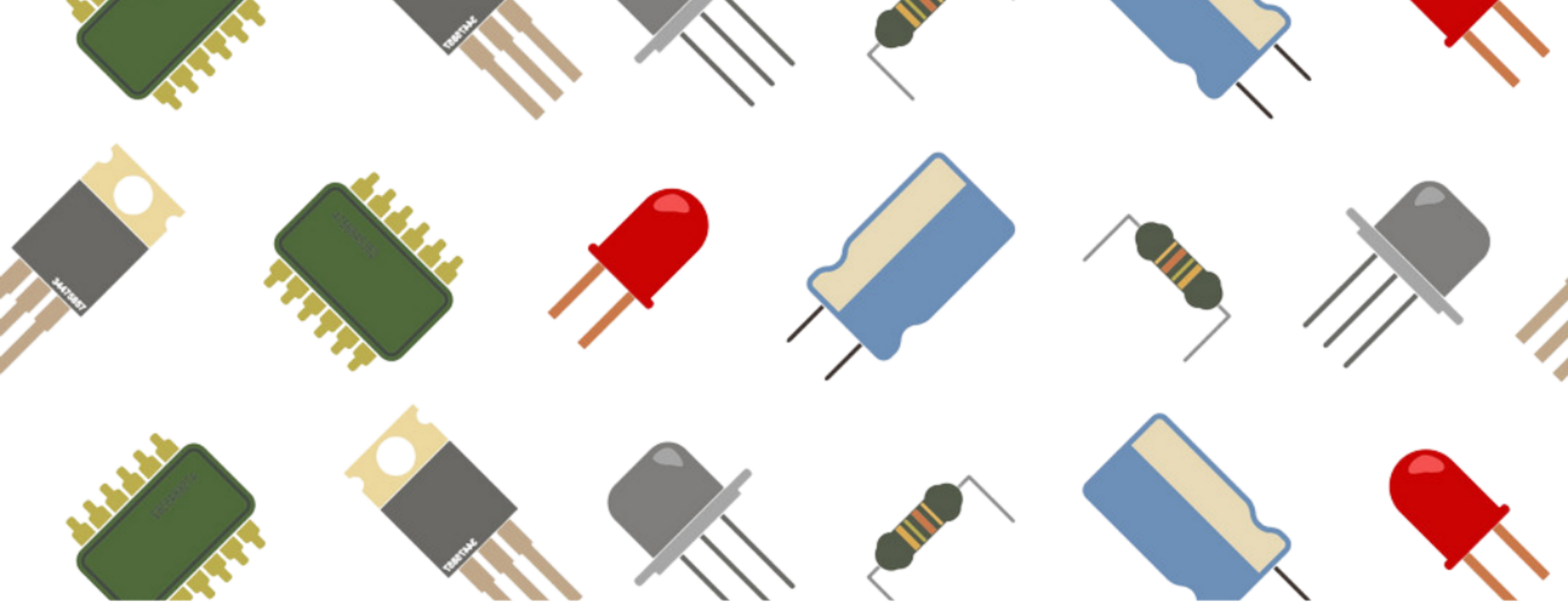

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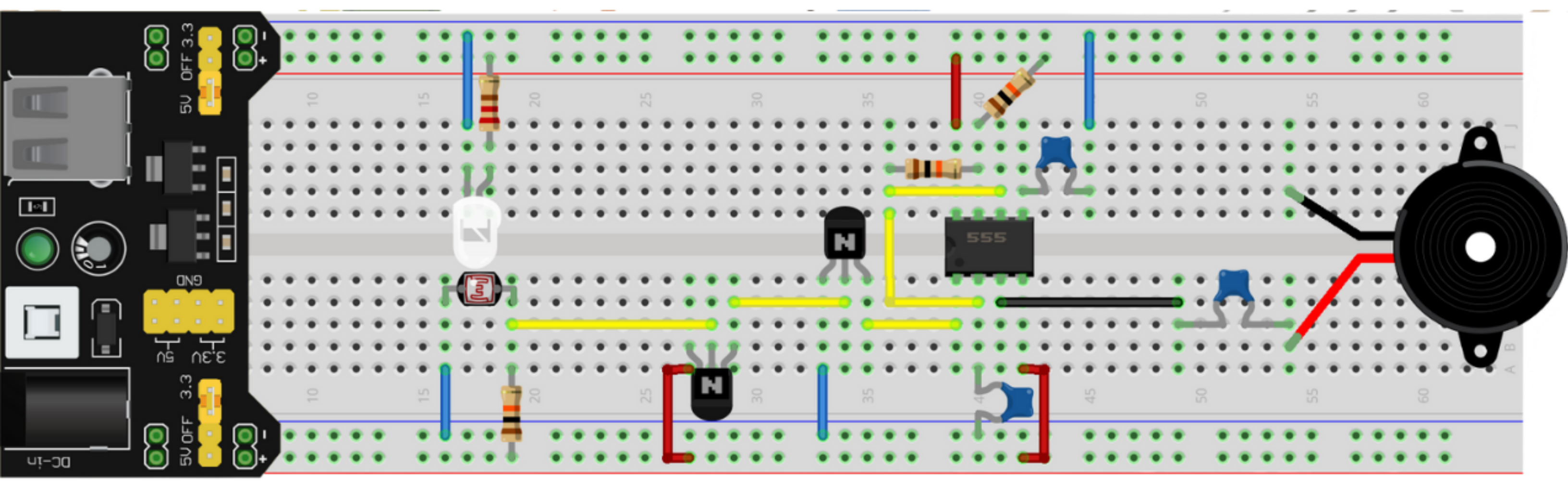

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First release, September 2020

Contents

1. Introduction

Creating means living - Dejan Stojanovic

This guide will guide you to make smart circuits or systems using discrete components like transistors, resistors, LEDs, NE555 timer IC, without micro-controllers or programming. In the following section, all the kits components' working and uses are explained thoroughly, and after that each chapter is divided according to the experiments and components. You can directly build the circuit you like or go through this guide to get an in-depth knowledge of every component and system and customize them to make your own circuits.

1.1 Kit Introduction

The list of components in the kits -

- Battery
- Battery Connector
- Jumper Wires
- Multi-color Single Strand Wires
- Wire Cutter
- Tweezer
- Male Headers
- Breadboard
- Resistor Box
- Ceramic Capacitor
- Potentiometer
- Potentiometer Knob
- LDR
- Push Button
- Diode
- LED

- Transistor
- Power Supply Module
- Buzzer
- NE555 IC
- Toy Motor
- Toy Fan

2. Fun with LEDs

2.1 Overview

In this section you'll learn about Light Emitting Diodes (LED) and how to turn it on using different methods.

2.2 Component Introduction

Before diving into making circuits, we will first learn about the components that we are going to use and how to select the right component.

2.2.1 Resistors

Resistor is a passive electric component that resists the flow of current through it. They are used in almost all electrical and electronic circuits and systems. The resistance of a resistor in measured in ohms (Ω). An ohm is the resistance that occurs when one ampere (A) of current flows through a resistor with potential (or voltage) drop of one volt (V) across it's terminal.

Figure 2.1: Resistor Symbol

Ohm's Law

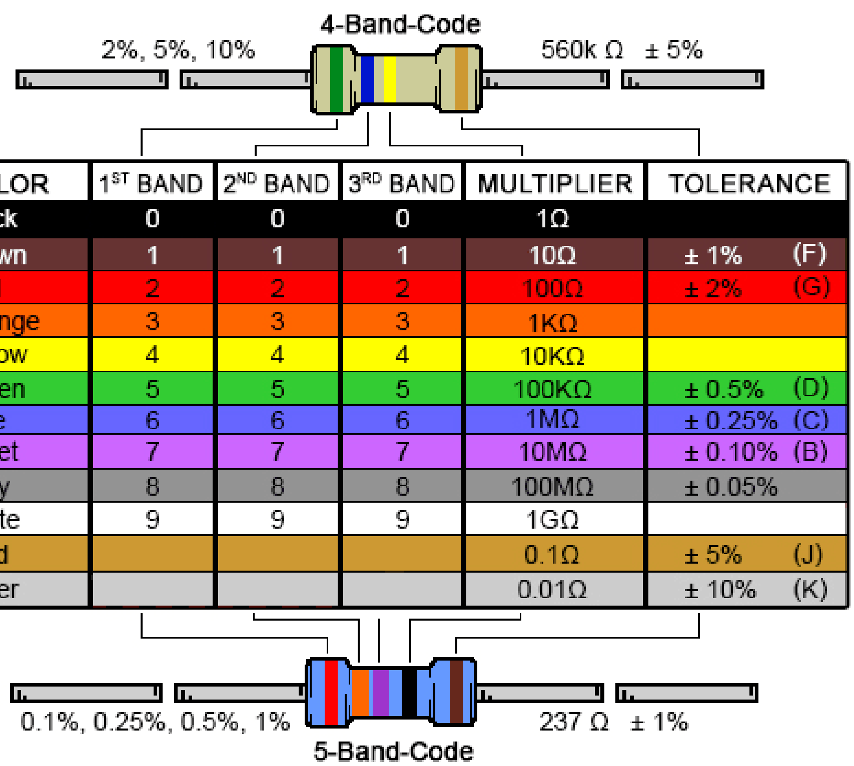
Ohm's law state that the current through a resistor is directly proportional to the voltage applied across it.

$$
\begin{aligned}
& I \propto V \\
\implies & R = \frac{V}{I} (\Omega)
\end{aligned}
$$

Reading Resistor Value

To read the value of resistance, first you need to know it's tolerance, this is known as E-series. E-24 series resistors have 5% tolerance, whereas E-48 has 2%. Once, you know the tolerance, you need to identify whether it's 4-Bands or 5-Bands. The last band represents tolerance (from the figure 2.2 you can tolerance band for 5%) and the second last is the exponential power of 10. So, if a 4-Bands resistor has a color code of Brown, Green, Orange and Gold it's value will be -

$$R_{Value} = (1_{Brown}5_{Green}) \times 10^{(3_{Orange})} \pm 5\%$$
$$R_{Value} = (15) \times 10^{(3)} \pm 5\%$$
$$R_{Value} = 15\mathrm{k}\Omega \pm 5\%$$



COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8	100MΩ	± 0.05%
White	9	9	9	1GΩ	
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)

Figure 2.2: Resistor Color Code

2.2.2 Light Emitting Diode

Light emitting diodes (LEDs) are semiconductor devices that emit lights of different wavelength depending on the substrate semiconductor material used when an electric current is applied. The color of light emitted depends on the amount of energy required by the electrons to cross the band gap of the semiconductor. Since, LEDs are basically a PN junction diode, they allow current flow only in one direction.

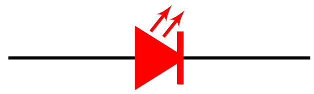


Figure 2.3: LED Symbol

Determining the pins of the LED

There are multiple ways to determine the anode and cathode of an LED:

1. Looking at the LED pins (or legs). The longer leg is anode and the shorter cathode. But sometimes the legs could be trimmed, therefore, you can use this method for new LEDs only.
2. Locate a flat edge on the LED. The pin close to flat edge is cathode.
3. By looking inside the LED, the bigger conductor (flag shaped) is the cathode.
4. By using multi-meter in continuity mode, only is one direction the LED will turn on (or the resistance in one direction will be smaller than in the other).

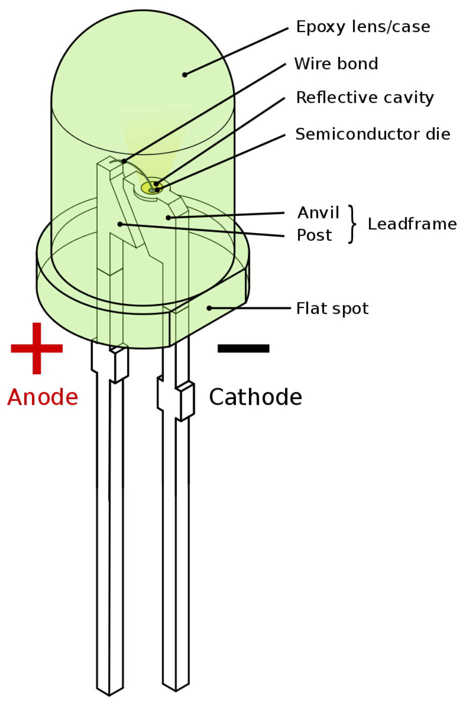


Figure 2.4: LED

2.2.3 Breadboard

A breadboard in a rectangular plastic board with a bunch of tiny holes in it. There's strip of metal inside the plastic. Most through hole components have pin spacing of 2.54mm, therefore, the holes have the same spacing between them. You can easily insert electrical components in these holes. There is also a deep grove in the middle, indicating the break in the connection. Some breadboard have two strips of holes (also called rails) along the long edges of the breadboard. They are used for power rails, with strip of metal inside. A breadboard is used to prototype an electronic circuit. The connection on breadboard are not permanent and can be removed easily. This makes breadboard

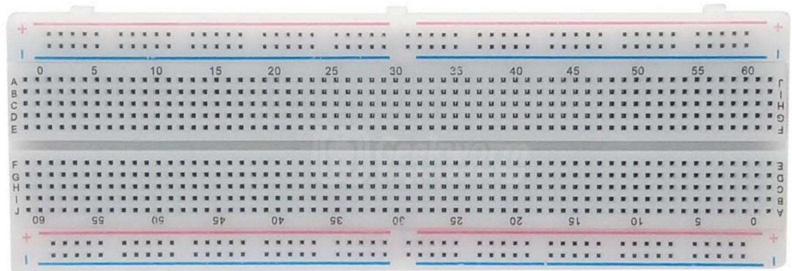


Figure 2.5: Breadboard

great for beginners who are new to electronics but the connections are not as reliable as soldered connections.

2.2.4 Breadboard Power Supply

A power supply is a hardware component that provides electricity to power devices like computer, fridge, lights and much more. The breadboard power supply of type linear DC to DC. A linear power supply has two major components, a linear regulator and filtering capacitors. The breadboard

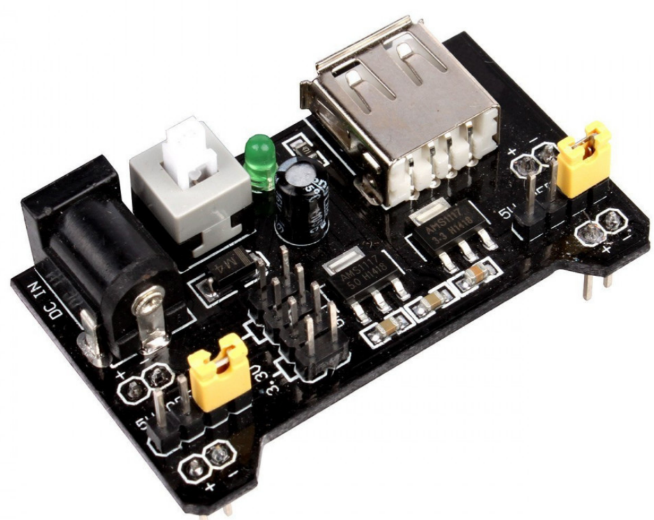


Figure 2.6: Breadboard Power Supply

power supply can provide constant 3.3V or 5V and is compatible with the breadboard power rails, i.e., you can directly plug in on top of the breadboard to have voltage across the power rails. The input voltage or power can be provided through the DC barrel jack (for 6-12V) or through the USB connector (5V).

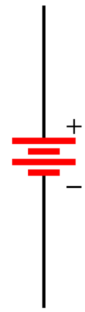


Figure 2.7: Battery Symbol

Calculating power dissipation

To calculate the power dissipation across the voltage regulator, we need to determine the output current. For linear regulator the input and output current remains same and the power difference is dissipated through the voltage regulator.

Example: We need 200mA current at 3,3V output, and the input power supply is of 9V. Then,

$$
\begin{aligned}
P_{out} &= 3.3V \times 0.2A = 0.66W \\
P_{in} &= 9V \times 0.2A = 1.8W \\
P_{reg} &= P_{in} - P_{out} \\
&= 1.8 - 0.66 \\
&= 1.14W \\
\eta &= \frac{P_{out}}{P_{in}} \times 100 \\
&= 36.67\%
\end{aligned}
$$

2.2.5 Push Button

Push button is use to control or provide input to the circuit. It is normally open and only when you press it the current will flow through it. And when released, the current will stop flowing. Push button have mechanical contacts, so when you press or release it, it doesn't instantaneously make or release contact. It bounces back and forth before making a firm connection.

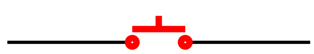


Figure 2.8: Push Button Symbol

2.2.6 Potentiometer

A potentiometer (pot) is a variable resistor and comes in different packages, size and values. They generally have 3 terminals. And the resistance between the outer most terminals is equal to the maximum resistance of the potentiometer and the resistance between middle and any outer pin can vary from 0 to the total resistance of potentiometer.

Figure 2.9: Tactile Push Button

Figure 2.10: Potentiometer Symbol

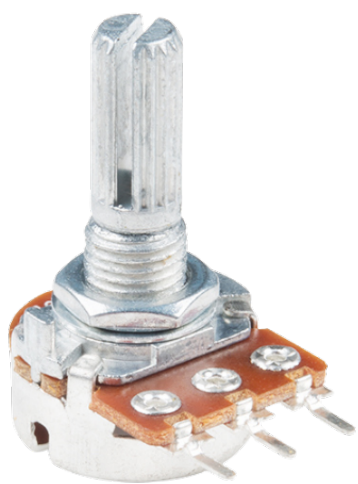


Figure 2.11: Potentiometer

2.2.7 Circuit

A circuit is a closed loop that provides path for current to flow. Circuit must have a path that start and end at the same component, or in order words must form a loop. Electronic circuits operates at low voltages.

A circuit has broadly the following components -

- Power sourcesupply
- Load (Light, led, motor etc)

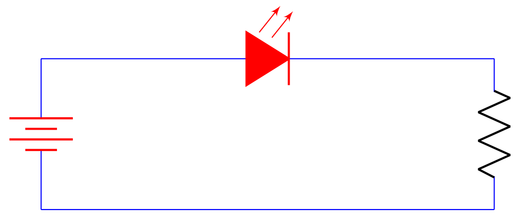


Figure 2.12: Simple Circuit

- Pathwire (conductive path providing current flow)

Apart from these, a circuit can have more complex design.

2.3 Lesson 1: Lighting up an LED

2.3.1 Objective

In this activity you'll learn how to turn on an LED

2.3.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 5mm Red LED × 1
6. 220Ω resistor × 1
7. Male to Male Jumper Wires × 2

2.3.3 Circuit

(a) Circuit A (b) Circuit B

Figure 2.13: Simple LED Circuits

Throughout this guide we'll be using these symbols for power supply.

(a) Circuit A (b) Circuit B

Figure 2.14: Simplified LED Circuits

2.3.4 Circuit Explanation

If we look at the graphs in the data-sheet of RED led[Sem13c], the forward current through the led (I_F) is typically in between 10 mA to 20 mA and the voltage drop (V_F) across it is 2 V. If we directly connect the LED across 5 V supply it will burn out due to excessive power. Therefore, we need a resistor in series with the LED to drop the voltage. This resistor is referred as the current-limiting resistor. If you look at the figure 2.13 both the circuits A & B are same because in series circuits the current remains same across all the components.

To calculate the series resistance (R_S) we'll use Ohm's law: We'll take the average value for I_F

$$\begin{aligned} V &= I \times R \\ R_S &= \frac{V_{5v} - V_F}{I_F} \\ &= \frac{5V - 2V}{15mA} \\ &= \frac{3 \times 1000}{15} \\ R_S &= 200\,\Omega \end{aligned}$$

Since, in the kit a 220 Ω is available, we will use that. If we calculate the current using a 220 Ω resistor, it will $3 \div 220 = 0.0136$ A = 13.6 mA which is in the range provided by the data-sheet.

2.3.5 Circuit Picture

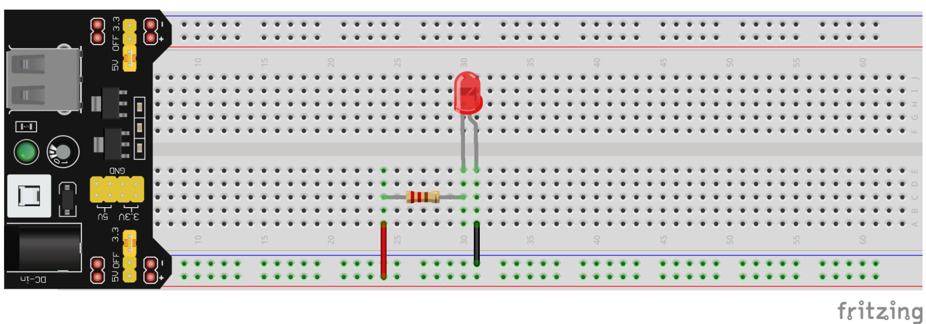


Figure 2.15: Simple Circuit Breadboard Schematic

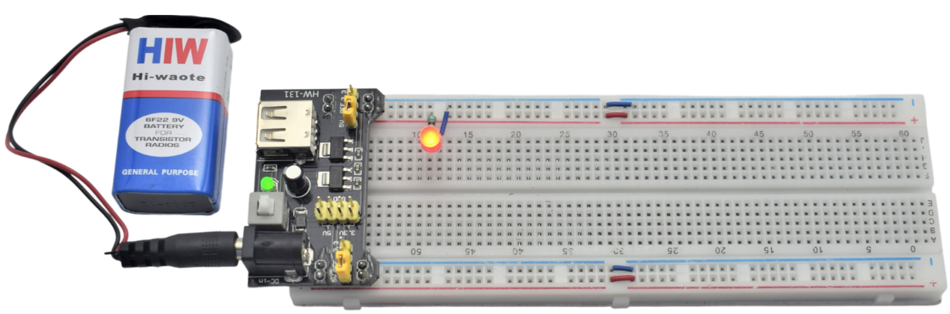


Figure 2.16: Simple Circuit on Breadboard

2.4 Lesson 2: Lighting up an LED by pressing a Switch

2.4.1 Objective

In this activity we'll turn on the led using a push button.

2.4.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 5mm Red LED × 1
6. 220Ω resistor × 1
7. Male to Male Jumper Wires × 2
8. Push Button × 1

2.4.3 Circuit

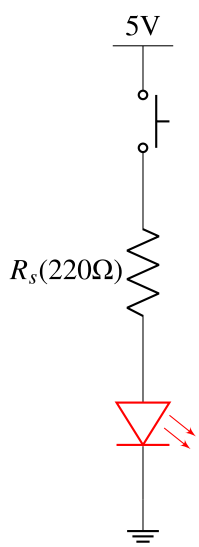


Figure 2.17: Push Button Circuit

2.4.4 Circuit Explanation

This circuit is similar to the one we made previously, except for the fact that we have a push button in series. The button is normally open, meaning no current flows through the circuit (no complete loop or path) and when we press the button the path is complete and LED will turn on.

2.4.5 Circuit Photo

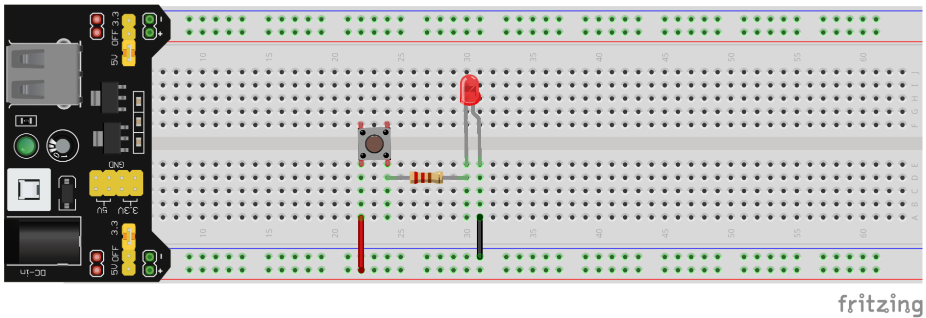


Figure 2.18: Breadboard Schematic

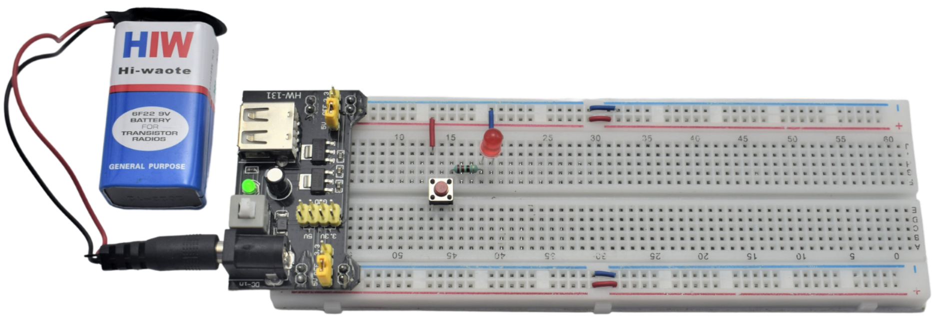


Figure 2.19: LED Off, Switch Open

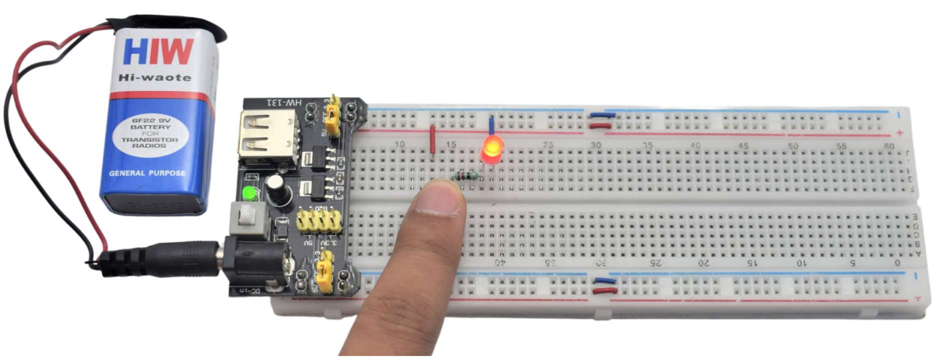


Figure 2.20: LED On, Switch Closed/Pressed

2.5 Lesson 3: Controlling LED brightness using a Potentiometer

2.5.1 Objective

In this activity, we'll control the LED brightness/intensity with help on a potentiometer.

2.5.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 5mm Red LED × 1
6. 220Ω resistor × 1
7. Male to Male Jumper Wires × 2
8. Potentiometer × 1

2.5.3 Circuit

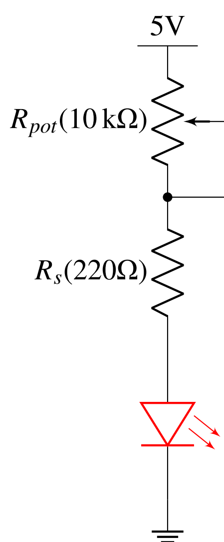


Figure 2.21: Potentiometer LED Circuit

2.5.4 Circuit Explanation

When the potentiometer resistance R_{pot} is 0Ω, the LED will be in series with R_S and glow. As we'll increase the resistance of potentiometer the effective series resistance will increase $R_t = R_S + R_{pot}$. With increase in the series resistance, the current through the circuit will decrease according to the Ohm's law ($I \propto \frac{1}{R}$) changing the intensity of the LED.

