Lecture 6

FINDING VOLTAGES IN A CIRCUIT

So far, we have been applying KVL and KCL "haphazardly" to find voltages and currents in a circuit.

Good for developing intuition, finding things quickly…

…but what if the circuit is complicated? What if you get stuck?

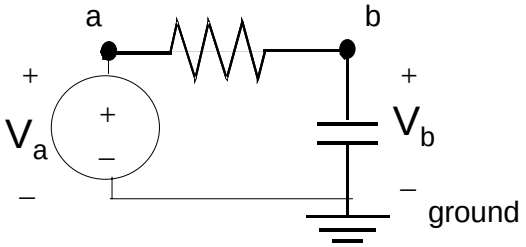
Systematic way to find all node voltages in a circuit:

Nodal Analysis

NOTATION: NODE VOLTAGES

The voltage drop from node X to a reference node (ground) is called the **node voltage** V_x.

Example:



FORMAL CIRCUIT ANALYSIS USING KCL: NODAL ANALYSIS

(Memorize these steps and apply them rigorously!)

1 Choose a reference node (ground, node 0) (look for the one with the most connections!)

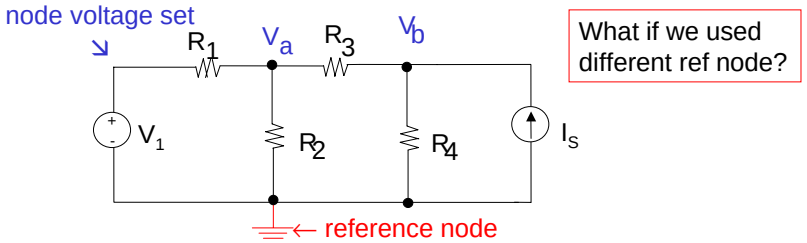
2 Define unknown node voltages (those not fixed by voltage sources)

3 Write KCL at each unknown node, expressing current in terms of the node voltages (using the I-V relationships of branch elements*)

4 Solve the set of equations (N equations for N unknown node voltages)

* with floating voltages we will use a modified Step 3

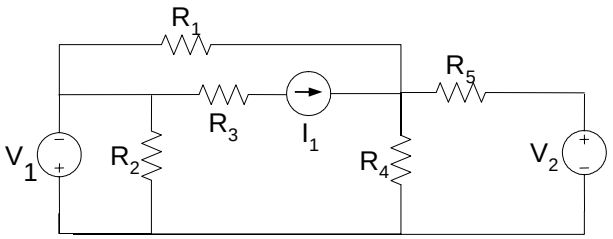
EXAMPLE OF NODE ANALYSIS



What if we used different ref node?

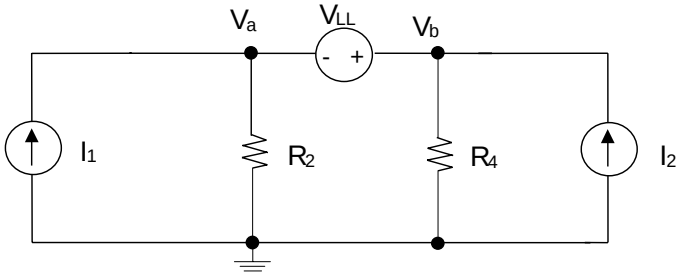
1. Choose a reference node.
2. Define the node voltages (except reference node and the one set by the voltage source).
3. Apply KCL at the nodes with unknown voltage.
4. Solve for Va and Vb in terms of circuit parameters.

EXAMPLE OF NODE ANALYSIS



NODAL ANALYSIS WITH "FLOATING" VOLTAGE SOURCES

A "floating" voltage source is a voltage source for which neither side is connected to the reference node. V_{LL} in the circuit below is an example.

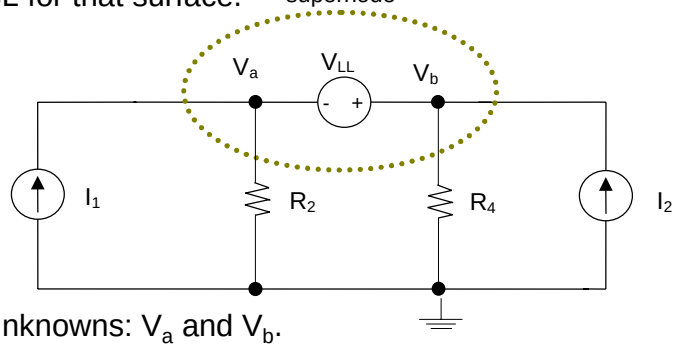


Problem: We cannot write KCL at node a or b because there is no way to express the current through the voltage source in terms of $V_a - V_b$.

Solution: Define a "supernode" – that chunk of the circuit containing nodes a and b. Express KCL at this supernode.

FLOATING VOLTAGE SOURCES (cont.)

Use a Gaussian surface to enclose the floating voltage source; write KCL for that surface.



Two unknowns: V_a and V_b.

Get one equation from KCL at supernode:

Get a second equation from the property of the voltage source:

ANOTHER EXAMPLE