21AIE114 Principle of Measurement & Sensors

PROJECT REPORT

Home Automation

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Abstract

This project implements a Home Automation System.

By automating tasks that are done by humans, we can save time and energy. The hectic daily life routine sometimes makes men forgetful such as forgetting to switch off the devices at home. This clumsy attitude and is packed with the daily life routine sometimes puts us in a hurry, resulting in us being careless about the devices at home. Also, it’ll have a significant impact on the electricity. In This regard, an automation system becomes relevant in these times.

Introduction

Our project includes different levels of automation aimed at better usability and energy conservation, which include:

- A keypad lock is fixed at the Gate. The right password provides access past the Gate.
- When the person approaches the door the door automatically opens with the help of a micro servo motor which an Ultrasonic Sensor controls.
- The PIR sensor can detect if a person is in a room and with the help of a DC motor the fan rotates keeping the person cool.
- A photo-resistor is present which can detect if it is day or night and automate the lighting after nightfall.

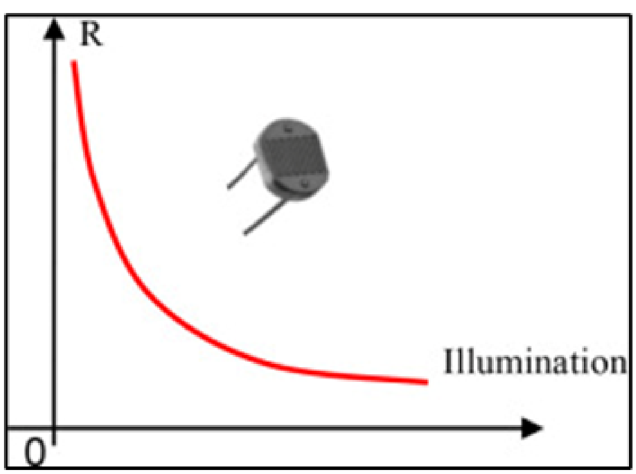
The home automation system includes a gas sensor which can ensure the safety of the person during gas leakages. It blasts a high-frequency audio warning of the life forms around the gas-affected area.

SENSORS USED AND RELEVANCY OF SENSORS IN REAL-TIME

1) Photoresistor

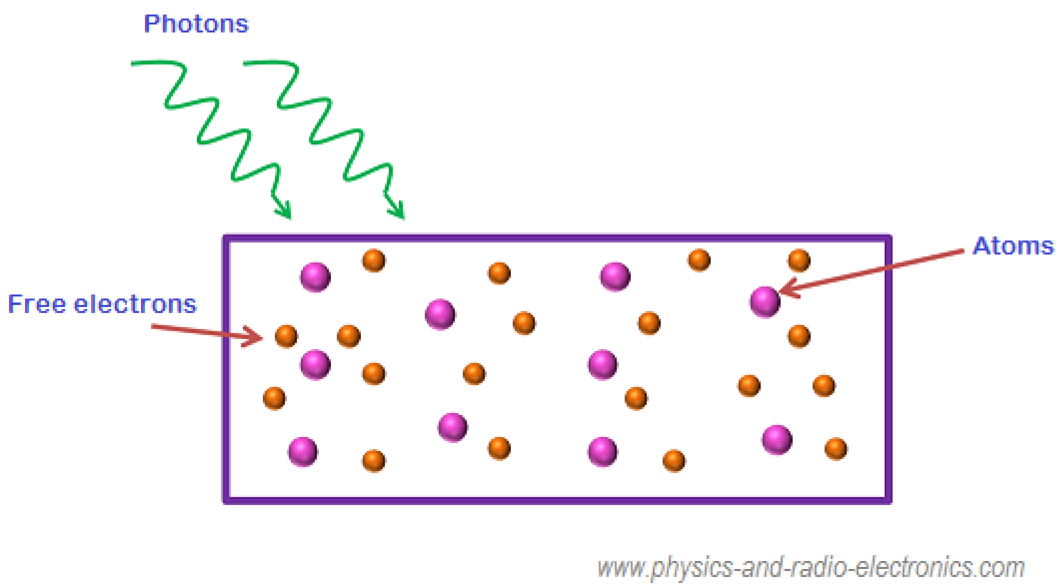
- **Short description**

The photoresistor is a component that has a (variable) resistance that changes with the light intensity that falls upon it. This allows them to be used in light-sensing circuits. Photoresistors are also called Light Dependent Resistors (LDR).



- **Working principle**

A photoresistor is sensitive to light. In the dark, their resistance is very high (sometimes up to 1 MΩ) but when the LDR sensor is exposed to light, the resistance drops by several ohms, depending on the intensity of the light. LDRs are nonlinear devices and have a sensitivity that varies with the wavelength of the light applied.



The photoresistor doesn't have a P-N junction like photodiodes. It is a passive component. These are made up of high-resistance semiconductor materials. When light is incident on the photoresistor, photons get absorbed by the semiconductor material. The energy from the photon gets absorbed by the electrons. When these electrons acquire sufficient energy to break the bond, they jump into the conduction band. Due to this, the resistance of the photoresistor decreases. With the decrease in resistance, conductivity increases.
Depending upon the type of semiconductor material used for photoresistor, their resistance range and sensitivity differs. In the absence of light, the photoresistor can have resistance values in megaohms. And during the presence of light, its resistance can decrease to a few hundred ohms.

- **Types of photoresistors**

Depending on the properties of semiconductor material used for designing a Photoresistor, these are classified into two types – Extrinsic and Intrinsic photoresistors. These semiconductors react differently under different wavelength conditions.

Intrinsic photoresistors: Intrinsic photoresistors are designed using Intrinsic semiconductor material. These intrinsic semiconductors have their own charge carriers. No free electrons are present in their conduction band. They contain holes in the valence band.
So, to excite electrons present in an intrinsic semiconductor, from the valence band to the conduction band, sufficient energy should be provided so that they can cross the entire bandgap. Hence we require higher energy photons to trigger the device. Hence, Intrinsic photoresistors are designed for higher frequency light detection.

Extrinsic photoresistors: Extrinsic semiconductors are formed by doping intrinsic semiconductors with impurities. These impurities provide free electrons or holes for conduction. These free conductors lie in the energy band closer to the conduction band. Thus, a little amount of energy can trigger them to jump into the conduction band. Extrinsic photoresistors are used for detecting longer wavelength and lower frequency light.
Higher the light intensity, the larger the resistance drop of the photoresistor. The sensitivity of photoresistors varies with the wavelength of the light applied. When there is no sufficient wavelength, enough trigger the device, the device doesn’t react to the light. Extrinsic photoresistors can react to infrared waves. Intrinsic photoresistors can detect higher frequency light waves.

- **Applications**

1. These are used as light sensors.
2. These are used to measure the intensity of light.
3. Night light and photography light meters use photoresistors.
4. Their latency property is used in audio compressors and outside sensing.

