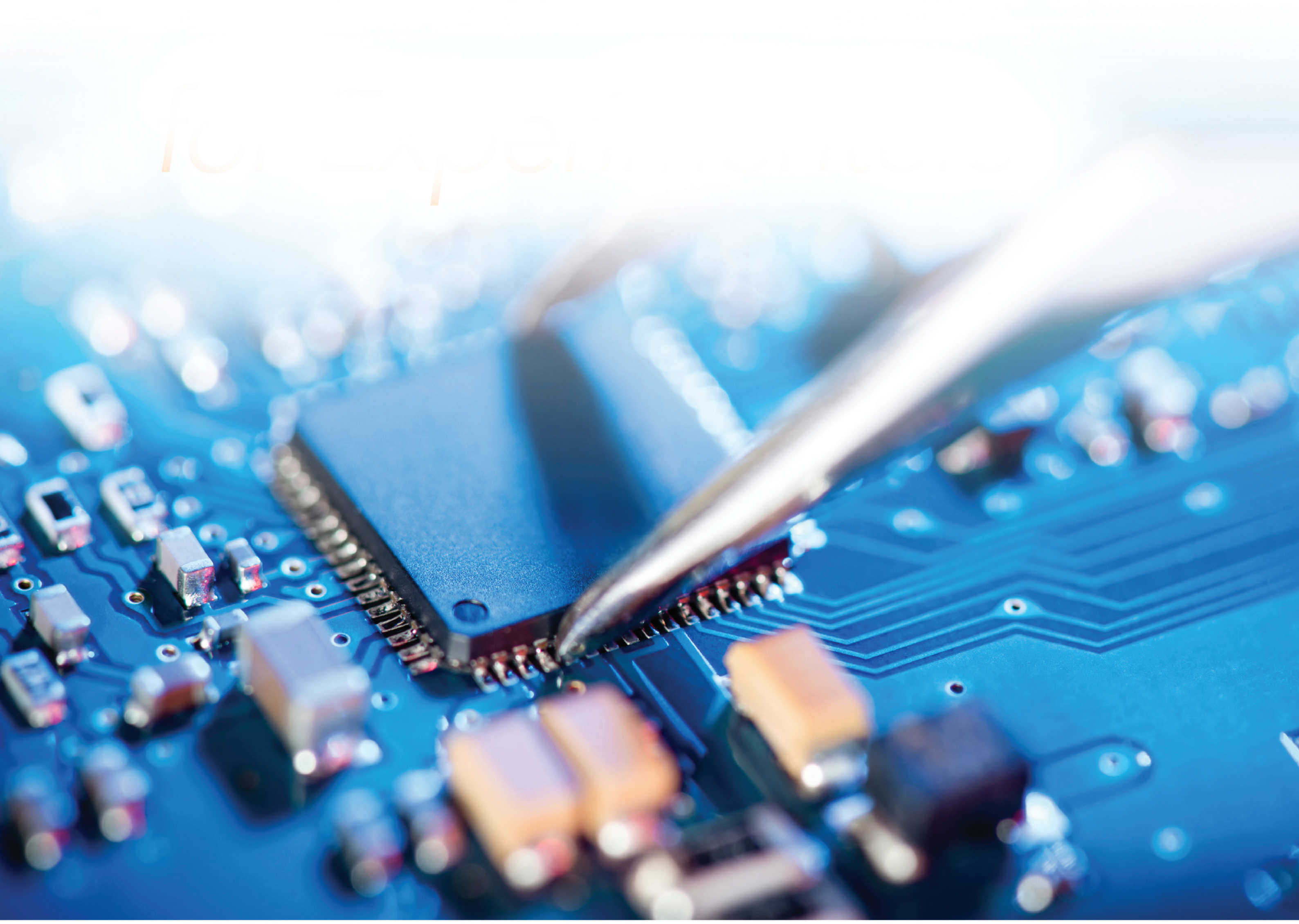
VOLUME - III

ELECTRONICS



ROBOTROD

by Olatus Systems Private Limited

Contents

3.5 Motors

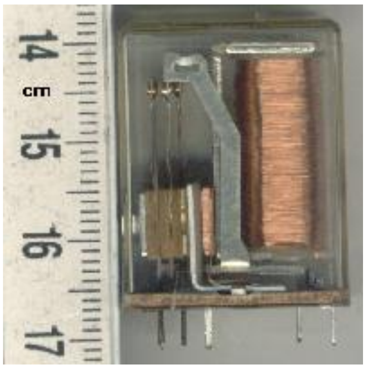
CHAPTER 1: RELAY

INTRODUCTION TO RELAYS

Before we talk about relays, we have to understand what actuators are. Actuators convert an electrical signal into a corresponding physical quantity such as movement, force, sound etc. An actuator is also classed as a transducer because it changes one type of physical quantity into another and is usually activated or operated by a low voltage command signal. Actuators can be classed as either binary or continuous devices based upon the number of stable states their output has.

The most common types of actuators or output devices are Electrical Relays, Lights, Motors and Loudspeakers.

ELECTRICAL RELAY - Electrical Relays can also be divided into mechanical action relays called "Electromechanical Relays" and those which use semiconductor transistors, thyristors, triacs, etc, as their switching device called "Solid State Relays" or SSR's.

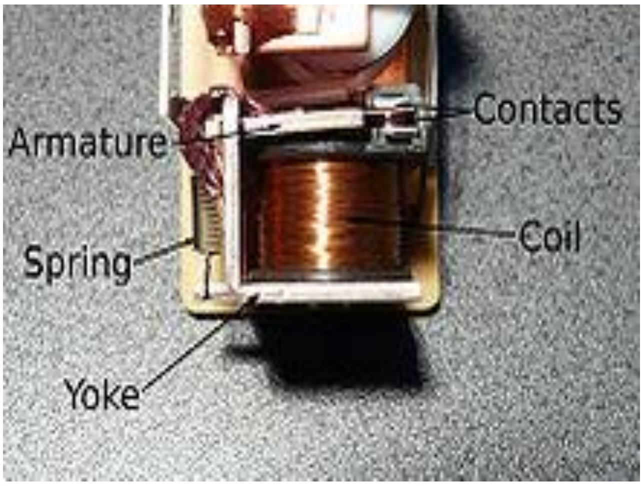


Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

BASIC DESIGN AND OPERATION

A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts (there are two contacts in the relay pictured). The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. The armature is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the printed circuit board (PCB) via the yoke, which is soldered to the PCB.

When an electric current is passed through the coil it generates a magnetic field that activates the armature and the consequent movement of the movable contact either makes or breaks (depending upon construction) a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in a high voltage or current application it reduces arcing.



When the coil is energized with direct current, a diode is often placed across the coil to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a voltage spike dangerous to semiconductor circuit components. Such diodes were not widely used before the application of transistors as relay drivers, but soon became ubiquitous as early germanium transistors were easily destroyed by this surge. Some automotive relays include a diode inside the relay case.

If the relay is driving a large, or especially a reactive load, there may be a similar problem of surge currents around the relay output contacts. In this case a snubbed circuit (a capacitor and resistor in series) across the contacts may absorb the surge. Suitably rated capacitors and the associated resistor are sold as a single packaged component for this commonplace use.

If the coil is designed to be energized with alternating current (AC), some method is used to split the flux into two out-of-phase components which add together, increasing the minimum pull on the armature during the AC cycle. Typically this is done with a small copper "shading ring" crimped around a portion of the core that creates the delayed, out-of-phase component, which holds the contacts during the zero crossings of the control voltage.

TYPES OF RELAYS BY POLES AND THROWS

- Single Pole Double Throw Relay - A Single Pole Single Throw Relay is a relay that has one input and one output terminal.

  Internally, it is wired so it is connected as shown below:

  Being that it only has one input and one output, they act as simple on-off switches in circuits, as they can only take on 1 of 2 states. When the relay does not receive any power, it is off and the Normally Open (NO) contact pin remains opens. When the relay receives sufficient power, the NO contact pin closes and whatever load is connected to it will power on.

