

RC Circuits

When a capacitor is placed in series with a battery and a resistor, the capacitor charges up to the voltage of the battery. This kind of circuit is called a RC Circuit because the only two components besides a power supply are a resistor and a capacitor. The resistor limits the electrical current so that the charging takes place over an extended time. This allows students time to think about what must be happening as the circuit charges up to the applied voltage of the battery. After the simple voltage—time data for the charging is collected, fundamental electrical quantities of charge, current, and capacitance can be calculated via a spreadsheet. At the end of the experiment, you will be able to understand how the charge, voltage, and current change as the capacitor charges.

OBJECTIVES

Collect voltage-time data for a capacitor in a RC circuit and curve fit the data.

Calculate the capacitance of the capacitor in a RC circuit.

Develop a mental image of what is happening to electrons during an RC circuit charging cycle. Prove addition Law for Capacitors in parallel and series.

THEORY

In the circuit shown below, when S_1 is closed the voltage across the capacitor charges:

$$V = V_0 \left(1 - e^{-\frac{t}{RC}} \right)$$

When S_1 is opened and S_2 is closed the voltage across the capacitor discharges $V = V_0 e^{-\frac{t}{RC}}$.

$$V = V_0 e^{-\frac{t}{\tau}} \quad \tau = RC$$

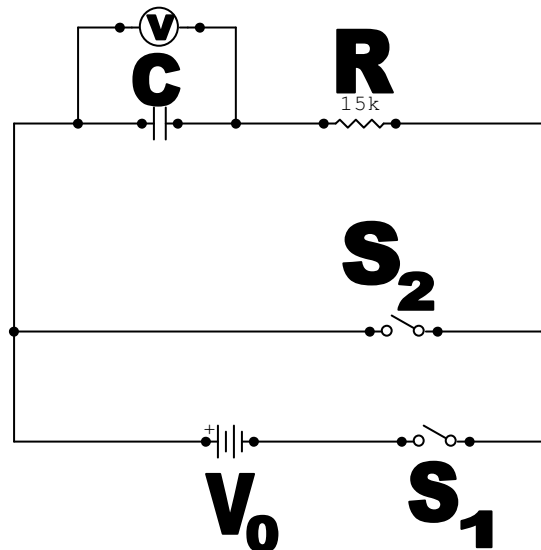


Figure 1

MATERIALS

PASCO *ScienceWorkshop* 500 or 750 computer interface, with *ScienceWorkshop* or DataStudio software, RC Circuit Board, Pasco Voltage Sensor with alligator clip leads, voltmeter (optional), and the Central Scientific Company Model #33031 (0 – 6 Volts) Low Voltage Power Supply.

PROCEDURE A: Measure Capacitor 1

- 1 Set the Battery/External power switch on the RC Circuit Board to “External”
- 2 Set the Charge/Discharge switch on the RC Circuit Board to “Discharge.”
- 3 Connect a wire between points A and B on the RC Circuit Board.
- 4 Connect the red lead of a computer interface voltage probe to the positive (+) side of the capacitor at board position #6. Connect the black lead of the computer interface voltage probe to the negative (-) side of the capacitor at board position #5.
- 5 Connect the DIN end of the voltage probe to port A of the computer interface.
- 6 Start the collection file and immediately move the Charge/Discharge switch on the RC Circuit Board to “Charge.” After the capacitor is charged move the charge/discharge switch to discharge.

PROCEDURE B: Measure Capacitor 2

Repeat above except for

Step 4: remove jumper/wire from points A and B, connect capacitor 2 between point C and B. Be careful to make sure capacitor is pointing the correct way. See figure below labeled “Measurement for Capacitor 2”. Also leave the voltage probe red lead at board position #6 while connecting the voltage probe black lead at board position #4.

PROCEDURE C: Measure Capacitors in series

Repeat above except for

Step 4: remove jumper/wire from points A to B, connect capacitor 2 between point A and B. Be careful to make sure capacitor is pointing the correct way. See figure below labeled “Measurement for Capacitors in series”. Also leave the voltage probe red lead at board position #6 while connecting the voltage probe black lead at board position #4.

PROCEDURE D: Measure Capacitors in parallel

Repeat above except for

Step 4: place jumper/wire from points A to B, connect capacitor 2 between point C to A. Be careful to make sure capacitor is pointing the correct way. See figure below labeled “Measurement for Capacitors in parallel”. Also leave the voltage probe red lead at board position #6 while reconnecting the voltage probe black lead back to board position #5.

ANALYSIS

Part A: Best Fit the Data

- 1 Best fit the discharging data with a curve fit available in the collection program.

Part B: Calculate the Capacitance

- 1 Calculate the actual capacitance of the capacitor in the RC Circuit for each procedure.
- 2 Using the calculated capacitor values determined from Procedure A and Procedure B, compare with the measured values from Procedure C and Procedure D, and calculate the percent error.

