DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION ENGINEERING

UNIVERSITY OF MORATUWA

EN2160 - Electronic Design Realization

LPG GAS LEAKAGE DETECTOR

Project Report

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Contents

1 | Introduction

In recent years, the utilization of Liquefied Petroleum Gas (LPG) as a clean and efficient energy source has gained significant popularity in residential, commercial, and industrial sectors. However, while LPG offers numerous benefits, it also poses potential hazards, particularly in the event of a gas leak. LPG gas leakage incidents can lead to disastrous consequences, including fire, explosions, and serious health risks for occupants.

To mitigate these risks and enhance safety, the implementation of an ***LPG gas leakage detector*** is imperative. This advanced technology serves as an early warning system, promptly ***detecting any leakage of LPG and alerting occupants to take immediate actions, preventing potential accidents and ensuring a secure environment.***

This product design report aims to outline the development and functionality of our LPG gas leakage detector. The report will delve into the comprehensive analysis of the detector's key features, design considerations, technical specifications, and the underlying principles governing its operation. Additionally, it will cover aspects related to manufacturing, testing, and quality assurance, highlighting the safety standards adhered to during the entire design process.

Our LPG gas leakage detector is the result of meticulous research, engineering excellence, and a commitment to safeguarding lives and properties. Through this report, we aim to present a comprehensive understanding of our product, its innovative features, and the seamless integration of technology that differentiates it from conventional gas detectors in the market.

Throughout the report, we will highlight the potential impact of our LPG gas leakage detector on safety standards, energy efficiency, and the overall well-being of society. As we delve into the various aspects of the design and functionality, we invite the readers to appreciate the innovation and dedication involved in creating a cutting-edge solution that addresses a critical need in the energy industry.

2 | Functionality & Features

LPG gas leakage detector offers a range of functionality and features to ensure efficient, reliable detection and notification. This section will outline the various capabilities and characteristics of the product.

Primary Functionality:

The primary functionality of the LPG gas leakage detector is to swiftly identify and detect any potential gas leakages within a room or a house. Equipped with advanced sensing technology, the detector continuously monitors the ambient air for traces of Liquefied Petroleum Gas (LPG).

Emergency Alarm:

In the event of a gas leak, the detector promptly activates an emergency alarm to alert the occupants within the area, providing them with an immediate warning of the hazardous situation.

SMS alert system & Call:

To enhance safety measures further, the detector also incorporates an integrated SMS alert system. Upon detecting a gas leakage, the detector automatically sends an alert message to the registered user's mobile phone, informing them about the potential hazard in real-time. This feature ensures that even if the occupants are not present in the vicinity, they can be promptly informed of the gas leak, enabling them to take swift and appropriate actions to mitigate the risk.

OLED Display:

The LPG gas leakage detector is equipped with an OLED display that continuously shows real-time gas levels, providing users with immediate awareness of potential hazards. Additionally, it offers the convenience of changing the user's phone number for SMS alerts through a secure configuration mode. This user-friendly feature ensures adaptability and seamless integration, making the detector a reliable and efficient safety device for residential and commercial spaces.

LED Power Indicator:

The LPG gas leakage detector incorporates a red LED indicator to signify its powered status. Upon activation, the LED emits a steady red light, providing users with a clear visual confirmation that the device is operational.

By incorporating these advanced functionalities and features, our LPG gas leakage detector presents users with a convenient and reliable solution for ensuring safety within their premises. With real-time gas level monitoring displayed on the OLED screen, occupants can stay constantly informed about potential gas leakages, allowing them to take prompt action when needed. The option to easily change the user's phone number for SMS alerts adds to the product's adaptability and user-friendliness, ensuring seamless integration into different settings. This detector aims to provide a customizable and user-centric experience, prioritizing the wellbeing of occupants and promoting a secure environment in both residential and commercial spaces.

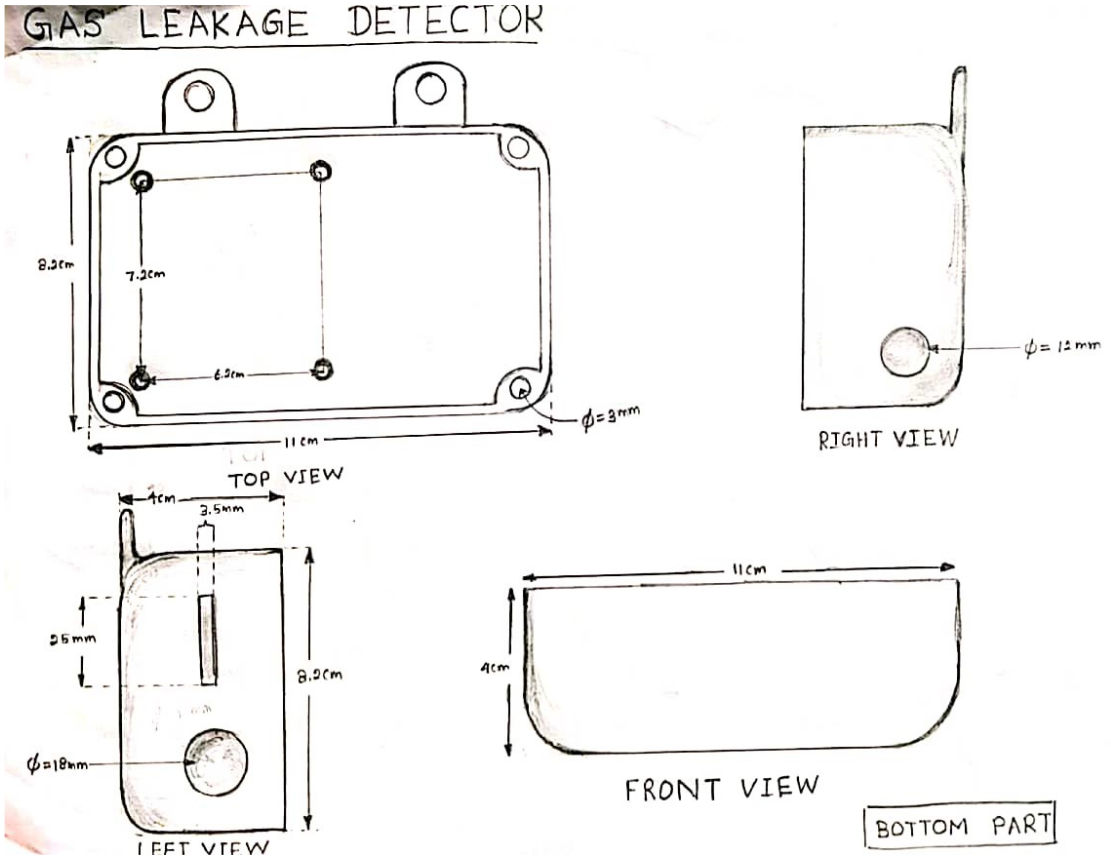


Figure 2.1: Initial Sketch of the Product

3 | Variations from Existing Market Products & Extra Features

3.1 Extra Features

1. Hazard Alarm and Emergency SMS Alert with Call: In addition to the hazard alarm, the device can send an SMS alert and initiate an emergency call to the user, ensuring that they are promptly notified of the gas leakage even if they are not in the vicinity.

2. Continuous Gas Level Display: The OLED display offers real-time gas level percentage readings, providing users with ongoing visibility of the gas concentration in the area.

3. RED Light Power Indicator: The red LED power indicator provides a visual cue of the device's active status, giving users quick confirmation of its operational state.

3.2 Variations

Direct Plug-In Design:

The device's direct plug-in design allows for straightforward installation, enabling users to easily connect it to AC 230V power supply. Will be powered using an AC-DC power adapter instead of using battery power.

