# ECE 205 Lab – RMS and AC Simulation

## Challenge: RMS and AC Simulation

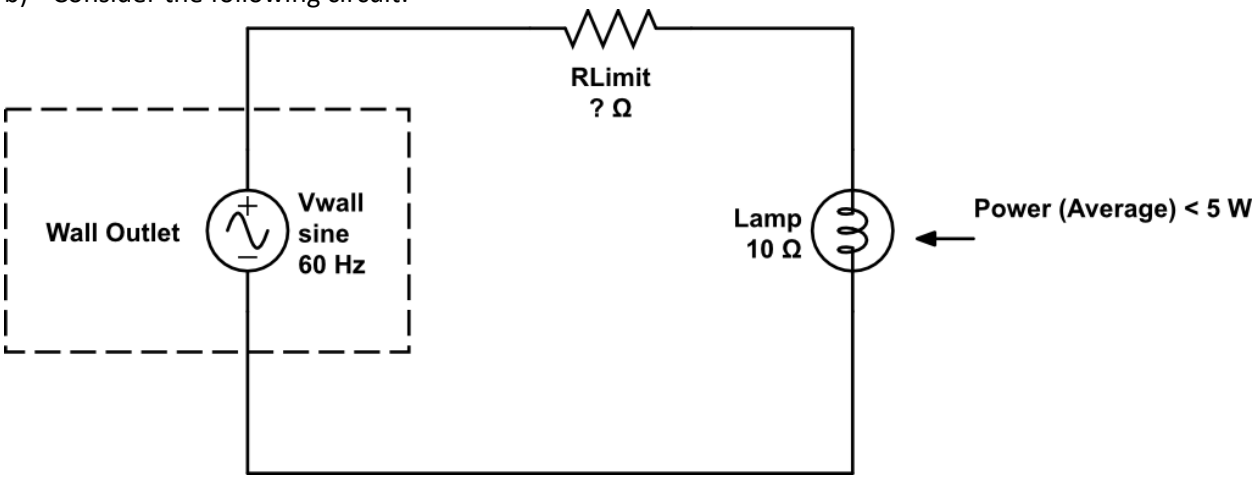
In lecture, you learned that for DC circuits, the power absorbed by a resistor (for example) may be found by $P_R = \frac{V^2}{R}$. However, for AC sinusoidal circuits, the average power through the same resistor as a function of the voltage across it is computed via $P_{R(AV)} = \frac{|V|^2}{2R}$. Note that there is difference of a factor of 2 even though the magnitudes are the same, this is due to the area under a sine wave being different than the area under a constant line. Thus, this is quite inconvenient when calculating power for arbitrarily shaped signals, since the magnitude (or maximum value) of a voltage or current is a poor representation of the actual power delivery ability of that voltage/current. Therefore, when working with AC power, we prefer to use the RMS (Root-Mean Squared) value instead of the magnitude.

RMS is easy enough to compute $\left(V_{rms} = \sqrt{\frac{1}{T}\int_{t0}^{t0+T} V^2(t)\,dt}\right)$, but tricky to measure.

Prelab Deliverables (need to be :

a) Mains (outlet) power in the US is often given as 120 V, 60 Hz. However, this is actually 120 V **RMS**. What is the amplitude (that is peak) of this waveform - note that mains power is supposed to be a sine wave.

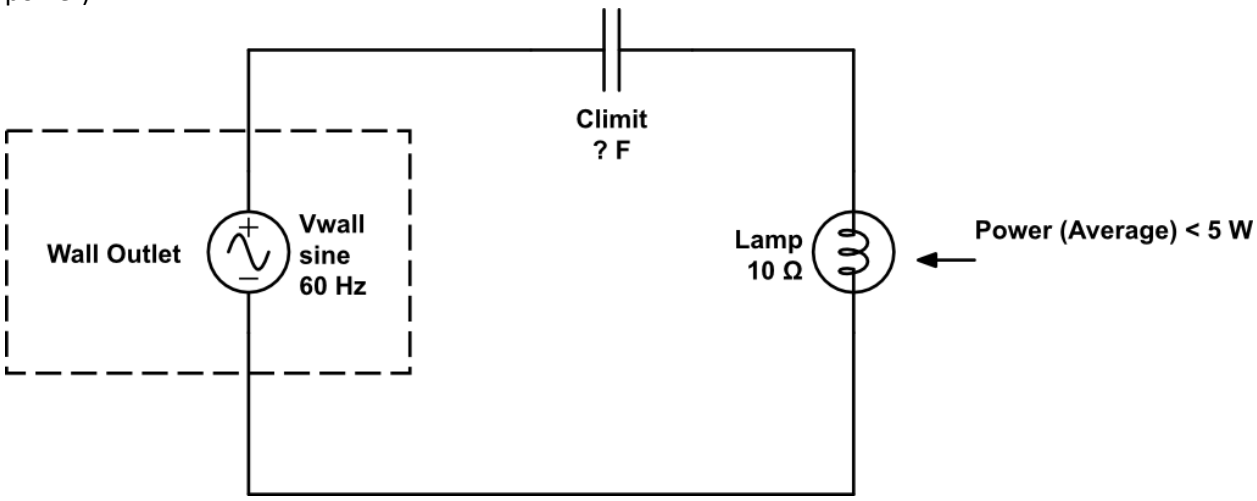
b) Consider the following circuit:



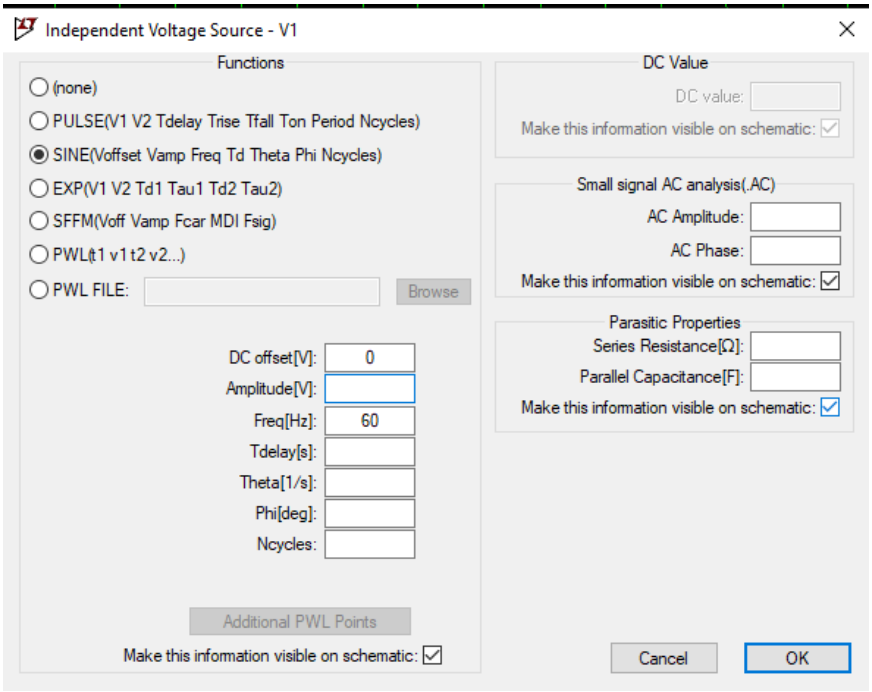

You are tasked with designing an indicator light which plugs into the wall to show that the line is active. The indicator is a small incandescent (e.g. standard) light bulb (Lamp in the circuit), which is modeled as a 10Ω resistor. The lamp is only rated for 5W so the average power must be kept under 5W. **Solve for the value of the current limiting resistor (RLimit) and compute the (average) power dissipated in the current limiting resistor if the (average) power in the lamp exactly 5 W.**

Challenge:

The prelab circuit works, however, the substantial power in the limiting resistor is wasted. Your goal is to use simulation to find a better way to current limit, without wasting all the power in a resistor. You can do this by using a capacitor, in place of the resistor – as the voltage source is AC (e.g. mains power).




Your goal is to find using simulation, the value of the capacitor required to keep the power in the lamp at 5 W. For this, you will do a **transient** simulation. The recommendation is that you start by building the prelab circuit (with the resistor), with the values that you solved for during the prelab, and verify that the power in the lamp is indeed 5 W (it is possible to compute the power directly in LTSpice by entering an expression for the simulation trace, or you may simply verify the amplitude of the voltage across the lamp using the equation $P_{R(AV)} = \frac{|V|^2}{2R}$. As a hint, your AC voltage source should be modeled as follows, with the Amplitude replaced by the value you found in the first part of the prelab. The other parameters may simply be left blank (Tdelay, Theta, etc..). The lamp may be modeled as just a resistor.




Then replace the resistor (the current limiting resistor) with a capacitor and try to get the same power (or voltage across the lamp). As a starting point, try Climit = 100uF. Double the capacitor, and observe the change, halve the capacitance, and observe the change, etc. Find a value which gets reasonably close but does not exceed the 5W limit.

Report Deliverables:

- Include the prelab with the calculations
- Include both circuits, the prelab circuit, and the lab circuit with the component values properly labeled (voltage source, current limiting resistor/capacitor, resistor for lamp).
- Include a simulation traces of the Power or Voltage across the lamp for both cases (current limiting resistor and capacitor).
- Include the procedure you used to determine the value of the current limiting capacitor.
- Your discussion should at least answer the following questions.
    - What is the advantage of using the capacitor vs the resistor to current limit? What is the power wasted in the capacitor?
    - If we took the circuit and plugged it into UK mains (230 V RMS, 50 Hz), what would the power in the lamp be?
- Include a theoretical calculation for the capacitor value. You may not be able to do this until after your lab week, but before your lab report is due.