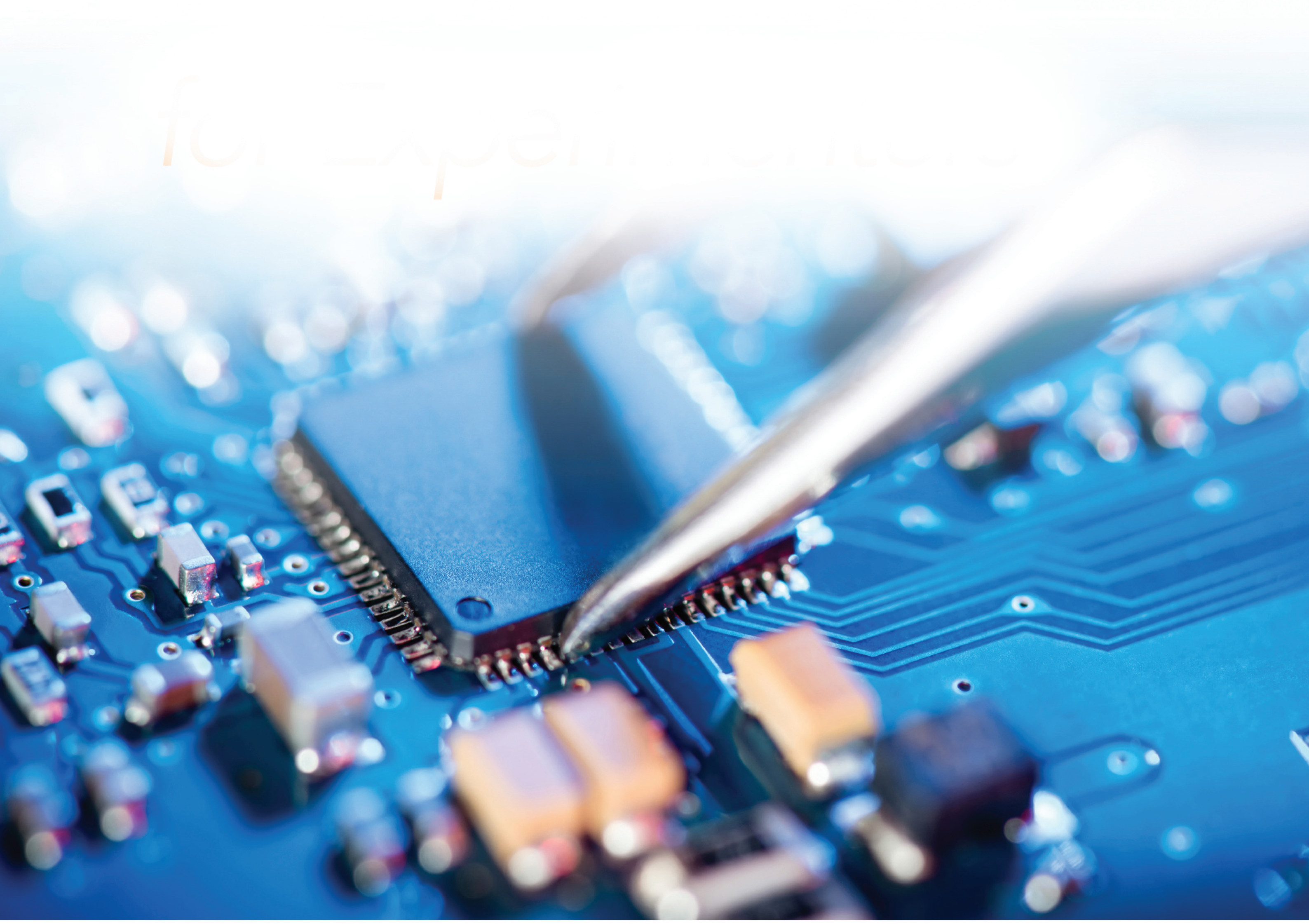
VOLUME - V

ELECTRONICS



ROBOTROD

by Olatus Systems Private Limited

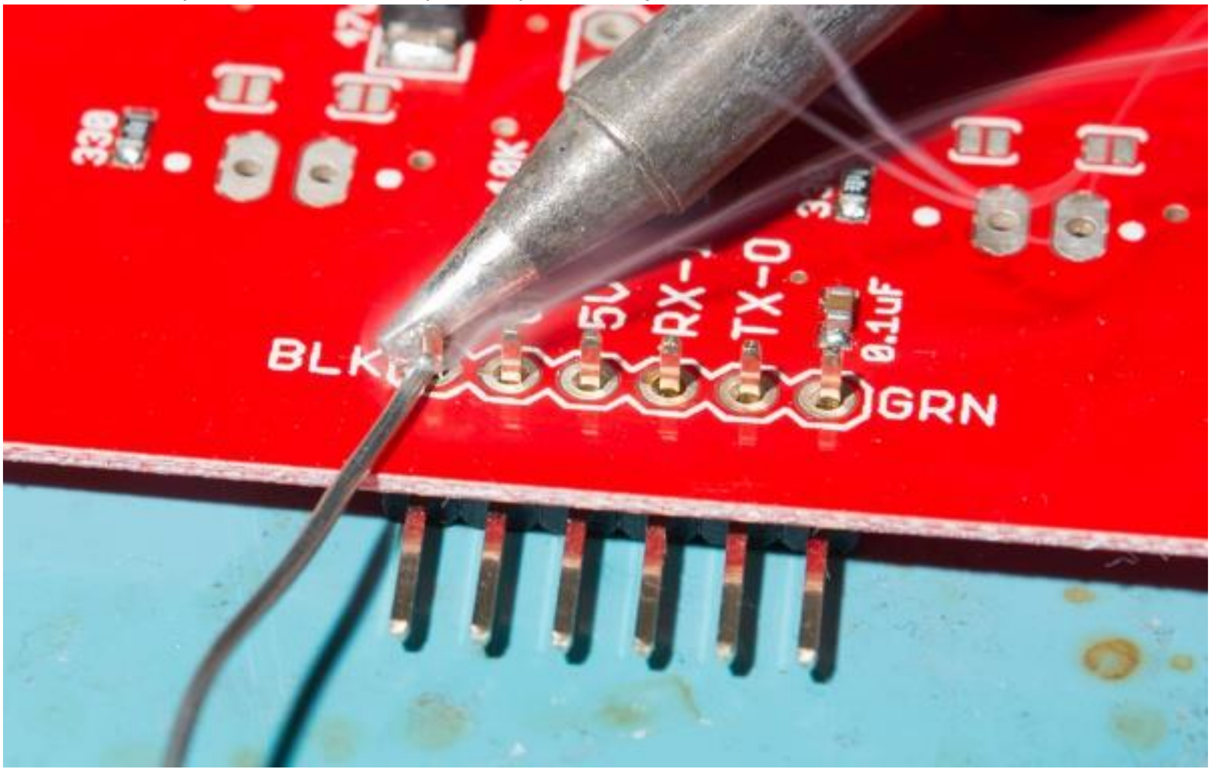
Contents

5.5 Dark Sensor Using Ldr

CHAPTER 1: PRINTED CIRCUIT BOARD USING SOLDERING

INTRODUCTION

Soldering is one of the most fundamental skills needed to dabble in the world of electronics. The two go together like peas and carrots. And, although it is possible to learn about and build electronics without needing to pick up a soldering iron, you'll soon discover that a whole new world is opened with this one simple skill. In a world of increasing technological surroundings, we believe it is important that people everywhere is able to not only understand the technologies they use every day but also be able to build, alter, and fix them as well. Soldering is one of many skills that will empower you to do just that.



What is Solder?

Before learning how to solder, it's always wise to learn a little bit about solder, its history, and the terminology that will be used while discussing it.

Solder, as a word, can be used in two different ways. Solder, *the noun*, refers to the alloy (a substance composed of two or more metals) that typically comes as a long, thin wire in spools or tubes. Solder, *the verb*, means to join together two pieces of metal in what is called a **solder joint**. So, we solder with solder!

Solder wire sold as a spool (left) and in a tube (right). These come in both leaded and lead-free varieties.

LEADED vs. LEAD- FREE SOLDER

One of the most important things to be aware of when it comes to solder is that, traditionally, solder was composed of mostly lead (Pb), tin (Sn), and a few other trace metals. This solder is known as **leaded solder**. As it has come to be known, lead is harmful to humans and can lead to lead poisoning when exposed to large amounts. Unfortunately, lead is also a very useful metal, and it was chosen as the go-to metal for soldering because of its low melting point and ability to create great solder joints.

With the adverse effects of leaded soldering known, some key individuals and countries decided it was best to not use leaded solder anymore. With that, the use of **lead-free solder** became the norm in electronics manufacturing.

Lead-free solder is very similar to its leaded counterpart, except, as the name states, it contains no lead. Instead is made up of mostly tin and other trace metals, such as silver and copper.

SOLDERING IRONS

There are many tools that aid in soldering, but none are more important than the soldering iron. If nothing else, you need at least an iron and some solder to accomplish the task at hand. Soldering irons come in a variety of from factors and range from simple to complex, but they all function roughly the same. Here, we'll discuss the parts of an iron and the different types of irons.

SOLDERING IRON ANATOMY

Here are the basic parts that make up a soldering iron.

- Soldering Tips - No iron is complete without an iron tip. The tip is the part of the iron that heats up and allows solder to flow around the two components being joined. Although solder will stick to the tip when applied, a common misconception is that the tip transfers the solder. The tip actually transfers heat, raising the temperature of the metal components to the melting point of the solder, and the solder melts accordingly. Most irons give you the option to change your tip, should you need to replace

  Several types of tips. From left to right, the bevel tip (aka hoof tip), two conical tips with varying widths, and the chisel tip. An old tip or if you need to switch to a different style of tip. Tips come in a variety of sizes and shapes to accommodate any component.

