Capacitors and Generators

Goals

- Use a generator to charge a capacitor
- Use the capacitor to power a motor
- Make calculations based on data

Background

During the mid-1700s, the gentlemen scientists of Europe and America were fascinated with a device called a Leyden Jar, which they would use to electrically shock each other at parties. Ben Franklin actually nearly killed himself while trying to electrocute a turkey with one.

People at the time already knew, as any child does today, that you can generate a static electric charge through friction. Rubbing your feet on carpet and approaching your victim with a finger pointed at them delivers a small electric shock. But the Leyden jar's shock was so large that Pieter van Musschenbroek, who invented it, declared after receiving a shock, "I would not take a second shock for the kingdom of France."

Aside from shocking famed scientists, there wasn't much that could be done with the Leyden jar. But todays technology wouldn't be possible without it because it led to the development of a device called a capacitor.

A capacitor is a device that stores electric charge in an electric field. Working on the same principles as the Leyden jar, it prevents current from flowing through it, causing a buildup of positive charge on one side and negative charge on the other. It can store electrical charge and release it at a steady rate, making it vital for any pieces of electronics that depend on getting just the right amounts of electricity.

Capacitors are found in nearly every electronic device today, from phones and computers to cars and airplanes. Our modern way of life owes much to those brave (and sometimes foolish) people who shocked each other in the name of science.

To charge our capacitor, we will use a hand-crank generator. A generator is basically a backwards electric motor: while an electric motor takes electrical energy and turns it to mechanical energy, a generator does the opposite. That means it's possible to use an electric motor to generate electricity by physically turning the motor.

This is the basic idea behind the hand-crank generator in your equipment. The motor is visible as a metal cylinder inside the plastic casing. By turning the crank, you rotate a set of magnets and coils of wire in the motor, generating electricity.

During this activity, we will use a hand-crank generator to build up electric charge on a supercapacitor (a capacitor with the ability to hold a large amount of electric charge) and we will use that charge to run a small motor.

Procedure

1. Look at the super capacitor. It's the long cylinder with one red and one black plug on one end. What wires do you think you should attach to it?

Capacitors and Generators

2. Once you've got wires attached to the super capacitor, you'll connect the other end of those wires to the potentiometer (po-ten-ti-OM-et-er). That's the dial with red, yellow, and green sections. Where do you think you'll attach the red and black wires? Will it matter which plugs you use?

3. The potentiometer will tell you when you've filled the super capacitor with energy, but you'll need the hand-crank generator to do that. Looking at the generator, how do you think you should attach it to the potentiometer?

4. If you've got your generator hooked up to the potentiometer, turn the hand-crank in a clockwise direction to transfer power to the super capacitor. (WARNING: Do not spin it in a counter-clockwise direction or you will damage the super capacitor!) What do you observe as you spin the hand-crank?

5. As you fill the super capacitor, you'll notice the dial on the potentiometer moving. How will you know when it's full?

6. When you've filled the super capacitor, disconnect the potentiometer from the super capacitor and connect the fan to the super capacitor using the red and black wires. The fan should start moving as soon as it's connected.

Observations

Experimentation

1. Will the capacitor keep its charge when disconnected, or does it lose charge over time? After charging the capacitor, wait before hooking it up to the motor and record what happens:

Trial:	Idle Time (sec):	Time (sec):	Observations:
1			
2			
3			
4			

Capacitors and Generators

2. Does charging the capacitor require the same number of turns of the generator every time?

Trial:	Turns:	Observations:
1		
2		
3		
4		

Measurement

For this section, you will need a multimeter or the Horizon Renewable Energy Monitor. For an introduction to using a multimeter, click here.

1. Record the highest current in Amps and highest voltage in Volts produced while the capacitor is powering the motor. Record your answers below:

Current: ______________ A

Voltage: ____________ V

2. Voltage is equal to the current in amps multiplied by the resistance in ohms (V = IR), so according to your data what is the resistance of the motor in ohms?

Resistance: _____________ Ω

3. Capacitance (C) is measured in farads. Look closely at your capacitor and you'll find that it lists its capacitance. Record it below:

Capacitance: _____________ F

Capacitors and Generators

4. Since C = q/V where q is the charge and V is the voltage, how many coulombs of charge does your capacitor hold?

Charge: ______________ C

5. The energy stored in a capacitor is equal to ½CV2 where C is the capacitance in farads and V is the voltage in volts. How many Joules of energy does your capacitor store?

Energy: ________________ J

Analysis

1. Make a scientific claim about what you observed while running your capacitor.

2. What evidence do you have to back up your scientific claim?

3. What reasoning did you use to support your claim?

Capacitors and Generators

4. Design an experiment that compares the energy produced by the generator to the energy discharged by the capacitor. Describe your experiment below.

Conclusions

1. Why do you think there is a limit to how much charge can be stored on a capacitor?

2. How could the amount of charge that a capacitor can store be increased?

3. Could a capacitor be a useful source of electricity for an electric car? Why or why not?

4. Do you think the generator was an efficient way to charge the capacitor? Why or why not?