Laboratory 3
Power Factor Correction and Maximum AC Power

Please do the following activities related to power factor correction.

1. Connect a 50 Ω resistor and a 1 mH inductor in series to the waveform generator. Draw a circuit diagram with an ideal voltage source in series with a resistor R_s = 50 Ω (why R_s?).

2. Set the waveform generator to produce a sine wave with 1 V amplitude at the ideal voltage source, and choose the frequency so that the load impedance is $\mathbf{Z}_L = (50 + j\,100)\ \Omega$. Draw a circuit diagram with phasors and impedances.

3. Calculate the complex power delivered by the source $\mathbf{S}_s$, the complex power absorbed by the load $\mathbf{S}_L$, and the average power absorbed by R_s. Also calculate the power factor seen by the voltage source and the power factor of the load impedance $\mathbf{Z}_L$.

4. Consider placing a capacitor in parallel ("shunt") with the load impedance, and let ($-j\,X_c$) denote the impedance of the capacitor. Write an expression for the equivalent impedance of the parallel combination $(-j\,X_c) \parallel \mathbf{Z}_L$. Determine the value for X_c that will increase the power factor seen by the voltage source to 1. (This is *power factor correction*.)

5. With the parallel capacitor in the circuit, repeat the calculations in step 3. How do the values of the average power absorbed by R_s and the 50 Ω resistor in the load compare with those calculated in step 3 *without* the capacitor? Describe the advantage of power factor correction.

6. Calculate the value of capacitor C (in farads) that produces a power factor of 1 for the voltage source and apply it to your circuit. Do you see a change in the voltage across the load impedance? Calculate the amplitude of the current from the voltage source with and without the capacitor, and explain how this affects the average power dissipated in R_s. What is the phase relationship between the source voltage and current with and without the capacitor?

Next, study study Section 8-5 on maximum power transfer and do the following activities.

1. Consider placing a capacitor in *series* with the load $\mathbf{Z}_L = (50 + j\,100)\ \Omega$ so that the average power absorbed by the 50 Ω load resistor is maximized. Determine the value for C (in farads) and apply it to your circuit. Calculate the average power absorbed by R_s and the 50 Ω resistor in the load. How do these values compare with steps 3 and 6 above? Calculate the amplitude of the current from the voltage source and compare with step 6 above.

2. Run the Matlab script `maxpower.m` and interpret the plots. (The script is in my `public\elec226` folder and linked to the ELEC 226 labs page.)

3. Please solve problems 8.26 and 8.27 in the textbook and make sure you obtain the following answers:
   8.26: $\mathbf{Z}_L = (0.8 + j2.4)\ \Omega$, max. average power = 12.5 W
   8.27: $\mathbf{Z}_L = (0.6 - j0.2)\ \Omega$, max. average power = 6.78 W
   Hint: Find the Thevenin equivalent circuit at the terminals of the load impedance.

Lab Report:

Each lab group should discuss their work with the instructor or lab assistant as they go through the activities.