

## Section 13: Generators - Induction Applied

In this lesson you will

- show how Faraday's Law is the basis of the electric generator by describing the production of alternating current from a single loop rotating in a magnetic field
- name the main parts of AC and DC generators
- describe the operation of a DC generator
- show graphically the resultant current for simple one and two loop DC generators.

 <http://www.generatorguide.net/howgeneratorworks.html>

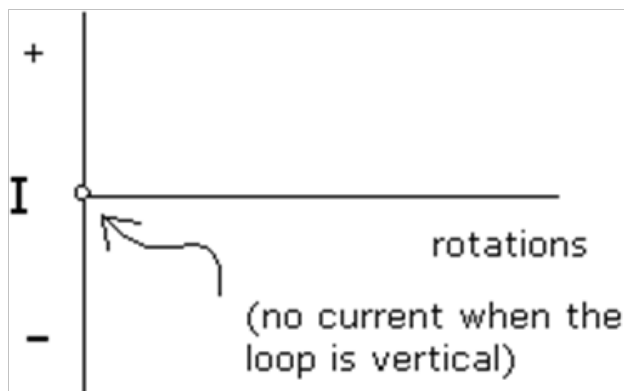
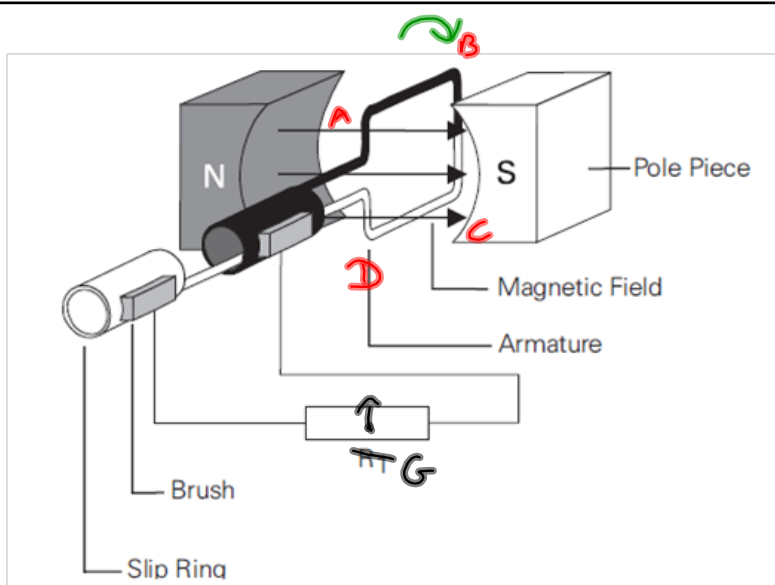
 [http://www.ecgf.uakron.edu/grover/web/ee381/applets/ph14e/generator\\_e.htm](http://www.ecgf.uakron.edu/grover/web/ee381/applets/ph14e/generator_e.htm)

## AC Generator

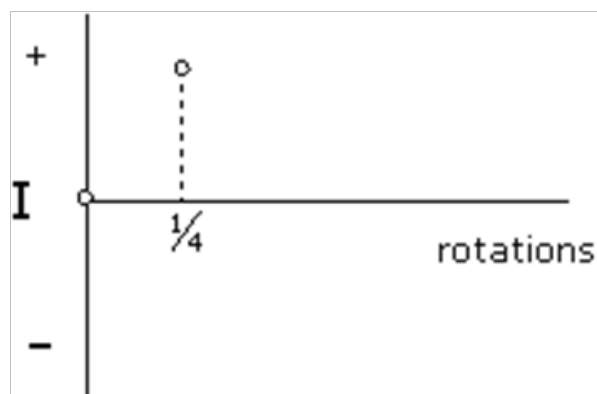
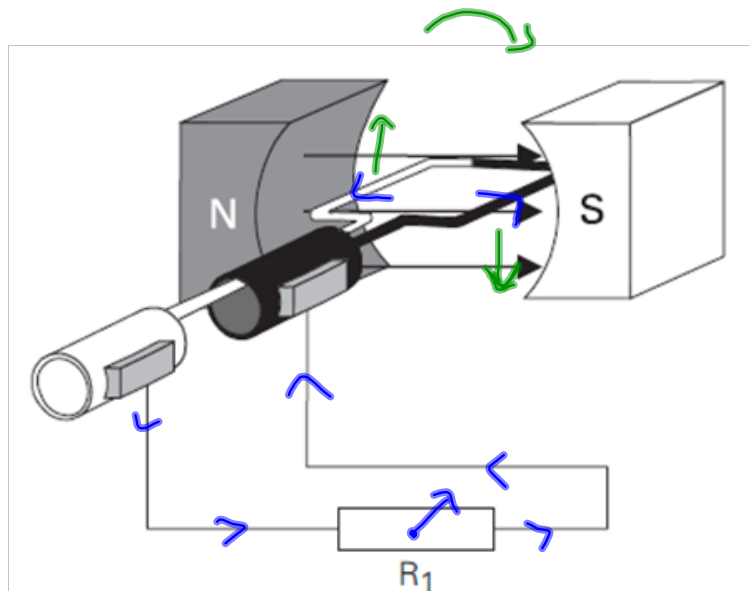
A basic AC generator consists of a magnetic field, an armature, slip rings, brushes and a resistive load. The magnetic field is usually an electromagnet. An armature is any number of conductive wires wound in loops which rotates through the magnetic field.

