NED University of Engineering & Technology

Electrical Engineering Department

Project Name:

IR MODULE WITH APPLICATION

Submitted By :

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CLASS:	**SECOND YEAR**
SECTION:	**B (ELECTRICAL)**
BATCH:	**2021**
COURSE TITLE:	**INSTRUMENTATION AND MEASUREMENTS**
COURSE CODE:	**EE-223**

OBJECTIVE:

To design an IR module (IR sensor circuit) with an extended circuit for its application.

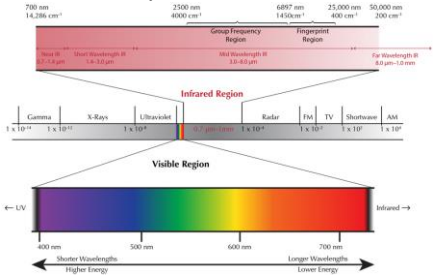
INTRODUCTION:

Low power, high impedance, response time, and improvement in sensitivity was the main problem in detecting objects in earlier generations. IR technology has made it simple for the world to operate their needs on less power, in quick time, economical profit, and high efficiency. IR sensors can provide various applications in different sectors of life. This IR technology is supported by wireless technology which has greatly reduced the human efforts.

IR SENSOR:

An IR (Infrared) sensor is an electronic device that can track Infrared Radiations from its surroundings and generates electric signals at the output accordingly. These Infrared Radiations are invisible to the naked eye. An IR sensor can measure both, movement as well as heat of a body.

The range of infrared region is 700 nm (0.7µm) -1 mm and it consists of three parts:



- Near Infrared (NIR): This region ranges from approximately 700 nm to 1,400 nm in wavelength. It is often used in applications such as remote controls, fibre optics, and near-infrared spectroscopy.
- Mid Infrared (MIR): This region ranges from approximately 1,400 nm to 25,000 nm (or 25 micrometres) in wavelength. It finds applications in thermal imaging, gas sensing, and spectroscopy.
- Far Infrared (FIR): This region ranges from approximately 25,000 nm to 1 mm in wavelength. It is commonly utilized in applications such as heat detection, thermal cameras, and astronomy.

WORKING PRINCIPLE:

An IR sensor is based on two parts, one is IR transmitter and the other is IR receiver. IR transmitter is basically an IR led which works like a simple led but emits light only in infrared spectrum. IR receiver is a photodiode. The sensor can also be called as a photodiode being sensitive to infrared light. Means photodiode does not come into working by applying voltages until unless an infrared light is made to fall on it. In other words, we can say that photodiode acts as an open circuit (infinite resistance) when received no signals. But as soon as they receive signals, the resistance starts to drop and current flows through it. The resistances and output voltages of the circuit are directly proportional to the magnitude of infrared light. By combining these two, a photo-coupler / opto-coupler can be formed. The laws of physics supported by this sensor are as follows:

PLANCK'S RADIATION LAW:

Objects having temperature not equal to absolute zero (0 Kelvin) will emit radiations.

STEPHAN BOLTZMANN LAW:

The total energy emitted at all wavelengths by a black body is related to the absolute temperature.

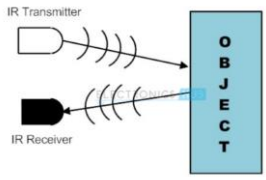
WEIN'S DISPLACEMENT LAW:

Objects of different temperature emit spectra that peak at different wavelengths that is inversely proportional to temperature.

WORKING OF THE CIRCUIT:

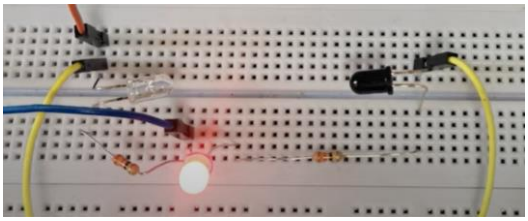
The circuit can only be operated when the wavelengths of both, IR transmitter and receiver would match. The Photodiode is functioned by striking Infrared radiations on it which are transmitted from an Infrared led. Note that this photodiode is different from the normal one (means that it will only detect Infrared radiations. We used an IR phototransistor (IR photodiode) but as it comes under the category of Photodiodes, so we can also simply call it a photodiode).

When the transmitter makes emission and it arrives at the object, some of the emissions will reflect towards the receiver. The output of the sensor can be decided by the receiver, depending on the intensity level of the response.

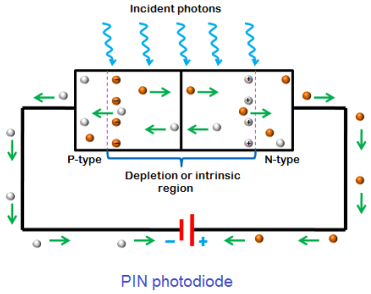


The type of circuit we would be designing is known as active infrared sensor as it contains two parts, IR Transmitter and IR Receiver, in major.

SIMPLE IR TRANSMITTER AND RECIEVER CIRCUIT:



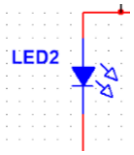
In this circuit, we connected resisters with both, IR Led and IR photodiode, in series, for current protection. The +ve terminal of IR led is common with the –ve terminal of photodiode and 5 volts are given to that common node. IR led is forward biased and the photodiode is reverse biased. (This is because initially when we apply voltages to this circuit, the opposite polarities of photodiode and supplied voltages causes electrons to flow. Some amount of current flows through the photodiode which is called transient current, which stops to flow further when the potential barrier of photodiode becomes equal to the voltages supplied, thus acting as an open path. When IR waves fall on photodiode, it makes the current to flow in opposite direction. That's why we connected it in reverse biasing situation). A normal led is connected in series with the resistor at receiver side to indicate the output signals.



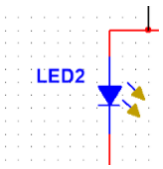
Right now, the IR led and photodiode are facing each other so maximum signals are being transmitted from transmitter to receiver and led is glowing. But when any object crosses the path of infrared signals or creates interference, then the path of signals will be completely blocked and there would be no current at output side, means led would not glow. And from here, comes the concept of Object detection using IR sensors.

SIMULATION (ON MULTISM):

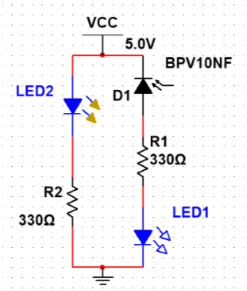
When IR LED is OFF



When IR LED is ON



Circuit of IR Transmitter and Receiver:



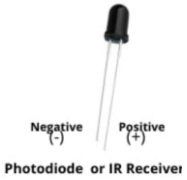
OBSTACLE SENSING CIRCUIT / IR SENSOR CIRCUIT:

The simple concept of an infrared sensor being implemented in an obstacle detector circuit is to transmit infrared signals. These infrared signals, when strike on reflective surface, bounce back towards an infrared receiver where these signals are received.

COMPONENTS USED:

IR LED:

PHOTODIODE:



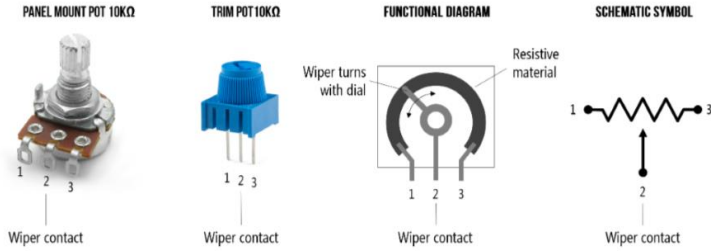
→ An IR phototransistor is a specialized type of photodiode that is designed to detect infrared light. IR phototransistors offer a higher sensitivity and faster response time compared to regular photodiodes, making them well-suited for motion detection and proximity sensing applications.

