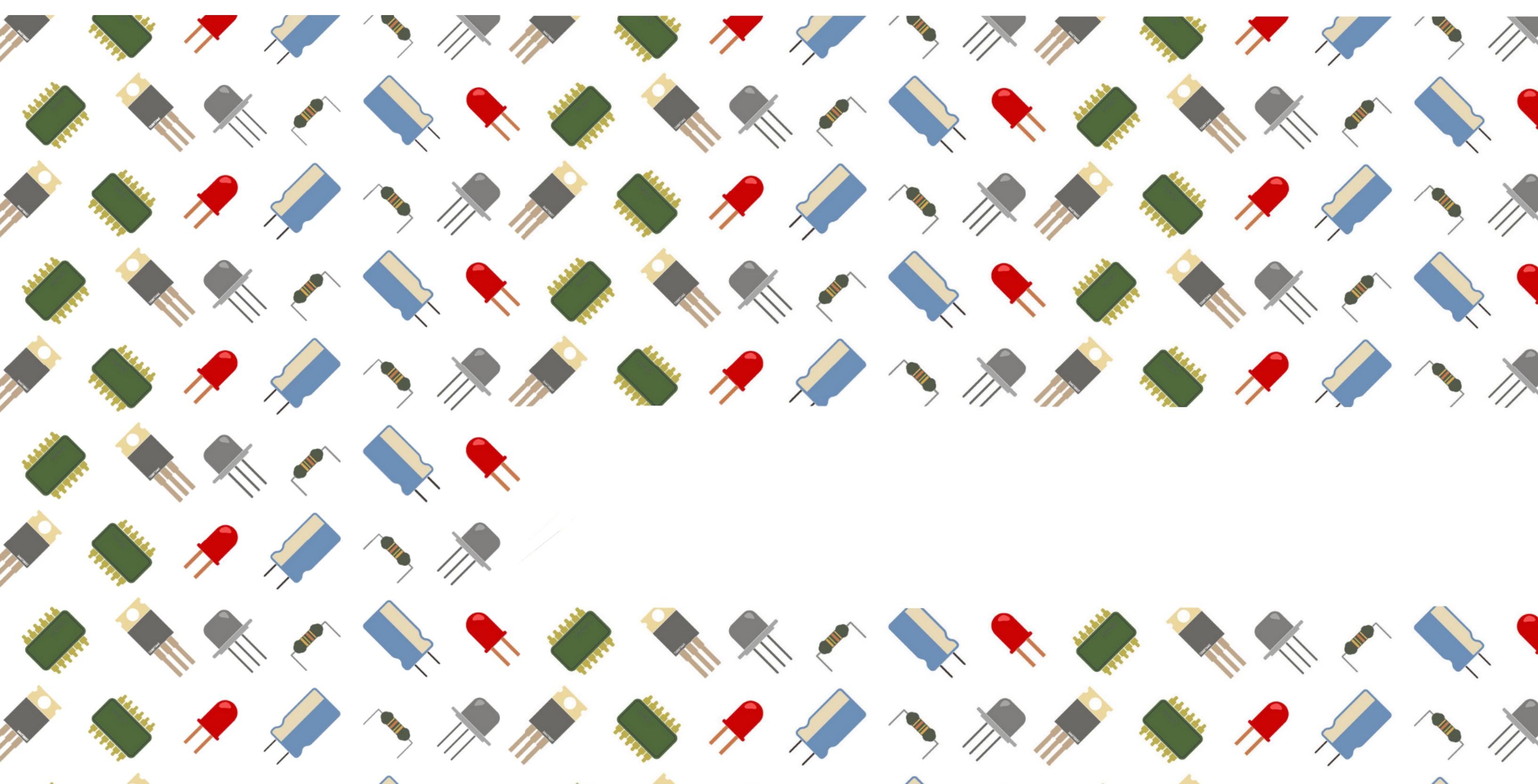

HatchnHack - A nest to your ideas

https://github.com/hatchnhack/Electronics-Starter-Kit

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Contents

1. Homopolar Motor

A motor is, elementarily, a device which converts electrical energy into mechanical energy and kids know it as something which moves or rotates. But one may question as to how exactly do these motors produce the rotational force. This rotational force is due to the interaction between an electric current and a magnetic field oriented in a specific direction. This basic principle can be seen in action and appreciated better with a simple demonstration of a homopolar motor. The homopolar motor, first created in 1821 by Michael Faraday, is the most fundamental example of a motor, and is really fun to experiment with.

