Revised Edition 4.3

Hobby Electronics
Student Projects & Kits

Electronics Projects

Circuits Book

www.HobbyElectronics.in

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, transitors etc. It is important to know how the components behave when they are connected in a closed circuitfor 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 permisable voltage rating along with polarity written on them , for resistors polarity doesnt 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 whereever 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 destryed 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 eample the simple LED lights project can be used as a bedroom lamp.

Finally a project is worthless if it isnt portable and useful. And what makes a circuit useful is actually the cabinet. Which hides all the tiny sensitive componnets 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 cant take out assemble components easily for replacements apart from this long contact with Soldering iron may damage sensitve components. Breadborad provides a perfect platform for testing circuits so we recommend using breadboard .

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

Contents

Basic Electronics Components

1. Resistor
2. LED—Light Emitting Diode
3. Electrolytic Capacitor
4. Ceramic Capacitor
5. Potentiometer or Variable Resistance
6. Preset
7. Light Dependent Resistance
8. Relay
9. Reed Switch
10. Microphone
11. TSOP IR Module
12. RGB LED
13. IC – Integrated Circuits
14. Thermistor
15. Transistor
16. Breadboard
17. Bread Board Wire

Working with paper panels
Work Gallery

1. The LED Circuits

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

2. Basic Laws

2.1 Ohm's Law Circuit
2.2 Demonstration Project
2.3 Kirchhoff's Laws
2.4 Seeback effect
2.5 Law of Induction
2.6 Electricity with Potatoes
2.7 Microphone with a Matchbox

3. Simple Transistor Circuit

3.1 Transistor As A Switch
3.2 Cupboard timer
3.3 Parking Light
3.4 Plant watering Reminder
3.5 Bar Graph Meter

4. Zener Diode Circuits

4.1 Concept of Zener Diode with simple circuit
4.2 Voltage regulator circuit
4.3 Low battery power indicator

Contents

5. Flip-Flop

5.1 Flip Flop Circuit
5.2 LED Blinker Project
5.3 RS Flip Flop
5.4 Logic Gates using simple Circuit

6. Melody Circuit

6.1 Melody Circuit
6.2 Sensitive Melody Circuit

7. Darlington Pair

7.1 Darlington Circuit
7.2 Water Tank Overflow Alarm/Rain Alarm
7.3 Fire Alarm
7.4 Light Sensitive Morning Alarm
7.5 LASER based Anti-Theft Alarm System
7.6 Wire Current Detector
7.7 Pencil And Paper Circuits
7.8 Paper Circuits Using Darlington Pair

8. 555 Timer Projects

8.1 4 Key Piano
8.2 Light sensitive music circuit
8.3 Light controlled Police Siren
8.4 Touch Switch
8.5 Timer
8.6 Continuity Tester
8.7 Knight Rider
8.8 Cricket Game
8.9 Two Light Flasher using IC 555
8.10 LED Flashing Circuit using 555
8.11 Multipurpose Circuit
8.12 Johnson counter
8.13 Mosquito Repellant
8.14 Raising Falling Siren

9. Infrared Projects

9.1 Simple IR Receiver
9.2 IR based Receiver and Transmitter

10. Audio Projects

10.1 Clap Switch
10.2 Intercom

11. 7 Seg Display Circuits

11.1 Random LED Blinker
11.2 Digital Dice

Contents

12. Test And Measurement

12.1 Resistance, Diode, Continuity measurement
12.2 Voltmeter And Ammeter
12.3 Wheatstone bridge

13. Circuit Designing Guide

13.1 Simple Transistor Sensor Circuits
13.2 Driver Circuit
13.3 Oscillator Circuit

Appendix I

Resistance Calculations

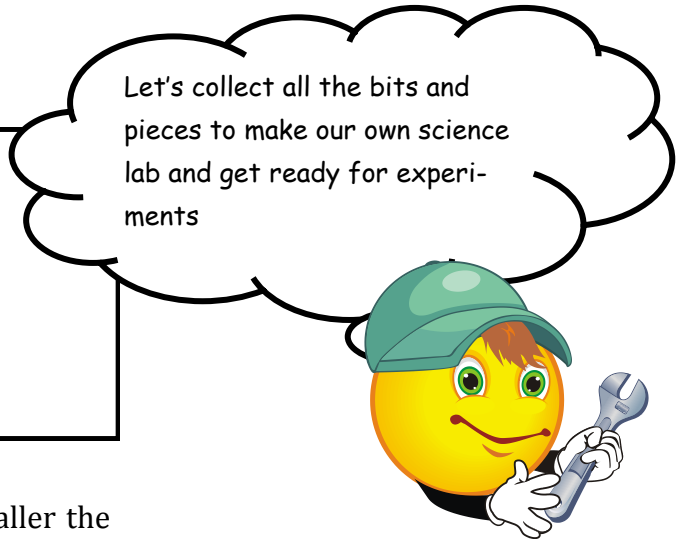
Appendix II

Capacitance Calculations

Appendix III

Working with Paper Panels
Making Your Own Paper Panel

Basic Electronics Components



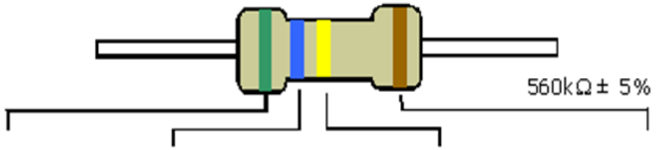
In this section we will see :

1. Resistor
2. LED
3. Electrolytic Capacitor
4. Ceramic Capacitor
5. Variable Resistance
6. Preset
7. Light Dependent Resistor
8. Relays
9. Reed switch
10. Microphone
11. TSOP IR Module
12. RGB LED
13. IC – Integrated Circuits
14. Thermistor
15. Transistor
16. Breadboard
17. Breadboard Wire

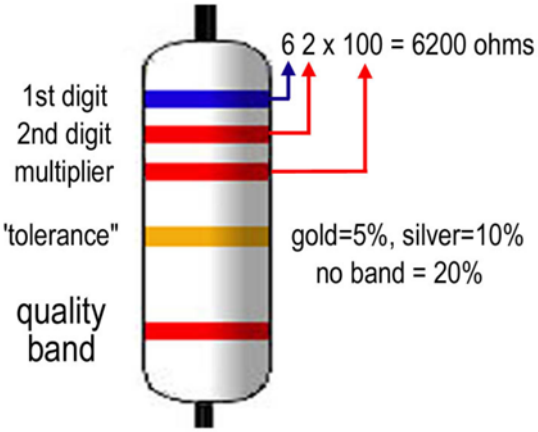
1. Resistor

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.

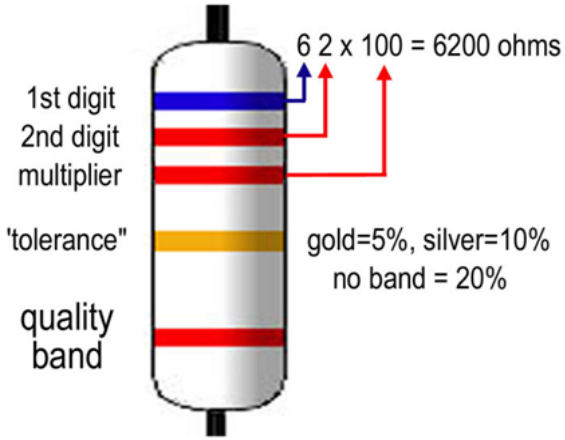
Resistances have a color coding scheme, you can calculate the value of it by just looking at color bands, This is because resistances are small and numbers can't be printed on them directly. In the right hand side figure, you can see the table showing all the colors and their values. Gold and silver color is present in every resistor to show its tolerance, Gold means that it value will be +/- 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	± 1%	(F)
Red	2	2	2	100Ω	± 2%	(G)
Orange	3	3	3	1KΩ		
Yellow	4	4	4	10KΩ		
Green	5	5	5	100KΩ	±0.5%	(D)
Blue	6	6	6	1MΩ	±0.25%	(C)
Violet	7	7	7	10MΩ	±0.10%	(B)
Grey	8	8	8		±0.05%	
White	9	9	9			
Gold				0.1	± 5%	(J)
Silver				0.01	± 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?



2. LED—Light Emitting Diode

A light-emitting diode (LED) is a semiconductor light source. It is same as a diode we have discussed earlier, It passes current only when connected in right direction (positive of diode to positive of battery and negative to negative) and do not pass any current when connected in opposite direction, with only difference that when it passes current it also emits light with it.

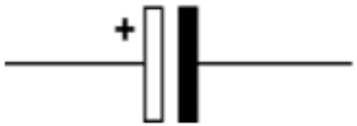
LED Symbol

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 µf and can handle a voltage of 400 v.



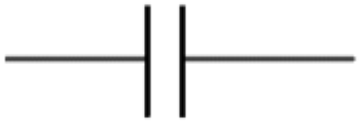
Capacitor Symbol

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 then 1microfarad (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

6. Preset

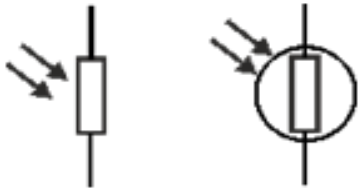
These are miniature versions of the standard variable resistor. They are designed to be mounted directly onto the circuit board and adjusted only when the circuit is built.

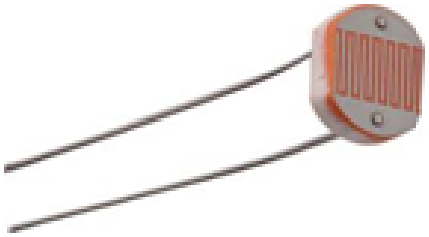
A Preset (same as variable resistance)

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

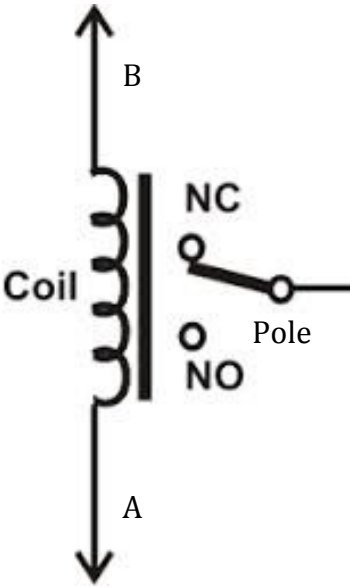
8. Relay

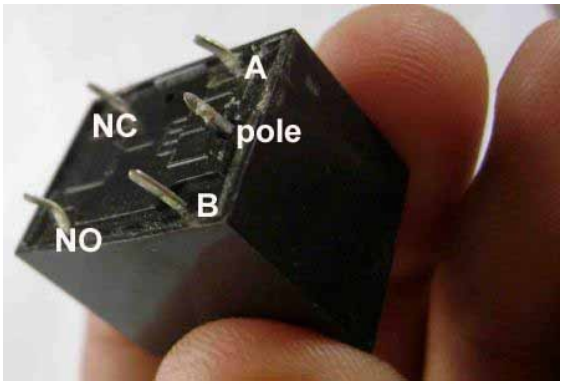
A relay is an electrically operated switch. Relays use an electro magnet to operate a switching mechanism mechanically . Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits)

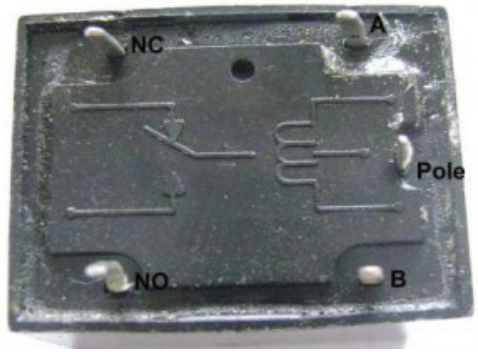
You can see the schematic diagram of a relay and an image of a real relay on right hand side.

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.



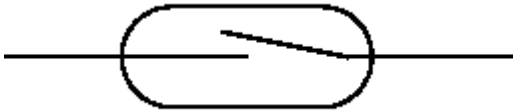




9. Reed Switch

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.

Reed Switch



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.***

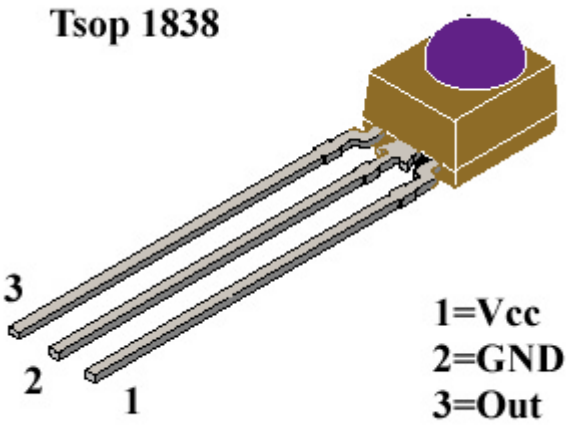
Microphone

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.



12. RGB LED

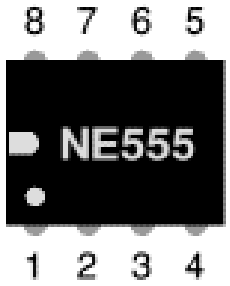
An RGB LED, as name suggests is a special LED which is capable of producing all colors by mixing Red, Green and Blue colors. In simple words It consists of 3 LEDs (Red,Green,Blue) together in a package and by variation of these 3 colors more colors can be formed.
An RGB LED is having 4 pins, one of which 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.

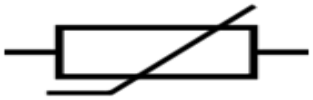


The most popular 555 timer IC

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

14. Thermistor

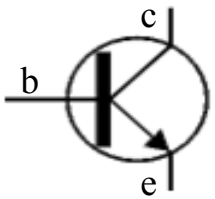
A thermistor is a type of resistor whose resistance varies significantly with temperature. When heated, its resistance gets small, when cooled its resistance increases.

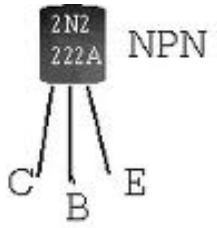


A Thermistor and its symbol

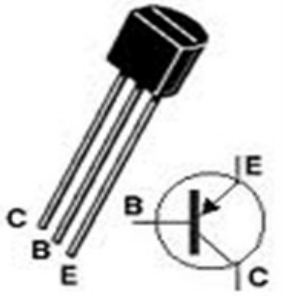
15. Transistor

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.





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



PNP transistor

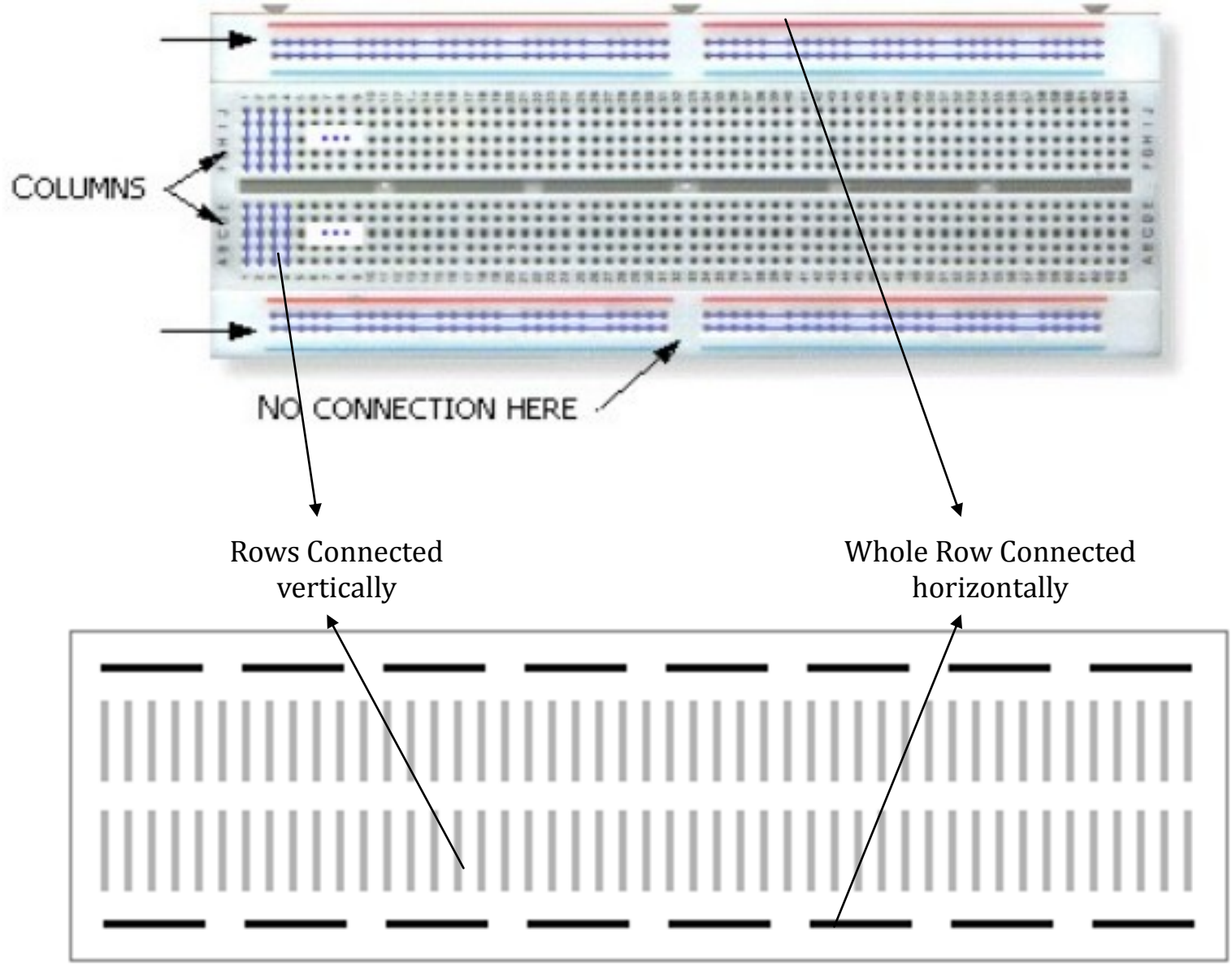
Caution: Transistors should be correctly connected or a wrong connection may damage transistor.

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

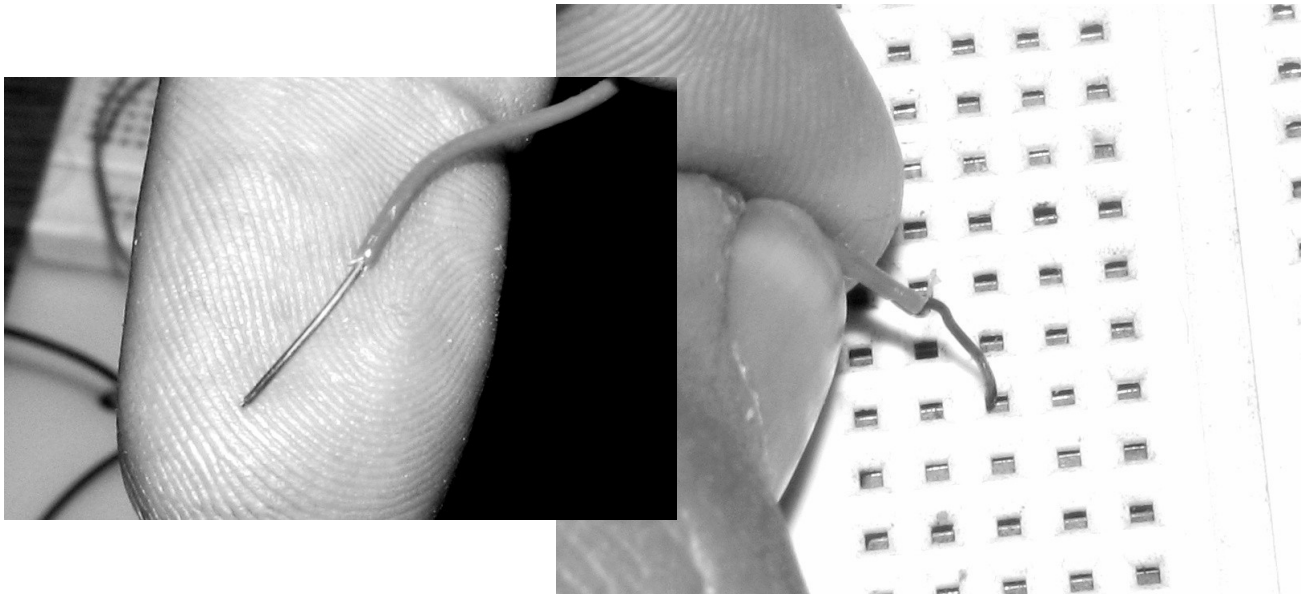
The figure on right side is showing the internal pins connections of a breadboard. The holes in the middle portion of board are connected vertically as shown by highlighted lines. The outer two rows of holes are connected horizontally as shown by red/black lines in the figure.



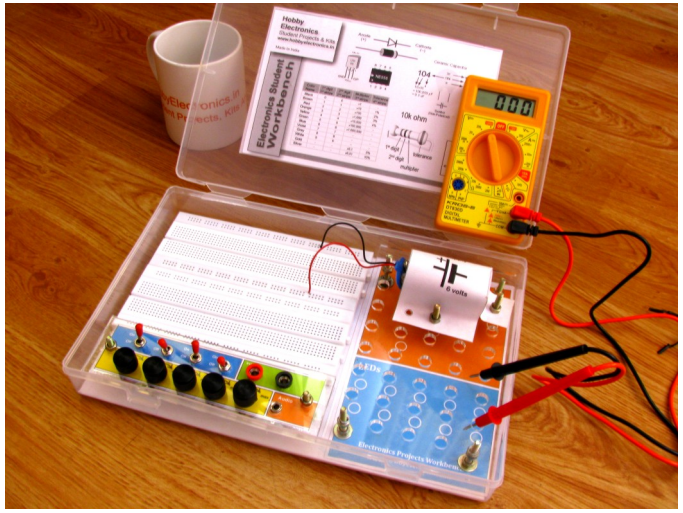
Internal Wiring Diagram of a Breadboard

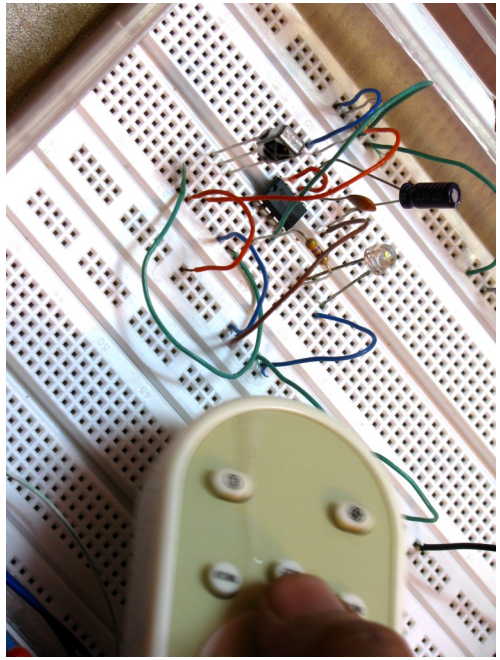
17. Breadboard Wire

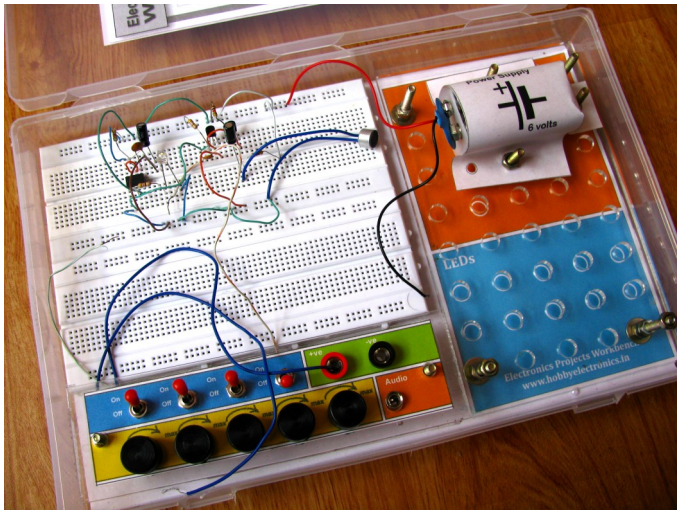
The best wire for breadboard is single core (Only one thick wire with insulting sleeve) copper wire, Please refer the picture below. Its not so tough to find this wire, mostly telephone wires and LAN wires are single core

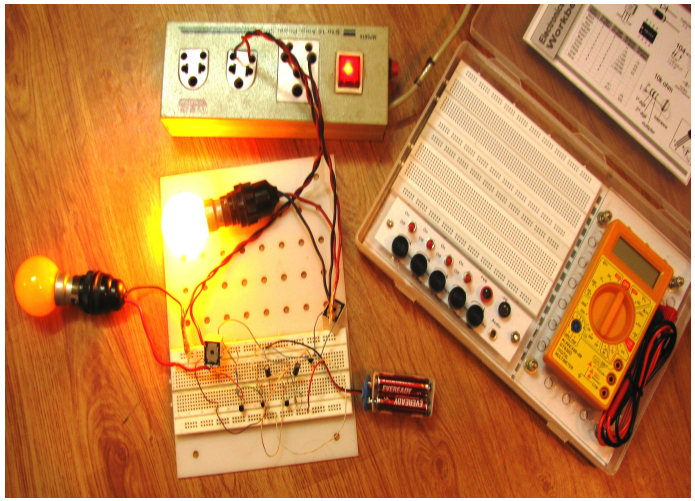


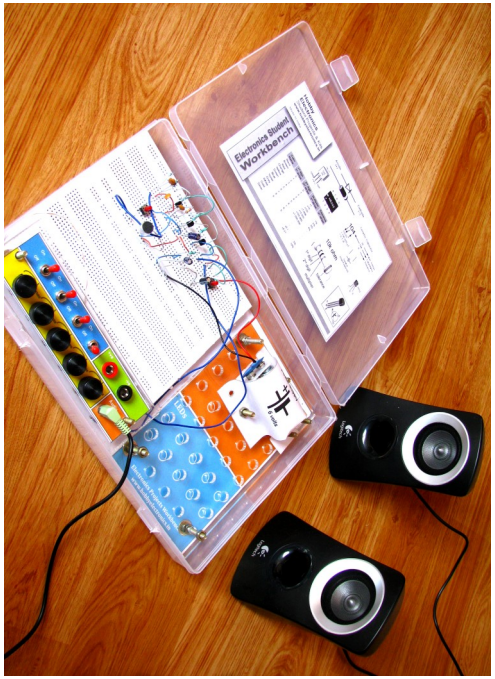
Electronics Student Workbench

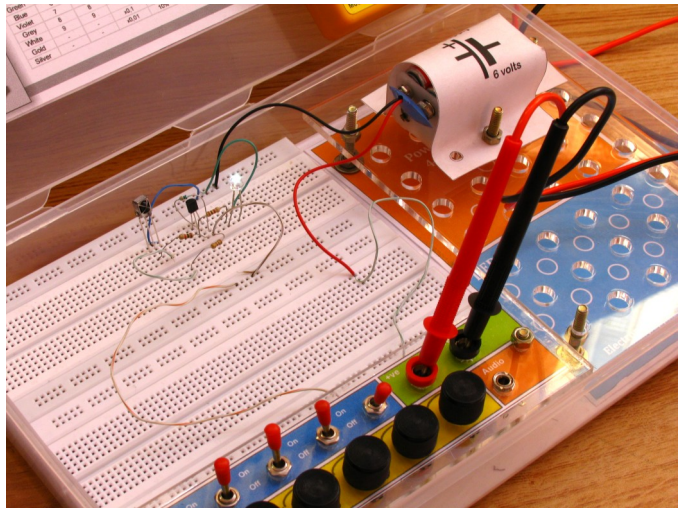




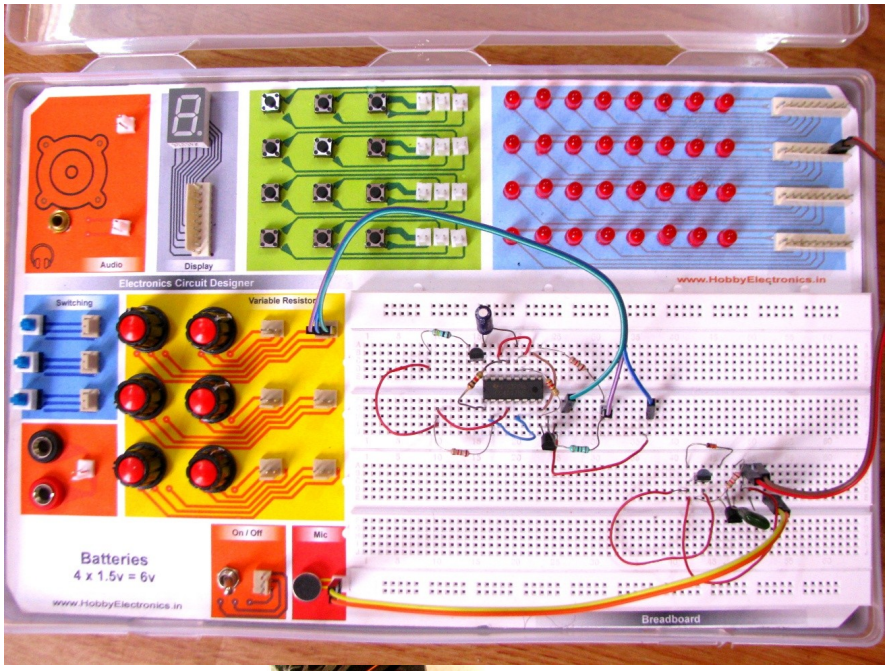


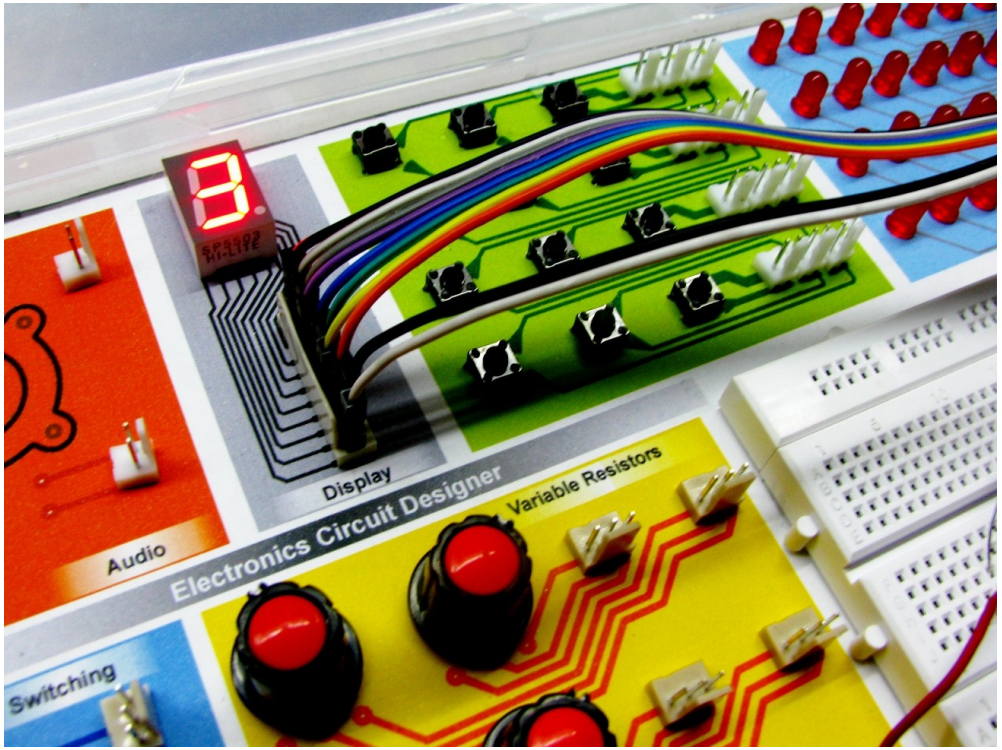


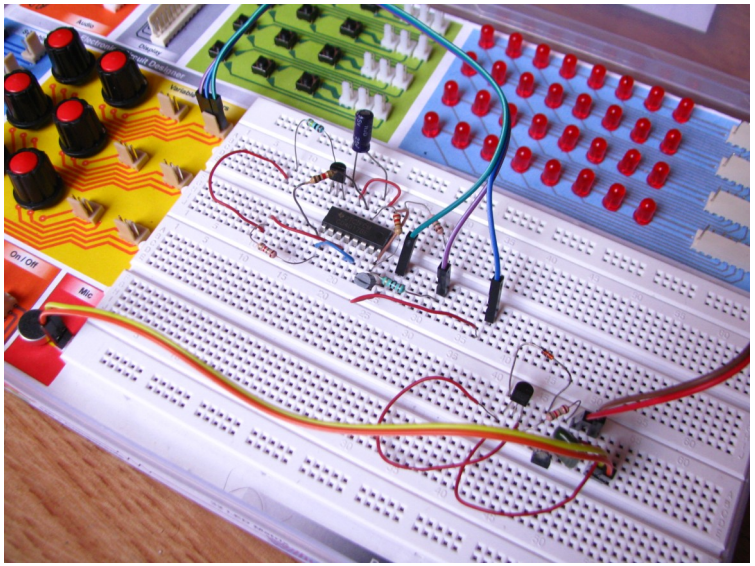




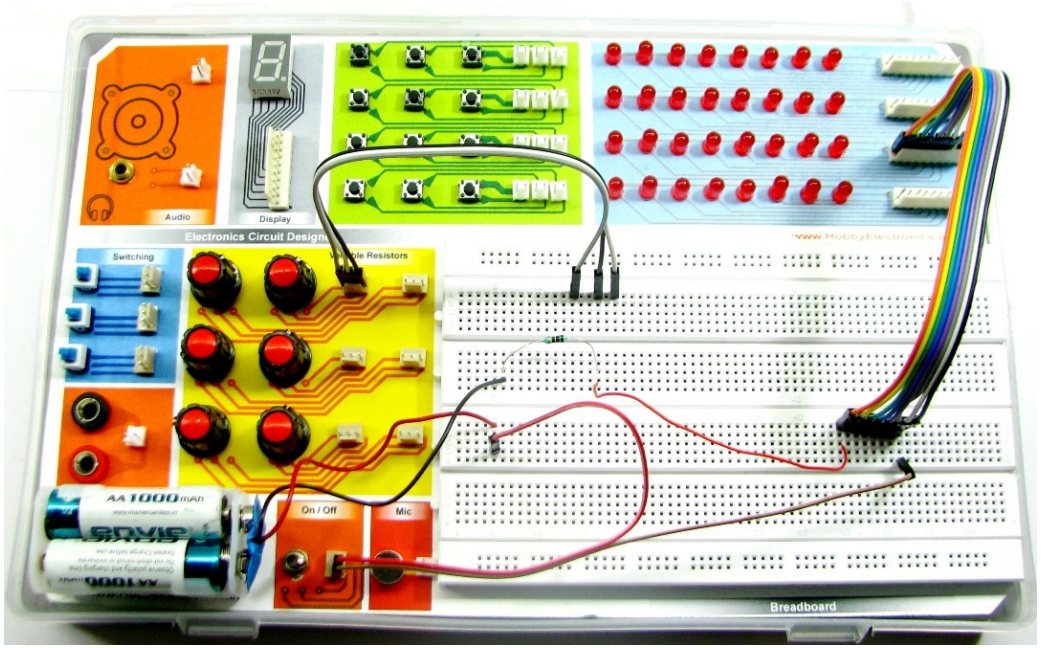
Electronics
Projects Mega Kit








Batteries
4 x 1.5v = 6v
www.HobbyElectronics.in
On / Off
Mic

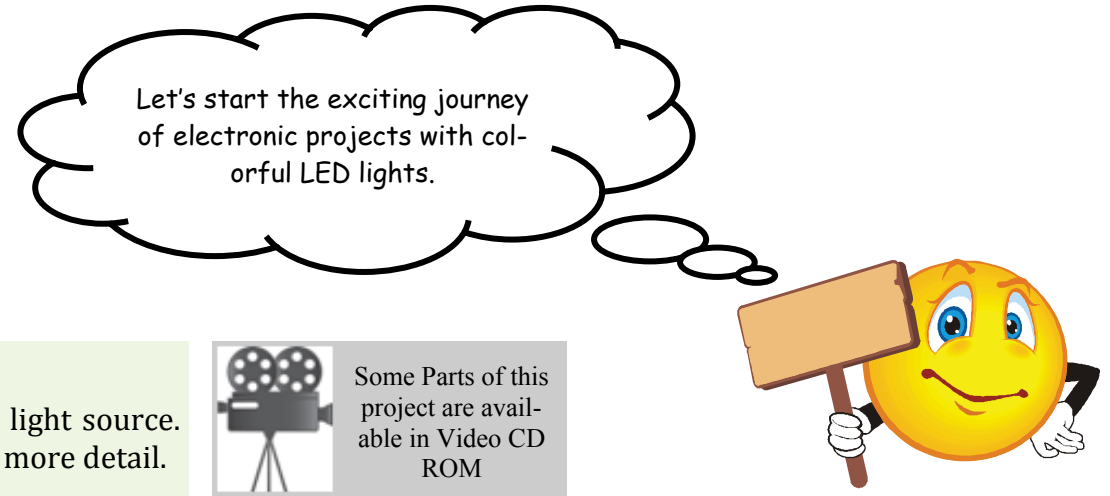

Audio
Display
Switching
On / Off
Mic
Breadboard


Electronics Components Box
Batteries
4 x 1.5v = 6v

1. The LED Circuits

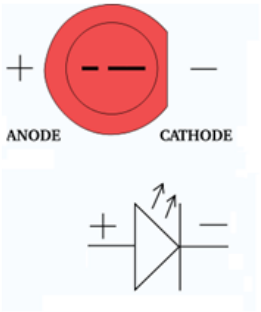
In this section we will make :

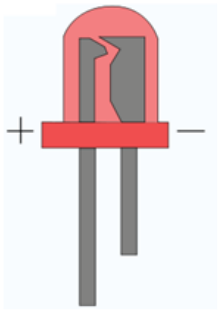
1.1 Simple LED Circuit
1.2 Multiple LEDs Circuit
1.3 An Ambient Light on MY Kit.
1.4 Simple Diode Circuit
1.5 Ambience Light with RGB LED



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

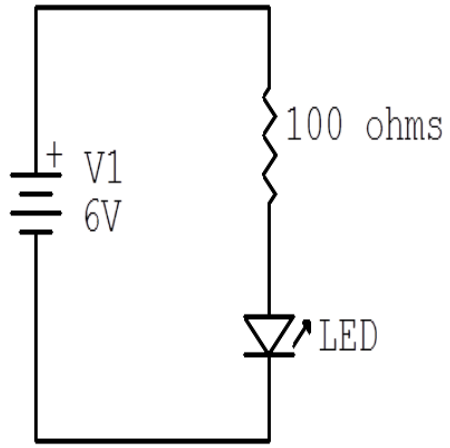




TIP:
The Longer leg of LED is always positive and must be connected to positive terminal of battery.

Let's Do It

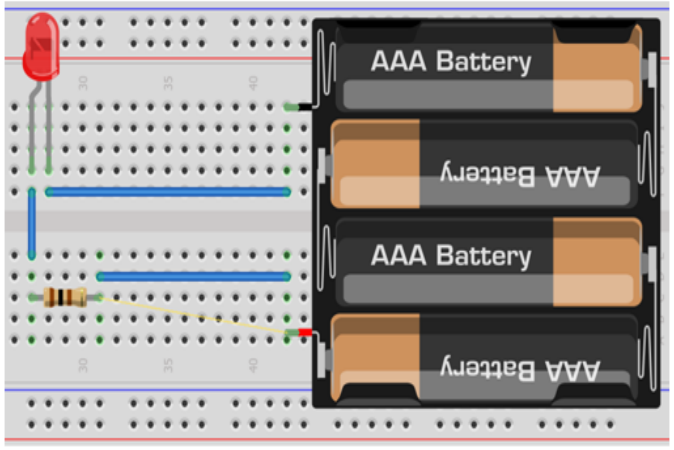
To start working with electronic circuits, Let's make a super simple circuit first. The circuit is all about lighting LEDs with battery. This circuit will also teach you how to use kit and connect wires in bread-

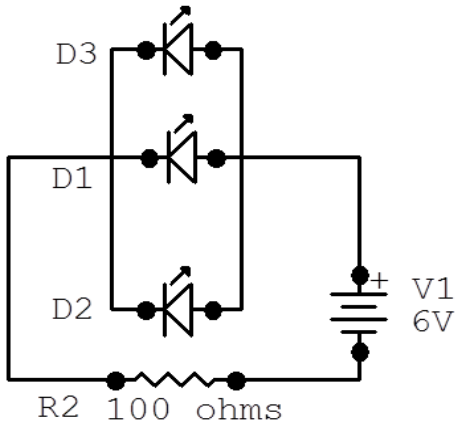


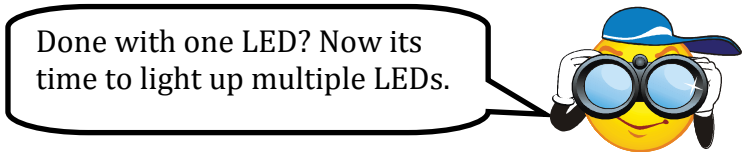
1.1 Simple LED Circuit

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.



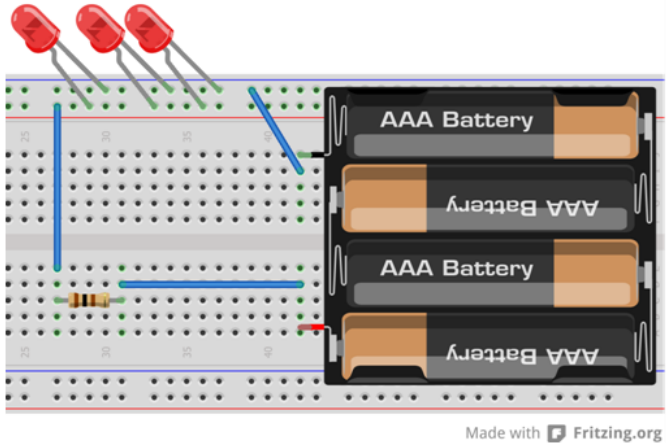




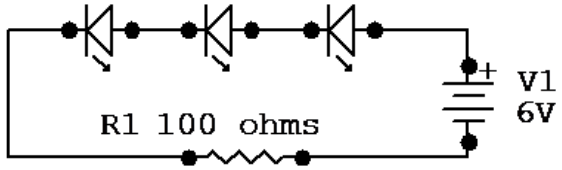
1.2 Multiple LEDs Circuit

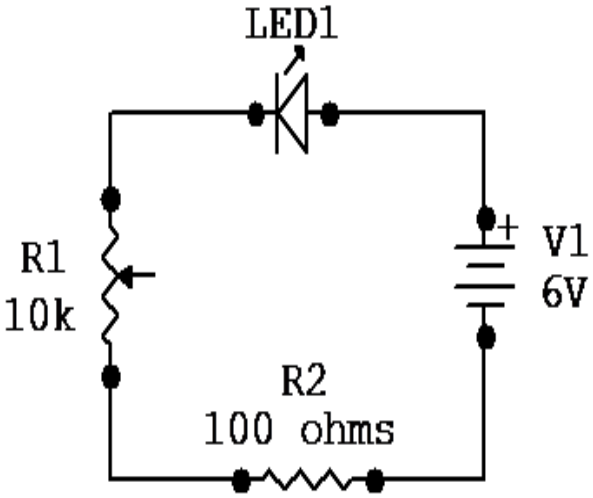
To make a multiple LED circuit we will add up more LEDs in parallel to previous circuit of single LED.

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



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.



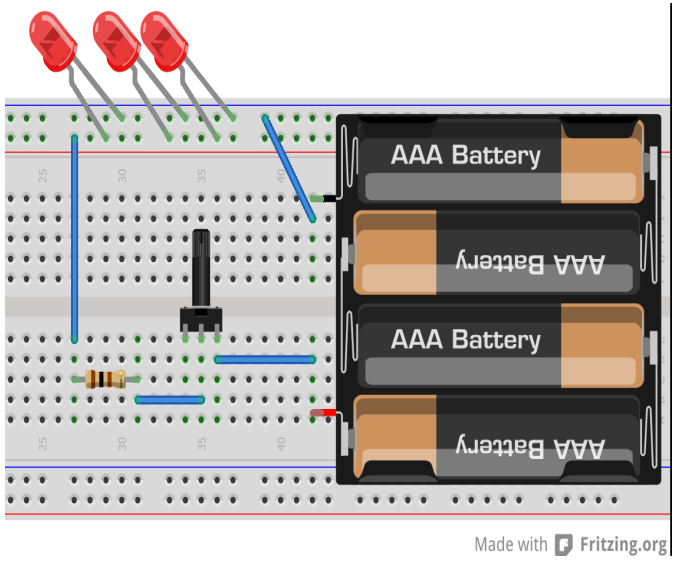


1.3 LED Ambient Lamp

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 the 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).



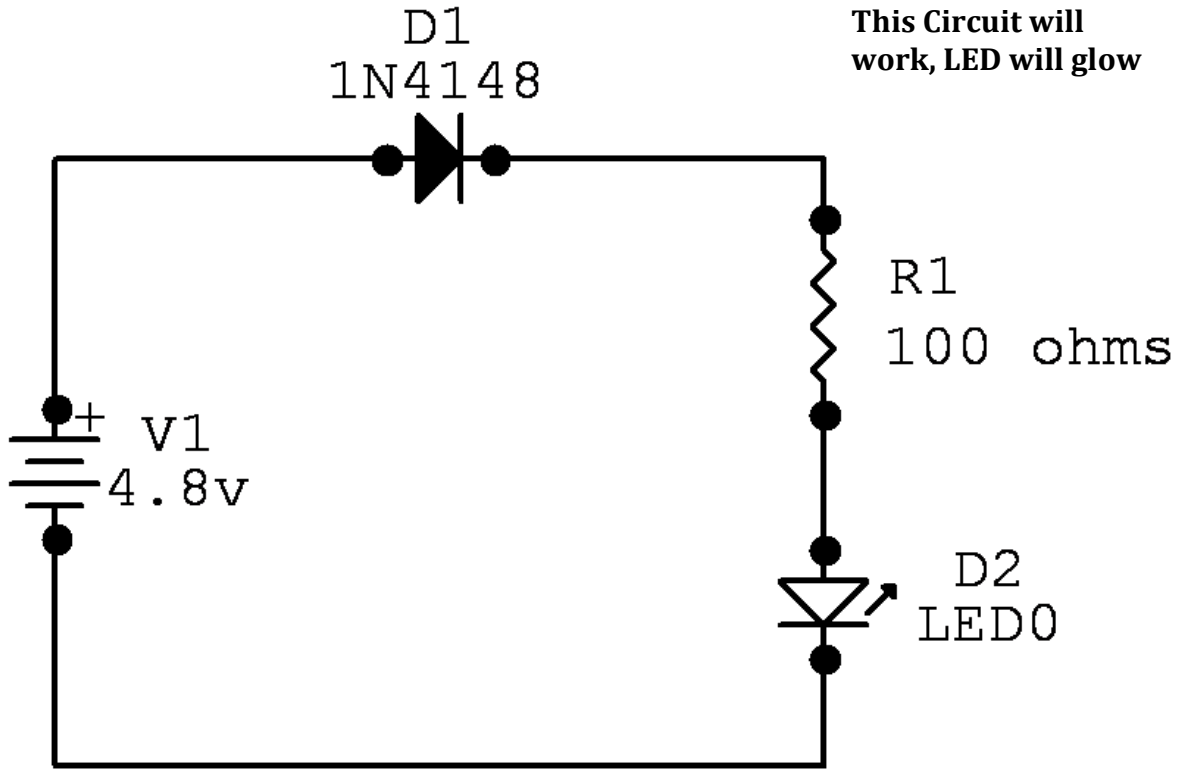
Step 2: Cut a small piece of paper and paste it on your Kit to cover up the LED. This will diffuse the light coming out of LED.

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

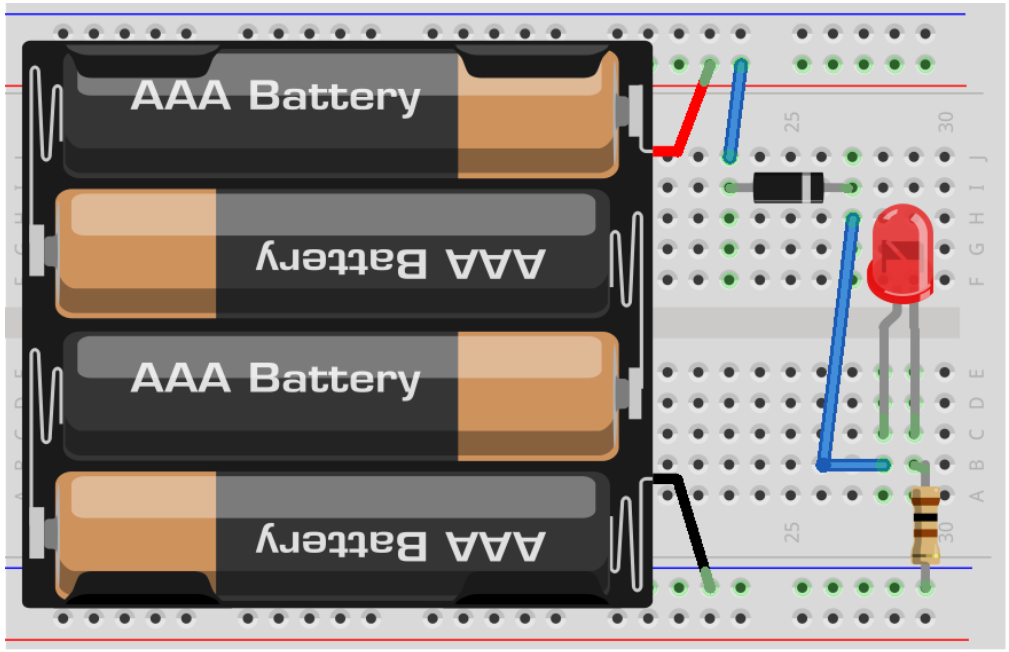
Lets make simple circuits to understand the working of a diode. To see how diode works, only when it is connected in one direction, we are going to connect diode in both directions one by one. If the above definition is correct the diode should conduct only in one circuit, which will be indicated by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



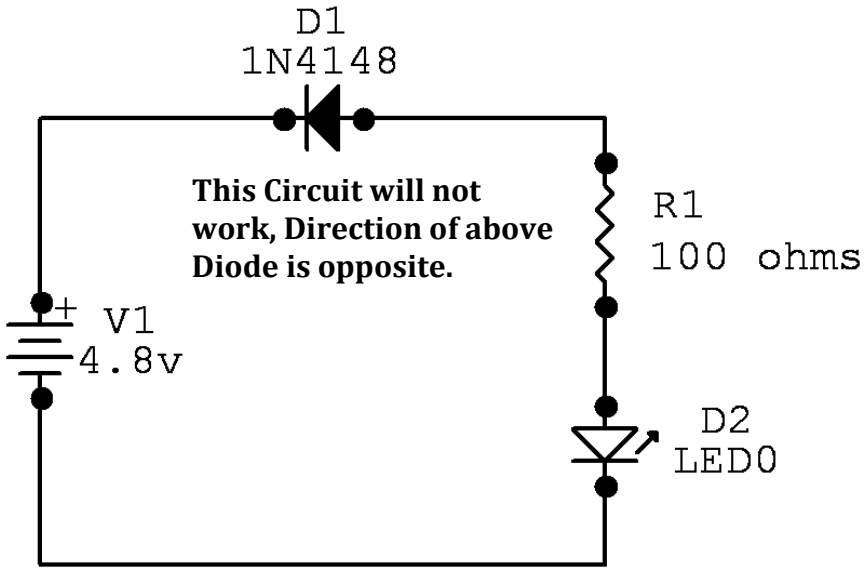
This Circuit will work, LED will glow

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.

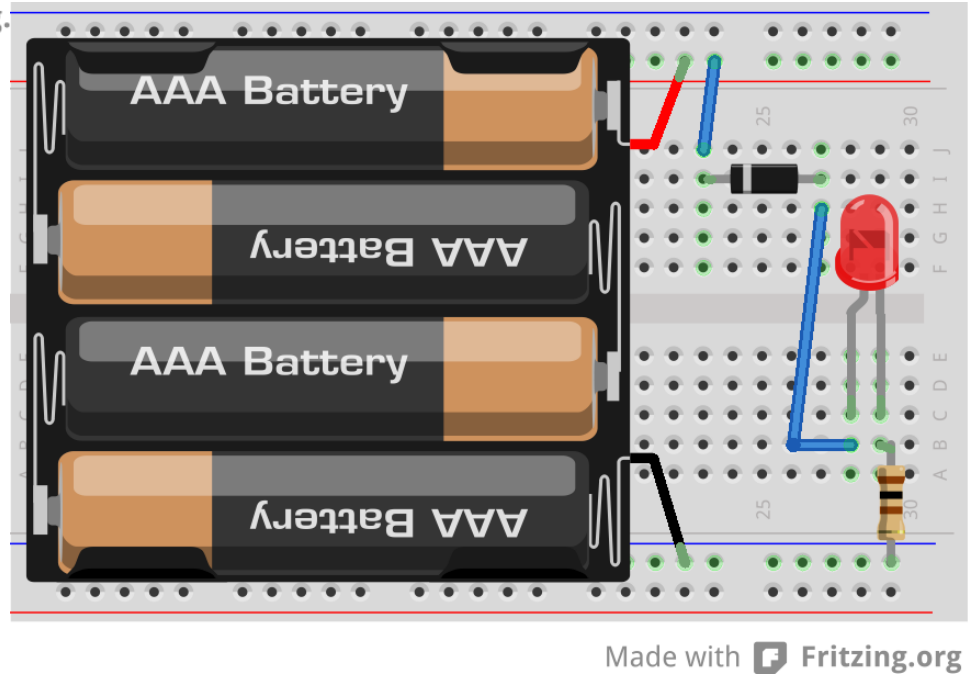


This Circuit will work, LED will glow



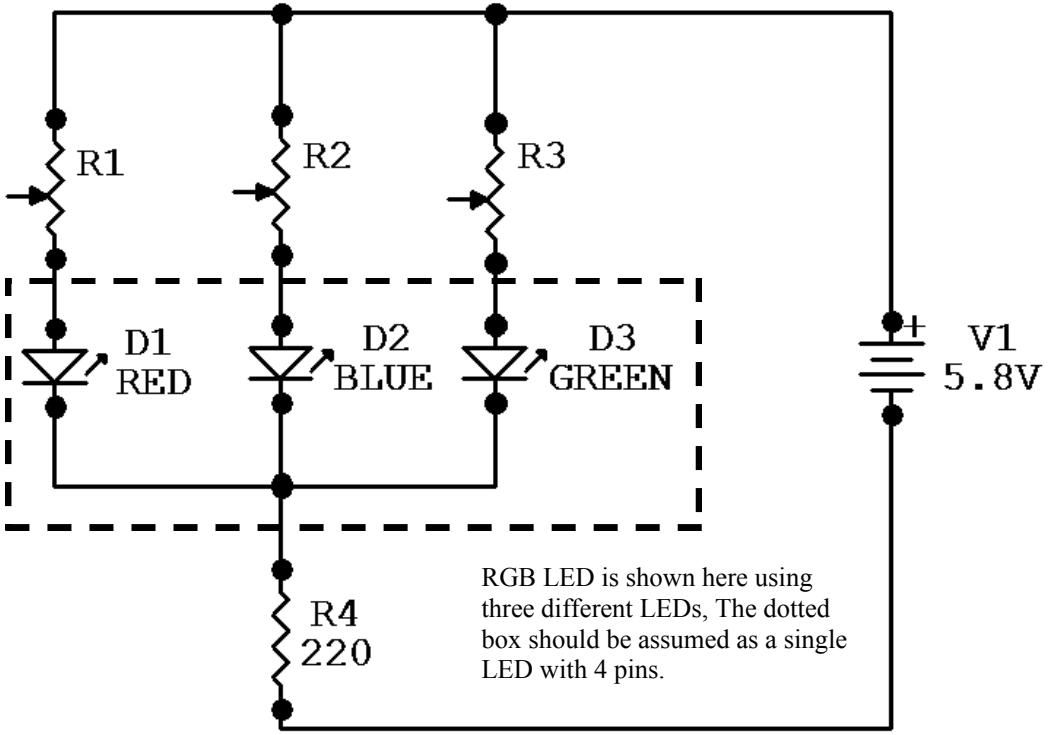
This Circuit will not work, Direction of above Diode is opposite.

This Circuit will not work, LED will not glow



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.

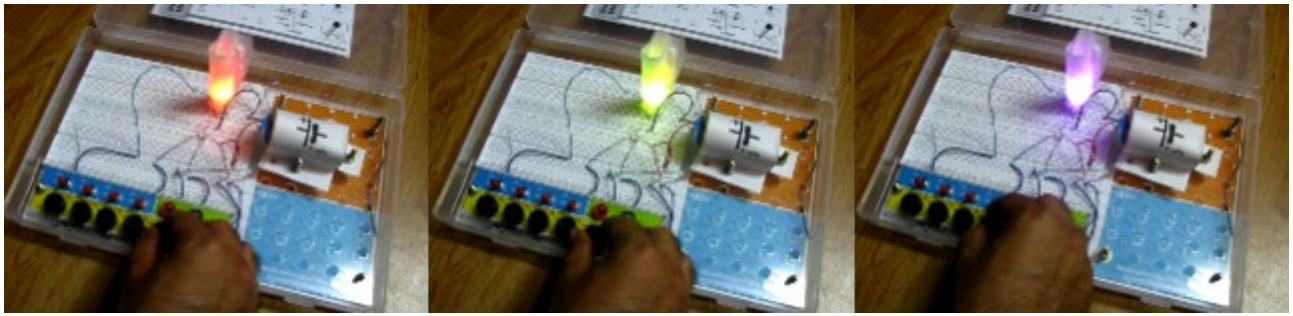
This is the principle on which LED Tv works. An LED Tv contains millions of RGB LEDs very close of each other. Each LED create one pixel of image.

