UNIVERSITY OF SOUTH AUSTRALIA

School of Electrical and Information Engineering
Electrical Circuit Theory

Practical No. 3   **RC CIRCUIT ANALYSIS**

Aim
The aim of this experiment is to examine the frequency and time characteristics of a simple RC filter. The findings will be verified by comparing the simulation results from Multisim (or OrCAD) with the experimental results obtained by performing the real experiment using the remote laboratory NetLab.

Equipment
NetLab
Computer with a Web browser (preferably Internet Explorer v.5 and later), Multisim (or OrCAD) and MATLAB.

Preparation

Part 1: Frequency domain analysis (Bode plots)
1. Draw a circuit diagram of a 1st order Low Pass RC filter with C = 0.1μF and R = 5kΩ. Use a voltage source of 1Vpp as an input excitation to the circuit. Identify the output signal.

2. Write the transfer function of the filter:

$$H(j\omega) = \frac{Y(j\omega)}{V_{in}(j\omega)}, \text{ where } Y(j\omega) \text{ is the phasor of the output signal.}$$

3. Sketch the Bode plots of the filter, both magnitude and phase. Calculate the corner (half-power) frequency f_c of the filter.
4. Use Multisim (or OrCAD) to simulate the RC filter in frequency domain in order to obtain magnitude and phase response plots. In Multisim you can use the Bode plotter (instrument) as shown in Figure 1 for this purpose.
5. Use the cursor to determine the corner frequency from the simulation plots and compare it with the calculated value.
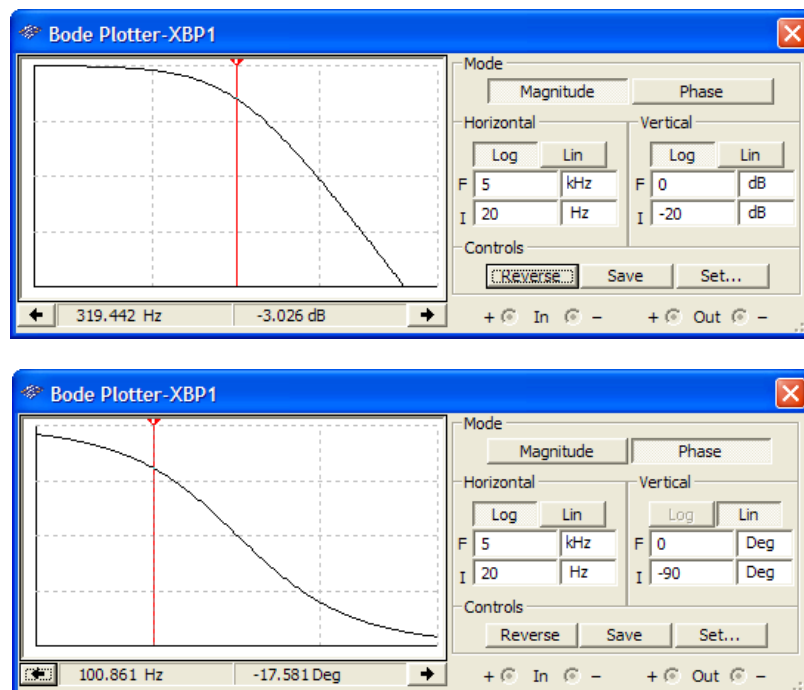6.

Figure 1 Bode Plotter in Multisim

Part 2: Time domain analysis (transients)

7. For the circuit shown in Figure 2 sketch the variation of the capacitor voltage versus time. Assume the capacitor fully charges during the positive part of the cycle and fully discharges during the negative part of the cycle. Calculate the time constant of the transient. Write the analytical expression for the capacitor voltage.

8. Use Multisim (or OrCAD) to obtain the transient response plot of the capacitor voltage as a function of time.
9. From the plot determine the time constant of the transient and compare it with the calculated value.
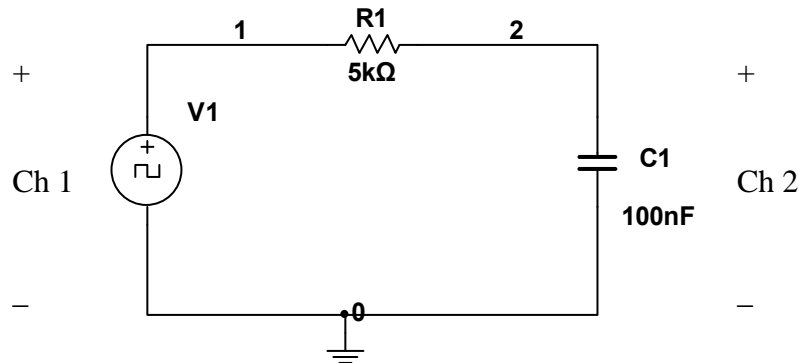10. **What is the relationship between the time constant of the circuit and the corner frequency in rad/sec?**

Figure 2: RC circuit

Experiment

Conduct the remote experiment as following:
    a. Use the Circuit Builder to wire and configure the Low Pass RC filter analysed in the preparation section. Wire the oscilloscope (CRO) to observe input voltage (V1) at channel 1 and the output signal at channel 2.
    b. Switch on the function generator and the digital storage oscilloscope (CRO). Check the system using the live Internet camera.

Frequency response:
    a. Set the magnitude of the sinusoidal supply voltage to 1Vpp (1Volt peak to peak) on the signal generator. Check it using oscilloscope.
    b. Vary the frequency of the supply voltage over the range (20Hz - 5kHz) to obtain frequency response. Select frequencies: 20Hz, 200Hz, 300Hz, 1kHz, 5kHz, and for each frequency measure the magnitudes of the input and output signals (Ch 1 and Ch 2), and the phase angle between them. Tabulate the results.

Transient response:
    a. Change the waveform of the supply voltage to square wave on the signal generator.
    b. Set the frequency of the supply voltage to 100 Hz.
    c. The supply voltage is displayed on Channel 1 of the digital storage oscilloscope and the output signal is displayed on Channel 2. Change the time scale and magnitude scale for both channels so you can clearly see both signals.
    d. Download the data to your computer.
    e. Disconnect the circuit: in Circuit Builder select all components and delete them; then press the Configure button.
    f. Log off from NetLab by closing the Web browser.

Report
- Use MATLAB to plot and conduct the mathematical analysis of the data saved from Multisim (or OrCAD) and downloaded from NetLab.
- Compare the simulation results with the calculated results and the experimental results. The best ways to compare these results are to use one graph for 3 plots: calculated, simulated and measured. In this case you will need one graph for magnitude responses, another one for the phase responses and the 3rd one for the transient responses. Use log-log plot for magnitude response and log scale for frequency of the phase response. Label all graphs and plots properly.
- Comment on discrepancies.
- Again compare the time constant of the circuit with the corner frequency in [rad/sec].
- Use AssignIT to submit your (group) report in electronic form.