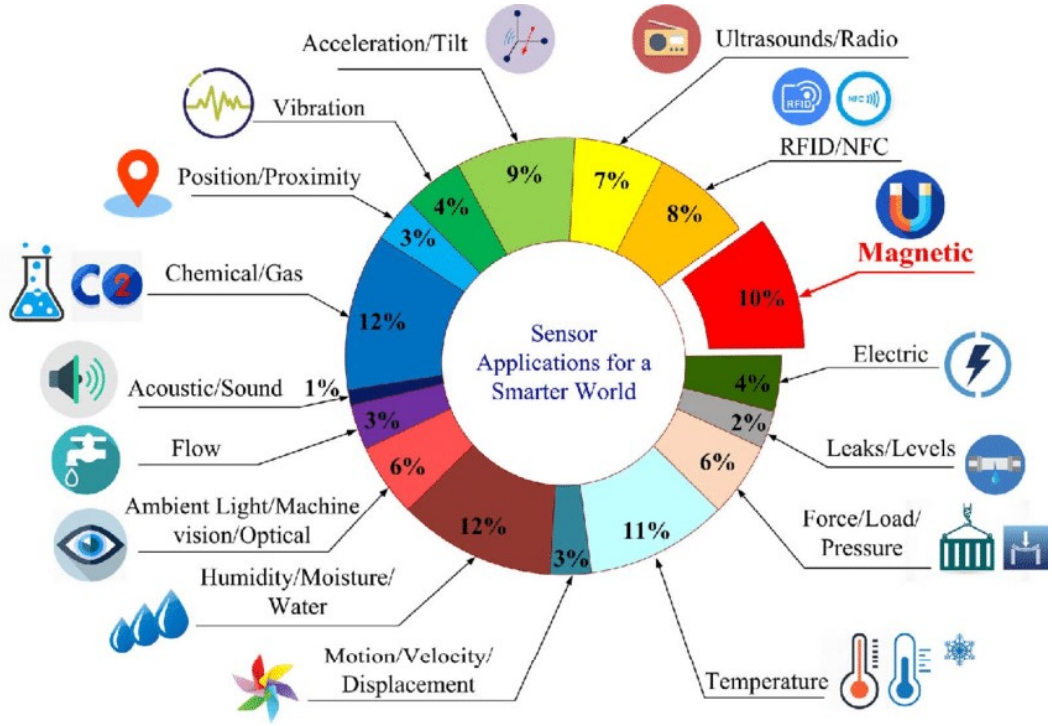


Sensor Modules for IoT applications

Objective of the session

- Brief introduction and interfacing of following sensor modules will be discussed

Hall effect

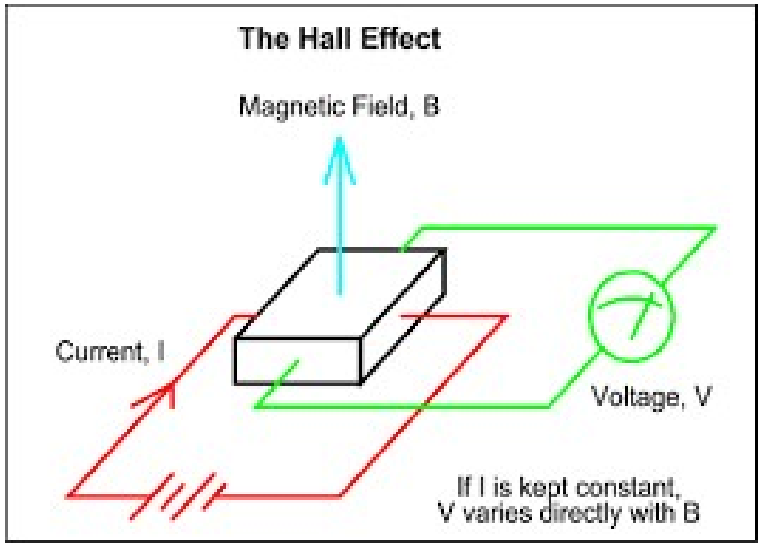
Ultrasonic

Accelerometer

PIR Sensor

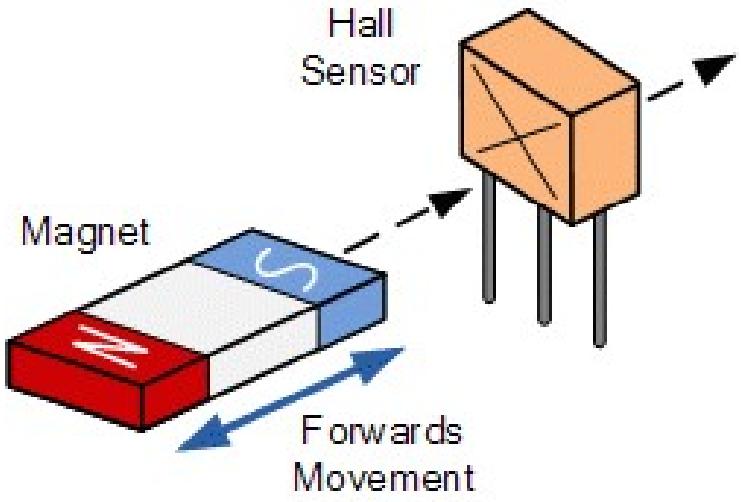
Photo Diode and LDR

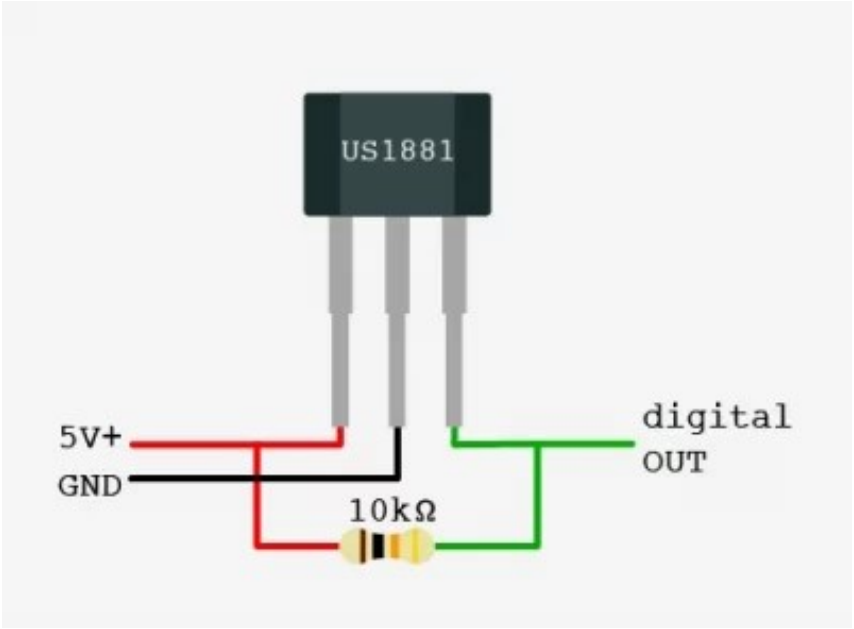
Hall effect sensor



- Semiconductor strip.
- Current is provided on side faces.
- In the presence of mutually perpendicular Magnetic field, Hall voltage produced on front and back face of strip

Hall effect sensor

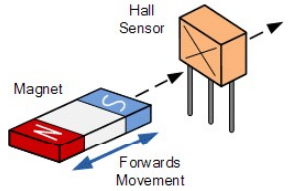




The US1881 Hall effect sensors have three pins: V_{CC}(5V), GND, and V_{out} (Signal).

Hall effect sensor

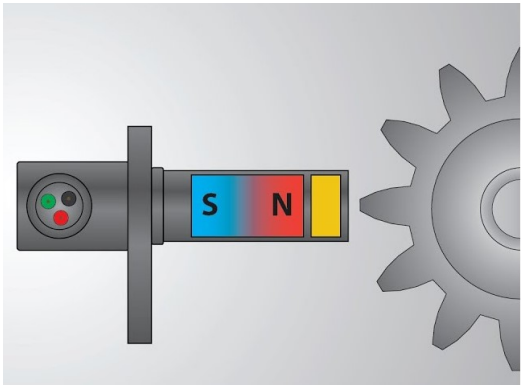
- The US1881 is a latching Hall effect sensor.
- The sensor gives out an output HIGH (5V) voltage whenever the NORTH pole of a magnet is brought close to it.
- The sensor still outputs a HIGH voltage (Latched state) and does not go LOW (0V), even when the magnet is removed.
- However, when the SOUTH pole of the magnet is brought close to it, sensor output goes LOW (0V).
- These sensors that latch on to a particular state are called latched Hall effect sensors.



Hall effect sensor

- The US5881 is a non-latching Hall effect sensor.
- The sensor gives an output HIGH whenever the NORTH pole of a magnet is brought close to it, and switches LOW whenever the magnet is removed.

