# LPG Leakage Measuring Instrument -Project Report

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## Problem Statement

Leakage of liquefied petroleum gas (LPG) poses a significant safety hazard in domestic and industrial environments. Early detection of LPG leaks is essential to prevent fire accidents, explosions, and health hazards. This project aims to design and develop a simple yet effective LPG measuring instrument using an MQ-6 gas sensor and an analog circuit to detect and measure LPG concentration.

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## Chosen Physical Quantity and Its Importance

LPG concentration in air is measured in parts per million (ppm). Accurate measurement is crucial for preventing hazardous conditions and ensuring safety compliance. The timely detection of LPG leaks helps prevent explosions, improves workplace safety, and supports regulatory standards for gas monitoring.

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## Applications and Industry Needs

### Application of the Instrument:

- Domestic gas leakage detection
- Industrial gas leakage monitoring
- Automotive LPG leak detection
- Gas storage facilities monitoring
- Safety systems in laboratories and chemical plants

### Industries Where It Can Be Used:

- Oil & Gas Industry
- Chemical Processing Industry
- Manufacturing Industry
- Food Processing Industry
- Residential and Commercial Buildings

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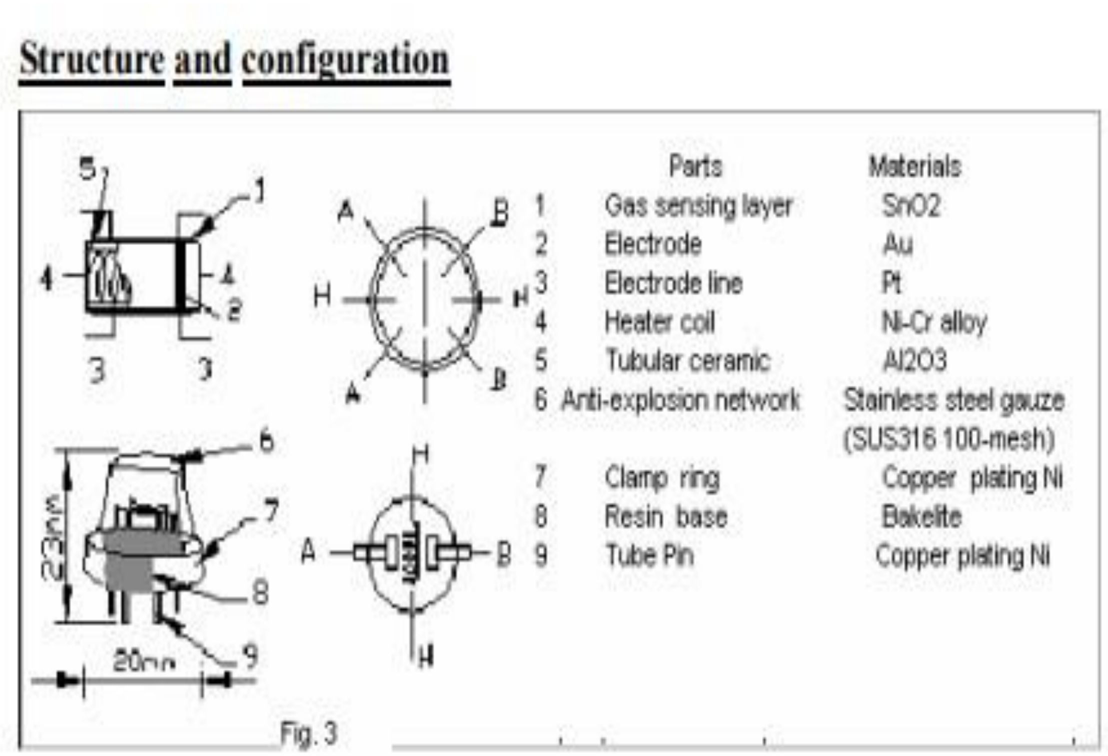
# Sensor Selection

## Sensor: MQ-6 Gas Sensor (Non-Module Version)

- **Part Number:** MQ-6
- **Input Range:** 5V DC
- **Output Range:** 0.2V – 4V (based on gas concentration)
- **Availability and Cost:** Readily available in electronics stores, cost: Rs.140/- • **Resolution and Tolerance:**
    - Detection Range: 200 – 10,000 ppm
    - Accuracy: ±10%
    - Operating Temperature: -10°C to 50°C