- Single Pole Double Throw Relay - A Single Pole Double Throw Relay is a relay that has one input and two outputs.

  Internally, it is wired so it is connected as shown below:

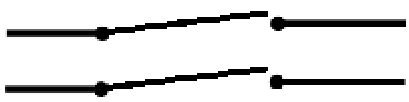
  

  Being that it has 2 outputs, it is more dynamic than a single throw relay. It can connect to 2 different outputs, so it can switch a circuit in between any 1 or 2 states, such as ready mode-pause mode, etc.

- Double Pole Single Throw Relay - A Double Pole Single Throw (DPST) Relay is a relay that has 2 inputs and 2 outputs.

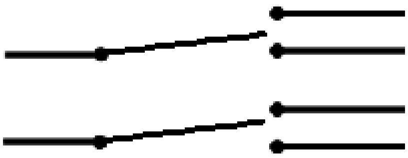
  Internally, it is wired so it is connected as shown below:

  Each of the inputs can connect to one output. A DPST relay is constructed internally as if they are 2 separate SPST relays connected together. So a DPST is really just 2 separate SPST relays.

- Double Pole Double Throw Relay - Double Pole Double Throw (DPDT) is a relay that has 2 inputs and 4 outputs.

  Internally, it is wired so it is connected as shown below:



  The 2 input stages can each connect to 2 different outputs, allowing for 4 different output modes. A circuit with a DPDT allows for the most dynamic and versatile of outputs being that it can switch between these different modes

SIGNIFICANCE OF RELAY

Relays are mainly used for remote switching, and for high voltage or high current switching. They are particularly valuable because they can control these high voltages and currents with only a small voltage or current in return.
Another important usage is for AC power lines. Relays function as AC power switches, and keep the control signals electrically isolated.

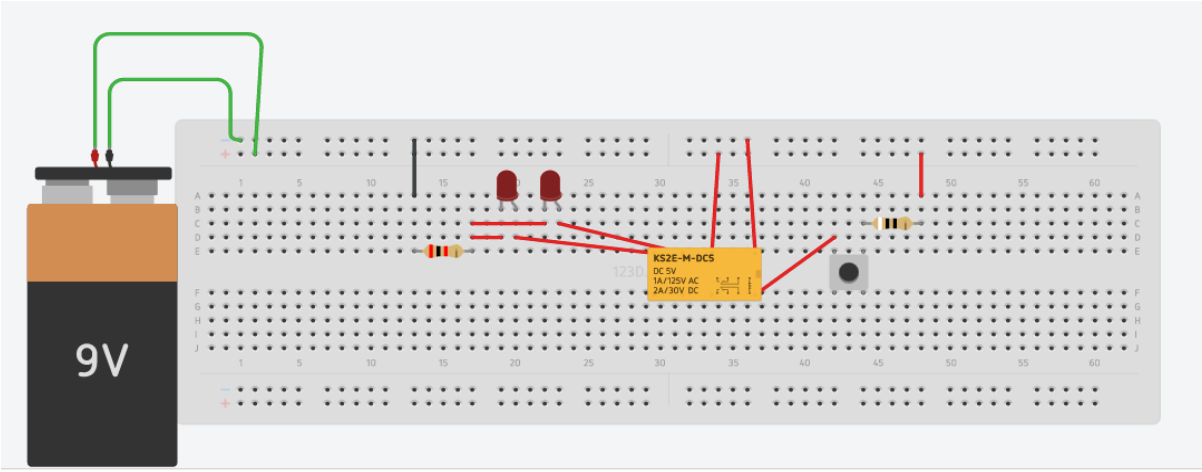
APPLICATIONS

1. Relay Drive by Means of a Transistor
2. Relay Drive by Means of SCR
3. Relay Drive from External Contacts
4. LED Series and Parallel Connections
5. Electronic Circuit Drive by Means of a Relay
6. Power Source Circuit
7. PC Board Design Considerations

ACTIVITY

Make a circuit to toggle between two LEDs using a relay

Circuit Diagram



Material Required

Name	Quantity
9V Battery	1
Resistance	2
LED	2
Breadboard	1
Push Button	1
Relay	1

Instructions

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

What happens when you push the button?

Can this circuit be made without using a relay?

CHAPTER 2: INTEGRATED CIRCUITS

INTRODUCTION TO INTEGRATED CIRCUITS

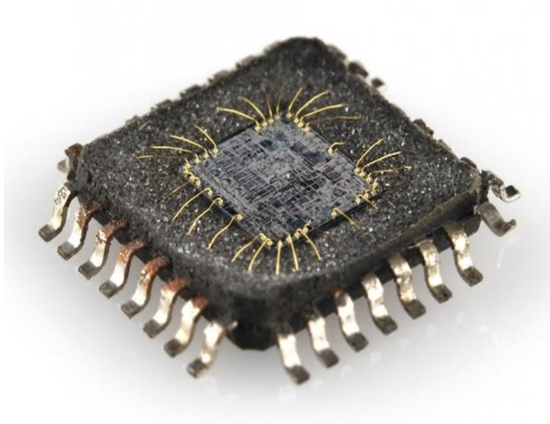
Integrated circuits (ICs) are a keystone of modern electronics. They are the heart and brains of most circuits. They are the ubiquitous little black "chips" you find on just about every circuit board. Unless you're some kind of crazy, analog electronics wizard, you're likely to have at least one IC in every electronics project you build, so it's important to understand them, inside and out.

Integrated circuits are the little black "chips", found all over embedded electronics.

An IC is a collection of electronic components – resistors, transistors, capacitors, etc. – all stuffed into a tiny chip, and connected together to achieve a common goal. They come in all sorts of flavors: single-circuit logic gates, op amps, 555 timers, voltage regulators, motor controllers, microcontrollers, microprocessors, FPGAs…the list just goes on-and-on.

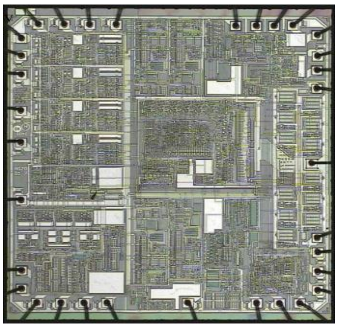
INSIDE THE IC

When we think integrated circuits, little black chips are what come to mind. But what's inside that black box?

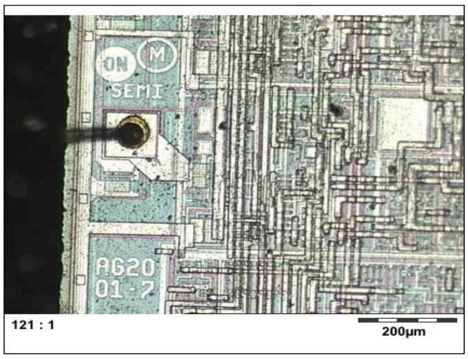


The real "meat" to an IC is a complex layering of semiconductor wafers, copper, and other materials, which interconnect to form transistors, resistors or other components in a circuit. The cut and formed combination of these wafers is called a **die**.

"The guts of an integrated circuit, visible after removing the top."



