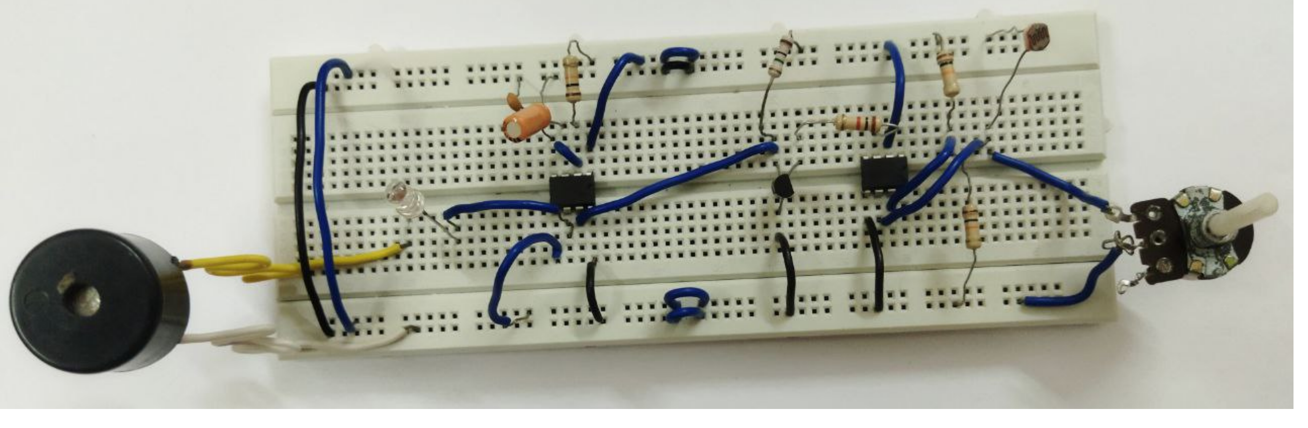
Automatic Fence Lighting with Alarm

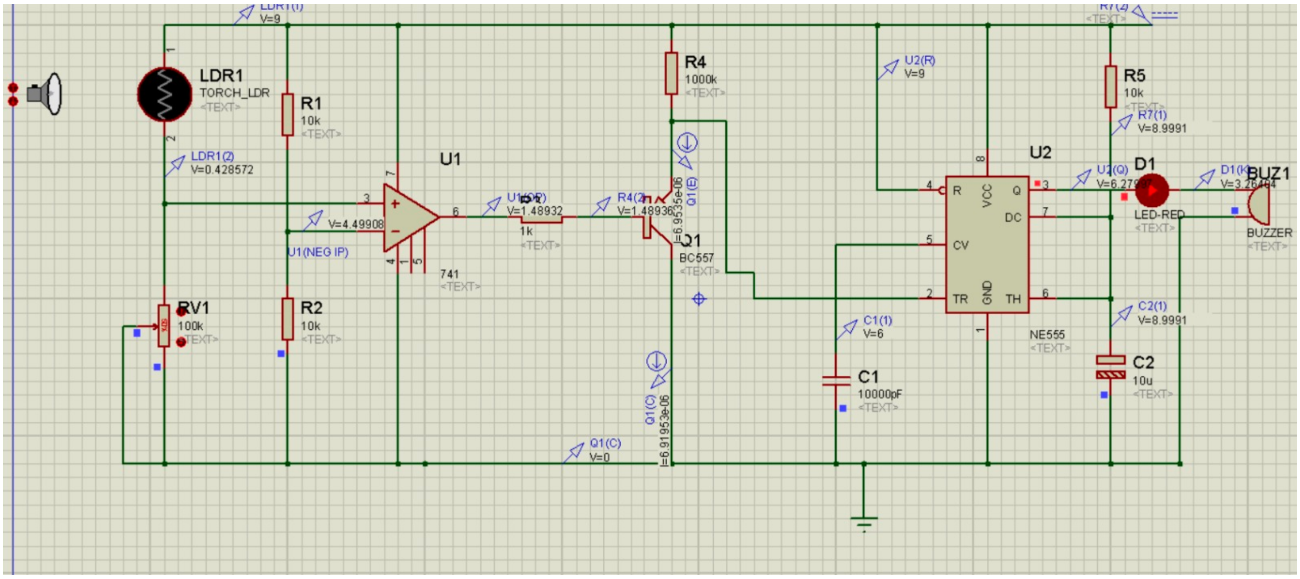
1. Description

The circuit of the automatic fence lighting circuit with alarm is shown in figure. The construction of this project is very simple and is built around readily available electronics components like op-amp 741, timer IC 555, PNP transistor BC557, LED, piezo buzzer, and a