Reasons,

■ Can run indefinitely without needing to replace batteries.

■ Simplifies complexity of the circuit and hence reduces cost.

■ Eliminates the space that would be required by batteries within the enclosure.

■ Eliminates the extra weight that needs to be supported if batteries were present inside the enclosure.

Compact and Lightweight: With dimensions approximately 11cm x 8cm x 4cm and weighing approximately 200g, the device boasts a compact and lightweight design, making it portable and unobtrusive in various settings.

These additional features contribute to the overall effectiveness of the LPG gas leakage detector.

4 | Functional Block Diagram

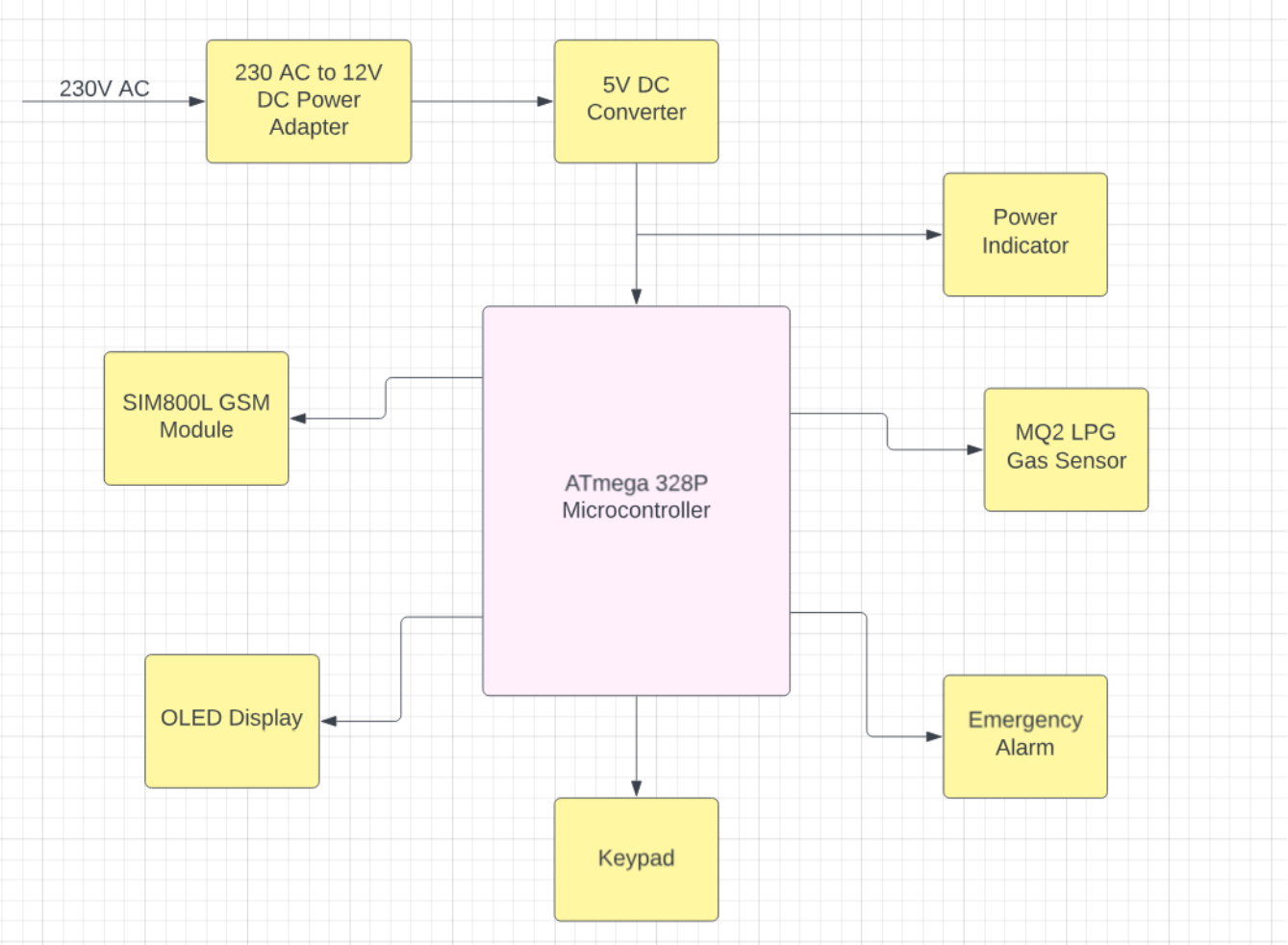


Figure 4.1: Functional Block Diagram

5 | Realization of Features & Selection of Components

5.1 Power Delivery

The device will be powered using an AC-DC power adapter instead of using battery power.

A commonly available AC-DC Switch Mode Power Supply Adapter with a 12V DC Output was selected for this purpose. The microcontroller, sensors and OLED Display all require a 5V DC source. LM7805 voltage regulator is used for 12V DC to 5V DC conversion. Since LM7805 input voltage range is 7-35V, alternatively 9V AC-DC power adapter can be used. In addition, the power supply provides features such as over-voltage protection, short-circuit protection and over-current protection. This also simplifies the internal power circuitry of the device.

Specifications of the selected power adapter:

- Input Voltage : 230V AC
- Output Voltage : 12V DC
- Rated Current : 1A (max)

Figure 5.1 12V AC-DC Power Adapter

5.2 Controller Implementation

The control of the device will be carried out using the ATmega328-PU microcontroller. The ATmega328P-PU microcontroller plays a crucial role in the operation of the LPG gas leakage detector, performing several essential tasks to ensure its functionality and responsiveness:

1. Gas Sensing and Data Acquisition: The microcontroller interfaces with the MQ2 gas sensor module to detect LPG gas levels in the environment. It reads analog signals from the gas sensor and converts them into digital data for further processing.

2. Real-time Gas Level Monitoring: The ATmega328P-PU continuously processes the digital data from the gas sensor and calculates the gas level percentage. It then sends this information to the OLED display, allowing users to monitor gas concentrations in real-time.

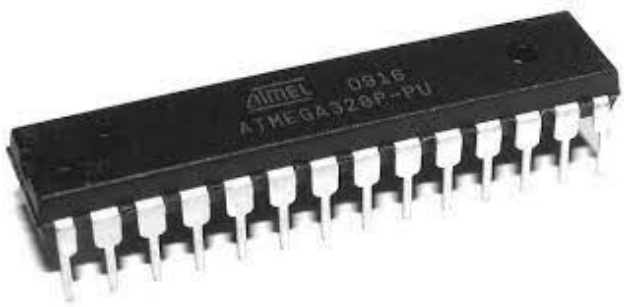


Figure 5.2: Atmega328P-PU Microcontroller

3. Hazard Detection: The microcontroller is responsible for analyzing the gas level data and determining if it exceeds a predefined threshold, indicating a potential gas leakage hazard.

4. Alarm and Alert Management: Upon detecting a hazardous gas level, the microcontroller triggers the high volume alarm to audibly notify occupants of the gas leak. Simultaneously, it activates the GSM 800L cellular connectivity module to send an SMS alert and initiate an emergency call to the registered user, promptly notifying them of the gas leakage.

5. User Interface and Control: The ATmega328P-PU microcontroller manages the user interface, allowing users to interact with the detector. It processes user inputs,

such as changing the phone number for SMS alerts, configuring settings, and controlling the alarm and display functions.

6. Safety Checks: The ATmega328P-PU performs safety checks to ensure the proper functioning of critical components, including the gas sensor, GSM module, and alarm, guaranteeing reliable operation and minimizing false alarms.