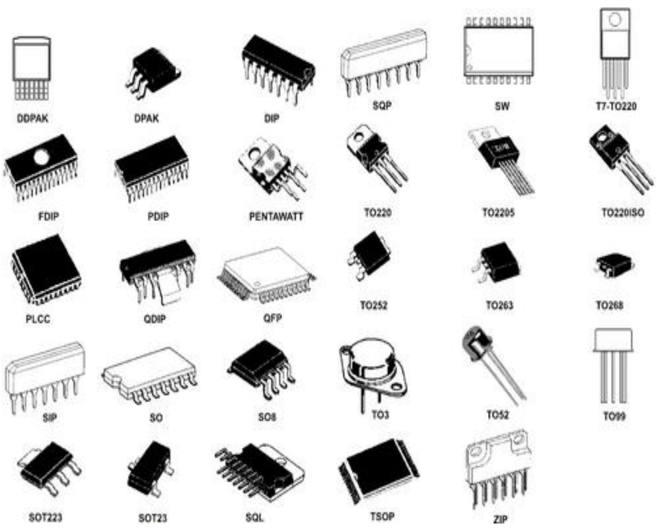
While the IC itself is tiny, the wafers of semiconductor and layers of copper it consists of are incredibly thin. The connections between the layers are very intricate. Here's a zoomed in section of the die above:



An IC die is the circuit in its smallest possible form, too small to solder or connect to. To make our job of connecting to the IC easier, we package the die. The IC package turns the delicate, tiny die, into the black chip we're all familiar with.

IC PACKAGES

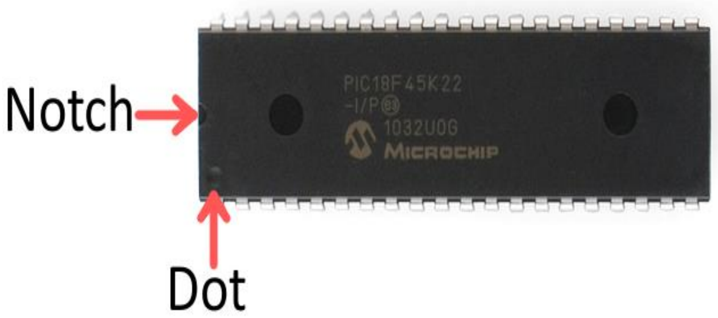
The package is what encapsulates the integrated circuit die and splays it out into a device we can more easily connect to. Each outer connection on the die is connected via a tiny piece of gold wire to a **pad** or **pin** on the package. Pins are the silver, extruding terminals on an IC, which go on to connect to other parts of a circuit. These are of utmost importance to us, because they're what will go on to connect to the rest of the components and wires in a circuit.



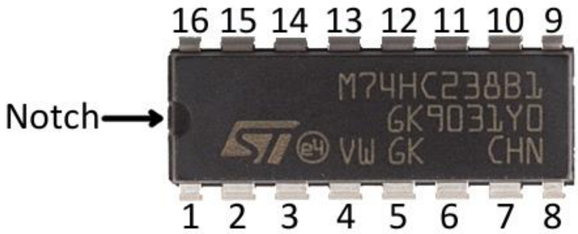
There are many different types of packages, each of which has unique dimensions, mounting-types, and/or pin-counts.

POLARITY MARKING AND PIN NUMBERING

All ICs are polarized, and every pin is unique in terms of both location and function. This means the package has to have some way to convey which pin is which. Most ICs will use either a **notch** or a **dot** to indicate which pin is the first pin. (Sometimes both, sometimes one or the other.)



Once you know where the first pin is, the remaining pin numbers increase sequentially as you move counter-clockwise around the chip.



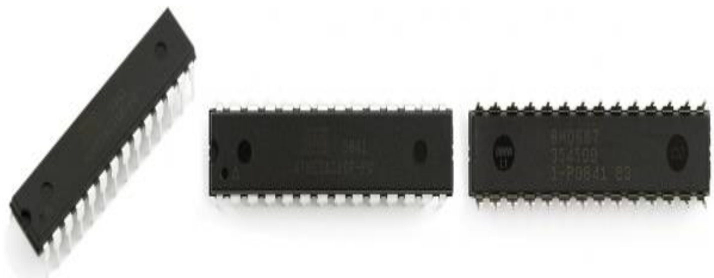
MOUNTING STYLE

One of the main distinguishing package type characteristics is the way they mount to a circuit board. All packages fall into one of two mounting types: through-hole (PTH) or surface-mount (SMD or SMT). Through-hole packages are generally bigger, and much easier to work with. They're designed to be stuck through one side of a board and soldered to the other side.

Surface-mount packages range in size from small to minuscule. They are all designed to sit on one side of a circuit board and be soldered to the surface. The pins of a SMD package either extrude out the side, perpendicular to the chip, or are sometimes arranged in a matrix on the bottom of the chip. ICs in this form factor are not very "hand-assembly-friendly." They usually require special tools to aid in the process.

DIP (Dual in-line packages)

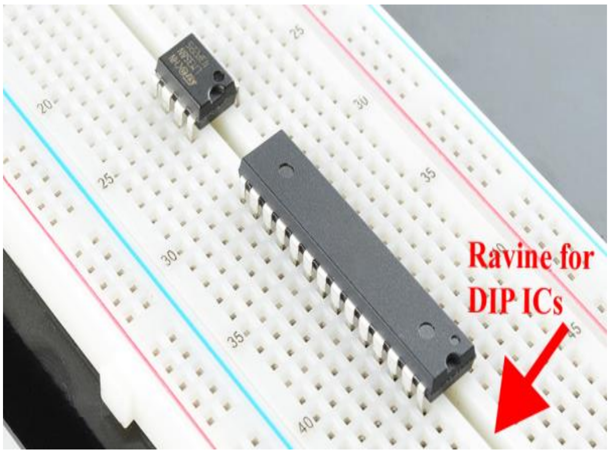
DIP, short for dual in-line package, is the most common through-hole IC package you'll encounter. These little chips have two parallel rows of pins extending perpendicularly out of a rectangular, black, plastic housing.



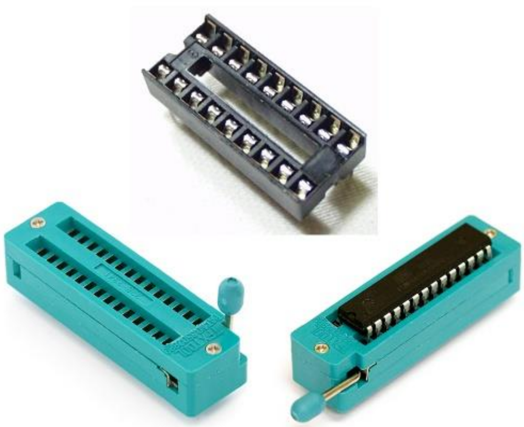
"The 28-pin ATmega328 is one of the more popular DIP-packaged microcontrollers (thanks, Arduino!)."

Each of the pins on a DIP IC are spaced by 0.1" (2.54mm), which is a standard spacing and perfect for fitting into breadboards and other prototyping boards. The overall dimensions of a DIP package depend on its pin count, which may be anywhere from four to 64.

The area between each row of pins is perfectly spaced to allow DIP ICs to straddle the center area of a breadboard. This provides each of the pins its own row in the board, and it makes sure they don't short to each other.



Aside from being used in breadboards, DIP ICs can also be **soldered into PCBs**. They're inserted into one side of the board and soldered into place on the other side. Sometimes, instead of soldering directly to the IC, it's a good idea to **socket** the chip. Using sockets allows for a DIP IC to be removed and swapped out, if it happens to "let its blue smoke out."



"A regular DIP socket (top) and a ZIF socket with and without an IC."

CLASSIFICATIONS OF INTEGRATED CIRCUITS

- Small Scale Integration or (SSI) – Contain up to 10 transistors or a few gates within a single package such as AND, OR, NOT gates.

- Medium Scale Integration or (MSI) – Between 10 and 100 transistors or tens of gates within a single package and perform digital operations such as adders, decoders, counters, flip-flops and multiplexers.

- Large Scale Integration or (LSI) – Between 100 and 1,000 transistors or hundreds of gates and perform specific digital operations such as I/O chips, memory, arithmetic and logic units.
- Very-Large Scale Integration or (VLSI) – Between 1,000 and 10,000 transistors or thousands of gates and perform computational operations such as processors, large memory arrays and programmable logic devices.
- Super-Large Scale Integration or (SLSI) – Between 10,000 and 100,000 transistors within a single package and perform computational operations such as microprocessor chips, micro-controllers, basic PICs and calculators.
- Ultra-Large Scale Integration or (ULSI) – More than 1 million transistors – the big boys that are used in computers CPUs, GPUs, video processors, micro-controllers, FPGAs and complex PICs.