few other passive components like resistors and capacitors.

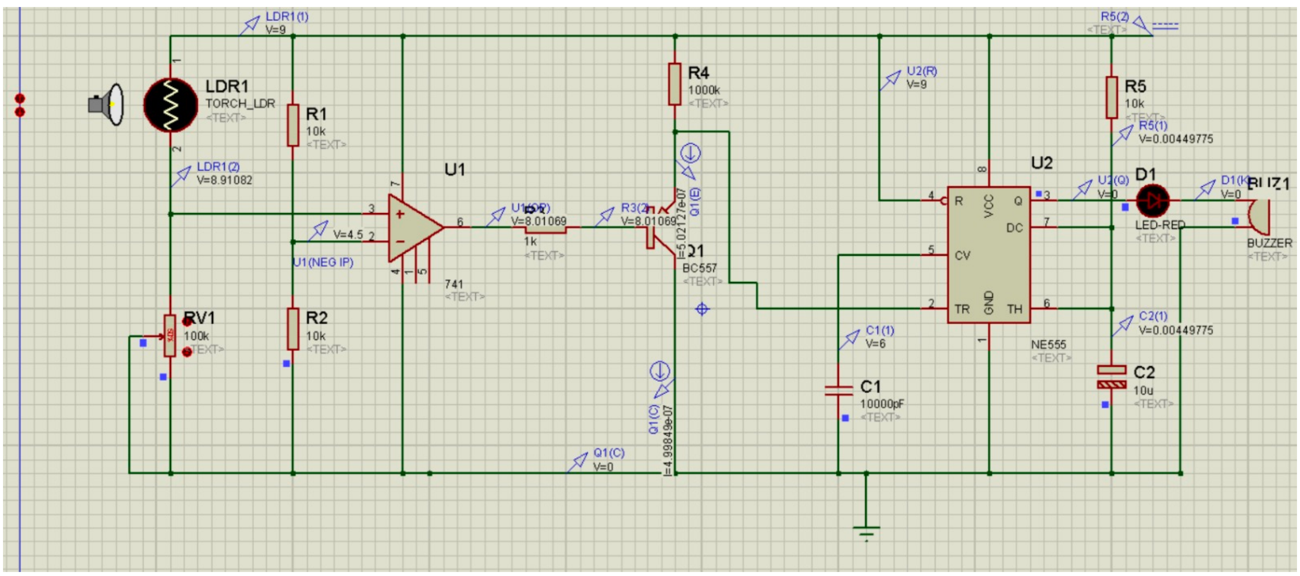


2. Circuit Diagram

ON State :



OFF State:



3. Components

- Resistors with resistances
  - 10k Ω (R1, R2, R5)
  - 1k Ω (R3)
  - 1000k Ω (R4)
- Potentiometer : 100k Ω (RV1)
- PNP transistor: BC 557

- 555 timer IC: NE 555
- Op Amp 741
- Capacitors :
  - 10000pF (C1)
  - 10uF (C2)
- LED
- Buzzer

