

PHYS245 Lab: Motors and Generators

Purpose:

- Understand the energy conversion processes in motors and generators
- Understand the fact that motors and generators are reversible processes in the same machine.
- Hands on experiences on a permanent-magnet-based toy motor/generator

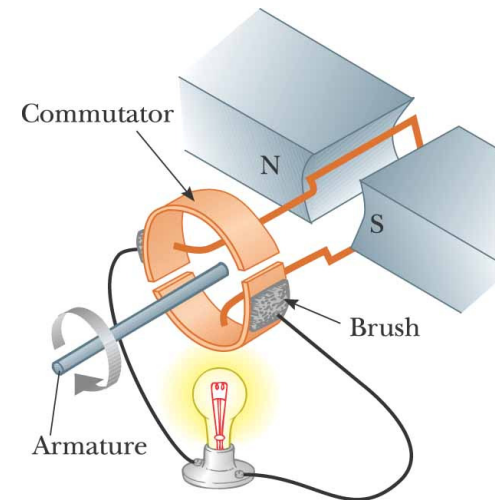
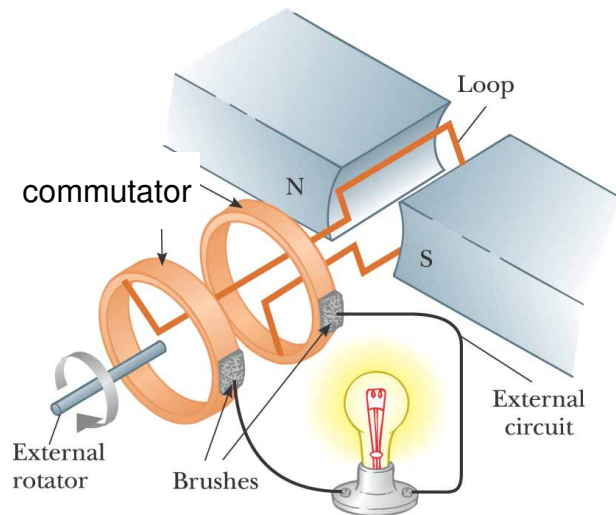
Equipments: ELVIS II, toy generator/motor system, jump wires, two coaxial cables with BNC connectors, banana-to-banana cables.

A motor converts electrical energy into mechanical energy. A generator converts mechanical energy into electrical energy. A motor and a generator can be realized in the same machinery, but in two reversible processes. This machine usually contains a long conducting wire wrapped around a rotor (or armature), forming a set of coils. The rotor is placed inside a magnetic field. When the electric current passes through the coils, the ampere forces on the coils will exert a torque on the rotor and rotate the rotor.

A generator is a reversed motor. An external mechanical energy source (wind, engine, or water flow) is used to rotate the rotor. Therefore magnetic flux through the coils are changing rapidly due to the rotation of the coils in the magnetic field. Thus an emf is induced in the coils and it will supply a voltage to the load.

Pre-Lab Exercises

Based on what you have learned in the lecture, identify from the two pictures below which one is a d.c. generator and which one is an a.c. generator.



