ESC201 Introduction to Electronics Lab 4 Handout for Lab Experiments
Frequency Response of Second Order Circuits and Maximum Power Transfer

Aim: The aim of this lab is to study the frequency response of second order circuits as well as to verify the maximum power transfer theorem.

Note: For all experiments in this lab: **Do not use the external FG, use the Gen-Out of the DSO**.

Experiment 1: Second Order Series RLC Circuit (*4 + 4 × 3 = 16 marks*)

1. Experimentally measure the internal resistance of the Gen Out of the DSO using a 100 Ω resistor. (See Lab 02 Experiment 01 for the detailed circuit).

2. Wire the RLC circuit as shown in Fig. E1. The values of the components are L = 1 mH, C = 0.1 μF. Apply an input through the Gen Out of the DSO which has an internal resistance (R_S) (about 50 Ω, but use the measured value you obtained). Connect the CH 1 of DSO to the input V_i and CH 2 to the output V_o. Using the Frequency Response Analysis functionality of the DSO (see Lab 03), find the Bode plots (both the magnitude and phase plots) for different values of the resistor R_L:
(a) R_L = 10 Ω, (b) R_L = 100 Ω, (c) R_L = 510 Ω.
In each case, set the frequency range for the Bode plots to be 100 Hz to 500 kHz and use 100 data points. In each case, find the resonance frequency and quality factor of the circuit from the results obtained. Verify the observed resonance frequency and quality factor values with those obtained from theory. (Note that the total series resistance of the circuit that one should use in the formula will be $R_{tot} = R_S + R_L$ considering the internal series resistance of the source which is not shown in the figure).

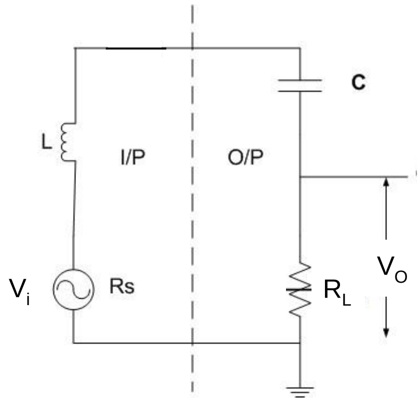

Figure E1: Series RLC Circuit

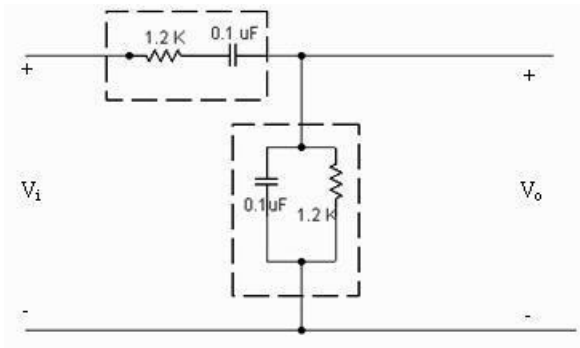

Figure E2: RC Circuit

Experiment 2: Second Order RC Circuit (*4 × 3 = 12 marks*)

1. The combination of RC circuits shown in Fig. E2 inside the dotted box is series-parallel combination. Wire the circuit of Fig. E2, connect Gen Out as well as CH-1 of the DSO to the input V_i and CH-2 of the DSO to the output V_o. Find the Bode plots (both the magnitude and phase plots) of the transfer function over a frequency range of 100 Hz to 100 kHz. Identify the transfer function of the circuit (Low pass, High pass, or Band pass), and explain the results.
2. Repeat the experiment to find the Bode plots (both the magnitude and phase plots) for the transfer function of the RC circuit with series-series combination (not shown), and explain the results.
3. Repeat the experiment to find the Bode plots (both the magnitude and phase plots) for the transfer function of the RC circuit with parallel-parallel combination (not shown), and explain the results.