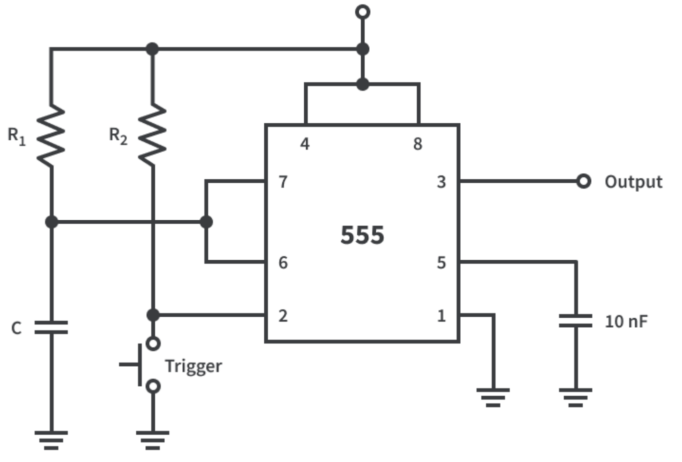
4. Working of Components

✏**IC 555**

The **NE555**, also known as the **555 timer IC** (integrated circuit), is a widely used electronic component that can function as a timer, oscillator, or pulse generator. Its main purpose is to produce accurate and stable time delays or oscillations in electronic circuits.

The NE555 consists of several components, including comparators, resistors, capacitors, and a flip-flop. Its operation is based on charging and discharging a capacitor through a timing resistor.

V_{CC}



Here is a simplified explanation of the NE555's operation:

Power Supply: The NE555 requires a power supply voltage (Vcc) typically between 4.5V and 15V to operate correctly.

External Components: To set the desired timing characteristics, you need to connect external components to the NE555. These usually include a timing resistor (R1), a timing capacitor (C1), and optionally a diode (D1) and a discharge resistor (R2). The values of these components determine the timing intervals.

Modes of Operation: The NE555 can operate in various modes, including monostable (one-shot) mode and astable (free-running oscillator) mode.

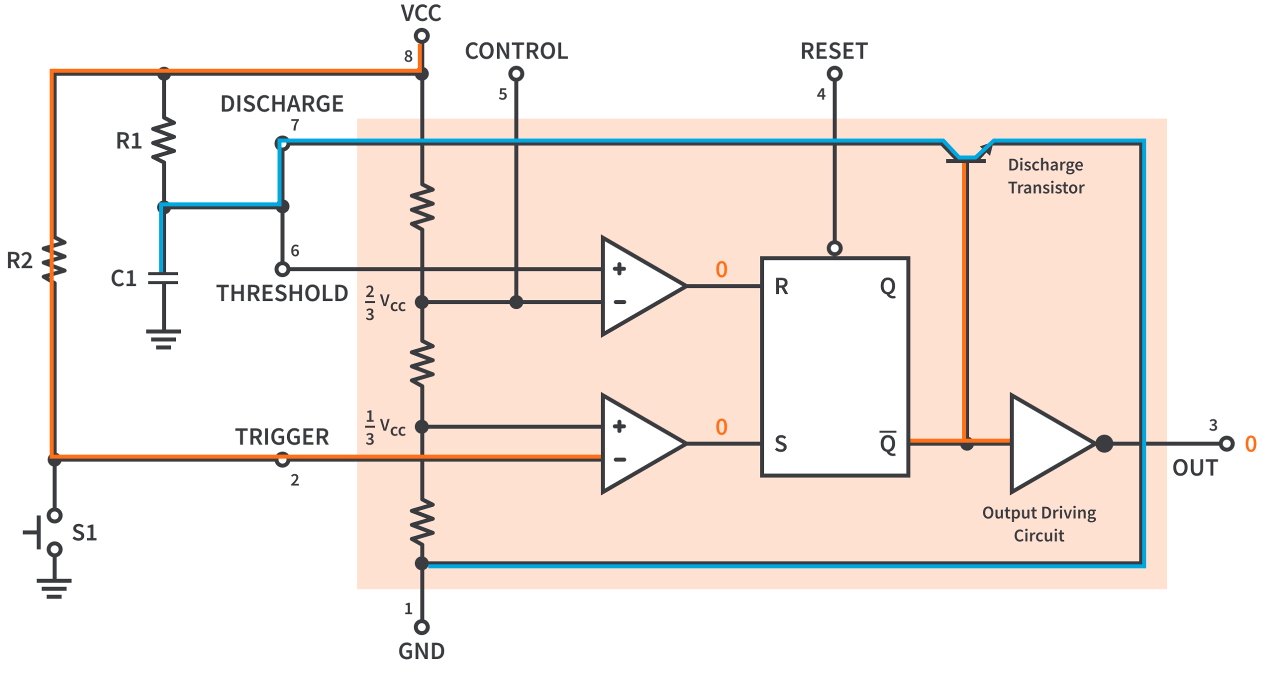
Monostable Mode: In this mode, the NE555 produces a single pulse of a specific duration when triggered. When a trigger input (pin 2) is momentarily pulled low (typically grounded), the output (pin 3) goes high for a fixed time determined by the timing components. After the time interval elapses, the output returns to its original low state. The trigger pulse can be generated by a sensor, switch, or other input signal.