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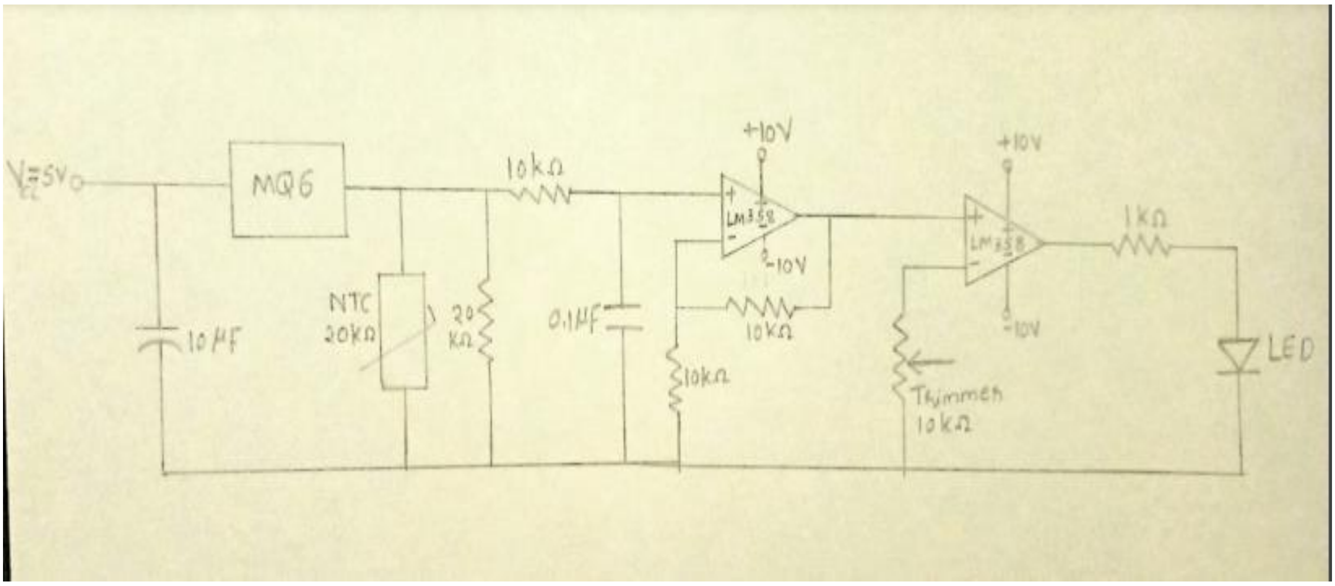
# 1. Signal Conditioning Circuit

## Components Used:

- MQ-6 Gas Sensor

- **Temperature compensation circuit: 20kΩ NTC Thermistor ,20kΩResistor**
- 10µF Capacitor: **to reduce voltage fluctuations and transient noise** in the Power supply
- **Low Pass Filter**: **10kΩ Resistor, 0.1µF Capacitor**
- **Operational Amplifier (LM358)**
- Trimmer Potentiometer: 10kΩ
- LED Indicator with Resistor: 1kΩ Resistor
- Amplifier Feedback Resistors: Two 10kΩ Resistors

## Circuit Diagram:




## 1. **Temperature compensation circuit**

The MQ-6 sensor's sensitivity varies with temperature, leading to fluctuations in its output voltage. The temperature compensation circuit helps **stabilize the load resistance**, reducing the effect of temperature variations on the sensor's response.

## Load Resistance:

$1/ R_L = 1/R_{NTC} + 1/R_{Fixed}$

where:

- $R_{NTC}$=20kΩ (at 25°C)
- $R_{Fixed}$=20kΩ

**2.Low Pass Filter Cutoff Frequency:**

$fc = 1 / (2\pi RC)$

Given: $R = 10k\Omega$, $C = 0.1\mu F$ fc
$= 1 / (2\pi(10,000)(0.1\times10^{-6}))$
$fc \approx 159.15Hz$
This filter helps in noise reduction beyond this frequency.

**3.Amplifier Gain Calculation:**

$G = 1 + (Rf / Rin)$
Given: $Rf = 10k\Omega$ , $Rin = 10k\Omega$

$G = 1 + (10k\Omega / 10k\Omega) = 2$

This means the sensor output is amplified by a factor of 2.