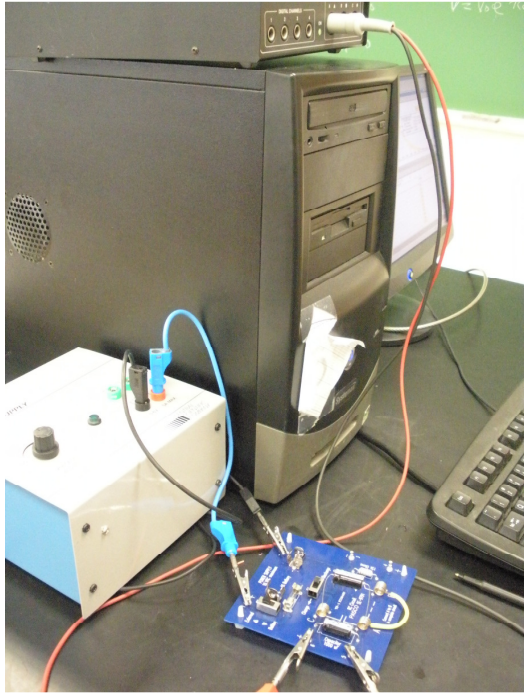
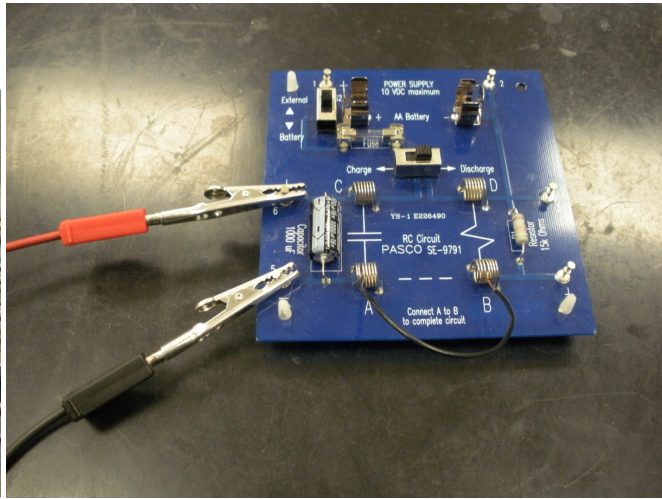
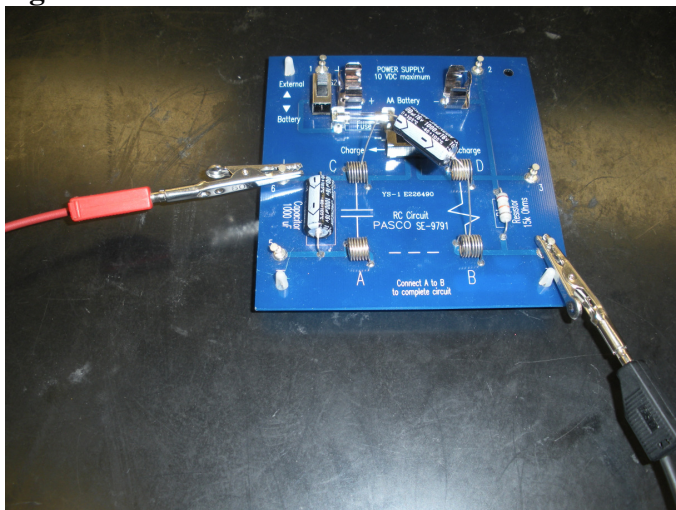


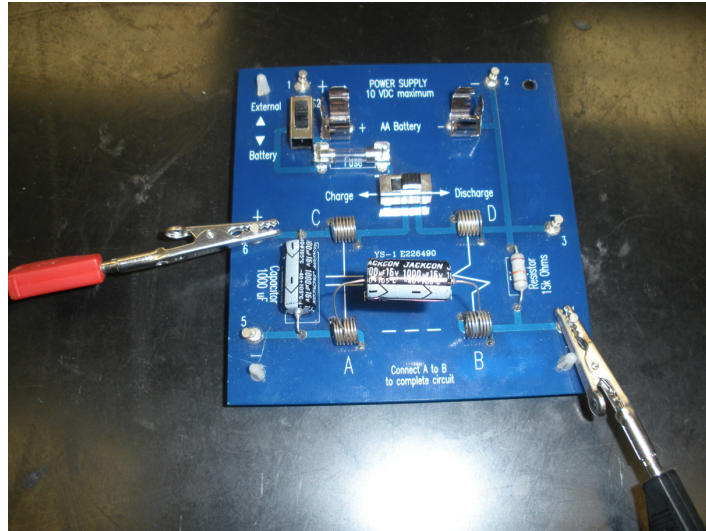
Figure 2



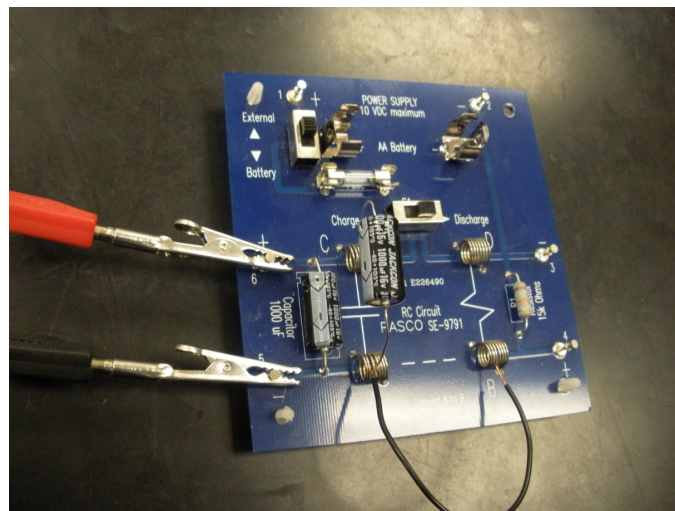
Measurement for Capacitor 1



Measurement for Capacitor 2



Measurement for Capacitors in Series



Measurement for Capacitors in Parallel