3 spice phase power driving loads

Review of LTspice:

- Draw circuits in a schematic (new schematics are under file).
- Many passive elements have a button on the tool bar (wire, resistors, capacitors, inductors, ground, and node labels)
- Most active elements (transistors, diodes, opamps, logic gates) are under selectable under the AND symbol.
- Voltage and current sources are also available under the AND symbol. They are DC by default, sinusoidal AC pulsed AC and others are selectable under the advanced button.
- Run simulations under the simulate menu. The most common simulation we do is a transient analysis which requires you to choose start and stop times. Often 10 oscillations is enough to reach steady state but judgement must be used upon seeing the voltage and current traces.
- See the trace result of your simulations by clicking on circuit elements. Clicking on wires gives voltages (wrt ground), clicking on other elements gives current.
- Calculate the average and RMS of voltage traces by control clicking the trace.
- See power traces by alt clicking a circuit element (e.g., resistor, inductor, power supply).
- Calculate the average power and the net energy (time integrated power) by control clicking a power trace.
- Right clicking on a trace allows you to edit the expression that is graphed.
  - V(n001) gives the voltage at node n001 with respect to ground.
  - V(n001,n002) gives the voltage at node n001 with respect to node n002, or quivalently V(n001)-V(n002).
  - I(R1) gives the current through resistor R1.

One-phase AC (240V/120V 1ϕ 3W)-a guided example:

Construct a 1-phase AC branch circuit using line voltage (V=120V RMS, f=60Hz) that drives a load with a net impedance z=10+7.54j, Figure 1 shows one circuit that does this. Be sure you understand how to calculate the resistance and inductance from the impedance and voltage source info.

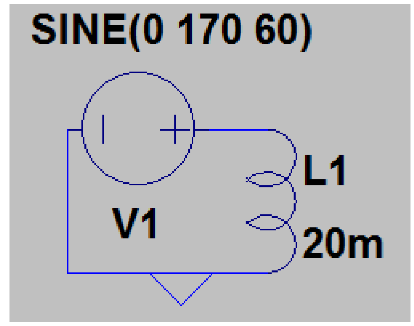

Figure 1 A 1-phase circuit, the inductor has internal series resistance.

1. Measure the phase shift of the load's voltage with respect to the current using the trace. Quote the value in degrees.

   Does the voltage lead or lag the current?
2. What is the RMS voltage across the load? What is the RMS current through the load?
3. What is the load's apparent power?
4. What is the real average power? Find it directly from LTspice.
5. What is the reactive power?
6. Use the apparent power and real power to determine the power factor. Compare this to the phase shift you estimated in question 1.

Phase from Trace	Lead/lag	V_{RMS}	I_{RMS}	S	<P>	Q	PF

Comparison:

Balanced 3-phase AC (208Y/120V 3ϕ 4Wire):

Phase to ground circuit:

1. Circuit Construction
    a. On paper, sketch a 3 phase AC power source in the Wye configuration using line voltage that drives 3 equal loads. Attach the loads so each connects phase to ground.
    b. Construct this circuit in LTSpice giving each load an impedance of z=10+7.54j.
2. Current and Voltage
    a. Measure the phase shift of one load's voltage with respect to the current using the trace. Quote the value in degrees. Does the voltage lead or lag the current?
    b. What is the RMS voltage across one load? What is the RMS current through one load?
    c. What is the neutral current?
3. Power
    a. What is the apparent power consumed by one load?
    b. What is the real average power consumed by one load? Find it directly from LTspice.
    c. What is the reactive power for one load?
    d. What is the net time-averaged total power used by all loads?

Phase to Phase circuit:

1. Circuit Construction
    a. On paper, sketch a 3 phase AC power source in the Wye configuration using line voltage that drives 3 equal loads. Attach the loads so each connects phase to phase.
    b. Construct this circuit in LTSpice giving each load an impedance of z=10+7.54j.

2. Current and Voltage
    a. Measure the phase shift of one load's voltage with respect to the current using the trace. Quote the value in degrees. Does the voltage lead or lag the current?
    b. What is the RMS voltage across one load? What is the RMS current through one load?
    c. What is the neutral current?
3. Power
    a. What is the apparent power consumed by one load?
    b. What is the real average power consumed by one load? Find it directly from LTspice.
    c. What is the reactive power for one load?
    d. What is the net time-averaged total power used by all loads?

Balanced 3-phase AC (240Δ/120V 3ϕ 3Wires):

1. Circuit Construction
   a. On paper, sketch a 3 phase AC power source in the Delta configuration using 240V_{RMS} between each phase being explicit about your choice of ground. Use that power source to drive 3 equal loads connected phase to phase.
   b. Construct this circuit in LTSpice giving each load an impedance of z=10+7.54j. Hint: You may need more than three voltage sources.
2. Current and Voltage
   a. Measure the phase shift of one load's voltage with respect to the current using the trace. Quote the value in degrees. Does the voltage lead or lag the current?
   b. What is the RMS voltage across one load? What is the RMS current through one load?
   c. What is the neutral current?

3. Power
   a. What is the apparent power consumed by one load?
   b. What is the real average power consumed by one load? Find it directly from LTspice.
   c. What is the reactive power for one load?
   d. What is the net time-averaged total power used by all loads?

	Phase from Trace	Lead/lag	Load V_{RMS}	Load I_{RMS}	I_n	S	<P>	Q	Net <P>
208Y/120V 3ϕ 4Wire, P-G									
208Y/120V 3ϕ 4Wire, P-P									
240Δ/120V 3ϕ 3Wires									