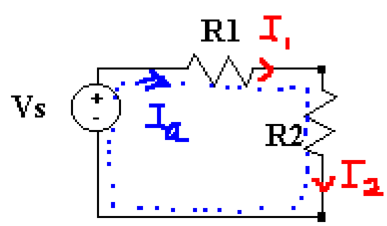
EECE 202 NETWORK ANALYSIS I Dr. Charles J. Kim

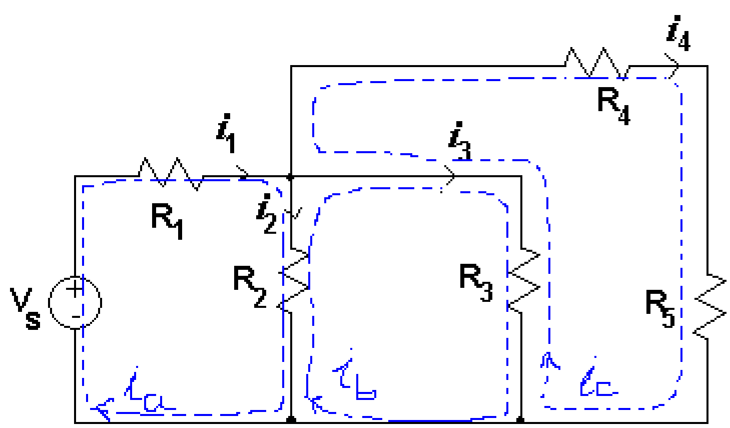
Note14: Why Do We Need Additional Methods in Circuit Analysis
-2. Mesh Current Method

A. Mesh Current Method

1. Now we discuss the second part of the methods.
2. By the way, let's discuss about the identity of *mesh current* first. What the heck is this illusive, non-physical current?
3. The tem “current” we use is the current through an element, or “element current.”
4. On the other hand, *mesh current* is defined as the *current that exists only in the perimeter of a mesh*.
5. In a simple circuit like one shown below, the term “current only in the perimeter” is not confusing at all. The mesh current along the only mesh, I_a, is the same as the element currents (or branch currents) $I_1=I_2$. Mesh current in this case is a physical entity, i.e., a measurable variable. Good. Let's move on.

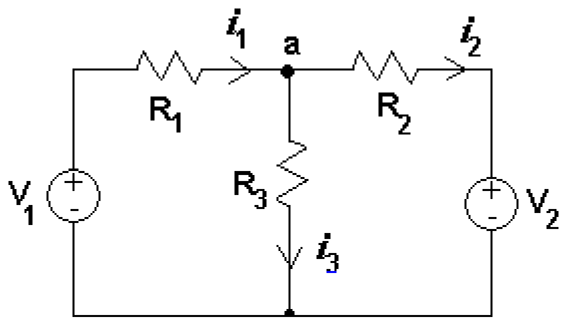


6. But, how about the circuit below? Since we have 3 meshes and the mesh currents are indicate as I_a, I_b, and I_c. And we have 4 branch currents (and they are measurable!).

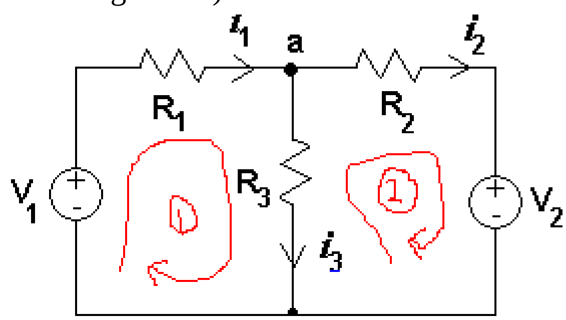


7. Some questions:
   Q1: Does mesh current I_a in the drawing imply that the current through R_1 is same as the current through R_2? Violation of KCL!!
   Q2: How come two current mesh (I_a and I_b) are assigned for a current through a resistor (R_2)? Same for I_b and I_c for R_3?
   Q3: Are the mesh currents are measurable and physical?
   Q4: Why do we need these ghost currents to solve circuit problems?
   Q5: Any benefit using them? –*This is the most relevant question on mesh analysis.*

8. The benefit of using mesh current is explained using the following example.
9. Let's use only **branch currents** for the following circuit.



10. Since there are three current variables, i_1, i_2, and i_3, we know we need 3 equations.
KCL at node a: $i_1 = i_2 + i_3$ or $i_3 = i_1 - i_2$ ------(1)
KVL at two loops: (See drawing below)



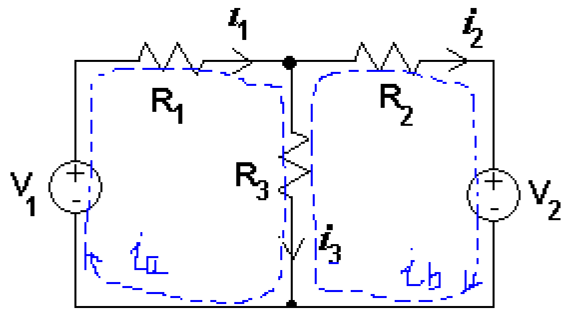
Loop 1: $-V_1 + i_1R_1 + i_3R_3 = 0$ -----(2)
Loop 2: $V_2 + i_2R_2 - i_3R_3 = 0$ ----(3)

So we have three equations for the three variables; (1), (2), and (3).

11. Now, we see that, by the substitution of i_3 from (1) for (i_1-i_2) at the equations (2) and (3), we can reduce the number of equations to 2:

(2) -----> $-V_1 + i_1R_1 + (i_1 - i_2)R_3 = 0$ ----(1)'
(3) -----> $V_2 + i_2R_2 + (i_2 - i_1)R_3 = 0$ ----(2)'

12. Now, let's define the currents in the perimeters as two **mesh currents** i_a and i_b.
Note that the branch current i_1 is same as i_a , and i_b=i_2.



13. Also, we can see that the branch current i3 is the net current of two mesh currents, i.e., $i_3 = i_a - i_b$
14. Then, if we directly apply KVL on the loops, we have:
    Left Loop: $-V_1 + i_1 R_1 + i_3 R_3 = -V_1 + i_a R_1 + (i_a - i_b) R_3 = 0$ ...(1)"
    Right Loop: $V_2 + i_2 R_2 - i_3 R_3 = V_2 + i_b R_2 - (i_a - i_b) R_3 = 0$ ...(2)"

15. What's the point then?

    a. When we use branch currents only, we need 3 equations to find all three current variables: equations. After some substitutions, they are reduced to 2 equations.
    b. When we define and use mesh currents, then we can get the same 2 equations directly from KVL.

16. We can say this statement, then, that mesh current method is actually applying KVL around a mesh with "net voltage drop" across an element.

17. Here is the order of mesh current method application:
    a. Assign mesh currents to the meshes
    b. Using Ohm's Law, express the voltages in a mesh in terms of the mesh current
    c. Apply KVL to each mesh
    d. Solve the resulting simultaneous equation to get the mesh current

B. Other methods and tools

1. In addition to the node method and the mesh method, we are going to study the following analysis techniques:
    a. Source transformation
    b. Thevenin equivalent circuit
    c. Superposition
2. Yes, the Laws are enough, but some methods derived from the Laws add some convenience like reduced number of equations, circuit simplification, and circuit equivalence.