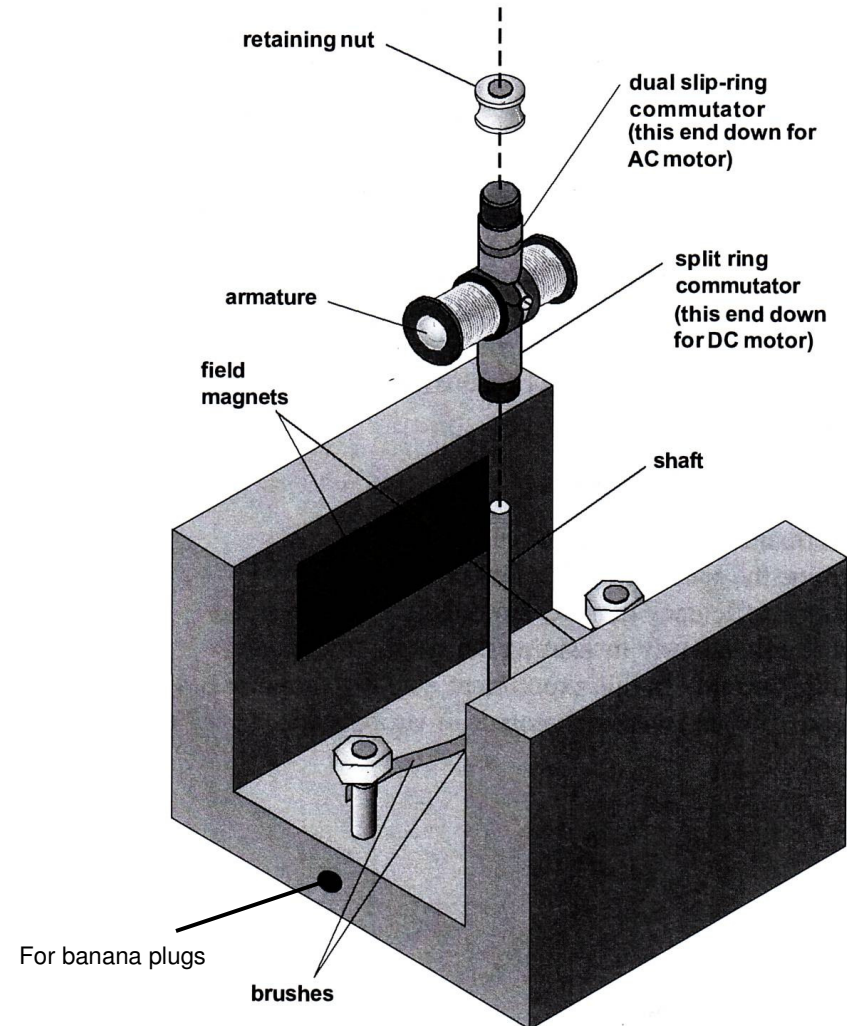
Experiment I: D.C. Motor and Generator



**Permanent magnet motor/generator
made by PASCO Scientific**

The retaining nut on the top can be taken off by turning it counter clockwise. For some models, it is a removable cap (red color), which can be pulled off by grabbing it and lifting it up gently. The armature-commutator assembly can be then lifted up from the shaft. There are two commutators in the assembly: a dual slip-ring commutator for a.c. motor operation and a split ring commutator for d.c. motor operation.

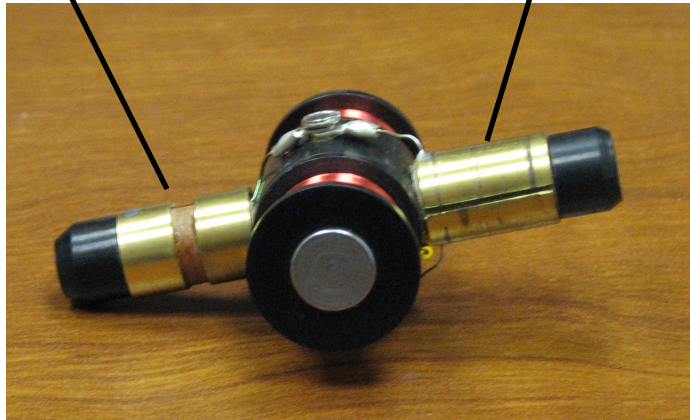
More descriptions of the two commutators can be found of the next page.



Schematics of the parts of motor/generator

Dual slip-ring commutator

Slip-ring commutator



This is a close-up view of the armature-commutator assembly. For d.c. motor/generator operation, the assembly has to be installed on the shaft so that the slip-ring commutator is at the bottom position embraced by the two brass brushes on the base.

Install the assembly on the shaft with proper orientation and then tighten the retaining nut clockwise (or [plug back the removable cap](#)).

Armature-commutator assembly

Use the banana-to-banana cables to deliver the 5 V d.c. voltage from the ELVIS II to the d.c. motor. The connection to the motor is made through the two holes located on the two opposite sides of the base. Use jump wires to deliver the 5 V power to the banana jacks (e.g. A and B) on the prototyping board. Then deliver the 5 V to the motor using the banana-to-banana cables.