Astable Mode: In this mode, the NE555 generates a continuous square wave output. The timing components determine the frequency and duty cycle of the square wave. The output oscillates between high and low states indefinitely until power is removed or the circuit is otherwise stopped.

Timing: In both modes, timing is achieved by charging and discharging the timing capacitor through the timing resistor. The charging and discharging times depend on the values of R1, C1, and the voltage levels set by the other components. These times control the output behaviour of the NE555.

Output: The NE555 has an open collector output, which means it can only sink current (provide a path to ground) but not source current. To use the output signal effectively, you might need to connect a pull-up resistor and possibly a diode for specific applications.

IC 555 as Monostable Multivibrator



Here's how it works:

Timing Components: To create a monostable multivibrator using the NE555, you need two external components: a resistor (R) and a capacitor (C). These components determine the timing of the output pulse.

Pin Configuration: The NE555 has eight pins. The relevant pins for a monostable configuration are:

Pin 1 (Ground): Connected to the ground or 0V reference.

Pin 2 (Trigger): Used to trigger the timer and start the timing process.

Pin 3 (Output): Provides the output pulse.

Pin 4 (Reset): Resets the timer and stops the timing process.

Pin 5 (Control Voltage): Not used in a basic monostable configuration.

Pin 6 (Threshold): Determines the timing of the output pulse.

Pin 7 (Discharge): Connected to an external capacitor during the timing process.

Pin 8 (Vcc): Connected to the positive supply voltage.

Operation:

Triggering: Initially, the capacitor (C) is discharged, and the output (Pin 3) is low. When a trigger signal is applied to Pin 2 (Trigger), it triggers the timer, starting the timing process.

Timing: The capacitor (C) starts charging through the resistor (R) connected between Pin 7 (Discharge) and Pin 8 (Vcc). The timing is determined by the values of R and C according to the formula $T = 1.1 \times R \times C$, where T is the timing period in seconds.

Output Pulse: While the capacitor charges, the output (Pin 3) remains high. Once the voltage across the capacitor reaches 2/3 of the supply voltage, the timer triggers the output to go low. This transition marks the end of the timing period and the generation of the output pulse.

Reset: The timer can also be reset prematurely by applying a low signal to Pin 4 (Reset) during the timing process, which stops the timing and forces the output to go low.

Output Pulse Duration: The duration of the output pulse is typically given by the formula $T = 1.1 \times R \times C$, where T is the timing period in seconds. You can adjust the pulse duration by selecting appropriate values for the resistor (R) and capacitor (C).

Remember to choose appropriate component values to ensure that the timing requirements and voltage limits of the NE555 are met. Additionally, you may need to consider the tolerance and stability of the components for accurate timing.

Op Amp 741 as Comparator

The operational amplifier (**Op Amp**) 741 can be used as a comparator in certain applications. A comparator is a device that compares two input voltages and produces a digital output based on the comparison. The 741 Op Amp, although primarily designed for amplification, can also be used as a comparator due to its high gain and fast response.

When using the 741 Op Amp as a comparator, it is important to keep in mind a few considerations:

Power supply: The 741 Op Amp requires a dual power supply (positive and negative) to operate correctly. Make sure to provide the required power supply voltages within the specified range.

Input voltages: The 741 Op Amp has two input terminals, the inverting (-) and non-inverting (+) terminals. When using it as a comparator, one input terminal is connected to a fixed reference voltage (typically the non-inverting terminal), and the other input terminal (inverting or non-inverting) is connected to the input voltage you want to compare.