1.1 What all you need

- Duracell AA Battery(1.5V)
- Tapered Screw
- Insulated Copper Wire
- Neodymium Magnet (diameter - 12mm)
- A piece of paper (optional)

1.2 Get ready to build the world's simplest motor

There is no better way to learn how a motor works than by building your very own motor! Here is what you have to do:

Step 1: Attach the head of the screw to the magnet as shown in Fig

Step 2: Connect the pointed side of the screw to the negative terminal of the battery as shown in Fig

Step 3: Use the insulated copper wire to connect the positive terminal of the battery to the side of the magnet. Be careful that the wire should touch the side of the magnet at right angles and not at its bottom.

1.3 Understanding the principle behind

When the screw is connected to the magnet, it gets magnetized. As soon as the wire is connected from one end of the battery to the side of the magnet (and not the bottom), the circuit gets completed. The rotation is produced because the direction of current and that of the magnetic field is perpendicular to each other. In this case, a force (known as Lorentz Force) is exerted in a direction perpendicular to BOTH of them, causing the spinning motion. Fig 2.5 specifies the directions of the Current, magnetic field and force. The direction is given by Fleming's Left Hand Rule (shown in Fig 2.6); which says that if the thumb, forefinger and middle finger of the left hand are stretched to be perpendicular to each other, and if the fore finger represents the direction of magnetic field, the middle finger represents the direction of current, then the thumb represents the direction of force.

The following mathematical equation represents the relationship:

$$F = I(\overrightarrow{L} \times \overrightarrow{B})$$

The stronger the magnet, the faster the wire will rotate. Neodymium magnets are the strongest in the world and therefore, while using an AA battery to make a homopolar motor, an ideal magnet to use is a 12mm diameter and a 6mm thick neodymium magnet.

1.4 Thinking Beyond

Now, you know how the simplest motor works and it is, in fact, true for all of the DC motors that you can think of. From the industrial fans, household devices like the food processor, food mixers, electric watches to the largest instances in automotive and ship propulsion, this principle is followed. Generally, an electric motor would contain a coil of wire that can create an electromagnetic field aligned with the centre of the coil, when electricity flows through it. This wire is referred to as an electromagnet. The magnetic field may be created using permanent magnets as well. When, a current is sent through this loop of wire, the electromagnet experiences a Lorentz force on it at right angles to the direction of the magnetic field and the current flowing. And this force causes the loop of wire to generate mechanical energy and rotate.

Why is this motor called homopolar motor? The homopolar motor gets its name from the fact that the direction of the electrical current and the magnetic field never reverses, unlike an AC motor, or a DC motor containing a commutator.

What more can you do? One may add a paper fan as shown in Fig 2.7 to this homopolar motor to see the motor actually rotating, even from a far distance. Just by adding a piece of paper or some plastic blades between the screw head and the magnet, you can see that as the screw rotates, the blades/paper rotates!

You can even bend a wire to form any shape, for example, a wired Ballerina! The shape of the wire should be such that allows it to balance properly, otherwise it might fall off the battery when it begins to spin.

2. Faraday Generator

Science is taught to us through textbooks. But not only can we observe various physical laws in real, we can also apply them to make cool stuff that demonstrates them. For example, conversion of one form of energy to another is a fascinating event to see. The glowing LED faraday generator is a perfect demonstration of Faraday's law. The fundamental principles behind the generation of electricity were based on Michael Faraday's discoveries in the nineteenth century. This DIY kinetic generator converts your mechanical power (just a number of shakes) to electrical power, based on his principle.