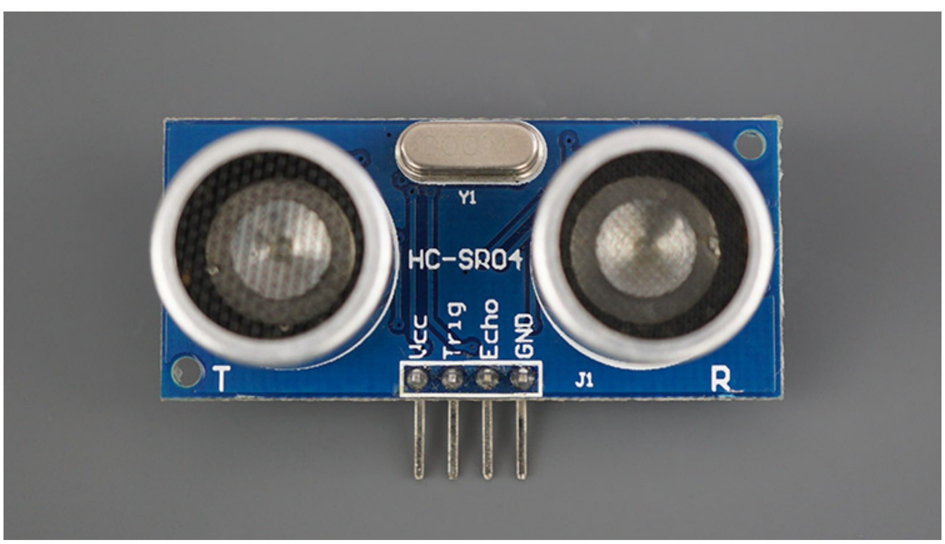
5. Photoresistors can also be found in Alarm clocks, outdoor clocks, solar street lamps, etc…
6. Infrared astronomy and Infrared Spectroscopy also use photoresistors for measuring the mid-infrared spectral region.

- **Sensor Specifications**

Light Resistance: 50-100 K Ohms
Rated Power: 200 W
Diameter: 3-20 mm
Input Voltage: 3.3-5 V

2)Ultrasonic sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves and converting the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. audible range of humans).



Ultrasonic sensors have two main components:

- The transmitter (which emits the sound using piezoelectric crystals)
- The Receiver (which encounters the sound after it has travelled to and from the target).

In order to calculate the distance between the sensor and the object, the sensor measures the time it takes between the emission of the sound by the transmitter to its contact with the receiver.

The formula for this calculation is $D = \frac{1}{2} T \times C$ (where D is the distance, T is the time, and C is the speed of sound ~ 343 meters/second).

- Ultrasonic sensors are used primarily as proximity sensors. They can be found in automobile self-parking technology and anti-collision safety systems. Ultrasonic sensors are also used in robotic obstacle detection systems, as well as manufacturing technology.
- Ultrasonic sensors are also used as level sensors to detect, monitor, and regulate liquid levels in closed containers (such as vats in chemical factories). Most notably, ultrasonic technology has enabled the medical industry to produce images of internal organs, identify tumours, and ensure the health of babies in the womb.

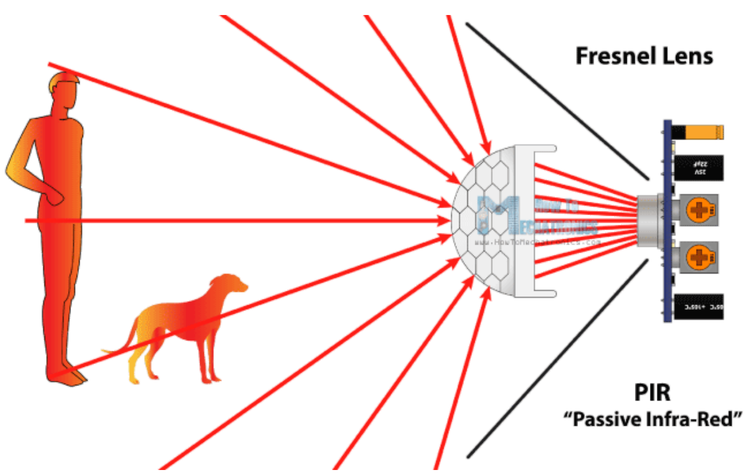
3) PIR Sensor

- **Short description**

Passive infrared (PIR) sensors use 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 room, for example), the sensor will engage.

- **Working Principle**

Generally, the PIR Sensor can detect animal/human movement in a required range. PIR is made of a pyroelectric sensor, which is able to detect different levels of infrared radiation. The detector itself does not emit any energy but passively receives it.



It detects infrared radiation from the environment. Once there is infrared radiation from the human body particle with temperature, focusing on the optical system causes the pyroelectric device to generate a sudden electrical signal. Simply, when a human body or any animal passes by, then it intercepts the first slot of the PIR sensor. This causes a positive differential change between the two bisects. When a human body leaves the sensing area, the sensor generates a negative differential change between the two bisects.

4)Gas Sensor

- **Short description**

A gas detector is a device that detects the presence of gasses in an area, often as part of a safety system. A gas detector can sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to leave
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The MQ9 sensor is sensitive to carbon monoxide and flammable gasses. It can detect carbon monoxide density from 10 ppm to 1000 ppm and flammable gasses density from 100 ppm to 10000 ppm. The MQ9 sensor has an internal heater which starts warming up if a 5V voltage is applied. The internal resistance of this sensor changes as the density of the detectable gas changes.

- **Working principle of Gas Sensor**

When tin dioxide (semiconductor particles) is heated in air at a high temperature, oxygen is adsorbed on the surface. In clean air, the donor electrons in tin dioxide are attracted toward oxygen, which is adsorbed on the surface of the sensing material, preventing electric current flow.

In the presence of reducing gasses, the surface density of adsorbed oxygen decreases as it reacts with the reducing gasses. Electrons are then released into the tin dioxide, allowing current to flow freely through the sensor.

These sensors are also called “burn-off” sensors. It means that the period where the sensor accumulates particles on its surface and the period where the sensor burns off the collected particles need to change with each other continuously to get the proper resistance readings. From the chart below it can be seen that the accumulation time should be 90 seconds long and the burn-off time should be 60 seconds long. During the accumulation, 1.4V should be supplied to the heater element and during the burn-off, the full 5V