IC LM358:

This LM358 IC is an OP-AMP (operational amplifier) which usually amplifies the input signals. But this OP-AMP is different from the others. Means that this IC can take 2 different inputs (each of the two inputs have inverting and non-inverting terminals), then acts as a comparator (means compares the voltage levels of the 2 inputs) and gives 2 different outputs at different terminals accordingly.

POTENTIOMETER (10kΩ):

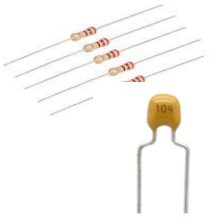
A potentiometer of value 10kΩ resistance is taken to vary the voltage levels at the input side of Op-Amp. Basically, it is built in circuits for adjustable range of the IR sensors.



PIN 1: VCC
PIN2:OUT
PIN 3: GND

CURRENT LIMITING RESISTORS (2x100Ω, 220Ω)

These resistors are used in series with IR Led and Indicating Leds to limit the current flow.



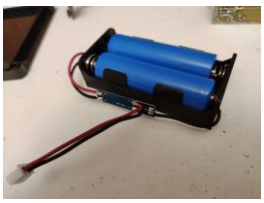
NON-POLAR CAPACITORS (2x 0.1 µF)

A non-polar capacitor or non-polarized capacitor is a two terminal electrical component, also known as non-electrolytic capacitor that stores charges in an electric field between its metal plates. It is made up of two metal plates (electrodes) having no polarities, i.e., both the plates are same. We used two 0.1µF ceramic capacitors near the Op-Amps input & output. Basically, these capacitors will block DC but if there exists any impedance or any other factor that could lead to voltage spikes, so these capacitors will filter out those fluctuations and make the DC signal smoother. Thus, protecting our Op-Amp from damaging due to voltage spikes and making its output more efficient.

VOLTAGE DIVIDING RESISTOR (10KΩ)

This resistor is connected in series with the photodiode for protection and also to set voltage level for the non-inverting (pin 3) of Op-Amp. Means whenever the photodiode allows current to pass through it, its voltage begins to drop and the voltage drop across the resistor starts increasing which is provided to the input of Op-Amp for comparison.

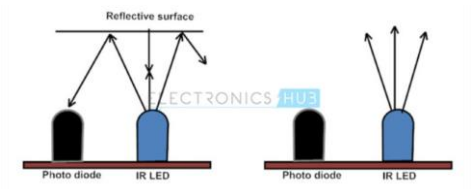
GREEN LED (for power on indication)
RED LED (for output indication)



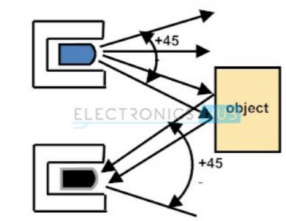
8V DC SUPPLY

WORKING PRINCIPLE:

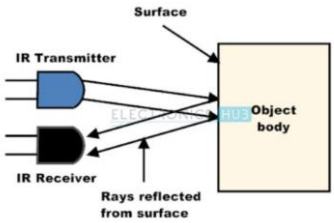
As we are concerned with the fact that black bodies completely absorb the radiations incident on it, and white bodies completely reflect the radiations incident on it. Using this principle, the exact positioning of the transmitter and receiver can be made possible. The IR led and photodiode are placed side by side to each other such that the receiver would not receive radiations emitted from the transmitter until unless an object comes in near the region of reflection of radiations. If the surface of object is reflective (that is: white or other light bodies) then IR sensor will work properly. But, if the surface of object is not reflective (that is: black or other dark bodies) the IR sensor would not work properly. This condition is like the absence of an object.



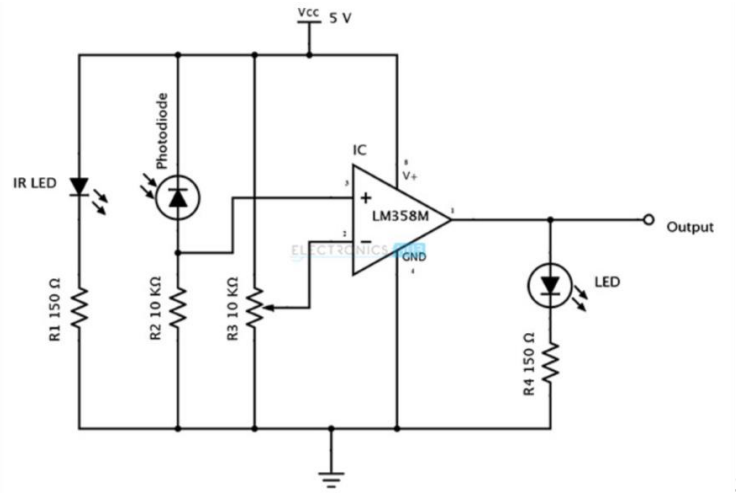
The preferred directivity is of +/- 45 degrees. To achieve this, the components are placed at a certain position. But this position is not necessary in all cases.



The principle of an IR sensor working as an Object / Motion Detection Sensor can be understood by the following figure.



CIRCUIT DIAGRAM:



SIMPLE IR MODULE

WORKING OF THE CIRCUIT:

When Voltages are supplied to the circuit, IR led emits infrared light rays but initially the photodiode acts as an open circuit (as it can't detect the radiations), but as soon as an object enters in the range of transmitter, infrared light rays are incident on it and it reflects those rays to the photodiode. When photodiode receives radiations, its resistance starts to drop and current flows. The voltage drop across 10KΩ starts increasing.

An we are using OP-AMP as a voltage comparator between two terminals which are connected to the pin numbers 2 (inverting) and 3 (non-inverting), and the output is taken from pin no. 1 at which a led in series with a current limiting resistor is connected to indicate the proper functioning of the circuit. And we can further exceed this circuit from output terminal depending on the requirements. The path linked with the pin 3 acts as a voltage divider across photodiode and 10kΩ resistor (Actually, provides a voltage level w.r.t GND at the input pin 3).

Inside a potentiometer, there is a resistance scale which is divided into 2 resistors by a wiper contact. So, when we adjust the knob of the pot, the resistances change and so the voltage drop across them changes. By using the concept, we will use voltage drop across R2 of the pot as a reference voltage which goes to the inverting (pin 2) of the Op-Amp **(When we rotate the knob of potentiometer in clockwise direction, then R2 decreases (its voltage drop decreases) and R1 increases (its voltage drop increases)**. Basically, potentiometer varies the resistance, which

results in variable voltage drop across pin number 2. We can change the sensitivity of IR sensor by varying the potentiometer. In other words, this potentiometer is used to vary the range of IR sensor.

Here, this OP-AMP also plays a vital role in Analog to Digital Converter as the photodiode outputs variable voltage levels but the output of Op-Amp will either be high (Vout) or low(0V).

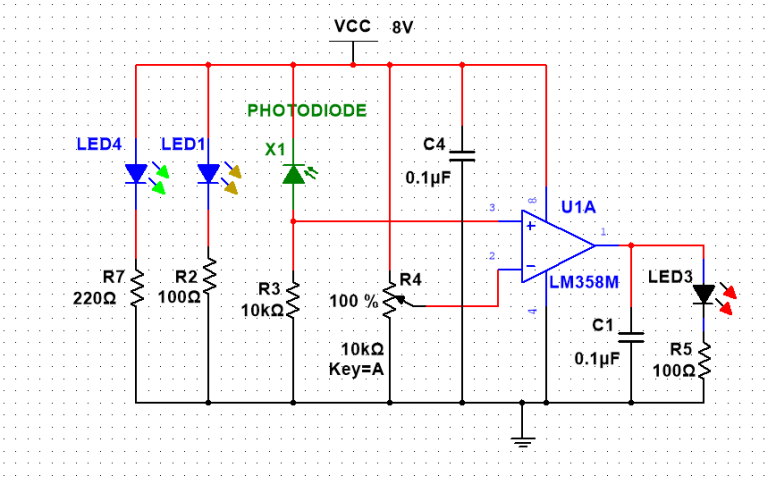
When the IR led is not in function, so IR photodiode will remain open circuit as it can't receive any signals. The voltage becomes low at non-inverting input than that of the inverting input of IC. As a result, the voltage at output becomes low and the Led doesn't glow. When IR led emits radiations and photodiode starts conducting current, there would be some voltage at inverting input depending on the intensity of IR sensor. (high intensity = high voltage and low intensity = low voltage) The IC compares the voltage coming from 10kΩ and the voltage coming from potentiometer (w.r.t GND) then takes the highest voltage from the two and gives relative output at pin 1.

