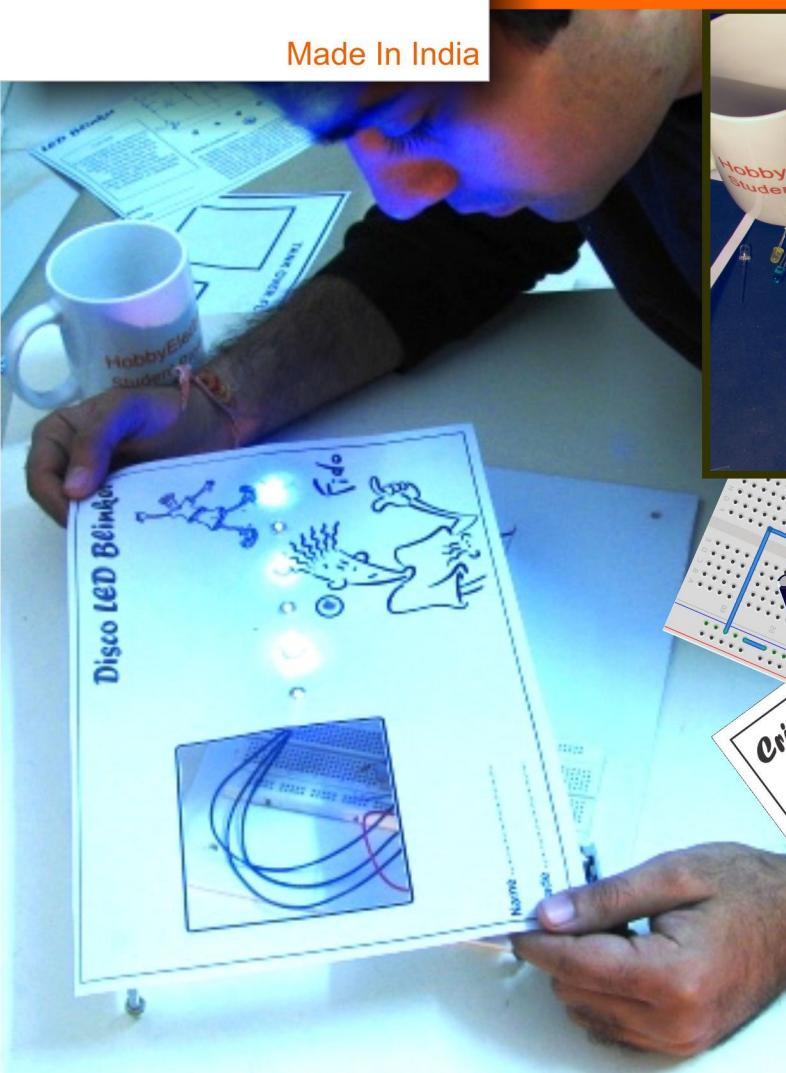


Hobby Electronics

Student Projects & Kits

Made In India

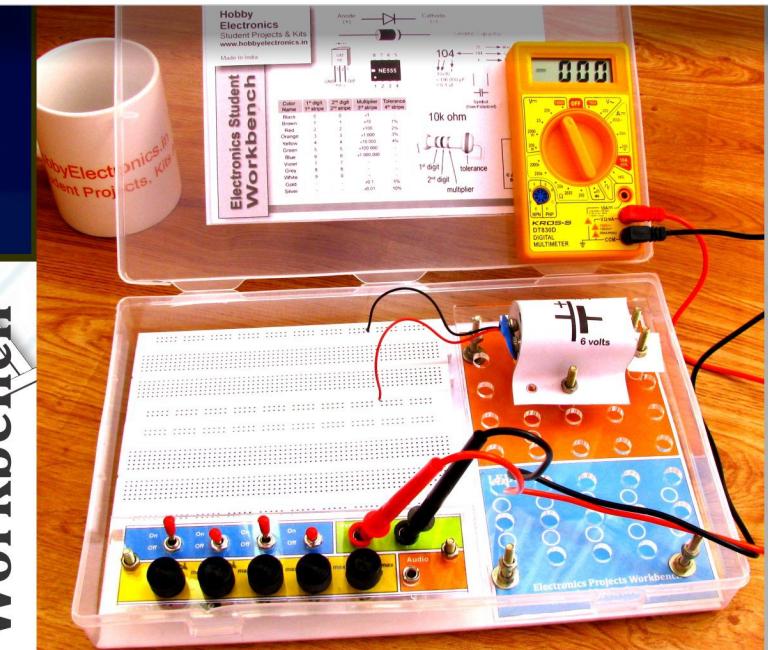


Electronics Projects



Circuits Book

www.HobbyElectronics.in



Workbench

Varun Bansal

How to use the book -

Know the basics—To start working with electronics circuits ad projects, one should be very well aware about all basic electronic components like Resistor, capacitors, transistors etc. It is important to know how the components behave when they are connected in a closed circuit for example—The purpose of a capacitor is to store charge and once charged capacitors cut off current supply through them. It is also important to understand what voltages should be applied to different components and the direction these components should be connected. For example—capacitors have a maximum possible permissible voltage rating along with polarity written on them , for resistors polarity doesn't matter. For most of electronics components manufactured today a voltage of around 5 volt is sufficient.

Testing circuits—After a circuit is assembled the level of excitement rises to test it right away, but it is important to check the connections and start with correct voltage for a short time just to check if circuit is working correctly , If not you should disconnect battery as soon as possible because the reason of no output of circuit can be wrong connections and if its a case then it can damage the components of circuit.



Words of caution—Throughout this book I have mentioned the warnings wherever nessecary with a warning icon on the left side. Warning text are written where it is very essential to inform a hobbyist about the possibilities of harming the circuit components. For example in The LEDs Circuit section , It is important to use a resistor to prevent LED to get destroyed by 4.8 or more voltage.



Ideas—In many circuits I have mentioned the ideas which were worth mentioning, There are many circuits which can be turned into useful projects . For example the simple LED lights project can be used as a bedroom lamp.

Finally a project is worthless if it isn't portable and useful. And what makes a circuit useful is actually the cabinet. Which hides all the tiny sensitive components from user. In all professional systems circuits are first assembled in a printed circuit board (PCB) and then it is fitted in a cabinet, exposing the only needed controls to user. Though PCBs provide good platform to assemble circuit, they are not a good testing platform. There are problems working with PCB that you can't take out assemble components easily for replacements apart from this long contact with Soldering iron may damage sensitive components. Breadboard provides a perfect platform for testing circuits so we recommend using breadboard . For cabinet enclosure www.hobbyelectronics.com - MY Kit provides a good option but you can also go for any other box if you are not using MY Kit.

For more free circuits and projects please connect to www.hobbyelectronics.in and click on blog section.

A word for Students and Hobbyists

As a hobbyist I had always struggled to buy the components what I needed for my circuits, i used to search local radio repair shops and used to visit old Lajpat Rai market opposite to red fort, old Delhi. 10 years back it was quite different situation, with less shops, very few online websites and nearly no online shopping site, Today things have changed and we have very good and rich online knowledge like blogs, sites and online shopping stores.

But some of the rules for shopping still remains the same. As For most of the basic components you should first search local radio shops And If you are from Delhi and around you can always find most of components from old Lajpat Rai market only some shopkeepers here are not interested in retail buyers as they are bulk dealers, So better to find shops which are selling retail.

If, However you want to buy online there are some options available. Just Google for electronics spares, There are sites which are selling spares and some selling complete kits also but i would recommend to start with basic and assemble your our circuits instead of using a ready made project.

By
Varun Bansal

Email me at: vanarova@gmail.com

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Working with Paper Panels

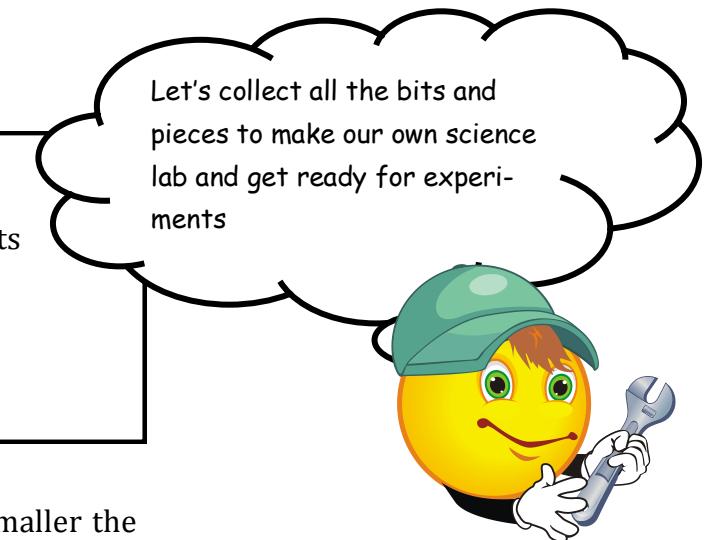
Making Your Own Paper Panel

Basic Electronics Components

In this section we will see :

- | | |
|---------------------------|------------------------------|
| 1. Resistor | 7. Light Dependent Resistor |
| 2. LED | 8. Relays |
| 3. Electrolytic Capacitor | 9. Reed switch |
| 4. Ceramic Capacitor | 10. Microphone |
| 5. Variable Resistance | 11. TSOP IR Module |
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Let's collect all the bits and pieces to make our own science lab and get ready for experiments

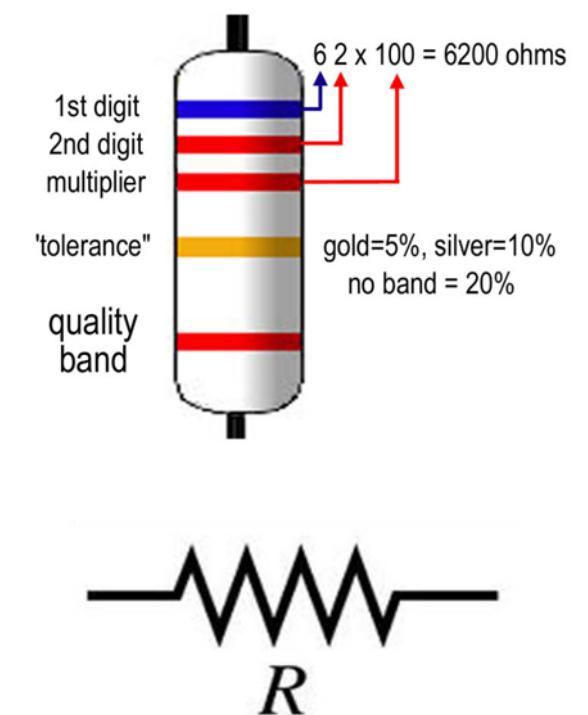


1. Resistor

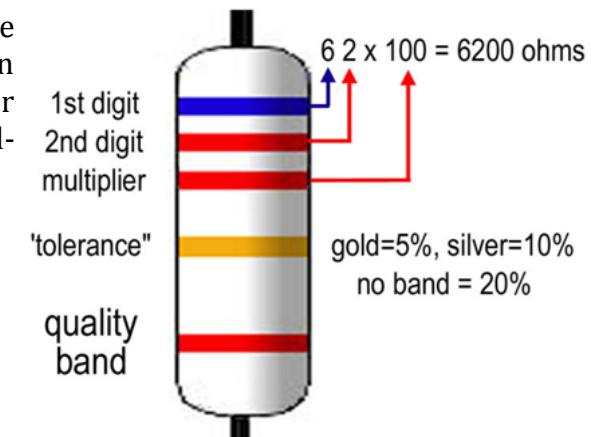
As name suggest it resists direct current in the circuit. The greater the resistance the smaller the current will be. For example—A resistance attached to a LED will dimmer the light of LED.

Resistances have a color coding scheme, you can calculate the value of it by just looking at color bands. This is because resistances are small and numbers can't be printed on them directly. In the right hand side figure, you can see the table showing all the colors and their values. Gold and silver color is present in every resistor to show its tolerance. Gold means that it value will be $\pm 5\%$ precise. For ex—A 100 ohm resistor with gold band means that it can be 105 ohm or can be 95 ohm also.

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



Calculation of resistance : For calculation of resistance we need to read color from the opposite side of gold or silver band. Which means the first color should not be golden or silver. As you can see the figure on right side, the first color is blue whose number is 6, second is red whose number is 2 and third is also red whose multiplier is two zeros (remember last color number is always multiplied), forth is gold and we don't include gold in calculation. So the resistance would be - Blue (6) , red (2) and red (100) = 6200 ohm, quiet easy isn't it?



LED Symbol



A LED – Light Emitting Diode

Warning:

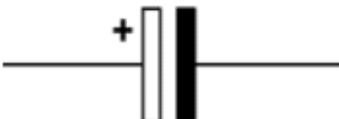
 while connecting LED to a battery, the voltage should not exceed to 4.5 volts, if you are using 4 cells = 6volt battery, Add a 100 ohms resistance to bring down voltage. LED are sensitive to voltage and high voltage can damage it permanently. In simple words, never connect a LED directly to power supply.

3. Electrolytic Capacitor

A capacitor (originally known as condenser) is a passive two-terminal electrical component used to store energy in an electric field. When there is a potential difference (voltage) across the conductors, a static electric field develops across the dielectric, causing positive charge to collect on one plate and negative charge on the other plate.

In simple words it stores electricity and is polar in nature (means positive terminal of this capacitor should be connected to the positive of battery and negative to negative)

Capacitance is measured in microfarads (μF) and a voltage is written on capacitors which tell the maximum voltage this capacitor can handle. If you see in the figure right hand side, The capacitor is of $15 \mu\text{F}$ and can handle a voltage of 400 v.



Capacitor Symbol

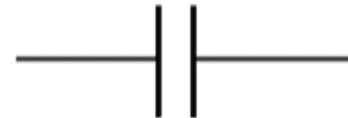


An Electrolytic Capacitor

4. Ceramic Capacitor

It is same as electrolytic capacitor and stores electricity with the only difference that it is not polar and can be connected in any direction. ceramic capacitors are generally available in smaller values, smaller than 1 microfarad (μf), whereas electrolytic capacitors are available in values greater than 1 microfarad

Symbol of Ceramic Capacitor

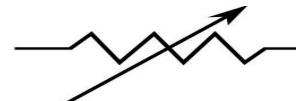


Ceramic Capacitor

5. Potentiometer or Variable Resistance

It is a resistance with a knob to increase or decrease the resistance. When the spindle is rotated to a direction it will increase the resistance and when it rotated to another direction the resistance decreases. **Use only two pins - middle pin and one pin from either side for circuit making.**

Symbol for preset or variable resistance



A Variable Resistance



A Preset (same as variable resistance)

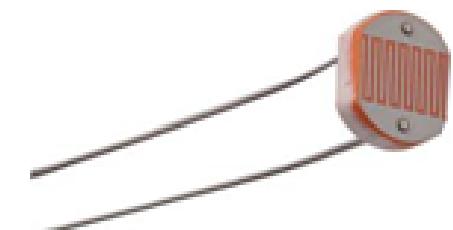
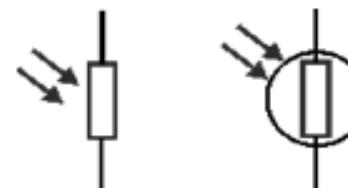
6. Preset

These are miniature versions of the standard variable resistor. They are designed to be mounted directly onto the circuit board and adjusted only when the circuit is built.

7. Light Dependent Resistance

A Photo resistor or Light Dependent Resistor (LDR) is a resistor whose resistance decreases with increasing incident light intensity. When Light falls on it, Its resistance becomes low and in dark its resistance is high.

Two possible symbols of the Light Dependent Resistance



A Light Dependent Resistance

8. Relay

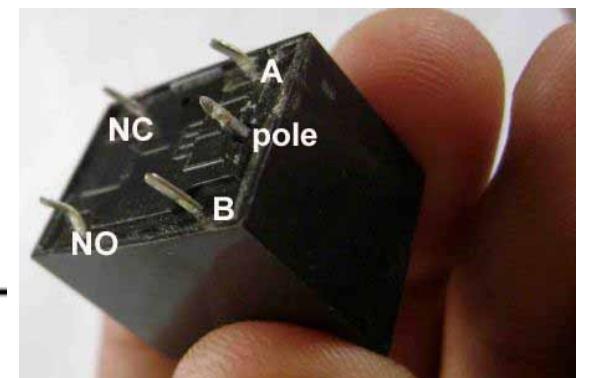
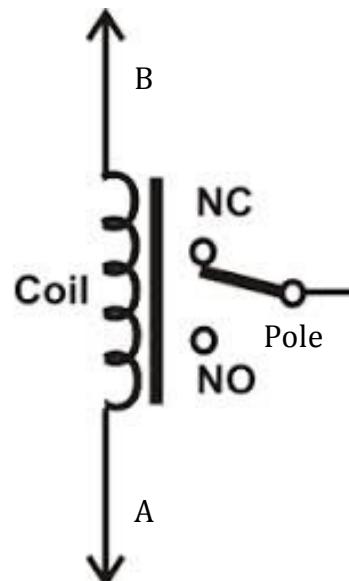
A relay is an electrically operated switch. Relays use an electro magnet to operate a switching mechanism mechanically . Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits)

You can see the schematic diagram of a relay and an image of a real relay on right hand side.

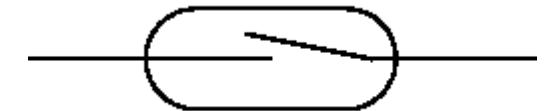
NC—Normally Closed, NO—Normally Open

A and B should be connected to battery.

Relay comes in variety of ratings and sizes, Generally a 5volt relay, 240VAC/ 7Amp is enough for a hobbyist. As it can drive almost all home appliances.



Reed Switch



Microphone

9. Reed Switch

The reed switch is an electrical switch operated by an applied magnetic field . It consists of a pair of contacts on iron metal reeds in a sealed glass envelope. When a magnet comes near to this switch, it magnetize the iron reeds and come together to make a contact. This temporary contact works as a switch. The moment magnet moves away, the switch turns Off and contacts are separated.

10. Microphone

It is a transducer that converts sound to an electrical audio signal. It consists of two metal plates separated by granules of carbon. One plate is very thin and faces outward, acting as a diaphragm. When sound waves strike this plate, the pressure on the granules changes, which in turn changes the electrical resistance between the plates. ***Please note the MIC is polar, The wire which is connected to its outer cover is -ve.***

11. TSOP IR Module

This IR sensor module consists of a PIN diode and a pre amplifier which are embedded into a single package. The output of TSOP is active low and it gives +5V in off state. When IR waves, from a source, with a centre frequency of 38 kHz incident on it, its output goes low

There are two kinds of TSOP available—1738 and 1838

From left to right, when seen from the front side;

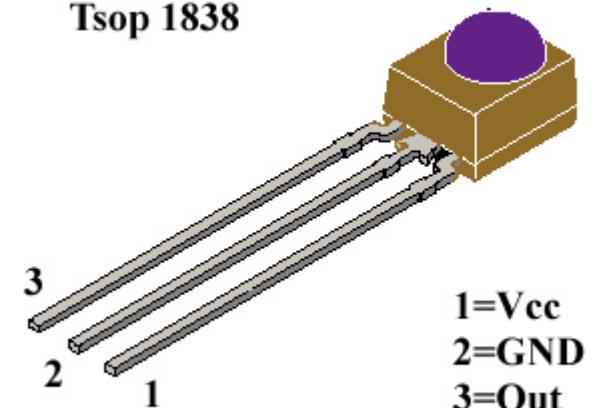
TSOP1838: Output, Ground, Vcc

TSOP1738: Ground, Vcc, Output

You can see the embedded markings, on top of TSOP.



Tsop 1838



12. RGB LED

An RGB LED, as name suggests is a special LED which is capable of producing all colors by mixing Red, Green and Blue colors. In simple words It consists of 3 LEDs (Red,Green,Blue) together in a package and by variation of these 3 colors more colors can be formed.

An RGB LED is having 4 pins, one of which is a common anode (-ve) and other 3 pins are for Red, Green and Blue respectively.

By manufacturers convention, the longest pin of LED is the one which is common anode for all three integrated LEDs.



This is the principle on which LED Tv works. An LED Tv contains millions of RGB LEDs very close of each other. Each LED create one pixel of image. According to the image, different voltage is applied on different LED and together they create a visual image, When looked from a distance we only see a image but when you look the screen from very close (maybe with a magnifying glass) you will observe LEDs

There are other forms of RGB LEDs also available in market



13. IC - Integrated Circuits

Integrated Circuits are usually called ICs or chips. They are complex circuits which have been etched onto tiny chips of semiconductor (silicon).

The pins are numbered anti-clockwise around the IC (chip) starting near the notch or dot. The diagram shows the numbering for 8-pin and 14-pin ICs, but the principle is the same for all sizes.



Warning: ICs are sensitive to voltages and wrong connections can damage them permanently.



The most popular 555 timer IC

14. Thermistor

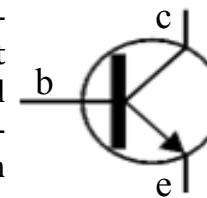
A thermistor is a type of resistor whose resistance varies significantly with temperature. When heated, its resistance gets small, when cooled its resistance increases.



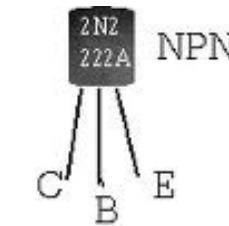
A Thermistor and its symbol

15. Transistor

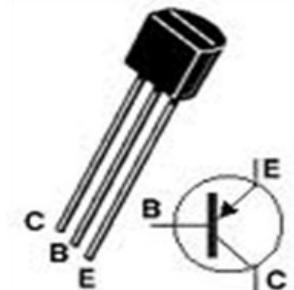
A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current flowing through another pair of terminals. Because the controlled (output) power can be higher than the controlling (input) power, a transistor can amplify a signal.



Caution: Transistors should be correctly connected or a wrong connection may damage transistor.



NPN transistor –
E-emitter, B-base,
C-collector



PNP transistor

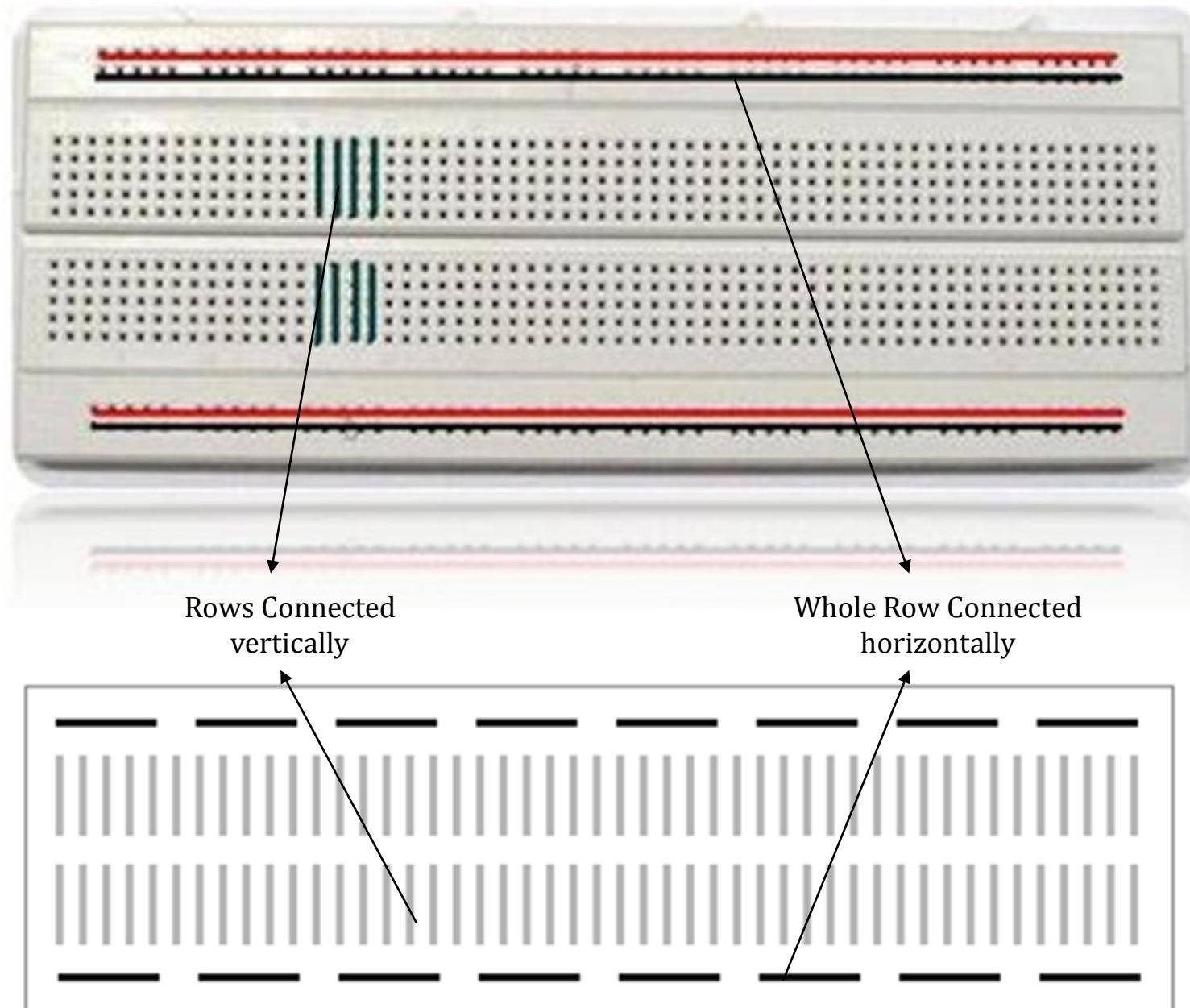
16. Breadboard

Using breadboard to design a circuit is the easiest and safest way. It not only protects you from warm soldering temperatures and smoke but it also protect the circuit components from being damaged by high temperatures.

It provides a fastest method of making a circuit and you can experiment with circuits by changing joints quickly and easily.

Connections

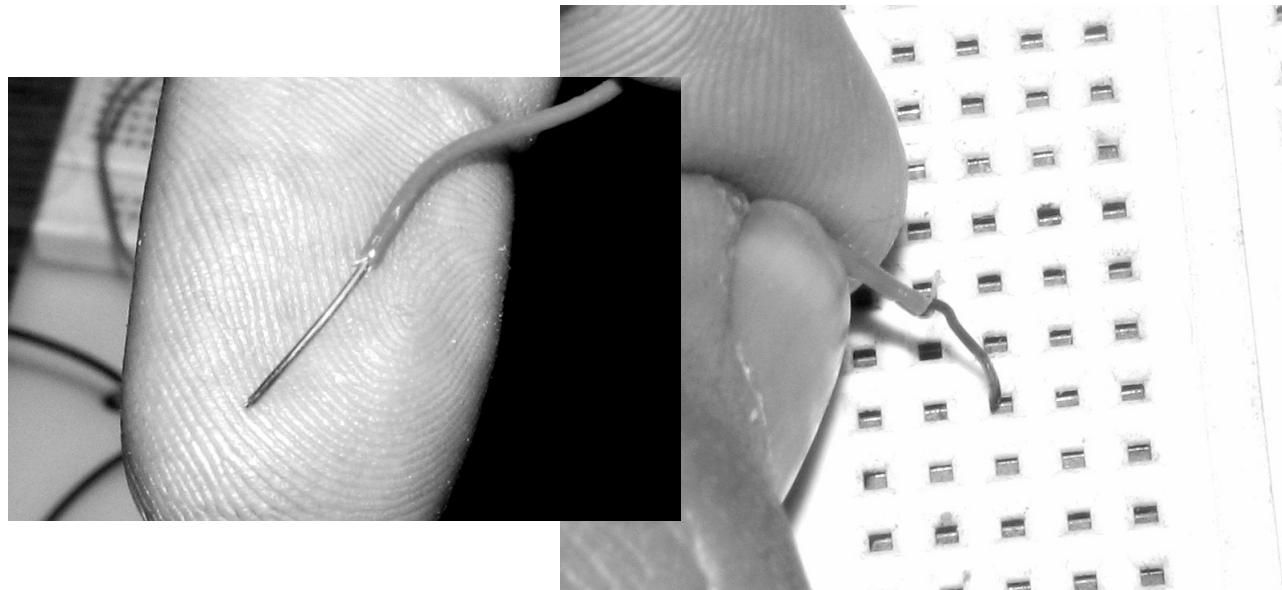
The figure on right side is showing the internal pins connections of a breadboard. The holes in the middle portion of board are connected vertically as shown by highlighted lines. The outer two rows of holes are connected horizontally as shown by red/black lines in the figure.



Internal Wiring Diagram of a Breadboard

17. Breadboard Wire

The best wire for breadboard is single core (Only one thick wire with insulting sleeve) copper wire, Please refer the picture below. Its not so tough to find this wire, mostly telephone wires and LAN wires are single core



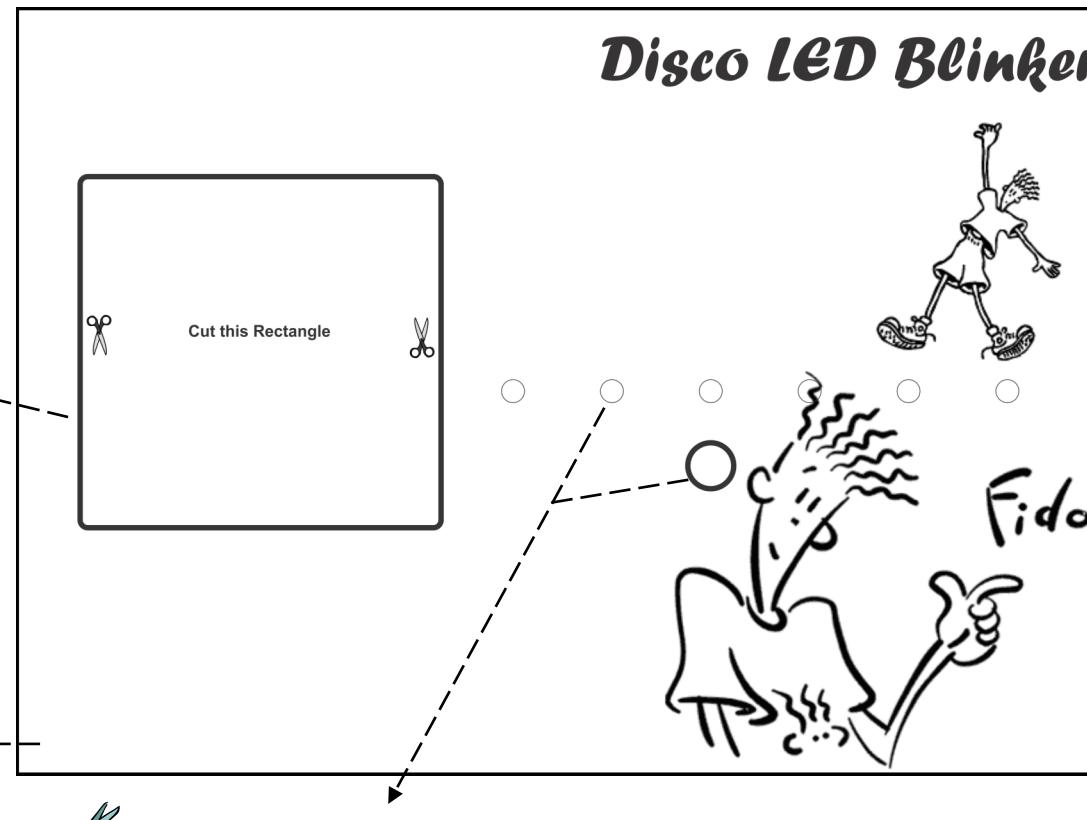
Working with paper panels



Paper panels are included in this book as drawings with each circuit. You can print them with printer or you can make your own panel

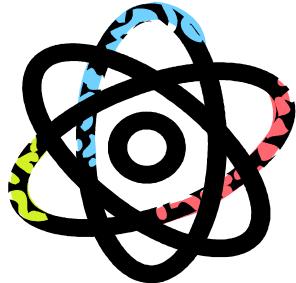
 You can cut the paper if you want your viewers to see your circuit, this will decrease their curiosity and it will help them understand the working of your project.

 Cut the holes for nuts. Just make a plus sign by paper cutting blade.



A Paper panel is a interface for viewers, as like every control panel of any equipment, It should be attractive, informative and easy to understand. It should describe your project very well. Now you can be more casual if you are making your project for fun or more serious and descriptive if you are making your project from a science fair.

<— A casual panel



Learn with fun

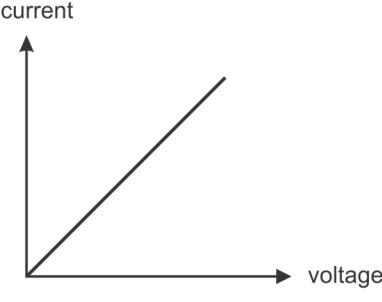
Here's is an example for a panel for school **science fairs and class projects**. As you see there is some theoretical knowledge provided to teach the circuit to fellow students and yourself.

A formal panel -->

Ohm's Law



current

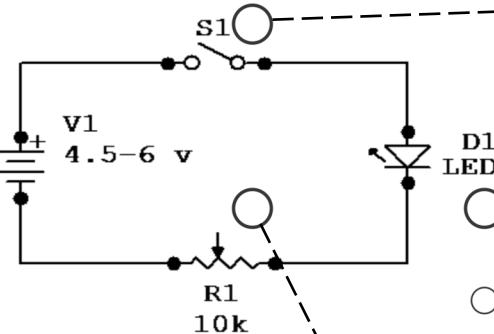


voltage

Ohm's law states that the current through a conductor between two points is directly proportional to the potential difference across the two points. Introducing the constant of proportionality, the resistance, one arrives at the usual mathematical equation that describes this relationship

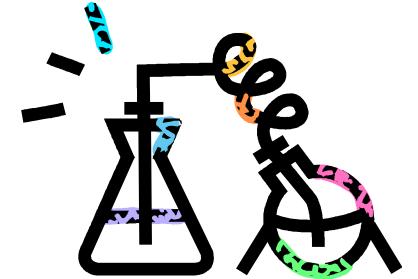
$$V = I/R$$

where I is the current through the conductor in units of amperes, V is the potential difference measured across the conductor in units of volts, and R is the resistance of the conductor in units of ohms.



 For Switch
 For LED

 For Regulator
 Cut the holes for nuts



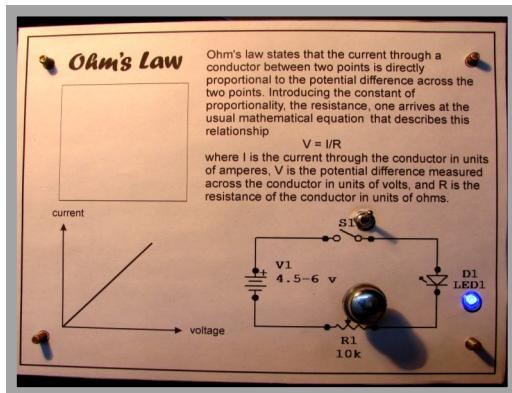
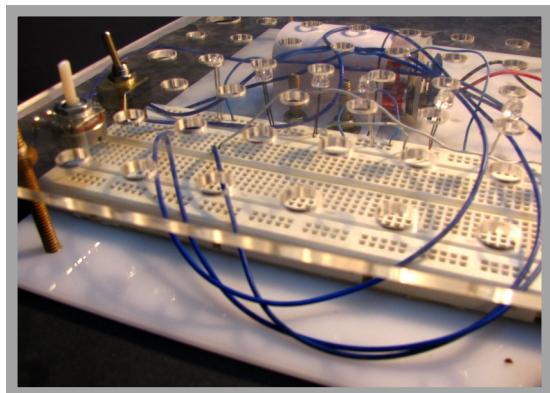
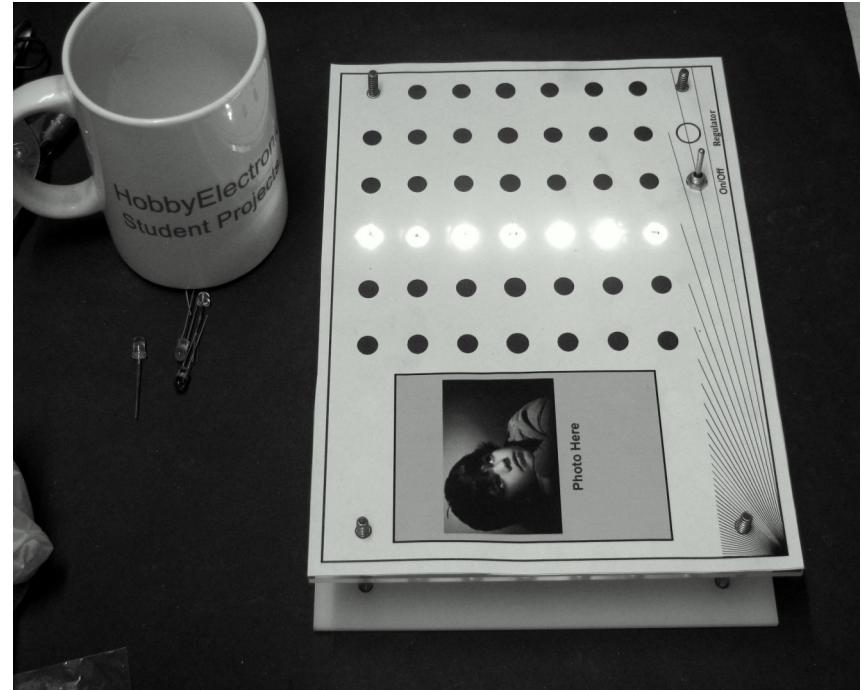
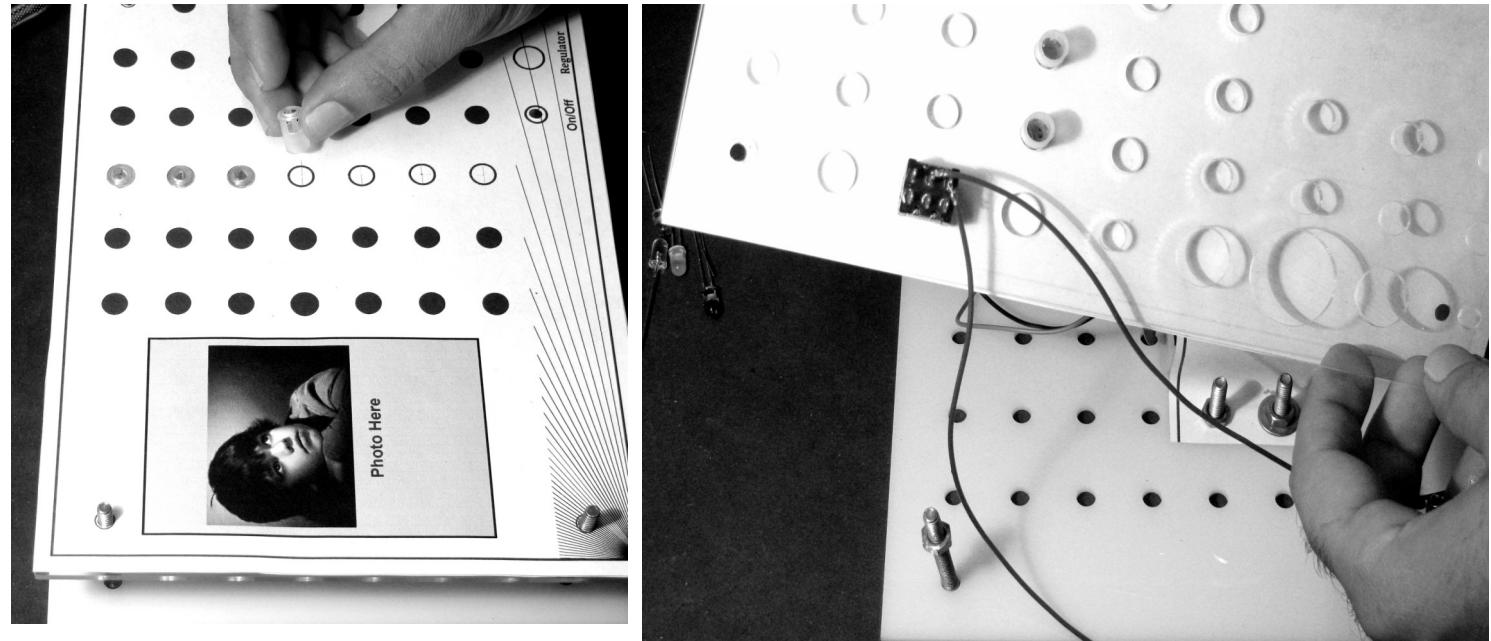
Finalizing The Design

To support fragile paper panel, we need some card board or plastic board.

You can buy a cardboard from stationery shop and cut it in exactly same size as your panel is and make holes for components. Or you can make a plastic panel. Making a plastic panel is bit more complicated and require some manufacturing tools. This panels shown on the right side are made by Laser cutting machine.

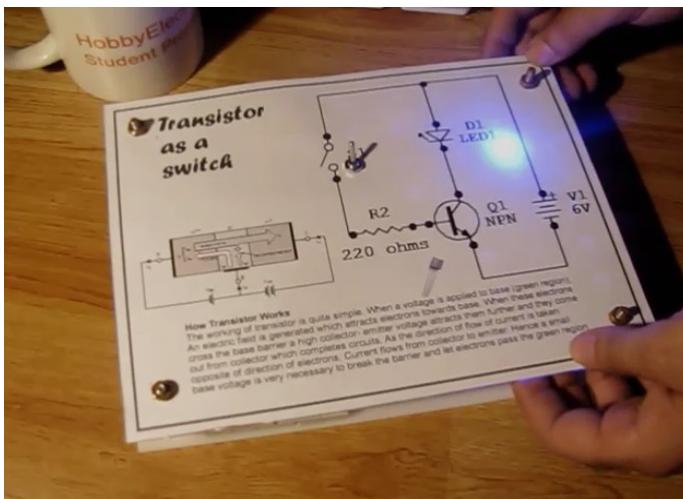
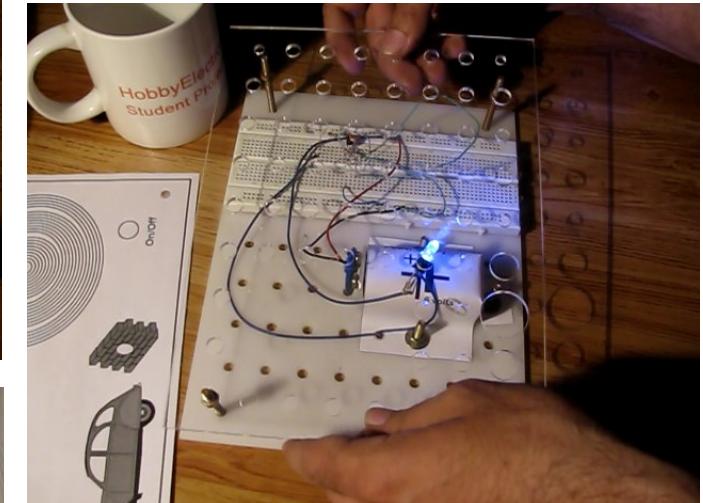
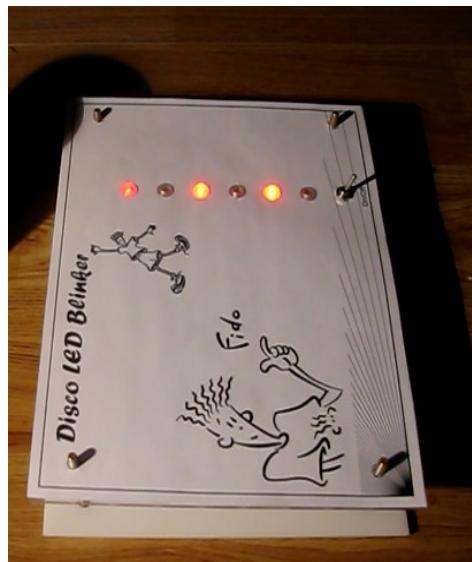
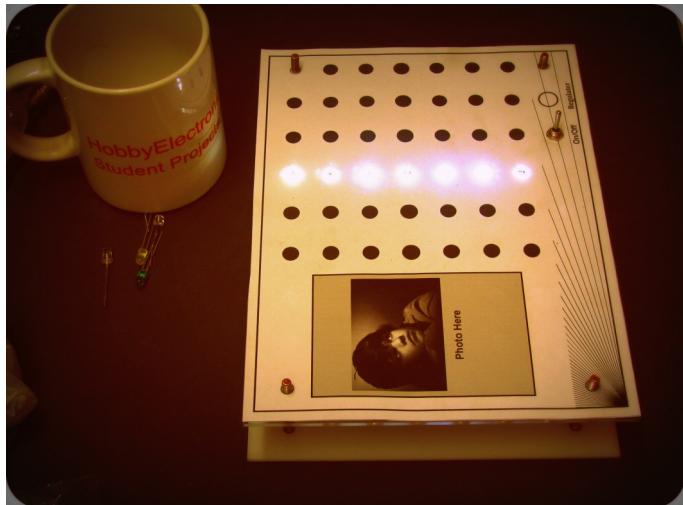
After the board is ready we just need to assemble the panel and components on board, put the nuts and bolts on and we are ready to go.

Easy.. Isn't it?

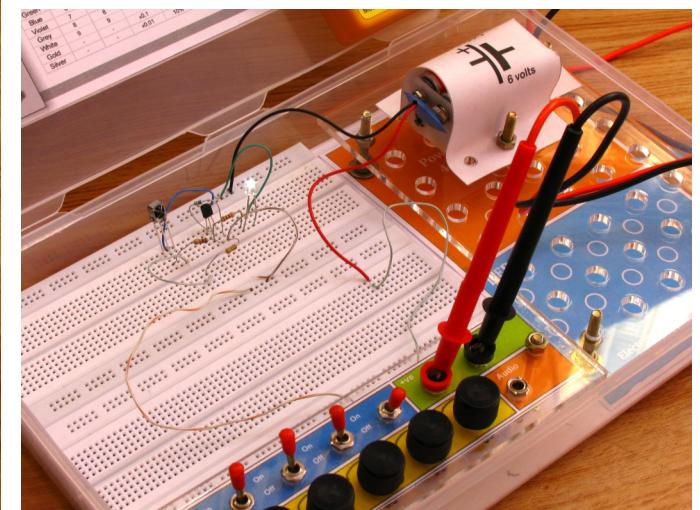
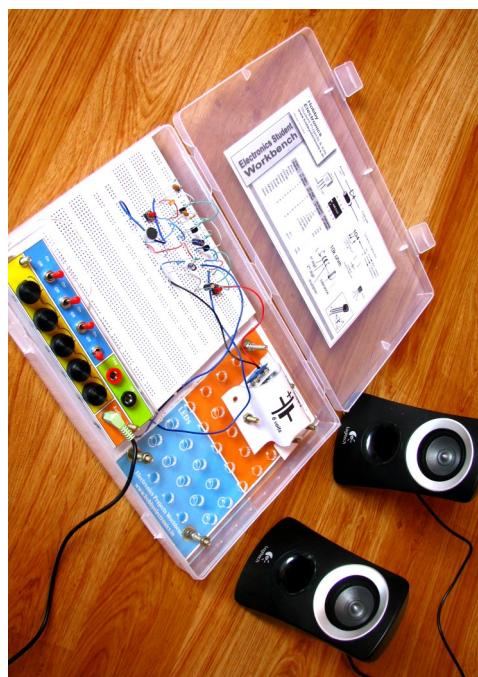
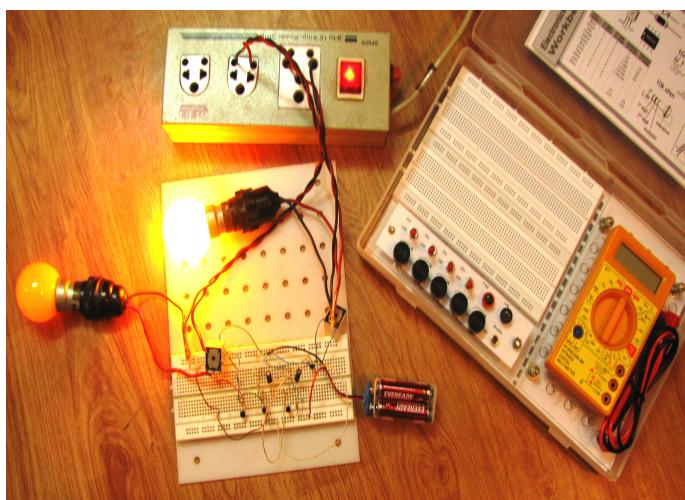
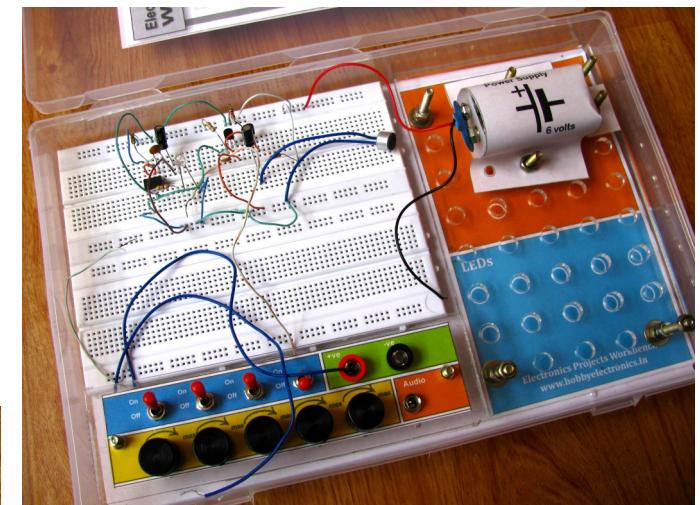
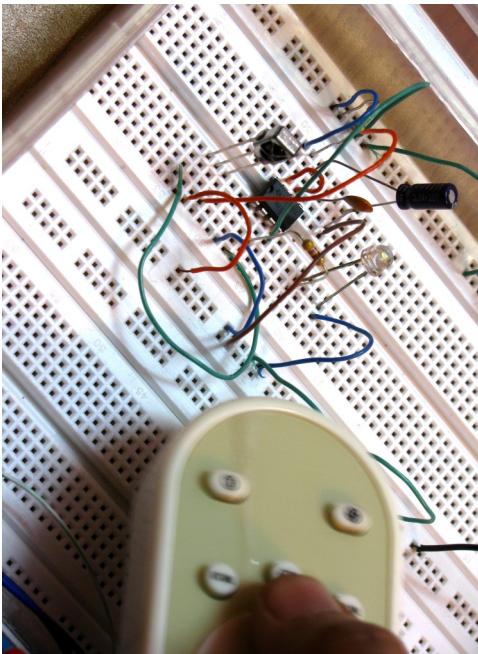
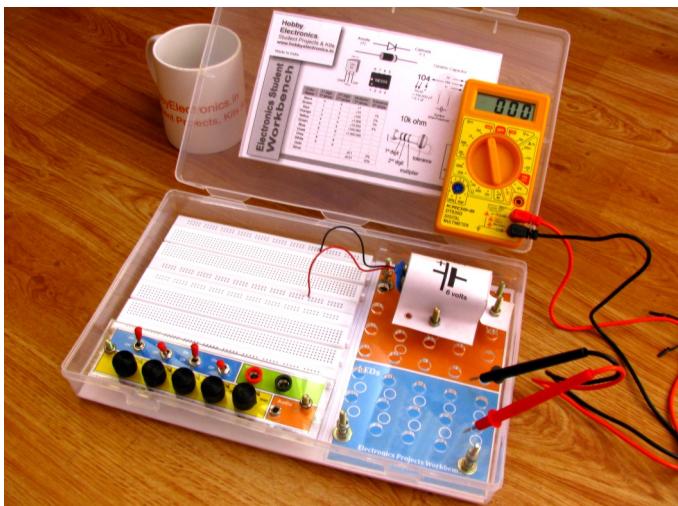


Work Gallery

MY Kit



Electronics Student Workbench



1. The LED Circuits

In this section we will make :

- 1.1 Simple LED Circuit
- 1.2 Multiple LEDs Circuit
- 1.3 An Ambient Light on MY Kit.
- 1.4 Simple Diode Circuit
- 1.5 Ambience Light with RGB LED

Let's start the exciting journey of electronic projects with colorful LED lights.

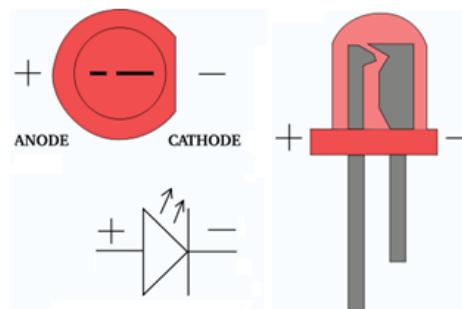


So what is LED ?

A light-emitting diode (LED) is a semiconductor light source. Please refer to components definition section for more detail.



Some Parts of this project are available in Video CD ROM

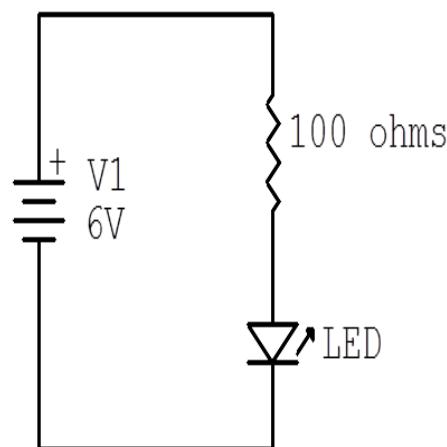


TIP:

The Longer leg of LED is always positive and must be connected to positive terminal of battery.

Let's Do It

To start working with electronic circuits, Let's make a super simple circuit first. The circuit is all about lighting LEDs with battery. This circuit will also teach you how to use kit and connect wires in bread-



1.1 Simple LED Circuit

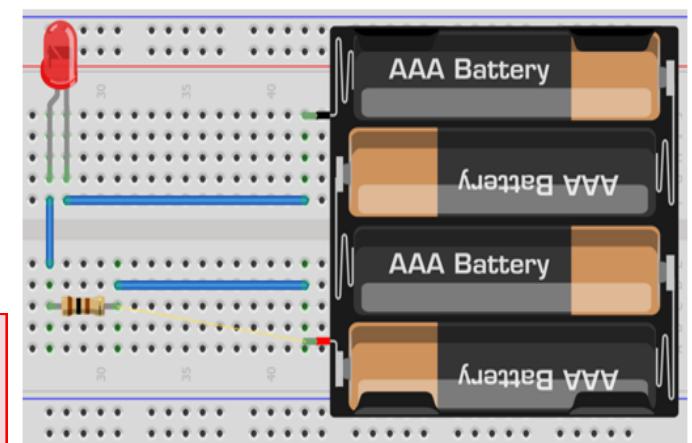
Step1: As Simple as it is, just Connect the batteries, resistance and one LED and try to light up the LED.

If it is not lighting then swap its legs, The longer leg of LED should be connected to positive of battery as told in tip.

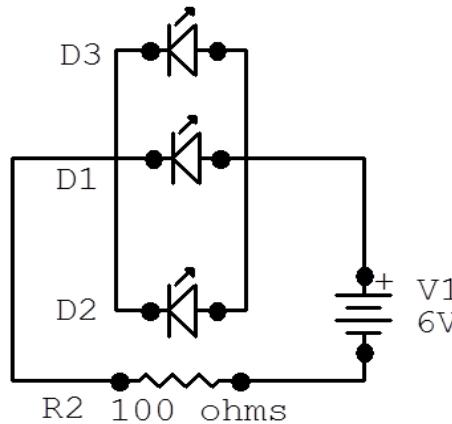


Warning:

A Resistance of 100 ohms or above should be connected with LED as most of the LEDs don't like voltages more than 4.5 v.



Made with Fritzing.org



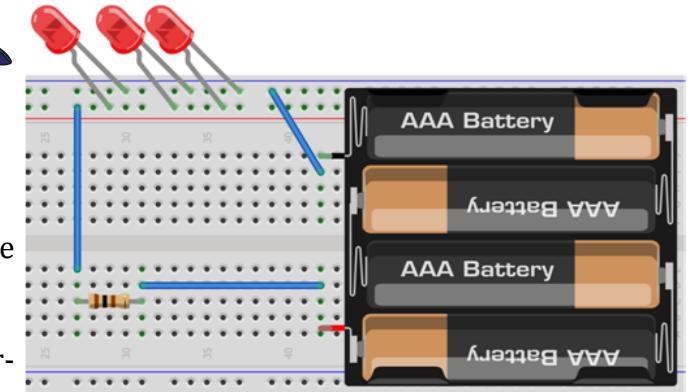
Done with one LED? Now its time to light up multiple LEDs.



1.2 Multiple LEDs Circuit

To make a multiple LED circuit we will add up more LEDs in parallel to previous circuit of single LED.

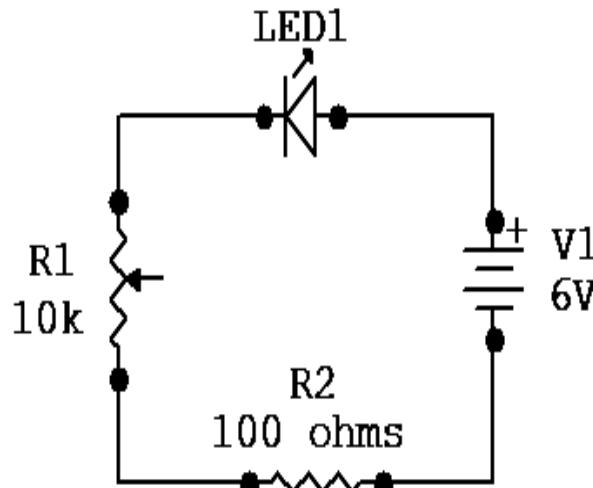
Step 1: Just add more LEDs in the holes which are parallel to first LED. Please refer diagram.



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TIP:

If you are thinking to make a multiple LED circuit by connecting LEDs in series then it **will not work** with 6 volts. As LEDs have high resistance and it is not possible to light up LEDs in series with lower voltages.

