# 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.

## Practice, 1-phase AC (240V/120V 1$\phi$ 3W):

Construct a 1 phase AC branch circuit using line voltage (V=120V RMS, f=60Hz) that drives a load with an impedance z=10+7.54j. Be sure to place the circuit ground in a convenient location.

1. Does the current lag or lead the voltage? Use the trace of each to support your assertion and to estimate the phase shift.
2. What is the RMS voltage across the load? What is the RMS current through the load?
3. What is the apparent power?
4. What is the reall average power? Find it directly from LTspice by summing the average power used by each piece of the load.
5. What is the reactive power?
6. What is the power factor? Compare this to the phase shift you estimated in question 1.

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

Construct a 3 phase AC power source in the Wye configuration using line voltage that drives 3 loads, each with an impedance of z=10+7.54j.

1. Wire the loads so each connects phase to ground.
    a. Does the current lag or lead the voltage? Use the trace of each to support your assertion and to estimate the phase shift.
    b. What is the RMS voltage across one load? What is the RMS current through one load?
    c. What is the apparent power?
    d. What is the real average power? Find it directly from LTspice by summing the average power used by each piece of the load.
    e. What is the reactive power?
    f. What is the power factor? Compare this to the phase shift you estimated in question a.
    g. What is the net time-averaged total power used by all loads?
    h. What is the neutral current?
2. Wire the loads so that they connect phase to phase.
    a. Does the current lag or lead the voltage? Use the trace of each to support your assertion and to estimate the phase shift.
    b. What is the RMS voltage across one load? What is the RMS current through one load?
    c. What is the apparent power?
    d. What is the real average power? Find it directly from LTspice by summing the average power used by each piece of the load.
    e. What is the reactive power?
    f. What is the power factor? Compare this to the phase shift you estimated in question a.
    g. What is the net time-averaged total power used by all loads?
    h. What is the neutral current?

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

Construct a 3 phase AC power source in the Delta configuration using $240V_{RMS}$ for each phase. Note that LTspice demands a ground point and one sensible place to put the ground is in the middle of the phase. One way to do that is to split a $240V_{RMS}$ voltage source into two $120V_{RMS}$ voltage sources in series, each with the same phase shift as the original voltage source. Connect 3 loads, each with an impedance of z=10+7.54j, across the power supply.

    a. Does the current lag or lead the voltage? Use the trace of each to support your assertion and to estimate the phase shift.
    b. What is the RMS voltage across one load? What is the RMS current through one load?
    c. What is the apparent power?
    d. What is the real average power? Find it directly from LTspice by summing the average power used by each piece of the load.
    e. What is the reactive power?
    f. What is the power factor? Compare this to the phase shift you estimated in question a.
    g. What is the net time-averaged total power used by all loads?

h. What is the neutral current?