National Institute of Technology Karnataka, Surathkal

Embedded Systems (EC342)

Project Report

Topic: Smart Helmet

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ABSTRACT

In today's fast moving world, most of the accidents and casualties happen due to drinking and driving. Many rules are being imposed to prevent these accidents although they are violated by the citizens. In spite of the fact that helmets are easily available everywhere, people aren't wearing them which leads to injuries and accidents. Thus one of the main objectives of this project is to ensure that PEOPLE WEAR HELMETS AND THEN RIDE BIKES . Another objective is to make sure the rider isn't drunk using ALCOHOL DETECTION. The rider won't be able to ride the bike if he is drunk. Also in case of accidents the FALL DETECTION feature is also added which can be further notified. To make the system more efficient a SOLAR PANEL is installed on the helmet which acts as a free source of power.

INTRODUCTION

To overcome this situation, a safety system has been embedded inside the "Smart Helmet". The circuitry follows two stages of safety before the bike start can be enabled. First stage is the HELMET WEAR DETECTION which is ensured by a FLEX SENSOR. An ALCOHOL LEVEL DETECTOR (using MQ2 sensor) is also present in the circuitry which is the second stage of safety before the bike can start. If either of the stages of safety fails, the bike system remains disabled. During the trip the person can switch between music and receive calls which is implemented using an ACCELEROMETER and GYROMETER (MPU6050) mounted over the helmet. Also ENVIRONMENTAL AWARENESS SYSTEM is installed on the helmet to ensure that the user is aware of the vehicles in its proximity that are trying to overtake. The FALL DETECTION SYSTEM notifies about the fall during the accident which is also done with the help of MPU6050. The power efficiency of the system is taken care by the SOLAR PANEL which continuously charges up the rechargeable LiPo battery which further power the rest of the circuit. Hence the system works efficiently in the long run.

FEATURES and IMPLEMENTATION

□ Arduino Based Circuit

In our smart helmet system, the arduino has been interfaced with a variety of sensors. They are: Flex Sensor, Alcohol sensor, Sound sensor and Ultrasonic Sensor (the description of each sensor has been given in the previous section).

a) Initially, when the arduino is powered using the solar panel based power supply, it checks if the user has worn the helmet or not by checking the flex sensor. When the flex sensor bends (User wears the helmet) and the analog reading of the same crosses a certain predetermined threshold, the arduino starts to check if the user/rider is drunk or not using the alcohol sensor (MQ3). Only when both conditions (Helmet worn and Not Drunk) are satisfied, the microcontroller goes ahead and allows the user to ride his/her bike.
b) Whenever the user is riding and there is a vehicle approaching him/her from behind, the ultrasonic sensor detects the presence of the vehicle and prompts the arduino to check if that vehicle is blowing its horn or not. The sound sensor then checks for the sound from the vehicle horn and alerts the user whenever the sound intensity crosses a certain preset threshold. Note: We have designed our system in such a way that this alert occurs as an interrupt from the arduino to the nodemcu. An Interrupt service routine(ISR) written for the NodeMCU alerts the user by switching on the Yellow light in the circuit.

□ NodeMCU based Circuit

The NodeMCU has been interfaced with an Accelerometer-Gyroscope module (MPU6050). It is also being used in the circuit to connect to a local network and send desired data to a cloud server.

The MPU6050 has been used in the circuit for two major purposes:

a) For gesture detection
b) For fall detection

When the NodeMCU is powered using the solar panel based power supply, it initially checks for an access point to connect to. The SSID and password of this access point are predefined in the dumped code. When the NodeMCU connects to the local network it moves ahead and calibrates the MPU6050.

The 3 values from the accelerometer (acceleration in x,y and z directions) are scaled by a factor of 10 for easy calculation. Using these 3 values, the microcontroller calculates the acceleration angles in x and y directions given by the following formulae.

Let Ax be absolute acceleration in the X direction, Ay be absolute acceleration in the Y direction and Az be absolute acceleration in the Z direction.