**4.Comparator Threshold Setting:**

The reference voltage for the comparator is set using a trimmer potentiometer.
The trimmer adjusts Vref to trigger the LED at a predefined concentration threshold.

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# 2. Calibration

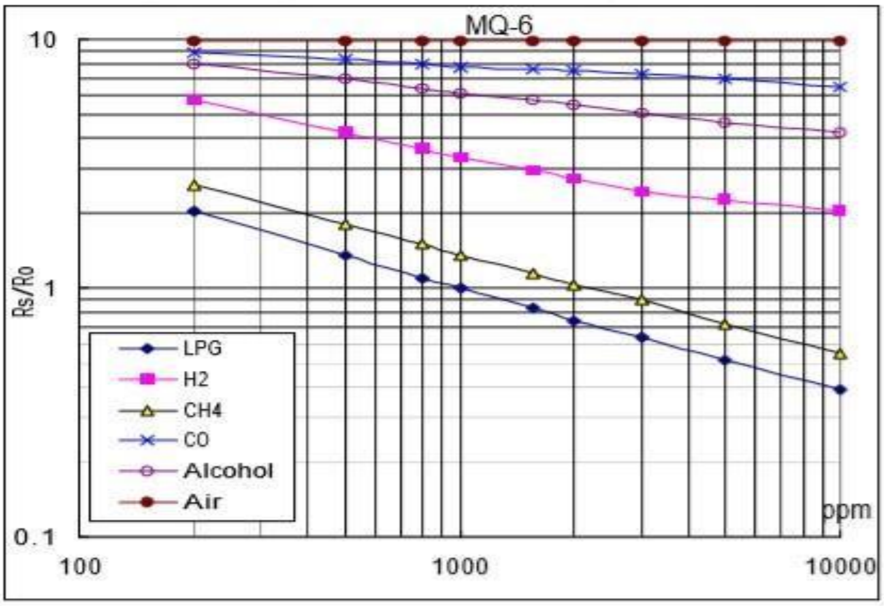
## Need for Calibration:

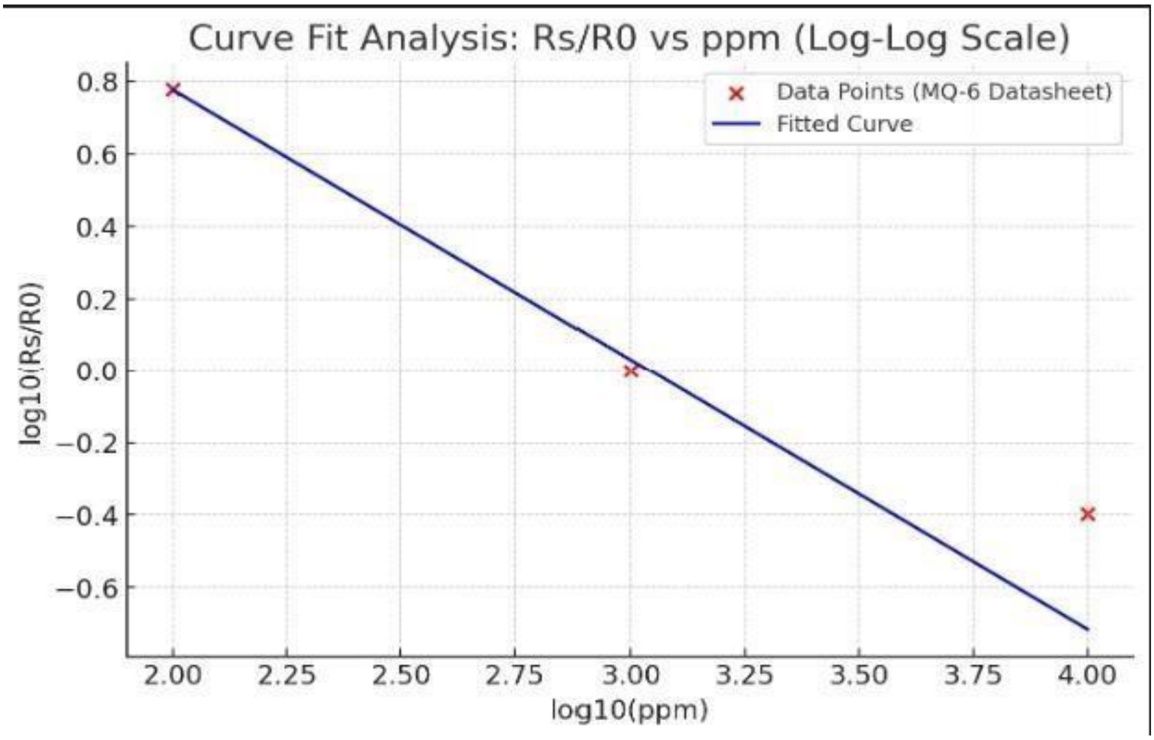
Calibration ensures accurate gas concentration measurements and reduces errors in detection.