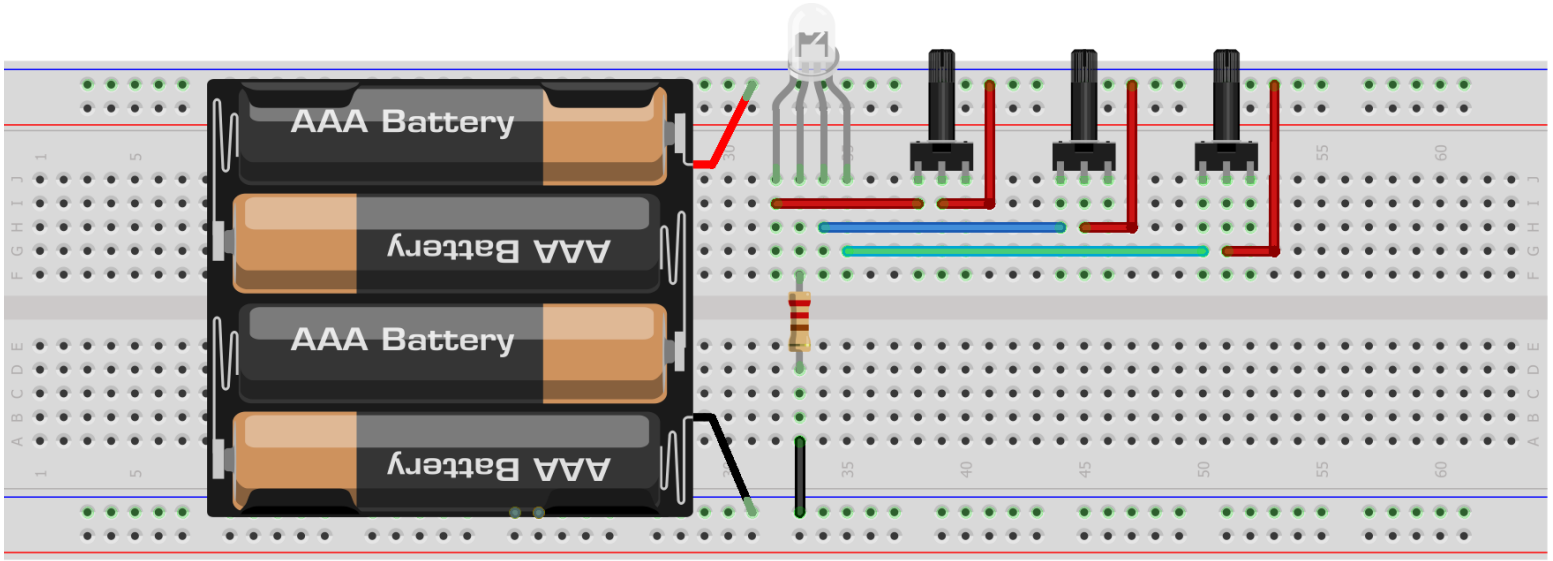
.According to the image, different voltage is applied on different LED and together they create a visual image, When looked from a distance we only see a image but when you look the screen from very close (maybe with a magnifying glass) you will observe LEDs. An RGB LED is having 4 pins, one of which 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



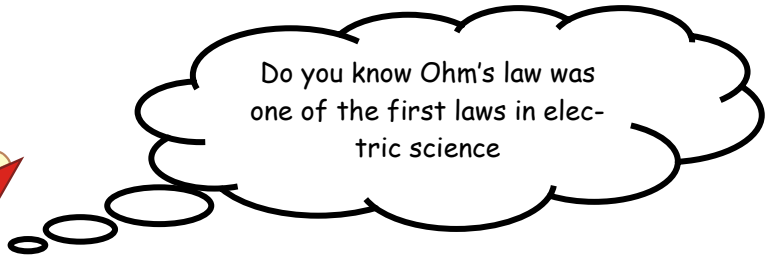


RGB LED Circuit

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



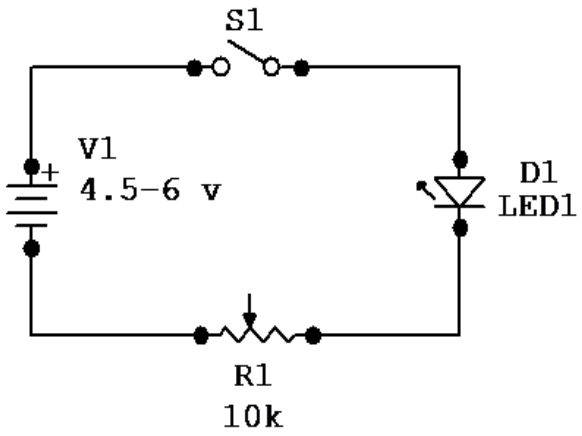
Some Parts of this project are available in Video CD ROM

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 —

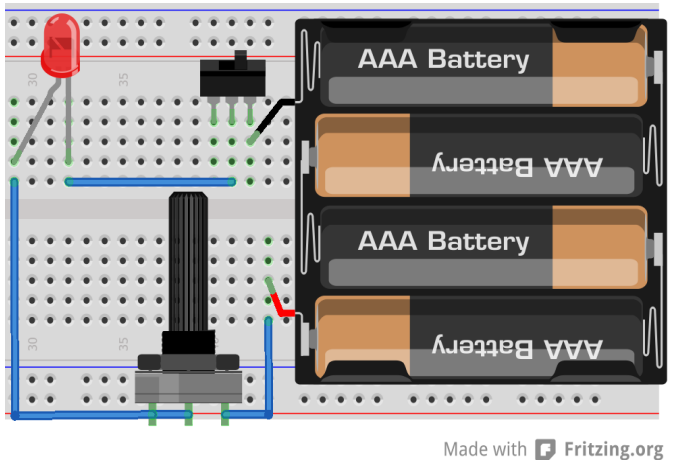
$$V = I/R$$

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.

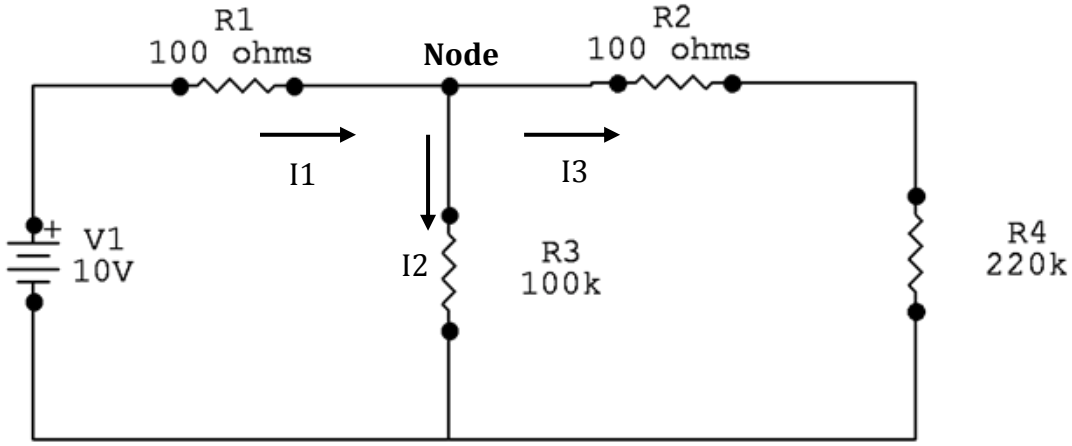
Step1: Short left two wires of potentiometer and then lengthen the third wire and one wire from shorted pins. Insert the two wires in breadboard.
Step2: Place the battery and switch as shown in figure, we are using only two pins of switch .
Step3: Switch on to test the circuit, If LED doesn't light up, 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.

2.3 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.

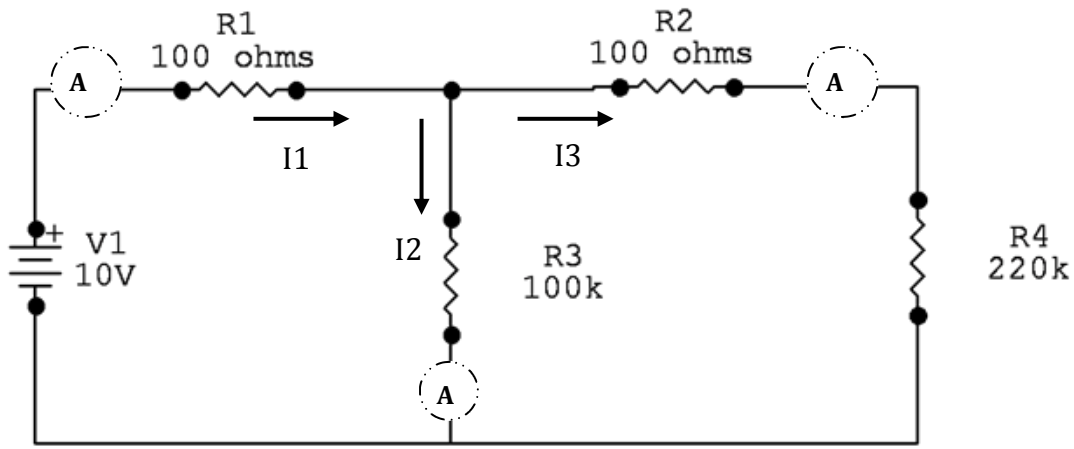
Lets prove the Kirchhoff's laws with electronics components without even touching notebook, I bet you will like them. Also the experiments we are doing to do here, could be a good project to share with your friends.

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 I1, I2, I3. According to kirchoff's law - I1+I2+I3 = 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 I1, I2, I3. 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.

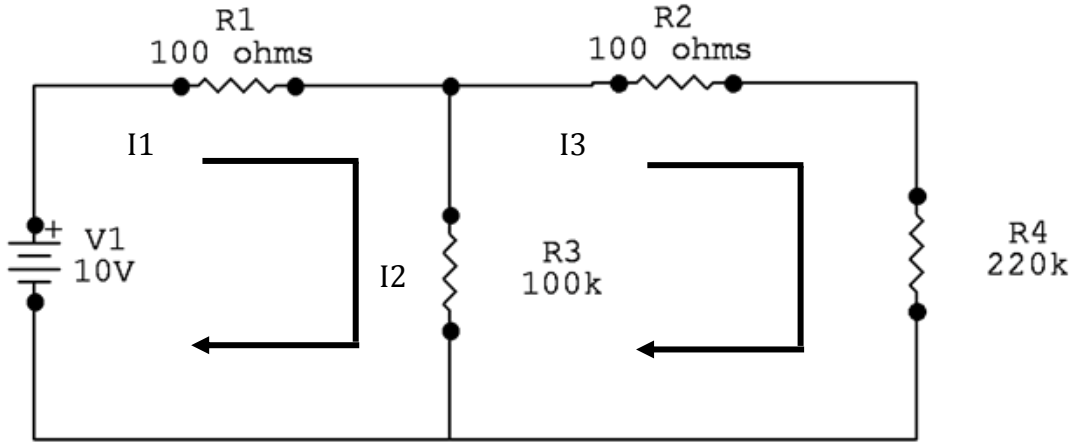


According to the circuit shown -
I1-I2-I3 = 0

It is quite obvious if you think about it, I1 is the source current further divides into I2 and I3, So I1 = I2 + I3 or I1-I2-I3 = 0 which is one and same thing.

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

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.



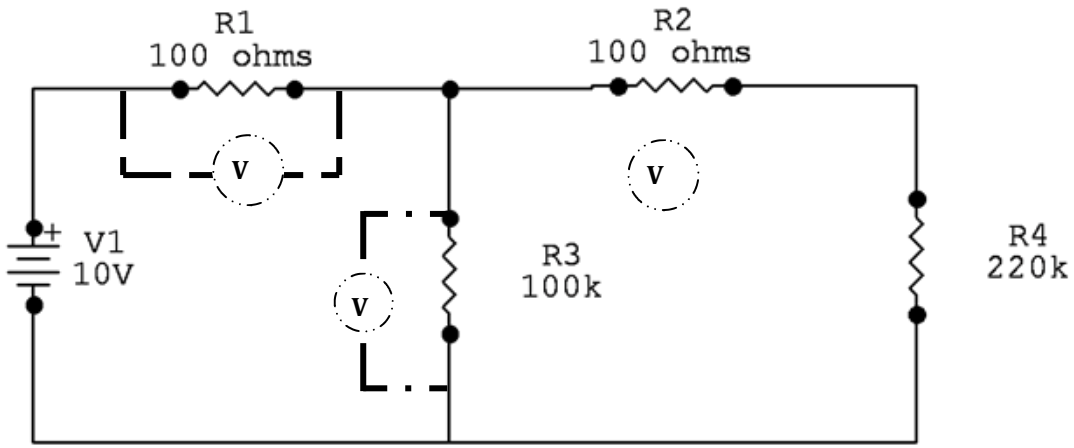
Lets explore the second law-
As said, the sum of voltages in a loop is zero. The important point here is to know the polarity of voltages across the loop, The arrowed line shown in figure shows the direction of current flowing. Usually this direction is taken in reference with battery's polarity.

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.
I1R1 is positive
I2R3 is positive (in direction with arrow)
V1 is negative (opposite direction)

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.

Lets prove this by using multi meter -

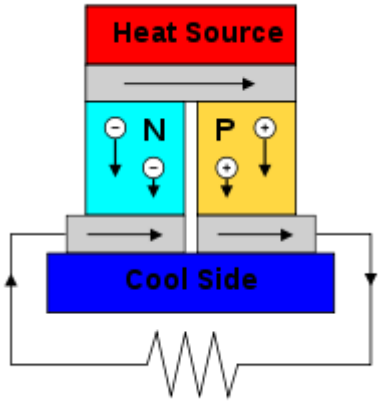
Steps -
Step1: Assemble the components as shown in figure,
Step2: Turn On the battery.
Step3: Use multi meter to measure voltages across all the components of loop.
Step4: Sum up all the voltages and check if they are equals to zero.



2.4 Seebeck effect

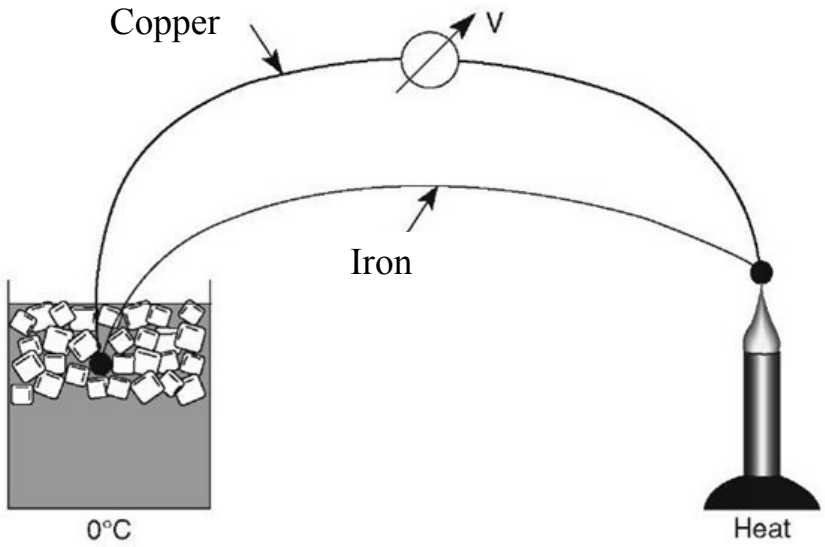
The **Seebeck effect** is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances. And is named after the Baltic German physicist Thomas Johann Seeback.

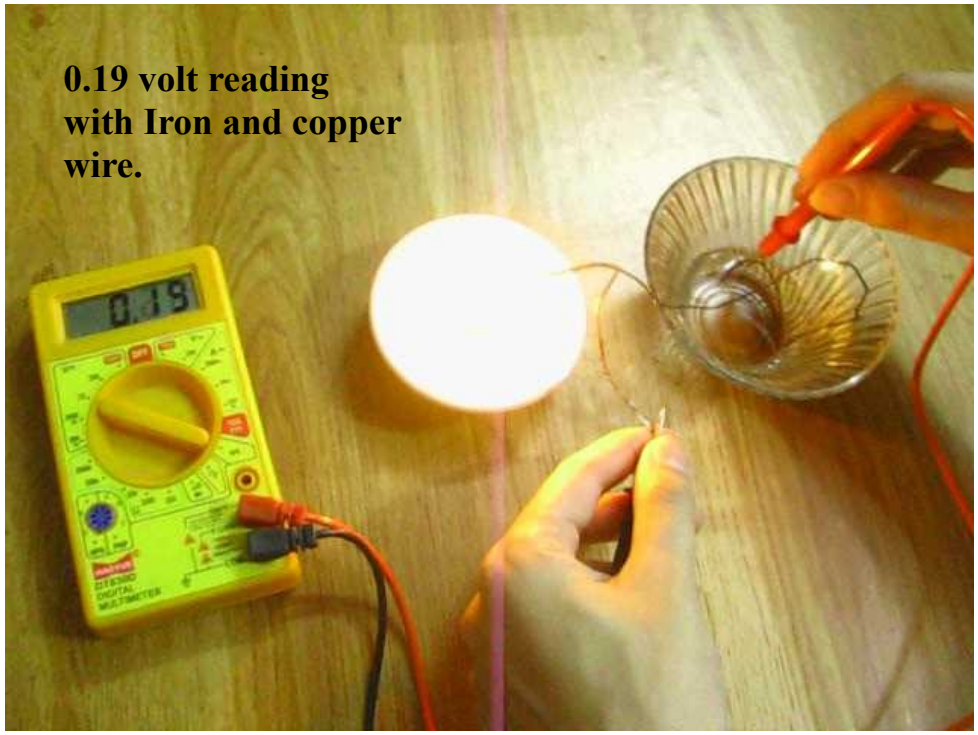
Some Parts of this project are available in Video CD ROM



The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, it creates a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side.

Its important to note here that we need to have to different conducting wires to produce a voltage in wires. Please refer figure on left side.



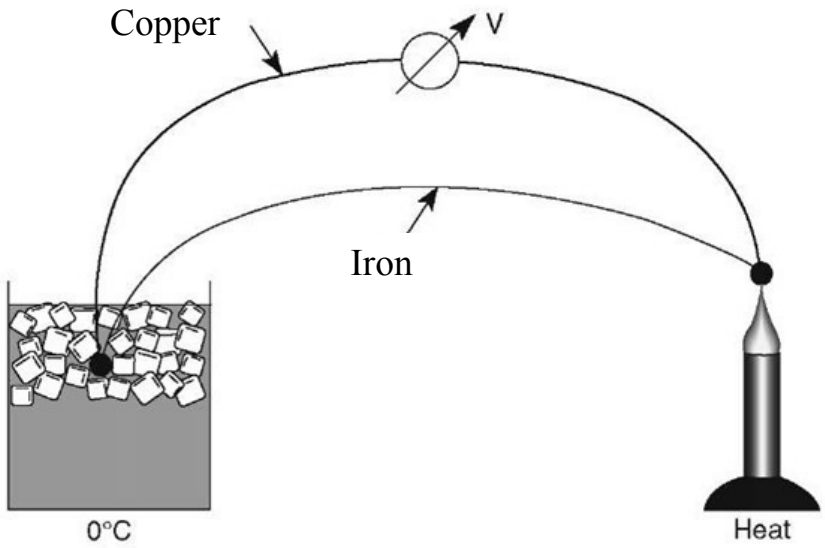


Lets explore seebeck effect with practical experiment. This experiment is very simple and require few components which are easily available around us.

Materials—Copper wire –1, iron wire—1, Multimeter—1

Steps—

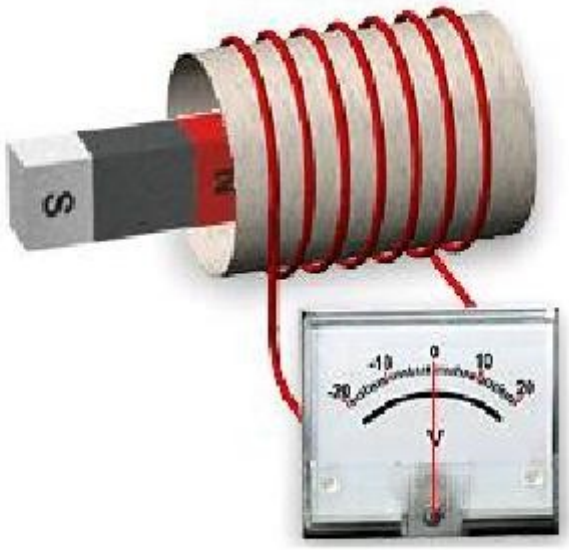
1. Take Iron and copper wire and tie both of there ends together.
2. Now cut the copper wire from middle and place multimeter needles here
3. As shown in figure, Place one end of copper-iron joint to candle and place another joint inside ice.
4. Adjust Multi meter to milivolt setting.
5. Observe that there will be a voltage reading in multimeter



Things to do—Try to replace the iron wire with other metal, You may use aluminum foil, zinc wire, brass spoon etc.

2.5 Law of Induction

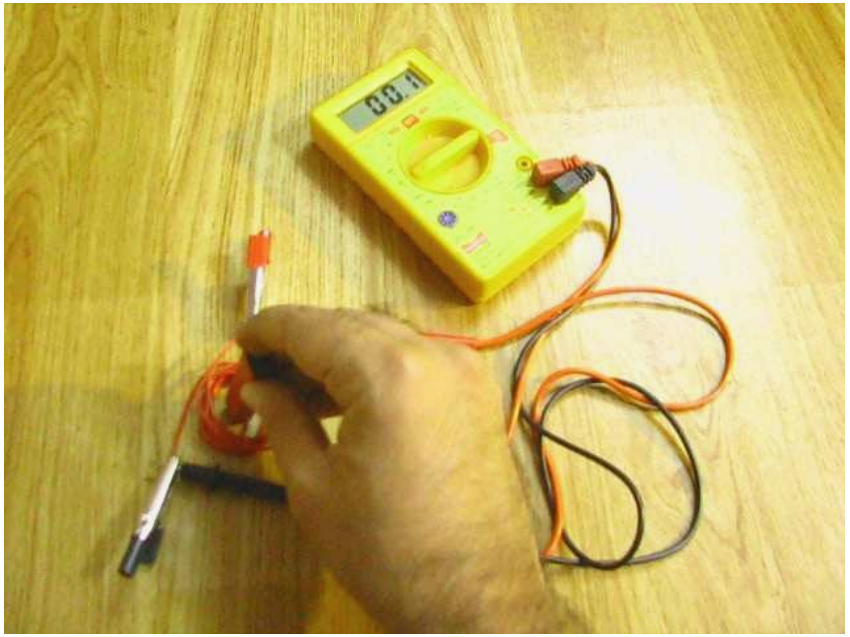
Electromagnetic induction is the production of an electromotive force across a conductor exposed to time varying magnetic fields. Michael Faraday, who mathematically described Faraday's law of induction, is generally credited with its discovery in 1831.



The law of physics describing the process of electromagnetic induction is known as Faraday's law of induction and the most widespread version of this law states that the induced electromotive force in any closed circuit is equal to the rate of change of the magnetic flux enclosed by the circuit.

Please refer—Wikipedia for more knowledge on faraday law induction

In this project we will be inducing voltage in a wire coil by using a simple bar magnet. The voltage induced in coil will be measured by using a multimeter at mili volt setting.



Materials -
1.5 meter sleeved wire, Multimeter –1, Magnet—1

Steps -

1. Take about 1.5 meter long wire and make a coil from it by curling it around two fingers. The coil should have enough diameter to pass bar magnet through it.
2. Connect both the ends of wire to multi meter.
3. Set multi meter to millivolt setting.
4. Take bar magnet and bring it close to coil.
Note: As per law of induction, the potential in coil is induced only when there is a change in magnetic field in coil, so we need to move bar magnet to and fro in coil to produce voltage in coil.
Note: one may take any magnet available if bar magnet is not available for this experiment.
5. Move magnet to and fro in coil. And observe voltage in multi meter.

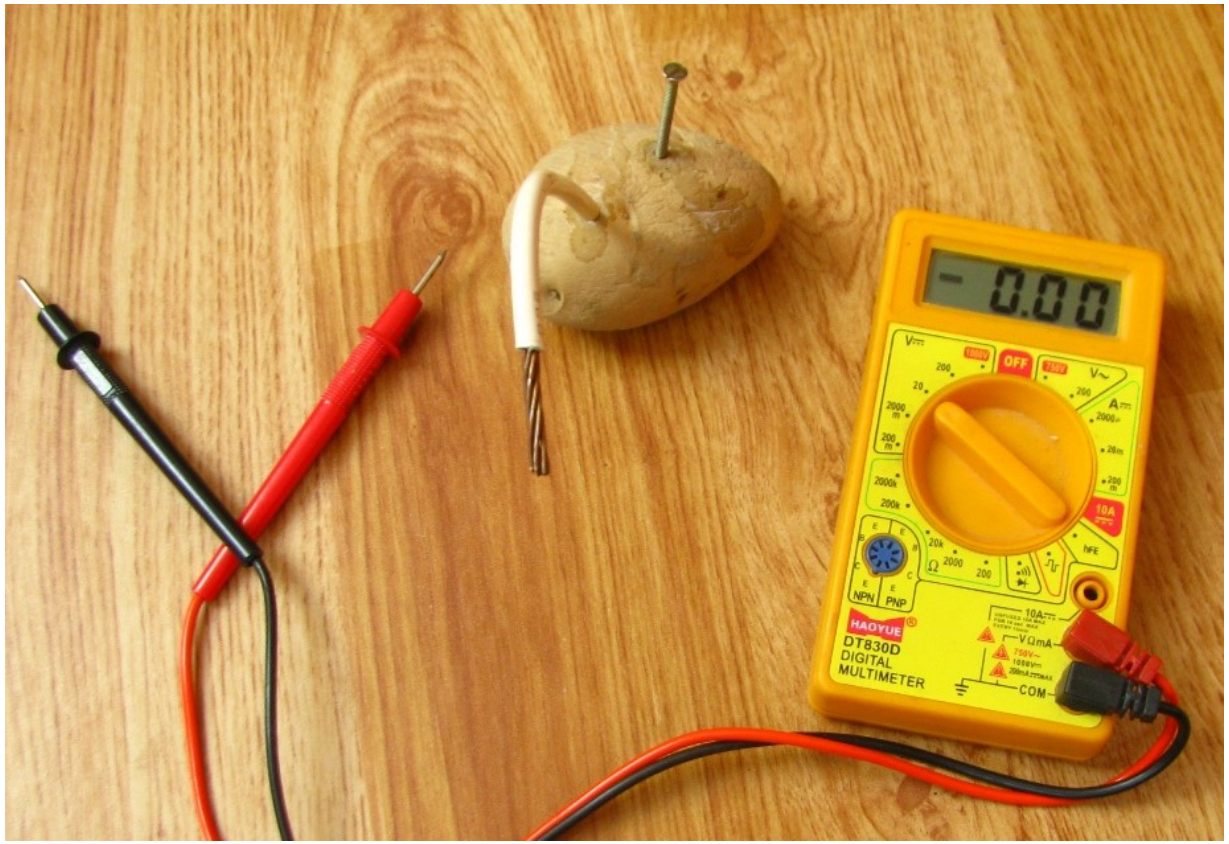
Things to Try -

You may connect the coil to a transistor's base to provide input voltage to transistor, Since transistor requires very small input voltage to turn itself On, The induced voltage will be sufficient to turn it On. You can drive a heavy load like—bulb etc on collector of transistor. So by moving of magnet in coil the bulb or LED will light up. Check circuit designing guide for help.

2.6 Electricity from Potatoes

Some Parts of this project are available in Video CD ROM

Electricity from potatoes—I hope everybody have seen this experiment in some or other science fair in schools or colleges. This concept of this experiment is fairly simple. You need to different metals and an electrolyte to create a battery. So where does the potato fit into it?
Well actually potato is good electrolyte, and we need to needle of different metal to insert into potato. Potato will not only hold them but will also act as a medium.



On right hand side figure, we are showing a potato with iron nail and a copper wire. Both of the materials are available easily in any house. We have set multimeter to milli volt setting. However if voltage is high enough you may rotate the knob of meter to volt setting. For us this experiment was generating 0.5-0.8 volts, so we were able to see it on 0-20 v setting.

Materials—Potato –1, Copper wire—1, Iron nail—1, multi meter –1

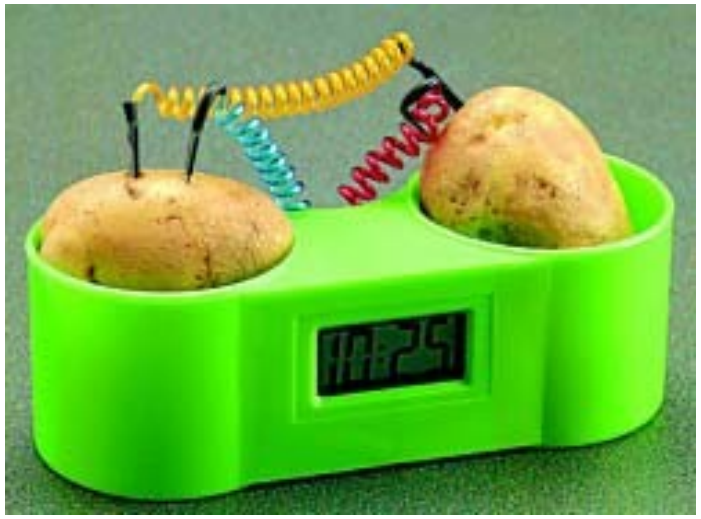
Steps -

1. Take potato and pierce it will iron nail. Leave the nail inside potato only.
2. Pierce copper wire in potato and leave it there only.
3. Take multimeter and set it to millivolt. Connect copper wire and iron nail to multi meter wires.
4. Observe the voltage on meter display.

Things to try—Since this is like a battery, you can connect two batteries in series to increase the voltage..

Connecting two or more potato batteries in series will increase voltage. For example—If you get 1v from one potato battery then by adding 2 more potatoes, you can get 3v easily and this is enough to light a LED (as shown in figure on left side)

People have come up with many innovative ideas with potatoes. A potato clock is shown in photo on right side, is powered by two potatoes.



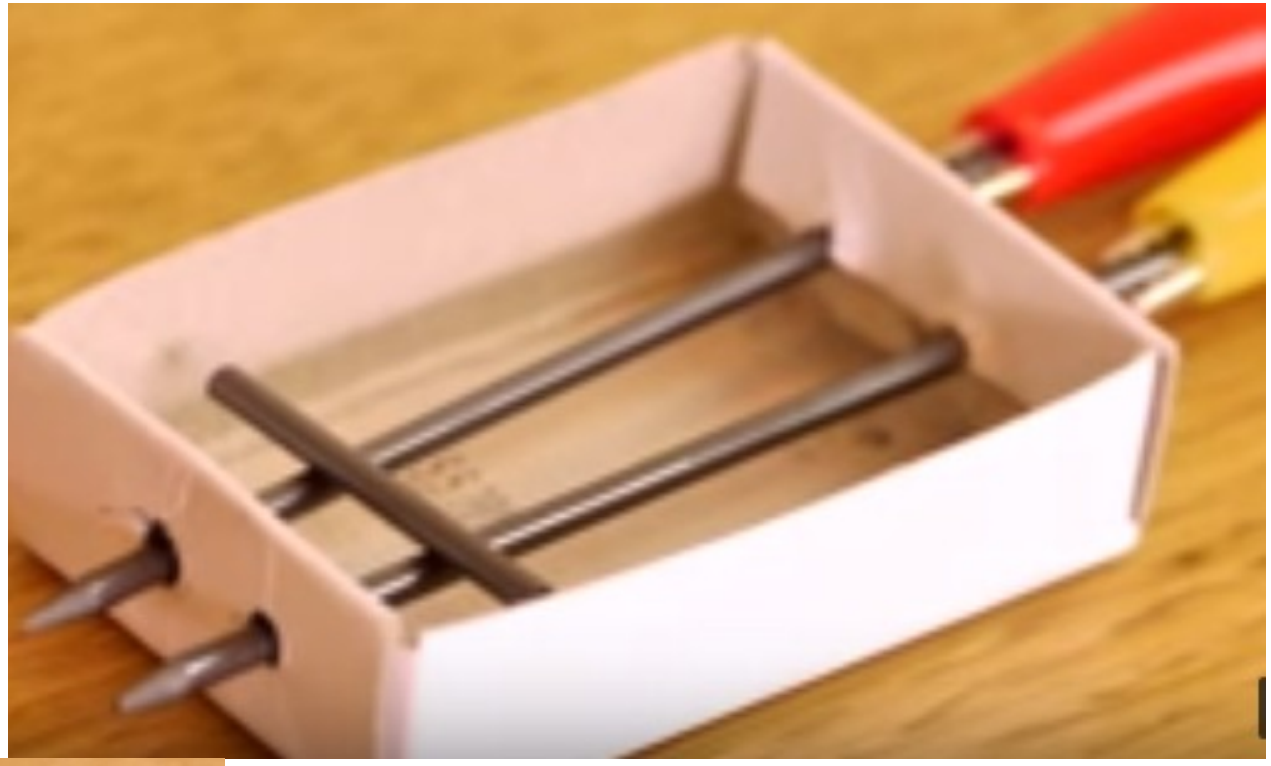
Tip:
Changing metals used as electrodes in potatoes can change the voltage also. One basic rule that increases voltage is that the metals should be as far as possible in periodic table of elements. For example Aluminum and iron will give more voltage then copper and iron. Because aluminum and iron are more distant elements in periodic table.

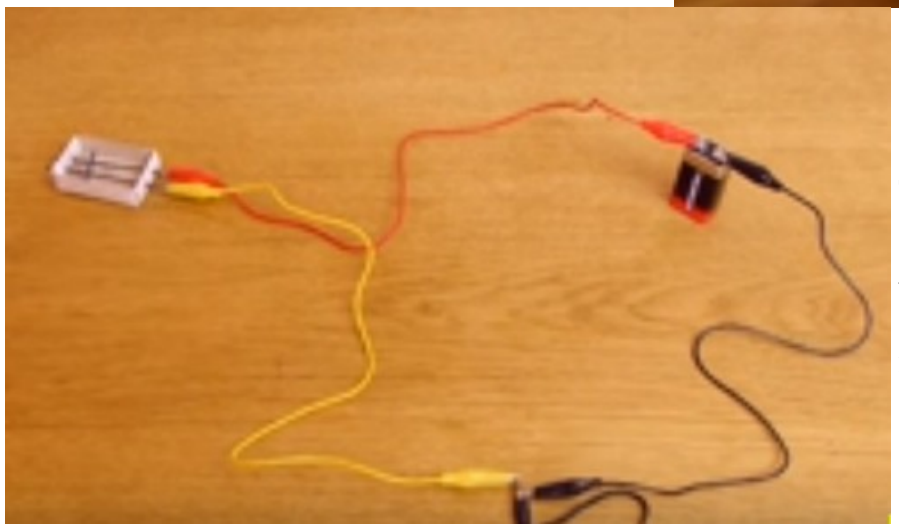
2.7 Microphone from Matchbox

Now here is a super simple experiment which will teach you to create your own microphone using simple pencil leads. Exciting isn't it!

There are many methods for making mic, you will be surprise that we can even use a speaker as a microphone also, you need to speak in front of speaker and your voice will compress its diaphragm, which will generate current in speaker coil. Here we are using a different method, we will be using leads to sense voice and to convert them into potential.

And This microphone works. You can actually use this microphone in your future experiments. We are going use an empty matchbox for this project.



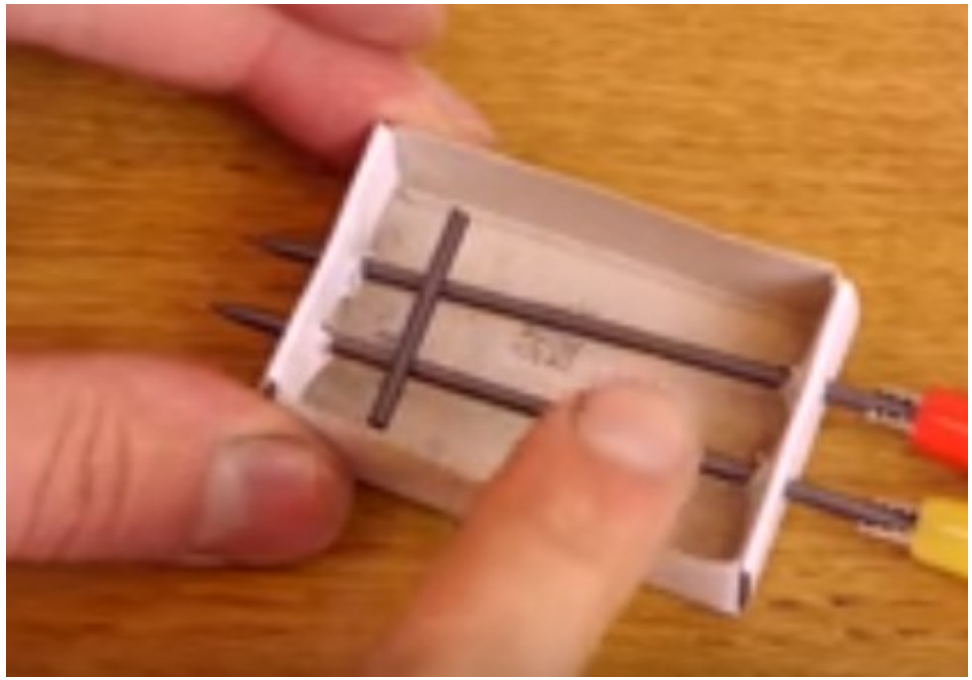


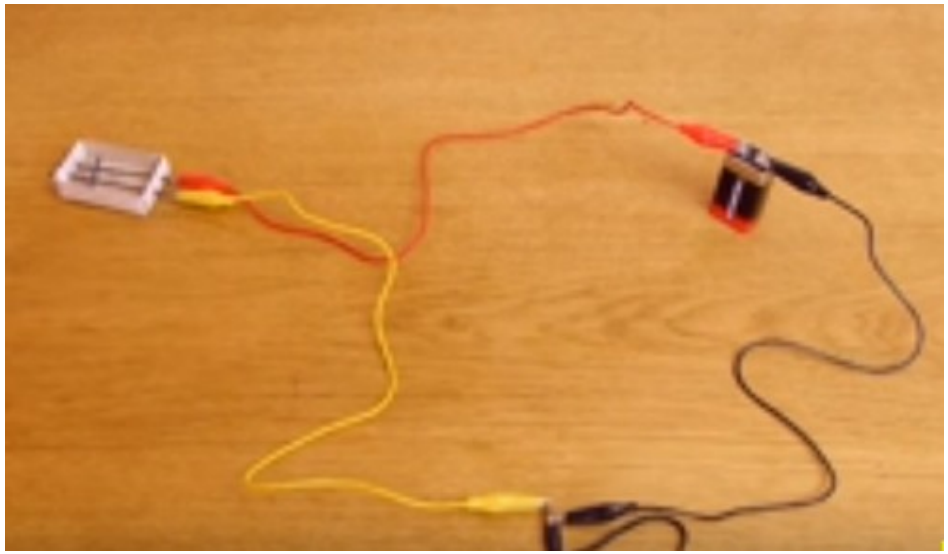
Materials—Pencil Leads –2, Match box—1, Croc Clips –2

Steps -

1. Take two long leads and insert them into match box as shown in figure.
2. Take third short lead and place it on the top of two leads perpendicular to both leads as shown in figure.
3. To test the microphone attach one of the leads of mic to battery as shown in figure and join another terminal of mic to headphone/speaker wire.

4. Join the remaining wire of speaker to battery.
5. Tap your finger over pencil lead very gently, so that it should not fall. And observe if there is a noise from head-phone/speaker.
6. Try to tap on table and observe if your tap noise is coming in speaker.





3. Simple Transistor Circuit

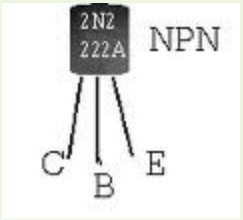
In this section we will make :

3.1 Transistor As A Switch
3.2 Cupboard timer
3.3 Parking Light
3.4 Plant Watering Reminder
3.5 Bar Graph Meter

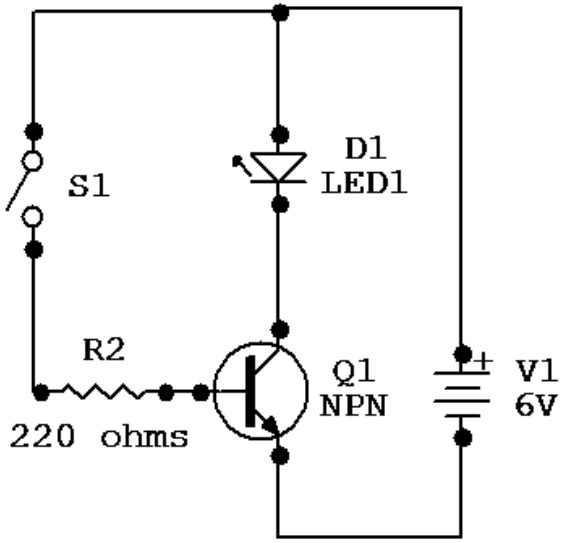
Some Parts of this project are available in Video CD ROM

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

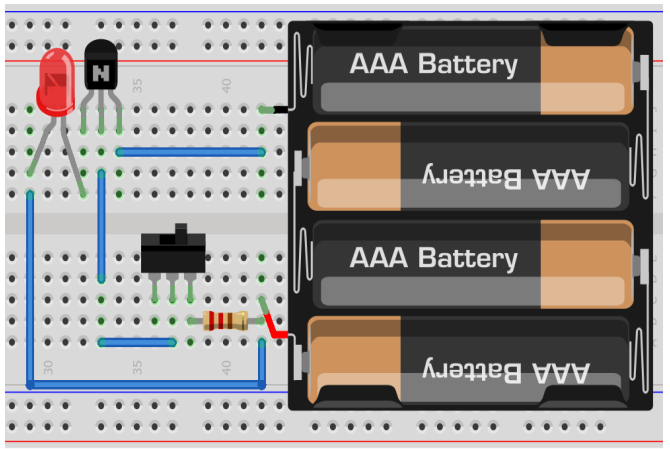
To start working with transistor, Let's make a simple circuit to see how transistor works as a switch.

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.



Tip:

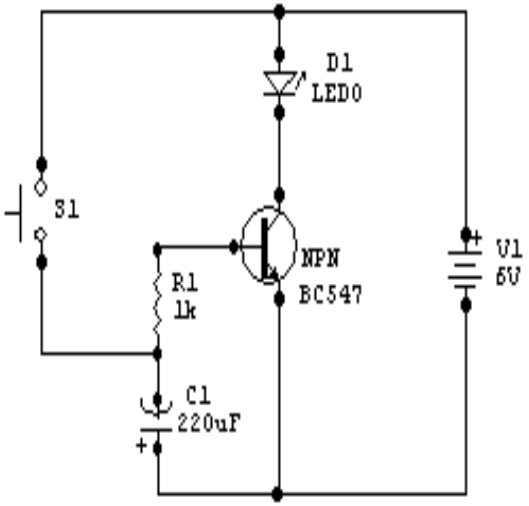
Transistor is a polar device and should be connected in correct direction of current. The arrow in transistor symbol shows the direction of flow of current, In NPN its from collector to emitter and in PNP its from emitter to collector.

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.

3.2 Cupboard Timer

Some Parts of this project are available in Video CD ROM

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.

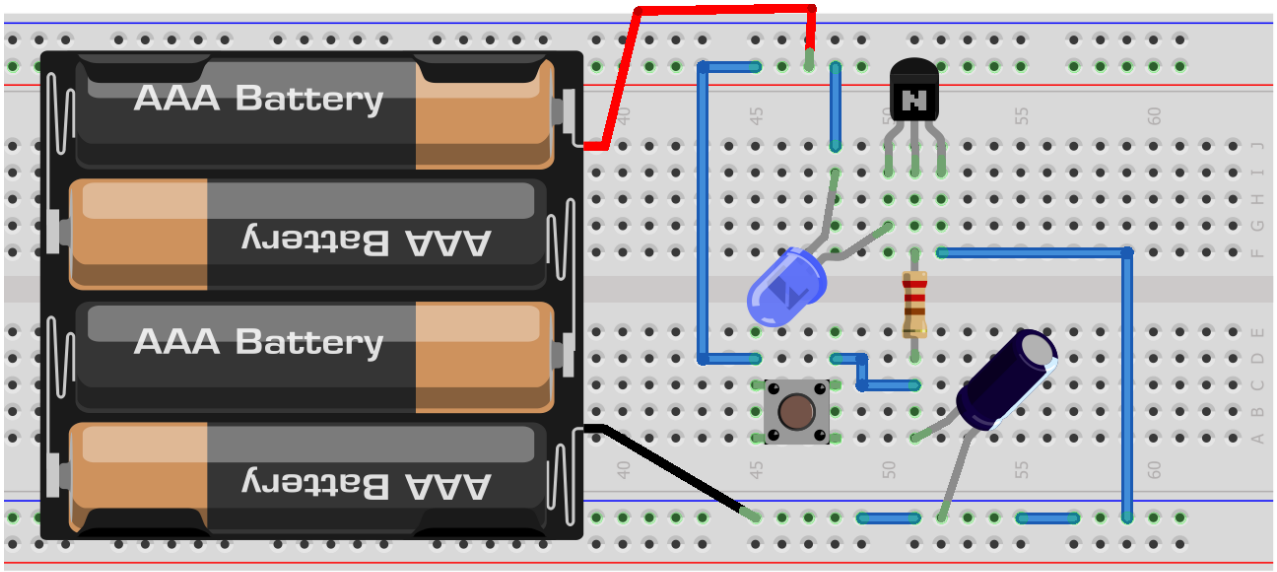


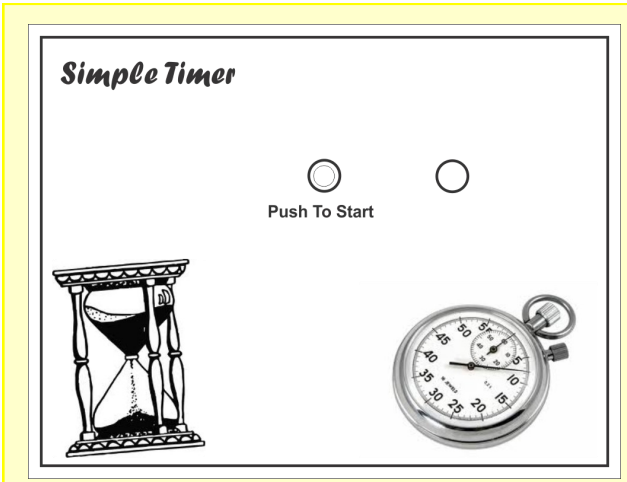
Materials : Q1- BC547, D1- LED, R2 –220 ohms, 4.8-6 v battery.

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 Cupboard Timer

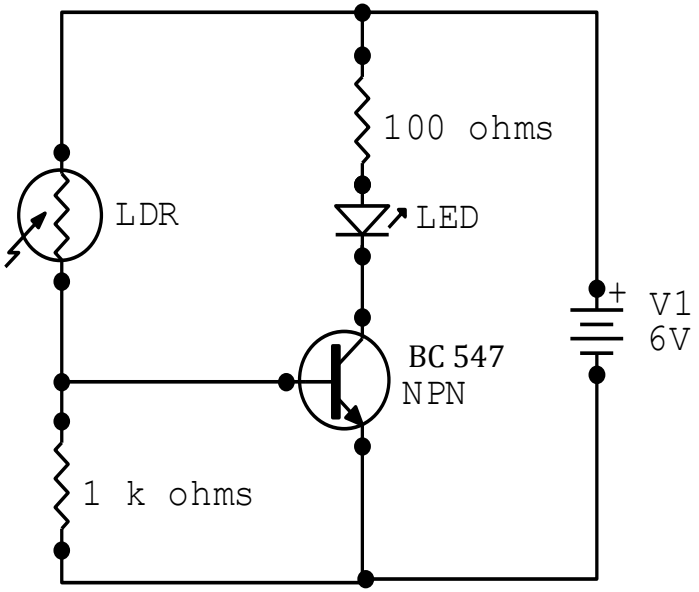
3.3 Parking Light

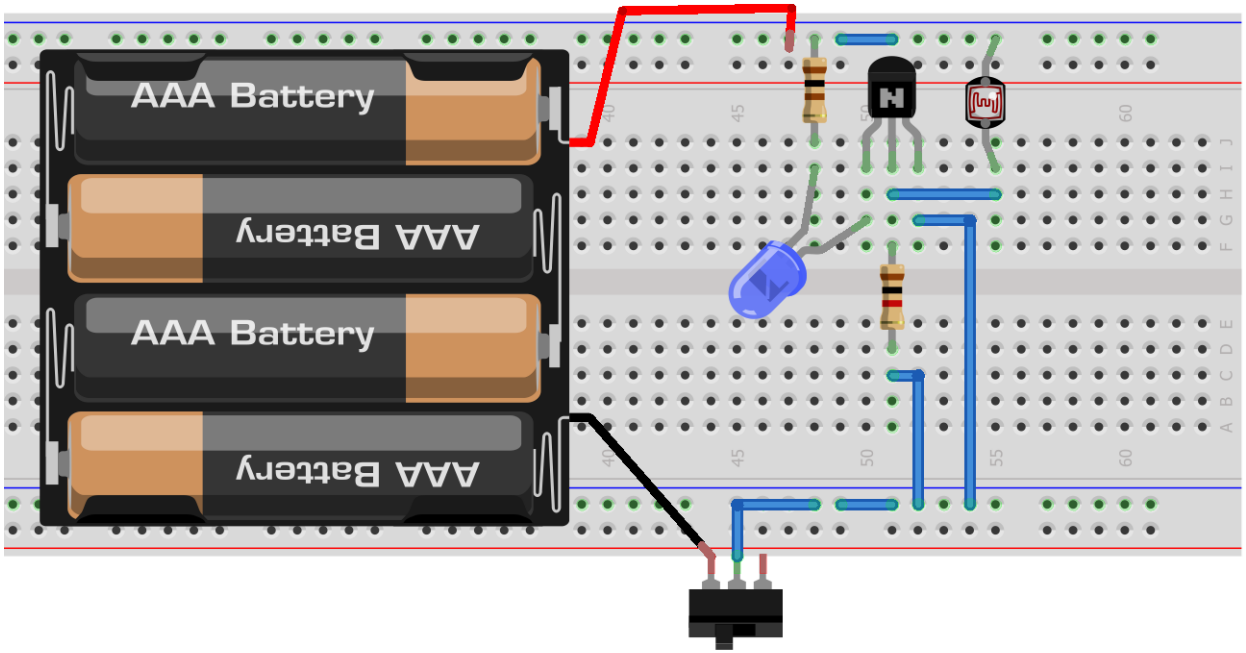
While backing your car its always required to have some one tell you how much space is left between your car and the wall of your garage. With this gadget installed on the wall you no longer need anybody help you, as this gadget is having a indicator light which tells you the exact position of wall. 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 turn 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.

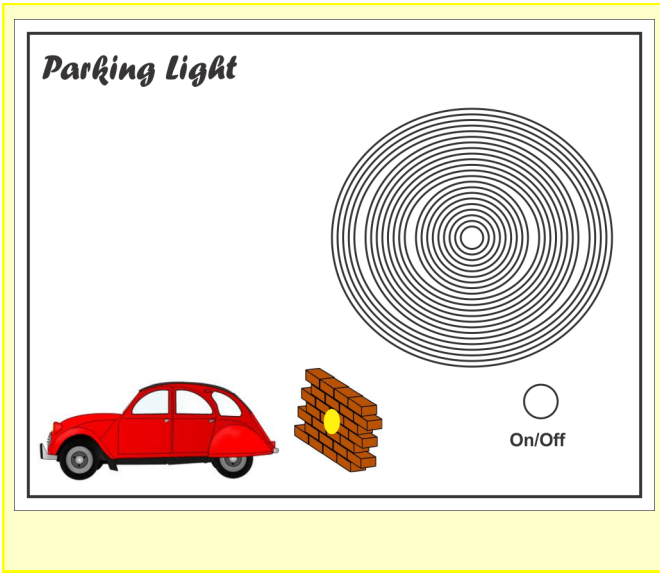
Materials : Q1- BC547, D1- LED, R2 –220 ohms, 4.8-6 v battery.

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.

Some Parts of this project are available in Video CD ROM

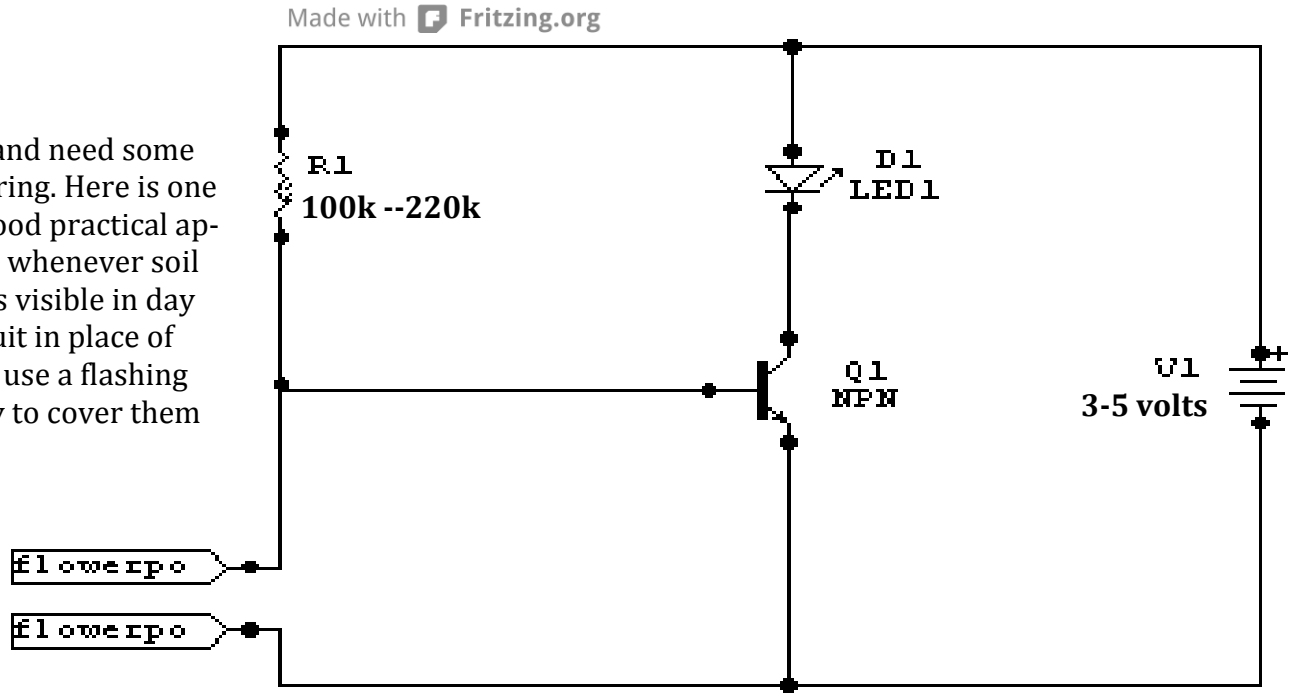






3.4 Plant Watering Reminder

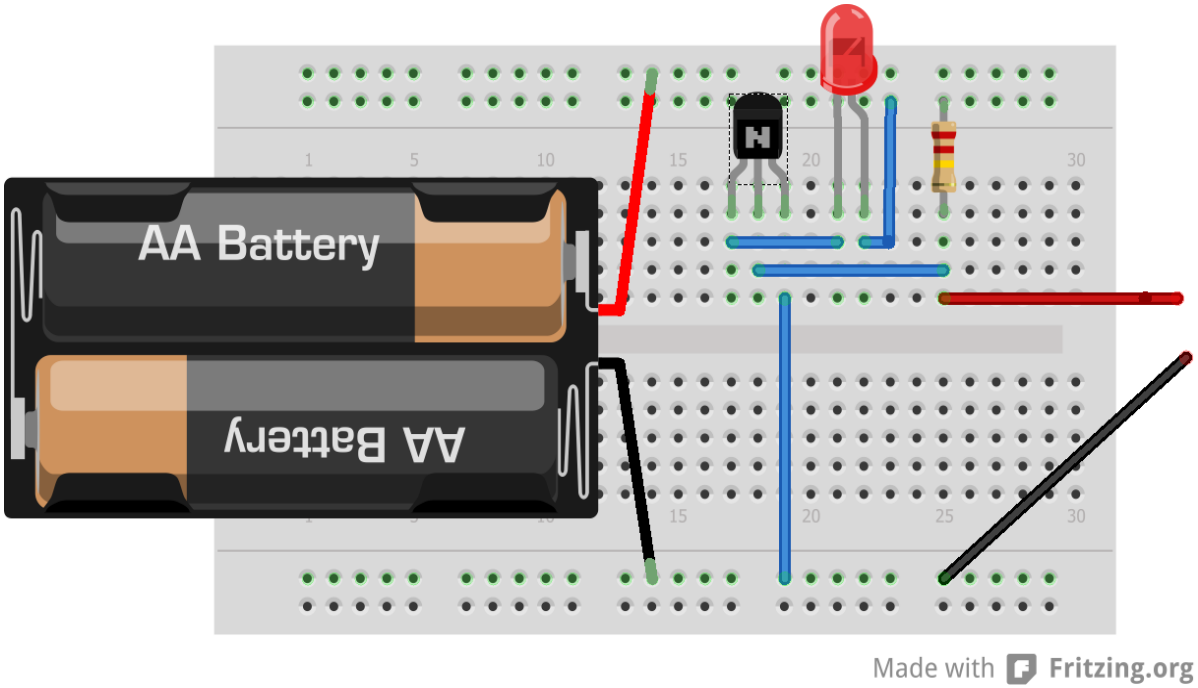
Are you often forgetting to water plants pots and need some alert system to remind you if plant need watering. Here is one of the simplest project which is having very good practical application. This will alert you by lighting a LED, whenever soil goes dry. You can use bright blue LED which is visible 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.



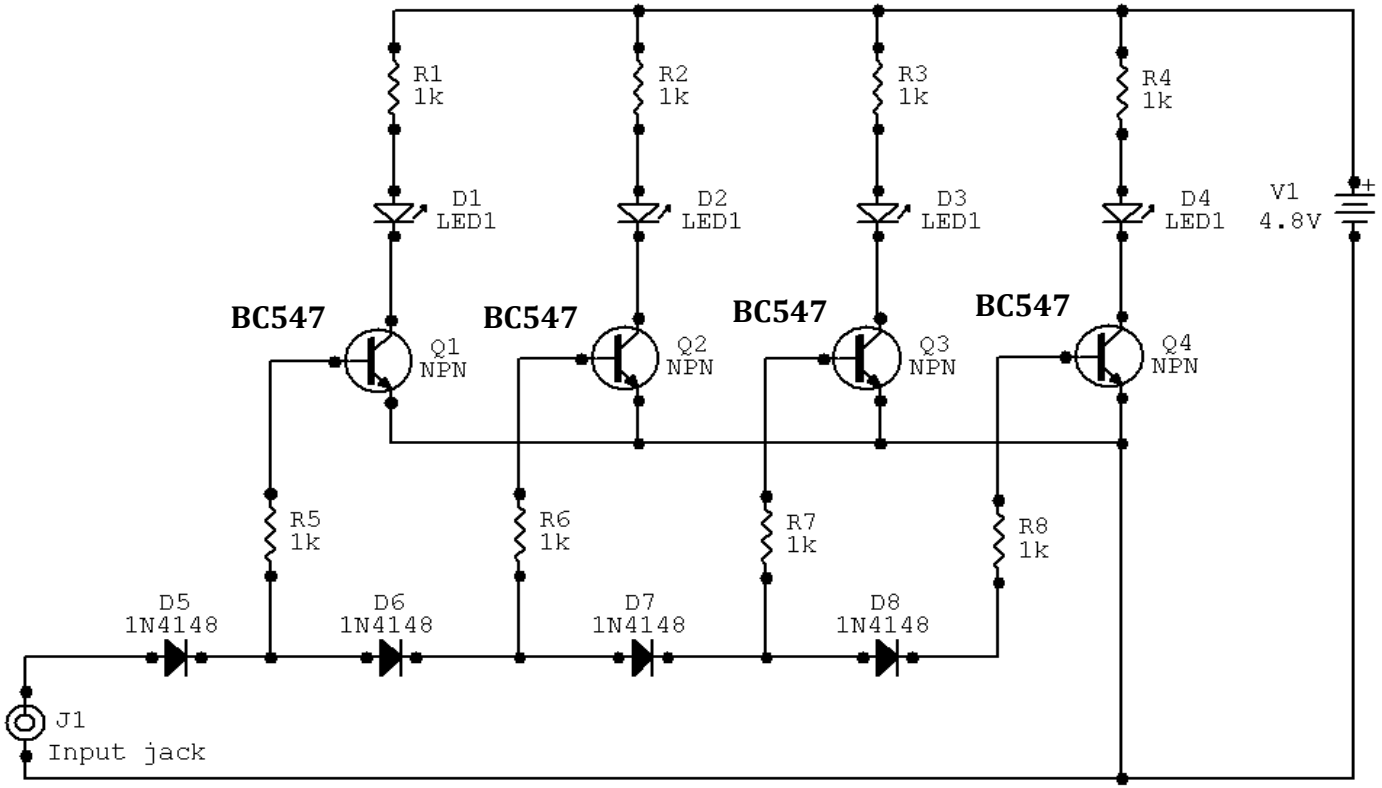
Soil sensor - In this project we need two probes to be inserted into soil, which will conduct when soil goes wet. To create these probes you may use any iron nail of steel nail and tie the wire to them. Just keep the probes close enough so that they can conduct properly.