  Changing the tip is a simple process that consists of either unscrewing the wand or simply pushing in and pulling out the tip

- Wand - The wand is the part of the iron that holds the tip. This is also the part that is handled by the user. Wands are usually made of a variety of insulating materials (such as rubber) to prevent the heat of the tip from transferring to the outside of the wand, but they also house wires and metal contacts that transfer heat from the base or outlet to the tip. This dual role of heating and preventing burns makes a high quality wand much appreciated.

  Two varieties of wands. Notice how the tips screw into the wand allowing for interchangeability. Some wands have tips that simply push in and pull out without any attaching mechanism.

  Some irons consist of just a wand that plugs into a wall outlet. These irons are as simple as they come, and they do not have any controls to vary the temperature. In these irons, the heating element is built directly into the wand.

- Base - The base of the soldering iron is the control box that allows the adjusting of temperatures. The wand attaches to the base and receives its heat from the electronics inside. There are analog bases, which have a dial that controls the temperature, and there are digital bases, which have buttons to set the temperature and a display that tells you the current temperature. Some bases even have extra features such as heat profiles that allow you to quickly change the amount of heat provided to the tip for soldering a variety of components.

  The base typically is comprised of some large transformer and several other control electronics that safely allow you to vary the heat of your tip.

  The insides of a soldering iron base

- Stand (Cradle) - The iron stand (often referred to as a cradle) is what houses the iron when it is not in use. The stand may seem trivial, but leaving an unattended iron laying around on your desk or workbench is a potential hazard: it could burn you, or, worse, it could burn your desk and start a fire. Again, they can be as simple as a metal stand, or they can be complex, offering an auto-shutoff feature that reduces the temperature of the tip when the wand is placed in the cradle. This helps prevent the wearing of your tip over time.

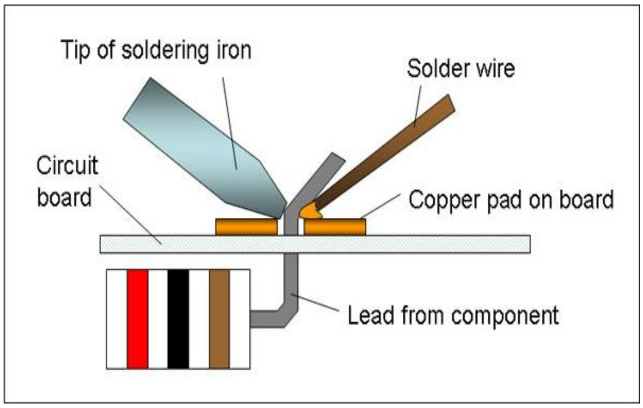
Different types of iron cradles. Notice some allow for a regular sponge while others hold a brass sponge.

- Brass Sponge - As you solder, your tip will tend to **oxidize**, which means it will turn black and not want to accept solder. Especially with lead-free solder, there are impurities in the solder that tend to build up on the tip of your iron, which causes this oxidization. This is where the sponge comes in. Every so often you should give your tip a good cleaning by wiping off this build-up. Traditionally, an actual wet sponge was used to accomplish this. However, using a wet sponge can drastically reduce the lifespan of your tip. By wiping your tip on a cool, wet sponge, the tip tends to expand and contract from the change in temperature. This expansion and contraction will wear out your tip and can sometime cause a hole to develop in the side of the tip. Once a tip has a hole, it is no good for soldering. Thus, brass sponges have become the standard for tip cleaning. Brass sponges pull the excess solder from your tip while allowing the tip to maintain its current heat level. If you do not have a brass sponge, a regular sponge is better than nothing.

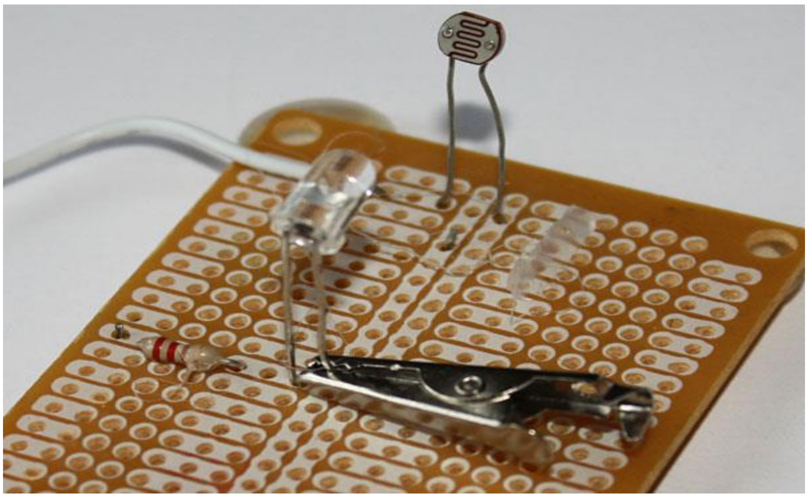
- Soldering
  1. Solder needs a clean surface on which to adhere.
     - Buff the copper foil of a PC board with steel wool before soldering.
     - Remove any oil, paint, wax, etc. with a solvent, steel wool, or fine sandpaper.

  2. To solder, heat the connection with the tip of the soldering iron for a few seconds, then apply the solder.

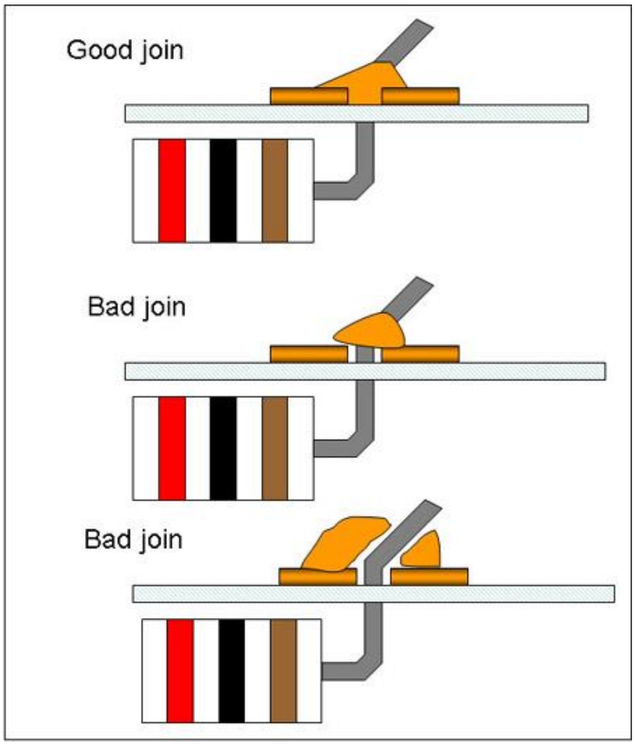
- Heat the connection, *not* the solder.
- Hold the soldering iron like a pen, near the base of the handle.
- Both parts that are being soldered have to be hot to form a good connection.



3. Keep the soldering tip on the connection as the solder is applied.
    - Solder will flow into and around well-heated connections.
    - Use just enough solder to form a strong connection.
4. Remove the tip from the connection as soon as the solder has flowed where you want it to be. Remove the solder, then the iron.
5. Don't move the connection while the solder is cooling.
6. Don't overheat the connection, as this might damage the electrical component you are soldering.
    - Transistors and some other components can be damaged by heat when soldering. A crocodile clip can be used as a heat sink to protect these components.



7. Soldering a connection should take just a few seconds.
    - Inspect the joint closely. It should look shiny.
    - If you are soldering a wire (called the *lead*) onto a PC board (on the *track*), it should have a volcano shape. See Figure 3.
    - If the connection looks bad, reheat it and try again.

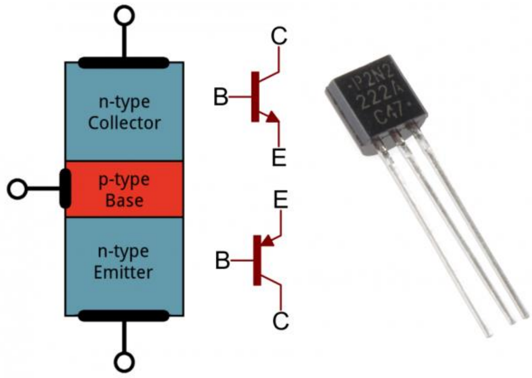


CHAPTER 2: TRANSISTORS

INTRODUCTION

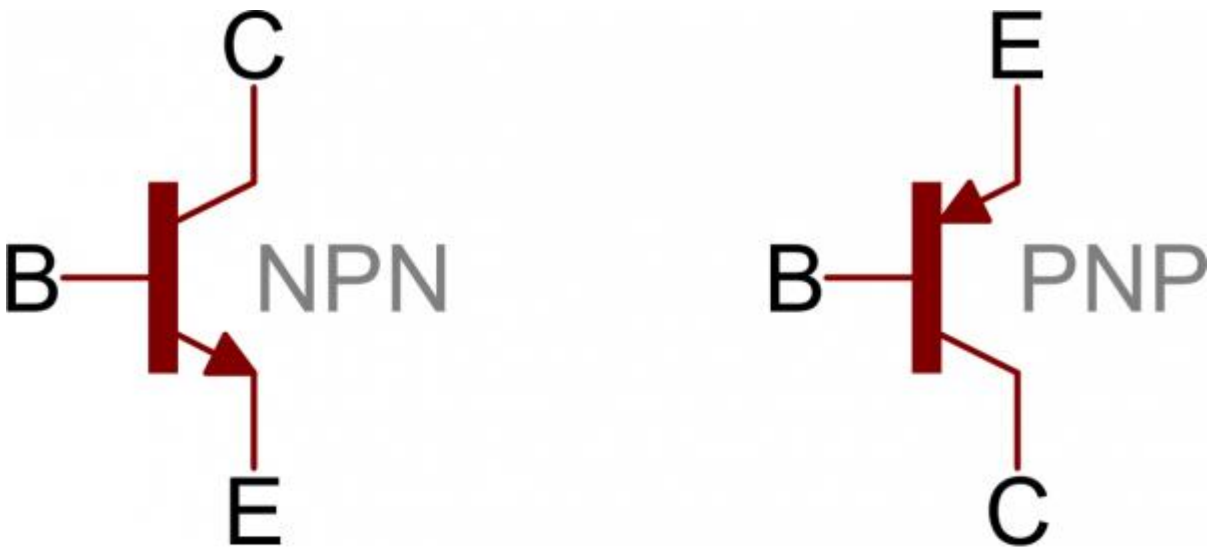
Transistors make our electronics world go 'round. They're critical as a control source in just about every modern circuit. Sometimes you see them, but more-often-than-not they're hidden deep within the die of an integrated circuit. In this tutorial we'll introduce you to the basics of the most common transistor around: the bi-polar junction transistor (BJT).