- **Types of Gas Sensors**

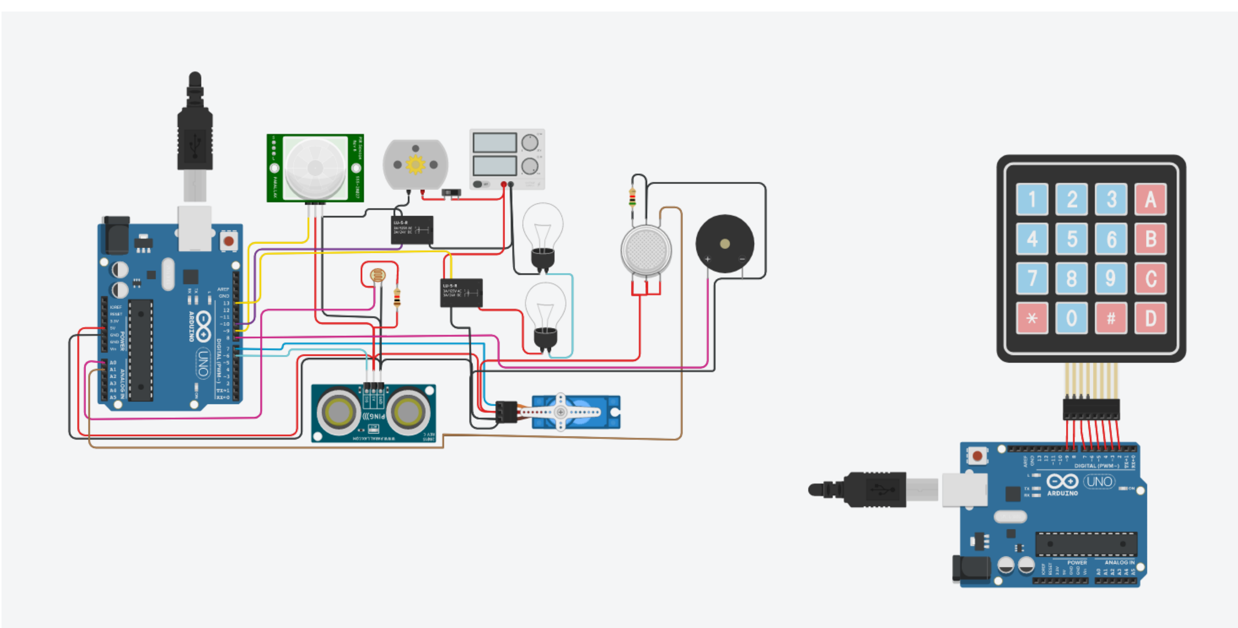
MQ gas sensors are the most common sensors available
There are various models according to the various gasses that they detect

- MQ-2 - Methane, Butane, LPG, smoke
- MQ-3 - Alcohol, Ethanol, smoke
- MQ-4 - Methane, CNG Gas
- MQ-5 - Natural gas, LPG
- MQ-6 - LPG, butane gas
- MQ-7 - Carbon Monoxide
- MQ-8 - Hydrogen Gas
- MQ-9 - Carbon Monoxide, flammable gasses
- MQ131 - Ozone
- MQ135 - Air Quality (CO, Ammonia, Benzene, Alcohol, smoke)
- MQ136 - Hydrogen Sulfide gas
- MQ137 - Ammonia
- MQ138 - Benzene, Toluene, Alcohol, Acetone, Propane, Formaldehyde gas, Hydrogen
- MQ214 - Methane, Natural gas

- **Application of Gas Sensors**

    - Safety application
    - Checking the quality of air inside the house
    - Medical Science applications
    - Industrial and agricultural applications
    - Fire suppression
    - Transporting application
    -
- **Sensor Specifications**
    1. Operating voltage: 5V
    2. Load resistance: 20 KΩ
    3. Heater resistance: 33Ω ± 5%
    4. Heating consumption: <800mw
    5. Sensing Resistance: 10 KΩ – 60 KΩ
    6. Concentration Scope: 200 – 10000ppm
    7. Preheat Time: Over 24 hours

Circuit Design



Components used

Arduino Uno - Arduino UNO is a microcontroller board based on the ATmega328P(a single-chip microcontroller created by Atmel in the megaAVR family). It has 14 digital input/output pins. It has a 5V input.

DC motor - A DC motor is any of a class of rotary electrical motors that converts direct current (DC) electrical energy into mechanical energy

Relay SPDT - Single Pole Double Throw (SPDT) relays have been described in the previous section. They can control one circuit because of a single pole but the relay can have two positions – Normally Open (NO) or Normally Closed (NC).

Micro servo - Micro Servo Motor SG90 is a tiny and lightweight servo motor with high output power. The servo can rotate approximately 180 degrees (90 in each direction) and works just like the standard kind but smaller. You can use any servo code, hardware or library to control these servos.

Piezo buzzer - In simplest terms, a piezo buzzer is a type of electronic device that's used to produce a tone, alarm or sound. It's lightweight with simple construction, and it's typically a low-cost product.

Light bulb - A device used to convert electricity into light, consisting of a source of illumination (e.g. an electric filament or one or more LEDs) enclosed within a transparent or translucent shell, typically having a rounded shape and designed to be fitted into a socket in a lamp.

Slide switch - A slide switch is a mechanical switch that slides from the open (off) position to the closed (on) position and allows control of a circuit's current flow without having to manually splice or cut wire.

Resistor - Provides resistance to the circuit

Connecting wires - Used to connect the components present in the circuit

Workflow

When a user approaches the gate, it demands a password and as the correct password is typed it grants access and allows the user to enter the home.

Firstly we set the rows and columns to 4 each and when the user clicks “A”, it prompts the user to input a password and when the user types the password, it checks the password set by us and if both the passwords are the same hence it grants access to enter the home.

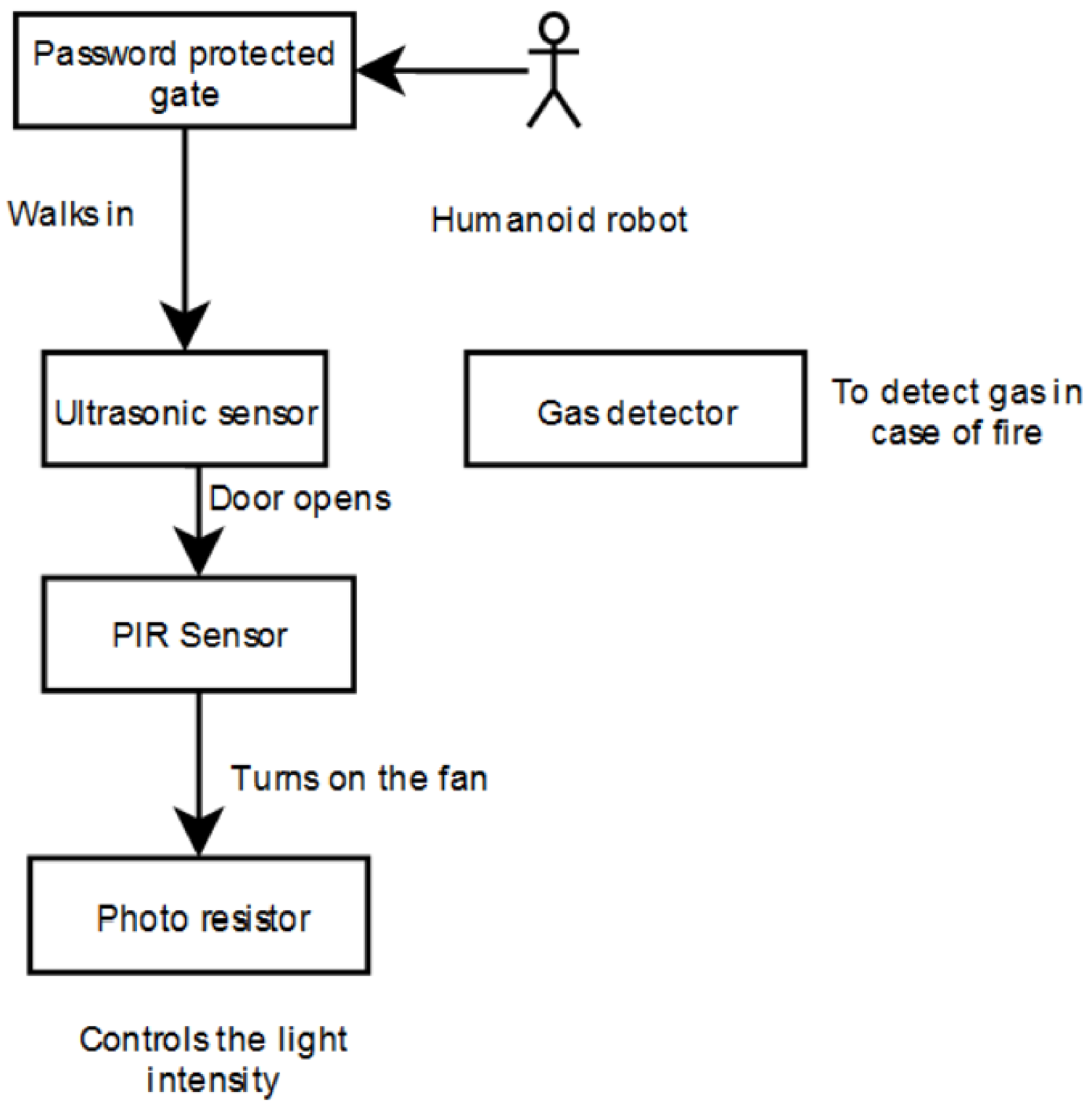
In the main circuit, we used 4 sensors and they are:
1) Ultrasonic Sensor
2) Passive InfraRed Sensor (PIR)
3) LDR
4) Gas Sensor

