Introduction to Capacitors

Subject Area(s) **Electronic, Material Science, Physics, Math**

Associated Unit **Engineering Technology, EET-1084C-T INTRODUCTION TO ELECTRONICS and ETS-1511C-T MOTORS AND CONTROLS T**

Associated Lesson **Inductors and Capacitors and Power Supply Filtering**

Activity Title **Introduction to Capacitors Experiments.**

Header

Figure 1

ADA Description: Figure 1 shows the most types of capacitors, and their differences according with on the type of dielectric material and shapes used between the two electrodes.

Source/Rights: Copyright © http://marinenotes.blogspot.com/2012/09/identify-various-capacitors-and.html

Caption: Identify various capacitors and understand their specifications

Grade Level Associate Degree

Time Required **180**___ minutes

Group Size Individual Activity

Expendable Cost per Group: All materials, devices and equipment will be provided by the school lab

Summary

Capacitors are physical entity in an electronic system, used to block DC voltages or low and high frequencies AC signals, which pass to another section of a circuit or system. Capacitors are components capable of temporarily storing energy, which is needed a short time later[1]. The activities in this lesson will help to understand the physical behavior of capacitor, identify materials used to build these kind of devices, as well how capacitors could be used in electrical and electronic application.

Experiment 1: In this experiment the students will learn how to make a simple capacitor and to test the capacitor in a circuit.
Experiment 2: The objective of this experiment is to verify the exponential behavior of capacitors during charging and discharging processes.

Engineering Connection

"Capacitors can be used in many different applications and circuits such as blocking DC current while passing audio signals, pulses, or alternating current, or other time varying wave forms. This ability to block DC currents enables capacitors to be used to smooth the output voltages of power supplies, to remove unwanted spikes from signals that would otherwise tend to cause damage or false triggering of semiconductors or digital components. Capacitors can also be used to adjust the frequency response of an audio circuit, or to couple together separate amplifier stages that must be protected from the transmission of DC current."[2]

Engineering Category =

Choose the category that best describes this activity's amount/depth of engineering content:

1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords

Capacitors, dielectrics, conductors, resistor.

Educational Standards

Program Title:	Engineering Technology
CIP Numbers:	1615000001
Program Length:	60 credit hours
SOC Code(s):	17-3023, 17-3026, 17-3027, 17-3029, 51-4012

Career & Technical Education (CTE) 2016-2017
Florida Department of Education, Student Performance Standards. At the completion of this lesson, the student will be able to:

03.0 Demonstrate a fundamental understanding of electronics and electricity

03.02 Demonstrate knowledge of AC/DC theory.
03.07 Solve problems involving capacitance in DC circuits.
03.12 Solve impedance problems in AC circuits.

04.0 Demonstrate an understanding of safety, health, and environmental requirements

04.03 Wear appropriate Personal Protective Equipment (PPE).
04.05 Demonstrate knowledge of, and follow applicable safety laws and regulations and the environment (e.g., Occupational Safety and Health Administration (OSHA).
04.06 Maintain a clean and safe work environment.
04.07 Maintain personal protection equipment.
04.08 Report unsafe conditions/practices.

Pre-Requisite Knowledge

- Basic Electricity, DC/AC concepts.
- Current, voltage, resistance
- Ohm's Law
- Meters Knowledge: Volt-Current-ohm meter, oscilloscope and frequency generator

Learning Objectives

This lab is designed to help students understand the concept of capacitance and how materials, surface area, and thickness impact the performance of a capacitor. After this activity, students should be able to:

- Explain the charging and discharging process for a capacitor
- List the physical factors that affect the value of a capacitor
- Define the following terms associated with capacitors: Farad, RC time constant, dielectric constant.

Materials List

School lab will provide all materials, components and equipment required to develop the experiments. Each student needs:

Experiment 1:

- volt-ohm meter or multimeter
- Roll of aluminum foil
- Sheets of paper, Sheets of plastic
- Scissors
- Tape
- Frequency Generator
- Two insulated alligator clips
- Resistor
- Ruler

Experiment 2:

- Capacitors,
- Frequency Generator
- Resistor
- LED

Introduction / Motivation

The increase in electric vehicles/hybrid electric vehicles (EVs/HEVs) is driving an increase in the number of electronic components in automobiles. Table 1 shows some of the examples of Electronic control units (ECUs) applications for automotive use, where aluminum electrolytic capacitors are used in all of the examples. In general, capacitors act as energy reservoirs that can be slowly charged and then discharged quickly to provide large amounts of energy in a short pulse. A capacitor can store electric energy when disconnected from its charging circuit, so it can be used like a temporary battery, or like other types of rechargeable energy storage systems. Capacitors are commonly used in electronic devices to maintain power supply while batteries are being charged[3].