In small, discrete quantities, transistors can be used to create simple electronic switches, digital logic, and signal amplifying circuits. In quantities of thousands, millions, and even billions, transistors are interconnected and embedded into tiny chips to create computer memories, microprocessors, and other complex ICs.



SYMBOLS, PINS AND CONSTRUCTION

Transistors are fundamentally three-terminal devices. On a bi-polar junction transistor (BJT), those pins are labeled **collector** (C), **base** (B), and **emitter** (E). The circuit symbols for both the NPN and PNP BJT are below:



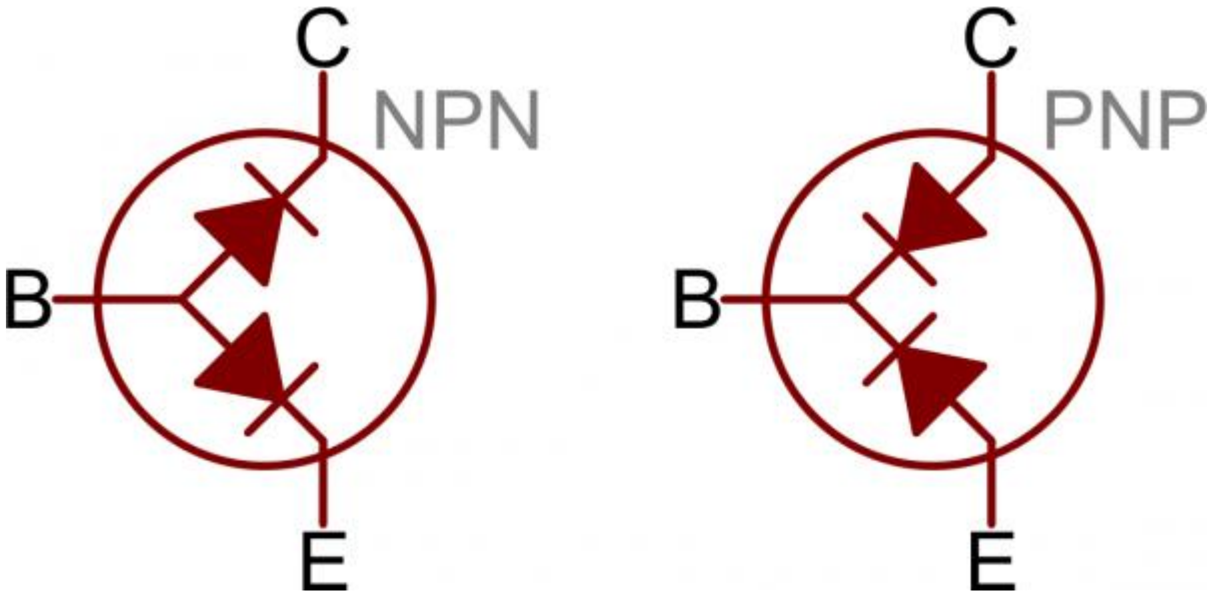
The only difference between an NPN and PNP is the direction of the arrow on the emitter. The arrow on an NPN points out, and on the PNP it points in.

TRANSISTORS CONSTRUCTION

Transistors rely on semiconductors to work their magic. A semiconductor is a material that's not quite a pure conductor (like copper wire) but also not an insulator (like air). The conductivity of a semiconductor – how easily it allows electrons to flow – depends on variables like temperature or the presence of more or less electrons.

A Transistor as Two Diodes

Transistors are kind of like an extension of another semiconductor component: diodes. In a way transistor are just two diodes with their cathodes (or anodes) tied together:



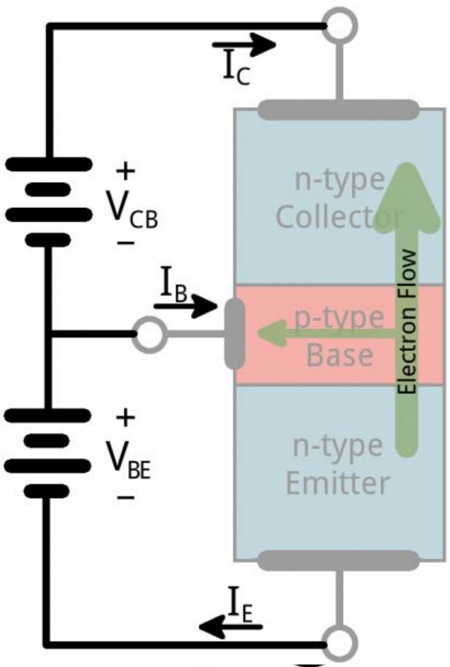
The diode connecting base to emitter is the important one here; it matches the direction of the arrow on the schematic symbol, and shows you which way current is intended to flow through the transistor.

The diode representation is a good place to start, but it's far from accurate. Don't base your understanding of a transistor's operation on that model (and definitely don't try to replicate it on a breadboard, it won't work). There's a whole lot of weird quantum physics level stuff controlling the interactions between the three terminals.

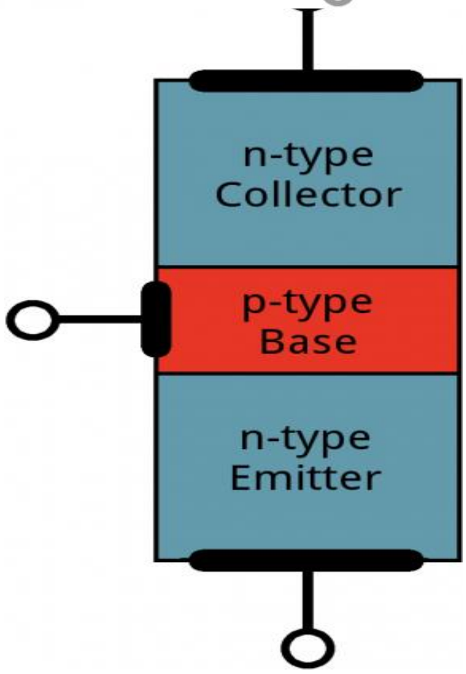
TRANSISTOR STRUCTURE AND OPERATION

Transistors are built by stacking three different layers of semiconductor material together. Some of those layers have extra electrons added to them (a process called "doping"), and others have electrons removed (doped with "holes" – the absence of electrons). A semiconductor material with *extra* electrons is called an **n-type** (*n* for negative because electrons have a negative charge) and a material with electrons removed is called a **p-type** (for positive). Transistors are created by either stacking an *n* on top of a *p* on top of an *n*, or *p* over *n* over *p*.

With some hand waving, we can say electrons can easily flow from *n* regions to *p* regions, as long as they have a little force (voltage) to push them. But flowing from a *p* region to an *n* region is really hard (requires a *lot* of voltage). But the special thing about a transistor – the part that makes our two-diode model obsolete – is the fact that electrons *can* easily flow from the p-type base to the n-type collector as long as the base-emitter junction is forward biased (meaning the base is at a higher voltage than the emitter).



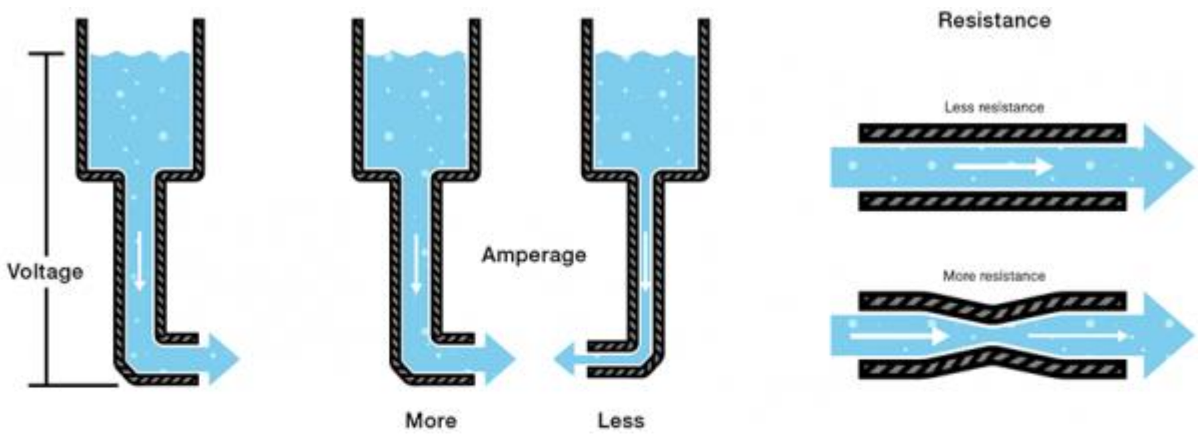
The NPN transistor is designed to pass electrons from the emitter to the collector (so conventional current flows from collector to emitter). The emitter “emits” electrons into the base, which controls the number of electrons the emitter emits. Most of the electrons emitted are “collected” by the collector, which sends them along to the next part of the circuit.



