EXPERIMENT 10

Recitation & MATLAB: AC Mesh and Nodal Analysis

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The objectives of this experiment are to:

- Practice solving ac circuits
- Learn how to perform complex number calculations in MATLAB

Introduction

Earlier we used MATLAB to solve a set of simultaneous equations, which yielded the node voltages or loop currents in dc circuits. We now apply this technique to ac circuits. In the ac case where the number-crunching involves complex numbers, we use j to represent the imaginary part of a complex number (unless it has been previously defined as something else), and the complex number x+jy is expressed in MATLAB as x + j*y. Although we use j in defining a complex number (and MATLAB will recognize this), MATLAB will list the complex number using i.

Although we make a practice of representing complex voltages in currents in polar form, MATLAB operates with complex numbers in rectangular form. So, when using MATLAB, we will have to express things in rectangular form, even though we might prefer to think about them in polar form (e.g., voltage and current sources). Also, MATLAB's standard trigonometric commands work in radians (type "help cos" in MATLAB's command window). We use the fact that 180° equals π radians. For example, a source V = 10∠45° will be entered into MATLAB as

V = 10*cos(45*pi/180) +j*10*sin(45*pi/180)

When using MATLAB to determine the node voltages in ac circuits, we enter the matrix, Y, the vector, I, and solve the equation V = Y\I. Consider the circuit in Figure 1.

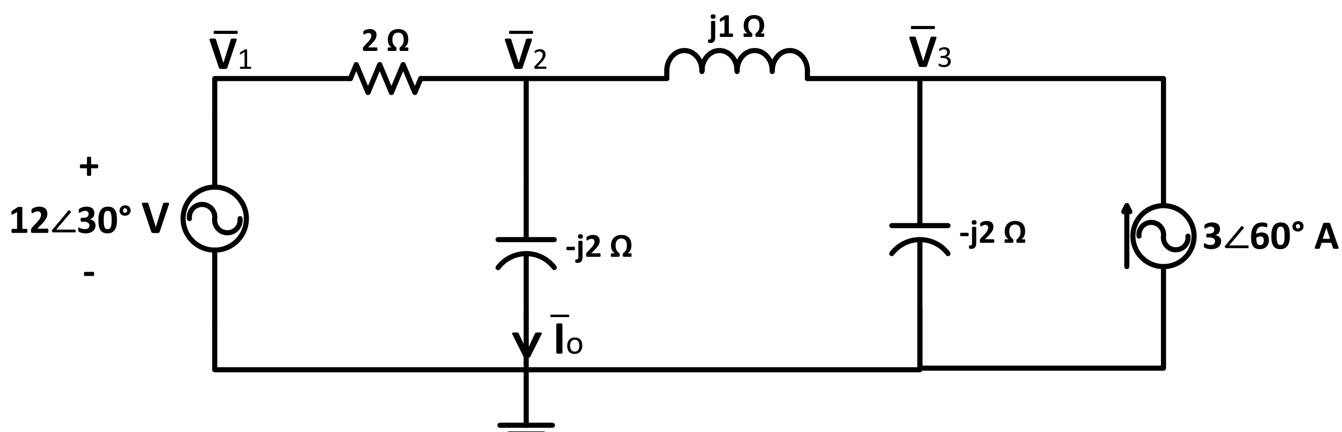

Figure 1: Example Circuit

Writing out and simplifying its nodal equations yields the following:

$$\begin{bmatrix} 1 & 0 & 0 \\ -0.5 & 0.5 - j0.5 & j \\ 0 & j & -j0.5 \end{bmatrix} \begin{bmatrix} \overline{V}_1 \\ \overline{V}_2 \\ \overline{V}_3 \end{bmatrix} = \begin{bmatrix} 12\angle 30^\circ \\ 0 \\ 3\angle 60^\circ \end{bmatrix}$$

The MATLAB script shown in Figure 2 populates the Y matrix and I vector, converts the sources to rectangular form, solves for the **V** vector, converts and displays the **V** vector in polar form (with angle in degrees) without saving the result, calculates the current, $\mathbf{I_o}$, and displays $\mathbf{I_o}$ in polar form (with angle in degrees) without saving the result. Note that if you have $\angle 0°$, you do not have to write out the trigonometric functions since, for example, $10\angle 0° = 10$.

Editor - E:\2110_redo\lab10ex.m

lab10ex.m

```
clc
clear all

Y = [1        0             0;
     -0.5 0.5-0.5*j         j;
     0        j        -0.5*j];

I = [12*cos(30*pi/180)  + j*12*sin(30*pi/180);
                          0;
     3*cos(60*pi/180)   + j*3*sin(60*pi/180)];

V = Y\I; % =inv(Y)*I
[abs(V)  angle(V)*180/pi]

Io = V(2)/(-2*j);
[abs(Io)  angle(Io)*180/pi]
```

Figure 2: MATLAB Script for Nodal Equations

Figure 3 shows a screenshot of the command window after executing the m-file in Figure 2. The first column displays magnitudes and the second column displays corresponding phase angles, in degrees, for each "ans".