When the User is inside the range of the Ultrasonic sensor it sends a message to the Servo motor to open the door. For the sensor to work first we set the Trigger pin as the output pin and to Low then hold it for 2 microseconds then it is set to HIGH for 10 microseconds and then to LOW and returns the echo pin value (Time taken for the signal to return in microseconds) as it is set to Input. The equation used for it is 0.01723 * readUltrasonicDistance(6, 6); when the value is less than 100 the servo motor turns 90 degrees and if it is higher then set the servo to 0.
As the user enters the home, the PIR sensor senses the motion of the person and according to it it will start the fans and provide cooling to the user.
The PIR sensor is mapped to digital pin 9 in Arduino and the Relay which acts as an NPN switch is mapped to digital pin 10. The Digital pin reads Binary and if the value is 1, it means motion is detected and sets the pin 10 to HIGH as it allows the NPN to switch to the ON position. If pin 9 reads 0, set the pin to LOW and Switch to the OFF position. The relay used here is SPDT(Single Pole Double Throw).

For controlling Light intensity in the room LDR sensor is used. LDR is mapped to Analogue Pin A0 and when the A0 reads a value greater than 500, then it sets pin 13 to LOW and it is connected to a relay, else it sets pin 13 to HIGH.

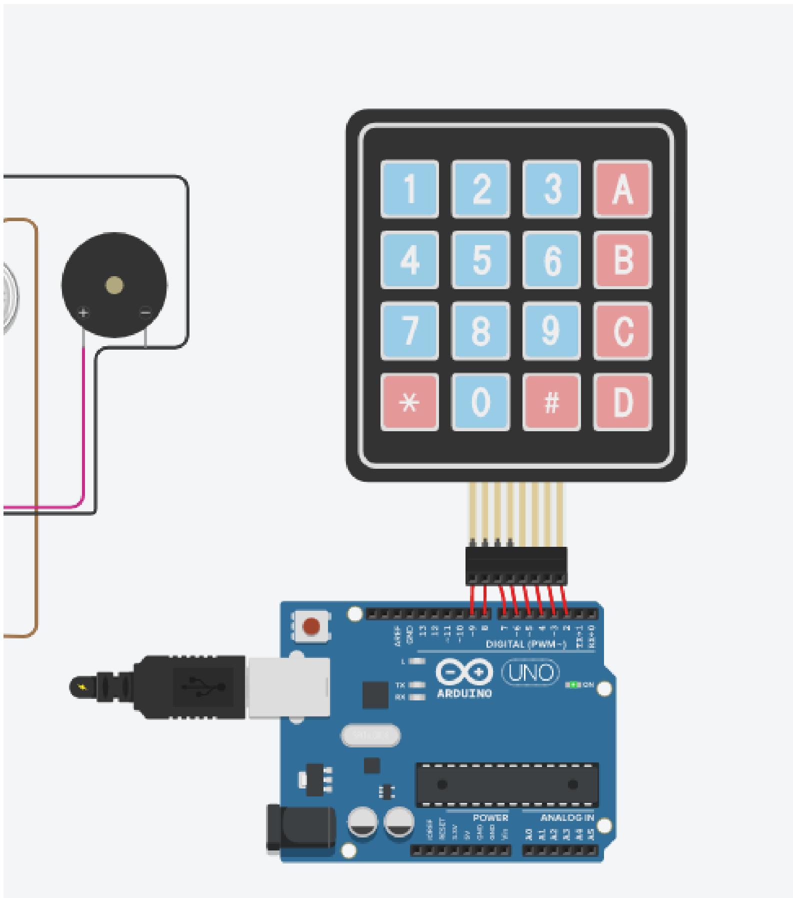
For the Gas sensor, it is mapped to the analogue Pin A1 in Arduino and sets the limit to 400 when the Value for A1 is greater than the limit, it calls an inbuilt function Tune which takes to parameters- Pin number and the output frequency. Here pin number is 8 and the tone frequency can be varied. A delay of 300 microseconds is given. If the value is less than the Limit, Notune inbuilt function is called which takes only the pin number as a parameter.

Block Diagram



Working of Tinkercad

- **KEYPAD**



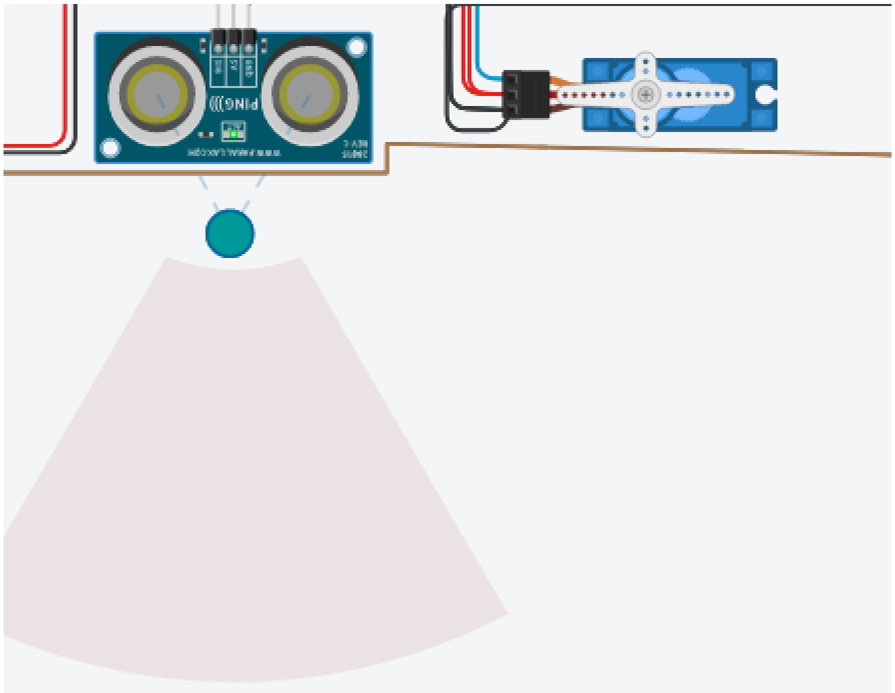
When the wrong password is typed

```
Enter Password
Validate the Password
Access Denied
```