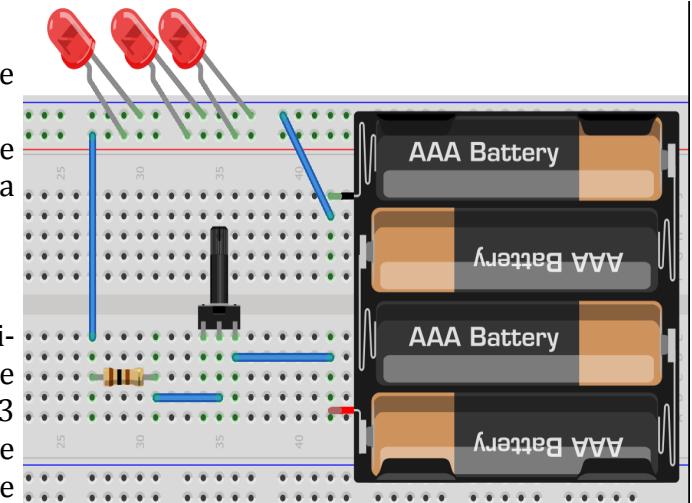


1.3 LED Ambient Lamp

Lets now make a project using what all we have learnt about lighting a LED with 4 AA cells. What we are going to do is just assemble the multiple LEDs circuit on MY Kit and design a front panel for our project.

Let's Do it

Step 1: Lets assemble the circuit, In the previous circuit we have added a variable resistance to dim the lights if needed. To convert the 3 wires into 2, Join the first 2 wires of variable resistance and use the joint and remaining one wire. (Please refer video).

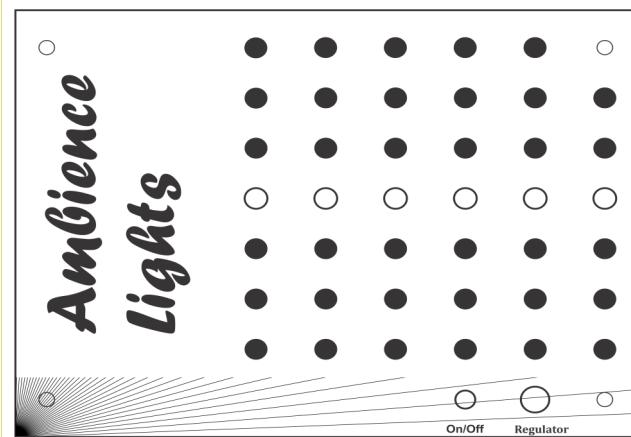


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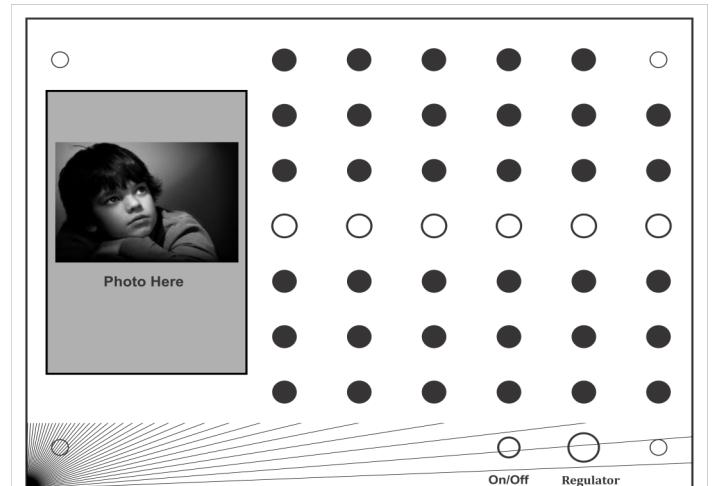
Step 2: Cut the panel design page and paste it on MY Kit.

Step 3: Screw the snap over LEDs and paste a small paper cutting on snap, to hide the LEDs and to give a diffused light.(A direct light is irritating for eyes) I have tried to give a designer look to our lamp, The dots give a mysterious look to the lamp when it is lighted up in dark.

Panel Design for LED ambient Lamp



More Ideas -
You also use this lamp as a photo frame, and stick your photo on the left space of panel, Use plastic tape and a paper to make a envelope, in which you can slide your photo in and it will protect your picture from dust and it will stay long.



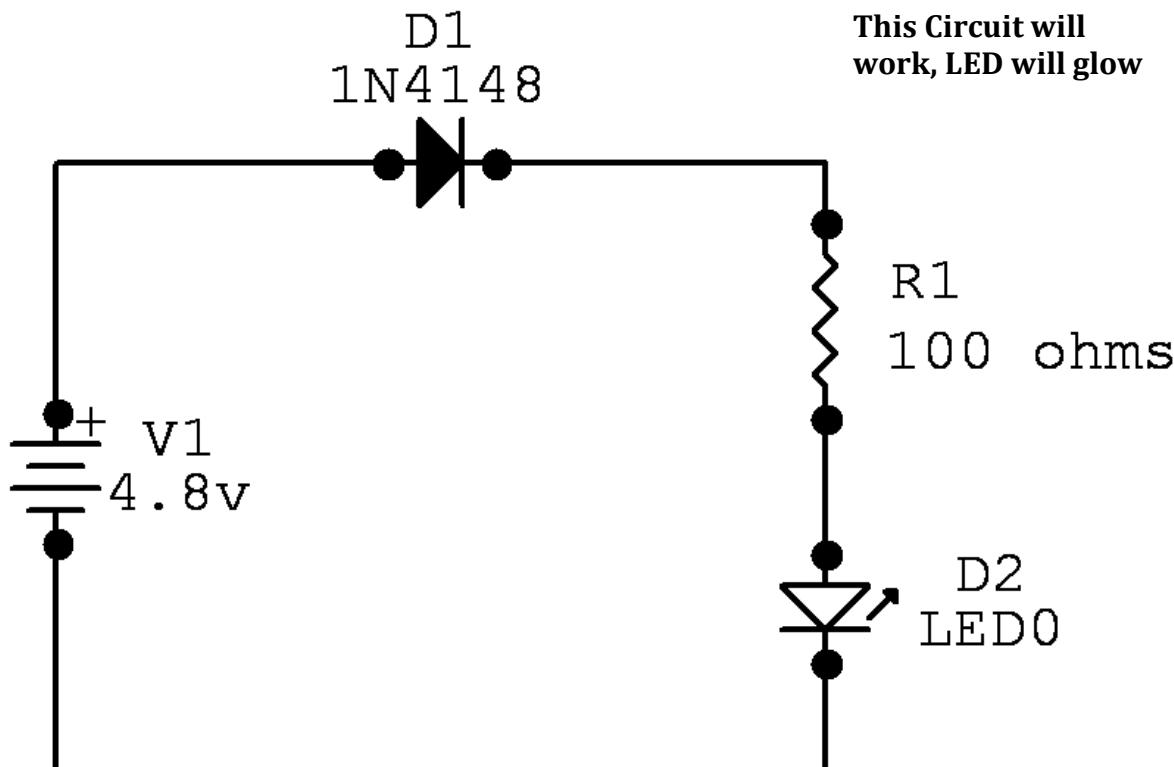
1.4 Simple Diode Circuit

Definition - A diode is a semi conducting electronics component which is having low (ideally zero) resistance to current in one direction and high (infinite) resistance in other direction. Diodes were the first and important step into modern day electronics, the principles of working of a diode eventually lead to invention of transistor and then other semiconductor components. Initially the size of diode was huge compared to present day diodes and vacuum tubes were used to make them. (vacuum tubes looks like big electric bulbs, they were used in electronics before the discovery of methods, involving usage of silicon as base material for semi conductors production)

The story of history of transistor is a good read, Please refer below wiki link to read this story-

http://en.wikipedia.org/wiki/History_of_the_transistor

Lets make simple circuits to understand the working of a diode. To see how diode works, only when it is connected in one direction, we are going to connect diode in both directions one by one. If the above definition is correct the diode should conduct only in one circuit, which will be indicated by glowing LED in that circuit. The other circuit wont work at all.



Steps:

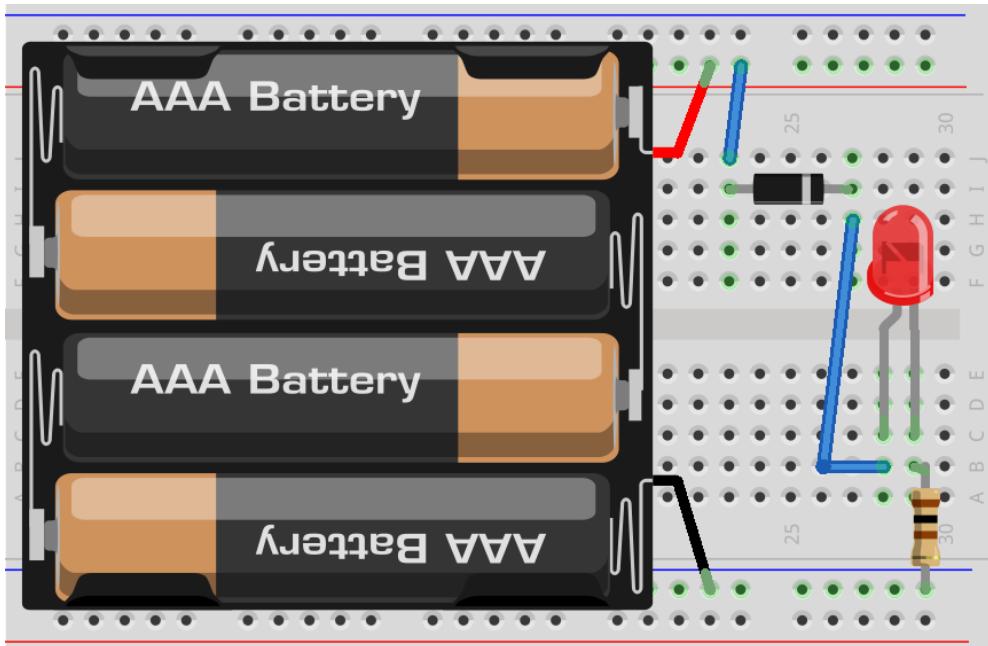
Step1: Identify the diode's P (positive) and N (negative) junction. The band printed on diode indicates P (positive).

Step2: Connect the positive junction (wire close to band) of diode to positive of battery.

Step3: Connect the negative wire of diode to LED and resistance. (The sequence of LED, Diode, resistance doesn't matter at all, just they all should be connected in series).

Step4: Turn On the battery and see if LED glows up.

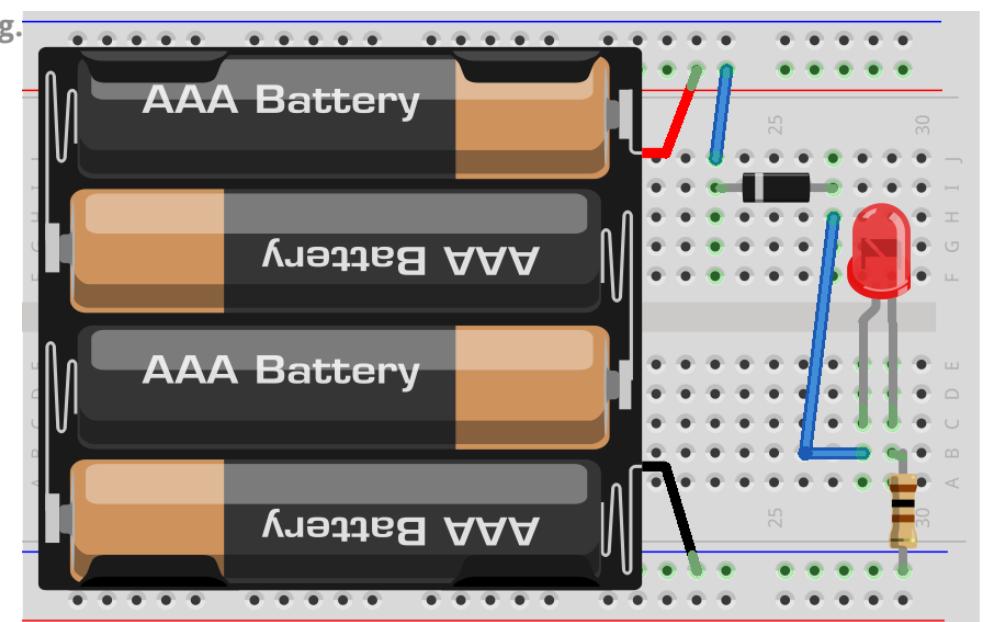
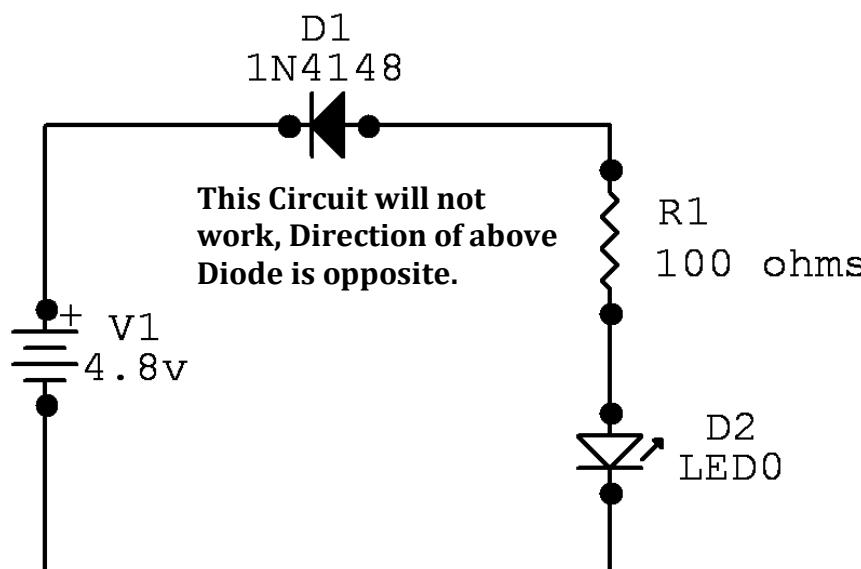
Step5: Repeat above steps again and change the direction of diode. Check that the LED should remain Off this time.



This Circuit will work, LED will glow

This Circuit will not work, LED will not glow

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1.5 Ambient Light With RGB LED

Lets design, yet another visually stunning project with RGB LEDs. Do you like colors and when one color transforms into another color and then transforms to another color. Giving a rainbow effect. You can use some crystal or glass object or just use a tissue paper pyramid to see all colors falling on it. And show your friends how 3 different colors mix to create more colors.

Working

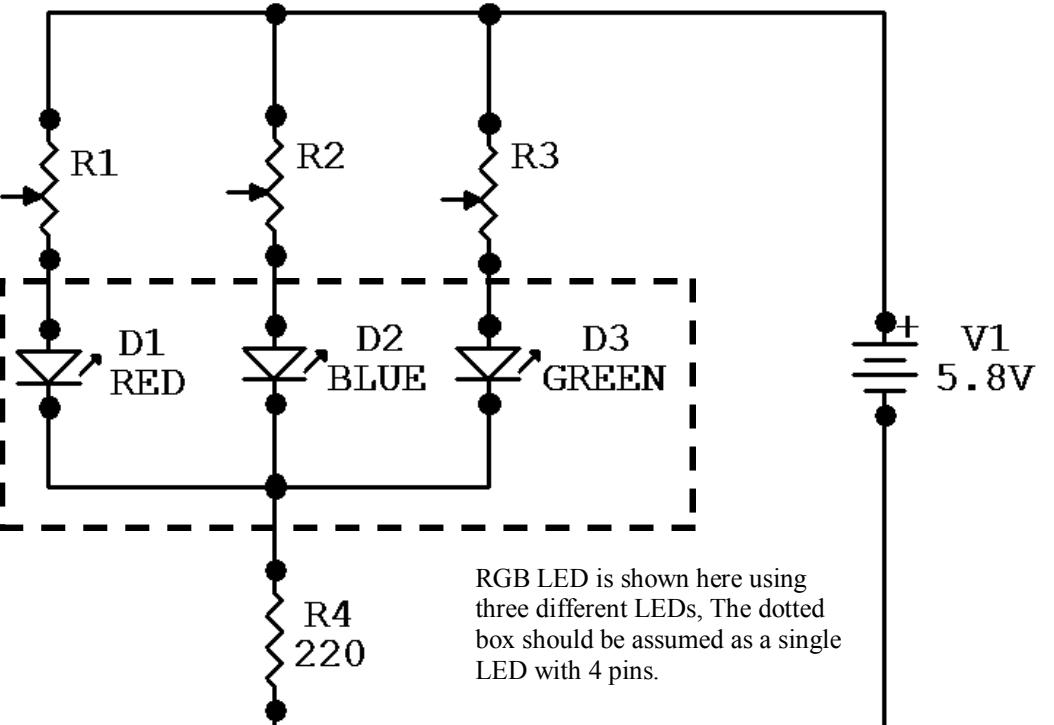
An RGB LED, as name suggests is a special LED which is capable of producing all colors by mixing Red, Green and Blue colors. In simple words It consists of 3 LEDs (Red,Green,Blue) together in a package and by variation of these 3 colors more colors can be formed.

This is the principle on which LED Tv works. An LED Tv contains millions of RGB LEDs very close of each other. Each LED create one pixel of image.

According to the image, different voltage is applied on different LED and together they create a visual image. When looked from a distance we only see a image but when you look the screen from very close (maybe with a magnifying glass) you will observe LEDs. An RGB LED is having 4 pins, one of which is a common anode (-ve) and other 3 pins are for Red, Green and Blue respectively.
By manufacturers convention, the longest pin of LED is the one which is common anode for all three integrated LEDs.

Lets Design an amazing and simple circuit with RGB LED, In this circuit we will try to create all the colors of rainbow by mixing different colors of RGB LED.

The basic idea behind this circuit is to give equal current to all 3 pins of RGB LED so that all 3 LEDs light up and then start vary currents (by using variable resistance) from each LED to produce all the possible colors.



Steps -

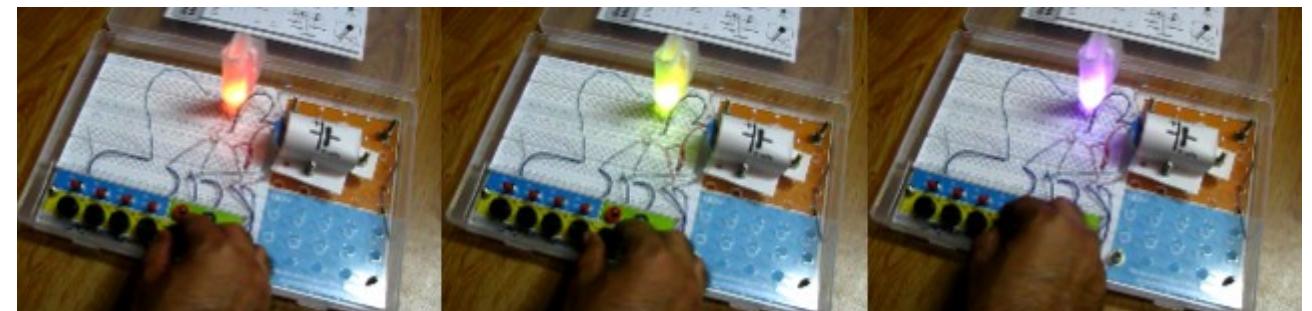
Step 1: Assemble all the components on breadboard.

Step 2: After assembling all the components check if circuit is complete according to diagram.

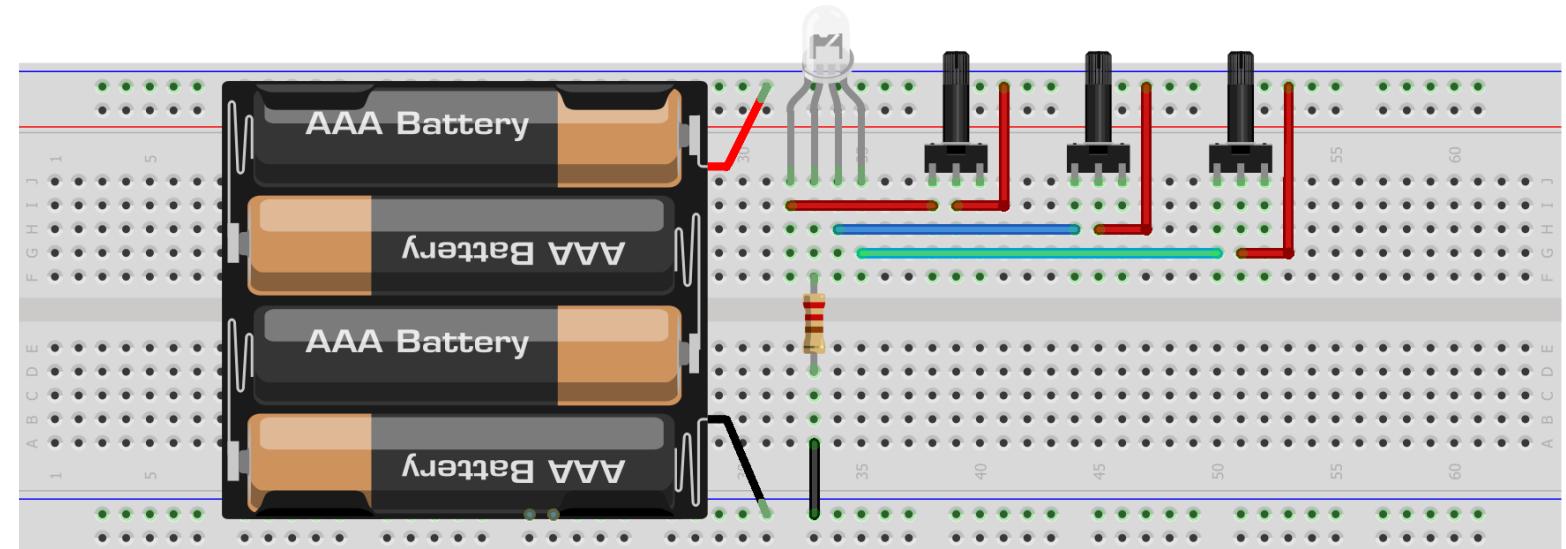
Step 3: Turn On the power and check if LED is glowing. If LED is not glowing turn Off power immediately and check for some short circuit or broken connection.

Step 4: If LED is glowing, Observe which colors are ON. You may vary the variable resistance to dim or brighten the colors. With different combination of brightness of LEDs different colors will be created, You may observe these colors by putting a tissue paper pyramid or some glass object over LED. Try to use some object which diffuses light to create and mix colors. Without diffusing light you may observe only RGB colors separately.

**RGB LED assembled
Workbench**



RGB LED Circuit

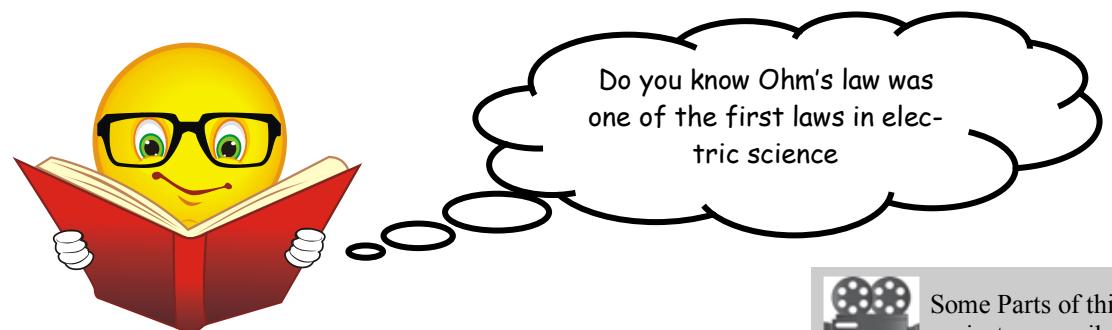


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2. Ohm's Law

In this section we will make :

- 2.1 Ohm's Law Circuit
- 2.2 Demonstration Project
- 2.3 Kirchhoff's law



Some Parts of this project are available in Video CD ROM

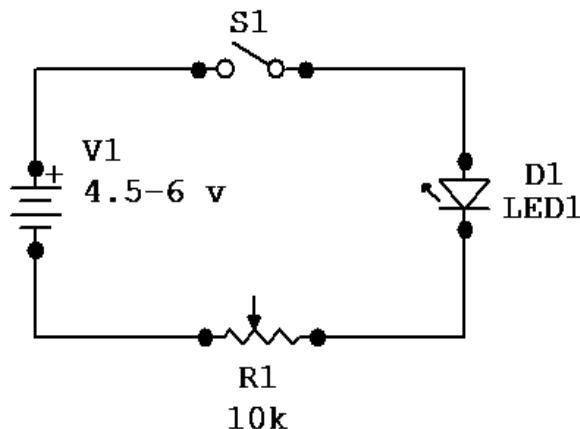


What is Ohm's Law ?

Ohm's law states that the current through a conductor between two points is directly proportional to the potential difference across the two points. Introducing the constant of proportionality, the resistance, one arrives at the usual mathematical equation that describes this relationship —

$$V = I/R$$

where I is the current through the conductor in units of amperes, V is the potential difference measured across the conductor in units of volts, and R is the resistance of the conductor in units of ohms. In Simple language, the law states that as voltage increases in a circuit, current also increases. Or as resistance decreases in a circuit, voltage increases.

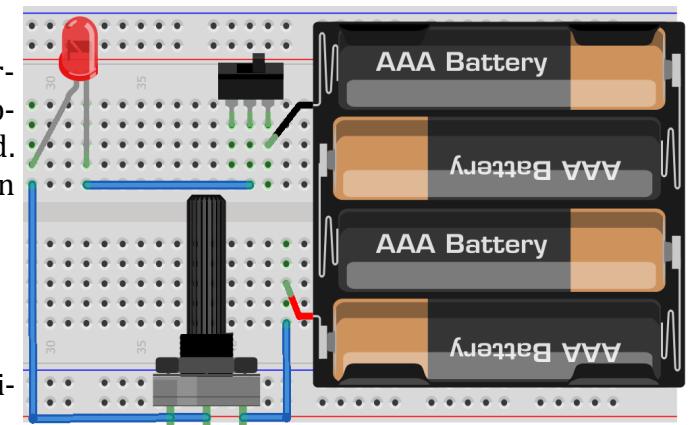


Let's Do It

To verify Ohm's Law we will make a simple circuit with variable resistance and see what happens when resistance is decreased or increased. As stated by law, LED should get dimmer when resistance is increased in the circuit.

2.1 Ohm's Law Circuit

Materials : D1- LED, R1 -10 k ohms Potentiometer, 4.8-6 v battery, S1 switch.



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Step1: Short left two wires of potentiometer and then lengthen the third wire and one wire from shorted pins. Insert the two wires in breadboard.

Step2: Place the battery and switch as shown in figure, we are using only two pins of switch .

Step3: Switch on to test the circuit, If LED doesn't light up, turn the potentiometer knob to right most corner to see if LED is dimming.

Step4: As per Ohm's law LED should gets bright when resistance is decreased in the circuit and gets dimmer when resistance is increased.

2.2 Demonstration Project

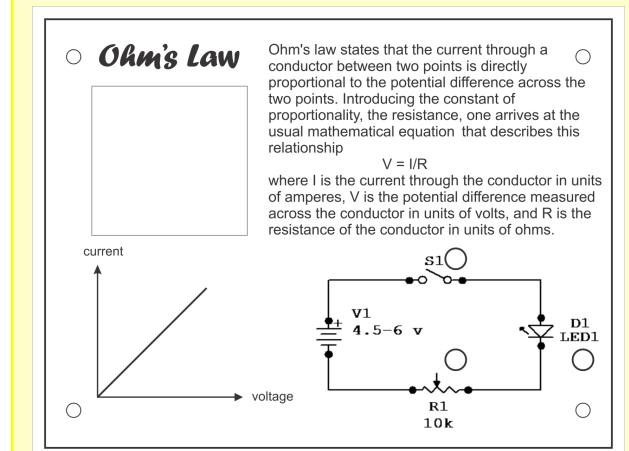
Lets assemble the circuit on MY Kit and make a demonstration project for school science fair or for your friends.

Step 1: Put LED in cover and lengthen the LED wires by joining some more wire with them.

Step 2: Similarly lengthen the switch wires also by adding some more wire to it. Remember we are only using two wires of switch.

Step 3: Screw LED and switch to panel.

Step 4: Cut the panel drawing sheet and paste it on MY Kit panel. And your project is ready for display.



Panel Design for Ohm Law demonstration

2.3 Kirchhoff's Laws

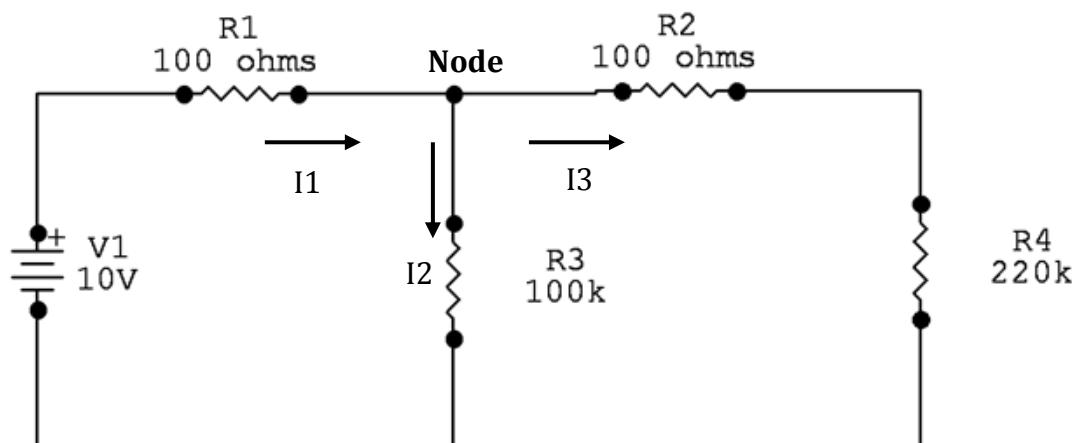
In this project we will discuss two very important laws in electronics, These are Kirchhoff's current and voltage laws. If you are studying in class 11 or in first year electronics graduation, then you might have already went through them in theory books. Theoretically these laws, looks a little complex, as words can't always explain all and then there are numerical to prove the laws which complicate things if you don't have basic understanding practically.

Lets prove the Kirchhoff's laws with electronics components without even touching notebook, I bet you will like them. Also the experiments we are doing to do here, could be a good project to share with your friends.



Kirchhoff First Law - The law of current

It states that the sum of currents flowing though a node must be zero. The point in a circuit where current splits is a node. The current which is coming to node is taken as positive and which going away from node is taken as negative.

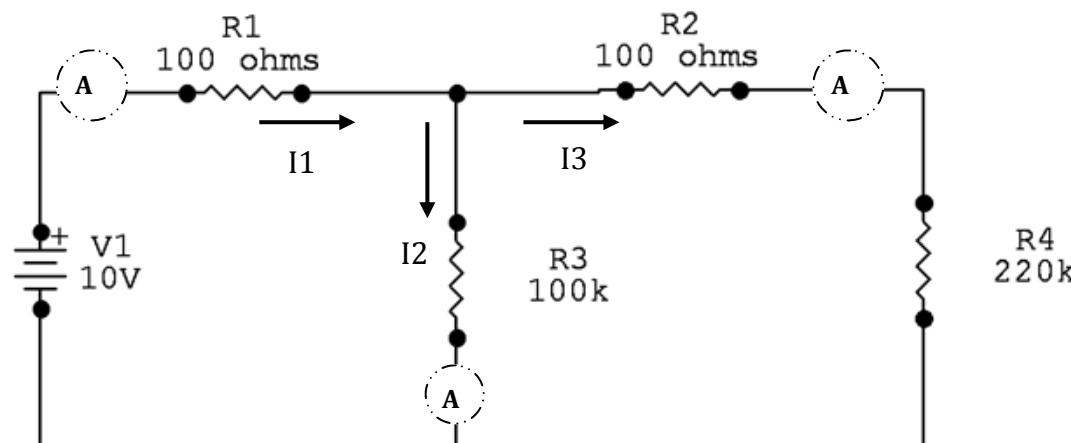


As we see on figure, left hand side. The Node that is dividing current into I_1, I_2, I_3 . According to kirchoff's law - $I_1 + I_2 + I_3 = 0$

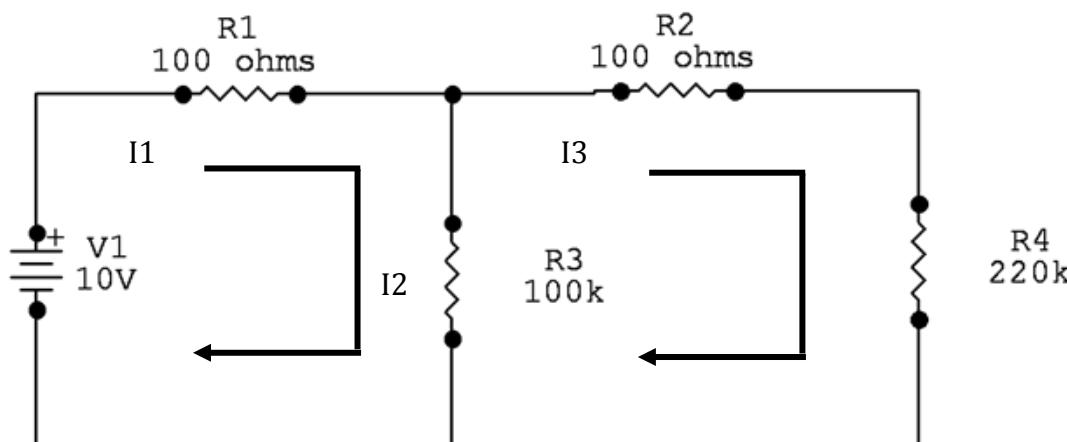
Lets prove this by using multi meter -

Steps -

- Step1: Assemble the components as shown in figure,
- Step2: Turn On the battery.
- Step3: Use multi meter to measure I_1, I_2, I_3 . Measure current one by one,
- Step4: Sum up all the current to check if the result is zero. Remember current which is coming to node is taken as positive and which going away from node is taken as negative.



Kirchhoff's second law, which is similar to his first law, states that the sum of all voltage drops across each electrical element (such as resistors, capacitors, batteries, etc.) in a circuit loop must be zero.



V1 is opposite? Yes, because when we pass through battery we first reaches at ground and then to positive which is opposite from the direction of current in whole loop.

According to the circuit shown -
 $I_1 - I_2 - I_3 = 0$

It is quite obvious if you think about it, I_1 is the source current further divides into I_2 and I_3 . So $I_1 = I_2 + I_3$ or $I_1 - I_2 - I_3 = 0$ which is one and same thing.

Please refer using multi meter as ammeter to measure current by using multi meter.

Lets explore the second law-

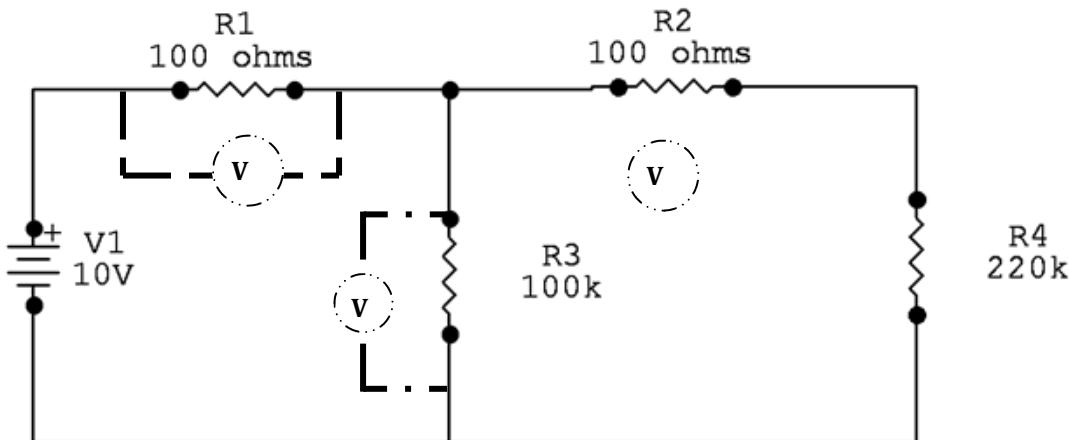
As said, the sum of voltages in a loop is zero. The important point here is to know the polarity of voltages across the loop. The arrowed line shown in figure shows the direction of current flowing. Usually this direction is taken in reference with battery's polarity.

Lets start with first loop shown in circuit.
 Since we have taken the direction of current in reference with battery (clock wise). We will now decide the polarities of each voltage drop in this loop.
 $I_1 R_1$ is positive
 $I_2 R_3$ is positive (in direction with arrow)
 V_1 is negative (opposite direction)

Lets prove this by using multi meter -

Steps -

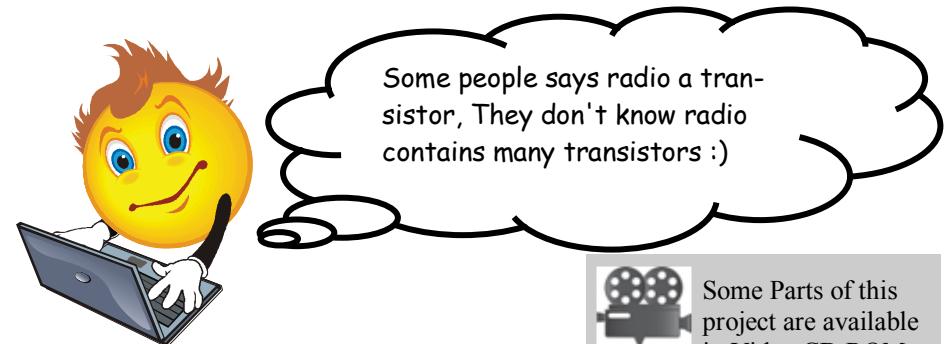
- Step1: Assemble the components as shown in figure,
- Step2: Turn On the battery.
- Step3: Use multi meter to measure voltages across all the components of loop.
- Step4: Sum up all the voltages and check if they are equals to zero.



3. Simple Transistor Circuit

In this section we will make :

- 3.1 Transistor As A Switch
- 3.2 Cupboard timer
- 3.3 Parking Light
- 3.4 Plant Watering Reminder



Some Parts of this project are available in Video CD ROM

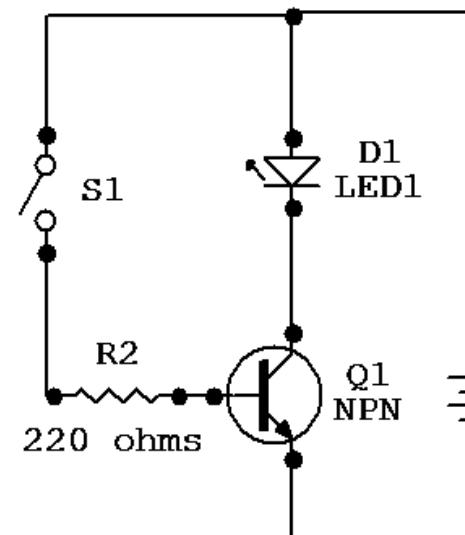


What is it about ?

We should recall what is transistor from previous section, Transistor is a very important component in modern day electronics. All computers in present day are made up of millions of transistors packaged in small ICs. There are about 700 million transistors in Intel Pentium Core I5 processor.

A transistor can work as a switch or as a voltage/current amplifier. In most digital circuits like computer, transistors are used as switches. Like in binary system—1 means transistor is On and 0 means its Off. So can you imagine how transistor acts as a switch ? The answer lies in its base, A small collector—base voltage (milivolts) turns on transistor and it allow a

large current flow from collector to emitter which turns on the LED, However transistor shuts off when no voltage is applied to collector-base and LED goes off



Let's Do It

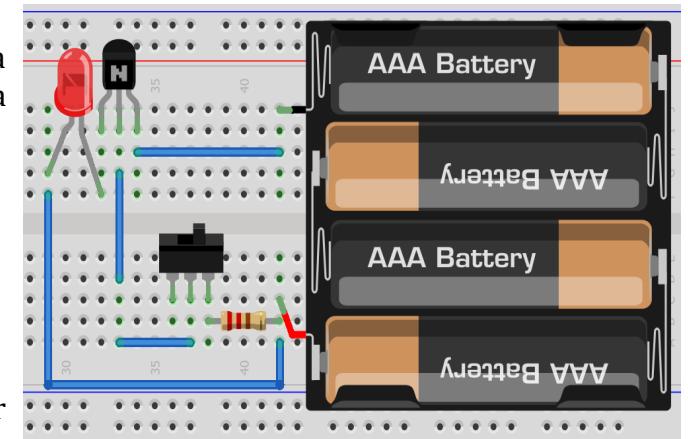
To start working with transistor, Let's make a simple circuit to see how transistor works as a switch.

3.1 Transistor As A Switch

Materials : Q1- SL100 or BC547, D1- LED, R2 – 220 ohms, 4.8-6 v battery.

Find materials at : www.hobbyelectronics.in

Step1: Identify the collector, base and emitter leads. And insert transistor in breadboard.



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Tip:

Transistor is a polar device and should be connected in correct direction of current. The arrow in transistor symbol shows the direction of flow of current, In NPN its from collector to emitter and in PNP its from emitter to collector.

Step2: Identify the longer (positive) wire of LED and connect it with battery as shown in figure.

Step3: Switch on to test the circuit, If LED doesn't light up, switch off immediately and check the connections again.

Demonstration Project

Lets assemble the circuit on MY Kit and make a demonstration project for school science fair or for your friends.

Step 1: Put LED in cover and lengthen the LED wires by joining some more wire with them.

Step2: Similarly lengthen the switch wires also by adding some more wire to it. Remember we are only using two wires of switch.

Step3: Cut the panel drawing sheet and paste it on MY Kit panel.

Step4: Screw LED and switch to panel. And your project is ready for display.

3.2 Cupboard Timer

I always miss a light in my cupboard as its also always dark in there and I need to open room lights to see in there. With this circuit you can install a light with timer inside cupboard. And you can press a button to light cupboard for few seconds, Afterwards it will automatically go off. You can even use this gadget near to door of any dark room and it will help you finding the way in room once you press the button.

Materials : Q1- BC547, D1- LED, R2 -220 ohms, 4.8-6 v battery.

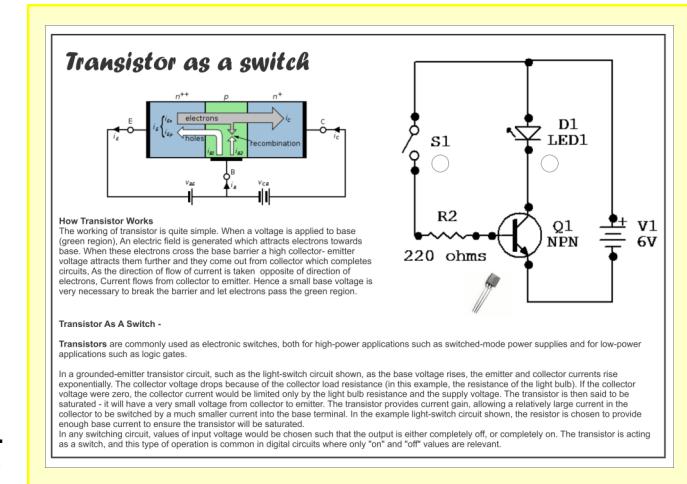
Step1: Identify the collector, base and emitter leads. And insert transistor in breadboard.

Step2: Identify the positive and negative wires of capacitor.

Step3: Assemble circuit components over bread board and test the circuit with power supply.

Note: Don't forget to use the push button instead of using normal On/Off switch in this circuit.

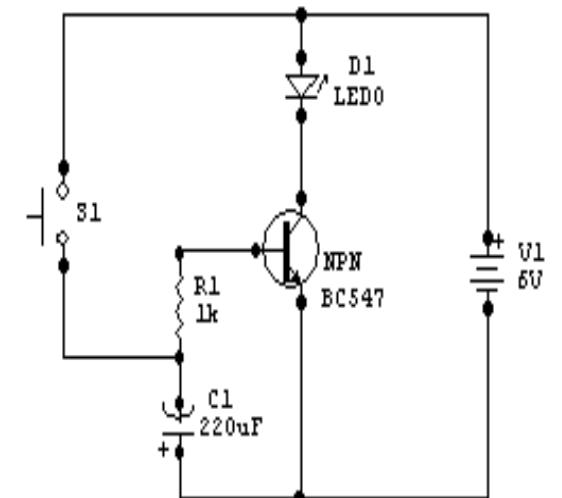
Step4: Cut the panel drawing sheet and paste it on panel. And your project is ready for display.

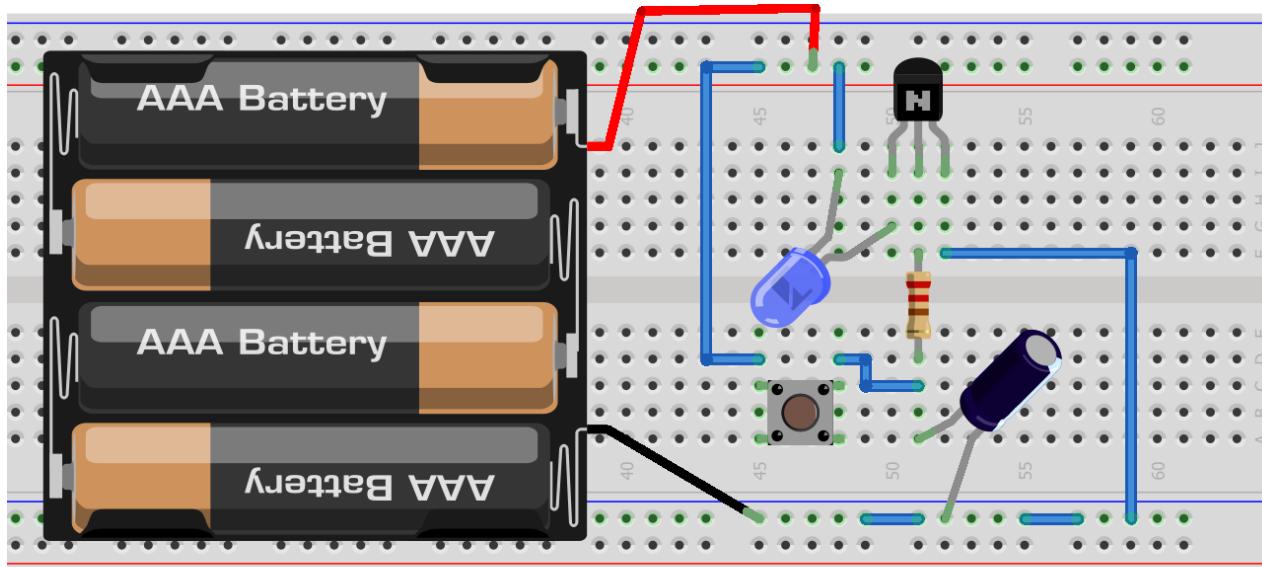


Panel Design for transistor as a switch



Some Parts of this project are available in Video CD ROM





Made with Fritzing.org

3.3 Parking Light

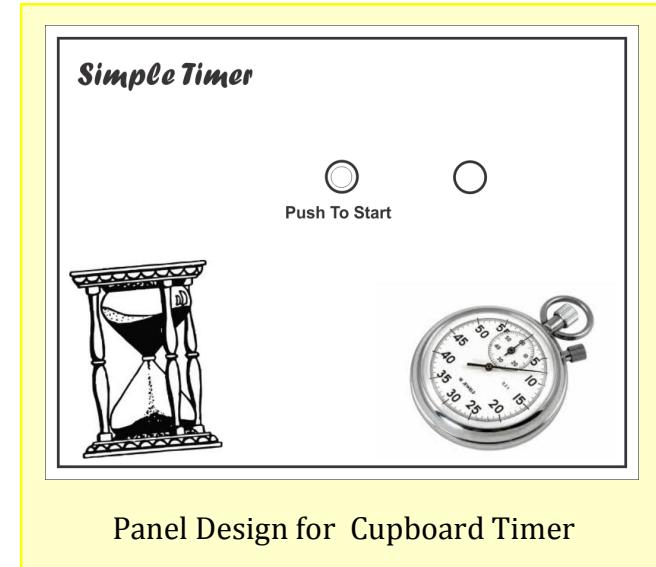
While backing your car it's always required to have someone tell you how much space is left between your car and the wall of your garage. With this gadget installed on the wall you no longer need anybody help you, as this gadget is having an indicator light which tells you the exact position of wall. And the circuit is completely automatic. It works on the back lights of car. The light sensor in this circuit senses the car back light and turns on its indicator to help driver see the indicator. This circuit can be used in many other ways also. So discover some new uses and let us know.

Materials : Q1- BC547, D1- LED, R2 -220 ohms, 4.8-6 v battery.

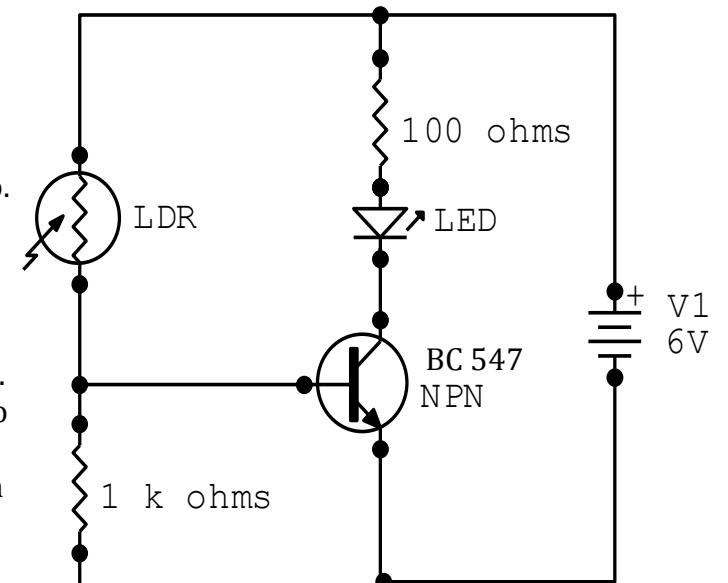
Step1: Identify the collector, base and emitter leads. And insert transistor in breadboard.

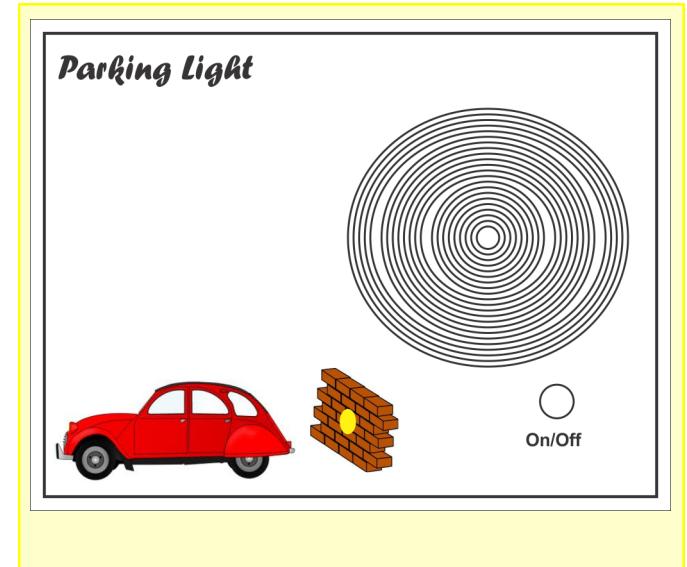
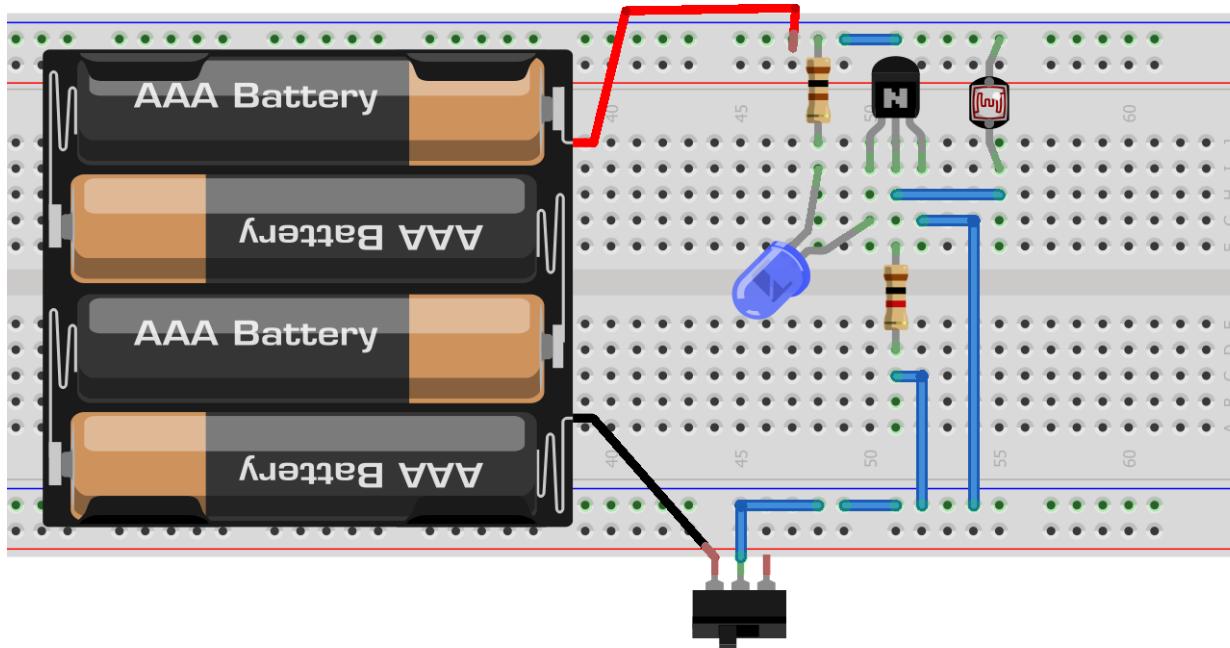
Step2: Identify the positive and negative ends of LED and positive should be connected to 100 Ohm resistor.

Step3: If you are making this circuit in enough light, the LED will glow up once you finish the assembly. To test further, try to hide LDR with finger and LED should also turn off.



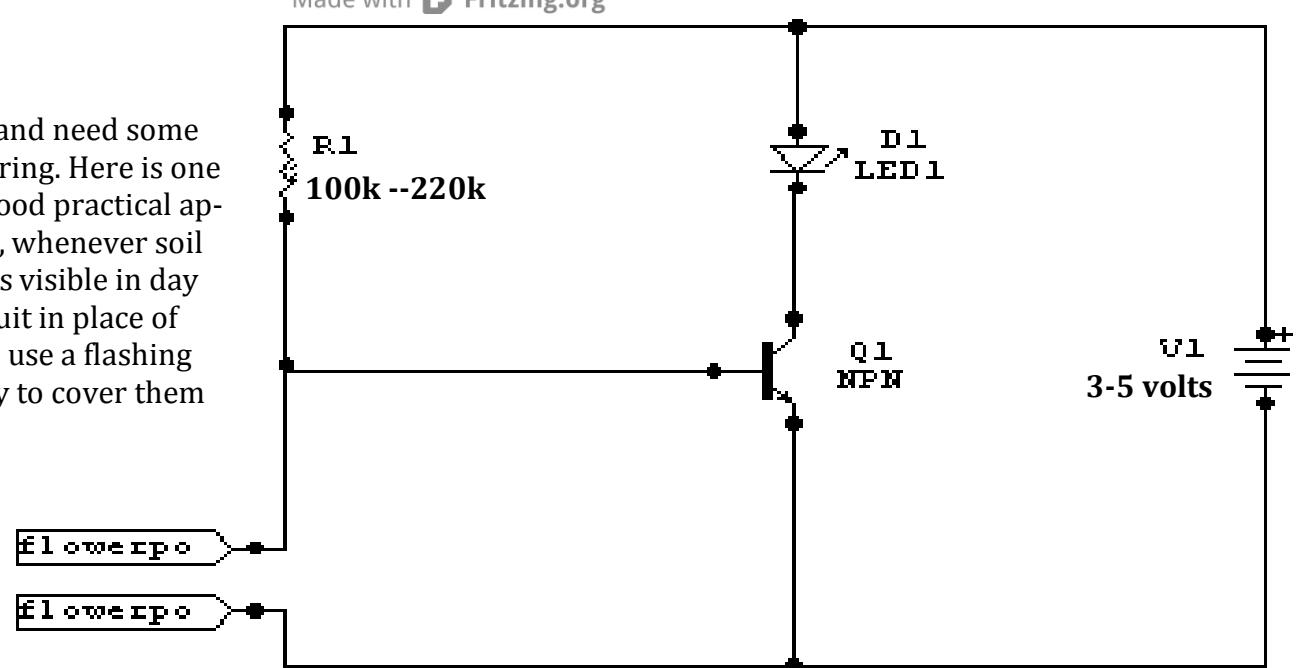
Panel Design for Cupboard Timer





3.4 Plant Watering Reminder

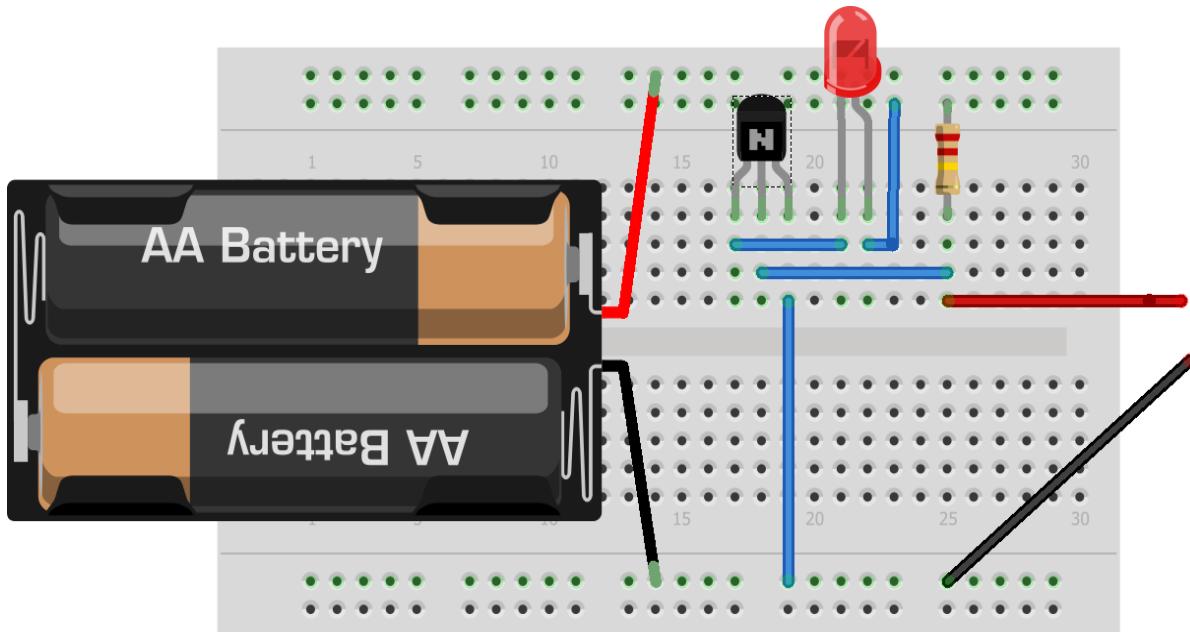
Are you often forgetting to water plants pots and need some alert system to remind you if plant need watering. Here is one of the simplest project which is having very good practical application. This will alert you by lighting a LED, whenever soil goes dry. You can use bright blue LED which is visible in day time also. Further you can connect alarm circuit in place of LED by using a driver transistor. Also you can use a flashing light circuit in place of simple LED. We will try to cover them all in this project.



