EXPERIMENT EE1002 LAB 2: Study of RC Circuit with Oscilloscope

Safety Precautions

1. **Always turn off power when you reconnecting the circuit.**
2. **Double check your circuit and the voltage source setting before reapplying power.**

I. OBJECTIVES

1. To get familiar with the oscilloscope controls.
2. To learn to the phase angle measurements.
3. Determine the reactance of a capacitor in a series RC circuit from voltage measurements.
4. Explain the effect of frequency on the impedance and voltage phasor for a series RC circuit.

II. EQUIPMENT REQUIRED

1. Oscilloscope (20 MHz, dual beam)
2. Variable power supply (0 - 10V)
3. Audio signal generator
4. Multimeter (for DC and AC voltage measurements)
5. Solderless breadboard
7. Components: 0.l uF capacitor, 1k resistor

III. REFERENCES

1. Helfrick, A.D. and Cooper, W.D. "Modern Instrumentation and Measurement Techniques": Chapter 7, sections 1,2,4,10.1.

2. Bell, D.A. "Electronic Instrumentation and Measurements": Chapter 11, sections 1-4, 6,

IV. PROCEDURE

PART I: BASIC OPERATION OF CRO

1. CRO Adjustments

In this part, you should learn how to locate the trace, adjust the brightness, focus and rotation of the trace, vary the position of the beam on the screen, change the input coupling mode.

You should learn how to use the oscilloscope to measure: DC voltages, the amplitude and frequency of simple waveforms, to make use of the dual trace mode.

You may consult the equipment manual regarding the initial adjustments in order to obtain a stable trace on the screen.

2. Vertical Deflection

In this section the effect of an input to the vertical or "Y" deflection system of the oscilloscope will be studied, together with the effect of the relevant controls on the display.

(1) With a horizontal trace on the screen, check that the vertical sensitivity of the oscilloscope is 0.5 volts/div and the trace is aligned with bottom line.

(2) Switch the AC-GND-DC coupling switch to DC.

(3) Set the output of the power supply to 0 volts (or as low as it will go) and connect it to a Y input (CH1) of the oscilloscope.

(4) Change the vertical sensitivity (volts/div) of the Y input and continue your investigations, checking on the effect of any "VARiable" control (if your oscilloscope has this control) associated with the vertical sensitivity.

(5) Investigate the effect of the AC-GND-DC switch.

3. Frequency Measurements

In this section the oscilloscope is used to measure the period (from which the frequency can be deduced) of simple waveforms.

(1) Set the AC-GND-DC vertical input coupling switch to GND and center the trace on the screen.

(2) Set the signal generator to produce a sine wave at a frequency of 1 kHz, with an

amplitude between 1 and 5 volts peak-to-peak, and connect it to the Y axis input of the oscilloscope in place of the power supply. Switch the AC-GND-DC switch back to AC.

(3) Use the oscilloscope to measure the period. For best accuracy, ensure that the controls are adjusted so that the waveform fills the screen vertically, and that your time measurements is from the zero crossing points rather than the peaks.

(4) Vary the position of the TIME/DIV switch and note its effect, and do the same for the VARiable control (if your oscilloscope has this control) associated with this switch.

4. Amplitude Measurements

In this section, we use oscilloscope to measure the amplitude of simple waveforms and the results can be compared with those from a multimeter.

(1) Set the signal generator to produce a 1 kHz sine wave, with an amplitude of 1 volt (effective).
(2) Set the Y axis sensitivity of the oscilloscope to 1 volt/div, and connect the signal generator to the Y axis input.

(3) Set the oscilloscope timebase (time/div) for the inclusion of several cycles in the display.
(4) Measure the peak value and the peak-to-peak value of the waveform and compare these values with the signal amplitude as measured by a multimeter.

5. Phase Shift Measurement (Dual Beam Mode)

When the dual-beam facility of an oscilloscope is used to display two signals simultaneously, it is a simple matter to estimate the phase shift of one relative to the other from the displacement along the time axis of one waveform relative to the other.

(1) Referring to the operation manual for the oscilloscope where necessary, turn on the oscilloscope and set the controls for dual beam operation, with alternate sweep. Set the trigger source to internal, channel 1, with the mode on automatic.

(2) Connect the circuit shown in Figure 1, and connect the channel 1 oscilloscope input across the input to the R-C network, and the channel 2 input across its output.

(3) Set the signal generator to produce a 500 Hz sine wave with 1 V peak-to-peak, and observe the traces on the oscilloscope screen.

PART II: RC CIRCUIT

Continue on the connection and measurement setup in Part I (5), perform further detailed investigation on the frequency response of RC circuit as following:

1. Set the function generator to give a sinusoidal output with 1-V peak-to-peak, dc offset = 0V, and frequency = 500 Hz. Check the frequency values on CH1 of the oscilloscope and record them in Table 1. Keep CH1 be connected to the signal generator throughout the experiment.
2. Connect CH2 of the oscilloscope across capacitor C and measure V_C .
3. Swap R and C connection so as to measurement voltage across R. Connect CH2 of the oscilloscope across resistor R and measure V_R. Compute current I_{PP} over the resistor.
4. Measure the phase angle between V_R and V_S traces.
5. Compute the capacitor's reactance X_C from $X_C = V_C/I_{PP}$. Compute C from the measured X_C.
6. Compute the total impedance Z_{Total} by applying Ohm's law to the circuit. Use the supply voltage set in step 1 and the current found in step 3. Remember, the impedance has both a magnitude and a phase angle (measured relative to the resistor). Convert the value to rectangular form and record it in the table.
7. Repeat steps 1 to 6 for the following frequencies: 1kHz, 2kHz, 5kHz, 10kHz, 20kHz.

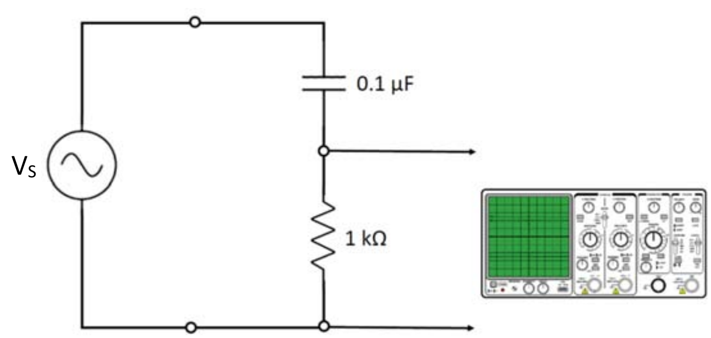

Figure 1

Table 1: Measured/calculated parameters for values of RC Circuit given in Fig.1.

Freq. (kHz)	V_R		i_R (peak-to-peak)		V_C (pp)		From Measurement		Theoretical
	mag (V)	angle	mag (V)	angle	mag (V)	angle	R (Ω)	X_c (Ω)	X_c (Ω)
0.5									
1									
2									
5									
10									
20									

Note that these frequencies are approximately equally spaced on a logarithmic scale, plot your results on semi-log graph paper.

V. EVALUATION

1. Compare and discuss on the ac voltage measurement with multimeter and CRO.

2. Plot the X_C value calculated from measurement data and X_C from theoretical calculation versus frequency in semi-log paper. Explain the discrepancies between the measured and theoretical data.

3. Plot phase angle of X_C as a function of frequency.

4. Discuss the frequency and phase dependencies of the RC series circuit.