A PNP works in a same but opposite fashion. The base still controls current flow, but that current flows in the opposite direction – from emitter to collector. Instead of electrons, the emitter emits “holes” (a conceptual absence of electrons) which are collected by the collector

WATER ANALOGY

We say that current is analogous to the flow rate of water, voltage is the pressure pushing that water through a pipe, and resistance is the width of the pipe.

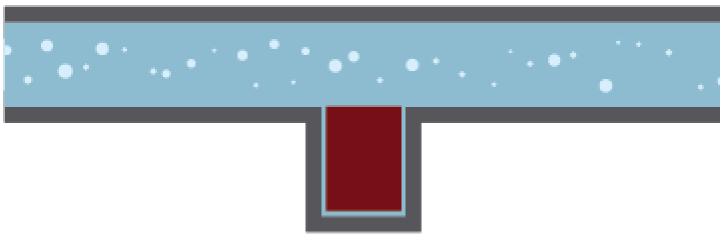


Unsurprisingly, the water analogy can be extended to transistors as well: a transistor is like a water valve – a mechanism we can use to control the flow rate.

There are three states we can use a valve in, each of which has a different effect on the flow rate in a system.

1) On – Short Circuit

A valve can be completely opened, allowing water to flow freely – passing through as if the valve wasn't even present.



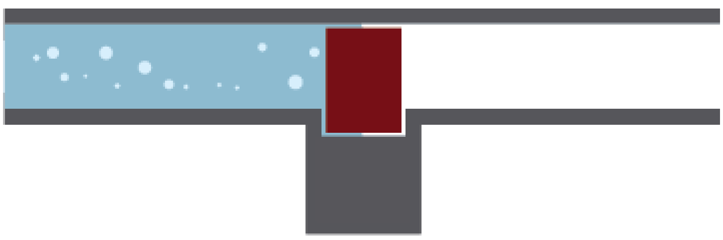
Transistor On

Likewise, under the right circumstances, a transistor can look like a **short circuit** between the collector and emitter pins. Current is free to flow through the collector, and out the emitter.

2) Off – Open Circuit

When it's closed, a valve can completely **stop the flow** of water.

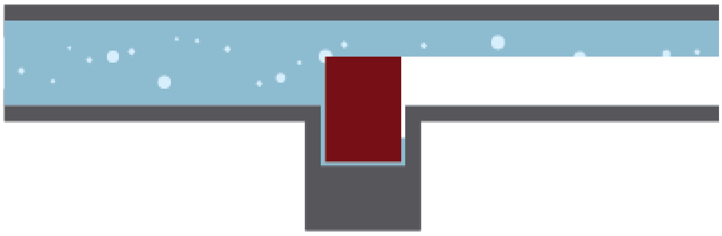
In the same way, a transistor can be used to create an **open circuit** between the collector and emitter pins.



Transistor Off

3) Linear Flow Control

With some precise tuning, a valve can be adjusted to finely control the flow rate to some point between fully open and closed.



Flow Control

A transistor can do the same thing – linearly controlling the current through a circuit at some point between fully off (an open circuit) and fully on (a short circuit).

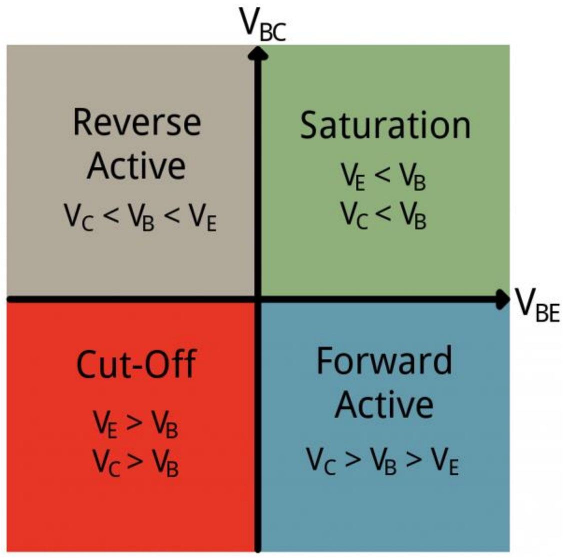
From our water analogy, the width of a pipe is similar to the resistance in a circuit. If a valve can finely adjust the width of a pipe, then a transistor can finely adjust the resistance between collector and emitter. So, in a way, a transistor is like a variable, adjustable resistor.

OPERATION MODES

Unlike resistors, which enforce a linear relationship between voltage and current, transistors are non-linear devices. They have four distinct modes of operation, which describe the current flowing through them. (When we talk about current flow through a transistor, we usually mean current flowing from collector to emitter of an NPN.)

The four transistor operation modes are:

- Saturation – The transistor acts like a short circuit. Current freely flows from collector to emitter.
- Cut-off – The transistor acts like an open circuit. No current flows from collector to emitter.
- Active – The current from collector to emitter is proportional to the current flowing into the base.



To determine which mode a transistor is in, we need to look at the voltages on each of the three pins, and how they relate to each other. The voltages from base to emitter (V_{BE}), and the from base to collector (V_{BC}) set the transistor's mode:

The simplified quadrant graph above shows how positive and negative voltages at those terminals affect the mode. In reality it's a bit more complicated than that.

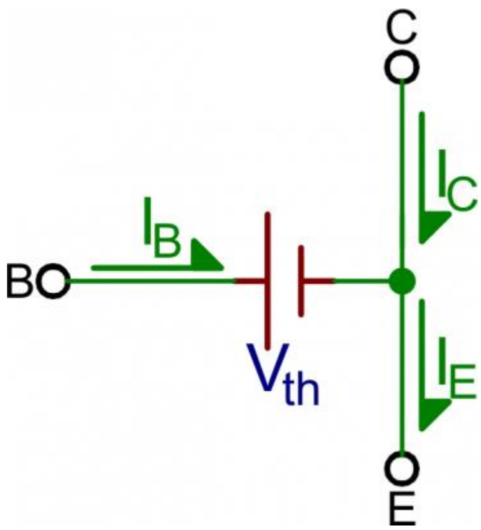
Let's look at all four transistor modes individually; we'll investigate how to put the device into that mode, and what effect it has on current flow.

SATURATION MODE

Saturation is the on mode of a transistor. A transistor in saturation mode acts like a short circuit between collector and emitter.

In saturation mode both of the "diodes" in the transistor are forward biased. That means V_{BE} must be greater than 0, *and* so must V_{BC}. In other words, V_B must be higher than both V_E and V_C.

$$V_B > V_C$$
$$V_B > V_E$$

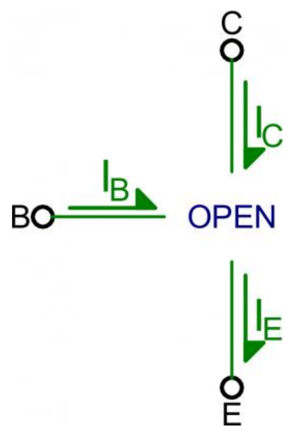


Because the junction from base to emitter looks just like a diode, in reality, V_{BE} must be greater than a threshold voltage to enter saturation. There are many abbreviations for this voltage drop – V_{th}, V_{γ}, and V_d are a few – and the actual value varies between transistors (and even further by temperature). For a lot of transistors (at room temperature) we can estimate this drop to be about 0.6V.

Another reality bummer: there won't be perfect conduction between emitter and collector. A small voltage drop will form between those nodes. Transistor datasheets will define this voltage as CE saturation voltage $V_{CE(sat)}$ – a voltage from collector to emitter required for saturation. This value is usually around 0.05-0.2V. This value means that V_C must be slightly greater than V_E (but both still less than V_B) to get the transistor in saturation mode.

CUTOFF MODE

Cutoff mode is the opposite of saturation. A transistor in cutoff mode is off – there is no collector current, and therefore no emitter current. It almost looks like an open circuit.



To get a transistor into cutoff mode, the base voltage must be less than both the emitter and collector voltages. V_{BC} and V_{BE} must both be negative.

$$V_C > V_B$$
$$V_E > V_B$$

In reality, V_{BE} can be anywhere between 0V and V_{th} (~0.6V) to achieve cutoff mode.

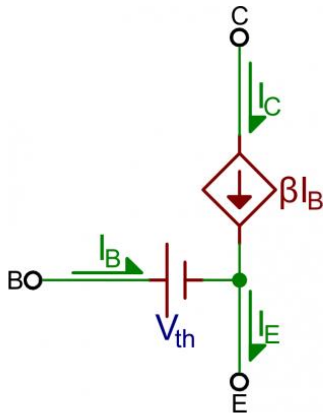
ACTIVE MODE

To operate in active mode, a transistor's V_{BE} must be greater than zero and V_{BC} must be negative. Thus, the base voltage must be less than the collector, but greater than the emitter. That also means the collector must be greater than the emitter.

$$V_C > V_B > V_E$$

In reality, we need a non-zero forward voltage drop (abbreviated either V_{th}, V_{γ}, or V_d) from base to emitter (V_{BE}) to "turn on" the transistor. Usually this voltage is usually around 0.6V.

