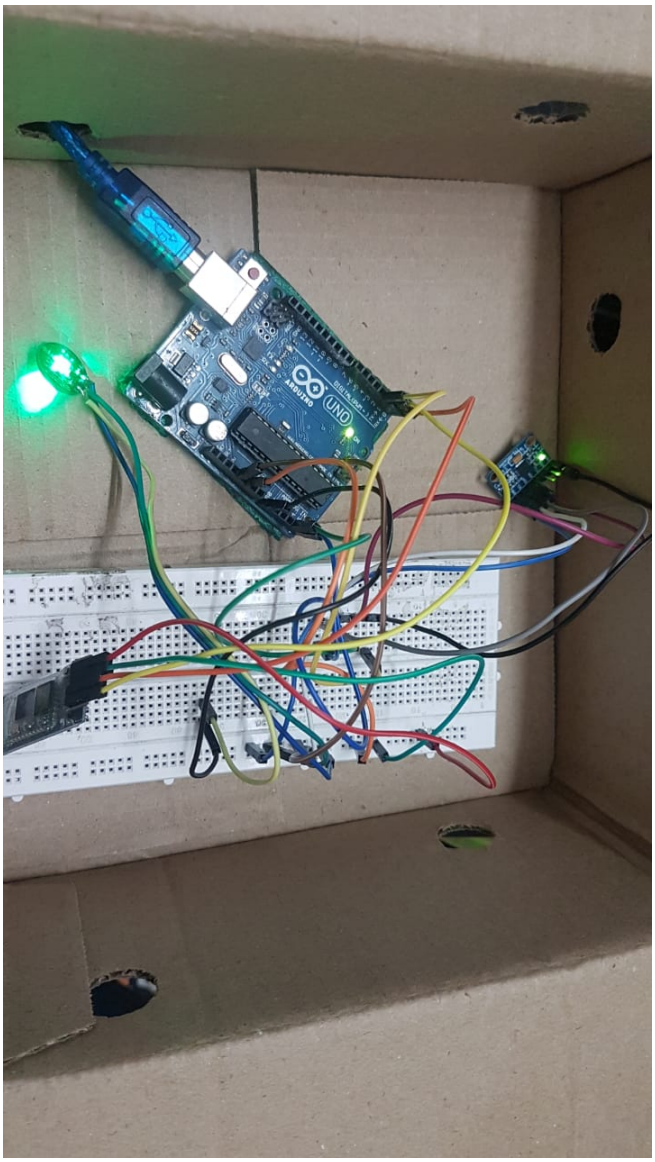
The Logic and Working

The Euler values gave the position of the gyroscope. Using this value, we can identify the sleeping position of the subject. These values are also used to measure the sudden movements in mid-sleep. Whenever a consecutive fluctuation in the gyroscopic output is detected, the program considers it as an interference in sleep. We have assigned a variable called “Sleep Points” which holds the value of quality of sleep. It starts from 1000, every time the device is started. Every time an interference is detected, its value is decremented. This decrement can be seen in the figure shown below.

Pulse Sensor

DESIGN AND SIMULATION

The Circuit simulation has been done and verified using the software Proteus. Since PIR module could not be used in Proteus to give simulation, a voltage source was used. Outputs are explained as shown below.



