**A-14.**

**Capacitive Reactance**

OBJECTIVES:

After performing this experiment, you will be able to:

1. Measure the capacitive reactance of a capacitor at a specified frequency.
2. Compare the reactance of capacitors connected in series and parallel.

READING:

None

MATERIALS NEEDED:

Capacitors:

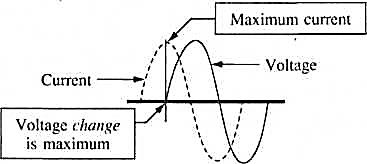
One of each: 0.1 μF, 0.047 μF Resistors:

One of each: 1.0 kΩ

For Further Investigation: One 1.0 μF capacitor, one 4.7 kΩ resistor, one 10 kΩ resistor Application Problem: One 100 kΩ resistor, one capacitor (value to be determined by student)

SUMMARY OF THEORY:

If a resistor is connected across a sine-wave generator, a current flows that is in phase with the applied voltage. If, instead of a resistor, we connect a capacitor across the generator, the current is not in phase with the voltage. This is illustrated in Figure 1, Note that the current and voltage have exactly the same frequency, but the current is leading the voltage by 1/4 cycle.



**Figure 1 Current and voltage relationship in a capacitor.**

Current in the capacitor is directly proportional to the capacitance and the rate of change of voltage. The largest current occurs when the voltage change is a maximum. If the capacitance is increased or the frequency is increased, there will be more current. This is why a capacitor is sometimes thought of as a high-frequency short.

Reactance is the opposition to ac current and is measured in ohms, like resistance. Capacitive reactance is written with the symbol XC. It can be defined as

where f is the generator frequency in hertz and C is the capacitance in farads.

Ohm’s law can be generalized to ac circuits. For a capacitor, we find the voltage across the capacitor using the current through the capacitor and the capacitive reactance. Ohm’s law for the voltage across a capacitor is written

PROCEDURE:

1. Obtain two capacitors with the values shown in Table 1. If you have a capacitance bridge available, measure their capacitance and record in Table 1; otherwise record the listed value of the capacitors. Measure and record the value of resistor R1.
2. Set up the circuit shown in Figure 2. Set the function generator for a 1.0 kHz sine wave with a 1.0 Vrms output. Measure the rms voltage with your DMM while it is connected to the circuit. Check the frequency and voltage with the oscilloscope. Note: 1.0 Vrms = 2.828 Vpp.

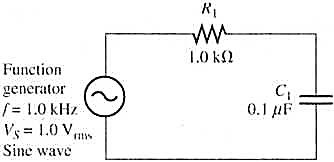


Figure 2

1. The circuit is a series circuit, so the current in the resistor and the capacitor are identical to the

total current (IR = Ic = IT). You can find this current easily by applying Ohm’s law to the resistor. Measure the voltage across the resistor, VR, using the DMM. Record the measured voltage in Table 2 in the column labeled Capacitor C1. Compute the current in the circuit by dividing the measured voltage by the resistance of R1 and enter the value in Table 2.

4. Measure the rms voltage across the capacitor, Vc. Record this voltage in Table 2. Then use this voltage to compute the capacitive reactance using Ohm’s law:

Enter this value as the capacitive reactance in Table 2.

5. Using the capacitive reactance found in step 4, compute the capacitance using the equation

Enter the computed capacitance in Table 2. This value should agree with the value marked on the capacitor and measured in step 1 within experimental tolerances.

1. Repeat steps 3,4, and 5 using capacitor C2. Enter the data in Table 2 in the column labeled Capacitor C2.
2. Now connect C1 in series with C2. The equivalent capacitive reactance and capacitance can be found for the series connection by measuring across both capacitors as if they were one capacitor. Enter the data in Table 3 in the column labeled Series Capacitors. The following steps will guide you:

(a) Check that the function generator is set to 1.0 Vrms Find the current in the circuit by measuring the voltage across the resistor as before and dividing by the resistance. Enter the measured voltage and the current you found in Table 3.

(b) Measure the voltage across both capacitors. Enter this voltage in Table 3.

(c) Use Ohm’s law to find the capacitive reactance of both capacitors. Use the voltage measured in step (b) and the current measured in step (a).

(d) Compute the total capacitance by using the equation

1. Connect the capacitors in parallel and repeat step 7. Assume the parallel capacitors are one equivalent capacitor for the measurements. Enter the data in Table 3 in the column labeled Parallel Capacitors.

|  |  |
| --- | --- |
| **Report for**  **Experiment A-14** | **Name**  **Date**  **Class** |

**ABSTRACT:**

**DATA:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 1   |  |  |  | | --- | --- | --- | | Component | Listed  Value | Measured  Value | | C1 | 0.1 μF |  | | C2 | 0.047 μF |  | | R1 | 1.0 kΩ |  | | **Table 2**   |  |  |  | | --- | --- | --- | |  | Capacitor C1 | Capacitor C2 | | Voltage across R1, (VR) |  |  | | Total current, IT |  |  | | Voltage across C, (VC) |  |  | | Capacitive reactance, XC |  |  | | Computed capacitance, C |  |  | |
| **Table 3**   |  |  |  |  | | --- | --- | --- | --- | | Step 7 |  | Series  Capacitors | Parallel  Capacitors  Capacitors | | (a) | Voltage across R1, VR |  |  | | Total current, IT |  |  | | (b) | Voltage accross capacitors, VC |  |  | | (c) | Capacitive reactance, XC |  |  | | (d) | Computed capacitance, CT |  |  | | |

**RESULTS AND CONCLUSION:**

EVALUATION AND REVIEW QUESTIONS:

1. Compare the capacitive reactance of the series capacitors with the capacitive reactance of the parallel capacitors. Use your data from Table 3.
2. Compare the total capacitance of the series capacitors with the total capacitance of the parallel capacitors.
3. If someone had mistakenly used too small a capacitor in a circuit, what would happen to the capacitive reactance?
4. Summarize the method used in this experiment to find the value of an unknown capacitor.
5. Assume the function generator is set to a higher (but known) frequency in this experiment. Will this affect the computed capacitance in this experiment? Explain.
6. Compute the capacitive reactance for a 800 pF capacitor at a frequency of 250 kHz.