7. Timer and Clock Management: The ATmega328P-PU uses internal timers and clocks to schedule tasks, such as periodic gas level readings and alarm activation, ensuring timely and accurate responses.

Through these tasks, the ATmega328P-PU microcontroller acts as the brain of the LPG gas leakage detector, coordinating its various components and functionalities to provide users with a comprehensive and dependable safety solution.

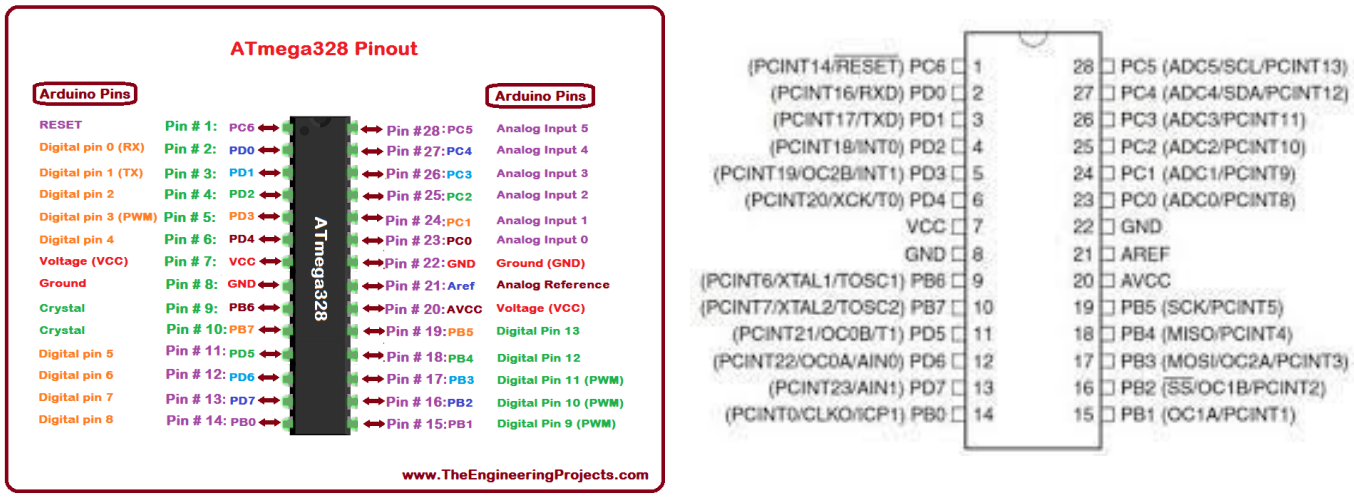


Figure 5.3: ATmega328P-PU Pinout

The ATmega328 microcontroller will be programmed using an Arduino board and Arduino language (C++) and will be connected to the PCB using a 28 pin IC socket along with the required peripheral circuitry. It was decided to use a DIP type microcontroller along with IC sockets to enable simple reprogramming, easy repair, and replacement instead of using an SMD type microcontroller.

When using an ATmega328 microcontroller without a development board, it is important to include a few components in its periphery for proper functionality. The peripheral circuitry for the ATmega328 is shown below. It includes a 16MHz

crystal oscillator accompanied by two 22pF ceramic capacitors. Also, a decoupling capacitor of 10uF will be used between VCC pin and GND pin.

5.3 LPG Gas sensor

The MQ2 gas sensor's main duty in the LPG gas leakage detector project is to detect the presence of LPG gas in the environment. It provides an analog output signal that corresponds to the gas concentration, which is then read and processed by the ATmega328P-PU microcontroller. The microcontroller calculates the gas level percentage and triggers appropriate actions, such as activating the alarm and sending SMS alerts, if the gas level exceeds a predefined threshold, indicating a potential gas leakage. The MQ2 gas sensor's reliable performance ensures accurate and timely gas leak detection, enhancing overall safety.

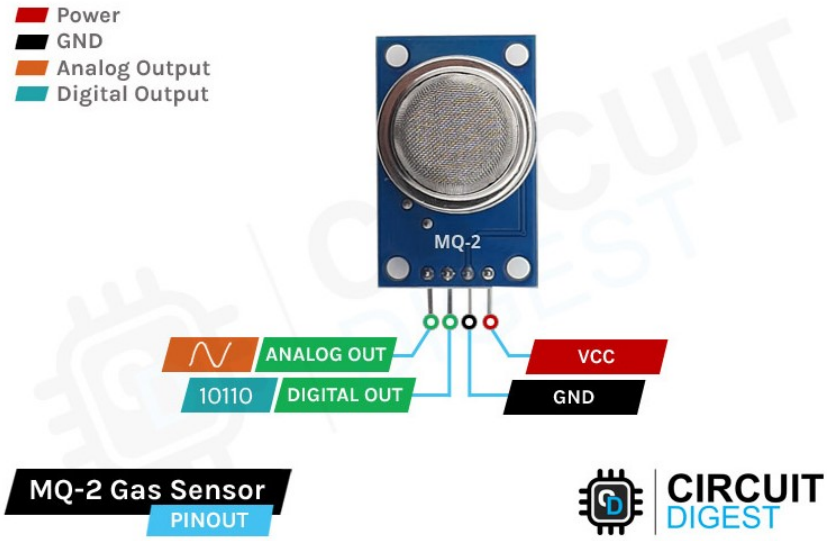


Figure 5.4: MQ-2 Gas Sensor

5.4 GSM Module

The choice of the SIM800L GSM module for this LPG gas leakage detector project is based on several compelling reasons:

1. Low Power Consumption: The SIM800L GSM module is known for its low power consumption, making it suitable for energy-efficient devices like the gas leakage detector. It helps extend the device's battery life, ensuring continuous and reliable operation.

2. Cost-Effectiveness: The SIM800L GSM module offers a cost-effective cellular connectivity solution, making it an attractive option for projects with budget constraints while still providing essential communication features.

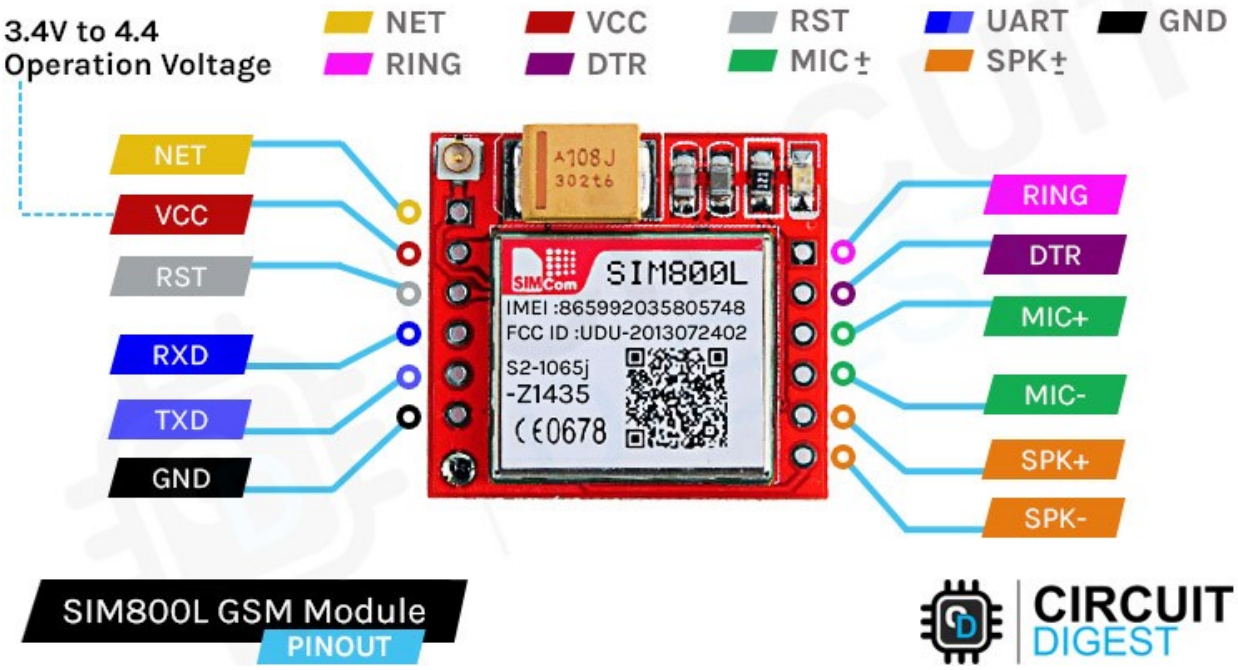


Figure 5.5: SIM800L GSM Module

3. Wide Network Coverage: The module supports various frequency bands and is compatible with numerous cellular networks worldwide. This wide network coverage ensures that the gas leakage detector can send SMS alerts and make emergency calls in different regions and locations.

