GEORGIA INSTITUTE OF TECHNOLOGY
School of Electrical and Computer Engineering

Course ECE 2040

Circuit Analysis

Assigned: January 28, 2000
Due: February 4, 2000

Problem Set #3

Reading: Read the following sections from the class notes:
Chapter 2, Sections 2.1.4, 2.1.5, 2.2, 2.3
Reading: Read the following sections from Irwin and Wu:
Chapter 4, Sections 4.1, 4.2; (linearity, source superposition)
Chapter 3, Sections 3.1, 3.2; (node and mesh methods)

Reminder: Quiz #1 will be held in class on Wednesday, February 2, 2000. It will be a *closed book* test covering the material in class lectures 1–7. Calculators are permitted.

Problem 3.1: We wish to solve the circuit in Figure 1 using the node method. Let $e_a(t)$ be the node potential at the indicated node.

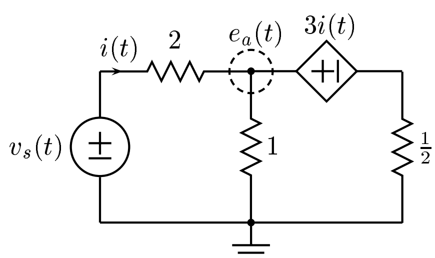

Figure 1: Circuit for Problem 3.1.

(a) Express $i(t)$ in terms of $e_a(t)$ and $v_s(t)$.

(b) Write a KCL equation at the surface in the complete network that corresponds to the non-ground node in the basic network. This equation should involve only the variables $e_a(t)$ and $v_s(t)$.

(c) Determine $e_a(t)$.

Problem 3.2: Find all of the element voltages and currents in the circuit of Figure 2 using the mesh method. Be sure to identify the variables clearly.

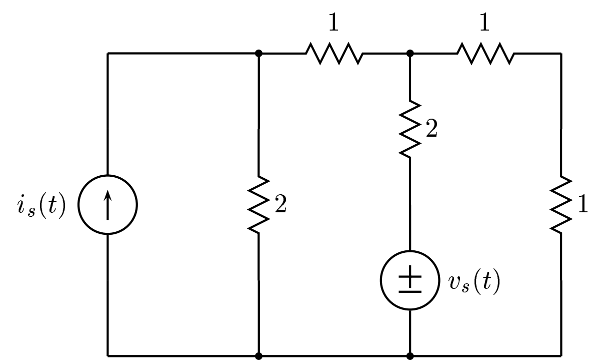

Figure 2: Circuit for Problem 3.2.

Problem 3.3: (a) Which method, the mesh method or the node method, will result in fewer equations to solve in order to determine $v(t)$ in the circuit in Figure 3?

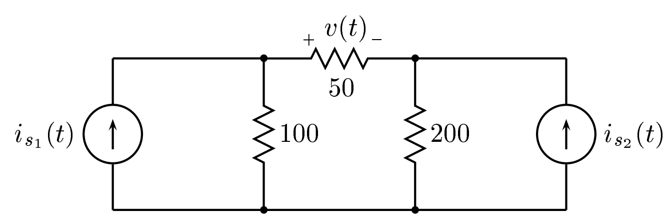

Figure 3: Circuit for Problem 3.3.

(b) Determine $v(t)$ using the method that you selected in (a).

Problem 3.4: The node method and the mesh method are not the only systematic methods for finding the equilibrium solution of a circuit, although they are the most popular. As an example of a different approach, consider the circuit in Figure 4.

(a) Show that all of the currents in the circuit (and, therefore, all of the voltages) can be expressed in terms of $i_a(t)$, $i_b(t)$, and $i_s(t)$, i.e., express $i_c(t)$, $i_d(t)$, and $i_e(t)$ in terms of $i_a(t)$, $i_b(t)$, and $i_s(t)$.

(b) Write a KVL equation over the path defined by each mesh in the basic network using only $i_a(t)$, $i_b(t)$, and $i_s(t)$ as variables.

(c) Express your equations in matrix-vector form by filling in the missing entries in the equation below:

$$\begin{bmatrix} \quad & \quad \\ \quad & \quad \end{bmatrix} \begin{bmatrix} i_a(t) \\ i_b(t) \end{bmatrix} = \begin{bmatrix} \quad \\ \quad \end{bmatrix} i_s(t)$$

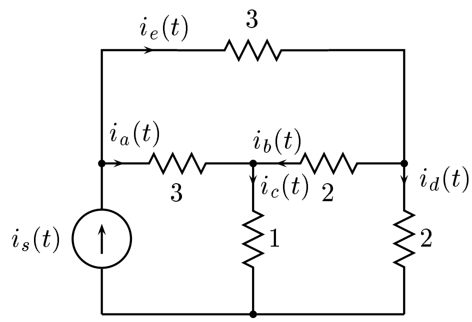

Figure 4: Circuit for Problem 3.4

(d) Solve your equations in (c) and use your solution to derive values for all the voltages and currents in the network.

Problem 3.5: In our derivation of the mesh method, we stressed its duality with the node method, i.e., the similarity of the two methods if the roles of voltages and currents, and nodes and meshes are reversed. This problem lets you explore this issue further. Consider the network in Figure 5.

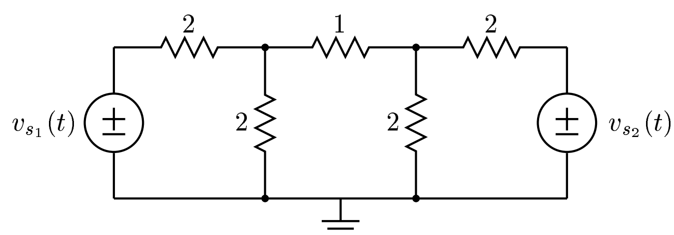

Figure 5: Circuit for Problem 3.5.

(a) Use the node method to determine the set of equations that must be solved to find the equilibrium solution. Omit the ground node when writing your equations. Express these equations in the form

$$\boldsymbol{C}\boldsymbol{v}(t) = \boldsymbol{s}_1 v_{s_1}(t) + \boldsymbol{s}_2 v_{s_2}(t).$$

Here $\boldsymbol{v}(t)$ is a vector of node potentials, $\boldsymbol{s}_1$ and $\boldsymbol{s}_2$ are column vectors of constants, and $\boldsymbol{C}$ is a constant matrix.

(b) Now design a *different* network containing two *current* sources with currents $i_{s_1}(t)$ and $i_{s_2}(t)$, such that the set of *mesh* equations that need to be solved to find the equilibrium solution is

$$\boldsymbol{C}\boldsymbol{i}(t) = \boldsymbol{s}_1 i_{s_1}(t) + \boldsymbol{s}_2 i_{s_2}(t).$$

and $\boldsymbol{i}(t)$ is the vector of mesh currents, where $\boldsymbol{C}$, $\boldsymbol{s}_1$ and $\boldsymbol{s}_2$ are the same as for your solution in part (a).

(c) Solve your equations from part (b).