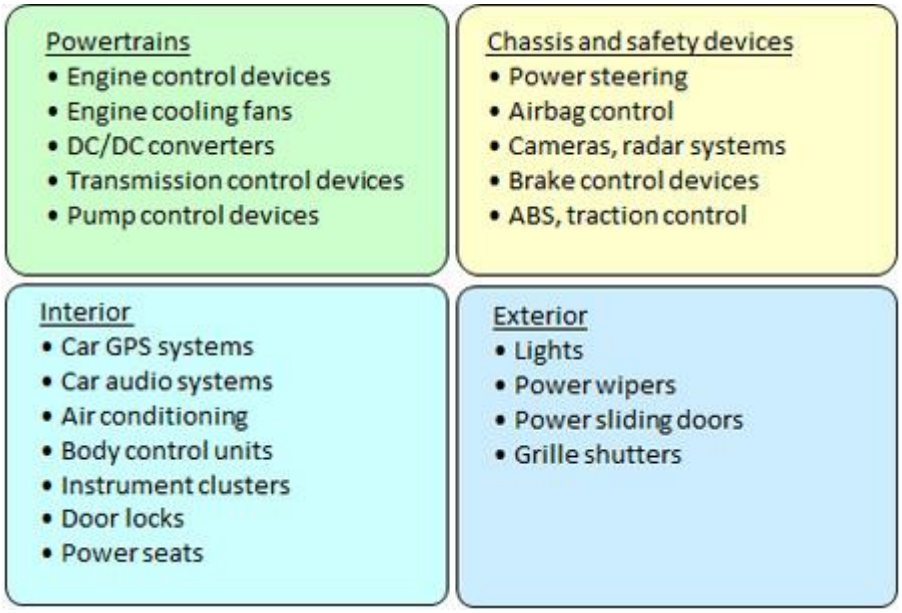


Table 1 Applications for aluminum electrolytic capacitors for automotive use[4]

Knowledge about capacitors help to understand how new technologies and applications such as electric cars and energy systems are being developed.

Vocabulary / Definitions

Word	Definition
Capacitor	A device which stores electrical energy. Commonly used for filtering out voltage spikes.
Conductor	A material that allows electrical current to pass easily through. The current is made up of electrons.
Insulator	A substance or body that resists the flow of electrical current through it.
Dielectric	Insulating material or a very poor conductor of electric current

Table 2: Vocabulary and definitions**[1], [5]–[7]**

Procedure

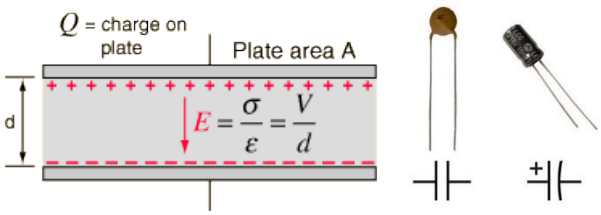
Background

In previous lessons, you learned about components such as resistors that alter and control current by restricting the flow of the current, and by affecting the voltage levels at various locations in a circuit. There are two other components used extensively in electronics used to alter and control current and voltages, capacitors and inductors. This lesson has focus in capacitors, which have a property that opposes a change in voltage.

Capacitors perform a variety of operations in a circuit. One primary function is to store electrons and release them at a later time. An example is in a DC power supply. A rectifier circuit converts an AC voltage to pulsating DC. The capacitor then converts the pulsating DC voltage to a constant DC voltage as it first stores electrons, and then releases them. Another function is to remove unwanted frequencies, such as the hum produced by stray 60Hz AC current in a radio, or a filter that removes unwanted noise on a landline phone produced by a DSL signal. Capacitors are also used in timer circuits. For example, the delay mode of an automobile.