AMPLIFYING IN ACTIVE MODE



Active mode is the most powerful mode of the transistor because it turns the device into an **amplifier**. Current going into the base pin amplifies current going into the collector and out the emitter.

Our shorthand notation for the **gain** (amplification factor) of a transistor is *β* (you may also see it as β_F, or h_{FE}). β linearly relates the collector current (I_C) to the base current (I_B):

$$I_C = \beta I_B$$

The actual value of *β* varies by transistor. It's usually **around 100**, but can range from 50 to 200…even 2000, depending on which transistor you're using and how much current is running through it. If your transistor had a β of 100, for example, that'd mean an input current of 1mA into the base could produce 100mA current through the collector.

Active mode model. $V_{BE} = V_{th}$, *and* $I_C = \beta I_B$.

What about the emitter current, I_E? In active mode, the collector and base currents go *into* the device, and the I_E comes out. To relate the emitter current to collector current, we have another constant value: **α**. α is the common-base current gain, it relates those currents as such:

$$I_C = \alpha I_E$$

α is usually *very* close to, but less than, 1. That means ***I_C* is very close to, but less than *I_E*** in active mode.

You can use β to calculate α, or vice-versa:

$$\beta = \frac{\alpha}{(1-\alpha)}$$
$$\alpha = \frac{\beta}{\beta+1}$$

If β is 100, for example, that means α is 0.99. So, if I_C is 100mA, for example, then I_E is 101mA.

RELATING TO PNP

After everything we've talked about on this page, we've still only covered half of the BJT spectrum. What about PNP transistors? PNP's work a lot like the NPN's – they have the same four modes – but everything is turned around. To find out which mode a PNP transistor is in, reverse all of the < and > signs.

For example, to put a PNP into saturation V_C and V_E must be higher than V_B. You pull the base low to turn the PNP on, and make it higher than the collector and emitter to turn it off. And, to put a PNP into active mode, V_E must be at a higher voltage than V_B, which must be higher than V_C.

IN SUMMARY

Another opposing characteristic of the NPNs and PNPs is the direction of current flow. In active and saturation modes, **current in PNP flows from emitter to collector**. This means the emitter must generally be at a higher voltage than the collector

Voltage relations	**NPN Mode**	**PNP Mode**
$V_E < V_B < V_C$	Active	Reverse
$V_E < V_B > V_C$	Saturation	Cutoff
$V_E > V_B < V_C$	Cutoff	Saturation
$V_E > V_B > V_C$	Reverse	Active

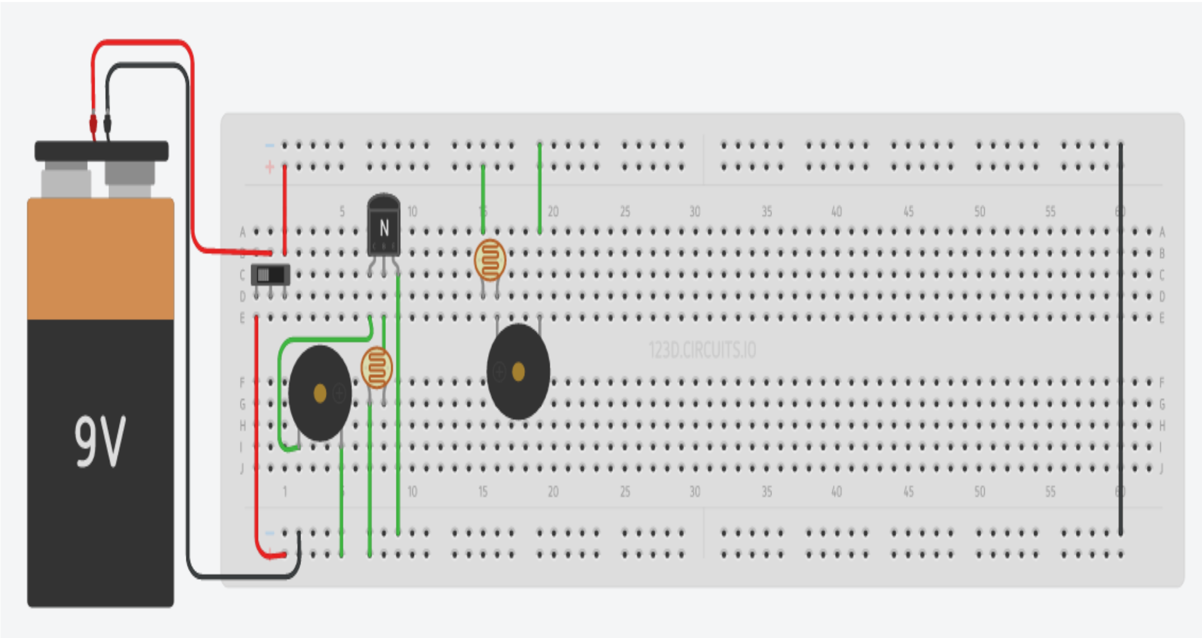
APPLICATIONS

- **Transistor switch**
- **Gates(AN, OR, NOT etc)**
- **H-Bridge**
- **Oscillators**
- **Amplifiers**
- **Multistage Amplifiers**

ACTIVITY

Make a circuit to demonstrate working of a transistor as an amplifier.

Circuit Diagram



Material Required

Breadboard	**1**
Battery 9V	**1**
Buzzer	**1**
LDR	**1**
NPN Transistor	**1**

Instructions

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Connect the battery to the circuit.
- Now Slide the switch to the position 1 and then to position 2.
- Record your observations.

Observation Table

Position of switch	Intensity of sound produced
1	
2	

In which configuration the intensity of sound produced by buzzer is more, providing that you are in a relatively dark room and why?

____
____
____
____

In which state does the transistor is working in this circuit?

____
____
____
____

Can we replace the NPN with PNP transistor?

____
____
____
____

CHAPTER 3:TRANSISTOR AS A SWITCH

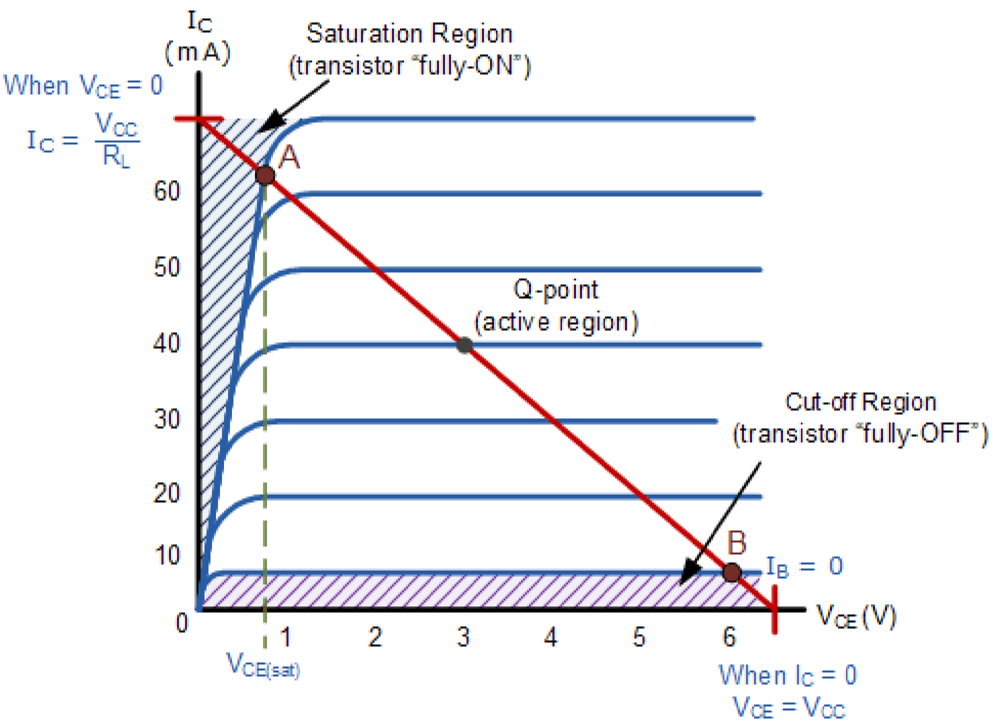
Both the NPN & PNP type bipolar transistors can be made to operate as “ON/OFF” type solid state switch by biasing the transistors Base terminal differently to that for a signal amplifier.

Solid state switches are one of the main applications for the use of transistor to switch a DC output “ON” or “OFF”. Some output devices, such as LED’s only require a few milliamps at logic level DC voltages and can therefore be driven directly by the output of a logic gate. However, high power devices such as motors, solenoids or lamps, often require more power than that supplied by an ordinary logic gate so transistor switches are used.

If the circuit uses the **Bipolar Transistor as a Switch**, then the biasing of the transistor, either NPN or PNP is arranged to operate the transistor at both sides of the “I-V” characteristics curves we have seen previously.

The areas of operation for a transistor switch are known as the **Saturation Region** and the **Cut-off Region**. This means then that we can ignore the operating Q-point biasing and voltage divider circuitry required for amplification, and use the transistor as a switch by driving it back and forth between its “fully-OFF” (cut-off) and “fully-ON” (saturation) regions as shown below.