Speed in RPM measurement by Hall sensor

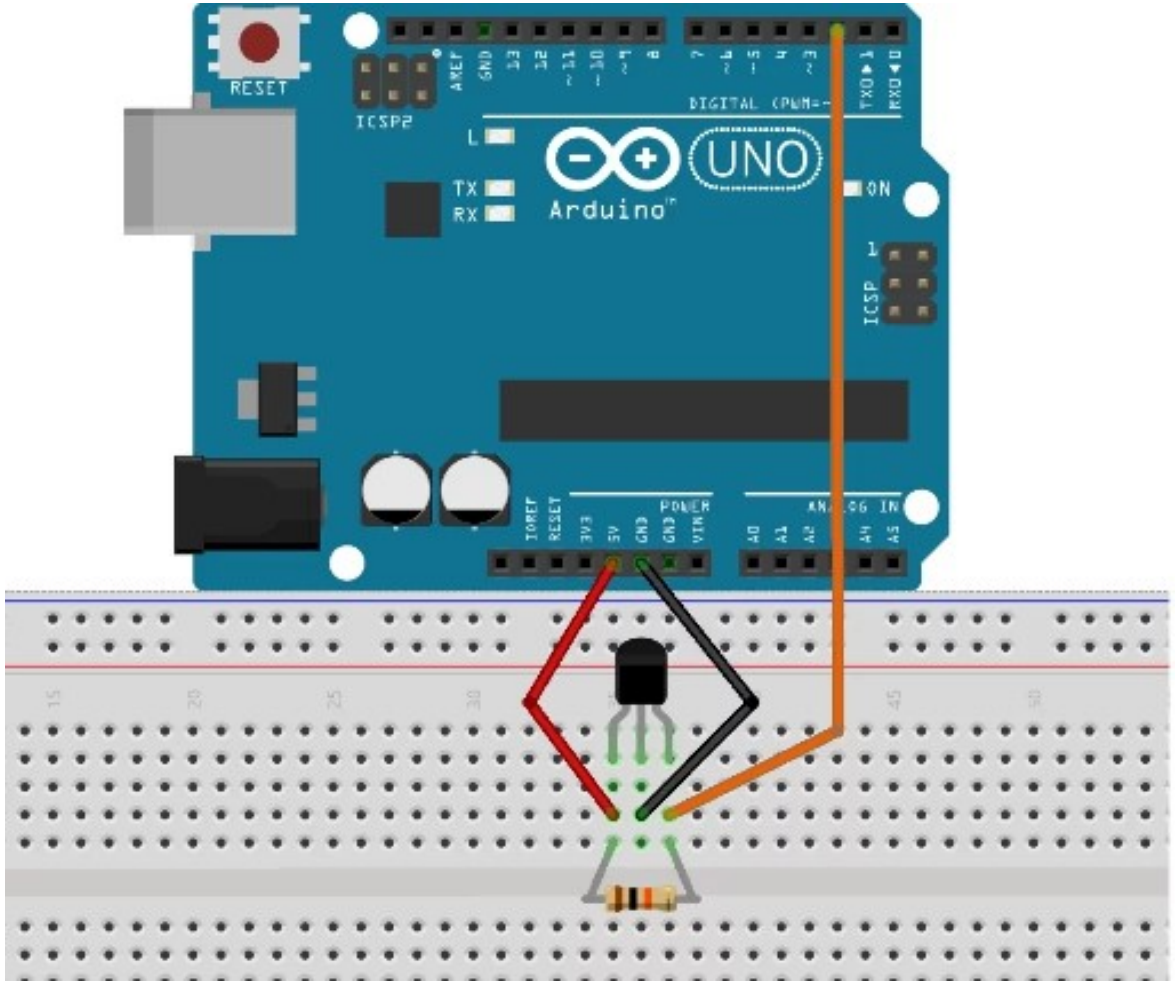


Making the Connections for the Arduino Hall Effect Sensor

Pin 1→ Vcc
Pin 2 → GND
Pin 3 → V_{out}

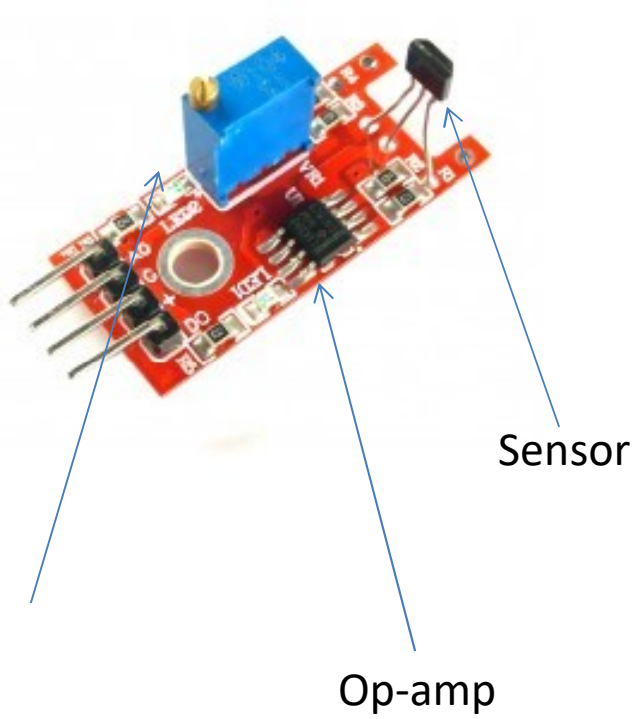
V_{out} → to pin 2 of Arduino

10K resistor is connected between the V_{CC} and V_{out}



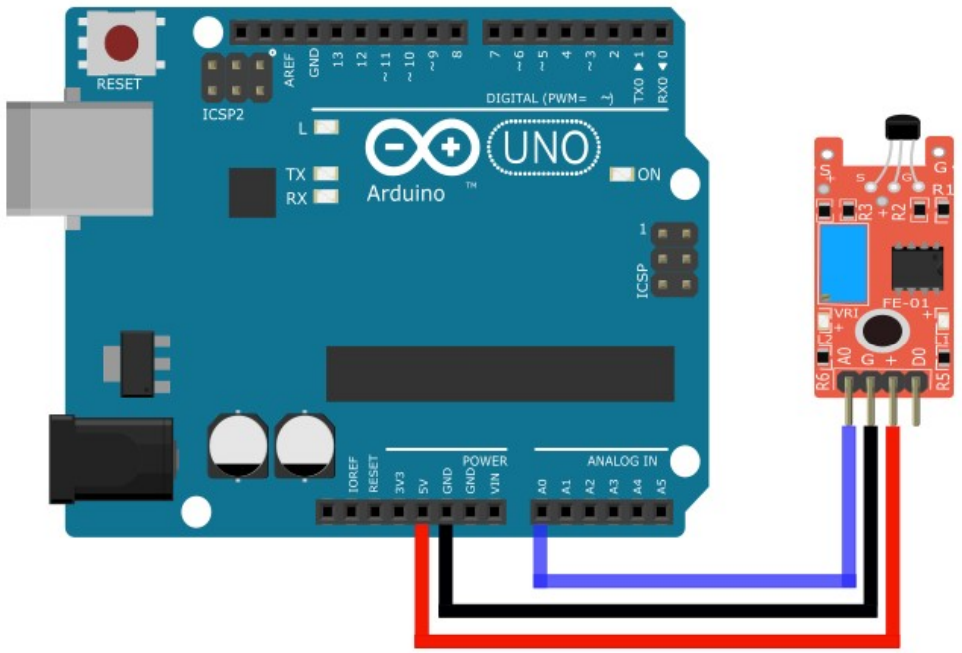
Linear analog Hall effect module

- Module (KY-024) has 4 pins
- It provide linear output values and are taken directly from the output of the operational amplifier with
- The output voltage is directly proportional to the magnetic field near the Hall sensor.



Interfacing

```
int inputVal = 0;
 void setup() {
Serial.begin(9600);
}
void loop() {
inputVal =analogRead(A0);

Serial.println(inputVal);
delay(1000);
}
```



KY-024	Arduino
A0	A0
G	GND
+	5V
D0	3

D0 is digital out pin. It can be used to read the status of near by Magnet , if present

Ultrasonic Sensors module

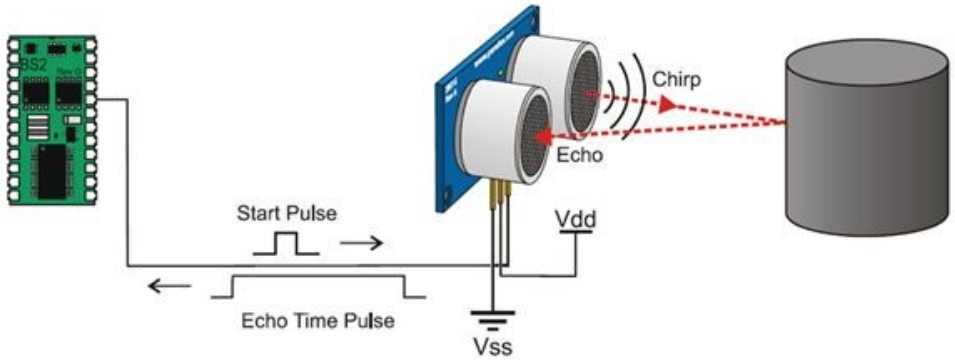
- Main features of Module
  - Power Supply :+5V DC
  - Working Current: 15mA
  - Ranging Distance : 2cm – 400 cm/1” – 13ft
  - Resolution : 0.3 cm
  - Measuring Angle: 30 degree
  - Trigger Input Pulse width: 10uS
- Ultrasonic Module has 4 pins:
  - VCC
  - Trig (input)
  - Echo (output)
  - Ground

Ultrasonic Sensors module: Working

- It emits an ultrasound at 40 kHz which travels through the air and if there is an object or obstacle on its path It will bounce back to the module.