2.5.5 Circuit Picture

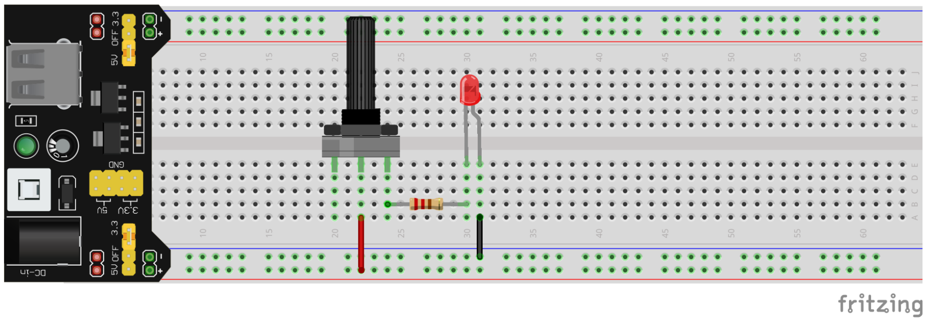


Figure 2.22: Breadboard Schematic

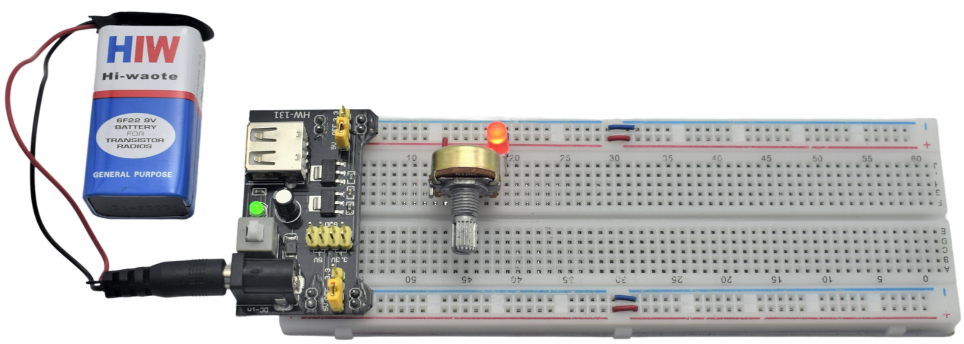


Figure 2.23: Max Intensity, $R_{pot} = 0$

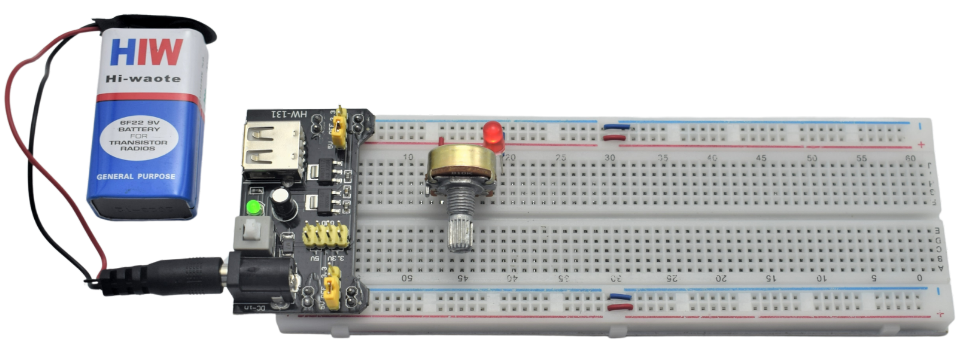


Figure 2.24: Min Intensity, $R_{pot} = 10\text{k}\Omega$

3. Transistors

3.1 Overview

In this section you'll learn about Light Emitting Diodes (LED) and how to turn it on using different methods.

3.2 Component Introduction

In this chapter we will be using transistor to make electronic circuits. There are different types of transistors available but we will be using bipolar junction transistor (BJTs) only. BJTs are the most common transistor type used among the hobbyists and DIYers.

3.2.1 BJT

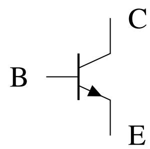
A transistor is a semiconductor device with 3 terminals or regions. The interface between each of the regions forms a p-n junction, it likes two diodes together. There are two types of BJTs - NPN, when a p-type semiconductor is in-between two n-type. PNP, when a n-type semiconductor is in-between two p-type. Transistors are used to amplify or switch electronic signals and electrical power. Each of the terminals or regions are named -

- Collector: The largest semiconductor region of the transistor.
- Emitter: The second largest semiconductor region of the transistor.
- Base: Middle region of the transistor. This serves as a gatekeeper that determines the amount of current that can flow through emitter-collector regions.

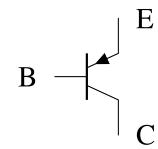
Operation Modes for Transistor

There are 4 modes in which a transistor works -

1. **Cut-off** In cut-off mode no current flows through the transistor. The transistor acts like an open circuit.
2. **Saturation** In saturation mode the transistor allows current to flow freely and acts like an short-circuit.



(a) NPN



(b) PNP

Figure 3.1: Transistor Symbol

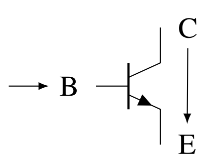
3. **Active** In active mode the amount of current flowing through the collector-emitter region is proportional to the current flowing through base.
4. **Reverse-Active** It is similar to active mode, but the direction of current is reversed. The transistors are not meant to operate in Reverse-Active mode.

If we make sure that the transistor operates in only cut-off or saturation region, then it can act like a switch turning current flow ON or OFF by controlling the base voltage. In this guide most of the circuits will use transistor in Saturation & cut-off mode. In NPN transistor, the base voltage should

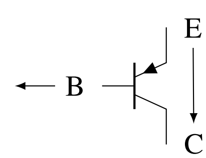
Figure 3.2: Transistor

be higher than the emitter voltage by threshold voltage V_{th}, defined in the data-sheet of the transistor. Generally it is near about 0.7 V.

For PNP, the base voltage should be lower than the emitter voltage by V_{th}.



(a) NPN



(b) PNP

Figure 3.3: Direction of Conventional current in BJTs

For both the transistors, $I_E = I_C + I_B$

3.2.2 Capacitor

Capacitor is a pretty simple electronic device. It consists of two conductive plates separated by an insulated medium called dielectric. Capacitors when powered are able to store energy in the form of electric field between the two plates. With different types of dielectric, there are different types of capacitors and have different qualities and uses. Capacitors can be polarized when dielectric used is polarized and favours electric field in one direction. The value of capacitor is measured in Farads (F),

(a) Non Polarized (b) Polarized

Figure 3.4: Capacitor Symbol

and one farad is a very big value. *The capacitance of earth is* 710 µF. Capacitors or Caps are used

Figure 3.5: Different types of Capacitors

in many ways and can be found in almost every electronic circuits. On Polar capacitors the exact values in written on the body, for ceramic capacitor the values is written with 2 significant digits and 1 multiplier, for example capacitance of a ceramic capacitor with 105 written on it is, 10×10^4pF = $1 \times 10^5 \times 1 \times 10^{-12}$F = 1×10^{-7}F = 0.1 µF

3.2.3 LDR

Light Dependent Resistor(LDR) or photocell or photo-resistor is a semiconductor device which exhibits a very special property, it acts like a resistor but the value of resistance depends on the amount of light falling on it. In bright light, the LDR resistance will be in the range of 0.01-10kΩ

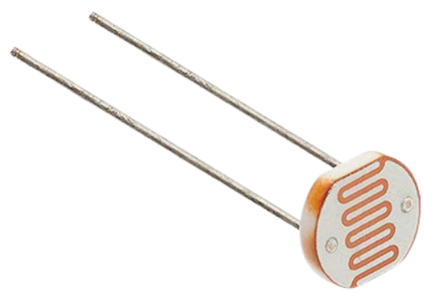


Figure 3.6: LDR

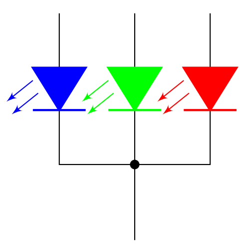
and in darkness it's resistance will be in the range of 100-1000kΩ.

Figure 3.7: LDR Symbol

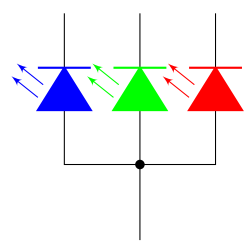
3.2.4 RGB LED

RGB LED is a combination of all three LEDs (RED, GREEN, BLUE) in one single package. You can produce different colors using RGB LEDs by configuring the intensity of each LED. There are two kinds of RGB LED, one shares the cathode pin and the other shares the anode pin.

Figure 3.8: RGB LED



(a) Common Anode



(b) Common Cathode

Figure 3.9: RGB LED Symbol

3.3 Lesson 4: Astable Multivibrator

3.3.1 Objective

In this activity, we will make an astable multivibrator using BJTs and flash two LEDs.

3.3.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. Red LED × 2
6. 220 Ω × 2
7. 100 kΩ × 2
8. 2N2222 NPN Transistor × 2
9. 10 µF × 2
10. Male-Male jumper wire × 6

3.3.3 Circuit

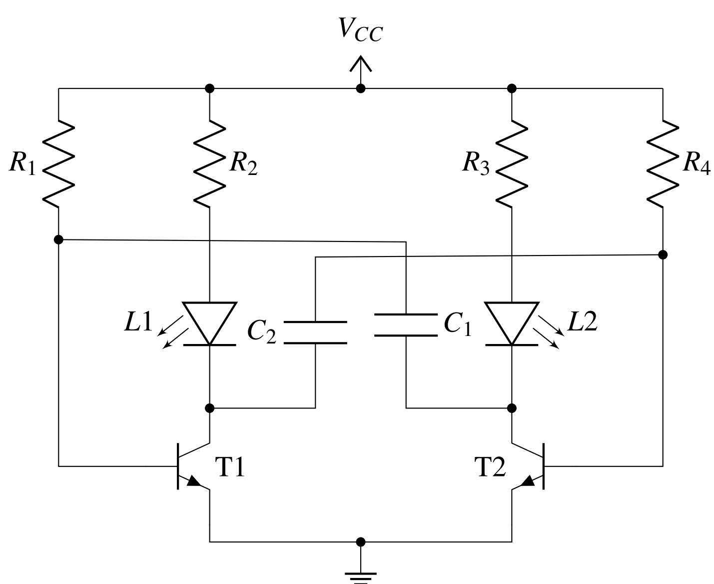


Figure 3.10: Astable Multivibrator

3.3.4 Circuit Explanation

Let's assume that $T1$ has just turned off and $T2$ has just turned on which means C_2 is fully charged and C_1 is discharged. Since, $T1$ is in cut-off mode, the collector $T1.C$ will rise to V_{cc} potential and the potential across the C_2 capacitor will be $V_{cc} - V_{th}$, where V_{th} is the threshold voltage of transistors.

$T2$ is fully on, the capacitor C_1 will start charging through resistor R_1 and the LED_1 will be turned on. When the plate of C_1 connected to base of $T1$ rises to potential V_{th} it will pull $T1$

into conduction and then saturation mode. When the transistor $T1$ is in saturation mode it will immediately pull the capacitor C_1 to ground, this rapid change in voltage at the plate of capacitor C_1 connected to $T1.C$ causes an equal and instantaneous fall in voltage at the plate connected to base of $T2$, turning it hard off. Now $T1$ is On turning LED_1 on and $T2$ is off and the same cycle repeats again, $C2$ starts charging turning $T2$ on and $C1$ turning $T1$ off.

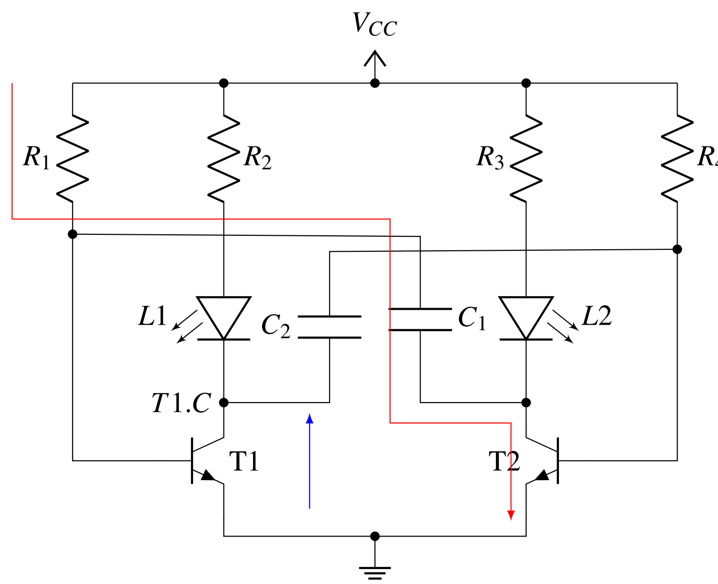


Figure 3.11: T1 off, T2 on

The time period or frequency of oscillation for astable multivibrator can be calculated using the below equations -

$$t_1 = 0.693 \times R_1 \times C_1$$
$$t_2 = 0.693 \times R_4 \times C_2$$

where, t_1 & t_2 are charging and discharging time period for the capacitors.

For symmetrical astable multivibrator $R_1 = R_2$ and $C_1 = C_2$.

The total time period is -

$$T = t_1 + t_2$$
$$T = 0.693RC + 0.693RC$$
$$T = 1.386RC$$

In our circuit we will use $R_2 = R_3 = 220\Omega$, $R_1 = R_4 = 100\text{k}\Omega$ and $C_1 = C_2 = 10\mu\text{F}$.

By changing the values of series RC we have change the time period of oscillation.

3.3.5 Circuit Picture

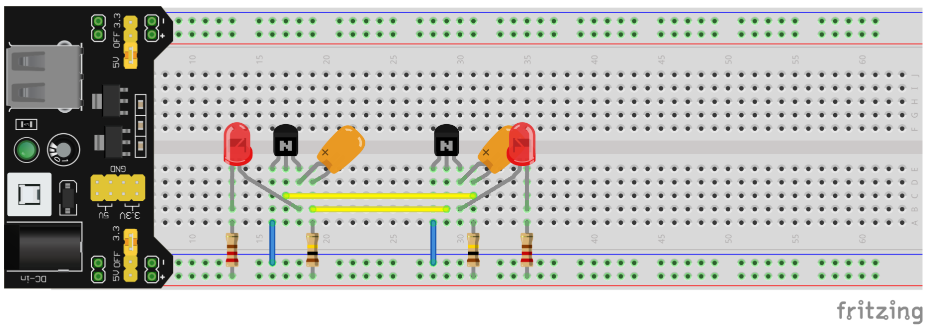


Figure 3.12: Circuit Schematic

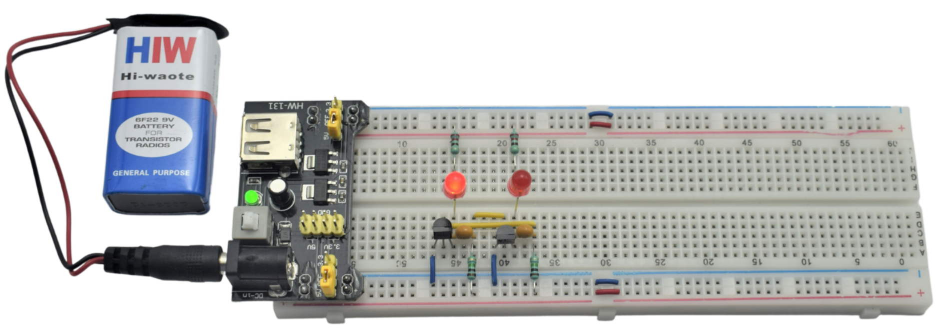


Figure 3.13: Astable Multivibrator Breadboard Schematic

3.4 Lesson 5: Transistor as Touch Sensor

3.4.1 Objective

In this activity we will build a very basic touch sensor using transistors.

3.4.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. Red LED × 1
6. 220 Ω × 1
7. 10 kΩ × 1
8. 2N2222 NPN Transistor × 2
9. Male pin header × 2
10. Male-Male jumper wire × 5

3.4.3 Circuit

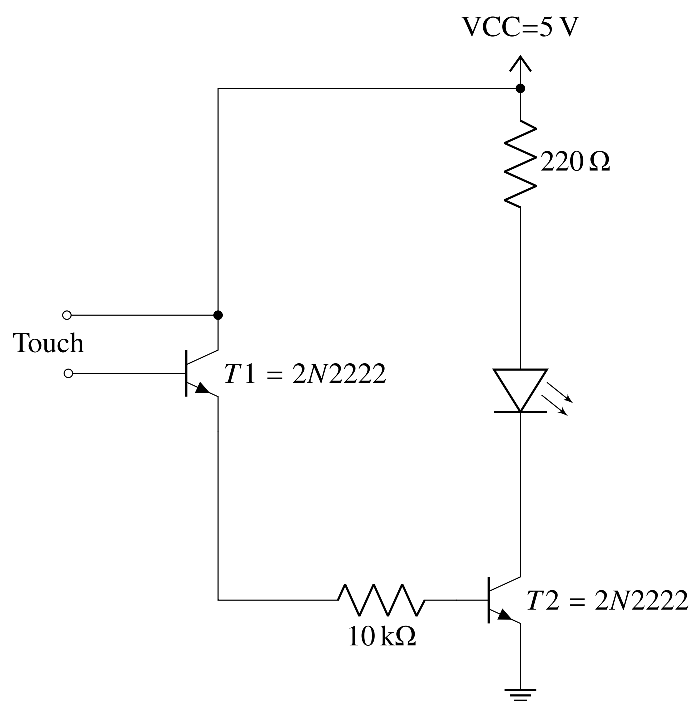


Figure 3.14: Transistors as Touch Sensor

3.4.4 Circuit Explanation

By default both the transistors are turned off. When you touch the male pin headers connected between VCC and the base of $T1$, you body acts like a resistor between them, allowing a very small current(I_{B1}) to pass through the base of $T1$. This current is not sufficient to push $T1$ into saturation.

Therefore, we have connected the base of $T2$ to the emitter of $T1$ and the base current(I_{B2}) for $T2$ is approximately equal to the collector current(I_{C1}) of $T1$, which is $\beta \times I_{B1}$. This current is sufficient to pull the $T2$ transistor into saturation mode and the LED turn on.

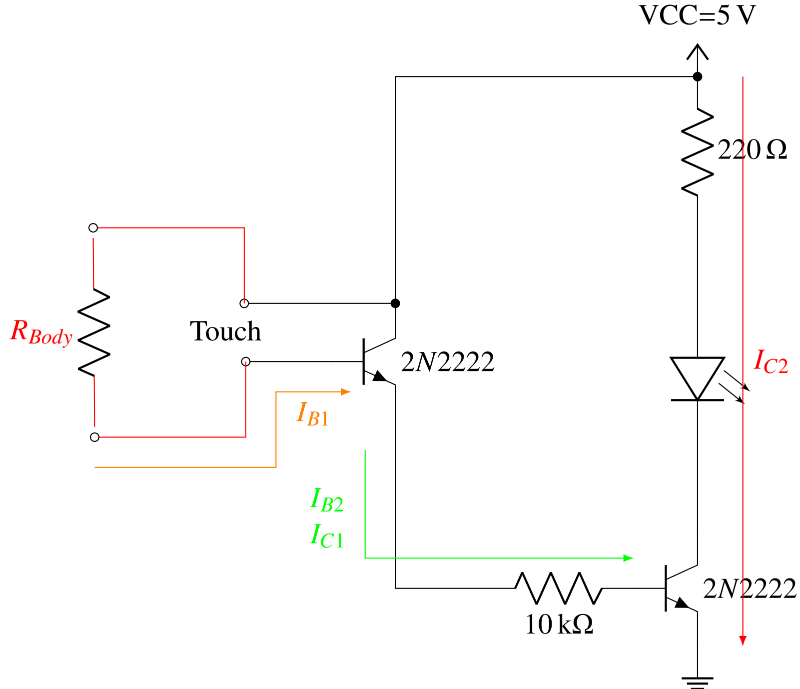


Figure 3.15: Touch Sensor Working

3.4.5 Circuit Picture

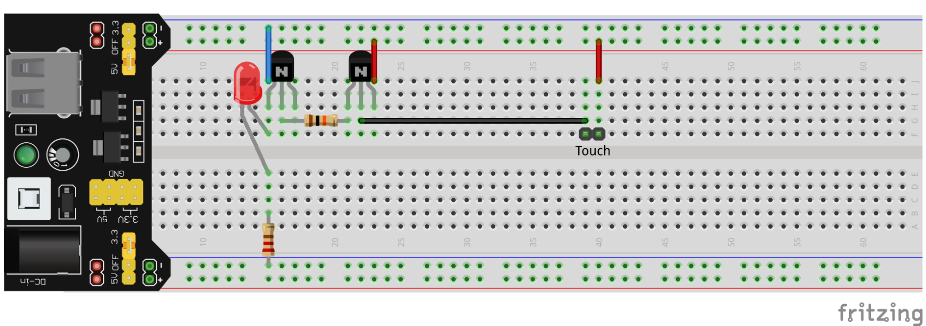


Figure 3.16: Breadboard Schematic

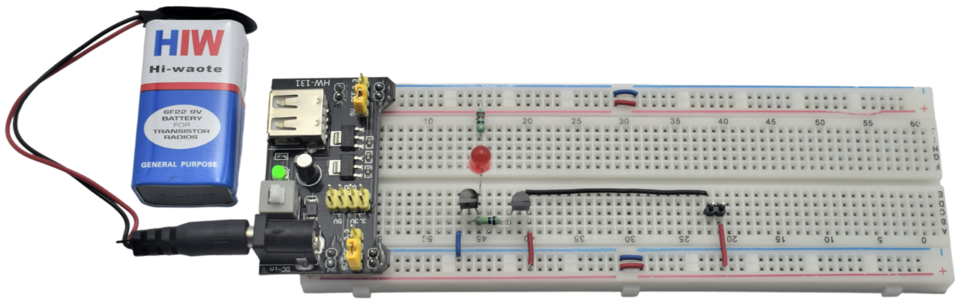


Figure 3.17: Touch Switch on Breadboard

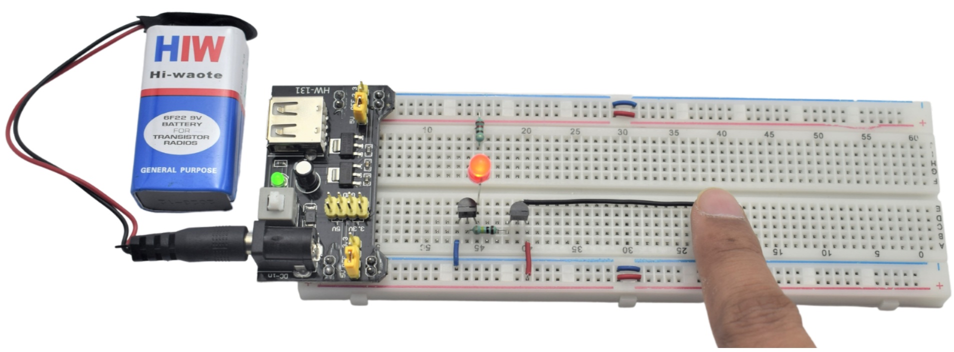


Figure 3.18: Touch Switch on Breadboard - LED glows on touching the pin headers

3.5 Lesson 6: Flip Flop

3.5.1 Objective

In this activity we'll use transistors and push buttons to make a flip flop circuit.

3.5.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. Red LED × 2
6. 1 kΩ × 2
7. 100 kΩ × 2
8. 2N2222 NPN Transistor × 2
9. 10-XX Push Buttons × 2
10. Male-Male jumper wire × 8

3.5.3 Circuit

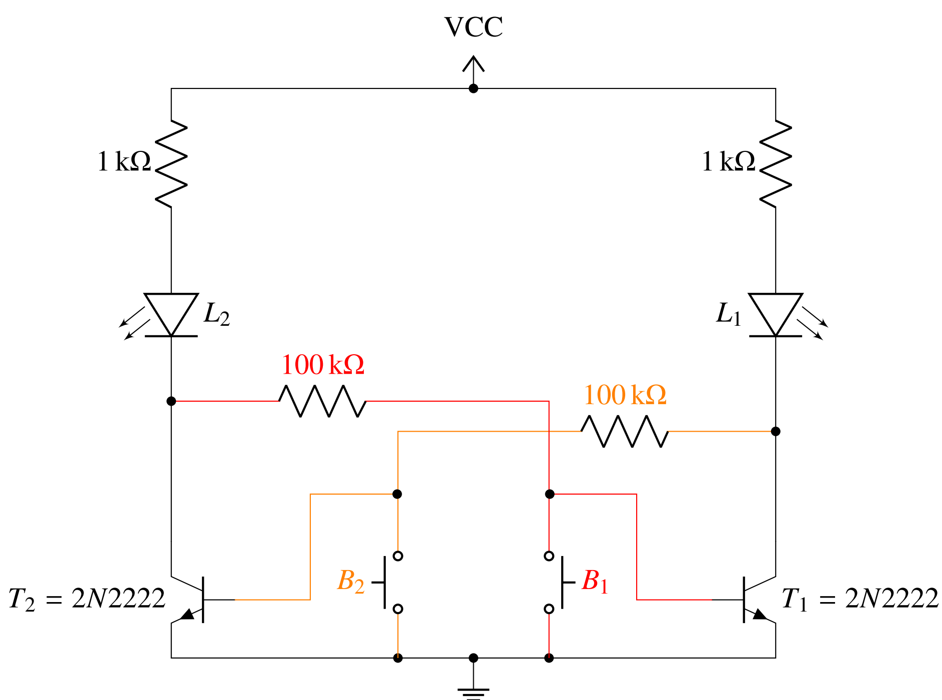


Figure 3.19: Flip Flop

3.5.4 Circuit Explanation

Let's assume that L_1 is on, which means there is a very small amount of current flowing through the L_2 to the base of transistor T_1. The current flowing through L_1 will prefer to go through the transistor T_1 because this path offers the least resistance.

Now, when we press the button B_1 the current going to the base of T_1 will now directly go to the ground, switching T_1 off. And there will be a small current going through the led L_1 to the base of transistor T_2, pushing it into saturation. And when we leave the button B_1 the current through L_2 will go through T_2 only, as it will offer a path with least resistance.

