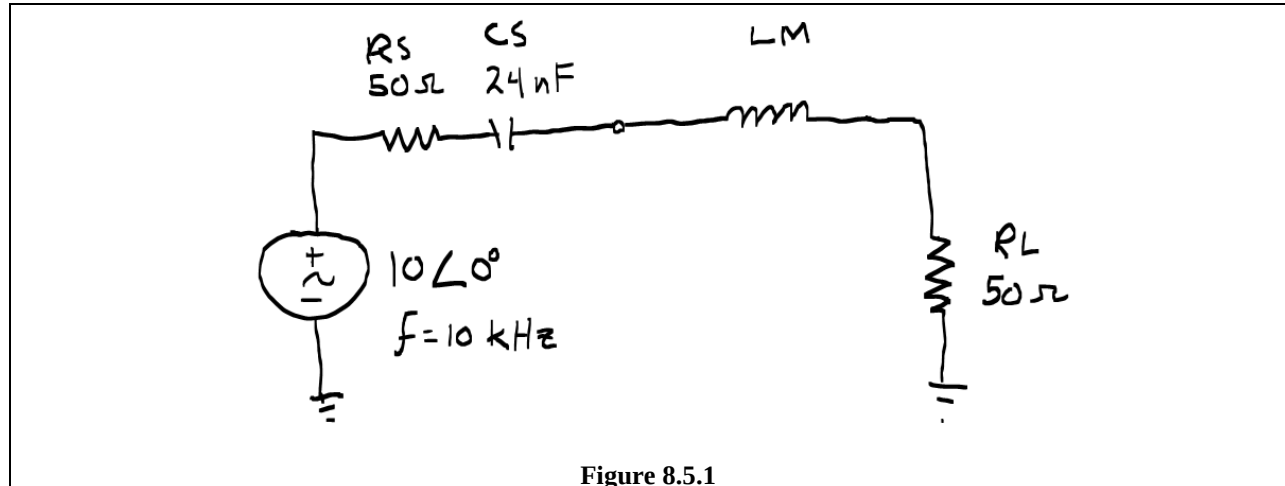


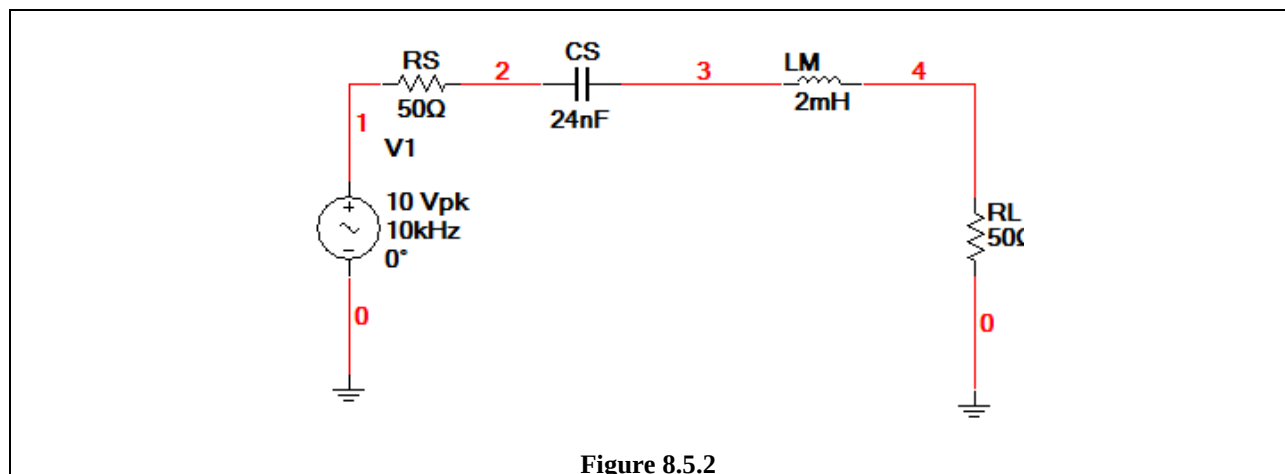
MULTISIM DEMO 8.5*: MAXIMIZING POWER DELIVERED TO A LOAD IN A COMPLEX CIRCUIT

In Multisim Demo 3.6 we looked at how power transfer to a load resistor is maximized when $R_S = R_L$. For complex circuits, we'll now show that power transfer to a load is maximized when $Z_S = Z_L^*$.