Also, let AccangleX be the acceleration angle in the X direction and AccangleY be the acceleration angle in the Y direction.

$$\text{AccangleX} = \arctan(Ay/(Ax^2 + Az^2)^{1/2})*180/\pi$$

$$\text{AccangleY} = \arctan(-Ax/(Ay^2 + Az^2)^{1/2})*180/\pi$$

□ Gesture Detection

Whenever the acceleration magnitude $((ax^2+ay^2+az^2)^{1/2})$ exceeds 2 units and is less than 8 units, the nodeMCU checks for the gesture. Depending on the values of the acceleration angles, it can be determined in what direction the user's head is moving (Left, Right or Forward). Once the gesture is recognised, it is sent to a Google Firebase cloud server and the cycle continues.

□ Fall Detection

Along with the gesture detection, there is also another feature for detecting whether the user has fallen or not. If the acceleration magnitude $((ax^2+ay^2+az^2)^{1/2})$ exceeds 12 units, i.e., if there is a sudden jerk, the arduino goes into a loop to check for fall.

Fall detection is a 3 trigger based system.

i) Trigger 1 checks if the acceleration magnitude has crossed 12 units. If it has, Trigger 1 is deactivated and Trigger 2 is activated.

ii) Trigger 2 checks if the angle change is greater than 80 degrees (Angle change is given by $(Gx^2 + Gy^2 + Gz^2)^{1/2}$ where Gx, Gy and Gz are outputs from the gyroscope). If it is, Trigger 2 is deactivated and Trigger 3 is activated.

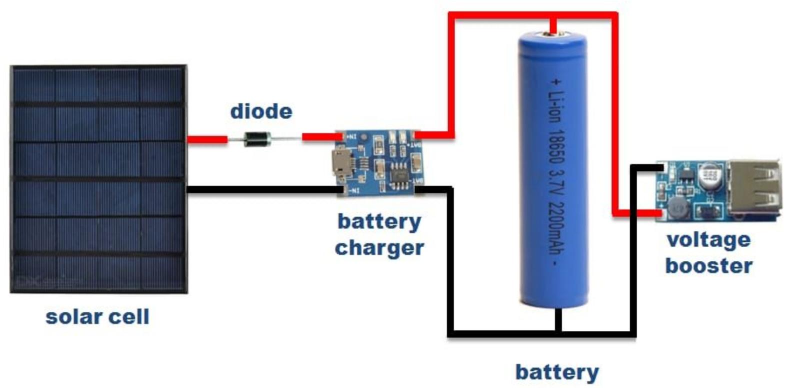
iii) Trigger 3 checks if, after the fall, the angle has changed or not. If it hasn't, fall is detected (User lying still after fall). If the angle has changed by more than 10 degrees, Trigger 3 is deactivated and fall is NOT detected.

SOLAR PANEL based Power Supply

In order to increase the efficiency of our embedded system, concept of free power supply is applied in the form of Solar Panel (Solar Energy).

The Smart Helmet is powered by LiPo batteries which in turn is continuously charged by the Solar Panel via a LiPo charger module. Whenever there is an availability of sunlight the Solar Panel charges up the LiPo battery until it charges up to a full capacity. The given circuit diagram explains the functioning of the power supply.

The Solar Panel is connected to the LiPo charger module which enables the charger and indicates the charging progress of the battery with the help of onboard LED. The red LED indicates charging in progress whereas the green LED indicates that the charging has finished. In absence of sunlight the battery can also be charged by the micro USB port on the charger module. The output of the LiPo charger module is directly connected to the 3.7V LiPo battery. Since the circuit requires 5V operating voltage, the 3.7V output of the battery needs to be stepped up to 5V. For this purpose DC-DC boost converter. The output of the converter is directly connected to the power supply inputs of various parts of the circuit.