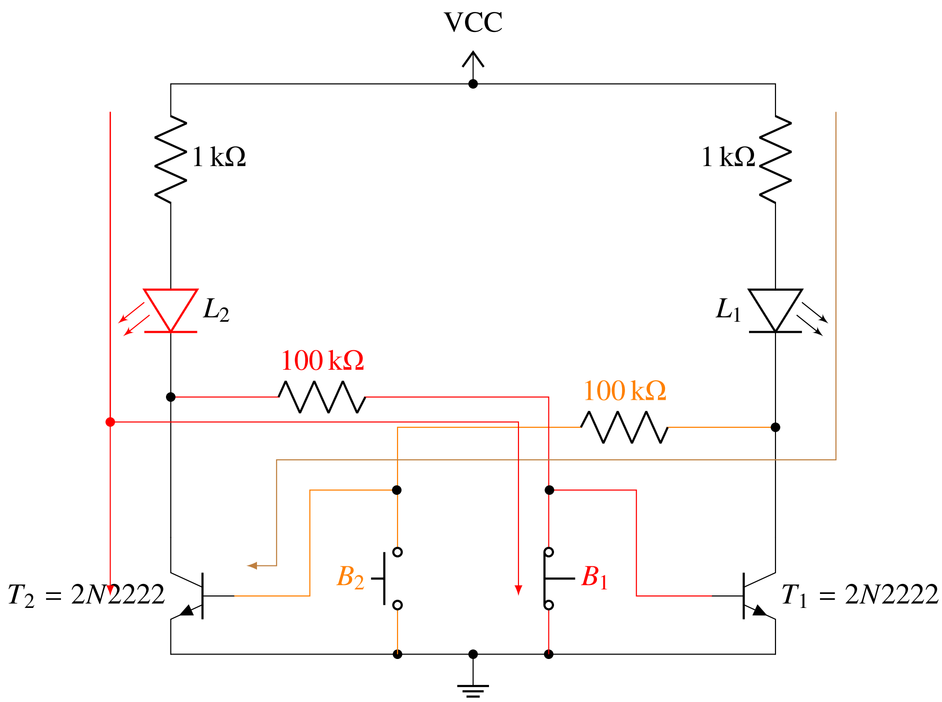


Figure 3.20: Flip Flop Working

3.5.5 Circuit Picture

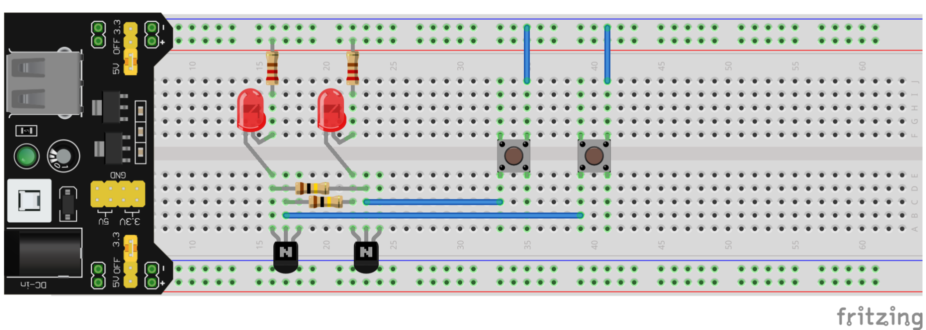


Figure 3.21: Breadboard Schematic

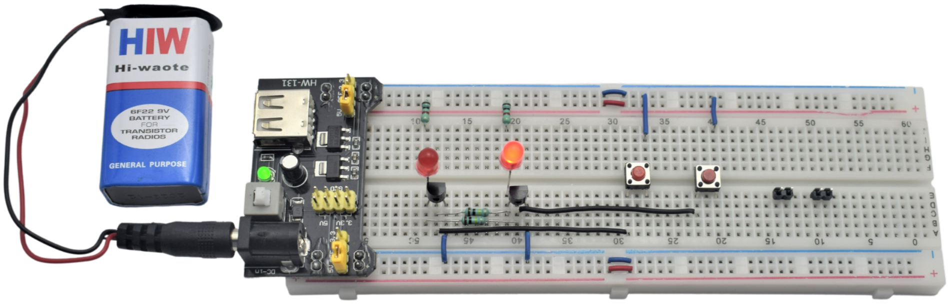


Figure 3.22: Flip/Flop using BJTs on Breadboard

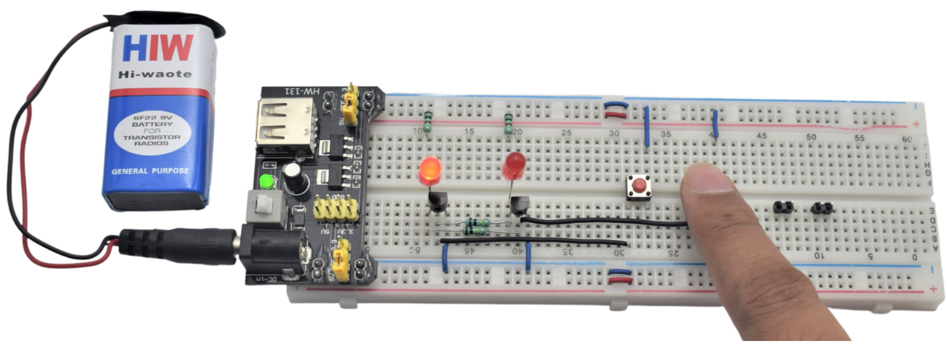


Figure 3.23: Flip/Flop using BJTs on Breadboard

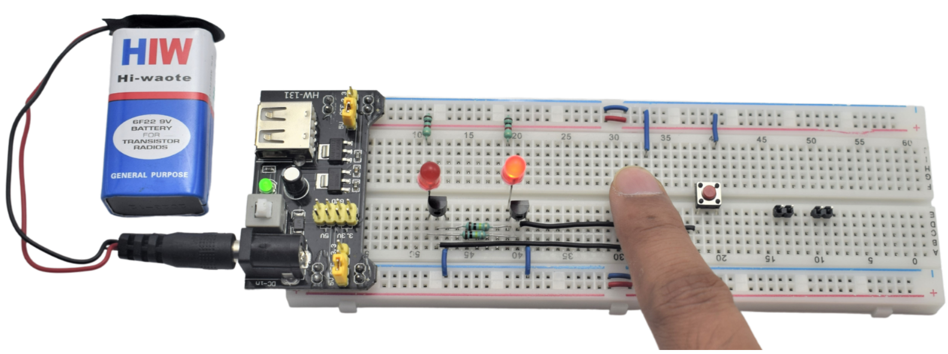


Figure 3.24: Flip/Flop using BJTs on Breadboard

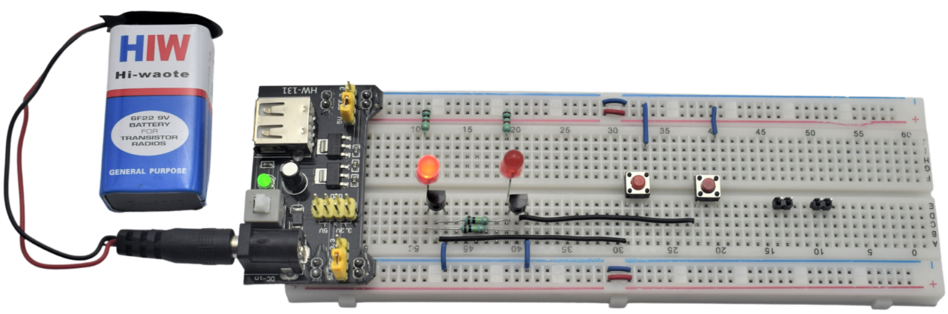


Figure 3.25: Flip/Flop using BJTs on Breadboard

3.6 Lesson 7: On/Off Touch using Transistors

3.6.1 Objective

In this activity we will make an on off touch switch using transistors, which will remember its state.

3.6.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. Red LED × 1
6. 220 Ω × 1
7. 10 kΩ × 1
8. 100 kΩ × 1
9. 2N2222 NPN Transistor × 3
10. 2N2907 PNP Transistor × 1
11. Male pin headers × 4
12. Male-Male jumper wire × 13

3.6.3 Circuit

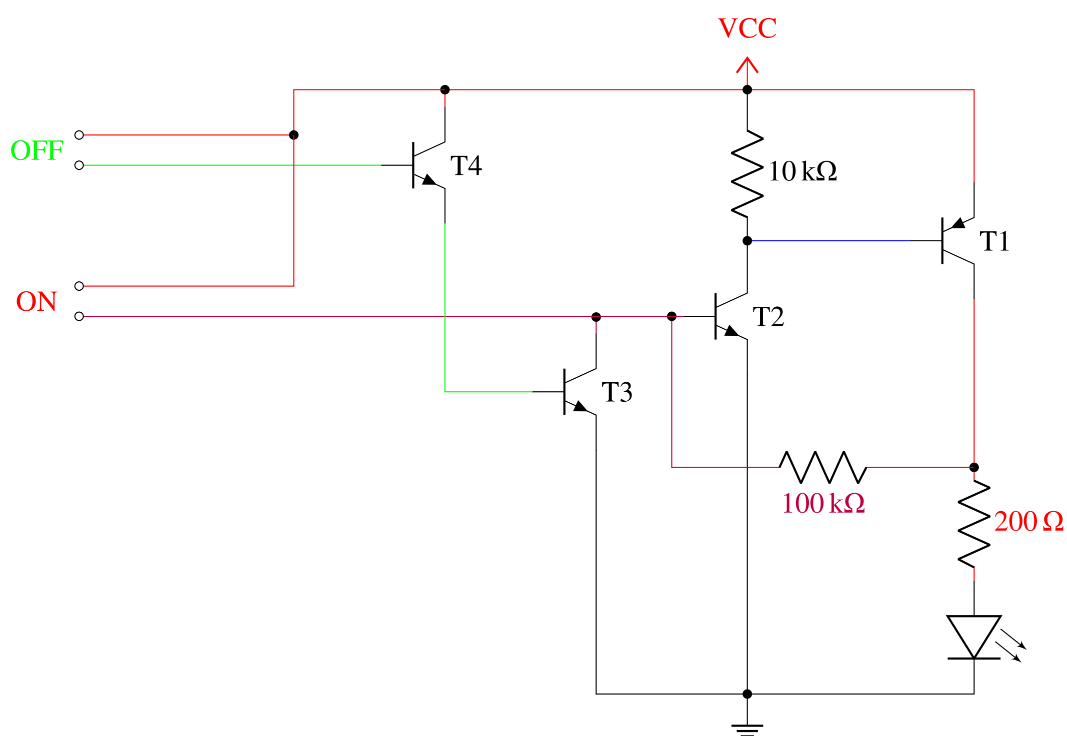


Figure 3.26: On/Off Touch Switch using Transistors

3.6.4 Circuit Explanation

When we touch the pin headers marked *on*, we introduce our body resistance between VCC and base of transistor $T2$, turning it on. When $T2$ is turned on, it pulls the base of transistor $T1$ to ground, pushing it to saturation mode. A small part of the current flowing through the collector of $T1$ goes to the base of $T2$ through feedback resistor. Now, when we remove our body resistance from the circuit the current through feedback keeps $T2$ on, which make sure the $T1$ is on and the led is glowing.

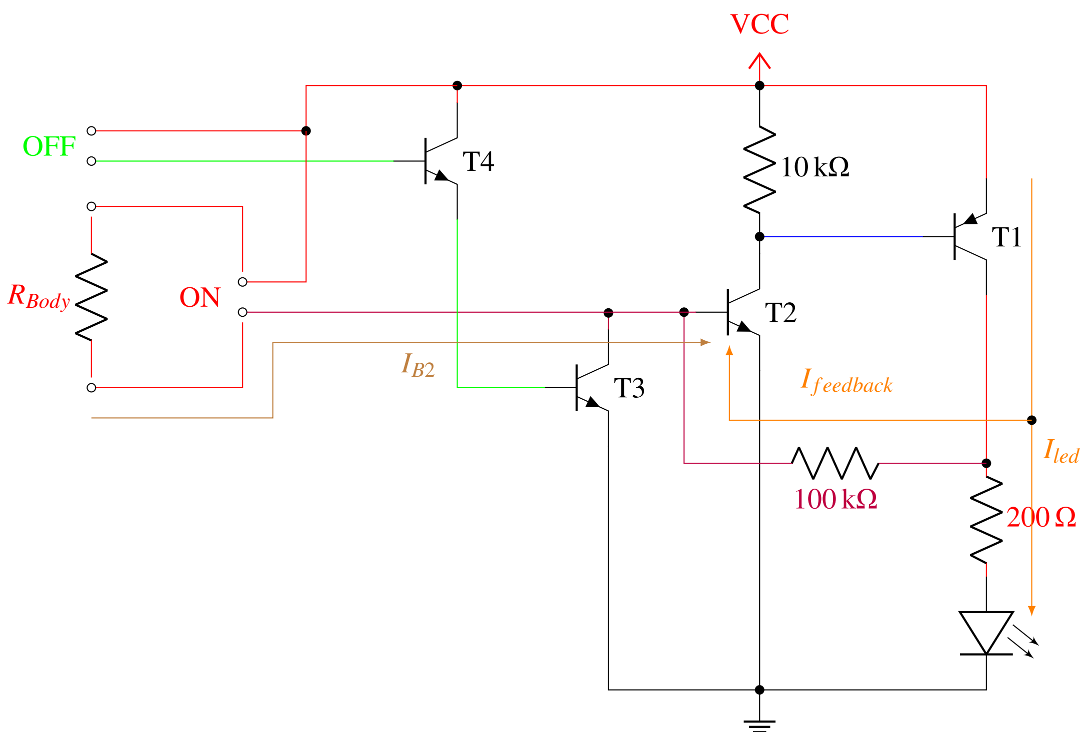


Figure 3.27: Touch Switch using Transistors - On State

Now, when we touch the pin header marked *off*, we introduce our body resistance in between the VCC and the base of $T4$, turning it on. The $T4$ collector current goes to the base of $T3$, turning it on. There are two things that causes the led to turn off, base of $T2$ is pulled to ground, and the feedback current keeping it on goes to ground via $T3$. It means $T2$ is switched off, and when $T2$ is off the base of $T1$ is pulled high, turning it hard off.

3.6.5 Circuit Picture

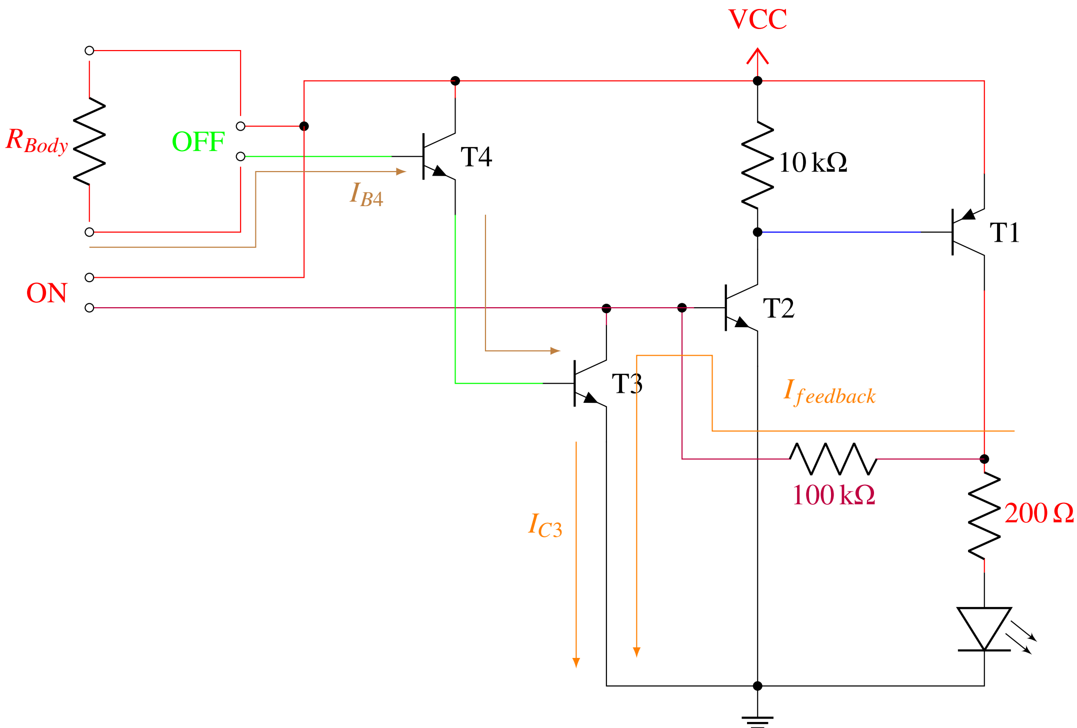


Figure 3.28: Touch Switch using Transistors - Off State

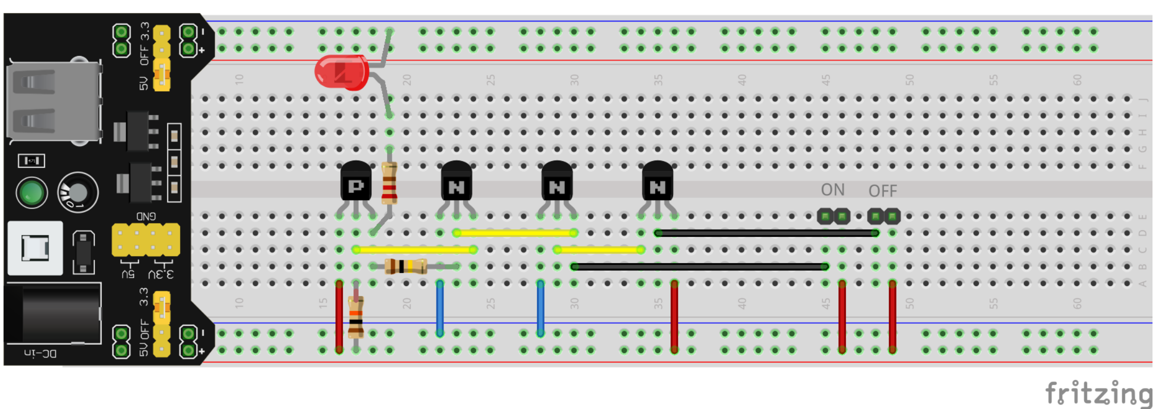


Figure 3.29: On/Off touch switch using BJTs Breadboard Schematic

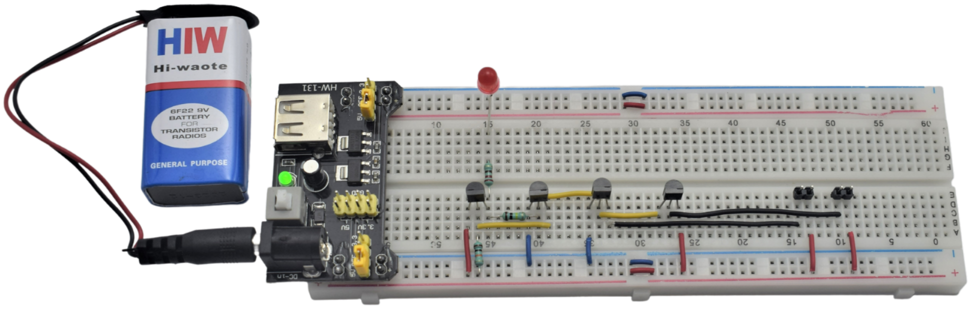


Figure 3.30: On/Off Touch Switch:

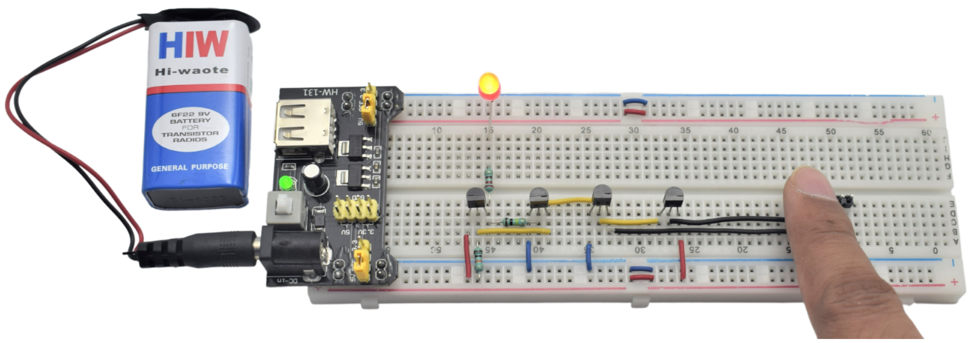


Figure 3.31: On/Off Touch Switch:

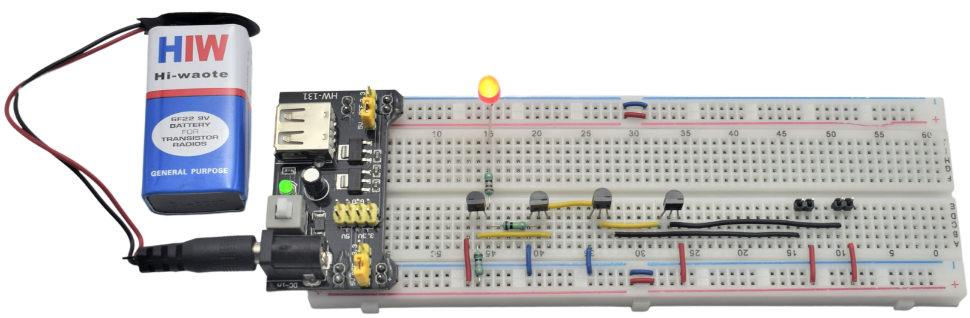


Figure 3.32: On/Off Touch Switch:

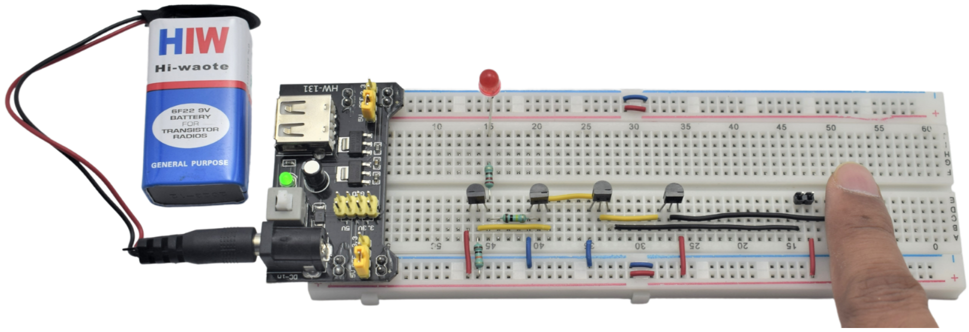


Figure 3.33: On/Off Touch Switch:

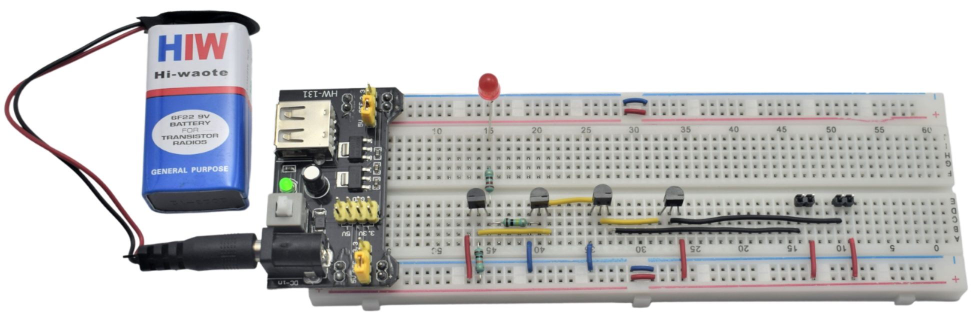


Figure 3.34: On/Off Touch Switch:

3.7 Lesson 8: Toggle Switch using Transistors

3.7.1 Objective

In this activity we will make an toggle switch which toggles the output state using push button and transistors.

3.7.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. Red LED × 1
6. 100 nF × 1
7. 220 Ω × 1
8. 10 kΩ × 1
9. 100 kΩ × 2
10. 1 MΩ × 2
11. 2N2222 NPN Transistor × 2
12. 2N2907 PNP Transistor × 1
13. 10-XX Push Button × 1
14. Male-Male jumper wire × 10

3.7.3 Circuit

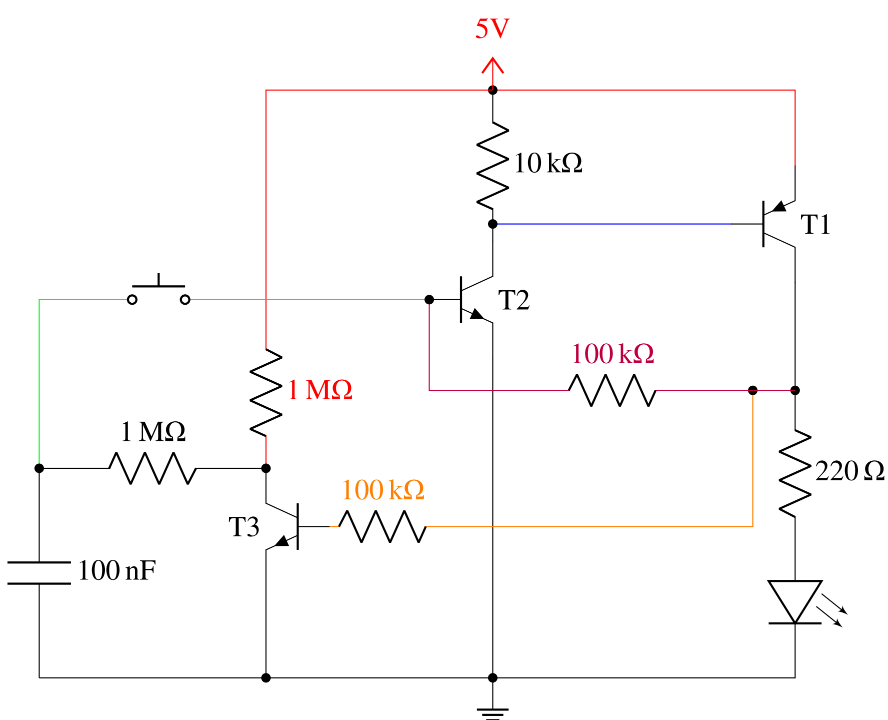


Figure 3.35: Toggle Switch using Transistors

3.7.4 Circuit Explanation

Let us assume that initially all the transistors are off along with the led. In this case, the capacitor gets charged via the two 1MΩ resistors. And no current is flowing through any transistor.

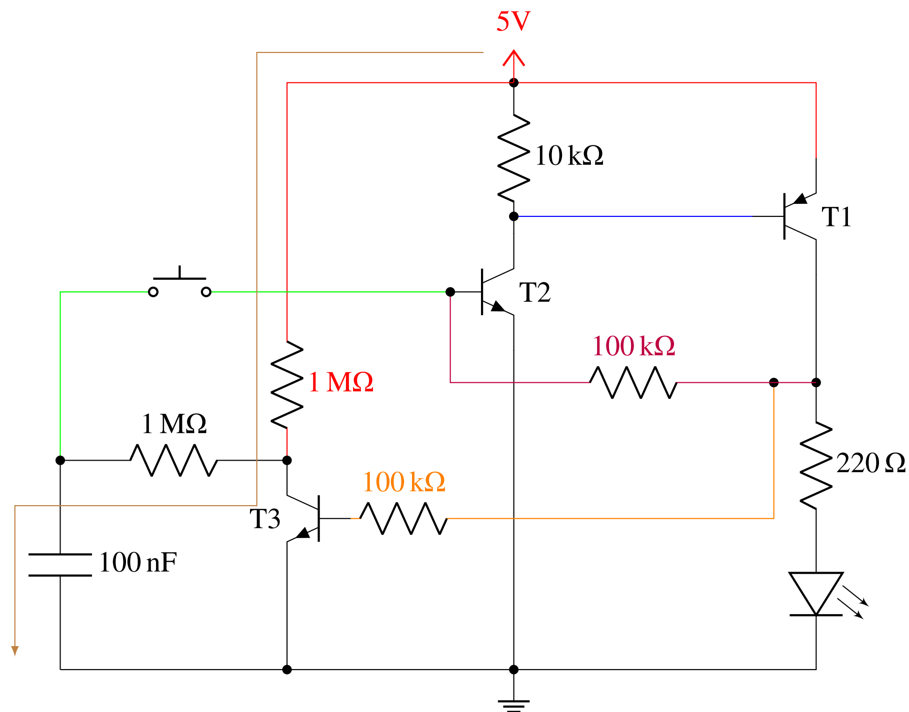


Figure 3.36: Toggle Switch using Transistor - Idle

When we press the switch, the capacitor's +ve plate is connected to the base of the transistor $T2$, and therefore a base current starts flowing, turning $T2$ on. With $T2$ on the base of transistor $T1$ is pulled to ground, turning it and the led on. There is also a feedback current flowing back to base of $T2$ and $T3$.

On leaving the switch, the feedback current keeps the $T2$ on which keeps $T1$ on. Also, this feedback current turn on the $T3$ which discharges the capacitor through it. At this stage all the transistors are on, led is on and the capacitor is completely discharged.

Now, when we again press the switch, the feedback current going to base of $T2$, goes to ground via the capacitor, which is discharged and therefore provide little to no resistance. This turns off the $T2$, and the base of $T1$ is pulled back to VCC, causing it to turn off. Now the led is off and all the transistor are not conducting, which is idle state.