## Calibration Procedure:

1. Expose the sensor to fresh air and note the output voltage (expected: 0.88V before amplification, **1.76V after amplification**).
2. Introduce a known LPG concentration and measure the sensor output.
3. Approximate ppm values are determined using the **graph from the MQ-6 sensor datasheet**.
4. Use a reference table to map voltage to ppm values.
5. Adjust the trimmer potentiometer to set the alarm threshold.

**Sensitivity Characteristics**




for Fresh Air Vout = 0.88V

The MQ-6 sensor follows the equation:

$Rs = RL \times ((Vcc / Vout) - 1)$ where:

- $Rs$ = Sensor resistance
- $RL$ = Load resistance (10kΩ)
- $Vcc$ = 5V supply voltage
- $Vout$ = sensor output voltage

For gas concentration estimation:

$$Rs / R0 = A \times (PPM)^{B}$$

where:

- $R0$ = Sensor resistance in fresh air
- A and B are constants obtained from curve fitting

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From the MQ-6 datasheet, **Rs/R0 in fresh air is about 9**.

Using the fresh air voltage **Vout = 0.88V** $Rs = 10k\Omega \times ((5 / 0.88) - 1) = 46.82k\Omega$

Now, using $Rs / R0 = 9$

$$R0 = Rs / 9 = 46.82k\Omega / 9 = 5.20k\Omega$$

So, **R0=5.20kΩ**

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$$Rs = 10k\Omega \times ((5/Vout) - 1)$$

Next, we compute PPM using the power-law relationship:

$$PPM = (Rs / AR0)^{(1/B)}$$

Using previously fitted values:

- A=186.51 , B=−0.7465

PPM = (Rs / (186.51×5.20kΩ))^(1 / −0.7465 )

Substituting Rs:

PPM=(10kΩ×((5 / Vout)−1)/(186.51×5.20kΩ))^(1 / −0.7465)

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To ensure **fresh air (0.88V) corresponds to 0 ppm**, we shift all ppm values by subtracting the ppm at **Vout = 0.88V**

PPM final = PPM raw − PPM at Vout = 0.88V

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### Final Corrected Equation

PPM = ((10kΩ×((5 / Vout)−1) / (186.51×5.20kΩ))^(1 / −0.7465)) −13.61

where **13.61 ppm is the original ppm value at Vout=0.88V.**

✅ **Now, fresh air correctly corresponds to 0 ppm, and ppm values increase accordingly!**

| Amplified Output Voltage (V) | Estimated LPG Concentration (ppm) |
|---|---|
| 2.000 | 57.98 |
| 2.636 | 102.21 |
| 3.272 | 161.04 |
| 3.91 | 239.52 |
| 4.546 | 345.55 |
| 5.182 | 491.85 |
| 5.818 | 700.04 |
| 6.454 | 1009.48 |
| 7.09 | 1498.92 |
| 7.728 | 2348.62 |
| 8.364 | 4064.67 |
| 9.000 | 8688.99 |

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# 3. Implementation

### Steps Taken:

1. **Circuit Assembly:** The components were assembled on a breadboard.
2. **Testing:** The sensor output was measured under different LPG concentrations.
3. **Tuning:** The gain of the amplifier and comparator threshold were adjusted for accurate detection.

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# 4. Error Analysis

### Sources of Error:

- Temperature dependence of MQ-6 sensor
- Variability in sensor response
- Power supply fluctuations
- External interference from other gases

### Error Measurement and Reduction:

- Using a temperature compensation circuit
- Shielding the circuit from electrical noise
- Regular recalibration
- Using high-precision resistors and capacitors

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# 6. Conclusion

This project successfully demonstrated an analog LPG measuring instrument using the MQ-6 sensor and LM358 op-amp. The system effectively detects and indicates LPG leaks through an LED warning system.

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