Experiment 3: Maximum Power Transfer (*4 × 3 = 12 marks*)

The power transferred from a source to a load is at its maximum when the resistance of the load is equal to the internal resistance of the source and the circuit reactance is zero.

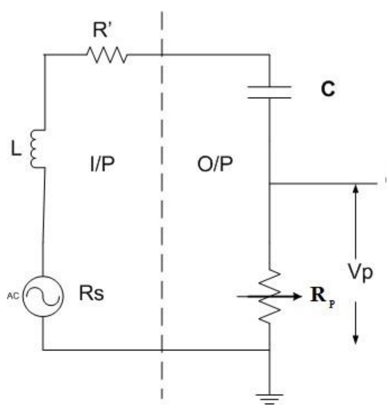

Figure E3a: RLC Circuit

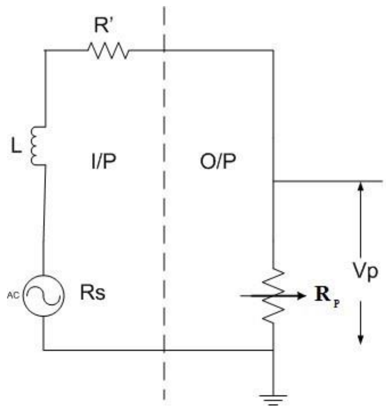

Figure E3b: RL Circuit

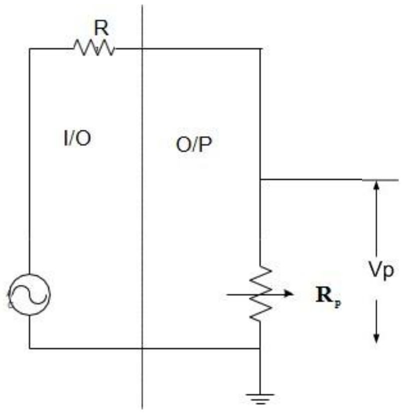

Figure E3c: R Circuit

1. RLC circuit:

Wire the circuit of Fig. E3a. Use L = 1 mH, C = 0.1 μF, R′ = 100 Ω. Retain the frequency of the source at resonance frequency f_c found in the Experiment 1 in the previous page.

Use the Difference Amplifier (DA) circuit to find the current through the resistance R′ and measure the power dissipation across the potentiometer (see Lab 02 Experiment 02 for the use of the DA and details of the circuit). Use CH 1 of the DSO to measure the voltage across the potentiometer R_P and CH 2 of the DSO to the output of DA to measure the voltage across R′. Multiply the two voltages shown in the CH-1 and CH-2 using “Math” function of the DSO to get the power dissipation across the potentiometer. Vary the value of R_P and measure the average power P_{avg} using the Math Fucntion of the DSO. Find R_P and P_{avg} at which P_{avg} is maximum and verify that this happens at $R_P = R_S + R'$.

2. RL circuit:

Get the circuit of Fig. E3b by removing the capacitor in Fig. E3a and substituting it with a shorting wire.

Use L = 1 mH, R′ = 100 Ω and keep the frequency of the source at resonance frequency f_c of part 1 above.

Use the Difference Amplifier circuit of the part 1 to measure the power dissipation across the potentiometer. Vary the value of R_P and measure the average power P_{avg} using the Math Fucntion of the DSO. Find R_P and P_{avg} at which P_{avg} is maximum and verify that $R_P = [(R_S + R')^2 + (2\pi f L)^2]^{1/2}$.

3. R circuit:

Get the circuit of Fig. E3c by removing the inductor in Fig. 3b and substituting it with a shorting wire.

Keep R′ = 100 Ω and the frequency of the source the same at resonance frequency f_c of part 1 above.

Use the Difference Amplifier circuit of the part 1 to measure the power dissipation across the potentiometer. Vary the value of R_P and measure the average power P_{avg} using the Math Fucntion of the DSO. Find R_P and P_{avg} at which P_{avg} is maximum and verify that this happens at $R_P = R_S + R'$.