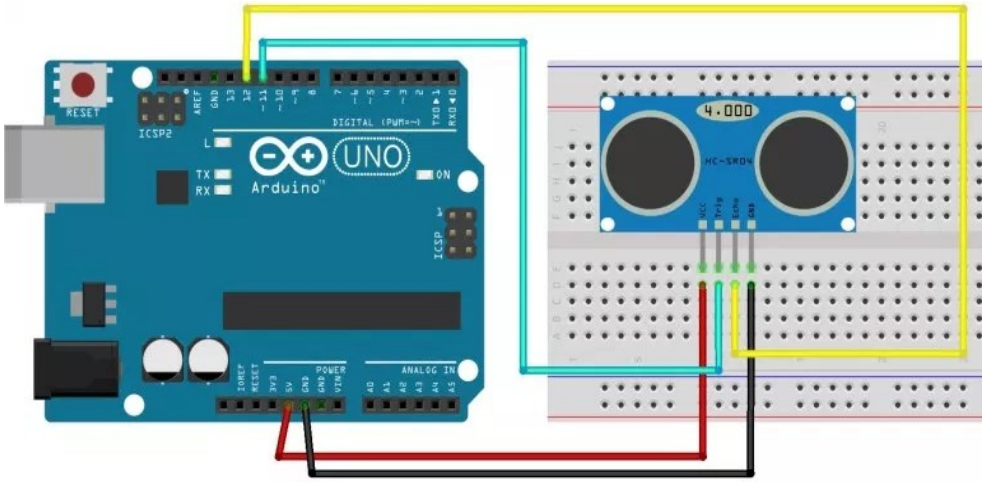
Applications:

1. Range finder
2. To measure distance,
3. Level measurement
4. Obstacle detection



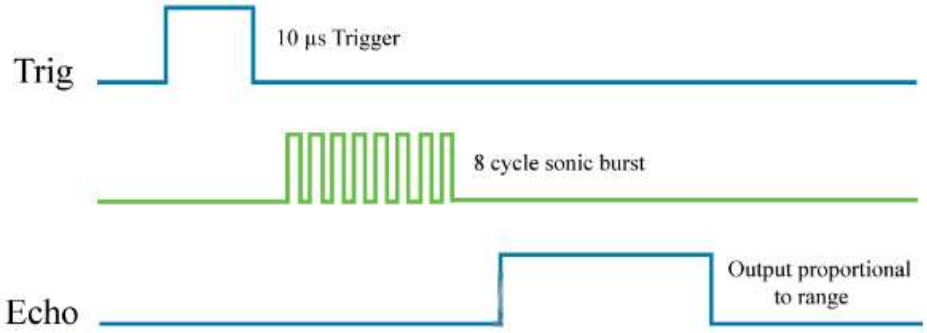
Interfacing with Arduino

Ultrasonic Sensor HC-SR04	Arduino
VCC	5V
Trig	Pin 11
Echo	Pin 12
GND	GND



Reading the duration

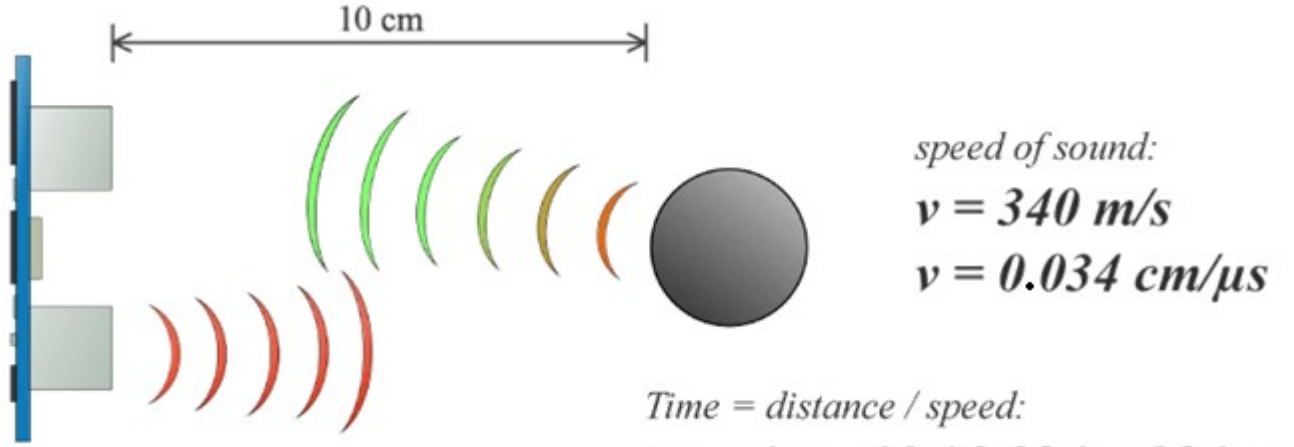
- In order to generate the ultrasound you need to set the Trig on a High State for 10 µs.
- That will send out an 8 cycle sonic burst which will travel at the speed of sound and it will be received in the Echo pin.
- The Echo pin will get the time in microseconds measured by 'pulsein' function




```
digitalWrite(trigPin, LOW);
delayMicroseconds(2);

// Sets the trigPin on HIGH state for 10 micro seconds
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
```

// Reads the echoPin, returns the sound wave travel time in microseconds
duration = pulseIn (echoPin, HIGH);

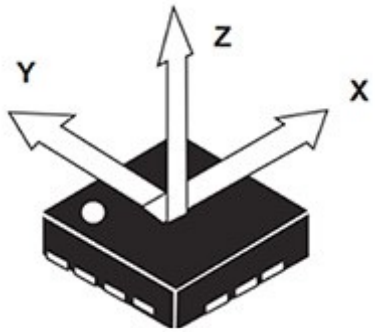
Ultrasonic Sensors module: Working




```
pinMode (echoPin, INPUT);
duration = pulseIn (echoPin, HIGH); // Convert the time into a distance

cm = (duration/2) / 29.4;          // Divide by 29.4 or multiply by 0.034
inches = (duration/2) / 74;        // Divide by 74 or multiply by 0.0135
```

Accelerometer

- **ADXL335** is a small, thin, low power, complete **3-axis accelerometer** with signal conditioned voltage outputs.
- The product measures acceleration with a minimum full-scale range of ±3 g.
- It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.

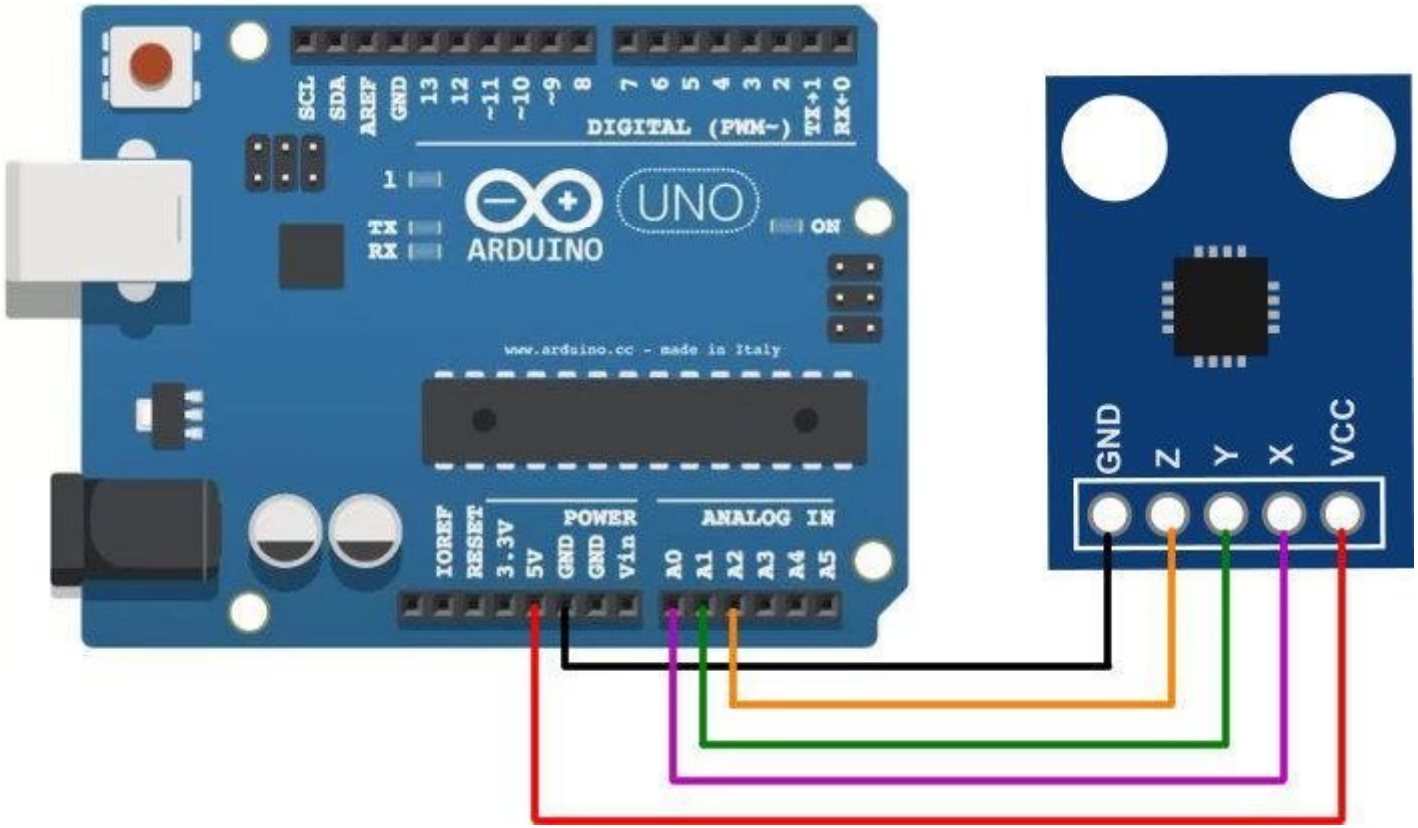


- ADXL335 is 3.3V compatible device.
- It has three outputs for each axis i.e. X, Y & Z. These are analog outputs and thus require an ADC in a micro-controller/Arduino.