OPERATING REGIONS

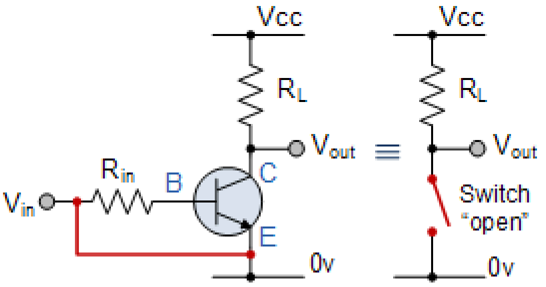


The pink shaded area at the bottom of the curves represents the “Cut-off” region while the blue area to the left represents the “Saturation” region of the transistor. Both these transistor regions are defined as:

1. Cut-off Region

Here the operating conditions of the transistor are zero input base current (I_B), zero output collector current (I_C) and maximum collector voltage (V_{CE}) which results in a large depletion layer and no current flowing through the device. Therefore the transistor is switched “Fully-OFF”.

CUT-OFF CHARACTERSTICS

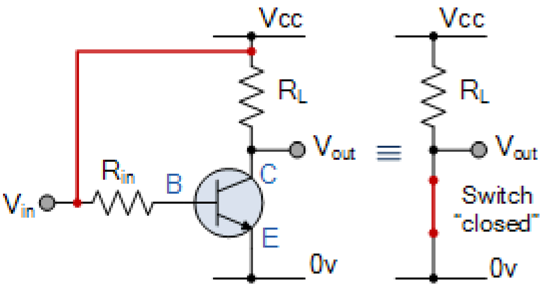
	• • The input and Base are grounded (0v) • • Base-Emitter voltage V_{BE} < 0.7v • • Base-Emitter junction is reverse biased • • Base-Collector junction is reverse biased • • Transistor is “fully-OFF” (Cut-off region) • • No Collector current flows ($I_C = 0$) • • $V_{OUT} = V_{CE} = V_{CC}$ = ”1” • • Transistor operates as an “open switch”

Then we can define the “cut-off region” or “OFF mode” when using a bipolar transistor as a switch as being, both junctions reverse biased, V_B < 0.7v and I_C = 0. For a PNP transistor, the Emitter potential must be negative with respect to the Base.

2. Saturation Region

Here the transistor will be biased so that the maximum amount of base current is applied, resulting in maximum collector current resulting in the minimum collector emitter voltage drop which results in the depletion layer being as small as possible and maximum current flowing through the transistor. Therefore the transistor is switched “Fully-ON”.

SATURATION CHARACTERSTICS



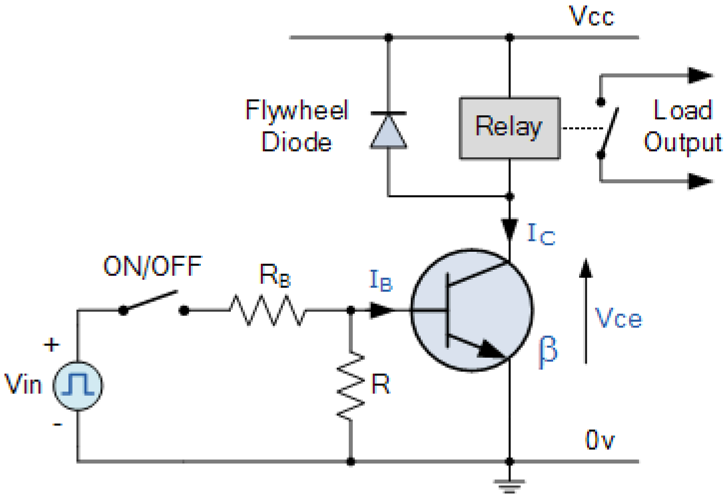
- • The input and Base are connected to V_{CC}
- • Base-Emitter voltage $V_{BE} > 0.7v$
- • Base-Emitter junction is forward biased
- • Base-Collector junction is forward biased
- • Transistor is "fully-ON" (saturation region)
- • Max Collector current flows ($I_C = Vcc/R_L$)
- • $V_{CE} = 0$ (ideal saturation)
- • $V_{OUT} = V_{CE}$ = "0"
- • Transistor operates as a "closed switch"

Then we can define the "saturation region" or "ON mode" when using a bipolar transistor as a switch as being, both junctions forward biased, $V_B > 0.7v$ and I_C = Maximum. For a PNP transistor, the Emitter potential must be positive with respect to the Base.

Then the transistor operates as a "single-pole single-throw" (SPST) solid state switch. With a zero signal applied to the Base of the transistor it turns "OFF" acting like an open switch and zero collector current flows. With a positive signal applied to the Base of the transistor it turns "ON" acting like a closed switch and maximum circuit current flows through the device.

The simplest way to switch moderate to high amounts of power is to use the transistor with an open-collector output and the transistors Emitter terminal connected directly to ground. When used in this way, the transistors open collector output can thus "sink" an externally supplied voltage to ground thereby controlling any connected load.

BASIC NPN TRANSISTOR SWITCHING SWITCH



The circuit resembles that of the *Common Emitter* circuit we looked at in the previous tutorials. The difference this time is that to operate the transistor as a switch the transistor needs to be turned either fully "OFF" (cut-off) or fully "ON" (saturated). An ideal transistor switch would have infinite circuit resistance between the Collector and Emitter when turned "fully-OFF" resulting in zero current flowing through it and zero resistance between the Collector and Emitter when turned "fully-ON", resulting in maximum current flow.

In practice when the transistor is turned "OFF", small leakage currents flow through the transistor and when fully "ON" the device has a low resistance value causing a small saturation voltage (V_{CE}) across it. Even though the transistor is not a perfect switch, in both the cut-off and saturation regions the power dissipated by the transistor is at its minimum.

In order for the Base current to flow, the Base input terminal must be made more positive than the Emitter by increasing it above the 0.7 volts needed for a silicon device. By varying this Base-Emitter voltage V_{BE}, the Base current is also altered and which in turn controls the amount of Collector current flowing through the transistor as previously discussed.

When maximum Collector current flows the transistor is said to be **saturated**. The value of the Base resistor determines how much input voltage is required and corresponding Base current to switch the transistor fully "ON".

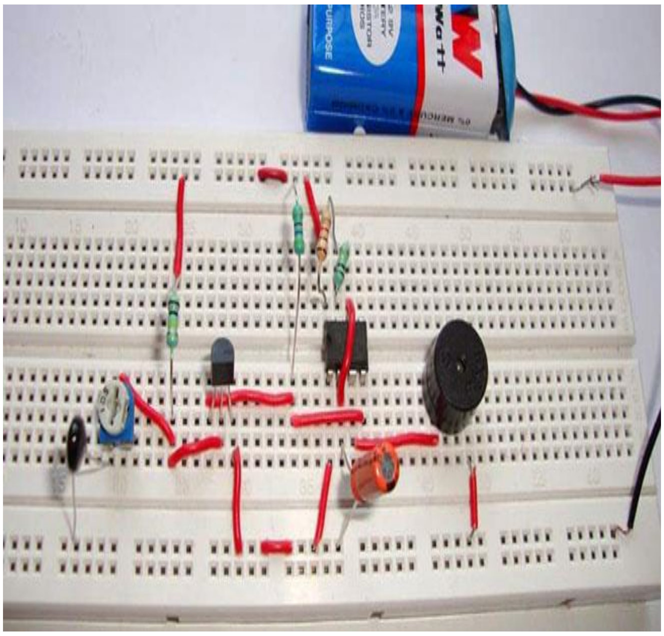
TRANSISTOR AS A SWITCH SUMMARY

Then to summaries when using a **Transistor as a Switch** the following conditions apply:

- Transistor switches can be used to switch and control lamps, relays or even motors.
- When using the bipolar transistor as a switch they must be either "fully-OFF" or "fully-ON".
- Transistors that are fully "ON" are said to be in their **Saturation** region.
- Transistors that are fully "OFF" are said to be in their **Cut-off** region.

CHAPTER 4: FIRE ALARM CIRCUIT

INTRODUCTION TO FIRE ALARM CIRCUIT

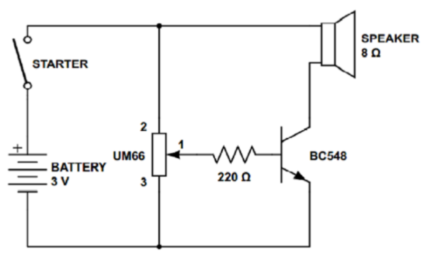


Fire alarms are prime necessities in modern buildings and architectures, especially in banks, data centers and gas stations. They detects the fire in ambiance at very early stage by sensing smoke or/and heat and raise an alarm which warns people about the fire and furnish sufficient time to take preventive measures. It not only prevents a big losses caused by deadly fire but sometimes proves to be life savers. Here we are building one **simple fire alarm system with the help of 555 Timer IC**, which will sense the fire (temperature rise in surrounding), and trigger the alarm.

The key component of the circuit is Thermistor, which has been used as fire detector or fire sensor. Thermistor is temperature sensitive resistor, whose resistance changes according to the temperature, its resistance decreases with the increase in temperature and vice versa.

We have built the circuit using, mainly three components that is, Thermistor, NPN transistor and 555 Timer IC.