MOBILE APPLICATION

The helmet transmits the state of its orientation (left, right, front, back, fallen down) to a variable in a Google Firebase server. The Android app reads the variable from the server repeatedly at fixed intervals of time. The variable is initially set to 'centre'. Whenever the variable changes, the app performs an action corresponding to the new variable value in the database and concurrently changes the variable in the database back to its initial 'centre' state.

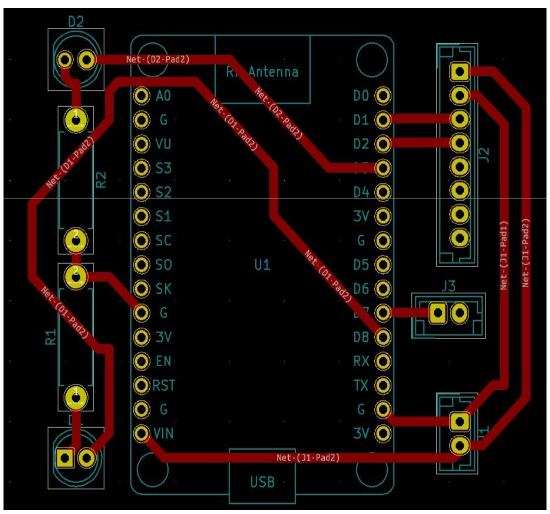
PCB Design

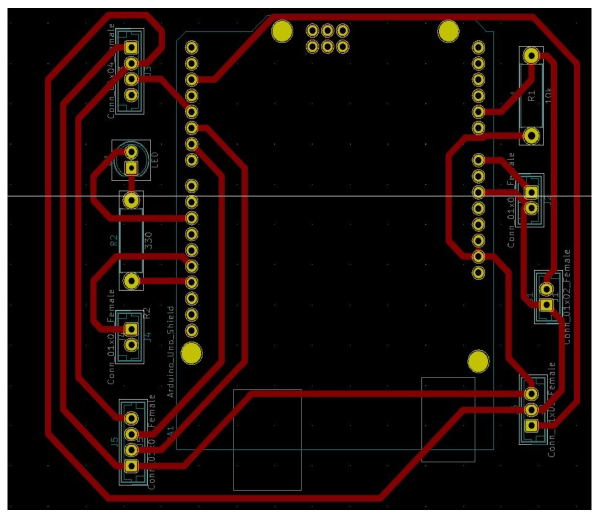
For this Smart Helmet system, we have designed two PCBs - one for the arduino based circuit and the other for the NodeMCU based circuit. The software used is KiCad.

- ✔ First, we made the schematic in KiCad Eeschema which involves drag and drop of components and connecting the same.
- ✔ Then, we assigned footprints to each and every component.
- ✔ After this, in the PCB design file, we placed the components and manually routed them.

  Placement was optimised to make routing easier.

- ✔ We exported the gerber files and gave it for printing in the ECE department.





Description of COMPONENTS used

1. Flex Sensor

A flex sensor or bend sensor measures the amount of deflection or bending. It is a variable resistor whose resistance increases as the body of the component bends. By combining the flex sensor with a static resistor to create a voltage divider, a variable voltage can be produced that is read by the microcontroller's analog-to-digital converter.

2. Alcohol Sensor (MQ3)

An alcohol sensor detects the attentiveness of alcohol gas in the air and an analog voltage is given at the output which is directly proportional to the concentration level of gaseous alcohol in the atmosphere. It consists of both digital and analog output pins along with a trim pot to set a desired threshold level.

3. Sound Sensor

This sensor is used to detect the intensity or loudness of a sound. It consists of a microphone at the input and a digital pin at the output which goes 'HIGH' whenever the input sound crosses a certain amplitude (this threshold can be decided by the user).

4. Ultrasonic Sensor

Ultrasonic sensors are used for distance measuring applications. These gadgets regularly transmit a short burst of ultrasonic sound to a target, which reflects the sound back to the sensor. The system then measures the time for the echo to return to the sensor and computes the distance to the target using the speed of sound within the medium.