If volts at inverting (pin 2) are high, then output at pin 1 gets low (OV). And if volts at non-inverting (pin 3) are high, then output at pin 1 gets high (Vout).

When the potentiometer is set to provide very low resistance (R2 low) then maximum current flows through it and low potential at pin 2. Photodiode will produce less voltages when the intensity of radiations is less (less intensity means that the range is extended and the object can be detected from far). And, photodiode will produce high voltages when the intensity of radiations is high.

But if we rotate the knob of potentiometer and provide maximum resistance (R2 high), so Voltage level at pin 2 gets high and higher voltage level is required at pin 3 (more than the potential at pin 2), then high intensity is required for object detection (means object should be near the sensor for high intensity).

SIMULATION ON MULTISM:

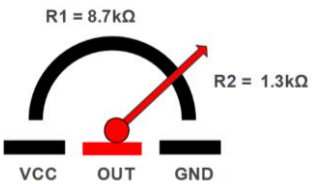


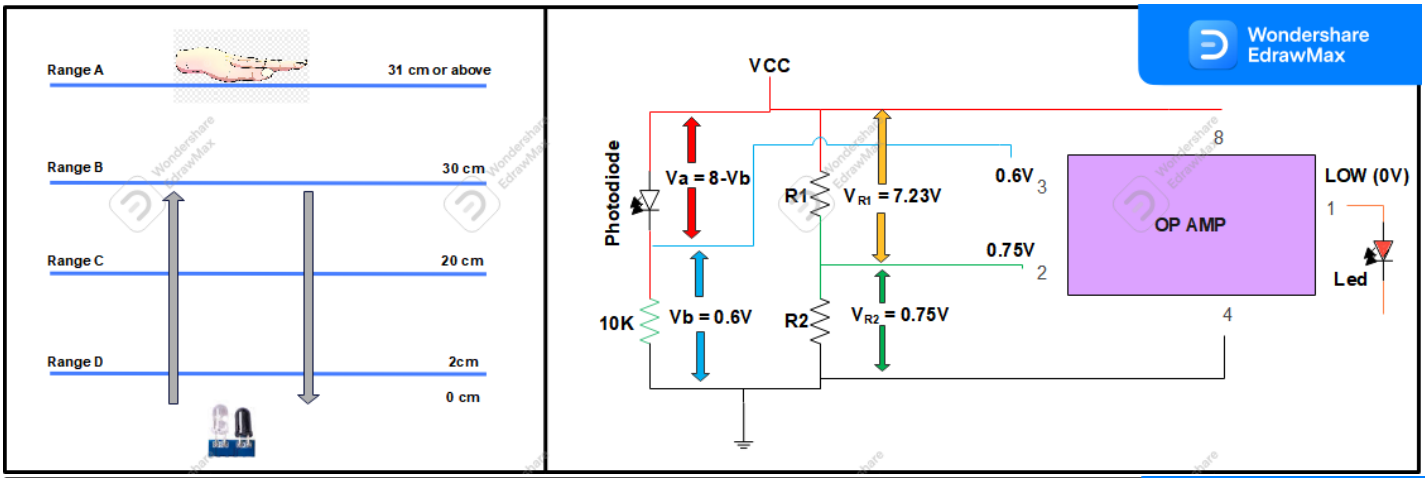
Naming it as "Simple IR Module"

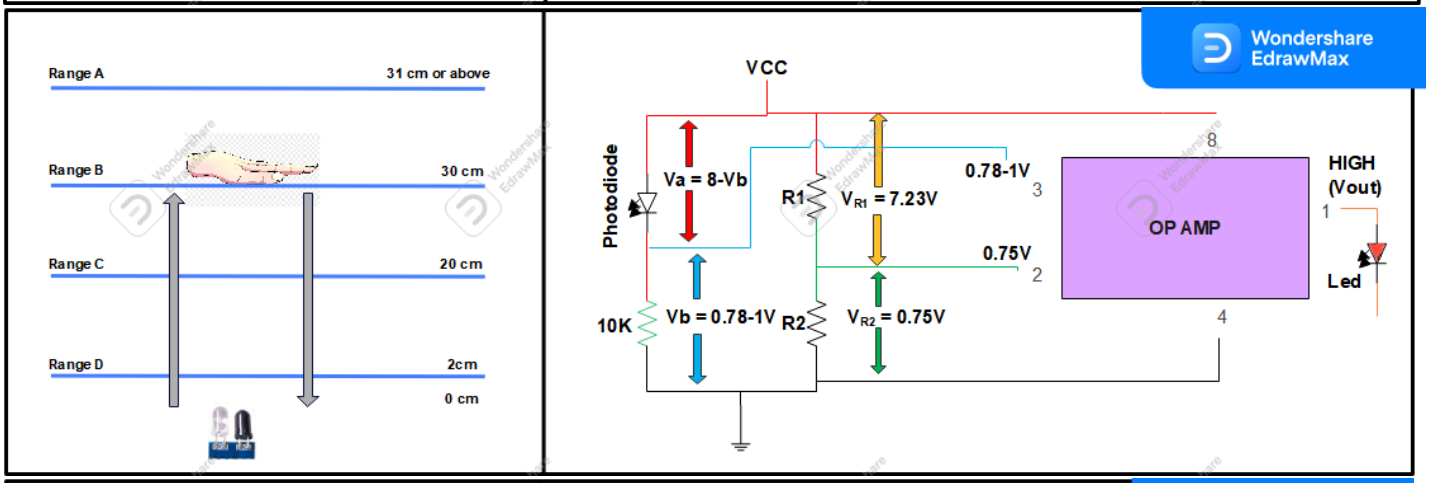
ANALYSIS AND OBSERVATION OF CIRCUIT:

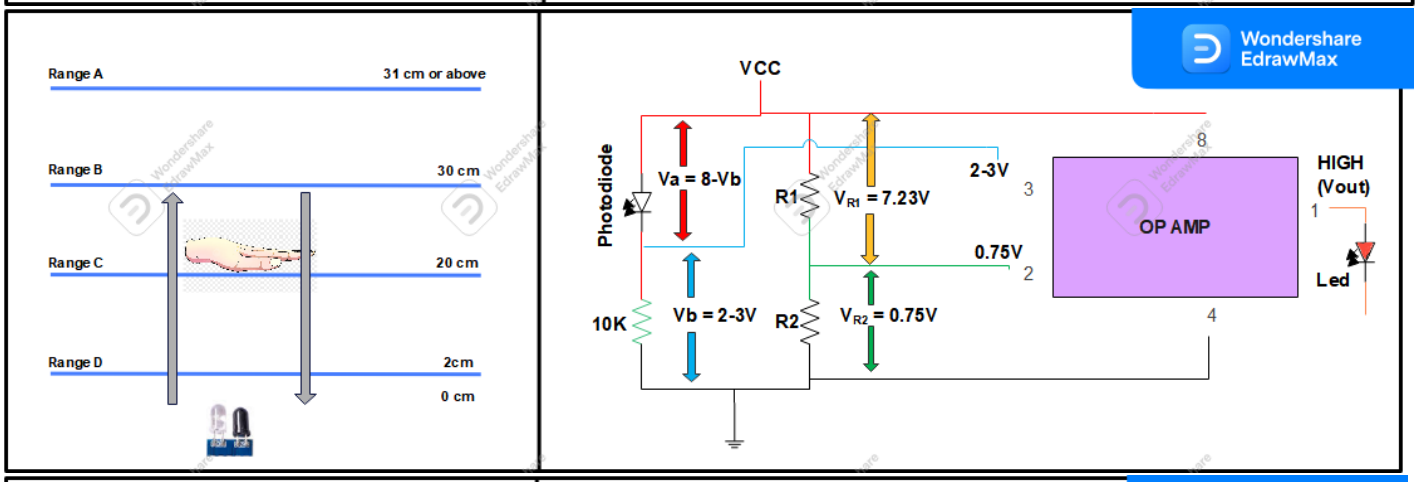
We did practical analysis of our circuit for different test cases and observed that:

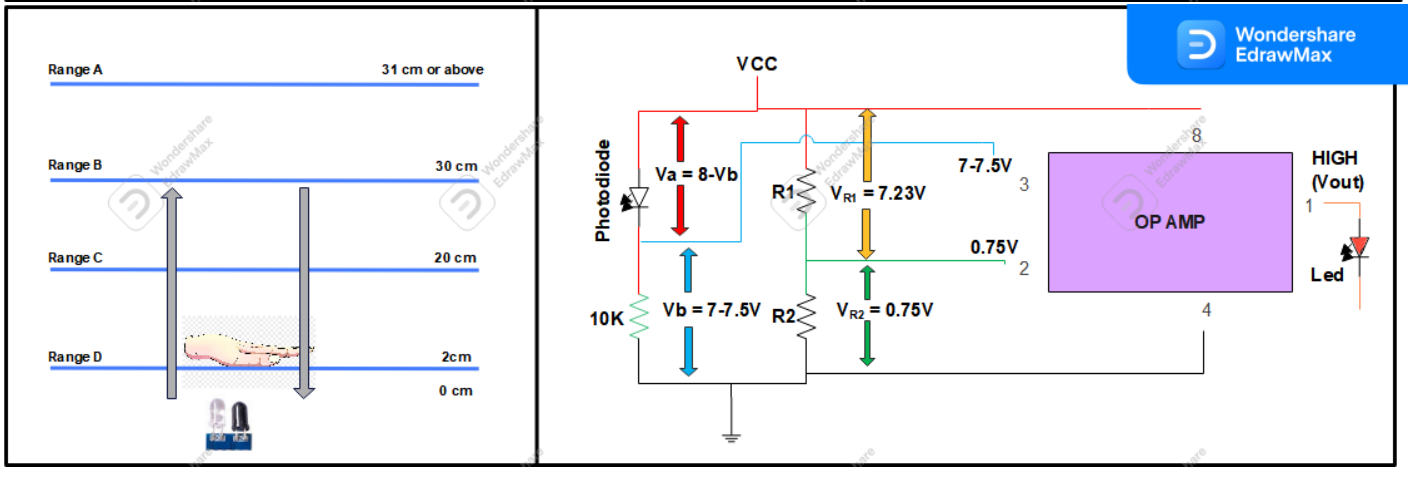
CASE 1: When the knob of POT is rotated by 80% to the right:

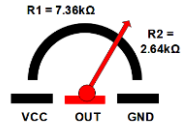



Range A
31 cm or above
Range B
30 cm
Range C
20 cm
Range D
2cm
0 cm
VCC
Photodiode
Va = 8-Vb
R1
VR1 = 7.23V
0.6V
0.75V
10K
Vb = 0.6V
R2
VR2 = 0.75V
OP AMP
LOW (0V)
Led
Wondershare EdrawMax

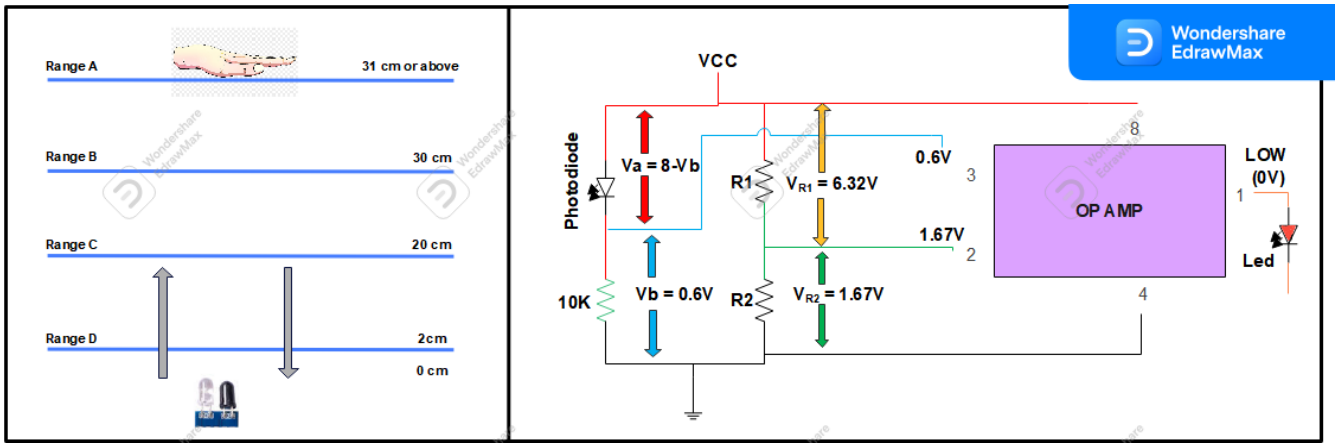

Range A
31 cm or above
Range B
30 cm
Range C
20 cm
Range D
2cm
0 cm
VCC
Photodiode
Va = 8-Vb
R1
VR1 = 7.23V
0.78-1V
0.75V
10K
Vb = 0.78-1V
R2
VR2 = 0.75V
OP AMP
HIGH (Vout)
Led
Wondershare EdrawMax

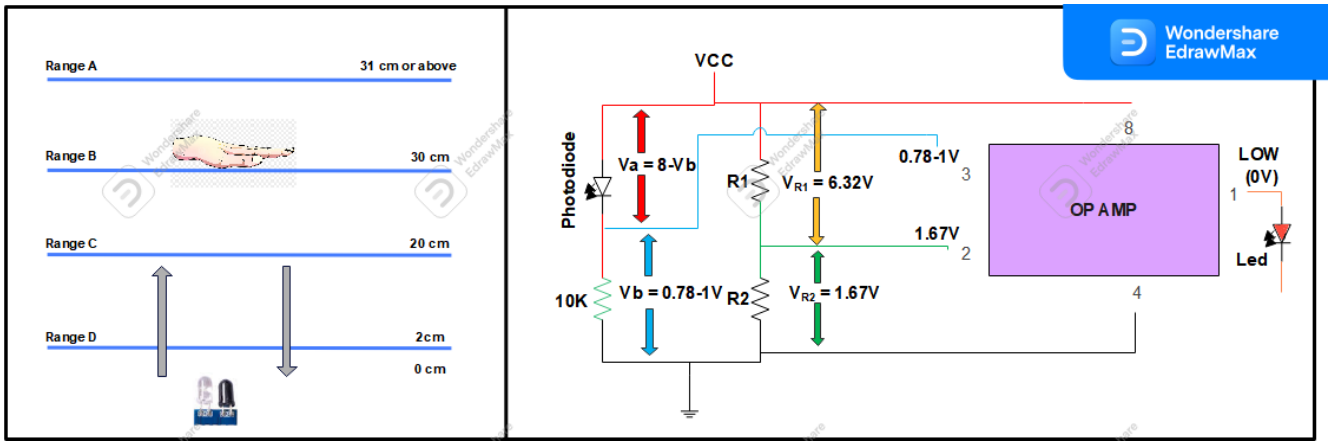

Range A
31 cm or above
Range B
30 cm
Range C
20 cm
Range D
2cm
0 cm
VCC
Photodiode
Va = 8-Vb
R1
VR1 = 7.23V
2-3V
0.75V
10K
Vb = 2-3V
R2
VR2 = 0.75V
OP AMP
HIGH (Vout)
Led
Wondershare EdrawMax