4. Reliable Communication: The SIM800L GSM module has a reputation for reliable and stable communication, which is crucial for an essential safety device like the gas leakage detector. It ensures that SMS alerts and emergency calls are sent promptly and accurately in case of gas leakages.

5. Compact Size: The compact size of the SIM800L GSM module makes it easy to integrate into the gas leakage detector's design, allowing for a more streamlined and compact overall product.

6. Easy Interface: The module provides simple and straightforward communication interfaces, allowing for easy integration with the ATmega328P-PU microcontroller and other components in the detector.

7. Versatility: The SIM800L GSM module supports various communication protocols, including AT commands, making it versatile and compatible with different microcontrollers and development platforms.

8. Proven Performance: The SIM800L GSM module is widely used in various IoT and communication applications, with a track record of reliable performance, ensuring its suitability for critical applications like gas leak detection.

Considering these factors, the SIM800L GSM module was chosen for its optimal combination of low power consumption, cost-effectiveness, reliable communication, and ease of integration, making it an ideal choice for the gas leakage detector project.

Power Consumption of SIM800L Module

The SIM800L, depending on its state, can be a relatively power-hungry device. The module's maximum current draw is around 2A (especially during a transmission burst). It won't usually draw that much, but it may need around 216mA during phone calls or 80mA during network transmissions. This chart from the datasheet summarizes what you can expect:

Modes	Frequency	Current Consumption
Power down		60 uA
Sleep mode		1 mA
Stand by		18 mA
Call	GSM850	199 mA
	EGSM900	216 mA
	DCS1800	146 mA
	PCS1900	131 mA
GPRS		453 mA
Transmission burst		2 A

Figure 5.6: Power Consumption of SIM800L Module

5.5 OLED Display

The OLED display offers real-time gas level monitoring with low power consumption, compact size, and wide viewing angles. Its high contrast, quick response time, and intuitive interface enhance readability, usability, and user experience in the gas leakage detector project.

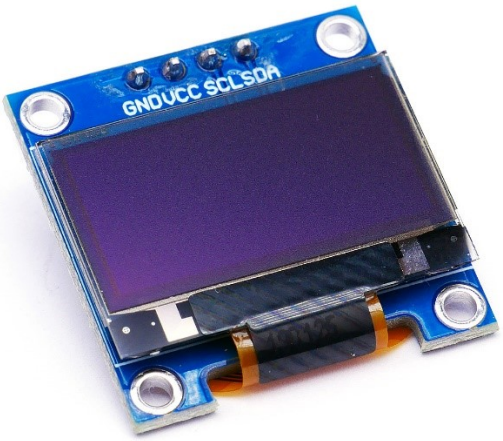


Figure 5.7: 128x64 OLED Display

Real-time Gas Level Display: The 128x64 OLED display continuously shows the current gas level percentage, allowing users to monitor gas concentrations in real-time.

Figure 5.8: Real-time Gas Level Display

Gas Leak Indication: The OLED display serves as a visual indicator, alerting users to potential gas leakages, complementing the audible alarm.

Figure 5.9: Gas Leak Indication

User Interface: The display acts as the user interface, enabling users to configure settings, change phone numbers for SMS alerts, and control functionalities.

Figure 5.10: User Interface

Status and Power Indicator: The OLED display may indicate the status of the gas detector, such as power-on or power-off, and confirm device functioning.

System Messages: Informative messages, such as "System Ready" and "Gas Leakage Detected," provide feedback on detector actions.

User Prompts: The display guides users through setup procedures and provides prompts for required actions, ensuring a user-friendly experience.

5.6 Mini Buzzer

The mini-Arduino 5V buzzer was chosen for its compact size, low power consumption, and loud sound output, making it an ideal choice for the gas leakage detector. Its easy integration with the ATmega328P-PU microcontroller and proven reliability ensure timely and effective alarm activation in case of gas leakages. Despite its small form factor, the buzzer delivers a clear and audible alert, enhancing the overall safety and functionality of the gas leakage detector while remaining cost-effective in the project's design.