Accelerometer

- The accelerometer module has 5 pins, namely GND-To be connected to Arduino's GND
- VCC-To be connected to Arduino's 5V
- X-To be connected to Analog Pin A0
- Y-To be connected to Analog Pin A1
- Z-To be connected to Analog Pin A2

Accelerometer



Accelerometer Interfacing Code

- x_g_value = ((((double)(x_adc_value * 5)/1024) - 1.65) / 0.330);
- /* Acceleration in x-direction in g units */

- y_g_value = ((((double)(y_adc_value * 5)/1024) - 1.65) / 0.330);
- /* Acceleration in y-direction in g units */

- z_g_value = ((((double)(z_adc_value * 5)/1024) - 1.80) / 0.330);
- /* Acceleration in z-direction in g units */

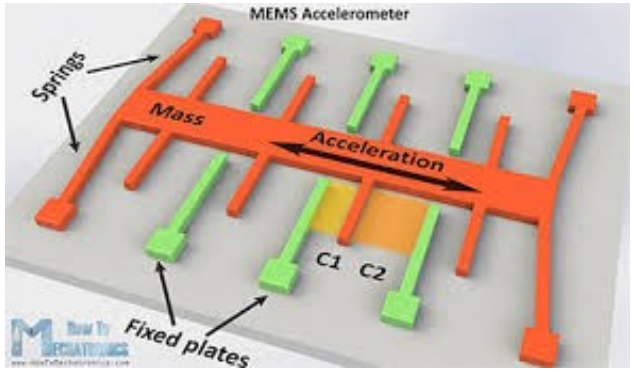
330 mV/g is the sensitivity of sensor

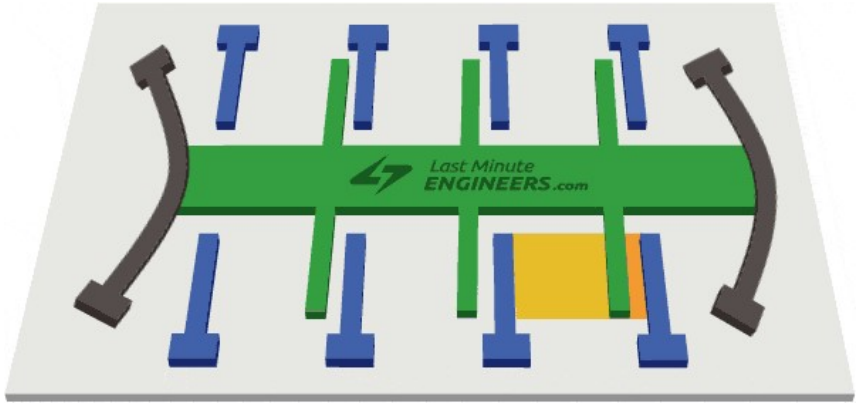
- roll = (((atan2(y_g_value,z_g_value) * 180) / 3.14) + 180);

- pitch = (((atan2(z_g_value,x_g_value) * 180) / 3.14) + 180);

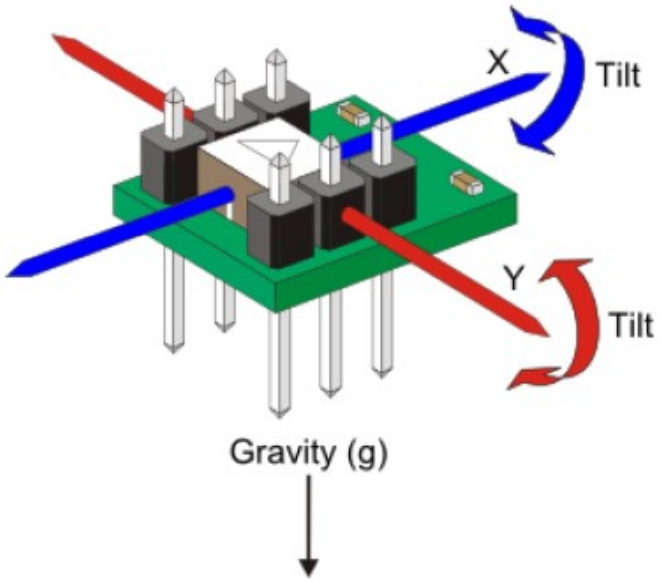
MEMS based Accelerometer

- Micro Electro Mechanical System (MEMES) based sensors have made using IC fabrication techniques.
- Miniature in size, fully functional
- Low power requirement



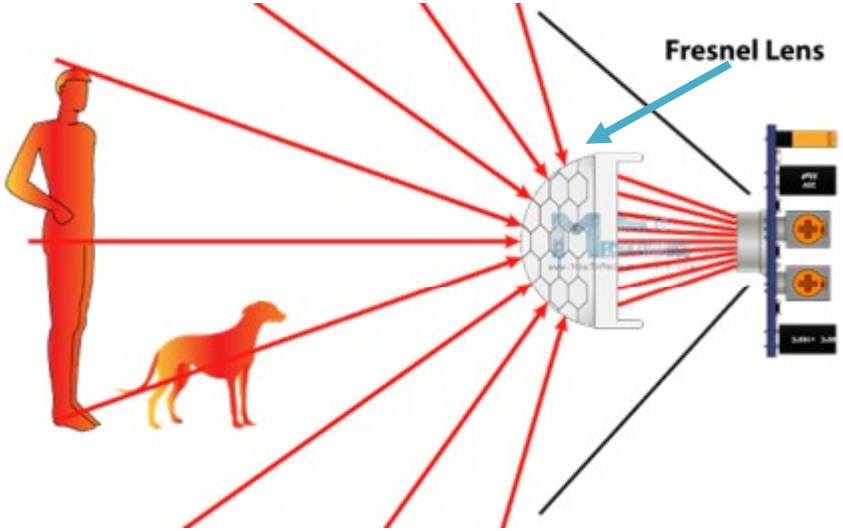


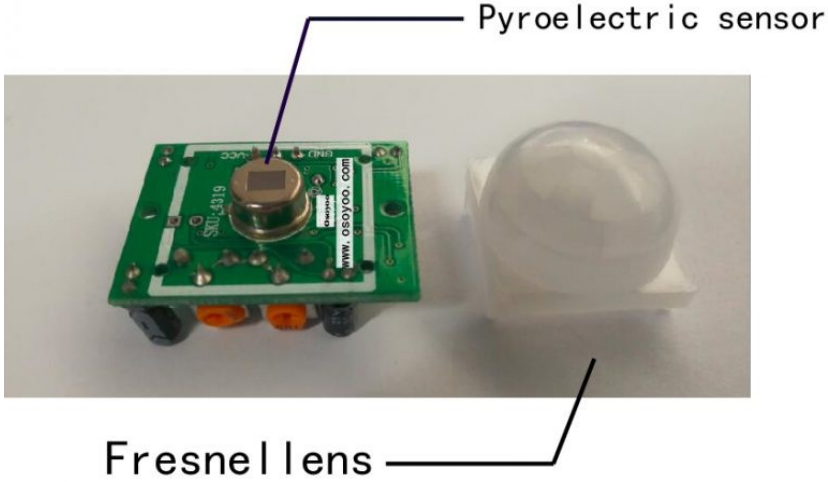
Movement in a given direction will cause change in Capacitance which can be measured in terms if change in X,Y or Z coordinates



PIR Motion Sensor

Pyroelectric or Passive Infra Red sensor HC-SR501

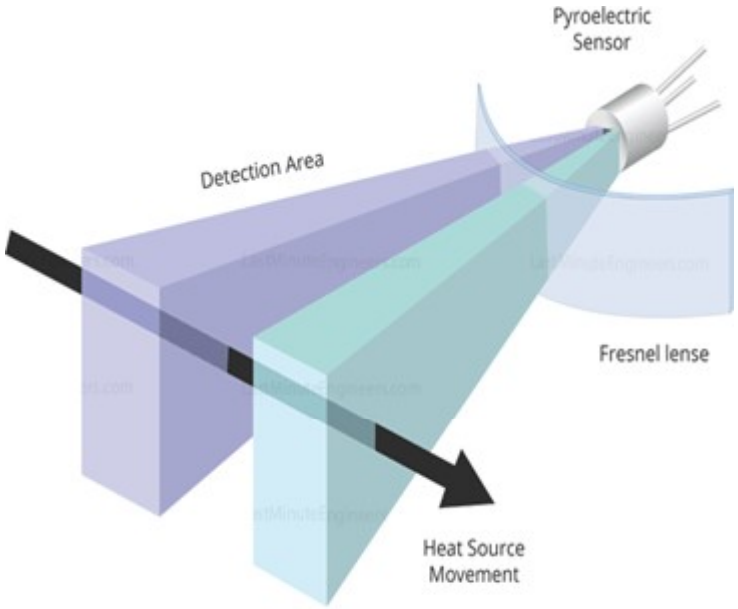


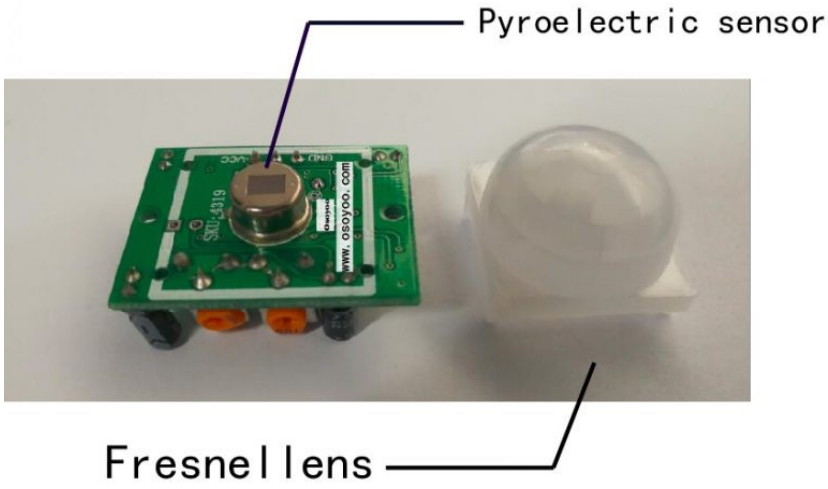


Principle: All objects with a temperature above Absolute Zero (0 Kelvin) emit heat energy in the form of infrared radiation, including human bodies. The hotter an object is, the more radiation it emits.
PIR sensor is specially designed to detect such levels of infrared radiation.