Command Window

```
ans =

   12.0000   30.0000
    7.3309  -26.5651
    8.6799  -24.1914


ans =

    3.6654   63.4349
```

Figure 3: Calculated Node Voltages and Current, $\mathbf{I_o}$ (respectively)

EXERCISES

For all exercises, include in your report circuit diagrams with all variables clearly labeled, <u>all hand calculations</u>, hand-written matrices consisting of nodal and mesh equations, MATLAB code, and MATLAB results. Be sure that you keep all parts of each exercise together (i.e., do not organize your report by "all hand calculations, all simulations, all MATLAB", but rather "all of #1, all of #2, all of #3, all of #4, all of #5"). Use the node voltage and mesh current definitions defined in each exercise.

Use m-files when typing MATLAB code. You should seldom type and execute code from the command window. All variables (node voltages and mesh currents) in the below figures are **phasors**. Use the given variable definitions for each exercise (though there can be some flexibility with the mesh current definitions).

1) Use MATLAB to solve the following set of equations. Include the MATLAB code required to solve this set of equations in your lab report. Also include the MATLAB solution in your report. Convert all answers to polar form and include in your report.

$$\begin{bmatrix} 1+j & -1 & 0 & 2-j & 0 \\ 0 & 1 & -2 & 0 & 0 \\ 0 & 0 & -1 & 1 & 0 \\ -j & -1 & 2 & 2+j & -1 \\ 0 & 0 & 0 & -3 & 1-j \end{bmatrix} \begin{bmatrix} \overline{V}_1 \\ \overline{V}_2 \\ \overline{V}_3 \\ \overline{V}_4 \\ \overline{V}_5 \end{bmatrix} = \begin{bmatrix} 2 \\ 0 \\ 12 \\ -2 \\ 0 \end{bmatrix}$$

2) Write nodal equations for the circuit in Figure 4 (put in matrix notation). Solve your equations using MATLAB and calculate $\mathbf{V_0}$. Repeat using mesh analysis. Include both your nodal and mesh equations, MATLAB code, MATLAB solutions (polar form), and any calculations required using your MATLAB solutions in your lab report.

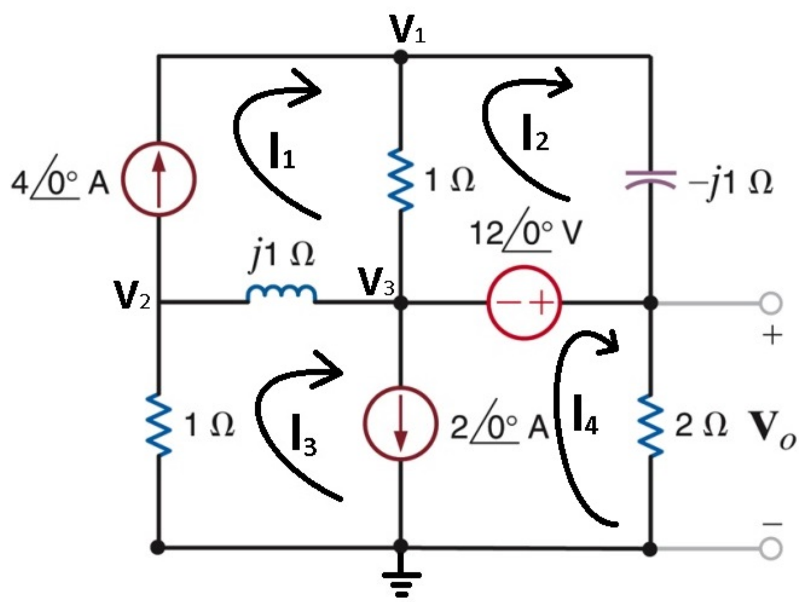

Figure 4: Circuit for Exercise 2

3) Write nodal equations for the circuit in Figure 5 (put in matrix notation). Solve your equations using MATLAB and calculate $\mathbf{V_0}$. Repeat using mesh analysis. Include both your nodal and mesh equations, MATLAB code, MATLAB solutions (polar form), and any calculations required using your MATLAB solutions in your lab report.