Steps:

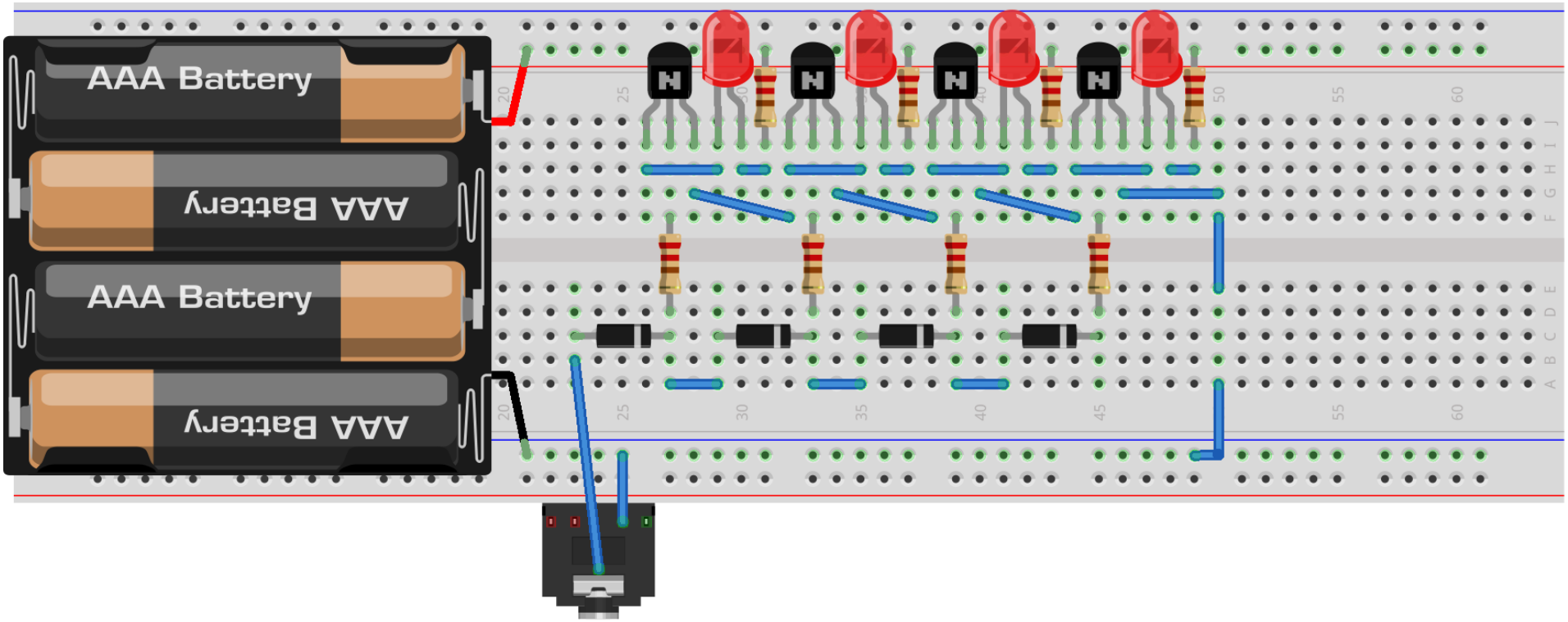
Step1: Assemble all components on breadboard.
Step2: Bring a plant pot with dry soil.
Step3: Put probes into the soil.
Step4: Turn On the battery current.
Step5: Check if LED is glowing. If it is not glowing. Turn Off battery immediately and check connections

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.

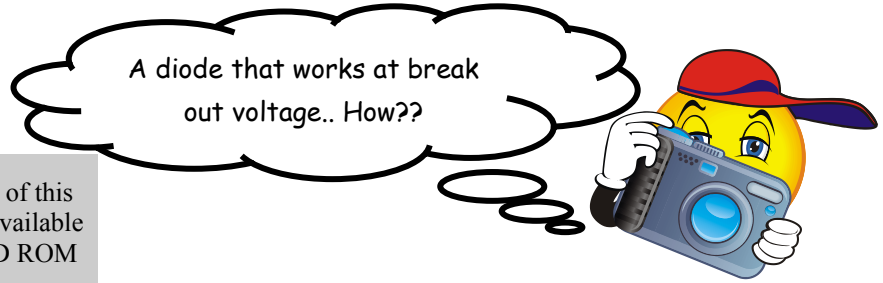


The circuit is using transistors to turn LEDs On/Off according to input signal, Starting from left most transistor which requires least voltage to turn its LED On. The second transistor require more voltage then first transistor, And third transistor require further more voltage signal. This is because 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.



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. Zener Diode Circuits



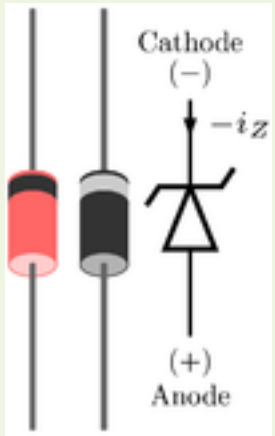
In this section we will make :

4.1 Concept of Zener Diode with simple circuit
4.2 Voltage regulator circuit
4.3 Low battery power indicator

Some Parts of this project are available in Video CD ROM

What is Zener diode ?

A Zener diode is a diode which allows current to flow in the forward direction in the same manner as an ideal diode, but also permits it to flow in the reverse direction when the voltage is above a certain value known as the breakdown voltage, "Zener knee voltage", "Zener voltage", "avalanche point", or "peak inverse voltage".



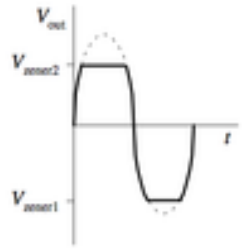
The device consists of a reverse biased, highly doped, p-n junction diode operating in the breakdown region. Conventional diodes and rectifiers never operate in the breakdown region, but the Zener diode makes a virtue of it and can safely be operated at this point.
The device was named after Clarence Zener, who discovered this electrical property.

Please refer symbol of zener diode in figure in left side.

Simple zener diode circuit— Zener diode is used a circuits where a voltage regulation is required, generally it is used in waveform clipper, voltage shifter and in voltage regulator circuits.

Waveform clipper

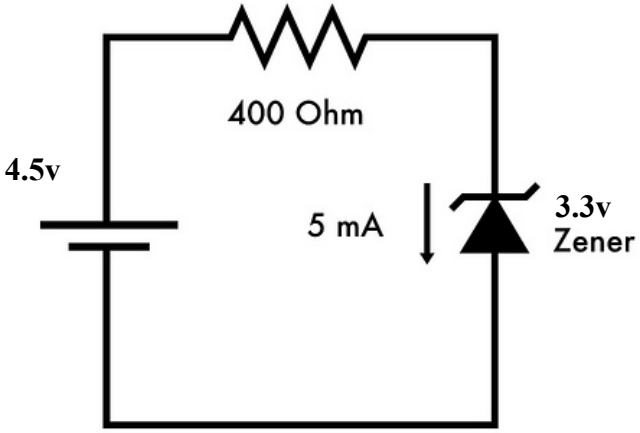
Two Zener diodes facing each other in series will act to clip both halves of an input signal. Waveform clippers can be used to not only reshape a signal, but also to prevent voltage spikes from affecting circuits that are connected to the power supply. (Referenced from Wikipedia—https://en.wikipedia.org/wiki/Zener_diode)



Voltage Shifter—A Zener diode can be applied to a circuit with a resistor to act as a voltage shifter. This circuit lowers the input voltage by a quantity that is equal to the Zener diode's breakdown voltage.

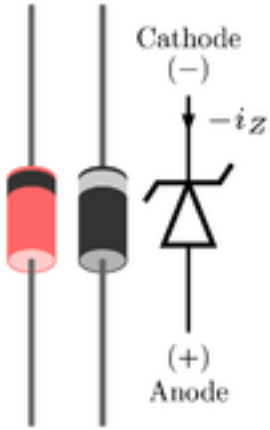
Voltage regulator—A Zener diode can be applied to a circuit to regulate the voltage applied to a load, such as in a linear regulator.

Lets explore a simple zener based circuit.

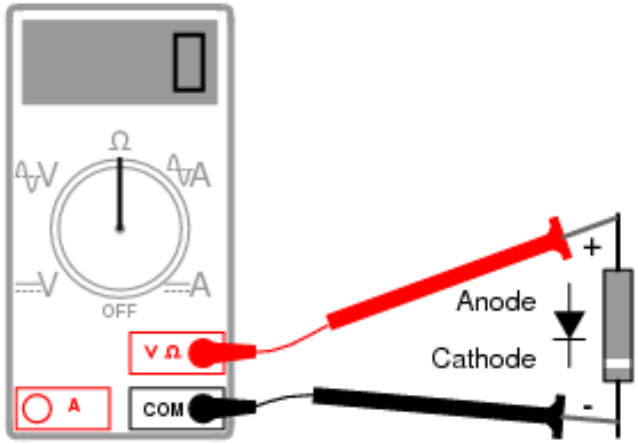


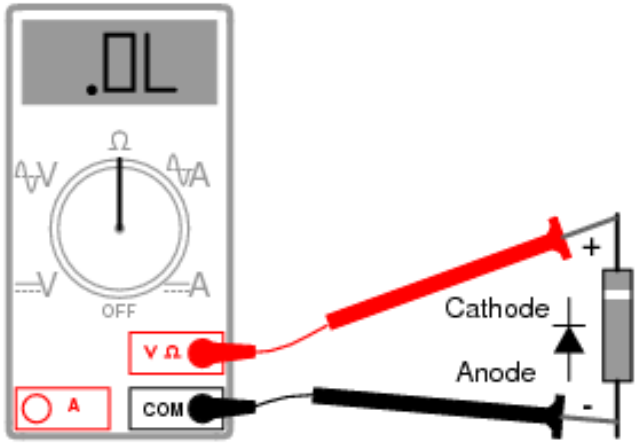
4.1 Simple Zener diode circuit

The circuit on the left is showing a basic circuit made from zener diode. Zener is always connected in reverse polarity. The positive terminal of battery is connected to negative of diode and vice versa. Please check the voltage across zener diode, It should be 3.3v.



In right hand figure we are testing continuity of a zener diode using a multimeter. Set the knob of meter to continuity test mode and put the test leads on diode to see what reading they show. Only one side of diode is conducting. This behavior is exactly same as in normal diodes. The zener diode is different only for zener/ break down voltages.

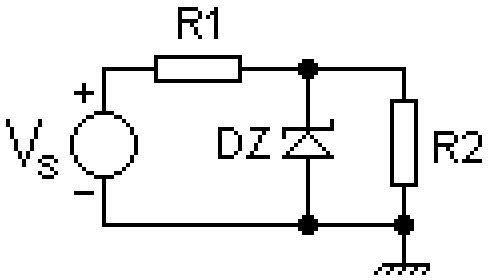


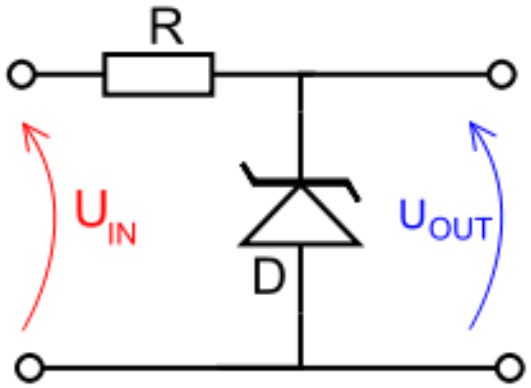


4.2 A simple voltage regulator circuit—Zener diodes are widely used as voltage references and as shunt regulators to regulate the voltage across small circuits. When connected in parallel with a variable voltage source so that it is reverse biased, a Zener diode conducts when the voltage reaches the diode's reverse breakdown voltage. From that point on, the relatively low impedance of the diode keeps the voltage across the diode at that value .

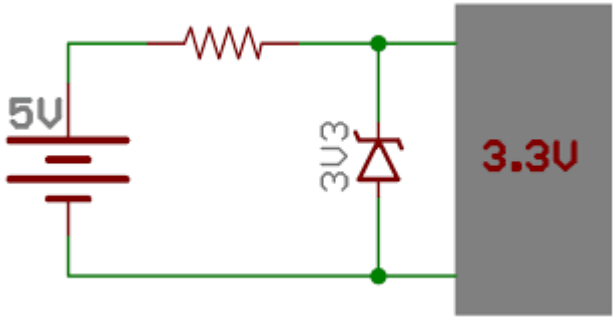
The image shows a simple shunt voltage regulator that operates by way of the Zener diode's action of maintaining a constant voltage across itself when the current through it is sufficient to take it into the Zener breakdown region.

The resistor R1 supplies the Zener current as well as the load current IR2 (R2 is the load). R1 can be calculated as $R1 = \frac{V_S - V_Z}{I_Z + I_{R2}}$, , where is the Zener voltage, and IR2 is the required load current. (Referenced from Wikipedia—https://en.wikipedia.org/wiki/Linear_regulator)





As you may see the circuit on right hand right is providing a constant voltage of 3.3v to load because we have used a zener diode of 3.3 volts. Any increase in voltage will turn the zener diode On and it will start to conduct. This new path for current will reduce the voltage in circuit across load and load will always get a regulated voltage of 3.3 v.



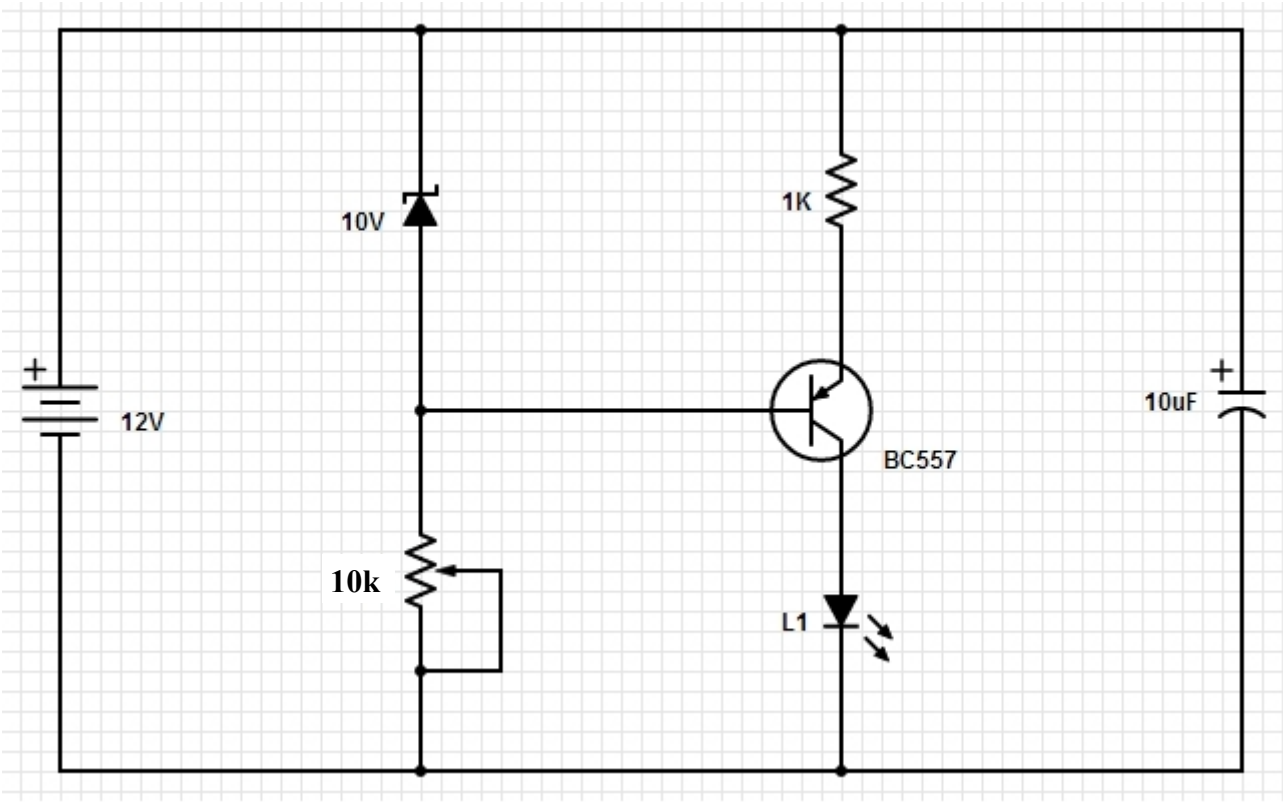
4.3 - Low battery power indicator—This is a simple circuit that will indicate a low voltage on a 12V lead acid battery. Many that have golf carts, small EV's, RV's, or solar power banks for homes have a number of 12V lead acid batteries to maintain and this circuit will help protect your investment while not using these batteries. When stored, batteries will self discharge, and if left for too long, will self-discharge to a damaging level. This circuit will light an LED when the battery voltage decreases to 11.6V. When the LED turns on, you' know it is time to charge the battery to prevent the battery from dying on the shelf.

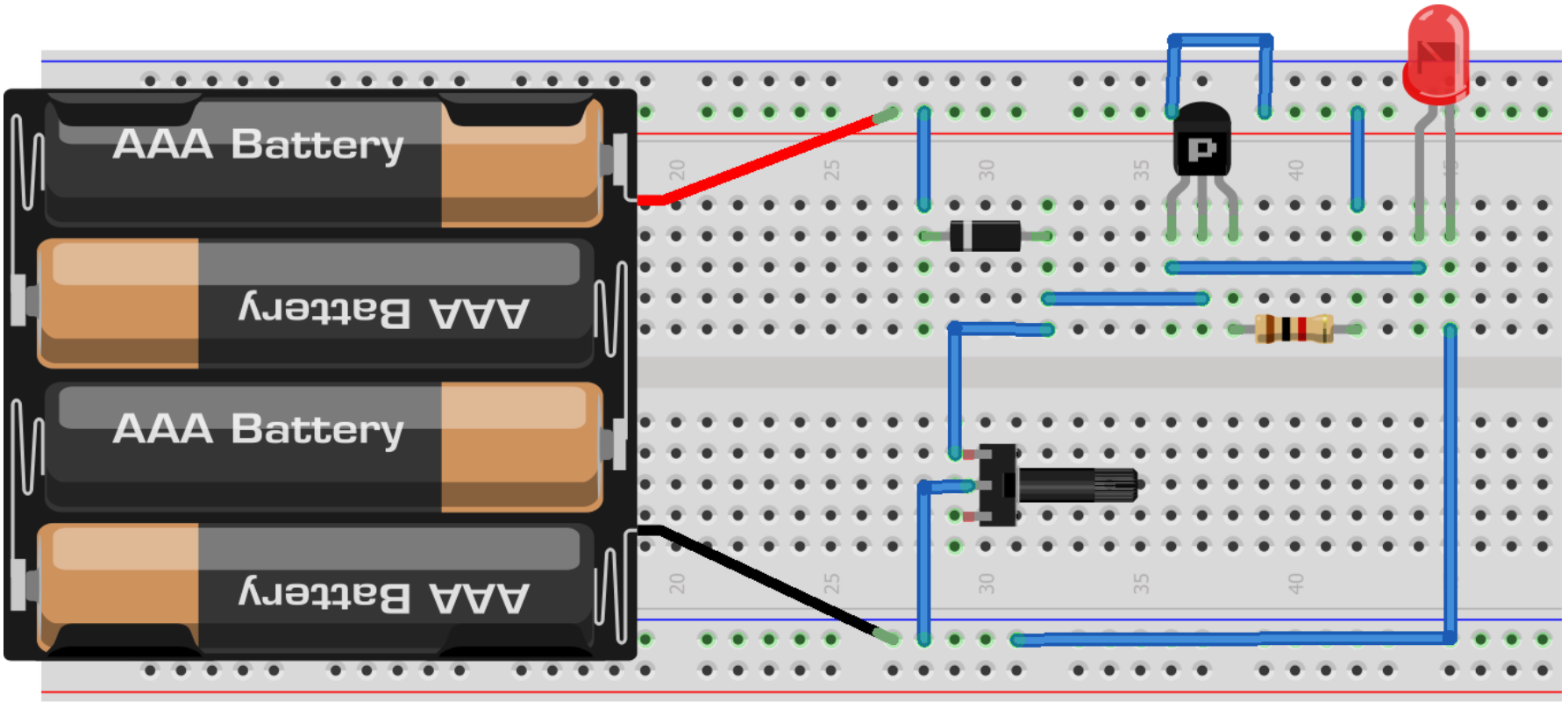
12V Lead Acid Battery Low Voltage Indicator Only a few parts are needed in the small but useful circuit. The BC557 PNP transistor controls the lighting of the LED. The BC557 transistors' base is biased by the 10V zener diode. As long as the battery voltage stays above 11.6V, the zener keeps the base of the BC557 transistor high. When the battery becomes discharged, the zener stops conducting and the base bias goes low, and BC557 begins conducting, and the LED alerts you to the low battery voltage. You can use a variable resistor to fine tune the low voltage indication, and/or use a set resistor when you have a good value figured out.

Materials—
BC557—1, Zener diode—10v—1, 1kohms—1, 10uf—1, 10k variable resistance

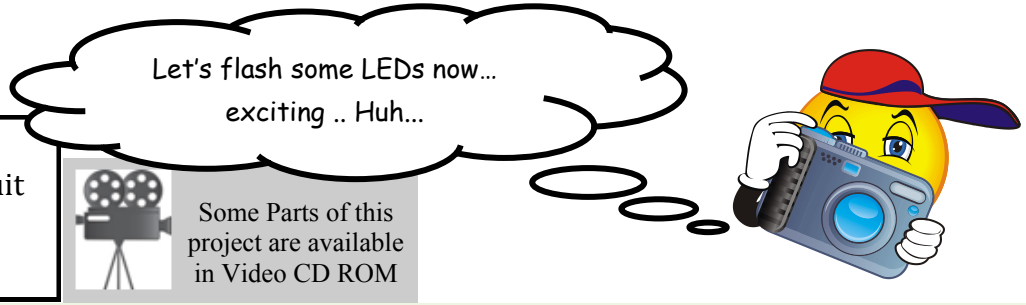
Steps—

1) Identify diode's pin. And connect it in reverse polarity than normal diode.
2) Assemble the component on bread-board and please note that we are using a PNP transistor in this circuit.
3) Turn On the circuit by attaching it with battery and calibrate the circuit with variable resistance.
4) The knob of variable resistance should be set just when LED goes ON to OFF. By this we will make sure that a small change (decrease) in voltage of battery will turn the LED On.




AAA Battery
AAA Battery
AAA Battery
AAA Battery

5. Flip-Flop



In this section we will make :

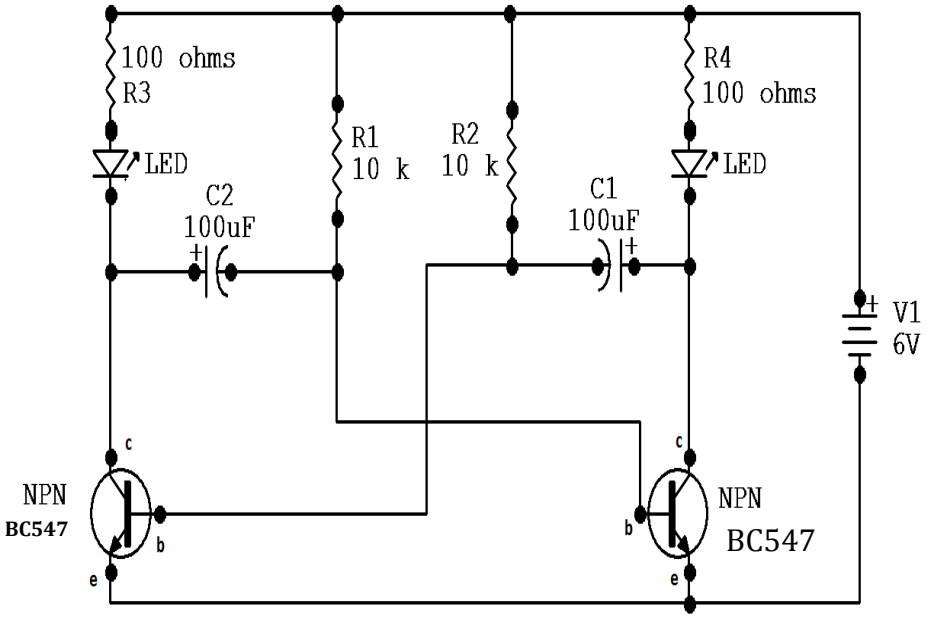
5.1 Flip Flop Circuit
5.2 LED Blinker Project
5.3 RS Flip Flop
5.4 Logic gates with LED Circuit

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*R2 and C2*R1.



Let's Do It

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

5.1 Flip Flop Circuit

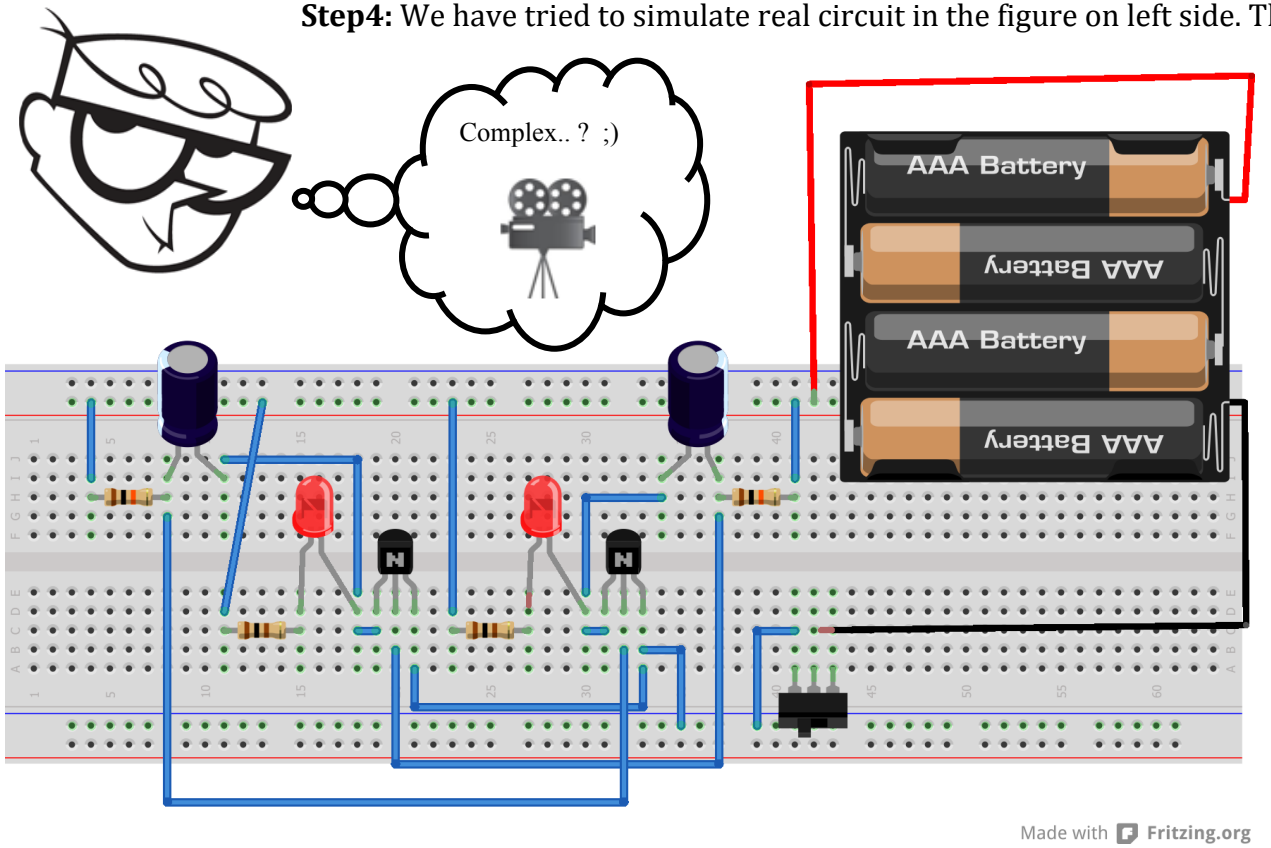
Materials : 2 - BC547, C1-C2—100µf or 220µf electrolytic capacitors, R1-R2—10k, R3-R4—100Ω, 4.8—6v battery, 2—LEDs

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.
Step5: If LEDs are not flashing close switch immediately or disconnect batteries and check connections again.

5.2 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 then other LED.

Lets assemble the circuit on the 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 3: Lengthen the switch wires to insert them in breadboard.
Step 4: assemble the LEDs and switch on 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

5.3 RS Flip Flop

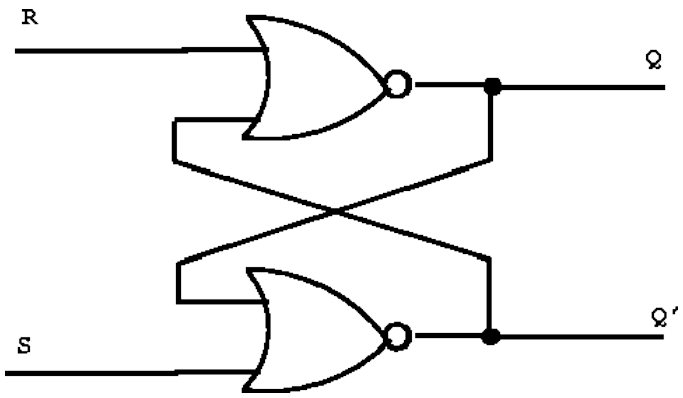
What is RS Flip Flop?

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.



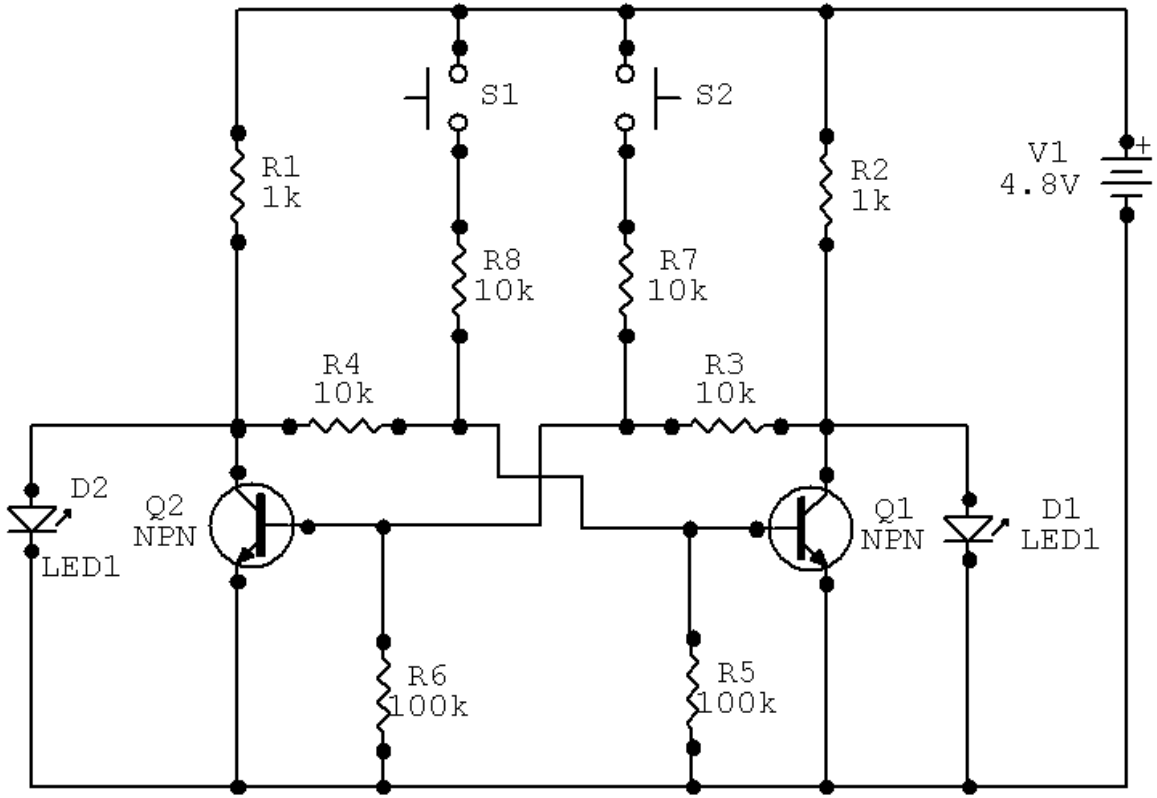
State	S	R	Q	Q'	Desc
Set	1	0	0	1	Set Q » 1
	1	1	0	1	no change
Reset	0	1	1	0	Reset
	1	1	1	0	no change
Invalid	0	0	1	1	Invalid

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.

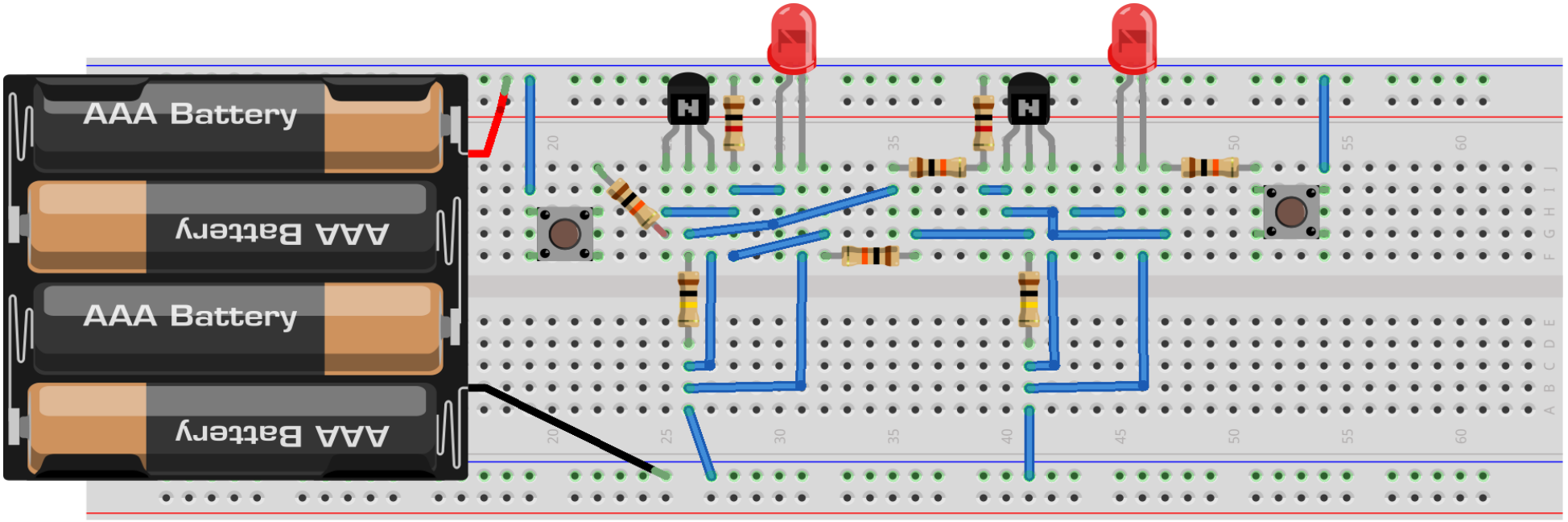
We have seen how RS flip flop works, now it's time to have some fun with it and see how we can use this circuit in our projects.

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.


AAA Battery
AAA Battery
AAA Battery
AAA Battery
Made with Fritzing.org

5.4 Logic Gates using simple LED Circuit

What are logic gates?
Logic gates are the basic building blocks of any digital system. It is an electronic circuit having one or more than one input and only one output. The relationship between the input and the output is based on a certain logic. In this project we will be studying about three basic logic gates—OR gate, AND gate & NOT gate. There are more gates created by combining these gates.

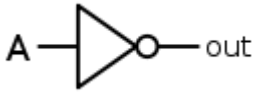
OR Gate - The OR gate is a digital logic gate that implements logical disjunction - it behaves according to the truth table to the right. A HIGH output (1) results if one or both the inputs to the gate are HIGH (1). If neither input is high, a LOW output (0) results Please refer truth table on right side to see how the output is generated when LOW (0), or HIGH (1) voltage is applied in input of gate.

INPUT		OUT-PUT
A	B	A OR B
0	0	0
0	1	1
1	0	1
1	1	1

INPUT		OUTPUT
A	B	A AND B
0	0	0
0	1	0
1	0	0
1	1	1

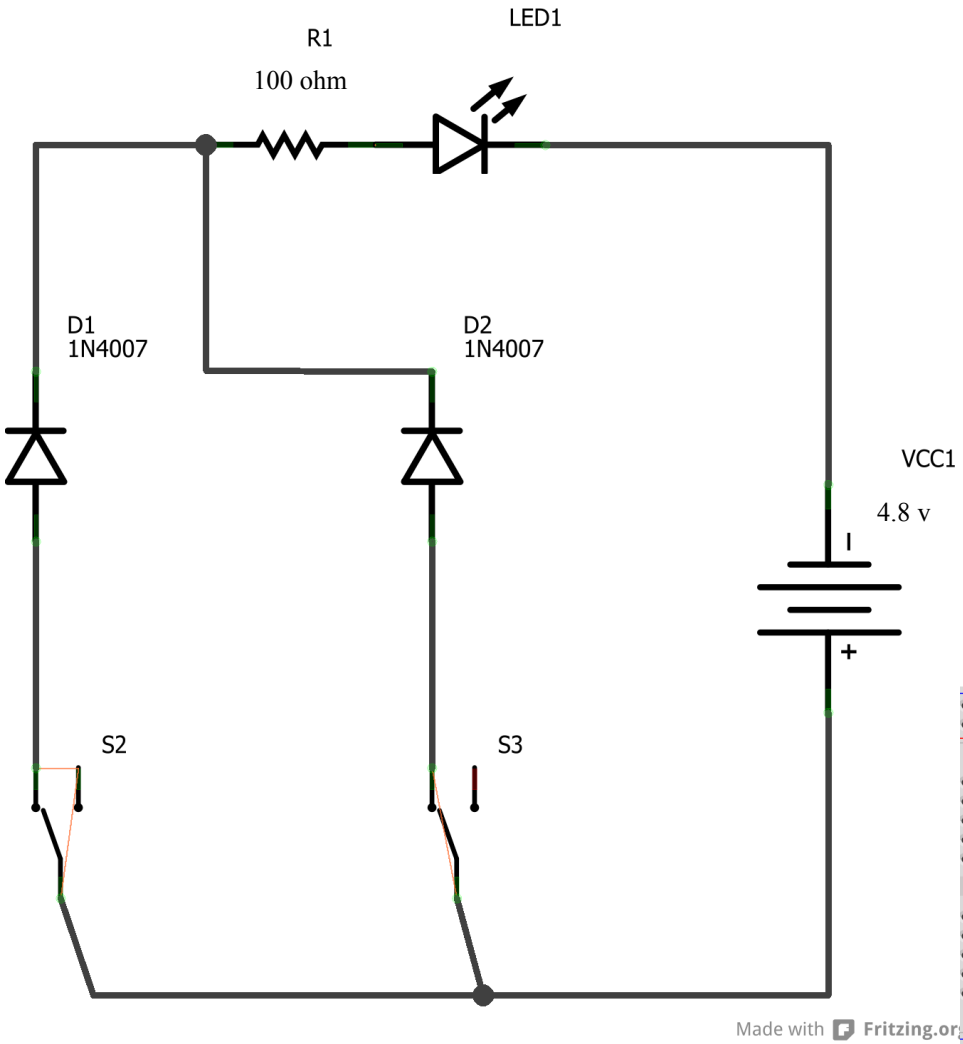
AND Gate—The AND gate is a basic digital logic gate that implements logical conjunction - it behaves according to the truth table to the right. A HIGH output (1) results only if both the inputs to the AND gate are HIGH (1). If neither or only one input to the AND gate is HIGH, a LOW output results. Please refer table & symbol on left side.

NOT Gate—In digital logic, an inverter or NOT gate is a logic gate which implements logical negation. The truth table and symbol is shown on the right.



INPUT	OUTPUT
A	NOT A
0	1
1	0

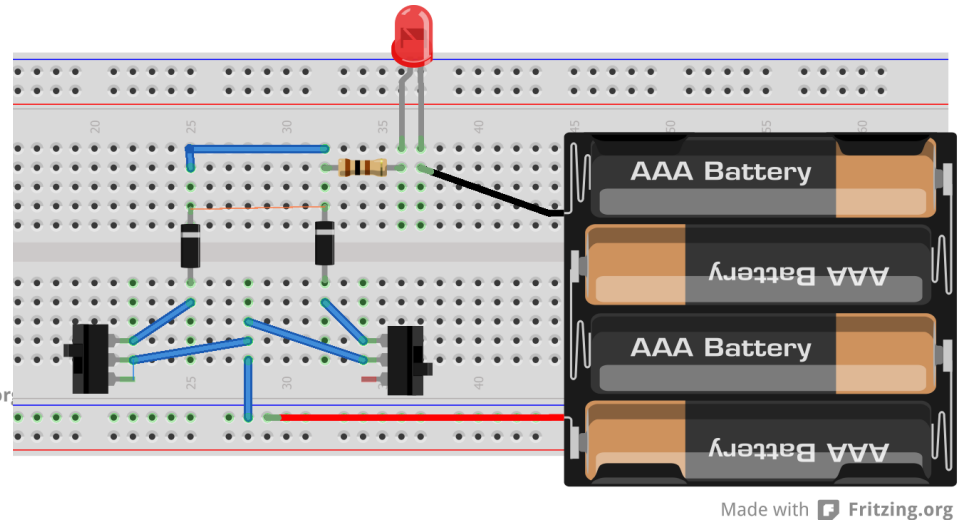
Lets explore, how to realize the gates using real circuits. This will not only help you in understanding basic of digital electronics but it will also help in creating digital circuits by combining basic gates.



OR Gate—Lets realize OR gate first, below is shown circuit for OR gate. Both of the switches are shown as high which means (as per truth table) the output will be high also.

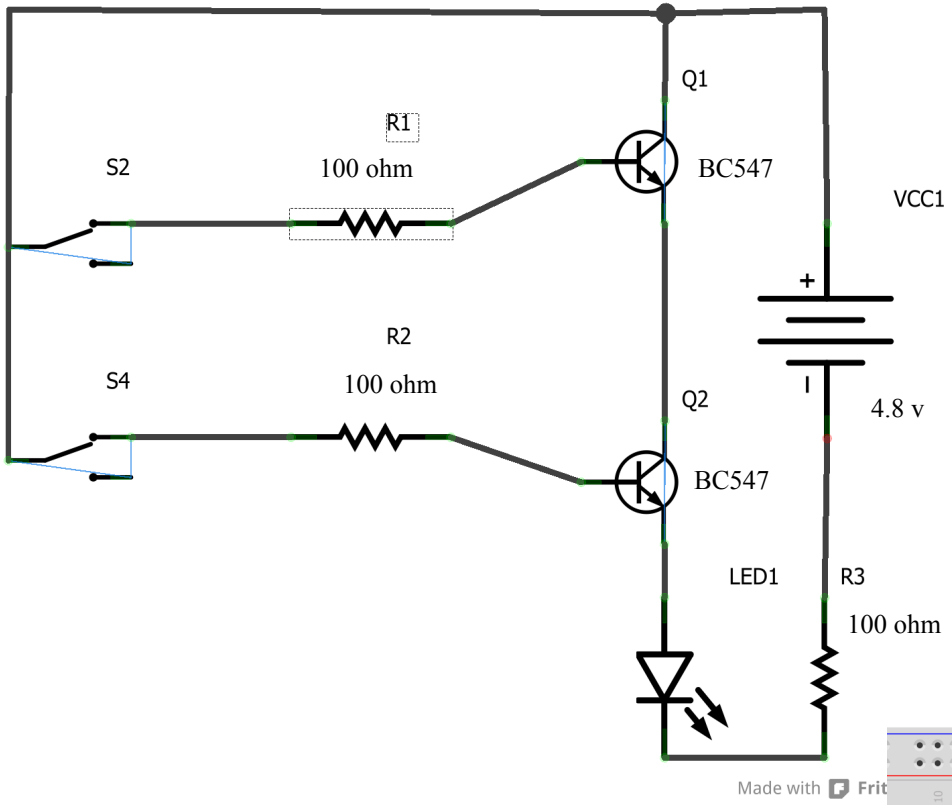
Please refer the breadboard circuit below for wire connections.

Materials: IN 4007 Diode - 2 , R1 100ohms, LED
Step1: Indentify the pins of LED.
Step2: Assemble the components and switch On the circuit.
Step3: Please check if LED lights up or not, If not disconnect battery immediately and check connections again.
Step4: Please follow truth table for inputs and for verifying the outputs



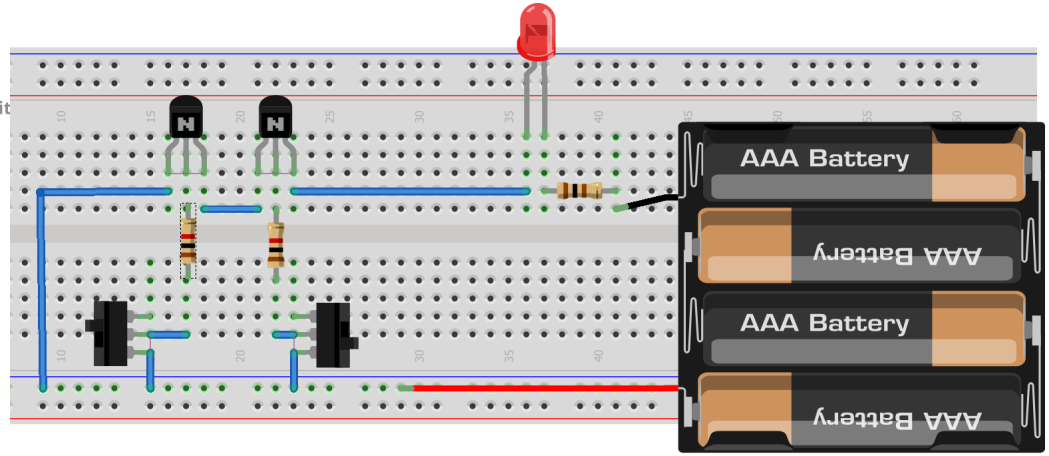
AND Gate—Lets realize AND gate.. We are going to use two transistors in this circuit. The LED will glow only when both of transistors are On. Else LED will not glow.

Please refer the breadboard circuit below for wire connections.

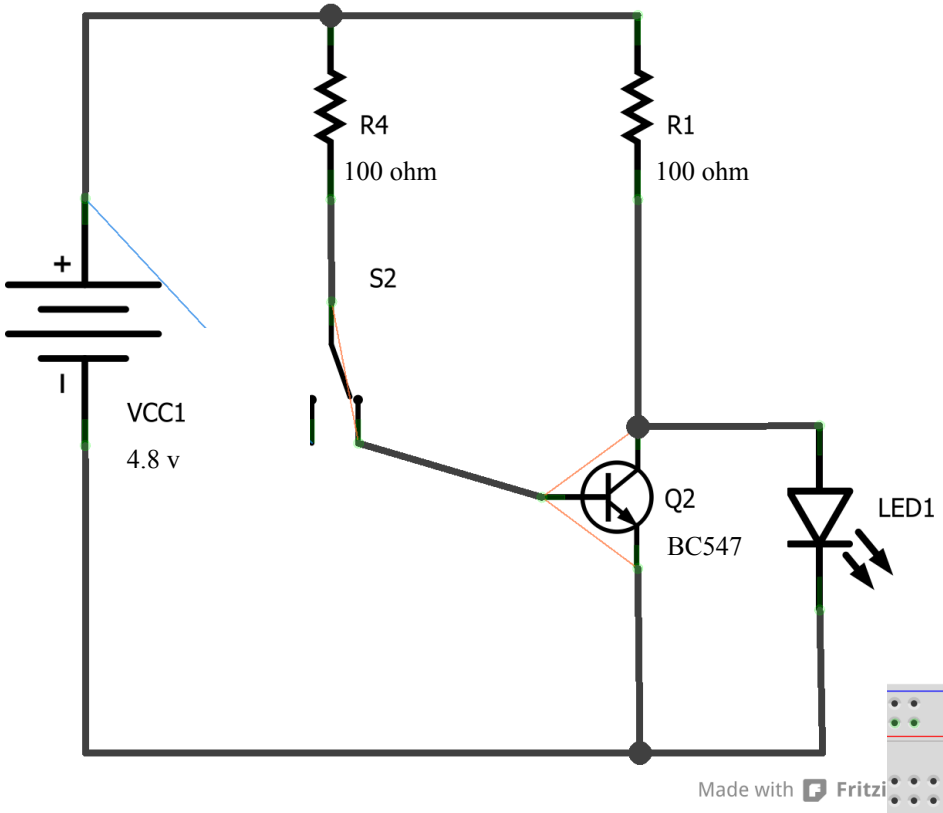


Materials: R1,R2,R3 - 100ohms, LED, BC547—2

Step1: Indentify the pins of LED.
Step2: Assemble the components and switch On the circuit by turning on both switches.
Step3: Please check if LED lights up or not, If not disconnect battery immediately and check connections again.
Step4: Please follow truth table for—inputs and for verifying the outputs



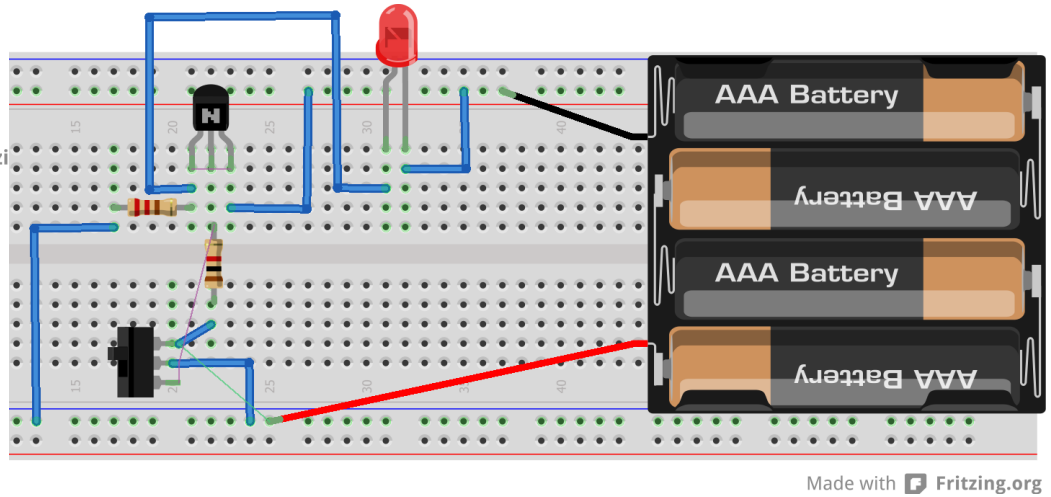
NOT Gate—A NOT gate is a circuit which simply negates the input. A HIGH voltage in input will make output LOW and vice versa. Pressing Button will provide a HIGH voltage in transistor, however a HIGH voltage at transistors base will make it conducting and LED will not have enough current to flow through it. Since transistor is having low resistance, all the current will pass through transistor. A LOW at transistor will turn it OFF and LED will start to glow.



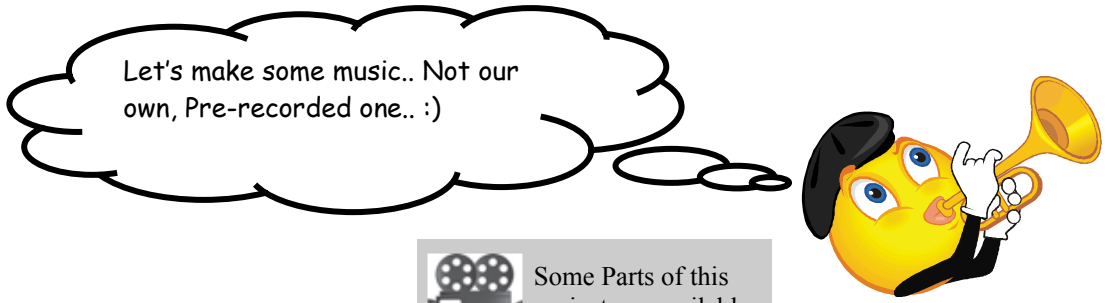
Please refer the breadboard circuit below for wire connections.

Materials: R1,R4 - 100ohms, LED, BC547

Step1: Indentify the pins of LED.
Step2: Assemble the components and switch On the circuit by turning on both switches.
Step3: Please check if LED lights up or not, If not disconnect battery immediately and check connections again.
Step4: Please follow truth table for—inputs and for verifying the outputs



6. Melody Circuit



In this section we will make :

6.1 Melody Circuit
6.2 Sensitive Melody Circuit

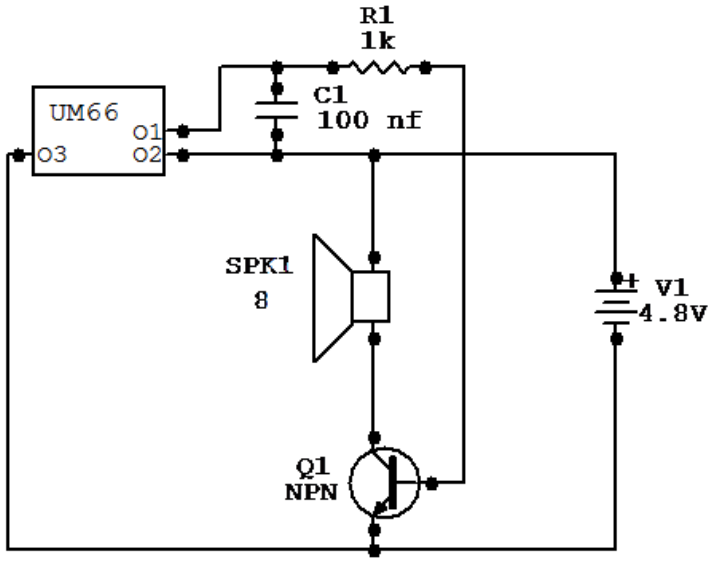
Some Parts of this project are available in Video CD ROM

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'.

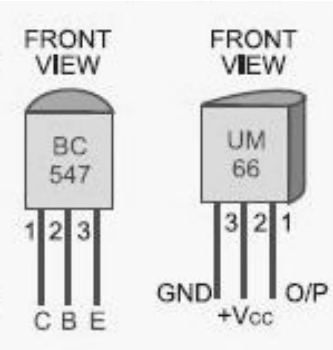
Let's Do It

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.



6.1 Melody Circuit

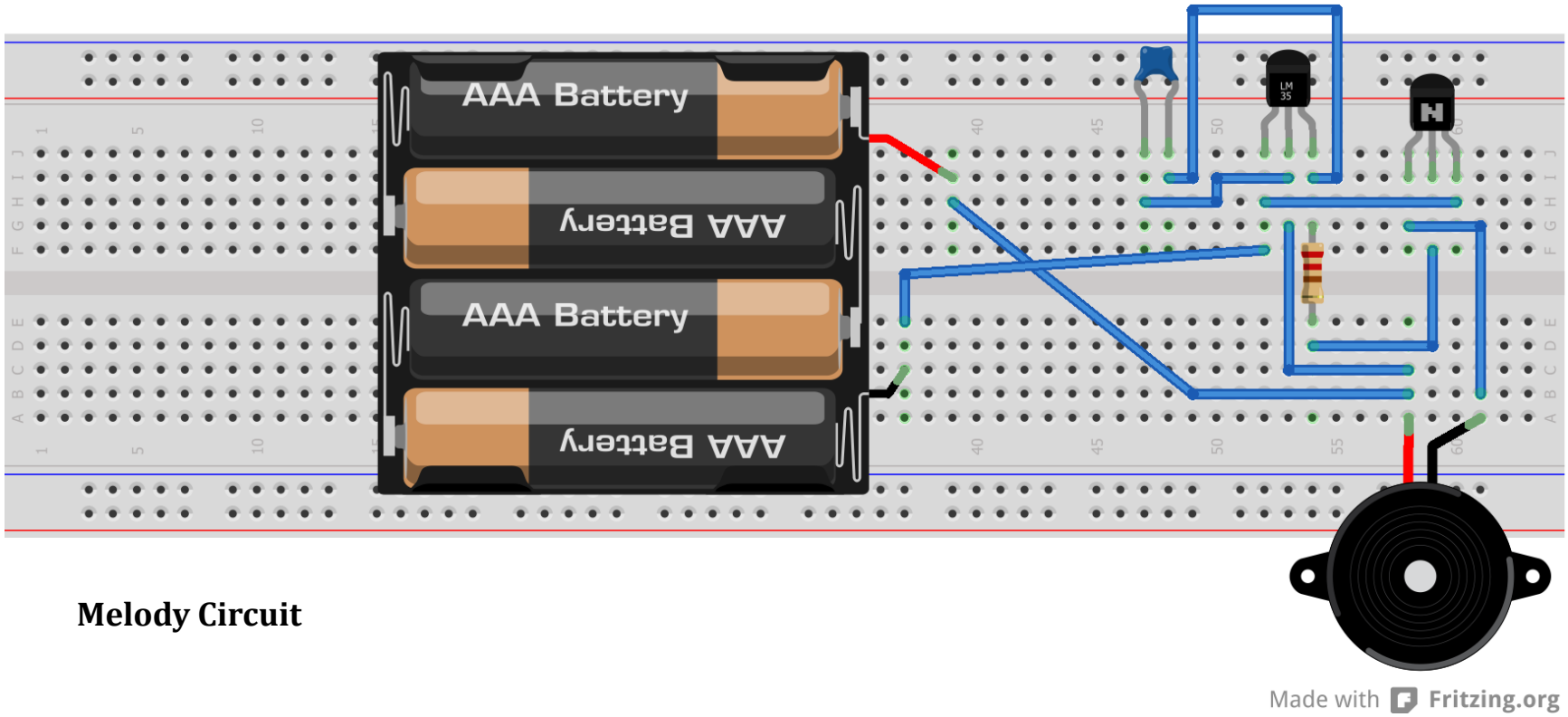
Materials: 1 Piezo speaker,1-100nf, 1– BC547 or BC108 transistor, 1—1kΩ resistance, 4.8v battery,
1– UM 66 music IC.



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.

Warning:
Do not provide more then 4.5 volts to IC UM 66.

Tip:
Louder Melody
Try BC 108 instead of BC547 & you will get more loud sound.



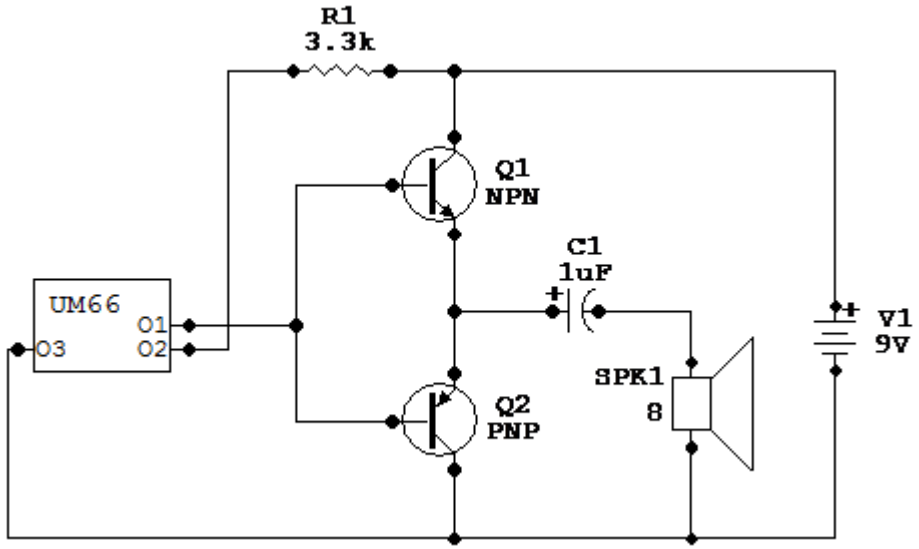
Melody Circuit

6.2 Sensitive Melody Circuit

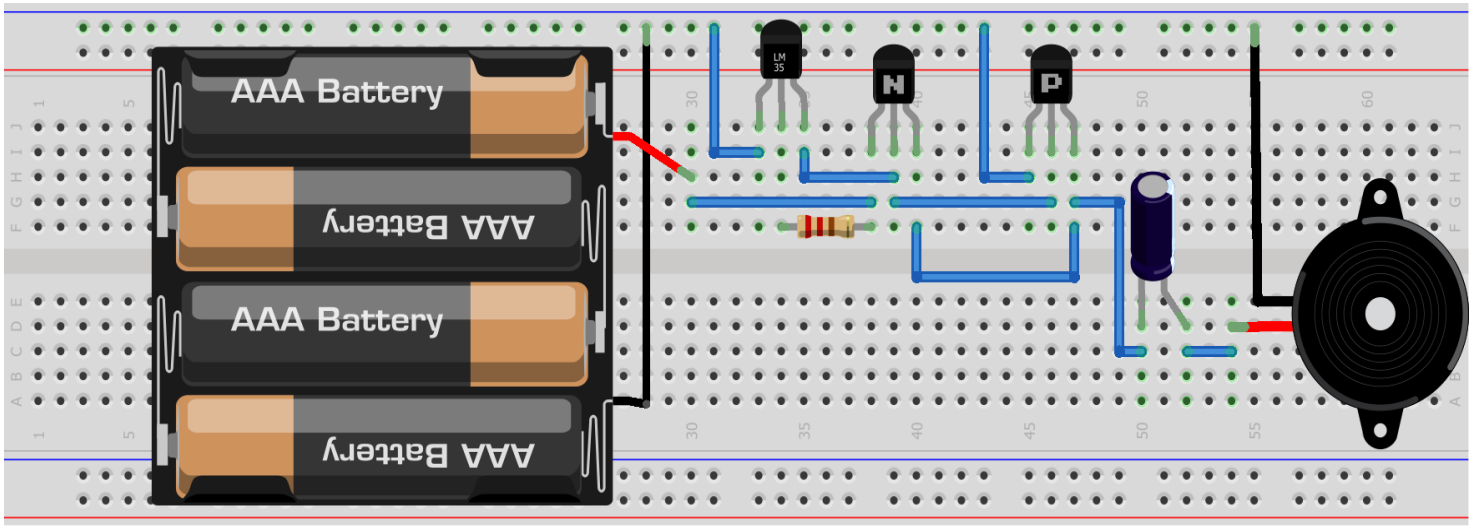
Lets increase the sensitivity of previous circuit by adding few more components and enjoy same music with low current. You can use this circuit in any another projects also.