3.7.5 Circuit Picture

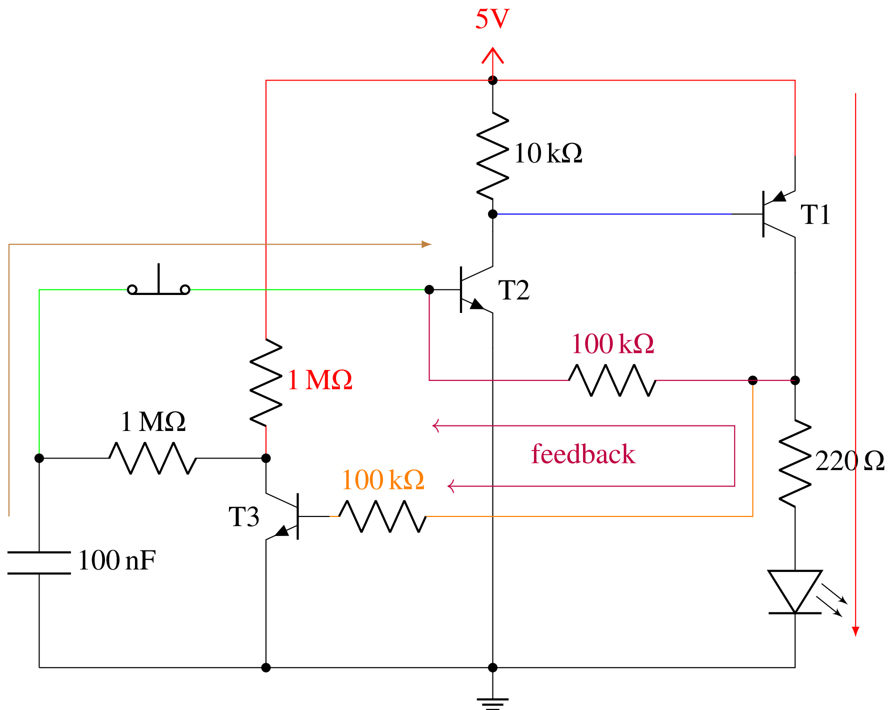


Figure 3.37: Toggle Switch using Transistor - On

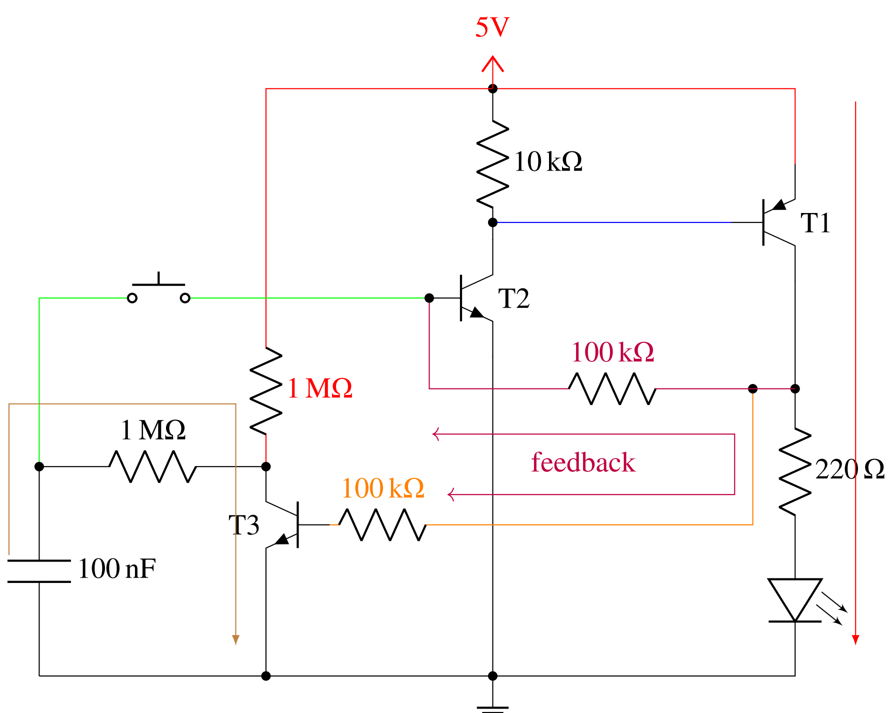


Figure 3.38: Toggle Switch using Transistor - Idle On

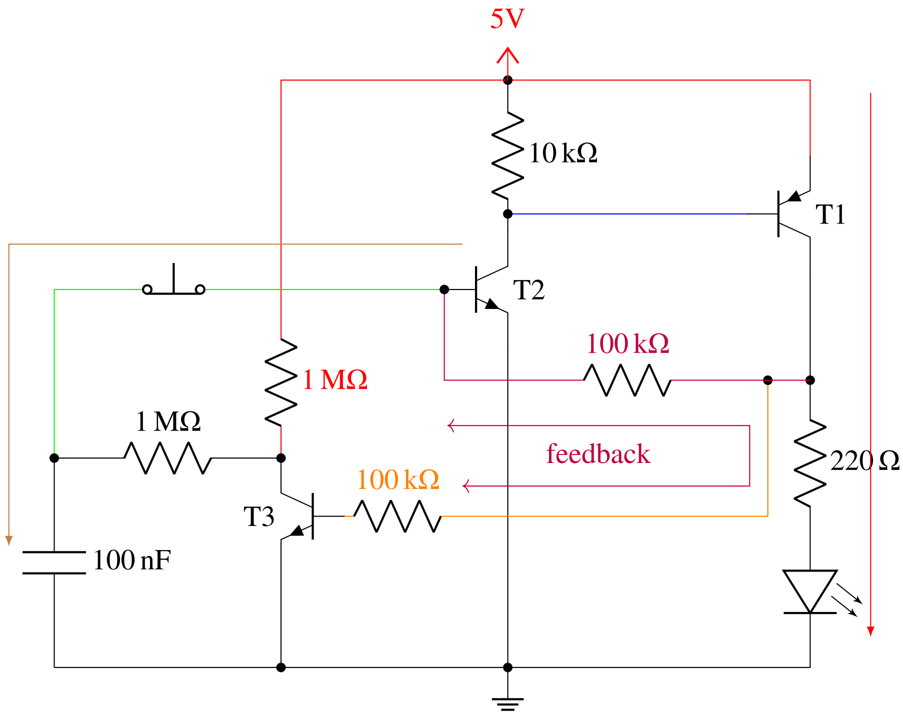


Figure 3.39: Toggle Switch using Transistor - Off

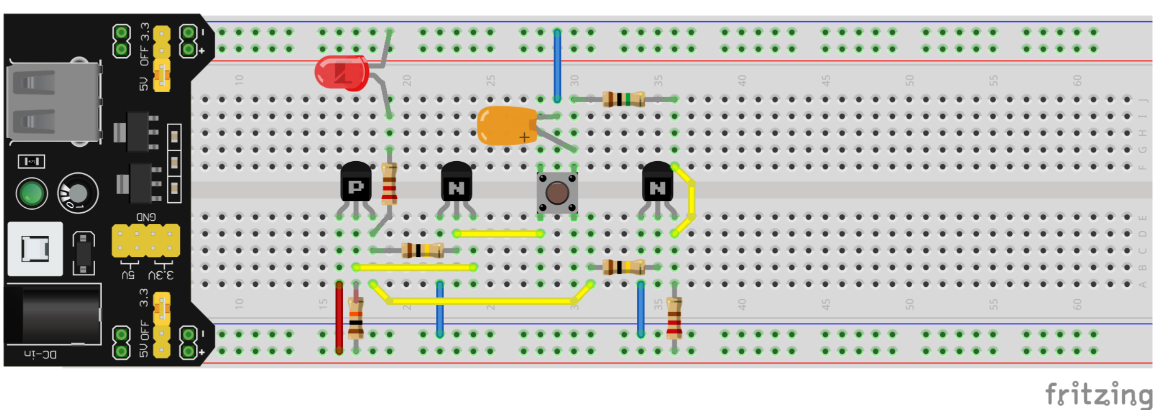


Figure 3.40: Toggle Switch using BJTs Breadboard Schematic

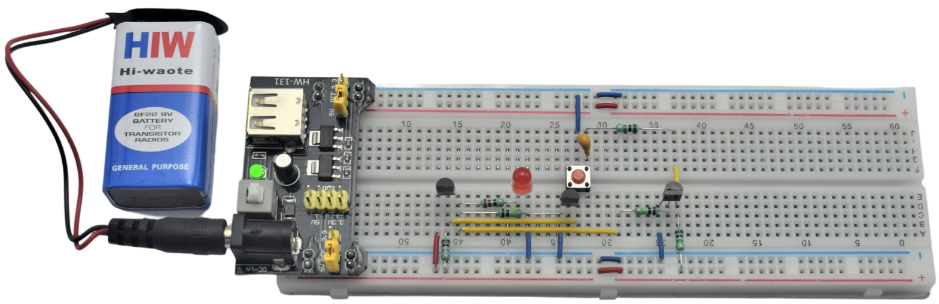


Figure 3.41: Toggle Switch: Off State

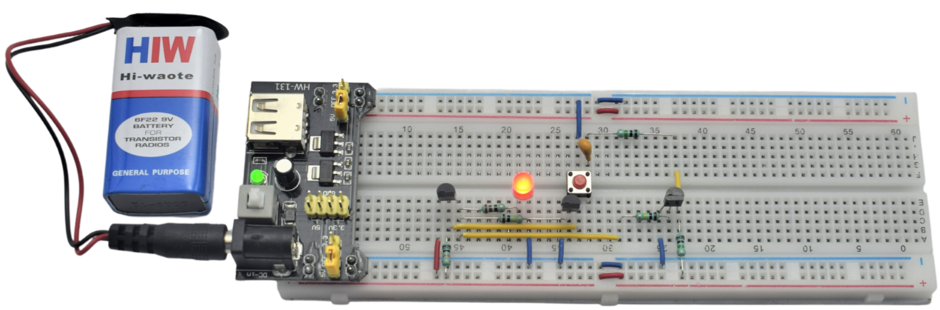


Figure 3.42: Toggle Switch: On State

3.8 Lesson 9: Two Color LED Flasher using Transistors

3.8.1 Objective

In this activity we will use the astable multivibrator to flash a rgb led.

3.8.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. RGB LED (Common Cathode) × 1
6. 220 Ω × 2
7. 100 kΩ × 2
8. 2N2222 NPN Transistor × 2
9. 10 µF × 2
10. Male-Male jumper wire × 5

3.8.3 Circuit

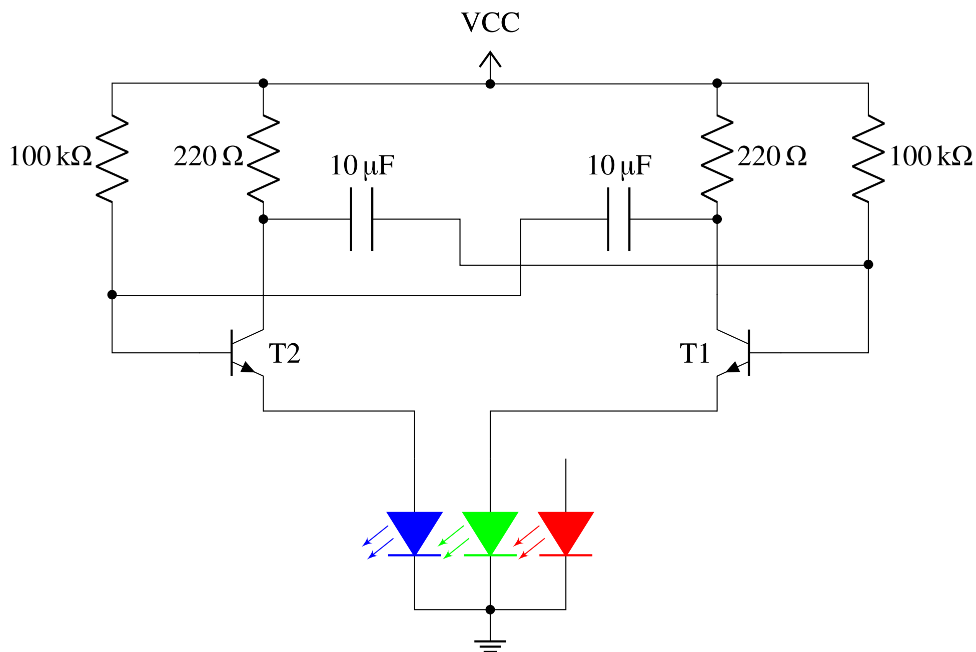


Figure 3.43: Two Color LED Flasher using Transistor

3.8.4 Circuit Explanation

This circuit operation is similar to that of astable multivibrator. Both the capacitors charge and discharge alternatively and thus turn on and off the transistors, causing the led to light up alternatively or in a flashing manner. By changing the capacitor and resistor values independently we can change the turn on and off time of both the LEDs.

3.8.5 Circuit Picture

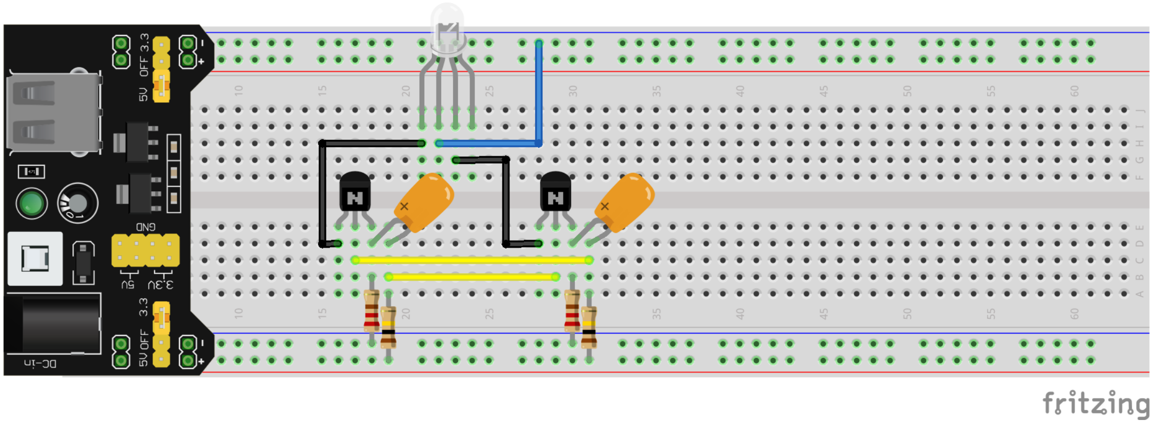


Figure 3.44: Two Color LED flasher using BJTs Breadboard Schematic

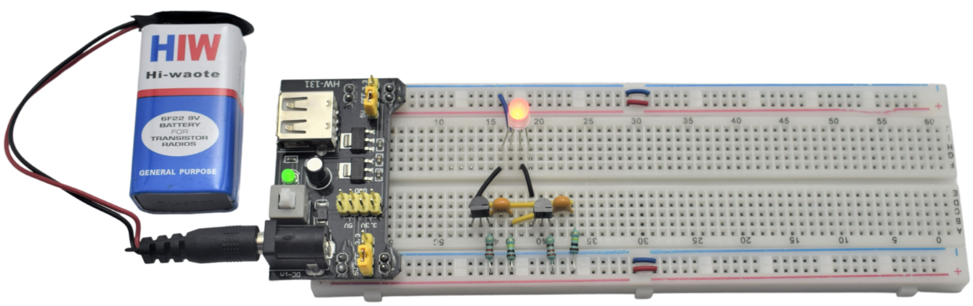


Figure 3.45: Two Color LED flasher

3.9 Lesson 10: Light Sensitive LED using LDR

3.9.1 Objective

In this activity we will make light sensitive LED, which will light up in darkness.

3.9.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. RGB LED (Common Cathode) × 1
6. 220 Ω × 1
7. 100 kΩ × 1
8. LDR (Photo-resistor) × 1
9. Male-Male jumper wire × 3

3.9.3 Circuit

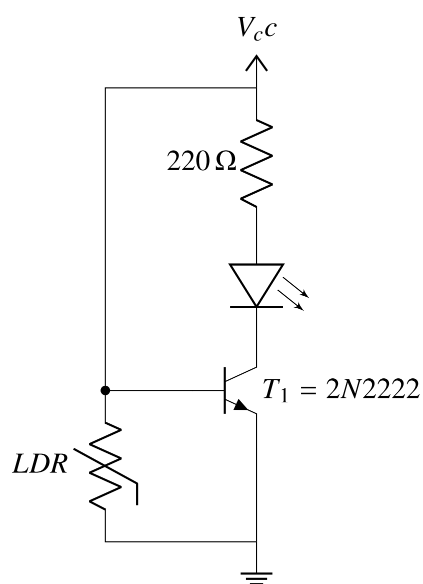


Figure 3.46: Light Sensitive LED

3.9.4 Circuit Explanation

We have used LDR in a voltage divider configuration. When there is change in light falling on the LDR, the voltage drop across it will change due to change in it's resistance.

The output voltage (V_{out}) can be calculate by using the formula -

$$V_{out} = V_{cc} \times \frac{R_{LDR}}{R_{LDR} + R_{fixed}}$$

According to LDR data-sheet, we can find the threshold value of R_{LDR} in dark and daylight, after that we need to find the value of R_{fixed} such that the following conditions below are met -

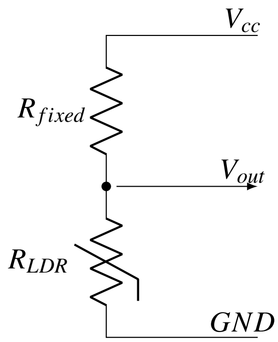


Figure 3.47: LDR as Voltage Divider

1. $0.7V \leq V_{out}$ in the dark.
2. $0.7V > V_{out}$ in the daylight.
3. The base current should be more than 20µA

In dark, $R_{LDR} = 550k\Omega$ and in daylight, $R_{LDR} = 6k\Omega$.
Let's work out each condition one by one.
The first condition

$$\begin{aligned}
0.7V &\leq V_{out} \\
V_{out} &\leq V_{cc} \times \frac{R_{LDR}}{R_{LDR} + R_{fixed}} \\
0.7V &\leq 5V \times \frac{550k\Omega}{550k\Omega + R_{fixed}} \\
R_{fixed} + 550k\Omega &\leq \frac{5}{0.7} \times 550kohm \\
R_{fixed} &\leq 3928.57k\Omega - 550k\Omega \\
R_{fixed} &\leq 3.38M\Omega
\end{aligned}$$

The second condition

$$\begin{aligned}
0.7V &> V_{out} \\
V_{out} &> V_{cc} \times \frac{R_{LDR}}{R_{LDR} + R_{fixed}} \\
0.7 &> 5V \times \frac{6k\Omega}{6k\Omega + R_{fixed}} \\
R_{fixed} + 6k\Omega &> \frac{5}{0.7} \times 6k\Omega \\
R_{fixed} &> 42.86k\Omega - 6k\Omega \\
R_{fixed} &> 36.86k\Omega
\end{aligned}$$

The third condition

$$V_{cc} > 0.7\text{V} + R_{fixed} \times I$$
$$R_{fixed} < \frac{5 - 0.7}{20\mu\text{A}}$$
$$R_{fixed} < 215\text{k}\Omega$$

Now, analyzing all the above three conditions we see that -

$$36.86\text{k}\Omega < R_{fixed} < 215\text{k}\Omega$$

We have selected $R_{fixed} = 100\text{k}\Omega$.

3.9.5 Circuit Picture

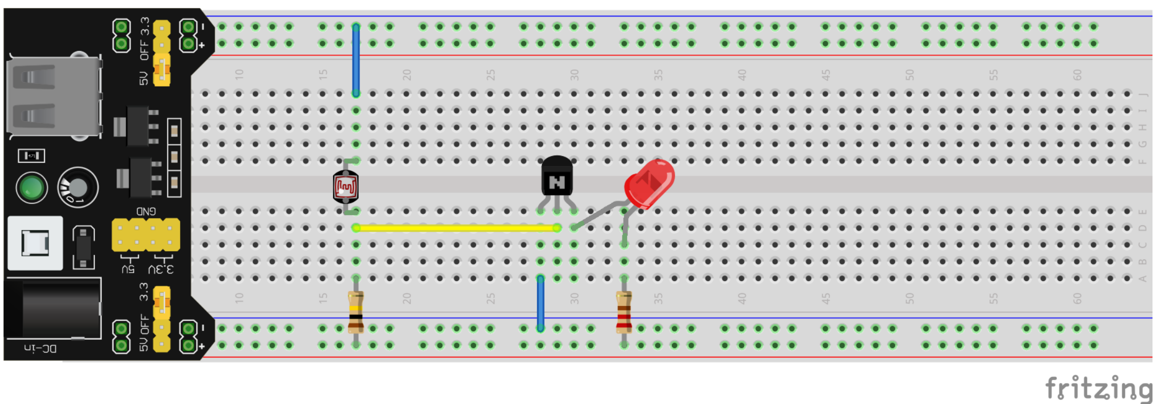


Figure 3.48: Light sensitive LED Breadboard Schematic

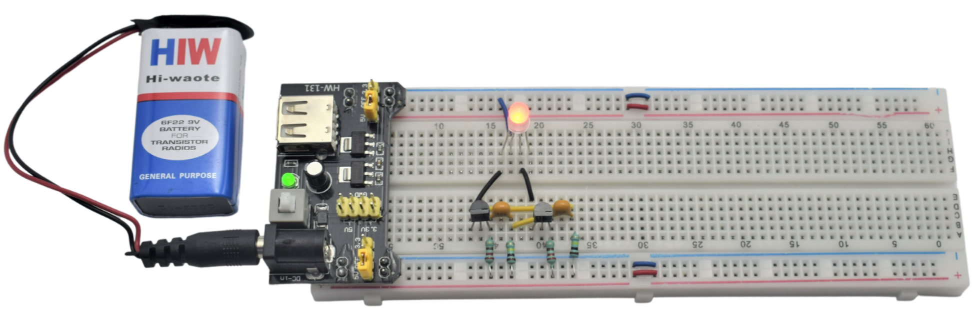


Figure 3.49: Light sensitive LED

4. 555

4.1 Overview

In this section you'll learn about one of the most famous integrated circuit (IC) in use. Each year millions of 555 Timer ICs are manufactured and sold. It's named 555 because there are three 5 kΩ resistors inside the IC. And as the name suggest, it is a timer circuit. The timing interval is controlled by an external resistor/capacitor network. And by changing the values for the resistor and capacitor the timing duration can be easily varied.

Let's take a look at the pins of 555 Timer IC:

1. **GND - Pin 1** Ground pin of the IC
2. **VCC - Pin 8** Positive supply is connected to this pin, the voltage must be at least 4.5 V and maximum 15 V.
3. **OUT - Pin 3** The output is either low (close to 0 V) or high (close to VCC).
4. **TRG - Pin 2** Trigger is active low, which means when the voltage on this pin drops below one-third of the supply voltage, the output of 555 goes high.
5. **DIS - Pin 7** This pin is used to discharge an external capacitor that works in conjunction with a resistor to control the timing of the 555 IC.
6. **THR - Pin 6** Threshold pin is used to monitor the voltage across the capacitor that's discharged by pin 7. When this voltage reaches two-third of the supply voltage, the output goes low.
7. **CTRL - Pin 5** Control pin can be used to vary the voltage level at the inverting input of the threshold comparator. It is generally connected to ground via 0.01 µF capacitor to eliminate any fluctuation on noise in the operation of the timer.
8. **RST - Pin 4** Reset pin is active low, which means when this pin is momentarily grounded the 555 timer will reset it's state and will stop until it is triggered again.

Figure 4.2 shows the schematic symbol for 555 IC that we will use in this chapter's circuit examples.

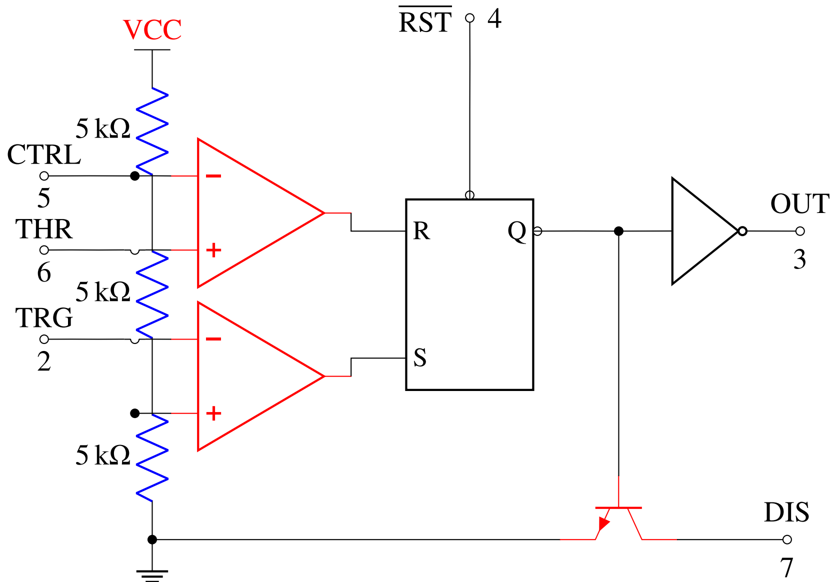


Figure 4.1: 555 Timer Circuit

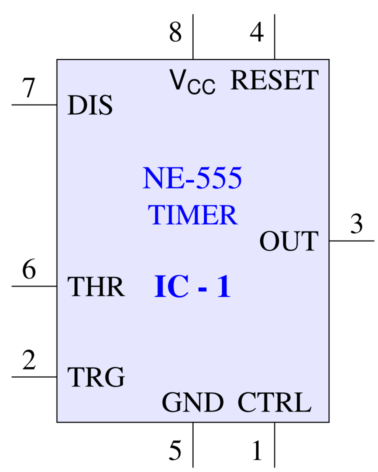


Figure 4.2: 555 Timer Symbol

4.2 555 : Working

To understand how 555 timer IC works, let's look at the figure 4.1. The voltage at the negative input of the upper comparator is $\frac{2V_{cc}}{3}$ and the voltage at the positive input of the lower comparator is $\frac{V_{cc}}{3}$. So, whenever the voltage at TRG or pin 2 of 555 IC is below $\frac{V_{cc}}{3}$, the output of lower comparator is high, setting the flip flop, and therefore making the output high and turning off the internal transistor. Just like this, if the voltage at the pin 6 or THR goes above $\frac{2V_{cc}}{3}$ the upper comparator output goes high, it resets the flip flop and thus turning the output low while turning on the internal transistor.

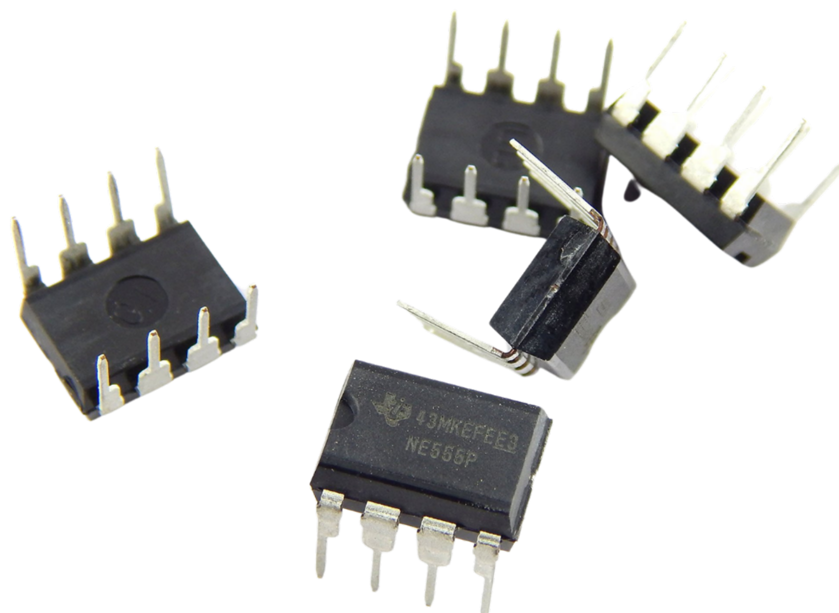


Figure 4.3: 555 Timer IC

4.2.1 Modes of Operations

The 555 timer has 3 modes of operation and all of the upcoming activities utilizes one or more operation modes of 555. In this section we will learn how to use different modes of operation of 555, after that we will build circuits using these modes.

4.2.2 Astable Mode

As the name suggests, in astable mode there is no stable state. The output continuously switches between high and low producing an square wave. This circuit can be used for turning an LED on and off at regular intervals or act as a clock input for digital ICs or control a motor by switching it on and off at regular time period.

555 Astable Multivibrator Circuit

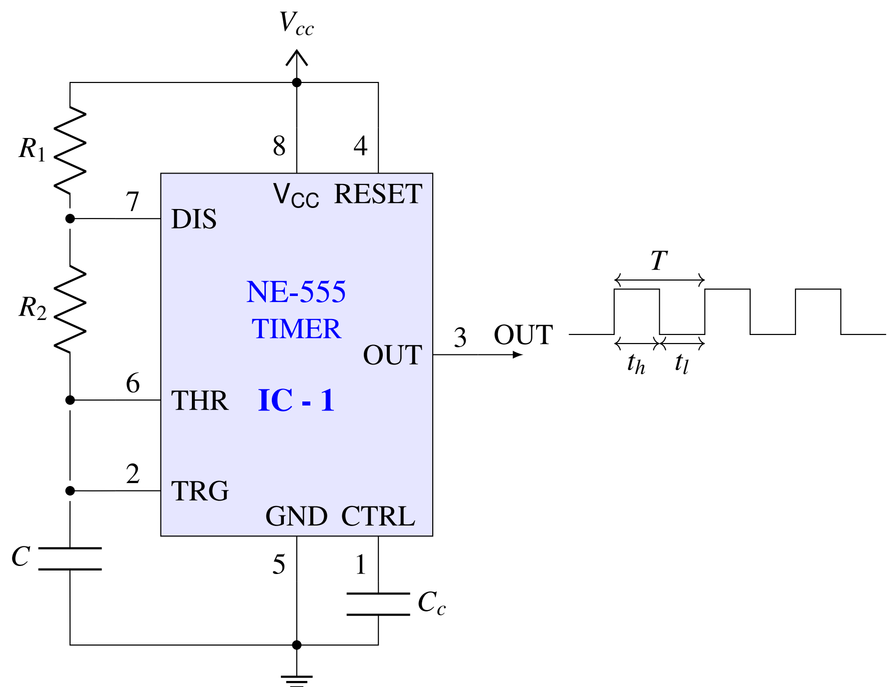


Figure 4.4: 555 as Astable Multivibrator

In astable configuration, both pin 2 (TRIG) and pin 6 (THR) are connected together, allowing the IC to re-trigger itself. This provides an oscillating output and the 555 works in an astable mode. When the power is turned on, the capacitor C has zero charge and starts charging through resistors R_1 and R_2. The voltage at pin 2 and 6 is also 0, which makes the output of upper and lower comparator as shown in figure 4.1 low and high, respectively. When the capacitor voltage reaches $\frac{2V_{cc}}{3}$, the upper comparator connected to pin 6 resets the flip flop making the output low and turning on the internal transistor.