It basically consists of two main parts: A Pyroelectric Sensor and A special lens called Fresnel lens which focuses the infrared signals onto the pyroelectric sensor.

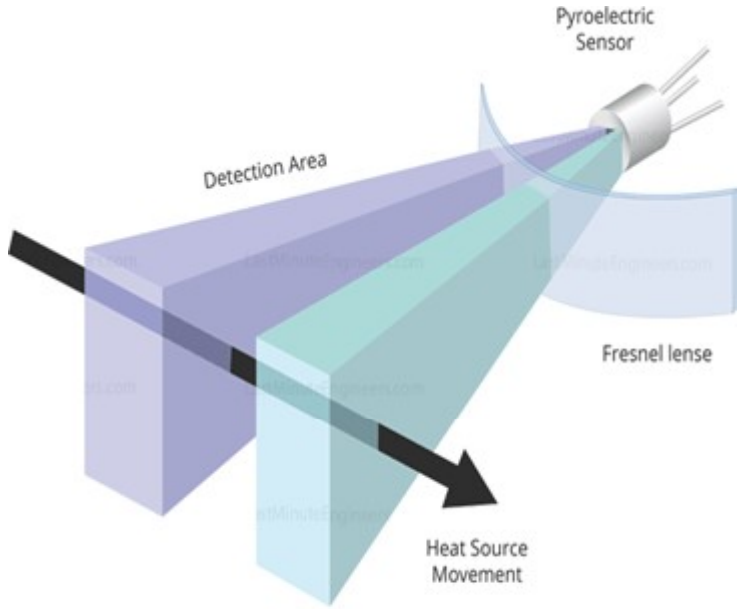
How it works

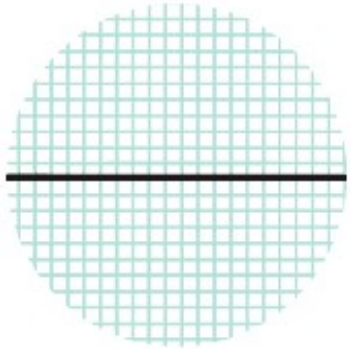




A Pyroelectric Sensor actually has two rectangular slots in it made of a material that allows the infrared radiation to pass.
Behind these, are two separate infrared sensor electrodes, one responsible for producing a positive output and the other a negative output.

How it works





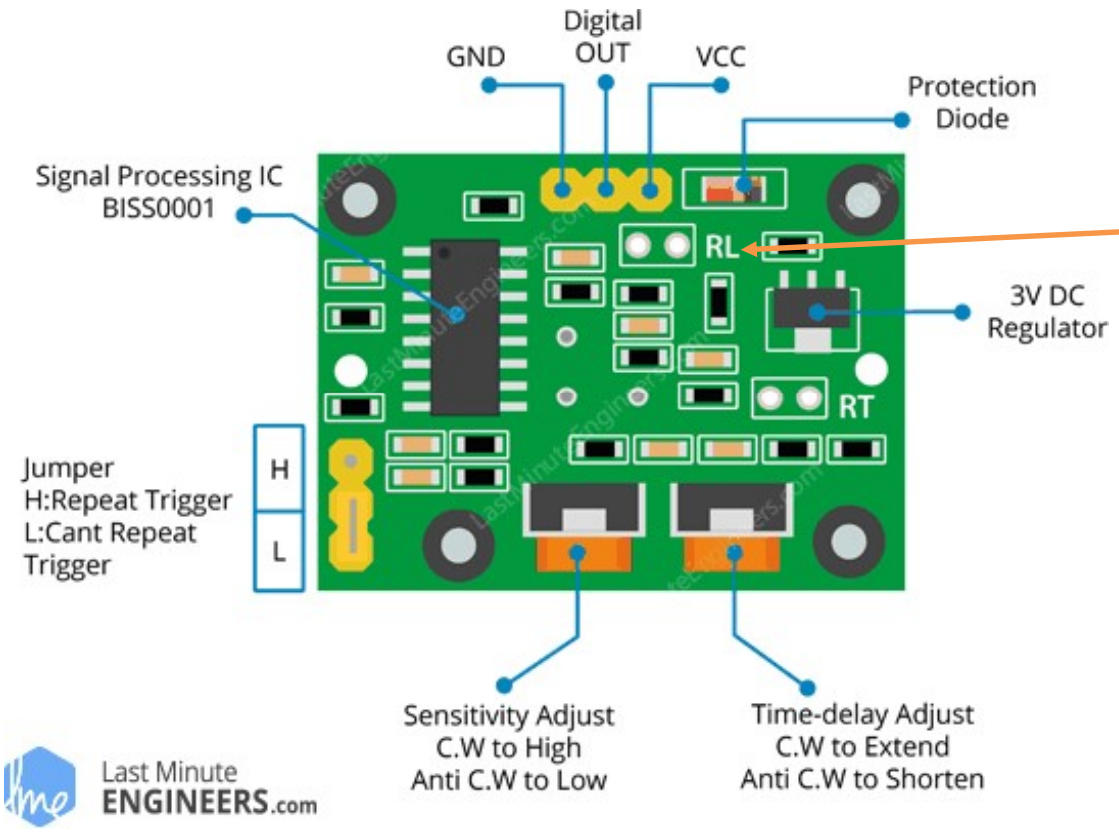
1. When the sensor is idle, i.e. there is no movement around the sensor; both slots detect the same amount of infrared radiation, resulting in a zero output signal.

2. But when a warm body passes by; it first intercepts one half of the PIR sensor, which causes a positive differential change between the two halves.

3. When the warm body leaves the sensing area, the reverse happens, the sensor generates a negative differential change.

4. The corresponding pulse of signals results in the sensor setting its output pin high.

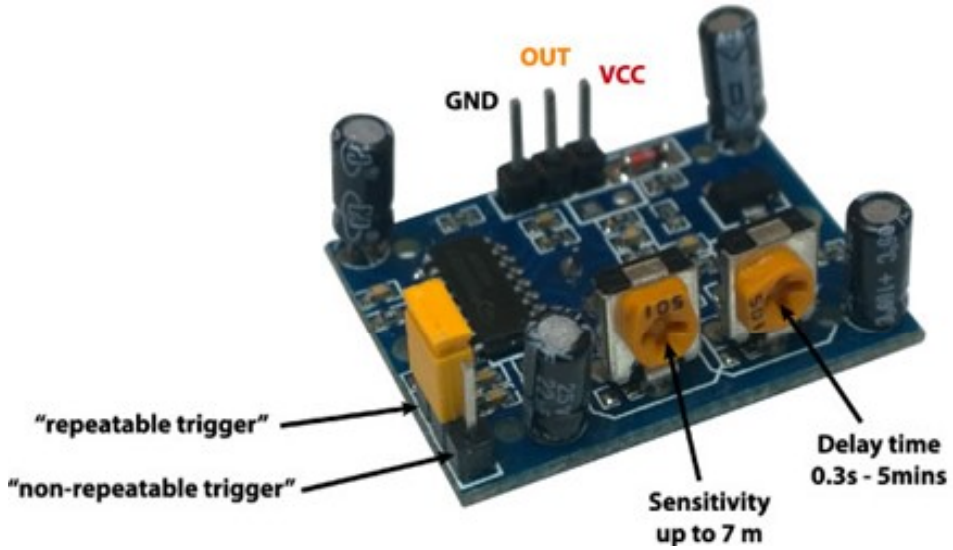
Whats on the board ?



To connect LDR .
Makes it more versatile

Working Modes

An output pin which gives high logic level if an object is detected



The module has three more pins with a jumper between two of them.
These pins are for selecting the **trigger modes**.
The first one is called "non-repeatable trigger" and works like this: when the sensor output is high and the delay time is over, the output will automatically change from high to low level.
The other mode called "repeatable trigger" will keep the output high all the time until the detected object is present in sensor's range.

Settings

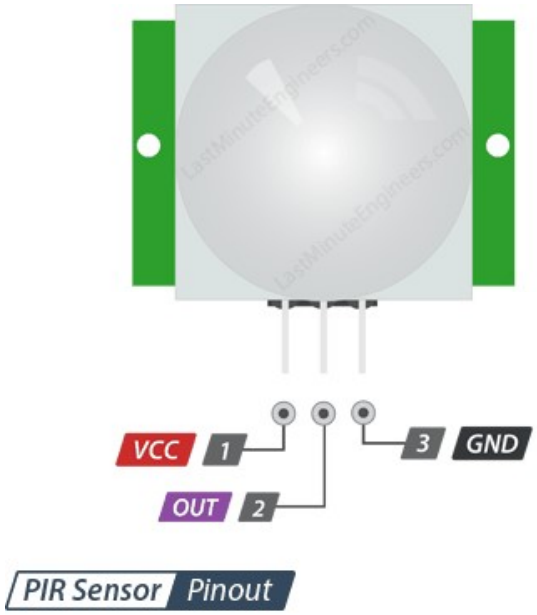
Counter-Clockwise or Left	Clockwise or Right
Increases Sensitivity. Fully left and the range will be approximately 7 meters.	Decreases Sensitivity. Fully right and the range will be approximately 3 meters.