The working of this circuit is very simple and it explains the concepts of transistor's working very well. Lets discuss how it works - When plant's pot is dry, soil is non conducting and transistor is On due to a small amount of base current flowing through resistance. Since transistor is On, LED is also ON and it is indicator the need of water in soil. Now somebody waters soil. It becomes wet and start conducting. Something magical happens now.

Imagine the current flowing from positive terminal of battery like a water stream. Previously when soil was dry, there was no current flowing through base to ground because that connection was open. Now when soil is conducting, an another way is open for current to flow, It can go from base to soil and then to batteries ground.

Like a water stream current will also flow through the way which is more easier for it (Like water flows from high altitude to low, current flows from high potential to low potential and like more water will flow from a thicker pipe then thin, more current will flow from a normal wire then a resistance) Since the second path for current is offering less resistance to reach ground of battery, it will follow that path and this will turn transistor OFF since there is not base current to keep it ON. And the LED indicator will remain OFF up till soil is conducting.



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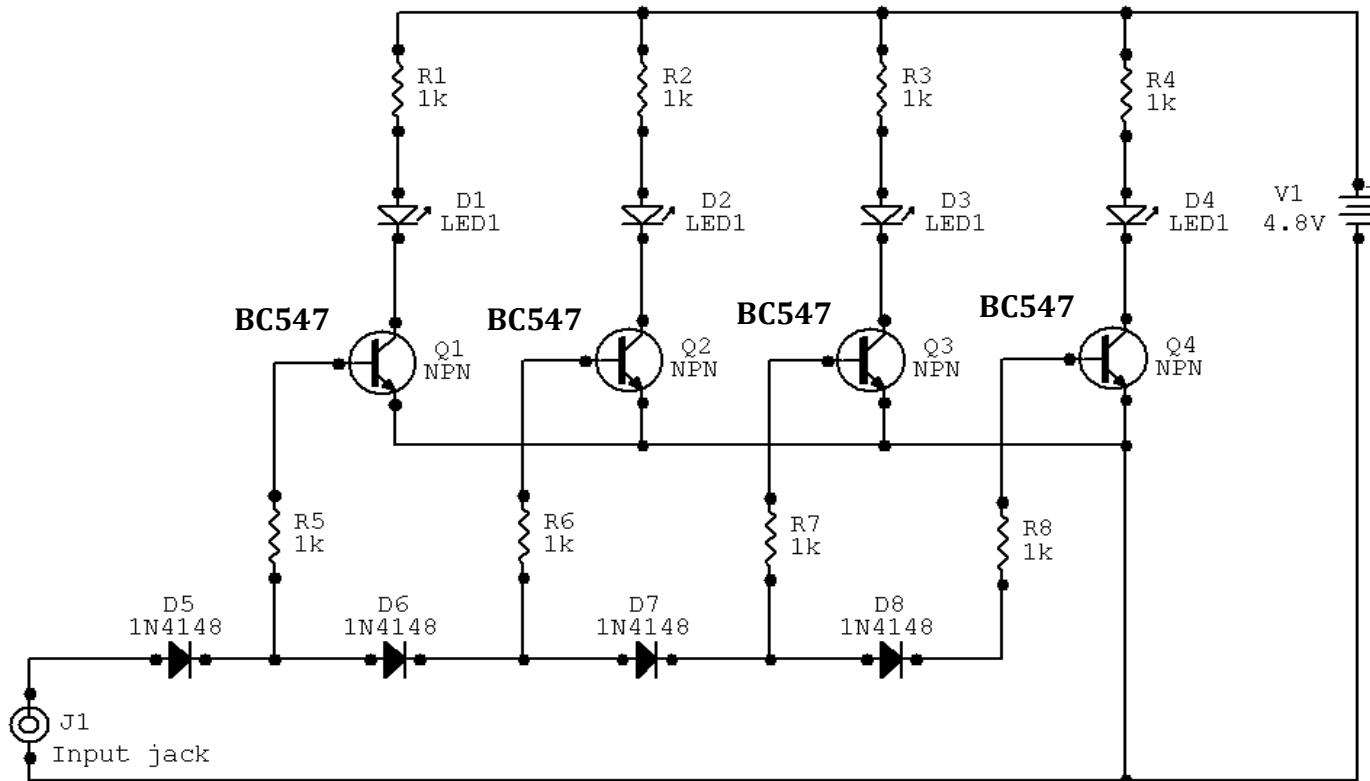
Soil sensor - In this project we need two probes to be inserted into soil, which will conduct when soil goes wet. To create these probes you may use any iron nail or steel nail and tie the wire to them. Just keep the probes close enough so that they can conduct properly.

Steps:

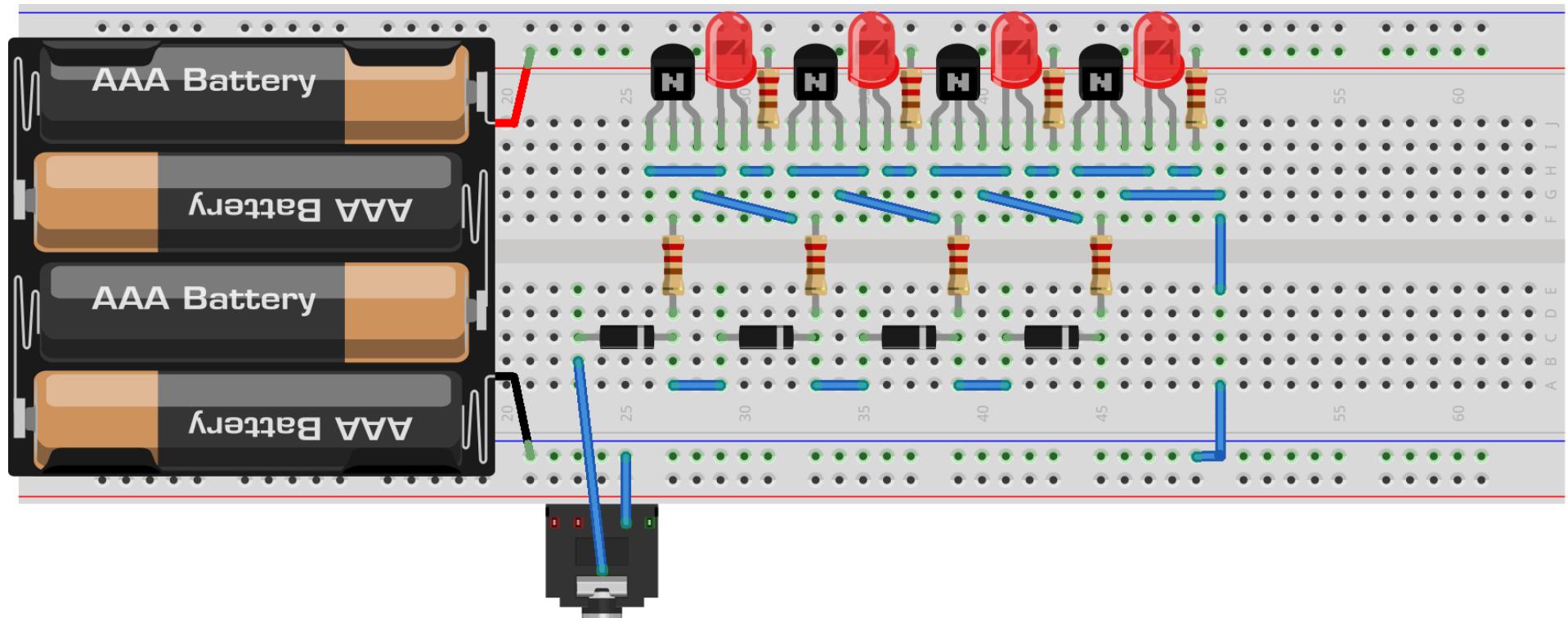
- Step1:** Assemble all components on breadboard.
- Step2:** Bring a plant pot with dry soil.
- Step3:** Put probes into the soil.
- Step4:** Turn On the battery current.
- Step5:** Check if LED is glowing. If it is not glowing. Turn Off battery immediately and check connections

3.5 Bar graph Meter

You may have observed the LED lights dancing on music, It was quite common with Cassette player stereos, With CD player's LCD screens this trend went away, But anyway LED dancing on music looks great. In this project we are going to create dancing LEDs. Based on input audio signals, the LEDs will turn On or Off. And based on the intensity of the input signal, some LEDs will remain On and some will remain Off. Together this makes a music measuring meter, with a intense beat all LEDs light up and with a normal beat only few LEDs light up. You can use any music source to input music signals like - walkman, Ipod, Radio, computer music output jack.



The circuit is using transistors to turn LEDs On/Off according to input signal, Starting from left most transistor which requires least voltage to turn its LED On. The second transistor require more voltage than first transistor, And third transistor require further more voltage signal. This is because of diodes ladder connected to the base of each transistor, as move on right each transistor's base meet with increased number of diodes which increases the resistance at base.



Made with  Fritzing.org

Steps -

Step1: Assemble the components as shown in figure.

Step2: Connect the input wire to audio jack.

Step3: Connect the battery and turn it On,

Step4: Open the music and check the circuit if LED are turning On and Off on music beats.

Step5: If LEDs are not lighting up, check the input audio signals, It is possible that the ground wire and audio signal wire is wrongly connected to one another. (The audio signals coming from music system consists ground and positive signals)

4. Flip-Flop

In this section we will make :

- 4.1 Flip Flop Circuit
- 4.2 LED Blinker Project
- 4.3 RS Flip Flop



Some Parts of this project are available in Video CD ROM

Let's flash some LEDs now...
exciting .. Huh...



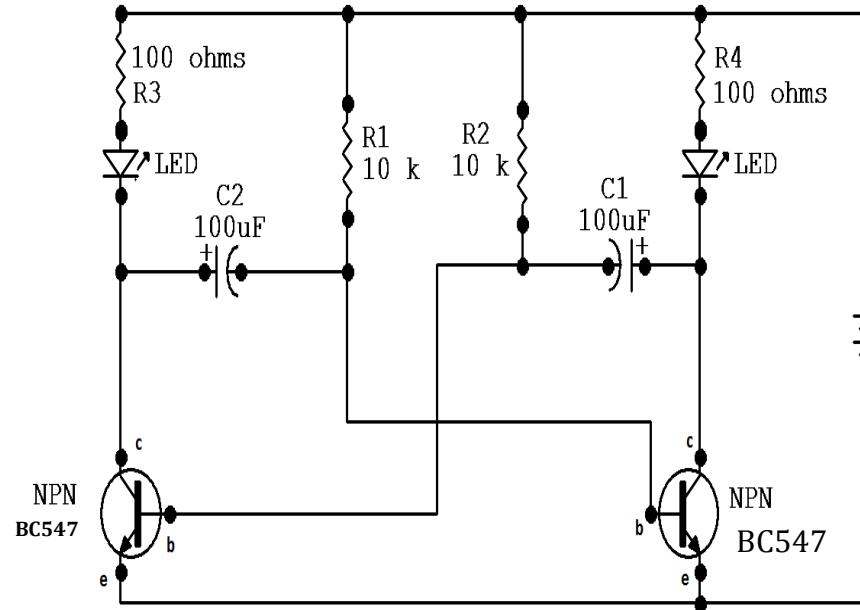
What is it about ?

A flip-flop or multi-vibrator is an electronic circuit used to implement a variety of simple two-state systems such as oscillators, timers. It is characterized by two amplifying devices (transistors, Op-amps or other devices) cross-coupled by resistors or capacitors.

The circuit presented here is a particular multi-vibrator known as astable multi-vibrator.

An astable multi-vibrator is a regenerative circuit consisting of two amplifying stages connected in a positive feedback loop by two capacitive -resistive coupling networks. The amplifying elements used here are transistors. The circuit is usually drawn in a symmetric form as a cross-coupled pair and each element of pair have two states (On and Off).

Lets try to understand the functioning of flip flop by analyzing circuit given below. The LED in this circuit flashes alternatively because each transistor is switched On and Off in turn due to C1 charging and discharging through R2 and C2 doing same through R1. the flashing rate depends on the values of $C1 \cdot R2$ and $C2 \cdot R1$.



Let's Do It

To start working with transistor, Let's make a simple circuit to see how transistor works as a switch.

4.1 Flip Flop Circuit

Materials : 2 - BC547, C1-C2—100 μ F or 220 μ F electrolytic capacitors, R1-R2—10k, R3-R4—100 Ω , 4.8—6v battery, 2—LEDs

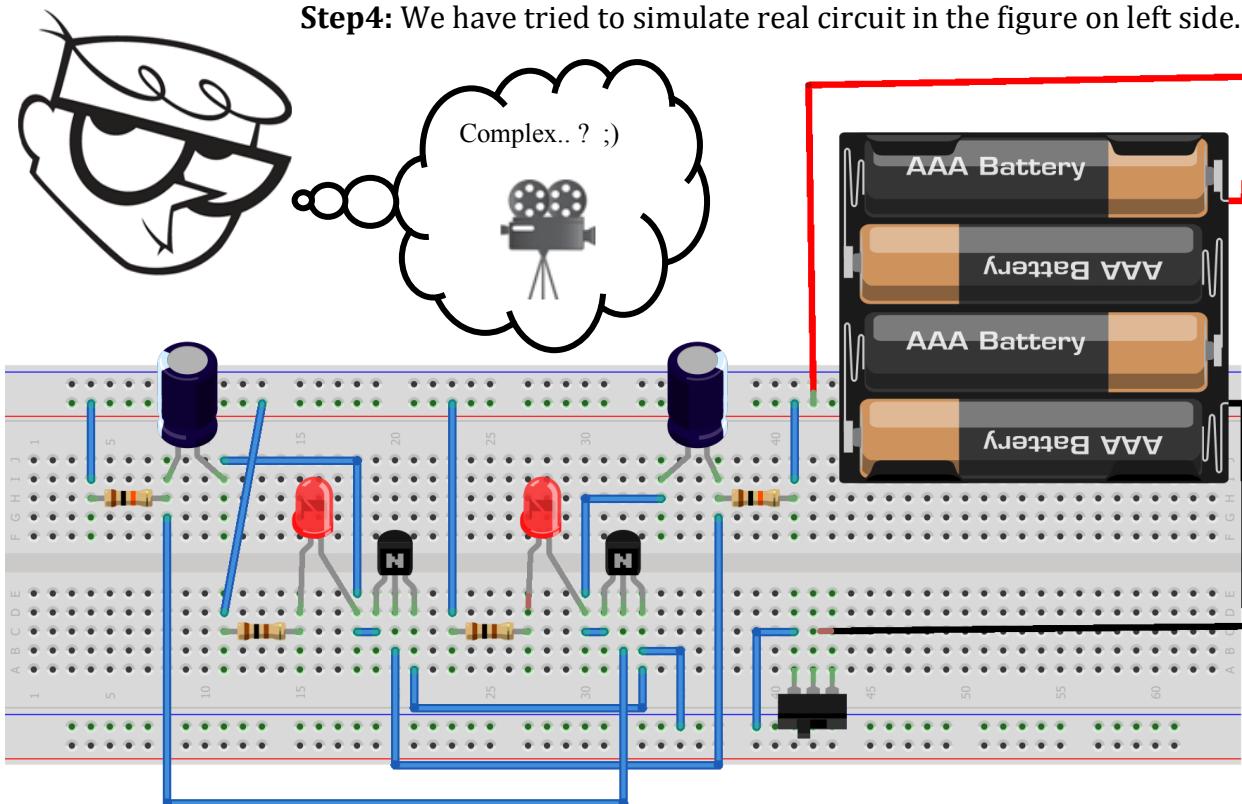
Find materials at : www.hobbyelectronics.in

Step1: Identify the collector, base and emitter leads. And insert transistor in breadboard.

Step2: Assemble the circuit making sure that electrolytic capacitors are the right way round. And that the transistor leads are not touching each other where they come out of the bottom the transistors.

Step3: If all is well, Switch On the circuit and see if the LEDs are Flashing.

Step4: We have tried to simulate real circuit in the figure on left side. The resistance color bands are taken true to actual values. In battery red wire shows positive terminal and black is negative.



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Lets assemble the circuit on MY Kit and make a demo project for your lab or for science fair.

Step 1: Lengthen the LED wires by joining some more wire with them and put LED in cover. Join more LEDs in parallel, just keep in mind that positives terminals should be joined to positives and negative to negatives. (Longer lead of LED is positive)

Step 2: Cut the panel design page shown in the figure on right and paste it on MY Kit.

Step 3: Lengthen the switch wires to insert them in breadboard.

Step 4: assemble the LEDs and switch on MY Kit.

Step 5: Use snap to screw the battery.

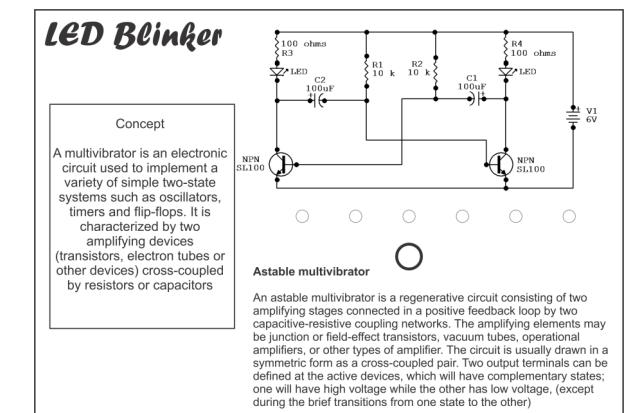
And you Kit is ready to use and demonstrate how a flip flop oscillator circuit works.



Some Parts of this project are available in Video CD ROM

4.2 LED Blinker Project

- Tip:**
- If you increase the value of capacitors, the blink rate will decrease because capacitors will store current for longer time.
 - Similarly if you decrease the value of capacitors then blink rate will be faster as capacitors will get discharged quickly.
 - If you increase one capacitor then corresponding LED will blink slower than other LED.



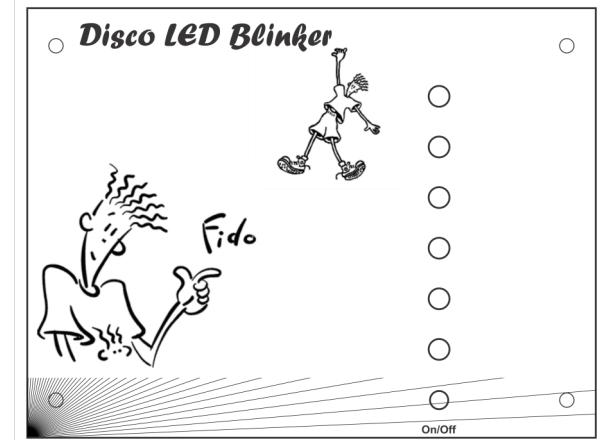


More Ideas -

Lets make a jazzy panel to have fun with the lights. Try out the panel shown in the figure on right. Paste it on MY Kit and try out different color of LEDs as you like, I tried white and blue LEDs alternatively.

Tip:

- You can also redesign circuit and add more capacitors in parallel with a switch to toggle them, If switch is On, it will change the blink rate of LEDs.
- You can also redesign the panel drawing and make more cool designs. If you are able to make a very cool design, Do send it to us at : hobbyelectronics.in@gmail.com



4.3 RS Flip Flop



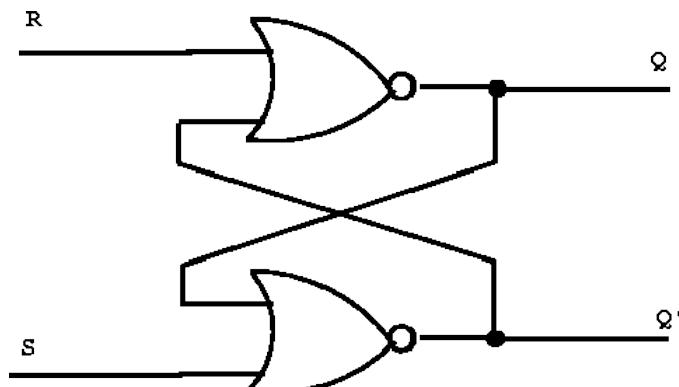
What is RS Flip Flop?

Flip Flops are the building elements of modern day digital computer electronics. They are used in logical circuits. A RS flip flop is one of the most basic forms of logical flip flops available. One of the uses of flip flop is in computer RAM, It holds data by using millions of flip flops. For one RS flip flop, you can say that this is a basic memory unit for a computer memory although it's quite a loose statement.

Below shown is a schematic diagram for RS flip flop, the two similar symbols here are NAND gates. As shown R means Reset and S is for Set, These are two states of RS flip flop.

TIP:

NAND gate is a combination of AND and OR gate. They are easy to understand but out of scope for this book. For further reading please refer Internet.



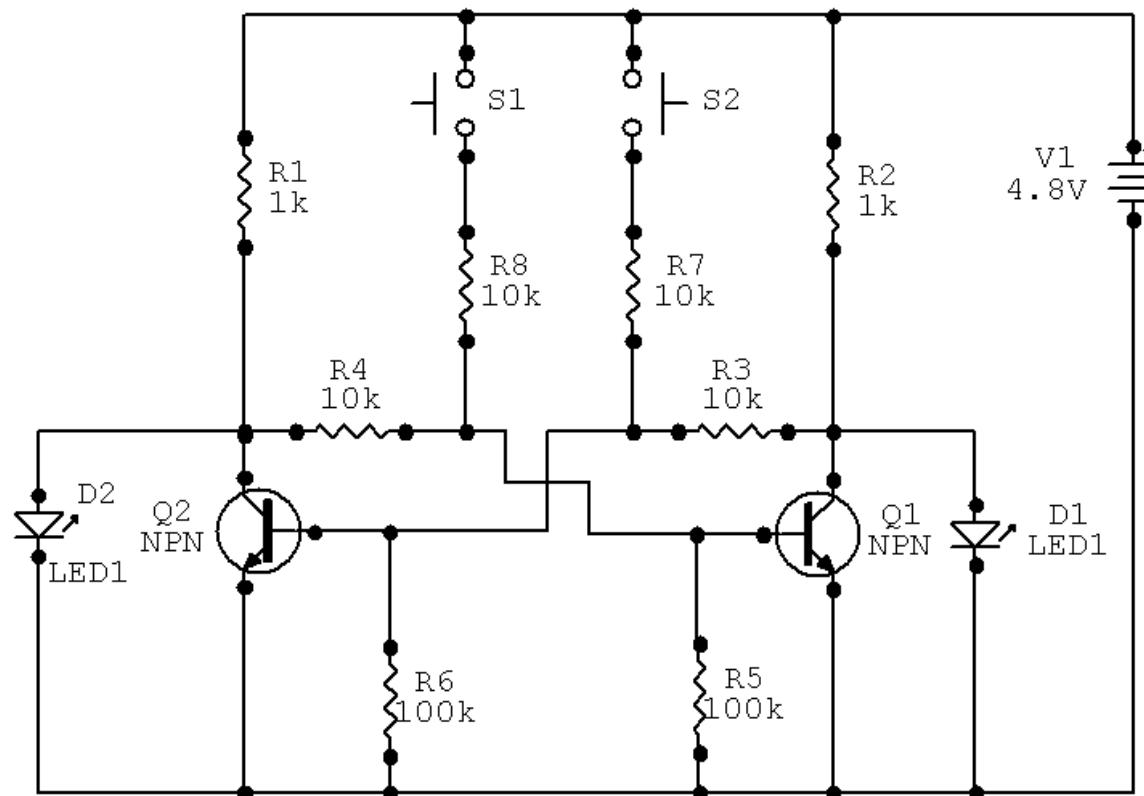
State	S	R	Q	Q'	Desc
Set	1	0	0	1	Set $Q \gg 1$
	1	1	0	1	no change
Reset	0	1	1	0	Reset
	1	1	1	0	no change
Invalid	0	0	1	1	Invalid

Truth table for SR flip flop - A truth table explains all possible input and output of a logic diagram in tabular format.

SR latch is used to SET a stable state, which means once you SET the latch to high or low state, It doesn't anymore depend on the input and that state will be maintained.

Note: In digital electronics 0volts = logic 0 and 5 volts is taken as logic 1.

SET State - Consider the below circuit, Let assume one of below transistor base as R=reset and another as S=set. If we apply 5volts potential to 'S' then that transistor 1 will surely turn ON and R1 (Q for RS flip flop) will glow and R4 will be OFF. At this point of time if you pass any input to S (like 0 or 5volt) it will not change the output state, hence we can call it as latched or SET.



RESET State - When we apply 5volts to R, It will reset the circuit and Transistor 2 will turn ON and another transistor will remain in OFF state. This will result in R4 as ON and again any further input to R will not have effect on this state.

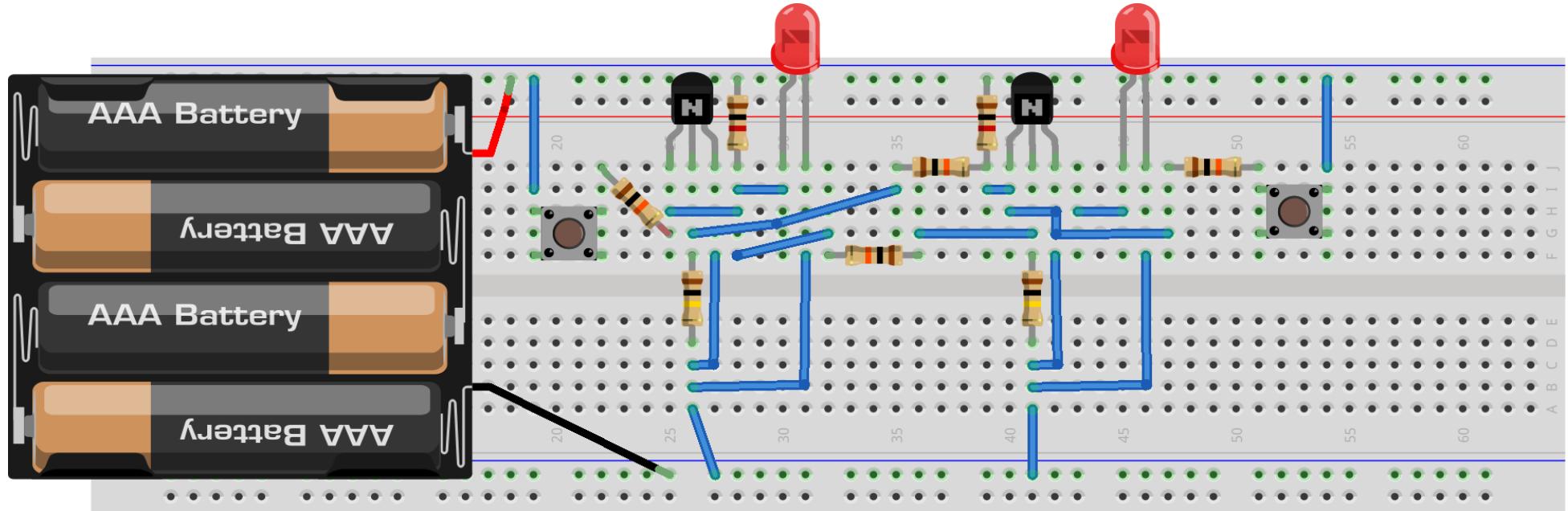
We have seen how RS flip flop works, now it's time to have some fun with it and see how we can use this circuit in our projects.

Steps:

Step1: Assemble all the components on breadboard.

Step2: Connect battery and check if one of the LEDs are glowing. If no LED is glowing, remove battery immediately and verify the circuit to check if all components are connected correctly.

Step3: If One of the LED is lighting up then press the opposite button and check if another LED glow up and previous one is Off.

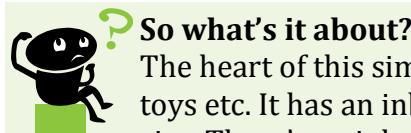


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5. Melody Circuit

In this section we will make :

- 5.1 Melody Circuit
- 5.2 Sensitive Melody Circuit

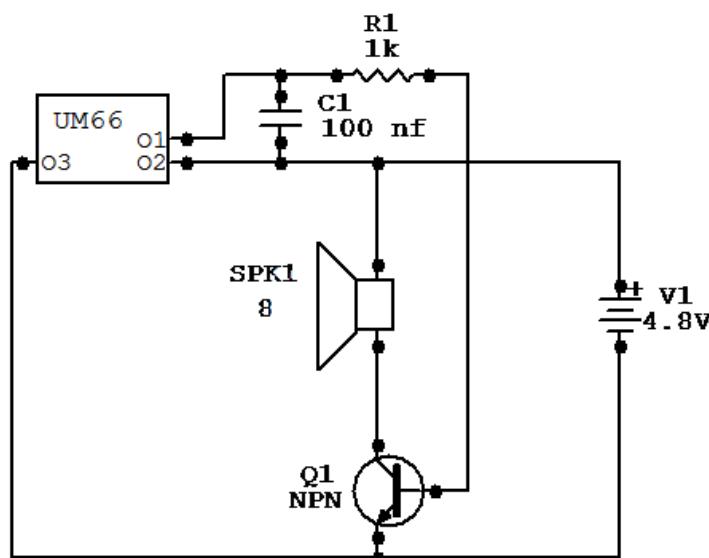


So what's it about?

The heart of this simple circuit is music IC UM 66. UM66T is a melody integrated circuit. It is designed for use in bells, telephones, toys etc. It has an inbuilt tone and a beat generator. The tone generator is a programmed divider which produces certain frequencies. There's an inbuilt oscillator circuit that serves as a time base for beat and tone generator. It has 62 notes ROM to play music. Many versions of UM66T are available which generate tone of different songs. For example, UM66T01 generates tone for songs 'Jingle bells', 'Santa Claus is coming to town' and 'We wish you a merry X'mas'.

Let's Do It

The circuit in itself is quite simple to make but a lot of work is going on inside IC so its not as simple as it looks like :)
Let's assemble the circuit now.



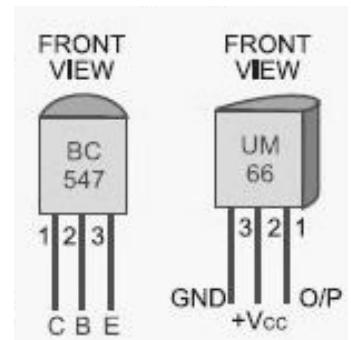
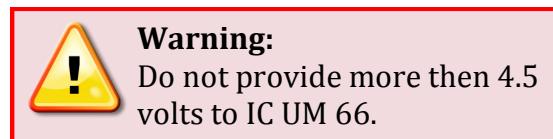
5.1 Melody Circuit

Materials: 1 Piezo speaker, 1-100nf, 1- BC547 or BC108 transistor, 1—1kΩ resistance, 4.8v battery, 1- UM 66 music IC.

Step1: Identify the pins of IC UM66 and transistor.

Step2: Identify Piezo speaker pins and it should be connected in correct direction.

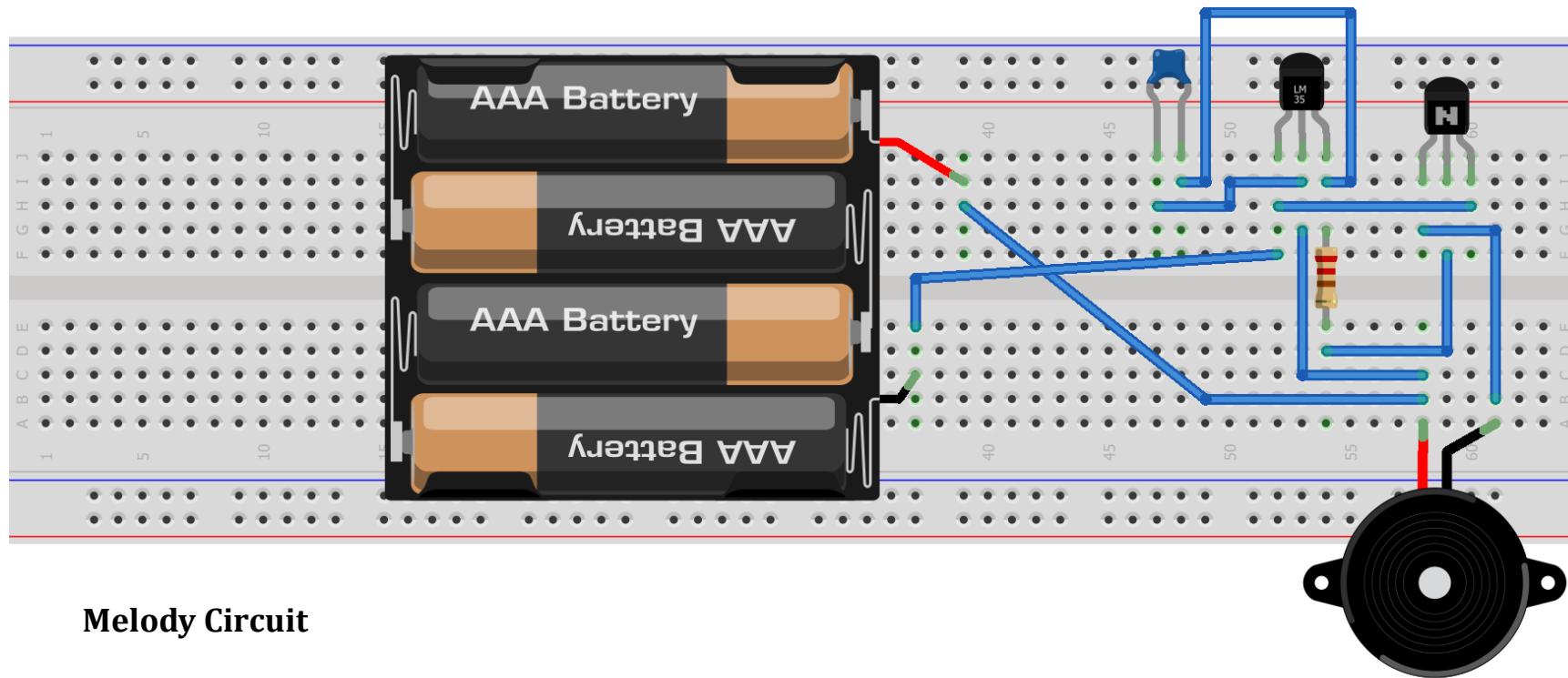
Step3: Assemble the circuit, you can use a switch to turn the music On and Off.





Tip:
Louder Melody

Try BC 108 instead of BC547 & you will get more loud sound.



Melody Circuit

Made with Fritzing.org

5.2 Sensitive Melody Circuit

Lets increase the sensitivity of previous circuit by adding few more components and enjoy same music with low current. You can use this circuit in any another projects also.

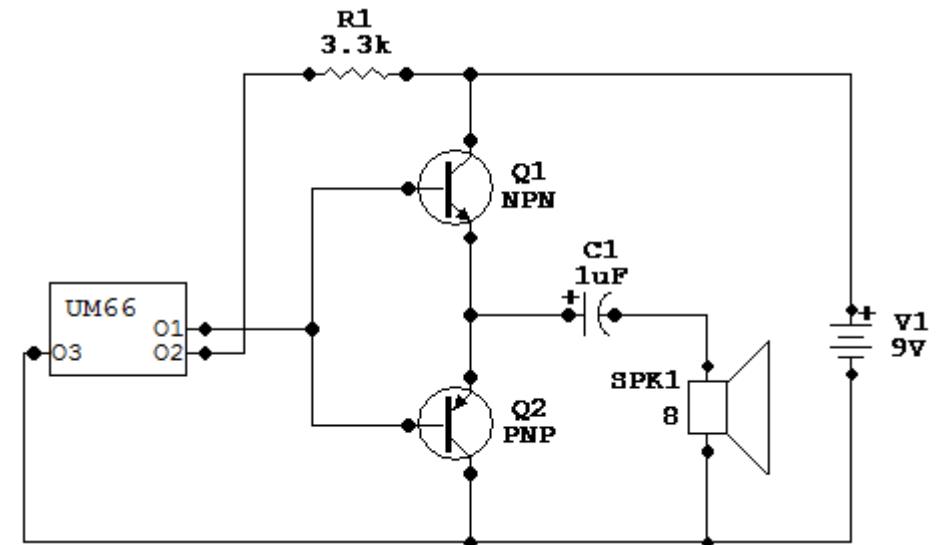
Materials: Apart from previous components we need 1 BC 547 1- μf , 1- $3.3\text{k}\Omega$.

Step1: Identify the pins of IC and transistor.

Step2: Assemble the components and switch On the circuit.

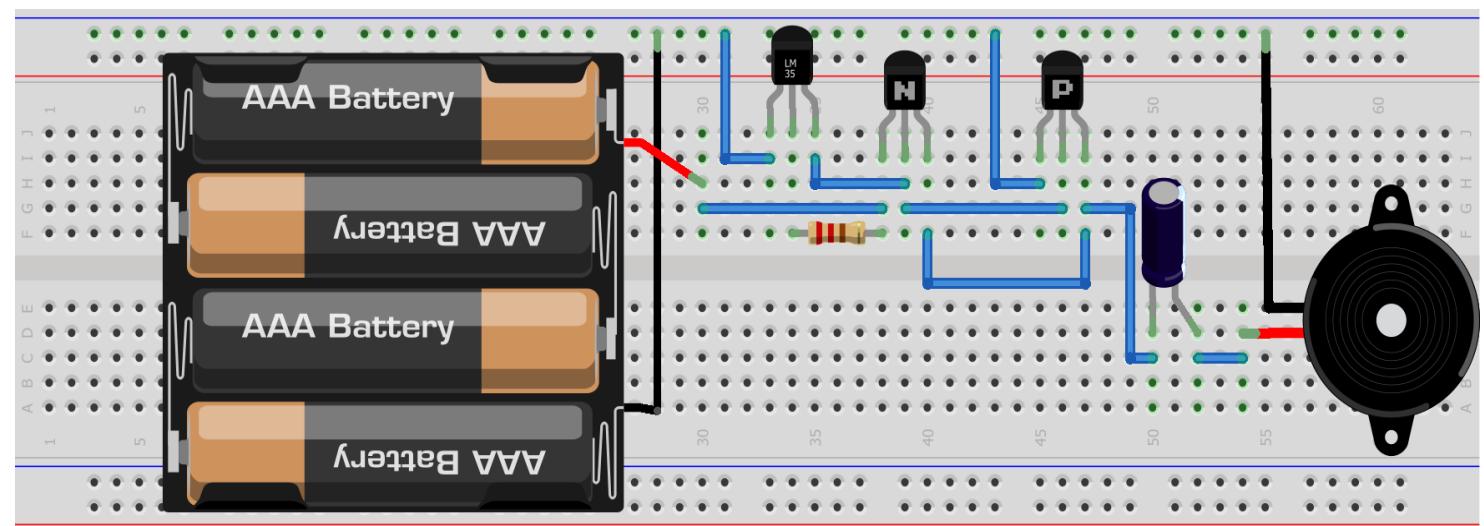
Step3: If you don't listen to any sound, remove battery and see connections again.

In this circuit, You can also use a speaker instead of piezo.



**Tip:
Louder Melody**

Try BC 108 instead
of BC547 & you
will get more loud sound.



Made with Fritzing.org

Correction : resistance colors are not matching
actual values in this circuit.

Sensitive Melody Circuit

6. Darlington Pair

In this section we will make :

- 6.1 Darlington Circuit
- 6.2 Water Tank Overflow Alarm/Rain Alarm
- 6.3 Fire Alarm
- 6.4 Light Sensitive Morning Alarm
- 6.5 LASER based Anti-Theft Alarm System
- 6.6 Wire Current Detector
- 6.7 Pencil And Paper Circuits
- 6.8 Paper circuit with Darlington Pair

Let's increase the powers, Discover more from transistors.



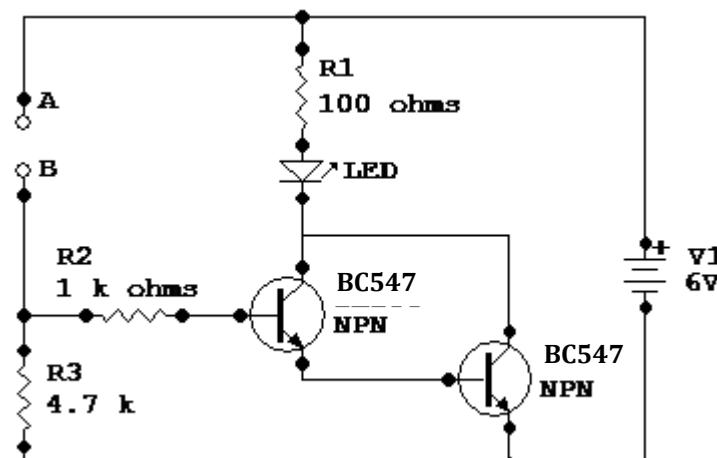
Some Parts of this project are available in Video CD ROM



What is it about ?

In electronics, the Darlington pair is a compound structure consisting of two bipolar transistors connected in such a way that the current amplified by the first transistor is amplified further by the second one. This configuration gives a much higher common-emitter current gain than each transistor taken separately.

In some application the amount of input current available to switch on a transistor is very low. This may mean that a single transistor may not be able to pass sufficient current required by the load. This can be achieved by using a Darlington Pair. The Darlington configuration was invented by Bell Laboratories engineer Sidney Darlington in 1953.



Tip: You can increase the sensitivity of this circuit by increasing value of resistance R3 by thrice or more.

Let's Do It

To start working with Darlington pair. Lets first try to make a simple circuit and then use the circuit for further projects.

6.1 Darlington Circuit

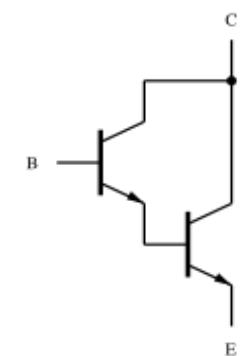
Materials : 2 - SL100 or BC547, Resistances— $1\text{k}\Omega$, $4.7\text{k}\Omega$, 100Ω , 4.8—6v battery, 1-LED

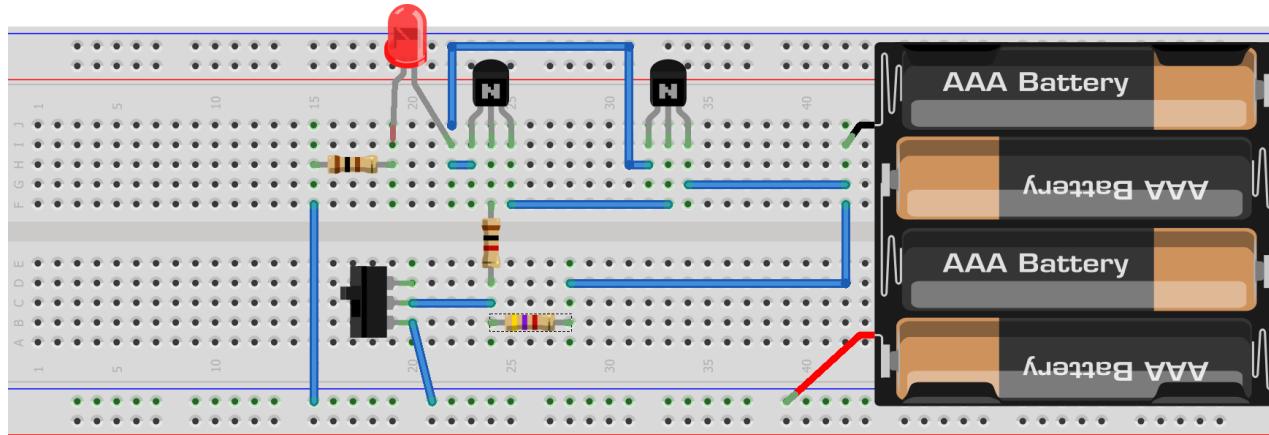
Step1: Identify the collector, base and emitter leads. And insert transistor in breadboard.

Step2: Assemble the circuit, making sure that LED is right way round. And that the transistor leads are not touching each other where they come out of the bottom the transistors.

Step3: Use a switch between open points or use wires, Try to short them and see if LED is glowing up.

Step4: Your circuit is ready, It needs very less current to turn LED On and the connecting wires can be extended to any length.





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Darlington Pair

Darlington transistor (often called a Darlington pair) is a compound structure consisting of two bipolar transistors (either integrated or separated devices) connected in such a way that the current amplified by the first transistor is amplified further by the second one

6.2 Water Overflow Alarm

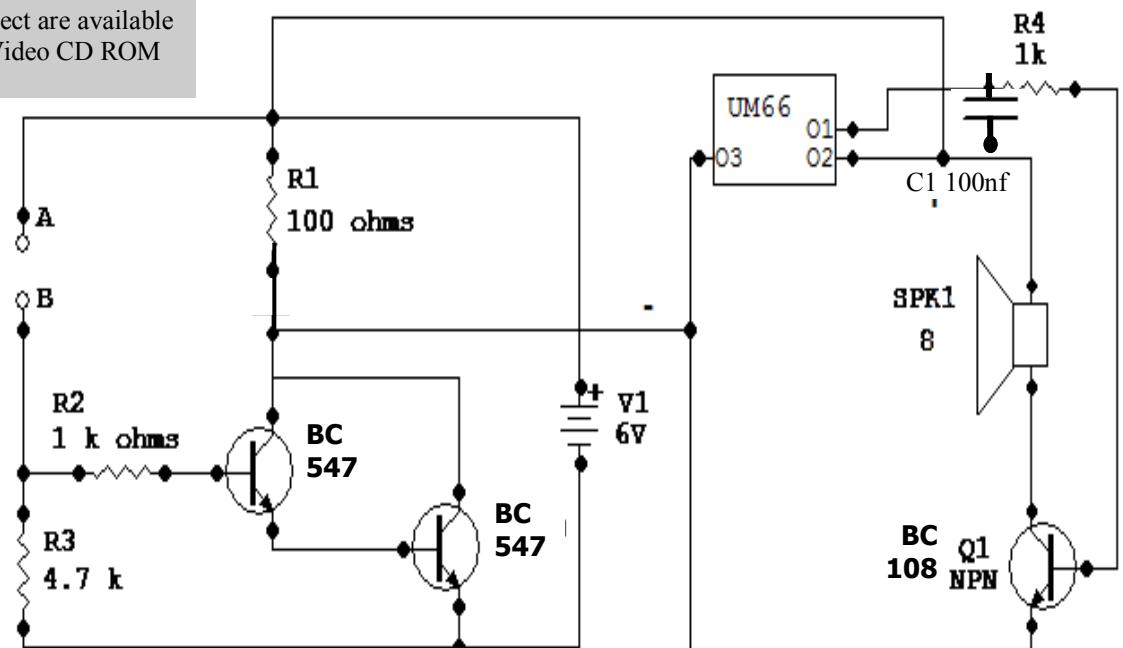
Tank water overflow is a common problem in every house where water is filled by pumps. If you forget to close pump switch on time, Water gets overflow and creates mess. Lets try to make a simple circuit using Darlington pair and melody circuit together.



Materials : Previous circuit components and 1 - BC108, 1—UM 66 Music IC, Resistances—220Ω.

Find materials at : www.hobbyelectronics.in

Step1: In the Darlington pair circuit just made above, Remove the switch and lengthen the wires to use them to insert in water tank.



Darlington pair

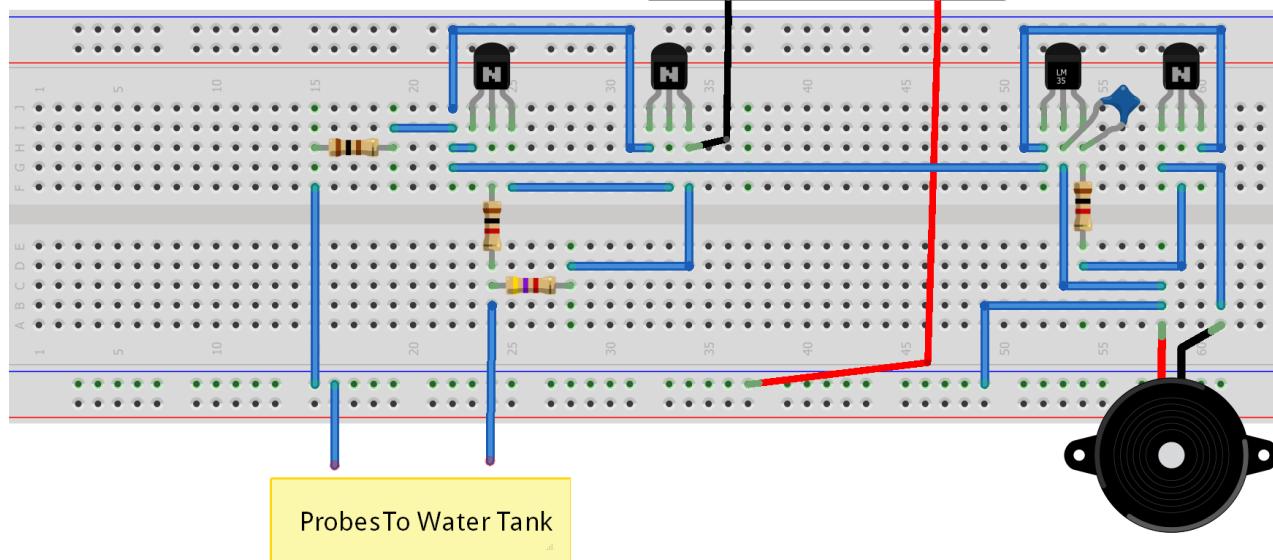
Melody circuit

Step5: Assemble the circuit on MY Kit to put it on display or for working. You can also find a box enclosure to assemble this circuit permanently in it.

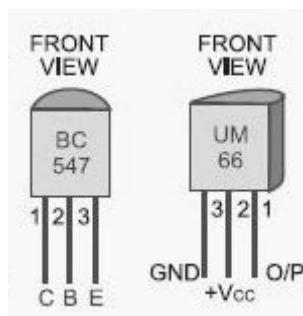


Tip:

Zoom this document to see resistance color codes.



Made with Fritzing.org



Tip:

Please refer figure on the left side to identify the right pin numbers for IC UM66 and Transistor BC



Step2: Assemble the melody circuit in breadboard, Please refer the previous melody project to make the circuit.

Step3: Connect the melody circuit to LED pins , So that melody circuit will also get power when LED will light up.

Step4: Switch On the circuit and touch short the two probe wires, LED should light up with ringing melody.

Step6: Instead of inserting the probes directly to water tank use corrosion tolerant steel bolt. This will ensure smooth working of your device for longer time.



Panel for Water overflow Alarm

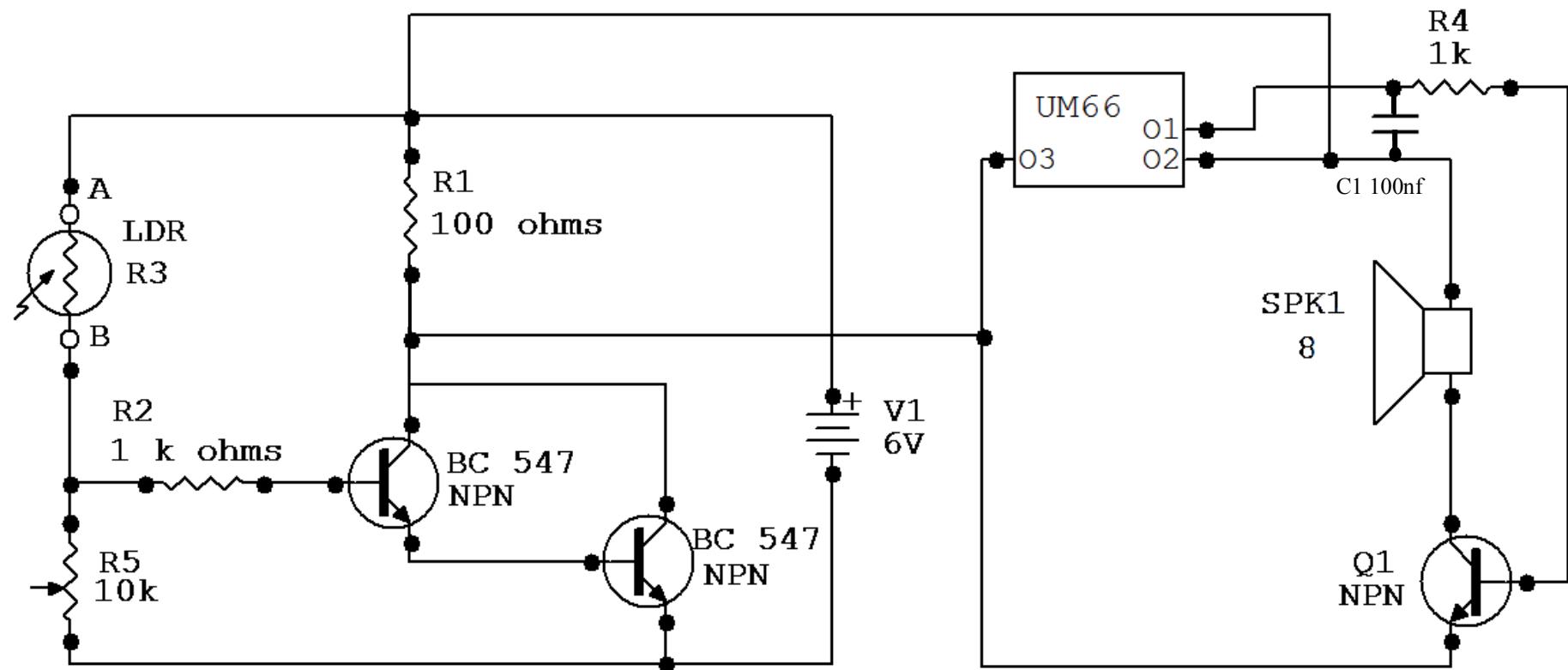
More Ideas: You can use a loud melody circuit with the Darlington pair circuit, you will need a 9volt battery if you are using a loud melody circuit.



6.3 Fire Alarm

Fire alarm is a very important device in any house. It protects us from unknown fires and give time to prevent any miss happening. In this project we are going to make a small fire alarm which can be installed on places like kitchen. It senses fire from close range so it can kept near to the places, which are vulnerable to fire. A smoke alarm is more effective which is generally installed on roof and detects smoke. The circuit is same as previous one, only we are going to insert a LDR in the probes which we kept open in above figure and a variable resistance in points A and B to adjust the sensitivity of circuit.

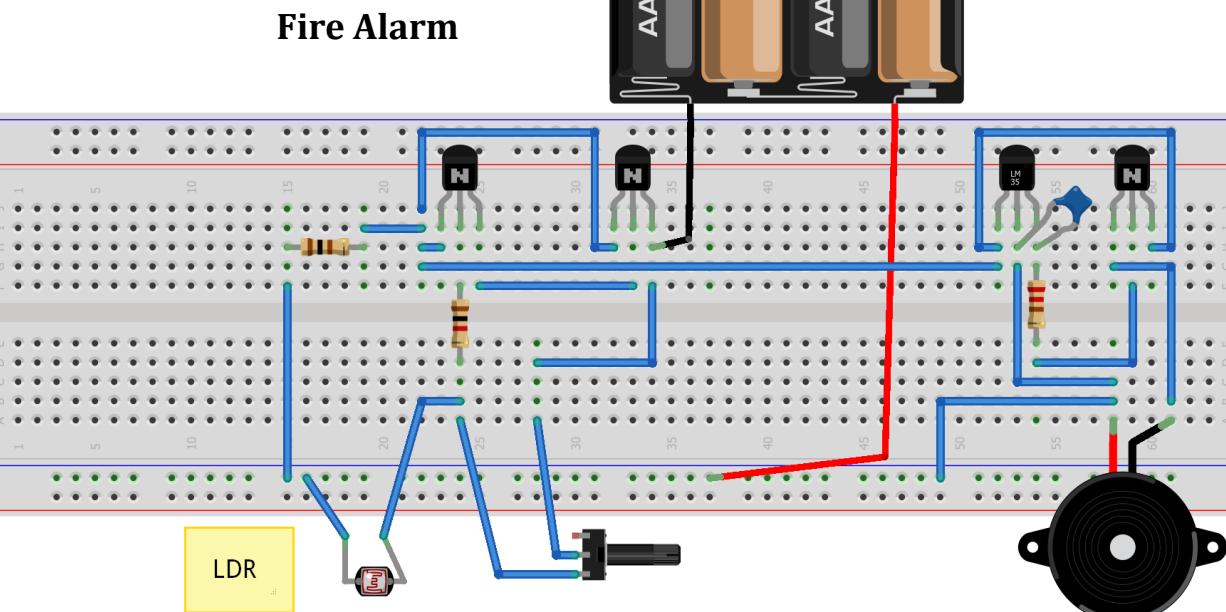
Materials: 1- LDR (Light dependent Resistance), R1-100, R4 - 1k, R5 - 10k, 3 Transistors -BC547, 1 IC -UM66, 1 Speaker, Battery - 6volts, 1 LED



The Light sensor used in this circuit, activates LED and alarm when bright light (light from fire) falls on LDR. In absence of bright light, LED should remain close, Variable resistance should be calibrated to adjust current flowing thorough R1 and to keep LED closed in absence of light. Set the position at a point where LED is just OFF or very dim.