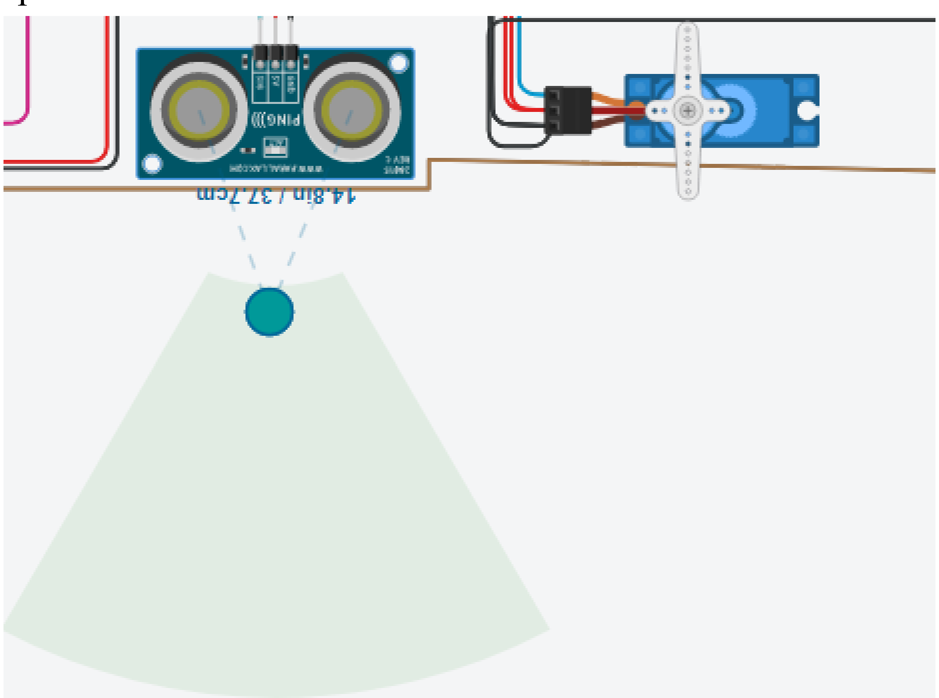
When the correct password is typed

```
Enter Password
Validate the Password
Access Granted
```

- **Ultrasonic Sensor**

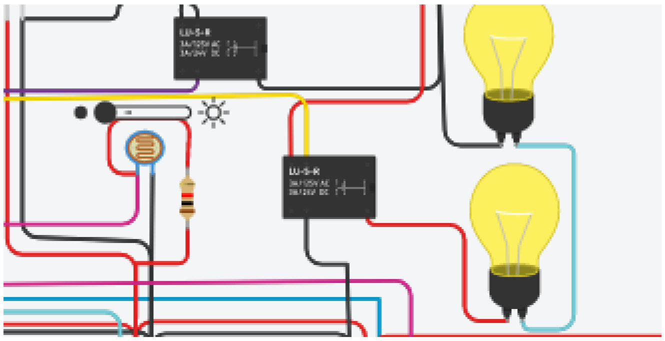


When a person is not in range the servo motor does not work and the gate does not open

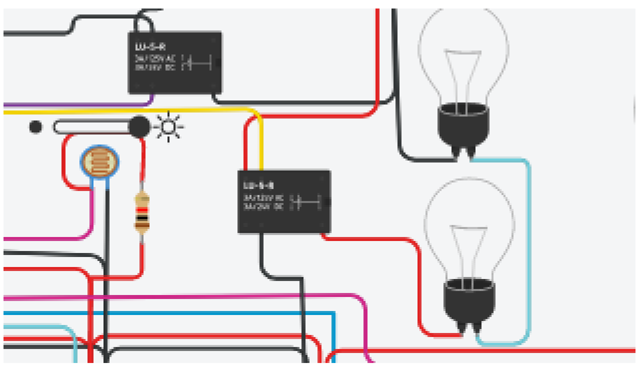


When the person is in range then the servo motor opens the gate

- **Light Detection Sensor**

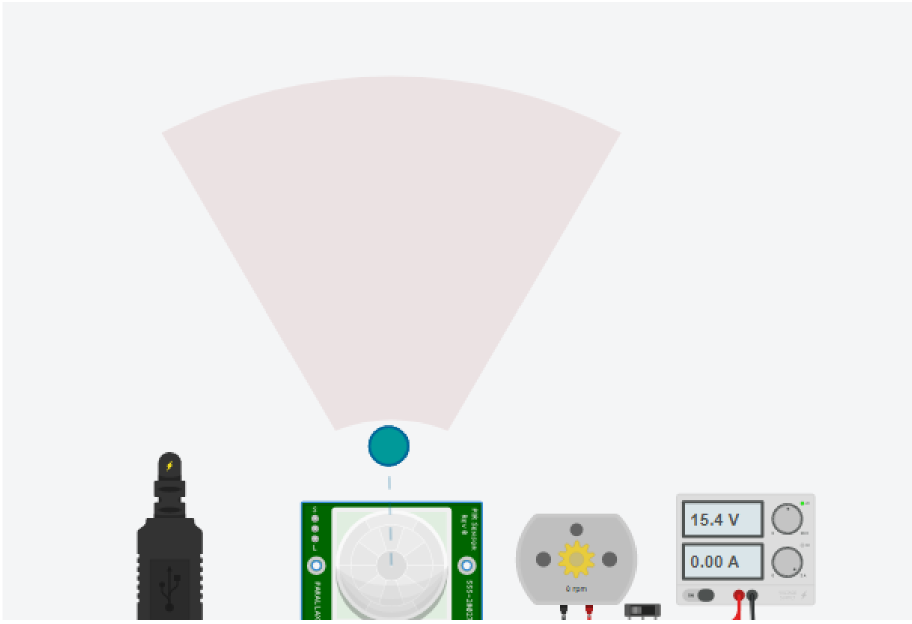


During the night the sensor senses minimal light outside therefore the light bulbs turn on

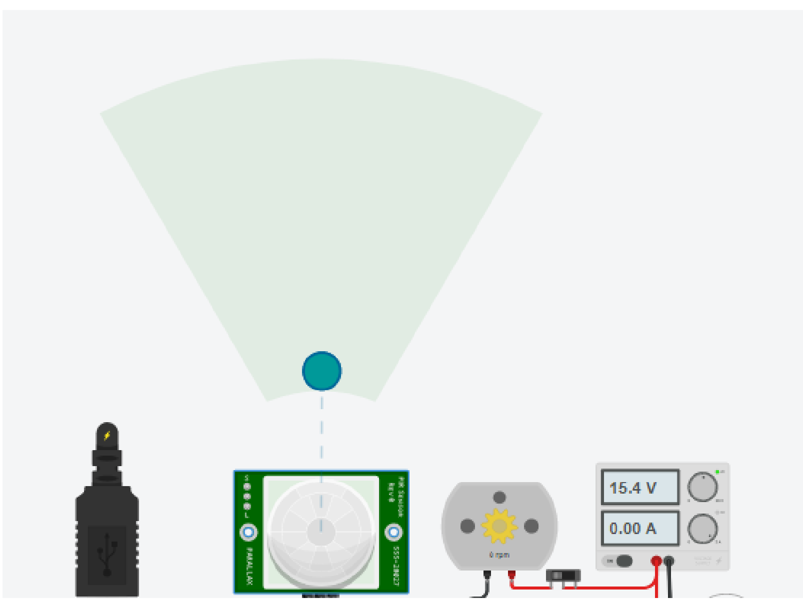


During the morning the sensor picks up maximum light outside hence the bulbs don't turn on