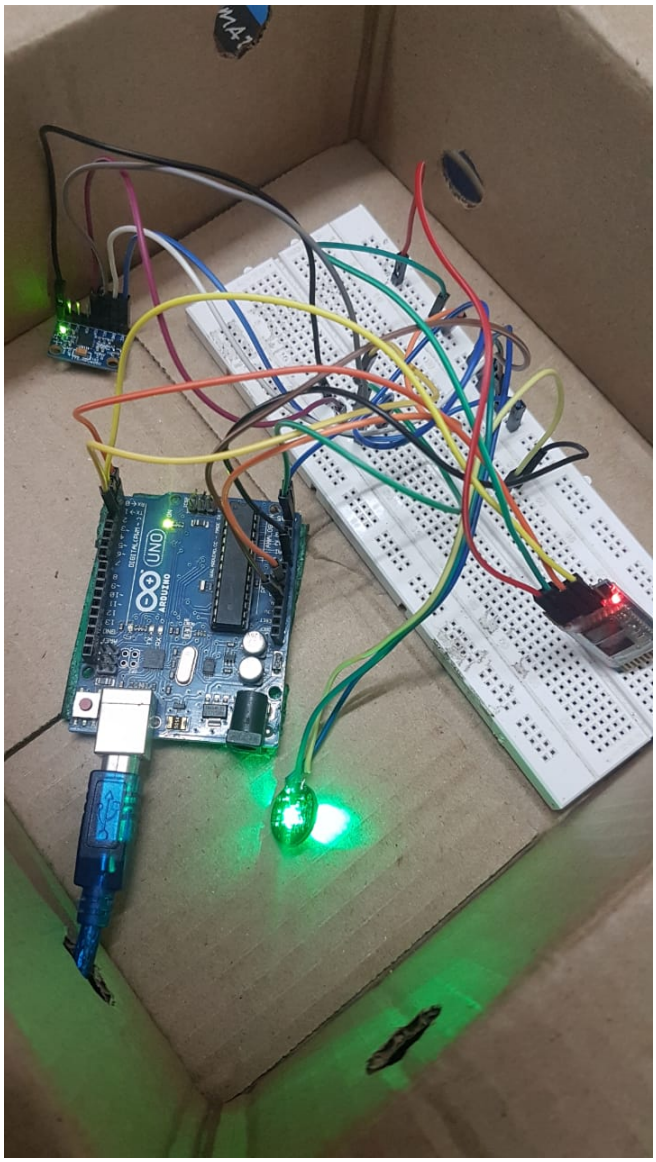


Figure 1

Off state

When no motion is detected there will be no potential developed as per the property of PIR sensor. So there will be no current through the transistor and the transistor won't conduct, instead the current will flow through R1 and hence the pin 2 of the 555 timer will be high and hence the output through 3 will be low and the bulb won't glow.