When the internal transistor is turned on it starts discharging the capacitor through resistor R_2 as shown in the figure 4.6, now the capacitor starts discharging from $\frac{2V_{cc}}{3}$ towards 0 and when it reaches $\frac{V_{cc}}{3}$ the output of lower comparator goes high, setting the flip flop, making the output high and turning off the internal transistor. Now, the transistor is off the capacitor again starts charging and the same cycle repeats itself continuously until power is removed or reset pin is pulled low.

The time taken by the capacitor to discharge from $\frac{2V_{cc}}{3}$ to $\frac{V_{cc}}{3}$ is

$$t_l = R_2 \dot{C} \dot{l} n(2)$$
$$t_l = 0.693 R_2 C$$

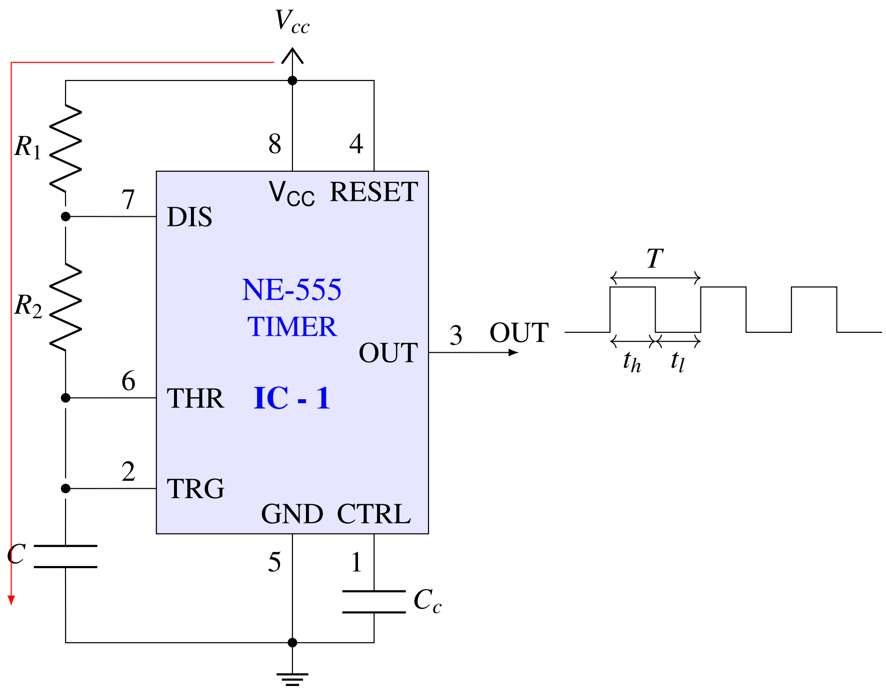


Figure 4.5: 555 as Astable Multivibrator : Capacitor Charging

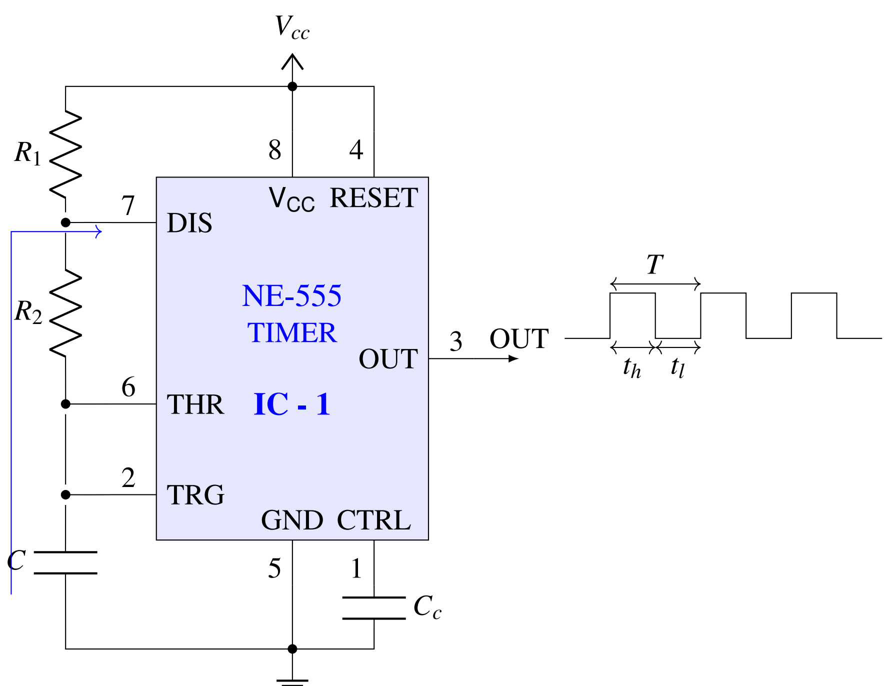


Figure 4.6: 555 as Astable Multivibrator : Capacitor Discharging

and the charging time of capacitor from $\frac{V_{cc}}{3}$ to $\frac{2V_{cc}}{3}$ is

$$t_h = (R_1 + R_2)\dot{C}\dot{l}n(2)$$
$$t_h = 0.693(R_1 + R_2)C$$

The total time period and duty cycle of the output wave can know be determined using the equations

$$T = t_l + t_h$$
$$T = 0.693R_2C + 0.693(R_1 + R_2)C$$
$$T = 0.693(R_1 + 2R_2)C$$
$$D = \frac{t_h}{t_h + t_l}$$
$$D = \frac{0.693(R_1 + R_2)}{0.693(R_1 + 2R_2)}$$
$$D = \frac{R_1 + R_2}{R_1 + 2R_2}$$

We can change the frequency or time period and duty cycle of the output by selecting the appropriate values of R_1, R_2 and C.

4.2.3 Monostable Mode

Monostable means only one stable state. In this mode 555 has only one stable state and can produce a pulse of set duration as a response against a trigger. The output stays low (the stable state) as long as there is no trigger received by the 555. Once, a trigger event happens, the output momentarily goes to high and then falls back to low after a set duration. This circuit can be used to provide a delay pulse, or turn on LED or motor or any mechanism for a fixed duration of time.

The monostable circuit is pretty simple, we have the trigger pin 2 connected to a switch or any other mechanism that can pull it high or low. On power on the capacitor has 0 charge and the output is set low, when the trigger pin goes low the capacitor gets discharged via the internal transistor and output is set high and the capacitor starts charging through resistor R_1. When the capacitor reaches the voltage $\frac{V_{cc}}{3}$, the output goes low and the capacitor gets discharged via the internal transistor.

4.2.4 Bistable Mode

In Bistable mode the 555 has two stable states. When it receives a trigger input pulse, the output goes to high state and stays there until it receives a reset pulse, which makes the output fall back to low. This circuit is sometimes called as flip/flop also, because it can store the value of it's state for as long as the device is not reset or set.

The bistable configuration is very simple, the reset and trigger pins are pulled up and connected to push buttons. When the TRIG button is pressed the output goes high and stays high until the RST button is pressed.

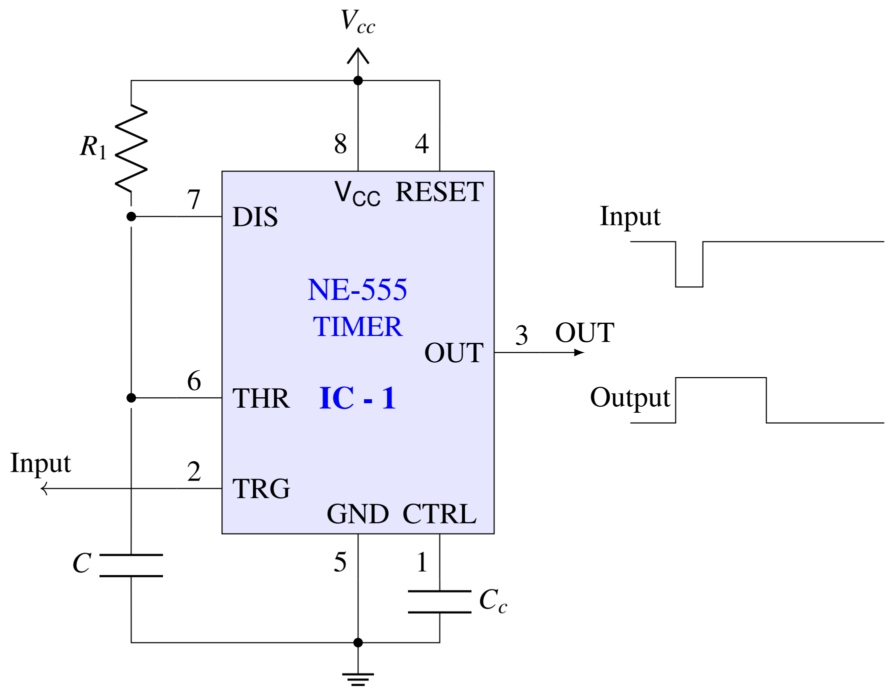


Figure 4.7: 555 as Monostable Multivibrator

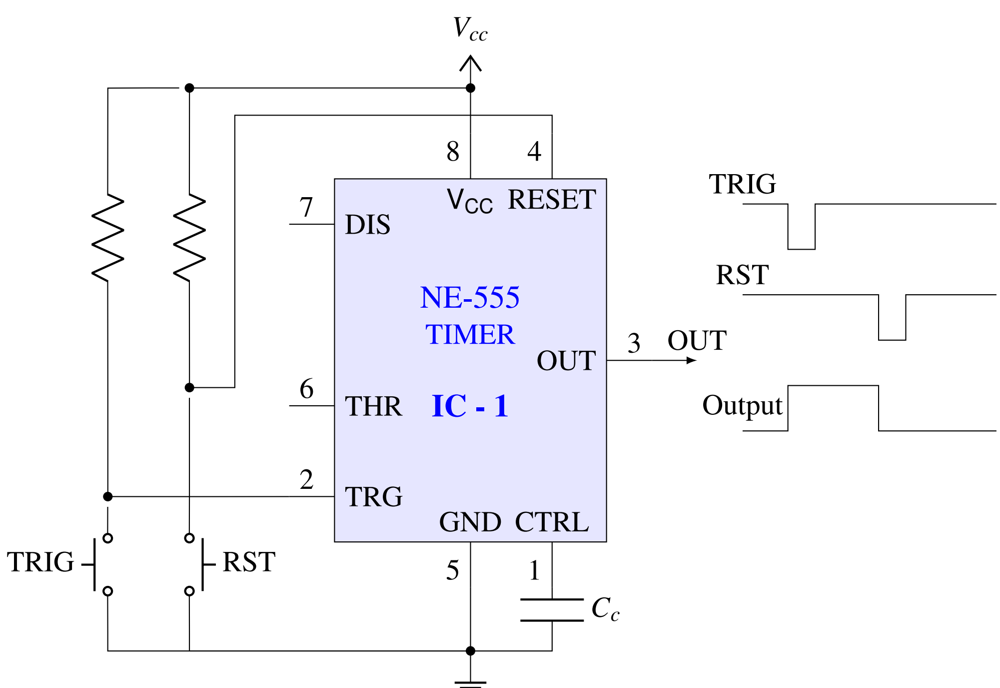


Figure 4.8: 555 in Bistable Mode

4.3 Lesson 11: 555 LED Flasher

4.3.1 Objective

In this activity we'll flash an LED using astable 555 multivibrator circuit.

4.3.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 1
6. Red LED × 1
7. 220 Ω × 1
8. 10 kΩ × 1
9. 100 kΩ × 1
10. 100 nF × 1
11. 10 µF × 1
12. Male-Male jumper wire × 7

4.3.3 Circuit

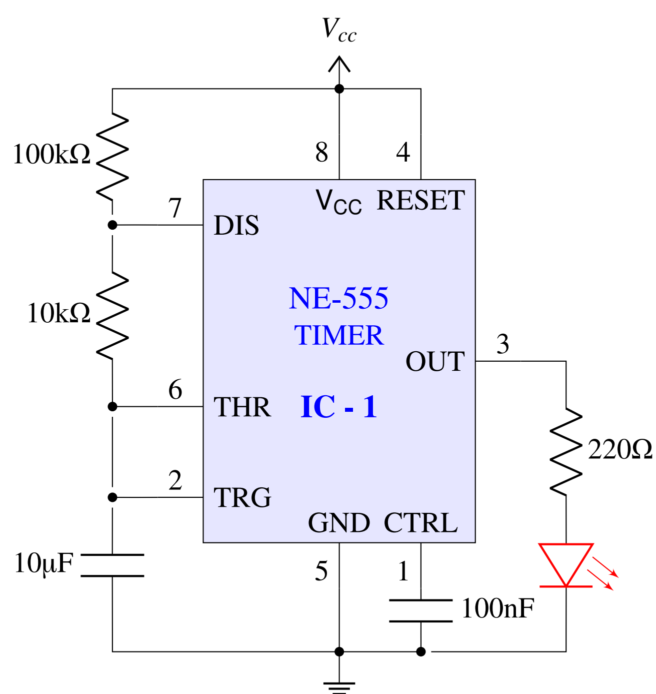


Figure 4.9: 555 LED Flasher Circuit

4.3.4 Circuit Explanation

The circuit operates in astable mode as explained in section 4.2.2.

4.3.5 Circuit Picture

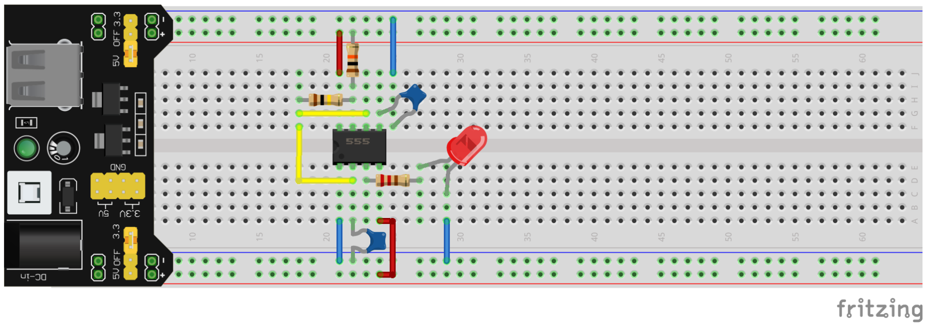


Figure 4.10: 555 LED flasher Breadboard Schematic

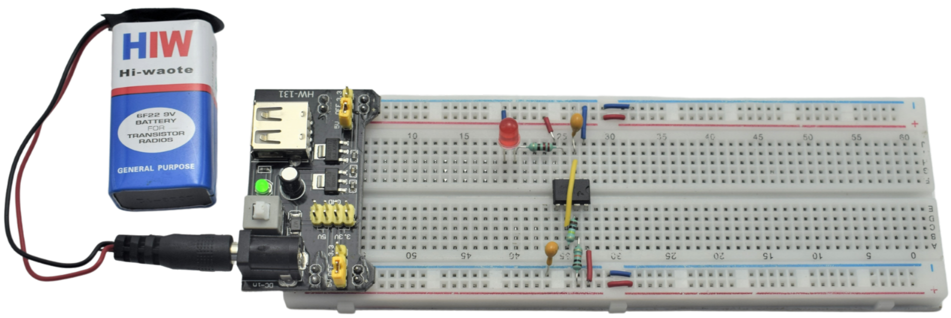


Figure 4.11: 555 LED flasher: LED OFF

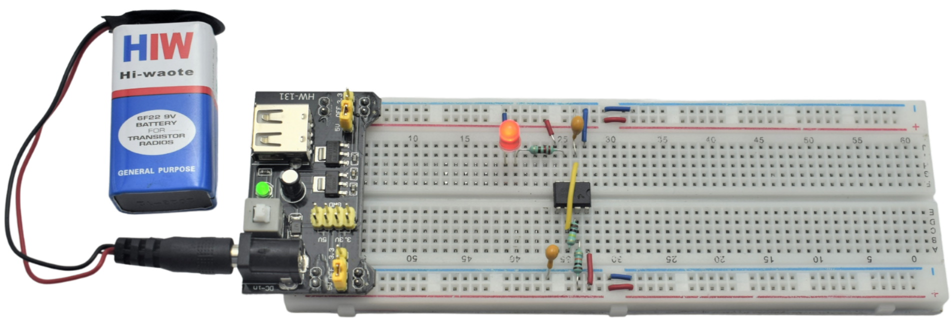


Figure 4.12: 555 LED flasher: LED ON

4.4 Lesson 12: 555 Dual LED Flasher

4.4.1 Objective

In this activity we'll flash two LEDs on and off using astable 555 multivibrator circuit.

4.4.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 1
6. Red LED × 1
7. Blue LED × 1
8. 220 Ω × 2
9. 10 kΩ × 1
10. 100 kΩ × 1
11. 100 nF × 1
12. 10 µF × 1
13. Male-Male jumper wire × 7

4.4.3 Circuit

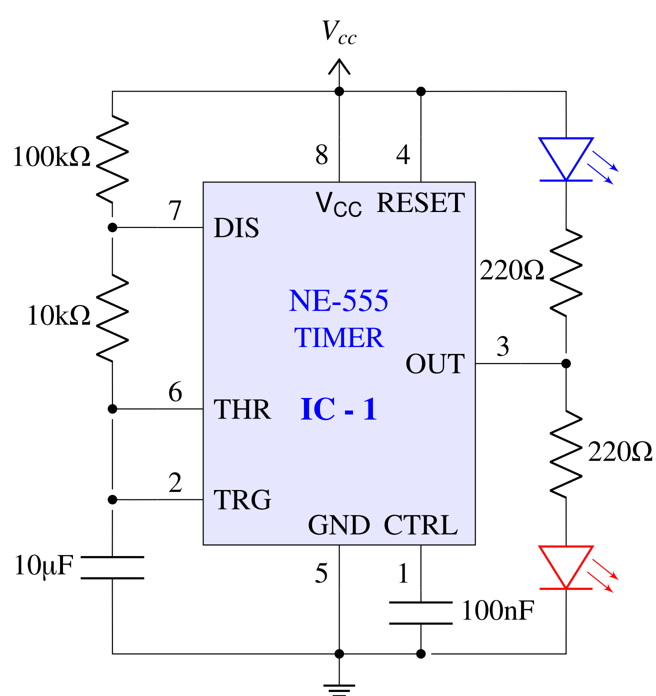


Figure 4.13: 555 Dual LED Flasher Circuit

4.4.4 Circuit Explanation

The circuit operates in astable mode as explained in section 4.2.2. In this circuit one more LED is connected between the output pin and V_{cc}, in such a way that it glows up when output is low and turns off when output is high.

4.4.5 Circuit Picture

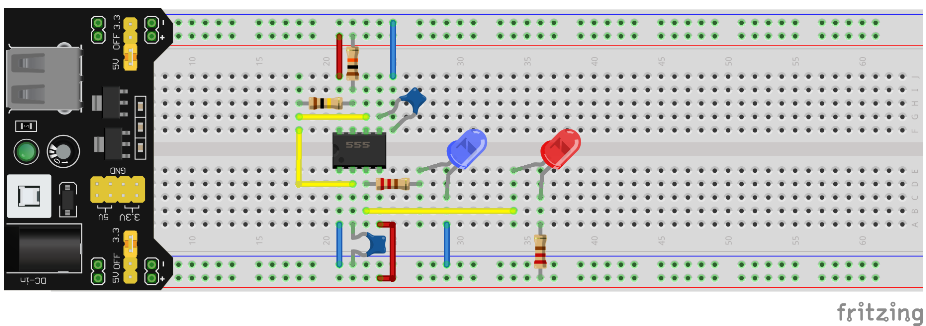


Figure 4.14: 555 Dual LED flasher Breadboard Schematic

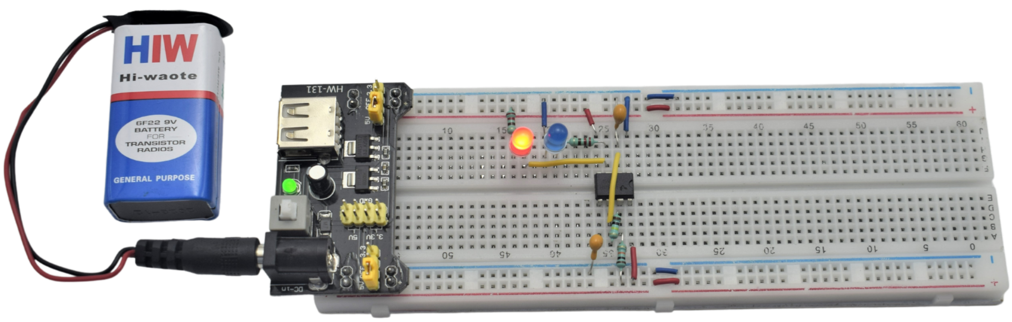


Figure 4.15: 555 Dual LED flasher 1

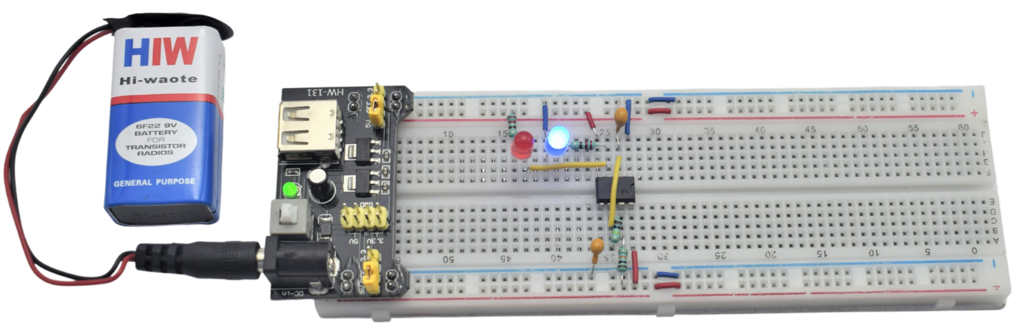


Figure 4.16: 555 LED flasher 2

4.5 Lesson 13: Fading LED using 555

4.5.1 Objective

In this activity we'll fade an LED up and down using astable 555 multivibrator circuit.

4.5.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 1
6. Red LED × 1
7. 2N2222 × 1
8. 220 Ω × 1
9. 10 kΩ × 1
10. 100 kΩ × 1
11. 1 MΩ × 1
12. 100 nF × 1
13. 10 µF × 2
14. Male-Male jumper wire × 11

4.5.3 Circuit

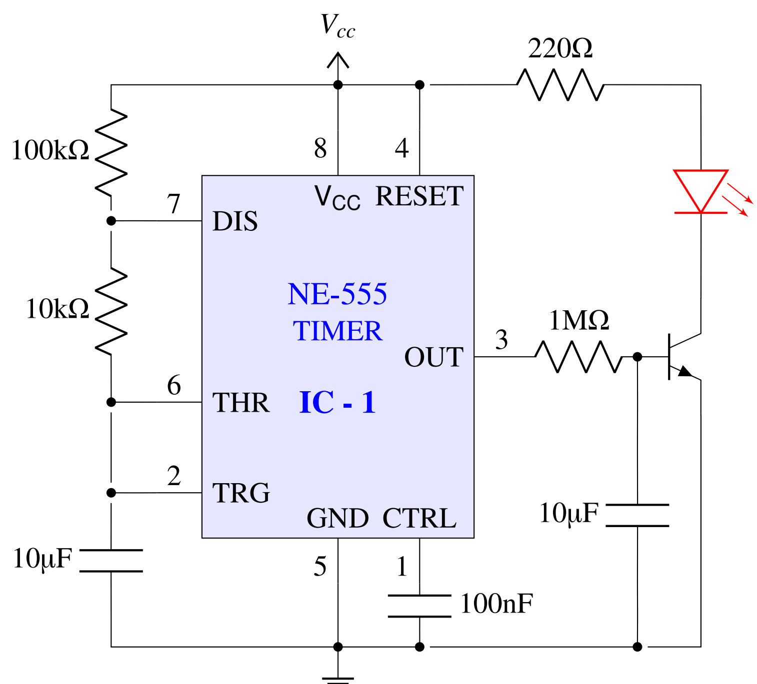


Figure 4.17: Fading LED using 555

4.5.4 Circuit Explanation

In this circuit 555 operates in astable mode 4.2.2. When the output is high, the capacitor connected to transistor base starts charging up, slowly lighting up the LED. And, as the output turns low, the capacitor slowly discharges through the transistor fading the LED off.

4.5.5 Circuit Picture

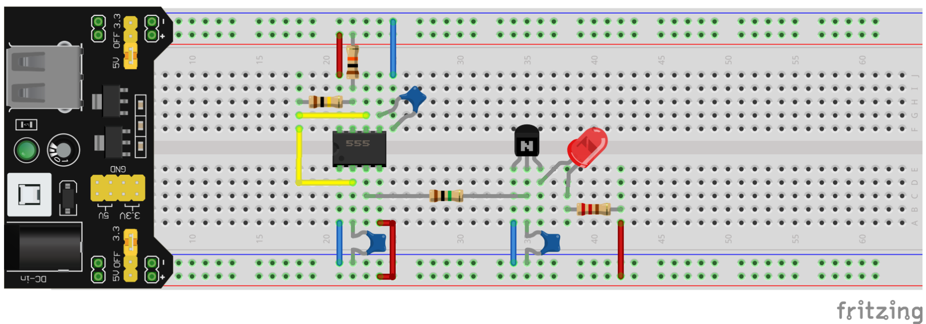


Figure 4.18: Fading LED using 555 Breadboard Schematic

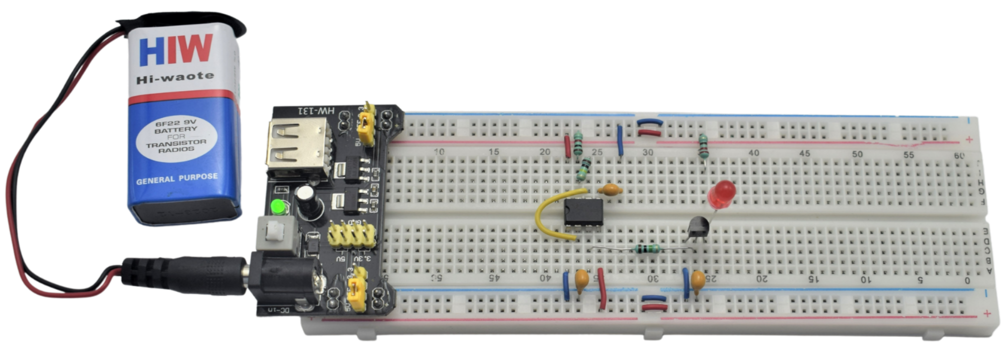


Figure 4.19: LED fading 1

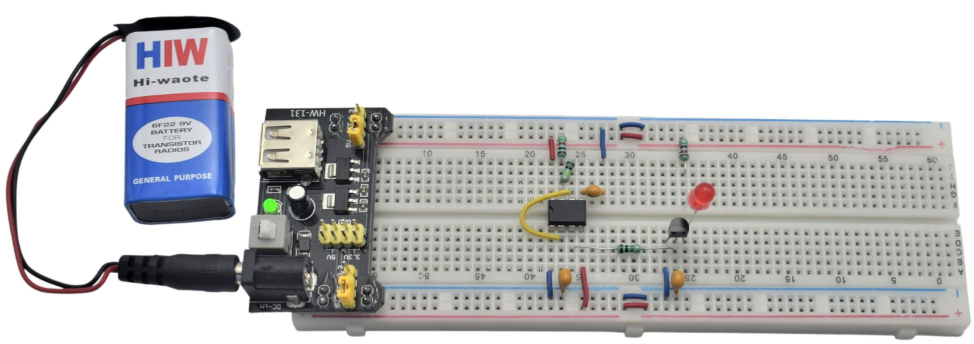


Figure 4.20: LED fading 2

4.6 Lesson 14: Bistable Button Flip/Flop using 555

4.6.1 Objective

In this activity we'll create bistable 555 circuit.