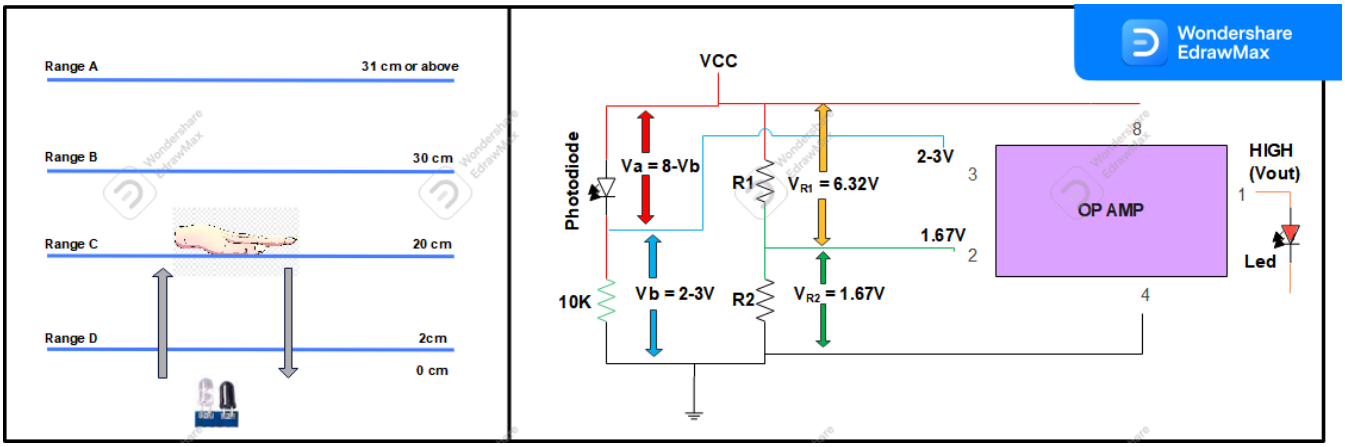

Range A
31 cm or above
Range B
30 cm
Range C
20 cm
Range D
2cm
0 cm
VCC
Photodiode
Va = 8-Vb
R1
VR1 = 7.23V
7-7.5V
0.75V
10K
Vb = 7-7.5V
R2
VR2 = 0.75V
OP AMP
HIGH (Vout)
Led
Wondershare EdrawMax

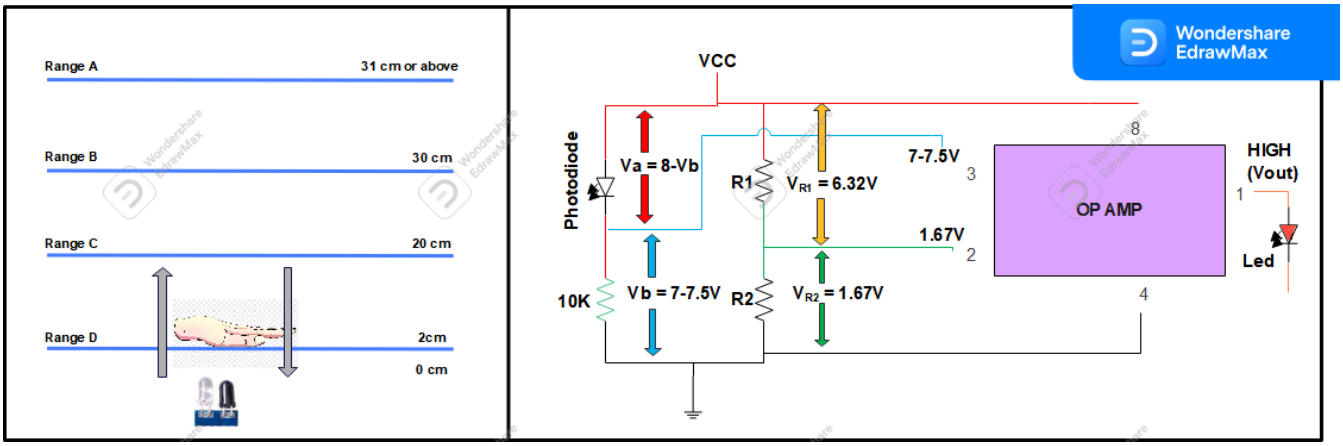


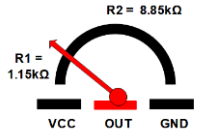
CASE 2: When the knob of POT is rotated by 60% to the right:



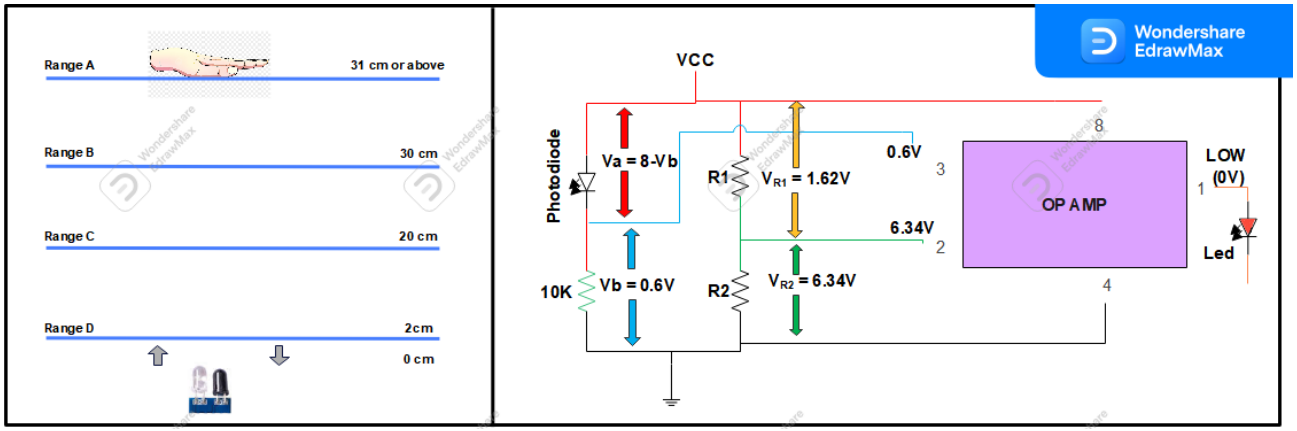


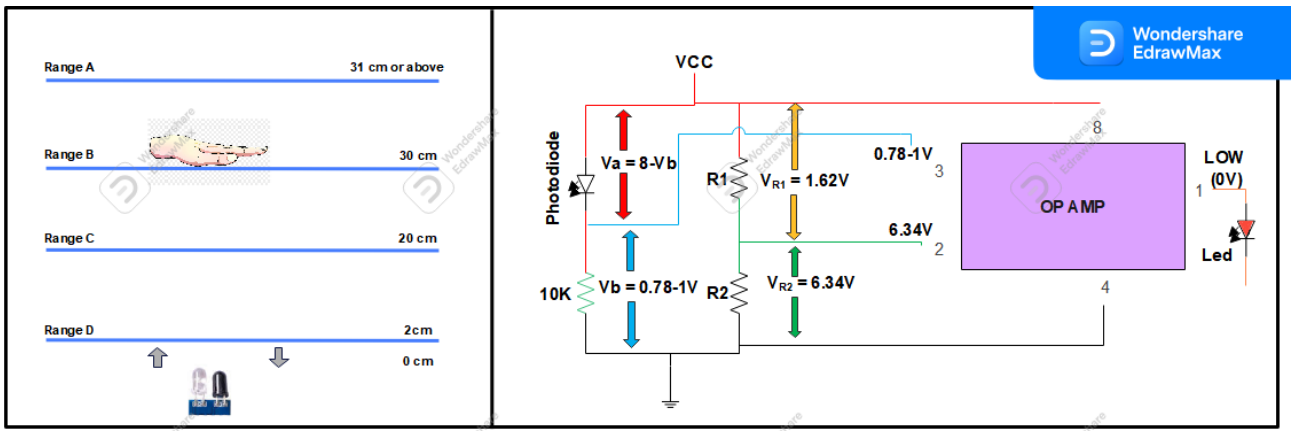


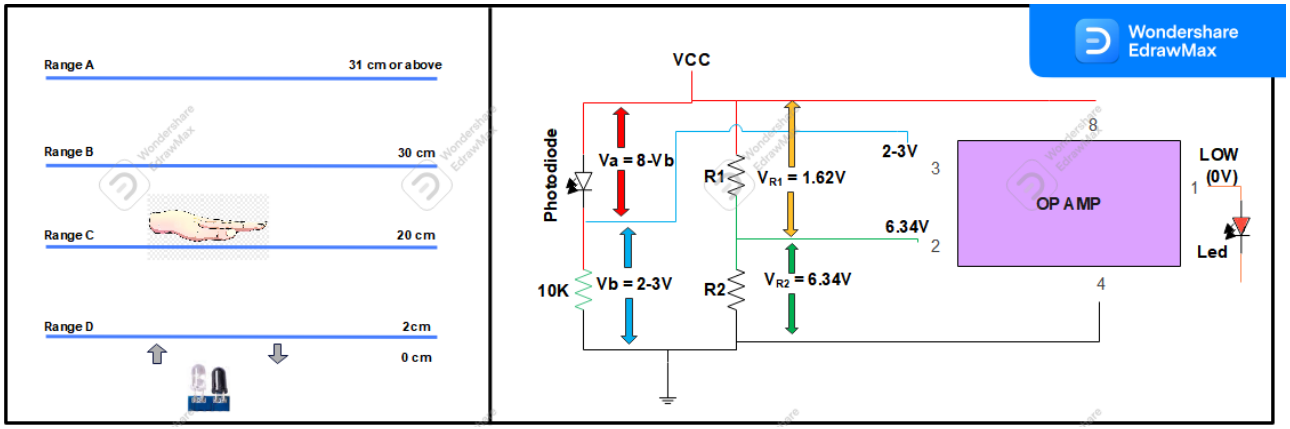


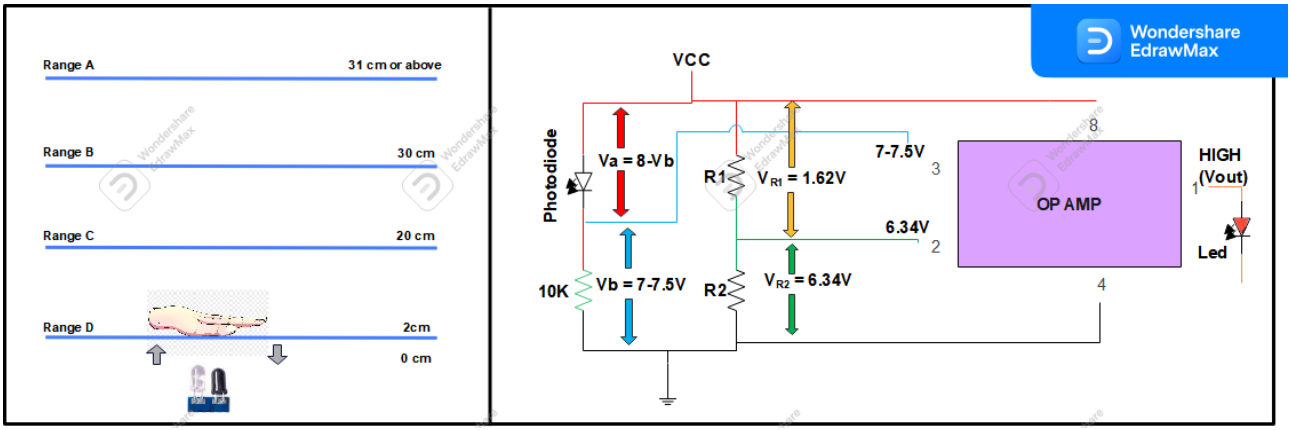


CASE 3: When the knob of POT is rotated by 20% to the right:

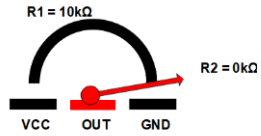


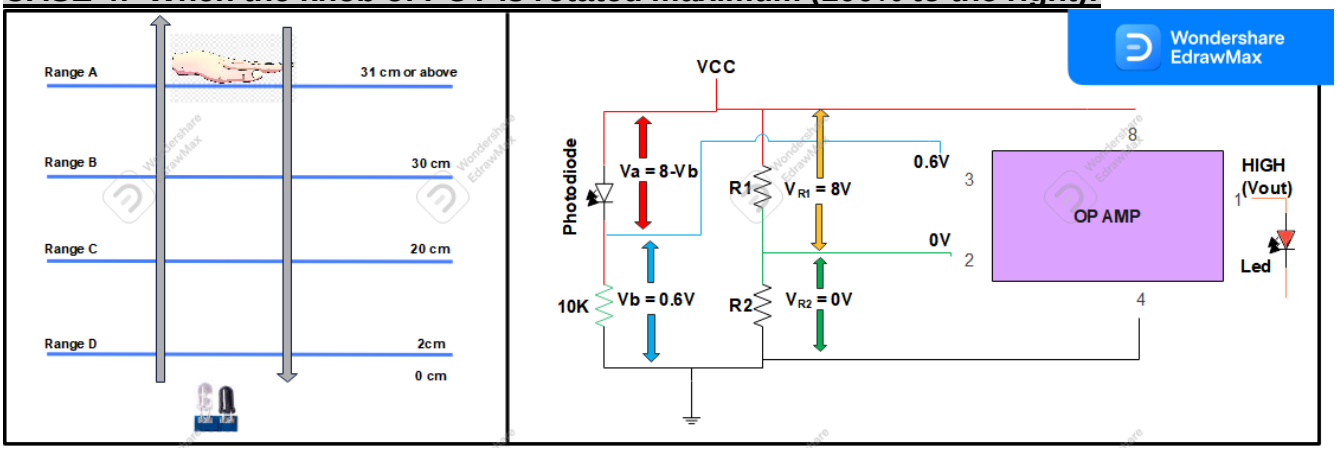


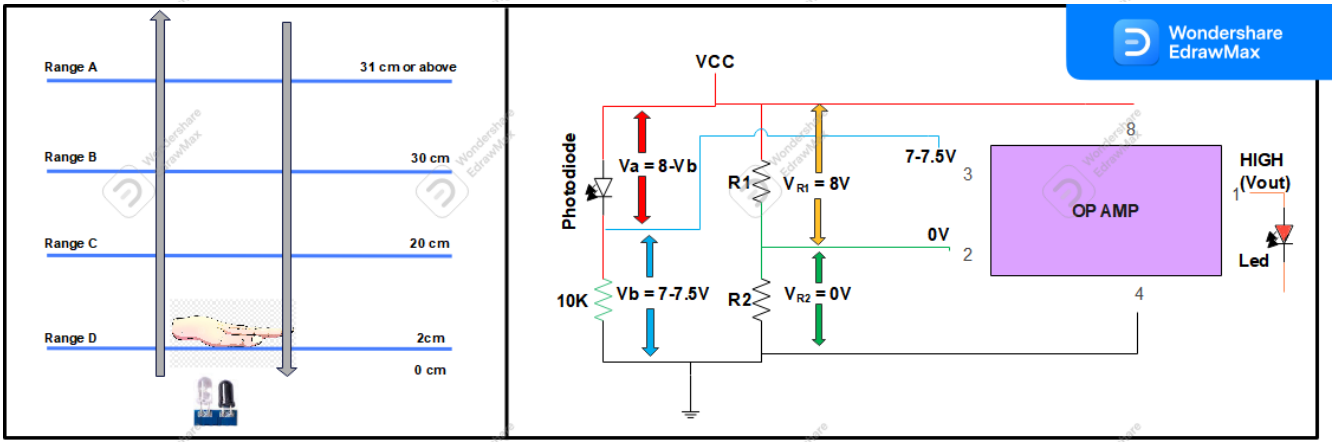




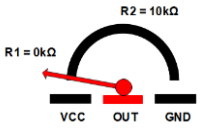
CASE 4: When the knob of POT is rotated maximum (100% to the right):