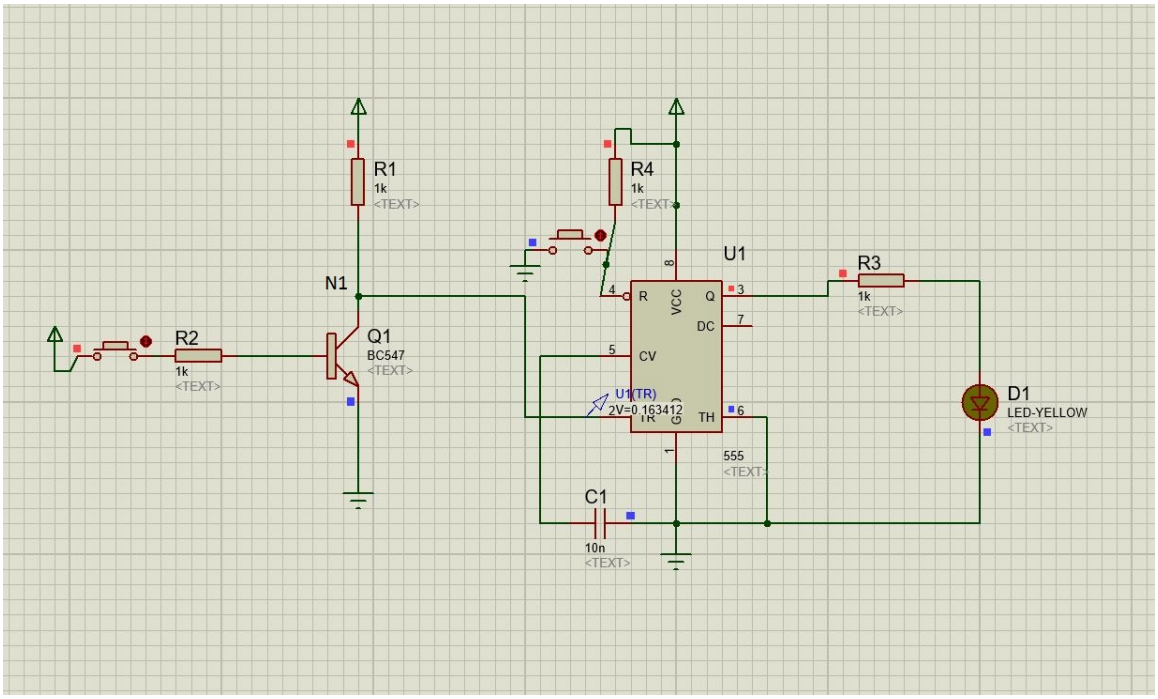


Figure 2

On State

When motion is detected there will be a potential developed as per the property of PIR sensor and current will flow through R2 and if the voltage is more than cut in voltage of the transistor then the transistor will be in the ON stage and the collector and emitter behaves as a short circuit. So node N1 is actually grounded and hence the pin 2 that is the input will be low and hence the output will be high and as a result the bulb will glow.

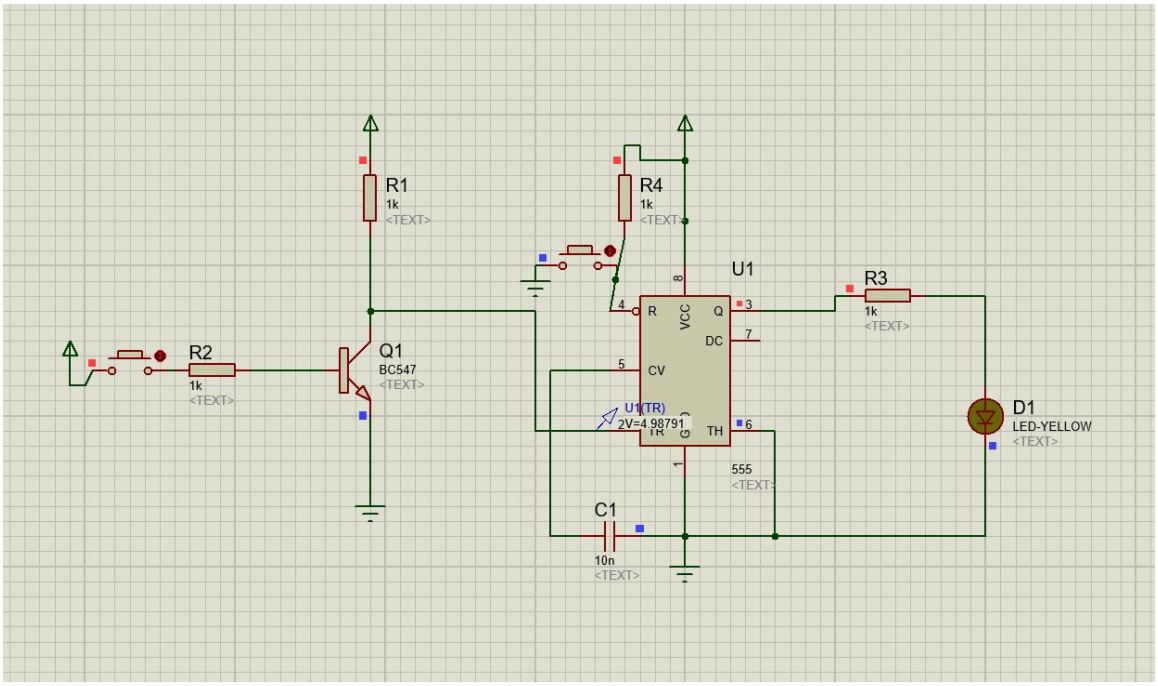


Figure 3

In this state (as shown in Fig.3) the circuit is in off state but even then the led bulb is glowing. This is because the circuit has been designed in such a way so that even though the sensor is off it will glow until someone is resets it manually. In this state the transistor switch is short-circuit state, so the ground (i.e. low signal) is directly connected to the input. The nature of 555 timer IC is that if low is end in the input pin, the output will be high. Thus, the led bulb is glowing even though no object is present in front of it.