Open-loop configuration: To use the 741 as a comparator, it is generally operated in an open-loop configuration, which means that the output is not connected to the negative feedback loop typically used in amplifier circuits. By doing this, the amplifier's gain is maximized, and the output voltage switches quickly between the two saturation levels based on the input comparison.

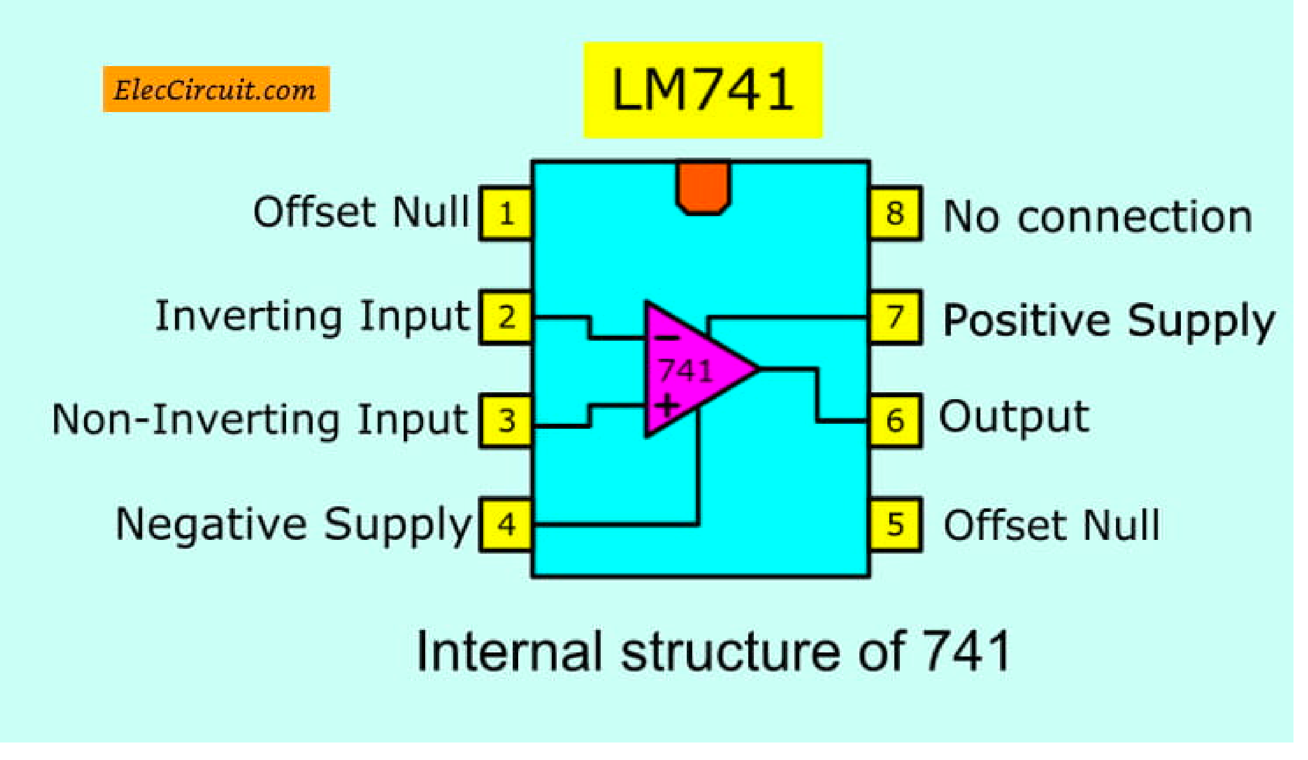
Output voltage levels: The output of the 741 Op Amp when used as a comparator can swing between its positive and negative saturation levels, typically close to the supply voltages. Ensure that the output voltage levels meet the requirements of your application.

Hysteresis: In some cases, you might want to add hysteresis to the comparator circuit to prevent rapid switching when the input voltage is close to the reference voltage. Hysteresis can be achieved by adding positive feedback, such as a resistor between the output and the inverting (-) input terminal.