4.6.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 1
6. Red LED × 1
7. Push Button × 2
8. 220 Ω × 1
9. 10 kΩ × 2
10. 100 nF × 2
11. Male-Male jumper wire × 9

4.6.3 Circuit

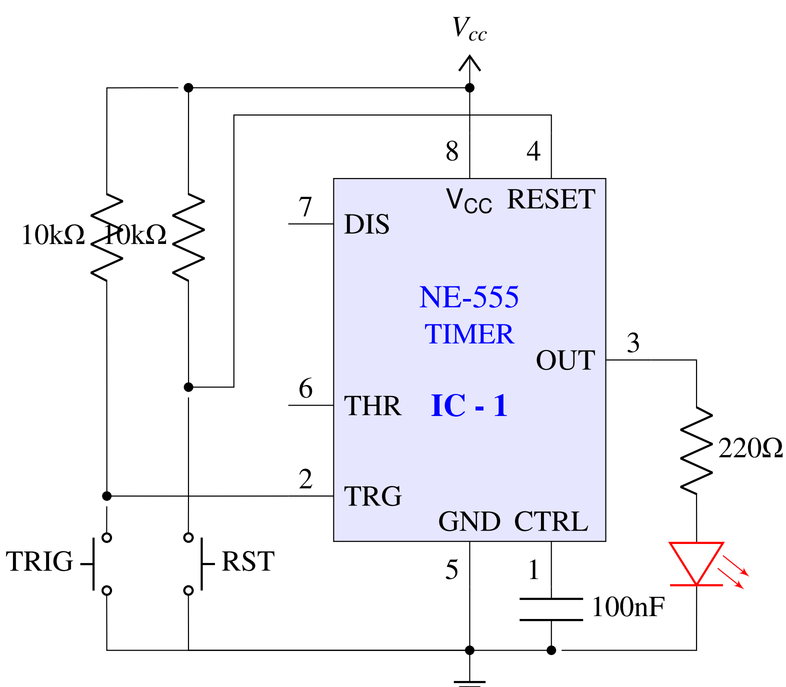


Figure 4.21: Bistable Button Flip/Flop Circuit

4.6.4 Circuit Explanation

This circuit is explained in section 4.2.4

4.6.5 Circuit Picture

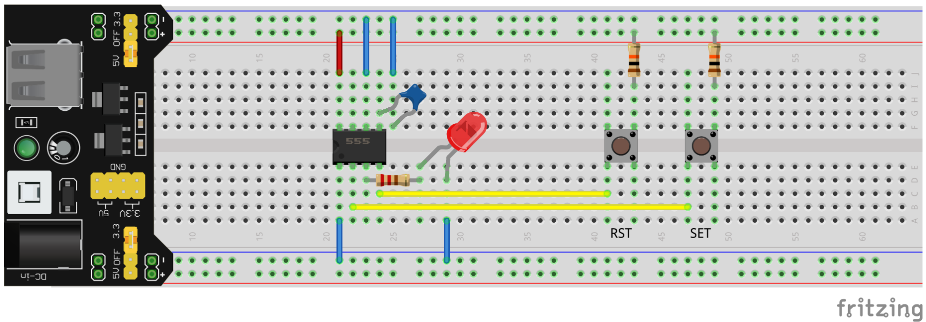


Figure 4.22: Bistable Button Flip/Flop using 555 Breadboard Schematic

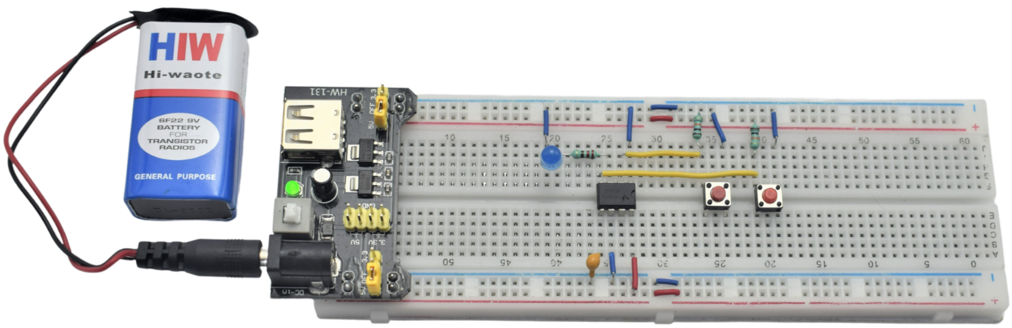


Figure 4.23: FF Idle

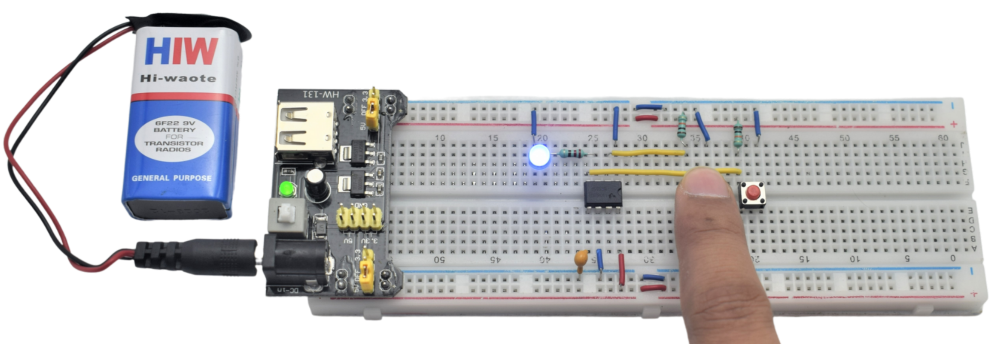


Figure 4.24: FF SET Button Pressed

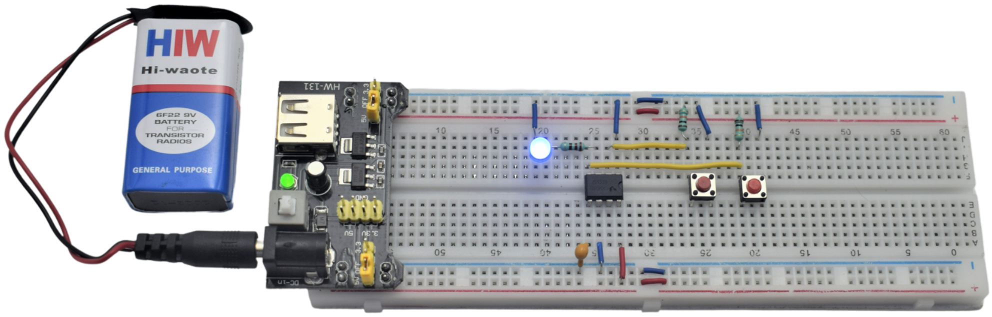


Figure 4.25: FF Idle after leaving SET button

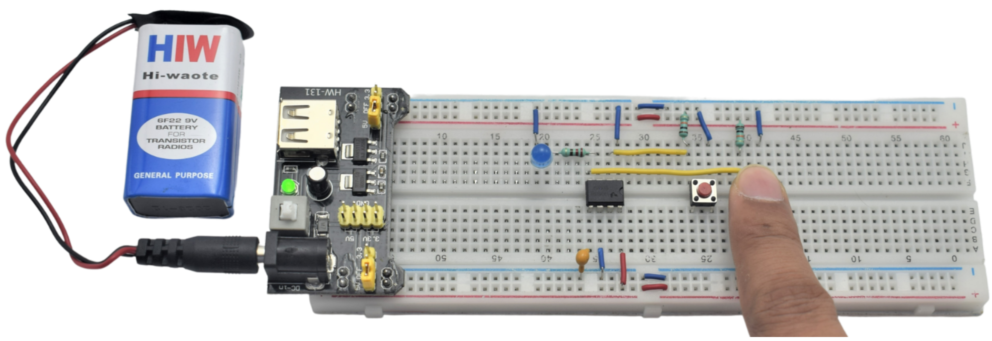


Figure 4.26: FF RST Button Pressed

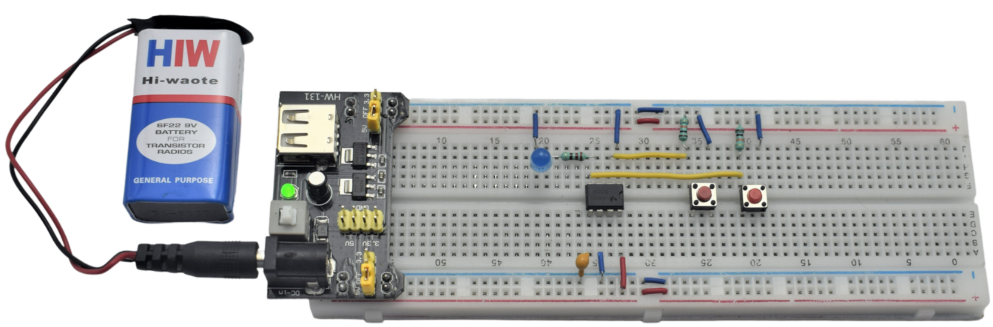


Figure 4.27: FF Idle after leaving RST Button

4.7 Lesson 15: Toggle Switch with 555

4.7.1 Objective

In this activity we'll create a toggle switch using bistable 555 circuit.

4.7.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 1
6. Red LED × 1
7. Push Button × 1
8. 220 Ω × 1
9. 10 kΩ × 2
10. 100 kΩ × 1
11. 100 nF × 2
12. Male-Male jumper wire × 11

4.7.3 Circuit

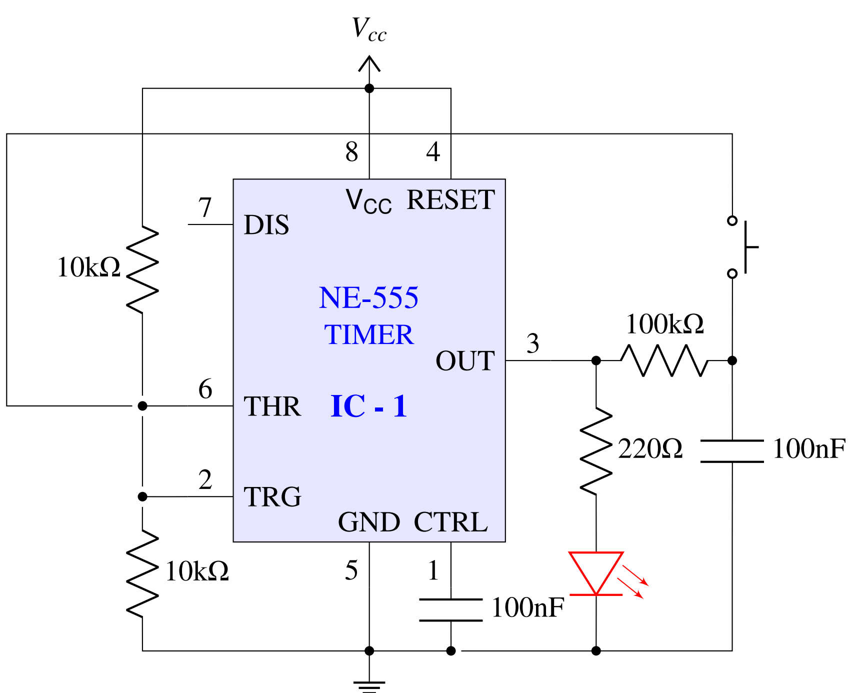


Figure 4.28: Toggle Switch with 555 Circuit

4.7.4 Circuit Explanation

In this circuit we control the voltage at pin 2 and 6 of the 555 IC with help of the push button and capacitor. When the circuit is powered on the capacitor C_2 is discharged, therefore it's upper plate is close to 0 volts. When the switch is pressed the voltage at pin 2 goes low, turning the output of 555 on. Now the LED is on and the capacitor starts charging.

Now, if we again press the switch, the capacitor is charged, therefore the upper plate is close to V_{out} which makes the voltage at pin 6 high, turning the 555 output low. Now the capacitor discharges through the 555 output pin and LED is turned off.

4.7.5 Circuit Picture

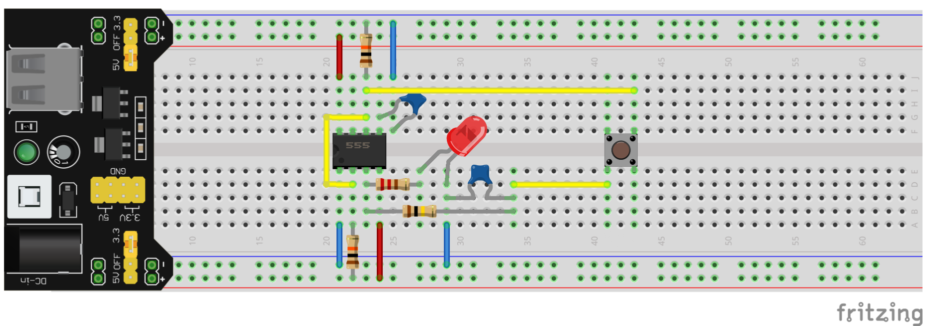


Figure 4.29: Toggle Switch using 555 Breadboard Schematic

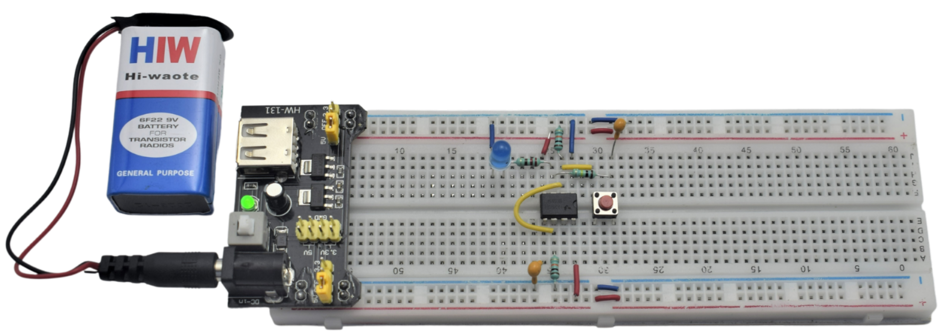


Figure 4.30: Idle

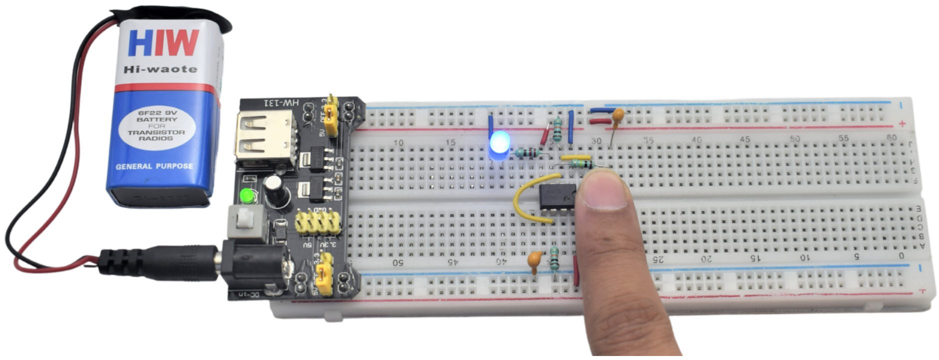


Figure 4.31: Button Pressed: LED turned ON

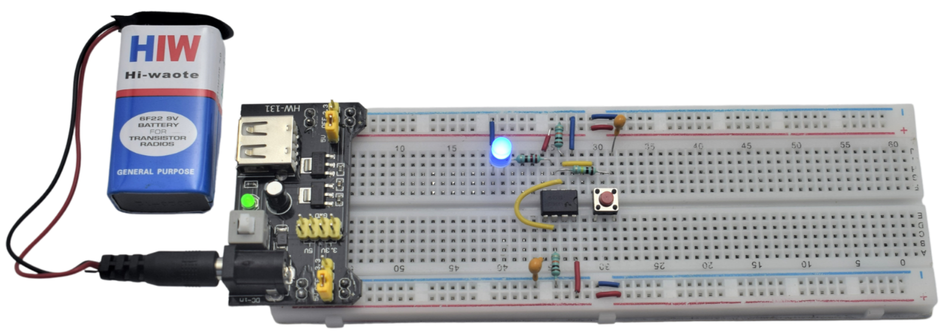


Figure 4.32: Button released

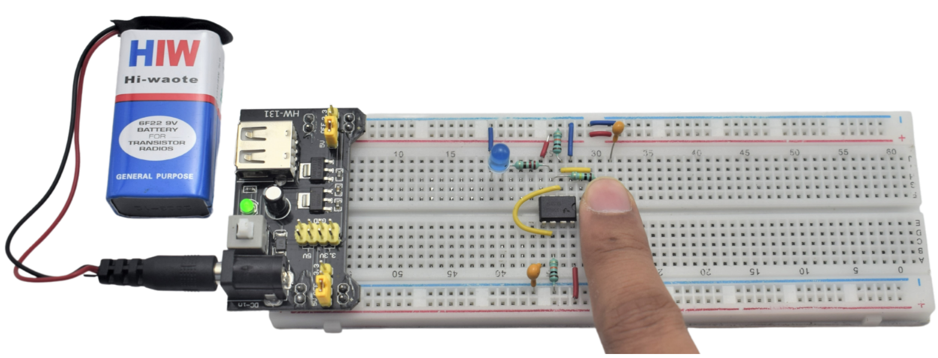


Figure 4.33: Button Pressed: LED turned OFF

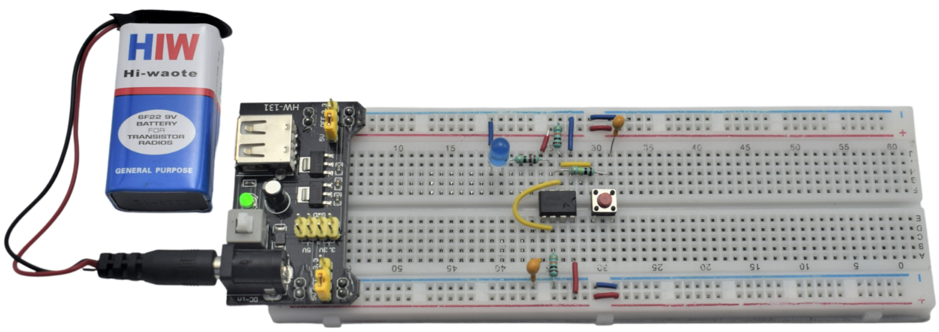


Figure 4.34: Button released

4.8 Lesson 16: Timer Delay using 555

4.8.1 Objective

In this activity we'll use monostable 555 circuit to turn on an LED for fixed duration.

4.8.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 1
6. Red LED × 1
7. Push Button × 1
8. 220 Ω × 1
9. 10 kΩ × 1
10. 1 MΩ × 1
11. 100 nF × 2
12. 100 nF × 2
13. Male-Male jumper wire × 11

4.8.3 Circuit

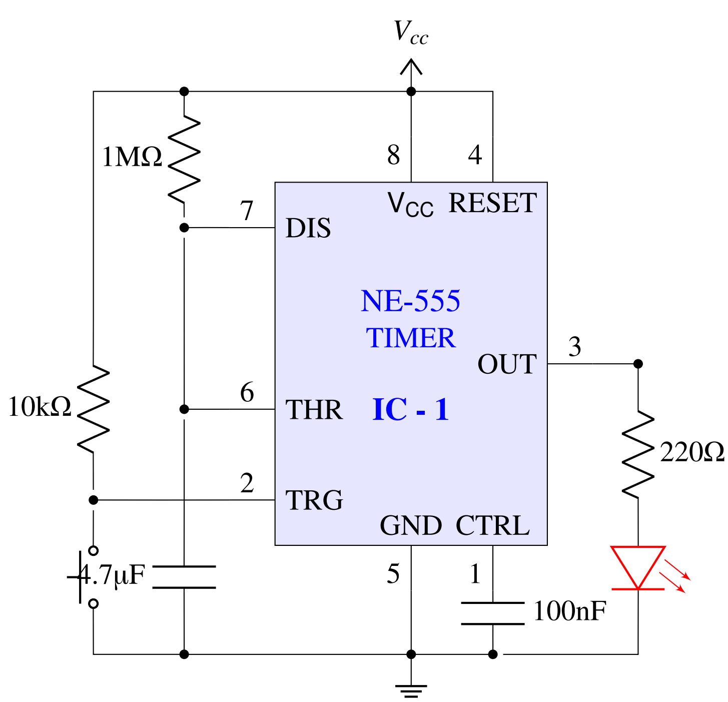


Figure 4.35: Timer Delay using 555 Circuit

4.8.4 Circuit Explanation

This circuit is explained in section 4.2.3.

4.8.5 Circuit Picture

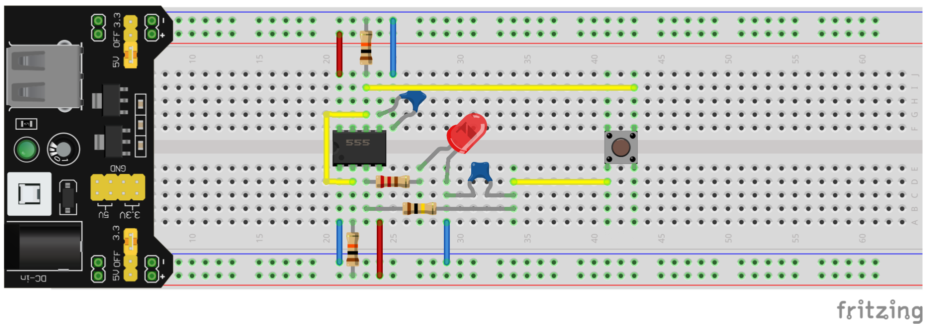


Figure 4.36: Timer Delay using 555 Breadboard Schematic

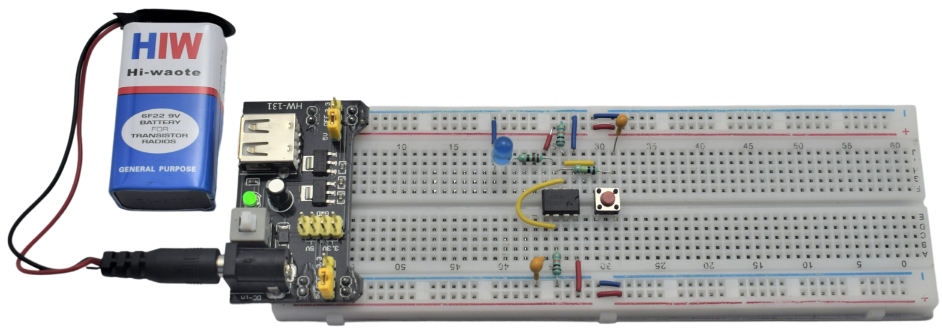


Figure 4.37: Idle

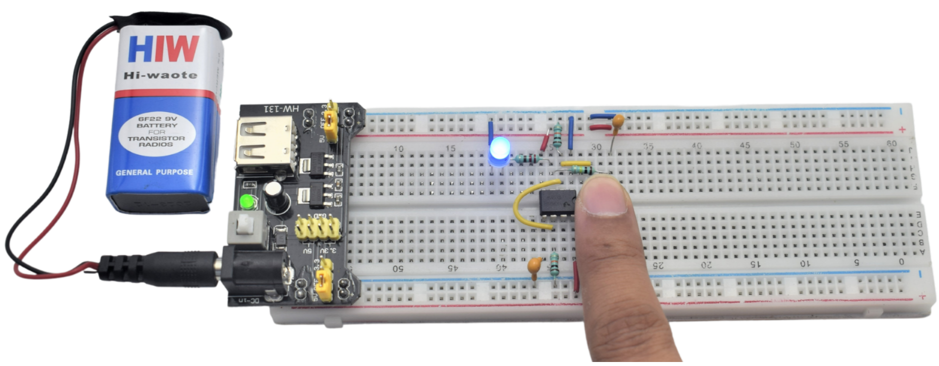


Figure 4.38: Button Pressed

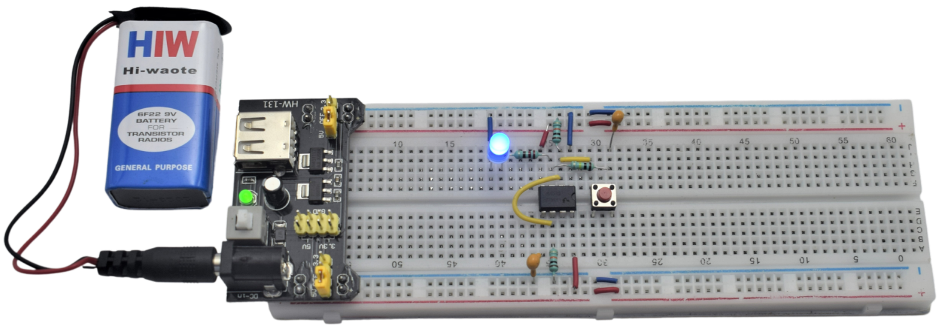


Figure 4.39: Button released

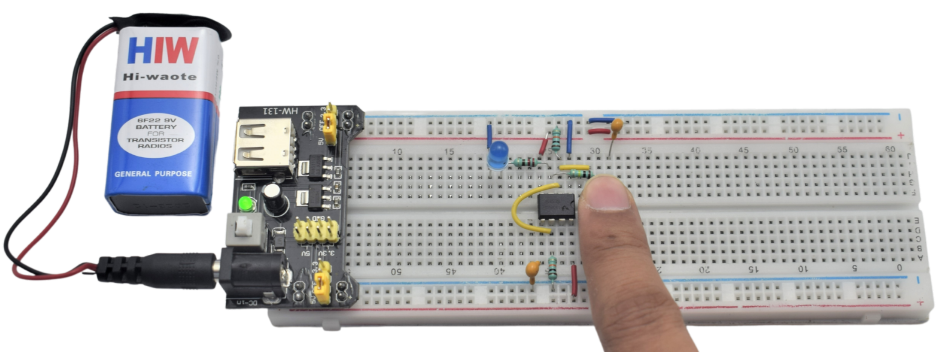


Figure 4.40: LED turned off after delay time

4.9 Lesson 17: Single Tone Buzzer with 555

4.9.1 Objective

In this activity we'll use astable 555 circuit to produce sound using an buzzer.

4.9.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 1
6. Active Buzzer × 1
7. 10 kΩ × 1
8. 100 kΩ × 1
9. 100 nF × 1
10. 10 µF × 1
11. Male-Male jumper wire × 7

4.9.3 Circuit

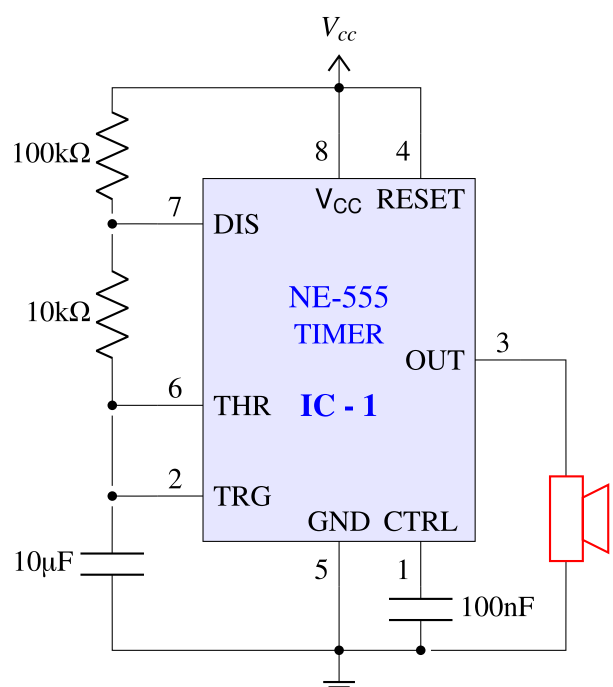


Figure 4.41: Single Tone Buzzer Circuit

4.9.4 Circuit Explanation

In this circuit 555 is in astable mode, with a buzzer connected at the output.