Tip:

For melody circuit, Try BC 108 instead of BC547 & See if you get more sound.



Light sensor detects light from fire



Don't use direct flame/candle with Light sensor.

Step1: In the Fire alarm circuit , just put LDR between the probes.

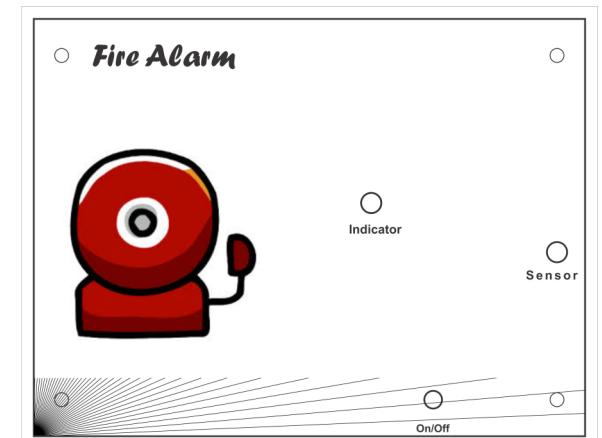
Step2: Assemble the melody circuit in breadboard, Please refer the previous melody project to make the circuit.

Step3: As done before, Connect the melody circuit to LED pins , So that melody circuit will also get power when LED will light up.

Step4: Switch On the circuit and fire a candle in front of LDR (Don't touch flame with LDR sensor), LED should light up with ringing melody. If it doesn't glow up circuit needs calibration. Rotate the variable resistance knob to see where the LDR is more sensitive.

Tip:

- Be patient with this circuit, As it requires calibration.
- If sound is breaking, Try using 9volt battery for smooth operation.



6.4 Light Sensitive Morning Alarm

If you want to wake up with the first sunlight, no alarm clock can help you. This gadget is designed to sense the light and it can wake you up with first sunlight for sure. Please note that this circuit is same as Fire alarm one, only this one should be adjusted as more light sensitive.

Materials: 1- Light Dependent Resistor (LDR), R1-100, R4 - 1k, R5 - 10k preset, 3 Transistors -BC547, 1 IC -UM66, 1 Speaker, Battery - 6volts, 1 LED

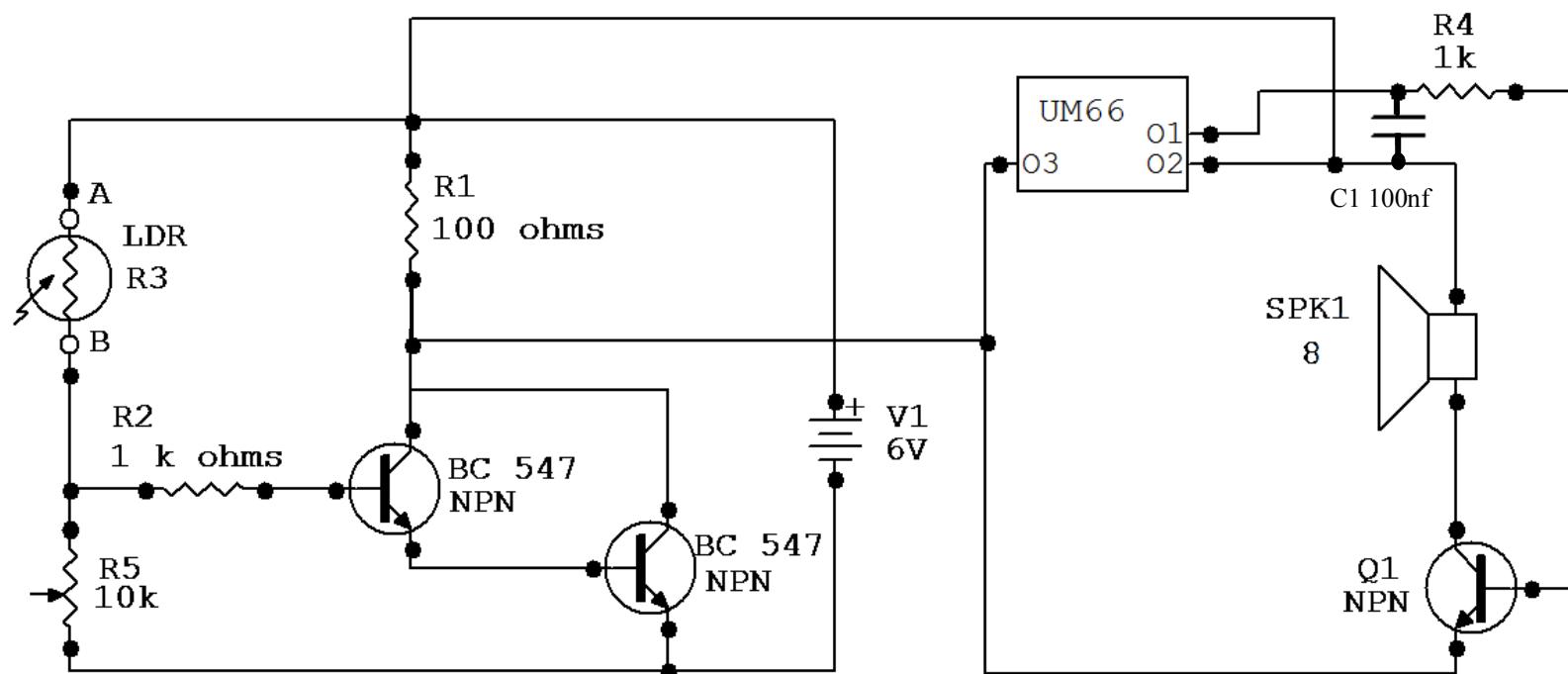
Find materials at : www.hobbyelectronics.in

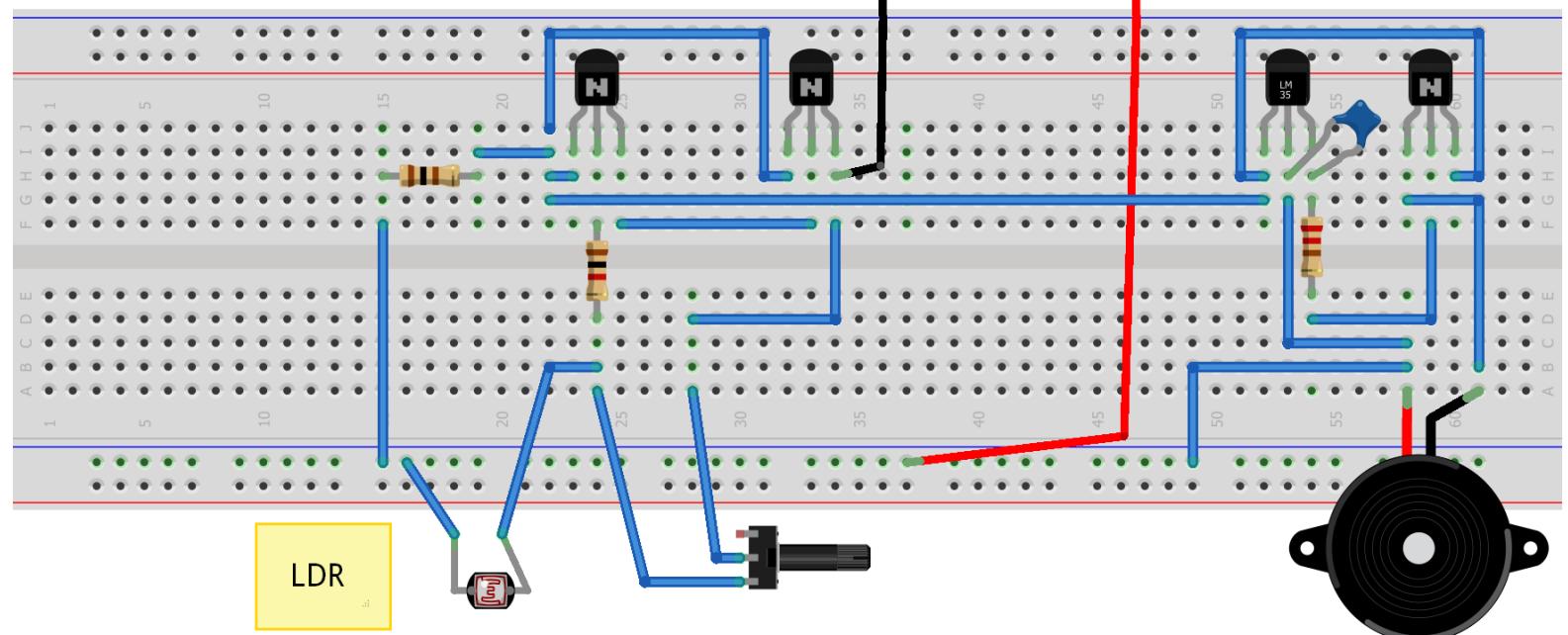
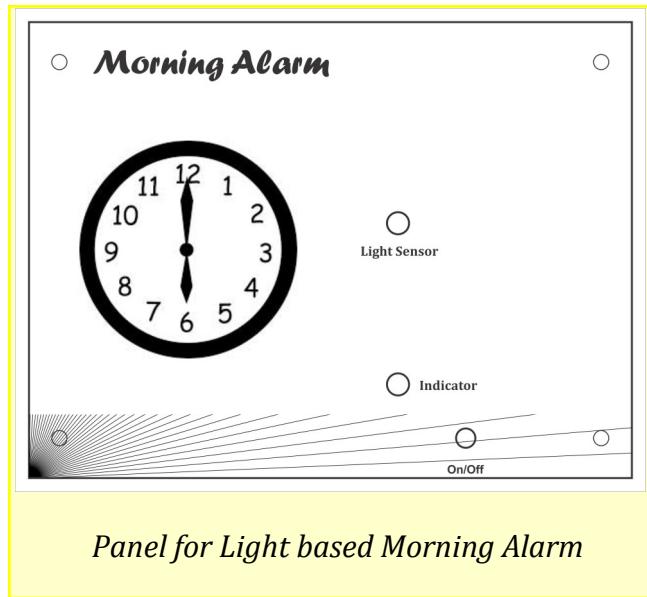
Step1: In this circuit , just replace A and B with LDR as a light sensor.

Step2: Assemble the melody circuit in breadboard first, Please refer the previous melody project to make the circuit.

Step3: As done before, Connect the melody circuit to LED pins , So that melody circuit will also get power when LED will light up.

Step4: Switch On the circuit probably in some dark room, bring a light torch over to LDR and see if the LED glows and melody circuit generates some music.







More Ideas:

Refrigerator door open alert system: You can use this circuit as an Refrigerator door open alarm system, which will alert the user to close the fridge door. This circuit works in light and closes itself Off in dark, which is what happens when we open fridge. As we open fridge door a small indicator lamp of fridge glows up in fridge to show you the things inside. And by absorbing the light of lamp our circuit will start to turn On the music, If somebody left the fridge door open, This alarm will annoy everybody and the only way to close this alarm Is to close fridge door.

Alarm will sound whenever
you open the fridge door, by
the light of fridge's lamp.



6.5 LASER Based Burglar Alarm

This is one of the exciting projects we have in this book, In this project we will create a real burglar system operated by laser lights. The concept of this circuit is opposite to “**Light Sensitive Morning Alarm**” where morning alarm was operating by light , this circuit will operate by darkness which means it needs a constant light to remain itself in Off mode. When this constant light source falling on Light sensor (LDR) is broken by some body, it toggles the circuit On and circuit raise an alarm.

With the help of mirrors (See image below) you can divert laser on different angles in room in such a way that finally the light must reach to this sensor, If any of the laser path is obstructed by anybody, The alarm will sound.

Materials: 1 Speaker, 1Battery - 6volts, 1 LED

Step1: In the previous circuit , just replace A and B with 10k preset and replace R5 with LDR.

Step2: Assemble the melody circuit in breadboard first, Please refer the previous melody project to make the circuit.

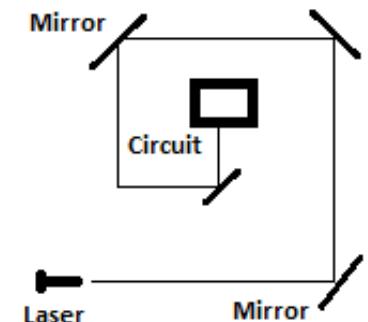
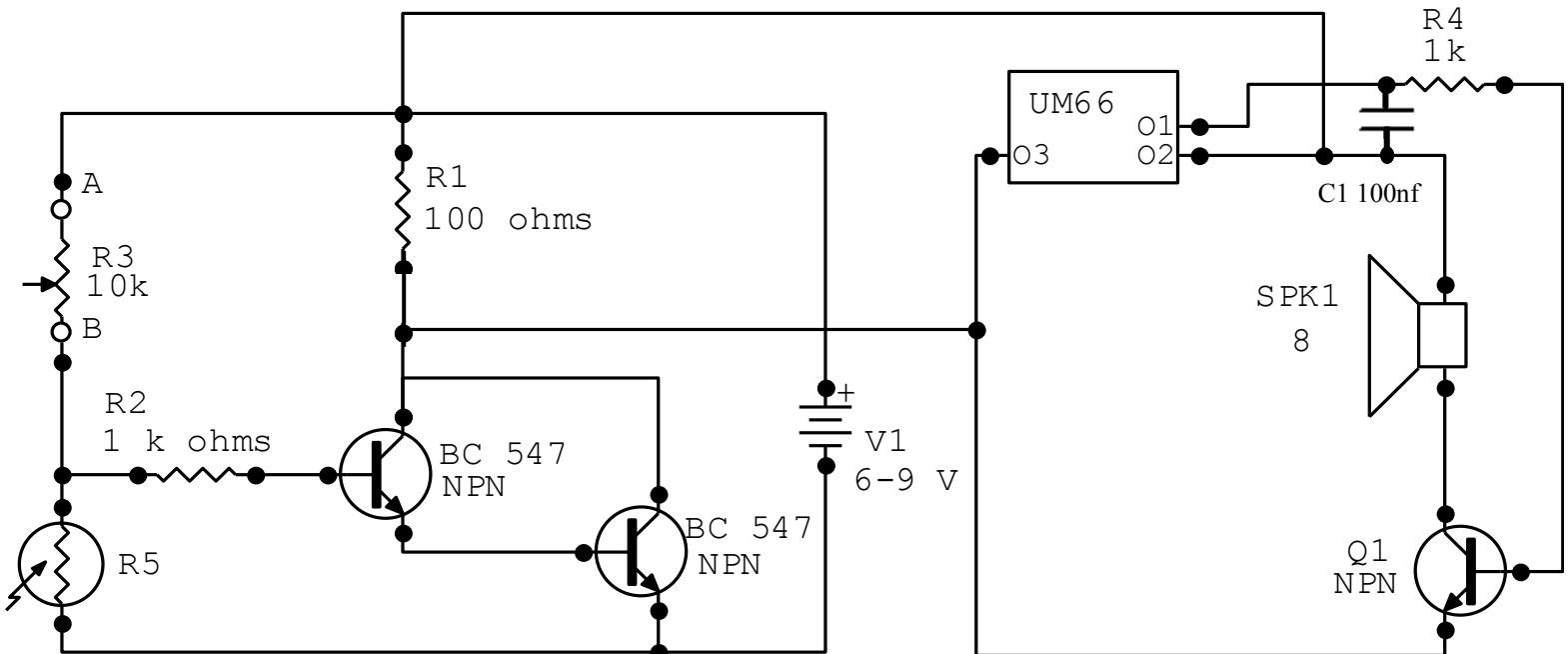
Step3: As done before, Connect the melody circuit to LED pins , So that melody circuit will also get power when LED will light up.

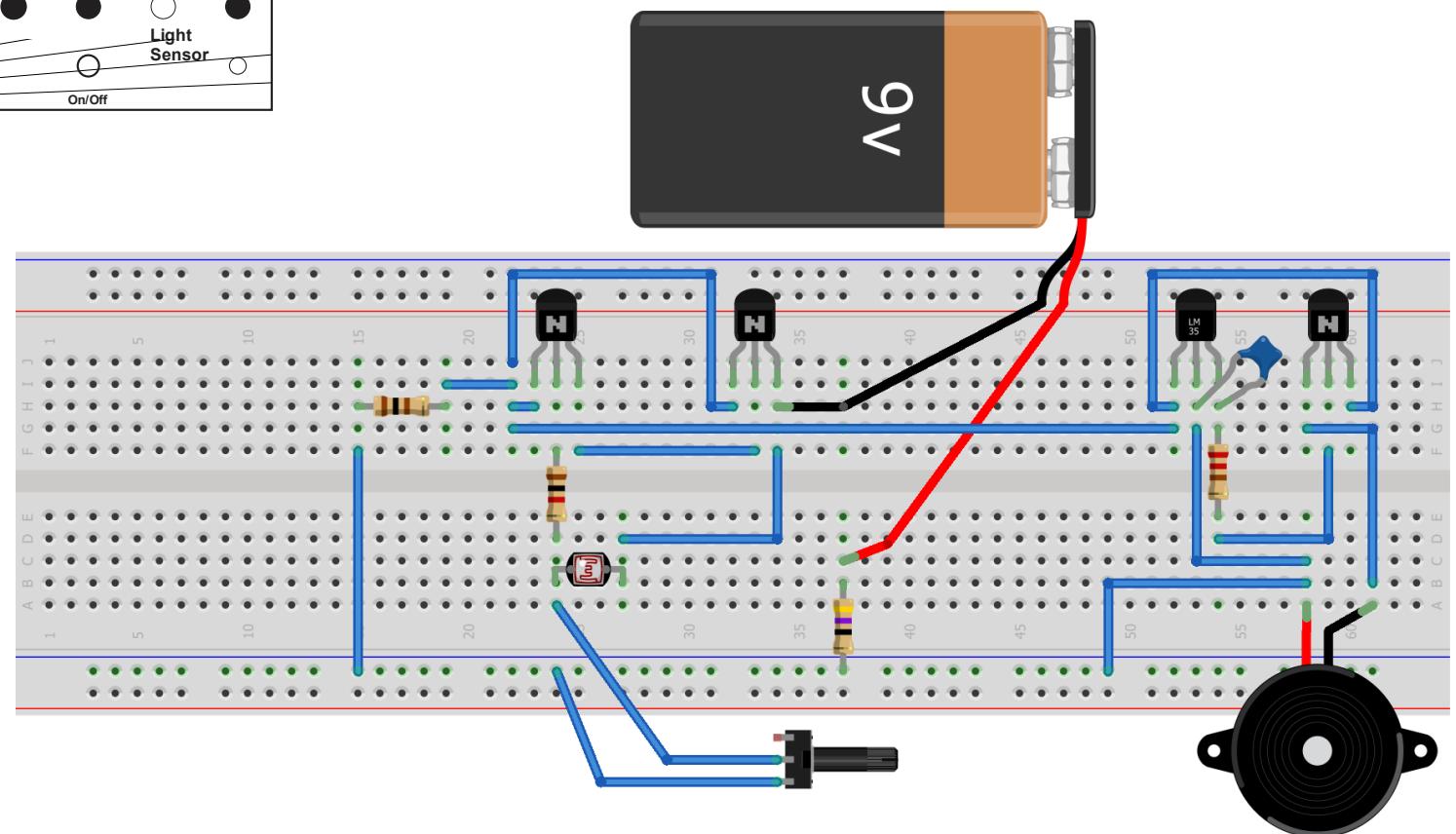
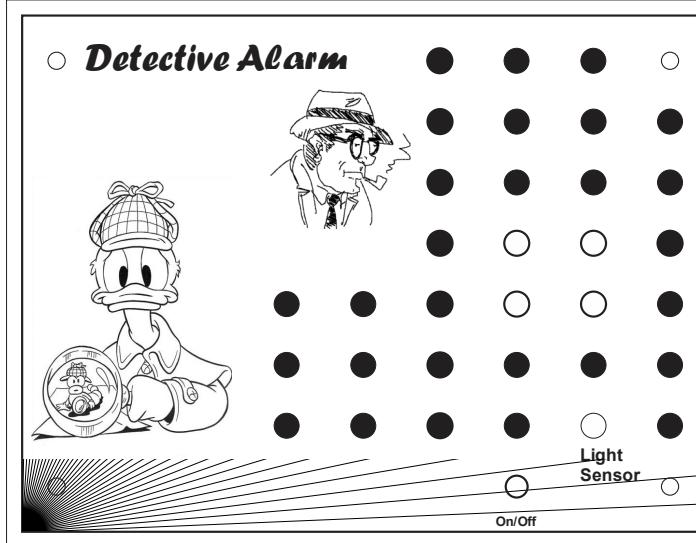
Step4: If you are using a 9volt battery , please use a 100 ohm protective resistor with battery wire, to limit battery voltage to around 6 volt

Step5: Test the circuit in a dark room with Laser light over LDR, The moment you stop falling light on

LDR, the circuit should sound an alarm.

Step6: If circuit is working fine, You can optionally use mirrors to divert Laser to different angles in room.





6.6 Wire Current Detector

In today's times all the wiring is done inside the walls and if there's some fault in that wiring, It's very difficult to catch it. With this gadget you can sense the wire going through the wall. It detects the electric field created by live wires and indicates you their position inside wall. Isn't it useful? Just use the touch plate to touch the wall or pipe in which wire are passing through and see the indicator.

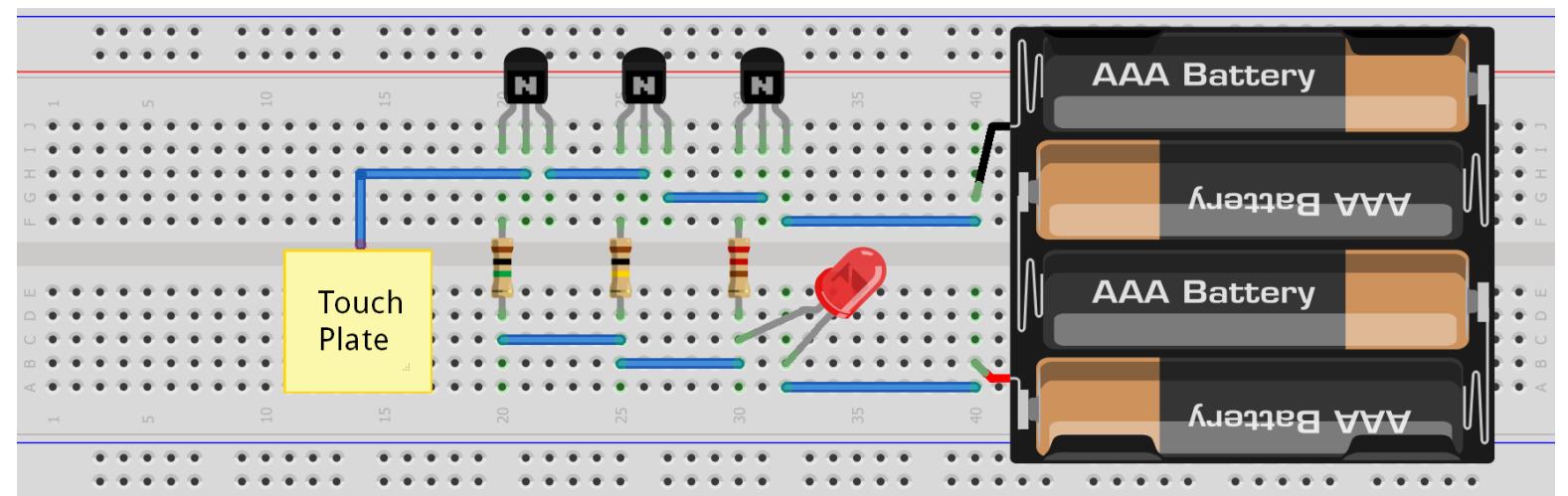
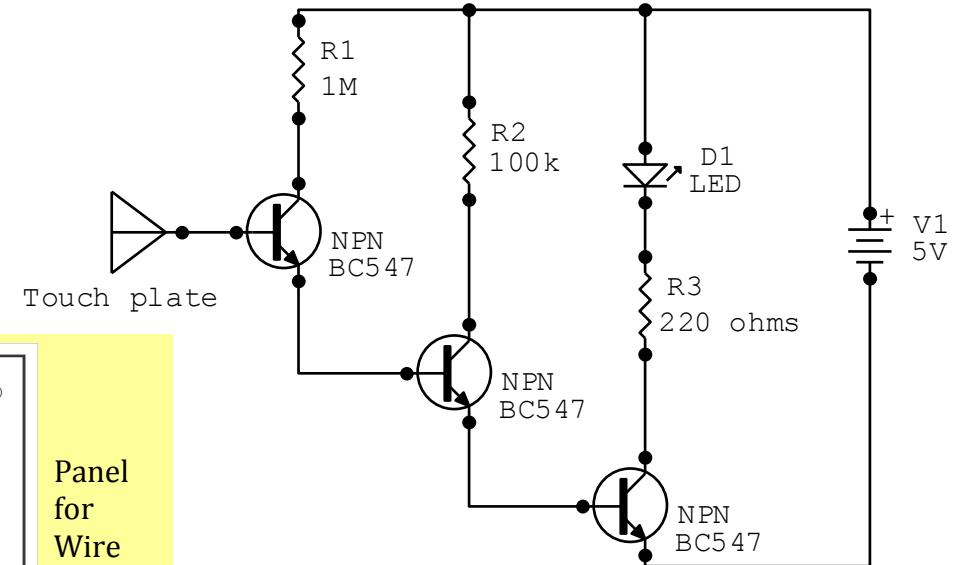
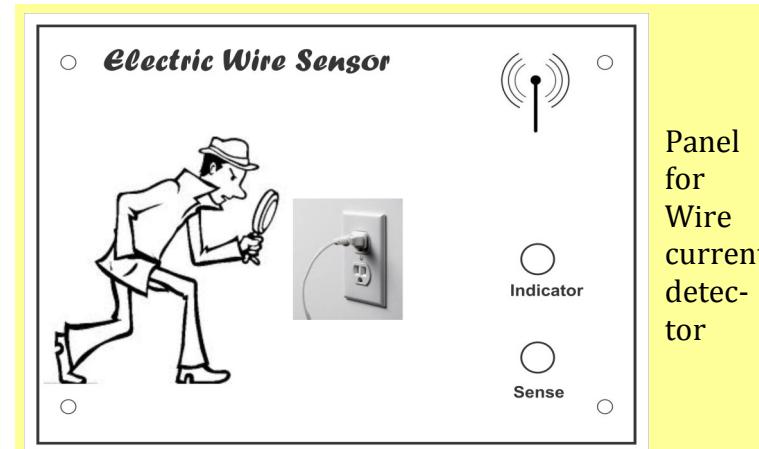
Materials: 3—BC 547 , 1
– $1M\Omega$, 1— $100k\Omega$, 1
 220Ω .

Step1: Identify the collector, base and emitter leads. And insert transistor in breadboard.

Step2: Identify the positive and negative wires of LED.

Step3: Assemble circuit components over bread board and test the circuit with power supply.

Step4: Cut the panel drawing sheet and paste it on panel. And your project is ready for display

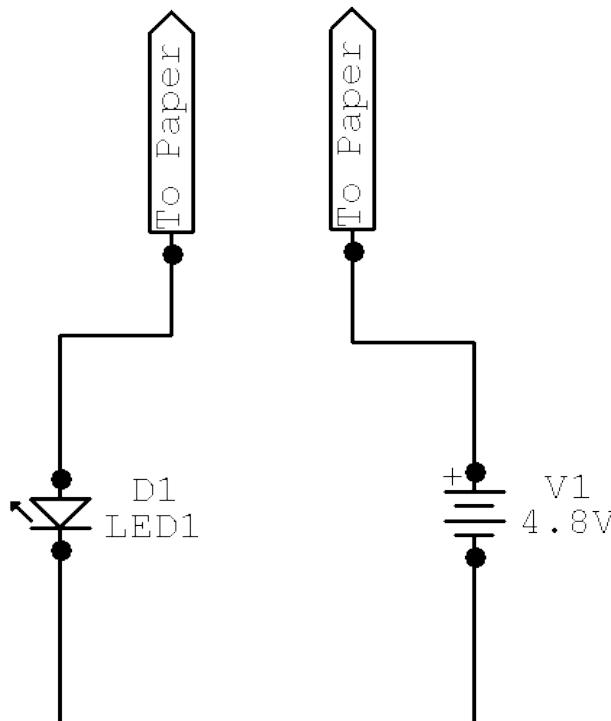


6.7 Pencil and Paper Circuits

Now this is very exciting project for all young hobbyists out there. We all use pencils some of us love them and some of us don't. you draw using pencils or can write. But do you know one more exciting use of pencil. The pencil lead made up of graphite is a very good conductor and when we write/draw using pencil, the characters or lines we draw are actually conducting current as long as they are continuous.

In other words, if we use whole lead from pencil, we can make conducting wires of it (lead is very good conductor). And if we draw lines on a paper and connect wires to those lines we may still get a conductor wire or more precisely a resistance.

So lets start experimenting with pencil leads and create some fun projects.



In this project we will try to light up a LED using a dark lead line drawn on paper. The Lead line will act as a resistance and when we extend the length of line it will conduct less electric current than when we draw a small line. In other words a small line drawn on paper will conduct better than a longer line. This also suggests that resistance of a conductor is proportional to its length.

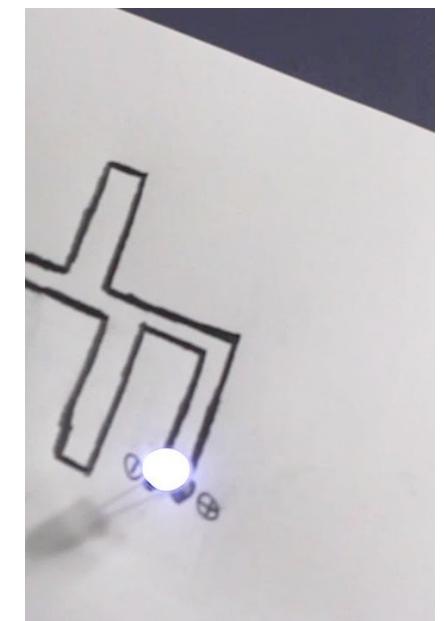
Steps:

Step1: Draw a dark line on a paper using a pencil. You can redraw same line again and again to achieve some darkness. A dark line conducts better as it is having more graphite layers.

Step2: Assemble circuit components on breadboard.

Step3: Touch the wires on the end of line and check if LED light up.

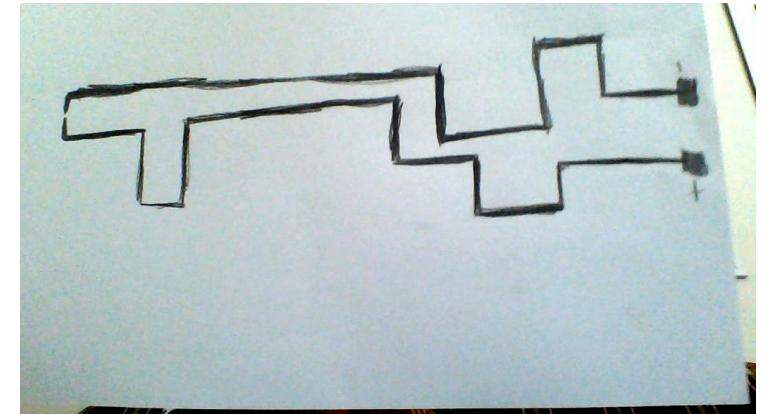
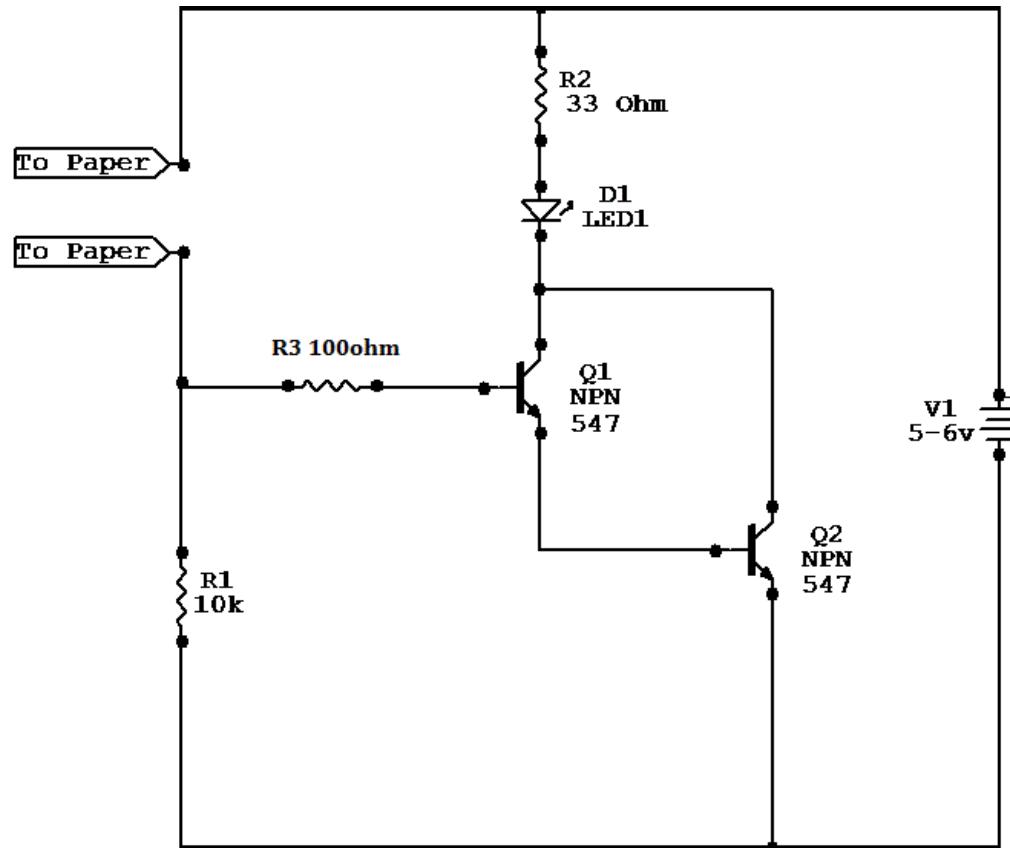
Step4: If LED is not lighting then bring the wires closer to each other and eventually you will find a point when they will start conducting.



6.8 Paper Circuits Using Darlington Pair

We know that a transistor require very small base current to turn ON. Once transistor is ON it conducts large amount of current from collector to emitter. So we will use this principle in this circuit. Here we are using a Darlington pair which needs even more lesser input signal to turn itself ON.

With using above circuit we can create longer lines with large resistances as the input current required for Darlington pair is very less.



Steps:

Step1: Draw a longer dark line on a paper using a pencil. You can redraw same line again and again to achieve some darkness.

Step2: Assemble circuit components on breadboard.

Step3: Touch the wires on the end of line and check if LED light up.

Step4: If LED is not lighting then bring the wires closer to each other and eventually you will find a point when they will start conducting.



More Ideas

Handwriting recognition - handwriting recognition is a complex science, here we will try to recognize hand writing by using only one aspect of writing and it is hand pressure applied on paper while writing. Every person write with different hand pressure which leaves different amount of graphite on paper which means each person's line have different resistances. By measuring the resistance of lines (use same length of line for example 0.5 cm of line) drawn by a person we can distinguish between people's hand writing.

7. 555 Timer Projects

In this section we will make :

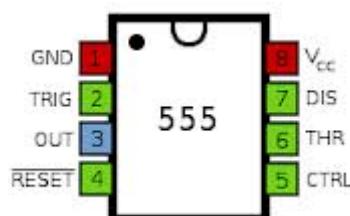
- | | |
|-----------------------------------|--------------------------|
| 7.1 4 Key Piano | 7.7 Knight Rider |
| 7.2 Light sensitive music circuit | 7.8 Cricket Game |
| 7.3 Light controlled Police Siren | 7.9 Multipurpose circuit |
| 7.4 Touch Switch | 7.10 Johnson counter |
| 7.5 Timer | |
| 7.6 Continuity Tester | |



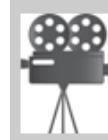
What is it about ?

555 timer integrated circuit (IC) is a very popular chip used in variety of applications like timer, pulse generation and oscillators. This is a low cost, stable and widely available chip which makes it favorite for hobbyists. The internal components of 555 as shown in figure consists of 2 comparators and a flip flop. All of these components contain 25 transistors and 15 resistors packed in the IC.

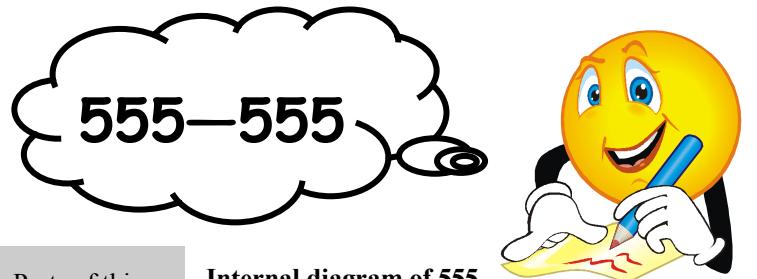
The three highlighted 5k resistors shown in figure are the reason why this IC is named as 555.



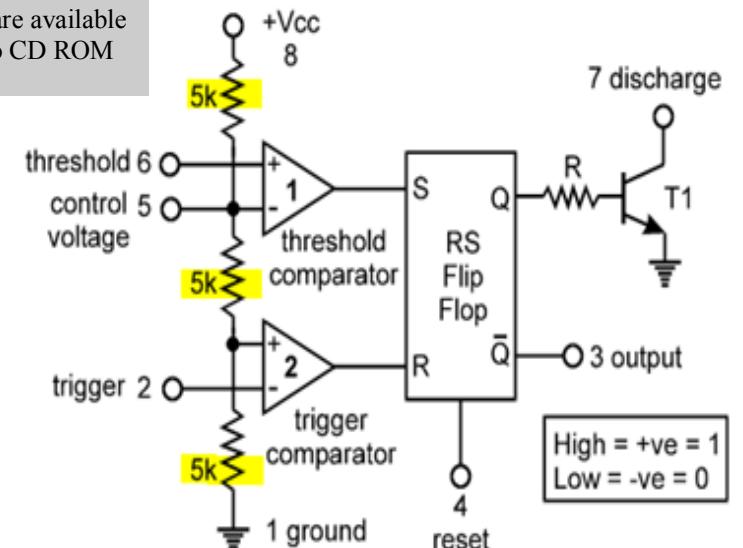
Please note the notch near first pin. This is made to indentify the first pin of IC.



Some Parts of this project are available in Video CD ROM



Internal diagram of 555



Pin	Name	Purpose
1	GND	Ground reference voltage, low level (0 V)
2	TRIG	The OUT pin goes high and a timing interval starts when this input falls below 1/2 of CTRL voltage (which is typically 1/3 of V_{CC} , when CTRL is open).
3	OUT	This output is driven to approximately 1.7V below $+V_{CC}$ or GND.
4	RESET	A timing interval may be reset by driving this input to GND, but the timing does not begin again until RESET rises above approximately 0.7 volts. Overrides TRIG which overrides THR.
5	CTRL	Provides "control" access to the internal voltage divider (by default, 2/3 V_{CC}).
6	THR	The timing (OUT high) interval ends when the voltage at THR is greater than that at CTRL.
7	DIS	Open collector output which may discharge a capacitor between intervals. In phase with output.
8	V_{CC}	Positive supply voltage, which is usually between 3 and 15 V depending on the variation.

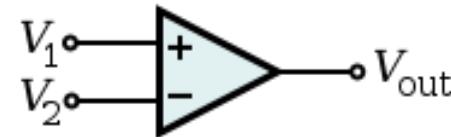
Working Principle

As you can see from the diagram on right hand side there are many new terms and symbols mentioned. As a matter of fact, Working of 555 IC is not very complicated, It just needs step by step approach to understand.

Lets start from the name of IC itself, 555 comes from the 5 highlighted resistances shown in figure. Now to start with working explanation, We will first understand what is comparator and RS Flip Flop.

Comparator : As name suggests, It compares and it compares two voltages and outputs a digital signal indicating which is larger.

V_{out} is 1 (1 means 5volts in digital electronics) when V_1 is greater than V_2 . V_{out} is 0 (0 volts) when V_1 is less than V_2 .

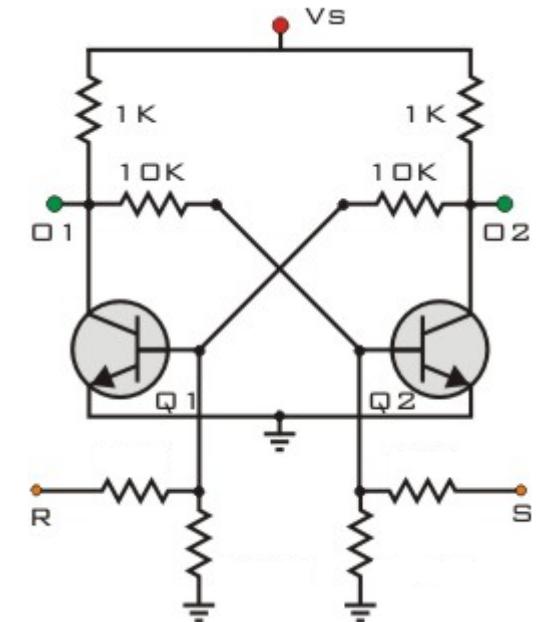
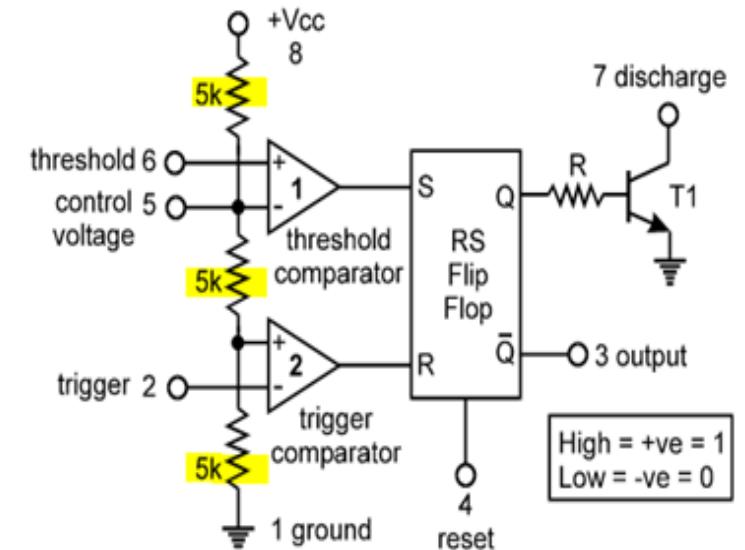


RS Flip Flop : Now here comes scary name, But its not actually, The purpose of RS flip flop is a latch, like a door latch, It just sets or resets, Below shown figure is a symbolic representation of

RS Flip Flop, The actual circuit is on right hand side. For a moment just understand this circuit on right. Two NPN transistor are connected with output fed back into bases at Q1 and Q2 and two another direct base inputs R and S, As we know that transistor acts a switch when a small current is applied at base. So when switch is ON a large current will flow from collector to emitter and this flow once started will also go to base of another transistor and activates it also. This is how both transistors are connected here.

Now S is termed as Set and R is Reset and base on this above simplified figure (left hand side) is created. If you elaborate the possible combination of inputs for R and S they can be - (0,0), (0,1), (1,0), (1,1) and depending on the input, Output will get generated in 1 and 0 at Q and Q'.

Lets tabularize the input and output of RS flip flop and then we will come back to IC 555 and its working.



State	S	R	Q'	Q (output)	Description
Set	1	0	0	1	Set Q » 1
	1	1	0	1	no change
Reset	0	1	1	0	Reset Q » 0
	1	1	1	0	no change
Invalid	0	0	1	1	Invalid Condition

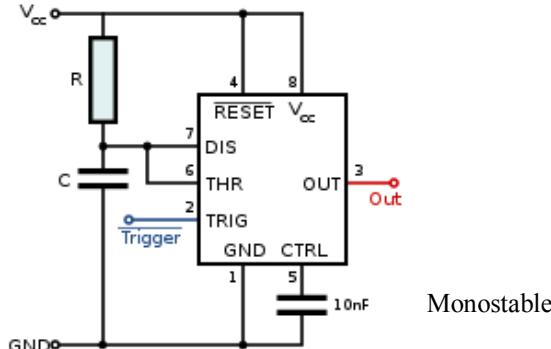
Being RS Flip Flop at the heart of IC, It is clear that this IC is used for generating alternating states of 1 and 0 based on input.

How it works

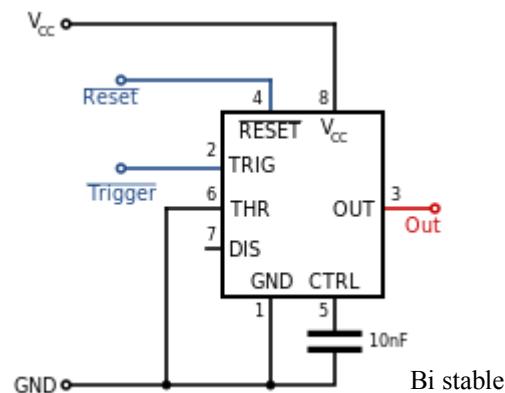
Comparator 1 is threshold comparator and second is trigger comparator, Control voltage is a base voltage which comparator will use to compare higher or lower voltage, So control voltage remains constant. A threshold voltage is applied at pin 6 at comparator 1 and if its greater than control voltage , It results a '1' from comparator and 'S' input of RS flip flop will get 1 value. The moment 'S' gets '1' Flip flop goes high at Q. And low at Q'. Please note that comparator 2 is having 0 as output at this stage and 'R' input to flip flop is 0.

Once the output is low. Comparator 1 cannot set it back to high, even if it tries to go 0. As per the table above if both the 'R' and 'S' are 0 then also Q is high. So it is now only comparator 2 which can make RS flip flop to go low. And if a negative voltage is applied at trigger pin 2 then only comparator 2 will go high and 'R' will get 1 and output goes high (see second row of table above).

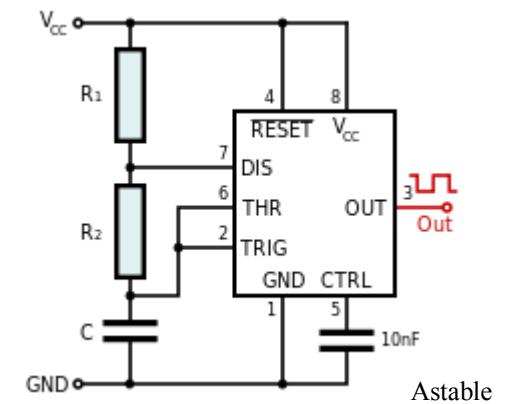
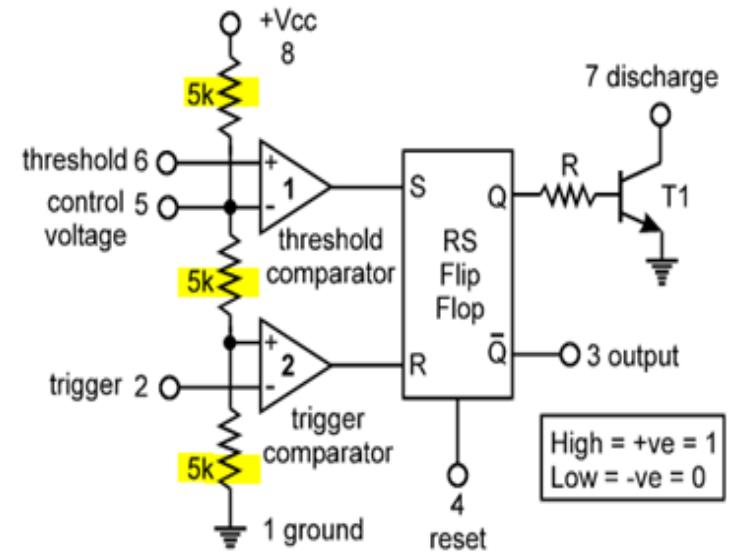
There can be three modes of operation for IC 555 -



Monostable



Bi stable



Astable

The three operating modes:

Monostable mode: in this mode, the 555 functions as a "one-shot" pulse generator. Applications include timers, missing pulse detection, bouncefree switches, touch switches, frequency divider, capacitance measurement, pulse-width modulation (PWM) and so on.

Astable - free running mode: the 555 can operate as an oscillator. Uses include LED and lamp flashers, pulse generation, logic clocks, tone generation, security alarms, pulse position modulation and so on. The 555 can be used as a simple ADC, converting an analog value to a pulse length. E.g. selecting a thermistor as timing resistor allows the use of the 555 in a temperature sensor: the period of the output pulse is determined by the temperature. The use of a microprocessor based circuit can then convert the pulse period to temperature, linearize it and even provide calibration means.

Bistable mode or Schmitt trigger: the 555 can operate as a flip-flop, if the DIS pin is not connected and no capacitor is used. Uses include bounce-free latched switches.

7.1 4 Key Piano

The circuit produces different sounds when keys are pressed.

Materials: IC 555, 1 –100 μ f or 220 μ f, 1 - 1 μ f, 2 -1k, 1 -10k, 1 - 4.7k, 1 -15k, 4 -Touch sensors, 1 -Speaker

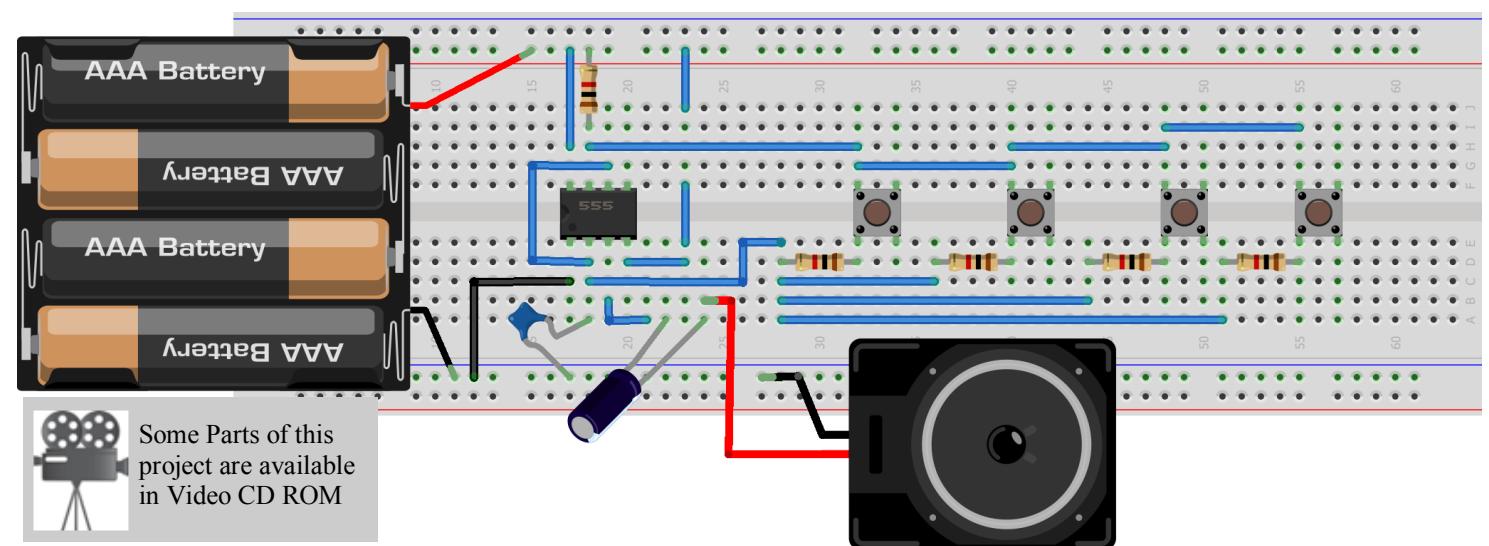
Step1: Identify the different resistors with there color codes.

Step2: Ensure all the pins of IC are properly inserted.

Step3: Ensure that electrolytic capacitors are right way round.

Step4: Assemble all remaining parts and insert the batteries at the end, and see if circuit working properly by pressing keys.

Step5: This is it, assemble the circuit on MY Kit and have fun.



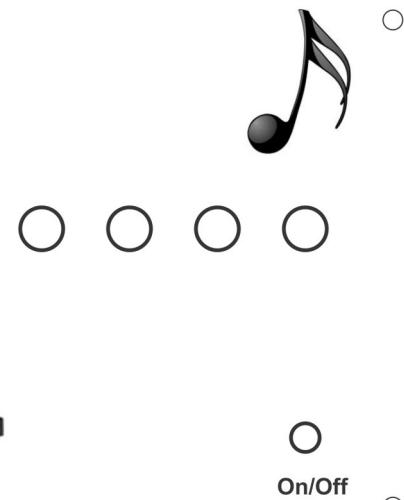
Made with Fritzing.org



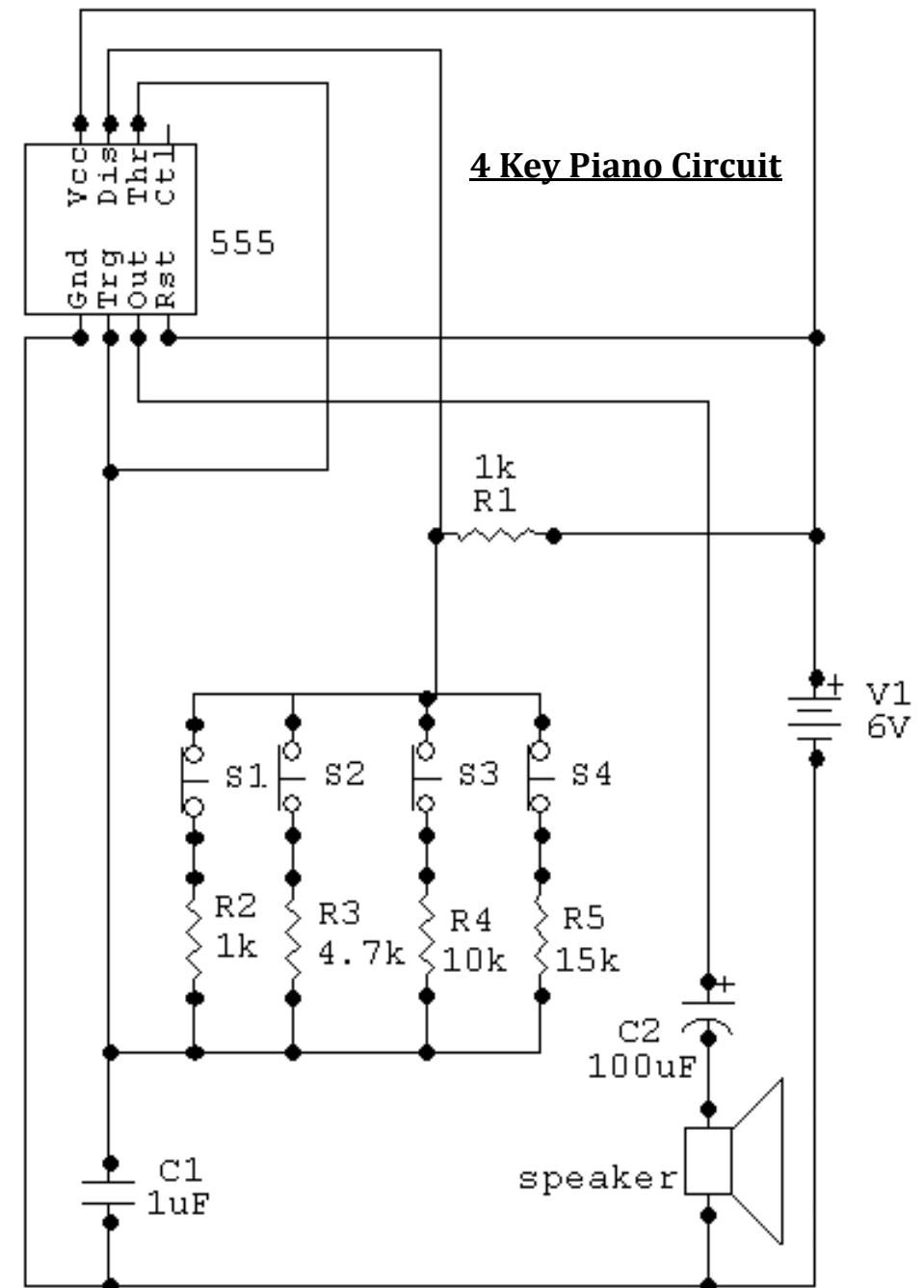
More Ideas -

You can add more resistances in increasing order and more push buttons to extend your piano keys. Also you can experiment with the existing resistances which will change the sounds of piano.

4 Key Piano



Lets assemble the circuit on MY Kit project kit. Please refer above figure to identify the correct design from panels. Use push buttons and assemble them on MY Kit. You should use



7.2 Light Sensitive music Circuit

This circuit produces music when light is thrown and removed on it. It is a very playful circuit.



Some Parts of this project are available in Video CD ROM

Materials: IC 555, 1 -100 μ f, 1 - 1 μ f, 1 - 1k, 1 - Speaker, 1 -LDR.

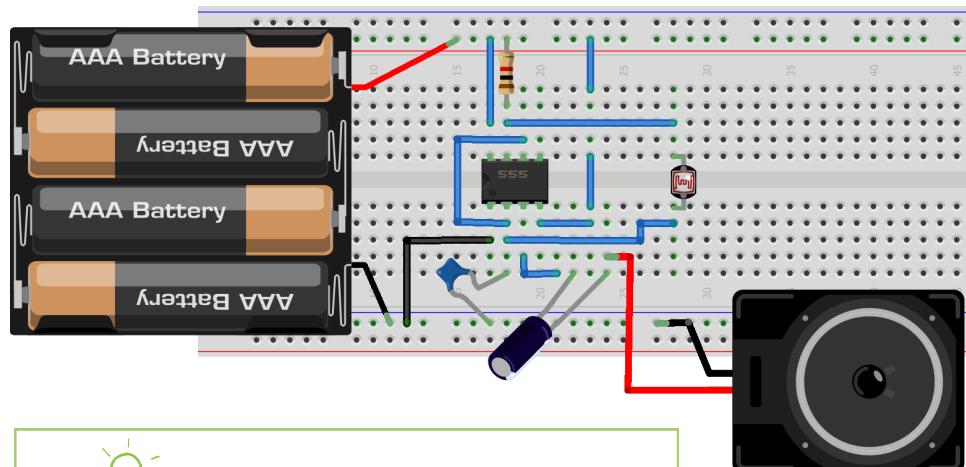
Find materials at : www.hobbyelectronics.in

Step1: Ensure all the pins of IC are properly inserted.