For simplicity, one loop is shown. When a conductor is moved through a magnetic field, a current is induced in the conductor. As the armature (the loop) rotates through the magnetic field, a current is generated in the armature which causes current to flow. Slip rings are attached to the armature (loop) and rotate with it. Carbon brushes ride against the slip rings to conduct current from the armature to a resistive load. The loop is being forced to spin clockwise by an external source of energy.

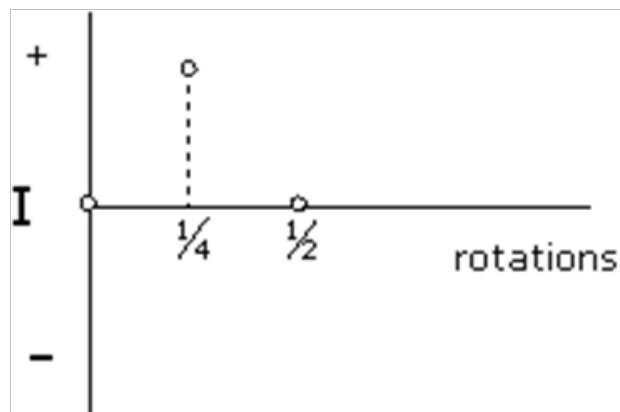
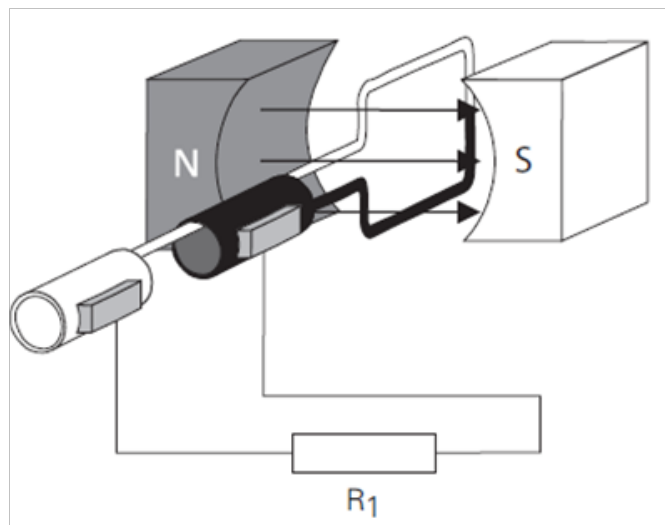
When the loop is in the vertical position, the black wire, AB, and the white wire, CD, are not cutting any of the magnetic field lines. The sides of the loop are just moving parallel to the lines of force. This means that no current is induced in the loop and the galvanometer reads zero. This absence of current is shown by the dot on the I-t graph.



