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# EECS 16A    Designing Information Devices and Systems I    Discussion 6A

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## 1 Circuit Analysis Algorithm

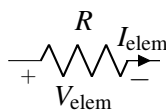
- **Step 1:** Pick a junction and label it as  $u = 0$  (“ground”), meaning that we will measure all of the voltages in the rest of the circuit relative to this point.
- **Step 2:** Label all remaining junctions as some “ $u_i$ ”, representing the potential at each junction relative to the zero junction/ground.
- **Step 3:** Label the current through every element in the circuit “ $i_n$ ”. Every element in the circuit that was listed above should have a current label, including ideal wires. The direction of the arrow indicates which direction of current flow you are considering to be positive. At this stage of the algorithm, you can pick the direction of all of the current arrows *arbitrarily* - as long as you are consistent with this choice and follow the rules described in the rest of this algorithm, the math will work out correctly.

Note that we only label the current once for each element – for example, we can label  $i_3$  as the current leaving the resistor *or* we can label it as the the current entering the resistor. These are equivalent because KCL also holds within the element itself – i.e., the current that enters an element must be equal to the current that exits that same element.

- **Step 4:** Add  $+/-$  labels on each element, following **Passive Sign Convention** (discussed below). These labels will indicate the direction with which voltage will be measured across that element.

### Passive sign convention

The **passive sign convention** dictates that positive current should *enter* the positive terminal and *exit* the negative terminal of an element. Below is an example for a resistor:



As long as this convention is followed consistently, it does not matter which direction you arbitrarily assigned each element current to; the voltage referencing will work out to determine the correct final sign. When we discuss *power* later in the module, you will see why we call this convention “passive.”

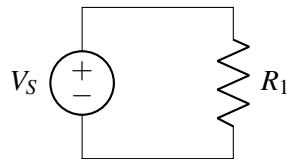
- **Step 5:** Set up the relationship  $\mathbf{A}\vec{x} = \vec{b}$ , where  $\vec{x}$  is comprised of the unknown circuit variables we want to solve for (currents and node potentials – that is, the  $i$ 's and  $u$ 's).  $\mathbf{A}$  will be an  $n \times n$  matrix where  $n$  is equal to the number of unknown variables.
- **Step 6:** Use KCL to fill in as many **Linearly Independent** rows of  $\mathbf{A}$  and  $\vec{b}$  as possible. You should get a KCL equation for every junction including the ground junction. However, one of these junctions will give us a linearly dependent equation. Generally, we do not write a KCL equation for the ground junction.

- **Step 7:** Use the  $IV$  relationships of each of the elements to fill in the remaining equations (rows of  $\mathbf{A}$  and values of  $\vec{b}$ ).

At this point the analysis procedure is effectively complete - all that's left to do is solve the system of linear equations (by applying Gaussian Elimination, inverting  $\mathbf{A}$ , etc.) to find the values for the  $u$ 's and  $i$ 's.

## 1. A Simple Circuit

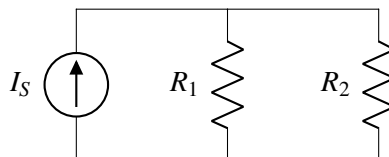
For the circuit shown below, find the voltages across all the elements and the currents through all the elements.



- In the above circuit, pick a ground node. Does your choice of ground matter?
- With your choice of ground, label the node potentials for every node in the circuit.
- Label all of the branch currents. Does the direction you pick matter?
- Draw the  $+/-$  labels on every element. What convention must you follow?
- Set up a matrix equation in the form  $\mathbf{A}\vec{x} = \vec{b}$  to solve for the unknown node potentials and currents. What are the dimensions of the matrix  $\mathbf{A}$ ?
- Use KCL to find as many equations as you can for the matrix.
- Use  $IV$  relations to find the remaining the equations for the matrix.
- Solve the system of equations if  $V_S = 5\text{ V}$  and  $R_1 = 5\ \Omega$ .

## 2. A Slightly More Complicated Circuit

For the circuit shown below, find the voltages across all the elements and the currents through all the elements.

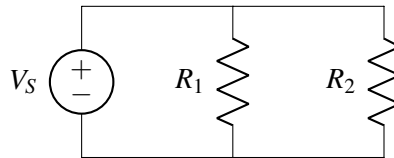


- In the above circuit, pick a ground node. Does your choice of ground matter?
- With your choice of ground, label the node potentials for every node in the circuit.
- Label all of the branch currents. Does the direction you pick matter?
- Draw the  $+/-$  labels on every element. What convention must you follow?
- Set up a matrix equation in the form  $\mathbf{A}\vec{x} = \vec{b}$  to solve for the unknown node potentials and currents. What are the dimensions of the matrix  $\mathbf{A}$ ?

- (f) Use KCL to find as many equations as you can for the matrix.
- (g) Use  $IV$  relations to find the remaining the equations for the matrix.
- (h) Solve the system of equations if  $I_S = 5 \text{ A}$ ,  $R_1 = 5 \Omega$ , and  $R_2 = 10 \Omega$ .

### 3. (PRACTICE) Another Circuit

For the circuit shown below, find the voltages across all the elements and the currents through all the elements.



- (a) In the above circuit, pick a ground node. Does your choice of ground matter?
- (b) With your choice of ground, label the node potentials for every node in the circuit.
- (c) Label all the branch currents. Does the direction you pick matter?
- (d) Draw the  $+/-$  labels on every element. What convention must you follow?
- (e) Set up a matrix equation in the form  $\mathbf{A}\vec{x} = \vec{b}$  to solve for the unknown node potentials and currents. What are the dimensions of the matrix  $\mathbf{A}$ ?
- (f) Use KCL to find as many equations as you can for the matrix.
- (g) Use  $IV$  relations to find the remaining equations for the matrix.
- (h) Solve the system of equations if  $V_S = 5 \text{ V}$ ,  $R_1 = 5 \Omega$ , and  $R_2 = 10 \Omega$ .