- Sensitivity setting from 3m to 7m (Range)

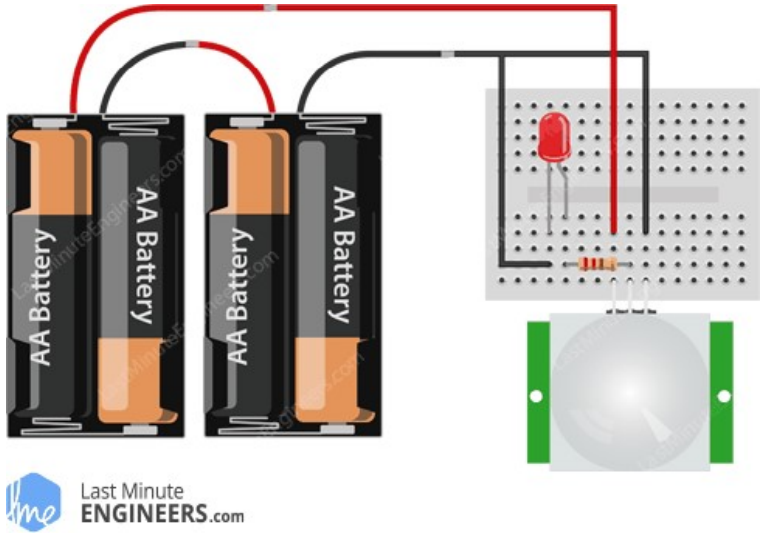
Counter-Clockwise or Left	Clockwise or Right
Decreases Delay Time. Fully left and the delay will be approximately 5 seconds.	Increases Delay Time. Fully right and the delay will be approximately 5 minutes.

- Delay time setting from 0.3 sec to 5 min. determines how long the output of the PIR sensor module will remain high after detection motion

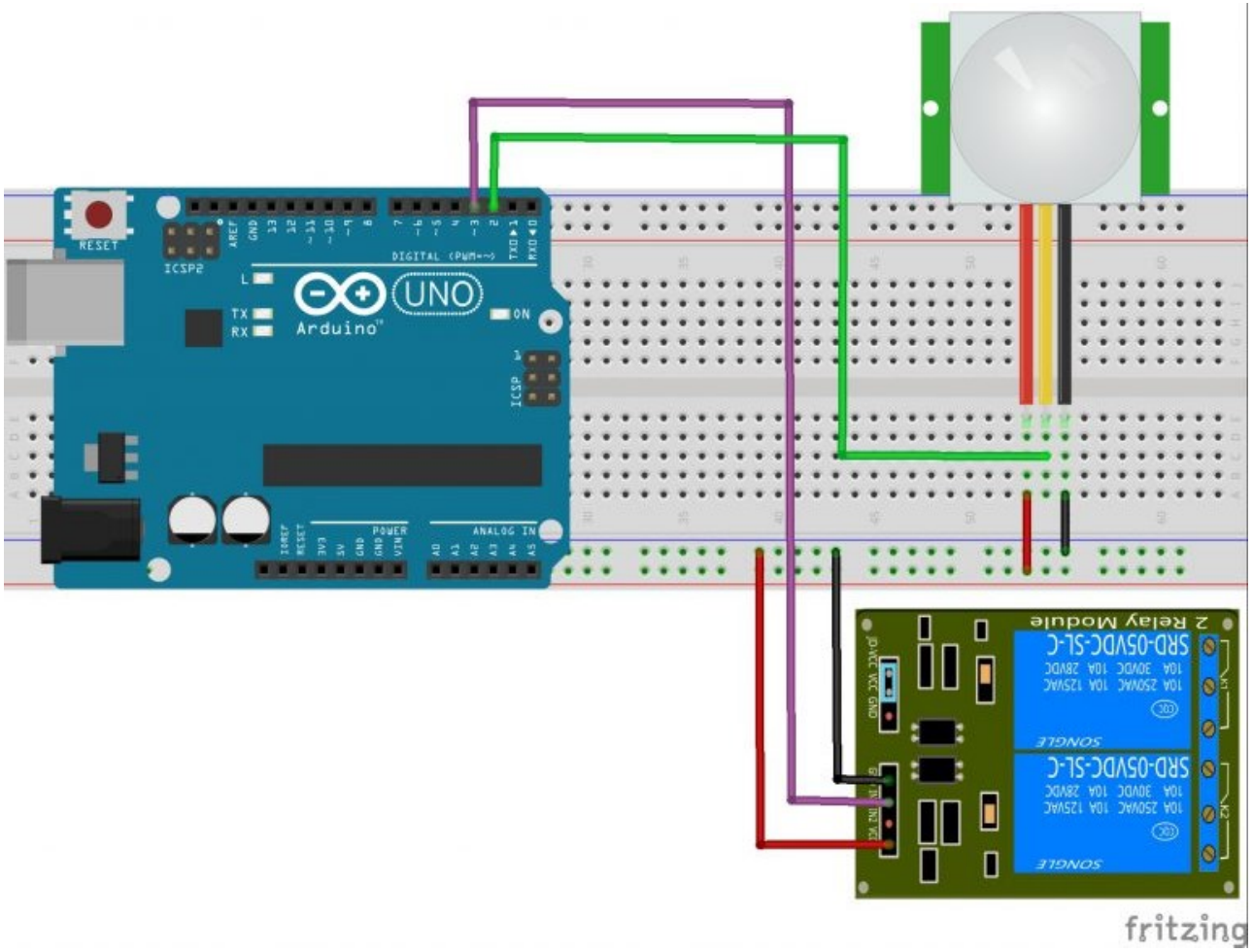
Interfacing of module

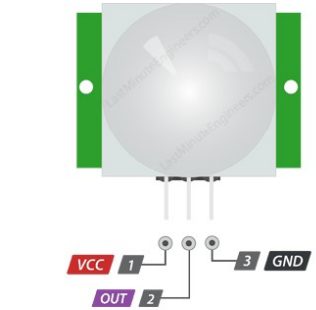


- Basic testing circuit



Interfacing with Arduino



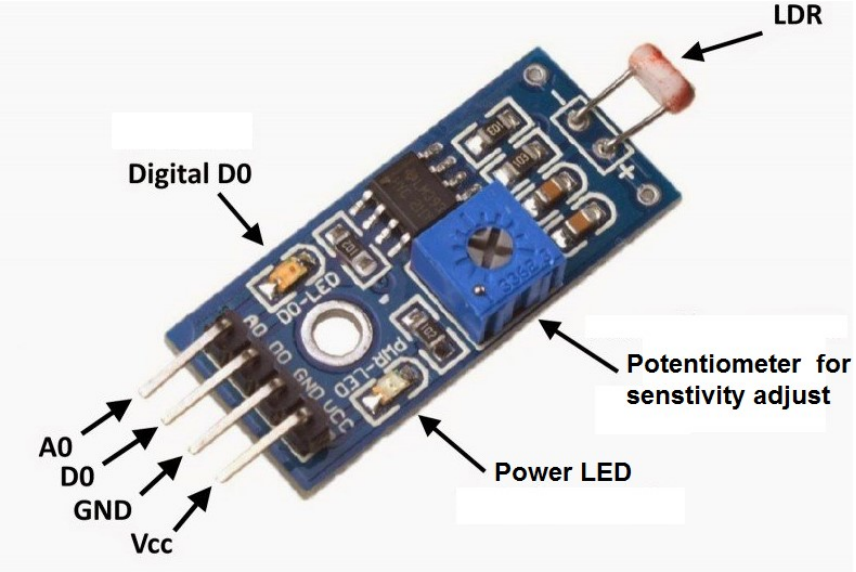


Arduino Code to operate Relay

```
int pirSensor = 2;
int relayInput = 3;
void setup() {
pinMode(pirSensor, INPUT);
pinMode(relayInput, OUTPUT);
}
void loop() {
int sensorValue = digitalRead(pirSensor);
if (sensorValue == 1) {
digitalWrite(relayInput, LOW); // The Relay Input works Inversly
}
}
```

LDR KY 018 Module

- Light dependent resistor
- Resistance decrease with increase in light
- As light photons fall on LDR surface, conduction increases and thus resistance decreases.

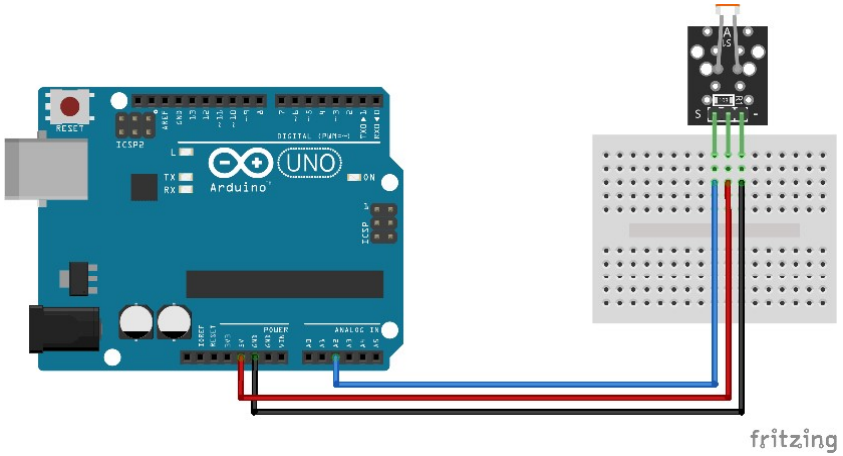


LDR interfacing

KY-018 Connection Diagram

Connect the Power line (middle) and ground (-) to +5 and GND respectively. Connect signal (S) to pin A2 on the Arduino.