- **PIR Sensor**

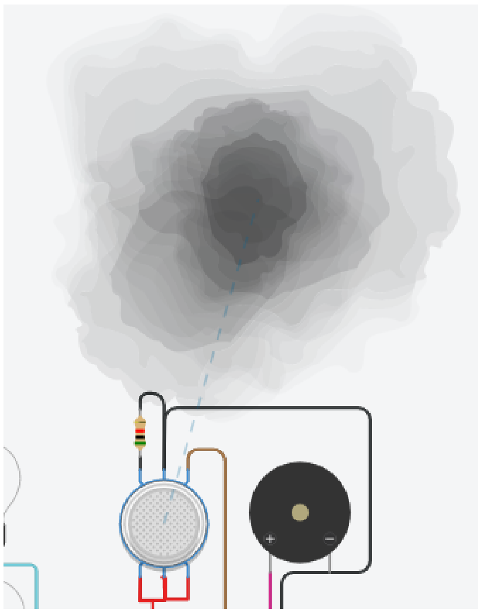


When the person is not in range of the PIR sensor the motor does not work hence the fans don't spin

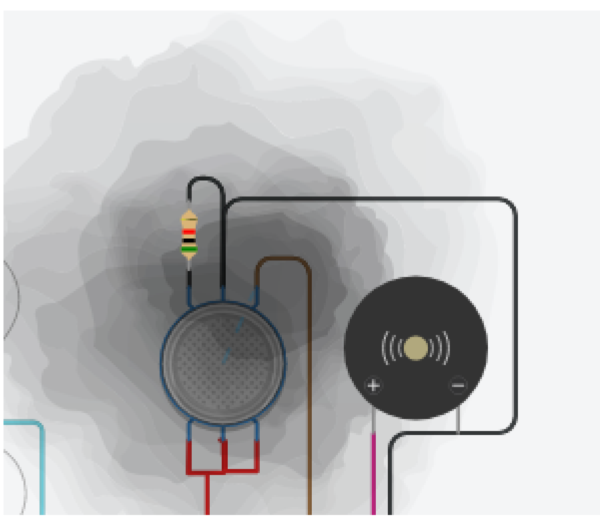


When a person is in range of the PIR sensor the motor works and the fans start spinning

- **GAS Sensor**



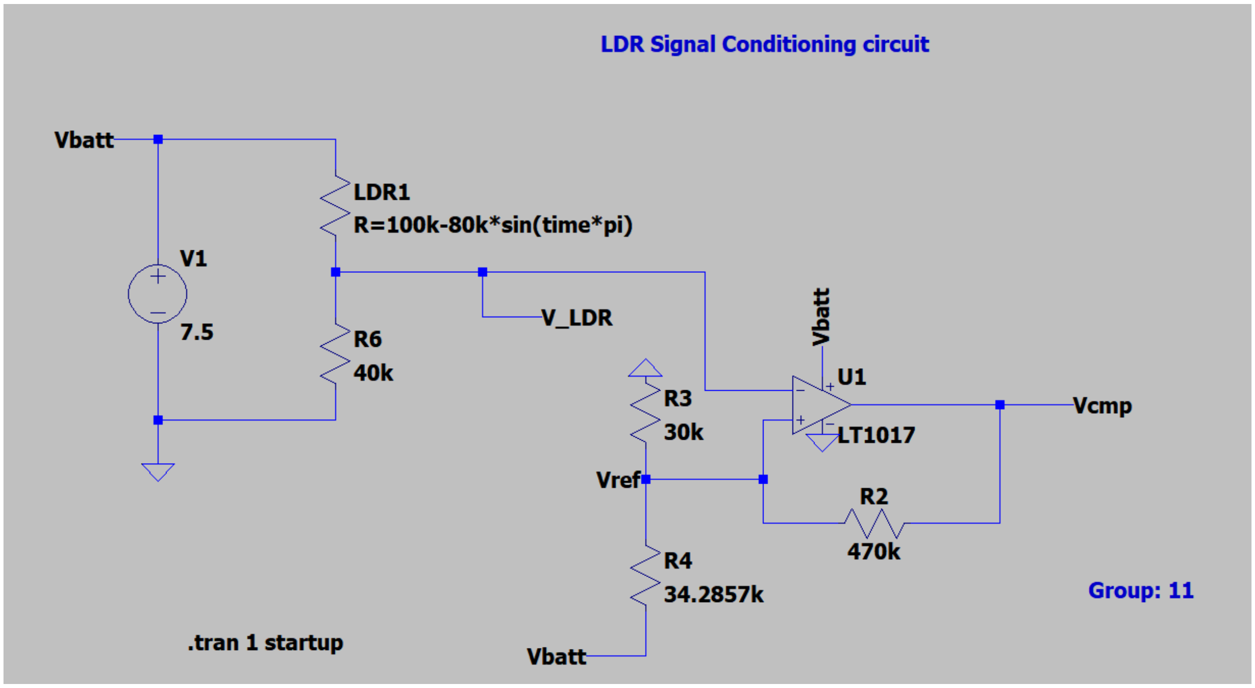
Since there is no presence of smoke the piezo buzzer will not send an alarm



Due to the presence of smoke, the smoke alarm sends a shrilling sound alarming the person of the imminent danger

Signal conditioning circuit diagrams

LDR



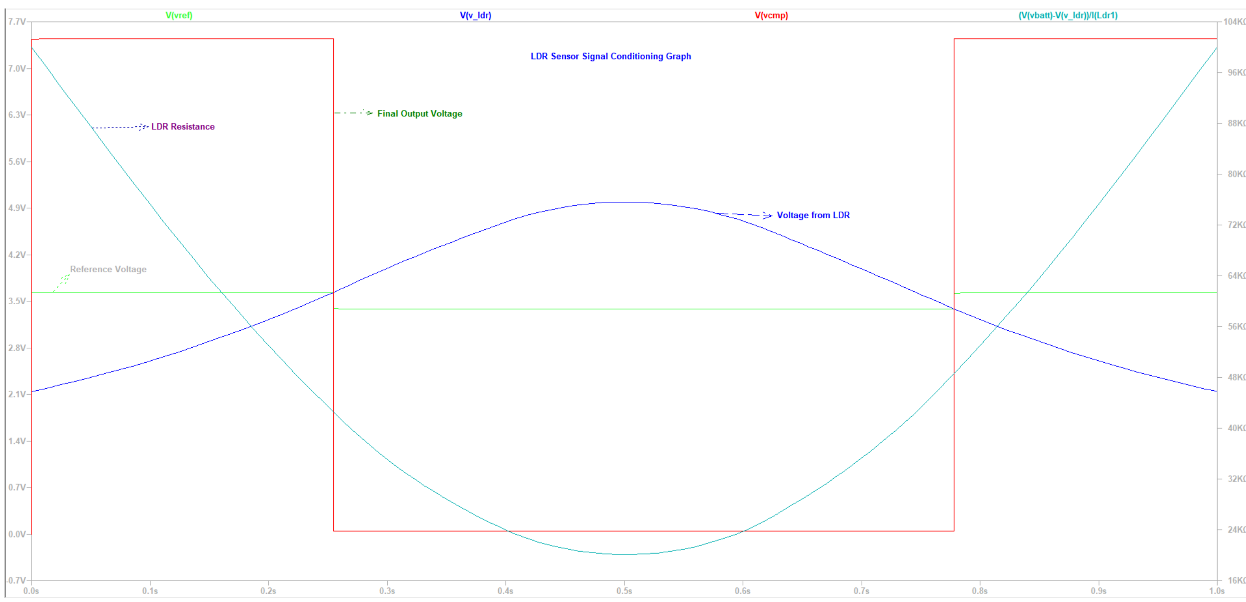
Here we take LDR1 as the resistance of LDR and this resistance varies according to the expression of R. Here we take the expression such that it varies between 100k ohm and 20k ohm. The expression also only considers the first positive half cycle of the sine wave which is mapped into a time interval of 1s.