4.9.5 Circuit Picture

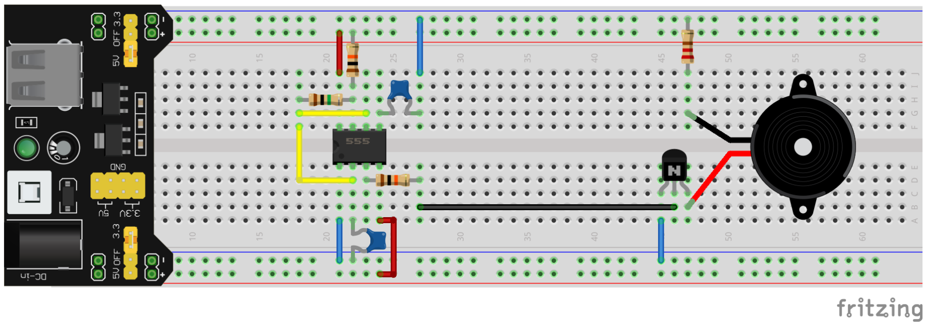


Figure 4.42: Single tone Buzzer with 555 Breadboard Schematic

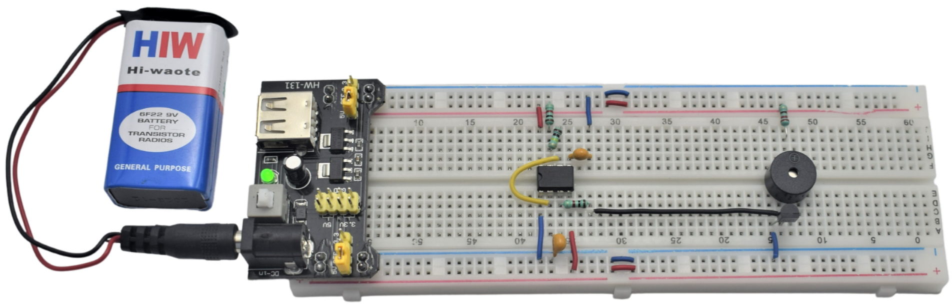


Figure 4.43: Single tone Buzzer

4.10 Lesson 18: Short Beep

4.10.1 Objective

In this activity we'll make a short beep sound.

4.10.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 1
6. Active Buzzer × 1
7. 1N4007 Diode × 1
8. 10 kΩ × 1
9. 100 kΩ × 1
10. 1 MΩ × 1
11. 100 nF × 1
12. 2.2 µF × 1
13. Male-Male jumper wire × 10

4.10.3 Circuit

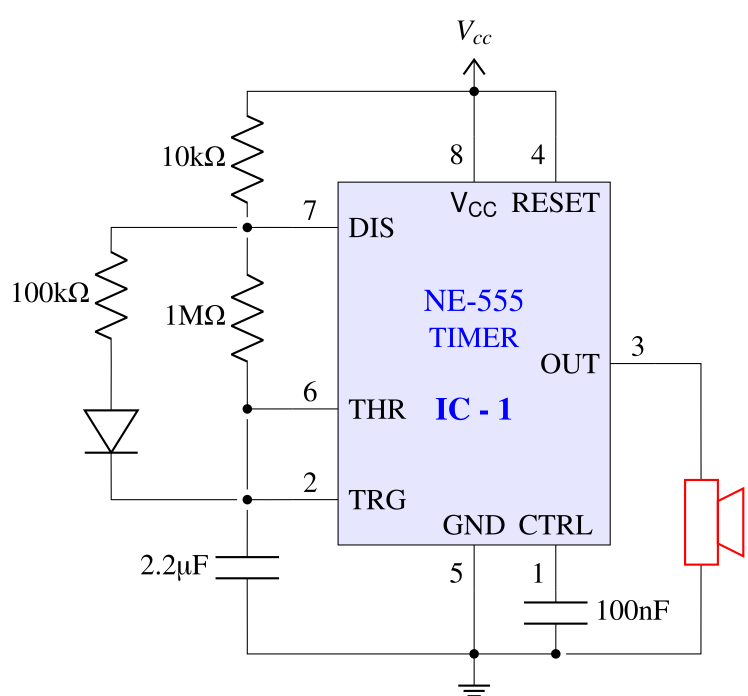


Figure 4.44: Short Beep Circuit

4.10.4 Circuit Explanation

In circuit is similar to the one explained in section 4.2.2. In this circuit when the output is high, the capacitor get charged via the 100kΩ resistor and diode instead of 1MΩ, therefore it charges very rapidly.

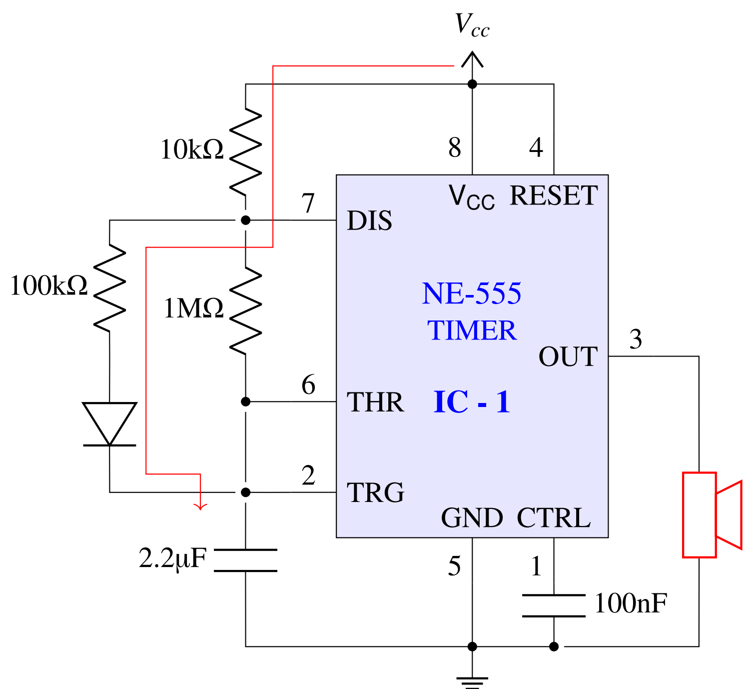


Figure 4.45: Short Beep Circuit : Capacitor Charging

And when the output is low, it discharges through 1MΩ resistor. Since the high time is very less compared to the low time, the buzzer produces a short beep tone.

4.10.5 Circuit Picture

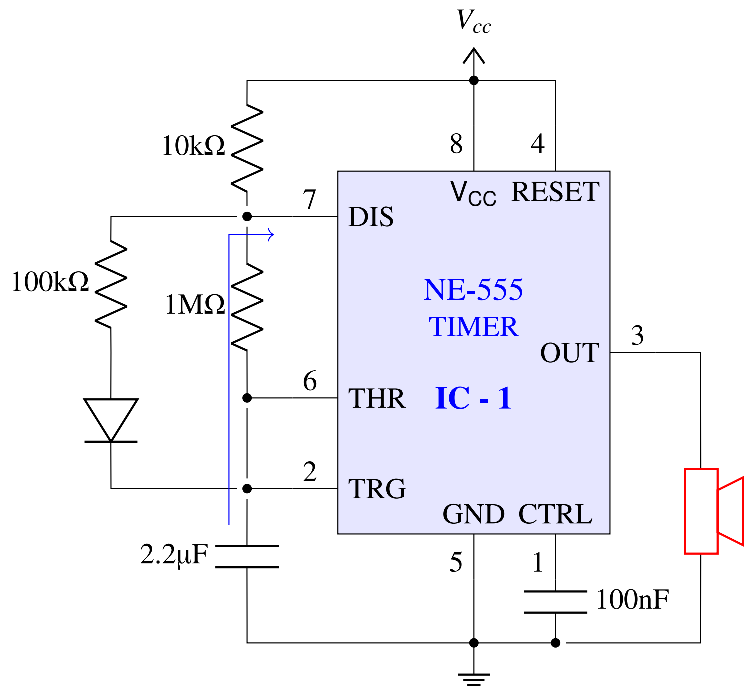


Figure 4.46: Short Beep Circuit : Capacitor Discharging

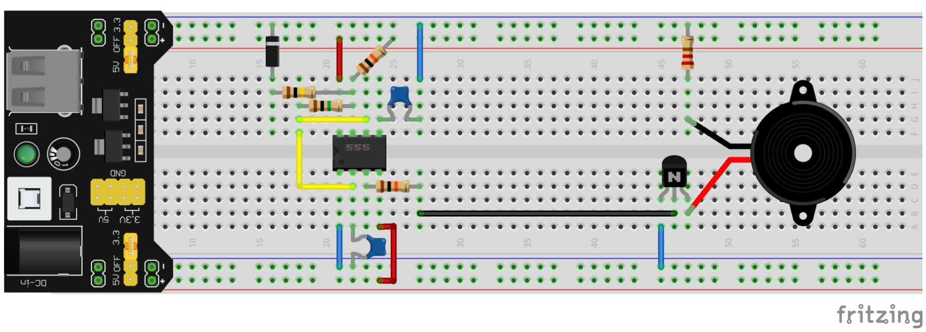


Figure 4.47: Short Beep using 555 Breadboard Schematic

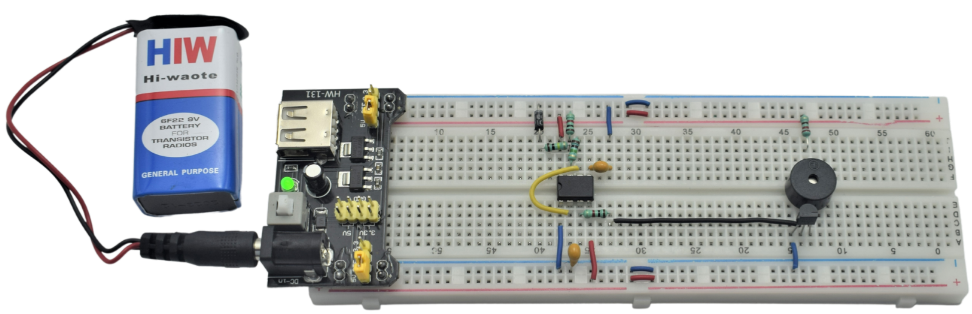


Figure 4.48: Short Beep

4.11 Lesson 19: Break Beam Detector using 555 and LDR

4.11.1 Objective

In this activity we'll make a break beam detector circuit.

4.11.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 1
6. Passive Buzzer × 1
7. White LED × 1
8. LDR × 1
9. 220 Ω × 1
10. 10 kΩ × 3
11. 100 nF × 2
12. 10 µF × 1
13. Male-Male jumper wire × 15

4.11.3 Circuit

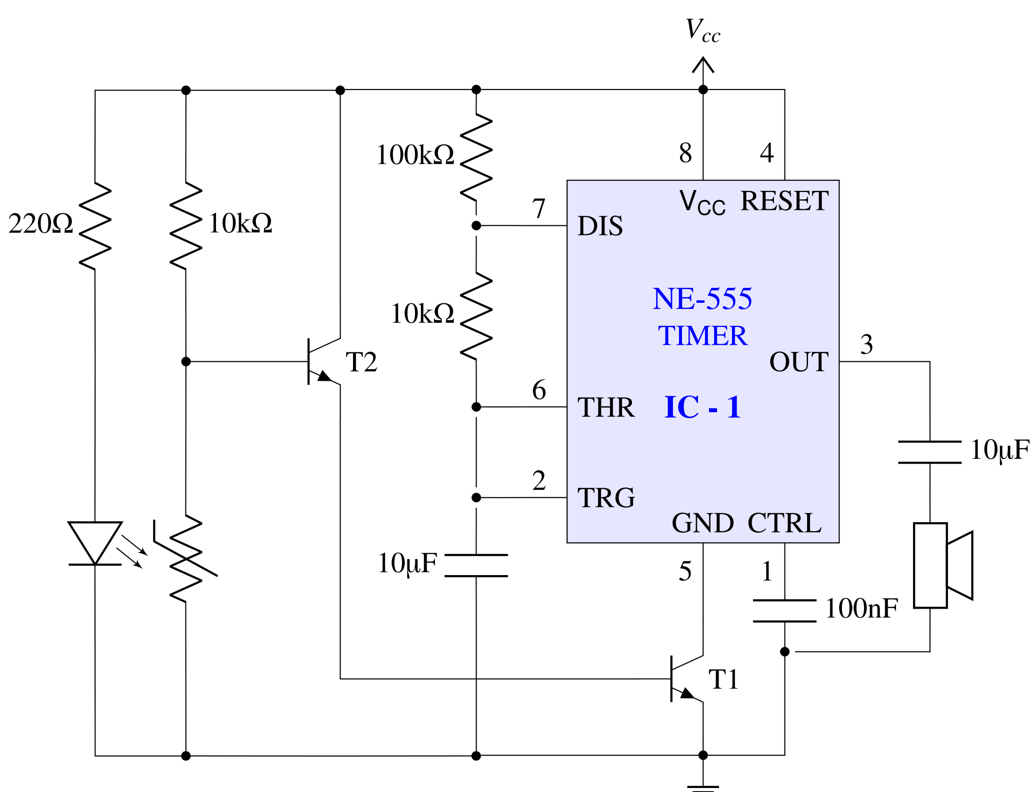


Figure 4.49: Break Beam Detector Circuit

4.11.4 Circuit Explanation

When there is no barrier in between the LED and LDR, the resistance of LDR is very low and there the base transistor $T2$ is near ground potential or 0 volt and is in cut-off mode. Since, $T2$ is off, $T1$ is also off and the 555 will not work, because the GND pin is connected to collector of $T1$.

When there is obstruction between light and LDR, the resistance of LDR goes high, turning the $T2$ on, which turns on the $T1$. Now $T1$ is and 555 will start operating in astable mode.

4.11.5 Circuit Picture

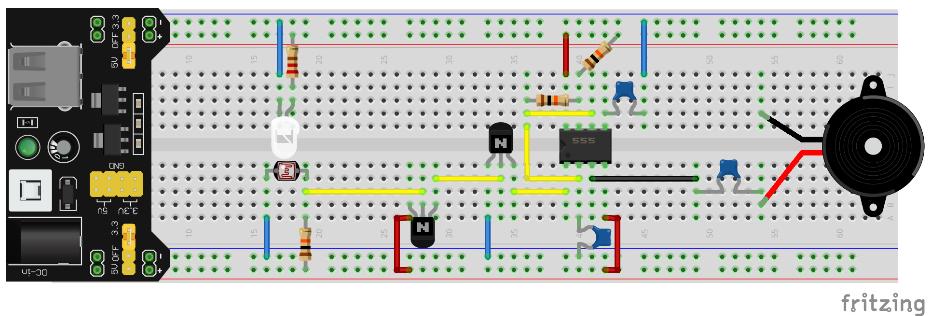


Figure 4.50: Break Beam Detector using 555 and LDR Breadboard Schematic

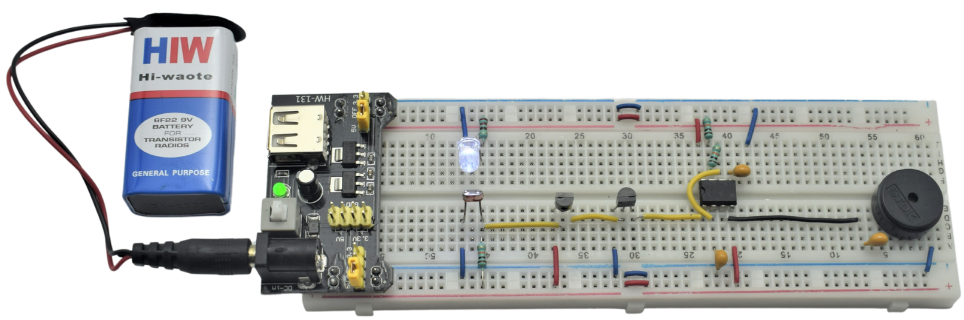


Figure 4.51: No Obstacle: Buzzer OFF

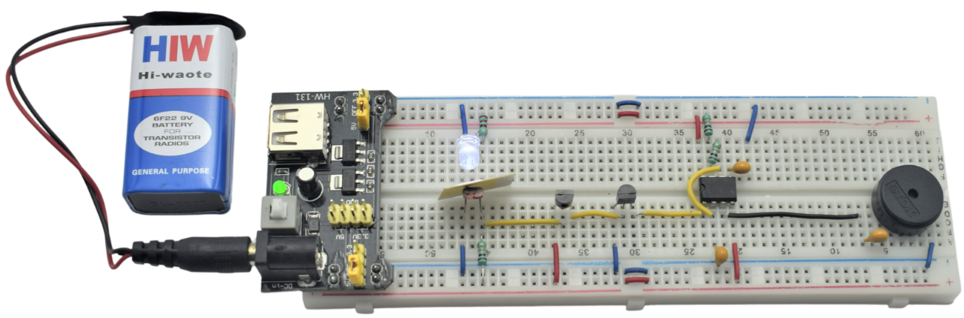


Figure 4.52: Obstacle: Buzzer ON

4.12 Lesson 20: Light reactive buzzer using 555 and LDR

4.12.1 Objective

In this activity we'll make a light reactive tone generator.

4.12.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 1
6. Passive Buzzer × 1
7. LDR × 1
8. 10 kΩ × 1
9. 100 nF × 2
10. 10 µF × 1
11. Male-Male jumper wire × 9

4.12.3 Circuit

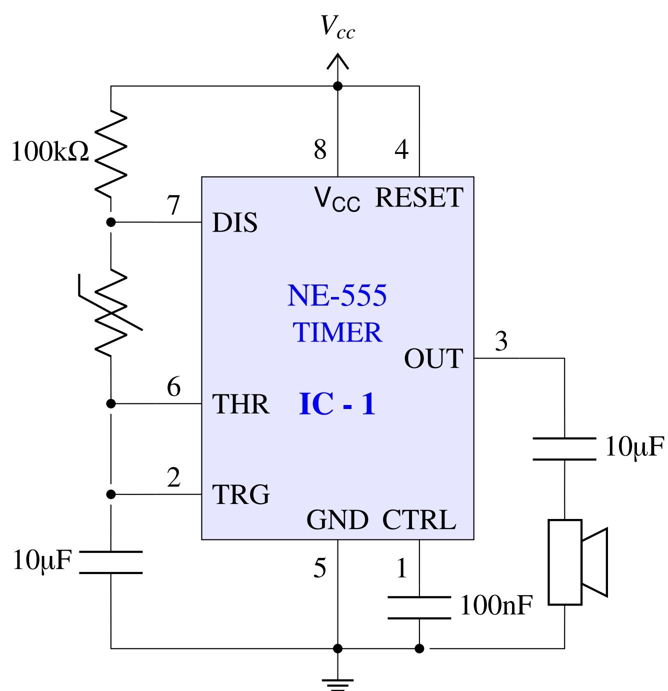


Figure 4.53: Light Reactive Buzzer Circuit

4.12.4 Circuit Explanation

In this circuit the 555 is in astable mode, but the R_2 resistor is replaced with an LDR, so according to the change in intensity of light falling on the LDR, the frequency of output is changed, changing the tone generated by the buzzer.

4.12.5 Circuit Picture

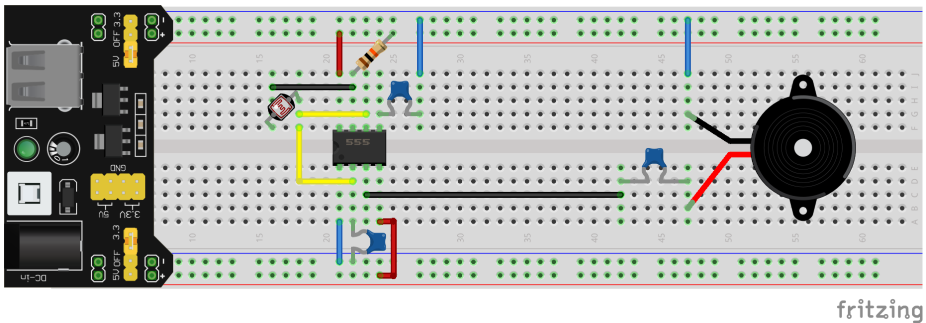


Figure 4.54: Light reactive Buzzer Breadboard Schematic

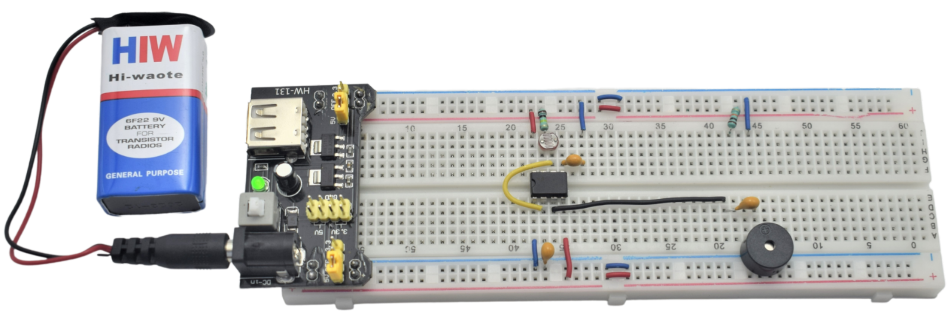


Figure 4.55: Light reactive Buzzer

4.13 Lesson 21: Audio Tone/Siren

4.13.1 Objective

In this activity we'll make an audio tone/siren generator.

4.13.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 2
6. Passive Buzzer × 1
7. 10 kΩ × 5
8. 100 kΩ × 1
9. 100 nF × 2
10. 10 µF × 2
11. Male-Male jumper wire × 14

4.13.3 Circuit

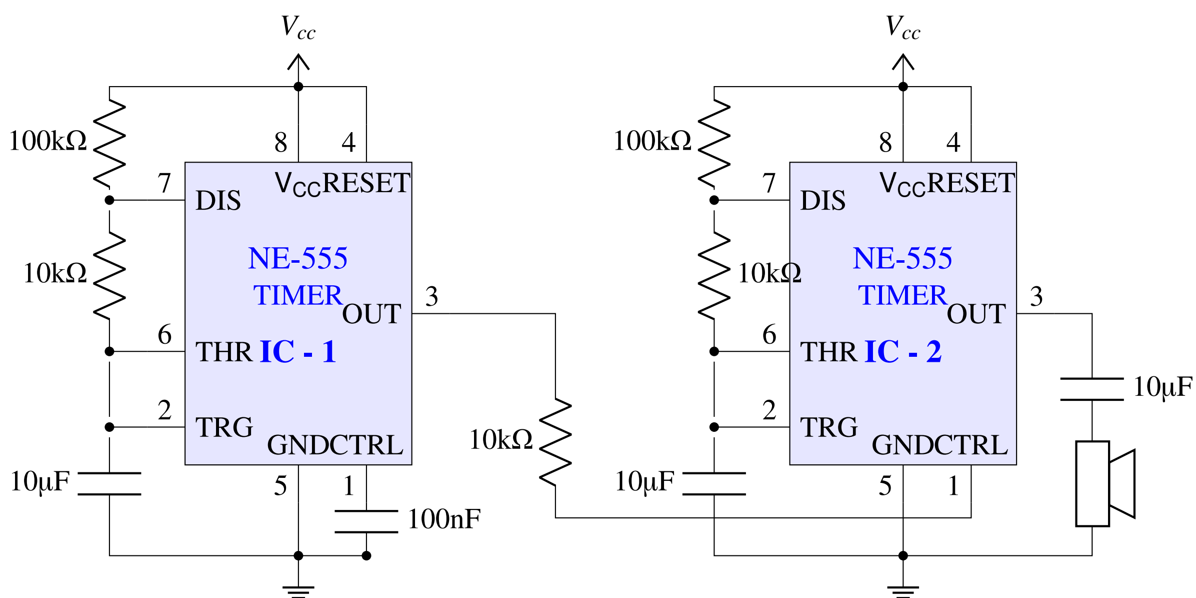


Figure 4.56: Audio Tone/Siren Circuit

4.13.4 Circuit Explanation

In this circuit both the 555 are running in astable. But, we are controlling the input voltage of the second 555 using the output of the first, such that whenever the output of first 555 changes, the frequency of output of second 555 changes, producing two different tone after each interval.

4.13.5 Circuit Picture

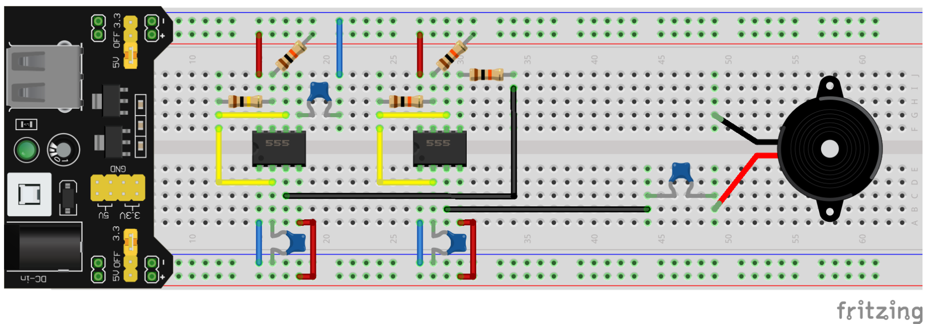


Figure 4.57: Audio Tone/Siren Breadboard Schematic

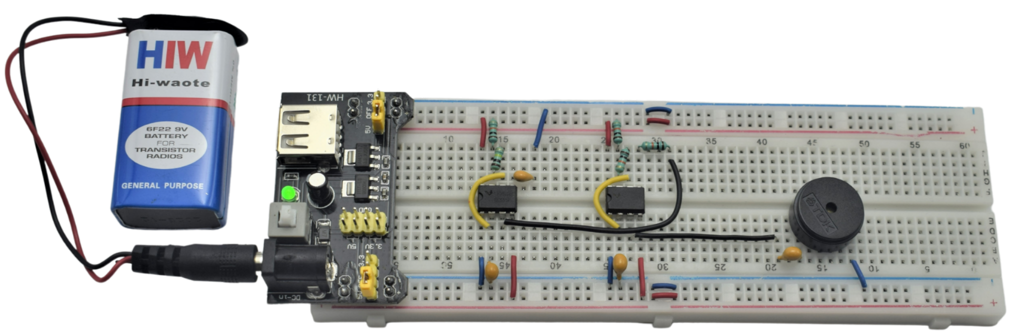


Figure 4.58: Audio Tone/Siren

4.14 Lesson 22: Traffic Light

4.14.1 Objective

In this activity we'll make a Traffic Light using 555.

4.14.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 2
6. Red LED × 1
7. Yellow LED × 1
8. Green LED × 1
9. 2N2222 × 1
10. 220 Ω × 3
11. 330 Ω × 3
12. 10 kΩ × 2
13. 1 MΩ × 2
14. 100 nF × 2
15. 2.2 µF × 1
16. 10 µF × 2
17. Male-Male jumper wire × 22

4.14.3 Circuit

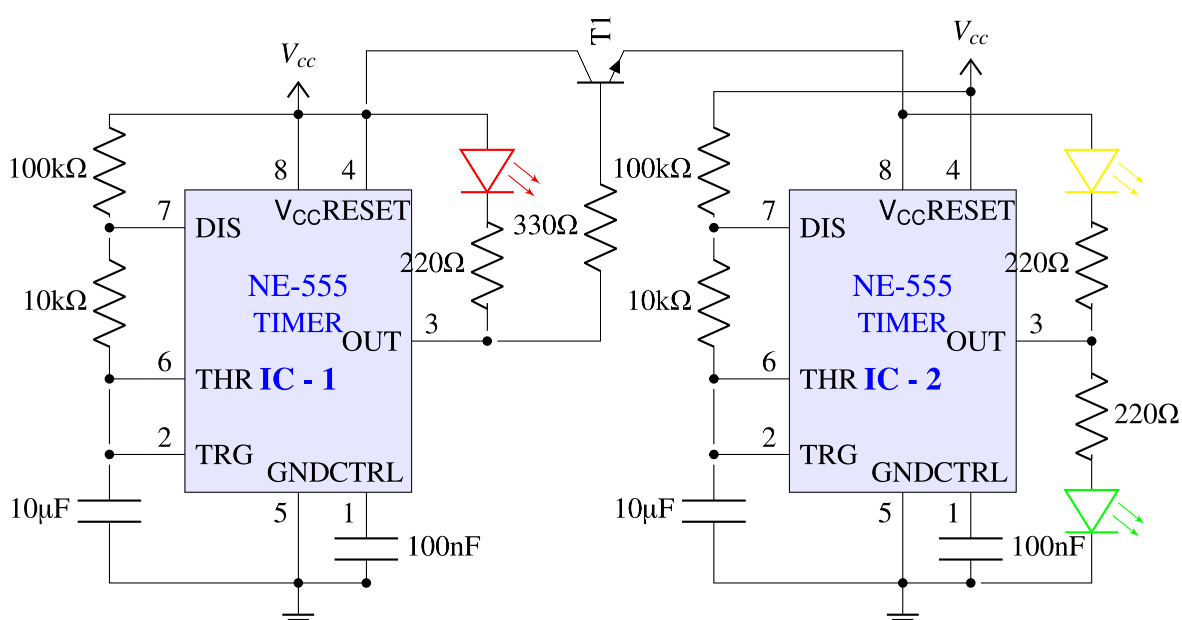


Figure 4.59: Traffic Light Circuit

4.14.4 Circuit Explanation

In this circuit both the 555 are in astable mode, and the supply of the second 555 is controlled by the output of first. To better understand what's going on look at the figure 4.60.