2.1 What all you need

To make your own glowing LED Faraday Generator, you will need the following materials:

- Thread spool × 1
- Enameled copper wire: 36-SWG × 50m
- Red LEDs × 2
- Neodymium Magnet (diameter- 7 mm) × 1
- Matchsticks × 2
- Needle/Compass × 1
- Sand Paper
- Watchmaker's File × 1
- Insulation Tape
- Soldering Equipment*

2.2 Understanding the principle behind

Before we apply the science, we must know the science. Michael Faraday, a master experimentalist of the nineteenth century, is best known for his invention of the phenomena of electromagnetic induction and that of the electric generator and motor. This was, in fact, his most revered contribution to two of the most coveted and bewildering subjects of science and innovation at that time, Electricity and Magnetism. His work formed a strong basis for the merger of these two, and its significance is paramount. The invention of an electric generator and motor finds application in almost every appliance today. From washing machines to fans, to food mixers and electric chargers, all use Faraday's theory of electromagnetic induction. The glowing LED faraday generator works on the Faraday's law of electromagnetic induction which states that:

"The induced electromotive force (or voltage) in any closed circuit is equal to the negative of the time rate of change of the magnetic flux enclosed by the circuit."

Here, your closed circuit is going to be the 50 m of copper wire wound around the thread spool and the magnetic flux is changed by shaking the thread spool. This changes the magnetic field due to the up-down motion of the magnet. The change of magnetic field as seen by the wire, generates an electromagnetic force(EMF) that is proportional to the number of turns of wire, as well as the rate at which the magnetic field is changed.

2.3 Get Ready to Shake and Generate

To make your own LED glowing faraday generator, all you need to do is to follow a set of few simple steps:

Step 1: Start by creating two marks on the thread spool, with the help of pen or a marker, such that the distance between them is equal to the length of the magnet.

Step 2: Now, with the help of a needle, pierce the thread spool at these marks as shown in Fig 3.2 such that you have holes on both the sides of the thread spool. Be careful, it would hurt if the needle pierces your finger instead of the thread spool.

Step 3: Using a watchmaker's file, file those holes and inside of the thread spool for smooth movement of the magnet inside the spool. Also, make sure that the holes are big enough to put a matchstick in them. Once the filing is done, put two matchsticks in these holes as shown in Fig 3.3.

Step 4: Now, we start winding the copper wire. Leave 6 to 8 cm of wire, wind 5-6 turns on one of the matchsticks and then start winding on the thread spool. By doing this, we fix one end of the wire. Be careful that you wind the copper wire between the matchsticks only. Have patience, it will take some time.

Step 5: Once the winding is done, put tape around the windings and then remove the matchsticks. Be careful not to stick ends of the wire inside the tape.

Step 6: Since we are using 'enameled' copper wire, we need to remove the enamel at the ends of the wire to make the connections. Sand the ends using a sandpaper very slowly and lightly, or otherwise, the wire might break.

Step 7: Now is the time for soldering. Solder two LEDs at the ends of the wire in opposite polarities (You can identify the polarity of an LED by seeing the length of its legs, the longer one is positive and the shorter one is negative).

NOTE:

The reason for opposite polarity of LEDs is Lenz's law which states that:

"The direction of current induced in a conductor by a changing magnetic field due to Faraday's law of induction will be such that it will create a magnetic field that opposes the change that produced it."

Hence, if a clockwise current is induced due to the upward motion of the magnet, then an anti-clockwise current will be induced due to the downward motion of the magnet. Thus, if one LED glows when the magnet goes up, the other will glow when the magnet goes down.

Step 8: Now stick the LEDs on the thread spool using tape. Stick them 180 degrees apart so that you can see both of them glowing separately. And you are done! Your glowing LED Faraday Generator is ready. Insert your magnet inside the spool and as you move the thread spool updown, you can see the LEDs glowing.

2.4 Thinking Beyond

This Faraday Generator, when shaken vigorously, can be used to generate sufficient energy to charge up capacitors. This energy stored in capacitors can be utilized in powering low power circuits. How about your TV Remote? You can get rid of those batteries with a Kinetic Remote or an Electronic Dice which gives a random number when you shake it!

3. DC Motor

A DC motor is a device which converts electrical energy into mechanical energy. One may find DC motors in many portable home appliances like fans, food mixers, in automobiles and in numerous industrial equipment. The rotational force is due to the interaction between an electric current and a magnetic field, both of which are oriented in specific different directions. This manual will help you make a very impressive motor of your own!

3.1 What all you need

- Zero PCB
- Hook up wires
- Insulated copper wires (single strand)
- Enameled copper wire(21 SWG)
- Neodymium magnets (diameter -12mm)
- Wire cutter
- Sand paper
- Double sided tape
- Duracell AA battery(1.5V)
- Paper Cutter
- Soldering Equipment

3.2 Get Ready to make your own DC Motor!

Step 1: Creating the coil

(a) Take the enameled copper wire (21 SWG) and cut a length of around 1 feet from it with the help of wire cutter as shown in Fig 4.2.

