MicroCap Steady State AC Analysis
EE210 – Circuits and Systems
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MicroCap is capable of performing three basic types of circuit analysis. In DC Analysis capacitors are treated as open circuits, inductors are treated as short circuits and MicroCap calculates voltages and currents that would be displayed by a DC voltmeter. In Transient Analysis, MicroCap numerically solves the differential equations that describe the circuit and show results that are typically seen on an oscilloscope. This analysis method is MicroCap's most powerful (realistic) circuit simulation method. It allows non-linear devices to be modeled and is therefore useful in the analysis and design of non-linear circuits (clippers, clamps, power supplies, switching circuits, etc.)

AC Analysis results are only meaningful if the circuit is linear. It uses a small-signal linear model for all non-linear devices (diodes, transistors) and provides meaningless results if these devices operate in a non-linear mode in the corresponding real-world circuit. There are a tremendous number of circuits that are linear (all of the RLC circuits we've looked at this semester and transistor and op amp based amplifiers are all linear). In AC Analysis, MicroCap does a complex phasor analysis and can therefore be used check the results of your phasor analysis homework.

We will use MicroCap to determine the currents $i_1$ and $i_2$ in the circuit shown in Figure 1. The source voltages are equal to $v_1 = 10 \cos (2\pi 160t)$ V and $v_2 = 20 \cos(2\pi 160t - 30^\circ)$ V.

![Figure 1: Example Circuit](image)

The corresponding MicroCap schematic is shown in Figure 2. The pin names (Plus and Minus) on resistors R1 and R2 are in agreement with the desired current directions. (To show the pin names double-click the resistor and click on the Pin Names check box in the window that appears. You may need to rotate the resistors so that the pin names agree with the desired current directions. Alternatively, in this circuit, the currents through L1 and L2 could be used to determine $i_1$ and $i_2$.)

The settings for voltage source $v_1$ are shown in Figure 3 (only a portion of the window is shown). Notice that the None source tab has been selected. Any of the sources could be used, in AC Analysis only the AC magnitude and AC Phase values have any effect on the simulation. All other values are ignored. (The DC value is used in DC Analysis all other values are used only during a Transient Analysis.) Note also that we do not enter in a simulation frequency at this point (that is done later). The AC magnitude and AC Phase are 10 V and 0° respectively.
The voltage settings for $v_2$ look very similar except that the *AC magnitude* is equal to 20 and the *AC Phase* is equal to -30.

Select *AC* from the *Analysis* menu and the *AC Analysis Limits* window shown in Figure 4 will appear. MicroCap is designed to do an *AC Analysis* at a range of frequencies, not just one frequency. We are interested in the currents when the sources are operating at 160 Hz. (Be careful here! MicroCap always wants frequency values in Hz, not in radians/sec, be sure that you have the correct frequency value.) We can make sure that MicroCap does an analysis at exactly the frequency we are interested in by specifying a frequency range in which that maximum frequency is one decade (a multiplicative factor of 10) above the desired frequency and a minimum frequency that is one decade below the desired frequency. For 160 Hz, the frequency range should therefore be 1600, 16. By specifying a *Log* frequency stepping method (from the pull-down menu box next to the *Frequency Range* setting) and an odd number of simulation points, we can be sure that MicroCap will simulate the circuit at the desired frequency. We've chosen only to simulate the circuit at 5 frequencies within the given frequency range. Using more points will give smoother plots, but the simulation takes longer and we are really only interested in results at one frequency. (If a lot of points are plotted it can be difficult to locate the point that corresponds to our desired frequency.) Also, 5 seems to be the minimum number of points that can be used when giving a frequency range. (Using a range of 160,160 and just 1 point doesn't give accurate results for the phase.)

In *AC Analysis* all circuit response variables are *complex* numbers. Note that we've chosen to plot the absolute value (the magnitude of the complex number) of the currents in one window and the phase angle (via the ph function) in a second window. By the way, MicroCap computes the phase angle in degrees and not radians. The simulation results are shown in Figure 5.
MicroCap’s tagging feature has been used to display actual magnitude and phase values at 160 Hz. The $i_1$ magnitude plot is topmost at 160 Hz while the $i_1$ phase plot is beneath that of $i_2$ at all simulated frequencies. The $I_1$ phasor is equal to (6.726 mA $\angle 38.217^\circ$) at 160 Hz while that of $I_2$ is equal to (5.951 mA $\angle 131.267^\circ$) These phasor values correspond to steady-state time-domain currents of:

\[
i_1 = 6.726 \cos(2\pi 160 t + 38.217^\circ) \text{ mA}
\]
\[
i_2 = 5.951 \cos(2\pi 160 t + 131.267^\circ) \text{ mA}
\]

Note that both phase angles are positive, so both currents lead voltage source $v_1$.

**Phasor Domain Circuits**

You can use MicroCap and transient analysis to obtain results even for phasor domain circuits. Just set up the simulation at a frequency of $f = 1$ Hz. For an inductor with an impedance of $jX$ use an inductance value of $L = X/(2\pi)$ in the simulation. (MicroCap will do the math for you, if you have an inductive impedance of $j200$ type in 200/(2*pi) for the inductance value.) For a capacitor with an impedance of $-jX$ use a capacitance value of $C = 1/(2\pi X)$. (Again let MicroCap do the math). Use a frequency range of 10, 0.1. The results at 1 Hz will then correspond to the results in the phasor domain circuit.

For example to obtain $V_o$ in the phasor domain circuit shown in Figure 6(a), we use the MicroCap schematic shown in Figure 6(b). At 1 Hz, the components shown in the MicroCap schematic will have exactly the same impedance as the corresponding component in the phasor domain circuit. Simulating over a frequency range of 10,0.1 indicates that $V_o$ is (11.314 V $\angle -45^\circ$) at 1 Hz. Manual phasor domain analysis of the original circuit yields a result of (11.314 V $\angle -45^\circ$) in exact agreement with MicroCap. (The MicroCap simulation was much faster than manual analysis!!)
Figure 5: AC Analysis Simulation Results

Figure 6: Phasor Domain Circuit (a) and Corresponding MicroCap Schematic (b)
Note the inductance and capacitance values used in MicroCap.