The voltage which is coming out of the LDR1 is taken as V_LDR, which varies according to the change in the resistance of the LDR. This voltage is compared with a reference voltage of approx. 3.5V ± hysteresis. The inverting comparator has a +ve V saturation of the same voltage as the battery and a -ve V saturation of 0V.

When the voltage from the LDR which is V_LDR is higher than the reference voltage the comparator will give -ve saturation voltage as the output. When the

V_LDR is lower than the reference voltage the comparator will give a +ve saturation voltage as output.
The comparator is a very sensitive device so a noisy input can cause significant variation in the output produced. The resistor R2 provides hysteresis in the comparator which makes sure that the comparator is not slowed down by the usage of any filters such as a low pass filter so that the input signal is filtered and the noise is reduced. This hysteresis changes Vref by about +- 20mV.

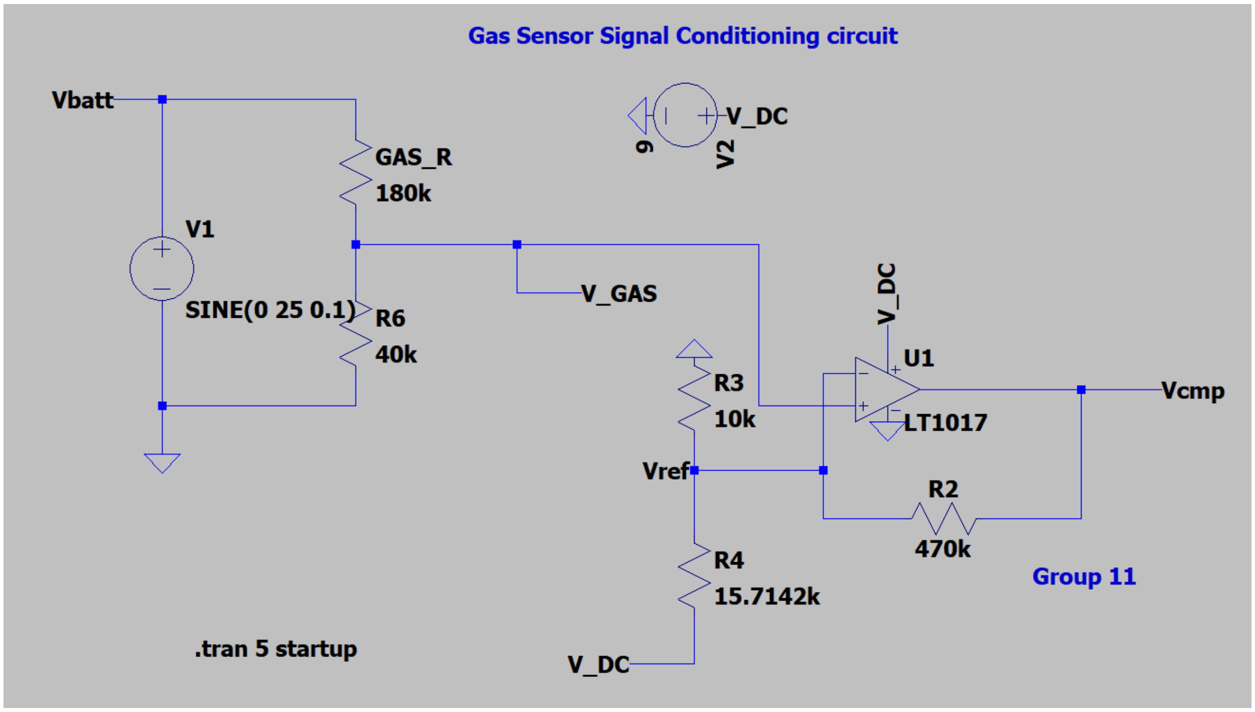
Output



When the voltage from the LDR is greater than the reference voltage value the final output of the system goes from +ve saturation voltage to -ve saturation voltage which is V_batt. That means during the day time the LED will be in the turned-off state

Similarly, when the voltage from LDR is lesser than the reference voltage the final output of the system goes back again into the +ve saturation voltage value which is zero. That means during the night time the LED will be in the turned-on state.

Gas Sensor

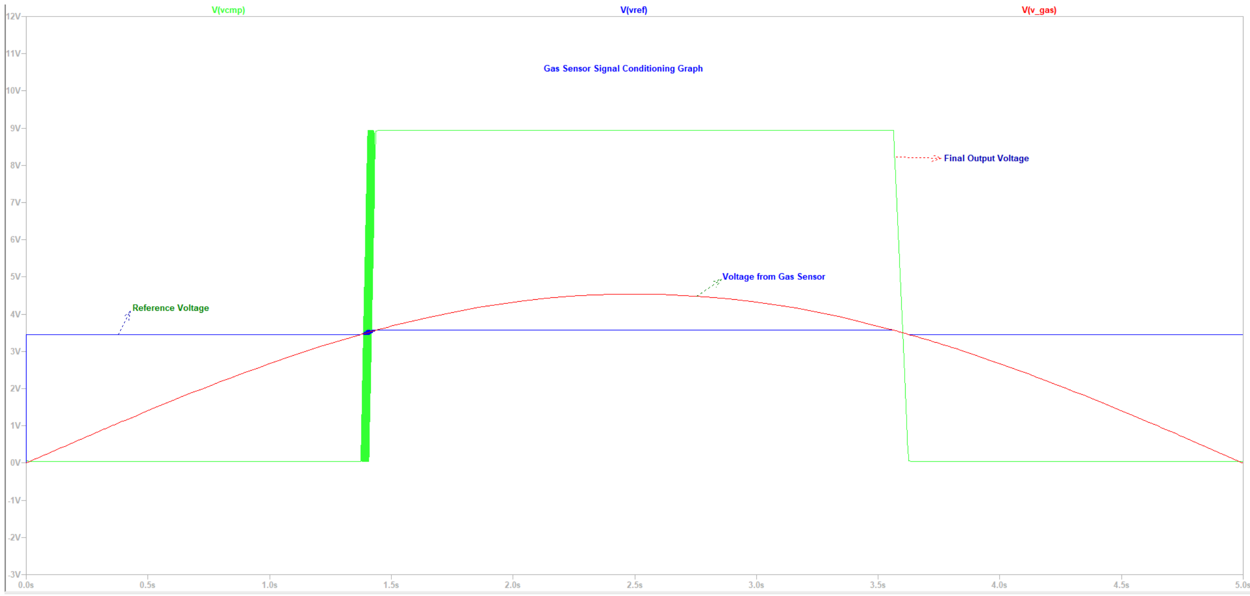


The output voltage from the sensor is taken as V_GAS which we obtained from the voltage divider circuit. The voltage we received is compared with the reference voltage Vref of 3.5V. Both V_GAS and vref are fed into a non-inverting comparator