Step2: Ensure that electrolytic capacitors are right way round.

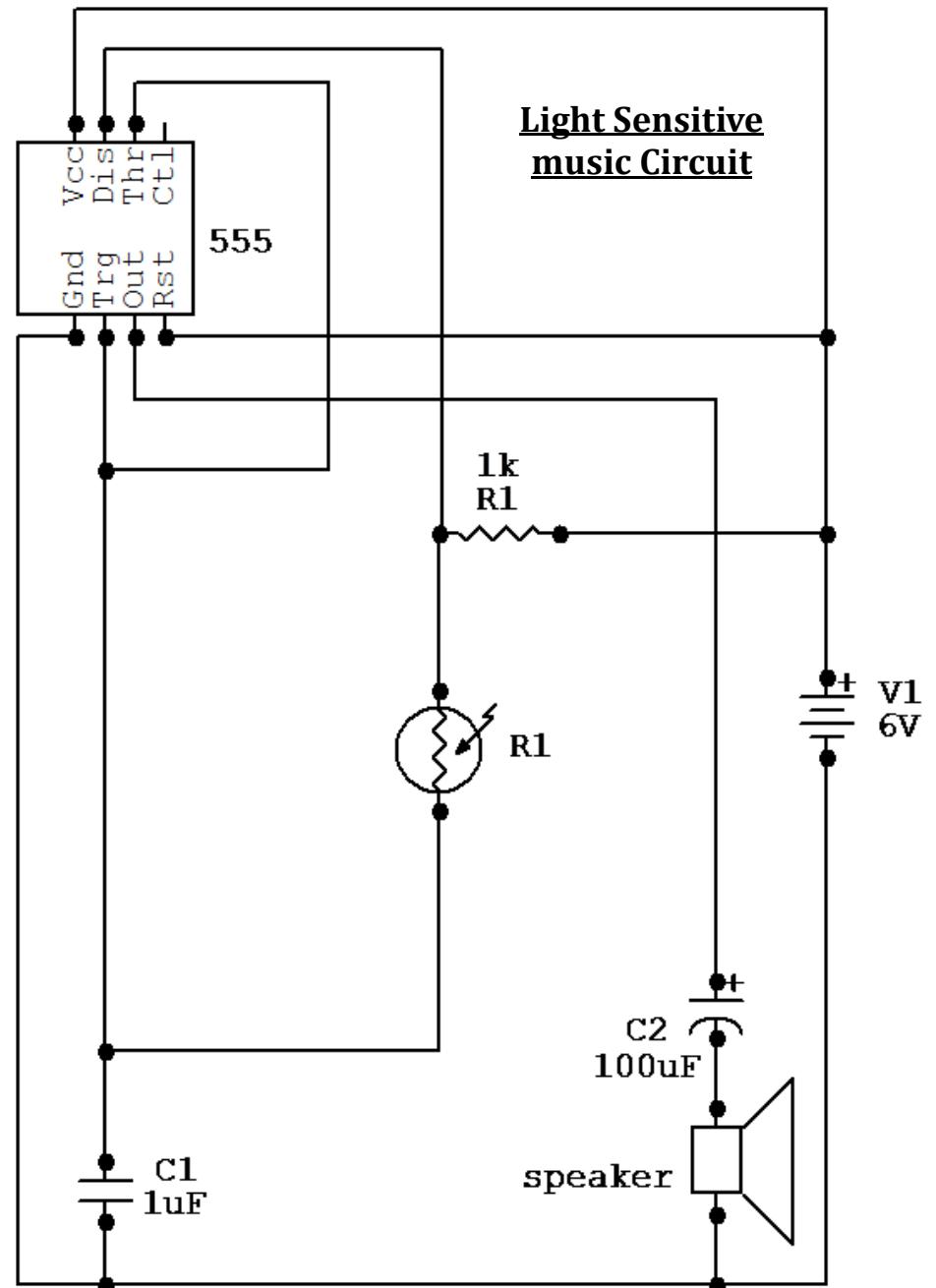
Step3: Assemble all remaining parts and insert the batteries at the end

Step4: A sound should be produced from speaker under room light conditions, when you cover the light sensor (LDR) from finger the sound will change and when you remove finger away slowly from sensor the sound will change gradually, producing a sound effect.



More Ideas -

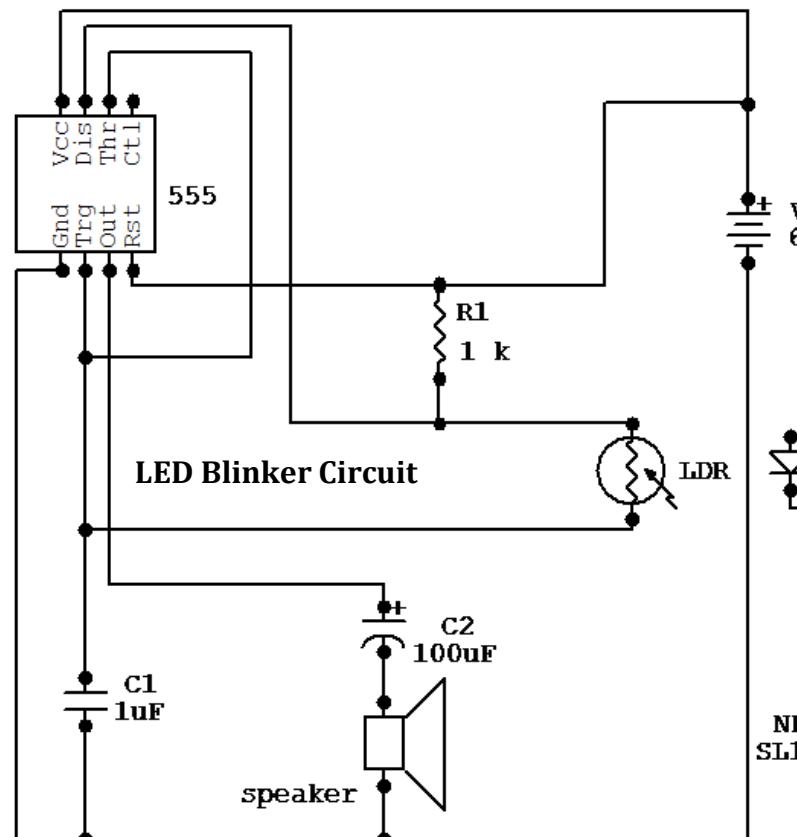
We are going to take this circuit forward and make a police siren from it.



○ **Laser Activated Organ**



*MY Kit Panel for -
Light Sensitive music Circuit - Lets assemble the circuit on
MY Kit project kit.
Please refer the left figure to identify the
correct design from panels.*



7.3 Light Controlled Police Siren

Taking forward to previous circuit where we made a light sensitive music generator, Here we will extend it to make a siren with flashing lights.

If you observe, we have used **LED blinker circuit** with **Light Sensitive music Circuit**. The blinking light falls on music circuit and it produces a On Off sound, which gives a siren like effect.

Materials: Same as we have used in **LED blinker circuit** and **Light Sensitive music Circuit**.

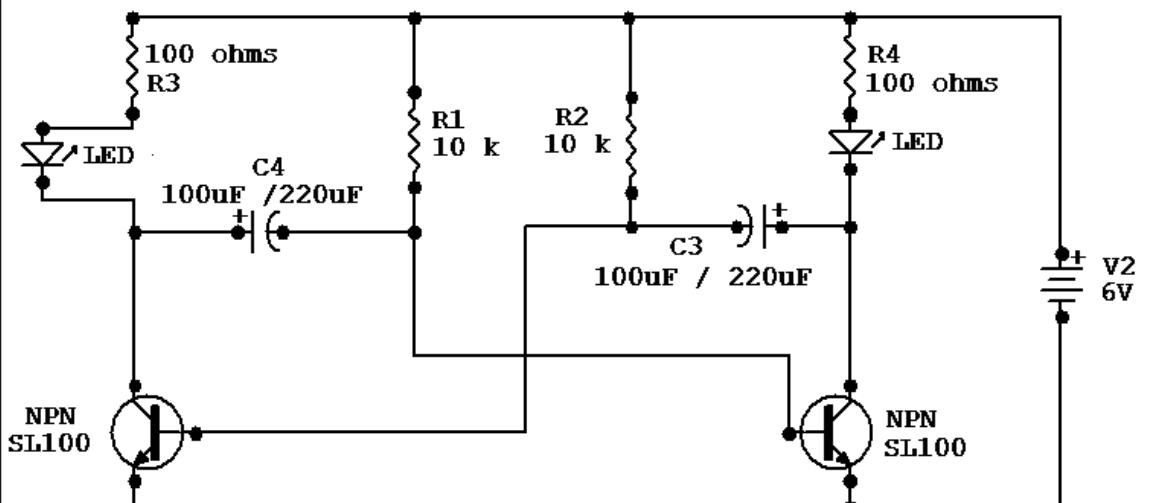
Find materials at : www.hobbyelectronics.in

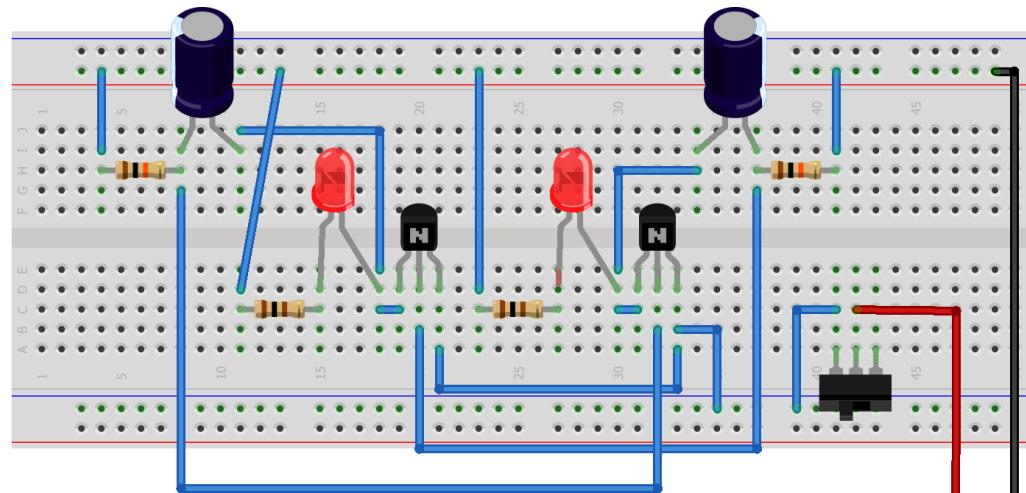
Step1: Assemble all the components of light blinker circuit and ensure that it is working fine .

Step2: Assemble all the components of Light sensitive music Circuit and ensure that it is working fine.

Step3: Now use a common battery to power both the circuits as shown in figure.

Light Sensitive music Circuit



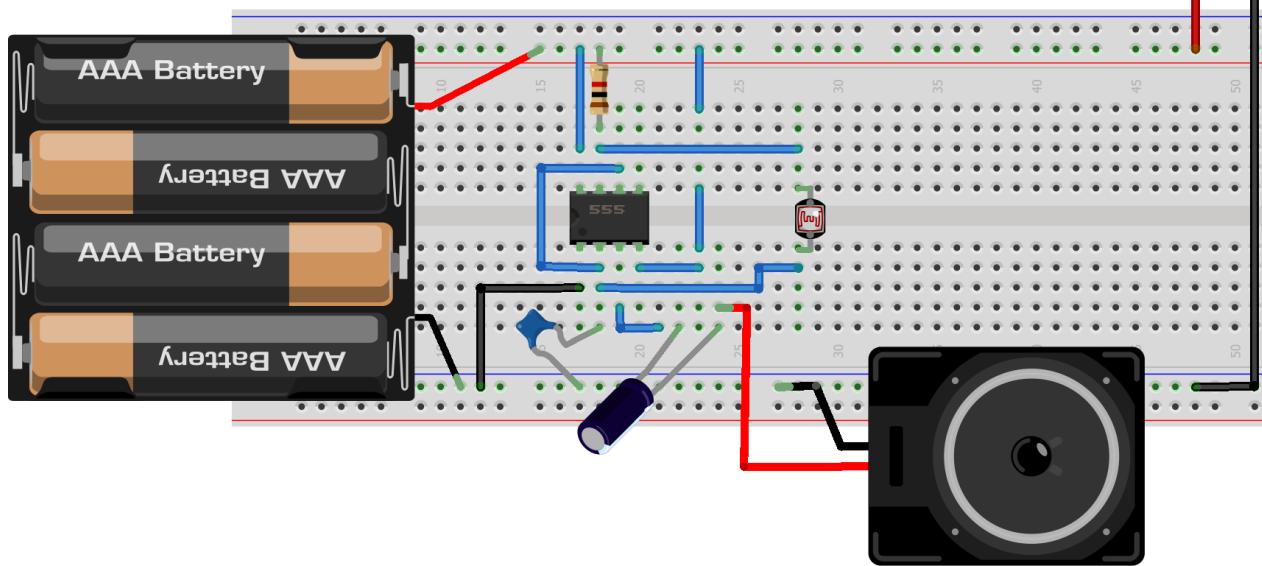


Light Controlled Police Siren



LED	LED
LDR	
Switch On/Off	

MY Kit Panel for -**Light Controlled Police Siren** - Lets assemble the circuit on MY Kit project kit. Please refer the left figure to identify the correct design from panels.



7.4 Touch Switch

By touching on plate, this circuit catches AC mains hum (static/stray voltages generated by mains) of your house from your finger. It needs very small amount of voltage to trigger itself. If you will try this circuit in open space like park, it wont work because of no voltage sources around. Apart from this circuit there are two more fundamentals on which touch circuits work—Resistive and capacitive. Both of these techniques are used in touch mobile. In resistive touch screen a finger touch passes current between two tightly spaced invisible resistors on screen.

Same happens in capacitive Where capacitors are used instead of resistors.

Touch Plate

Materials: IC 555, 1 -BC547, 1 - $10\mu F$, 1 - 100nf ,
1 - $1M\Omega$, 1 - $33k$, 1- 330Ω , 1 -LED,

Find materials at : www.hobbyelectronics.in

Step1: Ensure all the pins of IC are properly inserted.

Step2: Ensure that electrolytic capacitor is right way round.

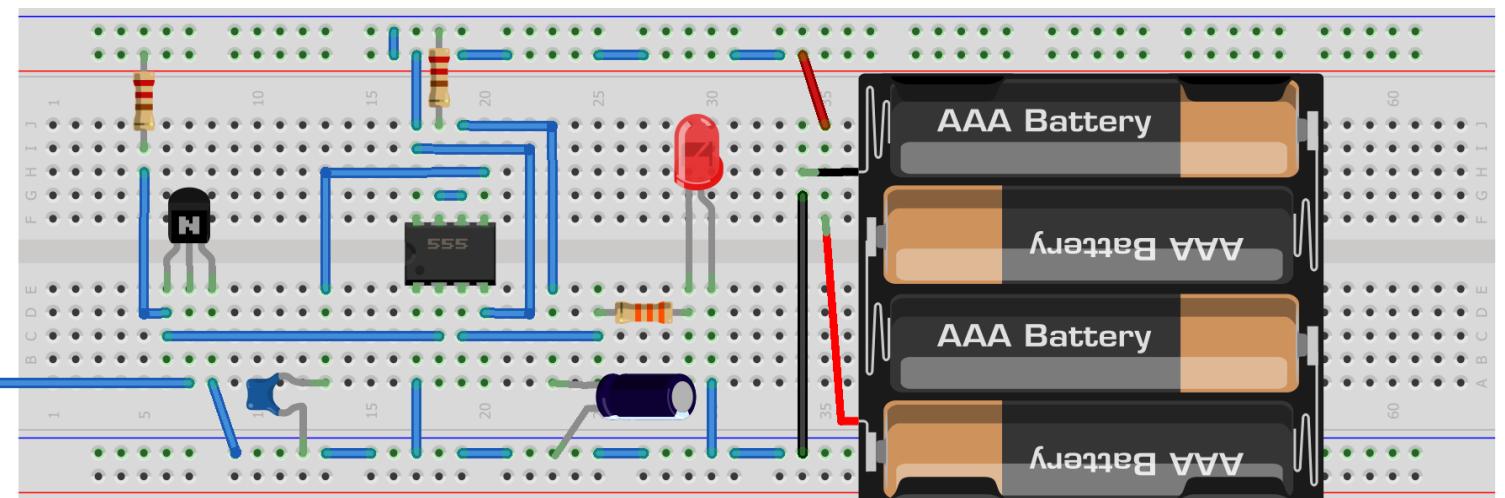
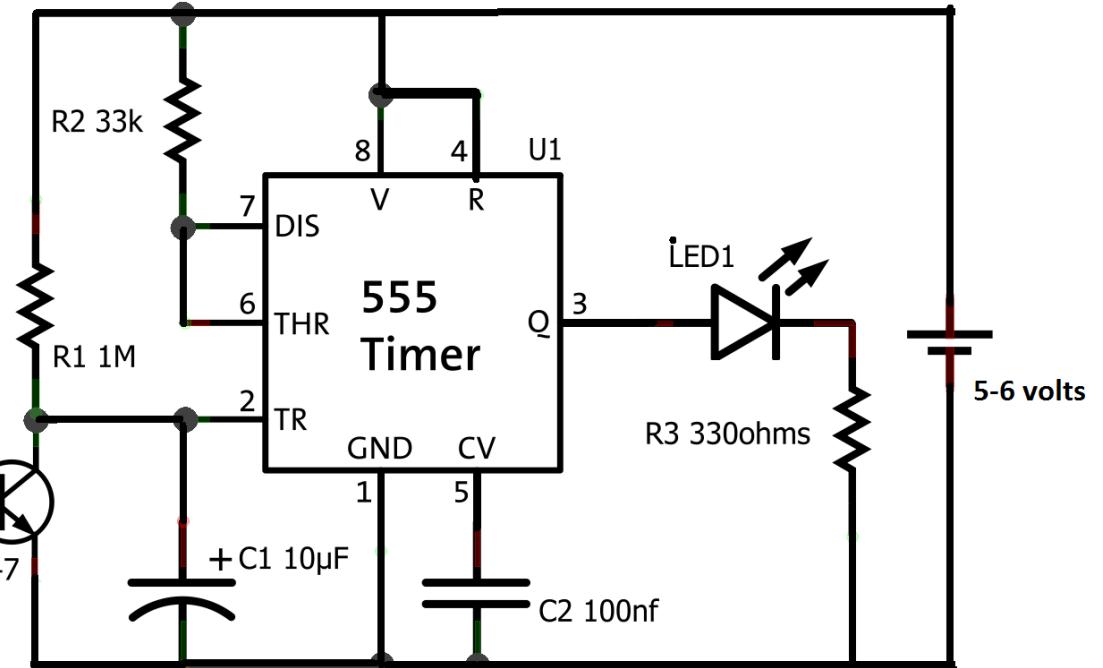
Step3: Assemble all remaining parts and insert the batteries at the end

Step4: After battery is connected, test the circuit by touching wire, to check if LED lights up . If it didn't light up check all the connections again.

Touch Plate



Some Parts of this project are available in Video CD ROM



○ **Sensitive Touch Switch**



MY Kit Panel for -Touch Switch - Lets assemble the circuit on MY Kit project kit. Please refer the figure on the right to identify the correct design from panels.

7.5 Timer

Timers are very useful gadgets in day to day life. When you forget something on gas, timer can remind you about it. Or when you forget to switch off geyser, heater etc, timer can always alert you to do so.

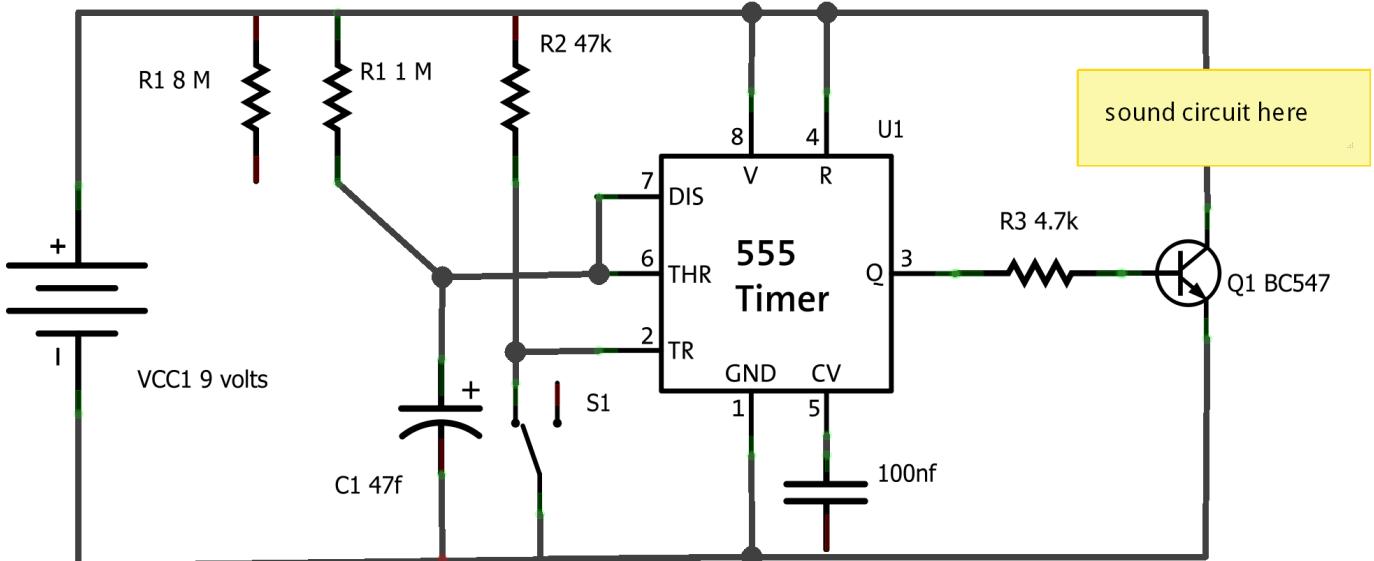
This circuit can be calibrated to adjust timings from a few seconds to a few minutes. Just increase R1 resistance by adding more Mega ohm (up to $40M\Omega \sim 30$ mins) resistances in series and you will get more time delay.

If you observe this circuit also uses a melody circuit along with timer circuit. We have already created melody circuit in previous project. You may refer previous circuits.

Materials:

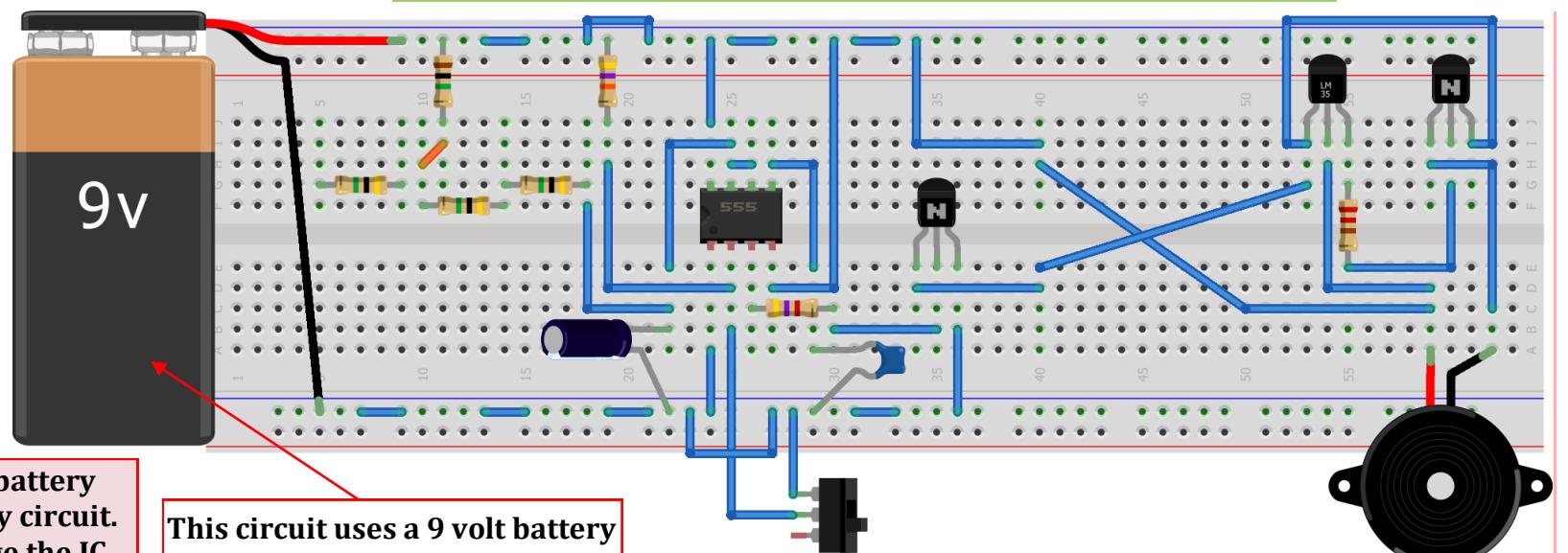
$1M\Omega/4M\Omega$ resistances, 1 - $4.7k$, 1 - $47k$, 1 - IC555, 1 - $47\mu f$, 1 - $100nf$, 1 - BC547

Step1: Assemble all the components of melody circuit first and test it with a 6v battery.



Made with Fritzing.org

Tip: See Appendix I to see resistance calculations for $4 M\Omega$ resistor.



Made with Fritzing.org

Step2: Assemble the components of timer circuit now and connect melody circuit with timer as shown in breadboard diagram.

Step3: Assemble all remaining parts and insert the batteries at the end.

Step4: You can change the wire contact connecting R1 and connect it to R2 to increase timing. In breadboard diagram, 3- 4M Ω resistors are used and current connection is using only 2 of them.



Timer project panel for MY Kit

7.6 Continuity Tester

This is a very useful circuit which can be used to test faulty appliances, it can detect continuity of any appliance. Every electric appliance is having an internal resistance, if its working fine. And we can measure this resistance using this circuit, It can measure up to 220k ohms of resistances. It just produces a sound to confirm connectivity.

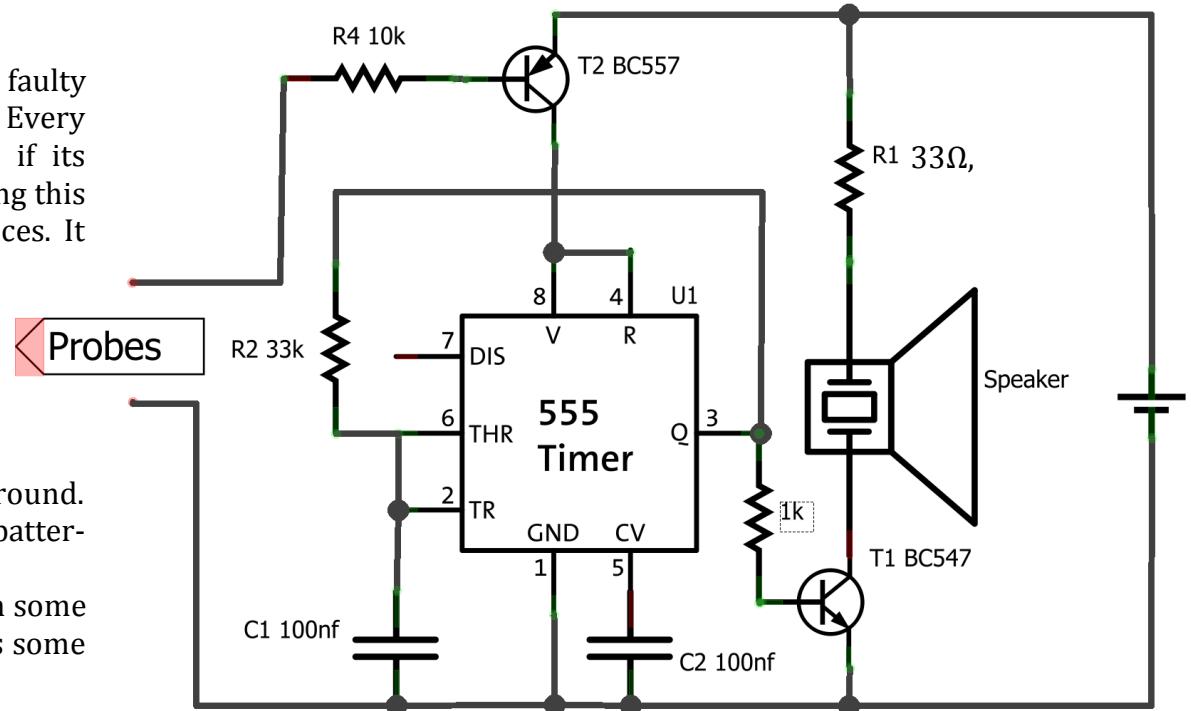
Materials: 1 - $33\text{k}\Omega$, 1 - $10\text{k}\Omega$, 1 - 33Ω , 1 - $1\text{k}\Omega$
1 -BC557(PNP), 1 -BC547 (NPN), 2 - 100nf , 1 - IC555

Find materials at : www.hobbyelectronics.in

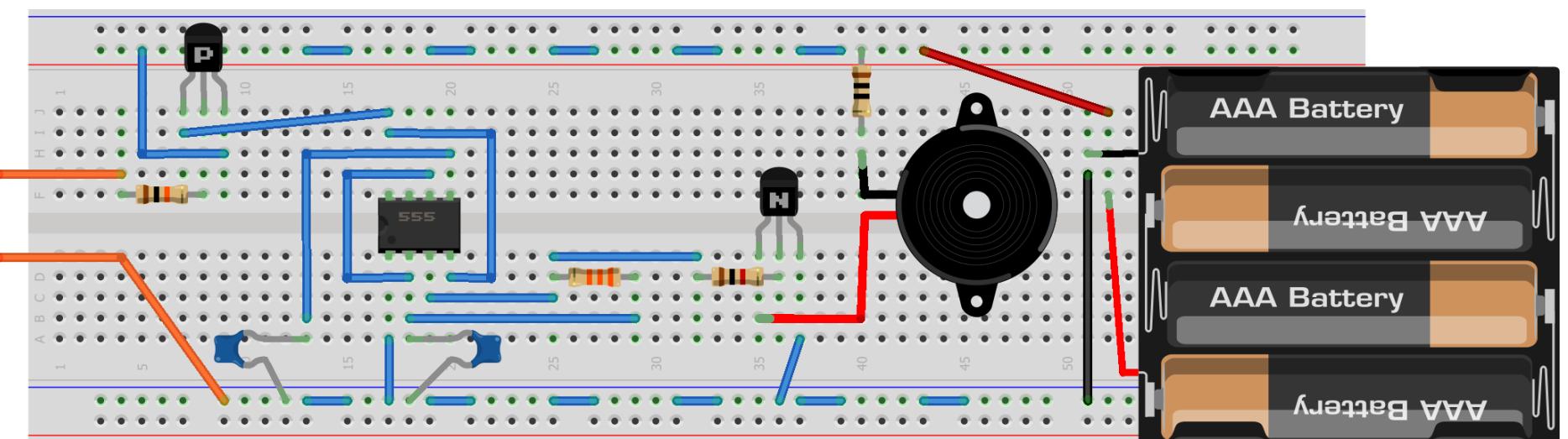
Step1: Ensure all the pins of IC are properly inserted.

Step2: Ensure that electrolytic capacitor is right way round.
Step3: Assemble all remaining parts and insert the batteries at the end

Step4: After battery is connected, test the circuit with some appliance like an adaptor. And see if circuit produces some sound.



Made with Fritzing.org

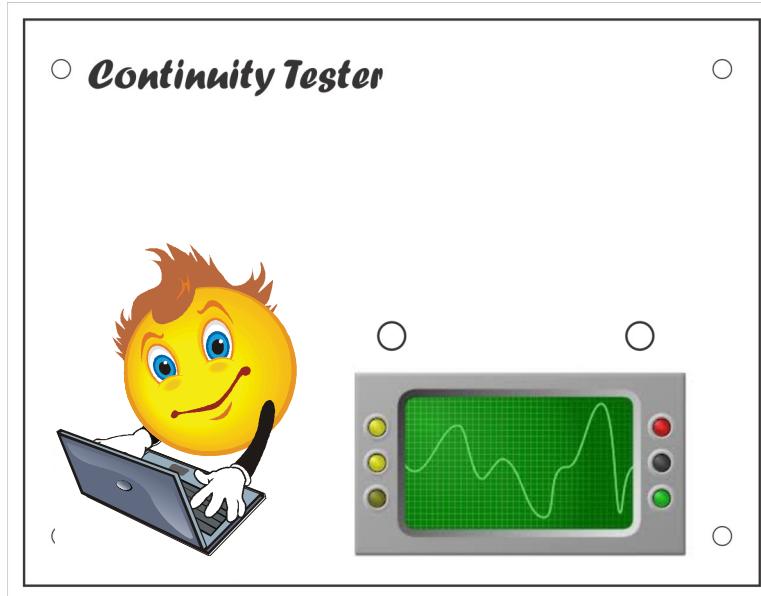


Made with Fritzing.org

Step2: Assemble the components of timer circuit now and connect melody circuit with timer as shown in breadboard diagram.

Step3: Assemble all remaining parts and insert the batteries at the end.

Step4: You can change the wire contact connecting R1 and connect it to R2 to increase timing. In breadboard diagram, 3- 4M Ω resistors are used and current connection is using only 2 of them.



Continuity tester project panel for MY Kit

7.7 Knight Rider

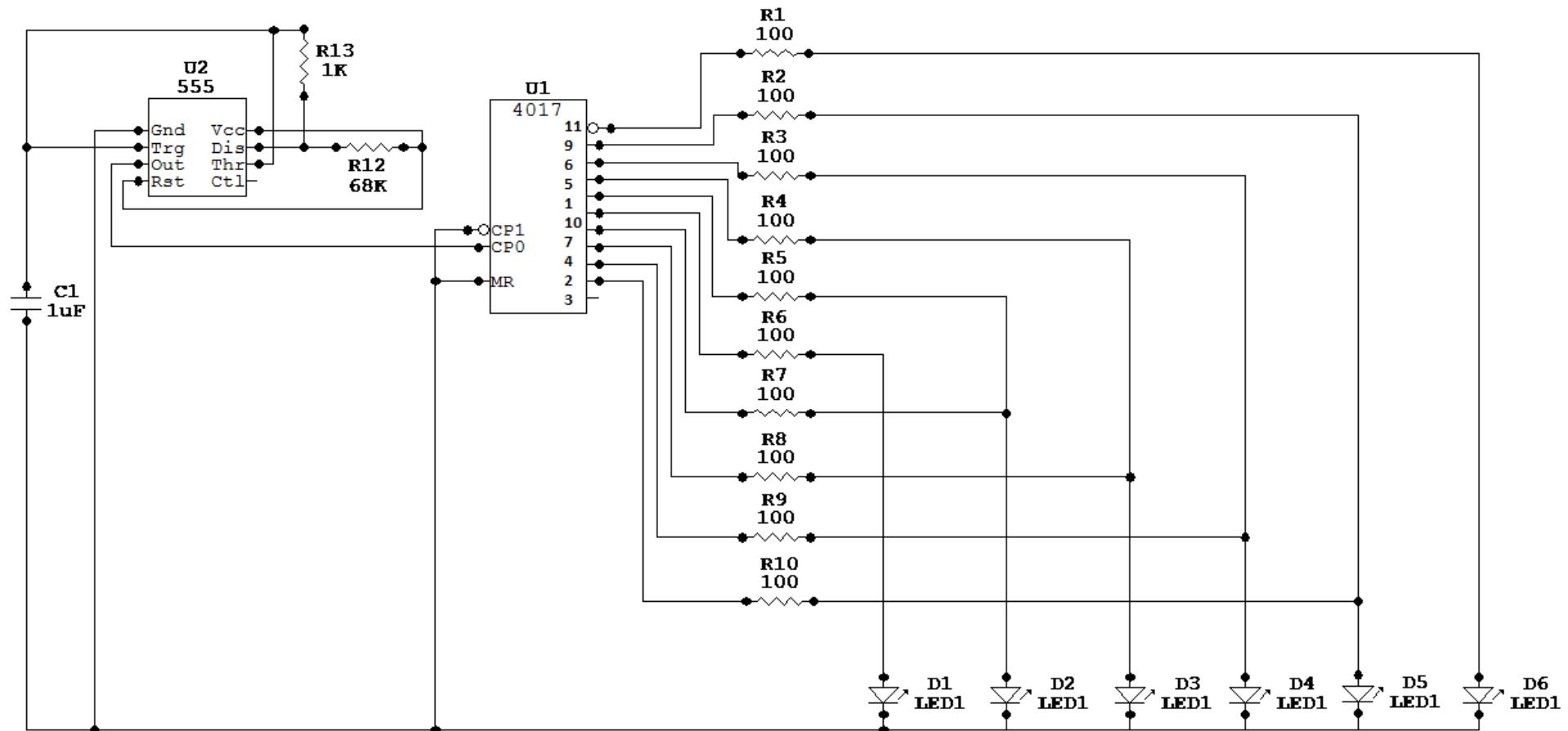
A treat for eyes, this circuit produces a very nice visual effect by circularly turning On and Off LEDs in a row. LEDs D1 to D6 starts up one by one producing a running effect and when LED D6 is On, All LEDs go Off for once and again starts up from LED D6 to D1.

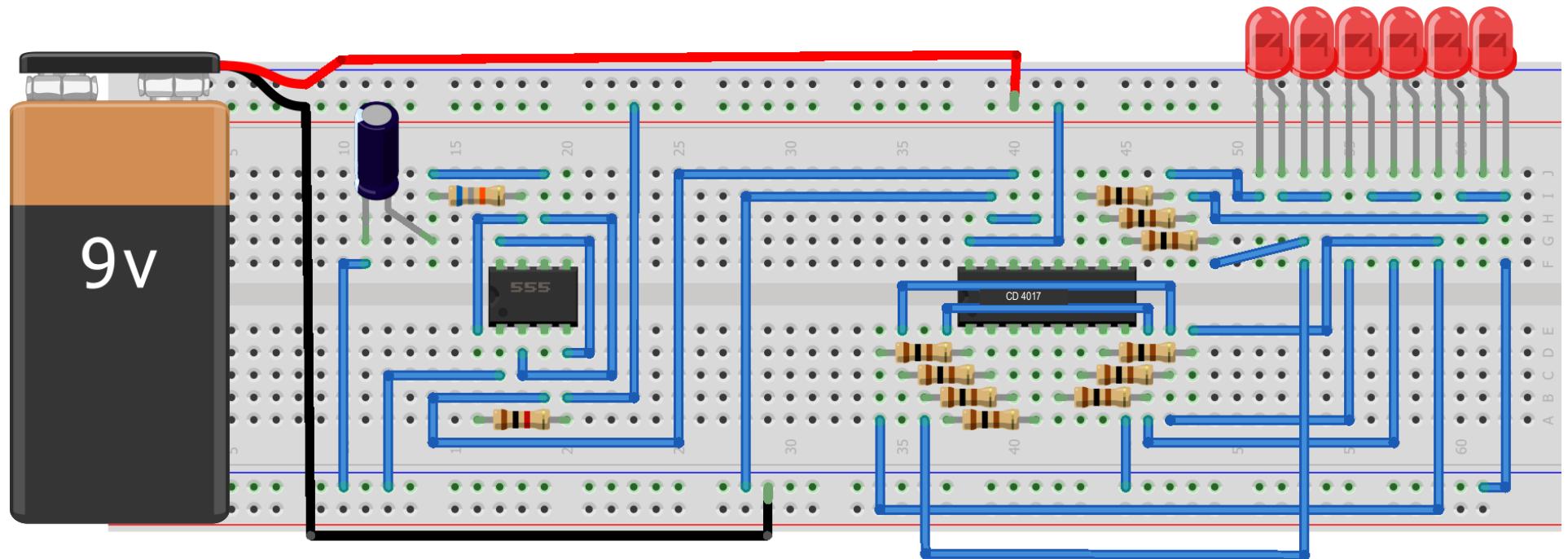
Materials: 1 - $68\text{k}\Omega$, 1 - $1\text{k}\Omega$, 10 - 100Ω , 1 - $1\mu\text{f}$, 1 - IC555, 1 - IC4017

Find materials at : www.hobbyelectronics.in



Some Parts of this
project are available
in Video CD ROM





Made with Fritzing.org

Step1: Ensure all the pins of IC are properly inserted.

Step2: Ensure that electrolytic capacitor is right way round.

Step3: Assemble all remaining parts and insert the batteries at the end.

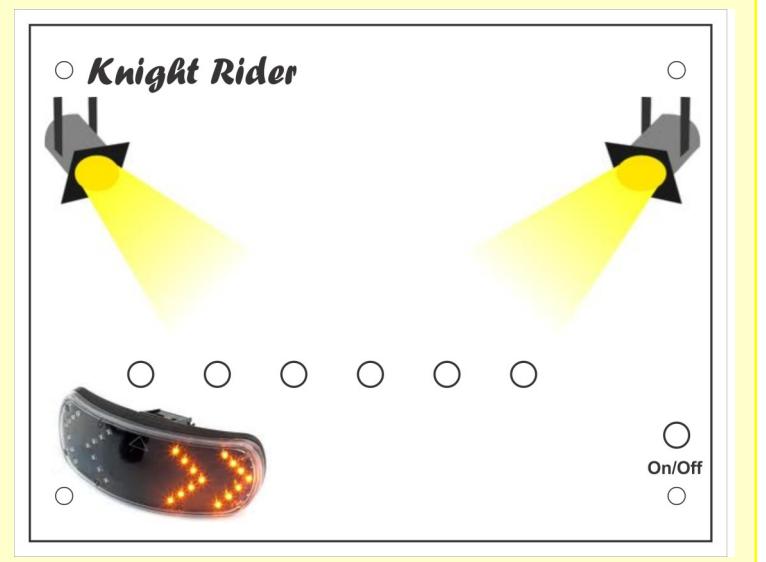
Step4: After battery is connected, test the circuit with some appliance like an adaptor. And see if LEDs are blinking fine or not.



More Ideas -

You can transform the previous circuit to a bike turning indicator circuit, A practical and useful circuit which can be used in bikes.

Lets assemble the circuit on MY Kit project kit. Please refer right hand side figure to identify the correct design from panels. Use LED holders to assemble LEDs on MY Kit.

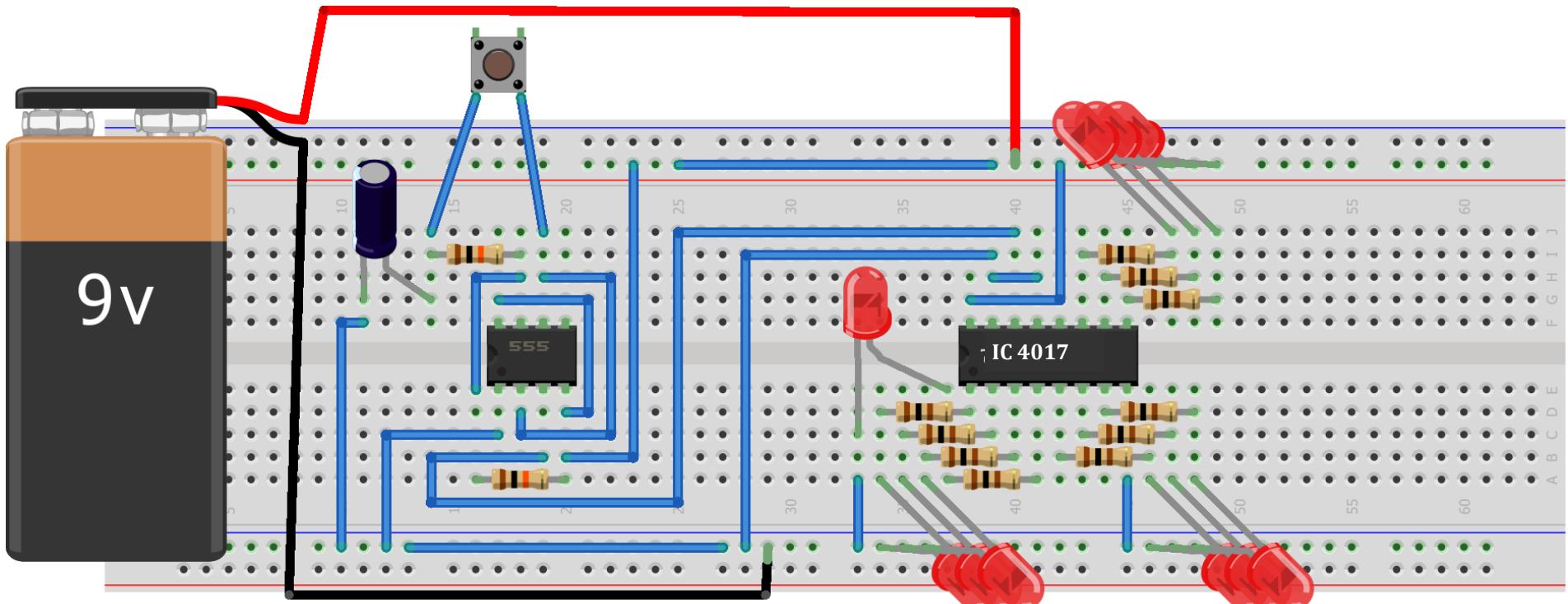


7.8 Cricket

Time to play some cricket now. The game play rules are quiet straight forward, One turn by each player, When he/she will press button, One of the random LED light will light up. You can play up till you are not out.

This is quiet a simple cricket, IC 555 generates a pulse which is fed into IC 4017 and it activates a random LED.

Materials: 1 - $68\text{k}\Omega$, 1 - $1\text{k}\Omega$, 10 - 100Ω , 1 - $1\mu\text{f}$, 1 - IC555, 1 - IC4017



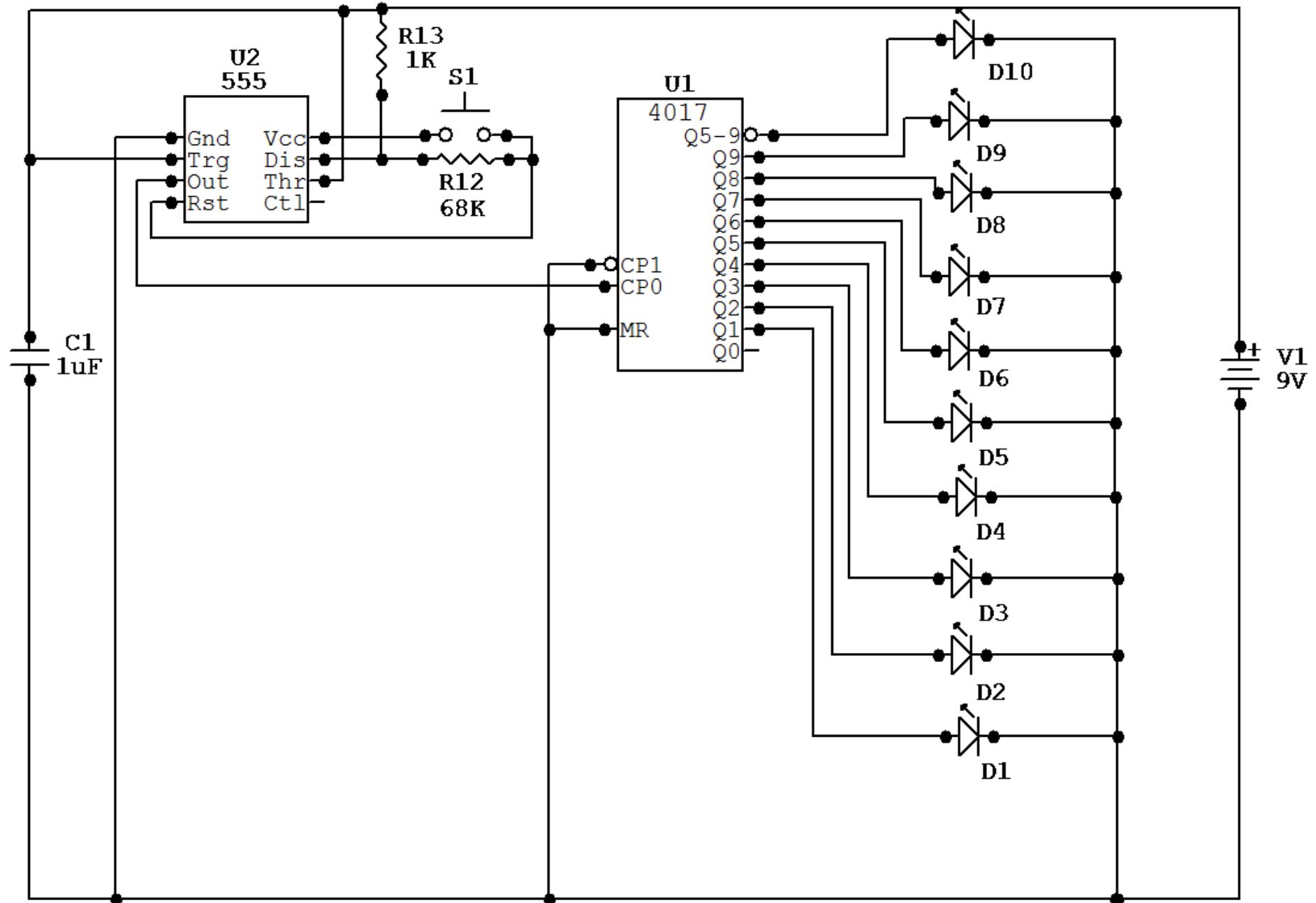
Made with Fritzing.org

Step1: Ensure all the pins of IC are properly inserted.

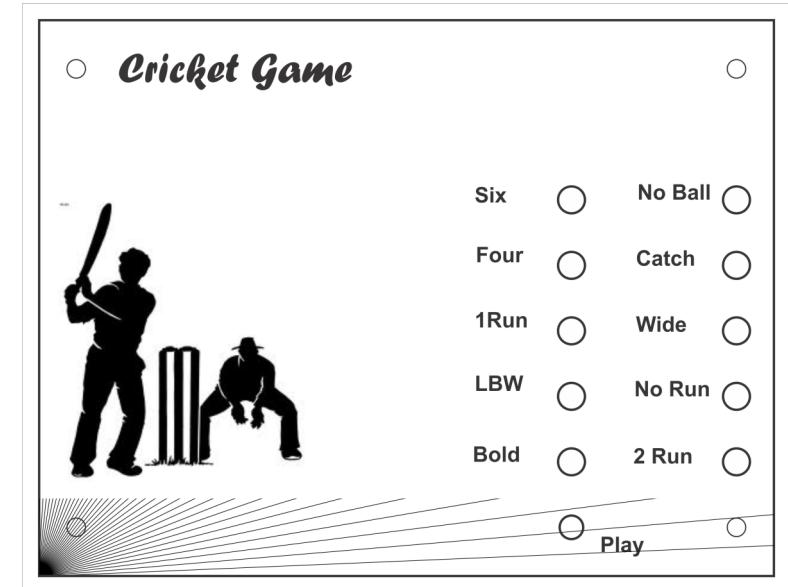
Step2: Ensure that electrolytic capacitor is right way round.

Step3: Assemble all remaining parts and insert the batteries at the end

Step4: After battery is connected, test the circuit with some appliance like an adaptor. And see if circuit produces some sound.



Lets assemble the circuit on MY Kit project kit. Please refer above figure to identify the correct design from panels. Use push buttons and assemble them on MY Kit. You should use nuts and washers to fit push buttons on MY Kit



7.9 Multipurpose circuit

This is a very useful circuit which can be used to test faulty appliances, it can detect continuity of any appliance.

Every electric appliance is having an internal resistance, if its working fine. And we can measure this resistance using this circuit, It can measure up to 220k ohms of resistances. It just produces a sound to confirm connectivity.

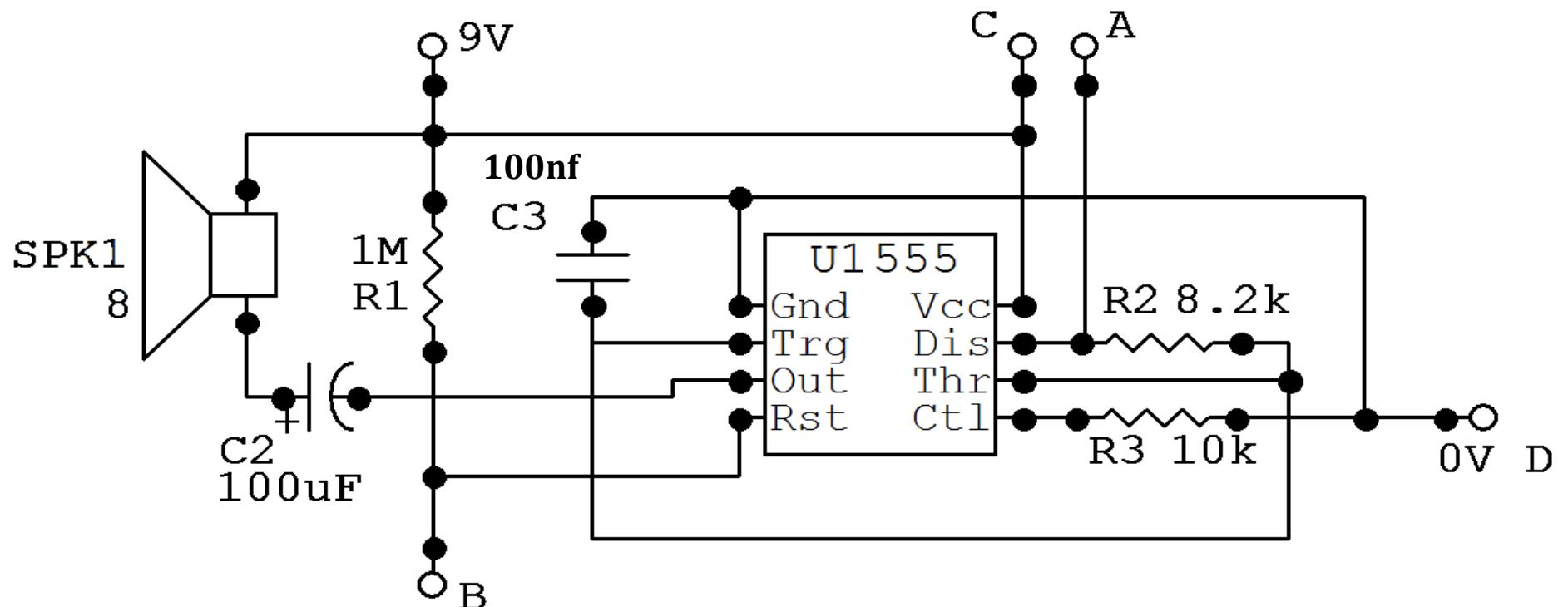
Materials: 1 - $1M\Omega$, 1 - $10k\Omega$, 1 - $8.2k\Omega$, 1 - $100\mu F$, 1 - $100nf$, 1 - IC555

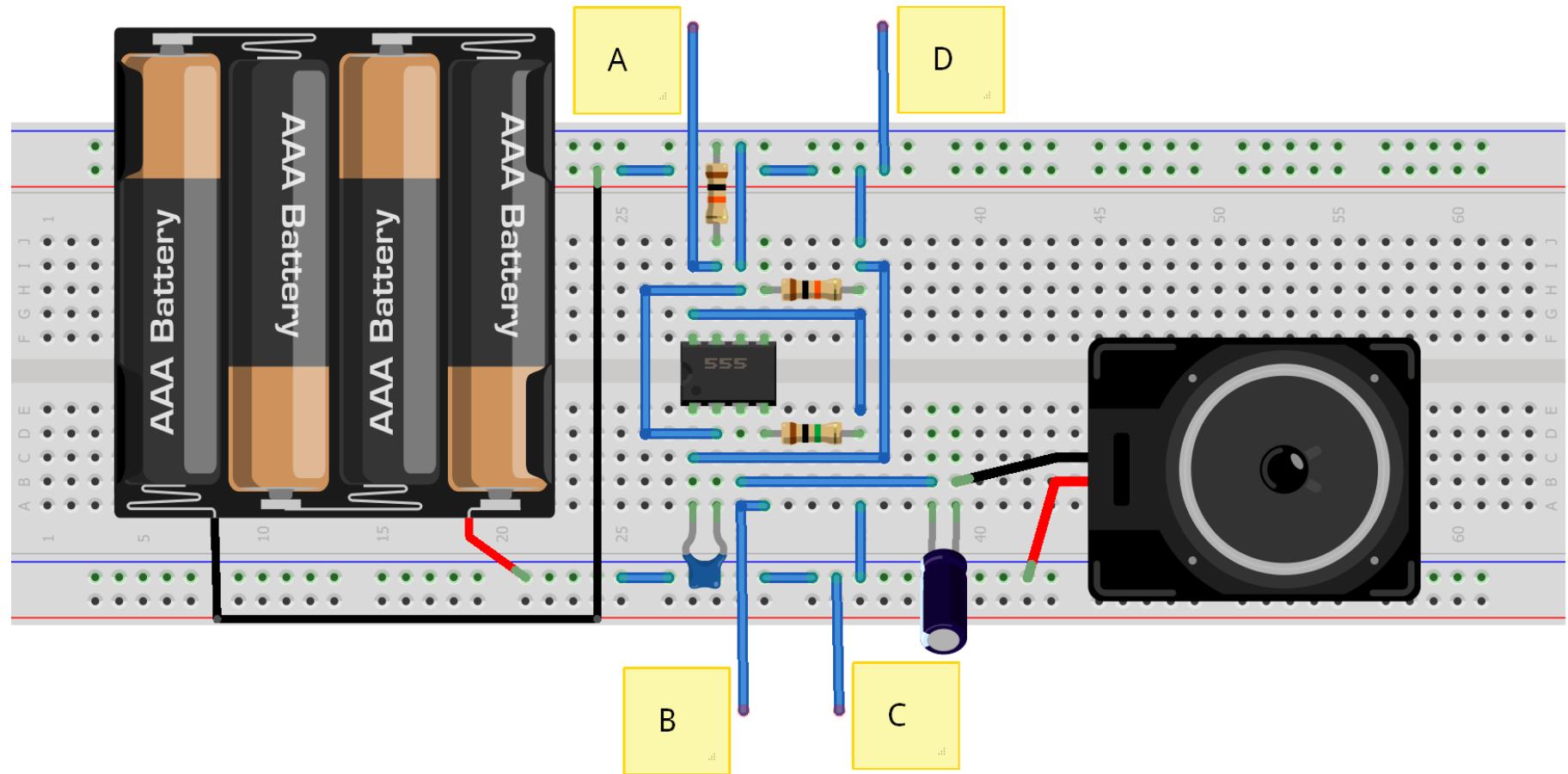
Step1: Ensure all the pins of IC are properly inserted.