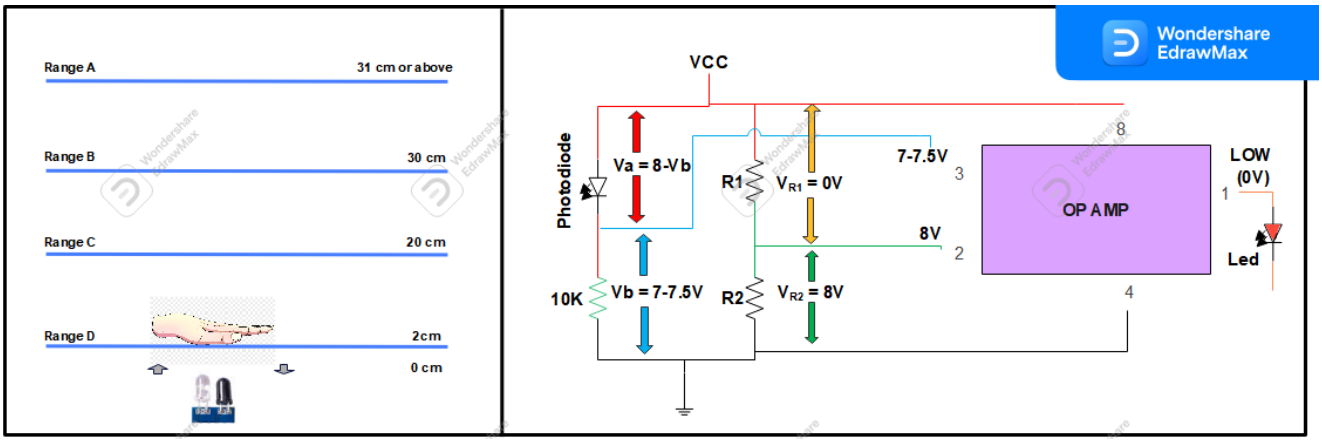






CASE 5: When the knob of POT is not rotated (0% to the right):





To Conclude, we can say that:

If Vb > Vr2, then, Vout = HIGH , +ve Saturation.

If Vb < Vr2, then, Vout = LOW, -ve Saturation.

EXTENDED CIRCUIT FOR IR MODULE TO UNDERSTAND ITS APPLICATION:

1) COUNTING :

The output we are getting from Op-Amp is nearly 4.5V. But if we want to drive a component that requires high voltage than 4.5 (example buzzer requires 5Vdc) then we can't operate that component with **Vout** and **GND** terminals. For this we used an NPN transistor which acts as a switch.

1) BC547B NPN TRANSISTOR:

NPN transistors are current-controlled devices. Current flows from the emitter to the base region and controls the larger current flowing from the collector to the emitter. NPN transistors are typically used for amplification and switching purposes in electronic circuits. They can amplify weak signals or act as a switch to control the flow of larger currents.

2) 100Ω RESISTOR:

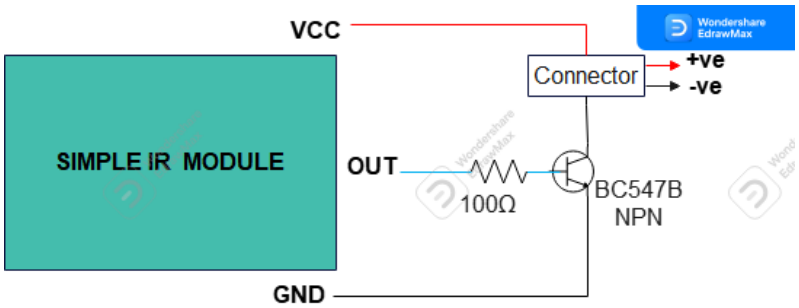
As we were getting output volts around 4.5, which could damage the transistor, so we used a 100 Ω resistor to limit the current flow.

3) CONNECTOR (2 PIN TERMINAL BLOCKS):

WORKING OF CIRCUIT

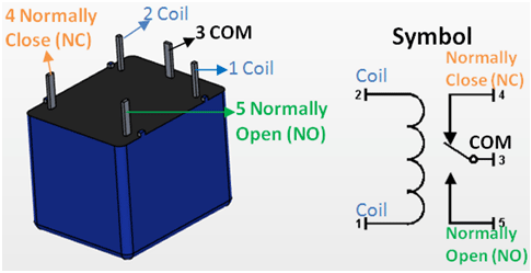
When no motion is detected, the transistor is in cut off mode as there is no base current. When the IR sensor detects motion, the output pin of comparator IC sends signal to the base of transistor, the small base current makes the transistor to operate in active mode, hence collector current starts to flow and transistor acts as closed switch for connector. We will get nearly 8V at the connecter terminals.

Now we can attach any electrical component based on the requirements. For a counting application, we can use a counter IC (like IC 7490 or any other IC) with relevant logic circuit. Whenever, an object is detected, a clock pulse goes to the counter IC and counts 1.



2) HOME AUTOMATION:

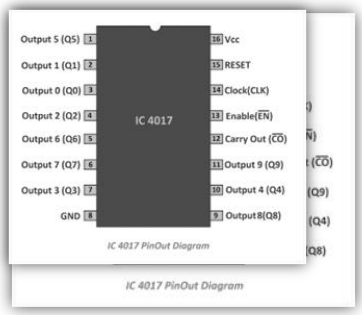
If we want to automatically power on any electrical component, then we can use a relay, a relevant logic IC and other components to build a MOTION SWITCH SENSOR.



1) **6VDC RELAY:**

A relay is an electrically operated switch. The function of a relay is to control the flow of electrical current in a circuit using an electromagnetic switch. It acts as a remote-controlled switch that allows a low-power signal to control a high-power circuit. Means when Voltages are applied to the relay, The armature moves from NC to NO pin, where, C pin is common. So the switch is closed. But when voltage source is disconnected, the spring brings the armature back from NO to NC pin and the switch is open.

2) **CD4017 IC:**



The 4017 IC, also known as the 74HC4017 or CD4017, is a versatile counter and decoder. It has a wide range of applications in various electronic circuits. The main function of the 4017 IC is to divide an input clock signal and sequentially activate its output pins in response to each clock pulse.

3) **CONNECTOR (2 PIN TERMINAL BLOCKS):**

4) **WHITE LED FOR INDICATION OF IC OUTPUT:**

5) **220Ω RESISTOR:**

6) **100µF POLAR CAPACITOR:**

7) **1N4007 DIODE:**

8) **BC547B NPN TRANSISTOR:**

CONNECTIONS:

- The output signal of Op-Amp is connected to pin no 14 of IC 4017BD. The pin no 16 is connected to Vcc and pin no 8 and 13(Enable pin) are connected to ground. The pin no 15 (reset) is connected to pin no 4 which is Q2. (Output 2) and we take output of IC from pin no 2 which is (Q1).
- The output pin of IC is connected to a 220Ω resistor which then goes to the base of an NPN transistor which acts as a switch for relay.
- One coil pin of relay is directly connected to Vcc and the other coil pin is connected to the collector pin of transistor. And the emitter pin is connected to ground.
- A 2-pin connector is connected to the common and NO (normally open) pins of the relay. And the NC (normally closed) pin of relay is not connected.