Materials: Apart from previous components we need 1 BC 547 1– 1µf, 1– 3.3kΩ.

Step1: Indentify 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.



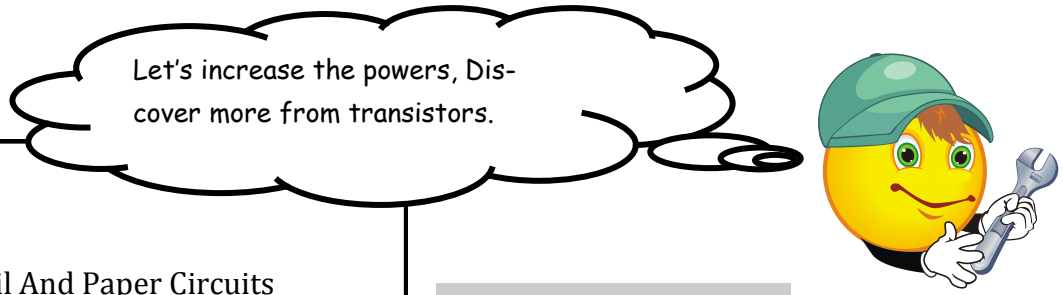
Tip:
Louder Melody
Try BC 108 instead of BC547 & you will get more loud sound.



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

Sensitive Melody Circuit

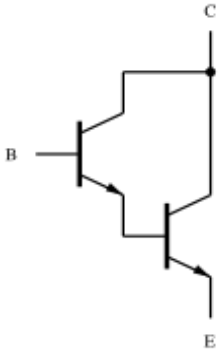
7. Darlington Pair



In this section we will make :

7.1 Darlington Circuit
7.2 Water Tank Overflow Alarm/Rain Alarm
7.3 Fire Alarm
7.4 Light Sensitive Morning Alarm
7.5 LASER based Anti-Theft Alarm System
7.6 Wire Current Detector
7.7 Pencil And Paper Circuits
7.8 Paper circuit with Darlington Pair

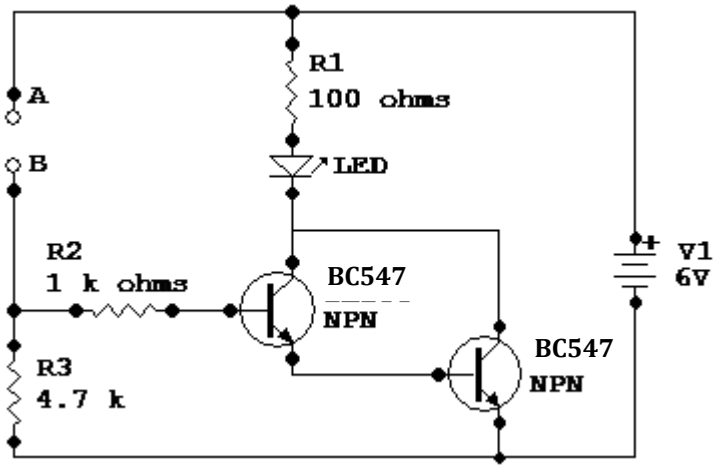
Some Parts of this project are available in Video CD ROM



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.

7.1 Darlington Circuit

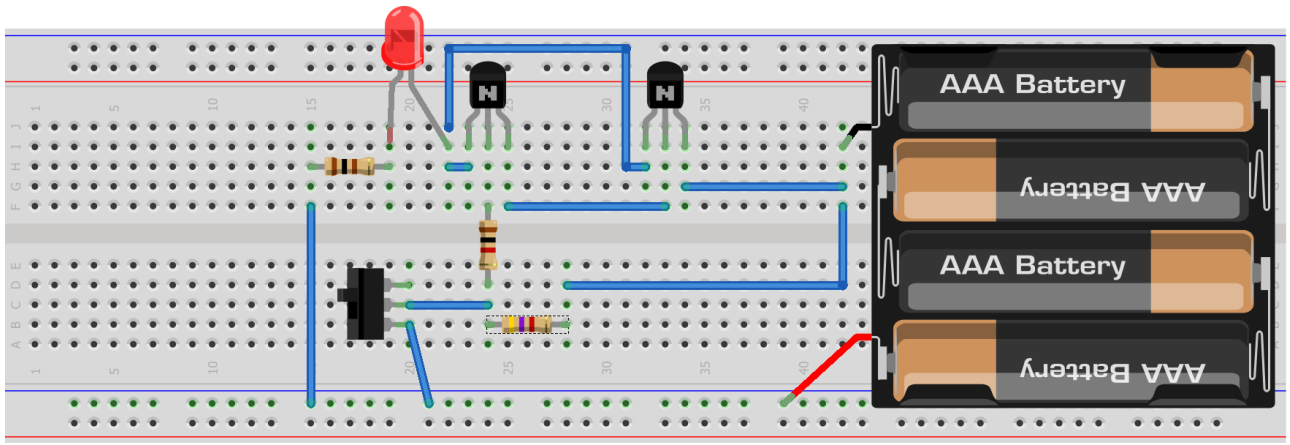
Materials : 2 - SL100 or BC547, Resistances—1kΩ,4.7kΩ,100Ω, 4.8—6v battery, 1-LED

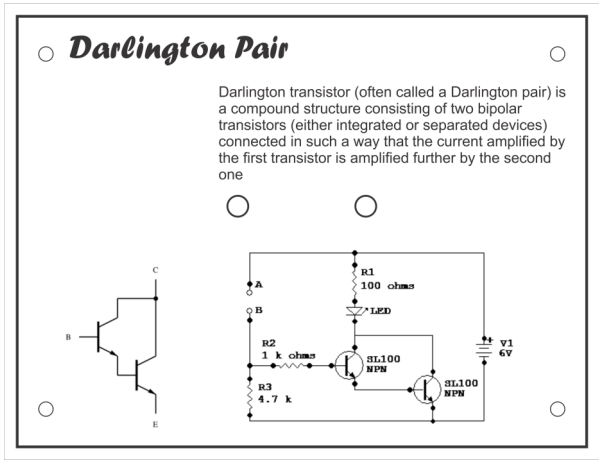
Step1: Identify the collector, base and emitter leads. And insert transistor in bread-board.

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.





Some Parts of this project are available in Video CD ROM

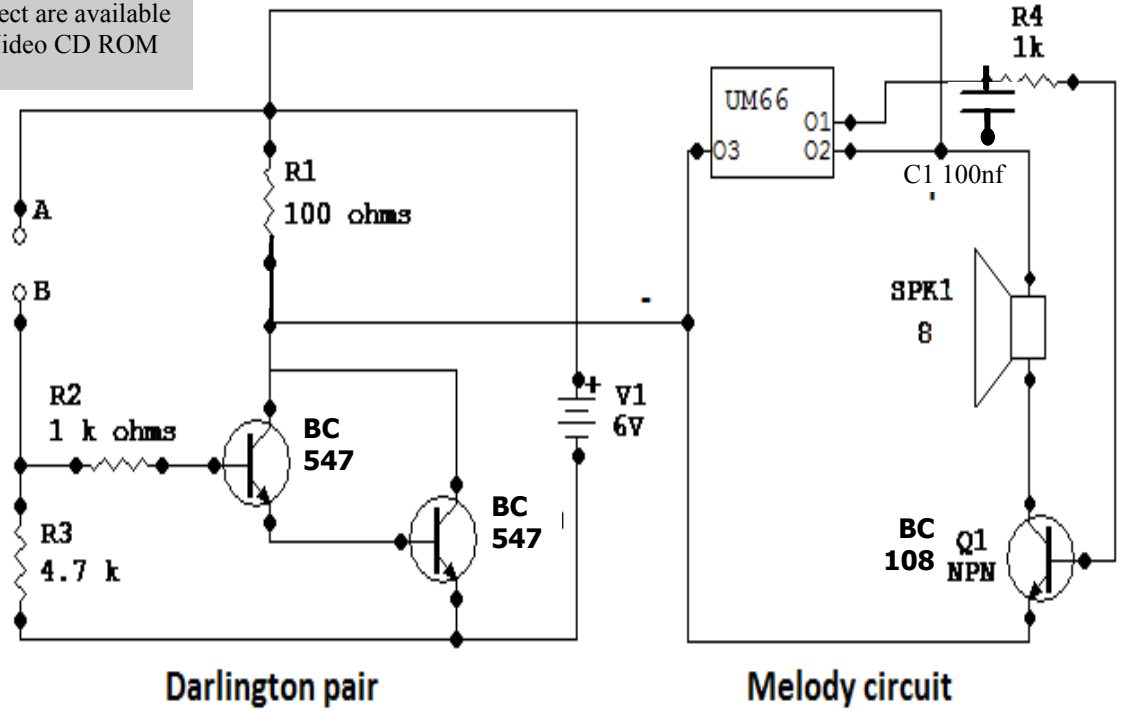
7.2 Water Overflow Alarm

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 over-flow and creates mess. Lets try to make a simple circuit using Darlington pair and melody circuit together.

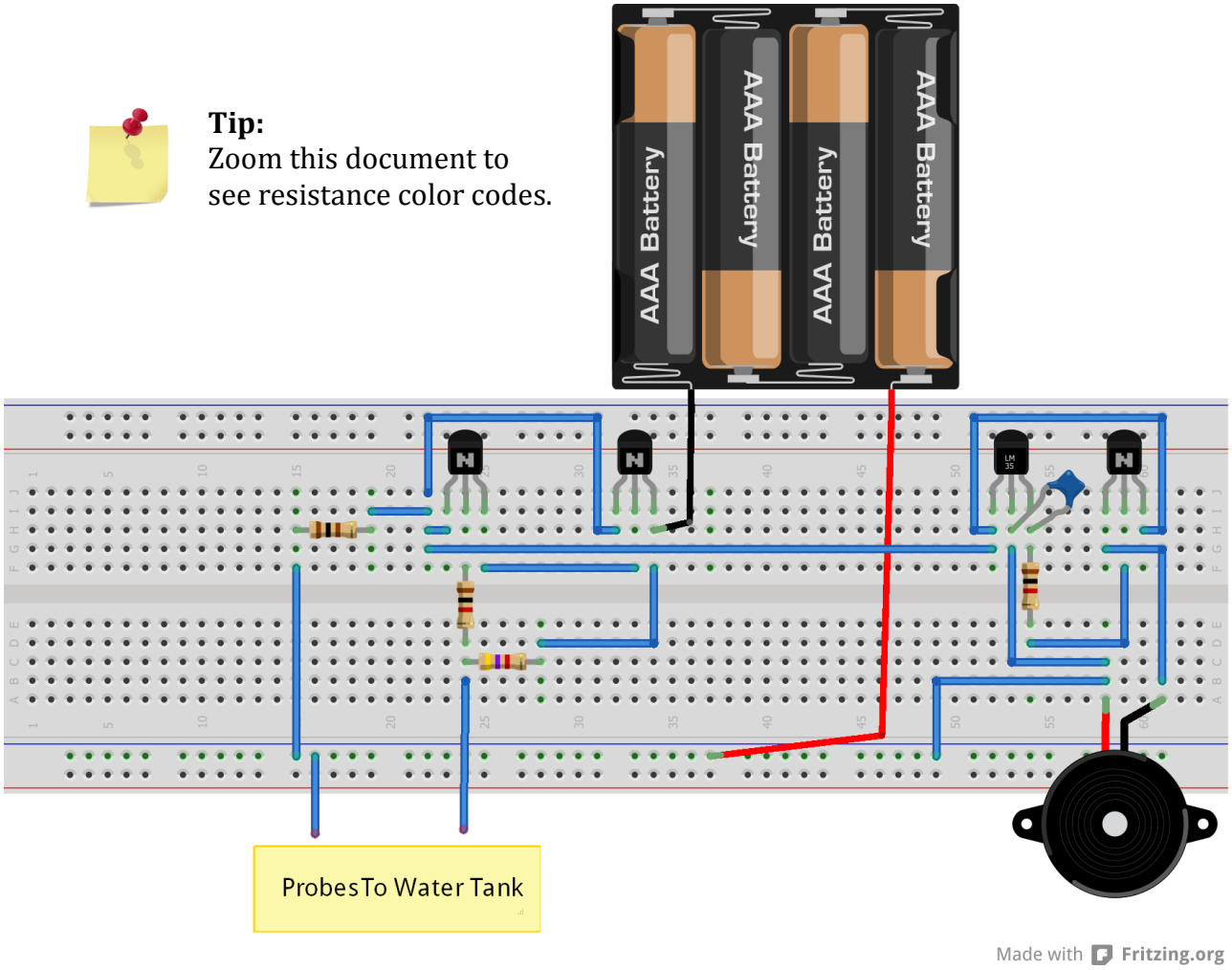
Materials : Previous circuit components and 1 - BC108, 1—UM 66 Music IC, Resistances—220Ω.

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.

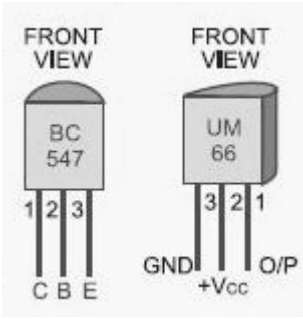


Tip:
Zoom this document to see resistance color codes.



Step2: Assemble the melody circuit in bread-board, 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.
Step5: 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

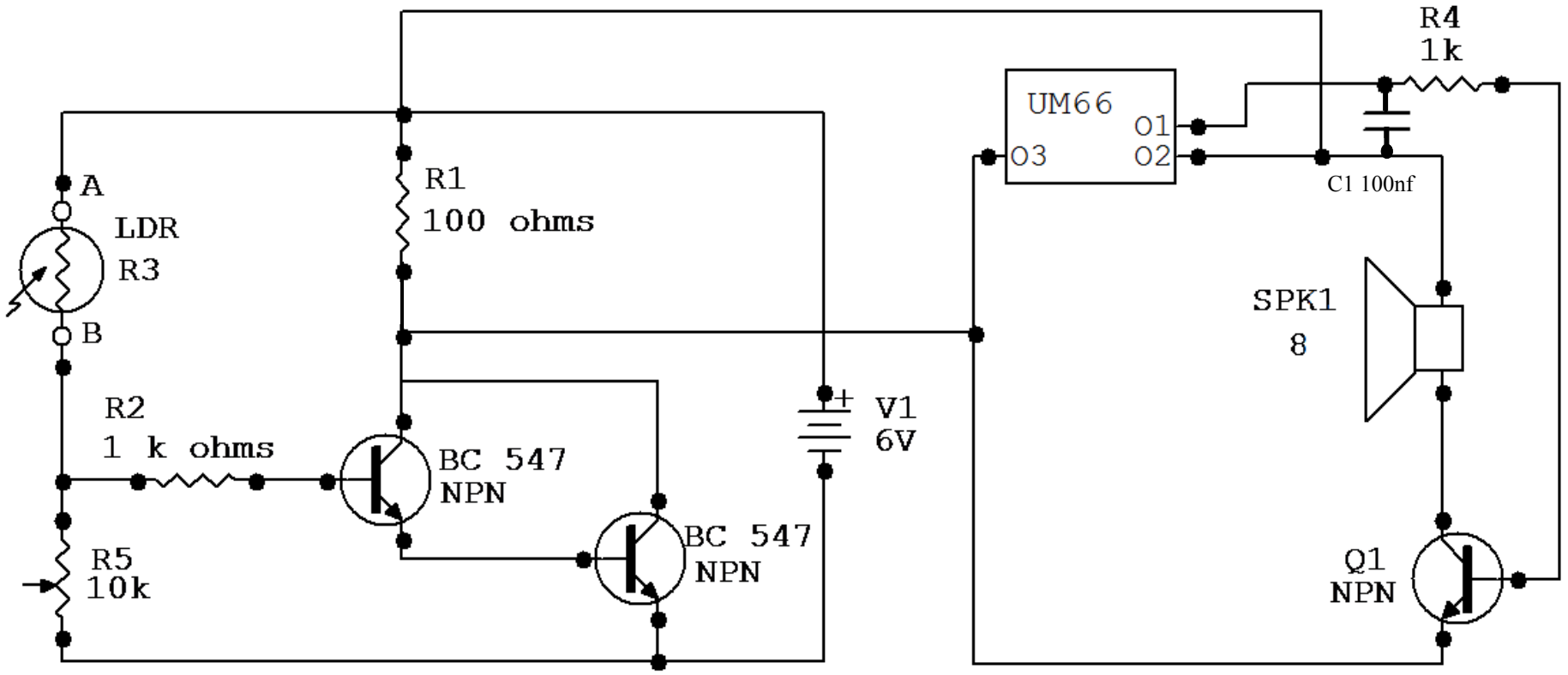


Tip:
Please refer figure on the left side to identify the right pin numbers for IC UM66 and Transistor BC

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.

7.3 Fire Alarm

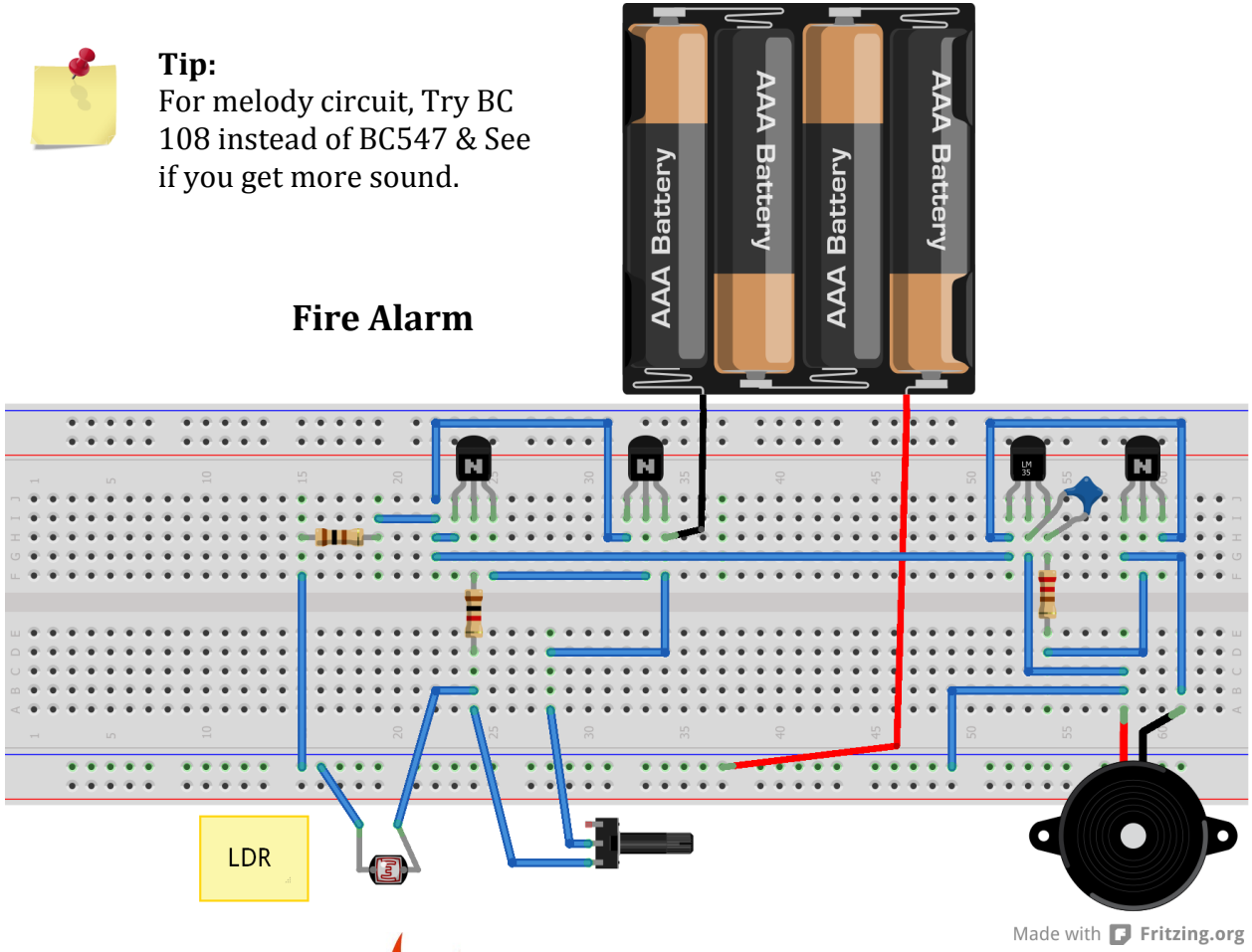
Fire alarm is a very important device in any house, It protects us from unknown fires and give time to prevent any miss happening. In this project we are going to make a small fire alarm which can be installed on places like kitchen. It senses fire from close range so it can kept near to the places, 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.

Fire Alarm



Light sensor detects light from fire

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.

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

7.4 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

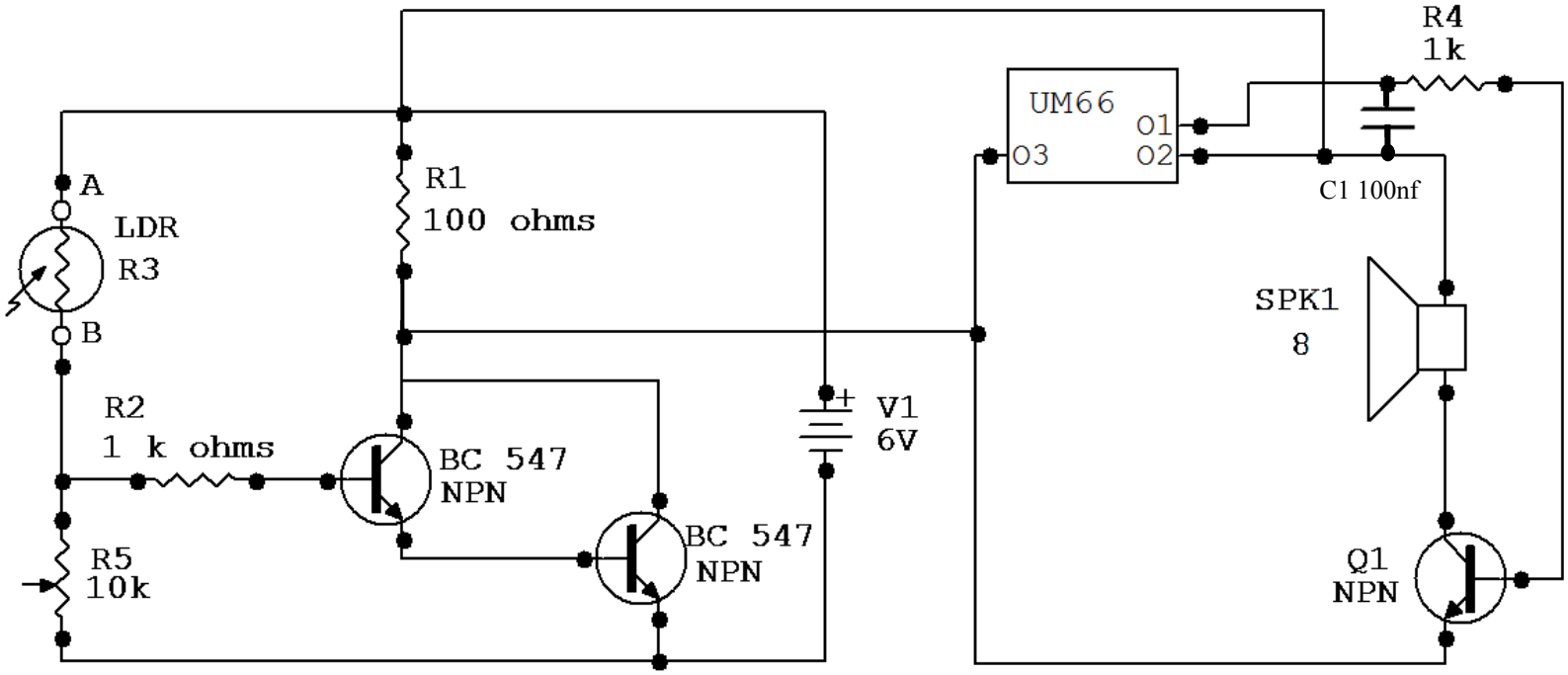
Find materials at : www.hobbyelectronics.in

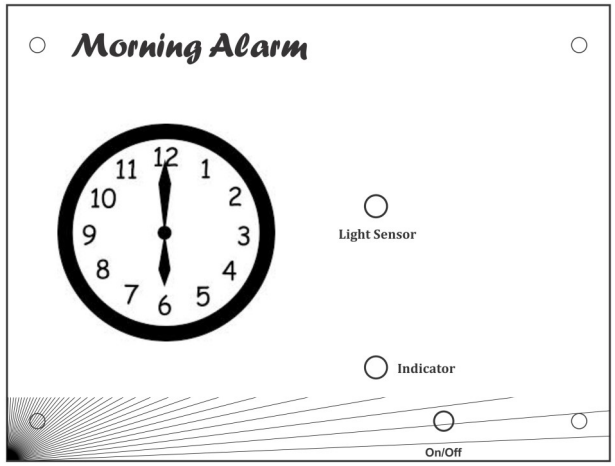
Step1: In this circuit , just replace A and B with LDR as a light sensor.

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

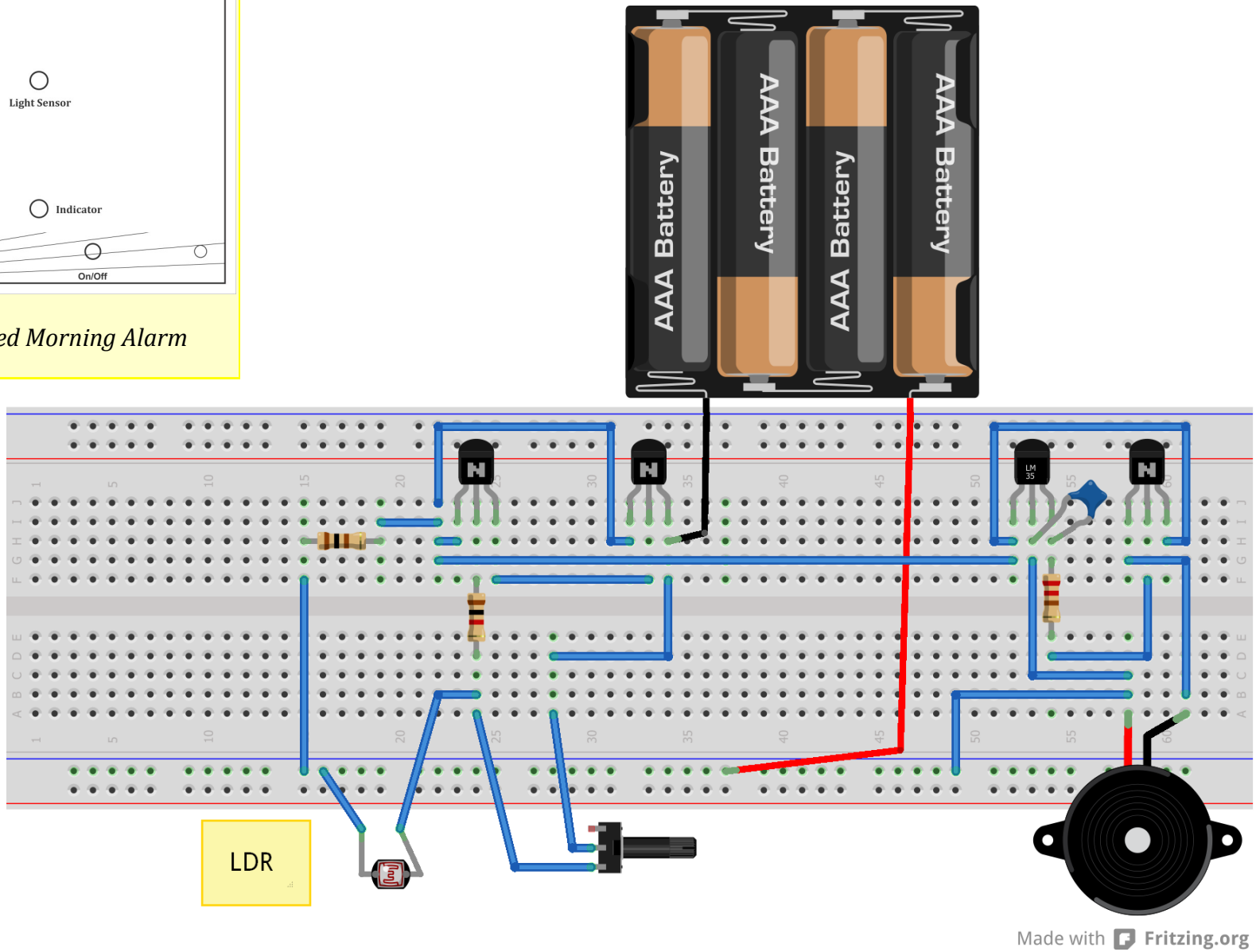
Step3: As done before, Connect the melody circuit to LED pins , So that melody circuit will also get power when LED will light up.

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.





Panel for Light based Morning Alarm



More Ideas:

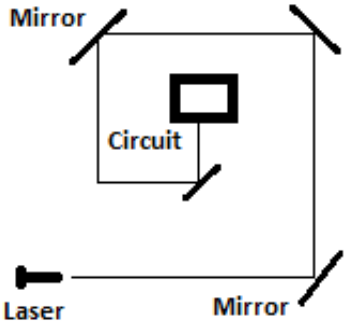
Refrigerator door open alert system: You can use this circuit as an Refrigerator door open alarm system, which will alert the user to close the fridge door. This circuit works in light and closes itself Off in dark, which is what happens when we open fridge, As we open fridge door a small indicator lamp 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.

7.5 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.

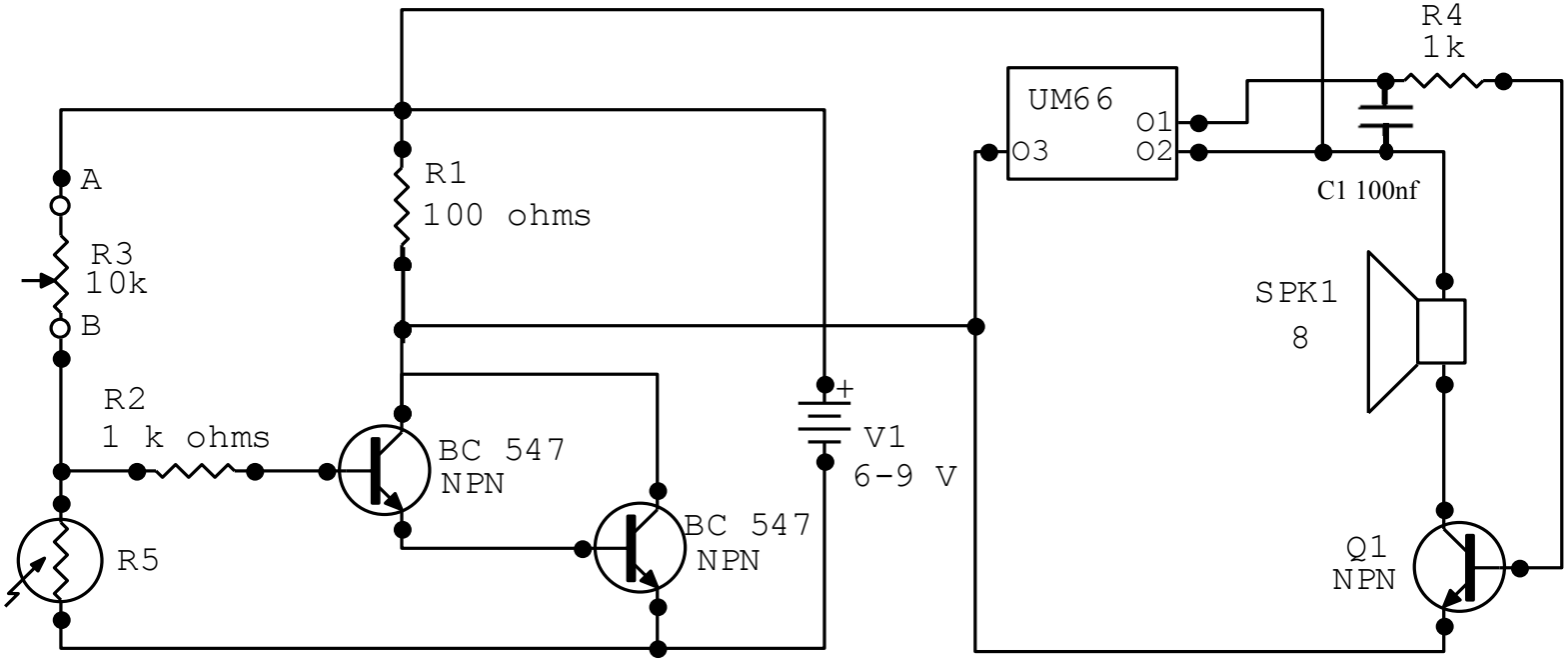
Step2: Assemble the melody circuit in breadboard first, Please refer the previous melody project to make the circuit.

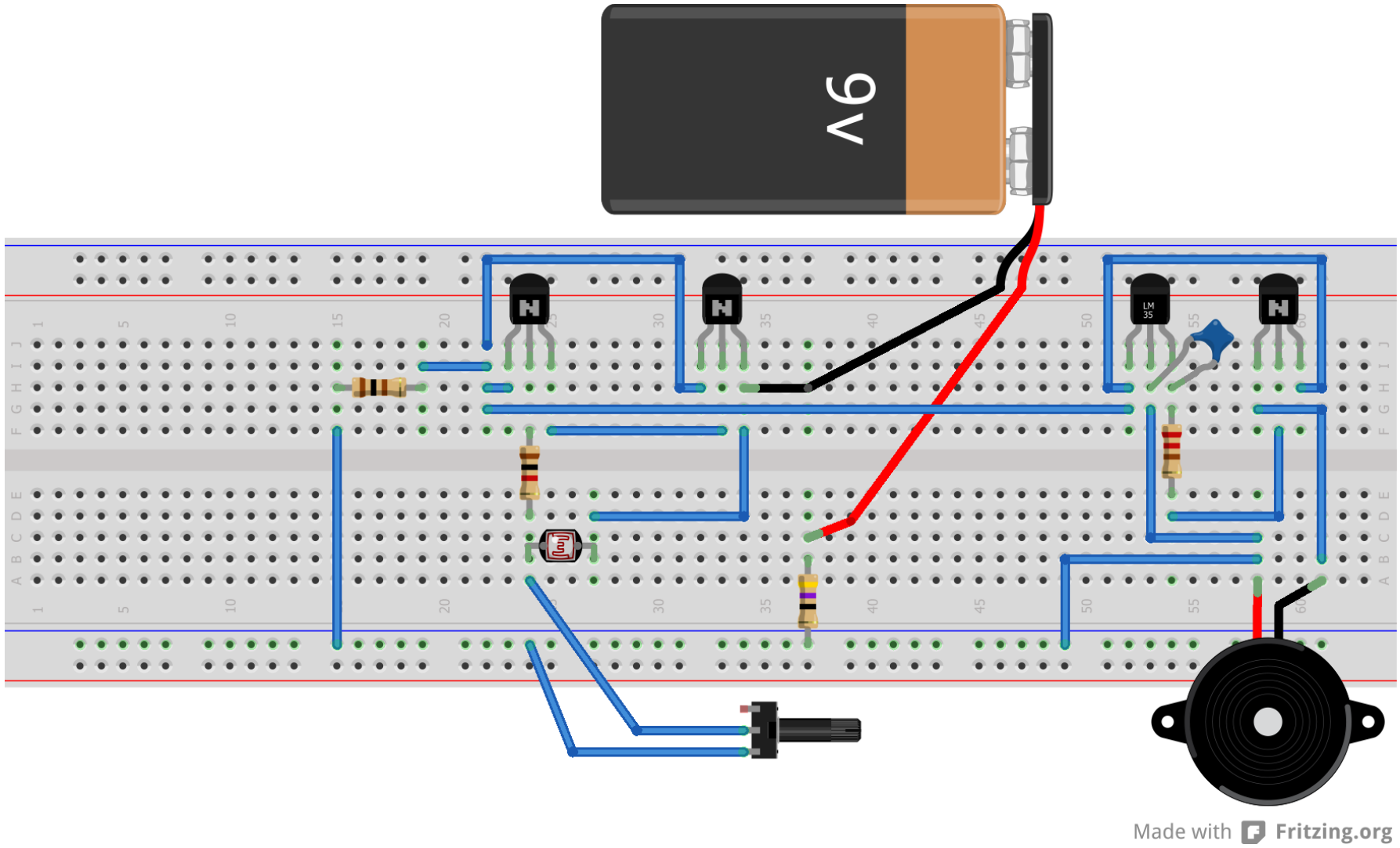
Step3: As done before, Connect the melody circuit to LED pins , So that melody circuit will also get power when LED will light up.

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.

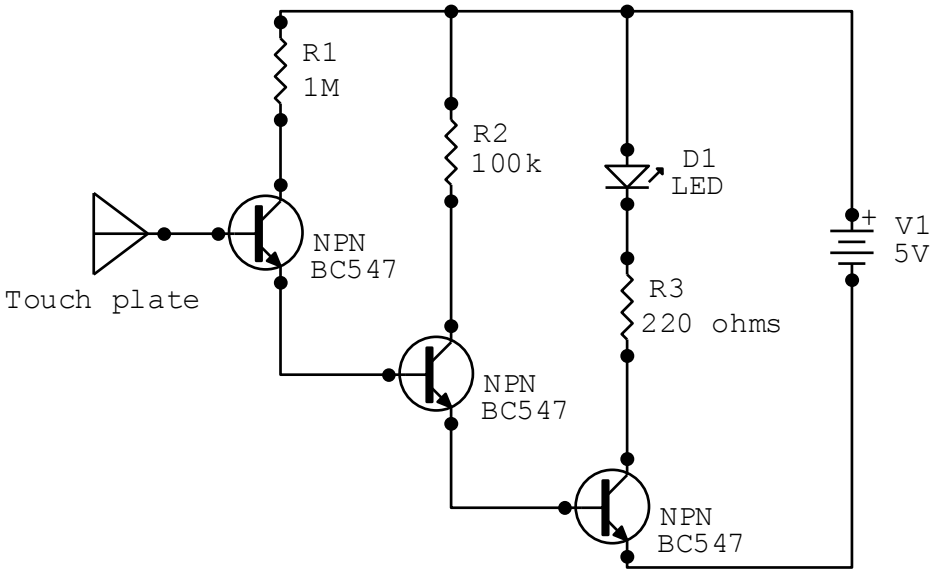
Step6: If circuit is working fine, You can optionally use mirrors to divert Laser to different angles in room.




9V
LM
35
Made with Fritzing.org

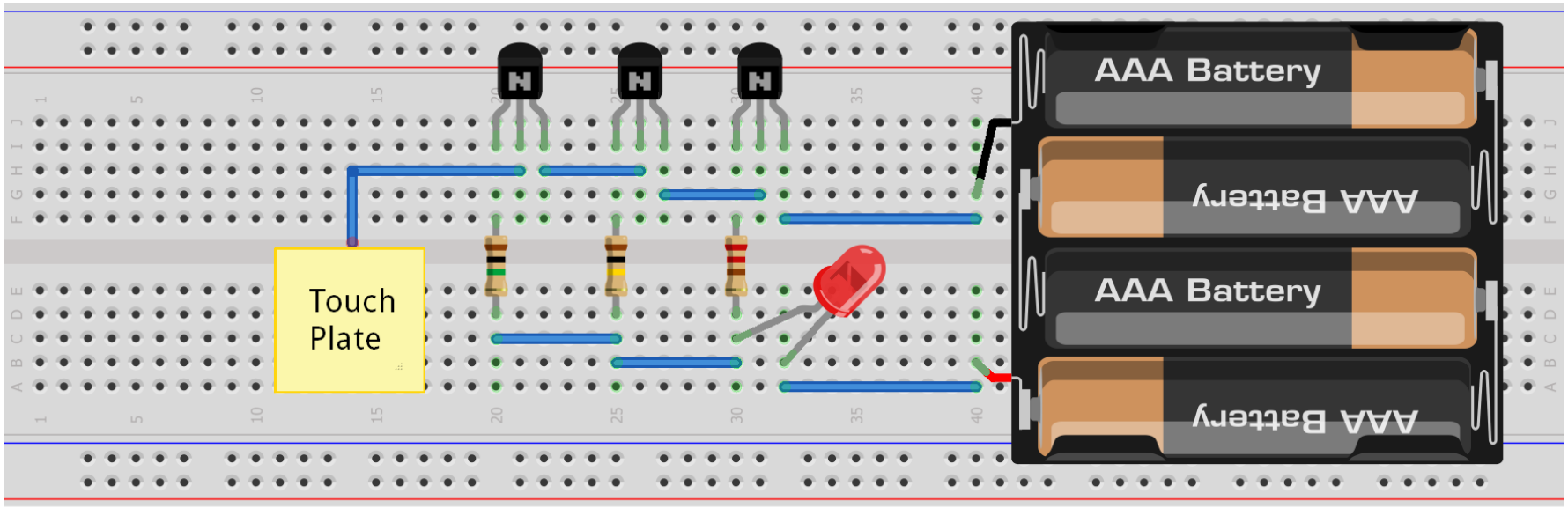
7.6 Wire Current Detector

In today's times all the wiring is done inside the walls and if there's some fault in that wiring, Its 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– 1MΩ, 1– 100kΩ, 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.

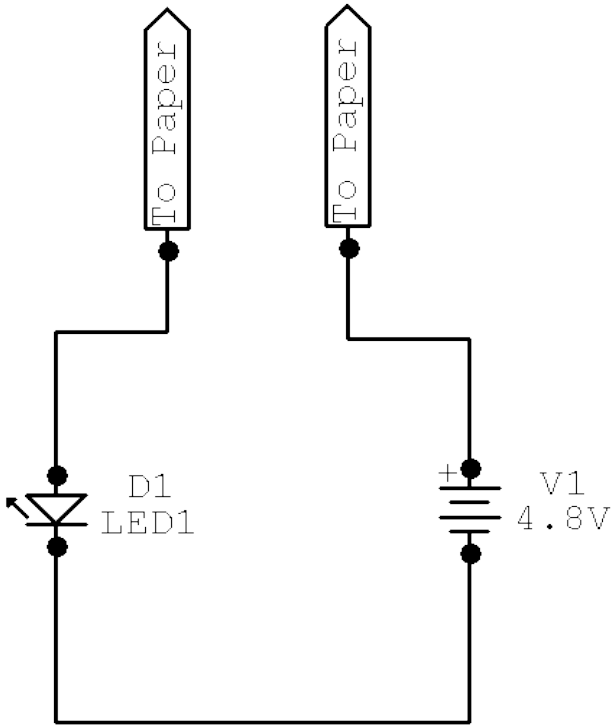


Made with Fritzing.org

7.7 Pencil and Paper Circuits

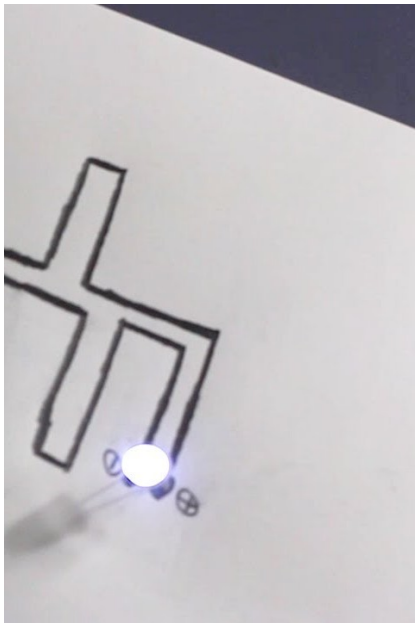
Now this is very exciting project for all young hobbyists out there. We all use pencils some of us love them and some of us don't. you draw using pencils or can write. But do you know one more exciting use of pencil. The pencil lead made up of graphite is a very good conductor and when we write/draw 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 then when we draw a small line. In other words a small line drawn on paper will conduct better then a longer line. This also suggests that resistance of a conductor is proportional to its length.

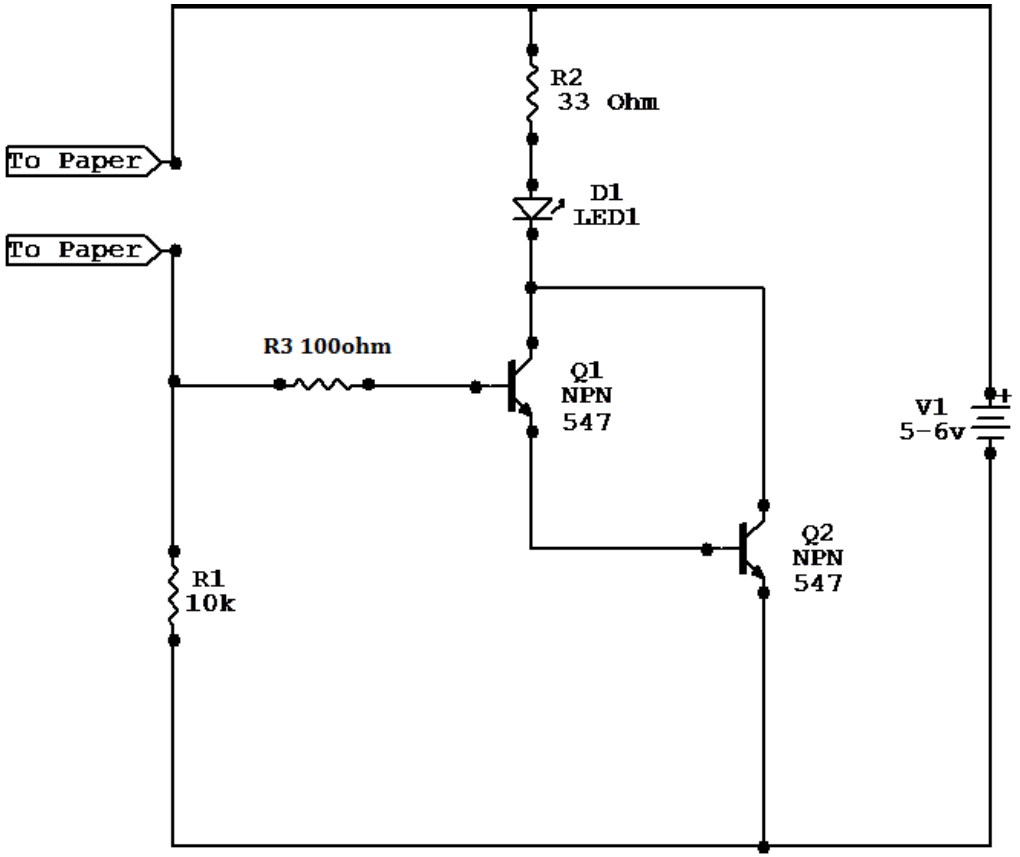
Steps:
Step1: Draw a dark line on a paper using a pencil. You can redraw same line again and again to achieve some darknesss. A dark line conducts better as it is having more graphite layers.
Step2: Assemble circuit components on breadboard.
Step3: Touch the wires on the end of line and check if LED 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.

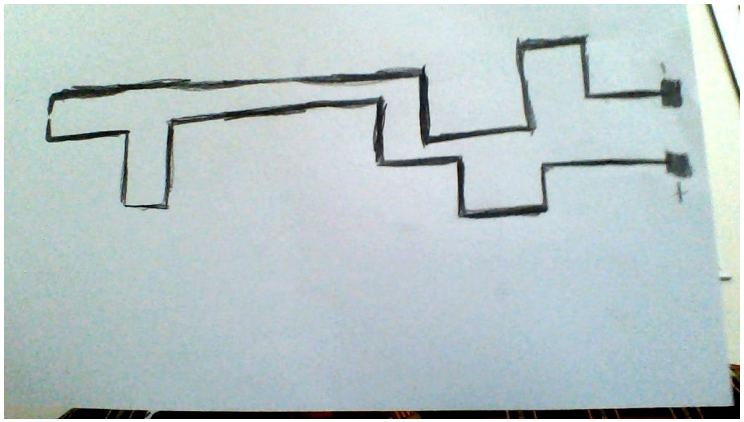


7.8 Paper Circuits Using Darlington Pair

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.

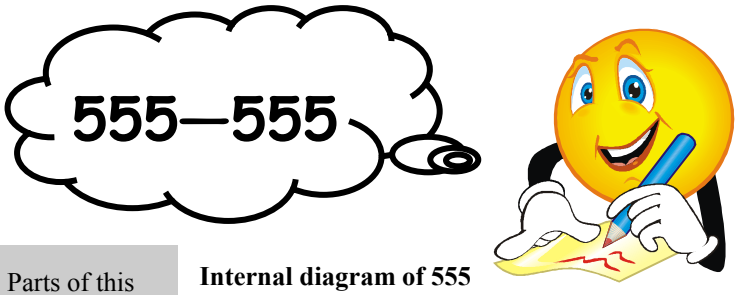
Step3: Touch the wires on the end of line and check if LED light up.

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.

8. 555 Timer Projects

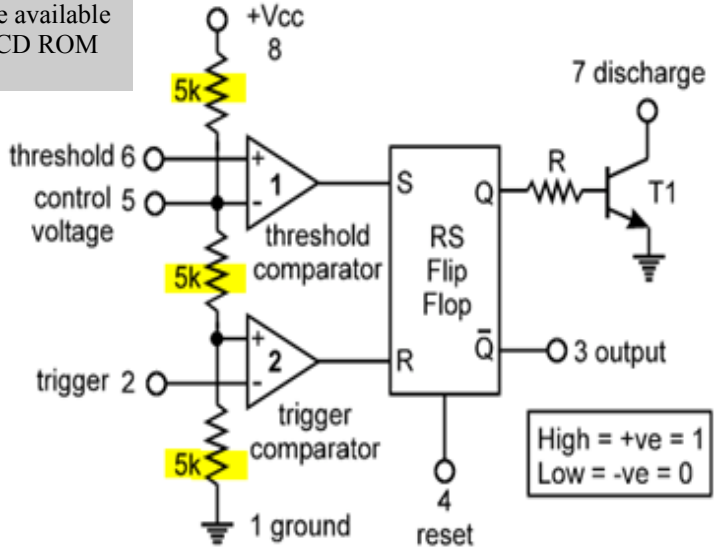


In this section we will make :

8.1 4 Key Piano
8.2 Light sensitive music circuit
8.3 Light controlled Police Siren
8.4 Touch Switch
8.5 Timer
8.6 Continuity Tester
8.7 Knight Rider
8.8 Cricket Game
8.9 Multipurpose circuit
8.11 Johnson counter

Some Parts of this project are available in Video CD ROM

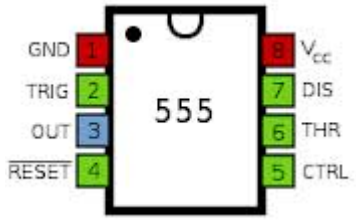
Internal diagram of 555



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 hobby-ists. 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.

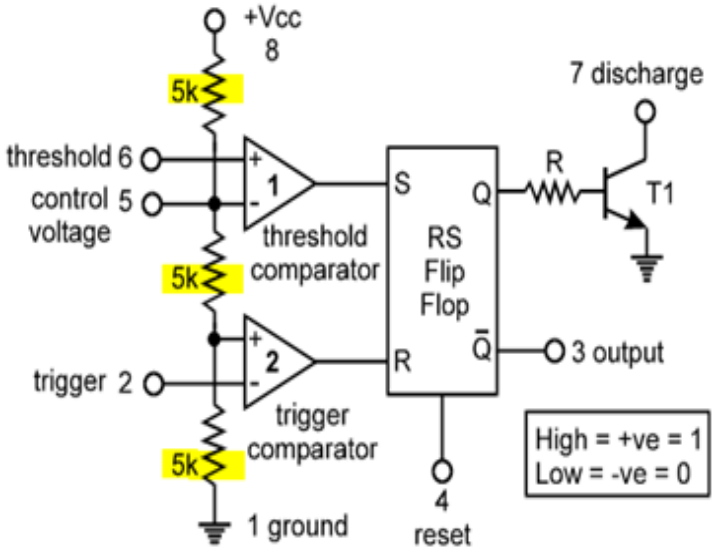


Please note the notch near first pin. This is made to indentify the first pin of IC.

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.

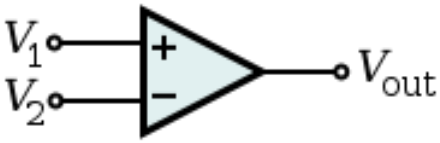
Working Principle

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.



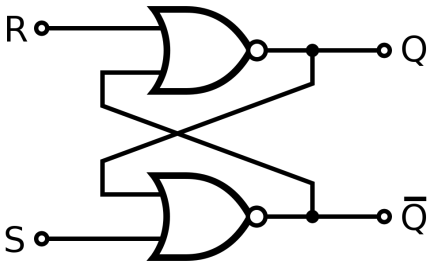
Lets start from the name of IC itself, 555 comes from the 5 highlighted resistances shown in figure. Now to start with working explanation, We will first understand what is comparator and RS Flip Flop.

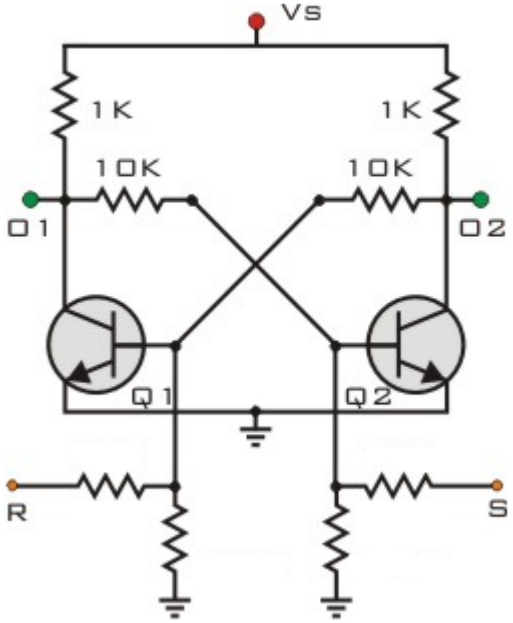
Comparator : As name suggests, It compares and it compares two voltages and outputs a digital signal indicating which is larger.



V out is 1 (1 means 5volts in digital electronics) when V1 is greater then V2. Vout is 0 (0 volts) when V1 is less then V2.

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.

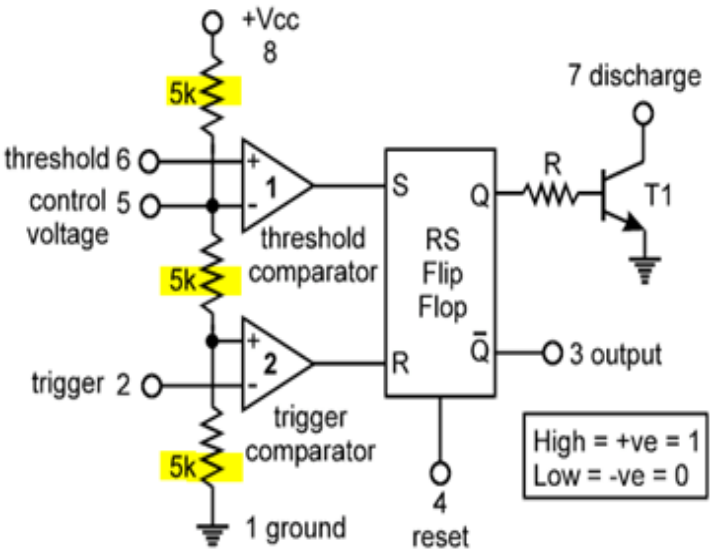




Now S is termed as Set and R is Reset and base on this above simplified figure (left hand side) is created. If you elaborate the possible combination of inputs for R and S they can be - (0,0) , (0,1) , (1,0), (1,1) and depending on the input, Output will get generated in 1 and 0 at Q and Q'.

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 »
	1	1	1	0	no change
Invalid	0	0	1	1	Invalid



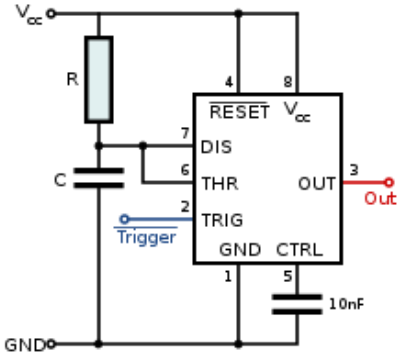
Being RS Flip Flop at the heart of IC, It is clear that this IC is used for generating alternating states of 1 and 0 based on input.

How it works

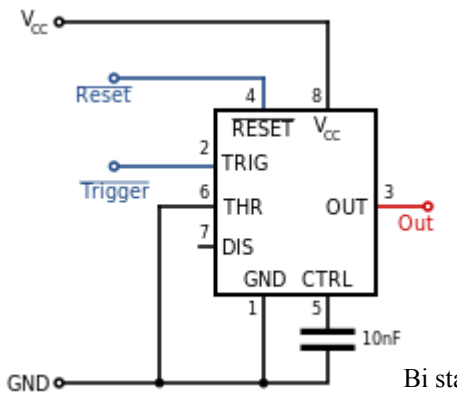
Comparator 1 is threshold comparator and second is trigger comparator, Control voltage is a base voltage which comparator will use to compare higher or lower voltage, So control voltage remains constant. A threshold voltage is applied at pin 6 at comparator 1 and if its greater then control voltage , 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).

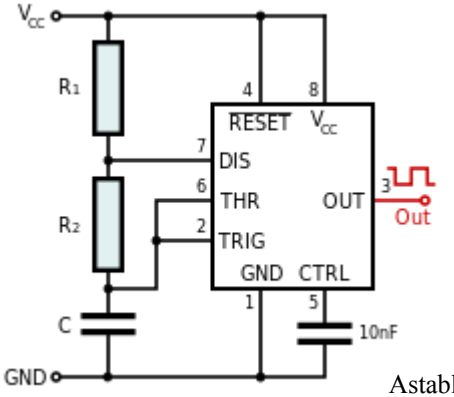
There can be three modes of operation for IC 555 -



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.

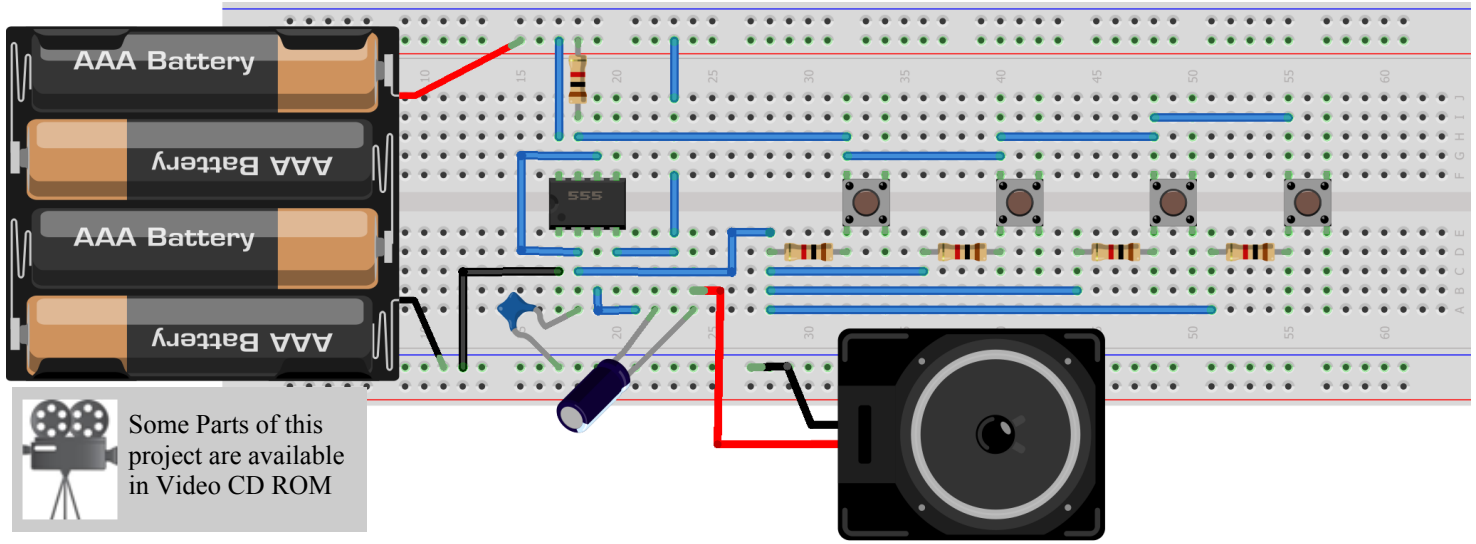
Astable - free running mode: the 555 can operate as an oscillator. Uses include LED and lamp flashers, pulse generation, logic clocks, tone generation, security alarms, pulse position modulation and so on. The 555 can be used as a simple ADC, converting an analog value to a pulse length. E.g. selecting 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.