Pins:

1. Offset Null: This pin is used to nullify any input offset voltage. It is usually not connected in most applications.
2. Inverting Input (-): This is the inverting input terminal of the Op Amp. The input signal is applied to this pin.
3. Non-Inverting Input (+): This is the non-inverting input terminal of the Op Amp. It is used for applying reference voltages or signals.

4. V- (Negative Power Supply): This pin is connected to the negative power supply or ground.
5. Offset Null: This is another pin for nullifying input offset voltage. Similar to Pin 1, it is usually not connected in most applications
6. Output: This pin provides the output voltage of the Op Amp.
7. V+ (Positive Power Supply): This pin is connected to the positive power supply.
8. N/C (No Connection): This pin is not connected and is left unused.



PNP transistor as a switch

Transistor Setup:
Connect the emitter terminal of the PNP transistor to the positive power supply

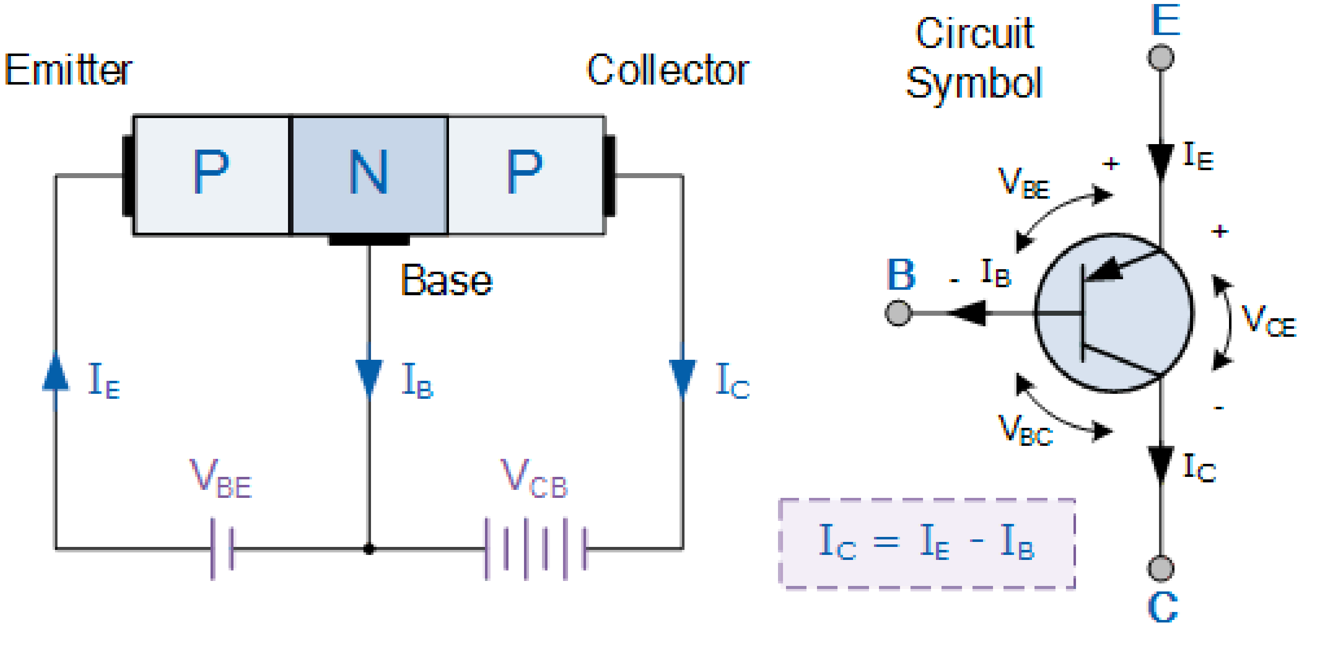
(Vcc), and connect the collector terminal to the load (such as an LED or a motor). The base terminal is where the control signal is applied.