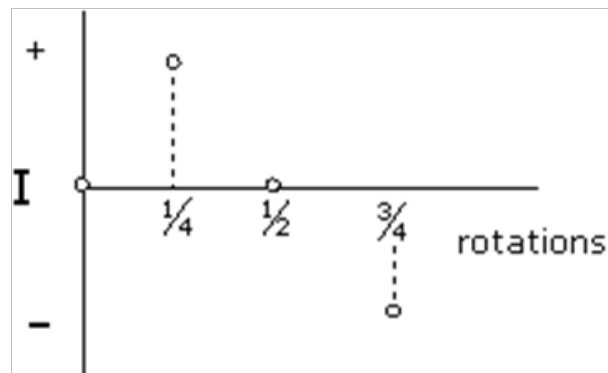
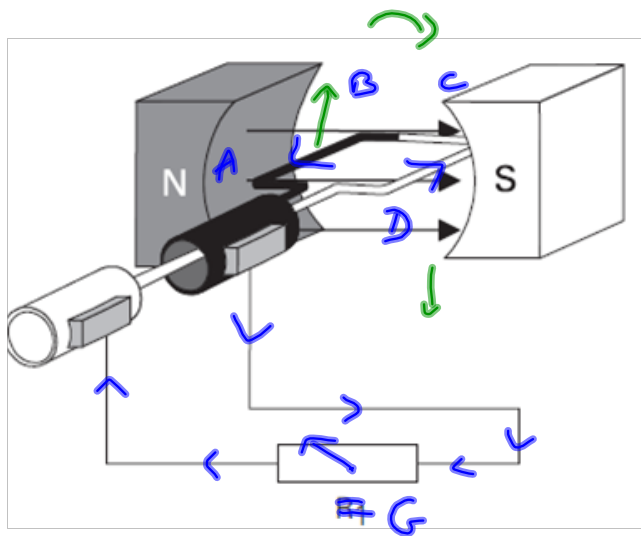
The armature rotates from zero to 90 degrees. The conductors cut through more and more lines of magnetic flux, building up to a maximum induced current in the positive direction. In the next diagram, the conductors are now cutting through the magnetic field lines in the maximum way possible. Thus, the induced current will be a maximum. The black and white ends of the loop slide around the inside of the slip rings, making contact all the time so that the current is feed to the galvanometer.



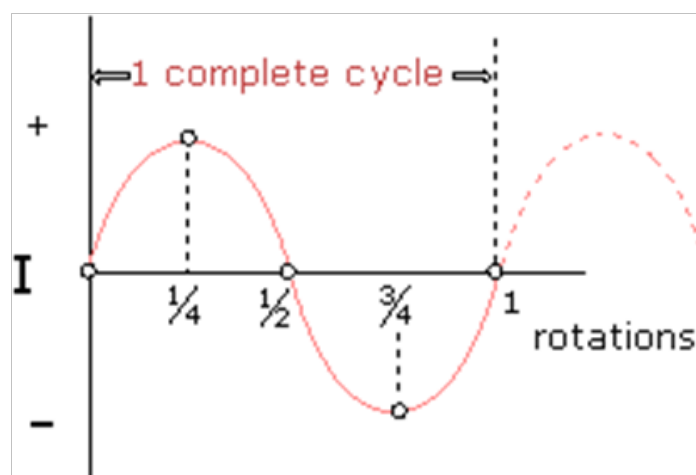
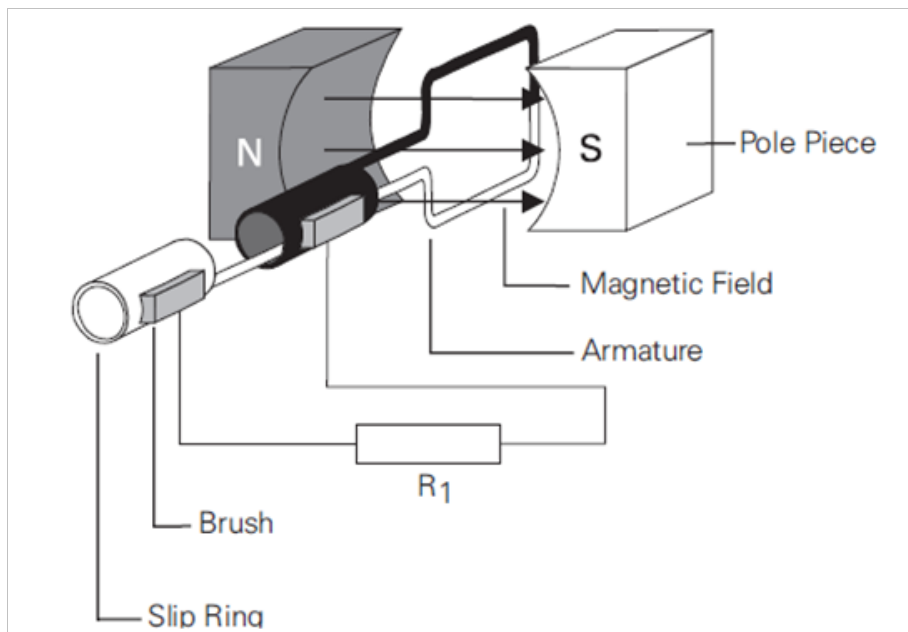
The armature continues to rotate from 90 to 180 degrees, cutting less lines of flux. The induced current decreases from a maximum positive value to zero.