8.1 4 Key Piano

The circuit produces different sounds when keys are pressed.

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

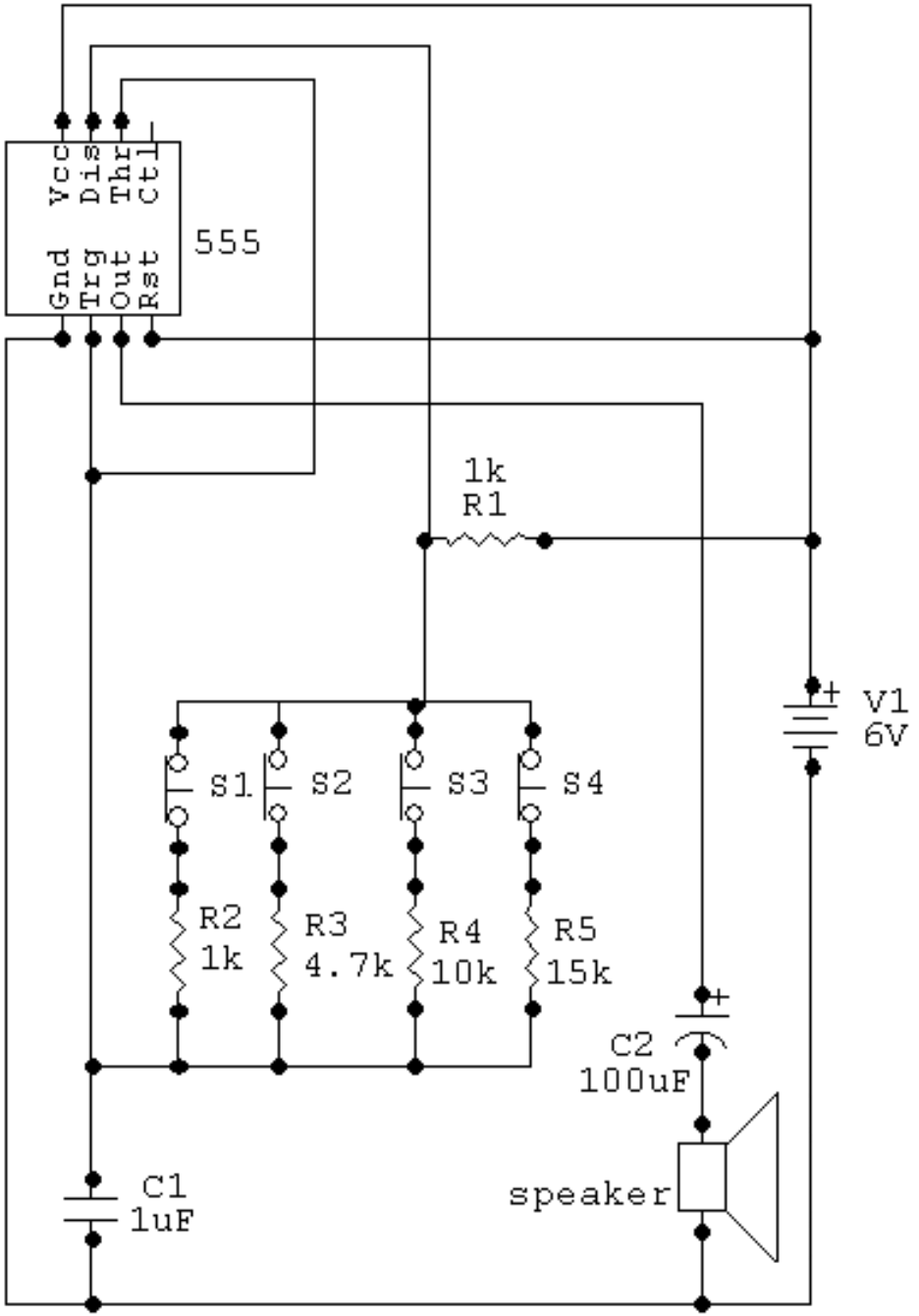


Some Parts of this project are available in Video CD ROM

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 Kit and have fun.

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 Circuit



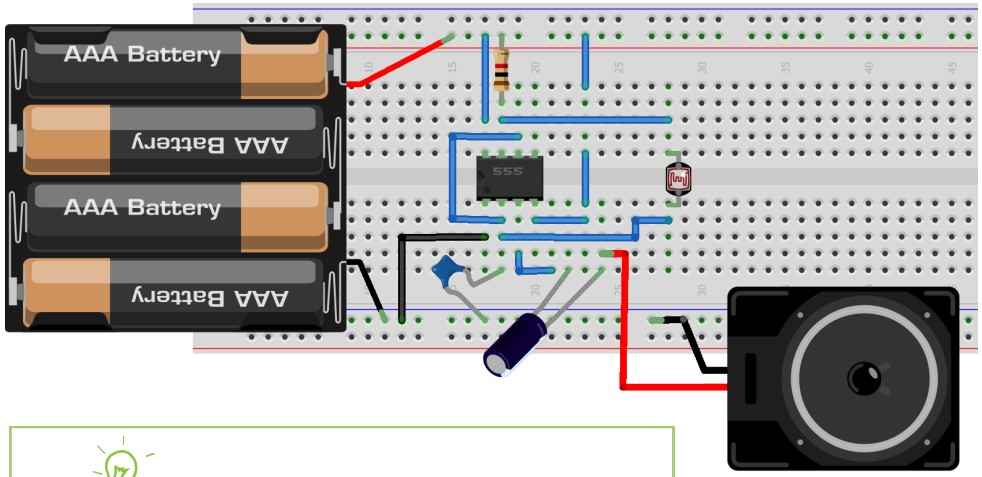
8.2 Light Sensitive music Circuit

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

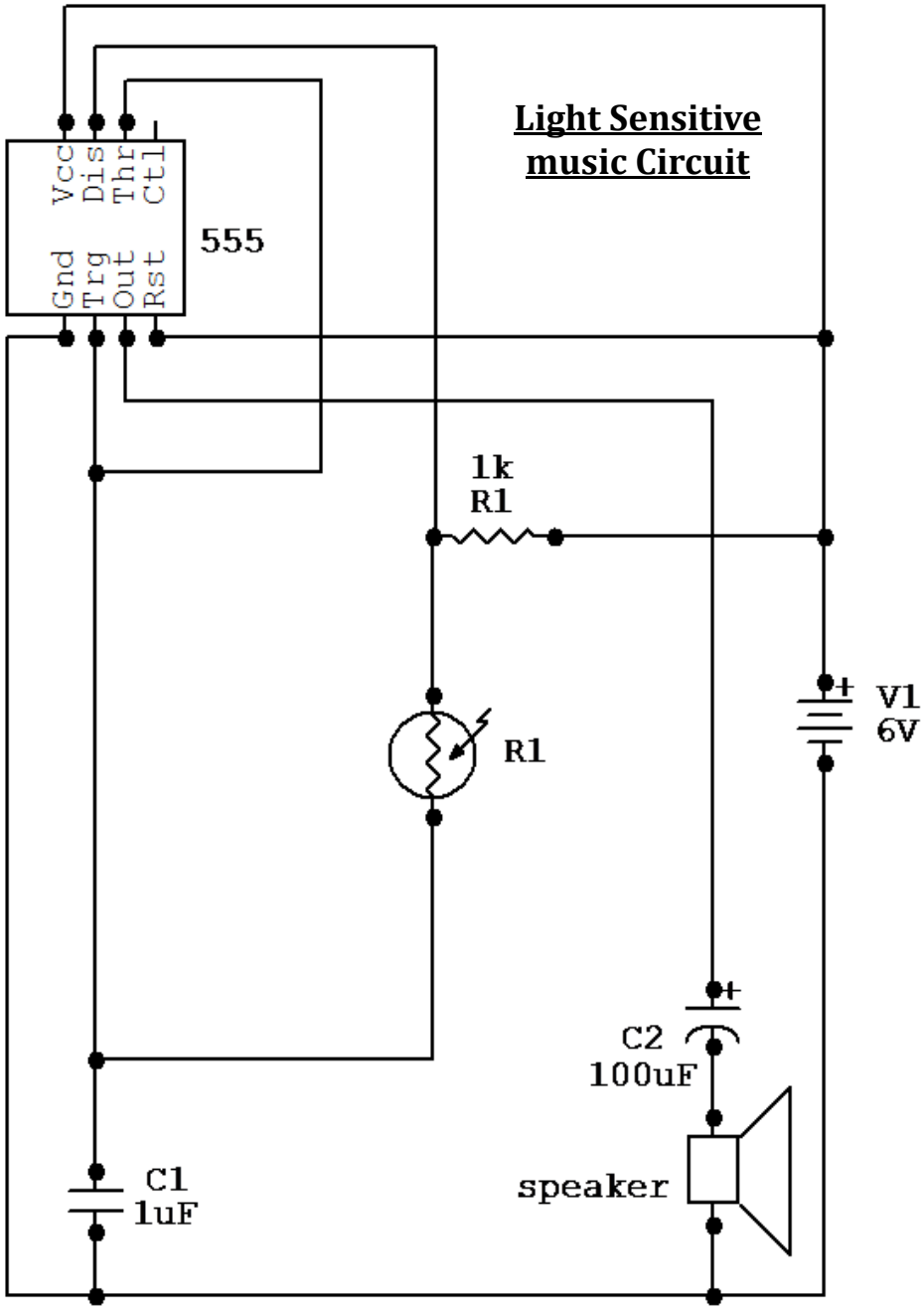
Some Parts of this project are available in Video CD ROM

Materials: IC 555, 1 –100µf, 1 - 1µf, 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.



8.3 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.

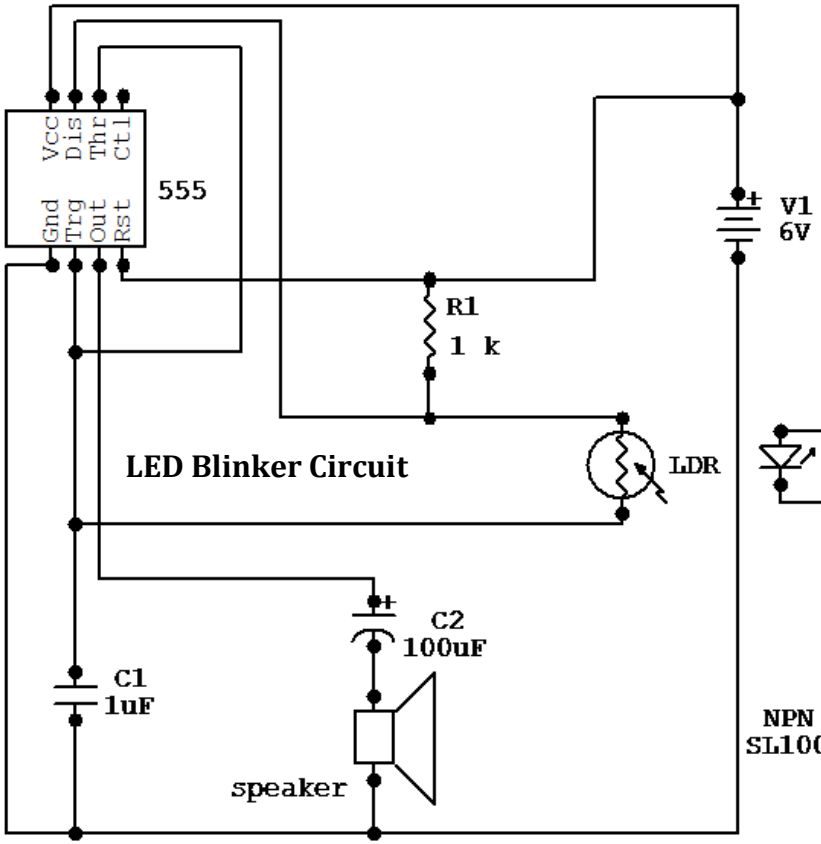
Materials: Same as we have used in **LED blinker circuit** and **Light Sensitive music Circuit .**

Find materials at : www.hobbyelectronics.in

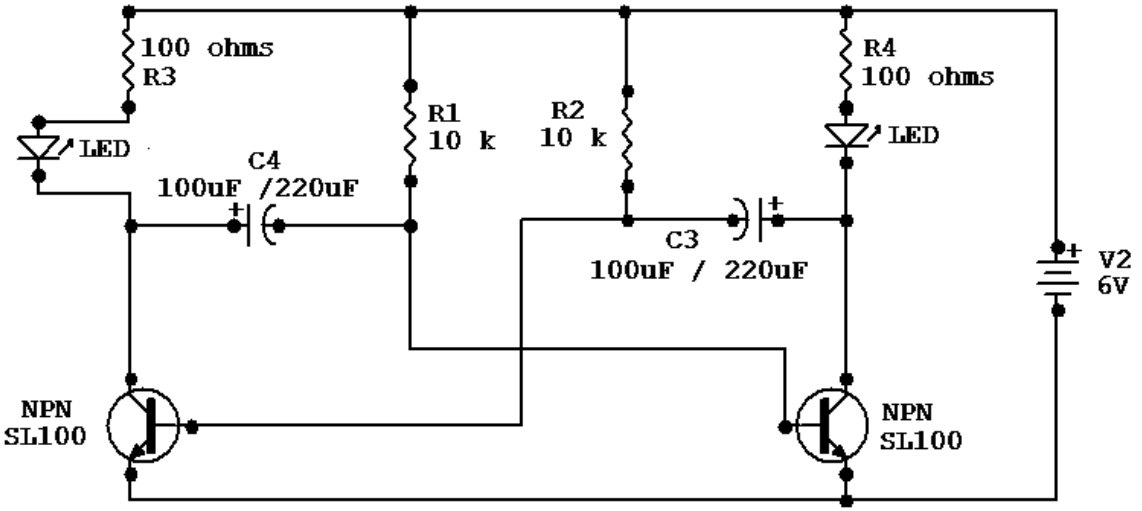
Step1: Assemble all the components of light blinker circuit and ensure that it is working fine .

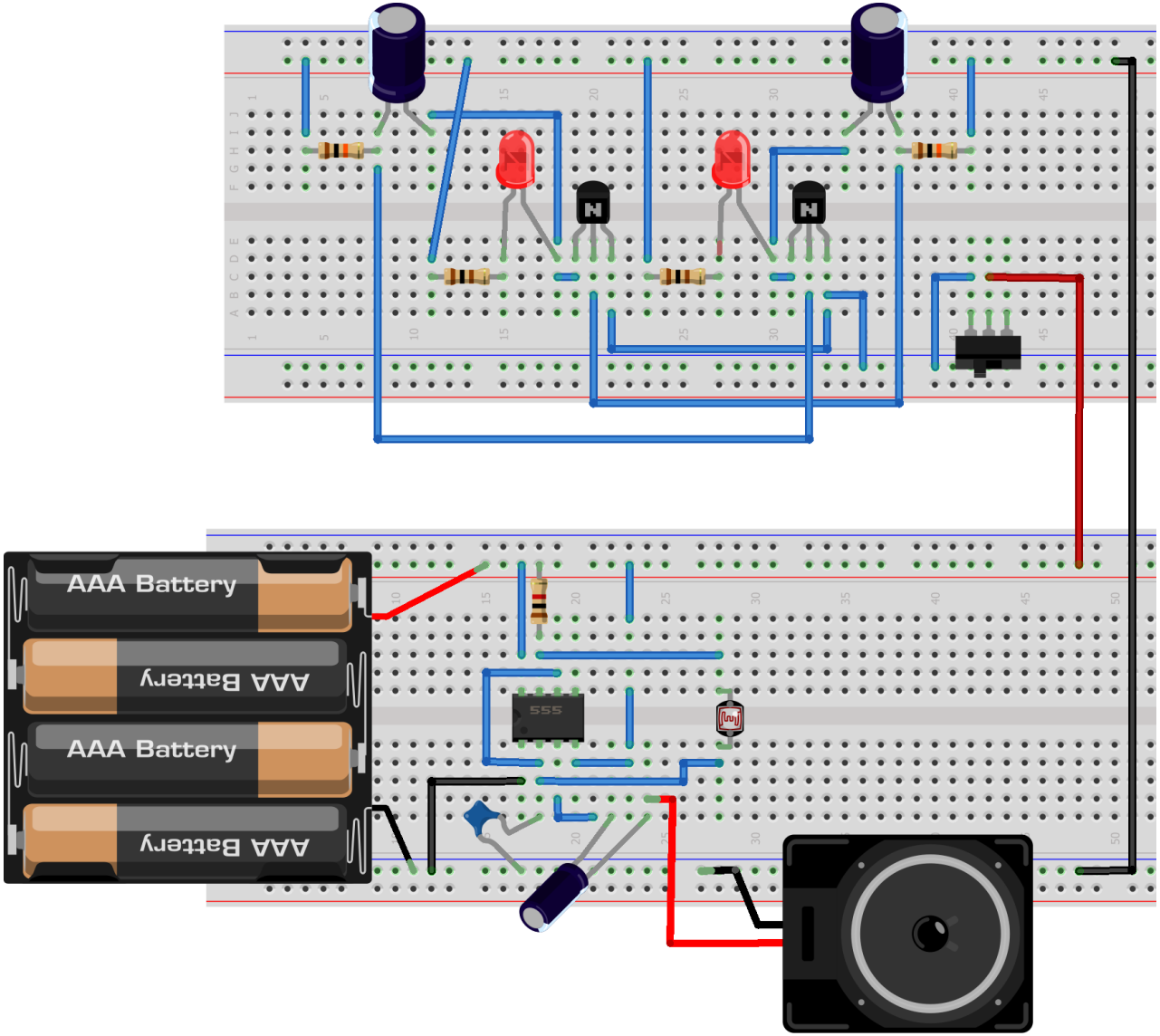
Step2: Assemble all the components of Light sensitive music Circuit and ensure that it is working fine.

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



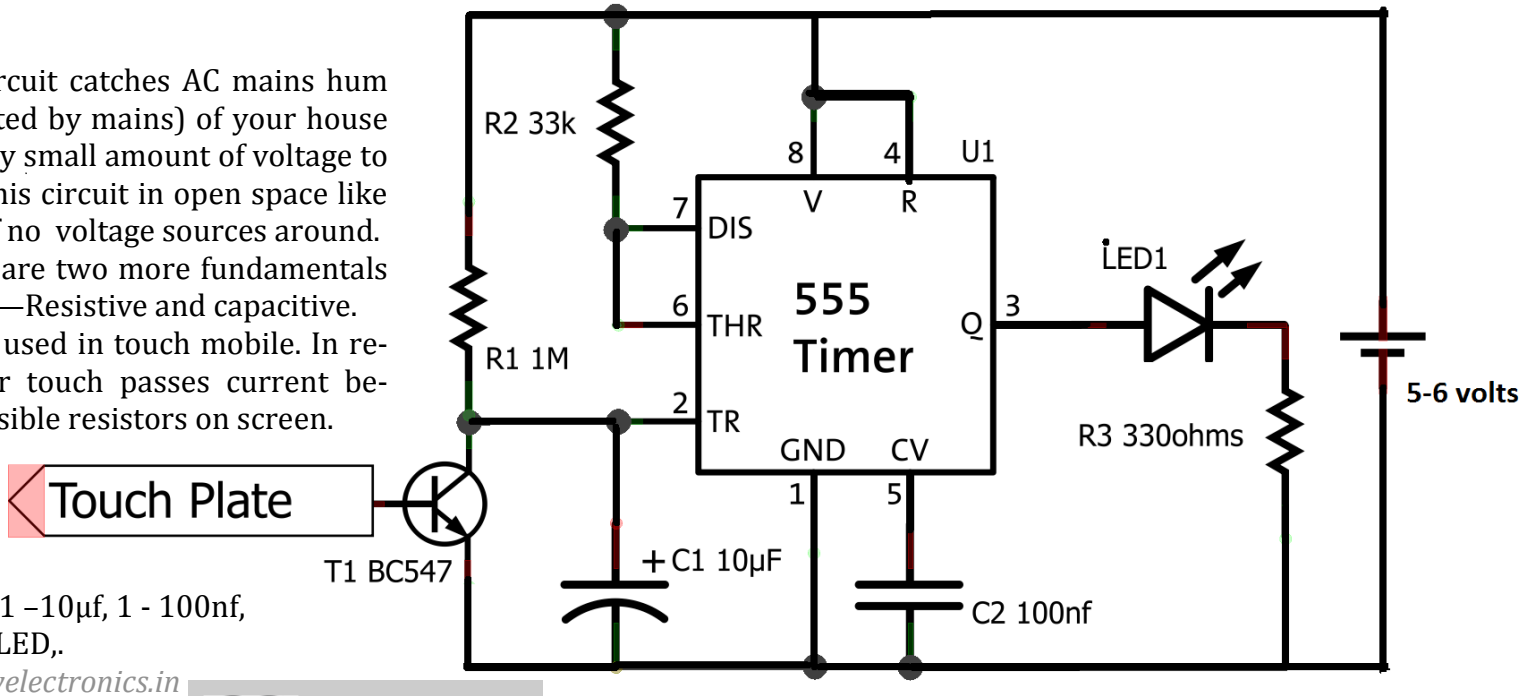
Light Sensitive music Circuit




AAA Battery
AAA Battery
AAA Battery
AAA Battery
555

8.4 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.

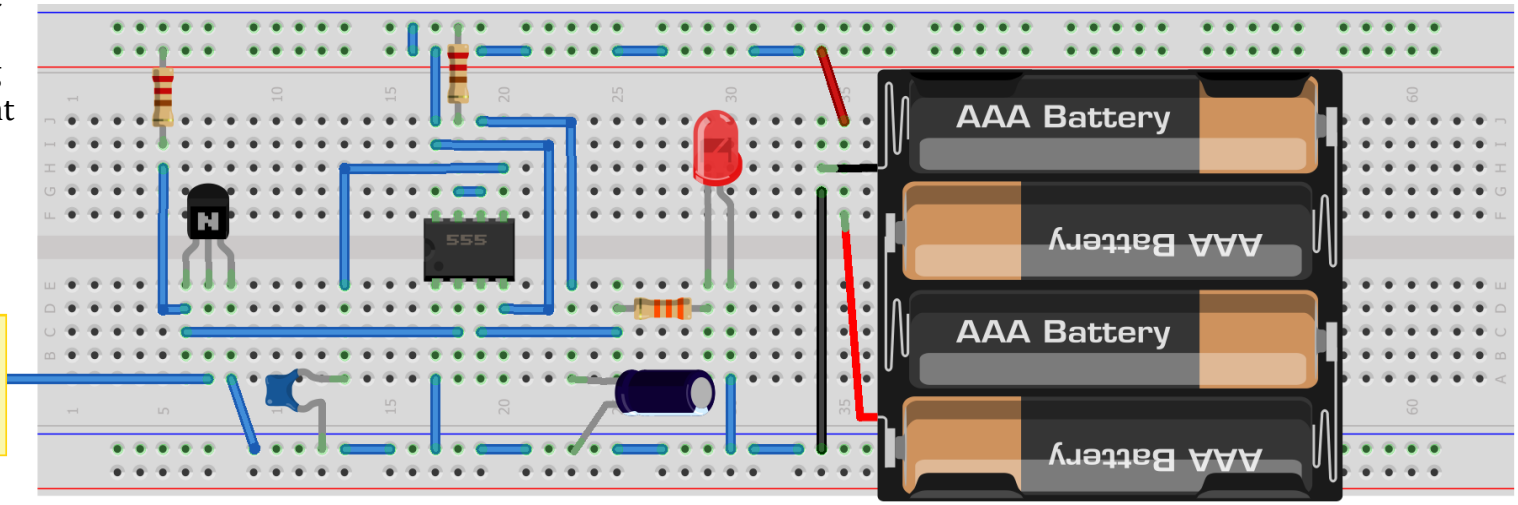


Materials: IC 555, 1 –BC547, 1 –10µf, 1 - 100nf, 1 –1MΩ, 1 - 33k, 1– 330Ω, 1 –LED,.

Find materials at : www.hobbyelectronics.in

Some Parts of this project are available in Video CD ROM

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.

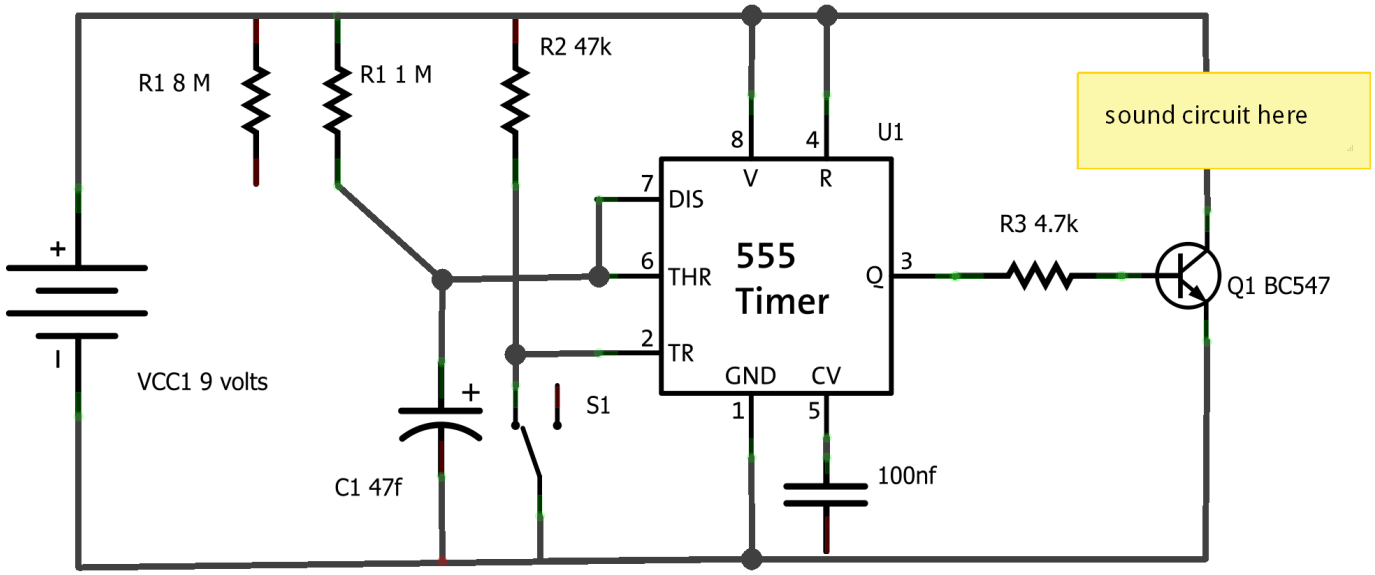


8.5 Timer

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 40MΩ ~ 30 mins) resistances in series and you will get more time delay.

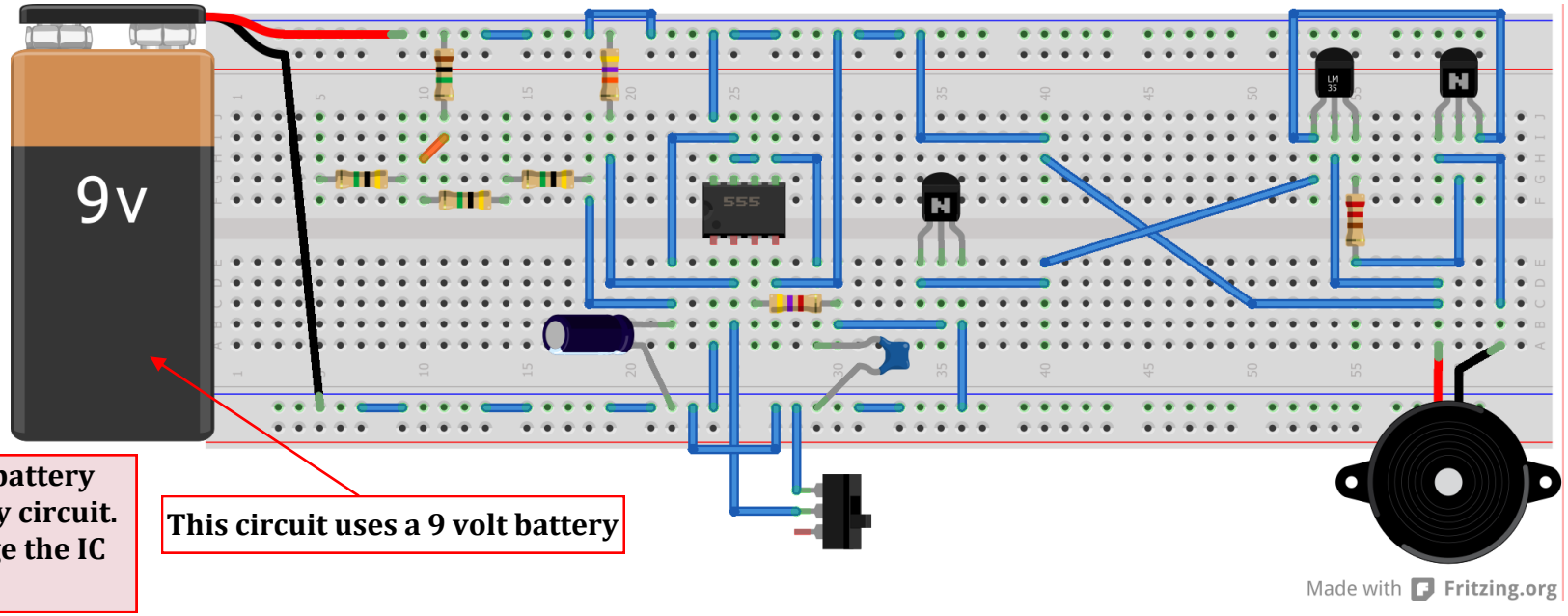
If you observe this circuit also uses a melody circuit along with timer circuit. We have already created melody circuit in previous project. You may refer previous circuits.



Tip: See Appendix I to see resisatnce calculations for 4 MΩ resistor.

Materials:
1MΩ/4MΩ resistances, 1 –4.7k, 1 – 47k, 1 –IC555, 1 - 47µf, 1 –100nf, 1– BC547

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



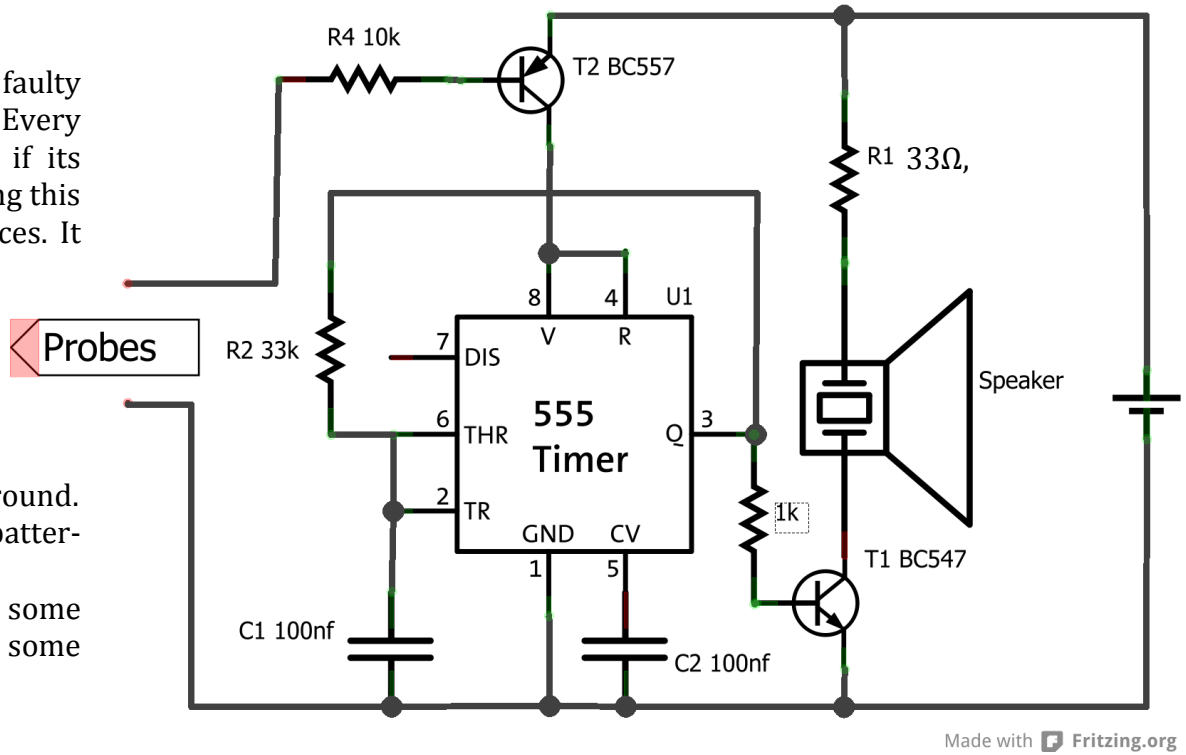
This circuit uses a 9 volt battery

Don't use 9v battery to test melody circuit. It may damage the IC UM66.

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– 4MΩ resistors are used and current connection is using only 2 of them.

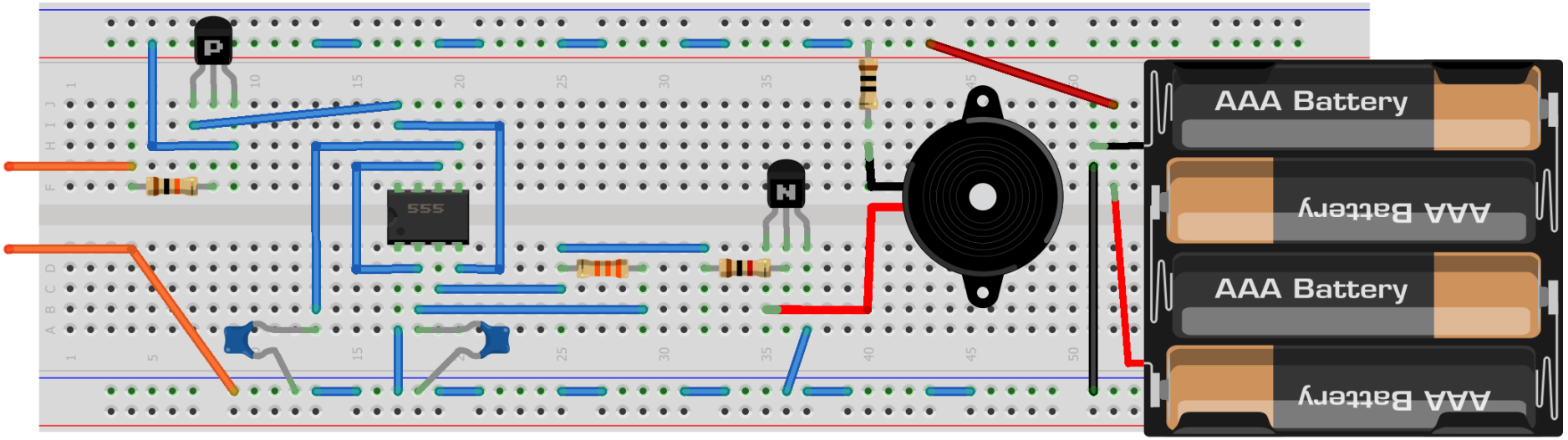
8.6 Continuity Tester

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 –33kΩ, 1 –10kΩ, 1 –33Ω, 1 –1kΩ
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.



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– 4MΩ resistors are used and current connection is using only 2 of them.

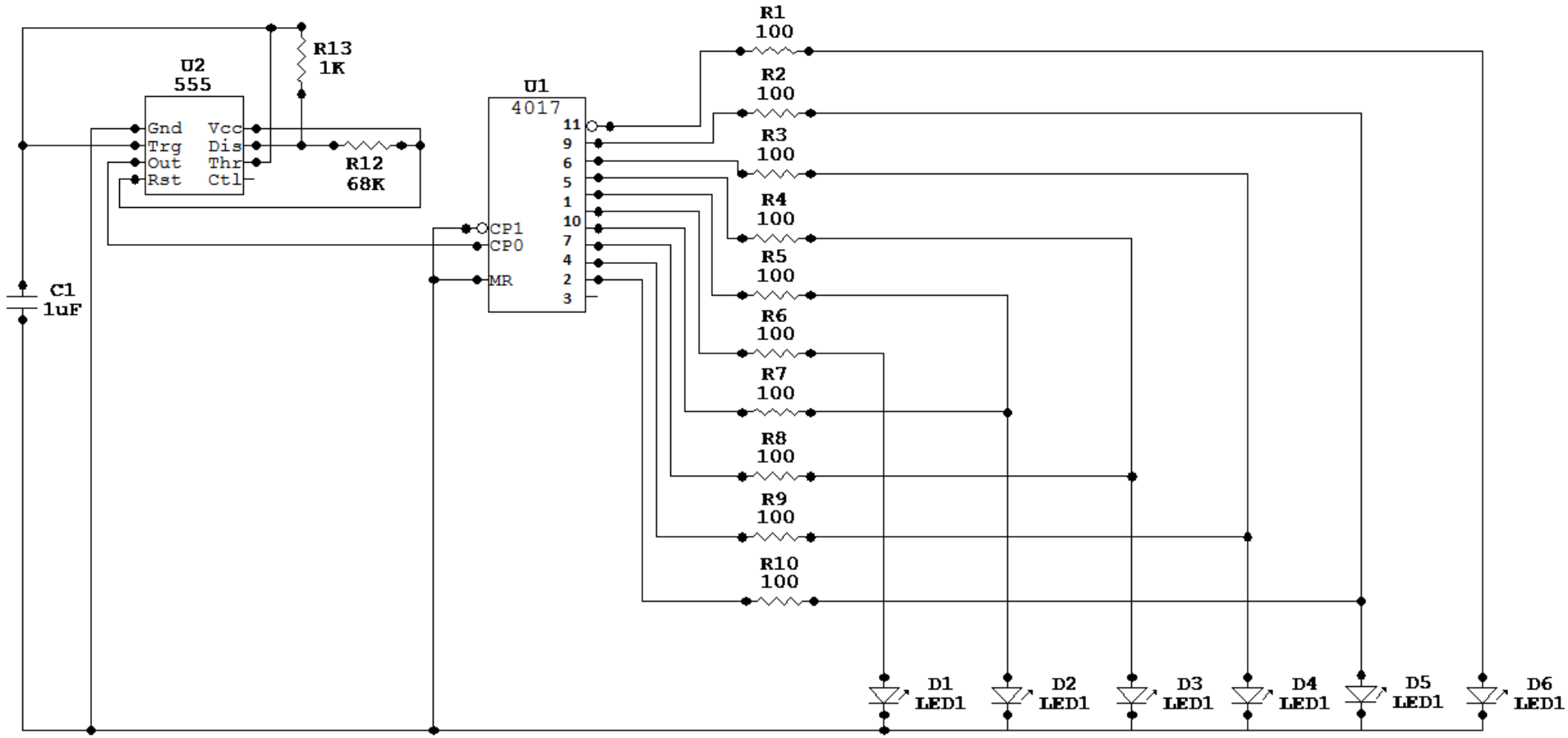
8.7 Knight Rider

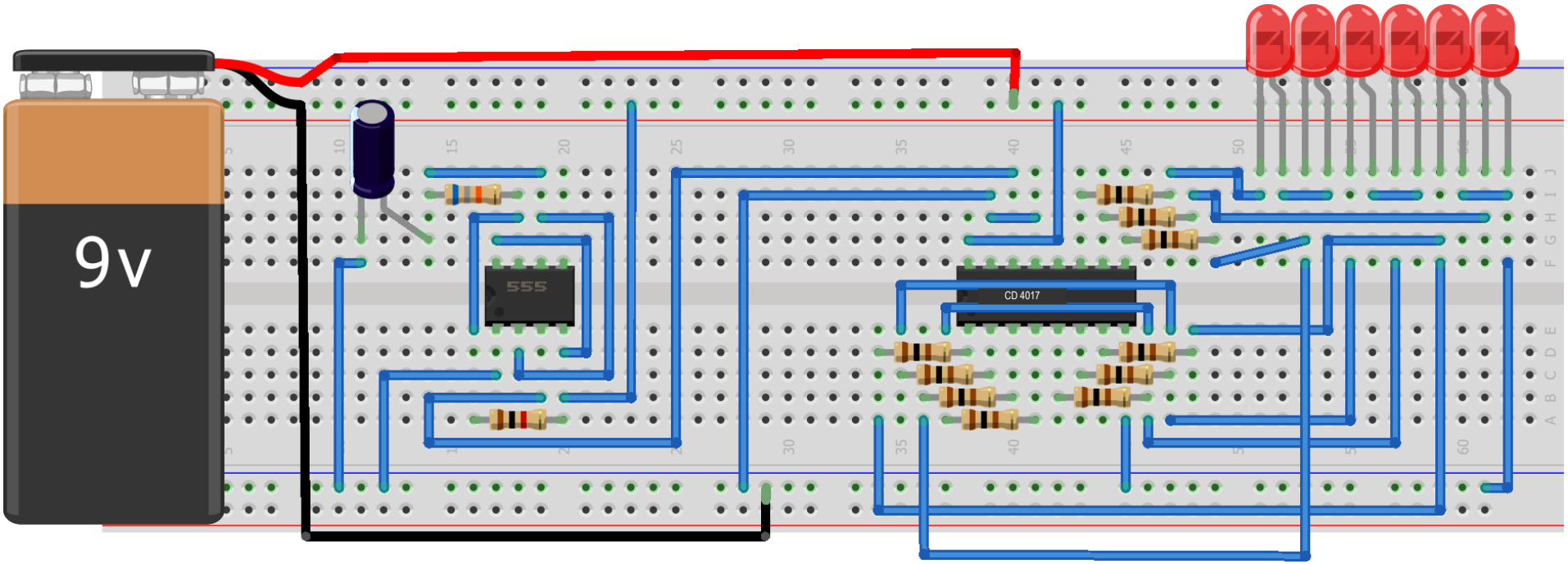
A treat for eyes, this circuit produces a very nice visual effect by circularly turning On and Off LEDs in a row. LEDs D1 to D6 starts up one by one producing a running effect and when LED D6 is On, All LEDs go Off for once and again starts up from LED D6 to D1.

Materials: 1 –68kΩ, 1 –1kΩ, 10 –100Ω, 1 –1µf, 1 - IC555, 1 - IC4017

Find materials at : www.hobbyelectronics.in

Some Parts of this project are available in Video CD ROM





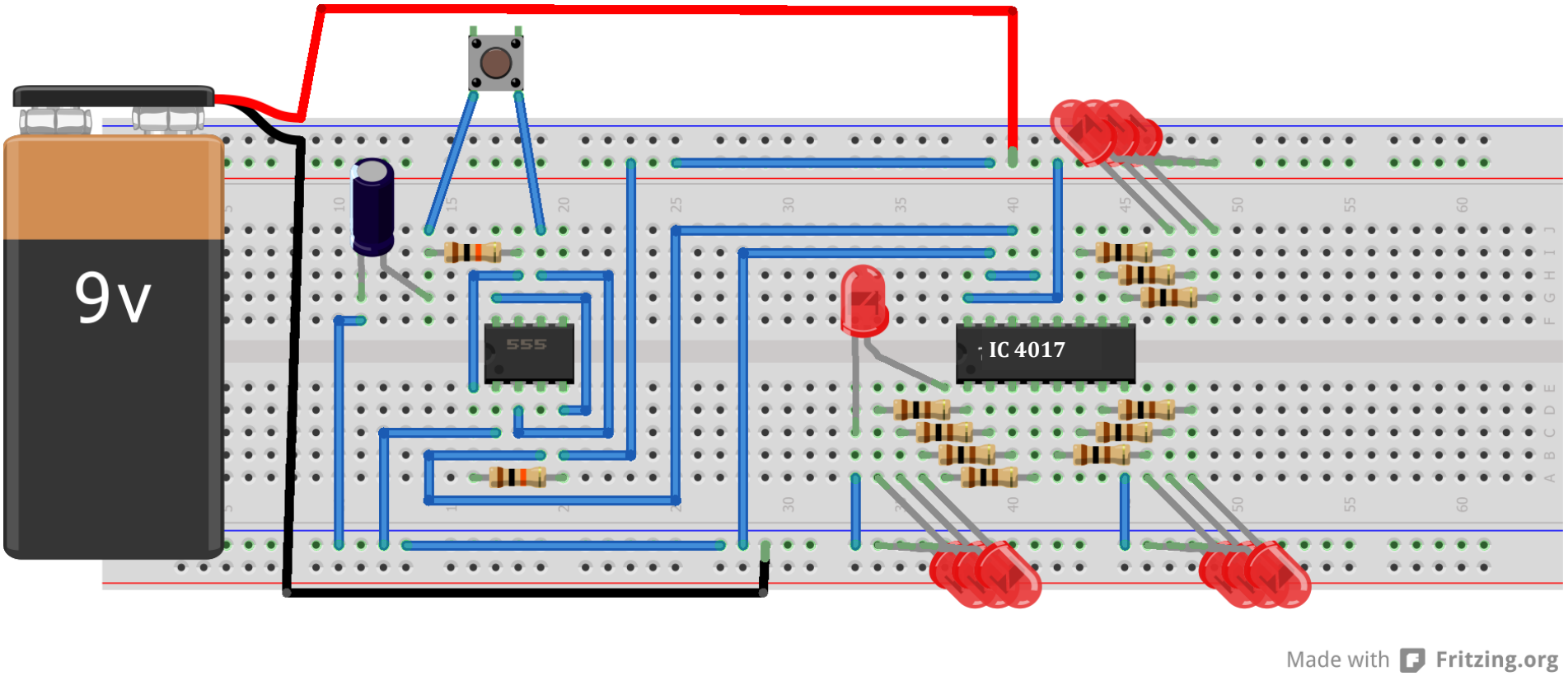
Step1: Ensure all the pins of IC are properly inserted.
Step2: Ensure that electrolytic capacitor is right way round.
Step3: Assemble all remaining parts and insert the batteries at the end.
Step4: After battery is connected, test the circuit with some appliance like an adaptor. And see if LEDs are blinking 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.

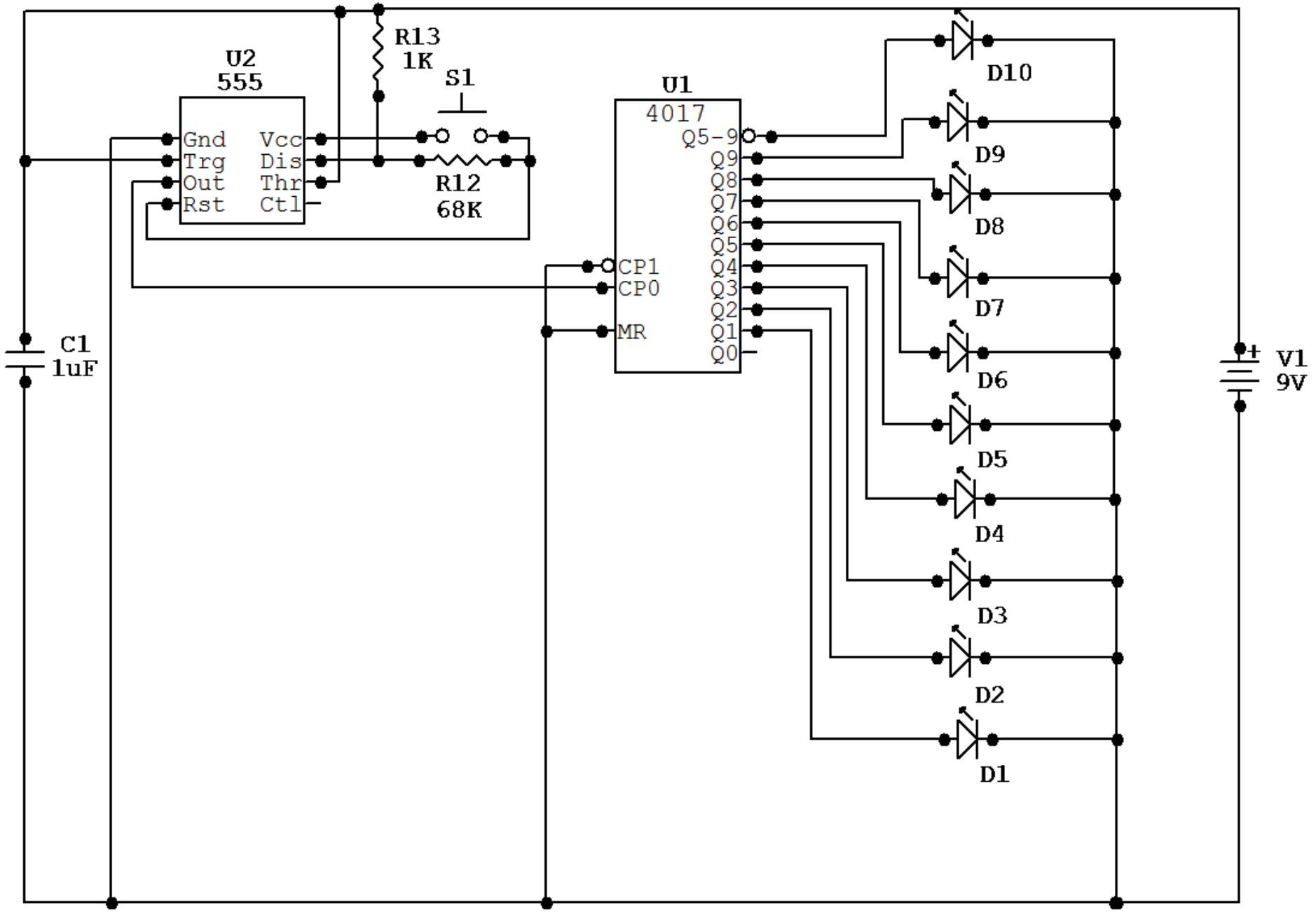
8.8 Cricket

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 –68kΩ, 1 –1kΩ, 10 –100Ω, 1 –1µf, 1 - IC555, 1 - IC4017



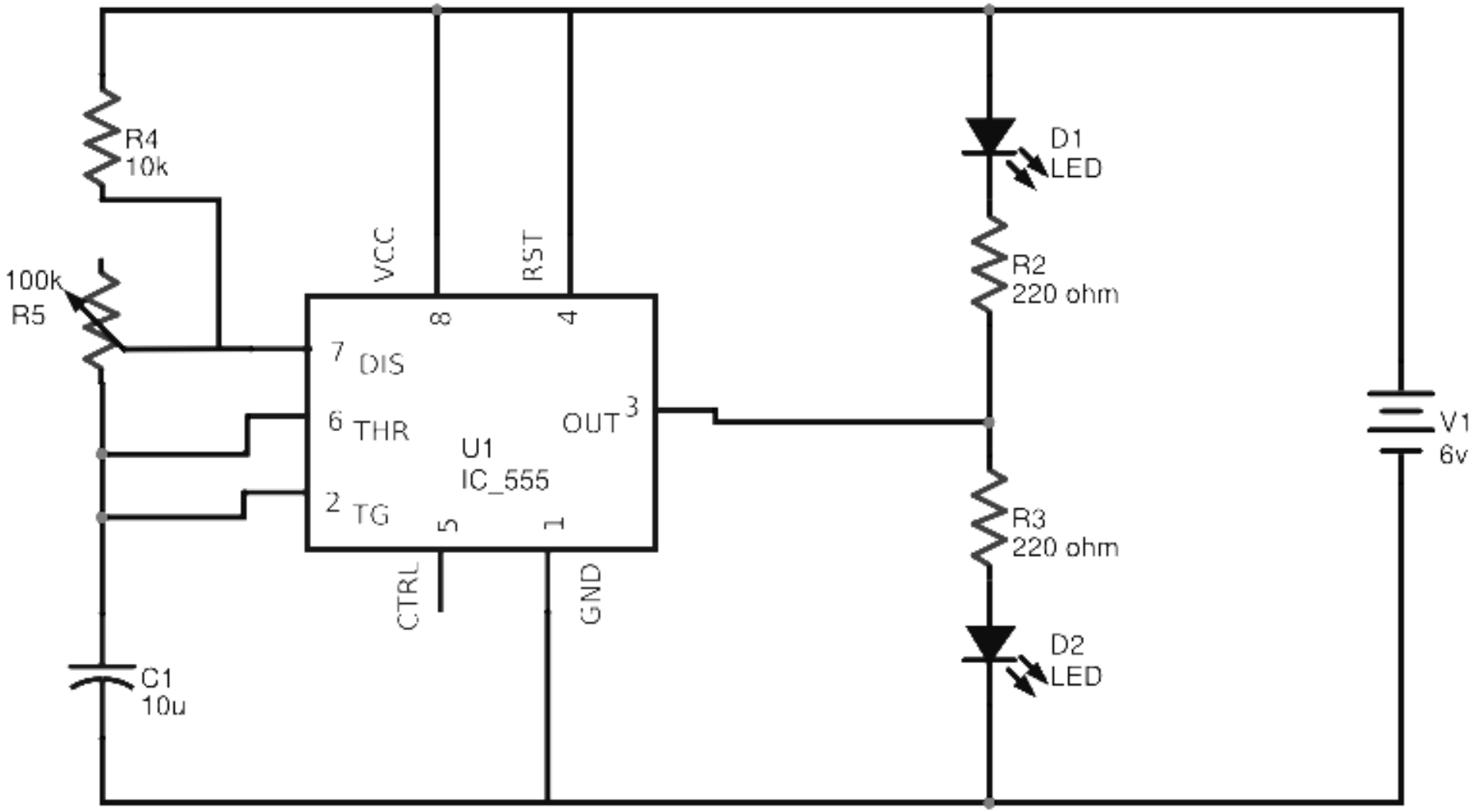
Step1: Ensure all the pins of IC are properly inserted.
Step2: Ensure that electrolytic capacitor is right way round.
Step3: Assemble all remaining parts and insert the batteries at the end
Step4: After battery is connected, test the circuit with some appliance like an adaptor. And see if circuit produces some sound.


U2
555
Gnd
Trg
Out
Rst
Vcc
Dis
Thr
Ctl
R13
1K
S1
R12
68K
U1
4017
CP1
CP0
MR
Q5-9
Q9
Q8
Q7
Q6
Q5
Q4
Q3
Q2
Q1
Q0
D10
D9
D8
D7
D6
D5
D4
D3
D2
D1
C1
1uF
V1
9V

8.9 Two Light Flasher using IC 555

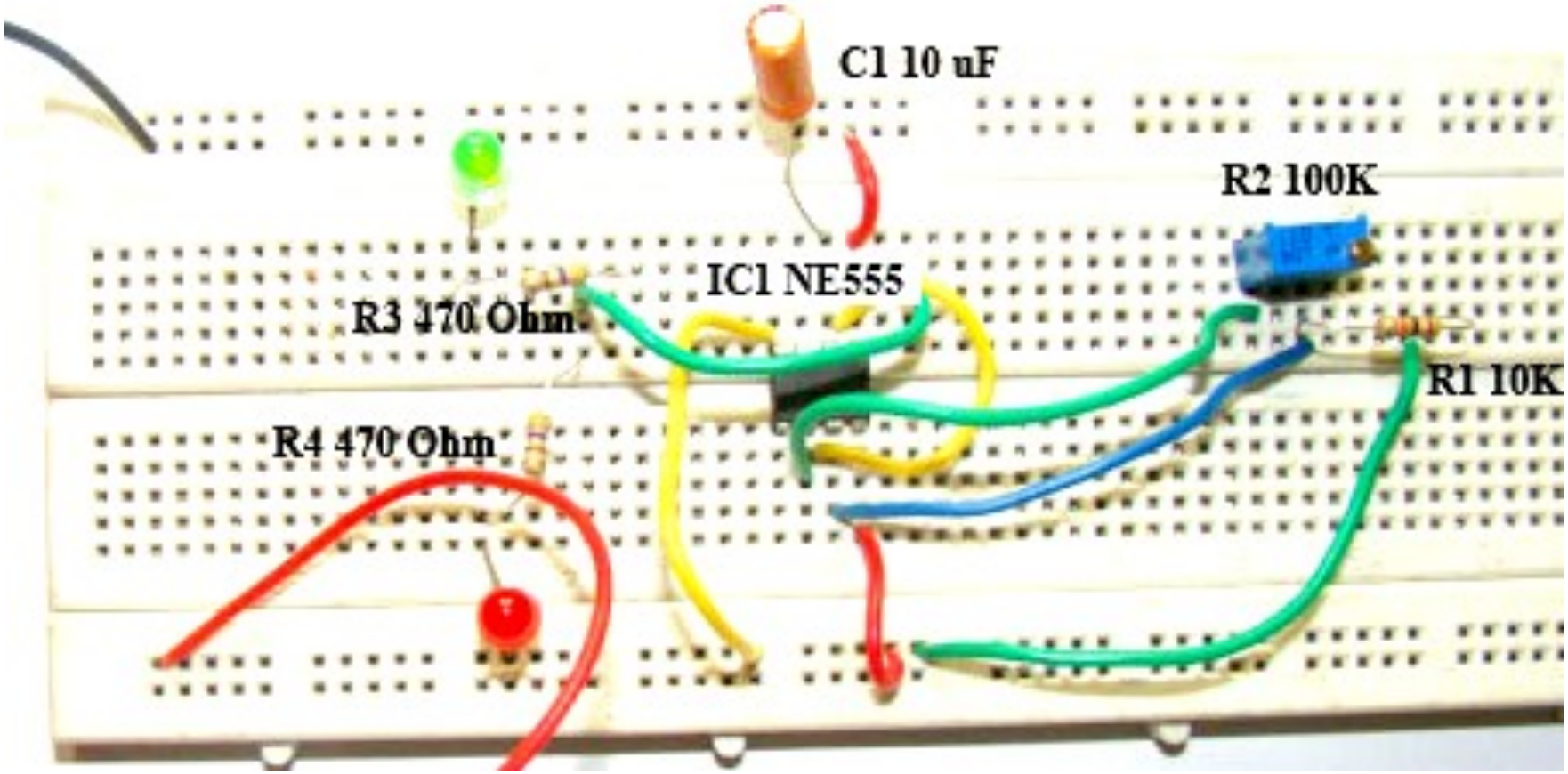
The application of this circuit is similar to transistor based oscillator circuits that we designed before in this book, however this circuit offers an accurate duty cycle then previous circuit and the speed control for flashing is also more precise.

Materials: 1 –10kΩ, 2 –220Ω, 1 – 100kΩ, 1 –10µf, 2 - LEDs, 1 - IC555



Step1: Ensure all the pins of IC are properly inserted.
Step2: Ensure that the electrolytic capacitor terminals are rightly connected.
Step3: Assemble all remaining parts and insert the batteries at the end
Step4: Check if LEDs are flashing, If LEDs are not flashing, remove batteries immediately and check circuit again.

Note: We are using only 2 wires of variable resistance third wire will remain unused as shown in circuit diagram (Use Left and middle wire)
Note: The image below is showing different version of variable resistance then the one provided with kit, However both works just fine.