Figure 5.11: Mini Buzzer

6 | Programming

The code is written in C++ and is designed for Arduino boards. It incorporates a gas leakage detection system using a gas sensor and alerts the user through an OLED display and a buzzer when gas is detected. The system can send SMS alerts and make phone calls using the SIM800L GSM module. It also allows the user to change the phone number for notifications using a hexadecimal keypad. The code utilizes various libraries for OLED display control, keypad handling, and serial communication with the GSM module.

```
#include <Wire.h>
#include <SPI.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#include <SoftwareSerial.h>
#include <Keypad.h>

// Pins for the SIM800L GSM module and the buzzer
#define txPin 2
#define rxPin 3
#define buzzer 9

// Number of rows and columns for the keypad
const byte ROWS = 4;
const byte COLS = 4;

// Variables to store gas readings and time
int gasCount;
double Ctime = 0;
String PhoneNo = "";
```

```
// Keypad matrix layout
byte rowPins[ROWS] = {13, 12, 11, 10};
byte colPins[COLS] = {8, 7, 6, 5};
char hexaKeys[ROWS][COLS] =
{
  {'1', '2', '3', 'A'},
  {'4', '5', '6', 'B'},
  {'7', '8', '9', 'C'},
  {'*', '0', '#', 'D'},
};

// Bitmap data for display
const unsigned char myBitmap [] PROGMEM = {
  // ... (bitmap data omitted for brevity)
};



// Initialize a SoftwareSerial object to communicate with the
SIM800L module
SoftwareSerial sim800L(rxPin, txPin);

// Initialize a Keypad object with the defined keypad layout
Keypad customKeypad = Keypad(makeKeymap(hexaKeys), rowPins,
colPins, ROWS, COLS);

// Initialize the OLED display object
Adafruit_SSD1306 display(128, 64, &Wire);
```

```
void setup() {
  // Initialize the OLED display
  display.begin(SSD1306_SWITCHCAPVCC, 0x3C);
  display.clearDisplay();

  // Display a bitmap splash screen for 3 seconds
  display.drawBitmap(0, 0, myBitmap, 128, 64, WHITE);
  display.display();
  delay(3000);
  display.clearDisplay();

  // Set the buzzer pin as an output
  pinMode(buzzer, OUTPUT);

  // Begin serial communication with Arduino IDE and SIM800L
module
  Serial.begin(9600);
  sim800L.begin(9600);
}

void loop() {
  // Gas leakage detection
  noTone(buzzer);
  gasCount = analogRead(0);
  if (gasCount > 200) {
    // Display gas leakage message and sound the buzzer
    display.setTextColor(WHITE);
    display.setTextSize(1);
    display.setCursor(20, 54);
    display.print("GAS LEAKAGE!!!");
```

```
  display.display();
  for (int i = 0; i < 10; i++) {
    display.dim(true);
    tone(buzzer, 1200, 250);
    delay(150);
    display.dim(false);
    tone(buzzer, 800, 250);
    delay(150);
  }

  // Send SMS and make a call if gas leakage is detected
  send_sms(PhoneNo);
  if ((millis() - Ctime) > 90000) {
    make_call(PhoneNo);
  }
}

// Check for keypad input
char customKey = customKeypad.getKey();
switch (customKey) {
  case 'A':
    // If 'A' key is pressed, enter phone number change mode
    while (customKey != 'B') {
      PhoneNumberChange();
      customKey = customKeypad.getKey();
    }
    break;
}
```

```
  // Display the gas reading
  DisplayBackground();
  display.setTextSize(5);
  display.setCursor(28, 18);
  display.print(gasCount);
  delay(100);
  display.display();
}

// Function to send an SMS using the SIM800L module
void send_sms(String phoneNumber) {
  String command = "AT+CMGS=\"" + phoneNumber + "\"\r";
  sim800L.println(command);
  waitForResponse();

  sim800L.print("Gas Leakage Detected.");
  sim800L.write(0x1A); // End of message character
  waitForResponse();
}

// Function to make a call using the SIM800L module
void make_call(String phoneNumber) {
  // Remove leading '0' from the phone number if present
  if (phoneNumber[0] == '0') {
    phoneNumber.remove(0, 1);
  }

  // Format the AT command to make a call
  String command = "ATD+94" + phoneNumber + ";"; // Assuming
it's a Sri Lankan number
```

```
  sim800L.println(command);
  waitForResponse();

  // Record the call time for auto-hangup
  Ctime = millis();
}

// Function to wait for a response from the SIM800L module
void waitForResponse() {
  delay(1000);
  while (sim800L.available()) {
    Serial.println(sim800L.readString());
  }
  sim800L.read();
}

// Function to display the background frame on the OLED
void DisplayBackground() {
  display.clearDisplay();
  display.setTextColor(WHITE);
  display.drawRect(0, 0, 127, 63, WHITE);
  display.drawLine(0, 15, 127, 15, WHITE);
  display.drawLine(0, 16, 127, 16, WHITE);

  display.setTextSize(1);
  display.setCursor(3, 5);
  display.print("GAS LEAKAGE DETECTOR");
}
```

```
// Function to change the phone number displayed on the OLED
void PhoneNumberChange() {
  display.clearDisplay();
  DisplayBackground();
  display.setTextColor(WHITE);
  display.setTextSize(1);
  display.setCursor(0, 18);
  display.print("PHONE NUMBER :");

  char customKey = customKeypad.getKey();
  if (customKey) {
    if (customKey == 'C') {
      PhoneNo = "";
      display.clearDisplay();
      DisplayBackground();
    } else if (customKey == 'A' || customKey == 'B') {
      return;
    } else {
      PhoneNo += customKey;
      Serial.println(PhoneNo);
      delay(150);
    }
  }
  display.setTextSize(2);
  display.setCursor(0, 35);
  display.print(PhoneNo);
  display.display();
}
/*-----------------End Of the code---------------------------*/
```

7 | Schematic Design

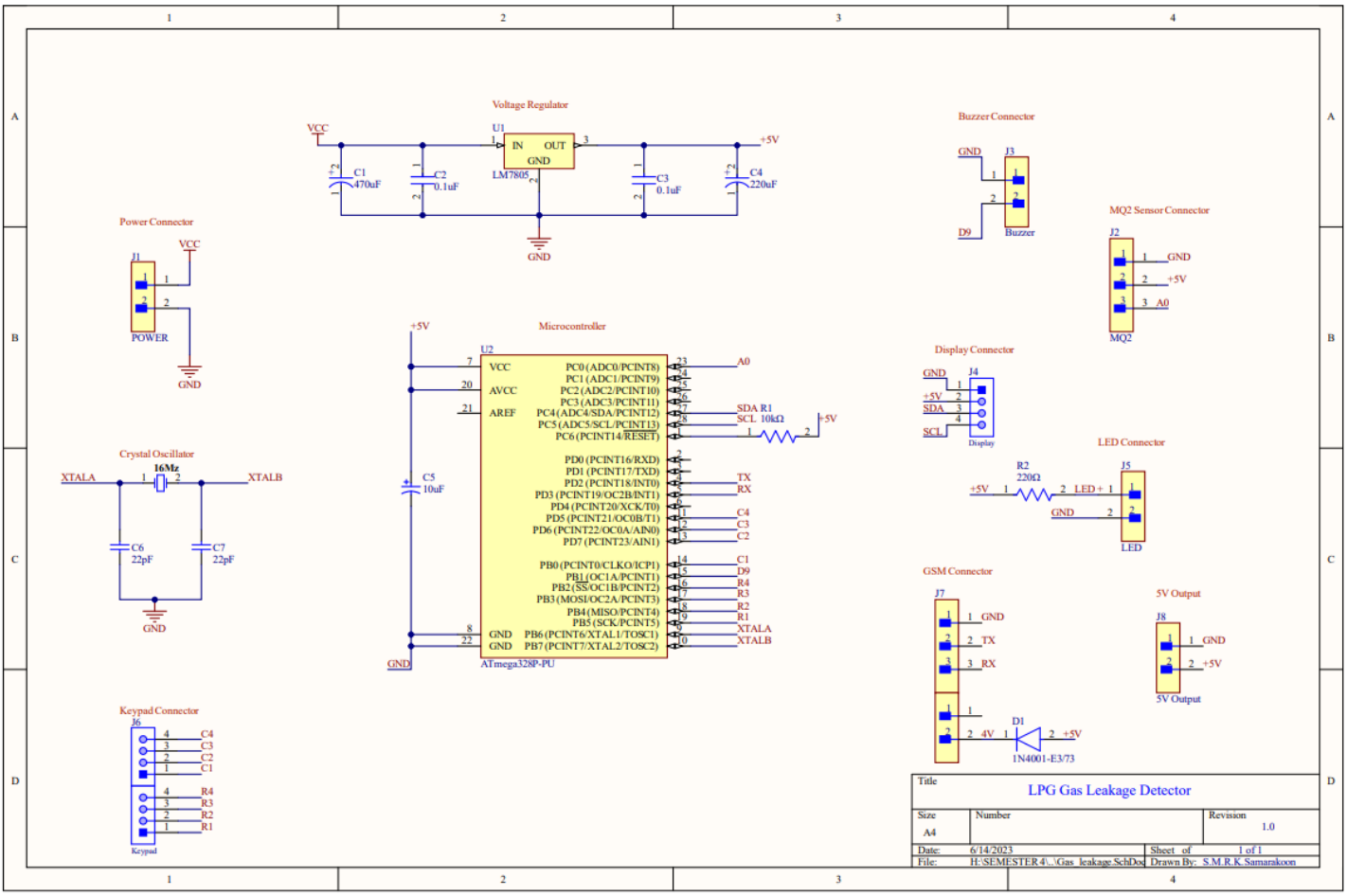
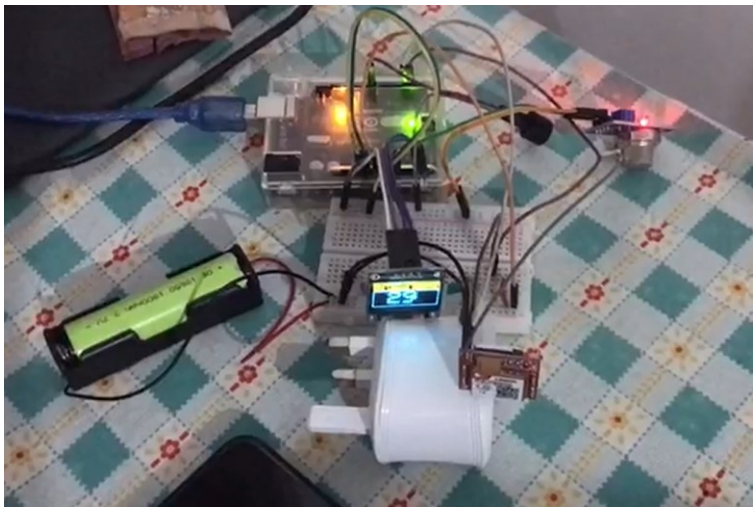
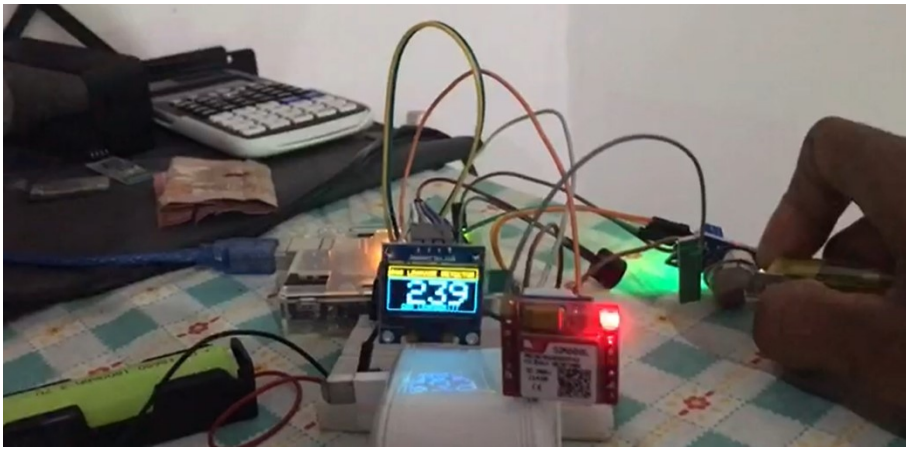