The armature continues to rotate from 180 degrees to 270 degrees. The conductors cut more and more lines of flux, but in the opposite direction. Current is induced in the negative direction building up to a maximum at 270 degrees.



The armature continues to rotate from 270 to 360 degrees. The induced current decreases from a maximum negative value to zero. This completes one cycle. The armature will continue to rotate at a constant speed. The cycle will continuously repeat as long as the armature rotates.



**Summary:**

As the loop rotates, there is an increase in the induced current from zero to the amount shown by the second point on the graph at  $1/4$  rotation. Next, as the loop approaches the second vertical position ( $1/2$  revolution), the current gradually diminishes once again to zero.

Then the induced current increases once again to a second maximum as the loop continues to rotate and cut the magnetic lines more and more at the  $3/4$  rotation point. Now, however, the current is in the opposite direction.

Once the armature returns to the original position, the current will once again have decreased to zero (the fifth point on the graph). As the loop continues to spin, the cycle is repeated.

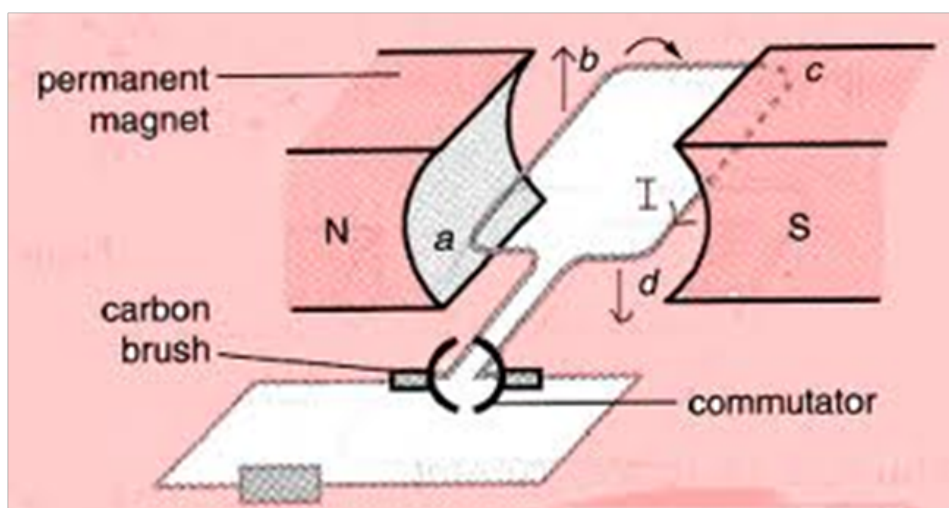


## DC Generator

If you make a slight change in the slip rings of an AC Generator, you can obtain direct current instead of alternating current.

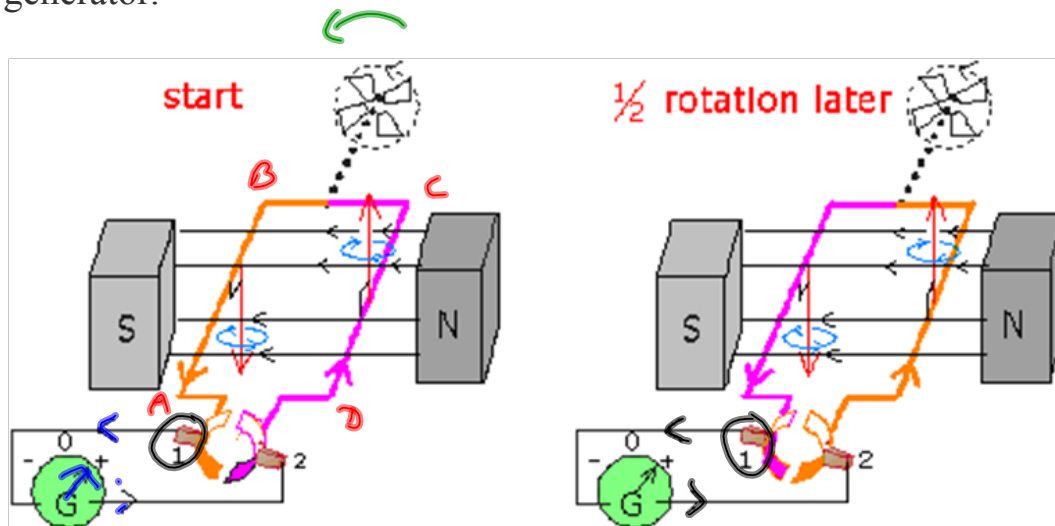
In the diagram below, the two slip rings have been changed to a SINGLE, TWO-SEGMENT RING called a **split ring commutator**. Segment *ab* is connected to the left-side of the split ring commutator and segment *cd* is connected to the right-side of the split ring commutator. The two segments are insulated from each other, so that no electrical contact is possible.