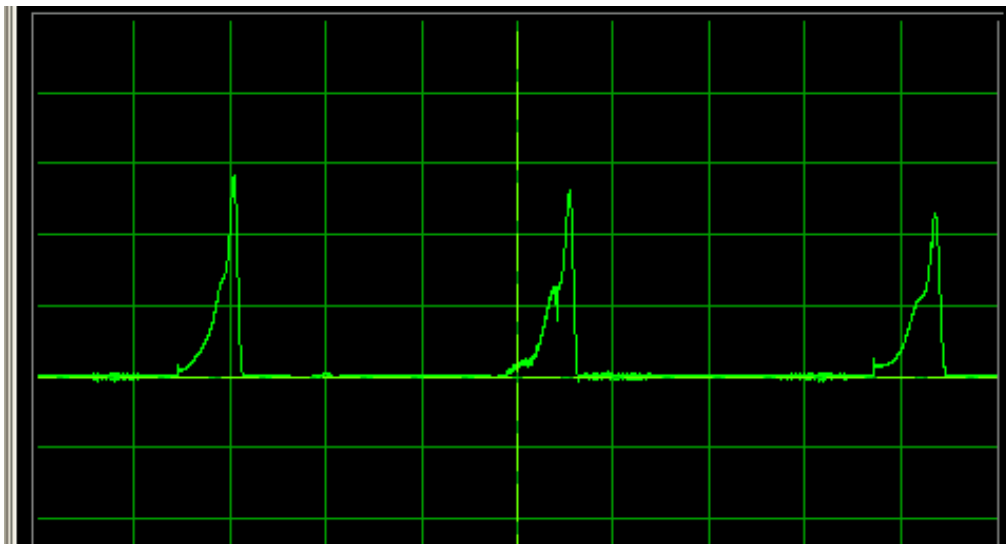
The motor should start to rotate at high speed. If not, use your hands to rotate the armature-commutator assembly around the shaft to give it a jump start. Try the opposite sense if still not working.

The exact same machine can operate as a d.c. generator, which turns mechanical energy into electricity. Disconnect the jump wires between the banana jacks and the 5 V power supply. Connect between the banana jacks and the BNC connectors using jump wires. Then use a coaxial cable to route signals from BNC connector to the Scope Ch 0. This way, the electric voltage generated can be displayed on the Scope.

Start with 200 mV for Volts/Div and 200 ms for timebase on the Scope. Use your thumb and index finger to grab the top commutator and rotate the armature-commutator assembly around the shaft steadily at a rate of roughly 1 turn per second. A series of electrical pulse should be displayed on the Scope as shown below. Adjust your rotating speed, the Volts/Div, and the timebase to achieve the best results. Confirm that the voltage is consistently positive or negative. Therefore it is indeed a d.c. motor.

Change the direction of the rotation and observe the display on the Scope. What has changed? Why?

Imagine that the armature-commutator assembly is rotating at high speed, driven by an engine or water flow. The adjacent voltage peaks should be much closer to each other on the time scale. This is how a generator works in reality.



Start with the following settings:

Volts/Div: 200 mV

Timebase: 200 ms

At these settings, the Scope is scanning slowly enough to catch the voltage spikes by the hand-driven-rotation of the armature.

Experiment II: A.C. generator

To convert the system to an a.c. motor/generator, change the orientation of the armature-commutator assembly so that the dual-slip ring commutator is at the bottom position and embraced by the two brass brushes. This is done by taking off the retaining nut (or the red cap for some models), flipping the assembly on the shaft, and finally tightening the retaining nut (or plugging back the red cap).

In principle, the motor can be driven by an a.c. current. But unfortunately the ELVIS II does not supply a large enough a.c. current. So we can not do the a.c. motor experiment. BUT, we can use it as a a.c. generator.

Connect the output of the generator to the Scope Ch 0. Actually you could do exactly the same connection as you did in the d.c. generator experiment. Then rotate the armature-commutator assembly at a rate of roughly 1 turn/second, and observe the output voltage displayed on the Scope.

Observe what is different for the output voltage, compared to the output from the d.c. generator. Explain why. Change the direction of the rotation. What difference does it make?