Figure 7.1 Final Schematic Drawn Using Altium Designer

8 | Circuit Verification

The proposed circuit was tested on a protoboard with physical components along with an Arduino UNO Development Board as the controller. After making some minor adjustments to the code, it was possible to achieve all of the expected functions of the device and functionality of the circuit was verified. Afterwards the final circuit was designed using only the ATMega microcontroller. (Without the Arduino UNO Development Board)





9 | Production

9.1 | PCB Design

Altium Designer was used for Schematic Capture (See Figure 7.1) and for PCB Design.

Afterwards, the relevant Gerber Files of the PCB were generated, and the PCB was manufactured via JLCPCB.

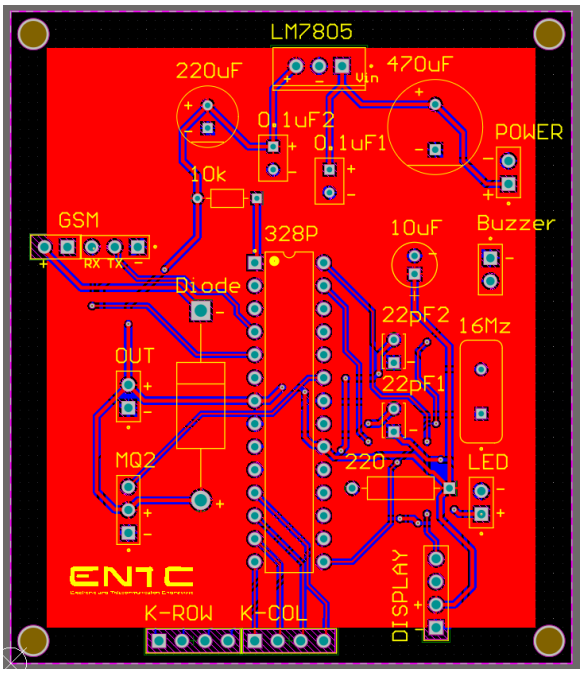


Figure 9.1 Top Layer

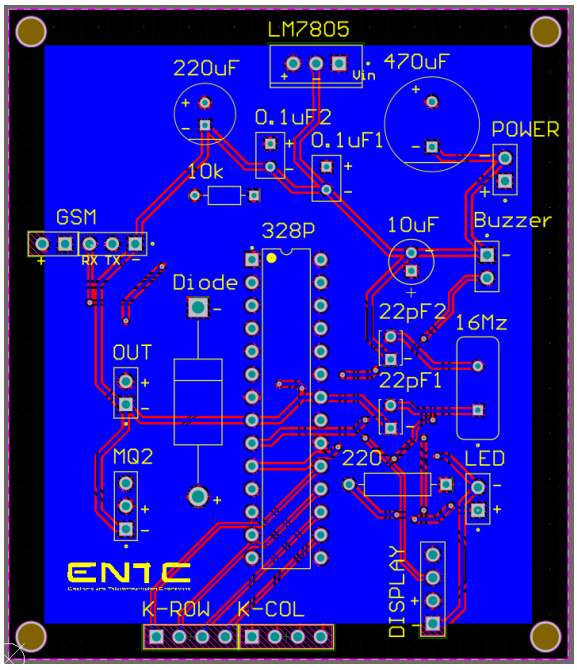


Figure 9.2 Bottom Layer

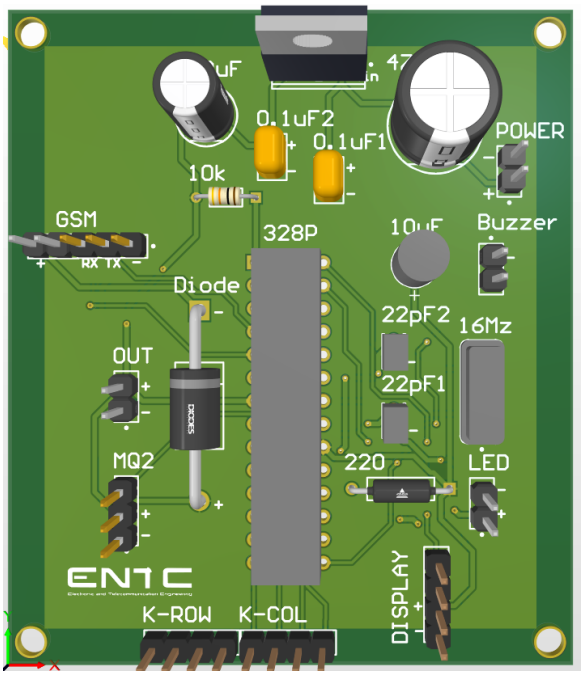


Figure 9.3 3D-View (TOP)