Base Current:
To turn on the PNP transistor and allow current to flow from the collector to the emitter, a sufficient base current (Ib) must be provided. The base current should be sourced from the control signal or a voltage divider connected to the control signal. The base-emitter junction of the PNP transistor is forward-biased when the base voltage is lower than the emitter voltage by about 0.7V (typically).

Transistor Operation:
When the base-emitter junction is forward-biased, current flows from the emitter to the base. This current activates the transistor and allows current to flow from the collector to the emitter, activating the load connected to the collector. The load can be an LED, a motor, or any other device.

Control Signal:
To control the switch, the control signal (such as a voltage or digital signal) is applied to the base terminal. When the control signal is high or greater than the emitter voltage, the transistor is turned on, and current flows through the load. When the control signal is low or lower than the emitter voltage, the transistor is turned off, and no current flows through the load.

It's essential to ensure that the base current is sufficient to turn on the transistor and that the load current does not exceed the maximum collector current (Ic) rating of the transistor. Additionally, a current-limiting resistor may be required in series with the base to control the base current.



5. Working of Circuit

The circuit of the automatic fence lighting circuit with the alarm is shown in Figure. The construction of this project is very simple and is built around readily available electronics components like op-amp 741, timer IC 555, PNP transistor BC557, LED, piezo buzzer, and a few other passive components like resistors and capacitors.

IC741 is configured in voltage comparator mode where resistor R1 and R2 a voltage divider that provides reference voltage and LDR with variable resistor RV1 is also a voltage divider and provide signal voltage. Timer IC 555 is configured in monostable multivibrator mode where resistor r6 and capacitor C2 are responsible for time delay because these two components are called the time constant.

A voltage comparator compares a signal voltage on one input of an op-amp with a known voltage called reference voltage on the other input. This circuit is also called a non-inverting comparator because Vin (input voltage signal) is given to the non-inverting pin (pin 3).

The reference voltage of about ½ of 4.5V is available at the inverting input (pin 2) and the signal voltage to be compared is available at the non-inverting input (pin 3) from the potential divider network build using LDR and VR1. The output may be high (+) and low (-) saturation voltage, depending on which input is larger.

When Vin at pin 3 is greater than Vref at pin 2 then the output of IC1 will be high, which drives transistor T1 in the off state. As a result, the LED becomes off and IC2 is also stopped from oscillating. Similarly, when light is interrupted on LDR, the voltage (Vin) at pin 3 is less than Vref voltage (voltage at pin 2) as a result the output of IC1 (741) becomes low. This low-output trigger timer IC 555 (IC2) activates the piezo buzzer for a definite time interval which is determined by resistors R6 and C2.

6. Time delay calculation:

Formula: **time delay = RC**

In the circuit, R = R5 = 10k ohm and C = C2 = 10uF

Time Delay = 0.1 sec

7. Application

1. **Fence Lighting:**
   LED lights or other lighting fixtures are installed along the perimeter fence, spaced at regular intervals. These lights are connected to a control circuit that activates them automatically when certain conditions are met.
2. **Motion Sensors:**
   Motion sensors are strategically placed along the perimeter fence to detect any movement or intrusion attempts. These sensors can use technologies such as passive infrared (PIR) or microwave sensors to detect changes in the environment.
3. **Control Circuit:**
   The control circuit is responsible for receiving signals from the motion sensors and triggering the appropriate response. When the motion sensors detect movement, they send a signal to the control circuit.
4. **Lighting Activation:**
   Upon receiving a signal from the motion sensors, the control circuit activates the fence lighting. This illuminates the area where the intrusion attempt has been detected, making it more visible and deterring potential intruders. The lights can be set to stay on for a specific duration or until manually turned off.
5. **Alarm Activation:**
   In addition to the lighting, the control circuit can also trigger an audible alarm when an intrusion is detected. This can be achieved through the use of sirens, buzzers, or other sound-producing devices. The alarm serves as an immediate alert to nearby individuals and can help draw attention to a potential security breach.
6. **Monitoring and Integration:**
   The entire system can be integrated with a central monitoring station or security control panel. This allows security personnel to receive notifications and respond to any detected intrusions promptly.

Integration with other security systems, such as CCTV cameras or access control systems, can provide a comprehensive security solution.