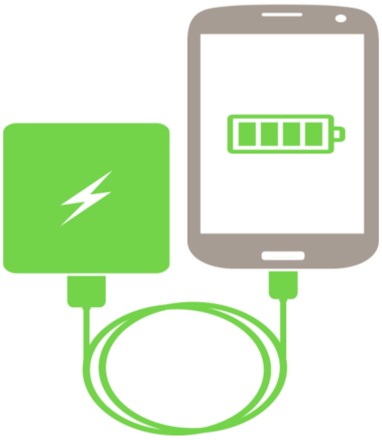
ADVANTAGES

The advantages of Integrated Circuits are:

- Very small size: Hundred times smaller than the discrete circuits.
- Lesser weight: As large number of components can be packed into a single chip, weight is reduced
- Reduced cost: The mass production technique has helped to reduce the price,
- High reliability: Due to absence of soldered connection, few interconnections and small temperature rise failure rate is low.
- Low power requirement: As the size is small power consumption is less.
- Easy replacement: In case of failure chip can easily be replaced.

CHAPTER 3: PORTABLE MOBILE CHARGER WITH 9 V BATTERY

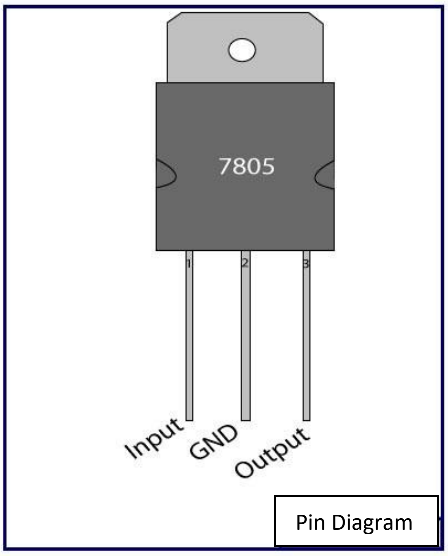
Mobile devices like Smartphone and tablets make life so much easier. That is, until they run out of battery power when there's nowhere to plug in. A lightweight, mobile battery pack you can carry anywhere. They go under different names: battery packs, portable chargers, fuel banks, pocket power cells and back-up charging devices to name just a few. But whatever you call them, they all do the same thing. we'll learn how to make a portable charger at home using a using a 9V battery and some other electric components.



RESOURCES REQUIRED

1. 7805 voltage regulator
2. 100 µF electrolytic capacitor
3. 10 µF electrolytic capacitor
4. 1N400x rectifier diode
5. 9 V battery
6. Female USB plug
7. PCB

IC 7805 (VOLTAGE REGULATOR IC)

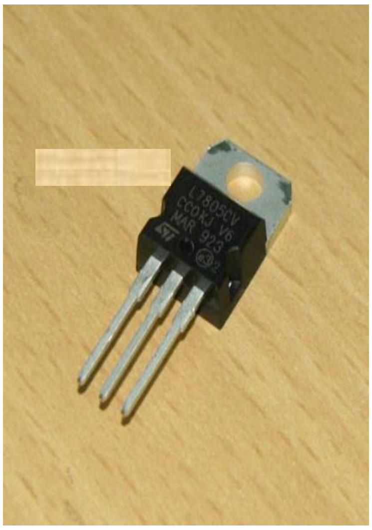


7805 is a voltage regulator integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The voltage regulator IC maintains the output voltage at a constant value. The xx in 78xx indicates the fixed output voltage it is designed to provide. 7805 provides +5V regulated power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels.

Pin Description:

Pin No	Function	Name
1	Input voltage (5V-18V)	INPUT
2	Ground (0V)	GROUND
3	Regulated output; 5V (4.8V-5.2V)	OUTPUT

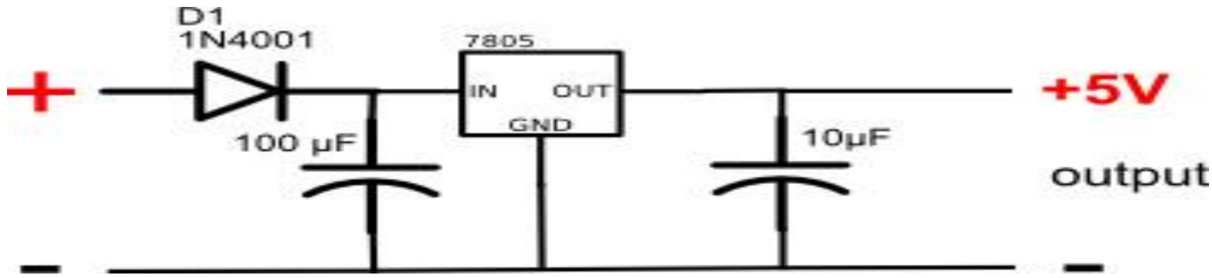
VOLTAGE REGULATOR CIRCUIT



Voltage regulator is basically a web of voltage dividers which adjust themselves to deliver the specified output voltage, depending on the input voltage. But what happens to the extra voltage? The excess energy has to be released somehow to give us our desired output voltage, and in this case, it is dissipated as heat. And if there is too much of a voltage difference between the input and output voltage, then the voltage regulator sets on fire.

So the message here is that we have to be careful, we do not want to feed too much voltage into the regulator, as it will get real hot because it has to work harder to drop an even higher voltage to 5V.

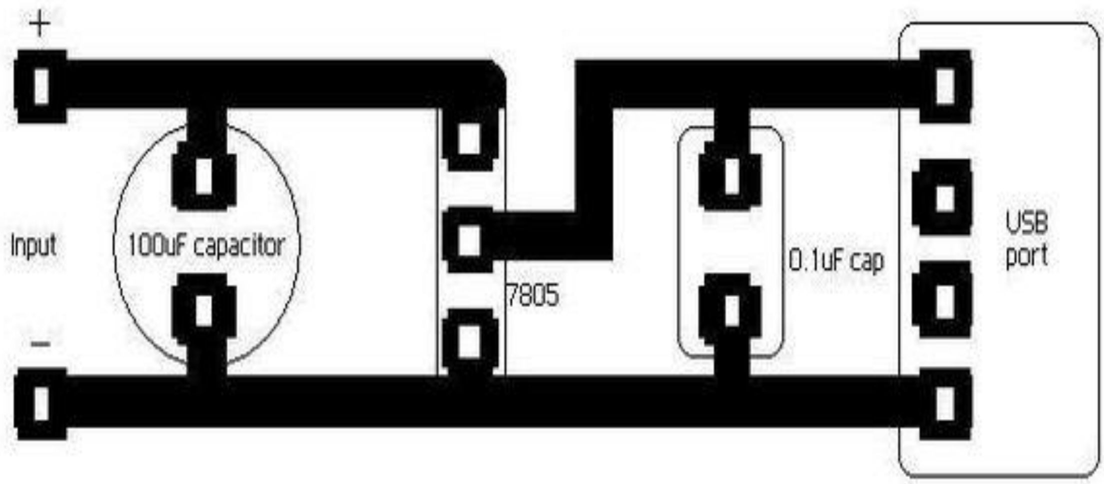
CIRCUIT DIAGRAM



CIRCUIT EXPLAINATION

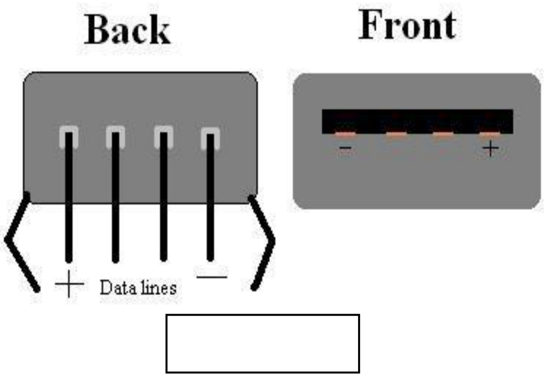
Take a look at the following circuit diagram, it's simple to follow and understand. Notice the diode which ensures current flows in only one direction. Of course, diodes do have a drop voltage, but its low enough to keep everything working great. Then we have two decoupling capacitors to smooth out the voltage coming in, and going out. Of course, we have the 7805 which regulates the voltage. The *IN* pin accepts the inward voltage from tour 9V battery, the *GND* pin connects to the negative terminal of the voltage source(Battery), and *OUT* delivers the outbound voltage.

