EXPERIMENT #5

CAPACITANCE

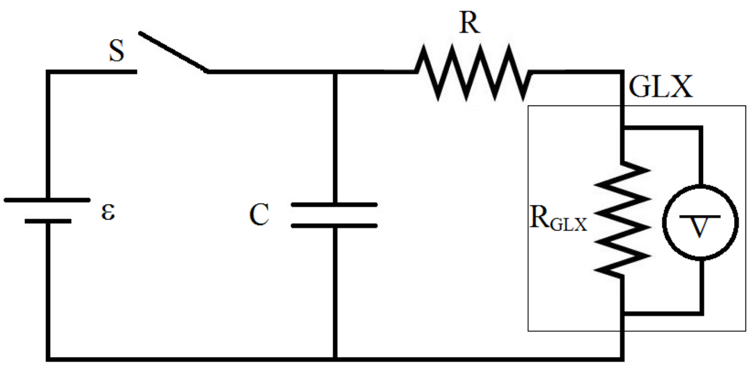
OBJECT: To study capacitance

EQUIPMENET: DC power source; Switch (key type); capacitor (1μF); Resistor (10 MΩ); GLX with Voltage-Current sensor

THEORY: Refer RC-circuit with a DC source

GENERAL DIRECTIONS:

1. Connect the following circuit.



ε = DC source

R = 10 MΩ

C = 1.0 μF

2. Use GLX and Voltage-Current sensor, record three sets of decreasing voltage versus time, and average data.
3. Write down the differential equation for the discharging capacitor in terms of capacitor charge, q, and find the solution. Using this time dependent function for charge, find the mathematical function which describes the voltage V of GLX in terms of time, R, C, R_{GLX}, and the initial GLX voltage V_0. Using this mathematical function for V, calculate the theoretically predicted value for the GLX voltage for each time point.
4. Plot the average measured values and calculated values on the same graph (make sure to use different legends to show the difference including smooth fit curves.)
5. Make a table for all your experimental and calculated values of voltage versus time. Compare the calculated values to the experimental values and explain why there may be any errors or difference. Also generally discuss the entire circuit and include the reason why V_0 is only a fraction of the battery's voltage.

How to use GLX for this lab

1. Connect Voltage-Current sensor to GLX and turn on the switch (right bottom, green button – push it about a second).

2. If the screen does not show menu, push “Home” button.

3. Using <, >, /\, and \/ keys, move to “sensors” and hit the check key.

4. Make sure the Sample Rate Unit is “samples/s” and Sample Rate is “10 samples per second” (if not, change it to 10), and push “Home” button.

5. Move to “Digits” and hit the check key. Record the initial voltage reading.

6. Turn on the power source and increase the voltage to 2 + initial voltage reading. Then, push “Home” button.

7. Move to “Graph” and push the check key. (the vertical axis should show “current”)

8. Hit the check button and “current” is highlighted.

9. Hit the check button again. It will change it to “voltage” and hit the check button again. (The vertical axis is now voltage.)

10. To record, hit “Play” button and open the switch.

11. Record it for 60 seconds and hit “Play” button again to stop recording.

How to retrieve the data from GLX

1. After recoded, hit “Home” button.
2. Go to “Table” and hit the check button.
3. On your data, transfer the last original voltage (V_0) as t = 0 sec and transfer every 20 data points (2 sec) for 50 seconds worth (i.e. there should be a total of 26 data points.)

EXPERIMENT #5 ½ - PHYSICS 231

RC Oscillation

OBJECT: To construct an RC oscillator circuit and determine the effect of resistance and capacitance on the oscillation period.

Equipment:
- Regulated DC source (90 V)
- Capacitors (1.0 μF, 0.5 μF, 0.1 μF)
- Resistors (1 MΩ, 10 MΩ, 22 MΩ)
- Neon Lamp

THEORY:

Many electronic devices use RC oscillators to keep time. An RC oscillator consists of a capacitor which is slowly charged through a resistor. Once the charge on the capacitor reaches a certain voltage, called breakdown voltage, the circuit rapidly discharges the capacitor, and the cycle repeats. Assuming that the time required to discharge the capacitor is negligible, the time required for one cycle of an RC oscillation circuit is

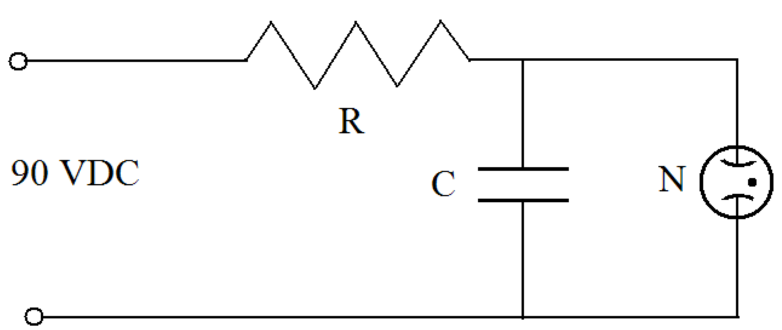
$$t = R\cdot C \ln\frac{V_s - V_{min}}{V_s - V_{max}},\ \text{where}$$

R = Resistance
C = Capacitance
V_s = Voltage used to charge capacitor
V_{max} = Breakdown voltage
V_{min} = Voltage capacitor discharges to

Most RC oscillators use a semiconductor device to discharge the capacitor when it reaches its maximum voltage. In this experiment, however, a neon lamp discharges the capacitor. A neon lamp consists of two electrodes placed in a glass envelope containing low-pressure neon gas. When a large enough voltage is applied across the two electrodes, the gas is ionized, becoming conductive and giving off visible light. The gas remains ionized as long as a current continues to flow. Once the flow of current ceases, the gas becomes non- conductive again.

GENERAL DIRECTIONS:

1. Construct the following circuit:



R – 1 MΩ Resistor

C – 1.0 μF Capacitor

N – Neon lamp

Although the 90 V power supply is current-limited for safety, use caution when working with high voltages.

2. Apply power to this circuit and allow the light to begin flashing. With a stopwatch, measure the total time required for 40 – 60 flashes. Use this time to find the period of a single oscillation.

3. Replace resistor R and capacitor C in the above circuit with the following combinations of resistor and capacitor and repeat step 2 for each one:

R	C
10 MΩ	0.5 μF
10 MΩ	0.1 μF
22 MΩ	0.1 μF

4. Find the value of the constant $\ln\left[\frac{V_s - V_{min}}{V_s - V_{max}}\right]$ for each of the RC oscillator configurations above. Then, find the mean for this data and express them as a percent error. Explain why there may be an error.

5. Derive the equation for the period of oscillation and discuss the general effects of charging the resistance and capacitance in an RC oscillation circuit.

To understand this lab well, do the homework below.

Fig. 27-53 shows the circuit of a flashing lamp, like those attached to barrels at highway construction sites. The fluorescent lamp L (of negligible capacitance) is connected in parallel across the capacitor C of an RC-circuit. There is a current through the lamp only when the potential difference across it reaches the breakdown voltage V_L; then the capacitor discharges completely through the lamp and the lamp flashes briefly. For a lamp with breakdown voltage V_L = 72.0 V, wired to a 95.0 V ideal battery and a 0.150 μF capacitor, what resistance R is needed for two flashes per second?

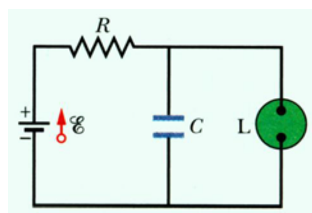


Fig. 27-53 Problem 52.