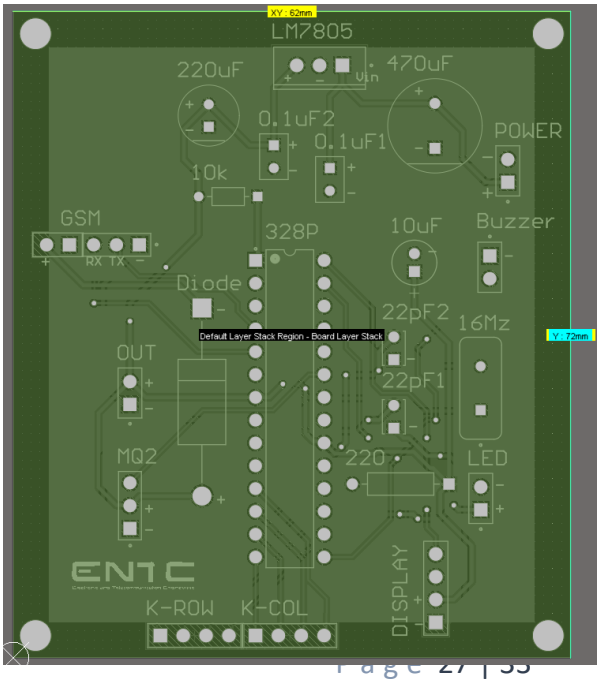


Figure 9.4 PCB Dimensions

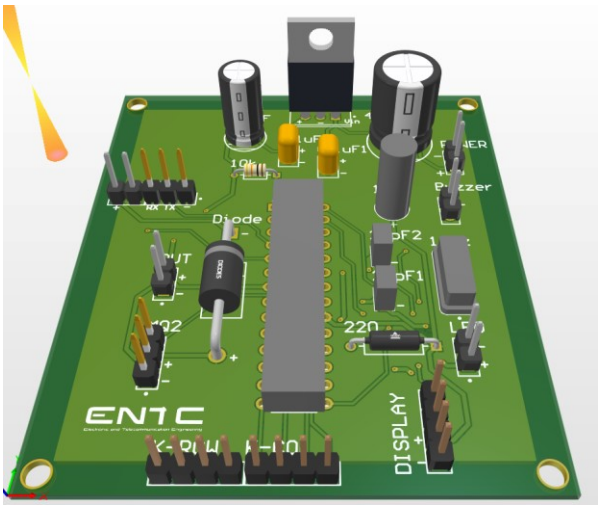


Figure 9.5 3D-View

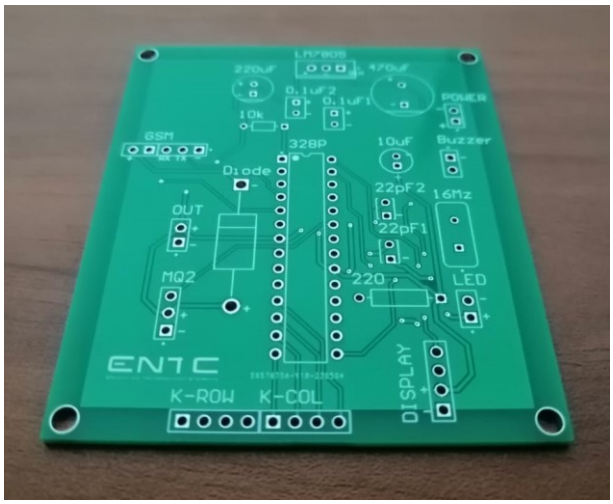


Figure 9.6 After PCB

Afterwards, all components were hand soldered onto the printed circuit board and the circuit was tested.

9.2 | Enclosure Design

First, a rough sketch of the enclosure was made considering PCB dimensions and component dimensions. Each part of the enclosure was designed using SolidWorks solid modeling software. To manufacture each part, 3D printing was used.