5. Accelerometer - Gyroscope Module (MPU6050)

MPU 6050 is a 6 DOF (Degrees of Freedom) or a six axis IMU sensor, which means that it gives six values as output. Three values from the accelerometer and three from the gyroscope. Both the accelerometer and the gyroscope is embedded inside a single chip. This chip uses I2C (Inter Integrated Circuit) protocol for communication.

An accelerometer works on the principle of piezoelectric effect. Imagine a cuboidal box, having a small ball inside it. The walls of this box are made with piezoelectric crystals. Whenever you tilt the box, the ball is forced to move in the direction of the inclination, due to gravity. The wall with which the ball collides, creates tiny piezo electric currents. There are totally three pairs of opposite walls in a cuboid. Each pair corresponds to an axis in 3D space: X, Y and Z axes. Depending on the current produced from the piezoelectric walls, we can determine the direction of inclination and its magnitude.

Gyroscopes work on the principle of Coriolis acceleration. Imagine that there is a fork like structure, that is in constant back and forth motion. It is held in place using piezoelectric crystals. Whenever, you try to tilt this arrangement, the crystals experience a force in the direction of inclination. This is caused as a result of the inertia of the moving fork. The crystals thus produce a current in consensus with the piezoelectric effect, and this current is amplified.

6. SOLAR PANEL

This mini solar panel module has ratings of 0.6W 6V which can thus provide up to a max current of 100mA(at full intensity of sunlight) which is sufficient to power the TP4056 LiPo charger module.

7. LiPo battery charger(TP4056)

This TP4056 1A Li-Ion Battery Charging Board Micro USB with Current Protection is a tiny module, perfect for charging single cell 3.7V 1 Ah or higher lithium ion (Li-Ion) cells such as 16550s that don't have their own protection circuit. Based on the TP4056 charger IC and DW01 battery protection IC this module will offer 1A charge current then cut off when finished.

Furthermore when the battery voltage drops below 2.4V the protection IC will switch the load off to protect the cell from running at too low of a voltage – and also protects against over-voltage and reverse polarity connection.

8. LiPo battery 3.7V

It is non- isolated step-up voltage converter featuring adjustable output voltage and high efficiency. Model No. 18650, Capacity: 1200maH, Output : 3.7V. It is a rechargeable battery which can be charged using suitable modules(TP4056) or circuitry.

9. DC to DC boost converter (XL6009)

Input Voltage range:3V - 32V , Output Voltage range: 5V – 32V. It is used to step up 3.7V to 5V DC.

10. Arduino UNO and NodeMCU

Primary microcontroller to be used in the project for integration with different sensors like Sound sensor, Alcohol sensor, MPU-6050 and other modules.

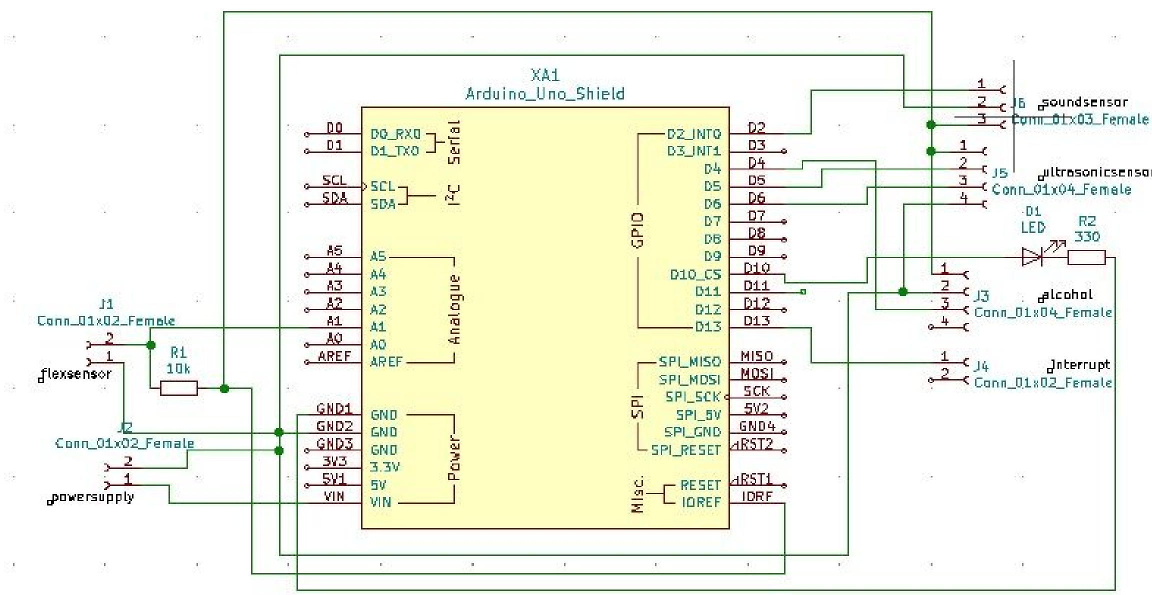
Processor Involved: Atmega328P in Arduino.