KY-018	Arduino
S	Pin A2
middle	+5V
-	GND

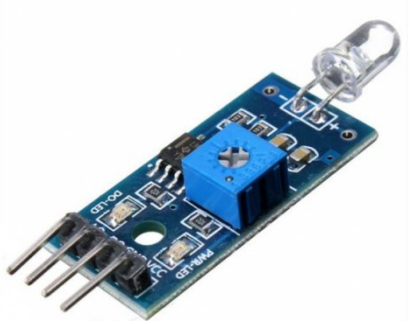


Arduino code

```
int sensorPin =A2; //define analog pin 2
int value = 0;

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

void loop() {
    value = analogRead(sensorPin);
    Serial.println(value);


    delay(100);
}
```

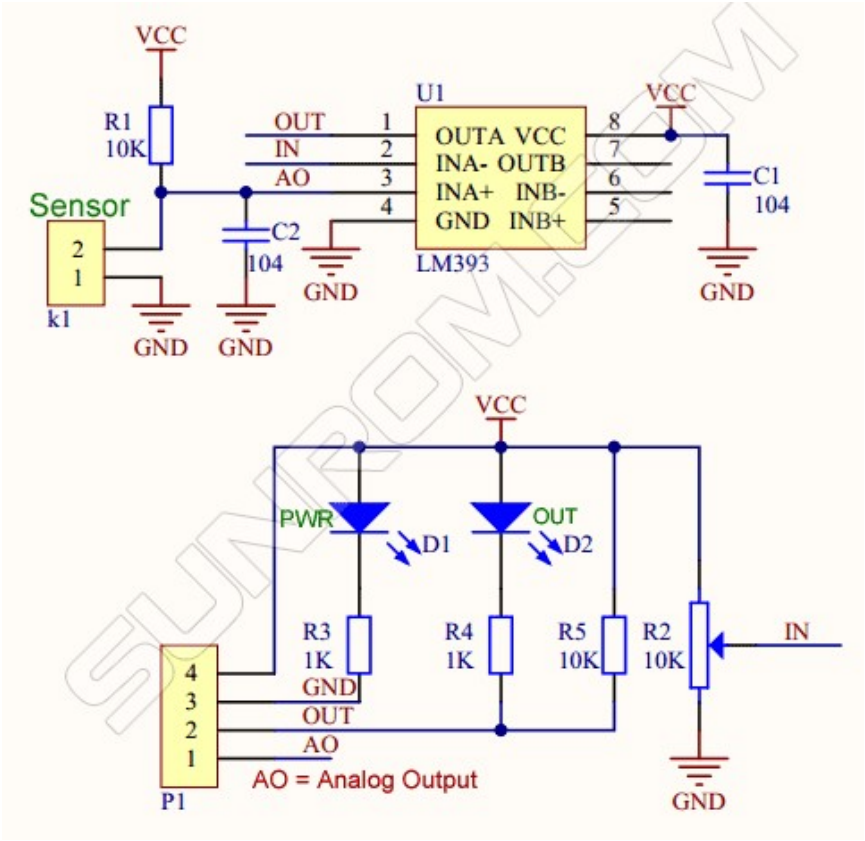
Photo diode Module

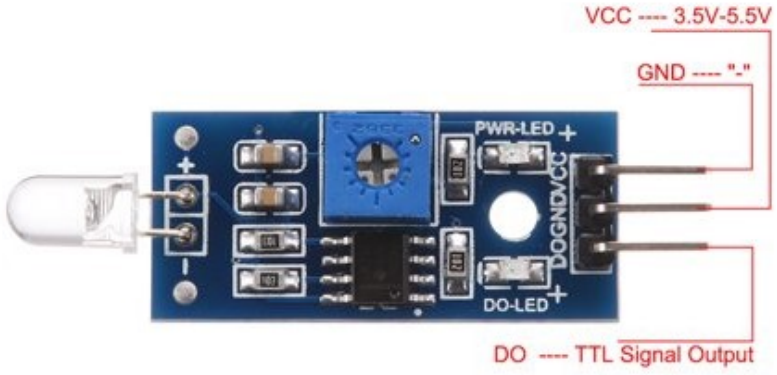
- Photodiode is a semiconductor which has a P-N junction, operated in **Reverse bias**, means it start conducting the current in reverse direction when Light falls on it, and the amount of current flow is proportional to the amount of Light.



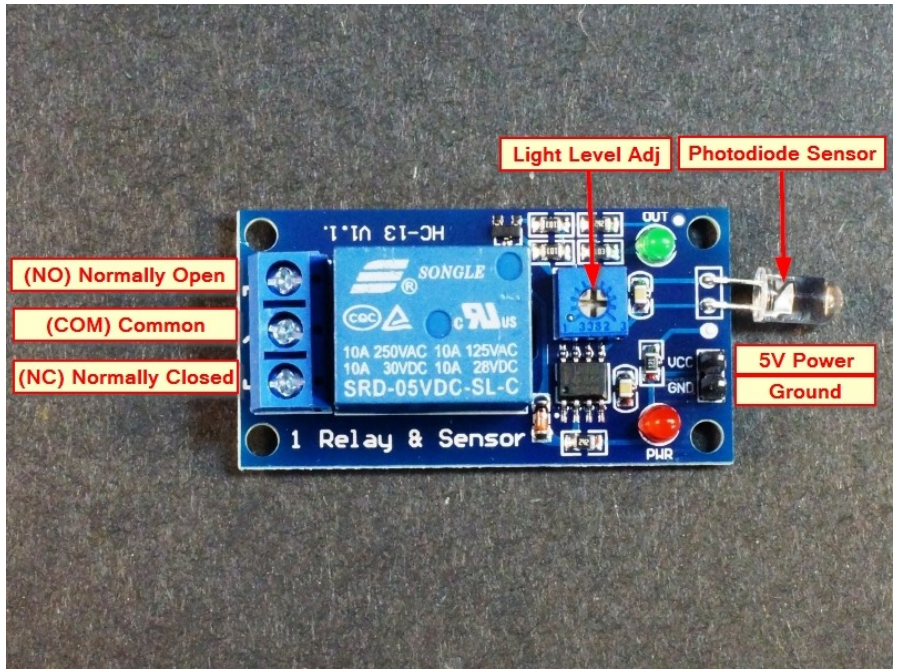
- Difference between LDR and PD is that photodiode module is direction sensitive
- It can be used to perceive the fixed direction of the light source.

Pinout and circuit diagram





Another version of module



- Photodiode operated Relay module.
- To control electrical appliances with a pointed light source (LASER)

MQ-2 Gas sensor/Smoke sensor

- MQ2 is one of the commonly used gas sensors in MQ sensor series.
- It is a Metal Oxide Semiconductor (MOS) type Gas Sensor also known as Chemiresistors.

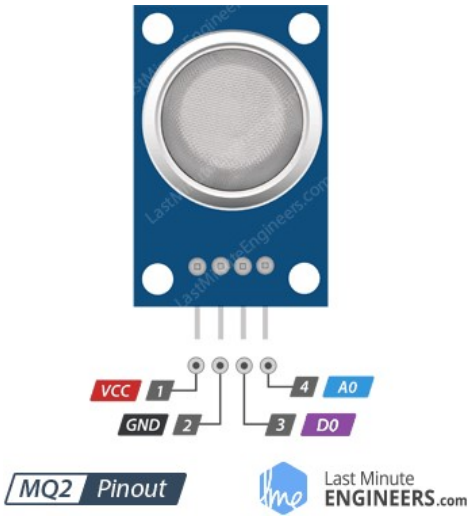
- The detection is based upon change of resistance of the sensing material when the Gas comes in contact with the material.
- Using a simple voltage divider network, concentrations of gas can be detected.

sensitive following flammable gases:

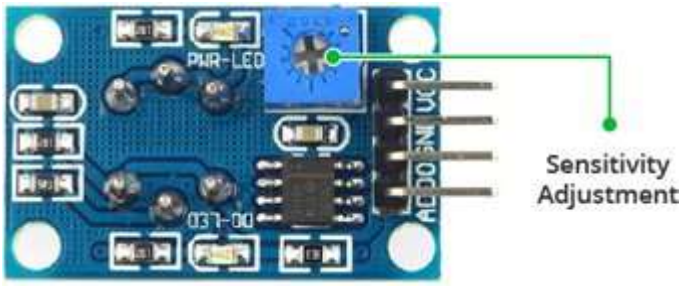
LPG
Butane
Propane
Methane
Alcohol
Hydrogen

The resistance of the sensor is different depending on the type of the gas.

Specifications and Pinout



Operating voltage	5V
Load resistance	20 KΩ
Heater resistance	33Ω ± 5%
Heating consumption	<800mw
Sensing Resistance	10 KΩ – 60 KΩ
Concentration Scope	200 – 10000ppm
Preheat Time	Over 24 hour

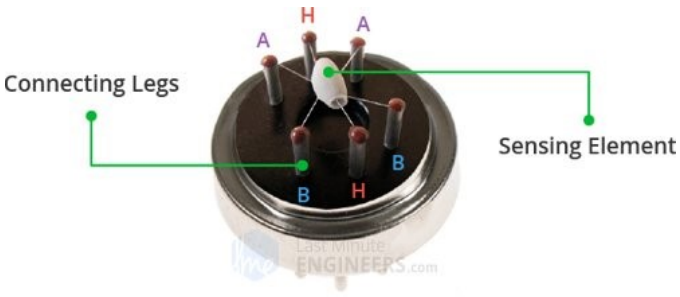


The sensor module has a built-in potentiometer that allows to adjust the sensor sensitivity.