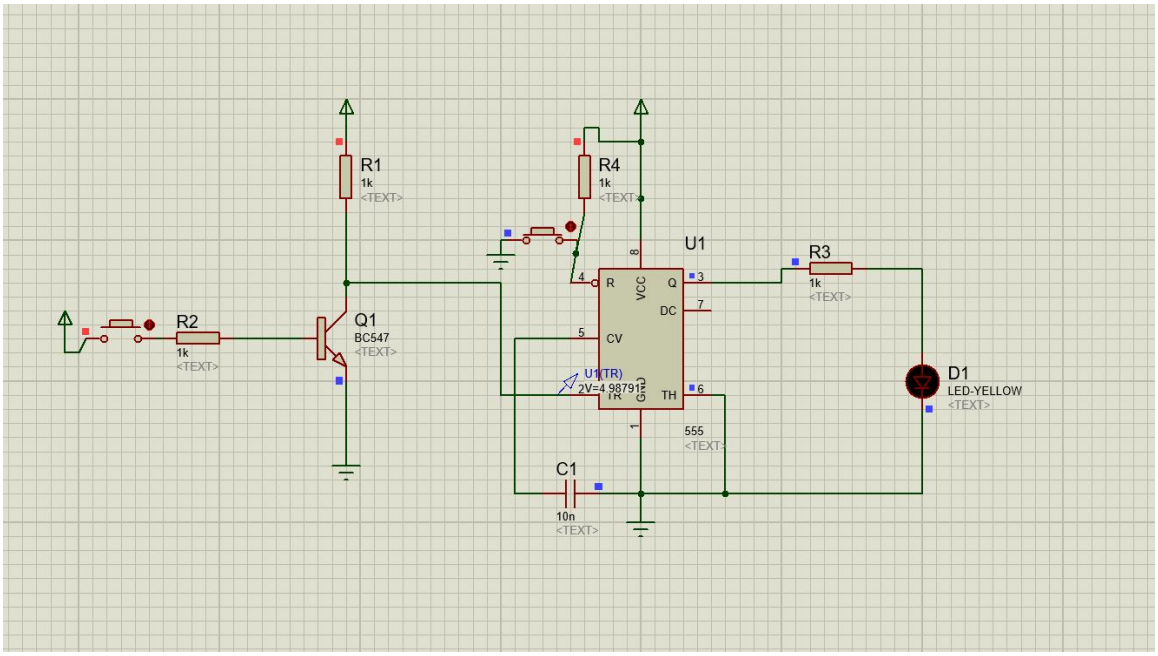


Figure 4

Reset State

In this state (as shown in Fig.4) the circuit has been turned off by resetting it manually. The resetting pin used here is pin 4 of the 555 timer IC. The function of the resetting pin is to reset the circuit into its original off state. The resetting pin takes the input of low and gives the output of low as well (unlike the input pin). As soon as the switch is closed the ground (i.e. low signal) is send to the resetting pin which in turn sends a low output, thus turning the circuit off.

In this pattern the process goes on. Each time something passes the IR, it triggers the circuit on, which in turn sets on an alarm. The alarm goes on even if the object has passed the IR range. The circuit needs to be manually reset in order to turn off the alarm.

CONCLUSION

This project has been an innovative experience for us as well as an eye opener to how such a simple circuit can have various applications in day to day life. This intrusion alert system can even be implemented in military levels. Some modifications can make this model even more powerful and reliable which creates the possibility for a potential start-up. But that is beyond the scope of this project.

Working with the 555 Timer IC and the BC547 transistor has given us a clear insight into its working principles. Though different sensors can be used to detect motion, we identified the Infra Red sensor to be the most appropriate and efficient for the circuitry. The vast scope of modifications on the design is one of the best features of the project that we are proud of. Though the model has many advantages, with it comes a few pitfalls. The IR sensor used in the circuit is incapable of detecting motion out of its line-of-sight. Neither can it detect motion from more than 2 meters from it. This downside wont affect the application if the system is used for small objects or for a single door.

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