Step2: Ensure that electrolytic capacitor is right way round.

Step3: Assemble all remaining parts and insert the batteries at the end

Step4: After battery is connected, test the circuit with some appliance like an adaptor. And see if circuit produces some sound.





Made with Fritzing.org

Lets use this circuit now and make other circuits from it.

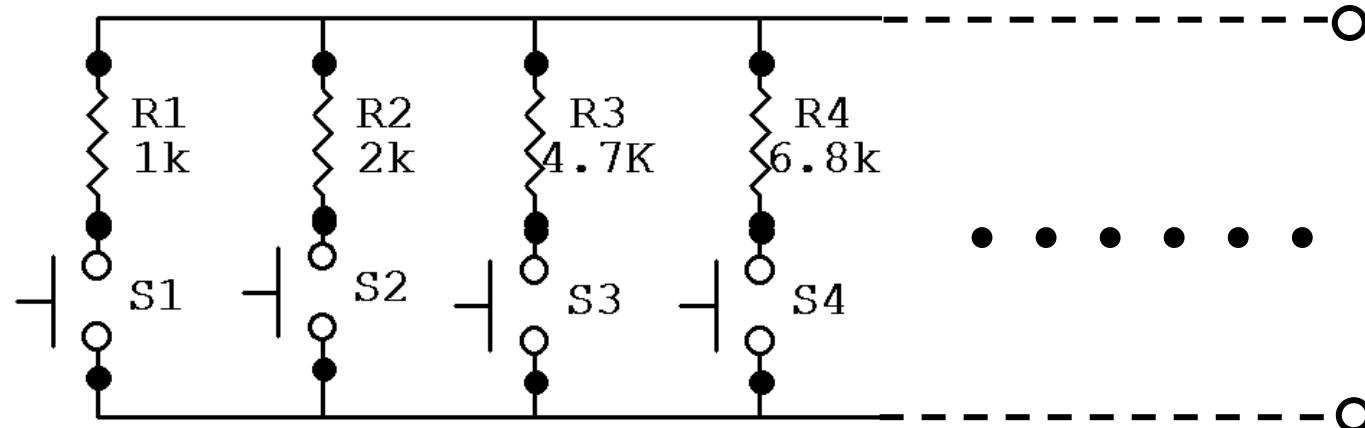
Electronic Organ:

Method:

Connect different resistors between A and C as shown in Figure

Instructions:

Each push button on being press gives a different musical note. You can experiment with the resistors also to change notes of sound.



Tip:

It happens sometimes that required resistance values are not available in market as only some standard values are manufactured. To make your own desired resistance values please see "Resistance Calculations" in Appendix I (last pages of this book).

Method:

Light Operated Alarm:

Connect a 20k~30k resistor between A and C, and LDR between B and C and a 100k preset between B and D

Dark Operated Alarm:

Connect a 20k resistor between A and C, an LDR between B and D. and a 100k preset between B and C

Rain Alarm:

Connect a 22k resistor between A and C and a 100k resistor between B and C. Connect B and C to probes.

Burglar Alarm:

Connect a 20K resistor between A and C and a 10 k resistor

Instructions:

The sound will come up when LDR will be brought to light and the sensitivity needs to be set by preset

The alarm sounds when LDR is brought in darkness and stays off in light. Sensitivity can be adjusted by preset.

When rain water will fall on probes the alarm will sound.

Between B and C.

Connect the ends of the fencing wire to Band D. The alarm operates when this wire is broken.

Continuity tester:

Connect 1k resistor between B and C

Connect A and C to test probes. The circuit will generate sound as an indication of continuity

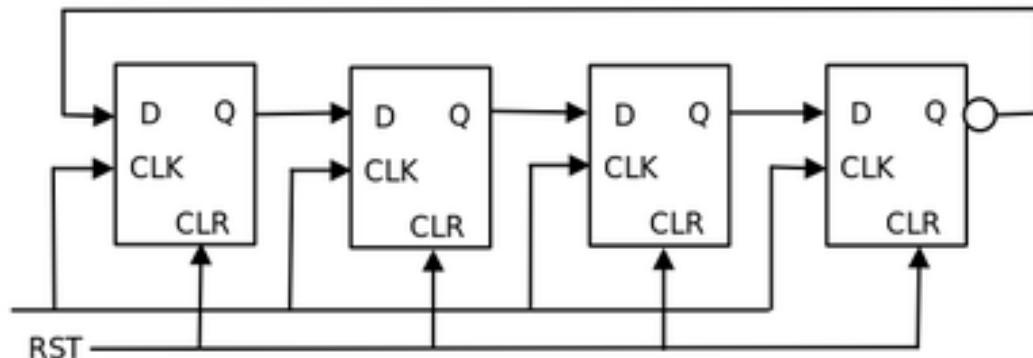
7.10 Johnson Counter

We have just created circuits using IC 4017, but we didn't know about the inner circuit or working of IC. In this project we will actually learn what is inside IC 4017 and how it works . We will also make a project that will actually demonstrate the working of IC.

IC 4017 is actually a counter IC, which counts from 0 to 8 and back again. we generally call this counter as ring counter because it feed back the output to its input. A special case of ring counter in which the complement (opposite) of output is fed to input is Johnson counter. IC 4017 is actually a Johnson counter, It is the reason why we used it in running lights.

How counters are made using electronic components?

Just describing a IC as counter doesn't answer the complete question. We now know that IC 4017 is a counter IC. But how counters are made using transistors and others electronics components is the real question. To answer this we need to learn the internal circuit diagram of IC4017 . Below shown block diagram displays the flip flops used to make a counter.



Johnson Counter Block diagram

Output of each flip flop is fed into the input of another and complement output of last flip flop is fed into first one. This is what makes it a ring counter. The truth table of ring counter is shown here on right side-

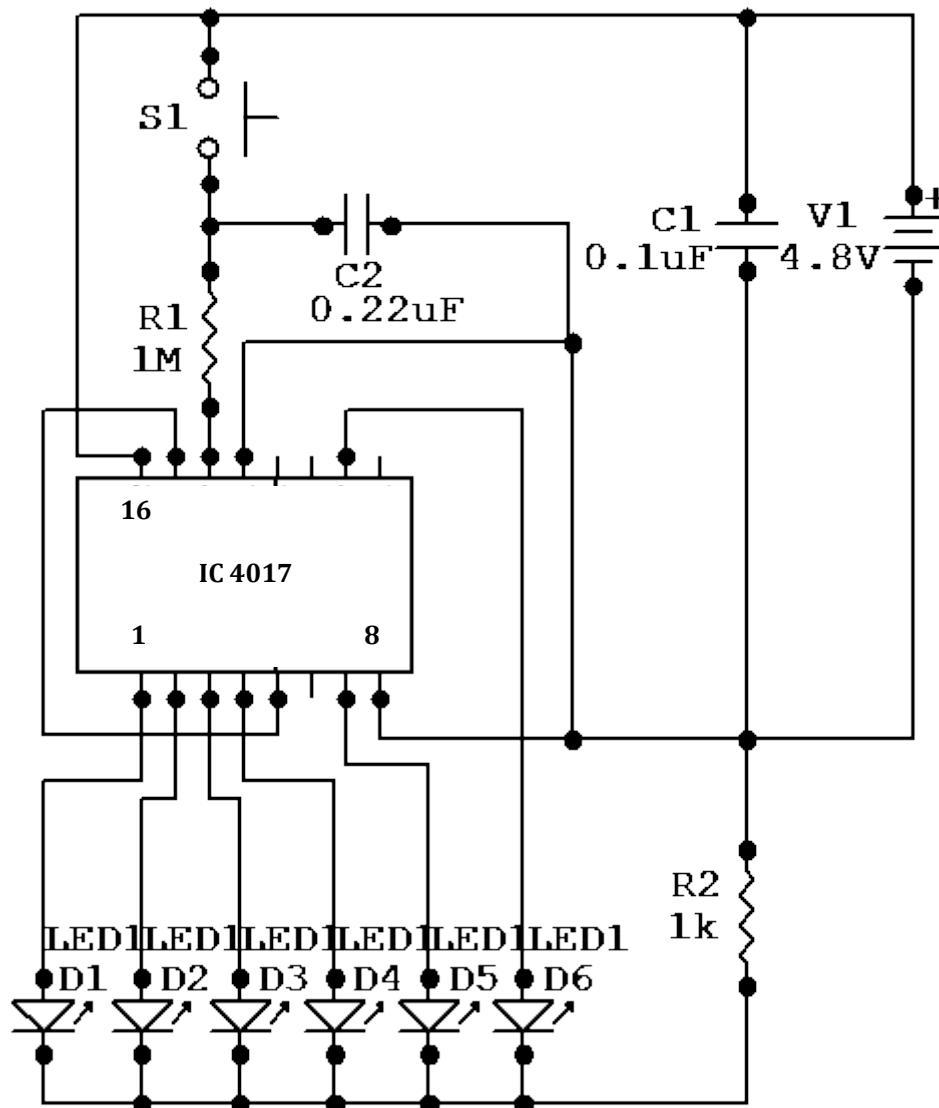
Application of Johnson Counters -

They are important and used in hardware logic design to create state machines (Mini logical machines—may call as mini computers)

As we have already learnt about flip flops. Here we see there practical application is circuits. The flip flop used here is D type, which is similar to RS flip flop which we designed in previous chapters.

Twisted ring/Johnson counter				
State	Q0	Q1	r2	Q3
0	0	0	0	0
1	1	0	0	0
2	1	1	0	0
3	1	1	1	0
4	1	1	1	1
5	0	1	1	1
6	0	0	1	1
7	0	0	0	1
0	0	0	0	0

We will now make one project to illustrate the working of a Johnson counter. In this project we will use IC 4017 and we will apply manual inputs to this IC, instead of an automatic input which we used in previous circuits (we before used IC 555 as a oscillator to apply 0...1...0 inputs).

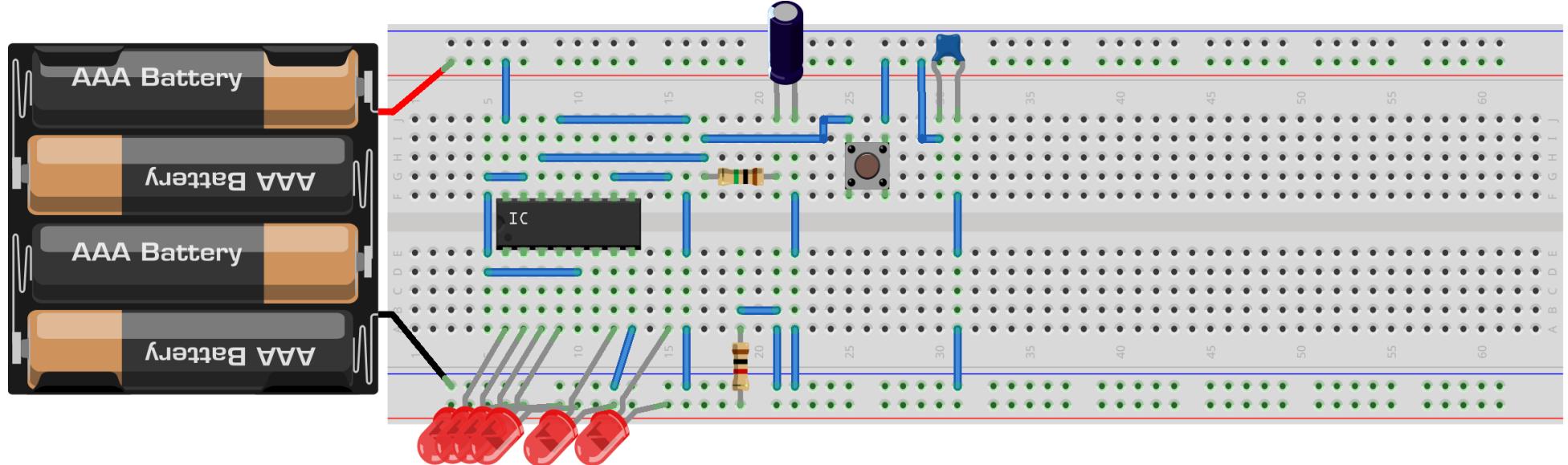


Step1: Ensure all the pins of IC are properly inserted.

Step2: Values of ceramic capacitor is not important and both ceramic capacitors can have same value.

Step3: Assemble all remaining parts and insert the batteries at the end

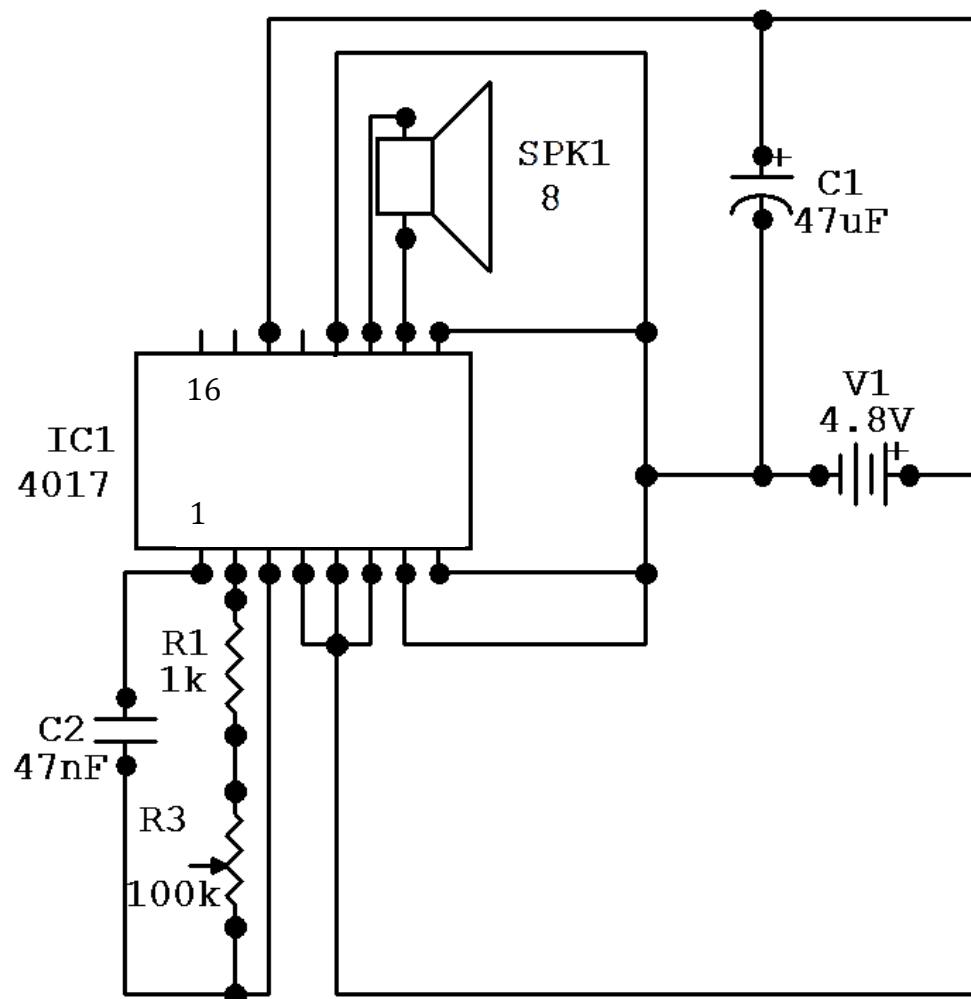
Step4: After battery is connected, test the circuit by pressing the push button. On pressing button LEDs should light up and light Off in a sequence. If LEDs are not lighting up. Disconnect batteries immediately and verify circuit with diagram again. An incorrect connection may damage IC quickly.



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7.11 Mosquito Repeller

Here's a different project, In this project we are going to design a high frequency audio signal generator circuit, this high frequency sound can't be heard by human ears, but it can be heard by mosquitoes and other insects. This sound irritates them and they try not to come close to this sound. The intensity of sound produced by this circuit will be enough to repel mosquitoes from 1-2 meters around it. However more intense sound is required to actually repel them away from room. At least this is good for a start.



This circuit uses a IC 4017 decade counter. We have already made few projects using this IC. In this circuit the duty cycle of count has increased up to a level that it becomes inaudible and very high frequency. This high frequency output is then fed into speaker. The output frequency can be adjusted by adjusting ceramic capacitor connected at pin 1 of IC and variable resistance connected at pin 2 of IC.

Steps:

- Step1:** Place all the components on breadboard.
- Step2:** Check the polarity of electrolytic capacitors, Ceramic capacitors don't have any polarity,
- Step3:** After assembling all components connect battery and check if there is sound coming out from speakers. It should be very low sound which should come while starting or closing circuit.
- Step4:** If no sound is coming from speakers, you may try to replace ceramic capacitor by 1uf electrolytic capacitor and check if sound is coming out from speaker, This is just to test the circuit, Once you are confirm that circuit is sounding, you may place the ceramic capacitor back in circuit.

Note: To make a 100k variable resistor, you can join five 10k variable resistors and a 47k resistor, all in series.

7.12 Rising-Falling Siren

In previous projects, we were using IC UM66 to create melody. However UM66 provides a ready made tune stored in chips memory. In this project we are actually creating sound effect by using two 555 ICs. Output of one IC is fed into another which actually creates a melody raising and falling siren like sound.

If we observe this circuit closely, we will be able to understand that this circuit is very easy to understand and not at all complex as it looks like. Lets dissect the circuit into two parts. The first 555 IC in this circuit is a complete unit in itself, This unit generate a low frequency oscillation (because of high value capacitor connected in input pin 2, The higher the value of capacitor the lower will be the frequency), This low frequency output is fed into second unit (second IC). Second IC circuit is a high frequency oscillator value capacitor is connected in input which fed its output into speaker and creates a sound tune, this tune is constant. However when first unit outputs its signal into second unit, The combined output is a varying tune. Rising and falling tune. So we get a sound effect.

Steps:

Step1: Place all the components on breadboard.

Step2: Check the polarity of electrolytic capacitors, Ceramic capacitors don't have any polarity,

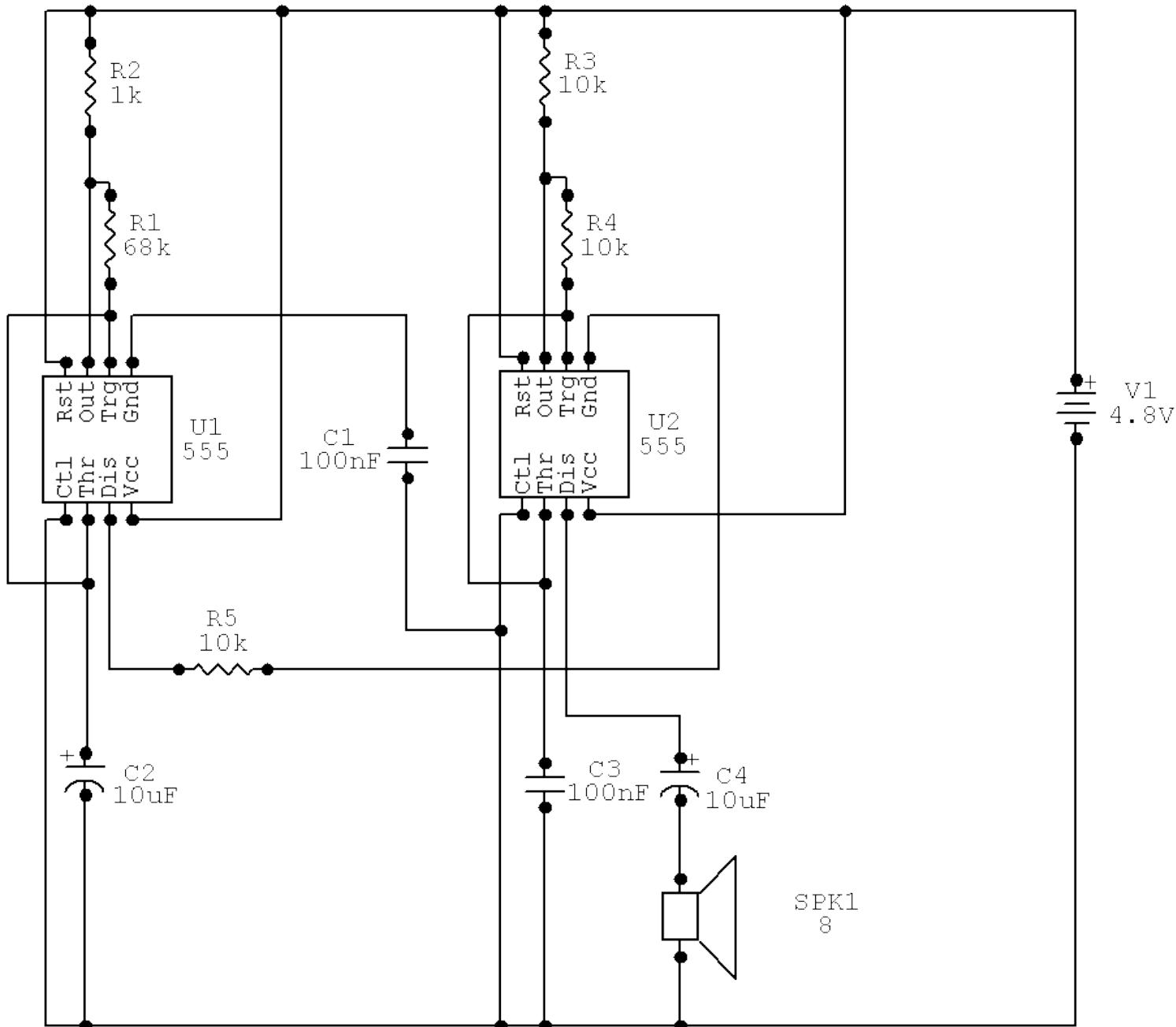
Step3: After assembling all components connect battery and check if there is sound coming out from speakers.

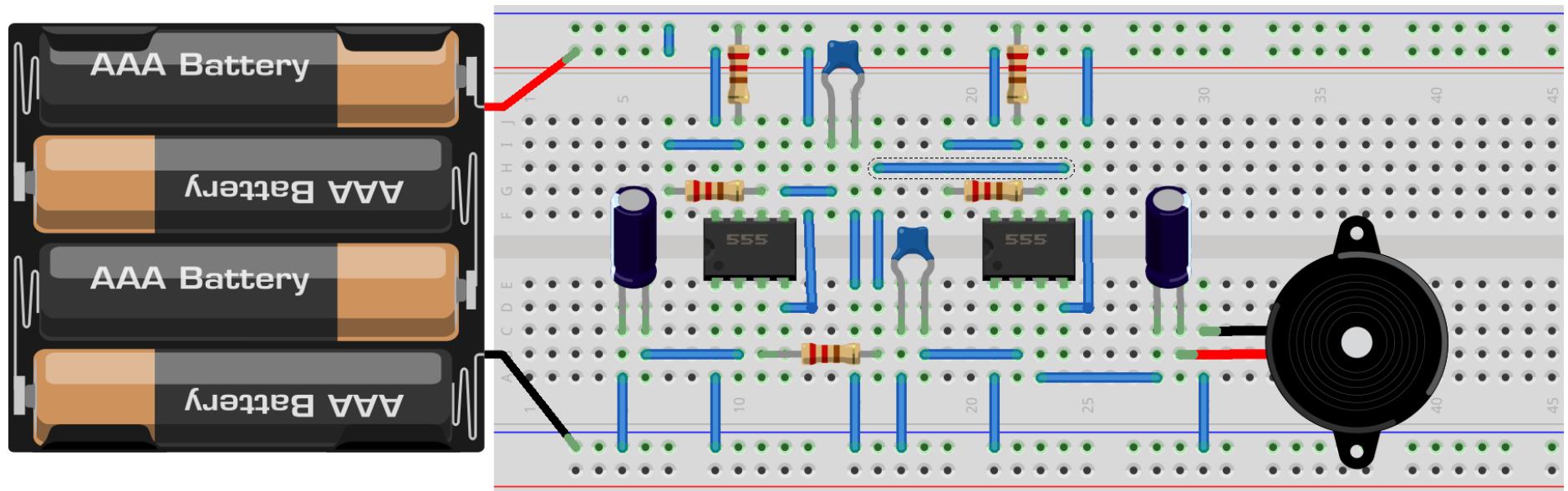
Step4: If no sound is coming from speakers, disconnect the batteries immediately. And verify all connections again with circuit diagram.



More Ideas

Try to change the capacitance of ceramic capacitors, you can do this by adding more ceramic capacitors in parallel or serial (refer appendix for capacitor calculations). By changing capacitor a change in tune output will occur.





8. Infrared Projects

In this section we will make :

- 8.1 Simple Infrared Receiver
- 8.2 Infrared Transmitter and Receiver



8.1 Simple Infrared Receiver

Lets start the exciting world of infrared light based circuits. Infrared light is not visible to us, as its frequency is more then the visible light. It is quite interesting that cameras can see this light and there are special cameras and sensors which can take images by using infrared light (You can Google infrared images to see how different they look then normal pictures). In this project we will use a TV remote control to activate this circuit and light up the LED.

In this book we are using an infrared sensor module called as TSOP 1738/1838 which detects infrared light of a particular frequency. we will be making several projects based on this infrared sensor. It is exciting to know how infrared light is very useful, some the application of infrared light is as below -

- 1) Remote control, A general TV remote uses infrared light transmitter. You may have noticed a LED in front part of remote control and it never lights up. It actually lights up with invisible light :) strange no?
- 2) Infrared based data transfer. This was very popular method of transferring data between mobiles up till Bluetooth has taken its place.
- 3) Infrared cameras - These special cameras are able to capture infrared light and produce very different images.
- 4) Infrared based security systems - Infrared beam and sensor can be used to make burglar alarms etc



IR image of a Cat, Cold parts look blue, white and hot parts will look yellow, red

What is this TSOP ?

TSOP is a Infrared receiver module - This small component includes a infrared sensitive diode and a pre-amplifier (To amplify the small signals from diode). The three pins of this module are ground, Vcc (positive) and Output. The output of this module varies according to a particular frequency of infrared light falling on it, and frequency is determined by last two digits of the number 1738, so 38khz is the frequency at which this module will get activated and send output signals.

It is important to note that the output of TSOP is low when it detects an infrared signal and output is high when it doesn't detect any signal. The output will also be high (no detection) when it receives a very low or high frequency of infrared light, then it should receive.

One of the benefits to use this module instead of using normal IR sensitive LED is that this module is not affected by ambient light. Also TSOP works on a particular frequency.



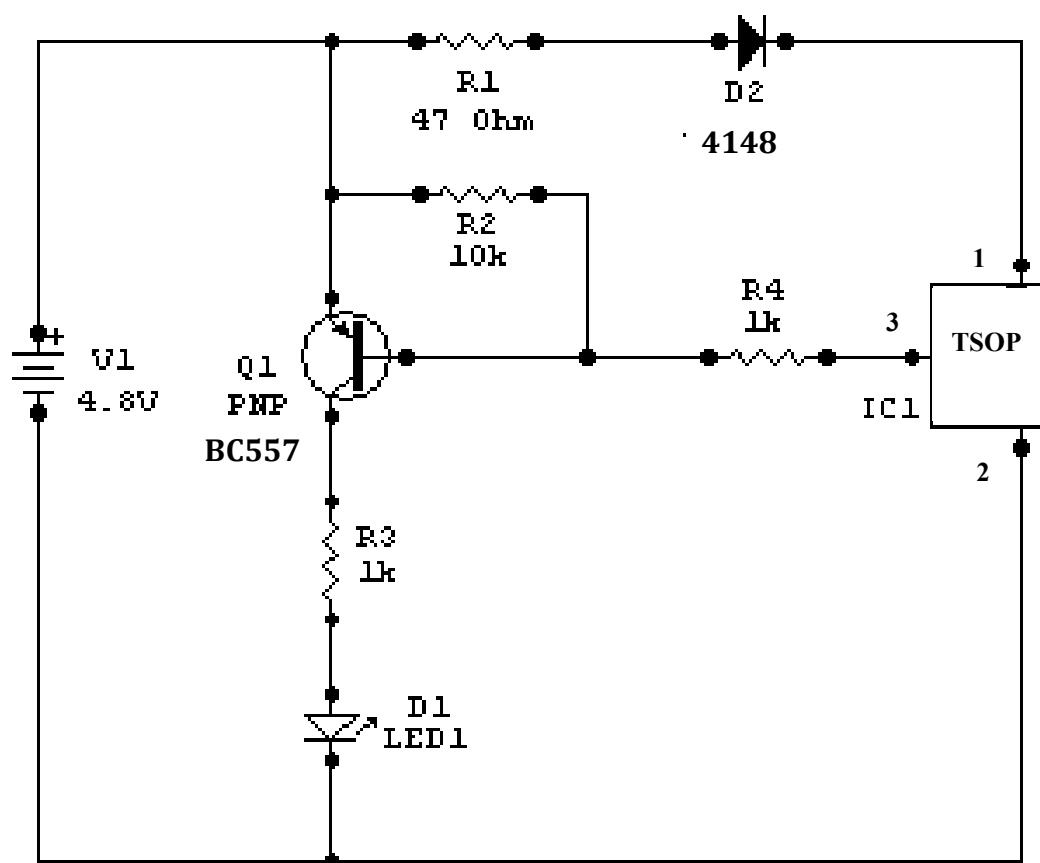
TSOP 1738

Some reference text on Infrared light from Wikipedia -

Infrared (IR) light is electromagnetic radiation with longer wavelengths than those of visible light, extending from the nominal red edge of the visible spectrum at 700 nanometers (nm) to 1 mm. This range of wavelengths corresponds to a frequency range of approximately 430 THz down to 300 GHz. Most of the thermal radiation emitted by objects near room temperature is infrared.

Infrared radiation was discovered in 1800 by astronomer William Herschel, who discovered a type of invisible radiation in the light spectrum beyond red light, by means of its effect upon a thermometer. Slightly more than half of the total energy from the Sun was eventually found to arrive on Earth in the form of infrared. The balance between absorbed and emitted infrared radiation has a critical effect on Earth's climate.

For more knowledge on Infrared light and its uses and importance, please visit Wikipedia or Google other sites.

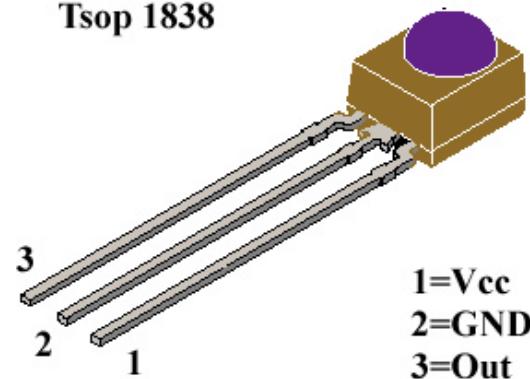


This circuit uses one PNP transistor which is acting as a switch, As we know that when a NPN (remember NPN) transistor's base is provided with a small voltage, It turns ON. In PNP transistor this happens also but instead of applying a positive voltage we need to ground the base terminal, so PNP turns ON when base is close to 0volts (grounded). This circuit uses this feature of PNP transistor and one another concept about Infrared sensor (TSOP) which we have just discussed, that sensor outputs no signal when it detects infrared light and it outputs 5v when it doesn't detect any infrared. So when we combine these two, we get a circuit which activates TSOP only when there is an infrared light and this in turn activates transistor with zero base voltage.

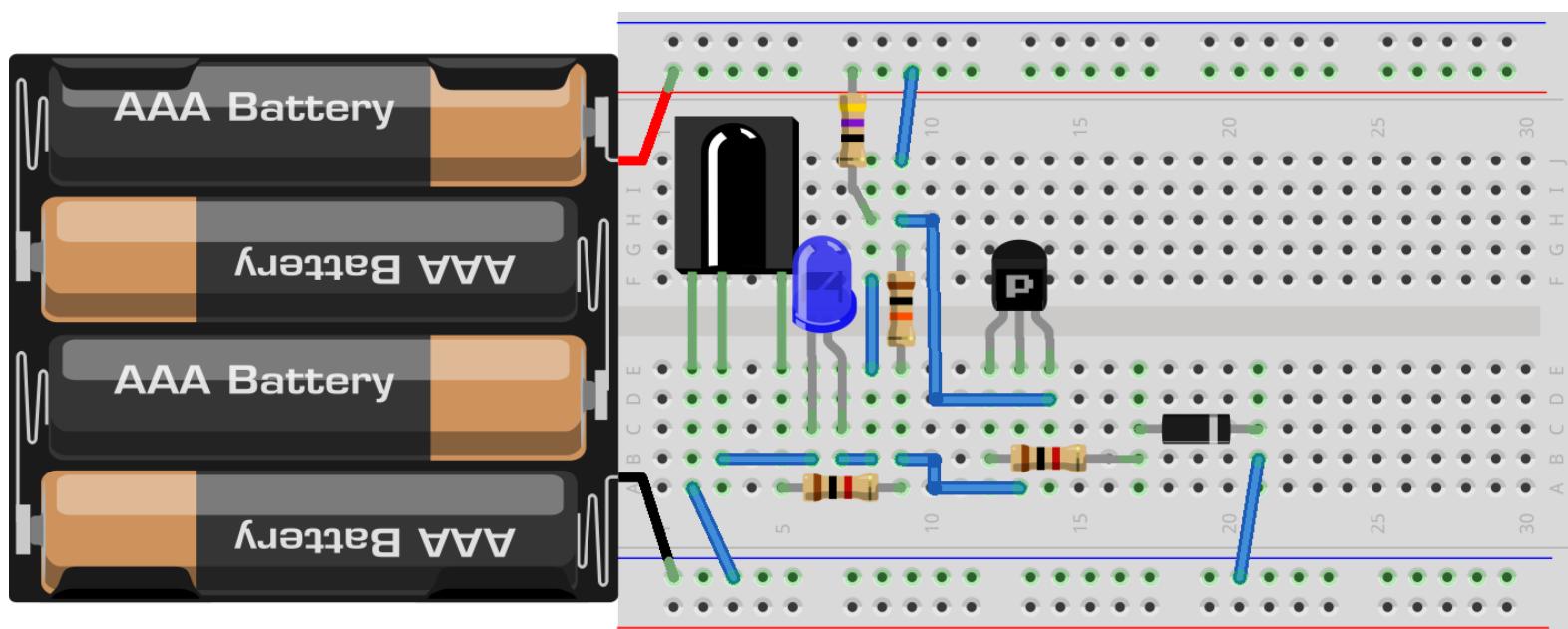
Steps:

- Step1:** Connect the components as shown in figure.
- Step2:** The pins of TSOP should identified correctly. Please refer figure on next page.

Tsop 1838



Step3: Connect the battery, after all components are assembled. Turn On the battery and check the circuit, You can use a TV/AC/DVD remote control to test this circuit.
Step4: Diode is optional and the circuit should work without it also.

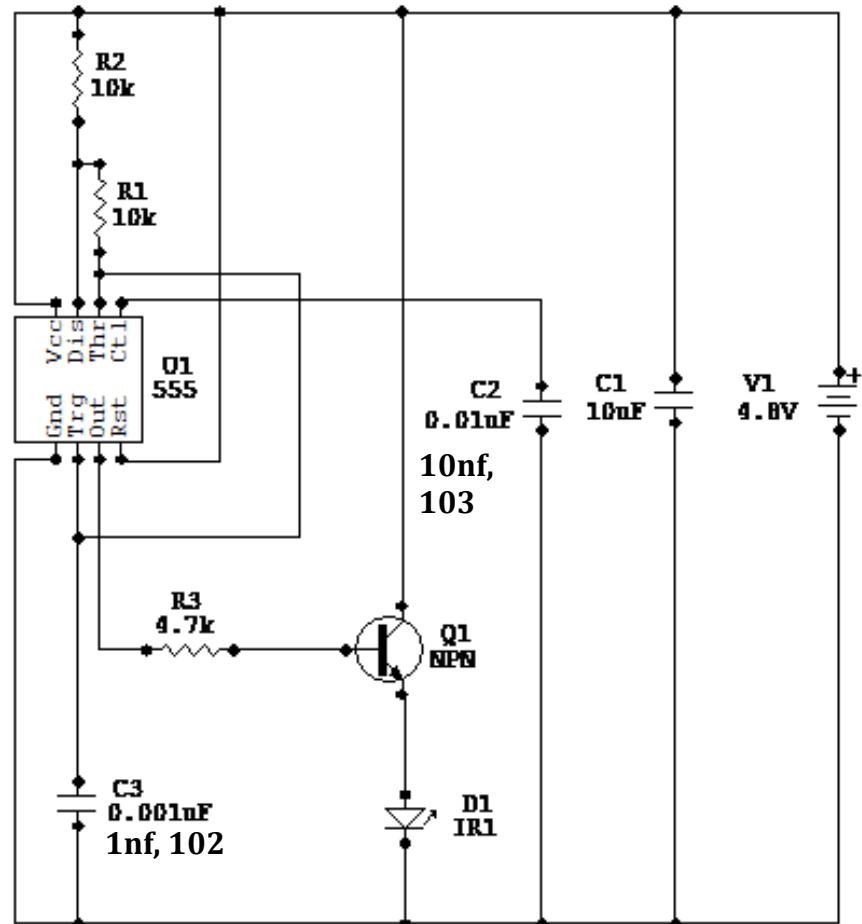


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8.2 Infrared Transmitter and Receiver

Are you fascinated with wireless technology, Does Infrared based wireless remote control for robots, cars, helicopter, TV excites you. If yes then this project is for you. In this project we will be making a complete remote switch with transmitter and receiver. A transmitter is a device that sends wireless signals in such a way that they can be interpret by intended listeners. Whereas a receiver is a device which listens to the transmitter. For a wireless communication to take place both transmitter and receiver should be of same frequency. In this project we are going to design a simple IR based transmitter and receiver which will operate at a frequency of around 38khz.

There are many possibilities with this circuit, you can convert this circuit into a remote controlled switch to control room lights. Or you may drive some your own circuit remotely by using this circuit. For all possibilities with this circuit, you may explore this circuit together with the circuits explained in 'circuit designing guide' chapter of this book.



Infrared Transmitter—

This circuit transmits IR waves of around 38khz, which when directed towards IR receiver circuit, It gets activate.

IC 555 is used here as a oscillator in astable multi vibrator mode. And it generates continuous oscillations.

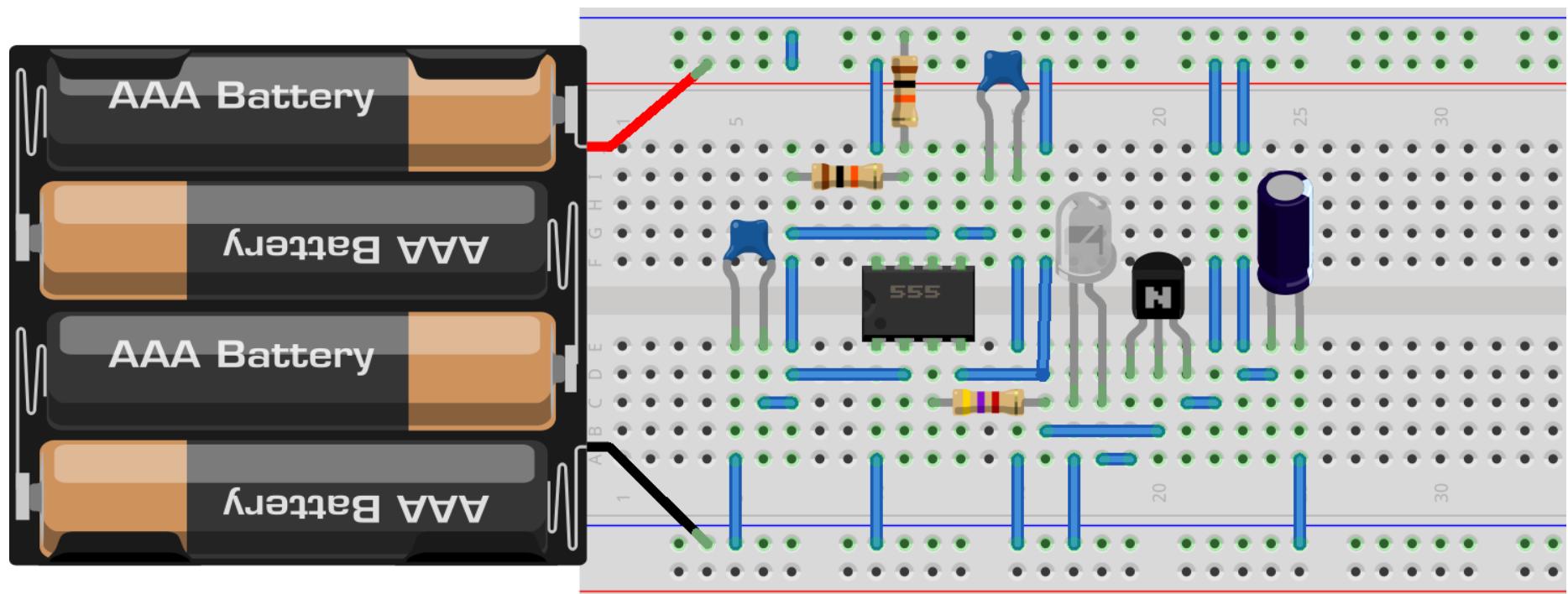
Steps:

Step1: Assemble all the components on breadboard.
Step2: Here we are using two different value of capacitors then that we have used before in previous circuits, 1nf and 10nf, there capacitor marking are 102 and 103 respectively. Please refer capacitor tables at the end of this book in Appendix.

Step3: When all the components are on breadboard, place battery and turn it On.

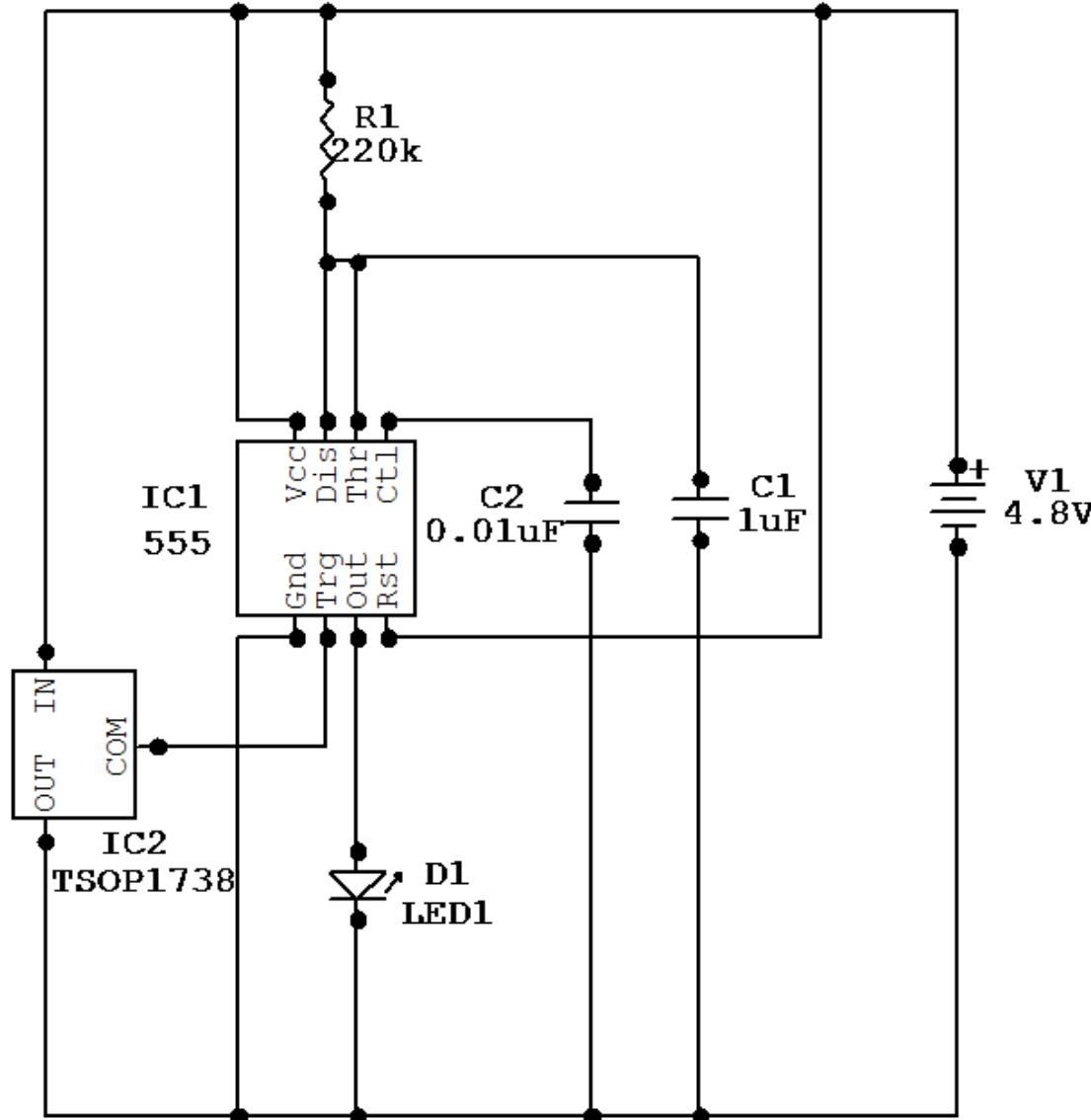
Step4: The IR LED in this circuit **will not** glow up and you should continue to make the receiver circuit. This circuit can only be tested along with receiver circuit.

Note: Please note that this circuit uses a special LED: "IR LED" which emits IR waves. As IR light is not visible to eyes, This LED's glow is also not visible to us. However it glows with IR light and can be seen only with special camera.



IR Receiver Circuit—

Now we will design IR receiver circuit, which is able to detect IR waves of 38khz,. When this circuit will sense infrared waves it will get activated.



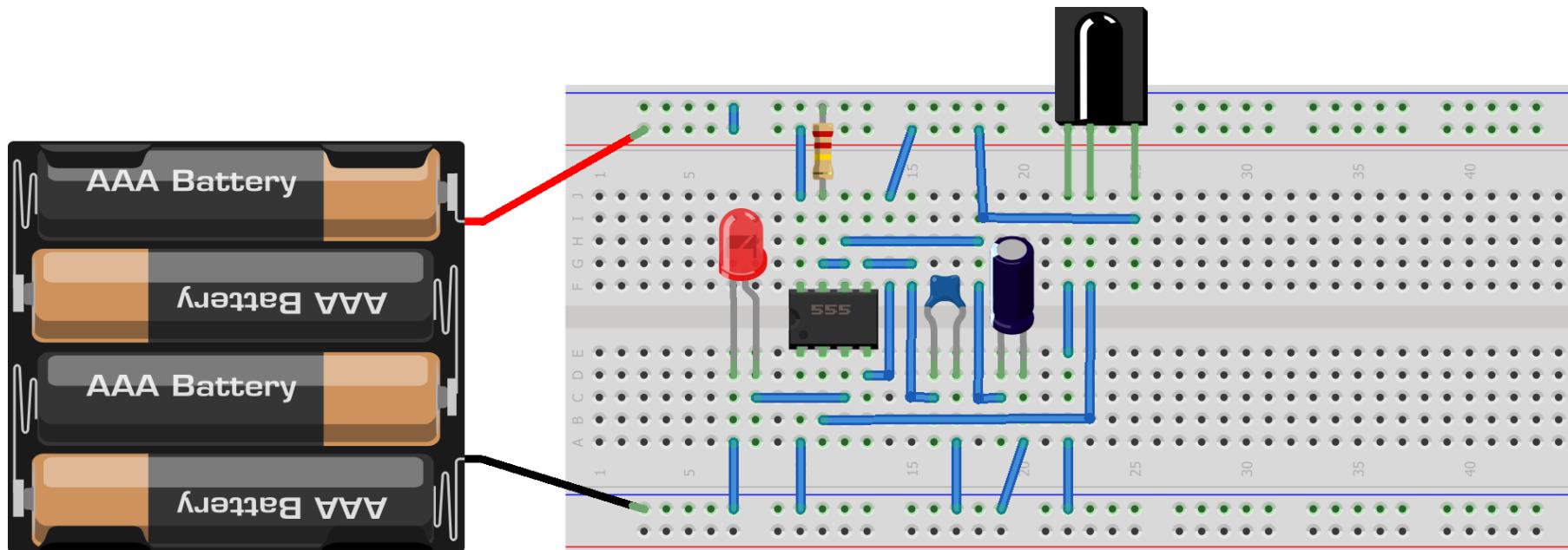
Steps:

Step1: Assemble all the components on breadboard.
Step2: Here we are using one different value of capacitor than that we have used before in other circuits, 0.01 uf or 10nf is having a marking of 103 on its ceramic cover.

Step3: When all the components are on breadboard, place battery and turn it On.

Step4: Bring close the IR transmitter circuit and turn it On. And check if the receiver circuit's LED started to glow.

This circuit can also be tested along with a TV remote. When any of remote's button is pressed, the receiver circuit should start to sense the transmission.



More Ideas -

Along with receiver circuit, you can use a relay driver circuit to drive mains appliance with remote. For more information about relay driver circuit, check circuit designing guide at the end of this book.

9. Audio Projects

In this section we will make :

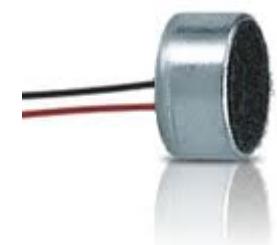
- 9.1 Clap Switch
- 9.2 Intercom



9.1 Clap Switch - Now here is some fun project. Clap switch is always a mysterious thing for non technical people. It is so magical that I have seen viewers amazed with "how can this be possible? "

This circuit is very simple and to de mystify it, we should know that it doesn't only work with a clap but any loud sound can trigger this circuit, so be careful while displaying this project in noisy places.

The basic principle behind this circuit is sound amplification which is done by using transistors and conversion of sound to electrical energy which is achieved by using a microphone. Once microphone gathers sound it converts it into very low current which has to be amplified. The amplification done by circuit is finally used to trigger a LED.



IC 555 used in this circuit as a mono stable mode. The transistors amplify the signals from microphone and fed them into input of IC, When IC detects the signal it changes its state and activate the output LED.

This can also be extended to be able to use with mains and to light up a lamp, for this we can add a relay driver circuit to the LED.

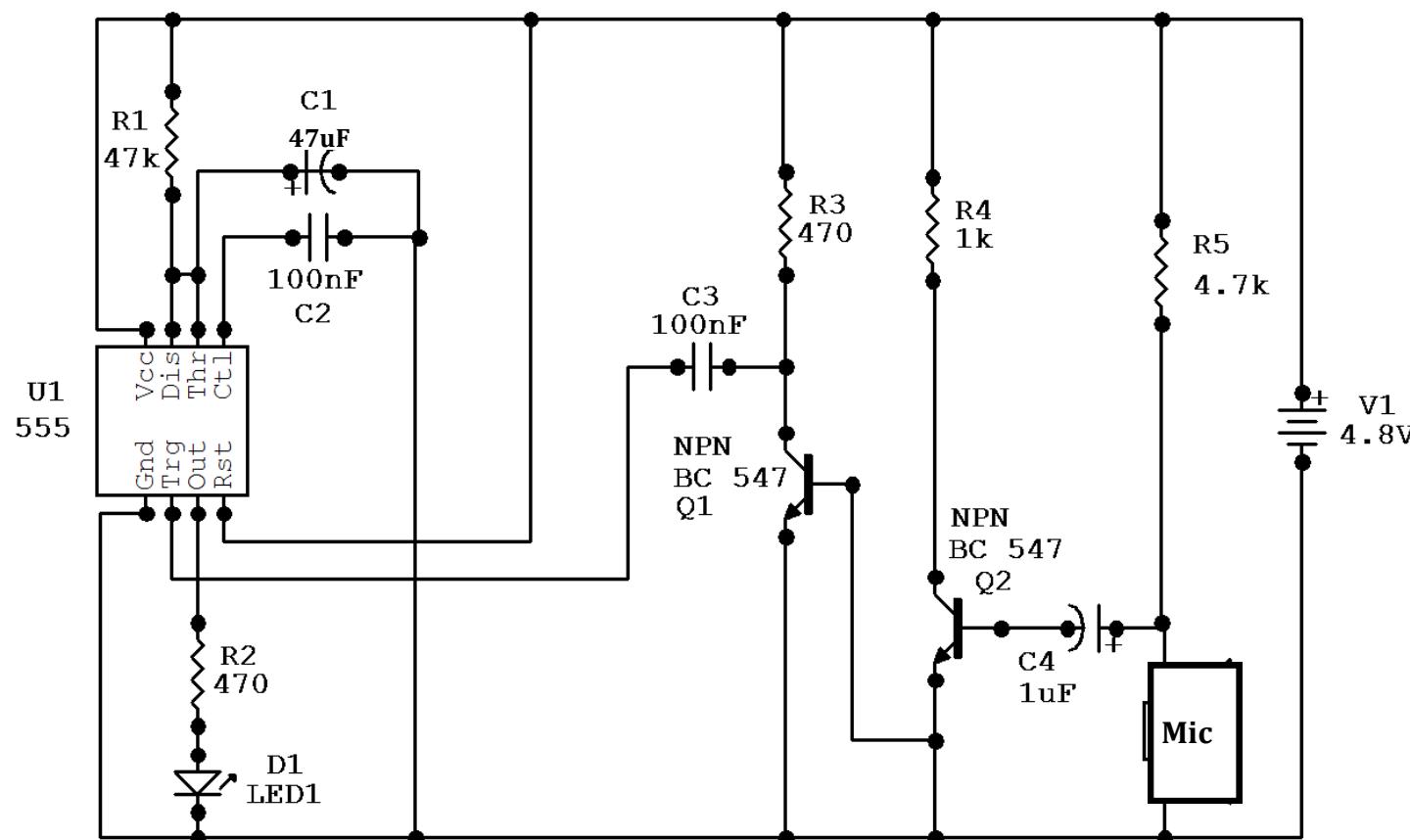
For Materials : please visit www.hobbyelectronics.in

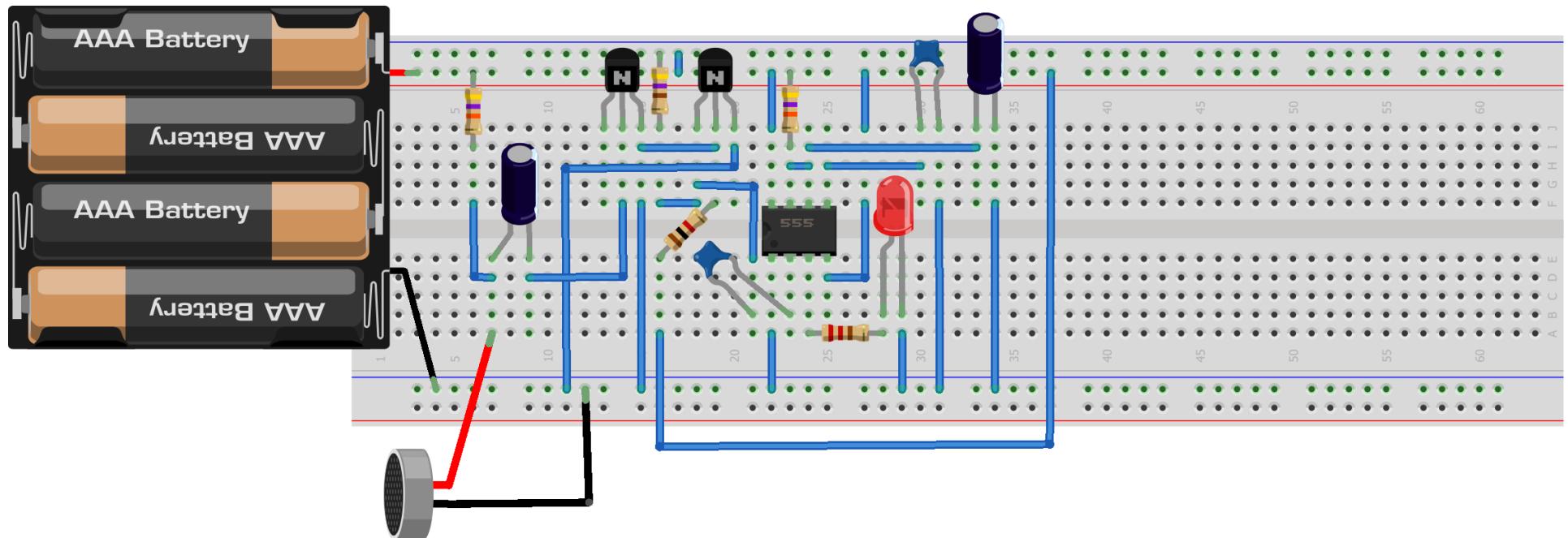
Steps:

Step1: Assemble all of the components on breadboard.

Step2: The connections to microphone should be correct and it should be connected with positive terminal to higher potential(+) and negative terminal to ground. If you see mic's connections, you will notice that one of the wire is connected to its outer shell, this wire is negative terminal of Mic. The other wire is positive.

Step3: Turn On the power and try to clap if LED doesn't glow, switch Off battery immediately and check connections again. Look for lose connections and verify connections with circuit diagram.