Capacitors

The simplest type of capacitor is constructed using two plates made of conductive materials separated by an insulator called a dielectric. Examples of dielectric materials are air, plastic, ceramic, aluminum oxide, and tantalum oxide. The schematic symbol of a capacitor, consisting of one straight line and one curved line that represent the plates, as shown in Figure 2b.



a. b.

Figure 2

ADA Description: Capacitor diagram showing dielectric between the plates and schematic representation of capacitors are showed in Figure 2

Source/Rights: Copyright ©

http://hyperphysics.phy-astr.gsu.edu/hbase/electric/pplate.html and https://www.elprocus.com/construction-of-capacitor-with-working/

Caption: a two plates capacitor made of conductive materials and separated by an insulator is showed in Fig. 2a, while commercial capacitors and schematic circuit are showed in Fig 2b.

The capacitor stores electrons when there is a voltage applied across the plates. Even though the dielectric creates an open because it is an insulator, current flows in the conductors between the voltage source and the plates. This current, that appears to flow through the capacitor, is referred to as displaced current. Current can only flow
while a capacitor is either charging or discharging. Capacitors are also referred to as condensers.

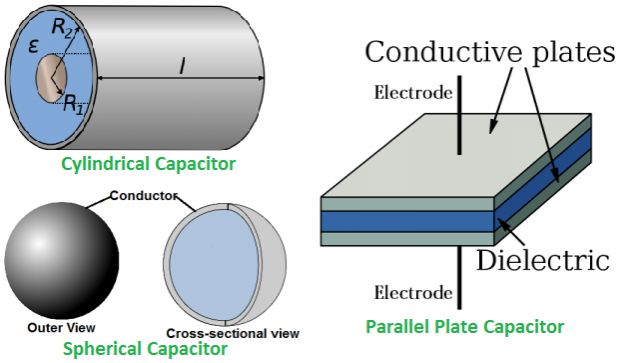


Figure 3

ADA Description: Types of Capacitors based on construction.

Source/Rights: https://electronicspani.com/types-of-capacitors/

Caption: Cylindrical, spherical and parallel plate capacitors are showed in Figure 3.

The value of the capacitor is determined by 3 physical factors: the amount of surface area of the parallel metallic plates (A); the separation or distance between the plates (d) and the insulating material or dielectric between the plates. The capacitance is given by the expression on Figure 4:

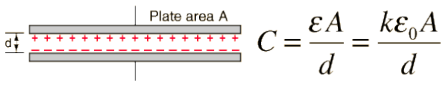


Figure 4 : Parallel Plate Capacitor[7]

Figure 4

ADA Description Parallel Plate Capacitor and equations

Source/Rights: http://hyperphysics.phy-astr.gsu.edu/hbase/electric/pplate.html

Caption: Figure 4 shows how can be calculating the capacitance, when is known the area A and the separation (d) between plates in a capacitor.

Experiment 1: How make a capacitor

Objectives: Students will be able to:

- Identify the variables that affect the capacitance and how each affects the capacitance. •
- Determine the relationships between charge, voltage, and stored energy for a capacitor. •
- Relate the design of the capacitor system to its ability to store energy.

Procedure:

- Cut two strips of aluminum foil 1" X 1"
- Cut two strips of paper 1½" X 1½" (Note: The insulator must be wider than the conductors)
- On a flat surface place one strip of aluminum foil
- Next, place a strip of paper on top of the foil you just laid down
- Place a strip of aluminum foil on the top of the paper strip (We are in a sense making a sandwich)
    - Position the top foil strip one inch over the piece of paper (Note: do not let the pieces of foil touch each other!).
- Lay the final strip of paper over top (You should now have four layers of material)
- Roll all four layers together starting at the end with the extra 1 inch of aluminum foil
    - Ensure you role them tightly as possible
- When your capacitor is formed, use tape to secure it
- Check to make sure we do not have a short circuit by placing the leads of your meter on the tow aluminum foils strips at the open end.
    - If your meter shows a "0" then your capacitor is ready. If you show a voltage, you have a short and will have to start again.
- Now, connect your jumper leads to the battery, one to the positive terminal and one to the negative terminal (Don't let the wire leads touch each other)
- Touch on of the foil strips with the lead connected to the positive battery terminal and then touch the other foil strip with the lead coming from the negative battery terminal. This will charge your capacitor! **Only make this connection for a second or two!**
- You should now have a charge built up across the aluminum foil plates

To check to see if your capacitor works complete the following:

- Place the leads from a volt meter across the foil ends. **Note the polarity!**
- Place the positive (+) lead from your VOM to the positive foil strip that was attached to the positive side of the battery (You may want to mark the foil with a (+) or (-) so you remember which one was which)
- Place the negative (-) lead from your VOM to the negative foil strip that was attached to the negative side of the battery.
- You should record a voltage reading on your VOM. If you did, congratulations! Your capacitor works! If not, you may have to start all over again.

