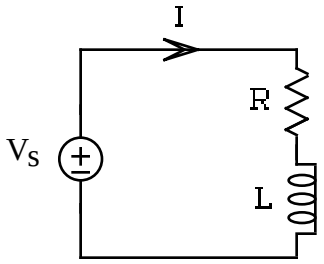
ECE 209 - AVERAGE POWER - INVESTIGATION 19
POWER FACTOR CORRECTION

FALL 2000 **A.P. FELZER**

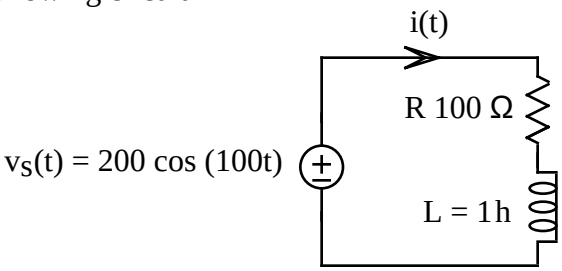
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs and tables.

Up to now we've been assuming all our wires are ideal with no resistance. But real wires - in particular real power lines - do have at least some resistance. And so some energy will always be lost as heat whenever current flows through them. The objective of this investigation is to come up with a scheme for minimizing the currents I and therefore the power losses in power lines connecting connecting generators to loads like the following



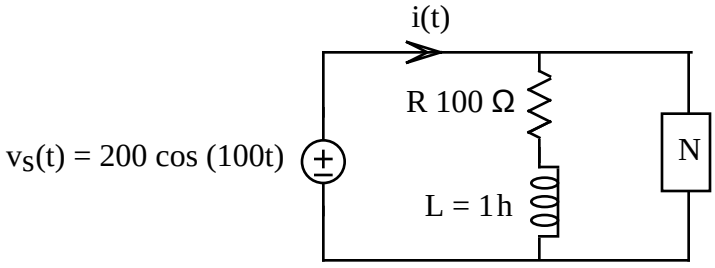
Our goal is to develop a scheme that increases the power factor pf (and therefore decreases the current I) without affecting the amount of power delivered to the RL load.

1. Let us begin with the following circuit



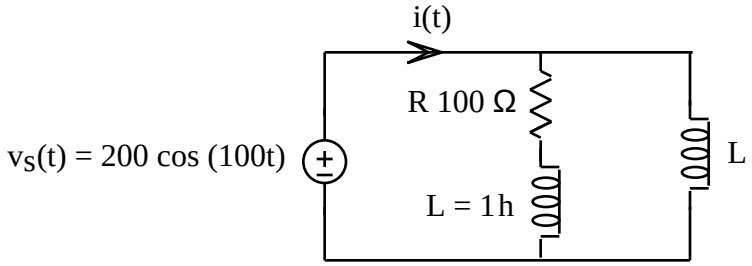
with an RL load equal to a simple model for a motor.

   a. Calculate the current I, the average power P_{av} being delivered to the RL load and the corresponding power factor pf.
   b. Our goal, as spelled out in the introduction, is to come up with a scheme to reduce I without affecting the amount of power being delivered to the RL load. The trick to accomplishing this is to add an appropriate circuit element N in parallel as follows



Explain in words why adding N does not affect the current through the RL load and therefore the power being delivered to it

c. Our first objective is to see the affects of different N's. We clearly don't want N to be a resistor since resistors dissipate energy. So let us begin by seeing what happens when we make N an inductor as follows



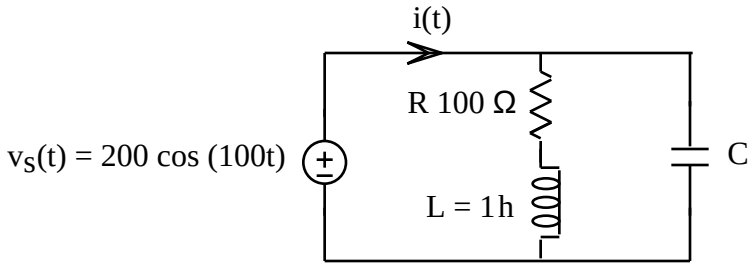
(i) First find an expression for the admittance $Y_{RL}(j100)$ of the RL load as the sum of a real and an imaginary part

(ii) Then make use of your result in part (i) to find the admittance $Y_{eq}(j100)$ of the RL load in parallel with the inductor as the sum of a real and imaginary part

(iii) Now $|I(j100)| = |Y_{eq}(j100)|\,|V_S|$ will be minimum when $|Y_{eq}(j100)|$ is minimum. What value of L will make $|Y_{eq}(j100)|$ minimum. What is the corresponding value of the power factor pf

(iv) Sketch and describe graphs of P_{av}, $|I(j100)|$ and the pf as functions of L.

d. Now let's see what happens when we make N in part (b) equal to a capacitor C as follows



(i) First find the admittance $Y_{eq}(j100)$ of the RL load in parallel with the capacitor as a sum of a real and imaginary part.

(ii) Then find the value of C that will make $|Y_{eq}(j100)|$ minimum.

(iii) What is the value of the maximum power factor pf in part (ii)

(iv) Sketch and describe graphs of P_{av}, $|I(j100)|$ and the pf as functions of C.

e. From parts (c) and (d) we know that adding a parallel inductor L decreases the pf but adding a capacitor C can increase the pf all the way to one. Draw the circuit and then calculate the corresponding minimum $|I(j100)|$ with your C in part (d) that makes pf = 1

f. By how much will the average power P_{av} being delivered by the source in the original RL circuit decrease when the capacitor of part (d) is added to the circuit when the resistance of the wires modeling the power lines is 10 Ω

g. Write out the steps in the algorithm for finding the value of the parallel capacitor C that maximizes the power factor of a circuit with an RL load. What, in particular, is the imaginary part of Y_{eq} when the power factor is one.

h. Make a general sketch of $|I(j\omega)|$ as a function of the power factor pf for a given P_{av}