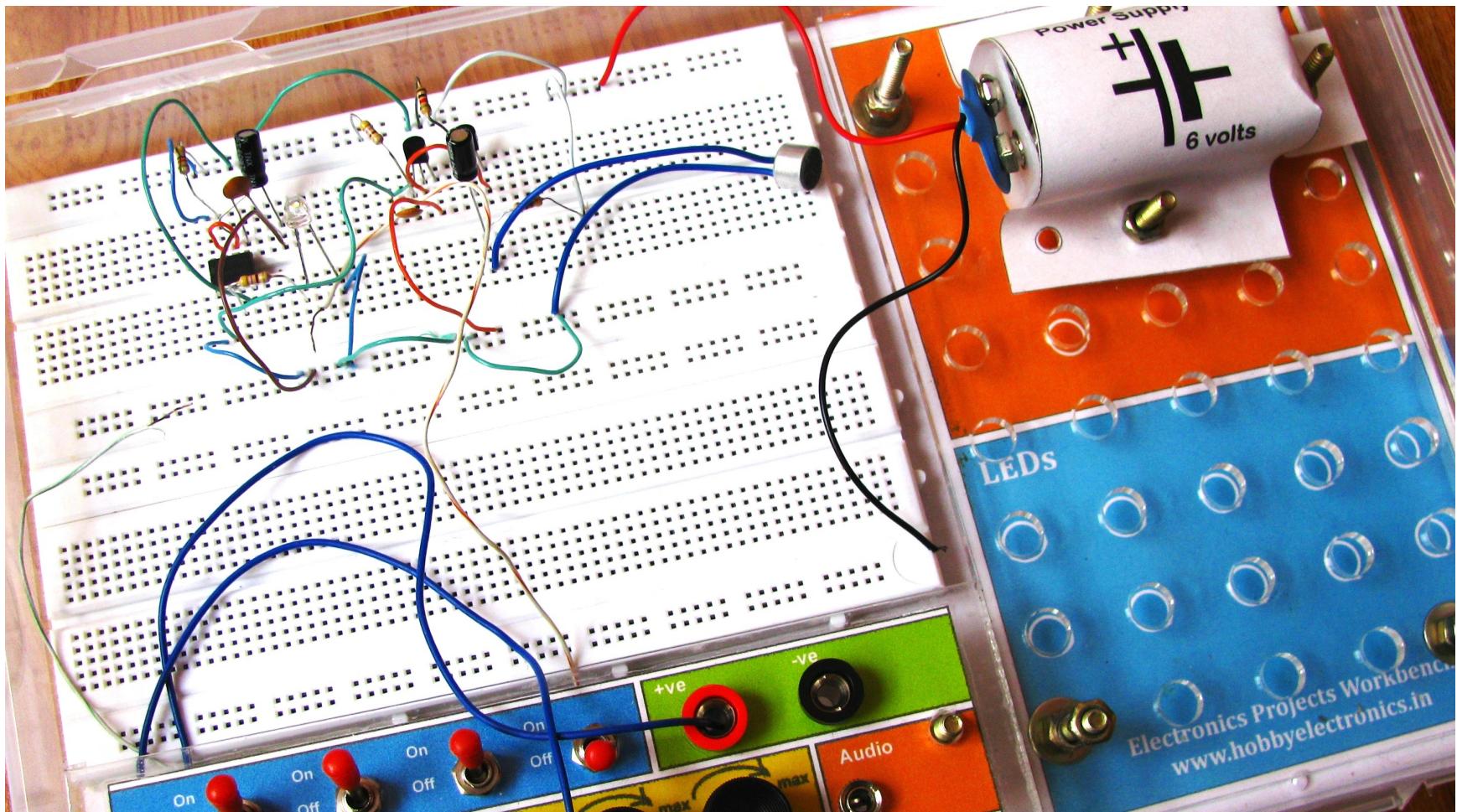
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To make a '**One Clap ON and Another Clap Off**' kind of Circuit, You need to add One more circuit with the output of above circuit. In circuit design guide I have mentioned On of such circuit—'**One Touch ON Another Touch OFF Switch**'. To connect just two circuits, you will need a **relay driver circuit** which is also mentioned in circuit designing guide.

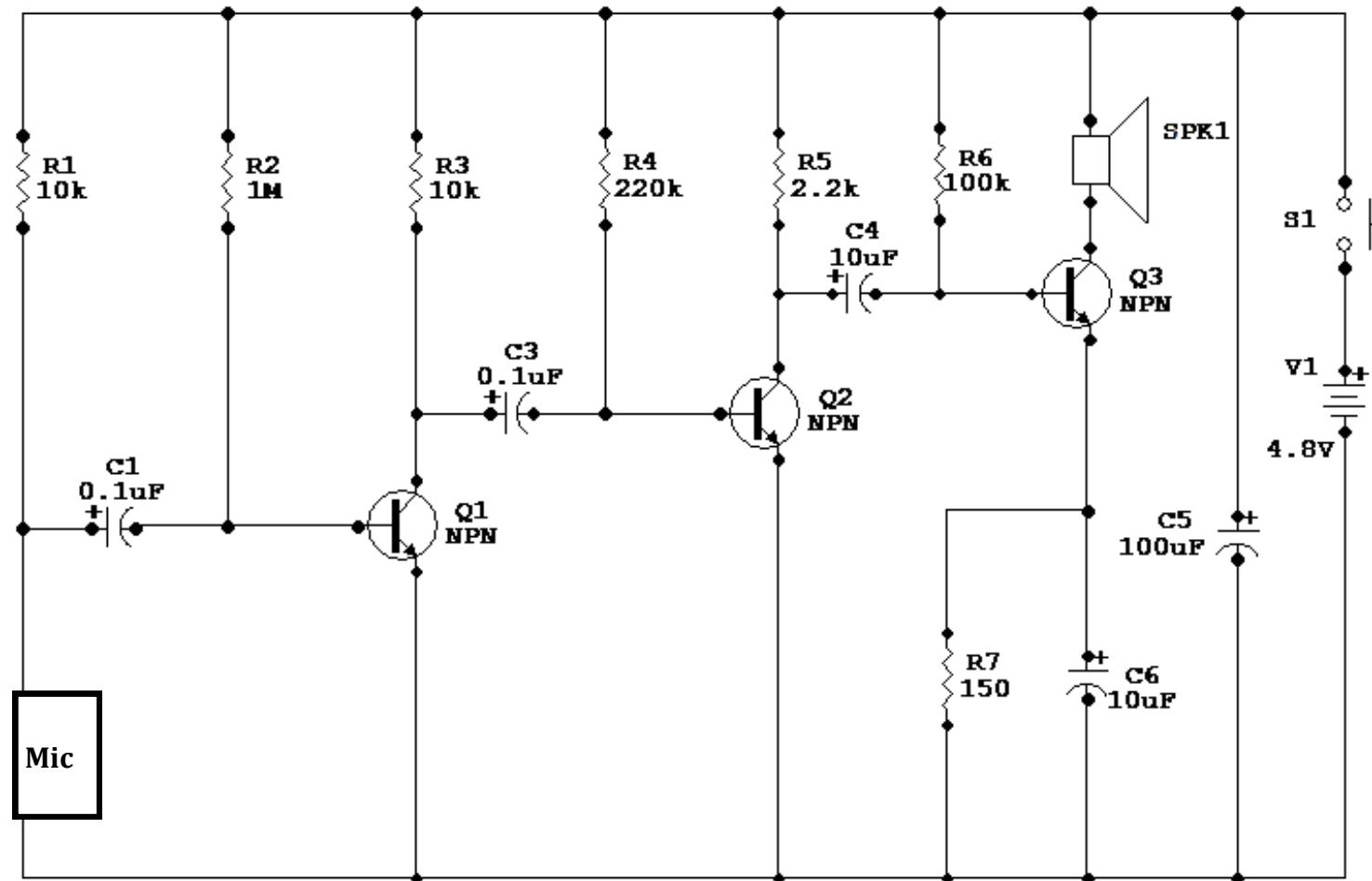
Another Idea, you can add a **latch circuit** (mentioned in circuit designing guide) with clap switch. A latch circuit will let the LED remain ON for few seconds and then it will turn Off. With another clap the LED will turn On again.

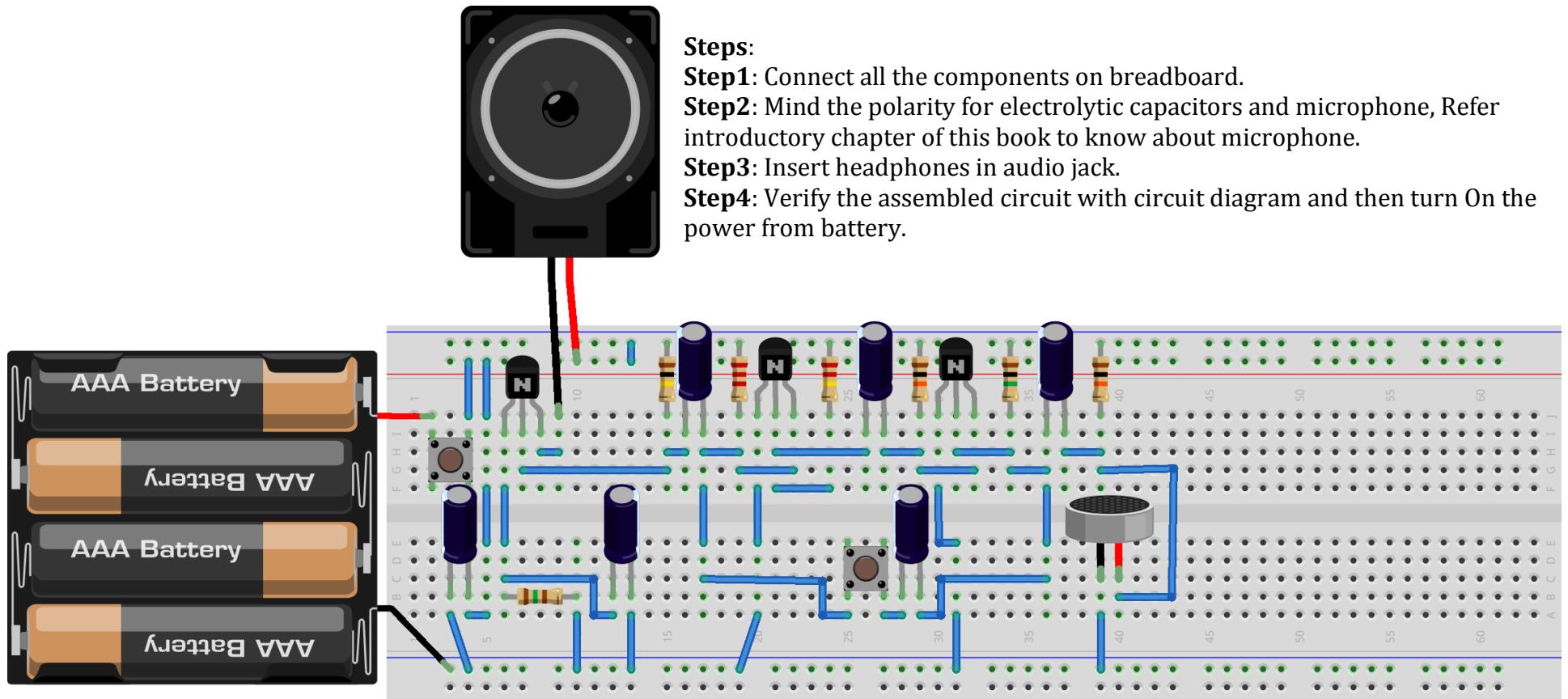
Another Idea, simply connect this circuit with a relay driver circuit and connect anything with relay, With clap that appliance with turn On momentarily and then go Off.



9.2 Intercom

Here we are going to create a very simple intercom circuit. This circuit is having three stages of amplification done by three transistors. When push button is pressed, the circuit behaves as a three stage amplifier and you can talk through it.





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Step5: Try to make some noise near to microphone and this noise should be hearable in headphones.

Step6: If no sound is occurring in headphones, turn the battery Off immediately and verify the circuit again with circuit diagram.



Two way intercom: This circuit can be used to make a two way intercom, For this you need to make another same circuit and the microphone of circuit A with speaker of circuit B should be packed together in a box, similarly microphone of circuit B and headphone from circuit A should be packed together. This arrangement would work like a indoor phone which can be used as a intercom to communicate between rooms.

Learning: You will notice lesser voice when you will extend the wire of speaker and microphone up to a distance of few meters, This is because of resistance of wires. Generally telephone companies use thick copper wires with low resistance.

10. Test & Measurement

Lets understand why
LEDs are not lighting..



In this section we will make :

- 10.1 Resistance, Voltage, Current, Diode, Continuity measurement
- 10.2 Voltmeter And Ammeter
- 10.3 Wheatstone bridge

10.1 Resistance, Voltage, Current, Diode, Continuity measurement

Calculating Resistance

A multi meter is capable of measuring resistance starting from 1 ohms to 100 Mega ohms (depending upon the multi meter model) with good accuracy. To measure resistance. Insert the measuring leads in voltage and com jacks (bottom two jacks, Don't use current jack) as shown in figure on right side.

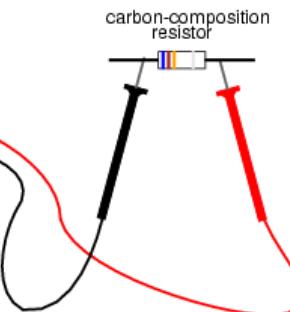
Values printed on meter's display dial are upper limits. For example - If you select 2000 then you can measure resistance of values up to 2000 ohms. Resistances with larger values will shown 1 on display.

Step1 :Turn the knob to resistance value selection section.

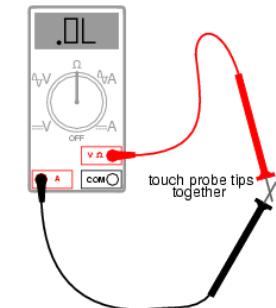
Step2 :If you want to measure 220 ohms then select the value, which is greater then 220 ohms, it can be 2000 (some multi meter have 200..2000..20k scale and some multi meter have scale in multiples of 100s) or 20k. It is advisable to select the value just greater then the resistance you are measuring. If you don't know the approximate value of resistance which you are measuring and this is a very valid scenario. Then in that case you should start with 20k selection setting.

Step 3: Put the lead terminals across the resistance which is to be measured.

Step 4 :If you get a 1 on display then it means the resistance value is greater then 20k and you should rotate knob to select higher value.



Touching together the leads of meter will show 0 resistance reading.

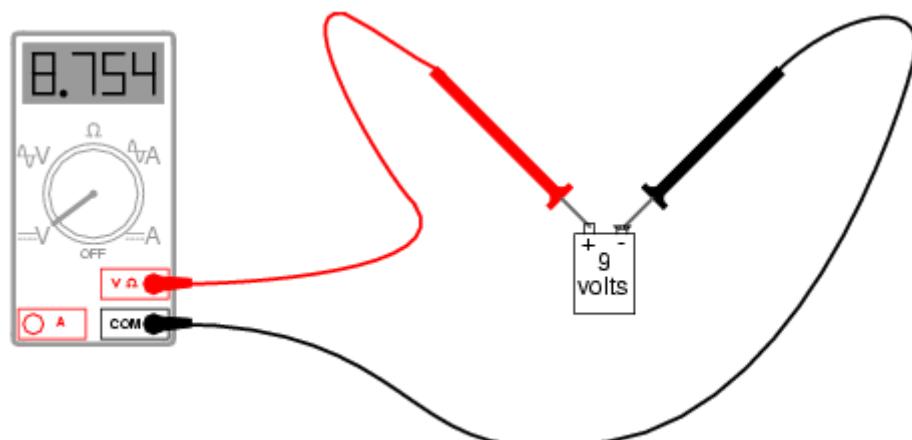


Voltage measurement

Similar to resistance measurement, Values printed on meter's selection dial sticker are upper limits of voltage that is possible to measure. For example - If we select 20 v then we can only measure voltage up to 20volts, If there is higher input voltage then meter will show 1. Please note, unlike resistance which we can measure without connecting it to any battery. In voltage measurement we always need a working voltage source (battery). We may measure voltage directly across voltage source or across some component connected to voltage source. Measuring voltage directly from terminals of voltage source will give us the reading of voltage across voltage source (4 AA cells should give a reading of 4.8 v). However if we make a circuit which includes a LED and a resistance and then measure the voltage across resistance then it would be lesser then the reading which we got when we connected meter directly into battery.

Steps:

- Step 1: Connect the Red and black leads in voltage, Com jacks, same as shown in previous figure.
- Step 2: Now rotate the selection knob to select a higher voltage value than what we want to measure, Generally for all circuits described in book, 20V setting is enough.
- Step 3: Turn On the circuit/battery whose voltage needs to be measured. Put the leads across the component which is to be measured (across battery/resistance etc)
- Step 4: Red lead should be connected to higher potential (or to positive) and black lead must be connected to lower potential.
- Step 5: If meter reading says 1. It means input voltage is greater than 20 volts and you should rotate the knob to select a higher value.



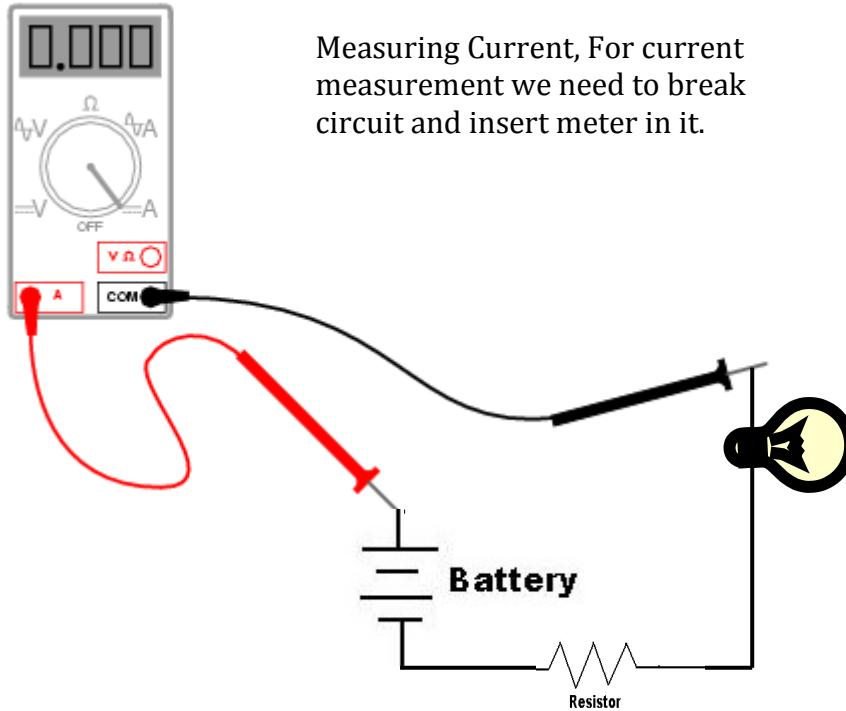
Measuring AC voltages

With multi meter it is possible to measure high voltage AC mains. Generally voltages up to 750 v is possible to measure, With selection knob on 250 or 750 volts, you can actually measure high voltages. As this is not in scope of this book, we will not discuss AC voltage measurement in detail. Be advised using digital multi meter with AC voltage may invite electric shock. It is better not to do it.

Measuring voltages with multi meter will be discussed in detail in next chapter, where we will see how multi meter can be used as a voltmeter in circuits.

Current measurement

A multi meter can be used as a **Ammeter** to measure current. To measure current we need to change the lead's position and insert lead into current measurement jack (Use top and bottom jack, don't use middle jack). On selection knob dial we have different current selection values starting from micro amperes to amperes. Generally from a AA battery we get current of around 200ma, So we may select 200 ma value to measure currents from 4xAA batteries.



Measuring Current, For current measurement we need to break circuit and insert meter in it.

Steps:

Step 1: Connect the Red and black leads in Current, Com jacks if current is less more then 1A. Else keep the leads connected in the below two jacks.

Step 2: Now rotate the selection knob to select a higher current value then what we want to measure, Generally for all circuits described in book, 200 ma (mili-amperes) setting is enough.

Step 3: Turn On the battery. Put the leads as shown in figure on left hand side.

Step 4: If meter reading says 1. It means input current is greater then 200 ma and you should rotate the knob to select a higher value.

Continuity measurement

One of the uses of a multi meter is to test the faulty appliances. A continuity meter is very useful to check faulty appliances. It tells us if appliance is working by measuring its internal resistance. A normally working appliance like electric bulb is having a finite value of resistance across its terminals. However if it is faulty (bulb filament broken). The internal resistance becomes infinite (An open connection is always having resistance as 1 or infinite, it is like a wire which is broken in middle and not able to pass current).

In most multi meters, for testing continuity , there is a beep function which actually beeps when the appliance under test is having low resistance or is conductive.



Diode measurement

Usually a diode test selection and continuity test selection is same on selection dial. This is because the resistance of diode is very low in forward bias mode (when P-N junction of diode is connected with positive and negative leads of meter respectively). As shown in figure a LED is connected with meter Leads, positive lead is connected with positive junction of LED and negative lead is connected with negative junction. Meter will sound a beep if diode is working and not short. This indicates that—

- 1) Diode is working properly
- 2) Diode is connected in right way

10.2 Voltmeter and Ammeter

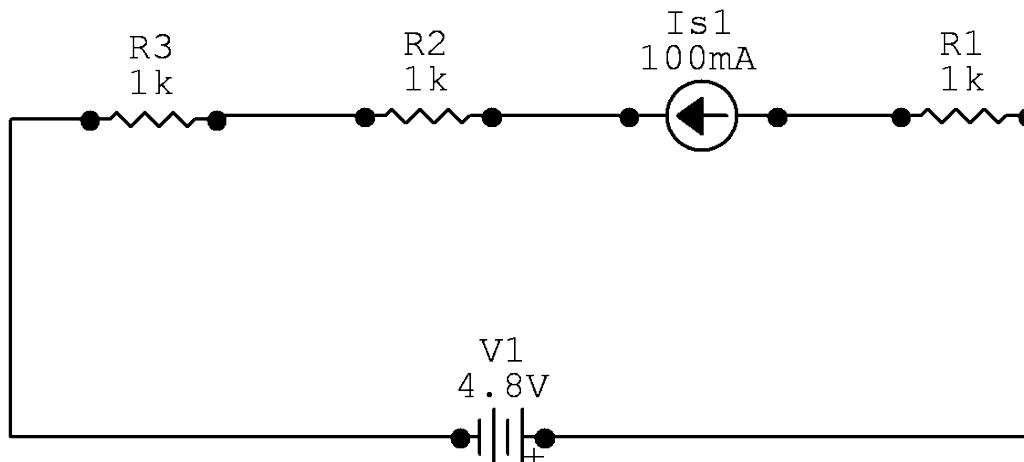


What is Ammeter?

An Ammeter is a current measuring device. Since the unit of measuring current is ampere, we call this device as Ammeter or Ampere meter. In early times Ammeters were created by using a sensitive magnetic deflection meter and a shunt (very small value resistance) resistance.



Some Parts of this project are available in Video CD ROM



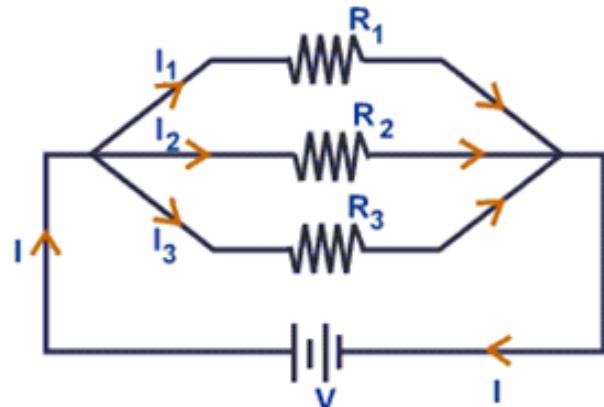
1.1 Ammeter

With recent development in electronics digital ammeters of high accuracy are developed. In this project we will use our multi meter as an ammeter. As we know that in a circuit with parallel resistance combinations (see below figure), current divides at a junction.



If I is the total amount of current entering in the circuit then It will divide to I_1, I_2, I_3 when it will come across 3 resistances connected in parallel and these current values can be calculated if we know the voltage supply from battery and resistance values using Kirchhoff's law (Please refer Kirchhoff's law from Google/Wiki or see the project dedicated to Kirchhoff's law).

We will first measure the currents (I_1, I_2, I_3) using our own ammeter and then we will calculate I_1, I_2, I_3 using voltage and resistance values, and will see that current values gathered from both ways will match exactly. In this way we can test if our ammeter is working fine.



Step1- Adjust multimeter and set it to Ammeter mode. Please refer previous multimeter circuits for details.

Step2 – Measure current I coming out from battery.

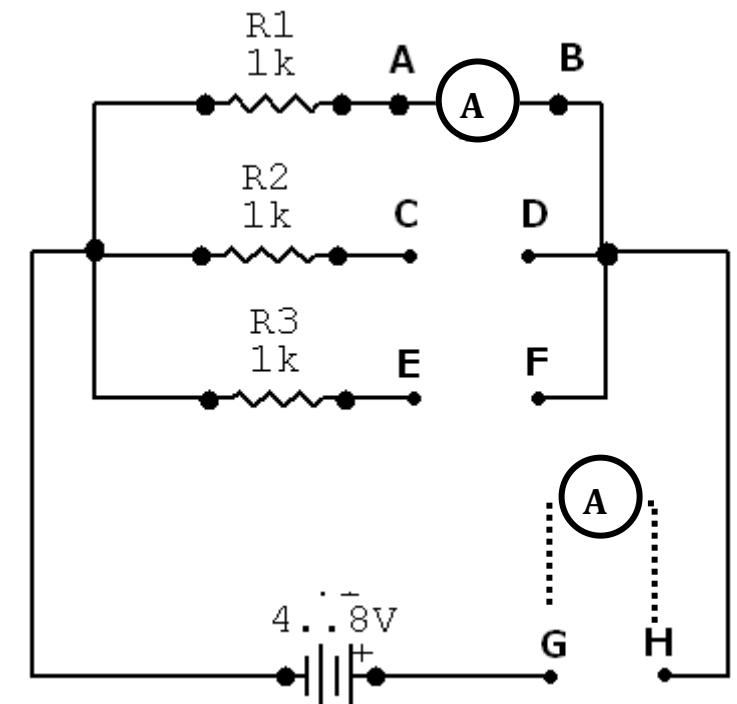
Step3 – Measure I_1, I_2 and I_3 one by one (through A & B, C & D, E & F and finally G & H for total current)

Step4 – Add I_1, I_2 and I_3 and check if they are equal to I . (between G & H)

Step5 – Calculate Currents from I_1, I_2, I_3 mathematically and check If they are coming equal to measured values.

$$I = I_1 + I_2 + I_3$$

$$I = I_1 + V_2/R_2 + V_3/R_3 \text{ (Since we want to calculate } I_1\text{)}$$



Since $V_1 = V_2 = V_3 = V$, because voltages across parallel resistances are equals, also in this circuit battery is directly connected to all resistances in parallel therefore voltage across all resistances are equal to voltage from battery. (Voltage divides or drops only when there are resistances connected in series with battery.)

$$\text{So, } I = I_1 + V(1/R_2 + 1/R_3)$$

$$I_1 = I - V(1/R_2 + 1/R_3)$$

Step6 – Verify if I_1 is coming equal as we measured it by multimeter.

What is Voltmeter?



A voltmeter is a device to measure potential difference between any two points in a circuit. There are two types of voltmeter in use - Analog and digital. Analog voltmeter uses magnetic deflection meter which deflects needle when current is passed into its coils. Digital voltmeter comprises of an ADC analog to digital converter which first measures voltage and then convert it into digital output. In this project we will be measuring voltages using multimeter which is having inbuilt voltmeter also.

As discussed in previous project we will use a similar circuit but this time we will connect resistances in series mode.

Why we are connecting resistances in series or in parallel?

When we connect resistances in series to battery then the voltage measured across all the resistances will be equal to voltage of battery but if you measure voltage across each single resistance then it will be lesser than battery voltage. Now If we connect all resistances in parallel then voltage across each resistance will be equal to voltage coming from battery because in parallel each resistance is directly connected to battery, whereas in series each resistance is not directly connected to battery instead it is connected to terminal of another resistance.

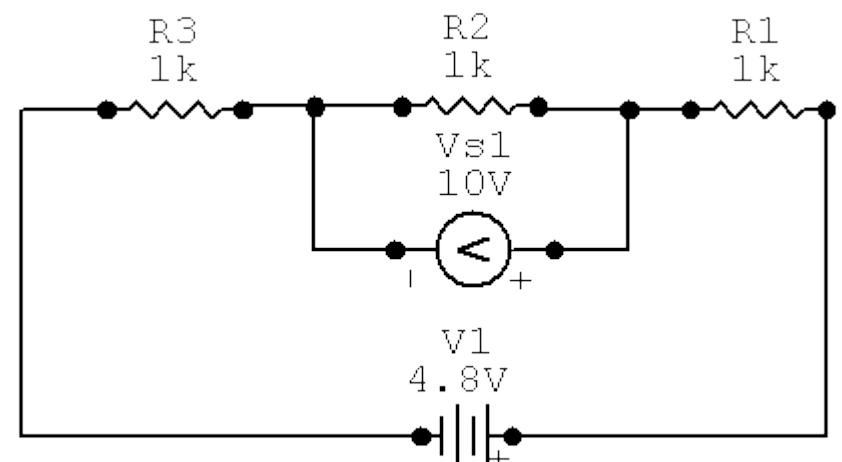
Step1- Measure the voltage across battery.

Step2 - Measure voltage across each resistance one by one.

Step3 - Voltage across battery should be equal to sum of voltages across each individual resistances.

$$V = V_1 + V_2 + V_3$$

Similar to previous circuit calculation we can calculate V_1 , V_2 , V_3 numerically if we know, V and I and value of each resistance. But this is a hobby book so we will not go further in calculation



10.3. Wheatstone bridge

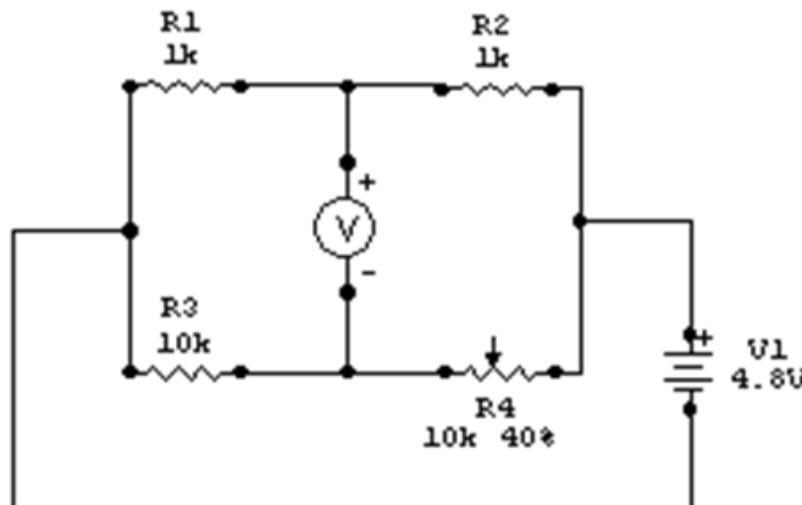


What is Wheatstone bridge?

Wheatstone Bridge - Lets learn about a magical resistance bridge, It was invented by Samuel Hunter Christie in 1833 and later used by Sir Charles Wheatstone. As you can see from figure below, this bridge consists 4 resistances contacted in a square arrangement, This simple arrangement was used in many applications and that's what made it important. This arrangement actually allows us to determine exact value of an unknown resistance. This unknown resistance can be made up of anything like – a washed out color coded resistance, A very long wire (wires of length of few meters may have some resistance), some another semi conducting material like saline water, to measure resistance (salinity) of soil etc.

The basic concept in this bridge is that:

When $R_1/R_2 = R_x/R_3$ then potential difference at points A and C becomes zero.

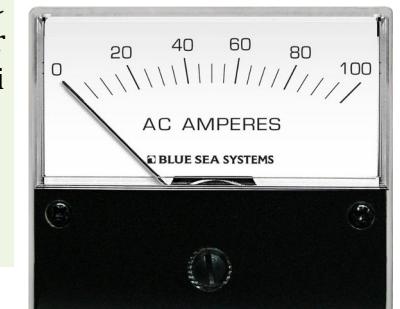


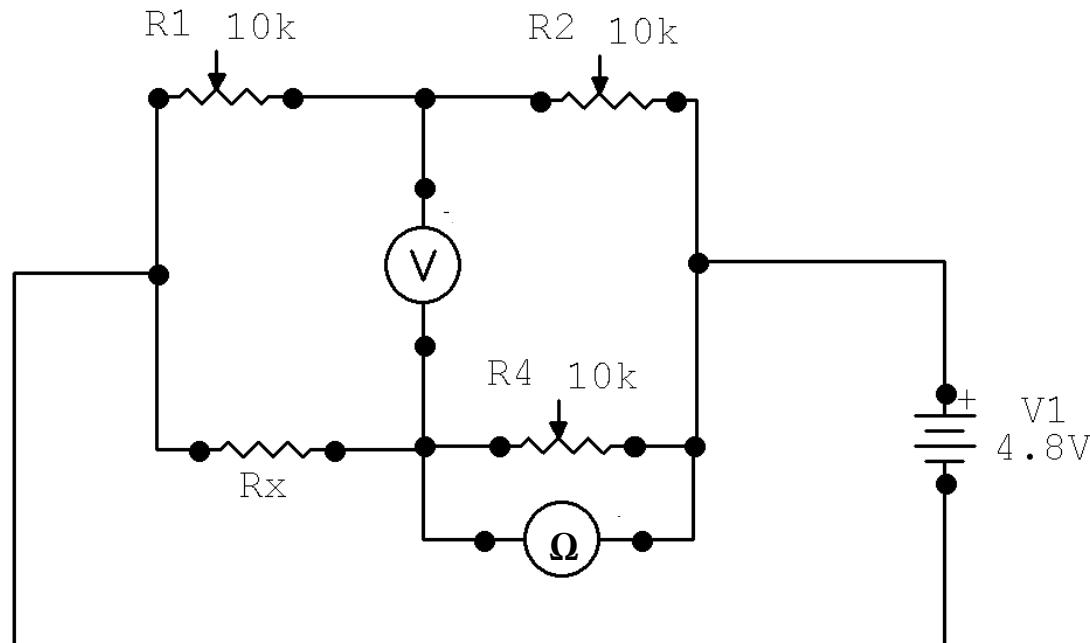
Circuit diagram of wheatstone bridge.

Photo of a wheatstone bridge based equipment.
Courtesy:Wikipedia



Some Parts of this project are available in Video CD ROM





1.1 Calculate unknown resistance

We can also state this as if potential difference between A and C is zero then above formula is valid.

Now Lets assume that we don't know one of the above resistances say R_x . If we somehow we can balance the bridge and make potential difference equal to 0 then we can determine R_x by using above formula.

To balance bridge, we vary one of the resistances from R_1, R_2, R_3 and see if the reading in meter is going near to 0 or not. We need to adjust the resistance up till voltmeter is not showing approx 0 volts.

Steps:

Step1 - Assemble the circuit as shown in figure, Here we are using 3 variable resistances to adjust resistance ratios.



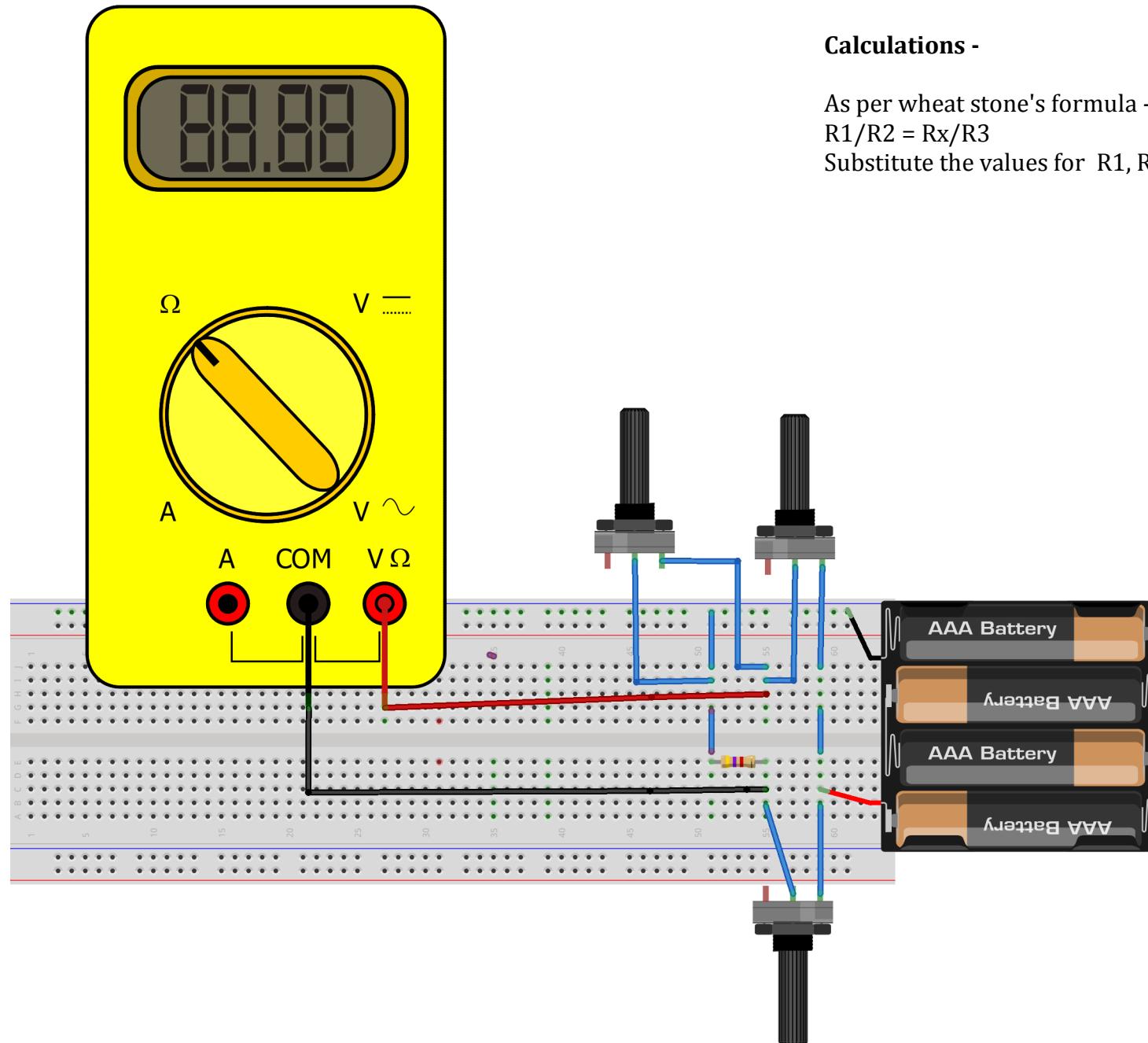
Tip : Only first two leads of variable resistance are used to vary resistance, the middle pin is actually connected to spindle which moves and vary resistance from 0 to max value.

Step2 - Connect the object which will use as unknown resistance, we may take a pre known resistance to verify the circuit for now, once verified we will change to some another material like - soil, wet sand, line drawing with pencil on a paper, wet chalk etc.

Step3 - Set voltmeter to 20 volts max and start balancing the bridge of resistances by varying knobs of resistances, we need to vary them to make voltmeter reading to zero.

Step4 - Once balanced take the meter probes out and set meter to 10 or 20k ohms max, we will now measure resistance of each variable resistance one by one and note them down for calculation.

Step5 - Put all the measured values (values of all 3 variable resistances) in formula and compute the 4th unknown resistance, If you are using a pre unknown resistance then the value of resistance should match with the value computed.



Calculations -

As per wheat stone's formula -

$$R_1/R_2 = R_x/R_3$$

Substitute the values for R_1 , R_2 , R_3 and compute R_x



More Ideas -

Soil Salinity measurement -

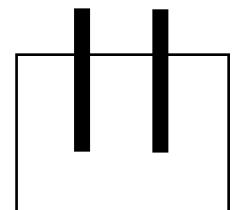
we may measure soil salinity using Wheatstone bridge, The salt content in soil determines the quality of soil and suitability for plants growth, The method described here was actually in practice few years ago and give realistic results. With advancement of technology more methods are developed to measure soil salt content.

The small round block that you can see in right hand side figure is actually a gypsum (cement) block with two nearly placed probes. A gypsum block sensor constitutes an electrochemical cell with a saturated solution of calcium sulphate as electrolyte.

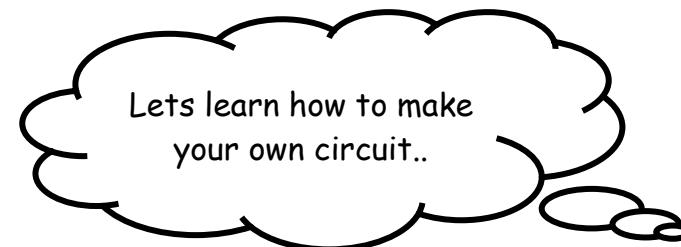
Since we are just developing prototype meter, we can make this sensor using two iron nails and cement block covering around them.



A Wheatstone bridge based equipment to measure soil salinity



11. Circuit Designing guide



In this section we will make :

- 11.1 Simple Transistor Sensor Circuits
- 11.2 Driver Circuit
- 11.3 Oscillator Circuit



11.1 Simple Transistor Sensor Circuits

Sensors Intro

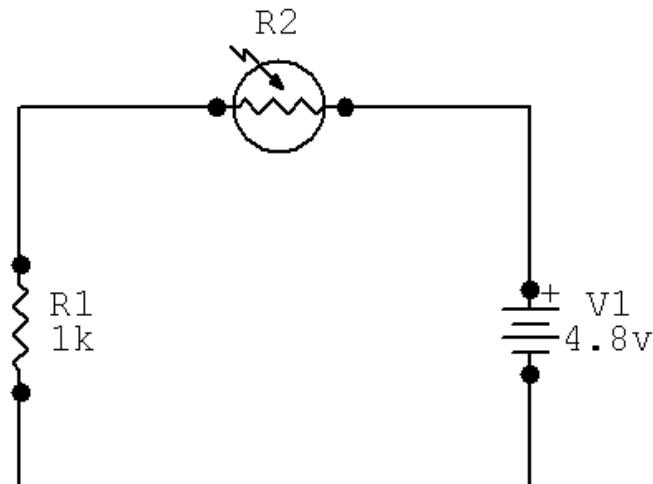
Believe it or not Hobby Circuits and electronics projects mostly imitate human senses. Like we have 5 senses. We have developed electronics sensors which enhance our ability of sense. If we talk about a Light sensor (Light dependent resistor). It is very distantly similar to our eyes. We use light sensor in circuits related to security which actually is similar to hire a security guard. So by these sensors we are actually reducing human intervention and extending our ability to sense our surrounding environment.

Similar to light sensor, sensor of sound is microphone which can be even more sensitive to human ears so it extends our ability to hear from few meters to few hundred meters or more. sensor of touch is touch pad. And Sensor of infrared light is an actual example where it extends human ability to visibility. As infrared light is not visible to our normal eyes. Infrared sensor can actually see it and tells us about it. Infrared cameras can actually provide us whole infrared pictures.

In this section we will learn about how to use sensors in electronics circuits. And to be more specific we will learn about how amplify the signals sent by sensors and use those signals to actually drive some light, siren, motor etc.

Each sensor is designed and is sensitive to a specific natural property of a substance, for example sound sensor reacts when there are sound vibrations in air. When these vibrations hits mic it produces a small amount of charge. The mechanism of this phenomenon is also very interesting but its out of scope of this book, you can search on internet about it.

The charge generated in microphone is then amplified by using one or more transistors. This amplified potential can be applied to LED or other devices like relay. (Relay is a electro mechanical switch which operates at 5-6 volts and is able to switch electric devices).

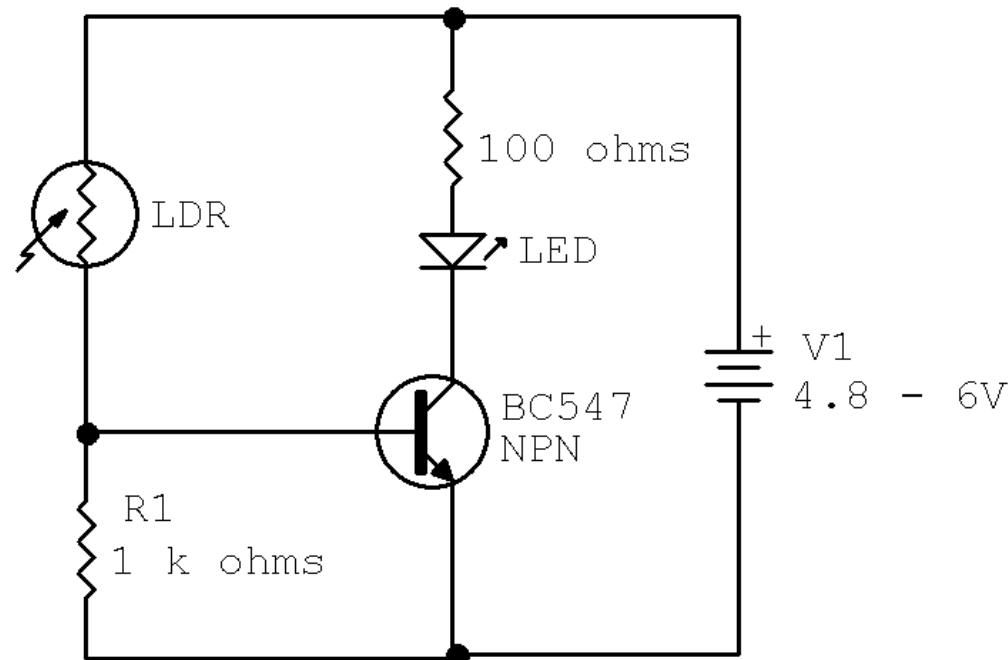


This circuit will not work as expected.

To start with sensors we are using only one transistor circuit, in which we will put sensor at base and will get output at collector.

Why this transistor is required here, Cant we use sensor directly with LED? Wont sensor will sense and turn LED ON?

This question is obvious, but we need to understand that most of sensors like LDR (light dependent sensor) doesn't produce enough resistance change (LDR reduces its resistance when light falls on it) This amount of resistance change is not enough to turn LED from OFF state to ON state, Either the LED will remain in ON mode and will just get bright with light Or it will remain OFF and light up very low when LDR is exposed to light. We actually need an electronic switch to solve this problem, A switch which is OFF normally and turns ON when It detects a change in signal. This electronic switch is transistor here. So we need a transistor in these circuits.



In left hand side circuit, transistor is used a switch and a small base current will be sufficient to turn On the transistor, which will allow flow of current from collector to emitter and turn the LED On.

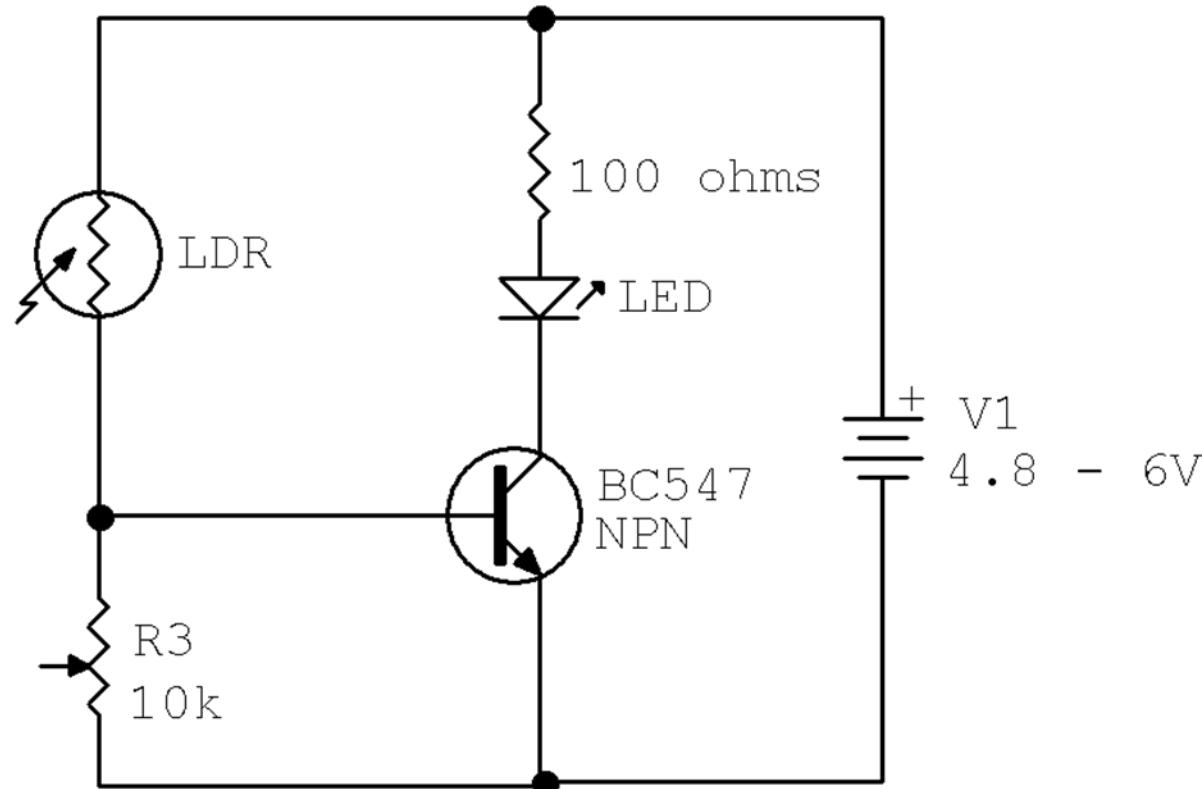
You may ask one question here – Why we have used R1 resistor between base and emitter?

This is very good question, Infact If you observe this circuit closely, You may also notice that R_1 is actually allowing positive charge from battery to go to ground directly and this is making base less positive because less current will go to base and this may turn the transistor Off. So Why this resistor?

The answer is that, we have intentionally adding this resistance to base and emitter to let transistor remain Off. The transistor will only turn On when we will receive a large current, large enough to trigger transistor's base even after an amount of it is going to ground. This also controls sensitivity of circuit and If we want to design a circuit where we want it trigger the LED only when there is too much light (like sunlight) then we will decrease R_1 (decreasing R_1 will increase flow of current from positive to ground and it wont allow transistor to turn On). After dcreasing R_1 we will need more light on light sensor so that it can pass more current (Light sensor decreases resistance when light falls on it).

If you want, you can design previous circuit with a variable resistance in place of R1, and you can adjust sensitivity of circuit.

Designing a circuit with sensitivity adjustor -



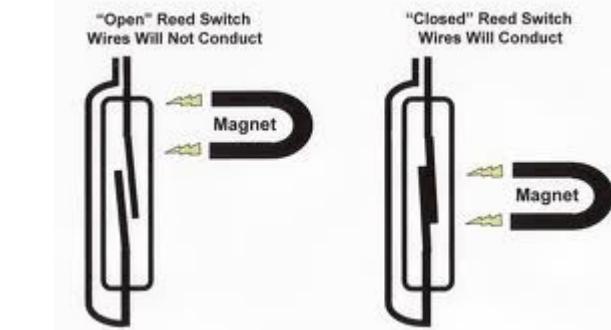
** For more information on thermistor you can refer starting pages of this book.



Zoom to view
images better



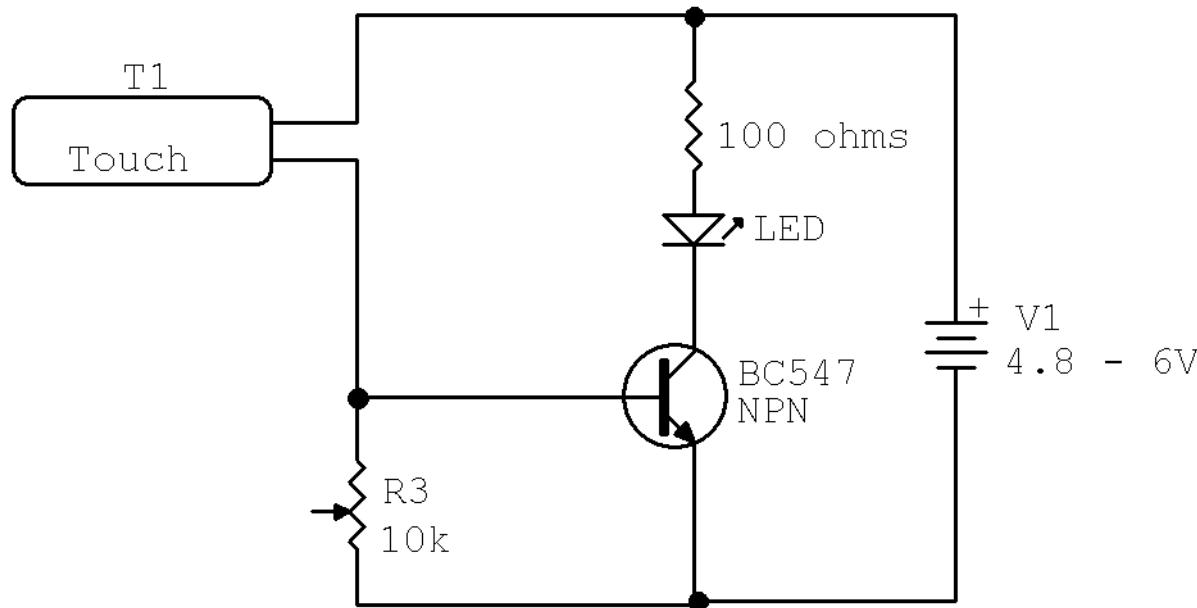
Commercially
available
magnetic
reed switches



Moving beyond Light sensor, We may use any kind of sensor we wish to. Only the property of sensor should be of changing resistance one. In other words, Any sensor which is changing resistance can be used in the circuit we just described for example thermistor** is changing resistance with temperature. Or a sensor which is switching On/Off can also be used like magnetic reed switch* and vibration sensor.

*A Magnetic reed switch is a switch which turns On when it comes near to a magnetic. So we can use a magnet to switch ON/Off circuit.

Below we are trying to create our own touch sensor which require just placing two wires very close to each other. The other sensors which can be used here is Thermistor (temperature sensor), Magnetic reed switch etc

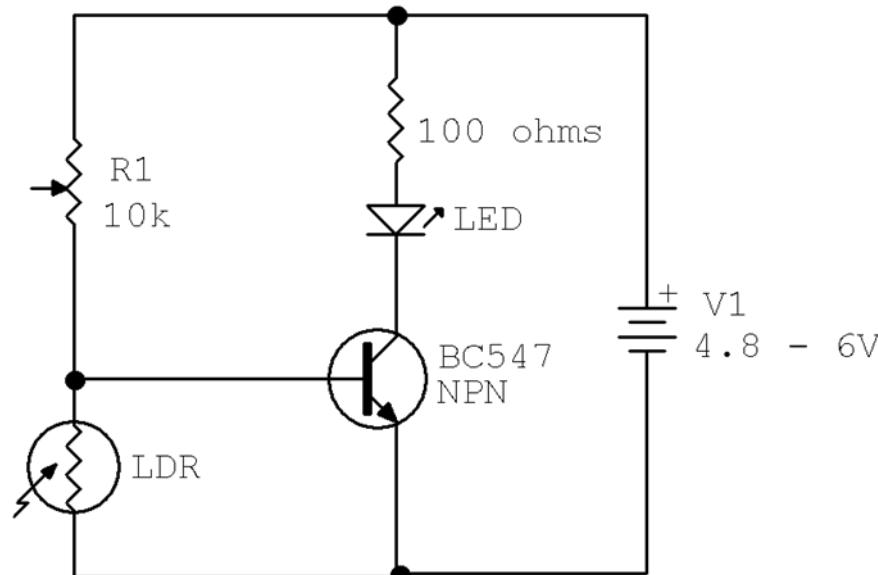


Switching the positions -

If you want to design a circuit which should work when you switch Off the current then this is also possible with above circuit. In other words, we are usually making contact o two wires to switch On the current, But we can design a circuit which will work when we break the connection instead of making it.

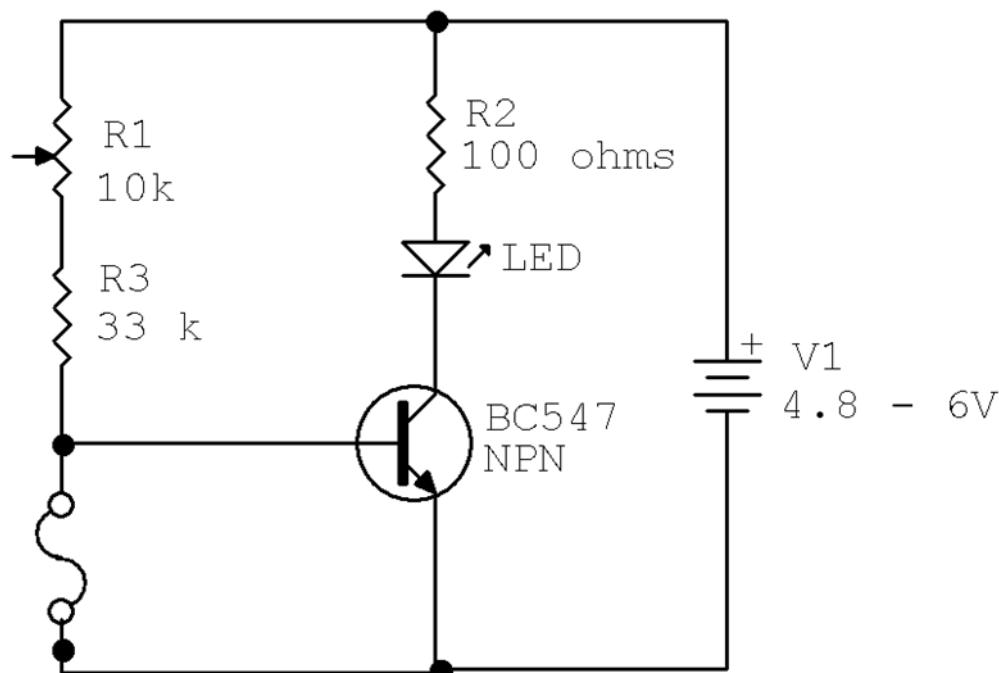
For making this kind of circuit we will be using the connection from base to emitter and instead of placing our sensors in between base and collector we will place them in between base and emitter.

Please refer below circuits –



This circuit will work when there is no light and LED will remain Off in light, This circuit is used in street light which work in nights and automatically close themselves in day.