Attaching the components



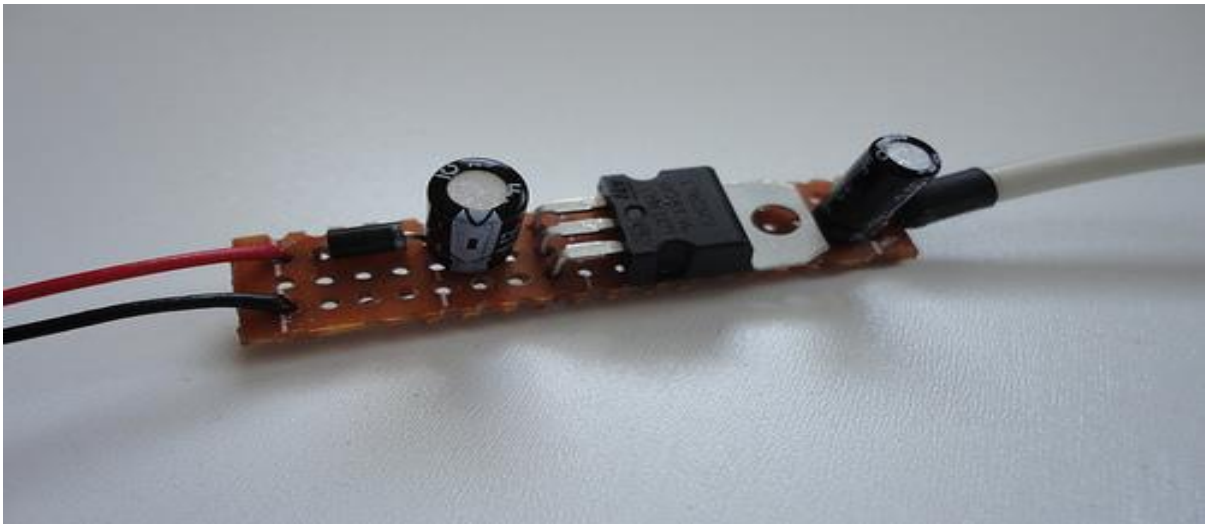
1. Attach all the components to PCB according to the diagram above.

2. In the image alongside is the pin description of USB Female type connector. Attach it to your circuit keeping in my mind that the polarity should be correct.



3. Before plugging in your USB device to this charger, test the charger's output using a multimeter. Hookup the 9-volt battery and measure voltage output, it should be between 4.8-volts to 5.2 volts.

Now that you've finished building your own portable charger, it should look something like this.

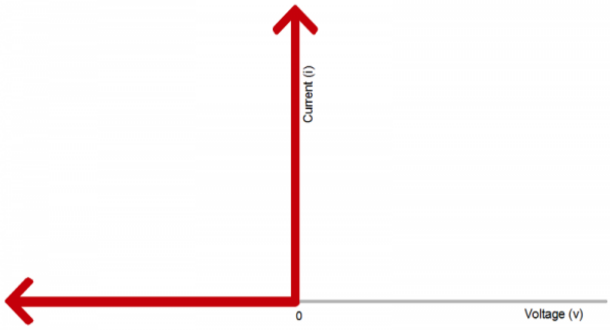


This *device* will work to power not only a mobile phone, but anything which requires 5V.

CHAPTER 4: DIODES

In electronics, a diode is a two-terminal electronic component that conducts primarily in one direction (asymmetric conductance); it has low (ideally zero) resistance to the flow of current in one direction, and high (ideally infinite) resistance in the other. A semiconductor diode, the most common type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals.

IDEAL DIODES



The key function of an **ideal** diode is to control the *direction* of current-flow. Current passing through a diode can only go in one direction, called the forward direction. Current trying to flow the reverse direction is blocked. They're like the one-way valve of electronics.

If the voltage across a diode is negative, no current can flow, and the ideal diode looks like an open circuit. In such a situation, the diode is said to be *off* or reverse biased.

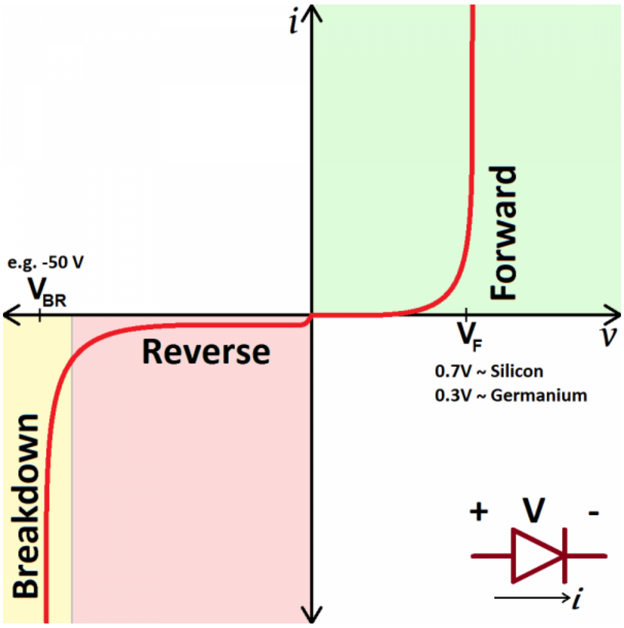
As long as the voltage across the diode isn't negative, it'll "turn on" and conduct current. Ideally a diode would act like a short circuit (0V across it) if it was conducting current. When a diode is conducting current it's forward biased (electronics jargon for "on").

"The current-voltage relationship of an ideal diode. Any negative voltage produces zero current – an open circuit. As long as the voltage is non-negative the diode looks like a short circuit."

Ideal Diode Characteristics		
Operation Mode	On (Forward biased)	Off (Reverse biased)
Current Through	I>0	I=0
Voltage Across	V=0	V<0
Diode looks like	Short circuit	Open circuit

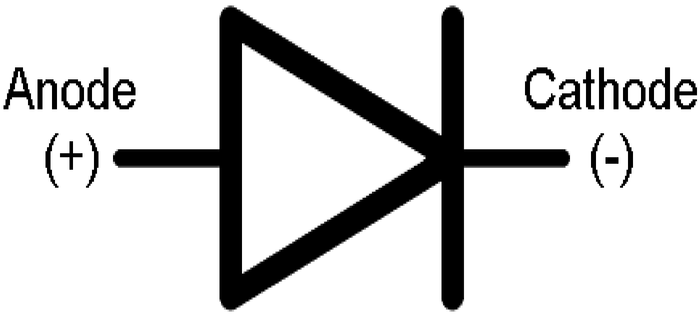
CIRCUIT SYMBOL

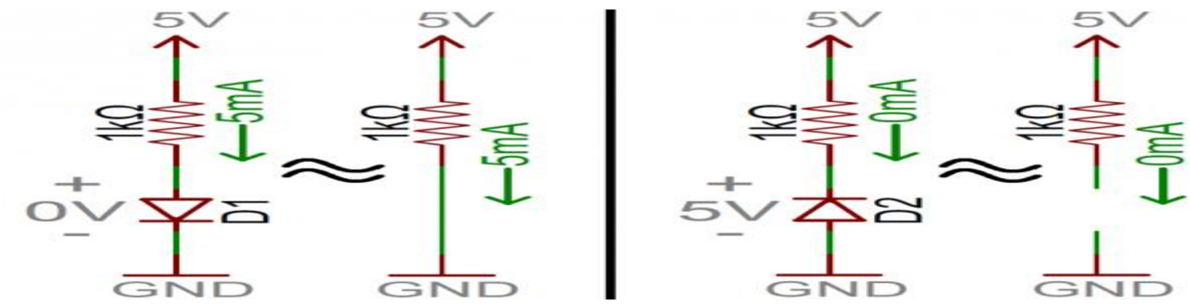
Every diode has two terminals – connections on each end of the component – and those terminals are polarized, meaning the two terminals are distinctly different. It's important not to mix the connections on a diode up. The positive end of a diode is called the anode, and the negative end is called the cathode. Current can flow from the anode end to the cathode, but not the other direction. If you forget which way current flows through a diode, try to remember the mnemonic *ACID*: "anode current in diode" (also *anode cathode is diode*).