Observe the circuit in Fig. 8.5.1. It is composed of an AC source with an amplitude of 10 V, a source resistor and capacitor, a load resistor, and a matching inductor. We will run an AC Analysis plotting the power dissipated in the load resistor for four values of matching inductor.



Once the circuit is constructed, it should resemble Fig. 8.5.2. Don't worry about the value of the inductor LM because we will be varying it in a Parameter Sweep Analysis.



Set up the Parameter Sweep using the values and selections shown in Fig. 8.5.3 on the next page. We will be sweeping the value of the inductor from 5 mH to 155 mH in 50 mH increments. Make sure to set the Analysis to sweep to be an AC Analysis, and set the specifics of said Analysis to those shown in Fig. 8.5.4.

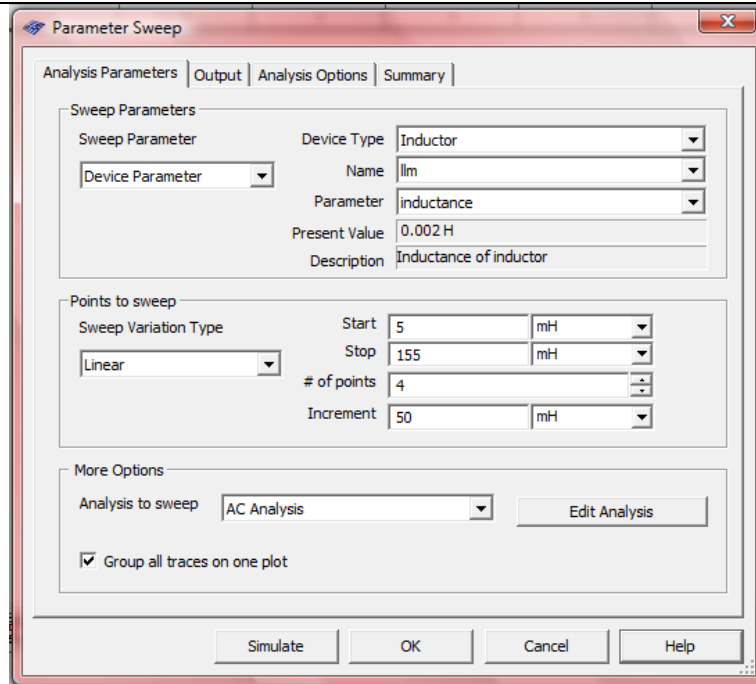


Figure 8.5.3 Parameter Sweep Analysis Specifications.

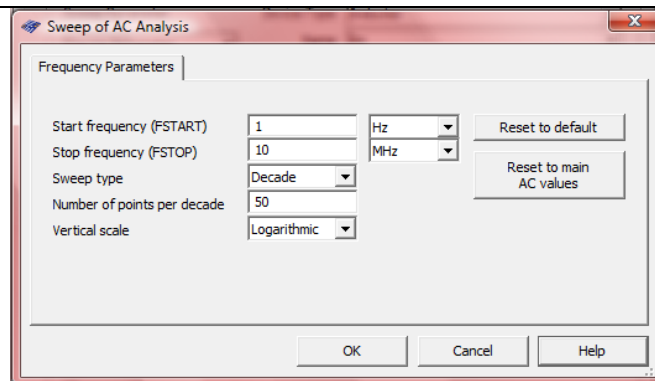


Figure 8.5.4 AC Analysis Specifications.

We want to plot the power dissipated in the load resistor. Therefore, the Selected variables for analysis field under the Output tab should contain the following variable equation: $\text{real}(0.5 \cdot V(4) \cdot (\text{real}(-I(v1)), -\text{imag}(-I(v1))))$. Make sure you keep track of your parentheses when writing this equation!