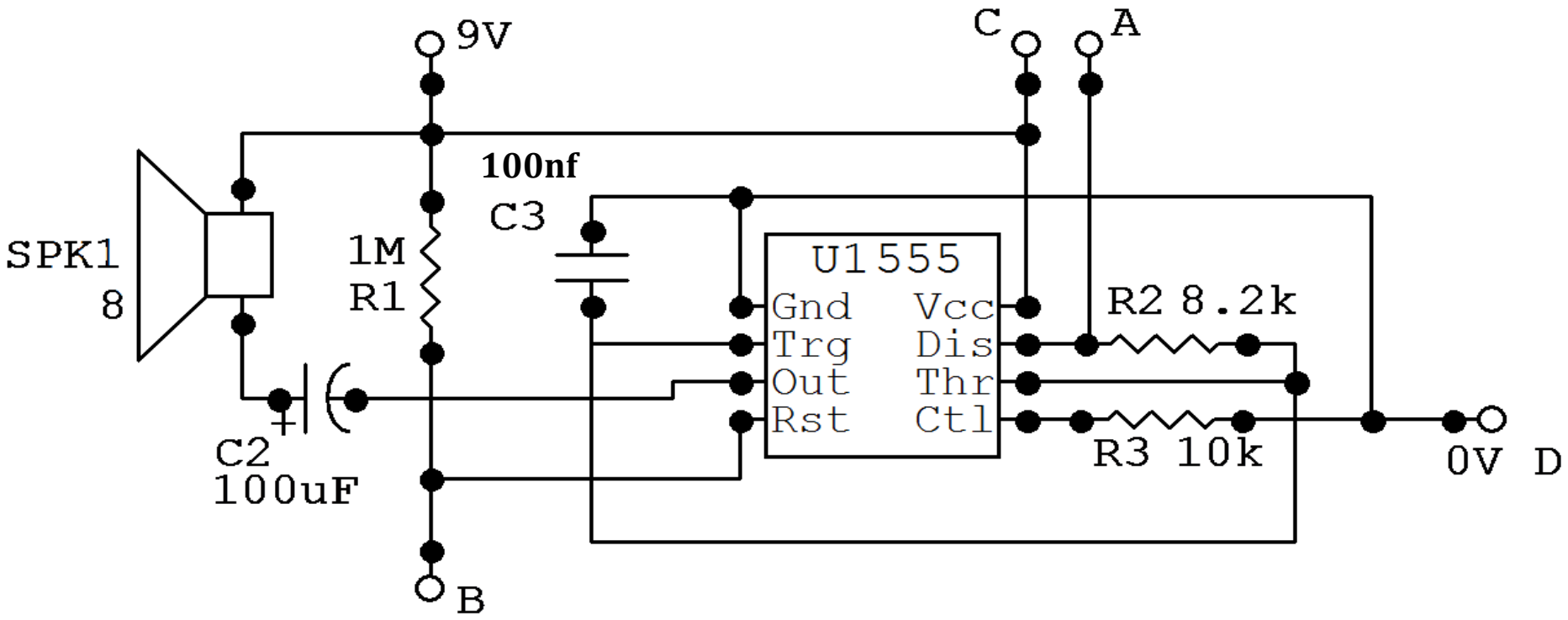


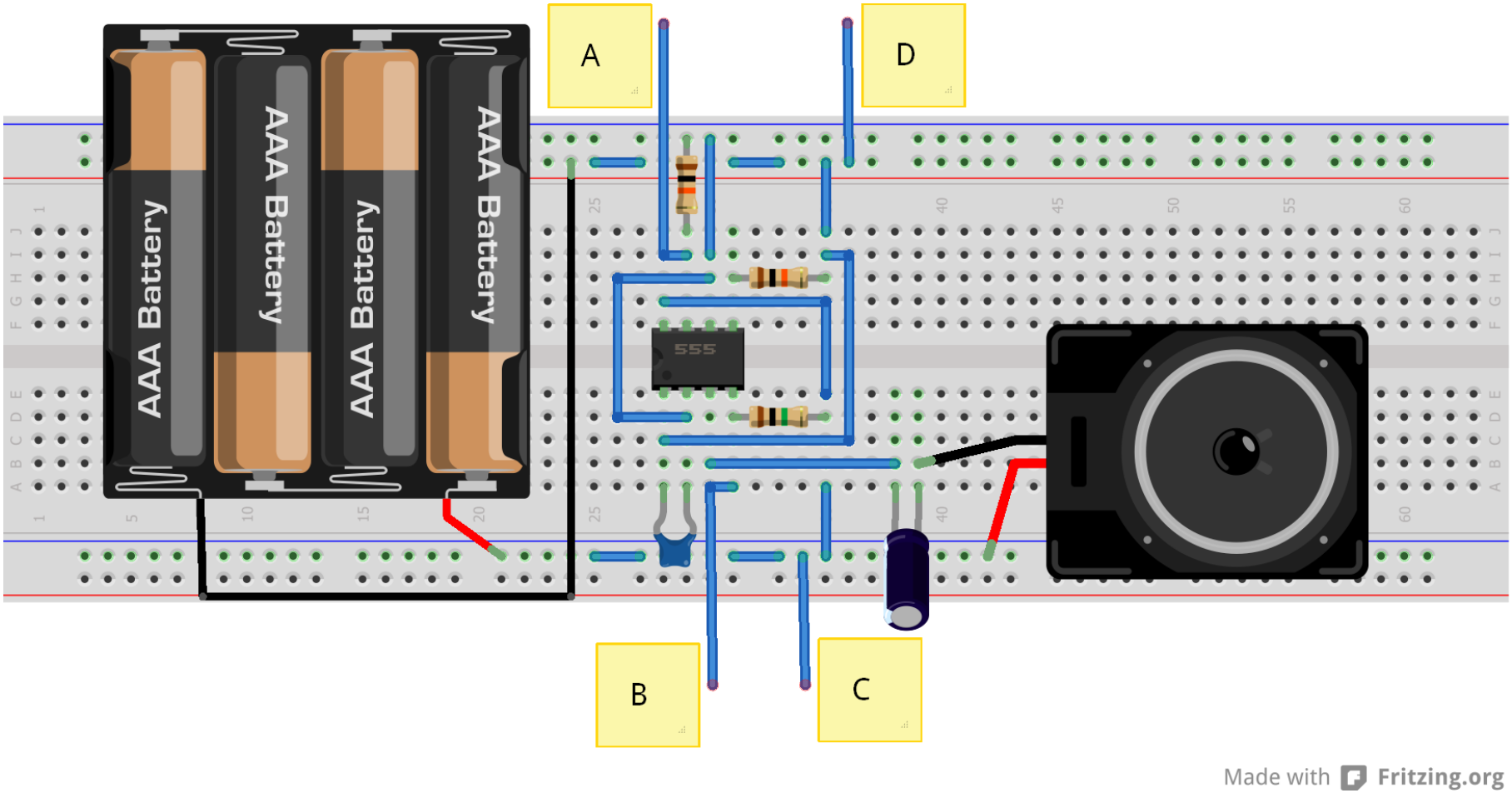
8.10 Multipurpose circuit

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 –1MΩ, 1 –10kΩ, 1 – 8.2kΩ, 1 –100µf, 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.





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

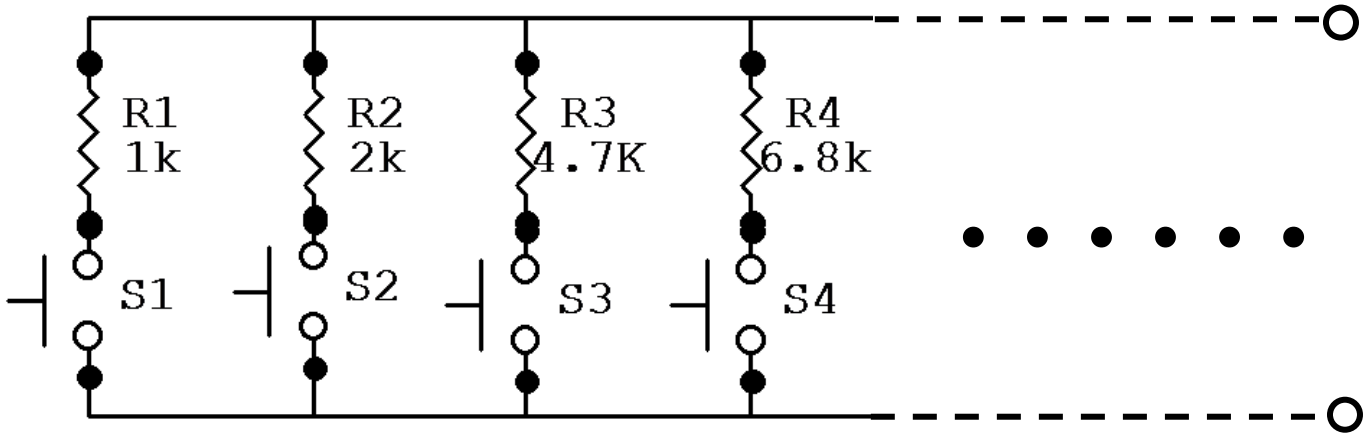
Electronic Organ:

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 in 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

Instructions:

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

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

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

Rain Alarm:

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

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

Burglar Alarm:

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

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

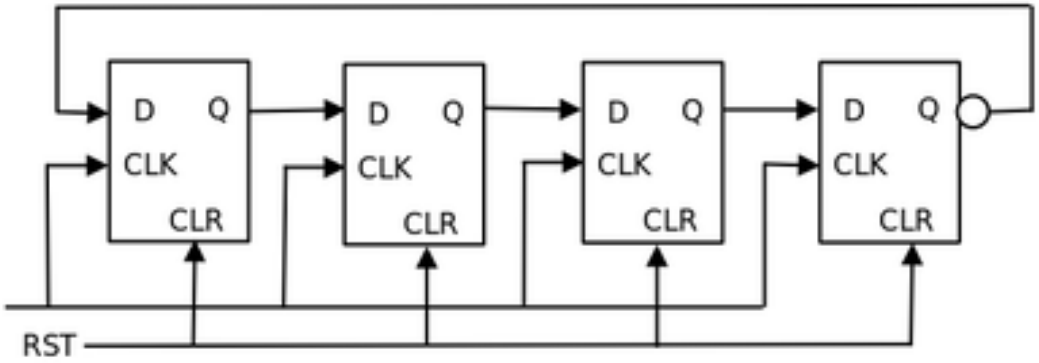
Connect A and C to test probes. The circuit will give generate sound as an indication of continuity

8.10 Johnson Counter

We have just created circuits using IC 4017, but we didn't knew 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

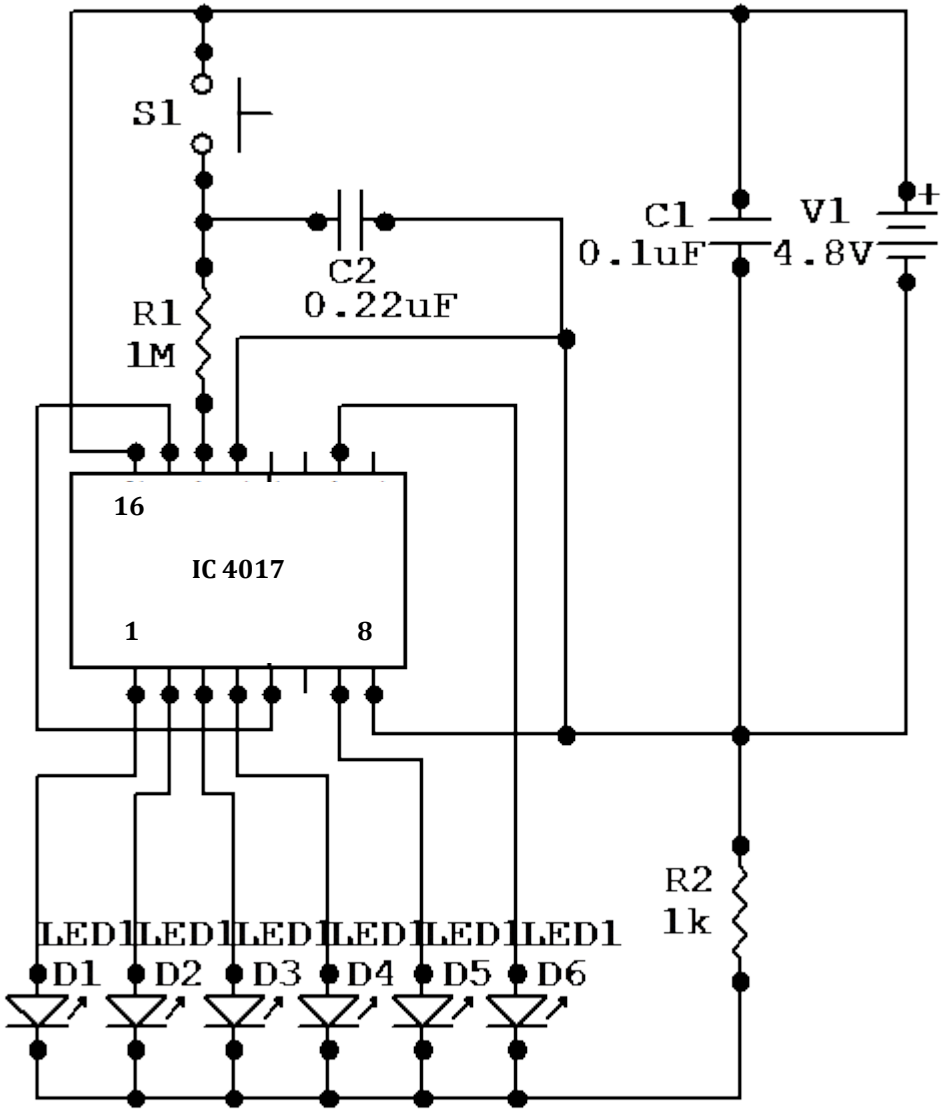
Output of each flip flop is fed into the input of another and complement output of last flip flop is fed into first one. This is what makes it a ring counter. The truth table of ring counter is shown here on right side-

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)

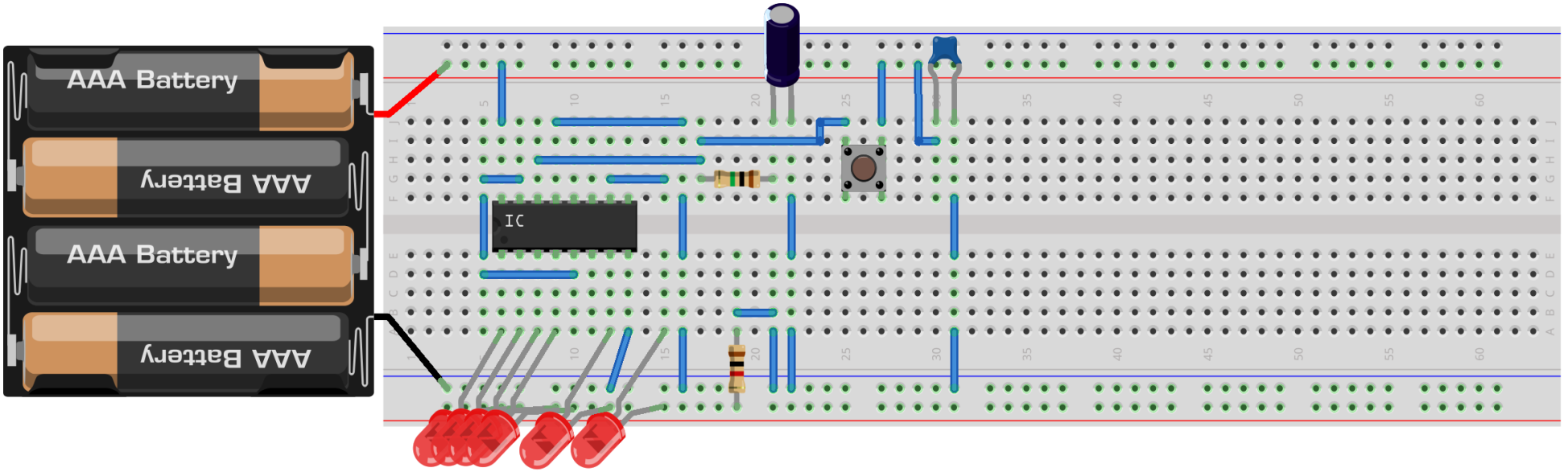
As we have already learnt about flip flops. Here we see there practical application is circuits. The flip flop used here is D type, which is similar to RS flip flop which we designed in previous chapters.

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).

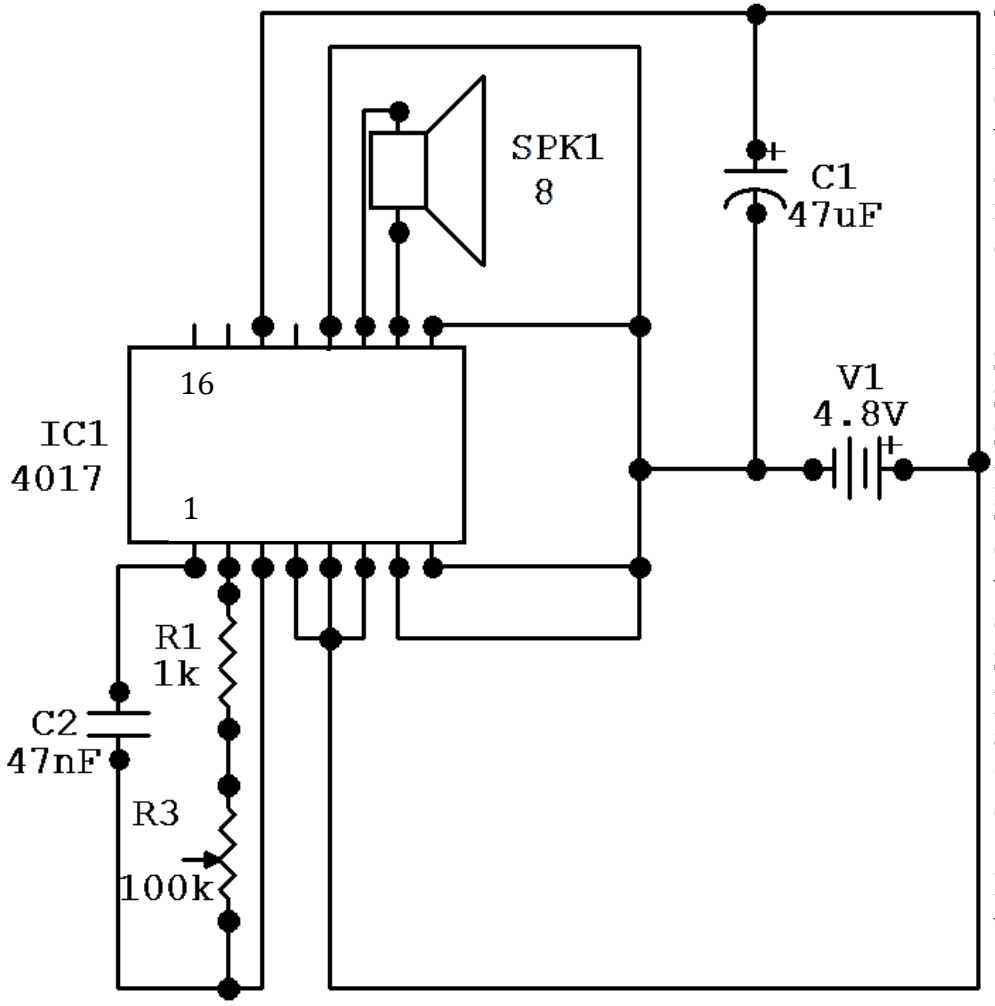


Step1: Ensure all the pins of IC are properly inserted.
Step2: Values of ceramic capacitor is not important and both ceramic capacitors can have same value.
Step3: Assemble all remaining parts and insert the batteries at the end
Step4: After battery is connected, test the circuit by pressing the push 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.


AAA Battery
AAA Battery
AAA Battery
AAA Battery
IC
Made with Fritzing.org

8.11 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 cant 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 a47k resistor, all in series.

8.12 Rising-Falling Siren

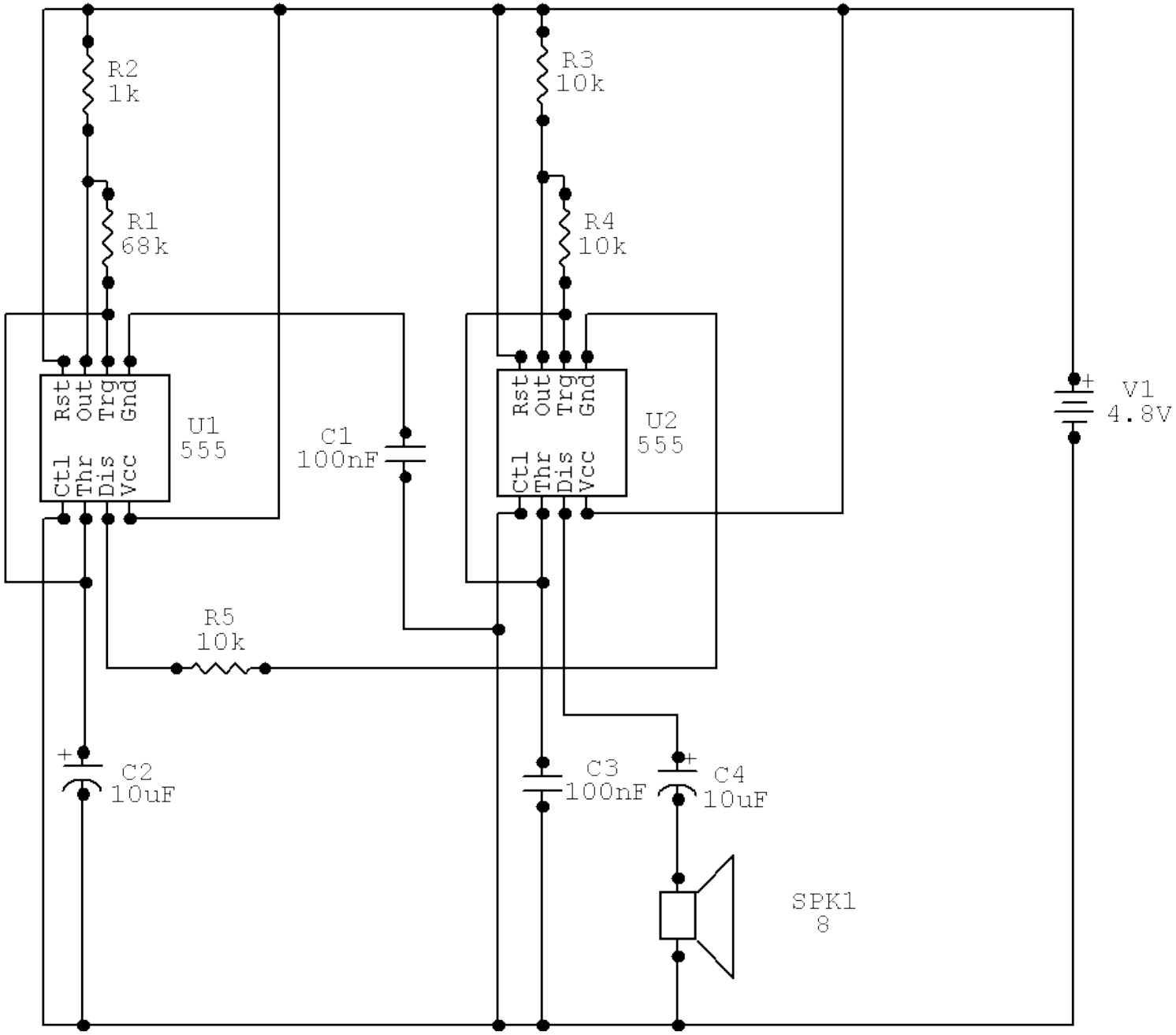
In previous projects, we were using IC UM66 to create melody. However UM66 provides a ready made tune stored in chips memory. In this project we are actually creating sound effect by using two 555 ICs. Output of one IC is fed into another which actually creates a melody raising and falling siren like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

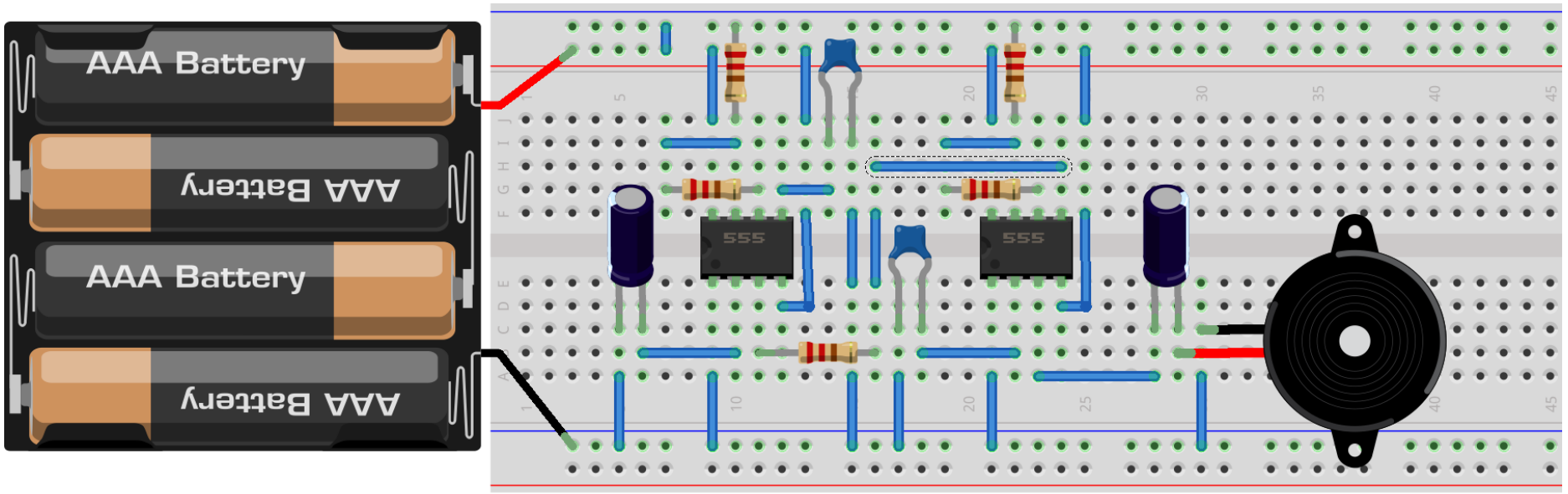
If we observe this circuit closely, we will be able to understand that this circuit is very easy to understand and not at all complex as it looks like. Lets dissect the circuit into two parts. The first 555 IC in this circuit is a complete unit in itself, This unit generate a low frequency oscillation (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:

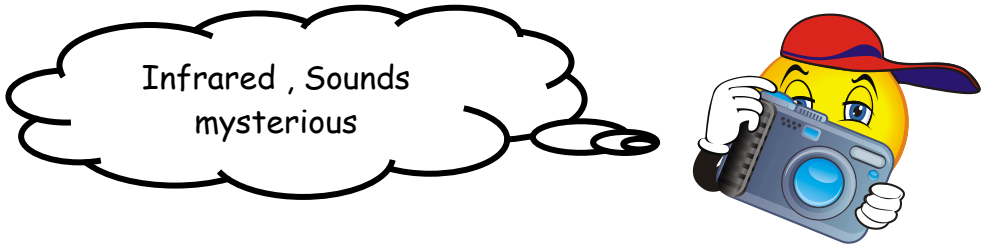
Step1: Place all the components on breadboard.
Step2: Check the polarity of electrolytic capacitors, Ceramic capacitors don't have any polarity,
Step3: After assembling all components connect battery and check if there is sound coming out from speakers.
Step4: If no sound is coming from speakers, disconnect 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.


R2
1k
R1
68k
R3
10k
R4
10k
Rst
Out
Trg
Gnd
Ctl
Thr
Dis
Vcc
U1
555
U2
555
C1
100nF
V1
4.8V
R5
10k
C2
10uF
C3
100nF
C4
10uF
SPK1
8


AAA Battery
AAA Battery
AAA Battery
AAA Battery
555
555

9. Infrared Projects

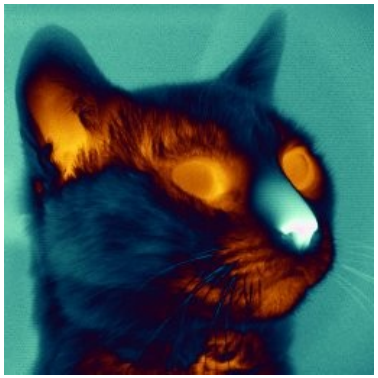


In this section we will make :

8.1 Simple Infrared Receiver
8.2 Infrared Transmitter and Receiver

9.1 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 -



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

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

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.

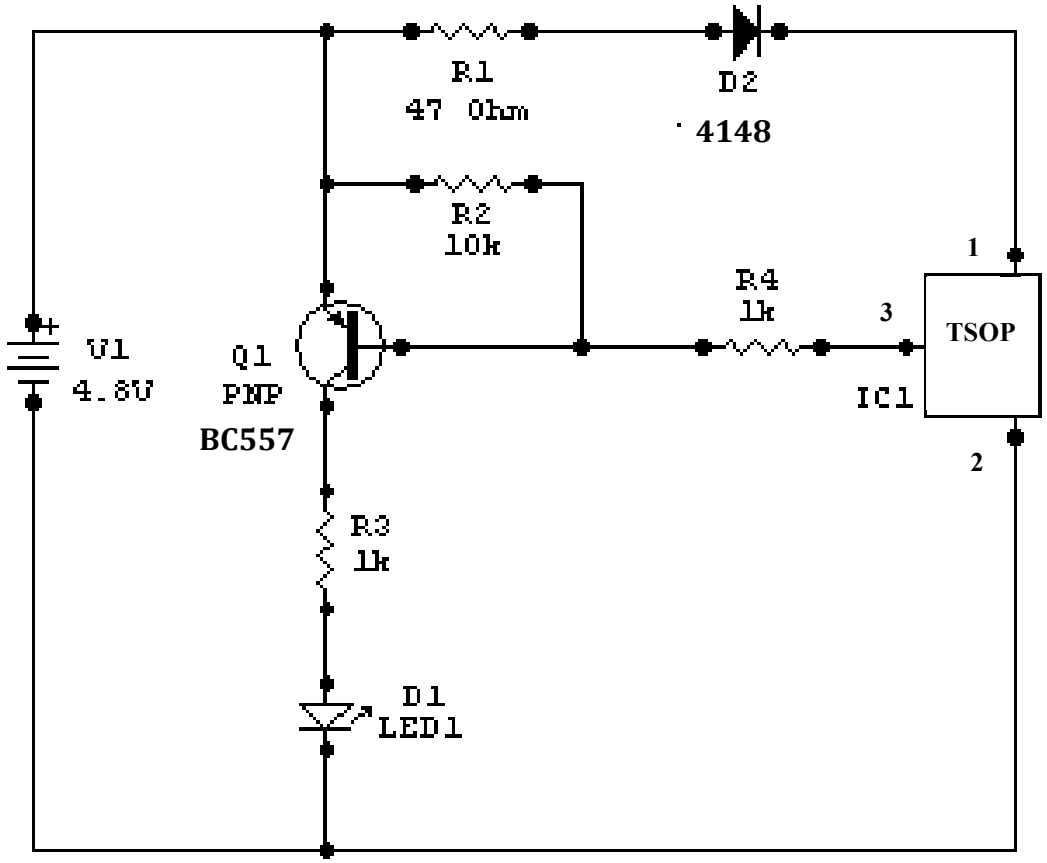
TSOP 1738

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.

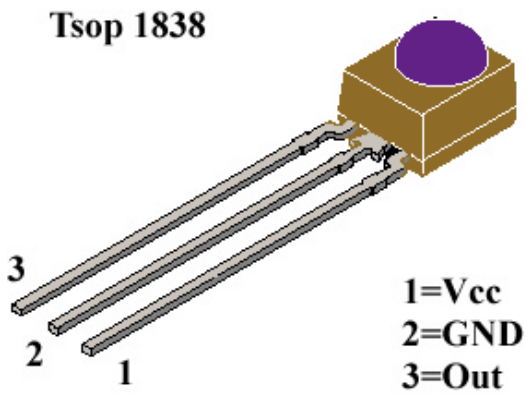
For more knowledge on Infrared light and its uses and importance, please visit Wikipedia or Google other sites.



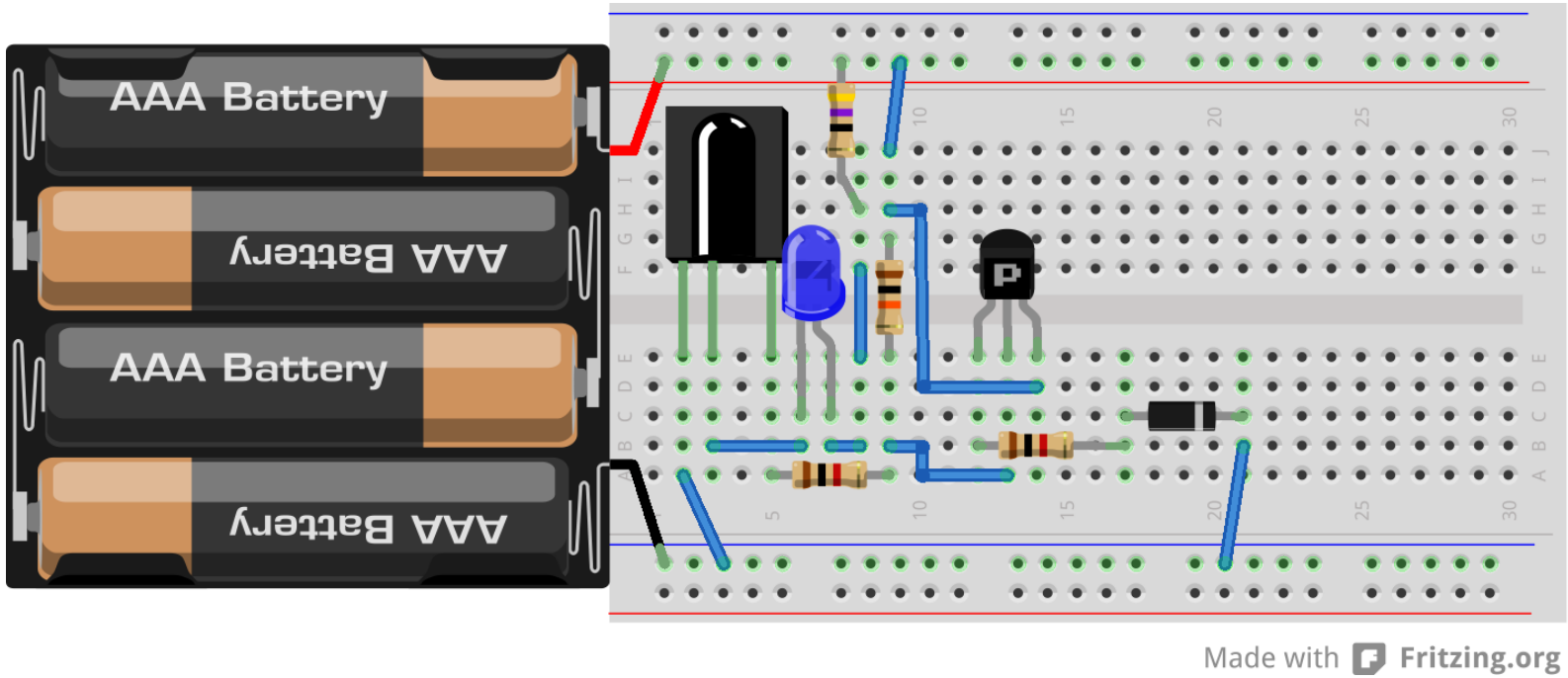
This circuit uses one PNP transistor which is acting as a switch, As we know that when a NPN (remember NPN) transistor's base is provided with a small voltage, It turns ON. In PNP transistor this happens also but instead of applying a positive voltage we need to ground the base terminal, so PNP turns 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.



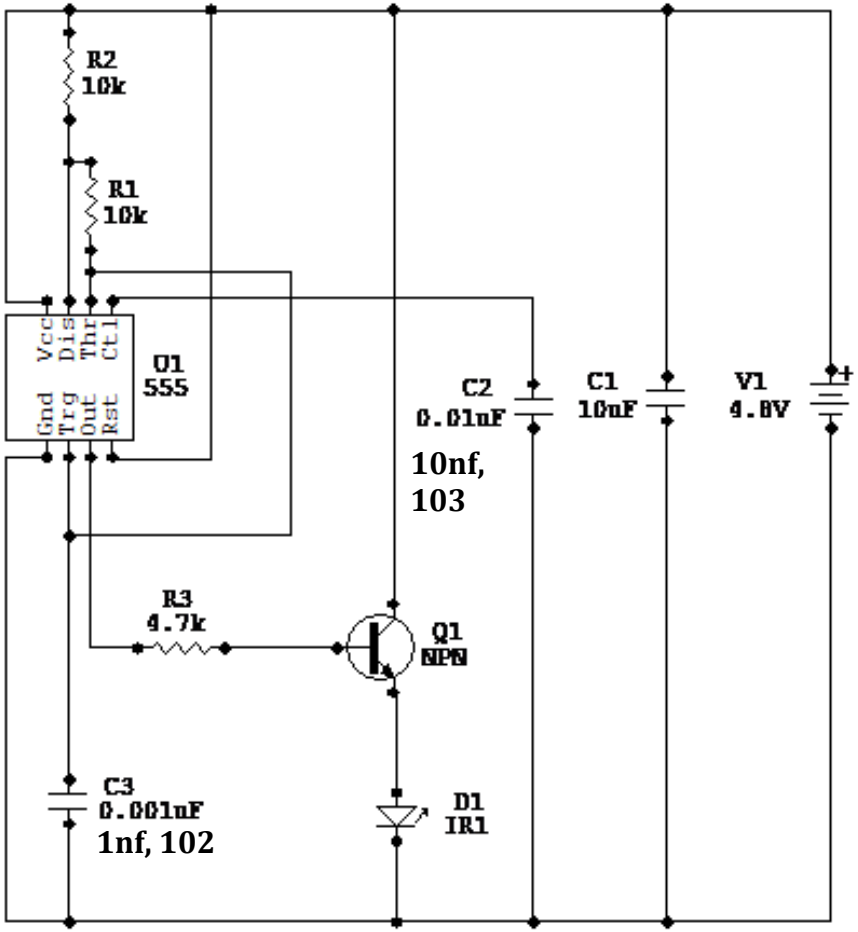
Step3: Connect the battery, after all components are assembled. Turn On the battery and check the circuit, You can use a TV/AC/DVD remote control to test this circuit.
Step4: Diode is optional and the circuit should work without it also.



9.2 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.

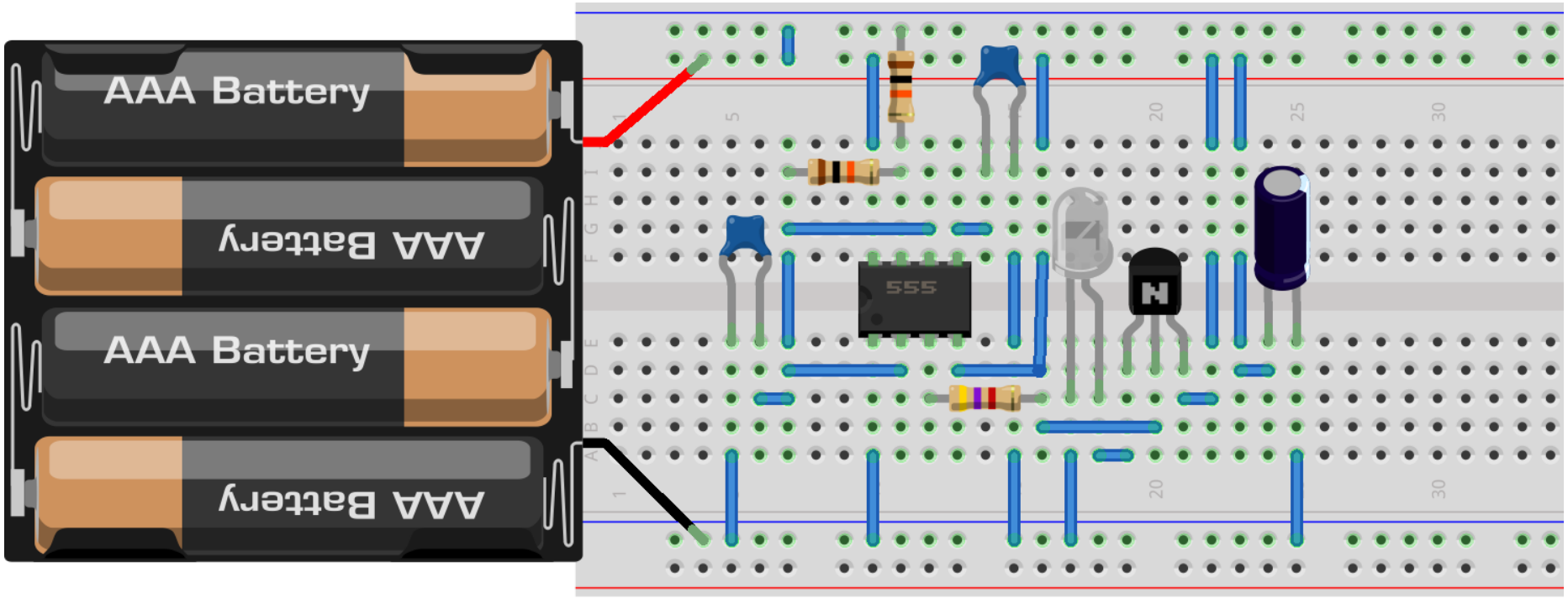
Step2: Here we are using two different value of capacitors then that we have used before in previous circuits, 1nf and 10nf, there capacitor marking are 102 and 103 respectively. Please refer capacitor tables at the end of this book in Appendix.

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.

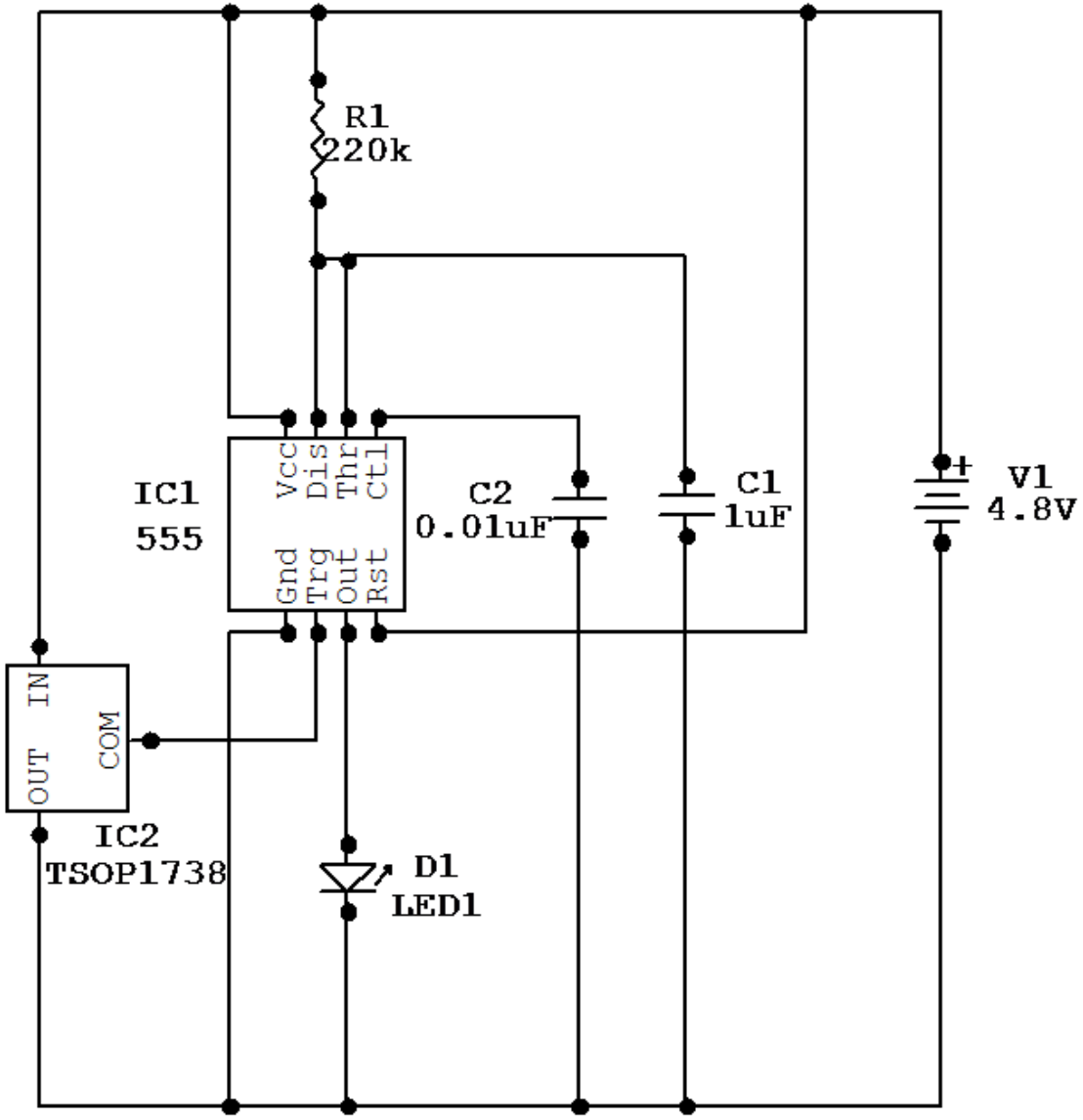
This circuit can only be tested along with receiver circuit.

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.



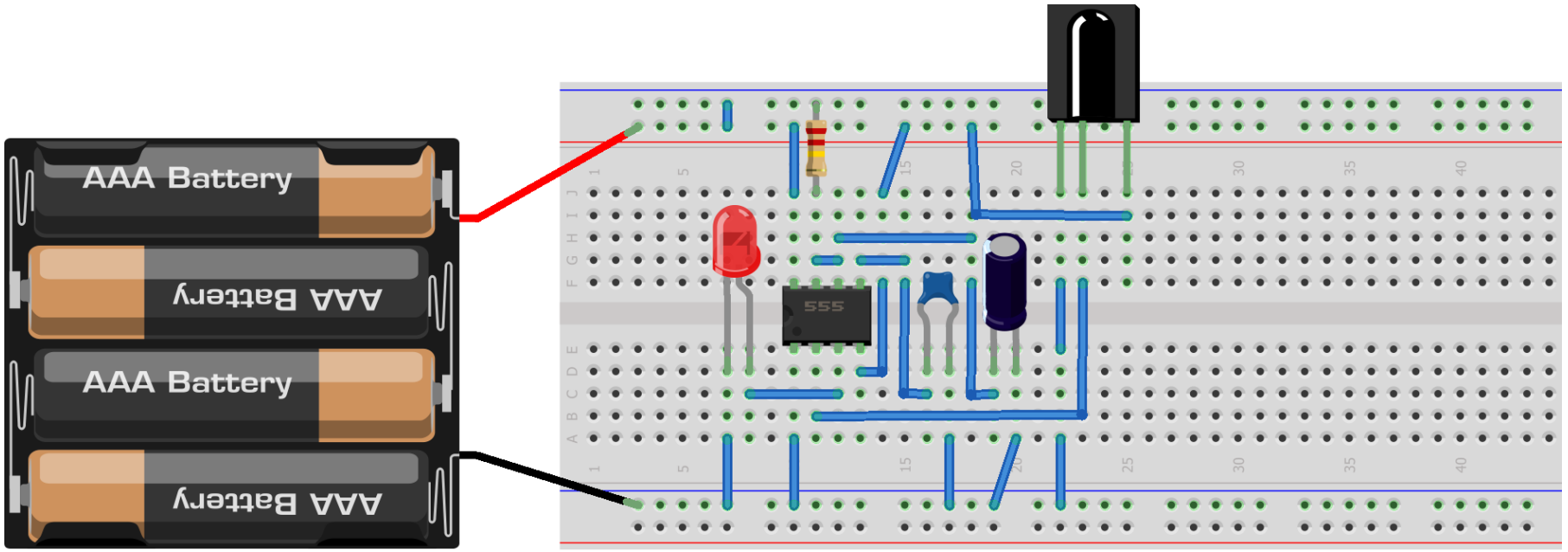
IR Receiver Circuit—

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



Steps:

Step1: Assemble all the components on breadboard.
Step2: Here we are using one different value of capacitor then 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 -

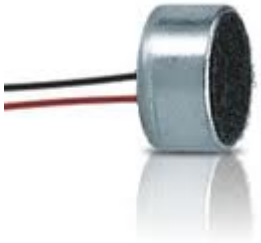
Along with receiver circuit, you can use a relay driver circuit to drive mains appliance with remote. For more information about relay driver circuit, check circuit designing guide at the end of this book.

10. Audio Projects

In this section we will make :

9.1 Clap Switch
9.2 Intercom

10.1 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.

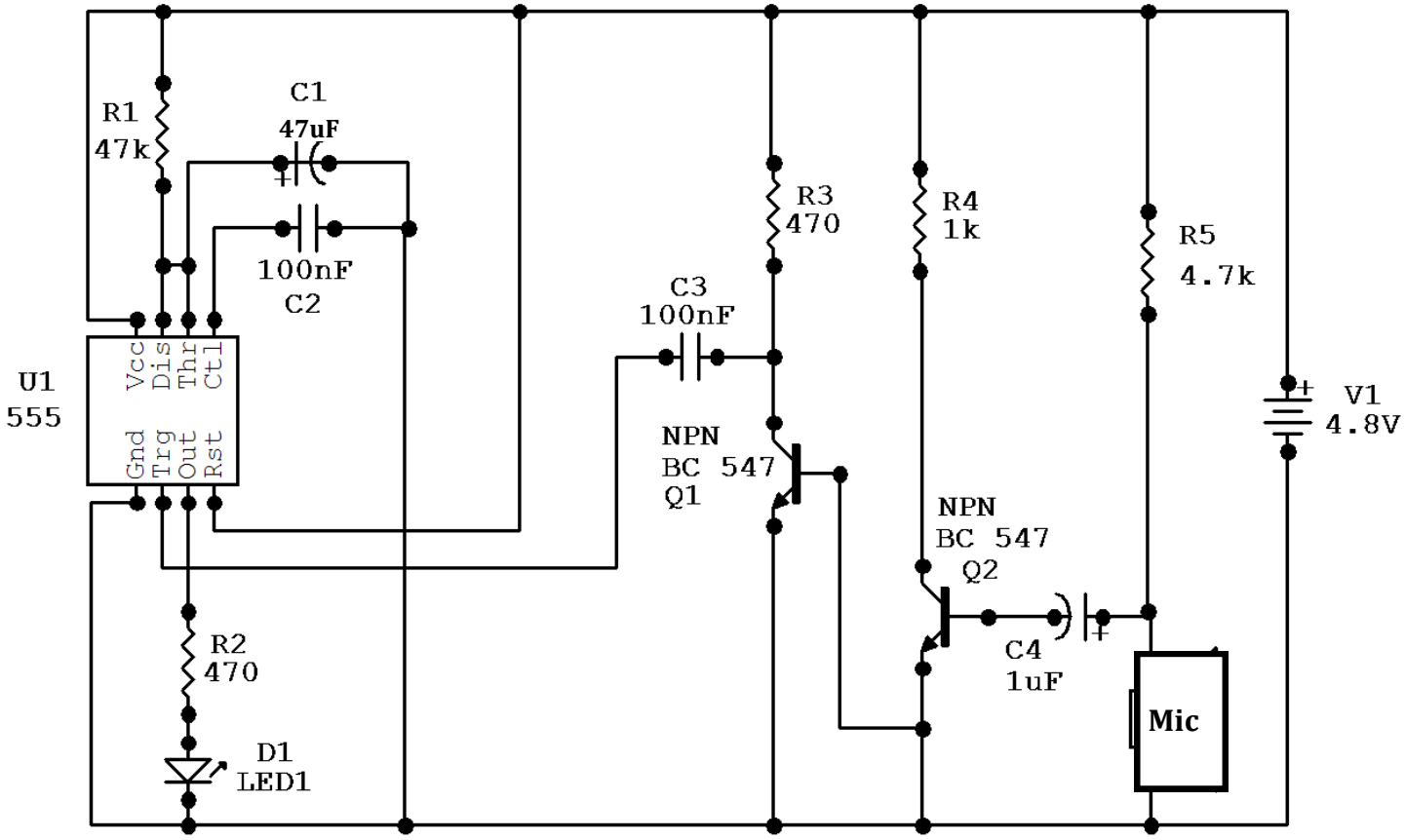
This can also be extended to be able to use with mains and to light up a lamp, for this we can add a relay driver circuit to the LED.

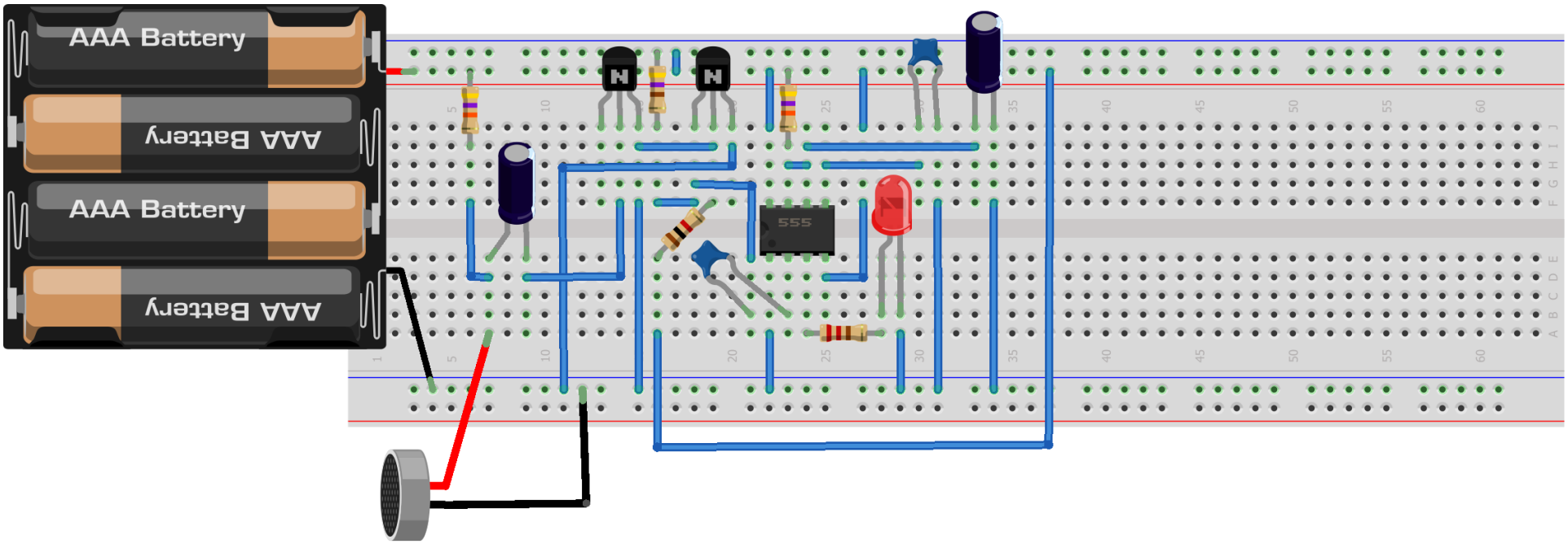
For Materials : please visit www.hobbyelectronics.in
Steps:

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.

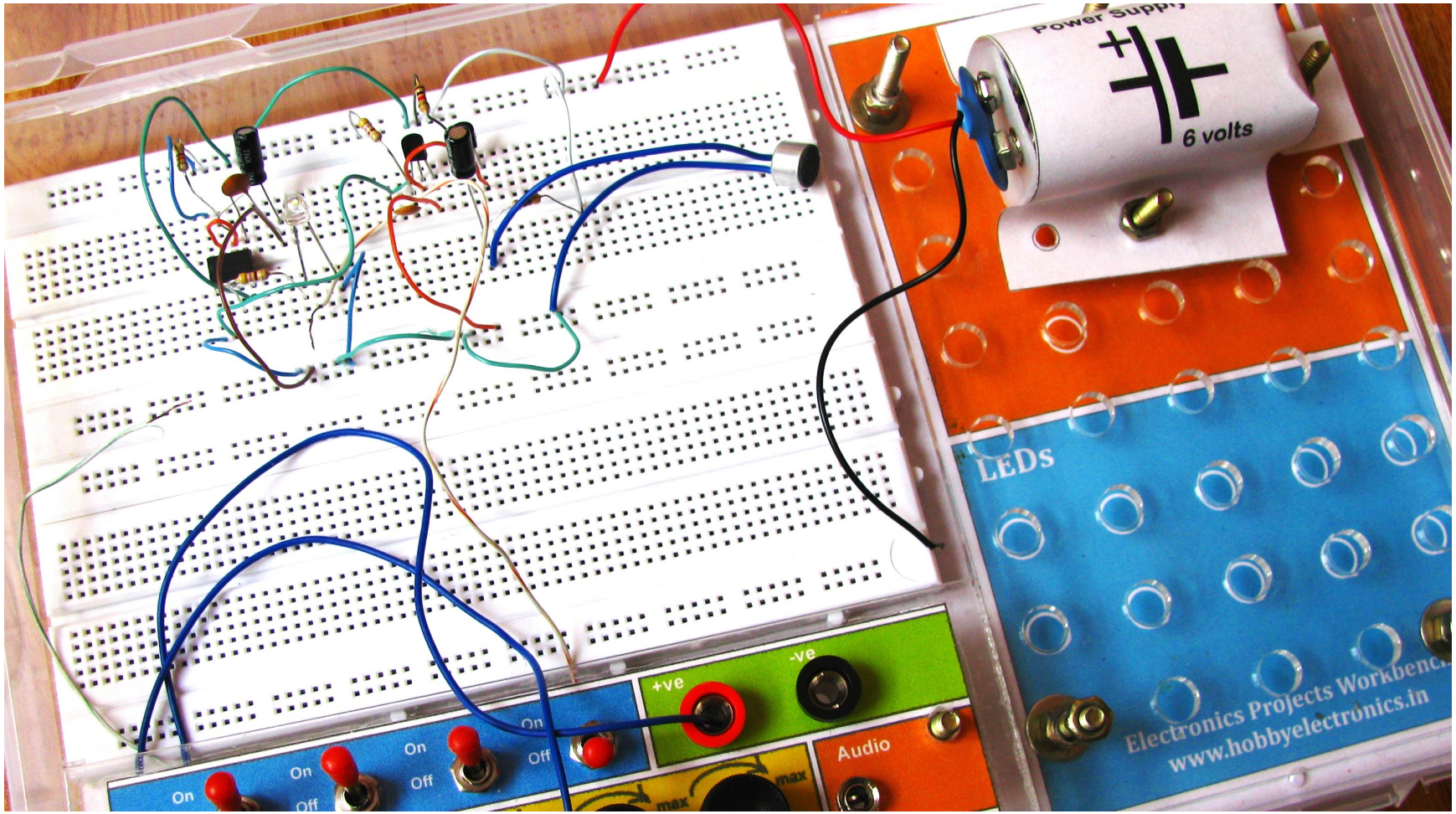




To make a **'One Clap ON and Another Clap Off'** kind of Circuit, You need to add One more circuit with the output of above circuit. In circuit design guide I have mentioned On of such circuit—'**One Touch ON Another Touch OFF Switch**'. To connect just two circuits, you will need a **relay driver circuit**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

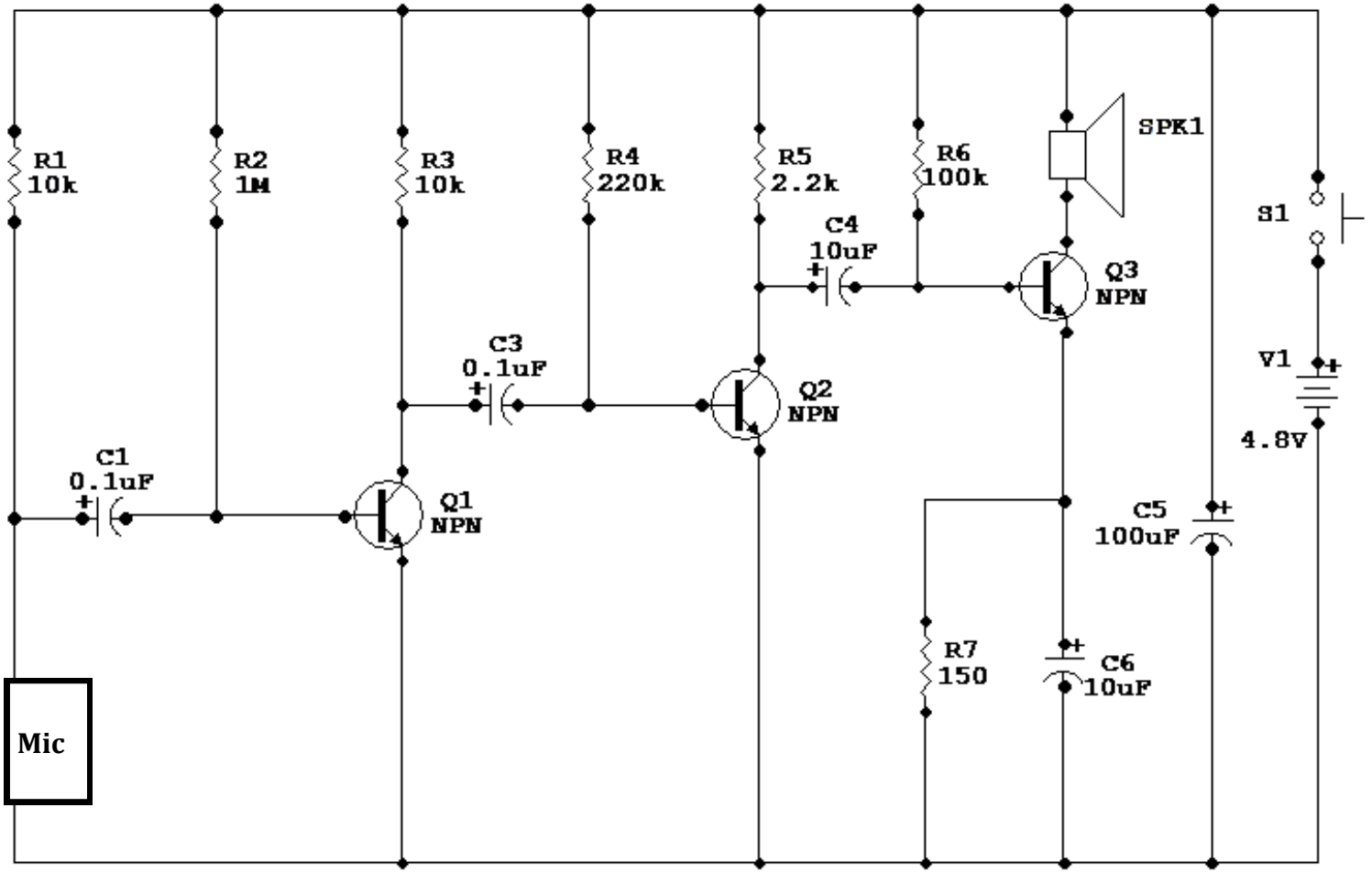
Another Idea, you can add a **latch circuit** (mentioned in circuit designing guide) with clap switch. A latch circuit will let the LED remain ON for few seconds and then it will turn Off. With another clap the LED will turn On again.