The circuit symbol of a standard diode is a triangle butting up against a line.

The terminal entering the flat edge of the triangle represents the anode. Current flows in the direction that the triangle/arrow is pointing, but it can't go the other way.





Above are a couple simple diode circuit examples. On the left, diode D1 is forward biased and allowing current to flow through the circuit. In essence it looks like a short circuit. On the right, diode D2 is reverse biased. Current cannot flow through the circuit, and it essentially looks like an open circuit.

Real Diode Characteristics

Ideally, diodes will block any and all current flowing the reverse direction, or just act like a short- circuit if current flow is forward. Unfortunately, actual diode behavior isn't quite ideal. Diodes do consume some amount of power when conducting forward current, and they won't block out all reverse current. Real-world diodes are a bit more complicated, and they all have unique characteristics which define how they actually operate.

Current-Voltage Relationship

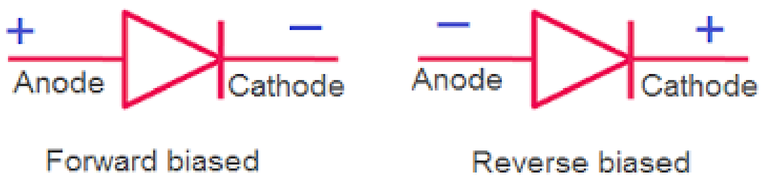
The most important diode characteristic is its current-voltage (*i-v*) relationship. This defines what the current running through a component is, given what voltage is measured across it. Resistors, for example, have a simple, linear *i-v* relationship… Ohm's Law. The *i-v* curve of a diode, though, is entirely *non*-linear. It looks something like this:

Depending on the voltage applied across it, a diode will operate in one of three regions:

1. Forward bias: When the voltage across the diode is positive the diode is "on" and current can run through. The voltage should be greater than the forward voltage (V_F) in order for the current to be anything significant.

2. Reverse bias: This is the "off" mode of the diode, where the voltage is less than V_F but greater than $-V_{BR}$. In this mode current flow is (mostly) blocked, and the diode is off. A *very* small amount of current (on the order of nA) – called reverse saturation current – is able to flow in reverse through the diode.

3. Breakdown: When the voltage applied across the diode is very large and negative, lots of current will be able to flow in the reverse direction, from cathode to anode.



FORWARD VOLTAGE

In order to "turn on" and conduct current in the forward direction, a diode requires a certain amount of positive voltage to be applied across it. The typical voltage required to turn the diode on is called the *forward voltage* (V_F). It might also be called either the *cut-in voltage* or *on-voltage*.

As we know from the ***i-v* curve**, the current through and voltage across a diode are interdependent. More current means more voltage, less voltage means less current. Once the voltage gets to about the forward voltage rating, though, large increases in current should still only mean a very small increase in voltage. If a diode is fully conducting, it can usually be assumed that the voltage across it is the forward voltage rating.

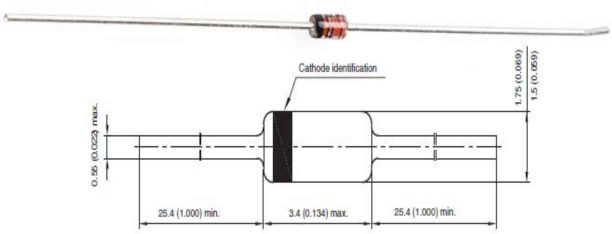
"A multimeter with a diode setting can be used to measure (the minimum of) a diode's forward voltage drop."

BREAKDOWN VOLTAGE

If a large enough negative voltage is applied to the diode, it will give in and allow current to flow in the reverse direction. This large negative voltage is called the **breakdown voltage**. Some diodes are actually designed to operate in the breakdown region, but for most normal diodes it's not very healthy for them to be subjected to large negative voltages.

TYPES OF DIODES

- ### Normal Diodes

  Standard signal diodes are among the most basic, average, no-frills members of the diode family. They usually have a medium-high forward voltage drop and a low maximum current rating. A common example of a signal diode is the **1N4148**. Very general purpose, it's got a typical forward voltage drop of 0.72V and a 300mA maximum forward current rating.

A small-signal diode, the 1N4148. Notice the black circle around the diode, that marks which of the terminals is the cathode.

- ### Rectifier or power diode

  Power Diode is a standard diode with a much higher maximum current rating. This higher current rating usually comes at the cost of a larger forward voltage. The 1N4001, for example, has a current rating of 1A and a forward voltage of 1.1V.

- ### Light-Emitting Diodes (LEDs!)

  The flashiest member of the diode family must be the light-emitting diode (LED). These diodes quite literally light up when a positive voltage is applied.

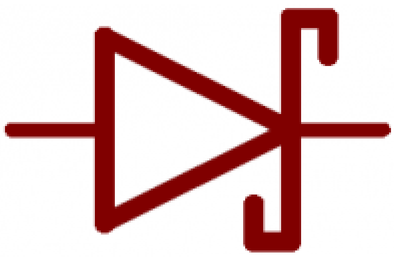
  

  Like normal diodes, LEDs only allow current through one direction. They also have a forward voltage rating, which the voltage is required for them to light up. The V_F rating of an LED is usually larger than that of a normal diode (1.2~3V), and it depends on the color the LED emits. For example, the rated forward voltage of a Super Bright Blue LED is around 3.3V, while that of the equal size Super Bright Red LED is only 2.2V.

- ### Schottky Diodes

  Another very common diode is the Schottky diode. The semiconductor composition of a Schottky diode is slightly different from a normal diode, and these results in a much **smaller forward voltage drop**, which is usually between 0.15V and 0.45V. They'll still have a very large breakdown voltage though.

  Schottky diodes are especially useful in limiting losses, when every last bit of voltage *must* be spared. They're unique enough to get a circuit symbol of their own, with a couple bends on the end of the cathode-line.

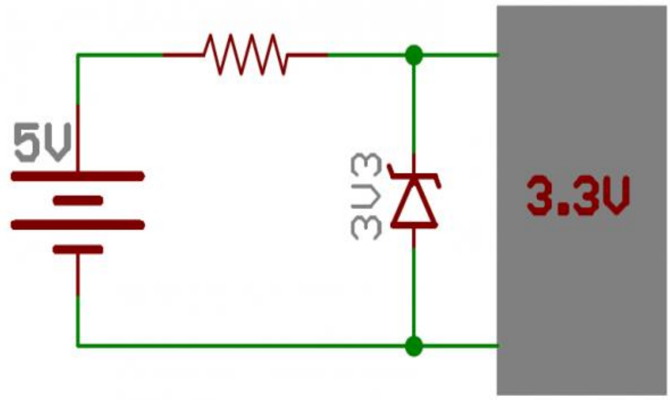
  

- Zener Diodes

Zener diodes are the weird outcast of the diode family. They're usually used to intentionally **conduct reverse current**. Zener's are designed to have a very precise breakdown voltage, called the **Zener breakdown** or **Zener voltage**. When enough current runs in reverse through the Zener, the voltage drop across it will hold steady at the breakdown voltage.