The non-inverting comparator has a positive saturation of 9V and a negative saturation of 0V as it is connected to the ground. When the input V_GAS is greater than the vref the comparator gives positive saturation voltage as the output
And when valueV_GAS is less than vref the comparator gives negative saturation voltage as the output

This output voltage can be used to control the piezo buzzer to fully operate the system at the correct required voltage.

Output



When the voltage from the gas sensor(V_GAS) is greater than the reference voltage(vref) the output becomes positively saturated. Therefore, if the gas concentration in the environment is high, the output voltage will be high, This turns on the piezo buzzer alerting the user of a possible gas leakage

When the amount of gas in the environment is low ie when the voltage from the gas sensor is below the reference voltage the output goes from positive saturation to negative saturation. This does not turn on the piezo buzzer hence no alarm occurs

Appendix

Arduino 1(For main circuit) :

```
#include <Servo.h>

int output1Value = 0;
int sen1Value = 0;
int sen2Value = 0;
int const gas_sensor = A1;
int const LDR = A0;
int limit = 400;

long readUltrasonicDistance(int triggerPin, int echoPin)
{
  pinMode(triggerPin, OUTPUT);  // Clear the trigger
  digitalWrite(triggerPin, LOW);
  delayMicroseconds(2);
// Sets the trigger pin to HIGH state for 10 microseconds
  digitalWrite(triggerPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(triggerPin, LOW);
  pinMode(echoPin, INPUT);
  // Reads the echo pin, and returns the sound wave travel time in microseconds
  return pulseIn(echoPin, HIGH);
}

Servo servo_7;

void setup()
{
   Serial.begin(9600);                  //initialize serial communication
  pinMode(A0, INPUT);                               //LDR
  pinMode(A1,INPUT);              //gas sensor
  pinMode(13, OUTPUT);                          //connected to relay
  servo_7.attach(7, 500, 2500); //servo motor

  pinMode(6,INPUT);         //signal to ultrasonic sensor
  pinMode(8,OUTPUT);              //signal to piezo buzzer
  pinMode(9, INPUT);                                //signal to PIR
  pinMode(10, OUTPUT);                          //signal to npn as switch

}

void loop()
{

     //------light intensity control------//
//--------------------------------------------------------------
    int val1 = analogRead(LDR);
  if (val1 > 500)
                {
                digitalWrite(13, LOW);
    Serial.print("Bulb ON = ");
    Serial.print(val1);
                }
```

```
  else
                {
                digitalWrite(13, HIGH);
    Serial.print("Bulb OFF = ");
   Serial.print(val1);
                }

//--------------------------------------------------------------
       //------  fan control --------//
//--------------------------------------------------------------
  sen2Value = digitalRead(9);
  if (sen2Value == 0)
                {
                digitalWrite(10, LOW); //npn as switch OFF
   Serial.print("     || NO Motion Detected    " );
                }

  if (sen2Value == 1)
                {
                digitalWrite(10, HIGH);//npn as switch ON
   delay(1000);
    Serial.print("           || Motion Detected!      " );
                }


//----------------------------------------------------------------
      // ------- Gas Sensor --------//
//----------------------------------------------------------------
int val = analogRead(gas_sensor);      //read sensor value
  Serial.print("|| Gas Sensor Value = ");
  Serial.print(val);                                          //Printing in serial monitor
  if (val > limit)
                {
                tone(8,669);
                }
                delay(300);
                noTone(8);

 //---------------------------------------------------------------
      //-------  servo motor  ---------//
 //--------------------------------------------------------------
  sen1Value = 0.01723 * readUltrasonicDistance(6, 6);

  if (sen1Value < 100)
                {
                servo_7.write(90);
   Serial.print("          || Door Open!  ; Distance = ");
   Serial.print(sen1Value);
  Serial.print("\n");

                }
  else
                {
                servo_7.write(0);
   Serial.print("          || Door Closed! ; Distance =  ");
   Serial.print(sen1Value);
   Serial.print("\n");
  }
  delay(10); // Delay a little bit to improve simulation performance
}
```

Arduino 2 (For gate function):

```
#include <Keypad.h>

const byte ROWS = 4; //Four rows
const byte COLS = 4; //Four columns
char keys[ROWS][COLS] = {
  {'1','2','3','A'},
  {'4','5','6','B'},
  {'7','8','9','C'},
  {'S','0','H','D'}
};
byte rowPins[ROWS] = {9, 8, 7, 6}; //connect to the row pinouts of the keypad
byte colPins[COLS] = {5, 4, 3, 2}; //connect to the column pinouts of the keypad

Keypad keypad = Keypad( makeKeymap(keys), rowPins, colPins, ROWS, COLS );

String v_passcode="";

void setup(){
  Serial.begin(9600);
}

void loop(){
  char key = keypad.getKey();

  if (key != NO_KEY){
    //Serial.println(key);

    v_passcode = v_passcode + key;

    if(key=='A')
    {
		Serial.println("Enter Password");
      v_passcode="";
    }

    if(key=='D')
    {
		Serial.println("Validate the Password");
		//Serial.println(v_passcode);

		if (v_passcode=="6969D")
      {
        Serial.println("Access Granted");
      }
		else
      {
		Serial.println("Access Denied");
      }
    }
  }
}
```

Conclusion

The home automation system implementation was successful
The ultrasonic sensor along with the keypad is useful in keeping the house secure from unwanted Visitors
The light detection sensor along with the PIR sensor (Passive Infrared Sensor) can help in reducing the electricity bill by switching on the electrical appliances only when it is necessary
The Gas sensor alerts the person in case of a gas leak and could even save the person's life Through this project, we learnt about using Arduino collectively with other sensors in building a home automation system. We were also able to study the implementation of these systems in Tinkercad. We were able to do the signal conditioning efficiently without losing the functioning of our sensors.

References

- https://www.semiconductorforu.com/applications-ldr-light-dependent-resistors/
- https://www.youtube.com/watch?v=bmeww8SGySc
- https://robu.in/pir-sensor-working-principle/
- https://www.watelectronics.com/light-dependent-resistor-ldr-with-applications/
- https://islproducts.com/design-note/servo-motor-fundamentals/#:~:text=Servo%20motors%20come%20in%20many,%2C%20continuous%20rotation%2C%20and%20linear.
- https://www.gdscorp.com/blog/offshore-gas-detection/working-principle-of-a-combustible-gas-sensor/#:~:text=A%20catalytic%20gas%20sensor%20contains,is%20considered%20a%20dangerous%20range.