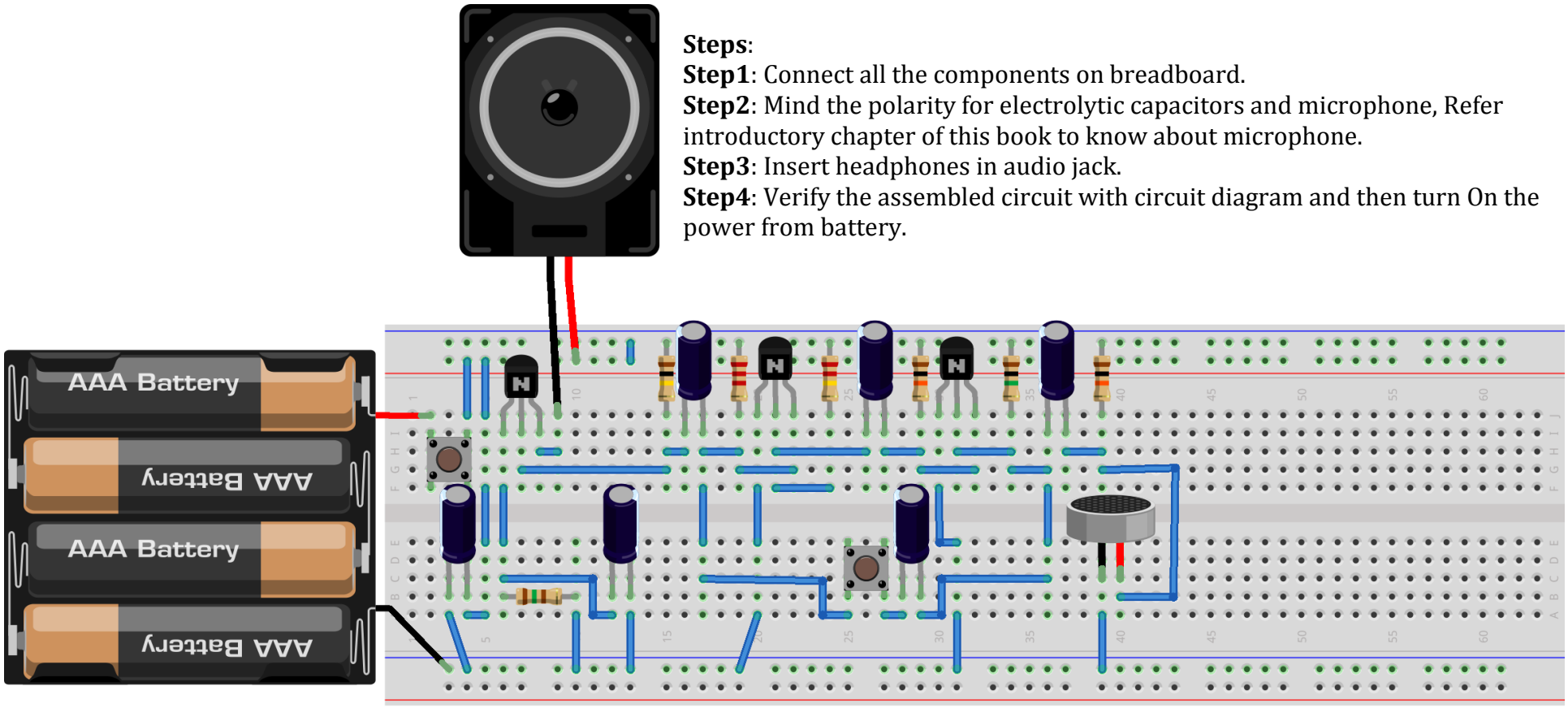
Another Idea, simply connect this circuit with a relay driver circuit and connect anything with relay, With clap that appliance with turn On momentarily and then go Off.


6 volts
LEDs
+ve
-ve
Audio
On
Off
Electronics Projects Workbench
www.hobbyelectronics.in

10.2 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.





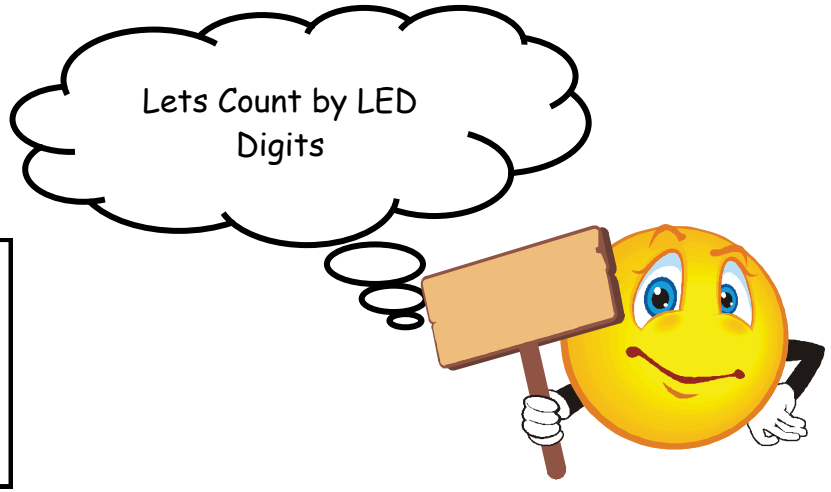
Steps:
Step1: Connect all the components on breadboard.
Step2: Mind the polarity for electrolytic capacitors and microphone, Refer introductory chapter of this book to know about microphone.
Step3: Insert headphones in audio jack.
Step4: Verify the assembled circuit with circuit diagram and then turn On the power from battery.

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.

11. 7 Segment Counter Circuits



In this section we will make :

11.1 Random LED Blinker
11..2 Digital Dice

In this section we will be making projects with 7 segment display and its driver IC 4026. But before starting lets first learn what is a 7 segment display and why we need a driver IC for it.

7 segment displays

A 7 segment display is an arrangement of LEDs which forms a number digit, Generally it looks like a digit of 8, This is because it is very easy to create any number by using digit 8. A variant of 7 segment display is 8 segment which is having an extra decimal LED also.

There are two variants of segment displays available in market - 1. Common anode 2. Common cathode. In common anode all the positive wires of LEDs in segment are connected together. which means that to drive LEDs a common positive voltage needs to be applied to LED segment and remaining wires will be connected to negative terminals.

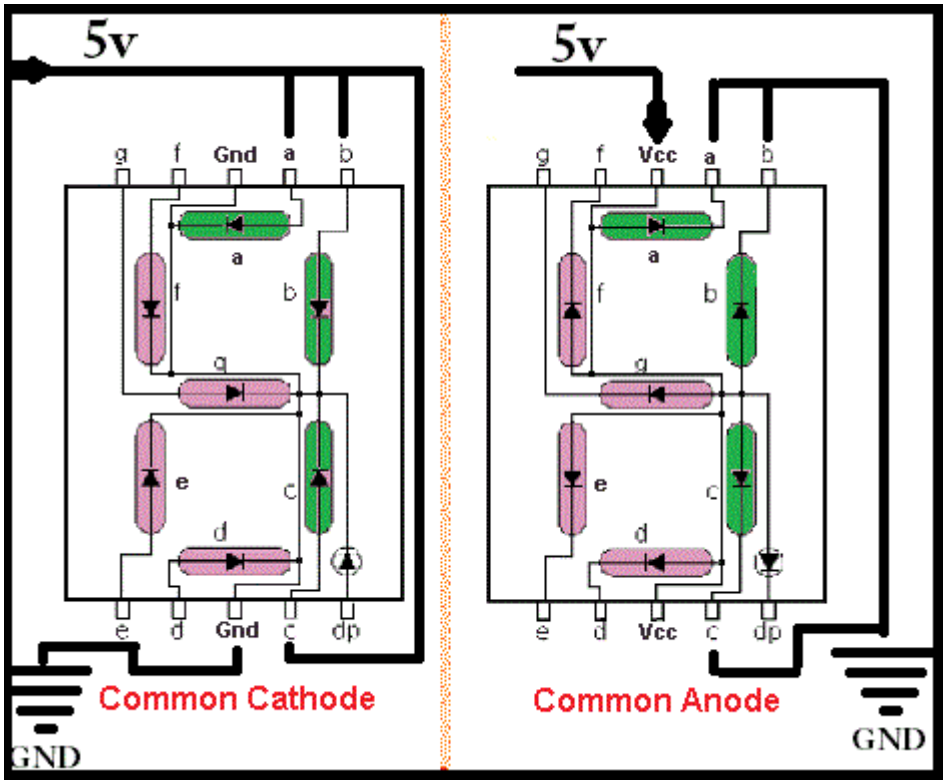
In common cathode all the negative terminals of LEDs are combined together. FOr driving this segment we need apply positive voltage to each LEDs which needs to glowed. With IC 4026/4033 best choice of segment is always common cathode. However if we have common anode we can still use it, only we have to use 7 transistors to invert the voltage and circuit looks odd and complex.

How to determine which segment display you have with you ?

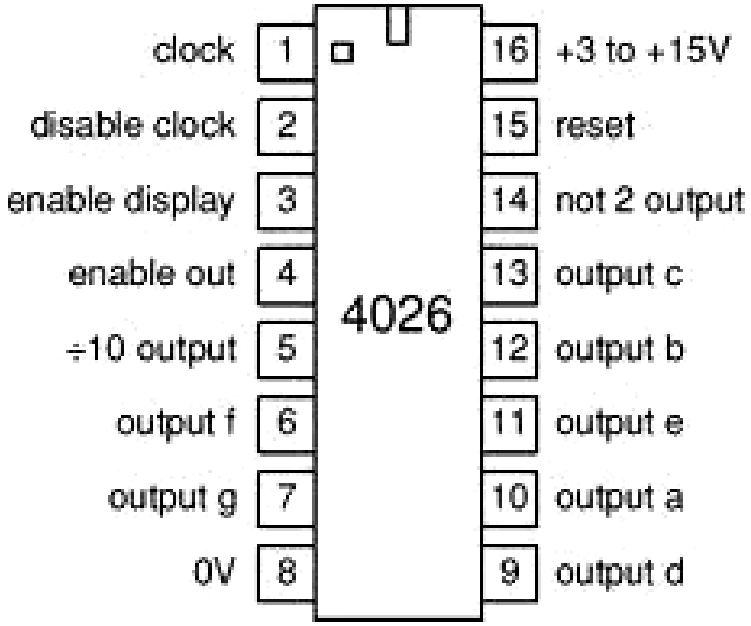
To check the type of segment display you need to test it with battery as shown in figure above, Connect the middle pin of segment to one terminal of battery and connect another terminal of battery some another pin of segment, if any LED glows, It means that the terminal (+ or -) which is connected to middle pin is the common terminal.

If the common terminal that you have just found is positive, it means it is common anode segment. If the common terminal of segment is negative then it means it is common cathode segment.

We at www.HobbyElectronics.in generally ship common cathode type displays. But we will be discussing both of them in our circuits.



IC 4026 and its working -



Description
To understand its working how we can interface 4026 with 7 segment display, first have to look on its pin diagram -

Now let us understand the working of individual pins-

1. Pin 1 or clock pin- It receives clock signals, and at every positive clock and counter advances one by one. You can provide clock with the switch, 555 timer or with the help of logic gates. In short high pulse on this input increments the counter.

2. Pin 2 or disable clock (clk inhibit) pin- 4026 counter advances one by one by receiving positive pulse at this time for this clock inhibit pin should be grounded. If it is connected to supply than counter advancement will be inhibited means there will be no meaning of clock pulse.

3. Pin 3 or enable display (En in) pin- It enable the 7 segment display to display the numeric value. It should be kept high for enabling the display. Mean output goes high when only when display enable is high.

4. Pin 4 or enable out- It Enables the carry out pin. In our circuit we have left this pin unconnected.

5. Pin 5 or divide by 10 output- It is used to complete one cycle for every 10 clock input cycle and it also used to cascade more IC's.

6.Pin 6, pin7 and Pin9 to pin 13 - These are 7 decoded output from a to g used to illuminates the corresponding segment of 7 segment display to display the digit from 0 to 9.

7. Pin 14 or not 2 output (UNGATED "C" SEGMENT) signals- They are not gated by the Display clock and therefore are available continuously. This feature is a requirement in implementation of certain divider function such a as divide by 60 and divide by 12.

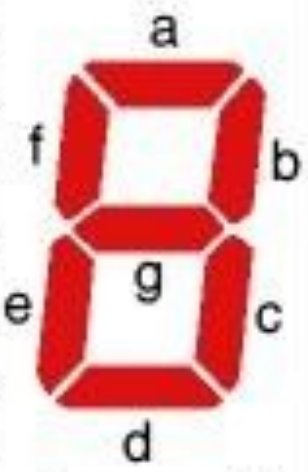
8. Pin 15 or Reset pin- It is used to reset the counter. When it receives high it clears the counter and counting again starts from zero. One important thing reset pin should again made low to start the counter once again.

9. Pin 8 or ground pin and Pin 16 known or Vdd it should be connected to power supply.

To understand its working assemble the circuit as shown in circuit diagram -

Outputs from the 4026 counter and display driver IC

Count	a	b	c	d	e	f	g	h
0	●	●	●	●	●	●		●
1		●	●					●
2	●	●		●	●		●	●
3	●	●	●	●			●	●
4		●	●			●	●	●
5	●		●	●		●	●	
6	●		●	●	●	●	●	
7	●	●	●					
8	●	●	●	●	●	●	●	
9	●	●	●	●		●	●	



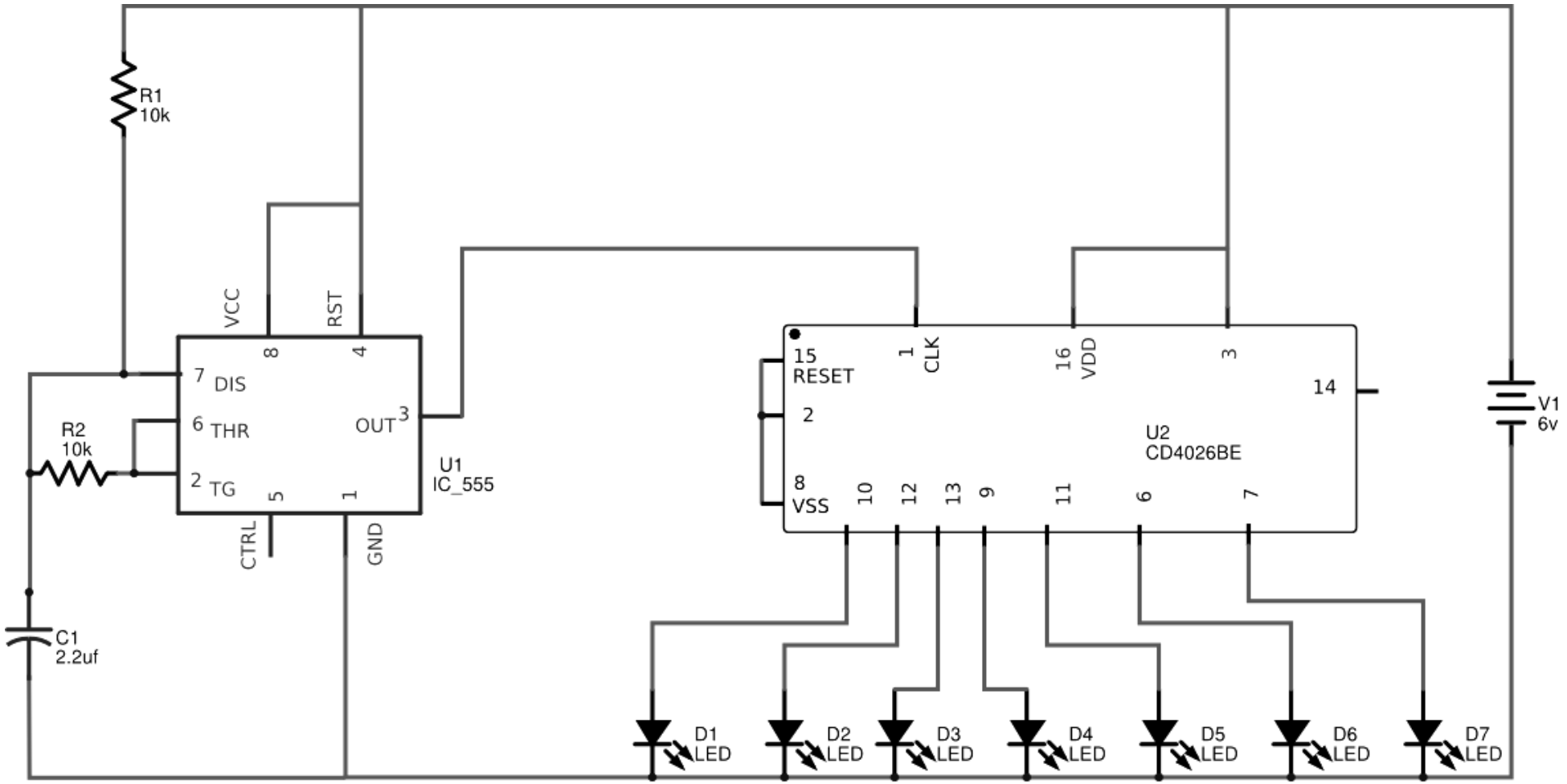
7-segment display

● = segment on. h is used to drive other counters.

To understand the working of IC 4026 better, Let create one circuit with this IC. In next project we will be creating a circuit with IC 4026.

11.1 Random LED blinker -

Well everybody likes blinking LEDs. The effect they generate looks nice to eye. This is why blinking lights are used in many places where public attention is needed for example - Police cars, Ambulances, Road sign boards etc. Blinking lights in specific format is easy and we can create simple blinking lights by using transistors only, however blinking lights in random format is difficult. Random blinking of multiple LEDs - sounds interesting !!



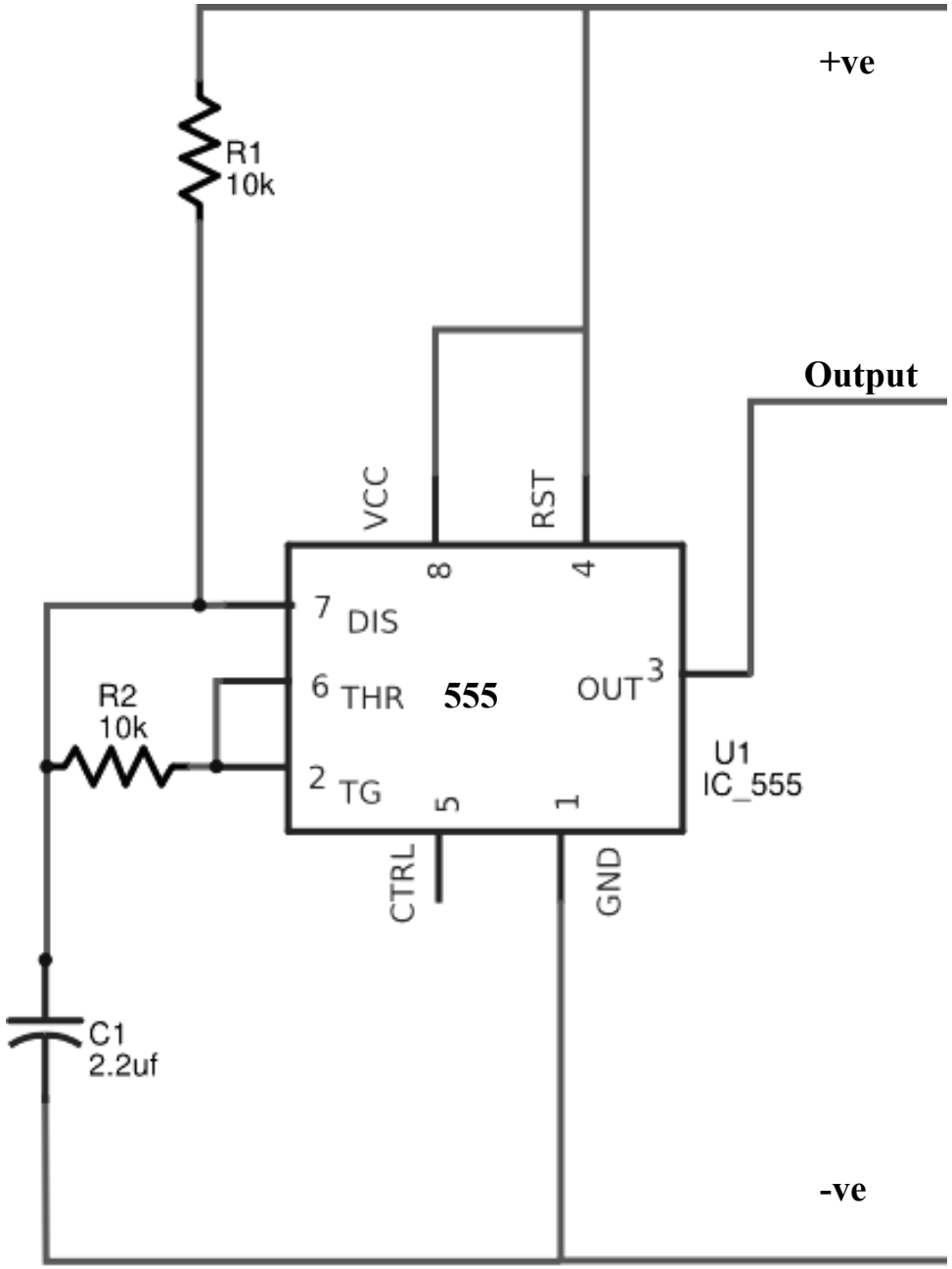
In this project we will be using IC 4026 to create a random LED blink effect. Though this circuit is not a true random blinker, Its duty cycle to repeat the same pattern is long enough that it create a illusion of random LED blinker. Offcourse if you are able to remember all of its sequences you may observe that the patterns are repeating.

In this project we are using IC 4026 which is a johnson counter IC. The output of IC 555 is connected to input of IC 4026. IC 555 is configured as a multivibrator here and sends pulses to 4026 (Please refer right hand side figure), which starts counter and different LEDs lights up with each increment of counter, though this random LEDs blinker is not truly random and it has a pattern but this pattern is not so predictable easily.

Materials—
IC555—1, IC4026—1, LED –7, 10kohms—2, 2.2uf—1

Steps -

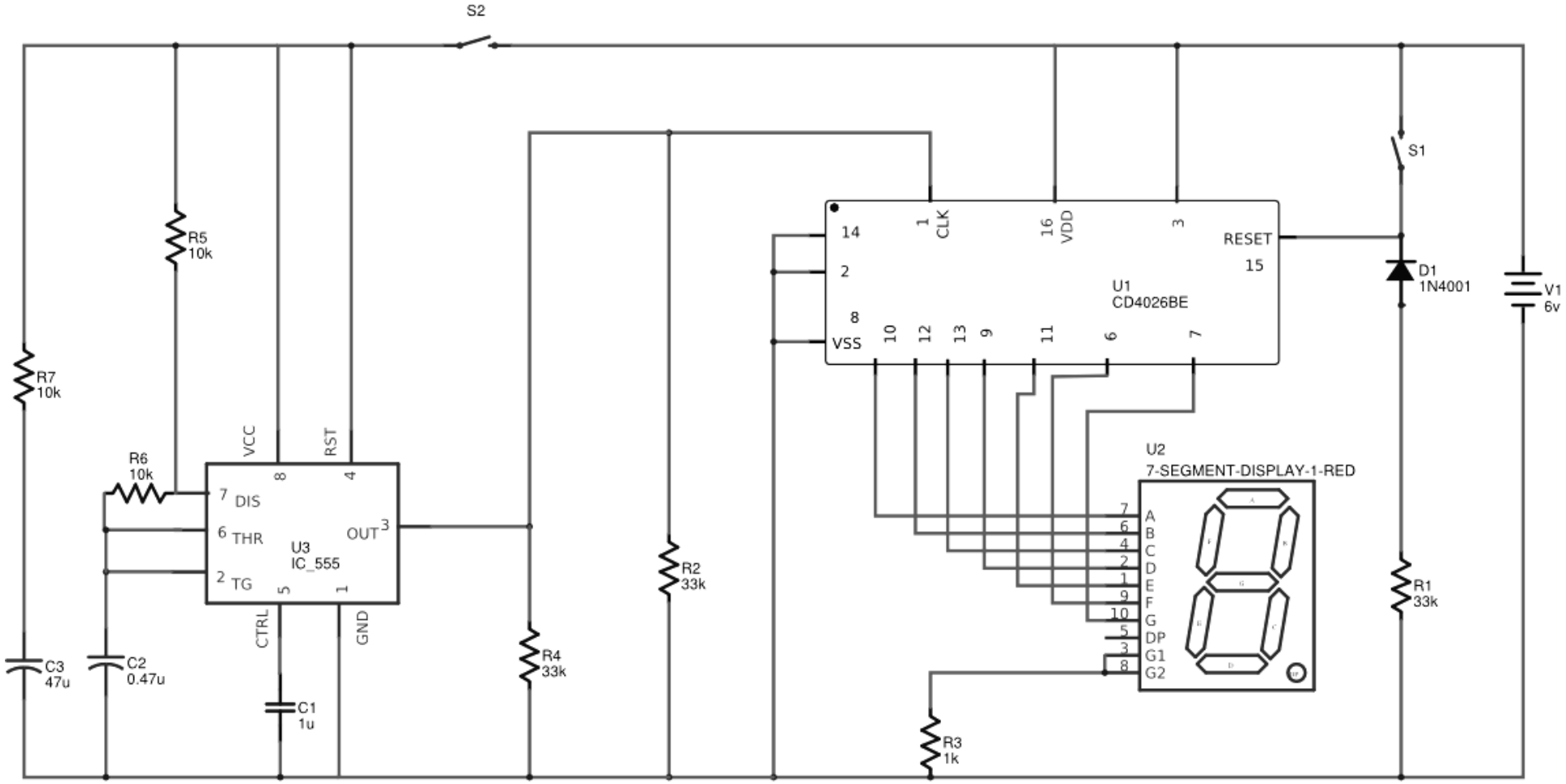
1. Please identify the correct pins for each LED as LED is polar in nature and have negative and positive connections.
2. Assemble the circuit on breadboard.
3. Connect battery to power the circuit, If LEDs don't light up, disconnect battery immediately and check the circuit again.

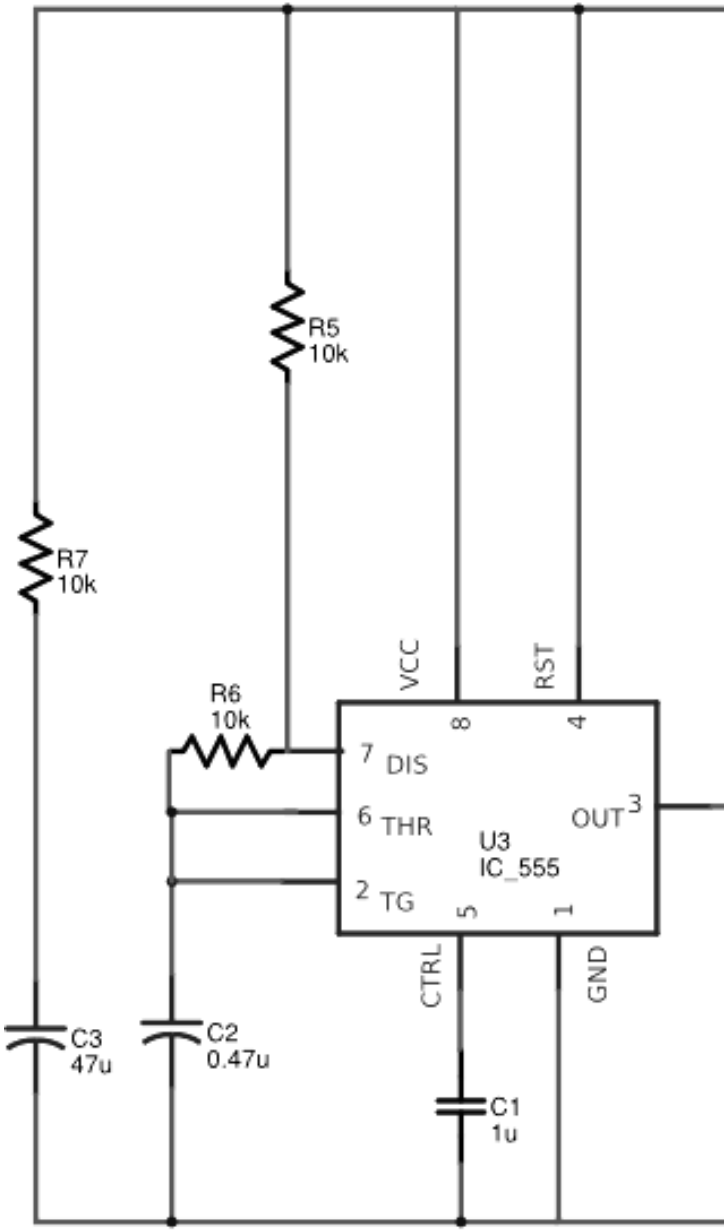


11.2 Digital Dice—

Counters, Digital Dices are generally used in games like horse racing, marathons, Running and many other games. Generally a big display board is used to show the numbers to everyone. Here we will be designing a small version of manual Dice which can be used with friends while playing. This dice will go from 1 to 9. And generate a random number every time player presses the key.

In this project we will be using 7 segment LED counter to count incoming pulses from IC 555. The IC 555 sends a clock pulse to IC 4026. IC 4026 is a counter IC. It has a 5 stage Johnson decade counter with decoder which convert the Johnson code to a 7 segment decoded output. This means it will convert the input into numeric display which can be seen on 7 segment display.





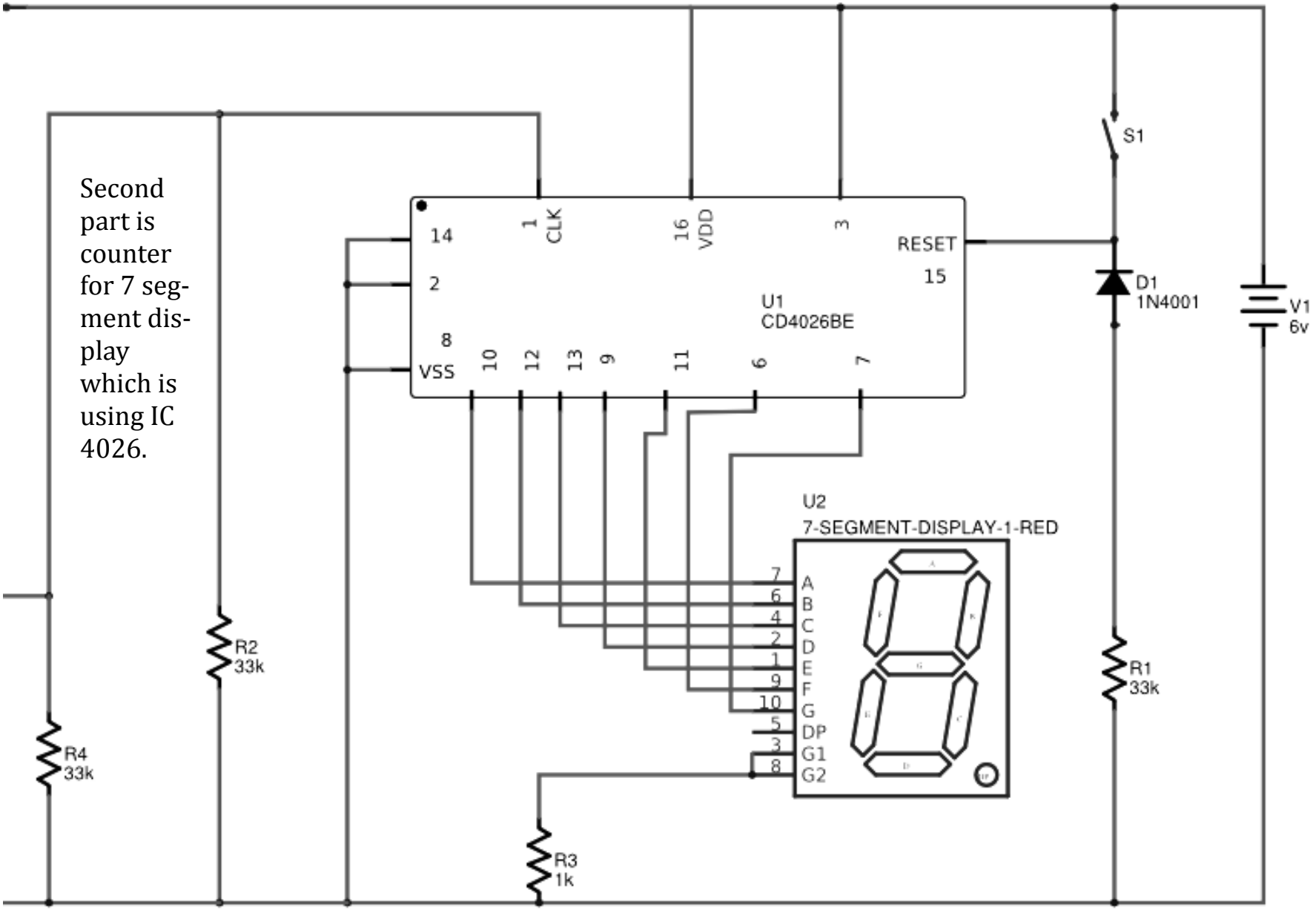
Steps -

1. Please identify the correct pins for 7 segment display, please refer previous diagrams to see the A,BC,D… pins of 7 segment display, The centre pins of segment will go to negative terminal of battery.
2. Assemble the circuit on breadboard.
3. Connect battery to power the circuit, If Segment LEDs don't light up, disconnect battery immediately and check the circuit again.

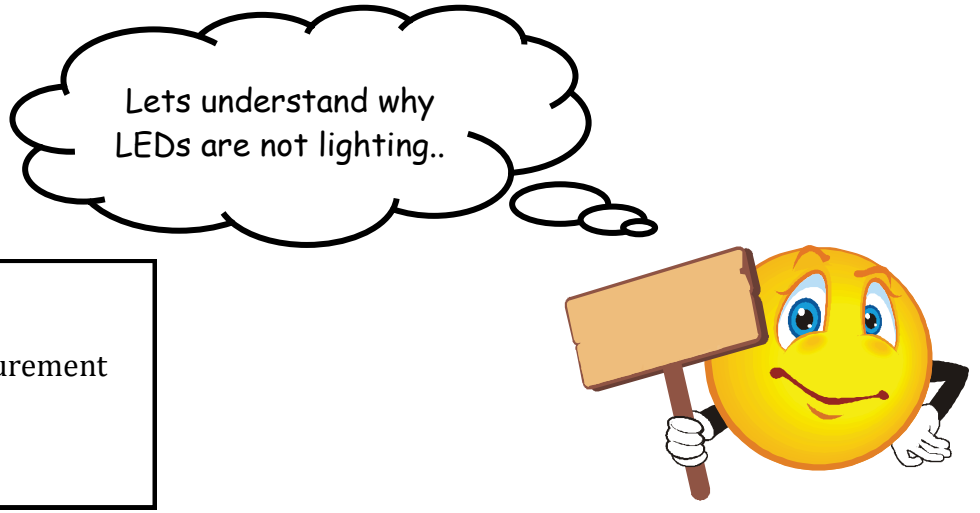
Note: Please note that the segment is having too many connections, and the wires to breadboard should be tight enough or some of the LEDs will not glow up and number will not be formed on display.

The circuit is divided into two parts, one is pulse generator with IC555, which acts as input for IC 4026

Second part is counter for 7 segment display which is using IC 4026.



12. Test & Measurement



In this section we will make :

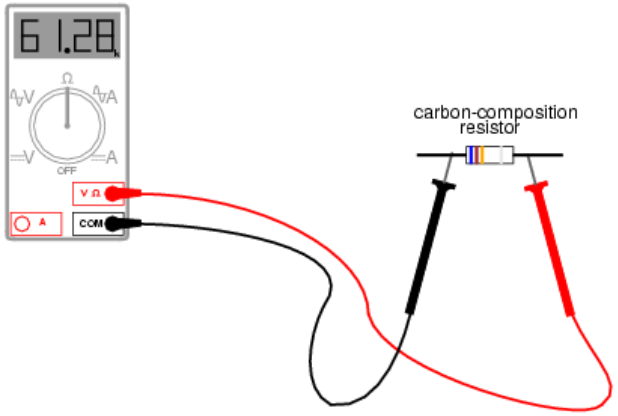
12.1 Resistance, Voltage, Current, Diode, Continuity measurement
12..2 Voltmeter And Ammeter
12..3 Wheatstone bridge

12.1 Resistance, Voltage, Current, Diode, Continuity measurement

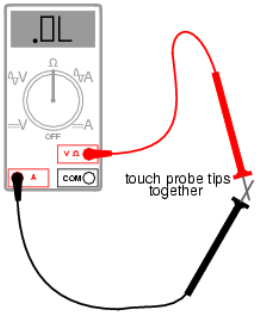
Calculating Resistance

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.

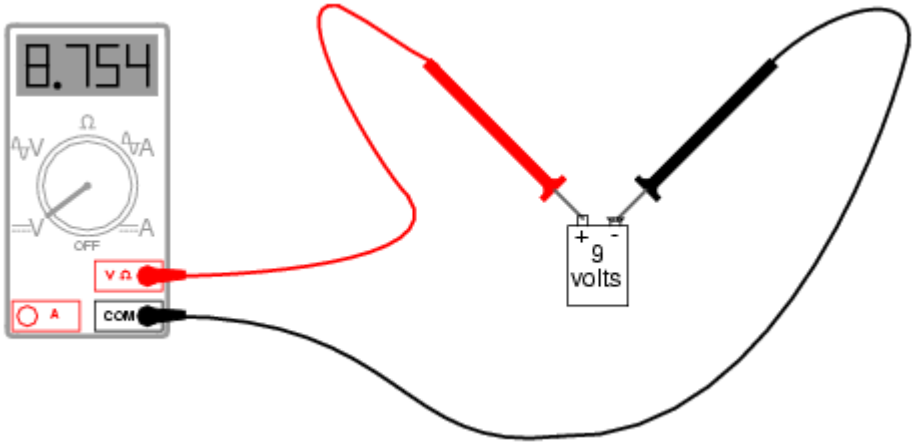


Voltage measurement

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 then 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 then 20 volts and you should rotate the knob to select a higher value.



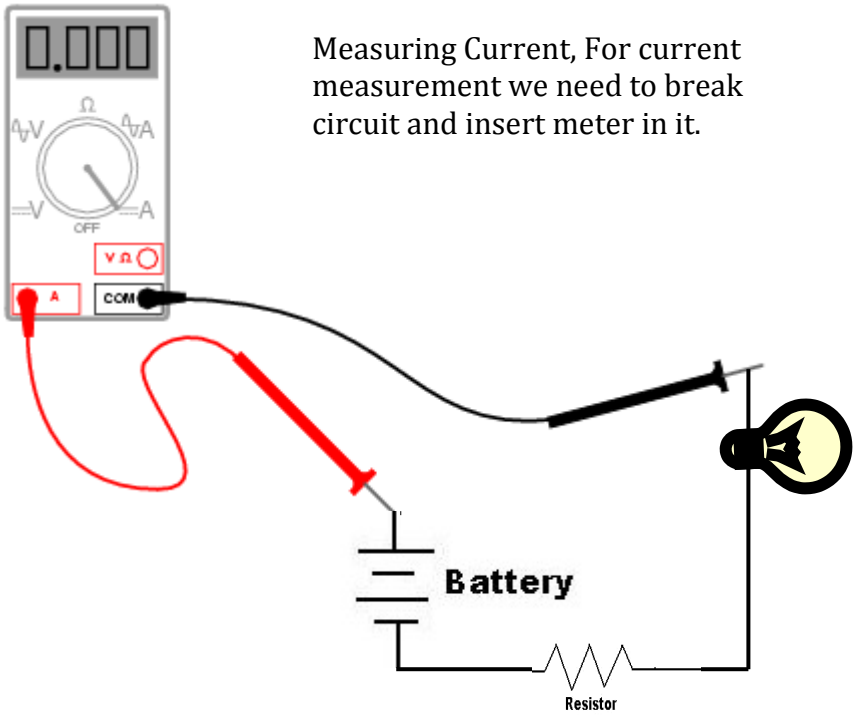
Measuring AC voltages

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.

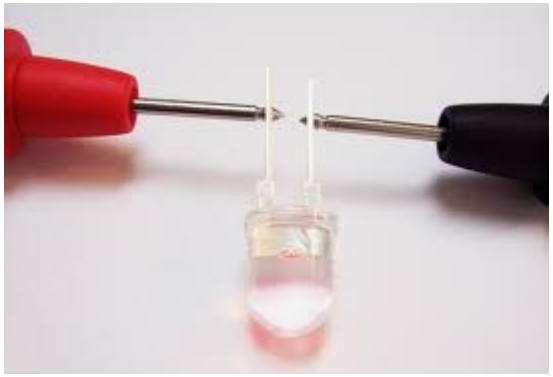
Step 3: Turn On the battery. Put the leads as shown in figure on left hand side.

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

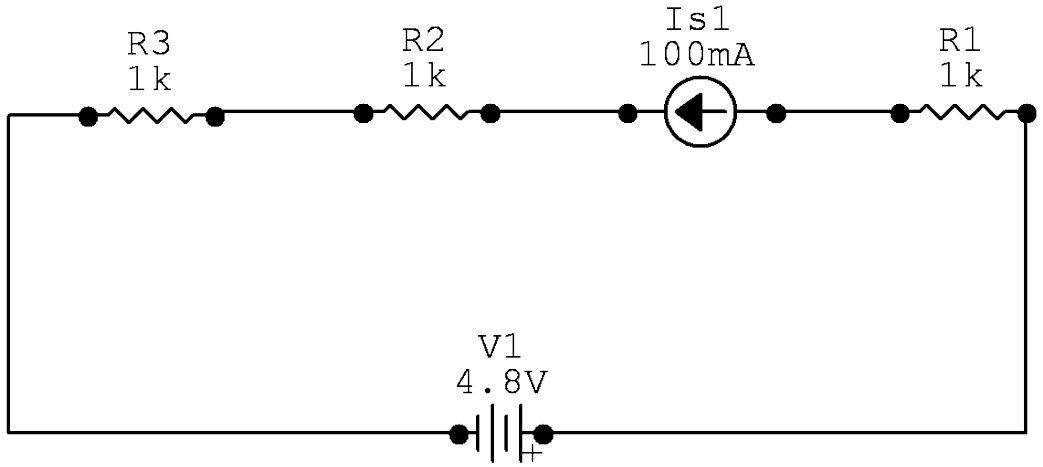
Usually a diode test selection and continuity test selection is same on selection dial. This is because the resistance of diode is very low in forward bias mode (when P-N junction of diode is connected with positive and negative leads of meter respectively). As shown in figure a LED is connected with 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

12.2 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.

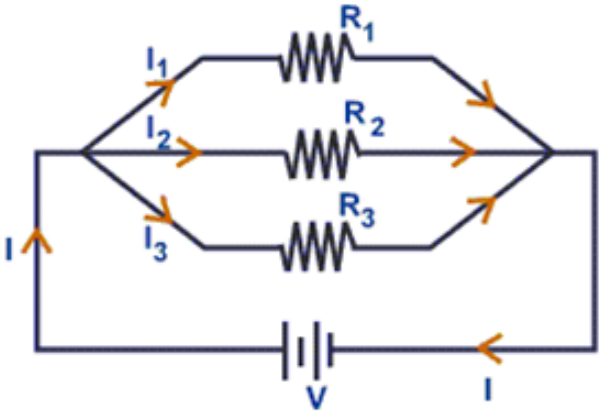
Some Parts of this project are available in Video CD ROM



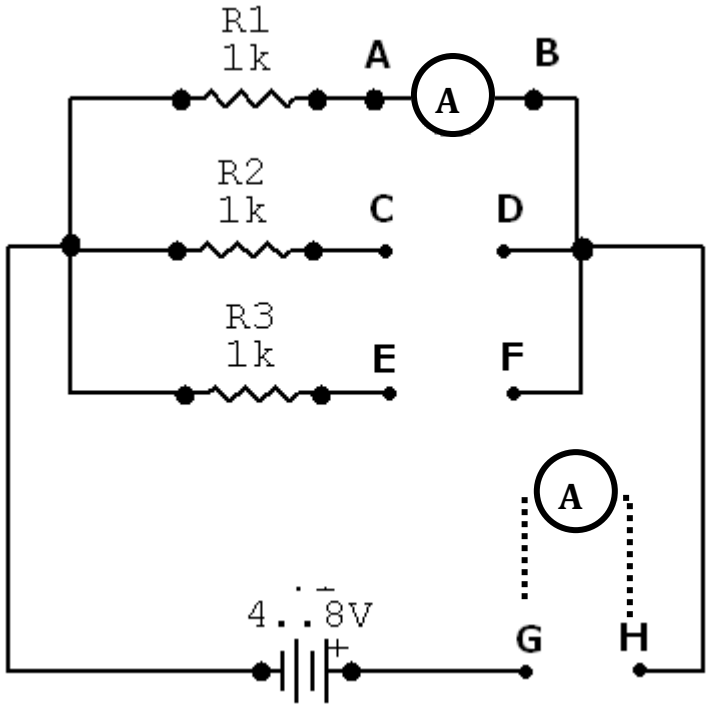
1.1 Ammeter

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 I1,I2,I3 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 (I1,I2,I3) using our own ammeter and then we will calculate I1,I2,I3 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 I1, I2 and I3 one by one (through A & B, C & D, E & F and finally G & H for total current)
Step4 – Add I1, I2 and I3 and check if they are equal to I. (between G & H)
Step5 – Calculate Currents from I1,I2,I3 mathematically and check If they are coming equal to measured values.
I = I1 + I2 + I3
I = I1 + V2/R2 + V3/R3 (Since we want to calculate I1)



Since V1 = V2 = V3 = 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.)

So, I = I1 + V(1/R2 + 1/R3)
I1 = I - V(1/R2 + 1/R3)

Step6 – Verify if I1 is coming equal as we measured it by multimeter.

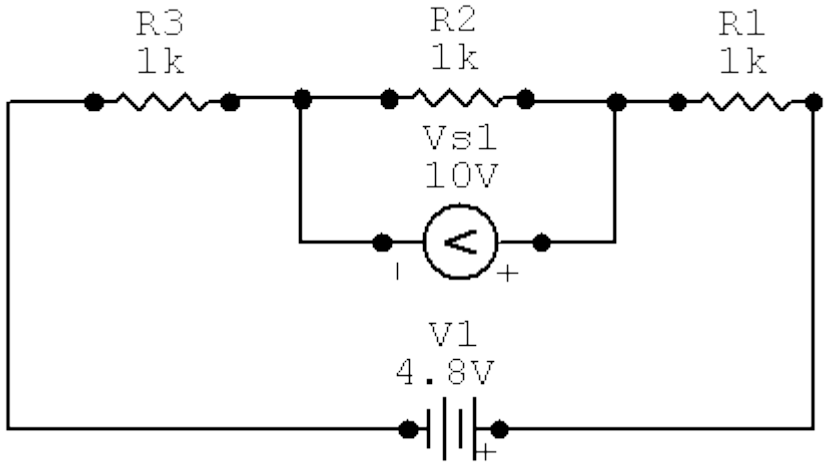
What is Voltmeter?

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 then 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 = V1 + V2 + V3
Similar to previous circuit calculation we can calculate V1, V2, V3 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

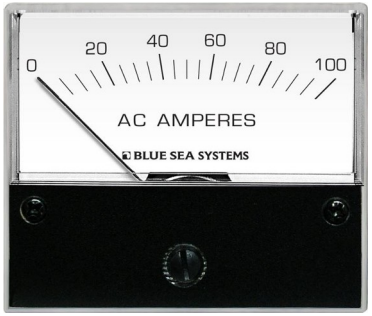
12.3. Wheatstone bridge

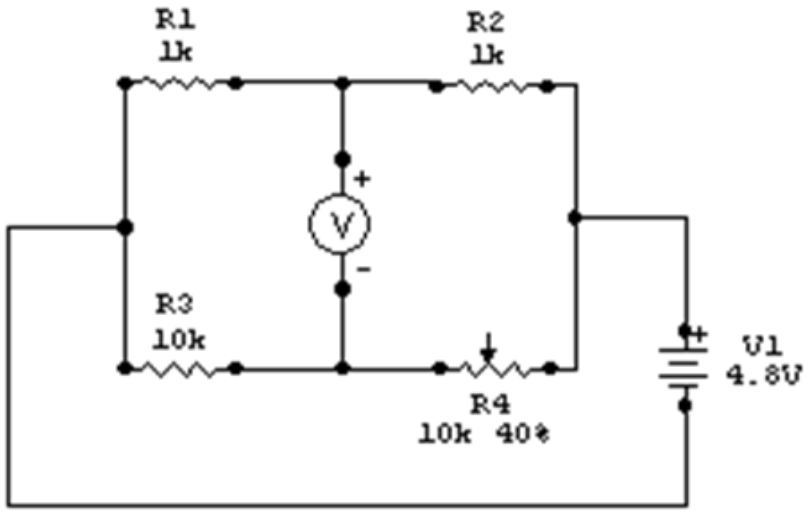
What is Wheatstone bridge?

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 R1/R2 = Rx/R3 then potential difference at points A and C becomes zero.

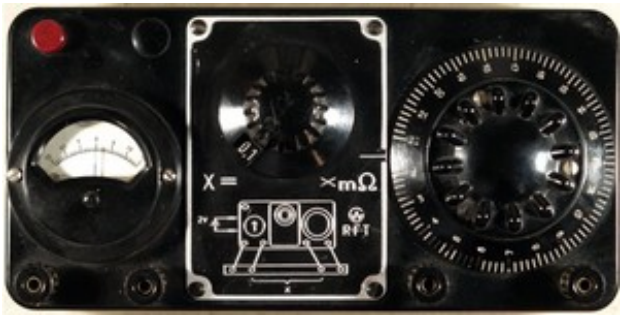
Some Parts of this project are available in Video CD ROM

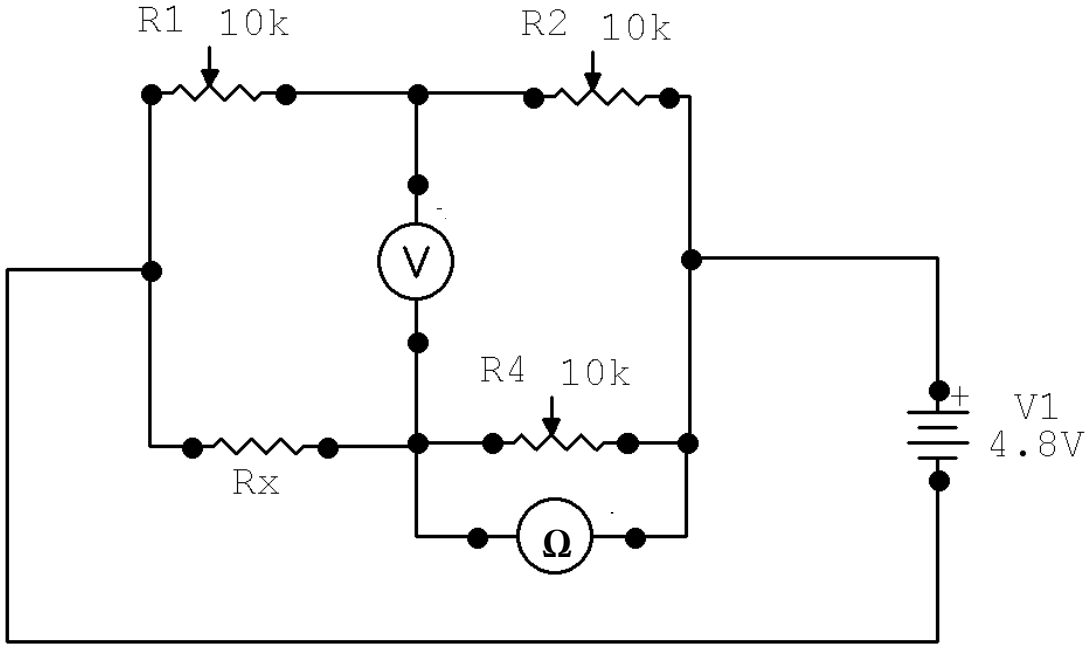




Circuit diagram of wheatstone bridge.

Photo of a wheatstone bridge based equipment.
Courtesy:Wikipedia





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 Rx. If we somehow we can balance the bridge and make potential difference equal to 0 then we can determine Rx by using above formula.
To balance bridge, we vary one of the resistances from R1,R2,R3 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.

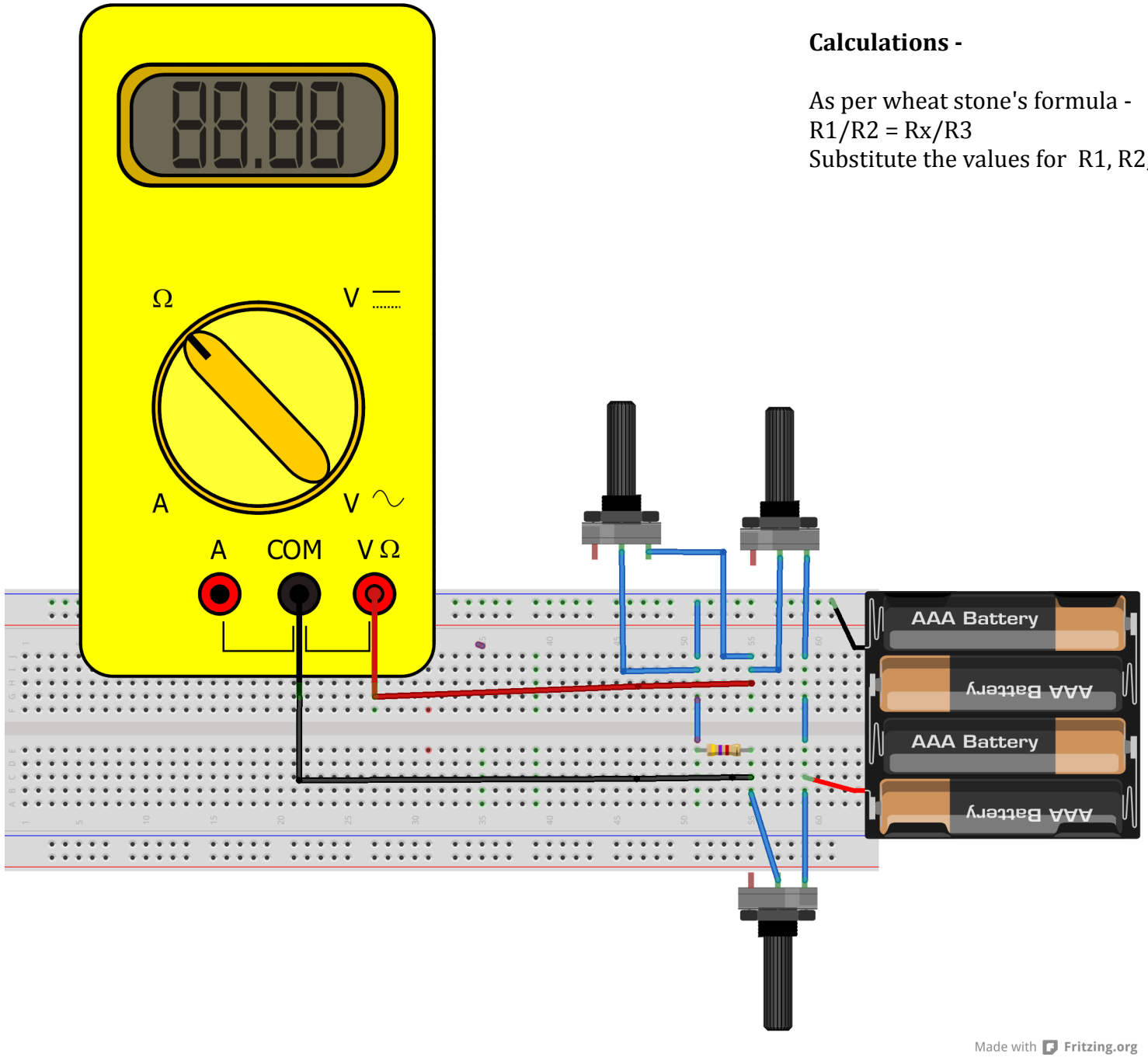
Tip : Only first two leads of variable resistance are used to vary resistance, the middle pin is actually connected to spindle which moves and vary resistance from 0 to max value.

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 -
R1/R2 = Rx/R3
Substitute the values for R1, R2, R3 and compute Rx

More Ideas -

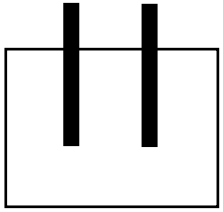
Soil Salinity measurement –

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.

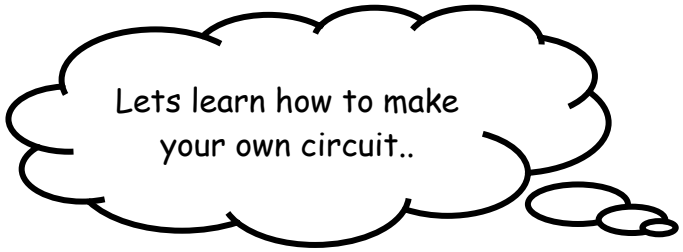
A Wheatstone bridge based equipment to measure soil salinity

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.



13. Circuit Designing guide



In this section we will make :

13.1 Simple Transistor Sensor Circuits
13.2 Driver Circuit
13.3 Oscillator Circuit

13.1 Simple Transistor Sensor Circuits

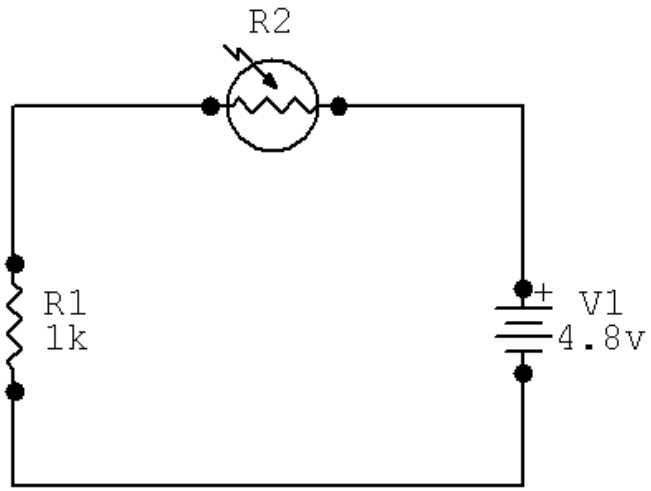
Sensors Intro

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.