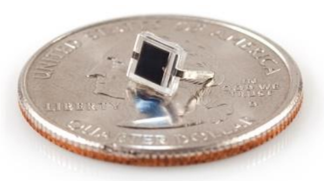
Taking advantage of their breakdown property, Zener diodes are often used to create a known reference voltage at exactly their Zener voltage. They can be used as a voltage regulator for small loads, but they're not really made to regulate voltage to circuits that will pull significant amounts of current.

Zener's are special enough to get their own circuit symbol, with wavy ends on the cathode-line. The symbol might even define what, exactly, the diode's Zener voltage is. Here's a 3.3V Zener diode acting to create a solid 3.3V voltage reference:



- Photodiodes

Photodiodes are specially constructed diodes, which capture energy from photons of light (see Physics, quantum) to generate electrical current. Kind of operating as an anti-LED.

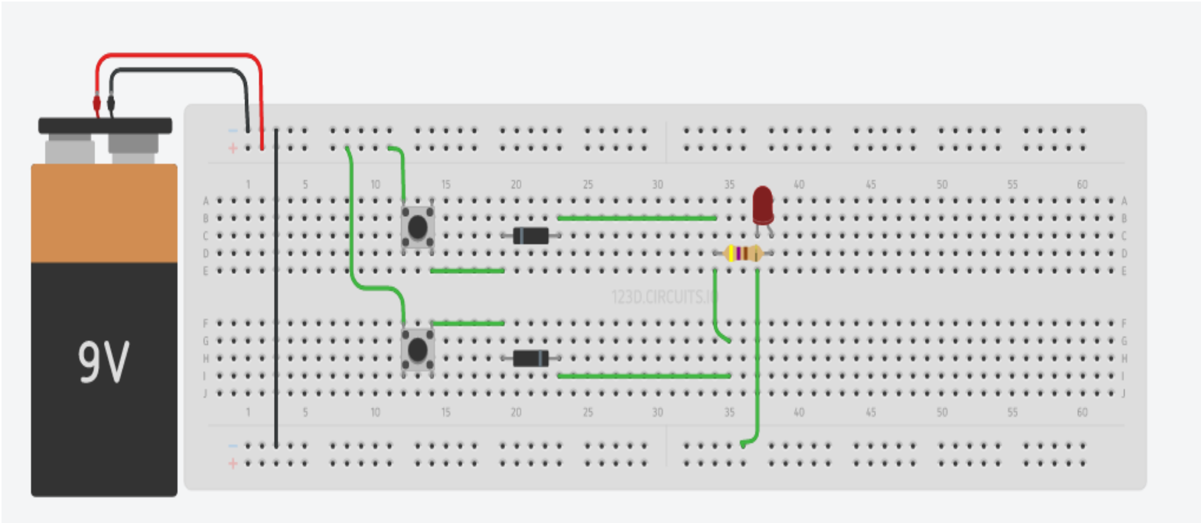


Solar cells are the main benefactor of photodiode technology. But these diodes can also be used to detect light, or even communicate optically.

ACTIVITY

Make a circuit to study the current blocking property of the diode

Circuit Diagram



Material Required

Name	Quantity
9V Battery	1
Resistance	1
LED	1
Breadboard	1
Button	2
Diode	2

Instructions

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Now connect the battery to the circuit.
- Now press button 1 and then button 2 and record your observations

Observations

	LED 1	LED 2
Button 1		
Button 2		

Diode works in which configuration, forward bias or reverse bias?

Diode 1 is in which configuration? (Give reason for your answer)

Diode 2 is in which configuration? (Give reason for your answer)

CHAPTER 5: MOTORS AND GENERATORS

INTRODUCION TO MOTORS AND GENERATORS

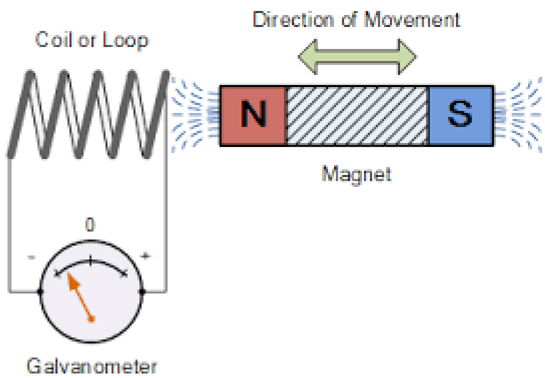
At the time of power cut, you may wish you had a candle or a flashlight so that you could see in your dark house. But what would be really useful is a generator because this converts mechanical energy into electrical energy. If the generator were powerful enough, you could use it to restore electricity to your house, at least for a little while.

Now that you know how handy a generator is reversed generator is an electrical motor, which converts electrical energy into mechanical energy.

While the generator and motor may serve different functions, they are actually two sides of the same coin. In fact, they are the same device! In an electrical motor, the input is electricity and the output is mechanical power. Contrary to this, a generator takes mechanical power and outputs electricity. In both cases, electricity is flowing - just in a different direction!

ELECTROMAGNETISM

Both motors and generators run because of something called electromagnetic induction. Discovered by Michael Faraday, this is when a voltage is induced by a changing magnetic field. With electromagnetic induction, an electric current can be produced in a coil of wire by moving a magnet in or out of that coil, or by moving the coil through the magnetic field. Either way, voltage is created through motion.



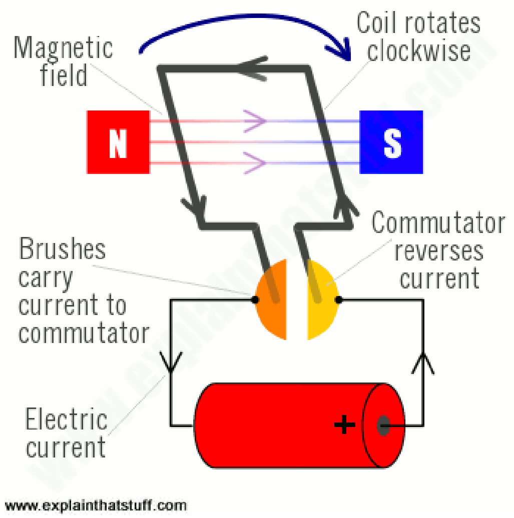
The amount of voltage induced depends on the number of loops in the coil of wire, as well as the speed at which the magnet is moved through the coil. A greater number of coils mean a greater amount of voltage is induced. Similarly, the faster the magnet is moved through the coil, the more voltage you get.

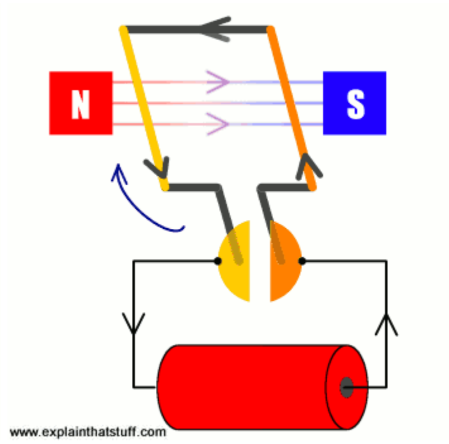
What does this have to do with motors and generators? Well, a generator produces electricity by rotating a coil in a stationary magnetic field, and in a motor, a current is passed through a coil, which forces it to spin. In both cases, Faraday's law of electromagnetic induction is employed, allowing you to produce electricity in your house and then use it to vacuum your floor, wash your dishes in the dishwasher, and keep food fresh in your refrigerator and so much more.