WORKING

The IC requires a continuous clock signal to operate and advance through its output states.

The clock pin (Pin-14) of CD4017 IC is connected to the output pin of LM358. So when any motion is detected, the 4017 IC receives a clock pulse and changes the current state of Pin-2. The Pin-2 of CD4017 is connected to the base of the BC547 NPN transistor, So when the Pin-2 becomes high the transistor turns on.

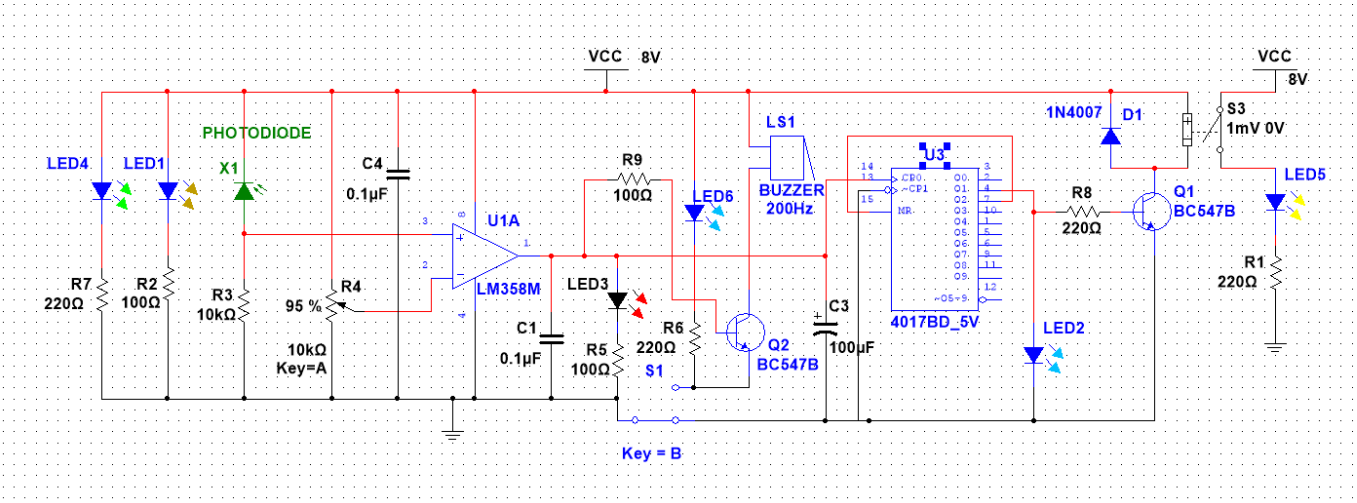
When the transistor turns on, the current can flow through the relay coil. So the load connected with the relay also turns on.

When the IR leds detect any motion the second time, it sends the next clock pulse to CD4017 IC. Then the Pin-2 becomes low. If the Pin-2 becomes low, the transistor turns off, and accordingly the load connected with the relay also turns off.

The clock signal on pin 14 serves as the input that triggers the IC to move from one output state to the next. In other words, the IC 4017BD effectively "freezes" its state when it does not receive a clock signal. It will maintain the output state that was active when the clock signal stopped until a new clock signal with a rising edge is applied to the clock input.

Diode is used as a flyback diode and its +ve terminal is connected to –ve pin of relay (2nd coil) and its –ve terminal is connected to +ve pin of relay (1st coil). This is because when transistor is in saturation mode, current flows through the relay and produces magnetic field around the coil, but when the transistor is in cutoff mode, the current stops flowing through relay, but an opposite current is produced due to the magnetic fields around the coil. and this could damage our circuit. But the –ve terminal of diode blocks that opposite current flow.

Now, if we can connect any AC/DC circuit at the connector pins and function the output accordingly.



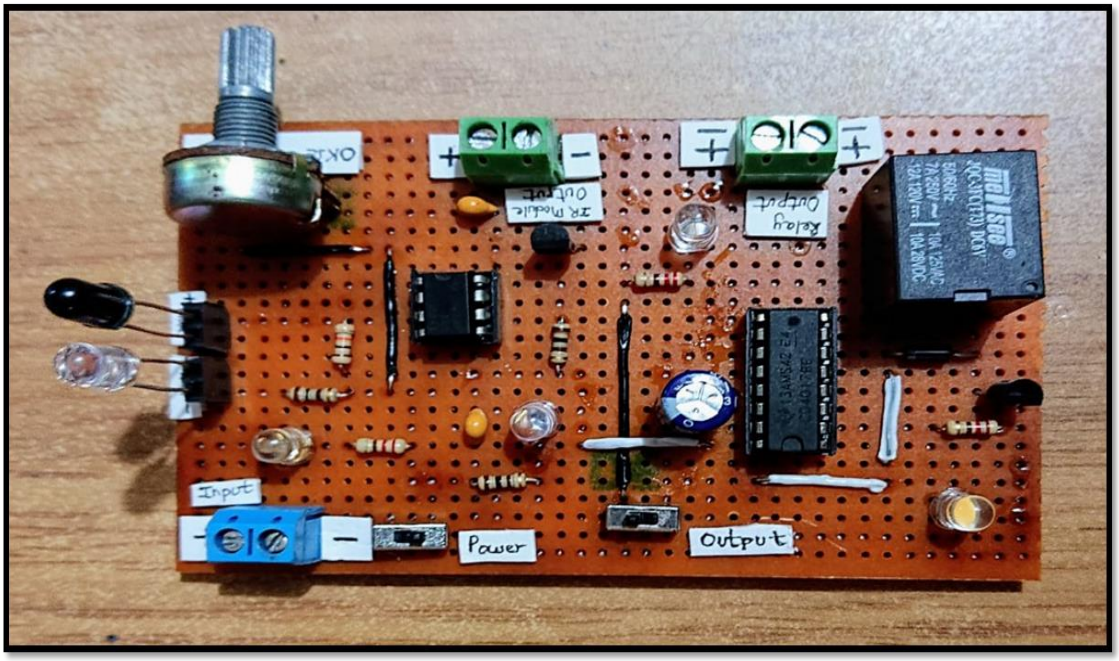
3) SECURITY SYSTEM:

We can connect +ve terminal of a buzzer to the connecter pin of relay output, and the -ve pin of buzzer to the –ve terminal of DC source, and the other +ve terminal of DC source to the other terminal of connecter. Now if someone comes infront of the sensor, the output of LM358 goes high, and the relay turns on, the switch turns on and the buzzer produces sound indicating security alarm. It will remain on until we switch off the circuit.

4) FIRE ALARM:

If we remove the IR led, then the photodiode can also sense heat and give output accordingly, hence working as a fire detector too.

OVERALL CIRCUIT ON VEROBOARD:



ADVANTAGES OF IR SENSORS:

1) Less power consumption.
2) Presence or absence of light doesn't matter for the detection of motion.
3) No data leakage because of the ray direction.
4) No effect of oxidation and corrosion.
5) Strong noise immunity.
6) They are the most modest in size.
7) Provides high reliability.
8) It responds more quickly as compared to thermocouples.
9) They don't need to get in touch with the objects for its detection or temperature measurement.

DISADVANTAGES OF IR SENSORS:

1) Requires line of sight.
2) Can be affected by the conditions of environment such as fog, dust, rain, etc.
3) Data transmission rate is low.
4) Range of detection is limited.
5) This sensor can easily be blocked with common objects.
6) High force IR signals can harm human eyes.

LIMITATIONS OF THE PROJECT:

As we have created an Active Infrared Sensor in which IR Led emits radiations and IR photodiode receives those radiations. Infrared radiations cannot reflect from the surface of black bodies because they absorb all the light radiations. So, the project we designed, won't be able to detect the motion of black objects.