WORKING CONCEPT

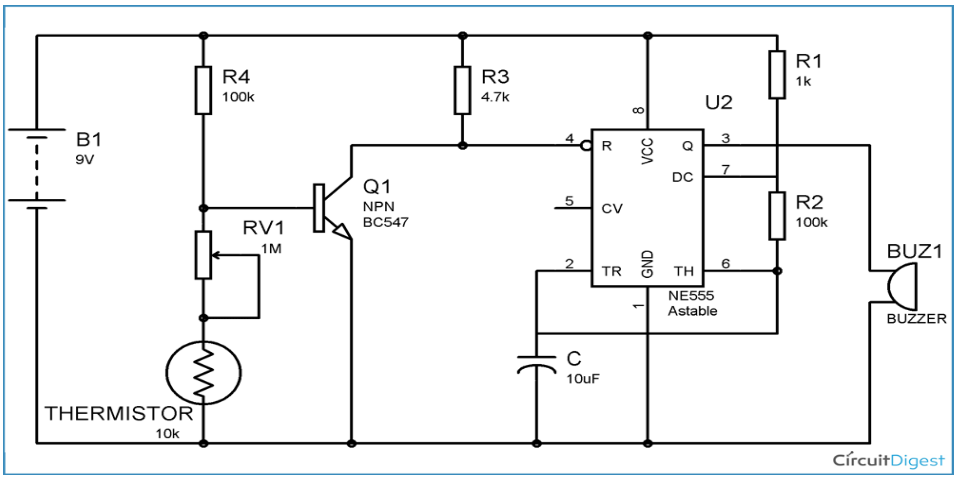


Here the **555 timer IC** has been configured in **Astable mode** so that Alarm (Buzzer) can produce an oscillating sound. In Astable mode, capacitor C charges though resistance R1 and R2, till 2/3 Vcc and discharges through R2 till it reaches to 1/3Vcc. During the charging time OUT PIN 3 of 555 IC remains HIGH and during discharging it remains LOW, that how it oscillate. We have connected a Buzzer to OUT pin, so that it produces a beep sound, when 555 is high. We can control the oscillation frequency of the alarm by adjusting the value of R2 and/or capacitor C.

COMPONENTS

- **555 Timer IC**
- **NPN Transistor BC547**
- **Thermistor (10K)**
- **Resistors (1K, 100K, 4.7K)**
- **Variable resistor (1M)**
- **Capacitor (10uF)**
- **Buzzer and Battery (9v)**

CIRCUIT DIAGRAM AND EXPLAINATION



You can see the circuit diagram of fire alarm in above figure. When there is no FIRE, thermistor remains at 10k ohm. And transistor remains at ON state because there is sufficient voltage across the base-emitter of transistor, which makes it ON. When the Transistor is ON, Pin 4 (RESET) is connected to the Ground, and when Reset pin is grounded, 555 IC doesn't operate.

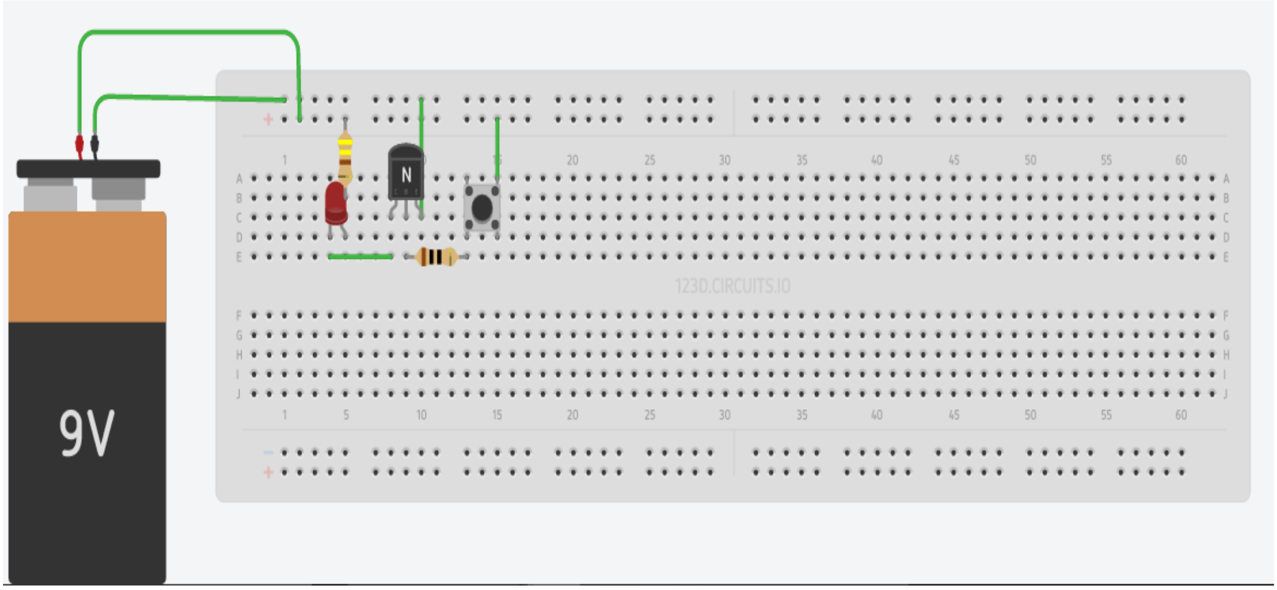
Now when we start heating the Thermistor through Fire, its resistance starts to decrease, and when its resistance decreases, the voltage at the base of Transistor starts to decrease and when the voltage becomes less than the operating voltage (base-emitter voltage V_{BE}) of transistor, then transistor becomes OFF. And when transistor becomes OFF, Reset pin of 555 timers IC, gets positive voltage through R3 and 555 IC starts to work and buzzer beeps.

In transistor, usually 0.7v voltage is required across the Base and Emitter, to turn it ON. So we have to carefully adjust the value of Variable resistance RV1 and Thermistor, to make the circuit work properly. To do this remove the thermistor and let RV1 be the grounded, now adjust the value of RV1 to that point, where even slight turning of the RV1 starts the Buzzer. Means from this point, if we decrease the resistance, even very little, Buzzer starts to beep. Now at this point, connect the thermistor again.

Activity

Make a circuit to demonstrate working of a transistor as a switch.

Circuit Diagram



Material Required

Breadboard	**1**
Battery 9V	**1**
LED	**1**
NPN Transistor	**1**
Resistor	**2**

Instructions

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Connect the battery to the circuit.
- Now push the button.
- Record your observations.

Observation Table

Position of switch	LED
Pushed	
Released	

In which state does the transistor is working when LED is glowing?

____
____
____
____
____

Can we replace the NPN with PNP transistor?

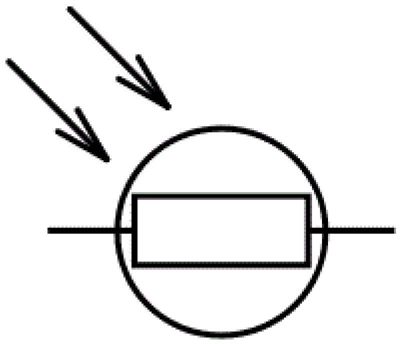
____
____
____
____
____

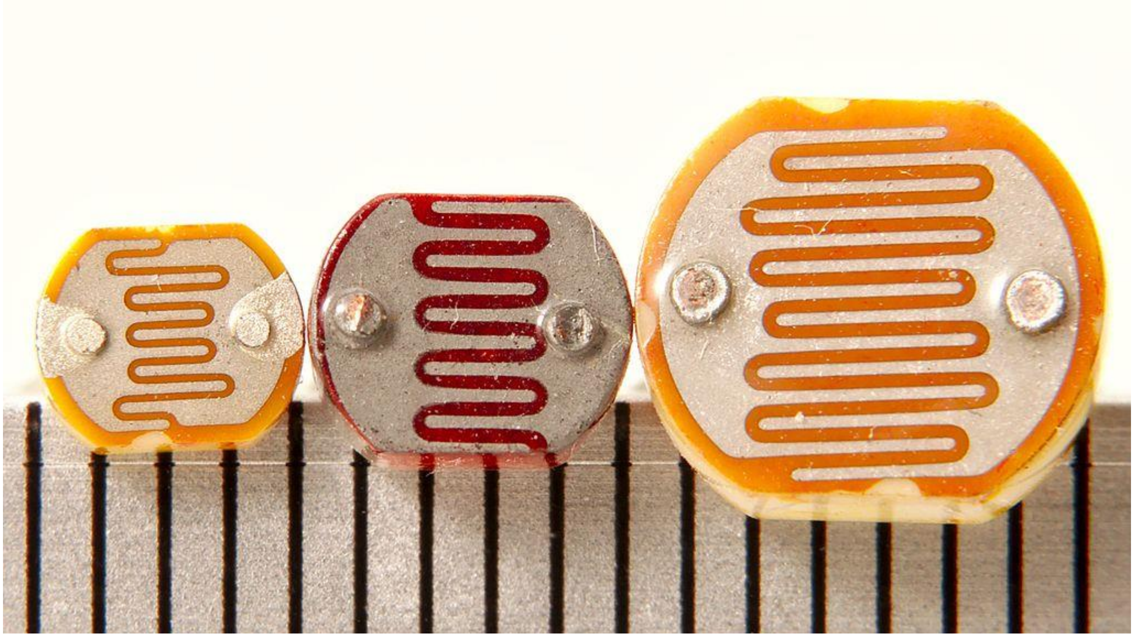
What changes do we have to make in the circuit to use PNP transistor instead of NPN?

____
____
____
____
____

CHAPTER 5: DARK SENSOR WITH LDR AND TRANSISTOR

A **Light Dependent Resistor** (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate a **LDR**, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it.