Initial Sketches

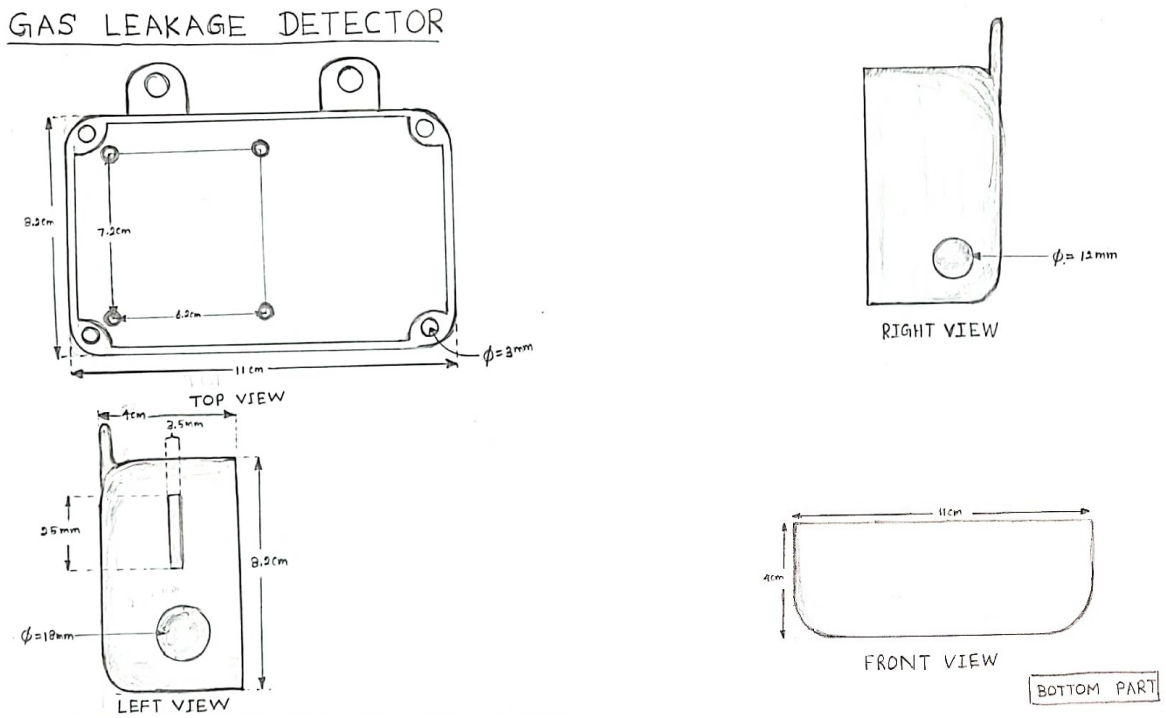


Figure 9.7 Bottom Part of the Enclosure

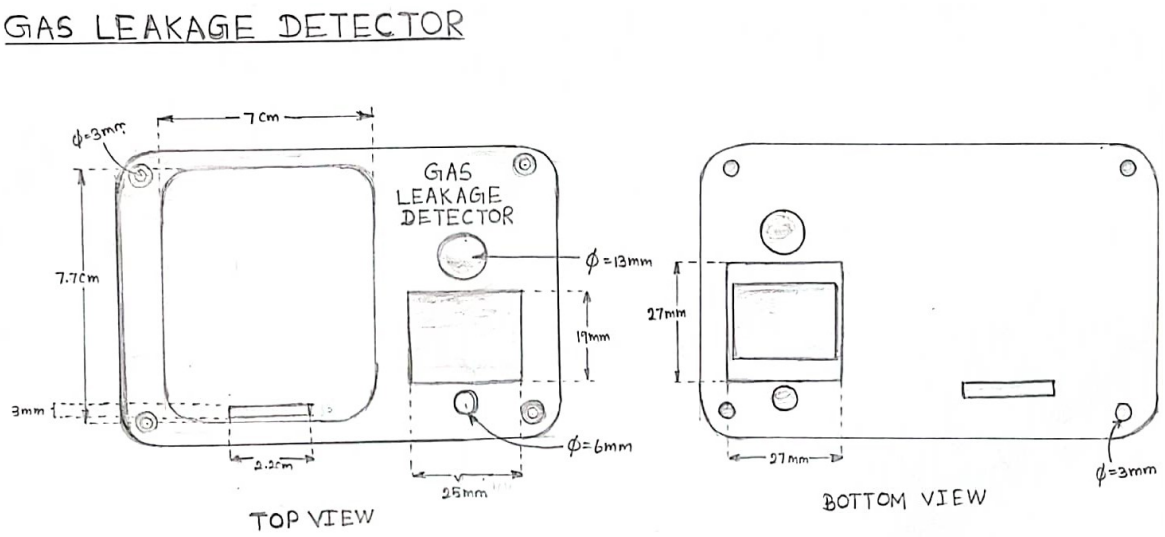
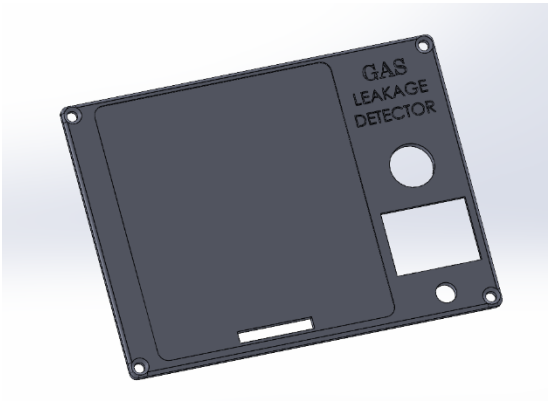
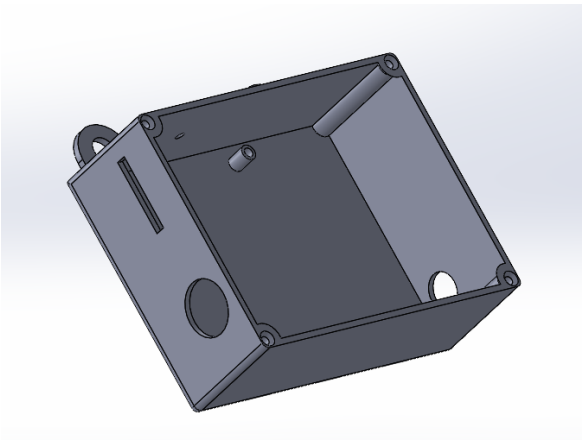
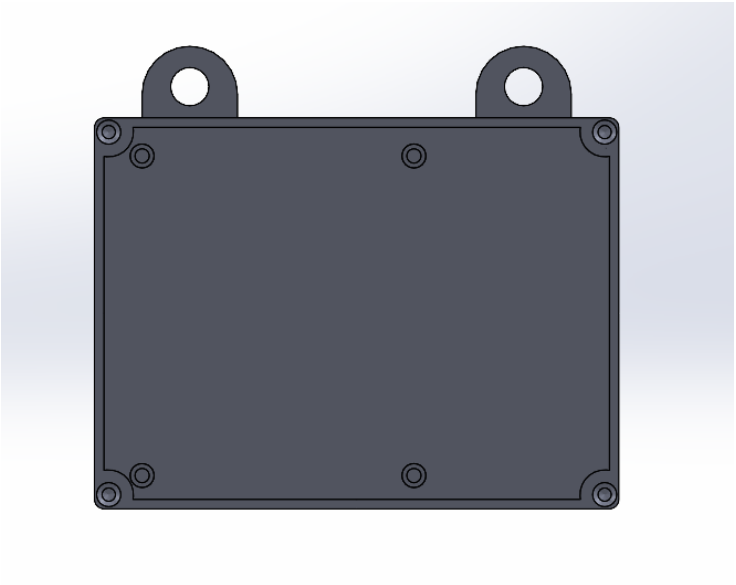


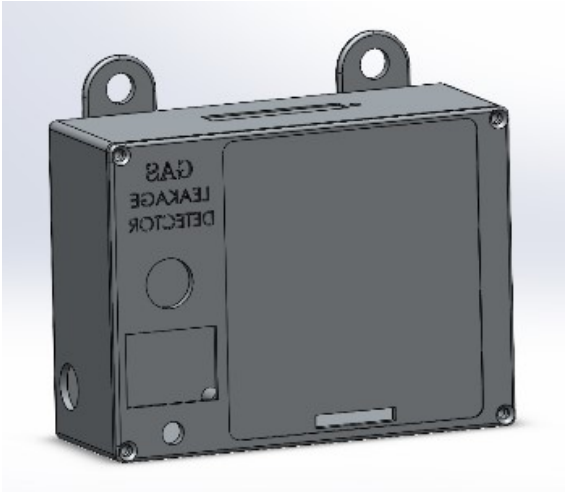
Figure 9.8 Top Part of the Enclosure

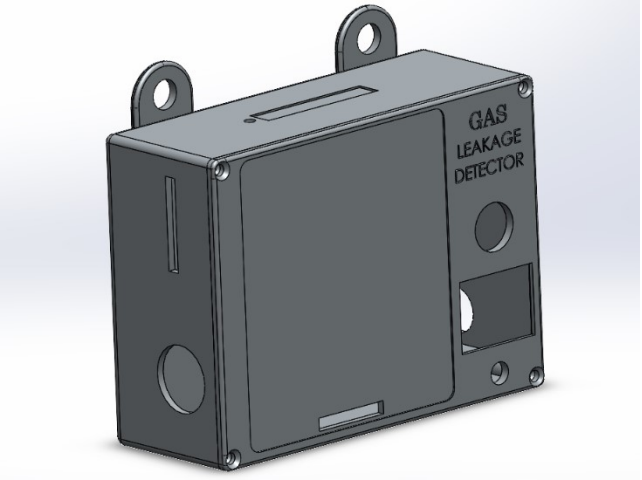
SolidWorks Design











9.3 | Assembly & Final Product

10 | Bill of Materials

Supplier	Description	Unit Price	Quantity	Cost (in LKR)
Column1	Column2	Column3	Column4	Column5
JLC PCB	Printed Circuit Board	328	1	328
Mex Lab 3D	3D Printed Enclosure	2500	1	2500
LCSC	ATMega328P MCU	1804	1	1804
LCSC	16MHz Crystal	28	1	28
LCSC	22 pF Capacitor	80	2	160
LCSC	10uF Capacitor	18	1	18
LCSC	10kOhm Resistor	3	1	3
LCSC	220Ohm Resistor	6	1	6
LCSC	100nF Capacitor	5	2	10
LCSC	220uF Capacitor	8	1	8
LCSC	470uF Capacitor	8	1	8
LCSC	LM7805 Regulator	521	1	521
LCSC	1N4001 Diode	12	1	12
Tronic.lk	MQ2 Gas Sensor	500	1	500
Tronic.lk	SIM 800L GSM Module	1200	1	1200
Tronic.lk	128x64 OLED Display	1030	1	1030
Tronic.lk	4x4 Matrix Keypad	180	1	180
Tronic.lk	Red LED	5	1	5
Tronic.lk	5V Active Buzzer	60	1	60
Tronic.lk	IC Base 28 Pin	20	1	20
Tronic.lk	Female Headers	20	1	20
Tronic.lk	AC/ DC 12v Adapter	550	1	550
Tronic.lk	DC Jack Female	20	1	20
Tronic.lk	JST Connector	20	5	100
TOTAL COST				9091

12 | Data Sheets

1. ATMega328P-PU Microcontroller
2. MQ2 Gas Sensor
3. SIM800L GSM Module
4. LM7805 Voltage Regulator
5. OLED Display

11 | References

1. "From Arduino to a Microcontroller on a Breadboard — Arduino Documentation," docs.arduino.cc. Available: https://docs.arduino.cc/built-in-examples/arduino-isp/ArduinoToBreadboard
2. "About SIM800L GSM module. Available:https://components101.com/wireless/sim800l-gsm-module-pinout-datasheet-equivalent-circuit-specs
3. Proto-Electronics, "Best Rules for PCB Components Placement." Available: https://www.proto-electronics.com/blog/best-rules-for-pcb-components-placement