Tensilica Xtensa® 32-bit LX106 RISC in NodeMCU.

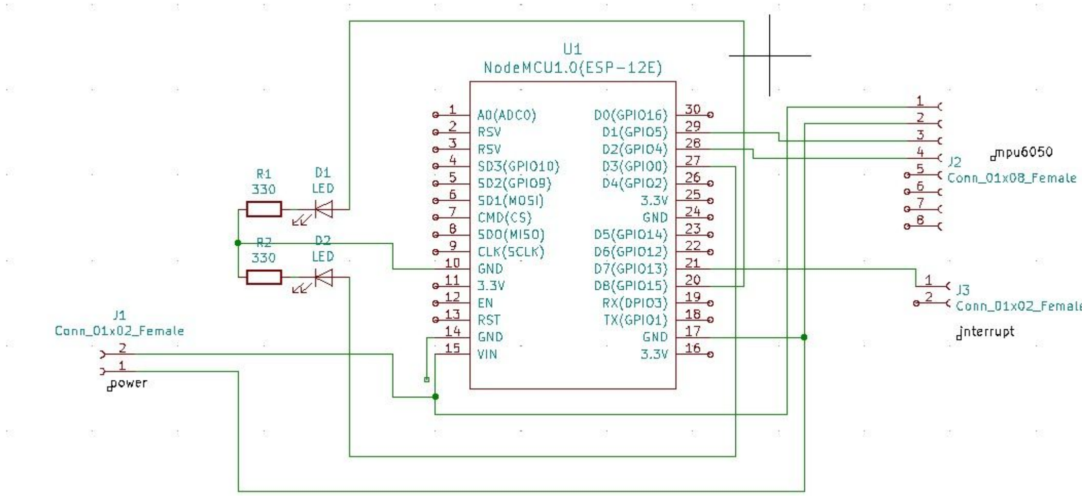
11. Motorcycle Helmet:

The base platform upon which the circuit will be implemented.