The two BRUSHES are on opposite SIDES of the SPLIT RING, mounted in such a manner that each brush is in contact with only one segment at a time.



## The DC Generator

The armature of the DC generator below is being rotated counter clockwise by a turbine. The turbine is turned by water or steam power, and the turbine then turns the **rotor** or **armature** of the generator.



From the previous discussion on AC generators, you know that the current is not induced in the armature when it is in the vertical position. It is only induced when it cuts across the magnetic field lines.

In the left-hand diagram, the current flows out through brush 1 and in through brush 2. (Lenz's Law).

The important difference between DC and AC generators depends on the operation of the split ring commutator.

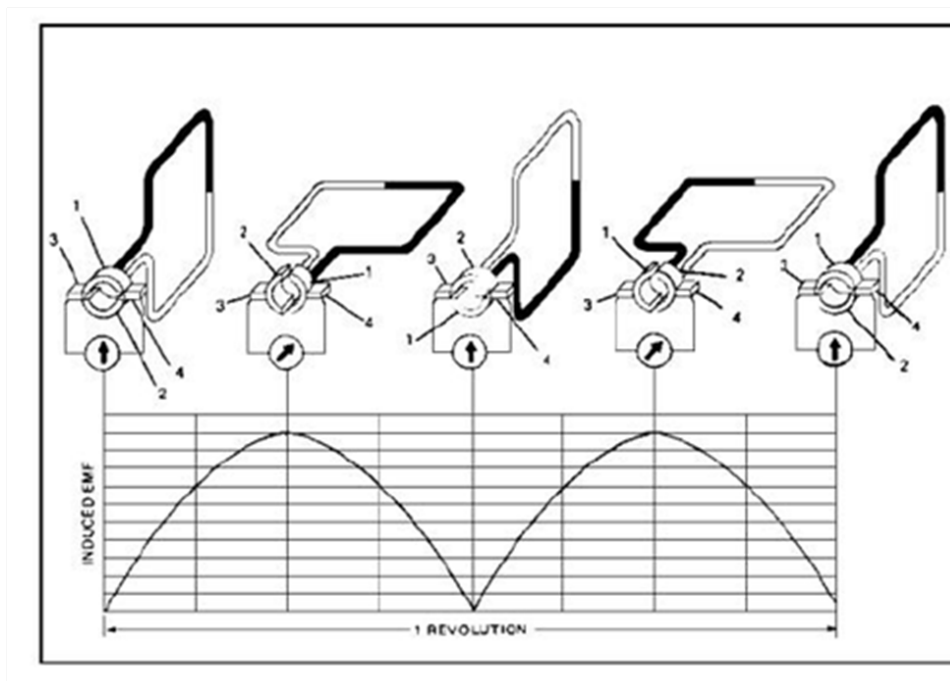
Note that at the start the orange conductor is moving downwards towards the floor, while the pink side is moving upwards towards the ceiling. The current is coming out through the orange part and going in through the pink part.

Now look at the picture one-half of a rotation later: the current is coming out of the pink side and going in through the orange side. The current in the loop has switched around, just as it did in the AC generator. **But, in the DC generator, the split half rings turn with the coil**. So, just as the current in the pink side switches, the pink half ring comes in contact with brush 1. This means the current will continue to come out through brush 1.

A similar statement can be made for brush 2. At the start the current was going in through brush 2 and up the pink side. In the second picture the orange side with its split ring has changed places with the pink ring, so that the current continues to go in through brush 2.

**All of this means that the current is always going the same way in the external circuit.** The needle of the galvanometer fluctuates from 0 to the + end as the loop goes from the vertical position to either one of the horizontal positions. **The current in the external circuit never reverses, even though it does reverse in the generator loops.** Since the generator is providing DC electricity to the external circuit, it is called a DC generator.

The current graph for a DC generator is like the next picture



To keep the descriptions simple, only single loop rotors or armatures have been presented so far. Of course, a generator has many loops. Look at a DC generator with two loops--one perpendicular to the other. Each loop has its own set of split rings. Just as the black loop loses contact with the brushes, the brown loop takes over. A plot of the current from a two-loop DC generator is shown to the right.