Internal structure of MQ2 Gas Sensor

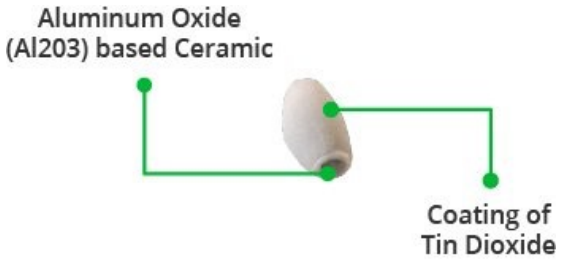
- The sensor is enclosed in two layers of fine stainless steel mesh called Anti-explosion network.
- It ensures that heater element inside the sensor will not cause an explosion, as we are sensing flammable gases.

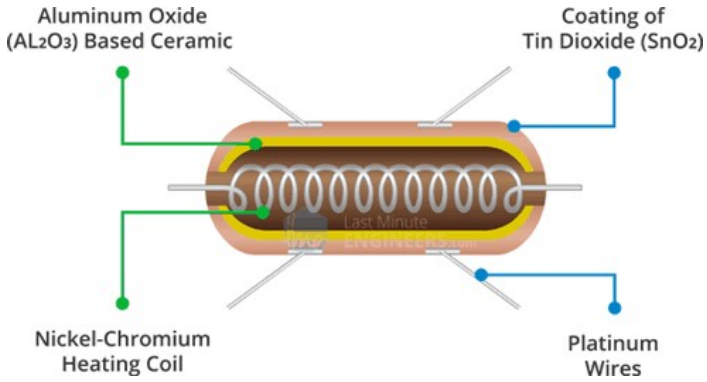
- It also provides protection for the sensor and filters out suspended particles so that only gaseous elements are able to pass inside the chamber.
- The star-shaped structure is formed by the sensing element and six connecting legs that extend beyond the Bakelite base.
- Out of six, two leads (H) are responsible for heating the sensing element and are connected through Nickel-Chromium coil, well known conductive alloy.



Internal structure of MQ2 Gas Sensor

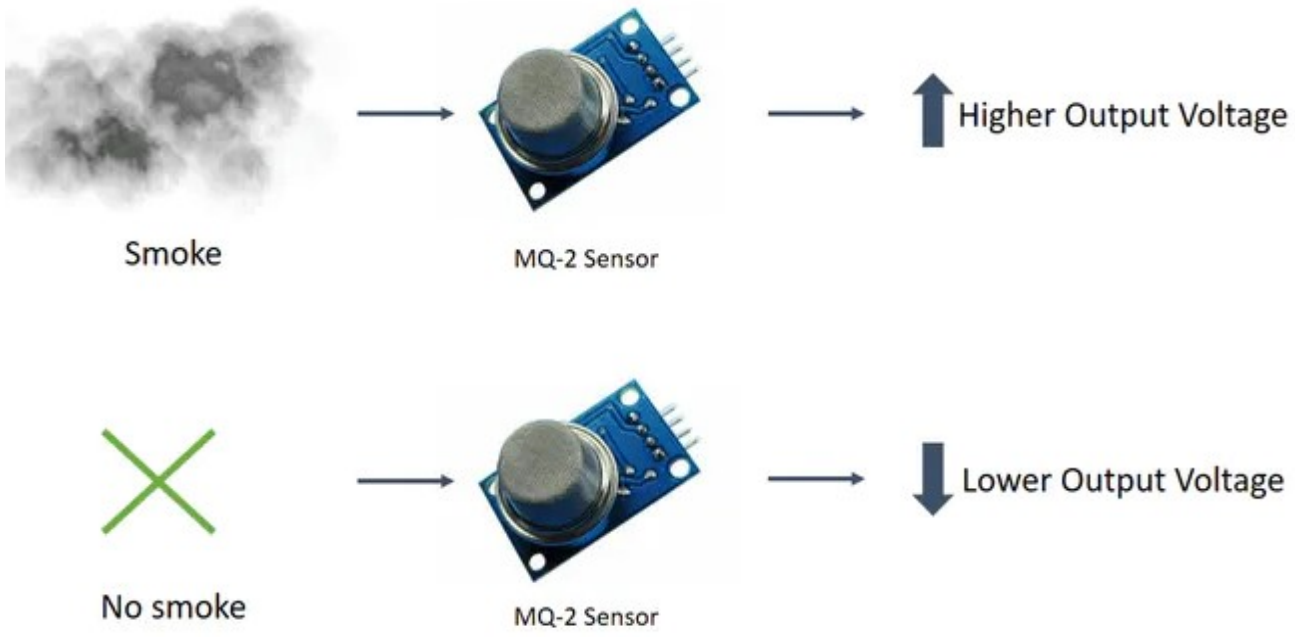
- The tubular sensing element is made up of Aluminum Oxide (AL_2O_3) based ceramic and has a coating of Tin Dioxide (SnO_2). The Tin Dioxide is the most important material being sensitive towards combustible gases. However, the ceramic substrate merely increases heating efficiency and ensures the sensor area is heated to a working temperature constantly.
- The remaining four leads (A & B) are for output signals are connected using Platinum Wires. These wires are connected to the body of the sensing element and convey small changes in the current that passes through the sensing element.
- So, the Nickel-Chromium coil and Aluminum Oxide based ceramic forms a Heating System; while Platinum wires and coating of Tin Dioxide forms a Sensing System.





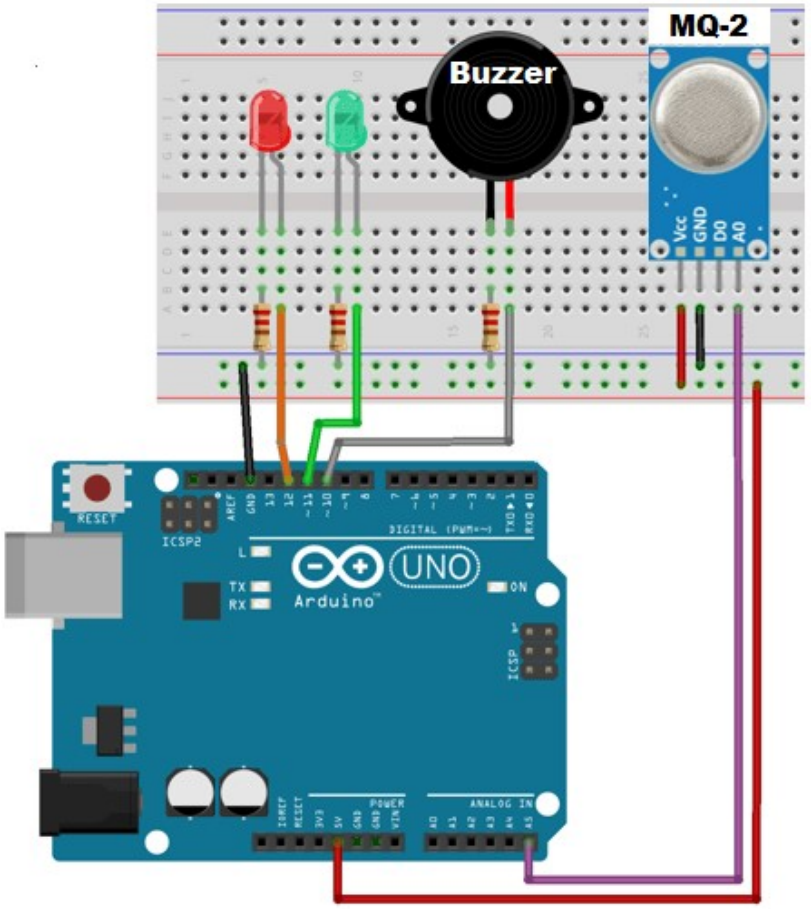
How it Works?

- The output voltage changes accordingly to the smoke/gas level that exists in the atmosphere.
- voltage is proportional to the concentration of smoke/gas.
- The greater the gas concentration, higher the output voltage
- The lower the gas concentration, lower the output voltage



Circuit diagram

PIN	Function
A5	A0 of MQ-2
10	Buzzer
11	LED Green
12	LED Red
GND	GND
Vcc	Vcc
D0 not connected	



Arduino Code

```
int redLed = 12;
int greenLed = 11;
int buzzer = 10;
int smokeA0 = A5;

int sensorThres = 400;                    // threshold value

void setup() {
  pinMode(redLed, OUTPUT);
  pinMode(greenLed, OUTPUT);
  pinMode(buzzer, OUTPUT);
  pinMode(smokeA0, INPUT);
  Serial.begin(9600);
}
```

```
void loop() {
  int analogSensor = analogRead(smokeA0);

  Serial.print("Pin A0: ");
  Serial.println(analogSensor);
  // Checks if it has reached the threshold value
  if (analogSensor > sensorThres)
  {
    digitalWrite(redLed, HIGH);
    digitalWrite(greenLed, LOW);
    tone(buzzer, 1000, 200);
  }
  else
  {
    digitalWrite(redLed, LOW);
    digitalWrite(greenLed, HIGH);
    noTone(buzzer);
  }
```

References

- https://learn.sparkfun.com/tutorials/adxl337-and-adxl377-accelerometer-hookup-guide/all
- https://lastminuteengineers.com

References

- https://youtu.be/QSIPNhOiMoE
- https://learn.sparkfun.com/tutorials/adxl337-and-adxl377-accelerometer-hookup-guide/all
- https://www.analog.com/en/analog-dialogue/articles/choosing-the-most-suitable-mems-accelerometer-for-your-application-part-1.html#