CIRCUIT DIAGRAM

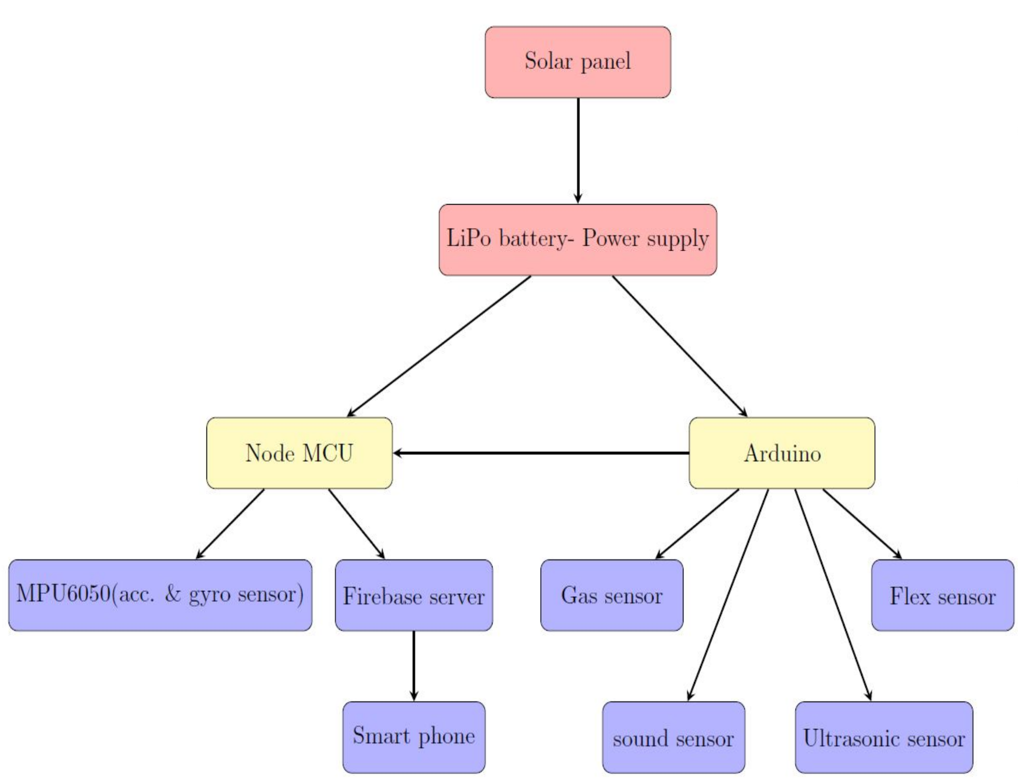


Arduino Based Circuit



NodeMCU Based Circuit

BLOCK DIAGRAM

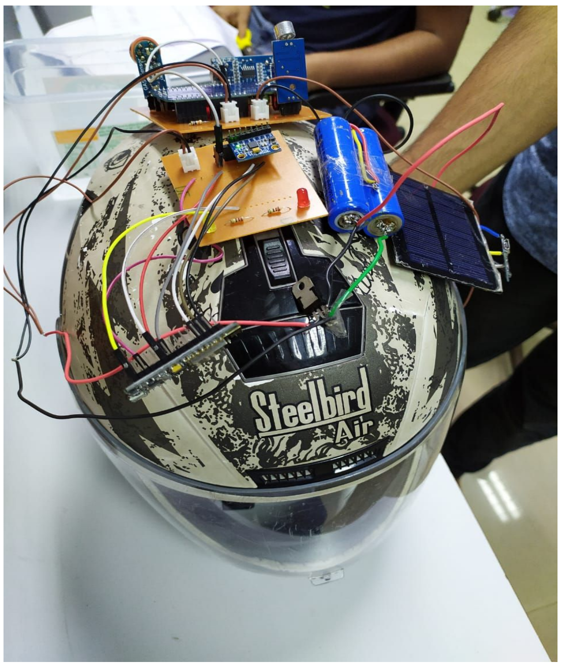


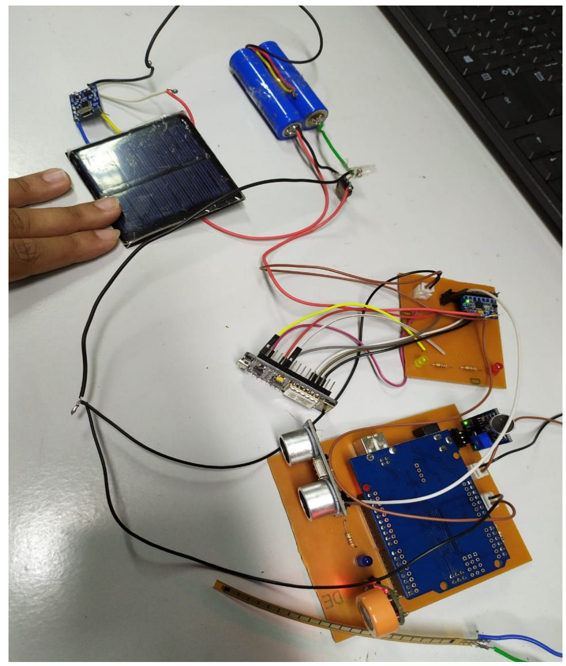
BILL OF MATERIALS

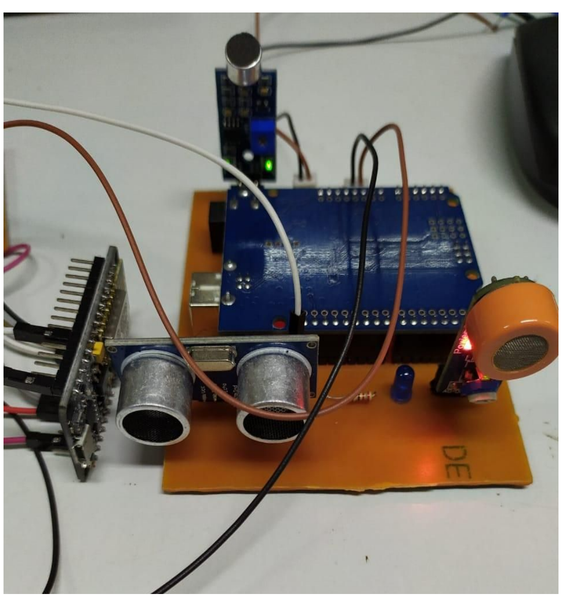
Component Name	Quantity	Cost (of 1 piece)	Total Cost
Arduino	1	350	350
NodeMCU	1	350	350
Solar Panel	1	120	120
DC-DC Boost Converter	1	150	150
LiPo Battery 18650	1	100	100
TP4056 Lipo Battery Charger	1	50	50
Flex Sensor	1	370	370
MPU6050	1	170	170
Ultrasonic Sensor	1	120	120
Sound Sensor	1	180	150
MQ3 Sensor	1	140	140
LEDs, Resistors, Wires	-	100	100
Copper Clad Board	1	150	150

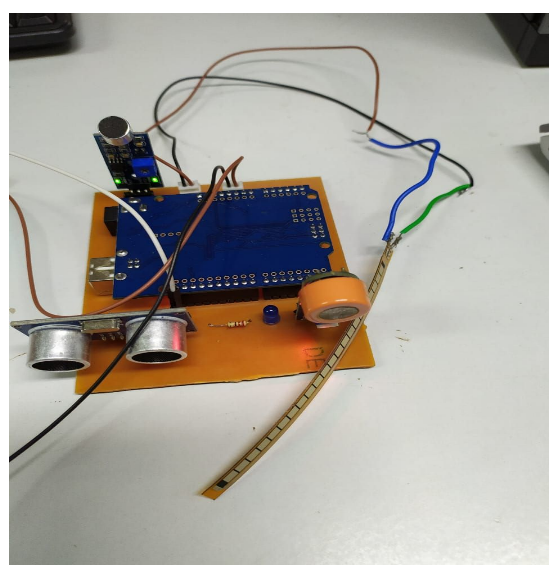
Grand Total: 2320 Rs

PICTURES









RESULT

- **The flex sensor and the alcoholic sensor were implemented and tested successfully. Whenever both conditions(Helmet worn and not drunk) were satisfied, the blue light was turned on.**
- **The sound sensor along with the ultrasonic sensor were tested by blocking the ultrasonic sensor's view and by creating a noise above a certain threshold level of intensity. As a result, the user was notified with an alert - The yellow light on the PCB was turned on.**
- **The fall detection was tested by manually dropping the PCBs. Most of the tests were successful. A red light was made to turn on whenever fall was detected.**

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SMART HELMET

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Design of Smart Helmet and Bike Management System

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