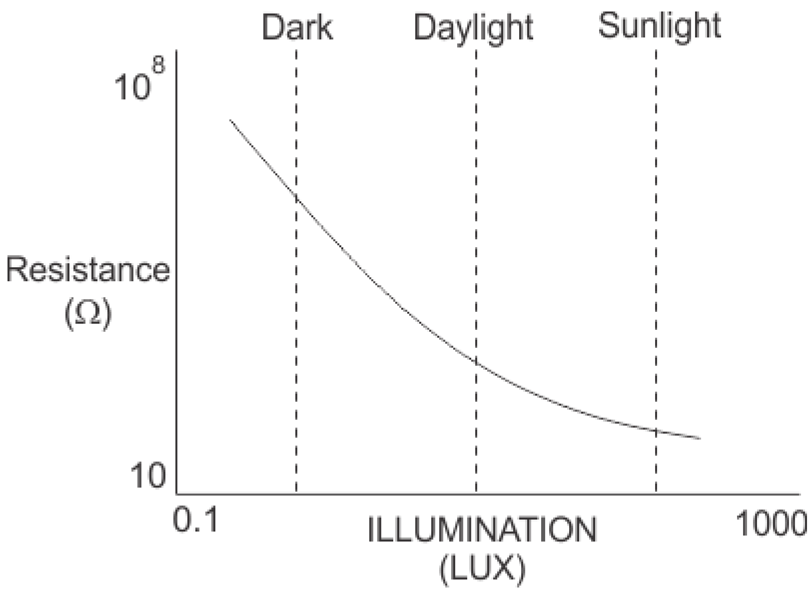


WORKING PRINCIPLE OF LDR

A **light dependent resistor** works on the principle of photo conductivity.
Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material. When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing throgh the device when the circuit is closed and hence it is said that the resistance of the device has been decreased. This is the most common working of LDR

CHARACTERSTIC OF LDR

LDR's are light dependent devices whose resistance is decreased when light falls on them and that is increased in the dark. When a **light dependent resistor** is kept in dark, its resistance is very high. This resistance is called as dark resistance. It can be as high as 10^{12} Ω and if the device is allowed to absorb light its resistance will be decreased drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing. Figure below shows resistance vs. illumination curve for a particular **LDR**.



Photocells or LDR's are nonlinear devices. There sensitivity varies with the wavelength of light incident on them. Some photocells might not at all response to a certain range of wavelengths. Based on the material used different cells have different spectral response curves.

When light is incident on a photocell it usually takes about 8 to 12 ms for the change in resistance to take place, while it takes one or more seconds for the resistance to rise back again to its initial value after removal of light. This phenomenon is called as resistance recovery rate. This property is used in audio compressors. Also, **LDR**'s are less sensitive than photo diodes and photo transistor. (A photo diode and a photocell (LDR) are not the same, a photo-diode is a p-n junction semiconductor device that converts light to electricity, whereas a photocell is a passive device, there is no p-n junction in this nor it "converts" light to electricity).

Types of Light Dependent Resistors:

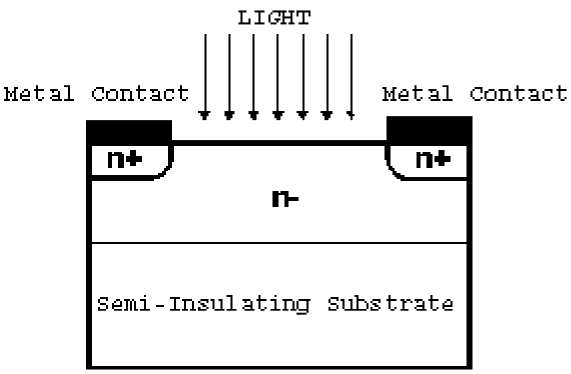
Based on the materials used they are classified as:

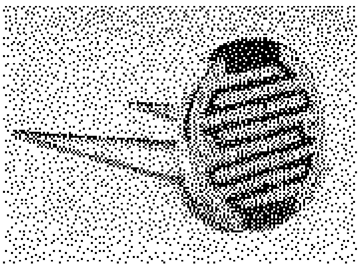
1. Intrinsic photo resistors (Un doped semiconductor): These are made of pure semiconductor materials such as silicon or germanium. Electrons get excited from valance band to conduction band when photons of enough energy fall on it and number charge carriers is increased.

2. Extrinsic photo resistors: These are semiconductor materials doped with impurities which are called as dopants. Theses dopants create new energy bands above the valence band which are filled with electrons. Hence this reduces the band gap and less energy is required in exciting them. Extrinsic photo resistors are generally used for long wavelengths.

CONSTRUCTION OF A PHOTOCELL

The structure of a light dependent resistor consists of a light sensitive material which is deposited on an insulating substrate such as ceramic. The material is deposited in zigzag pattern in order to obtain the desired resistance and power rating. This zigzag area separates the metal deposited areas into two regions. Then the ohmic contacts are made on the either sides of the area. The resistances of these contacts should be as less as possible to make sure that the resistance mainly changes due to the effect of light only. Materials normally used are cadmium sulphide, cadmium selenide, and indiumantimonide and cadmium sulphonide. The use of lead and cadmium is avoided as they are harmful to the environment.



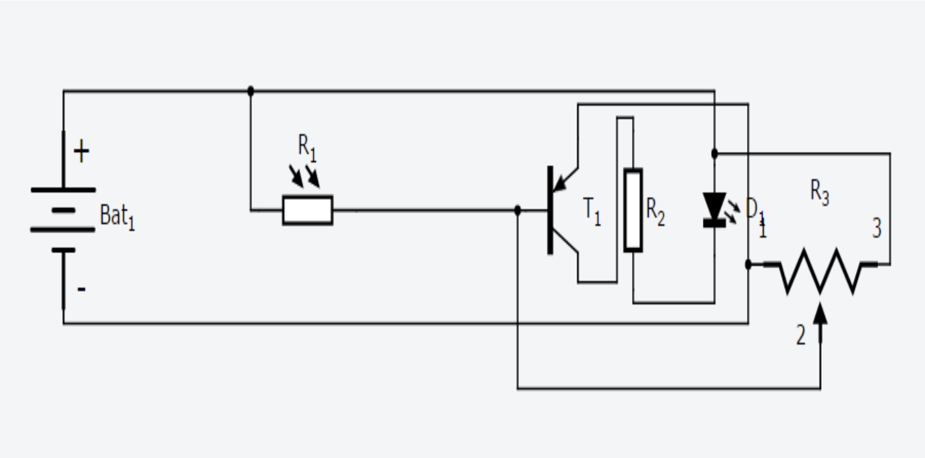


WORKING

The LDR circuit diagram works like this:

When it's dark, the LDR has high resistance. This makes the voltage at the base of the transistor too low to turn the transistor ON. Therefore, current will go from the collector to the emitter of the transistor. This makes the LED light up.

When it's light, the LDR has low resistance. This makes the voltage at the base of the transistor higher. High enough to turn the transistor ON. Because the transistor is turned on, LED will not light up.



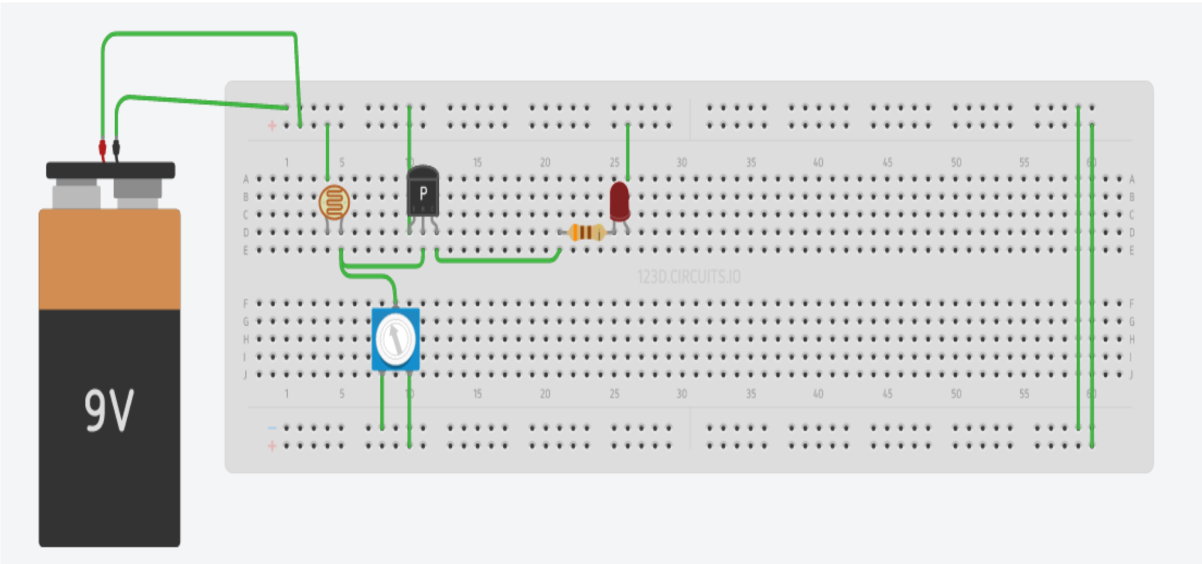
APPLICATIONS OF LDR

LDR's have low cost and simple structure. They are often used as light sensors. They are used when there is a need to detect absences or presences of light like in a camera light meter. Used in street lamps, alarm clock, burglar alarm circuits, light intensity meters, for counting the packages moving on a conveyor belt, etc.

ACTIVITY

Dark sensor using LDR and Transistor.

Circuit Diagram



Material Required

Breadboard	**1**
Battery 9V	**1**
LED	**1**
PNP Transistor	**1**
Resistor	**1**
Potentiometer	**1**

Instructions

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Connect the battery to the circuit.
- Now cover the LDR with your hand
- Record your observations.

Observation Table

LDR	LED
Covered	
Uncovered	

In which state does the transistor is working when LED is glowing?

What will happen if we replace the PNP with NPN transistor?

What is the need of Potentiometer in the above Circuit?