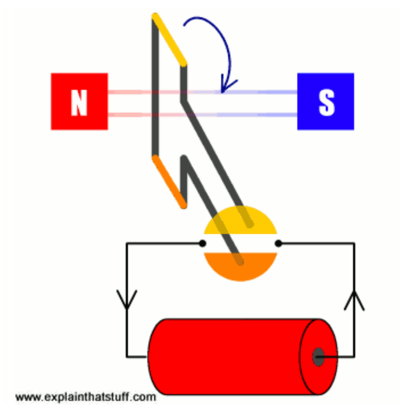
Remember before how we said that a motor and a generator are the same device, but producing opposite results? What we mean here is that the flow of electricity is reversed, not that the machine itself operates in reverse. So, you can't just take a generator and turn it into a motor by 'reversing' the components of the machine. Likewise, with an electric motor you can't just flip a switch that makes the components operate in reverse to produce electricity. Instead, what you have to change is the direction the electricity flows: inward for a motor and outward for a generator.

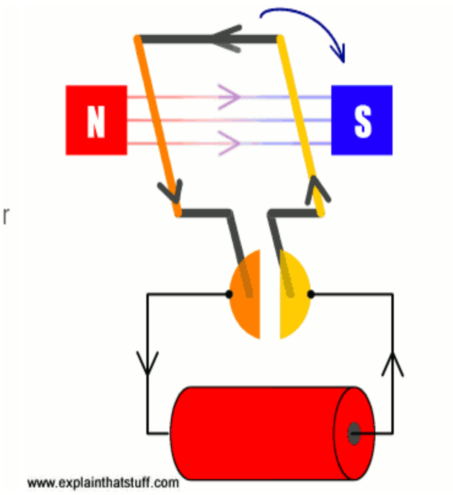
MOTOR (WORKING)

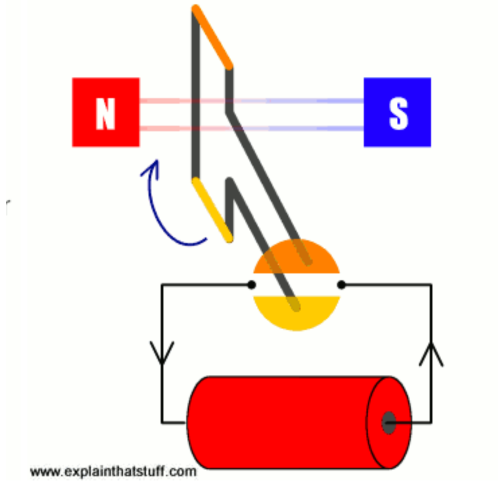
There are two ways to overcome this problem. One is to use a kind of electric current that periodically reverses direction, which is known as an alternating current (AC). In the kind of small, battery-powered motors we use around the home, a better solution is to add a component called a commutator to the ends of the coil. (Don't worry about the meaningless technical name: this slightly old-fashioned word "commutation" is a bit like the word "commute". It simply means to change back and forth in the same way that commutes means to travel back and forth.) In its simplest form, the commutator is a metal ring divided into two separate halves and its job is to reverse the electric current in the coil each time the coil rotates through half a turn. One end of the coil is attached to each half of the commutator. The electric current from the battery connects to the motor's electric terminals. These feed electric power into the commutator through a pair of loose connectors called brushes, made either from pieces of graphite (soft carbon similar to pencil "lead") or thin lengths of springy metal, which (as the name suggests) "brush" against the commutator. With the commutator in place, when electricity flows through the circuit, the coil will rotate continually in the same direction.







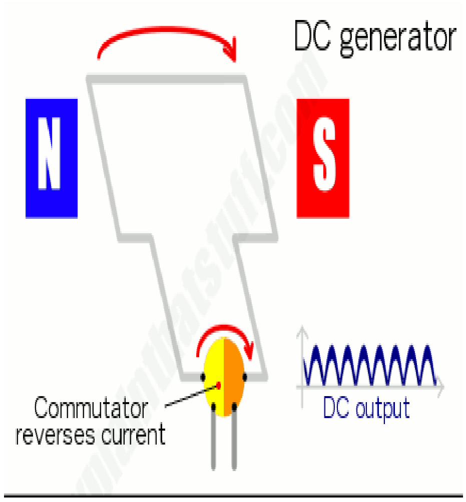




A simple, experimental motor such as this isn't capable of making much power. We can increase the turning force (or torque) that the motor can create in three ways: either we can have a more powerful permanent magnet, or we can increase the electric current flowing through the wire, or we can make the coil so it has many "turns" (loops) of very thin wire instead of one "turn" of thick wire. In practice, a motor also has the permanent magnet curved in a circular shape so it almost touches the coil of wire that rotates inside it. The closer together the magnet and the coil, the greater the force the motor can produce.

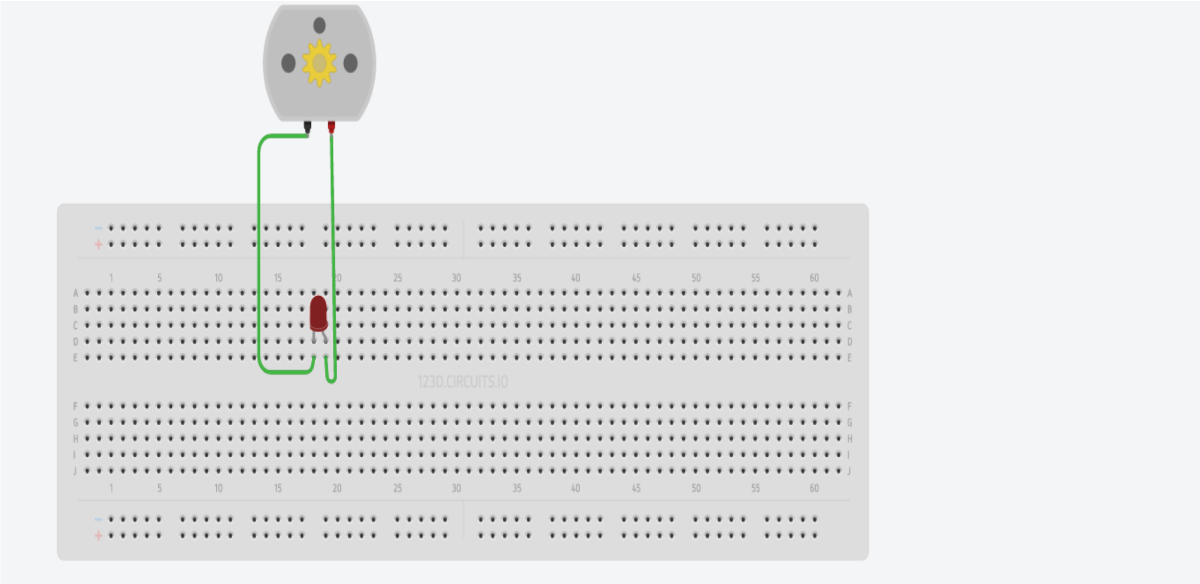
GENERATOR (WORKING)

Just as a simple DC electric motor uses direct current (DC) electricity to produce continual, rotary motion, so a simple DC generator produces a steady supply of direct current electricity when it spins around. Like a DC motor, a DC generator uses a **commutator**. It sounds technical, but it's just a metal ring with splits in it that periodically reverses the electrical contacts from the generator coil, reversing the current at the same time. As we saw up above, a simple loop of wire automatically reverses the current it produces every half-turn, simply because it's rotating, and the commutator's job is to cancel out the effect of the coil's rotation, ensuring that a direct current is produced.



Make a circuit for a simple hand-crank generator

Circuit Diagram



Material Required

Name	Quantity
LED	1
Breadboard	1
Motor	1

Instructions

For LED circuit

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Rotate the shaft of the motor with your hand as fast as you can for a short amount of time.
- Record Your Observation

Observations

Position of Pot	Intensity of LED
Motor At Rest	
Motor At Medium Speed	
Motor At High Speed	

Explain the reason behind your observation.

____

____

____

____

____

What scientific phenomena is responsible for your observation?

____

____

____

____

____

____