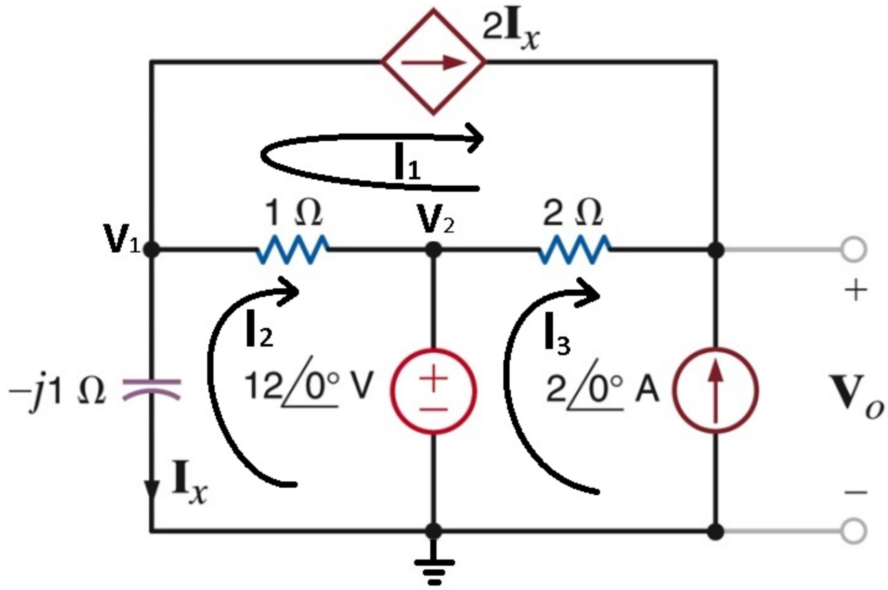

Figure 5: Circuit for Exercise 3

4) Write nodal equations for the circuit in Figure 6 (put in matrix notation). Solve your equations using MATLAB and calculate $\mathbf{I_0}$. Repeat using mesh analysis. Include both your nodal and mesh equations, MATLAB code, MATLAB solutions (polar form), and any calculations required using your MATLAB solutions in your lab report.

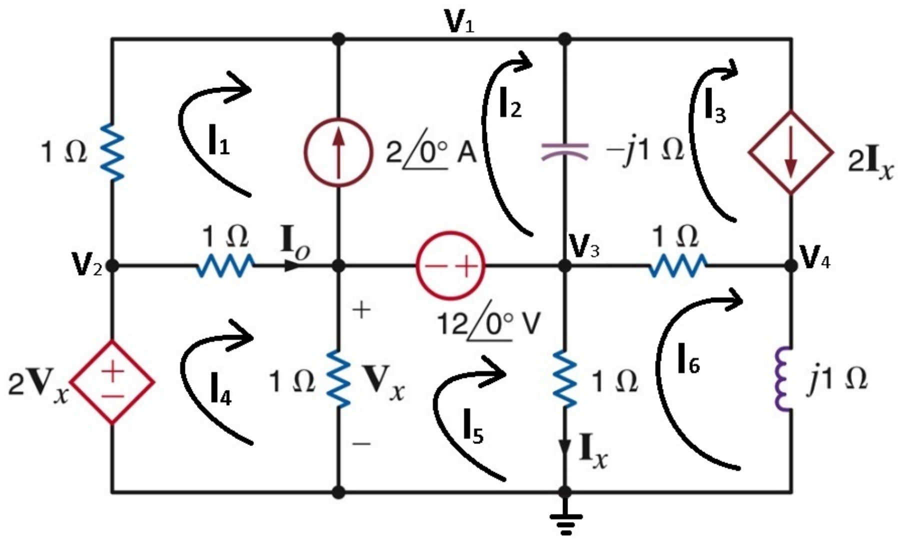

Figure 6: Circuit for Exercise 4

5) Write nodal equations for the circuit in Figure 7 (put in matrix notation). Solve your equations using MATLAB. Include your nodal equations, MATLAB code, and MATLAB solution (polar form) in your report. No mesh analysis is required for this exercise.

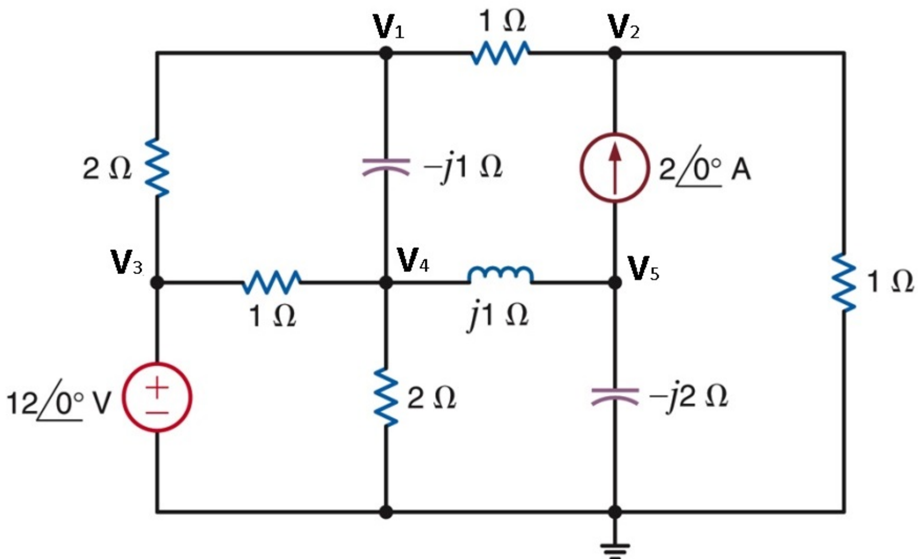

Figure 7: Circuit for Exercise 5