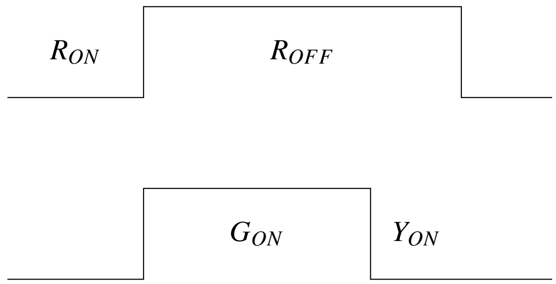


Figure 4.60: Traffic Light Timing Diagram

When the output of first 555 is low, the second 555 is off. Red light is on and both yellow and green are off. As soon as the output of the first 555 goes high, the second 555 starts working turning the green light on and both red and yellow are off. The on and off time of 555 output are set such that before the red light turns on again, the yellow light is momentarily turned on.

4.14.5 Circuit Picture

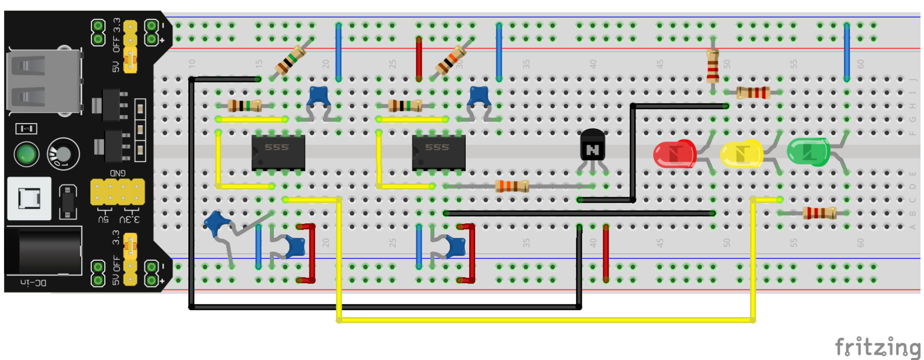


Figure 4.61: Traffic Light Breadboard Schematic

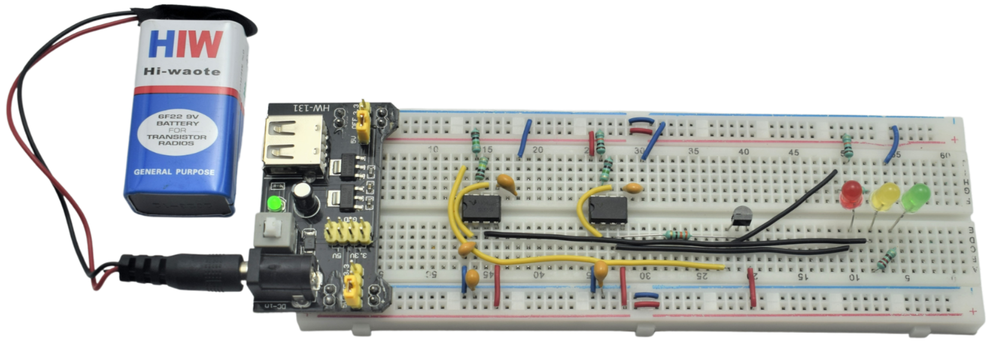


Figure 4.62: Green Light On

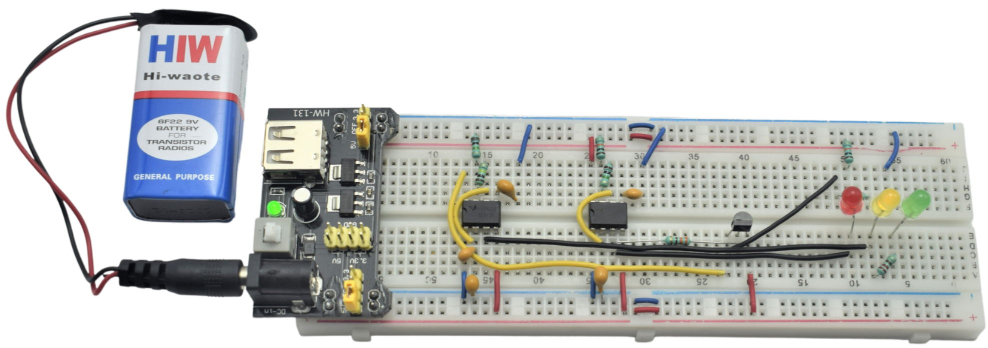


Figure 4.63: Yellow Light On

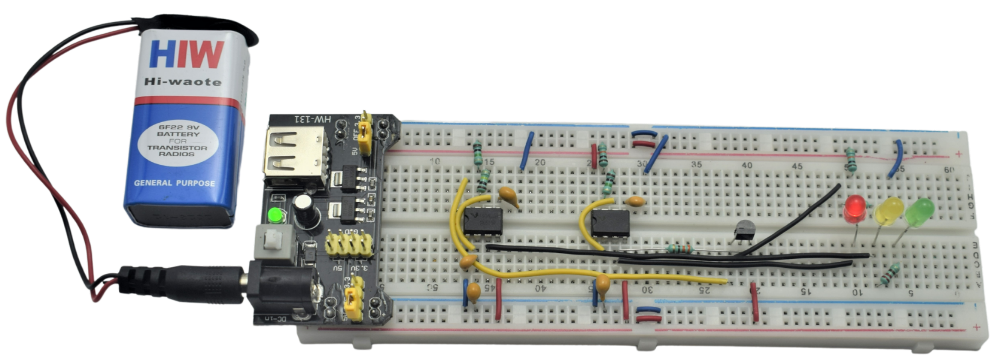


Figure 4.64: Red Light On

4.15 Lesson 23: Doorbell

4.15.1 Objective

In this activity we'll make a doorbell system using 555.

4.15.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 2
6. 2N2222 × 3
7. Passive Buzzer × 1
8. Push Button × 1
9. 1 kΩ × 3
10. 10 kΩ × 3
11. 1 MΩ × 1
12. 100 nF × 2
13. 1 µF × 1
14. Male-Male jumper wire × 23

4.15.3 Circuit

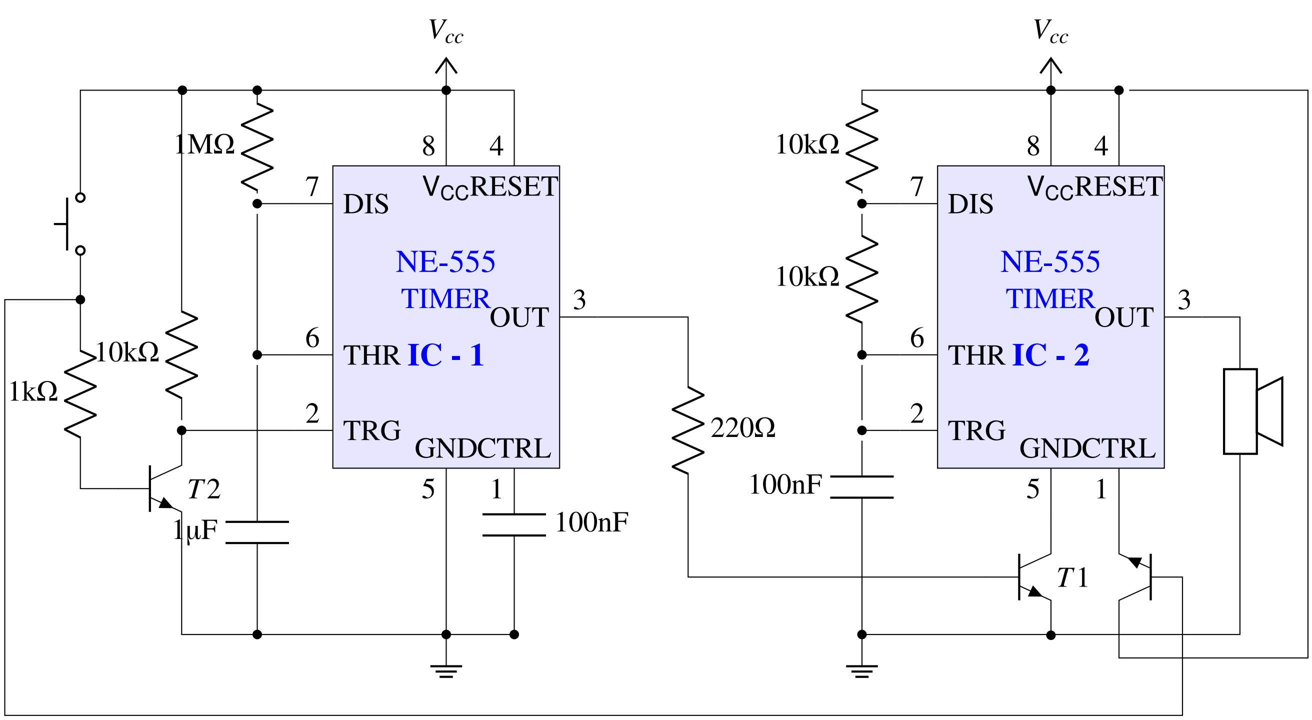


Figure 4.65: Doorbell Circuit

4.15.4 Circuit Explanation

In this circuit the first 555 is in monostable mode and the second one is in astable mode. When powered on, the second 555 is off, as it's ground is disconnected. When the button is pressed the output of first 555 goes high, turning on the second one. And, the output of first 555 also controls the internal voltage of the second 555, so when the button is pressed the second 555 sounds the buzzer in one frequency and when the button is released it sound the buzzer in different frequency till the output of the first 555 goes low.

4.15.5 Circuit Picture

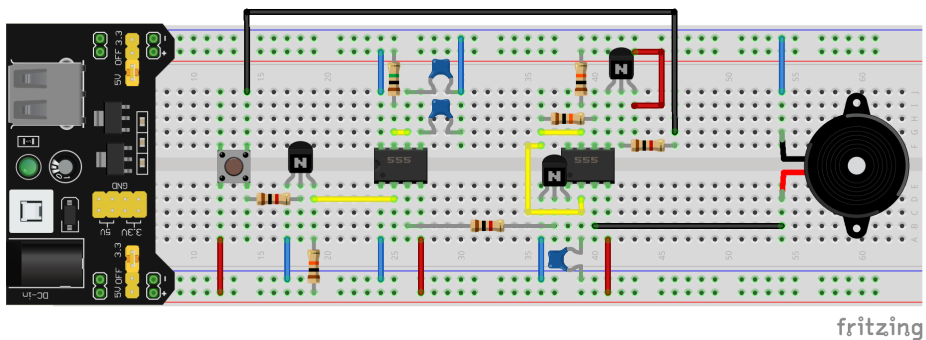


Figure 4.66: Doorbell Breadboard Schematic

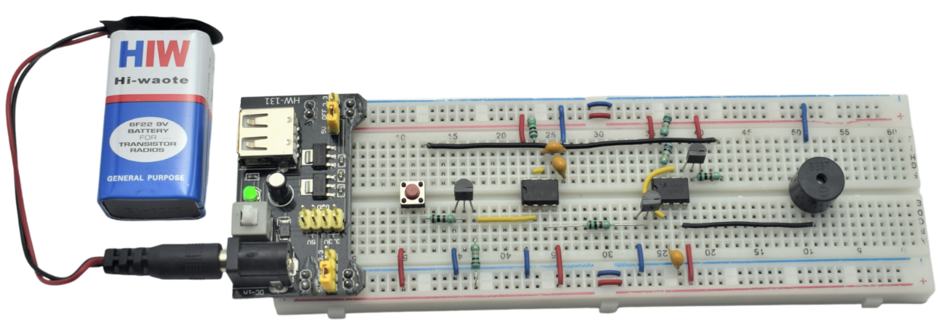


Figure 4.67: Idle: Buzzer OFF

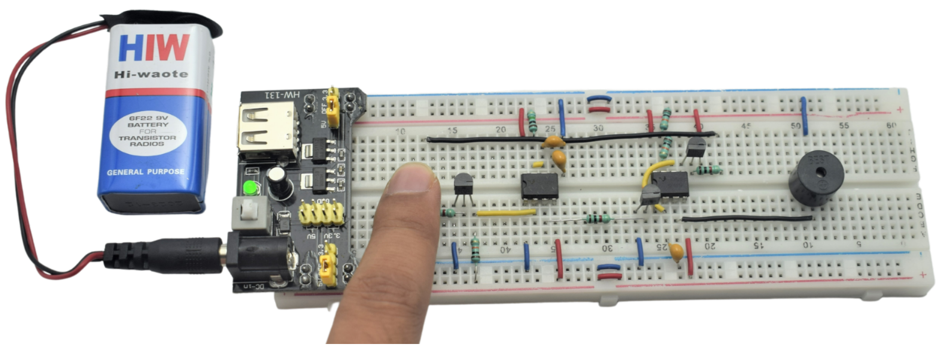


Figure 4.68: Button Pressed: Buzzer ON for sometime

4.16 Lesson 24: PWM Speed Controller

4.16.1 Objective

In this activity we'll control a dc motor using 555 as PWM generator.

4.16.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 1
6. 2N2222 × 1
7. DC Motor × 1
8. Propeller × 1
9. 1N4007 Diode × 2
10. 1 kΩ × 1
11. 2 kΩ × 1
12. 10 kΩ × 1
13. 10 kΩ Potentiometer × 1
14. 100 nF × 2
15. 10 µF × 1
16. Male-Male jumper wire × 11

4.16.3 Circuit

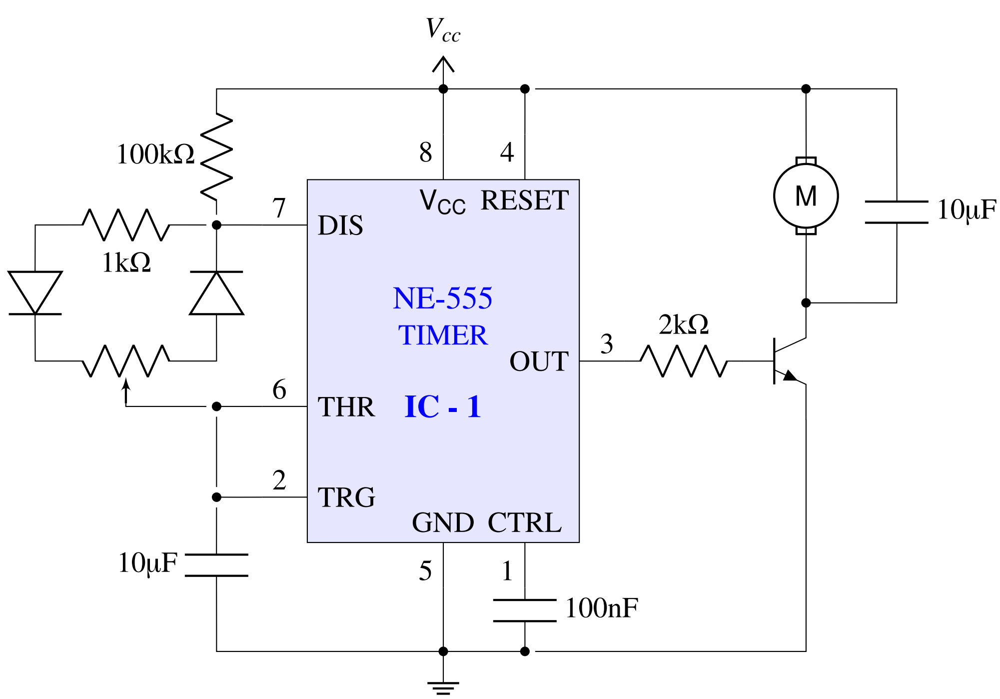


Figure 4.69: PWM Speed Controller

4.16.4 Circuit Explanation

In this circuit the 555 is in astable mode with two different paths for charging and discharging the timing capacitor. The PWM duty cycle is controlled with the help of the potentiometer.

4.16.5 Circuit Picture

Figure 4.70: PWM Speed Controller Breadboard Schematic

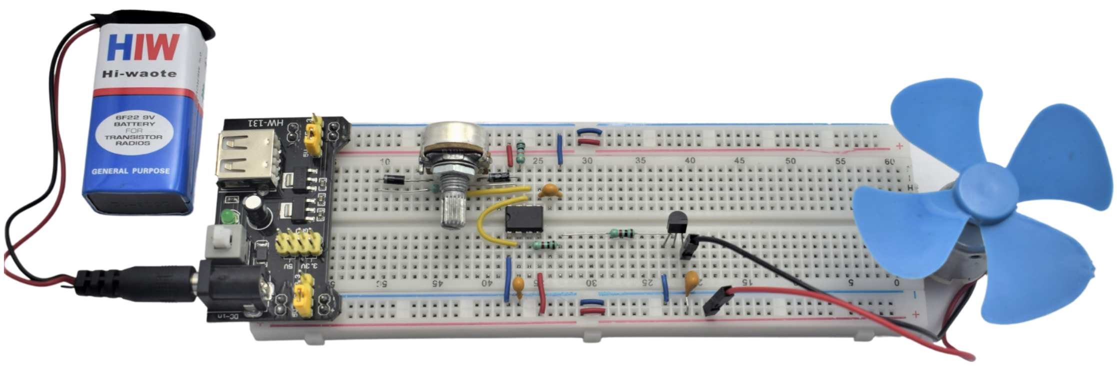


Figure 4.71: PWM 0 Duty Cycle

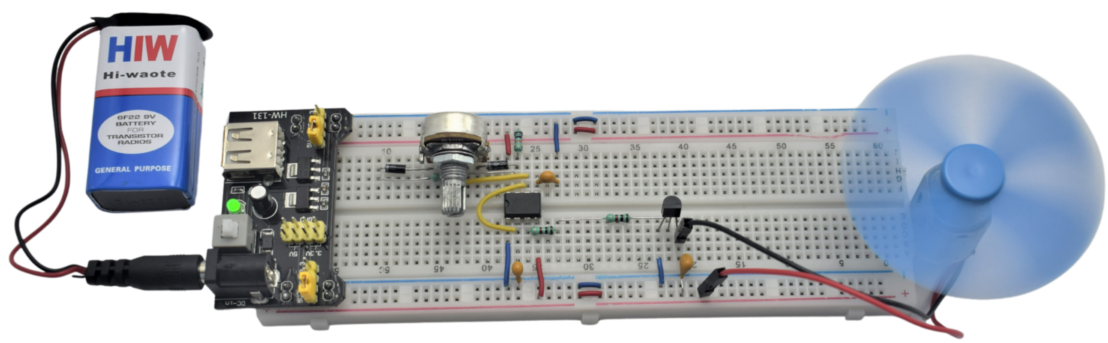


Figure 4.72: PWM half Duty Cycle

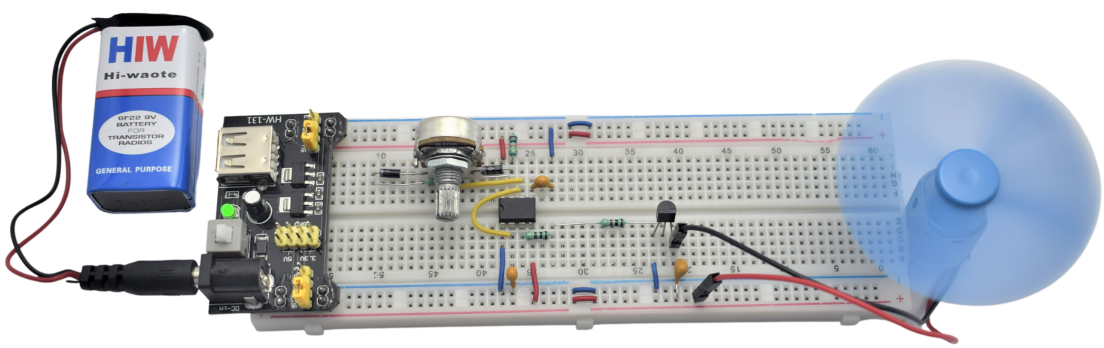


Figure 4.73: PWM full Duty Cycle

4.17 Lesson 25: 555 RGB Flasher

4.17.1 Objective

In this activity we'll use 3 astable 555 circuit to flash RGB LED

4.17.2 Components Required

1. Breadboard Power Supply × 1
2. 9V Battery × 1
3. 9V Battery Connector × 1
4. Breadboard × 1
5. 555 IC × 3
6. RGB LED × 1
7. 2N2222 × 3
8. 220 Ω × 3
9. 10 kΩ × 3
10. 100 kΩ × 3
11. 1 MΩ × 3
12. 100 nF × 3
13. 2.2 μF × 1
14. 4.7 μF × 1
15. 10 μF × 4
16. Male-Male jumper wire × 30

4.17.3 Circuit

4.17.4 Circuit Explanation

In this circuit we have used 3 555 in astable configuration to flash a RGB LED.

4.17.5 Circuit Picture

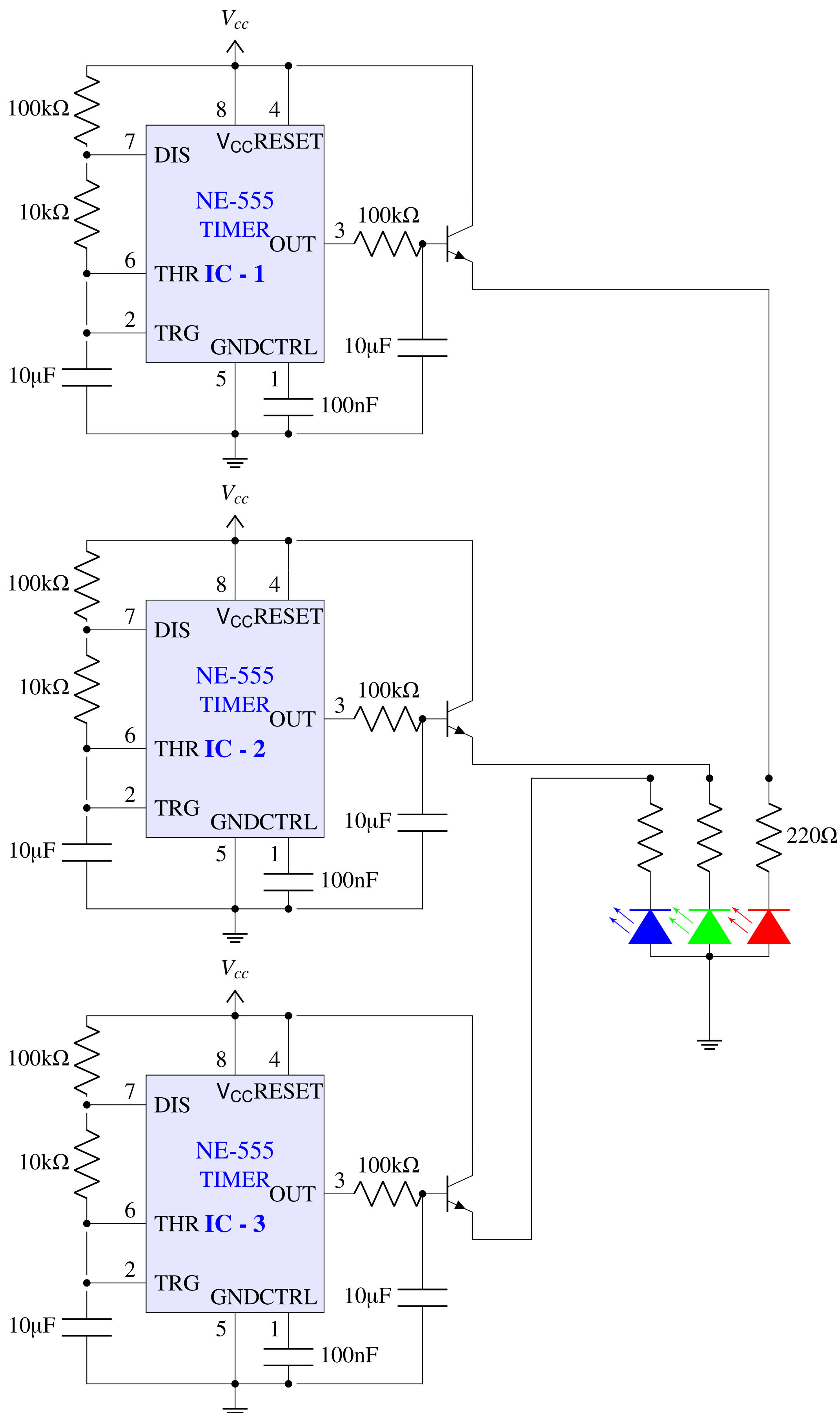


Figure 4.74: RGB Flasher using 555 circuit

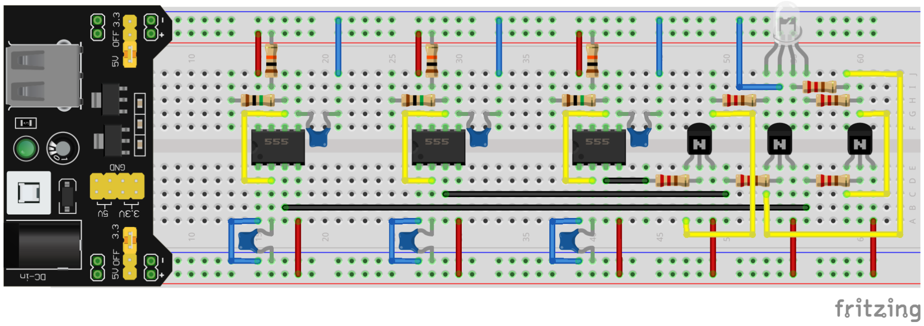


Figure 4.75: RGB LED Flasher Breadboard Schematic

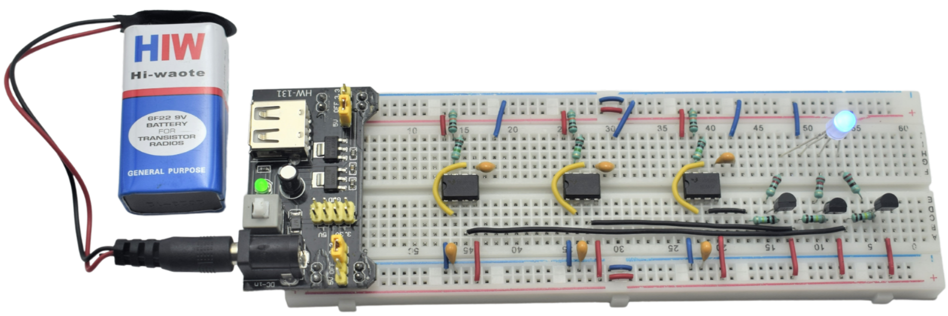


Figure 4.76: RGB Flasher

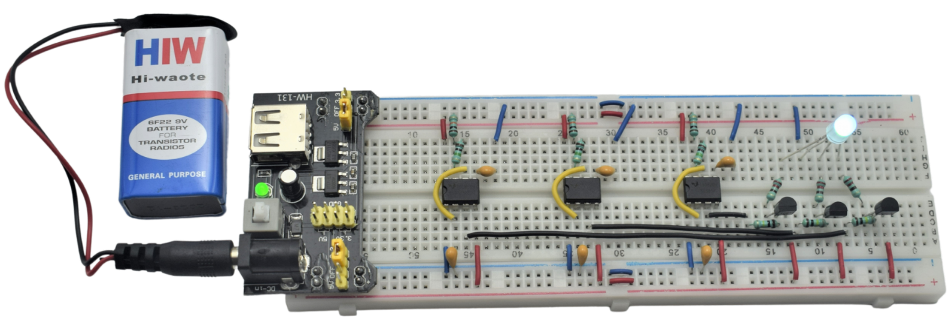


Figure 4.77: RGB Flasher

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