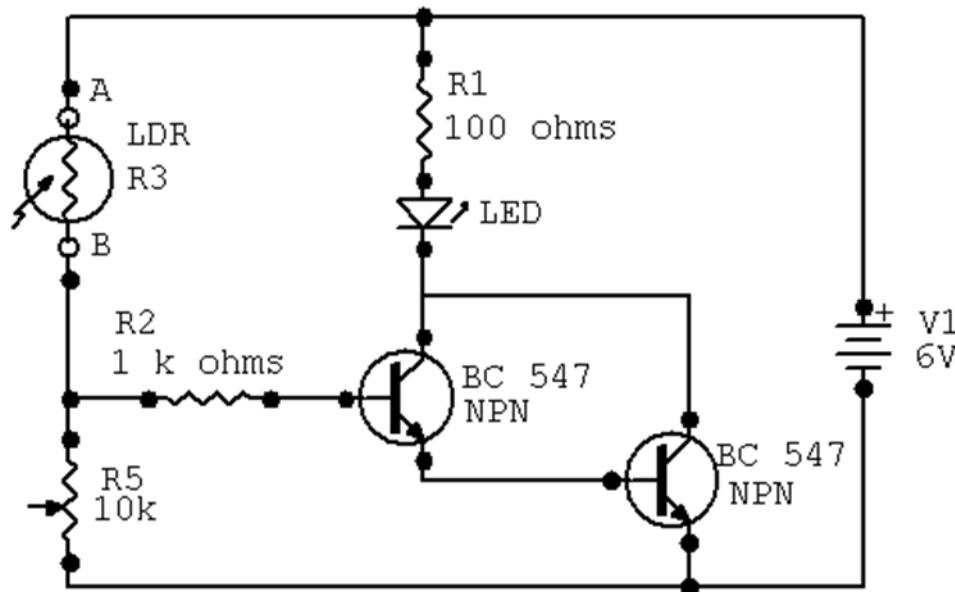
With this arrangement of circuit shown on right hand side, There are more possibilities to design circuits like burglar alarm, animal trap etc where we need to trigger circuit when there is a broken connection. Please refer circuit below for a simple burglar alarm.



In this circuit the LED will glow when somebody will break the wire connected between A and B. This will stop current going to ground and allow transistor's base to get current coming from positive terminal of battery. The transistor will switch On and LED will glow.

Darlington Pair

More sensitive sensor circuit - A more sensitive circuit can be developed by using transistors connected in a specific way. This arrangement is also known as Darlington pair. What is sensitive about this circuit is that it reacts on very small potential difference at base (very small base signal). Just to reiterate the working of sensor based input circuits, these circuits actually amplify small base inputs, The more smaller input voltage the circuit reacts to, the more sensitive is the circuit.



The Darlington pair circuit described here is sensitive enough for most of hobby projects, In fact the circuit can be activated even by just touching the base of transistor (Base actually picks up mains hum from finger when you touch transistor's base. This wont work in outdoors). And It can sense humidity by placing wires very close to each other. You can use almost all sensors with Darlington pair and make your own circuits.

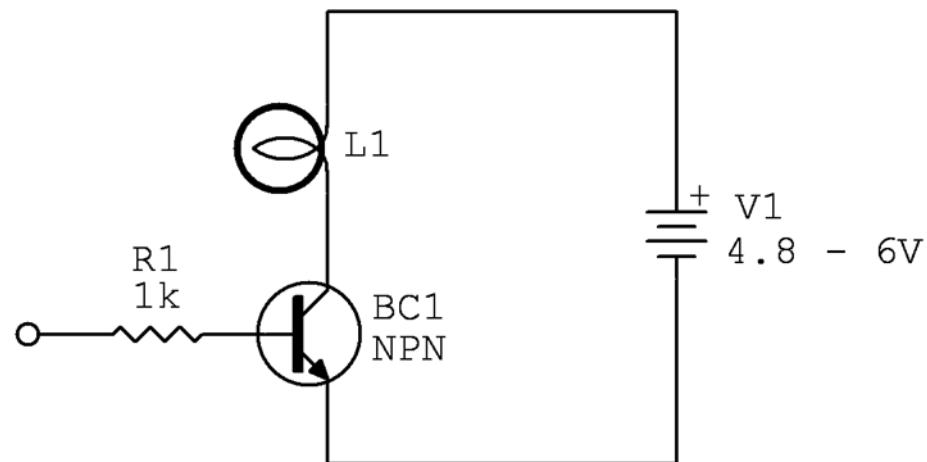
This Darlington pair circuit can be used in place of previously designed sensor circuits as well as with the circuits we are going to design later from here. You just need to replace single transistor with this two transistor pair.

In above and previous sections we have seen how we can use transistor and sensors to design a working circuit. Now we will see how to use the output of above circuits to actually drive some load. Up till now we were using LED indicator as output. But this is not enough to most of projects as we may need to drive some melody bell, lamp, high volume buzzer, motor. Or we may need to drive some electric appliance.

All this is possible but using a combination of driver circuit and relays, which we will learn now.

Driver Circuit -

A driver circuit is nothing but electronics switch which turns ON when it detects input signal. Below shown is a circuit diagram which can be used as a driver circuit for most of hobby circuits.



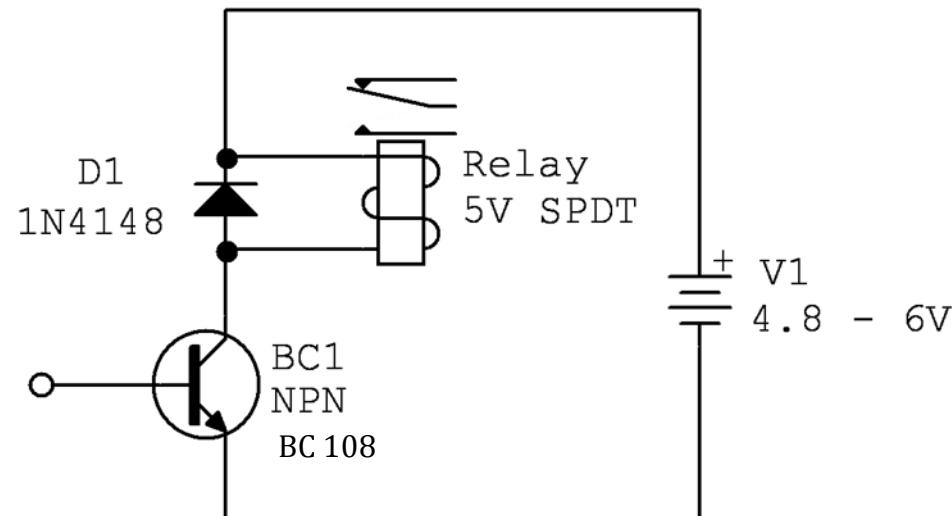
In this circuit we are using a 6volt lamp with a power transistor (BC108). When this circuit detects a small voltage at base it activates lamp. Since lamp draws more current than LED, we are using a metallic power transistor here. The input voltage in this circuit can be increased up to 9volts for brighter light.

Relay driver circuit -

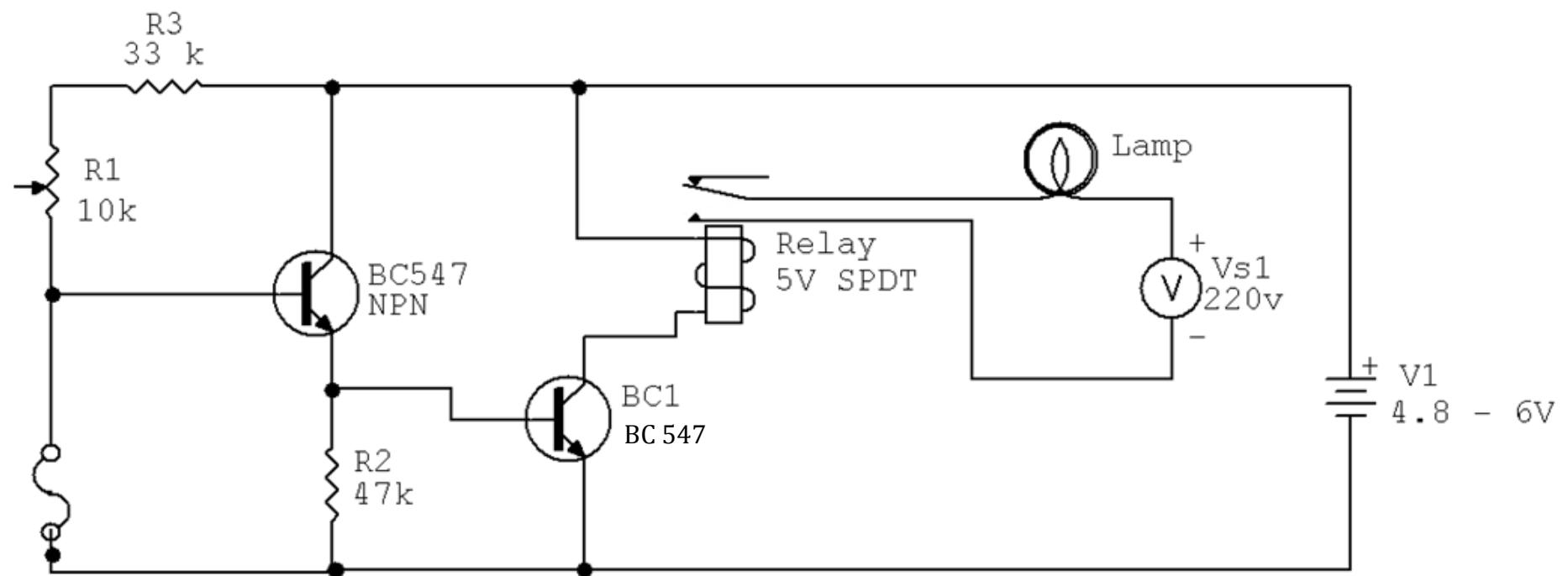
Relay is a special electro mechanical switch and is just like a switch which we use in our room's switchboard. The only difference between a normal switch and relay is that, In a normal switch board switch somebody needs to go and press it to turn it On. But in relay this pressing of switch is done by a electromechanical arrangement (solenoid with iron bar which acts as a electro magnet), when current is passed through solenoid it turns the iron bar into a magnet and this magnet pulls one iron lever towards itself with a click sound and the switch is pressed On. All is done by small 5-9v battery. Now you can guess how we can use relay in electronic circuits.

One use of relay is done in car indicators. You must have heard the click-click sound, when you open the turn indicators of your car, this click sound is generated by relays. Relays are also used frequently in voltage stabilizers, Invertors etc.

Below shown is a relay driver circuit, which is similar to above circuit with one extra diode. This diode protects from high current surge, that occurs when we turn open relay and solenoid coil gets charge. A solenoid coil may store energy.



Now we will actually use above driver circuit with our previously designed circuits to drive some load. Below shown is a complete circuit with sensor circuit, relay driver circuit and load.



Remember you may use a 9volt battery in above circuit, if 6volts is not enough to energize relay, just you need to protect BC547 transistor with an extra resistor of $\sim 1k$ at its collector.

Also you may choose to replace sensor circuit with other ones we have already designed.

Latch circuit -

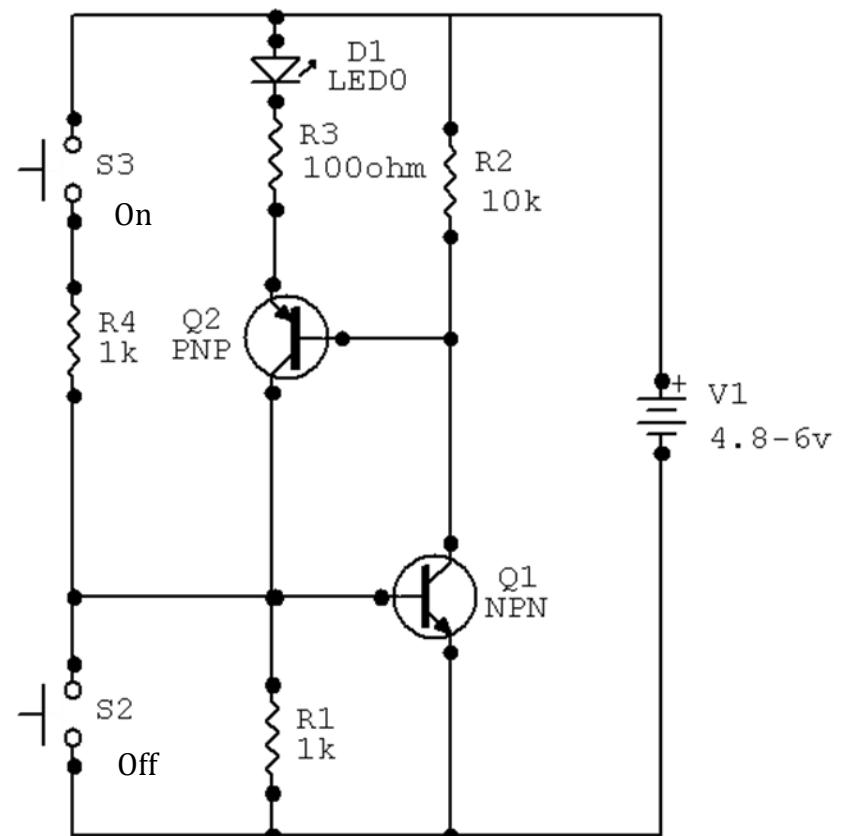
A latch circuit is a circuit which latches output when it detects any input. In other words it turns output to high and keeps it high no matter if input goes low. It only needs one small spike of input voltage first time to turn itself on. Latch circuit is very useful in hobby circuits where we are sure about stable input signal and we need to trigger another circuit anyway. For example A water tank overflow alarm may use a latch circuit which will trigger alarm when first connection is made. After this trigger no matter how many times connection is again made or break by water, Alarm will continuously ring. Otherwise, without latch circuit, alarm may ring with breaks in between.

Above shown circuit is of a manual latch switch, this circuit is also a transistor equivalent of SCR (*SCR is silicon controlled rectifier – you may understand scr as an equivalent to relay, but without any moving part in it. This is a solid state component using silicon layers. Search more about SCR on internet or wiki*)



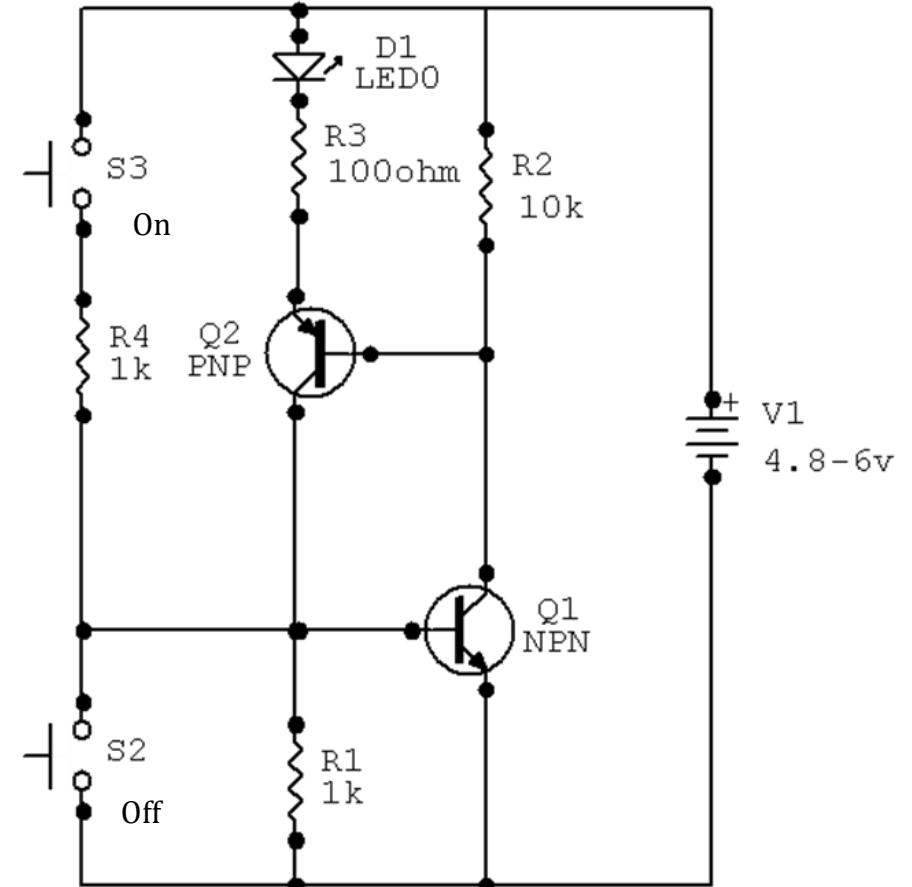
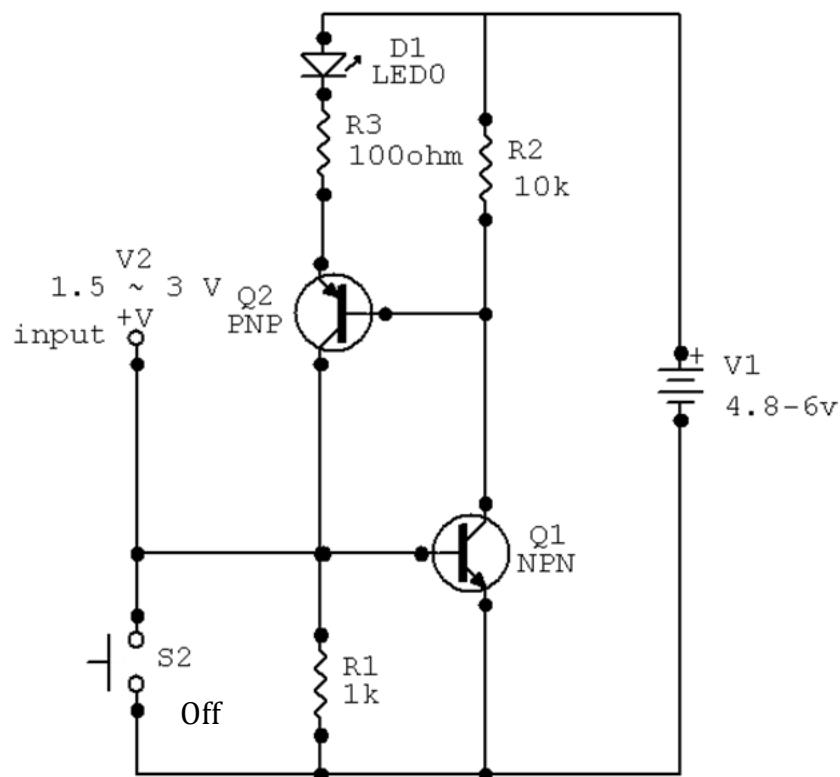
Image: Commercial SCRs

SCR is commercially used in high power circuits. However as a hobbyist and learner, a transistor equivalent of SCR is good enough to create a latch.



The ON switch connected between positive terminal of battery and base of Q1 NPN transistor can be used to turn On Q1 transistor. Once Q1 is on, current will start to flow from Q1's collector to emitter. The base of transistor Q2 will get more negative as R2 is connected between base and battery, So voltage drop after R2 makes base of transistor Q2 at low potential and it starts conducting (Remember Q2 is a PNP transistor which conducts when base is at low potential/voltage then collector).

Since right hand side circuit is a manual On /Off circuit, we need a latch which operates by input signals. So we will remove ON switch and keep the terminal open for input signal connections. Please refer below circuit .



You can use a relay driver circuit at the output of latch circuit, Just replace LED and 100ohms resistance with a 47K-68k resistance and take output from emitter of Q2 transistor for input in relay driver circuit.

The output LED and 100 ohm resistor can be replaced with a 10k resistor and an output wire can be taken out from collector of transistor Q2 to drive a driver circuit which will drive some load in turn.

Another Idea – You can use a latch circuit with a vibration sensor, This sensor is very simple to create and need one small spring (for example – the spring used in Pen etc). And you need one metallic pin which should be inserted in middle of spring but must not touch it anywhere. Now you need to keep them attached in this position (attach them using Mseal or some fast sealing adhesive) and connect them to wires (One wire to battery and one to latch input), When somebody will vibrate whole set up, Spring will vibrate and it will touch the metallic pin and this will pass current to latch input and latch will trigger On. On right hand image you can see one commercially produced vibration sensor.

This kind of vibration sensor and latch based circuit can be used to make an anti theft alarm system for bikes.

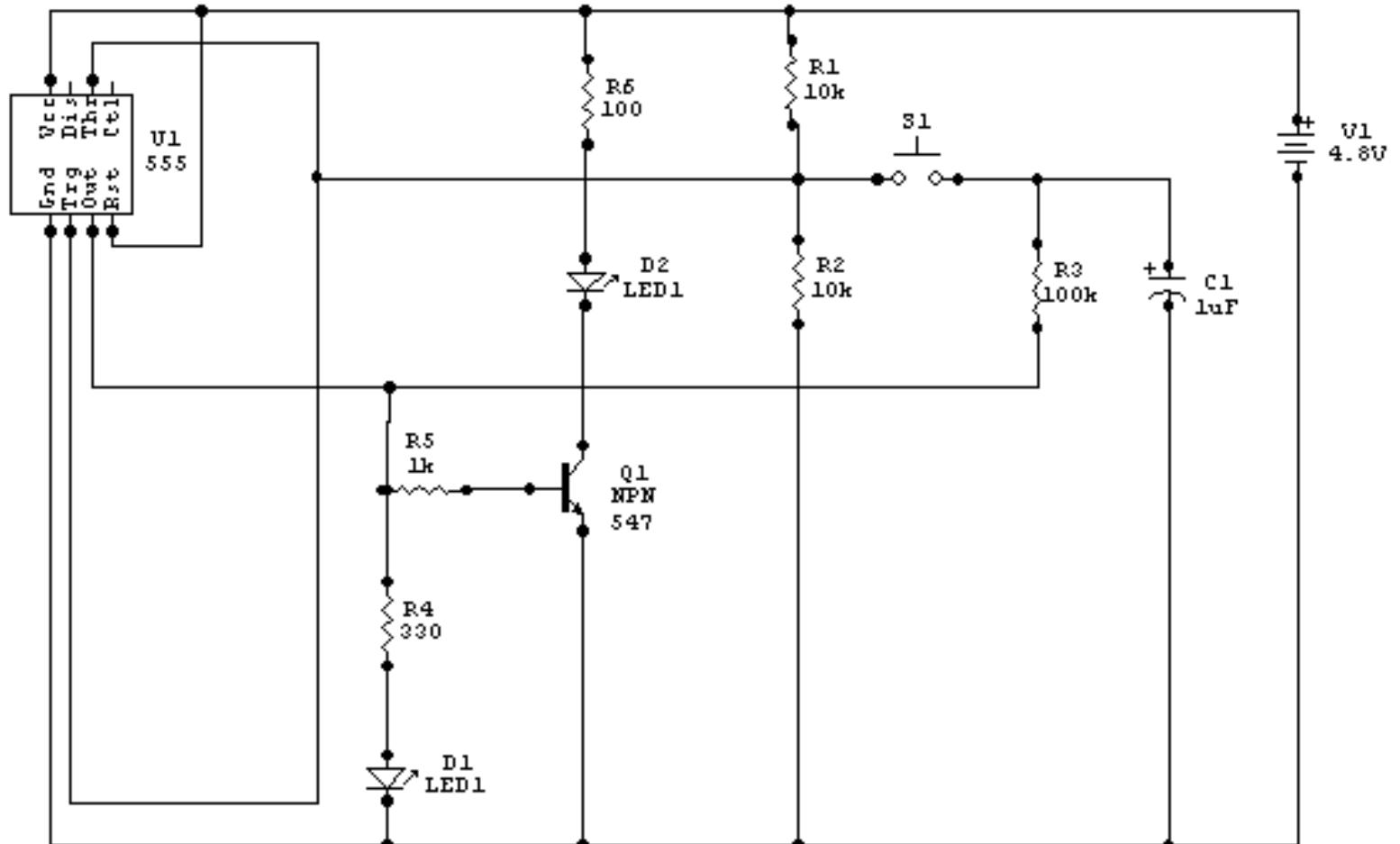


One Touch ON Another Touch OFF Switch-

This is a very useful circuit which can be used with other circuits. This circuit can be used where, we need to turn an appliance On with a pulse and Turn it Off with another pulse.

To simply connect this circuit with another circuit. Try removing the touch switch and connect a relay instead. Relay is just like switch and can be operated by another circuit.

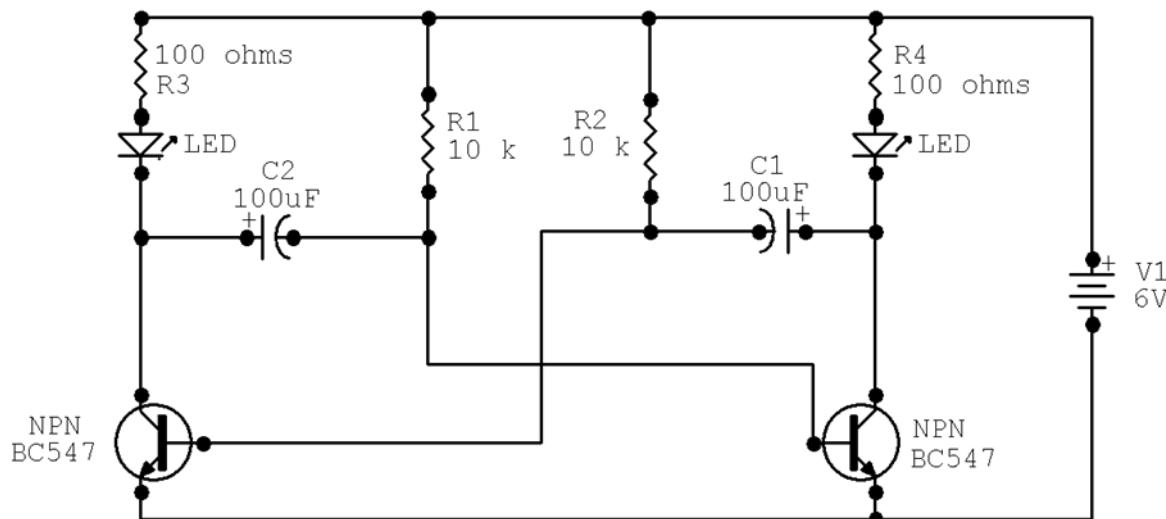
Another method to connect this circuit with another circuit is to inject the output of another circuit directly into the input (Pin 2) of IC 555. And keep the switch S1 open (disconnected).



Oscillators - oscillators are very important in electronics, they are used in many important circuits like - timers, music generators, Radio circuits, Light blinkers. In advance electronics and computers, Oscillators play very important role. for example CPU in computers use very high frequency oscillators to process input instructions per cycle.

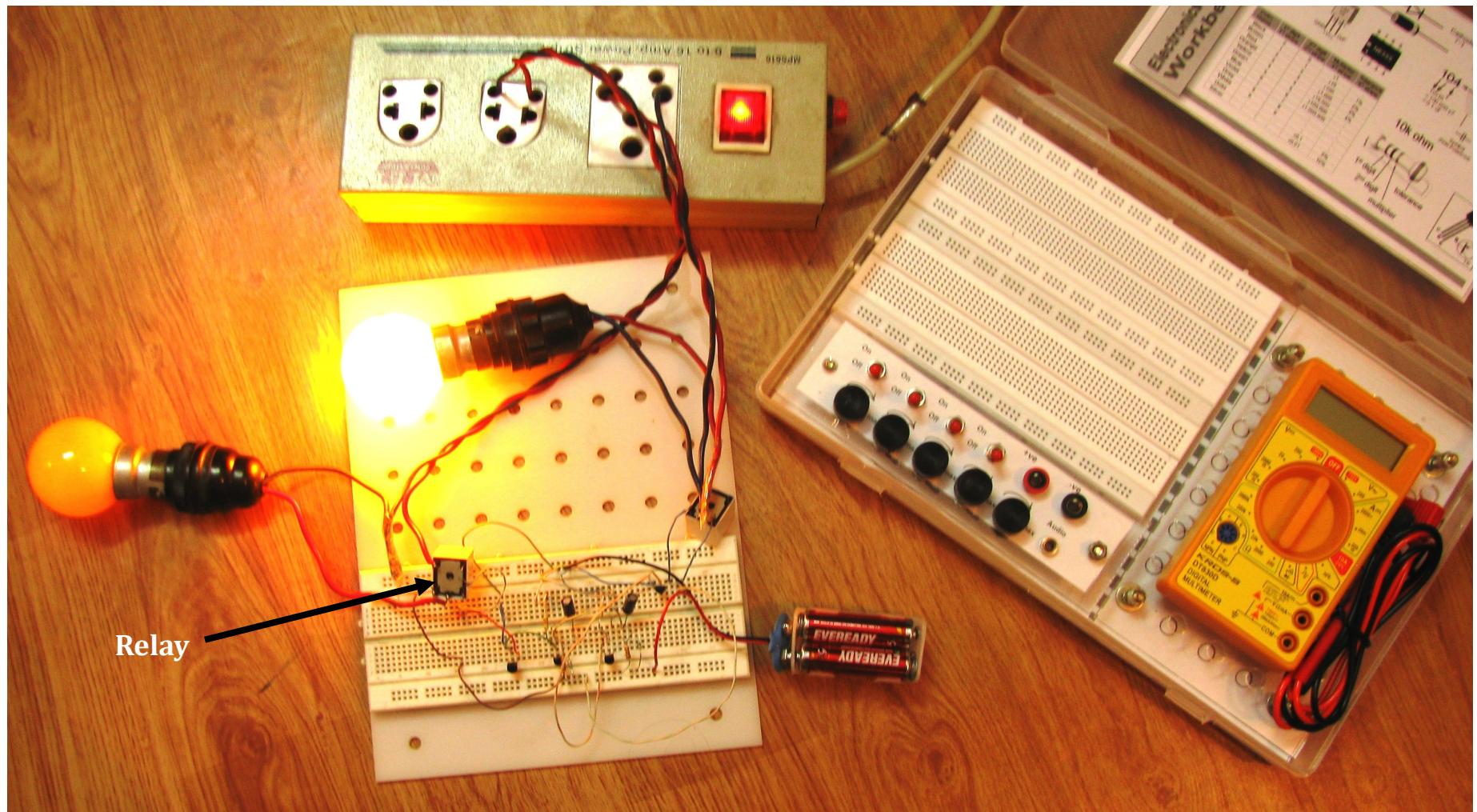
For a hobbyist, it is very important to know how to design oscillator circuits. In this book, we will start with creating very simple oscillators using transistors and capacitors and then we will create more complex oscillators using IC 555. The frequency of oscillations also play an important role while designing specific type of circuit. A very high frequency oscillator can be used in a mosquito, rodent repeller project where we need a very high frequency sound which is not hearable to human ears. A very low frequency oscillator can be used to make a timer, where one oscillation cycle may take 5-15 minutes of time.

Lets start by making a very simple oscillator -

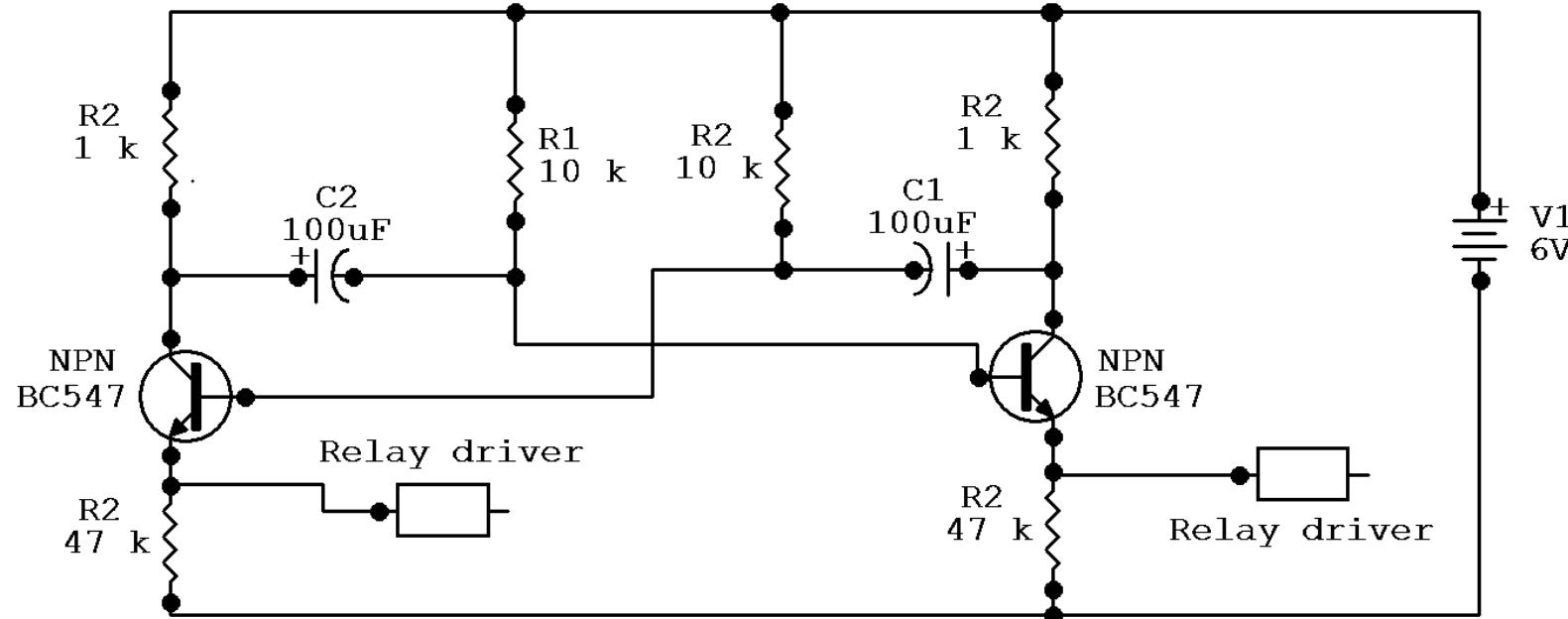


The above Resistor-capacitor based (RC oscillator) oscillator circuit is one of the simplest oscillator to design. There are various other forms of Oscillators like - Inductor-capacitor (LC) oscillators, Op-amp based oscillators etc. For now we will just discuss RC oscillators here. If you are curious about other oscillators, you can search them on internet and try to make some circuit with them.

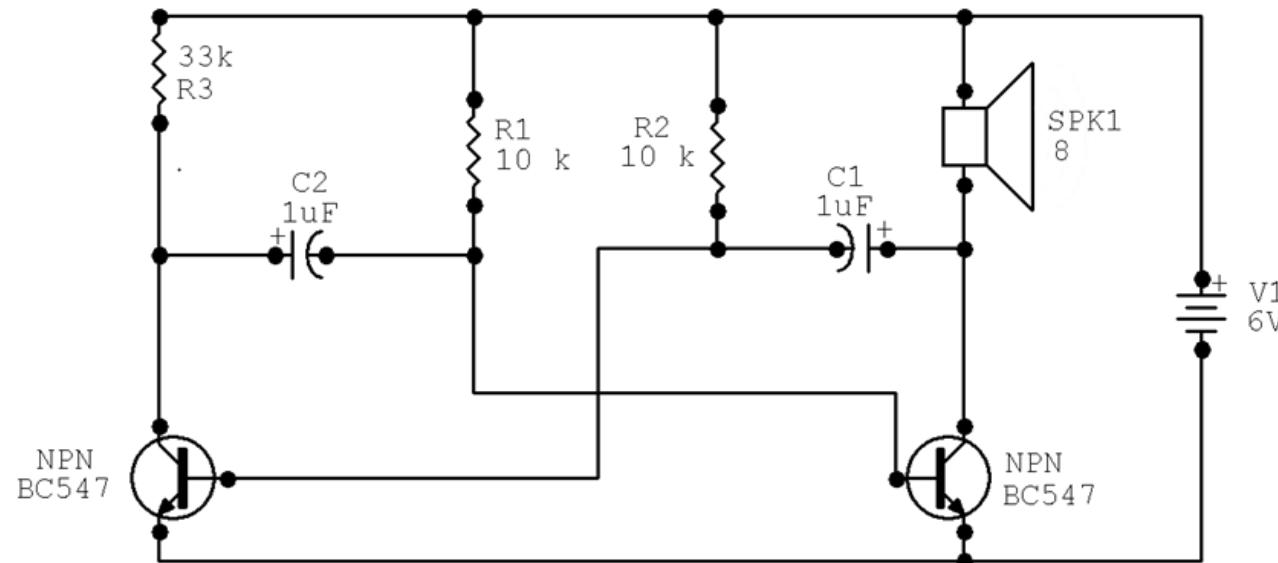
Above oscillator circuit can be tweaked to create many useful hobby circuits, Above oscillator circuit looks like a simple LED light blinder, But this circuit can be turn into a something very exciting like - A rhythmic fountain driver, if we add two relay driver circuits at output instead LEDs, and connect relay with fountain pumps. Or a Bulb blinder, A Diwali Lights blinder. You can see below a image showing how relays can transform a simple circuit into something that can be used with any appliance.



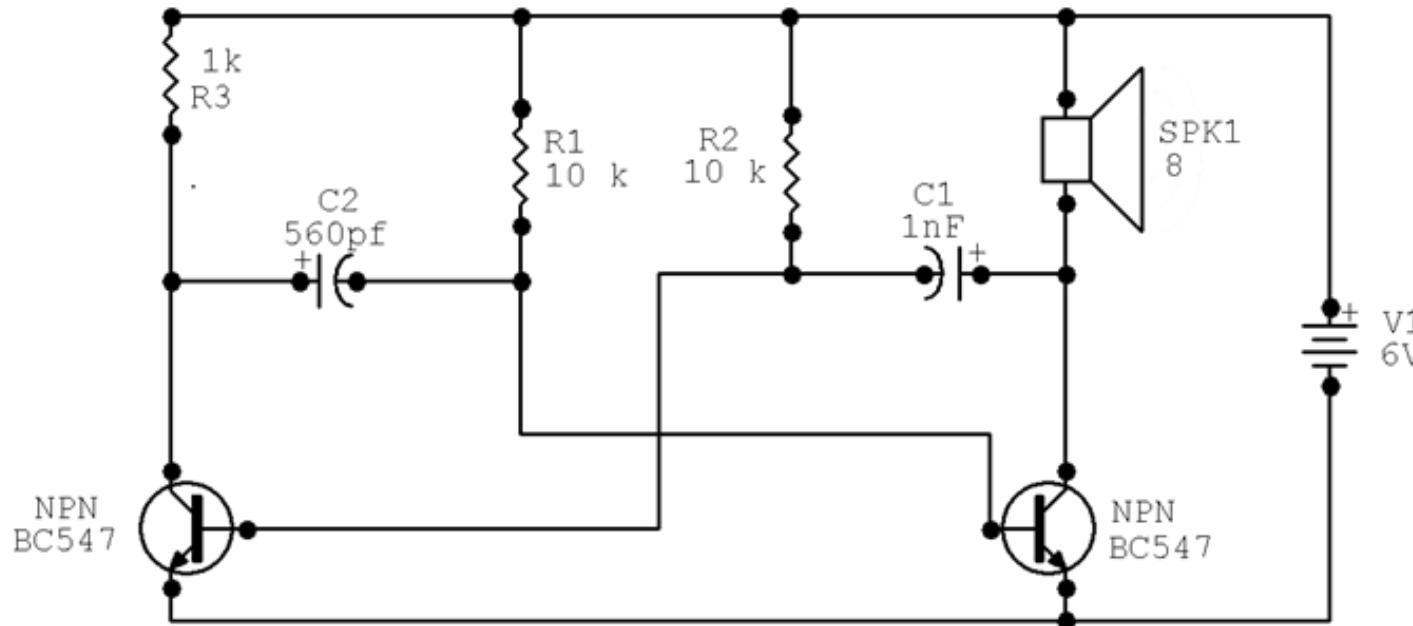
A bulb blinder



Further we can design a sound beeper, if we replace the LEDs with speakers. So lets design with this circuit now-



In above circuit, we can tweak the click sound coming out from speaker by changing the value of Capacitor and resistor. A more high frequency sound will be generated if the value of capacitor is decreased and a continuous tune may be achieved instead of clicks. Further decreasing the value of capacitor may lead to an inaudible frequency which can only be heard by small insects and not human ears. So this kind of circuit can be used as a mosquito/insects repellant.



Coming Soon - Circuit Using IC 555 - In this upcoming section we will be designing circuits using IC 555 as oscillator.

Appendix I

Resistance Calculations

It's often needed to have a resistance with some odd and non standard value like— 5k. When you need such values it's often easy to make it by combining the standard values like— $4.7\text{k}\Omega + 220\Omega + 68\Omega = 4.988\text{ k}\Omega$ which is approx equal to 5k Ω .

There are two ways to combine resistances

- 1) Series**
- 2) Parallel**

Series combination—When we add resistance in series one after another , their values add up simply and resultant resistance is sum of all the resistances in series.

$$R = R_1 + R_2 + R_3 + R_4$$

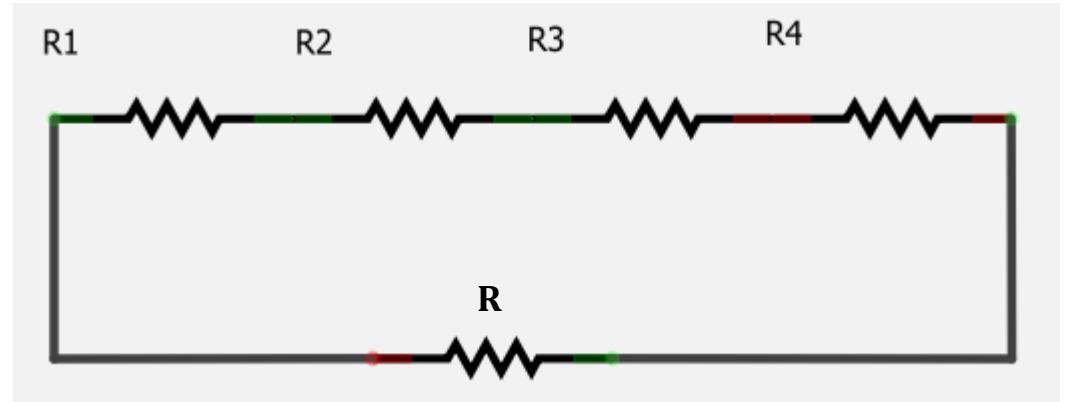
Series combination = Increases Resistance

For Example Suppose—

$$R_1 = 100\Omega \text{ and } R_2 = 100\Omega$$

And if we connect these two in series, then resultant resistance would be —

$$\begin{aligned} R &= R_1 + R_2 \\ R &= 100 + 100 = 200\Omega \end{aligned}$$



So we can make our own resistance by using series combination. It is very useful when we have smaller resistance and we want to have a larger value like if we want 4 M Ω , we can make it by using four 1M Ω resistances.

Question: What If I am not able to make the exact value needed?

Answer: If you are not able to create an exact value, you should use the nearest possible value. In most of the analog circuits this would give same results.

Parallel Combination—When we add resistance in parallel , the resultant value decreases. We can make extremely small values by joining resistances in parallel.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} \dots$$

For two resistances—

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R = R_1 * R_2 / (R_1 + R_2)$$

For Example—

$$R_1 = 100\Omega \text{ and } R_2 = 100\Omega$$

And if we connect these two in parallel then resulting resistance would be—

$$R = 100 * 100 / (100 + 100)$$

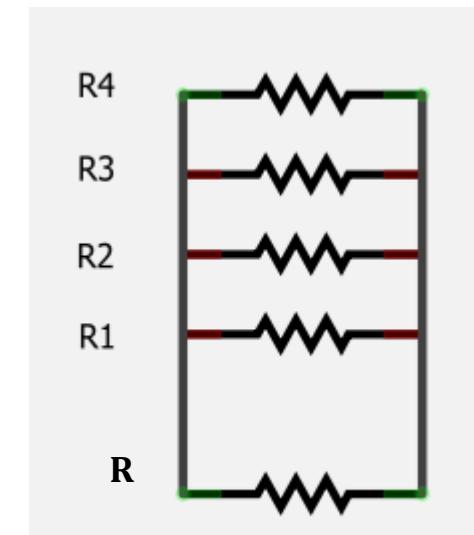
$$R = 10000 / 200$$

$$R = 50 \Omega$$

And if we connect these two in series—

$$R = R_1 + R_2$$

$$R = 100 + 100 = 200\Omega$$



Parallel combination = Decreases Resistance

Appendix II

Capacitance Calculations

As like resistance, Its often needed to have a capacitor with some odd and non standard value like— $147\mu\text{f}$. When you need such values its often easy to make it by combining the standard values like— $100\mu\text{f} + 47\mu\text{f} = 147\mu\text{f}$.

There are two ways to combine capacitors and they methods are completely opposite to resistances which means unlike resistances capacitors decrease their value when combined in series and increase it when combined in parallel.

- 1) Series**
- 2) Parallel**

Series combination—When we add capacitors in series one after another , their values decreases and resultant capacitance is computed by following formula -

$$1/C = 1/C_1 + 1/C_2$$

Series combination = Decreases Capacitance

For Example Suppose—

$$C_1 = 100\mu\text{f} \text{ and } C_2 = 100\mu\text{f}$$

And if we connect these two in series, then resultant capacitance would be —

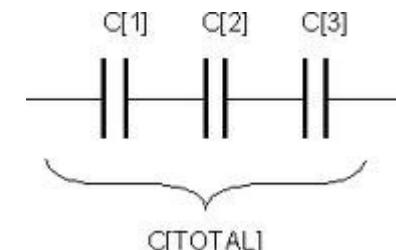
$$1/C = 1/C_1 + 1/C_2$$

$$1/C = 1/100 + 1/100$$

$$1/C = 200/(100*100)$$

$$1/C = 2/100 = 1/50$$

$$C = 50\mu\text{f}$$



So we can make our own capacitance by using series combination. And this is completely opposite to resistance calculation.

Parallel Combination—When we add capacitors in parallel , the resultant value is a simple sum of all capacitors. This is similar in calculation like series combination of resistance.

$$C = C_1 + C_2 + C_3$$

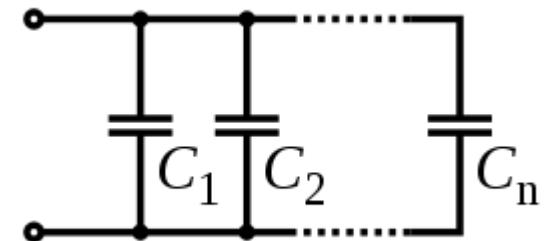
For Example—

$$C_1 = 100\mu F \text{ and } C_2 = 100\mu F$$

And if we connect these two in parallel then resulting capacitance would be—

$$C = 100 + 100$$

$$C = 200 \mu F$$



Parallel combination = Increases Capacitance

Ceramic Capacitor's reading and conversion chart -

Please refer below chart for converting a marking on ceramic capacitor to its actual value. For example we will use 104 ceramic which we are using in our circuits quite often, This capacitor is having actual value in farads as : 0.1 micro farad (uf) or 100 nano farads (nf). By seeing below table you can easily see that 104 capacitor (in right most column) can be converted as $1 + 0 + 10^4 = 100000$ pf. Similarly 103 would be $1 + 0 + 10^3 = 10000$ pf

uf,microFarads $=10^6$ Farads	nf,nanoFarads $=10^9$ Farads	pf,picoFarads $=10^{12}$ Farads	Multiplier used Exemple = .01uF = 103
0.000001uf=	0.001nf=	1pf	(1)
0.00001uf=	0.01nf=	10pf	(10)
0.0001uf=	0.1nf=	100pf	(101)
0.001uf=	1nf=	1000pf	(102)
0.01uf=	10nf=	10000pf	(103)
0.1uf=	100nf=	100000pf	(104)
1.uf=	1000nf=	1000000pf	(105)
100uf	100000nf=	100000000pf	—————

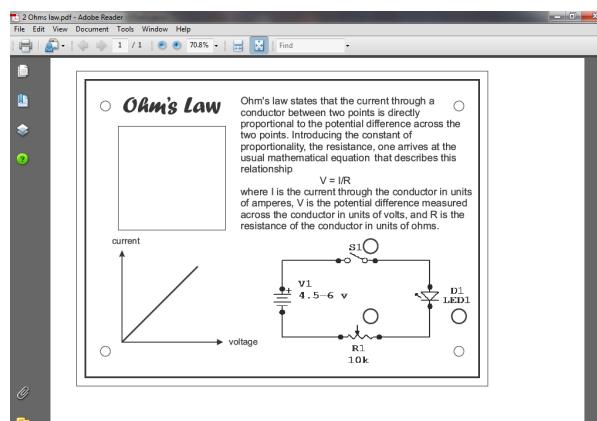
Appendix III

Working with Paper Panels

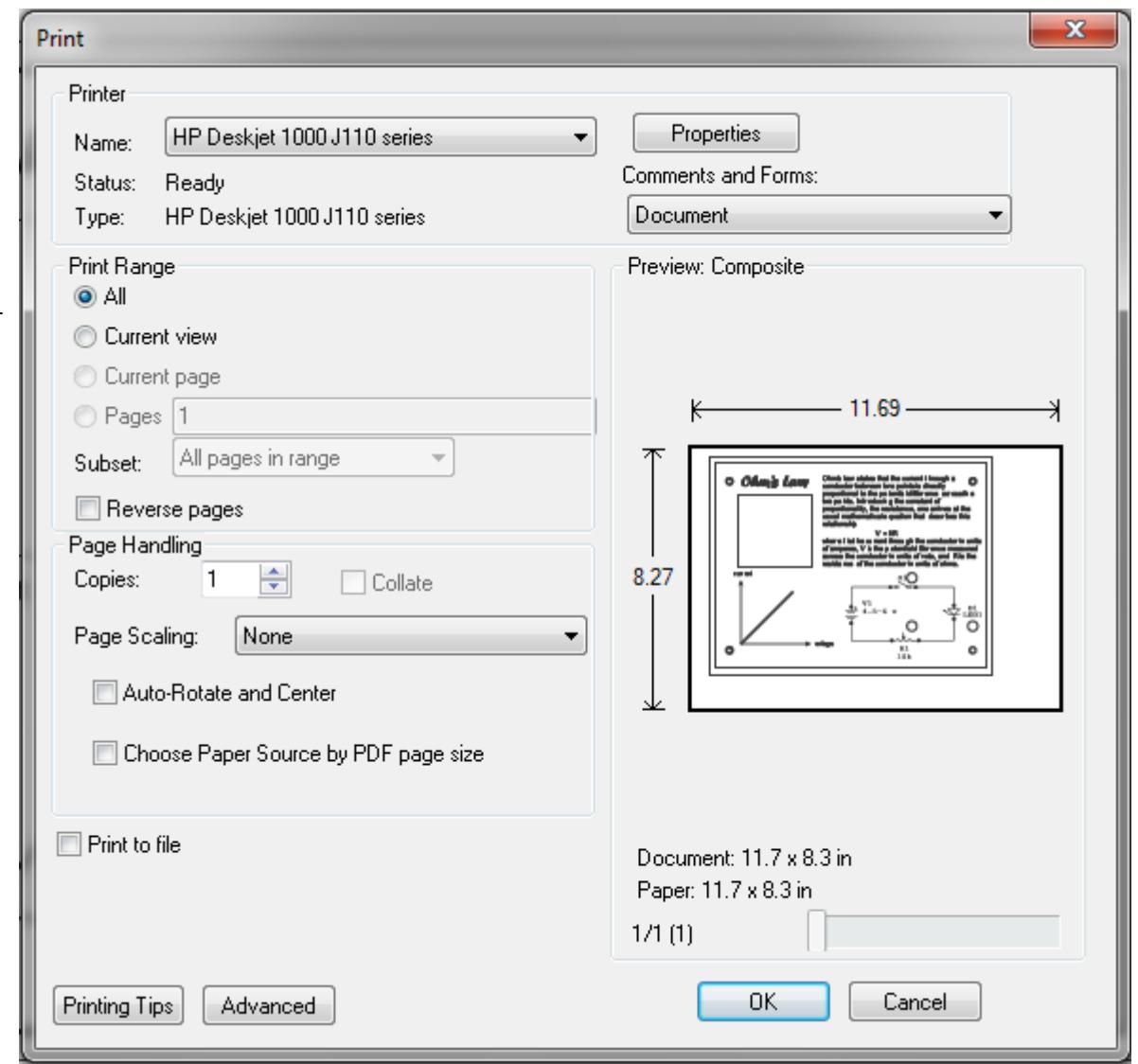
If you are using one of the downloaded panel's PDF file from our website (www.hobbyelectronics.in), then you should configure your printer in order to print the file in correct size.

Please follow below steps—

- 1) Refer figure on the right and set “comments and forms” as “Document”.. Also set page scaling to “None”
- 2) Click on Properties button and set page size to—“A4”
- 3) Verify that your page size is coming as 8.27 and 11.69 as shown in figure.



Panel Drawing opened in Adobe PDF Reader.

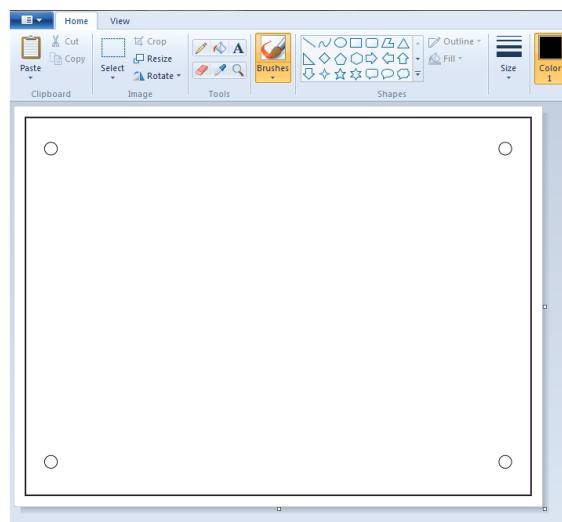


Making Your Own Paper Panel

As Making your own design is always fun and exciting, You can imagine you own console with lot of buttons and lights like a airplane cockpit or you can make your science book experiments to show them to school science fairs.

To start make your own panel you need to have a exact size template of panel and then you need to follow the steps mentioned below -

- 1) Open the Empty panel drawing in MSPaint (Paint brush or any another photo edit software), You can find the empty panel drawing in CD/DVD in panel folder or you can download it from www.hobbyelectronics.in website.



Empty Panel Drawing opened in Microsoft Paint Software

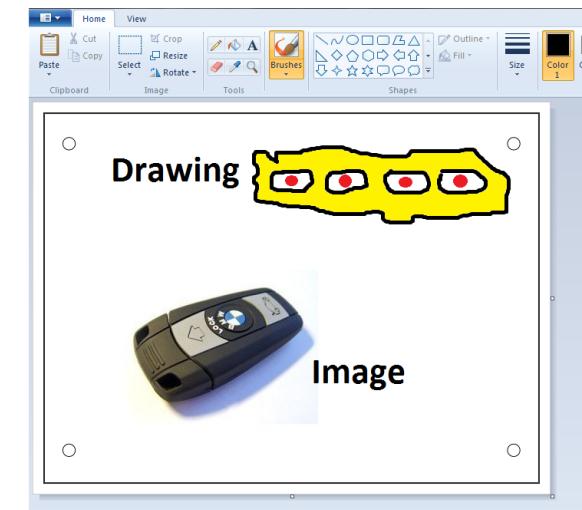
- 2) Draw the desired drawing in between panel boundaries (Refer the figure on right side).

- 3) Copy images from Internet/ local computer and paste them in panel.

- 4) Save your drawing and take a print out, And remember not to do any resize or 'fit to page' settings while printing, Or it will change the size of panel.



Printing your panel on A4 paper



After Drawing

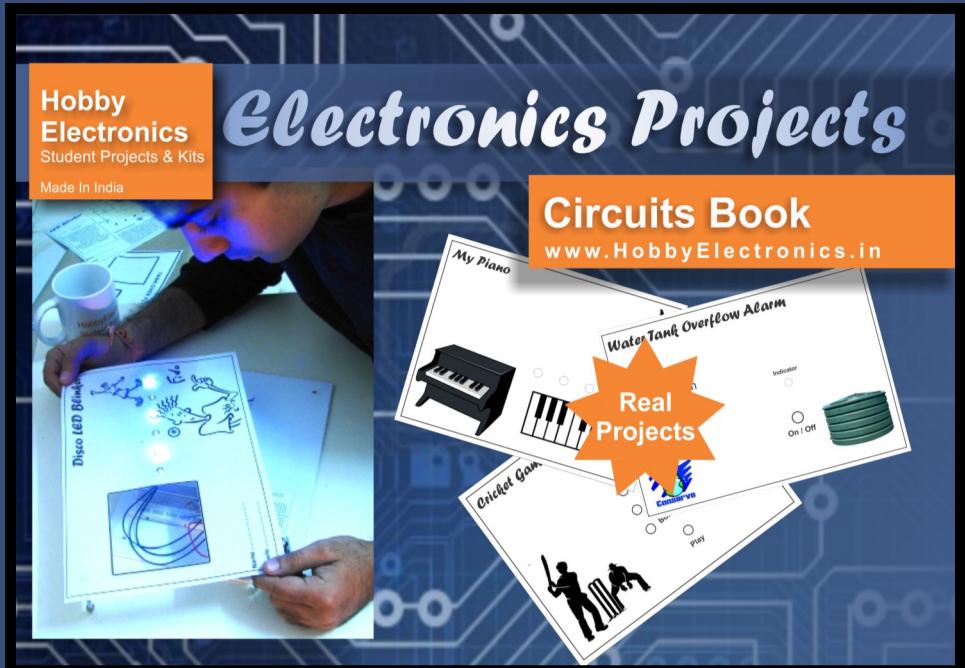
About Book

This Book provides a practical hands on learning experience to the students who are curious towards the wonderful world of electronics. The projects created in this book explains important basic electronic concepts in simple and descriptive manner. Every possible effort has been made to make/include in this book -

- Self Descriptive
- Rich Images and Illustrations
- Easy to make Projects
- Battery Operated and Safe circuits
- Emphasis on Electronics Concepts

For Children of age 14 and above

Choking Hazard: The projects described in this book uses small components



About Author

Varun Bansal (B tech in IT) is electronics hobbyist by heart and Computer programmer by work. Whenever he gets time he try to make his own gadgets and use them. Apart from electronic circuits he maintains a website—

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www.myphototrips.wordpress.com

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