Experiment 2: Charge and discharge of a capacitor.

The purpose of this experiment is to investigate the charging and the discharging of a capacitor by measuring the potential difference (voltage) across the capacitor as a function of time.
Using the capacitor definition and knowing about how the electrical charge is stored. Each student should conduct the next experiment:
By the use of a capacitor, a DC power supply, a LED, and a resistor (All of them provided by the instructor), understand how a capacitor work. Follow these steps:

- Take a lead from your resistor and wrap it around the long (positive +) lead of your LED.
- Charge your capacitor by placing the long (positive +) lead to the positive post of the power supply and short (Negative -) lead the negative post on the power supply. It will only take a few seconds for the capacitor to charge.
- Touch the positive lead of the capacitor to the resistor.
- Touch the negative lead of the capacitor to the negative lead of the LED
- The LED will light up and slowly dim until the capacitor is fully discharged

Before the Activity

- Each student must complete all assignments from section 1, which include Lab 1, worksheet 1, and discussion 1 and 2.

Safety Issues

The students should be careful when working with circuits, in special if an AC or DC power supply is connected used. Remember we learned what this means and the dangers it could have for your body.

Investigating Questions

Assessment

Pre-Activity Assessment
Descriptive Title: ___?

Activity Embedded Assessment
Descriptive Title: Experiment 1 and 2

Post-Activity Assessment
Descriptive Title: Lab Report

Activity Extensions

Activity Scaling

- For lower grades, ___?
- For higher grades, ___?

Additional Multimedia Support

Simulators:
https://phet.colorado.edu/en/simulation/legacy/capacitor-lab

References

[1] B. & Noble, "Industrial Control Electronics / Edition 3," *Barnes & Noble*. [Online]. Available: https://www.barnesandnoble.com/p/industrial-control-electronics-terry-lm-bartelt/1100965166/2677345530394.

[2] "Introduction to Capacitors, Capacitance and Charge," *Basic Electronics Tutorials*, 26-Jul-2013. .

[3] nisargamin6236, "Capacitors final," 03:18:23 UTC.

[4] "NICHICON CORPORATION | Technical Library | Recent Technology Trends in Vibration-Resistant Aluminum Electrolytic Capacitors." [Online]. Available: http://www.nichicon.co.jp/english/lib/new139.html. [Accessed: 27-Jul-2017].

[5] "Capacitors." [Online]. Available: http://www.learnabout-electronics.org/ac_theory/capacitors01.php. [Accessed: 27-Jul-2017].

[6] "Introduction to Capacitors, Capacitance and Charge." [Online]. Available: http://www.electronics-tutorials.ws/capacitor/cap_1.html. [Accessed: 27-Jul-2017].

[7] "Parallel Plate Capacitor." [Online]. Available: http://hyperphysics.phy-astr.gsu.edu/hbase/electric/pplate.html. [Accessed: 27-Jul-2017].

[8] "Construction of Capacitors with Working and Applications," *ElProCus - Electronic Projects for Engineering Students*, 09-Feb-2016. .

[9] "Types of Capacitors," *Electronics Tutorials*, 20-Nov-2014. .

Resources

http://www.facstaff.bucknell.edu/mastascu/eLessonsHTML/LC/Capac1.htm
http://electronics.howstuffworks.com/capacitor1.htm
https://phet.colorado.edu/en/simulation/legacy/capacitor-lab
http://m.wikihow.com/Build-a-Capacitor
https://nationalmaglab.org/education/magnet-academy/watch-play/interactive/capacitor

Redirect URL

N/A

Contributors

This lesson plan was written by Henry Cabra

Supporting Program

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Classroom Testing Information

N/A