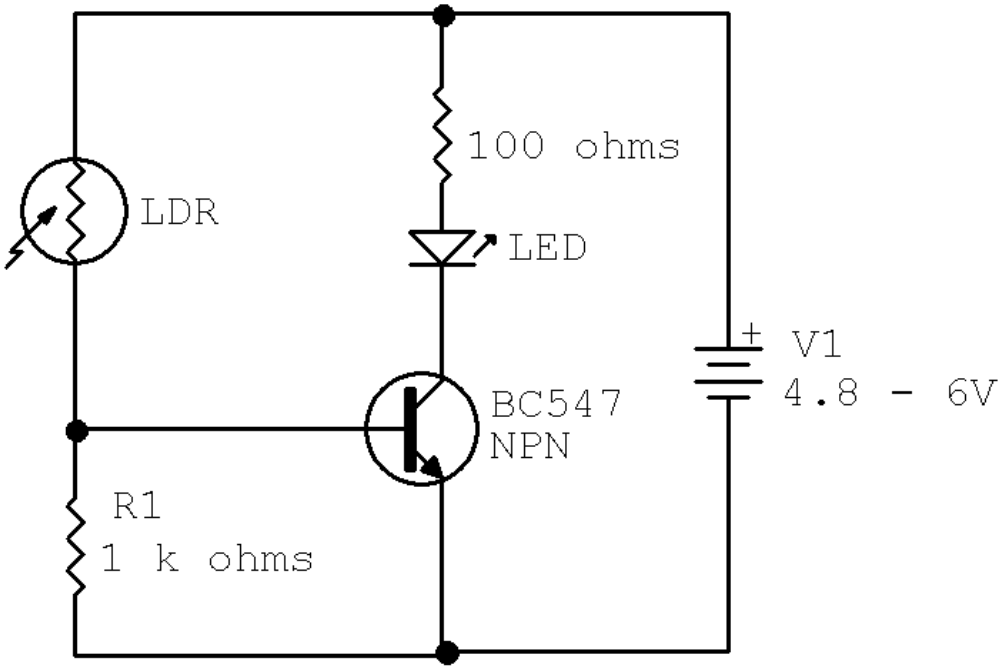
The charge generated in microphone is then amplified by using one or more transistors. This amplified potential can be applied to LED or other devices like relay. (Relay is a electro mechanical switch which operates at 5-6 volts and is able to switch electric devices).



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.

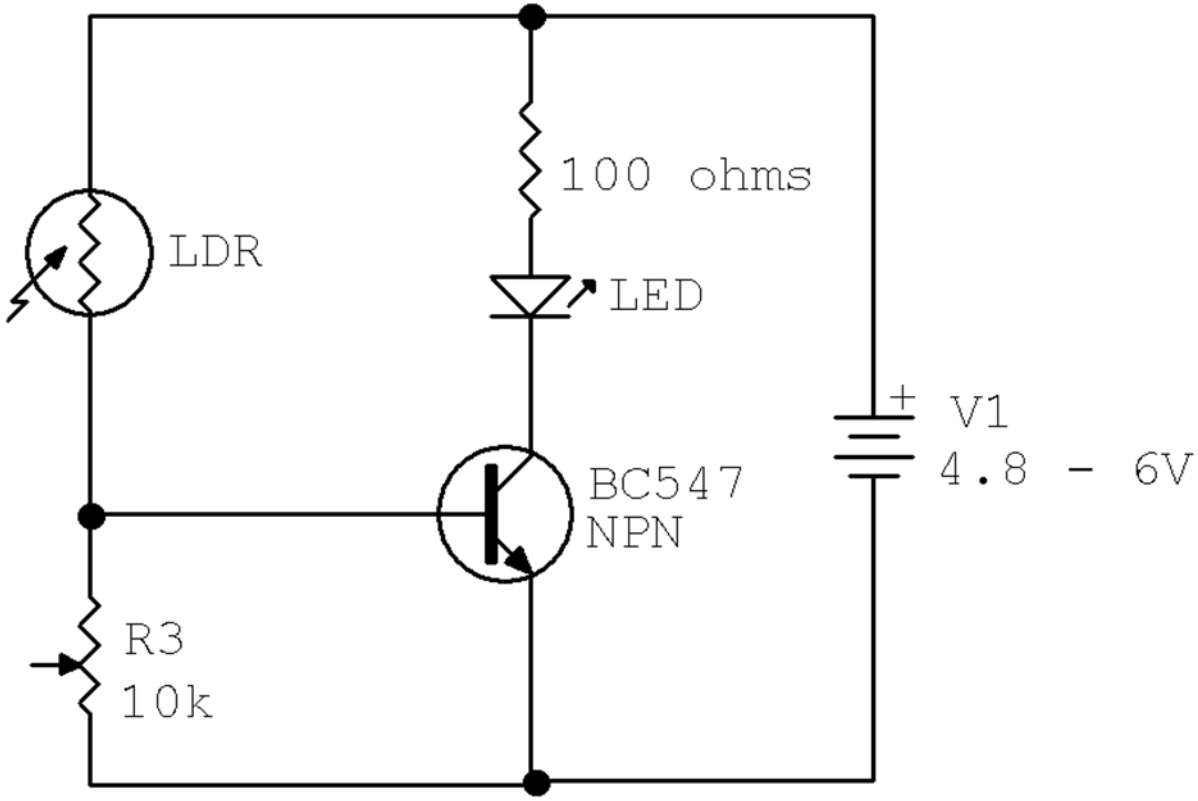


In left hand side circuit, transistor is used a switch and a small base current will be sufficient to turn On the transistor, which will allow flow of current from collector to emitter and turn the LED On.

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 R1 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 R1 (decreasing R1 will increase flow of current from positive to ground and it wont allow transistor to turn On). After dcreasing R1 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.

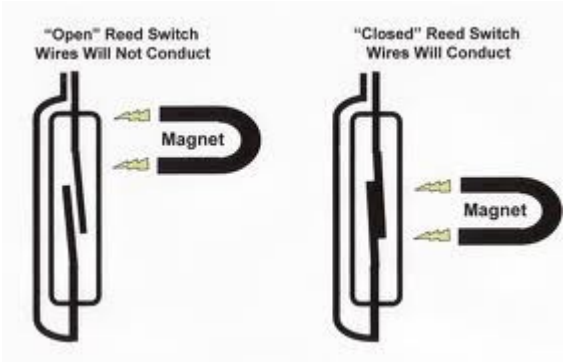
Designing a circuit with sensitivity adjustor -



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

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.

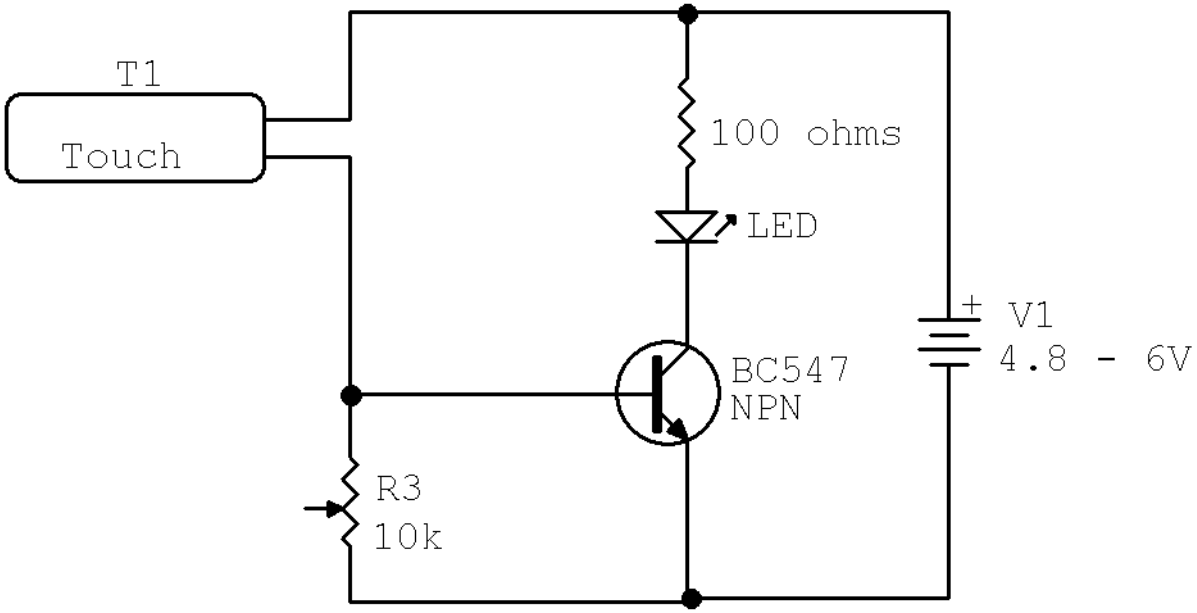
*A Magnetic reed switch is a switch which turns On when it comes near to a magnetic. So we can use a magnet to switch ON/Off circuit.



Zoom to view images better

Commercially available magnetic reed switches

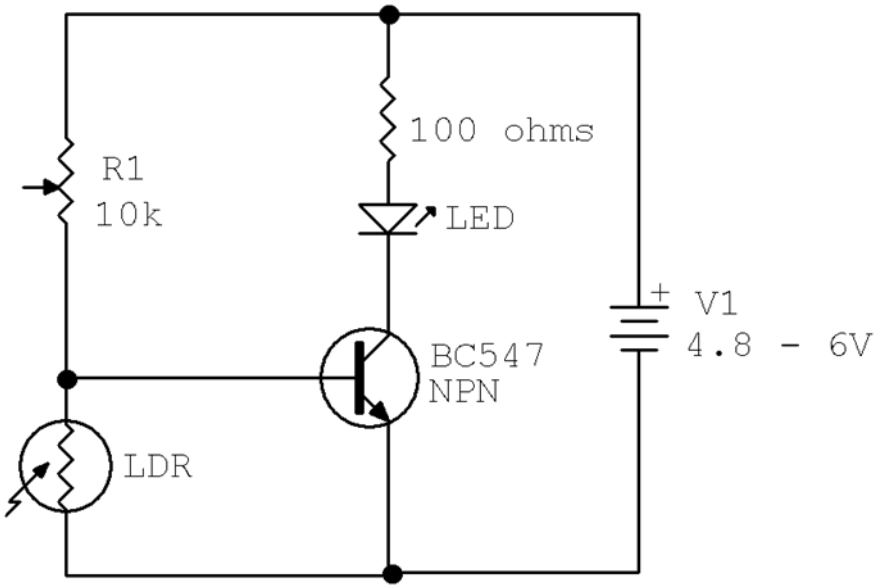
Below we are trying to create our own touch sensor which require just placing two wires very close to each other. The other sensors which can be used here is Thermistor (temperature sensor), Magnetic reed switch etc



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.

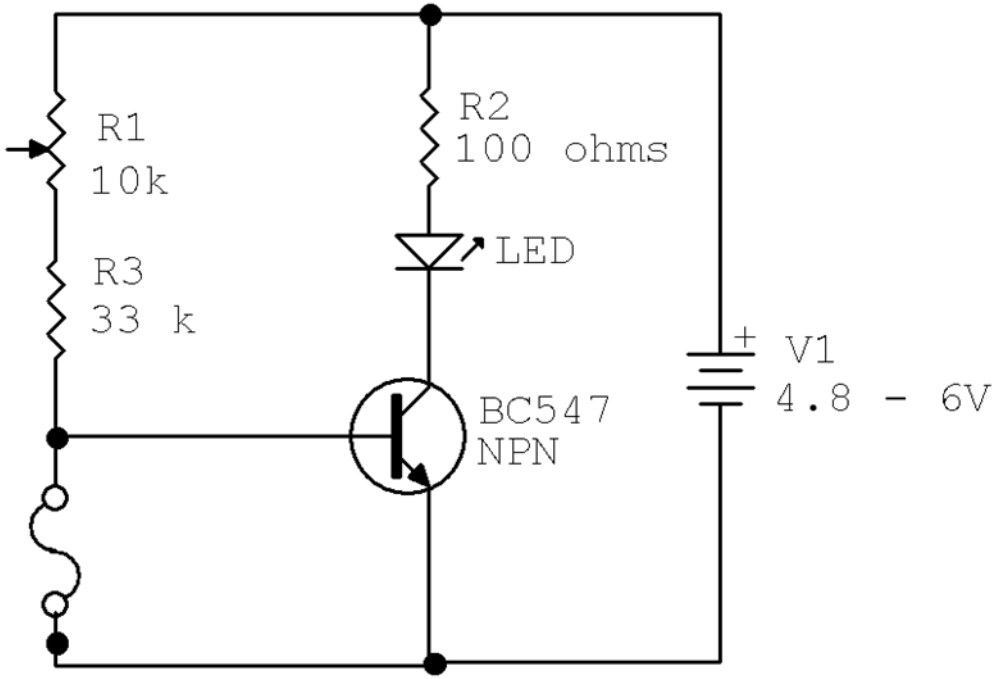
For making this kind of circuit we will be using the connection from base to emitter and instead of placing our sensors in between base and collector we will place them in between base and emitter.

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.

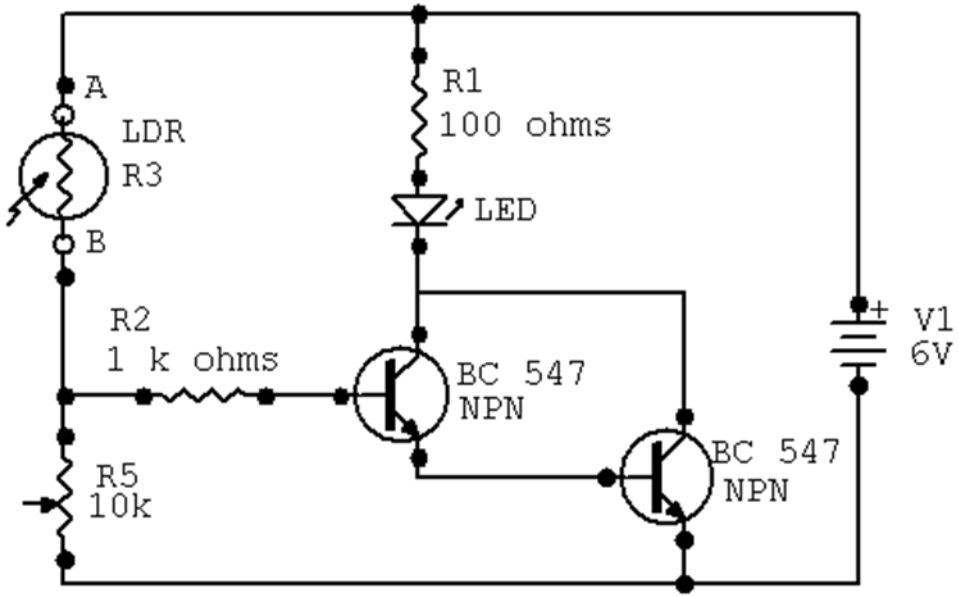
With this arrangement of circuit shown on right hand side, There are more possibilities to design circuits like burglar alarm, animal trap etc where we need to trigger circuit when there is a broken connection. Please refer circuit below for a simple burglar alarm.



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.

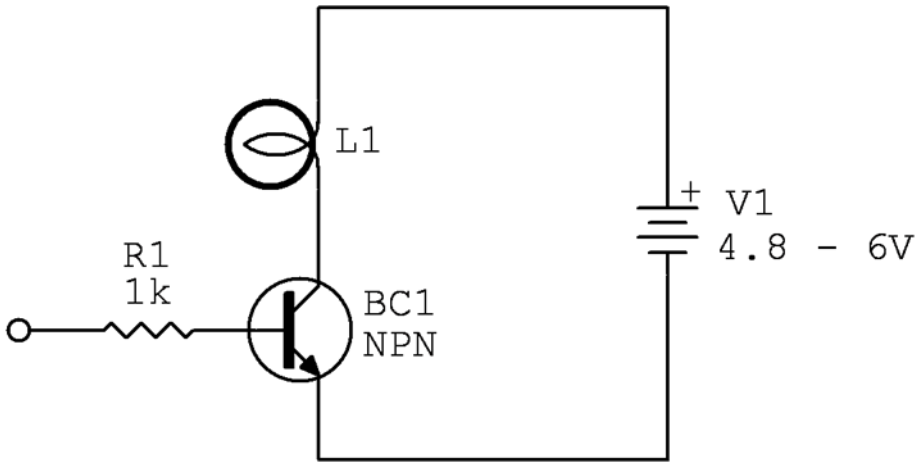
This Darlington pair circuit can be used in place of previously designed sensor circuits as well as with the circuits we are going to design later from here. You just need to replace single transistor with this two transistor pair.

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.



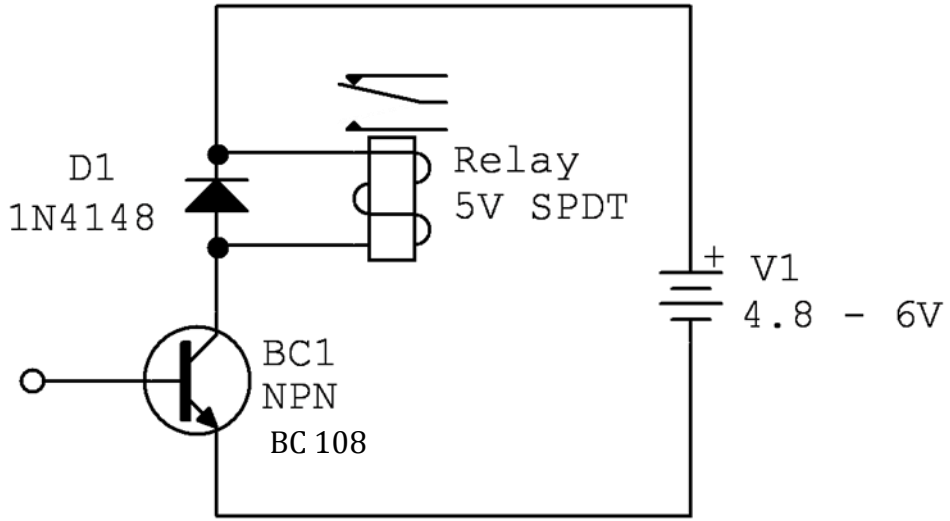
In this circuit we are using a 6volt lamp with a power transistor (BC108). When this circuit detects a small voltage at base it activates lamp. Since lamp draws more current then LED, we are using a metallic power transistor here. The input voltage in this circuit can be increased up to 9volts for brighter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

Relay driver circuit –

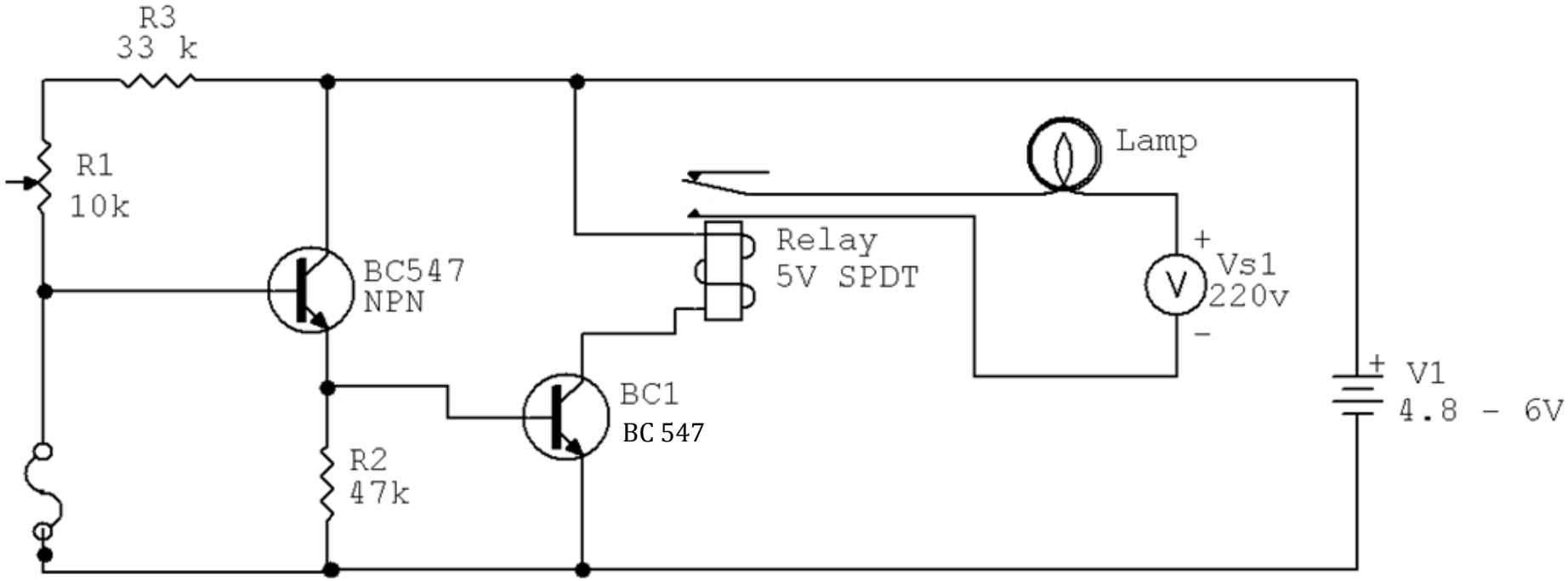
Relay is a special electro mechanical switch and is just like a switch which we use in our room's switchboard. The only difference between a normal switch and relay is that, In a normal switch board switch somebody needs to go and press it to turn it On. But in relay this pressing of switch is done by 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 is the 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 ~ 1k at its collector.
Also you may choose to replace sensor circuit with other ones we have already designed.

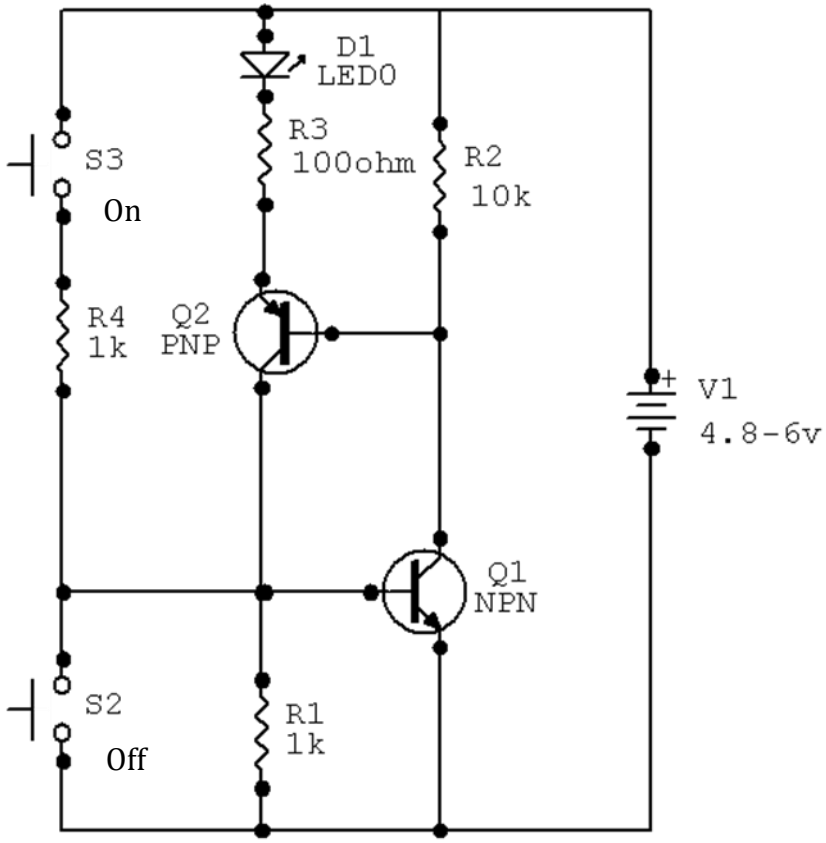
Latch circuit –

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)*

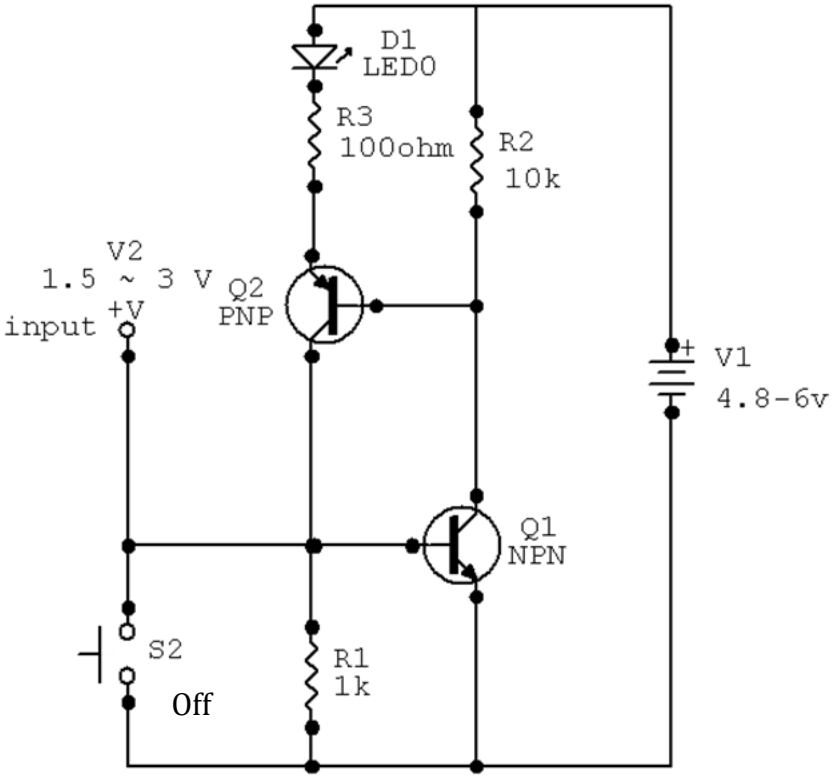
Image: Commercial SCRs

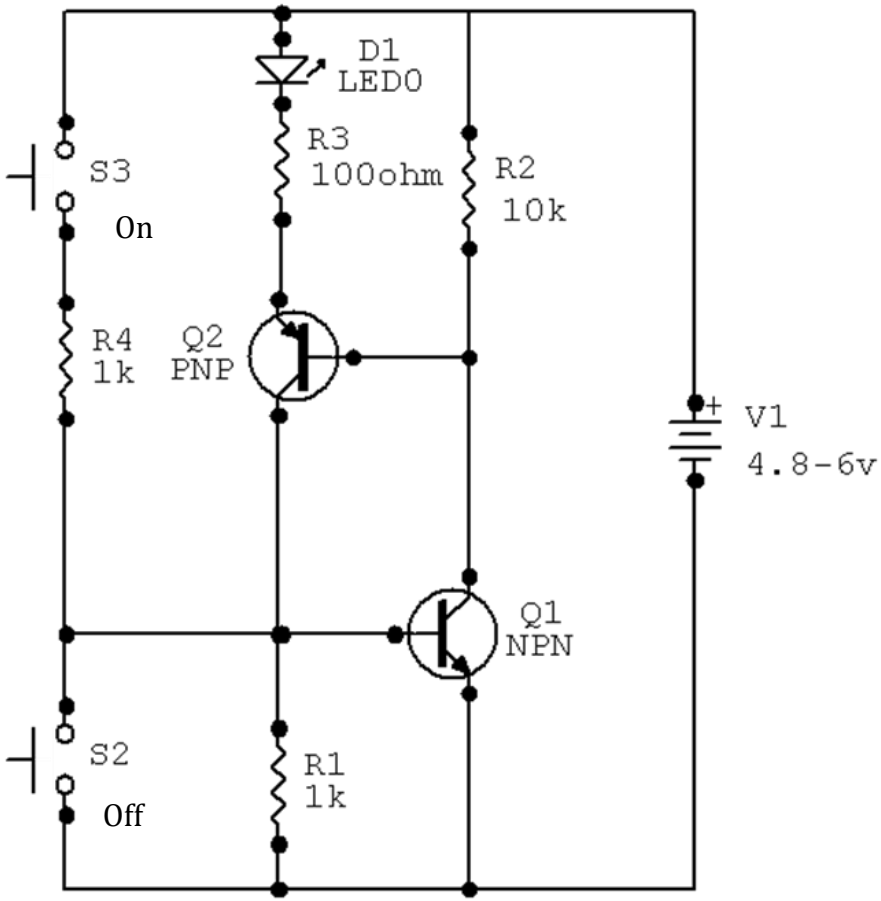
SCR is commercially used in high power circuits. However as a hobbyist and learner, a transistor equivalent of SCR is good enough to create a latch.



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 .





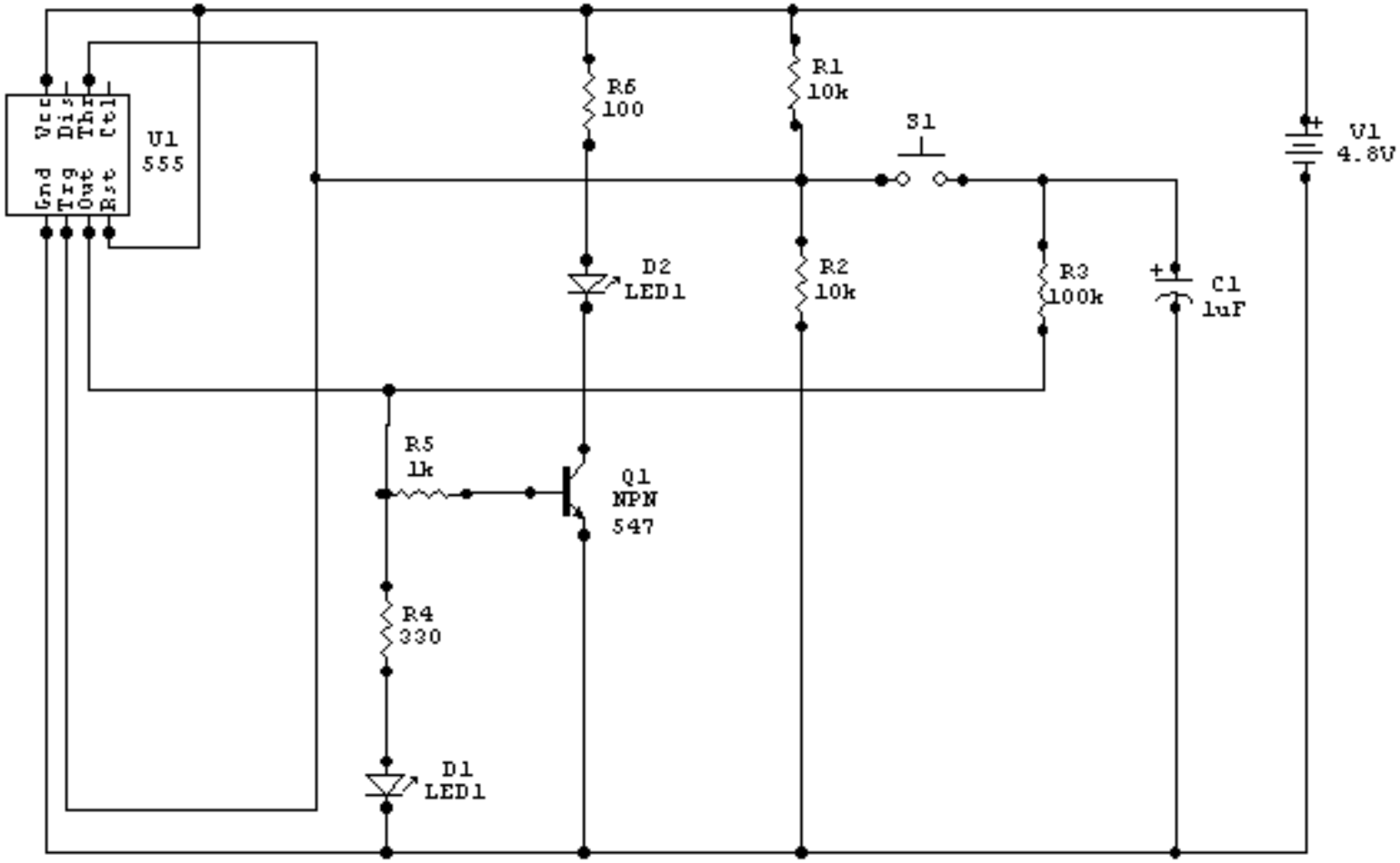
You can use a relay driver circuit at the output of latch circuit, Just replace LED and 100ohms resistance with a 47K-68k resistance and take output from emitter of Q2 transistor for input in relay driver circuit.

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.



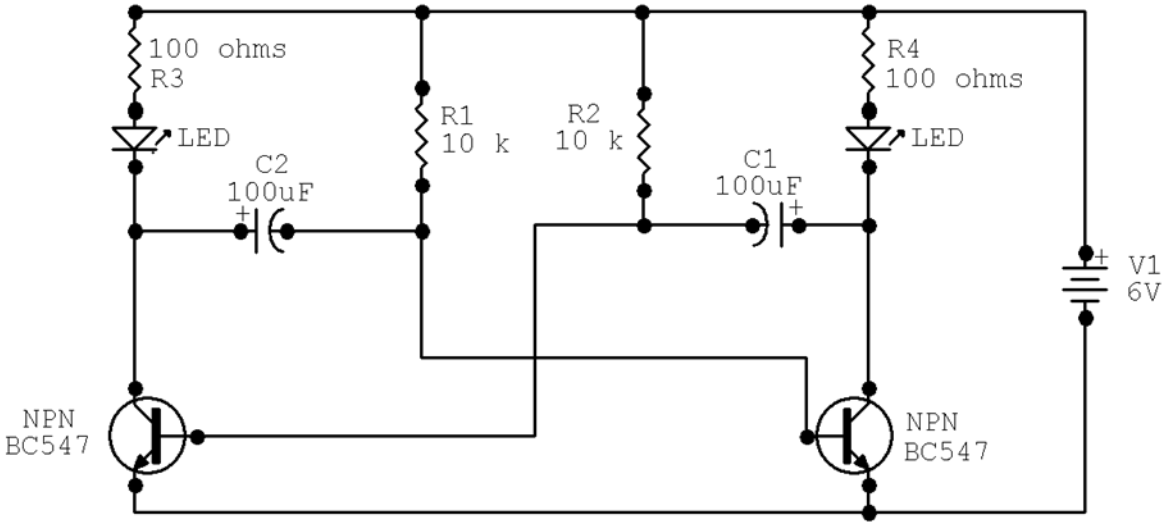
To simply connect this circuit with another circuit. Try removing the touch switch and connect a relay instead. Relay is just like switch and can be operated by another circuit.

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).

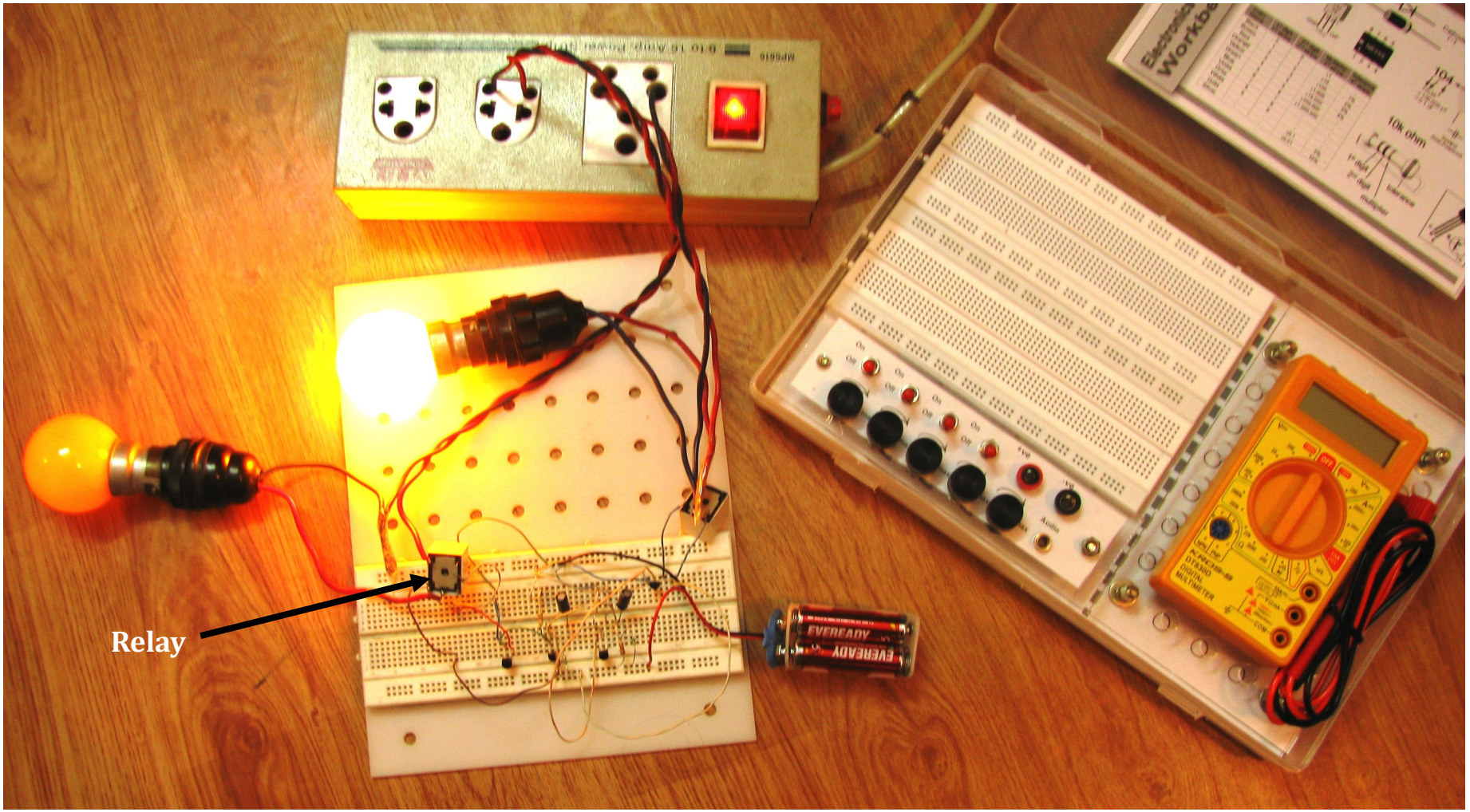
Oscillators - oscillators are very important in electronics, they are used in many important circuits like - timers, music generators, Radio circuits, Light blinkers. In advance electronics and computers, Oscillators play very important role. for example CPU in computers use very high frequency oscillators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

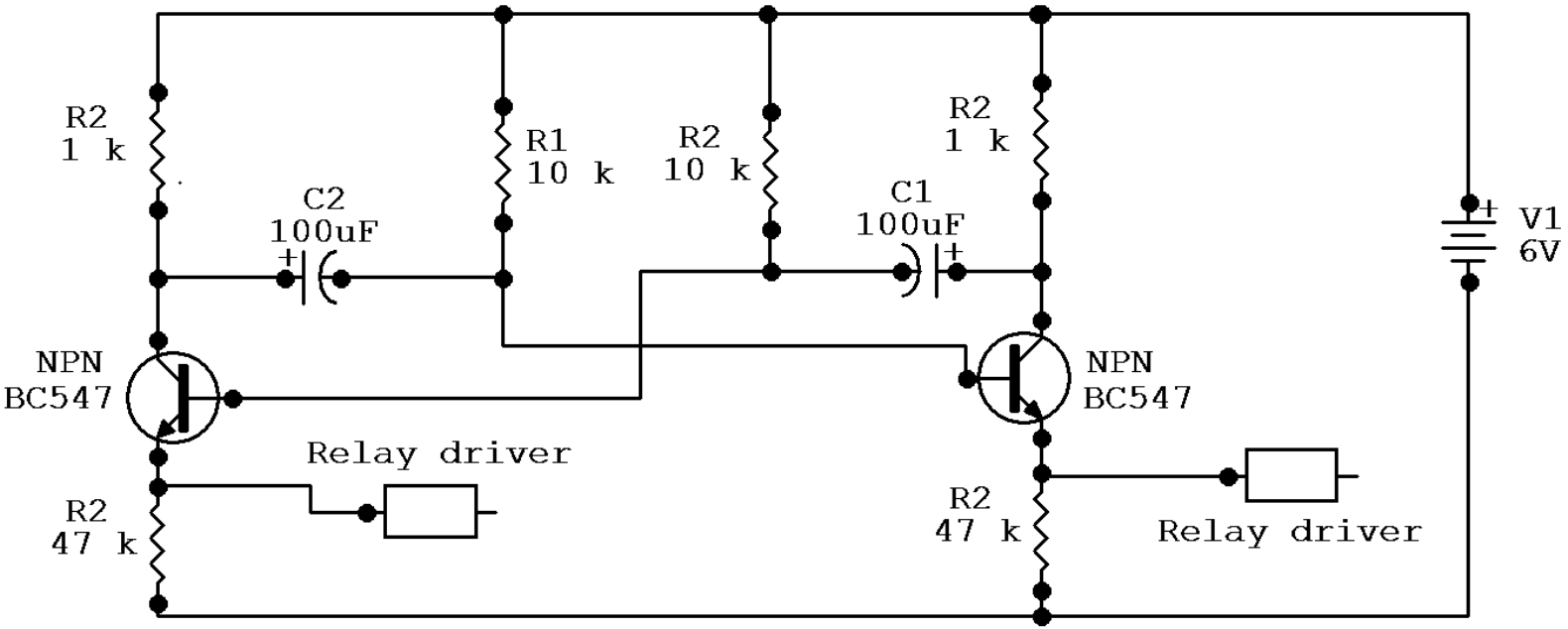
Lets start by making a very simple oscillator -



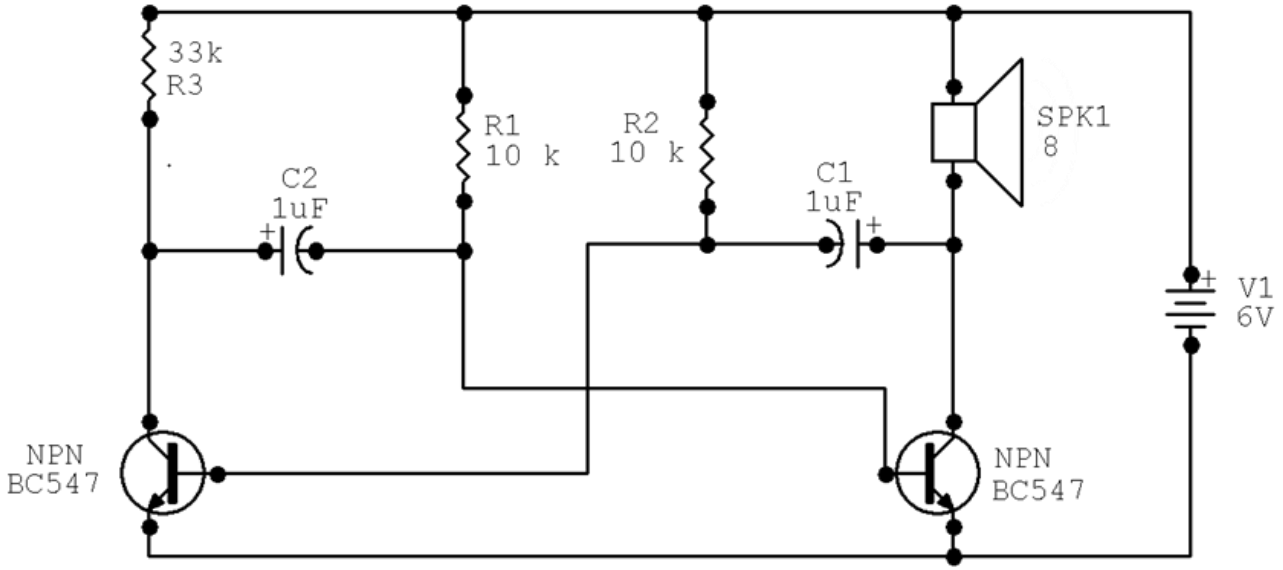
The above Resistor-capacitor based (RC oscillator) oscillator circuit is one of the simplest oscillator to design. There are various other forms of Oscillators like - Inductor-capacitor (LC) oscillators, Op-amp based oscillators etc. For now we will just discuss RC oscillators here. If you are curious 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 blinker, 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 blinker, A Diwali Lights blinker. You can see below a image showing how relays can transform a simple circuit into something that can be used with any appliance.



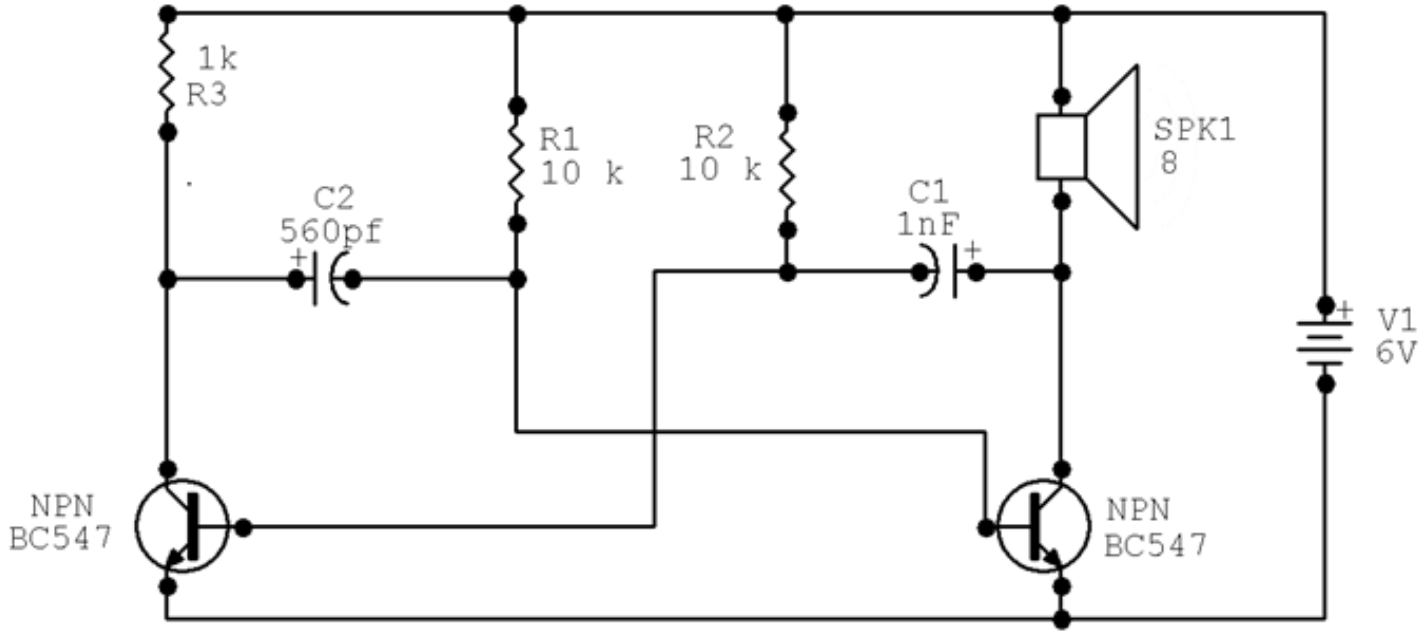
A bulb blinker



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

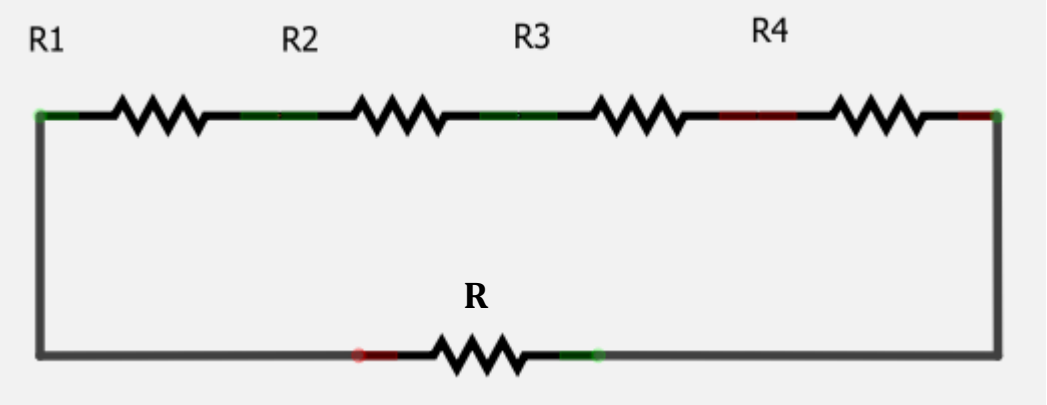
Its often needed to have a resistance with some odd and non standard value like— 5k. When you need such values its often easy to make it by combining the standard values like— 4.7kΩ + 220Ω + 68Ω = 4.988 kΩ which is approx equal to 5kΩ.
There are two ways to combine resistances

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 = R1+R2+R3+R4

Series combination = Increases Resistance



For Example Suppose—

R1 = 100Ω and R2 = 100Ω

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

R = R1 + R2
R = 100 + 100 = 200Ω

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 MΩ, we can make it by using four 1MΩ 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.

$$1/R = 1/R1 + 1/R2 + 1/R3 + 1/R4 ...$$

For two resistances—

$$1/R = 1/R1+1/R2$$
$$R = R1*R2/ (R1+R2)$$

For Example—

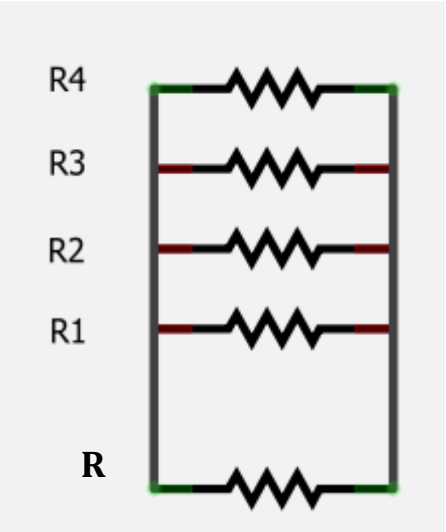
$$R1 = 100\Omega \text{ and } R2 = 100\Omega$$

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—

$$R = R1 + R2$$
$$R = 100 + 100 = 200\Omega$$



Parallel combination = Decreases Resistance

Appendix II

Capacitance Calculations

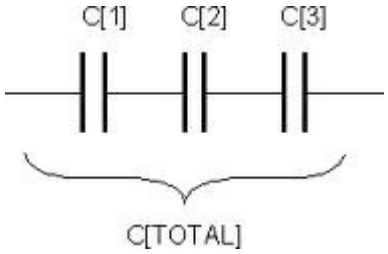
As like resistance, Its often needed to have a capacitor with some odd and non standard value like— 147µf. When you need such values its often easy to make it by combining the standard values like— 100µf + 47µf = 147µf.
There are two ways to combine capacitors and they methods are completely opposite 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 -

$$1/C = 1/C1+1/C2$$

Series combination = Decreases Capacitance



For Example Suppose—

C1 = 100µf and C2 = 100µf

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

$$1/C = 1/C1 + 1/C2$$
$$1/C = 1/100 + 1/100$$
$$1/C = 200/(100*100)$$
$$1/C = 2/100 = 1/50$$
$$C = 50\mu f$$

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 = C1 + C2 + C3

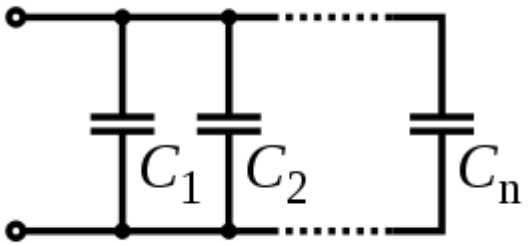
For Example—

C1 = 100µf and C2 = 100µf

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

C = 100 + 100

C = 200 µf



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

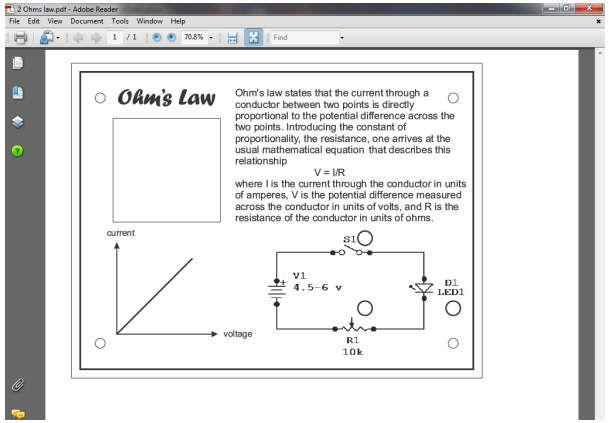
uf,microFarads $=10^6$ Farads	nf,nanoFarads $=10^9$ Farads	pf,picoFarads $=10^{12}$Farads	Multiplier used Exemple = .01uF = 103
0.000001uf=	0.001nf=	1pf	(1)
0.00001uf=	0.01nf=	10pf	(10)
0.0001uf=	0.1nf=	100pf	(101)
0.001uf=	1nf=	1000pf	(102)
0.01uf=	10nf=	10000pf	(103)
0.1uf=	100nf=	100000pf	(104)
1.uf=	1000nf=	1000000pf	(105)
100uf	100000nf=	10000000pf	———

Appendix III

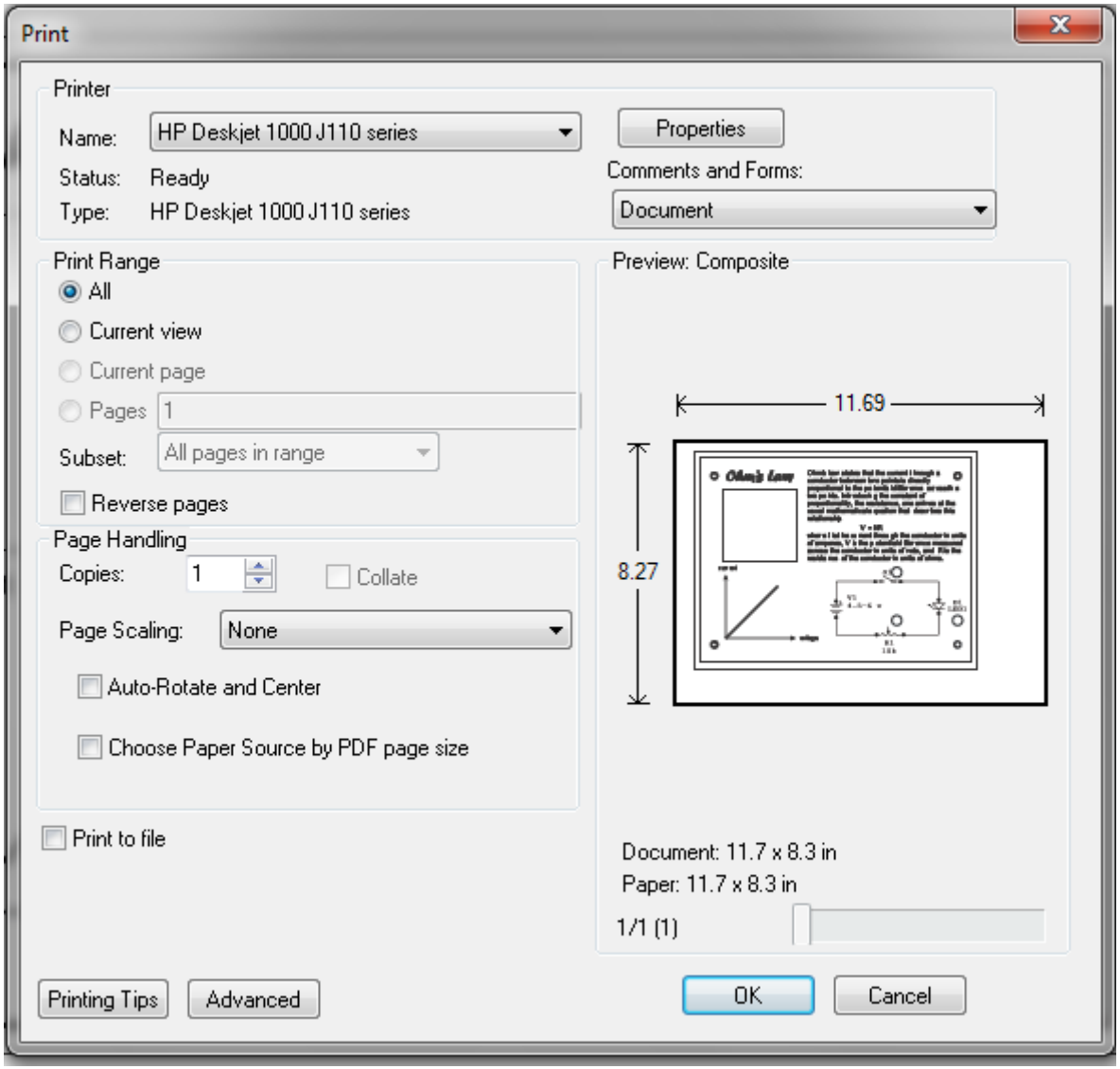
Working with Paper Panels

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.

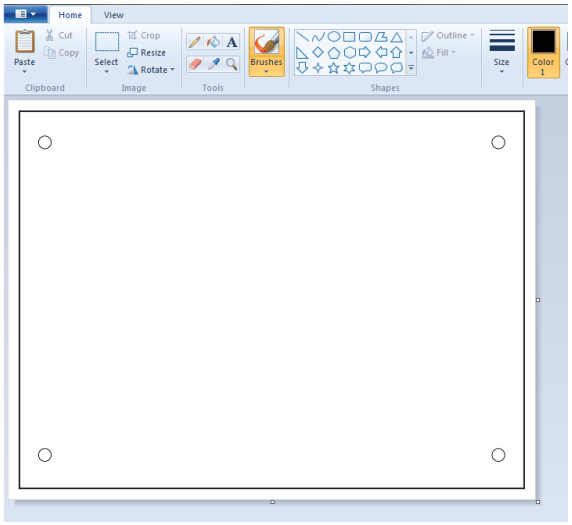


Making Your Own Paper Panel

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 cock pit 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.



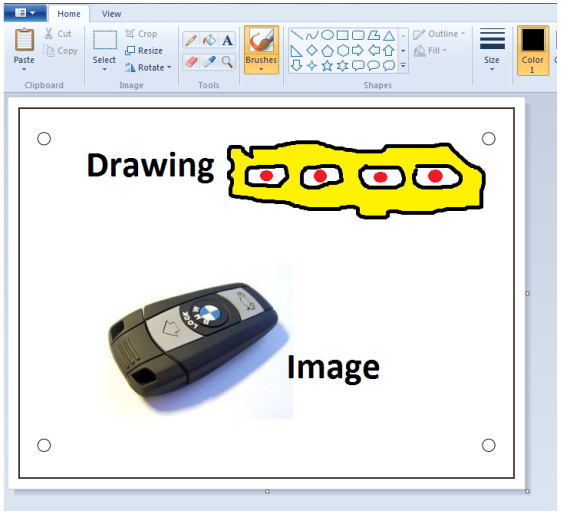
Empty Panel Drawing opened in Microsoft Paint Software

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



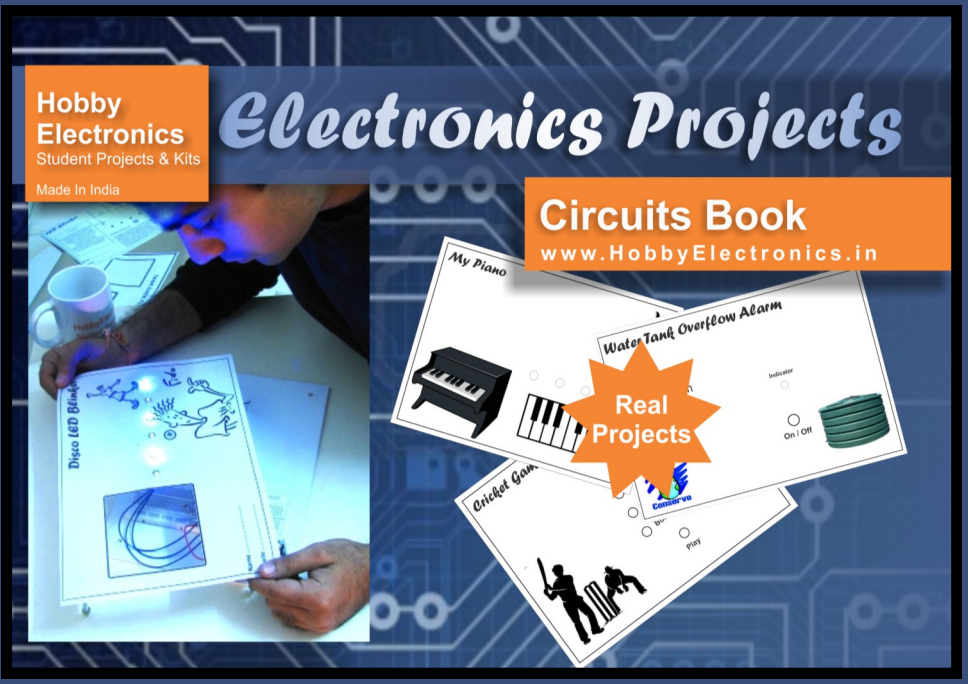
After Drawing

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—
www.hobbyelectronics.in
and a photography Blog—
www.myphototrips.wordpress.com
This is his first book, You can contact him for any query or suggestion at : vanarova@gmail.com