When everything is all set, press Simulate. The results of the simulation are shown on the next page in Fig. 8.5.5 and 8.5.6. Why are the peaks for each value at different frequencies? The reason is as follows:

Because R_L and R_S are equal we need only pay attention to the value of C_S and L_M . In order for Z_L to equal Z_S^* we need to have the impedance contribution from L_M be equal in magnitude but opposite in sign to the impedance contribution of C_S . Thankfully the sign difference is taken care of by the fact that one component is a capacitor and the other is an inductor. Thus we need:

$$\frac{-j}{\omega \cdot C} = -j \cdot \omega \cdot L$$

Since we know the value of C (it is CS) and we essentially pick a value of L in the simulation, we should be able to calculate a frequency where L and C cancel one another out, which should result in maximum power transfer. This equation is:

$$f = \frac{1}{2\pi\sqrt{L \cdot C}}$$

Well this is interesting...that's nothing more than the resonance frequency of the two components. Very interesting...Let's find the frequency for each inductor value at which the power transfer should be maximum and compare it to the values obtained in the plots.

$LM = 5 \text{ mH:}$ $f = 14.529 \text{ kHz}$
 $LM = 55 \text{ mH:}$ $f = 4.381 \text{ kHz}$
 $LM = 105 \text{ mH:}$ $f = 3.170 \text{ kHz}$
 $LM = 155 \text{ mH:}$ $f = 2.609 \text{ kHz}$

From looking at Figures 8.5.5 and 8.5.6 we obtain the values:

$LM = 5 \text{ mH:}$ $f = 14.454 \text{ kHz}$
 $LM = 55 \text{ mH:}$ $f = 4.365 \text{ kHz}$
 $LM = 105 \text{ mH:}$ $f = 3.162 \text{ kHz}$
 $LM = 155 \text{ mH:}$ $f = 2.630 \text{ kHz}$

The values are all very close to one another. Excellent!