(b) Take the AA battery and wrap the wire over the battery leaving approximately 2 inches of wire from each of the ends as shown in Fig 4.3.

(c) The coil should be tightly wound because a balanced coil will rotate more swiftly.

(d) Wrap the ends of the coil 2 or 3 times through the coil to make the coil maintain its shape.
(e) The trailing ends should be diametrically opposite to each other, for the symmetrical shape and for the balance of the motor.

Step 2: Removing the insulation from the ends of the coil
The next step is a bit difficult and, so, has to be performed with care. The insulation of the ends of the coils has to be removed, to unleash the metal underneath it, to make it conducting. Take one end of the coil and start removing the enamel, using a paper cutter, leaving a shiny new layer of copper wire. The enamel from the end of the coil has to be removed from only one half of the perimeter of the wire, say, the upper half. Similarly, the insulation from the other end has to be removed from only the upper half of the perimeter. This process is done so that the force exerted by the magnet to the coil should be unidirectional, and the motion is sustained.The enamel should be removed properly to ensure a good electrical connection between the wire and coil. After this, you will have a coil that is ready to be the armature of your motor, as shown in Fig 4.6.

Step 3: Creating posts for the motor coil to rotate
The posts will form a stand for your motor, aiding its rotation.
(a) To start building a stand for the motor, you need a Zero Board and two hookup wires.
(b) Measure the length of your coil end to end leaving 1 inch on either end and mark it on the Zero Board.
(c) Take a hookup wire of nearly 2 inches length and make it straight using a tweezer.
(d) Then make a small U-shape at one end of it through a plier/tweezer.
(e) Put it through the mark on the Zero Board from downwards side. Press the smaller end of the U-shaped post in the zero board, so that the wire stands straight. Repeat the process for the other wire as well.Now, you have two wire posts (each of lengths 2 inches) standing straight on the Zero Board. Solder the Hookup Wires in place.
(f) Using the plier, make a loop at the top end of each of the wires. Ensure that the loops are similar to both the posts.Now take your coil and try to suspend it with the help of these loops made on the posts.
(g) If it suspends in a perfectly horizontal fashion, then proceed. Otherwise, adjust the posts and the height of the loops to make it suspend horizontally.

Step 4: Making the electrical connections
For the electric current to flow through your coil, you need to connect the battery to the motor
(a) Take two single strand copper wires, preferably 15 cm in length.
(b) Strip off its insulation up to half inches from either side, for both the wires.
(c) Take one wire and wrap one of its ends at the bottom end of a post, thus establishing a connection. Do the same with the other wire as well. Make sure that the connection should be strong enough to hold.

Step 5: Attaching the magnet
Now it is time for assembling the most important part of this motor, the magnet.
(a) Take the magnet and place it at the centre of the two posts and mark its place.
(b) Now cut a piece of double-sided tape and paste it at the mark you just made for the magnet. Take off the other covering of the tape at put the magnet there. Apply some pressure so that it holds good. Take care that the magnet should be around 2-3 cm below where the coil would be, and perfectly under it.

Step 6: Testing the motor and making the necessary twitches

(a) Suspend the copper coil on the wire posts. Make sure that the exposed ends should make contact with the hookup wires.
(b) Take up the battery and fix one of one of the copper wires to the end of the wire through a tape, preferably, to fix a connection. Take the other end and complete the electrical circuit by touching it to the other end of the battery.
(c) The copper coil may start rotating on its own, but may also, sometimes, require a small push to start rotating. If the coil is not spinning after this, you may need to sand the ends of the coil or you may need to make the coil more balanced to make it rotate. Keep trying till it doesn't start rotating!

3.3 Understanding the principle behind

A motor is an electrical machine which converts electrical energy into mechanical energy. The working principle behind in a motor is that, whenever a current carrying conductor is placed in a magnetic field, it experiences a force, according to the Fleming's Left-Hand Rule (discussed on page 7). When the armature coils are connected to a DC voltage supply, some current starts flowing in the conductor. The magnetic field may be provided by electromagnets or by using permanent magnets. In this case, current carrying armature conductors experience a force due to the magnetic field provided by a neodymium magnet present near the base of the coil.

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