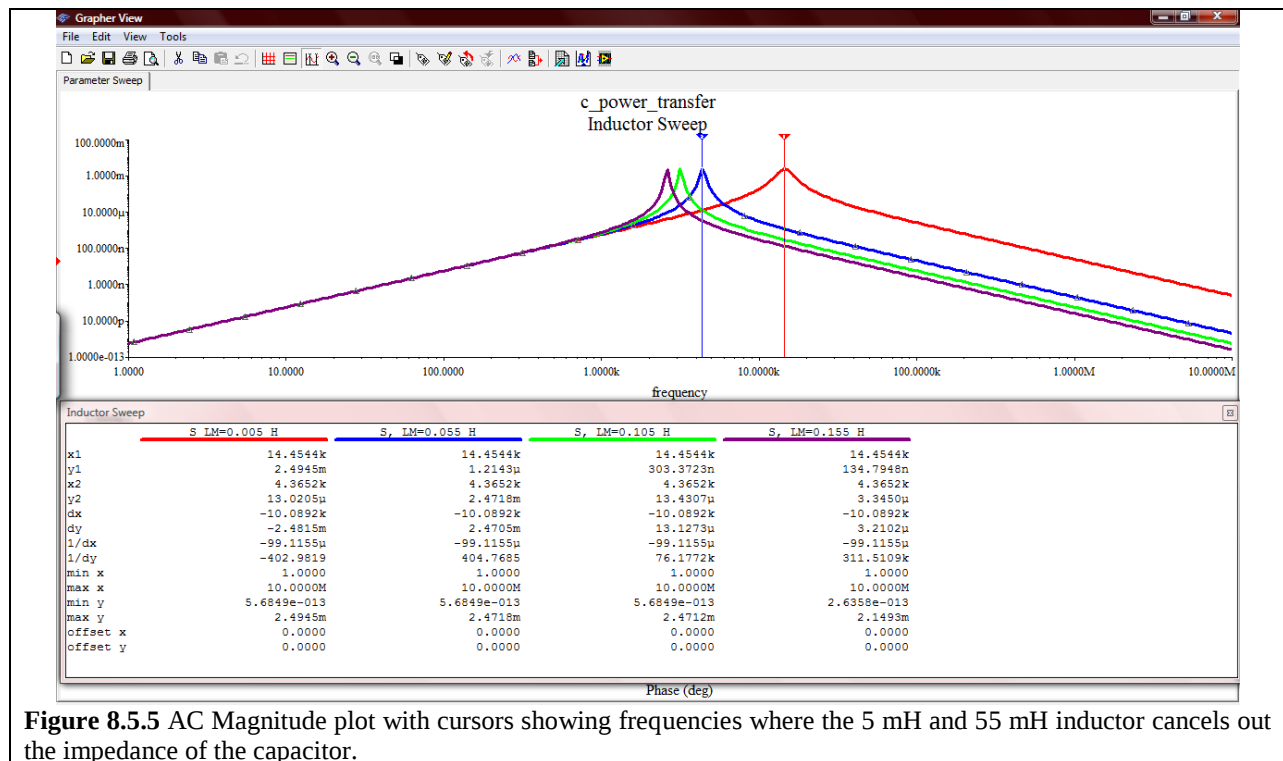


Figure 8.5.5 AC Magnitude plot with cursors showing frequencies where the 5 mH and 55 mH inductor cancels out the impedance of the capacitor.

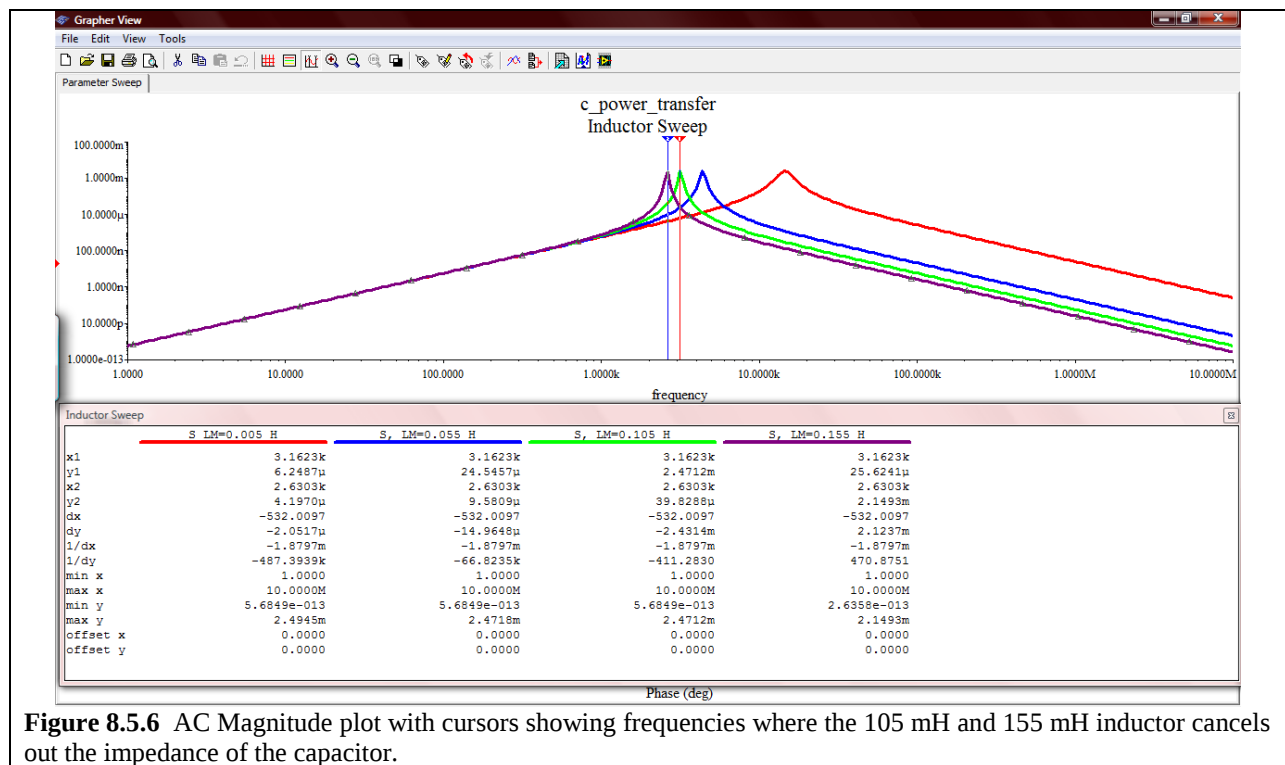


Figure 8.5.6 AC Magnitude plot with cursors showing frequencies where the 105 mH and 155 mH inductor cancels out the impedance of the capacitor.